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Appendix A. Acceptable Aluminum Toxicity Data for Assessment

A.1 Acceptable Acute Aluminum Toxicity Data.

Order	Family	Common name (lifestage) / Species	Method[a]	Chemical	Hardness (mg/L as $CaCO_3$)	pH	DOC (mg/L)	Normalized LC50 or EC50 (µg/L)[b]	Reference	Species Mean Acute Value (µg/L)	Genus Mean Acute Value (µg/L)	Family Mean Acute Value (µg/L)	Order Mean Acute Value (µg/L)
FRESHWATER													
Tubificida	Naididae	Worm (adult, 1.0 cm), *Nais elinguis*	R, M, T	Aluminum sulfate	17.89	6.5	3.2	9,224	Shuhaimi-Othman et al. 2012a, 2013	9,224	9,224	9,224	9,224
Basommatophora	Physidae	Snail (adult), *Physa sp.*	S, M, T	Aluminum chloride	47.4	6.6	1.1	>52,593	Call 1984; Call et al. 1984	41,858	41,858	41,858	41,858
Basommatophora	Physidae	Snail (adult), *Physa sp.*	S, M, T	Aluminum chloride	47.4	7.6	1.1	27,057	Call 1984; Call et al. 1984				
Basommatophora	Physidae	Snail (adult), *Physa sp.*	S, M, T	Aluminum chloride	47.4	7.5	1.1	51,539	Call 1984; Call et al. 1984				
Neotaenioglossa	Thiaridae	Snail (adult, 1.5-2.0 cm, 22.5 mg), *Melanoides tuberculata*	R, M, T	Aluminum sulfate	18.72	6.7	3.2	119,427	Shuhaimi-Othman et al. 2012b, 2013	119,427	119,427	119,427	119,427
Unionoida	Unionidea	Fatmucket (juvenile, 7-8 d, 0.38 mm), *Lampsilis siliquoidea*	F, M, T	Aluminum nitrate	106.0	6.12	0.48	>29,492	Wang et al. 2016; Wang et al. 2018	>29,492	>29,492	>29,492	>29,492
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, M, A	Aluminum chloride	50.0	7.4	1.1	1,771	McCauley et al. 1986	5,863	7,770	4,250	4,250
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, M, A	Aluminum chloride	50.5	7.9	1.1	1,170	McCauley et al. 1986				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, M, A	Aluminum chloride	50.0	8.1	1.1	1,974	McCauley et al. 1986				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	R, M, T	Aluminum chloride	25	7.5	0.5	1,321	ENSR 1992d				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	R, M, T	Aluminum chloride	49	7.7	0.5	2,516	ENSR 1992d				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, M, T	Aluminum chloride	95	7.9	0.5	2,559	ENSR 1992d				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	R, M, T	Aluminum chloride	193	8.1	0.5	>88,933	ENSR 1992d				

Order	Family	Common name (lifestage) / Species	Method[a]	Chemical	Hardness (mg/L as $CaCO_3$)	pH	DOC (mg/L)	Normalized LC50 or EC50 (µg/L)[b]	Reference	Species Mean Acute Value (µg/L)	Genus Mean Acute Value (µg/L)	Family Mean Acute Value (µg/L)	Order Mean Acute Value (µg/L)
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, NR	Aluminum sulfate	90	7.2	0.5	5,243	Fort and Stover 1995				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, NR	Aluminum sulfate	90	7.2	0.5	7,981	Fort and Stover 1995				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, NR	Aluminum sulfate	89	8.2	0.5	3,189	Soucek et al. 2001				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	R, U, T	Aluminum chloride	142	8.2	1.6	77,169	Griffitt et al. 2008				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	10.6	6	0.5	2,009	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	10.6	6.1	2	7,721	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	10.6	6.1	4	10,568	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	10.6	6	0.5	1,924	European Al Association 2009; Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	10.6	6	0.5	4,394	European Al Association 2009; Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	10.6	6	0.5	5,546	European Al Association 2009; Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	10.6	5.9	0.5	4,945	European Al Association 2009; Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	10.6	7	0.5	>5,842	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	10.6	7.9	0.5	>9,735	European Al Association 2009				

Order	Family	Common name (lifestage) / Species	Method[a]	Chemical	Hardness (mg/L as $CaCO_3$)	pH	DOC (mg/L)	Normalized LC50 or EC50 (µg/L)[b]	Reference	Species Mean Acute Value (µg/L)	Genus Mean Acute Value (µg/L)	Family Mean Acute Value (µg/L)	Order Mean Acute Value (µg/L)
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	10.6	6.8	2	>26,061	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	10.6	7.8	2	>12,984	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	10.6	6.8	4	>18,075	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	10.6	7.7	4	>9,538	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	10.6	7.9	0.5	>3,793	European Al Association 2009; Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	10.6	7.9	0.5	>3,812	European Al Association 2009; Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	60	6	0.5	867.5	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	60	6	2	4,376	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	60	5.7	4	34,704	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	60	6.7	0.5	>26,800	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	60	7.8	0.5	>5,975	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	60	6.8	2	>10,615	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	60	7.7	2	>8,154	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	60	6.7	4	>12,073	European Al Association 2009				

Order	Family	Common name (lifestage) / Species	Method[a]	Chemical	Hardness (mg/L as $CaCO_3$)	pH	DOC (mg/L)	Normalized LC50 or EC50 (µg/L)[b]	Reference	Species Mean Acute Value (µg/L)	Genus Mean Acute Value (µg/L)	Family Mean Acute Value (µg/L)	Order Mean Acute Value (µg/L)
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	60	7.6	4	>5,487	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	120	6.1	2	6,889	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	120	5.6	4	34,985	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	120	6.9	0.5	>7,361	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	120	7.9	0.5	>4,896	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	120	6.8	2	>11,400	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	120	7.7	2	>6,471	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	120	6.6	4	>9,047	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, U, T	Aluminum nitrate	120	7.6	4	>4,366	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, M, T	Aluminum nitrate	10.6	6	0.5	3,227	European Al Association 2010				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, M, T	Aluminum nitrate	10.6	6	0.5	7,407	European Al Association 2010				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, M, T	Aluminum nitrate	10.6	6	0.5	3,234	European Al Association 2010				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, M, T	Aluminum nitrate	10.6	6.1	0.5	2,273	European Al Association 2010				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, M, T	Aluminum nitrate	10.6	7.1	0.5	>3,528	European Al Association 2010				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, M, T	Aluminum nitrate	10.6	7.8	0.5	>8,625	European Al Association 2010				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, M, T	Aluminum nitrate	10.6	7.5	0.5	322.4	European Al Association 2010				

Order	Family	Common name (lifestage) / Species	Method[a]	Chemical	Hardness (mg/L as $CaCO_3$)	pH	DOC (mg/L)	Normalized LC50 or EC50 (µg/L)[b]	Reference	Species Mean Acute Value (µg/L)	Genus Mean Acute Value (µg/L)	Family Mean Acute Value (µg/L)	Order Mean Acute Value (µg/L)
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, M, T	Aluminum nitrate	60.0	6	0.5	3,845	European Al Association 2010				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	S, M, T	Aluminum nitrate	60.0	6	0.5	>7,415	European Al Association 2010				
Diplostraca	Daphniidae	Cladoceran (0-24 hr), *Ceriodaphnia reticulata*	F, M, T	Aluminum chloride	45.1	6.0	1.1	1,967	Shephard 1983	10,299			
Diplostraca	Daphniidae	Cladoceran (0-24 hr), *Ceriodaphnia reticulata*	F, M, T	Aluminum chloride	4.0	5.5	1.1	53,910	Shephard 1983				
Diplostraca	Daphniidae	Cladoceran (0-24 hr), *Daphnia magna*	S, U, NR	Aluminum chloride	48.5	7.8	1.1	3,117	Biesinger and Christensen 1972	2,944	2,325		
Diplostraca	Daphniidae	Cladoceran (0-24 hr), *Daphnia magna*	S, M, T	Aluminum sulfate	220	7.6	1.6	15,625	Kimball 1978				
Diplostraca	Daphniidae	Cladoceran (0-24 hr), *Daphnia magna*	S, U, T	Aluminum chloride	45.1	7.3	1.1	3,070	Shephard 1983				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Daphnia magna*	S, U, T	Aluminum nitrate	168	6	0.5	>2,075	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Daphnia magna*	S, U, T	Aluminum nitrate	168	7.9	0.5	713.2	European Al Association 2009				
Diplostraca	Daphniidae	Cladoceran (adult), *Daphnia pulex*	R, U, T	Aluminum chloride	142	8.2	1.6	1,836	Griffitt et al. 2008	1,836			
Podocopida	Cyprididae	Ostracod (adult, 1.5 mm, 0.3 mg), *Stenocypris major*	R, M, T	Aluminum sulfate	15.63	6.5	3.2	8,000	Shuhaimi-Othman et al. 2011a, 2013	8,000	8,000	8,000	8,000
Amphipoda	Crangonyctidae	Amphipod (4 mm), *Crangonyx pseudogracilis*	R, U, T	Aluminum sulfate	50	6.8	1.6	12,901	Martin and Holdich 1986	12,901	12,901	12,901	18,926
Amphipoda	Hyalellidae	Amphipod (juvenile, 7 d, 1.32 mm), *Hyalella azteca*	F, M, T	Aluminum nitrate	105	6.1	0.48	>27,766	Wang et al. 2016, 2018	>27,766	>27,766	>27,766	
Diptera	Chironomidae	Midge (3rd-4th instar larvae), *Chironomus plumosus*	S, U, T	Aluminum chloride	80	7.0	1.6	25,216	Fargasova 2001, 2003	25,216	25,216	42,207	42,207

Order	Family	Common name (lifestage) / Species	Method[a]	Chemical	Hardness (mg/L as $CaCO_3$)	pH	DOC (mg/L)	Normalized LC50 or EC50 (µg/L)[b]	Reference	Species Mean Acute Value (µg/L)	Genus Mean Acute Value (µg/L)	Family Mean Acute Value (µg/L)	Order Mean Acute Value (µg/L)
Diptera	Chironomidae	Midge (2nd-3rd instar larvae), *Paratanytarsus dissimilis*	S, M, T	Aluminum sulfate	17.43	7.3	2.8	>70,647	Lamb and Bailey 1981, 1983	>70,647	>70,647		
Salmoniformes	Salmonidae	Rainbow trout (juvenile, 1-3 g), *Oncorhynchus mykiss*	F, M, T	Aluminum chloride	26.35	7.6	0.5	>7,216	Gundersen et al. 1994	3,312	3,312	8,150	8,150
Salmoniformes	Salmonidae	Rainbow trout (juvenile, 1-3 g), *Oncorhynchus mykiss*	F, M, T	Aluminum chloride	45.5	7.6	0.5	>5,766	Gundersen et al. 1994				
Salmoniformes	Salmonidae	Rainbow trout (juvenile, 1-3 g), *Oncorhynchus mykiss*	F, M, T	Aluminum chloride	88.05	7.6	0.5	>5,390	Gundersen et al. 1994				
Salmoniformes	Salmonidae	Rainbow trout (juvenile, 1-3 g), *Oncorhynchus mykiss*	F, M, T	Aluminum chloride	127.6	7.6	0.5	>5,164	Gundersen et al. 1994				
Salmoniformes	Salmonidae	Rainbow trout (juvenile, 1-3 g), *Oncorhynchus mykiss*	F, M, T	Aluminum chloride	23.25	8.3	0.5	1,685	Gundersen et al. 1994				
Salmoniformes	Salmonidae	Rainbow trout (juvenile, 1-3 g), *Oncorhynchus mykiss*	F, M, T	Aluminum chloride	35.4	8.3	0.5	1,680	Gundersen et al. 1994				
Salmoniformes	Salmonidae	Rainbow trout (juvenile, 1-3 g), *Oncorhynchus mykiss*	F, M, T	Aluminum chloride	83.6	8.3	0.5	2,180	Gundersen et al. 1994				
Salmoniformes	Salmonidae	Rainbow trout (juvenile, 1-3 g), *Oncorhynchus mykiss*	F, M, T	Aluminum chloride	128.5	8.31	0.5	2,026	Gundersen et al. 1994				
Salmoniformes	Salmonidae	Atlantic salmon (sac fry, ≈0.2 g), *Salmo salar*	S, U, T	Aluminum chloride	6.8	5.5	0.5	20,749	Hamilton and Haines 1995	8,642	8,642		
Salmoniformes	Salmonidae	Atlantic salmon (sac fry, ≈0.2 g), *Salmo salar*	S, U, T	Aluminum chloride	6.8	6.5	0.5	3,599	Hamilton and Haines 1995				

Order	Family	Common name (lifestage) / Species	Method[a]	Chemical	Hardness (mg/L as $CaCO_3$)	pH	DOC (mg/L)	Normalized LC50 or EC50 (µg/L)[b]	Reference	Species Mean Acute Value (µg/L)	Genus Mean Acute Value (µg/L)	Family Mean Acute Value (µg/L)	Order Mean Acute Value (µg/L)
Salmoniformes	Salmonidae	Brook trout (0.6 g, 4.4-7.5 cm), *Salvelinus fontinalis*	S, U, T	Aluminum sulfate	40	5.6	1.6	30,038	Tandjung 1982	18,913	18,913		
Salmoniformes	Salmonidae	Brook trout (0.6 g, 4.4-7.5 cm), *Salvelinus fontinalis*	S, U, T	Aluminum sulfate	18	5.6	1.6	24,514	Tandjung 1982				
Salmoniformes	Salmonidae	Brook trout (0.6 g, 4.4-7.5 cm), *Salvelinus fontinalis*	S, U, T	Aluminum sulfate	2	5.6	1.6	9,187	Tandjung 1982				
Cypriniformes	Cyprinidae	Rio Grande silvery minnow (larva, 3-5 dph), *Hybognathus amarus*	R, M, T	Aluminum chloride	140	8.1	0.5	>21,779	Buhl 2002	>21,779	>21,779	>21,937	>21,937
Cypriniformes	Cyprinidae	Fathead minnow (juvenile, 32-33 d), *Pimephales promelas*	S, M, T	Aluminum chloride	47.4	7.6	1.1	>28,019	Call et al. 1984	>22,095	>22,095		
Cypriniformes	Cyprinidae	Fathead minnow (juvenile, 32-33 d), *Pimephales promelas*	S, M, T	Aluminum chloride	47.4	8.1	1.1	>17,678	Call et al. 1984				
Cypriniformes	Cyprinidae	Fathead minnow (larva, 4-6 dph), *Pimephales promelas*	R, M, T	Aluminum chloride	140	8.1	0.5	>21,779	Buhl 2002				
Cyprinodontiformes	Poeciliidae	Guppy, *Poecilia reticulata*	R, M, T	Aluminum sulfate	18.72	6.68	3.2	9,061	Shuhaimi-Othman et al. 2013	9,061	9,061	9,061	9,061
Perciformes	Centrarchidae	Green sunfish (juvenile, 3 mo.), *Lepomis cyanellus*	S, M, T	Aluminum chloride	47.4	7.6	1.1	>31,087	Call et al. 1984	>31,087	>31,087	9,637	9,637
Perciformes	Centrarchidae	Smallmouth bass (larvae, 48 hph), *Micropterus dolomieu*	S, M, T	Aluminum sulfate	12.15	5.1	1.6	2,442	Kane 1984; Kane and Rabeni 1987	2,988	2,988		
Perciformes	Centrarchidae	Smallmouth bass (larvae, 48 hph), *Micropterus dolomieu*	S, M, T	Aluminum sulfate	12.4	6.3	1.6	>3,655	Kane 1984; Kane and Rabeni 1987				

Order	Family	Common name (lifestage) / Species	Method[a]	Chemical	Hardness (mg/L as $CaCO_3$)	pH	DOC (mg/L)	Normalized LC50 or EC50 (µg/L)[b]	Reference	Species Mean Acute Value (µg/L)	Genus Mean Acute Value (µg/L)	Family Mean Acute Value (µg/L)	Order Mean Acute Value (µg/L)
Anura	Hylidae	Green tree frog (tadpole, <1 dph), *Hyla cinerea*	R, M, T	Aluminum chloride	4.55	5.5	0.5	>18,563	Jung and Jagoe 1995	>18,563	>18,563	>18,563	>18,563

[a] S=static, F=flow-through, U=unmeasured, M=measured, A=acid exchangeable aluminum, T=total aluminum, D=dissolved aluminum, NR=not reported.
[b] All values expressed as total aluminum, normalized to pH 7, DOC of 1 mg/L and 100 mg/L hardness as $CaCO_3$; normalized using MLR equations indentified in USEPA (2018).

A.2 Acceptable Chronic Aluminum Toxicity Data.

Order	Family	Common name (lifestage) / Species	Chemical	Test[a]	Hardness (mg/L as $CaCO_3$)	pH	DOC (mg/L)	EC20 Endpoint	Normalized EC20 (µg/L)[b]	Reference	Species Mean Chronic Value (µg/L)	Genus Mean Chronic Value (µg/L)	Family Mean Chronic Value (µg/L)	Order Mean Chronic Value (µg/L)
FRESHWATER														
-	Aeolosomatidae	Oligochaete (<24 hr)	Aluminum nitrate	ELS	48	5.95	0.25	Reproduction (population size)	20,514	OSU 2012e; Cardwell et al. 2018	20,514	20,514	20,514	20,514
Ploima	Brachionidae	Rotifer (newly hatched, <2 hr), *Brachionus calyciflorus*	Aluminum nitrate	LC	100	6.45	0.25	Reproduction (population size)	1,845	OSU 2012c; Cardwell et al. 2018	3,539	3,539	3,539	3,539
Ploima	Brachionidae	Rotifer (newly hatched, <2 hr), *Brachionus calyciflorus*	Aluminum nitrate	LC	63	6.3	1.39	Reproduction (population size)	4,518	OSU 2018e				
Ploima	Brachionidae	Rotifer (newly hatched, <2 hr), *Brachionus calyciflorus*	Aluminum nitrate	LC	105	6.3	1.39	Reproduction (population size)	3,844	OSU 2018e				
Ploima	Brachionidae	Rotifer (newly hatched, <2 hr), *Brachionus calyciflorus*	Aluminum nitrate	LC	114	6.2	2.63	Reproduction (population size)	4,323	OSU 2018e				
Ploima	Brachionidae	Rotifer (newly hatched, <2 hr), *Brachionus calyciflorus*	Aluminum nitrate	LC	105	6.1	3.77	Reproduction (population size)	6,653	OSU 2018e				

Order	Family	Common name (lifestage) / Species	Chemical	Test[a]	Hardness (mg/L as $CaCO_3$)	pH	DOC (mg/L)	EC20 Endpoint	Normalized EC20 (µg/L)[b]	Reference	Species Mean Chronic Value (µg/L)	Genus Mean Chronic Value (µg/L)	Family Mean Chronic Value (µg/L)	Order Mean Chronic Value (µg/L)
Ploima	Brachionidae	Rotifer (newly hatched, <2 hr), *Brachionus calyciflorus*	Aluminum nitrate	LC	185	6.3	1.33	Reproduction (population size)	2,132	OSU 2018e				
Basommatophora	Lymnaeidae	Great pond snail (newly-hatched, <24 hr), *Lymnaea stagnalis*	Aluminum nitrate	ELS (30 d)	117	6	0.25	Biomass	5,945	OSU 2012b; Cardwell et al. 2018	3,119	3,119	3,119	3,119
Basommatophora	Lymnaeidae	Great pond snail (newly-hatched, <24 hr), *Lymnaea stagnalis*	Aluminum nitrate	ELS (30 d)	121	6.15	1.37	Biomass	1,812	OSU 2018f				
Basommatophora	Lymnaeidae	Great pond snail (newly-hatched, <24 hr), *Lymnaea stagnalis*	Aluminum nitrate	ELS (30 d)	124	6.17	1.45	Biomass	3,902	OSU 2018f				
Basommatophora	Lymnaeidae	Great pond snail (newly-hatched, <24 hr), *Lymnaea stagnalis*	Aluminum nitrate	ELS (30 d)	117	5.98	3.85	Biomass	2,251	OSU 2018f				
Unionoida	Unionidea	Fatmucket (6 wk, 1.97 mm), *Lampsilis siliquoidea*	Aluminum nitrate	ELS (28 d)	105.5	6.04	0.40	Biomass	1,026	Wang et al. 2016, 2018	1,026	1,026	1,026	1,026
Diplostraca	Daphniidae	Cladoceran (≤16 hr), *Ceriodaphnia dubia*	Aluminum chloride	LC	50	7.15	1.1	Reproduction - young/starting adult	2,031	McCauley et al. 1986	1,181	1,181	1,079	1,079
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum chloride	LC	25	7.65	0.5	Reproduction - young/female	2,602	ENSR 1992b				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum chloride	LC	47	7.7	0.5	Reproduction - young/female	1,077	ENSR 1992b				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum chloride	LC	94	8.2	0.5	Reproduction - young/female	709	ENSR 1992b				

Order	Family	Common name (lifestage) / Species	Chemical	Test[a]	Hardness (mg/L as $CaCO_3$)	pH	DOC (mg/L)	EC20 Endpoint	Normalized EC20 (µg/L)[b]	Reference	Species Mean Chronic Value (µg/L)	Genus Mean Chronic Value (µg/L)	Family Mean Chronic Value (µg/L)	Order Mean Chronic Value (µg/L)
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum chloride	LC	196	8.45	0.5	Reproduction - young/female	747	ENSR 1992b				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	25	6.34	0.5	Reproduction	292	European Al Association 2010; Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	60	6.4	0.5	Reproduction	668	European Al Association 2010; Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	120	6.38	0.5	Reproduction	619	European Al Association 2010; Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	25	6.34	2	Reproduction	1,315	European Al Association 2010; Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	60	6.38	2	Reproduction	1,187	European Al Association 2010; Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	120	6.37	2	Reproduction	1,254	European Al Association 2010; Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	25	6.33	4	Reproduction	1,460	European Al Association 2010; Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	60	6.3	4	Reproduction	981	European Al Association 2010; Gensemer et al. 2018				

Order	Family	Common name (lifestage) / Species	Chemical	Test[a]	Hardness (mg/L as $CaCO_3$)	pH	DOC (mg/L)	EC20 Endpoint	Normalized EC20 (µg/L)[b]	Reference	Species Mean Chronic Value (µg/L)	Genus Mean Chronic Value (µg/L)	Family Mean Chronic Value (µg/L)	Order Mean Chronic Value (µg/L)
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	120	6.38	4	Reproduction	679	European Al Association 2010; Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	25	6.37	2	Reproduction	1,164	Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	25	6.34	2	Reproduction	1,576	Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	25	6.35	2	Reproduction	1,504	Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	25	7.04	0.5	Reproduction (young/female)	701	CECM 2014; Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	120	7.14	0.5	Reproduction (young/female)	1,072	CECM 2014; Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	25	7.98	0.5	Reproduction (young/female)	1,029	CECM 2014; Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	60	8.03	0.5	Reproduction (young/female)	1,189	CECM 2014; Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	120	8.10	0.5	Reproduction (young/female)	880	CECM 2014; Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	25	6.34	0.5	Reproduction (young/female)	2,072	CECM 2014; Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	120	6.36	0.5	Reproduction (young/female)	1,122	CECM 2014; Gensemer et al. 2018				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	64	6.42	1.87	Reproduction (young/female)	1,463	OSU 2018a				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	133	6.33	8.71	Reproduction (young/female)	1,973	OSU 2018a				

Order	Family	Common name (lifestage) / Species	Chemical	Test[a]	Hardness (mg/L as $CaCO_3$)	pH	DOC (mg/L)	EC20 Endpoint	Normalized EC20 (µg/L)[b]	Reference	Species Mean Chronic Value (µg/L)	Genus Mean Chronic Value (µg/L)	Family Mean Chronic Value (µg/L)	Order Mean Chronic Value (µg/L)
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	138	6.4	12.3	Reproduction (young/female)	2,308	OSU 2018a				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	428	6.3	1.64	Reproduction (young/female)	1,388	OSU 2018a				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	125	7.21	6.57	Reproduction (young/female)	1,614	OSU 2018a				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	127	7.19	12.01	Reproduction (young/female)	1,170	OSU 2018a				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	263	8.17	1.3	Reproduction (young/female)	1,854	OSU 2018a				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	425	8.21	1.2	Reproduction (young/female)	1,372	OSU 2018a				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Ceriodaphnia dubia*	Aluminum nitrate	LC	125	8.7	1.04	Reproduction (young/female)	1,530	OSU 2018a				
Diplostraca	Daphniidae	Cladoceran (<24 hr), *Daphnia magna*	Aluminum nitrate	LC	140	6.3	2	Reproduction (young/female)	985.3	European Al Association 2010; Gensemer et al. 2018	985.3	985.3		
Amphipoda	Hyalellidae	Amphipod (juvenile, 7-9 d), *Hyalella azteca*	Aluminum nitrate	ELS (28 d)	95	6.35	0.51	Biomass	665.9	OSU 2012h; Cardwell et al. 2018	1,387	1,387	1,387	1,387
Amphipoda	Hyalellidae	Amphipod (juvenile, 7 d, 1.31 mm), *Hyalella azteca*	Aluminum nitrate	ELS (28 d)	106	6.04	0.33	Biomass	2,890	Wang et al. 2016, 2018				
Diptera	Chironomidae	Midge (1st instar larva, <24 hr), *Chironomus riparius*	Aluminum sulfate	PLC	11.8	5.58	1.8	Adult midge emergence	1,075	Palawski et al. 1989	5,099	5,099	5,099	5,099
Diptera	Chironomidae	Midge (1st instar larva, <24 hr), *Chironomus riparius*	Aluminum sulfate	PLC	11.9	5.05	1.8	Adult midge emergence	15,069	Palawski et al. 1989				
Diptera	Chironomidae	Midge (1st instar larva, 3d), *Chironomus riparius*	Aluminum nitrate	LC	91	6.6	0.51	Reproduction (# of eggs/case)	8,181	OSU 2012f; Cardwell et al. 2018				

Order	Family	Common name (lifestage) / Species	Chemical	Test[a]	Hardness (mg/L as $CaCO_3$)	pH	DOC (mg/L)	EC20 Endpoint	Normalized EC20 (µg/L)[b]	Reference	Species Mean Chronic Value (µg/L)	Genus Mean Chronic Value (µg/L)	Family Mean Chronic Value (µg/L)	Order Mean Chronic Value (µg/L)
Salmoniformes	Salmonidae	Atlantic salmon (embryo), *Salmo salar*	Aluminum sulfate	ELS (60 d)	12.7	5.7	1.8	Biomass	434.4	McKee et al. 1989	434.4	434.4	526.5	526.5
Salmoniformes	Salmonidae	Brook trout (eyed eggs), *Salvelinus fontinalis*	Aluminum sulfate	ELS (60 d)	12.3	6.55	1.9	Biomass	378.7	Cleveland et al. 1989	638.2	638.2		
Salmoniformes	Salmonidae	Brook trout (eyed eggs), *Salvelinus fontinalis*	Aluminum sulfate	ELS (60 d)	12.8	5.65	1.8	Biomass	1,076	Cleveland et al. 1989				
Cypriniformes	Cyprinidae	Fathead minnow, *Pimephales promelas*	Aluminum sulfate	ELS (28 d)	220	7.70	1.6	Biomass	2,690	Kimball 1978	2,407	2,407	1,797	1,797
Cypriniformes	Cyprinidae	Fathead minnow (embryo, <24 hr), *Pimephales promelas*	Aluminum nitrate	ELS (33 d)	96	6.20	0.25	Fry survival	2,154	OSU 2012g; Cardwell et al. 2018				
Cypriniformes	Cyprinidae	Zebrafish (embryo, <36hpf), *Danio rerio*	Aluminum nitrate	ELS (33 d)	83	6.15	0.25	Biomass	1,342	OSU 2013; Cardwell et al. 2018	1,342	1,342		
Anura[c]	Ranidae	Wood frog (larva, Gosner stage 25), *Rana sylvatica*	Aluminum sulfate	Larva - complete metamorph. (43-120 d)	115	4.69	1.6	MATC	10,684	Peles 2013	>10,684	>10,684	>10,684	>10,684

[a] LC=Life cycle, ELS=Early life-stage.
[b] All values expressed as total aluminum, normalized to pH 7, DOC of 1 mg/L and 100 mg/L hardness as $CaCO_3$; normalized using MLR equations indentified in USEPA (2018).
[c] Other Data that can be used to fulfill missing MDR group.

Appendix B. Test Information, C-R Data and Resulting C-R models for Acute and Chronic Aluminum Toxicity Tests Considered Acceptable, Qualitatively Acceptable, or Unacceptable for TAF and MAF Calculation

B.1 Test Information, C-R Data and Resulting C-R models for Acute Aluminum Toxicity Tests Acceptable, Qualitatively Acceptable, or Unacceptable for Acute TAF and MAF Calculation.

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
mg/L	0.3	1.00	96 hr Survival	10	Physa sp.	Call et al 1984	Al-Acute 4	Unacceptable (3)	Model: Log Logistic type 1, 3 para, upper @ 1; This model suffers from a lack of range of responses, similar to the above models. Only one out of three parameters is significant. Large standard error with respect to estimate for EC10 value.	8.171	7.084	1.154
	0.3	1.00										
	2.4	1.00										
	2.6	1.00										
	5.2	1.00										
	5.6	1.00										
	12.0	0.20										
	11.6	0.80										
	23.4	0.80										
	23.5	1.00										
mg/L	0.3	1.00	96 hr Survival	10	Physa sp.	Call et al 1984	Al-Acute 5	Acceptable (1)	Model: Weibull type 2, 2 para; No significant problems with this model.	29.27	18.97	1.543
	0.3	1.00										
	6.4	1.00										
	6.3	1.00										
	12.3	1.00										
	12.3	1.00										
	24.8	0.40										
	25.2	1.00										
	50.2	0.20										
	50.4	0.00										
mg/L	0.3	1.00	96 hr Survival	10	Physa sp.	Call et al 1984	Al-Acute 6	Unacceptable (3)	Model: Weibull type 2, 2 para; No model produces significant parameters. Large standard errors on EC estimates. Overly influential observation. Poor model.	238.5	9.704	24.58
	0.3	1.00										
	3.1	1.00										
	3.5	1.00										
	6.0	1.00										
	6.4	1.00										
	12.1	0.80										
	12.0	0.80										
	12.4	1.00										
	24.7	1.00										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
mg/L	0.3	1.00	96 hr Survival	10	Physa sp.	Call et al 1984	Al-Acute 7	Acceptable (1)	Model: Log Logistic type 2, 2 para; No significant problems with this model.	61.97	7.391	8.385
	0.3	1.00										
	6	1.00										
	6	1.00										
	9.5	0.60										
	9.5	1.00										
	16.2	1.00										
	16.2	1.00										
	26	0.60										
	26	1.00										
	42.7	0.20										
	42.7	0.80										
	72.1	0.40										
	72.1	0.60										
mg/L	0.1	1.00	48 hr Survival	20	Ceriodaphnia dubia	ENSR 1992d	Al-Acute 8	Acceptable (1)	Model: Log Logistic type 2, 2 para; Well performing model.	0.7379	0.0841	8.773
	0.1	1.00										
	0.1	1.00										
	0.1	0.80										
	0.41	0.60										
	0.41	0.80										
	0.41	0.60										
	0.41	0.60										
	1.02	0.40										
	1.02	0.20										
	1.02	0.60										
	1.02	0.20										
	2.06	0.20										
	2.06	0.20										
	2.06	0.60										
	2.06	0.40										
	4.18	0.00										
	4.18	0.00										
	4.18	0.00										
	4.18	0.00										
	7.02	0.00										
	7.02	0.20										
	7.02	0.00										
	7.02	0.00										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
mg/L	0.05	1.00	48 hr Survival	20	Ceriodaphnia dubia	ENSR 1992d	Al-Acute 9	Acceptable (1)	Model: Log Logistic type 2, 2 para; Well performing model.	1.898	0.2902	6.541
	0.05	1.00										
	0.05	1.00										
	0.05	1.00										
	0.84	0.60										
	0.84	0.80										
	0.84	0.80										
	0.84	0.80										
	2.07	0.40										
	2.07	0.60										
	2.07	0.40										
	2.07	0.60										
	4.55	0.40										
	4.55	0.20										
	4.55	0.40										
	4.55	0.00										
	6.96	0.20										
	6.96	0.00										
	6.96	0.00										
	6.96	0.00										
	15.1	0.20										
	15.1	0.00										
	15.1	0.00										
	15.1	0.00										
mg/L	0.13	1.00	48 hr Survival	20	Ceriodaphnia dubia	ENSR 1992d	Al-Acute 10	Acceptable (1)	Model: Weibull type 2, 2 para; Model performs well.	2.822	0.2189	12.90
	0.13	1.00										
	0.13	1.00										
	0.13	1.00										
	0.92	1.00										
	0.92	1.00										
	0.92	0.60										
	0.92	0.80										
	1.04	0.40										
	1.04	0.60										
	1.04	0.40										
	1.04	0.80										
	1.62	0.80										
	1.62	0.60										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
	1.62	0.40										
	1.62	0.20										
	8.07	0.60										
	8.07	0.20										
	8.07	0.40										
	8.07	0.80										
	34.7	0.00										
	34.7	0.20										
	34.7	0.00										
	34.7	0.20										
mg/L	0.06	1.00	48 hr Survival	20	Ceriodaphnia dubia	ENSR 1992d	Al-Acute 11	Qualitatively Acceptable (2)	Model: Log Logistic type 2, 2 para; Cannot fit a model with all significant parameters. Large standard errors for EC estimates and fitted curve.	782.8	0.6008	1,303
	0.06	1.00										
	0.06	1.00										
	0.06	1.00										
	5.46	0.80										
	5.46	1.00										
	5.46	0.80										
	5.46	0.80										
	8.10	1.00										
	8.10	1.00										
	8.10	0.60										
	8.10	0.80										
	19.9	0.80										
	19.9	0.80										
	19.9	0.80										
	19.9	0.80										
	30.2	1.00										
	30.2	0.60										
	30.2	0.80										
	30.2	0.80										
	99.6	1.00										
	99.6	0.80										
	99.6	0.60										
	99.6	0.60										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
µg/L	0	1.00	48 hr Survival	20	Daphnia magna	European Al Association 2009	Al-Acute 13	Qualitatively Acceptable (2)	Model: Weibull type 1, 2 para; Large standard errors for EC estimates.	806.8	102.8	7.850
	0	1.00										
	0	1.00										
	0	1.00										
	400	0.80										
	400	0.60										
	400	0.60										
	400	0.80										
	600	0.60										
	600	0.80										
	600	0.60										
	600	0.60										
	800	0.60										
	800	0.60										
	800	0.80										
	800	0.60										
	1000	0.00										
	1000	0.20										
	1000	0.20										
	1000	0.60										
	1200	0.60										
	1200	0.00										
	1200	0.20										
	1200	0.60										
µg/L	0.0	1.00	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2009	Al-Acute 14	Acceptable (1)	Model: Weibull type 1, 3 para; Well performing model, although the standard error for EC5 is a bit high relative to the estimate.	72.07	17.30	4.165
	0.0	0.80										
	0.0	1.00										
	0.0	1.00										
	62.5	0.60										
	62.5	0.60										
	62.5	0.80										
	62.5	0.20										
	125.0	0.20										
	125.0	0.00										
	125.0	0.20										
	125.0	0.20										
	250.0	0.00										
	250.0	0.00										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
	250.0	0.00										
	250.0	0.00										
	500.0	0.00										
	500.0	0.00										
	500.0	0.00										
	500.0	0.00										
	1000.0	0.00										
	1000.0	0.00										
	1000.0	0.00										
	1000.0	0.00										
µg/L	0.0	1.00	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2009	Al-Acute 15	Qualitatively Acceptable (2)	Model: Weibull type 1, 2 para; Model performs fairly well, although the low EC estimates have negative lower bounds.	115.0	1.485	77.45
	0.0	1.00										
	0.0	1.00										
	0.0	1.00										
	62.5	0.60										
	62.5	0.20										
	62.5	1.00										
	62.5	0.80										
	125.0	0.20										
	125.0	0.00										
	125.0	1.00										
	125.0	0.40										
	250.0	0.40										
	250.0	0.20										
	250.0	0.60										
	250.0	0.20										
	500.0	0.60										
	500.0	0.00										
	500.0	0.20										
	500.0	0.20										
	1000.0	0.00										
	1000.0	0.20										
	1000.0	0.00										
	1000.0	0.00										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
µg/L	0.0	1.00	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2009	Al-Acute 16	Acceptable (1)	Model: Weibull type 1, 3 para; Model performs well.	792.4	371.3	2.134
	0.0	1.00										
	0.0	1.00										
	0.0	1.00										
	100.0	0.80										
	100.0	1.00										
	100.0	1.00										
	100.0	1.00										
	400.0	1.00										
	400.0	0.60										
	400.0	1.00										
	400.0	0.80										
	700.0	0.40										
	700.0	0.80										
	700.0	0.60										
	700.0	0.80										
	1000.0	0.00										
	1000.0	0.20										
	1000.0	0.60										
	1000.0	0.20										
	1300.0	0.00										
	1300.0	0.00										
	1300.0	0.00										
	1300.0	0.00										
µg/L	0.0	1.00	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2009	Al-Acute 17	Acceptable (1)	Model: Weibull type 2, 2 para; Model performs well.	1,005	422.6	2.378
	0.0	1.00										
	0.0	1.00										
	0.0	1.00										
	250.0	1.00										
	250.0	1.00										
	250.0	1.00										
	250.0	1.00										
	500.0	1.00										
	500.0	0.60										
	500.0	1.00										
	500.0	1.00										
	1000.0	0.20										
	1000.0	0.60										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
	1000.0	0.40										
	1000.0	0.80										
	2000.0	0.40										
	2000.0	0.20										
	2000.0	0.00										
	2000.0	0.00										
	4000.0	0.00										
	4000.0	0.20										
	4000.0	0.00										
	4000.0	0.20										
µg/L	0.0	1.00	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2009	Al-Acute 18	Qualitatively Acceptable (2)	Model: Weibull type 1, 2 para; Model performs fairly well, although the EC estimates have large standard errors.	3,326	239.6	13.89
	0.0	1.00										
	0.0	1.00										
	0.0	1.00										
	1000.0	0.40										
	1000.0	0.80										
	1000.0	0.80										
	1000.0	1.00										
	2000.0	0.40										
	2000.0	0.60										
	2000.0	0.60										
	2000.0	1.00										
	3000.0	0.20										
	3000.0	0.60										
	3000.0	0.80										
	3000.0	0.80										
	4000.0	0.40										
	4000.0	0.80										
	4000.0	0.60										
	4000.0	0.80										
	5000.0	0.00										
	5000.0	0.20										
	5000.0	0.20										
	5000.0	0.20										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
µg/L	0.0	1.00	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2009	Al-Acute 19	Qualitatively Acceptable (2)	Model: Weibull type 1, 3 para; One parameter not significant.	1,712	1,400	1.223
	0.0	1.00										
	0.0	0.80										
	0.0	1.00										
	1000.0	1.00										
	1000.0	0.80										
	1000.0	0.80										
	1000.0	1.00										
	1300.0	0.60										
	1300.0	0.60										
	1300.0	0.60										
	1300.0	0.80										
	1600.0	1.00										
	1600.0	0.80										
	1600.0	0.40										
	1600.0	0.60										
	1900.0	0.00										
	1900.0	0.20										
	1900.0	0.00										
	1900.0	0.00										
	2200.0	0.00										
	2200.0	0.00										
	2200.0	0.00										
	2200.0	0.00										
µg/L	0.0	1.00	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2009	Al-Acute 20	Acceptable (1)	Model: Weibull type 1, 2 para; Model performs well.	8,801	3,202	2.748
	0.0	1.00										
	0.0	1.00										
	0.0	1.00										
	1000.0	1.00										
	1000.0	1.00										
	1000.0	1.00										
	1000.0	1.00										
	3000.0	1.00										
	3000.0	1.00										
	3000.0	1.00										
	3000.0	1.00										
	5000.0	0.40										
	5000.0	0.80										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
	5000.0	1.00										
	5000.0	0.80										
	10000.0	0.00										
	10000.0	0.40										
	10000.0	0.80										
	10000.0	0.60										
	15000.0	0.00										
	15000.0	0.00										
	15000.0	0.20										
	15000.0	0.00										
µg/L	0.0	1.00	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2009	Al-Acute 21	Acceptable (1)	Model: Weibull type 1, 2 para; Model performs well.	10,636	2,071	5.136
	0.0	1.00										
	0.0	1.00										
	0.0	1.00										
	1000.0	1.00										
	1000.0	0.80										
	1000.0	1.00										
	1000.0	1.00										
	3000.0	1.00										
	3000.0	0.80										
	3000.0	1.00										
	3000.0	1.00										
	5000.0	0.60										
	5000.0	0.80										
	5000.0	1.00										
	5000.0	1.00										
	10000.0	0.20										
	10000.0	0.20										
	10000.0	1.00										
	10000.0	0.60										
	15000.0	0.40										
	15000.0	0.00										
	15000.0	0.60										
	15000.0	0.20										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
µg/L	0.0	1.00	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2009	Al-Acute 23	Unacceptable (3)	Model: Weibull type 1, 3 para; One parameter not significant. Large standard errors.	15,142	4,899	3.091
	0.0	1.00										
	0.0	0.80										
	0.0	1.00										
	1000.0	1.00										
	1000.0	1.00										
	1000.0	0.80										
	1000.0	0.80										
	3000.0	0.60										
	3000.0	1.00										
	3000.0	0.80										
	3000.0	0.80										
	5000.0	0.80										
	5000.0	0.80										
	5000.0	1.00										
	5000.0	1.00										
	10000.0	0.80										
	10000.0	0.80										
	10000.0	0.40										
	10000.0	0.80										
	15000.0	0.40										
	15000.0	0.80										
	15000.0	0.20										
	15000.0	0.40										
µg/L	0.0	1.00	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2009	Al-Acute 24	Unacceptable (3)	Model: Weibull type 1, 2 para; No model fit had significant parameters.	33,051	29.26	1,129
	0.0	1.00										
	0.0	1.00										
	0.0	1.00										
	1000.0	1.00										
	1000.0	0.80										
	1000.0	0.80										
	1000.0	0.60										
	2000.0	0.60										
	2000.0	1.00										
	2000.0	0.80										
	2000.0	1.00										
	3000.0	0.60										
	3000.0	0.80										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
	3000.0	0.60										
	3000.0	0.60										
	4000.0	0.80										
	4000.0	0.80										
	4000.0	1.00										
	4000.0	0.80										
	5000.0	0.80										
	5000.0	0.80										
	5000.0	0.60										
	5000.0	0.40										
µg/L	0.0	1.00	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2009	Al-Acute 25	Qualitatively Acceptable (2)	Model: Weibull type 1, 2 para; Five models had lower AIC values, but yielded insignificant parameters. This model is not too bad in terms of AIC, but has all significant parameters. Somewhat large standard error on EC estimates.	7,790	906.3	8.596
	0.0	1.00										
	0.0	1.00										
	0.0	1.00										
	1000.0	1.00										
	1000.0	0.80										
	1000.0	1.00										
	1000.0	1.00										
	3000.0	0.40										
	3000.0	0.40										
	3000.0	0.80										
	3000.0	0.60										
	5000.0	1.00										
	5000.0	0.60										
	5000.0	1.00										
	5000.0	0.80										
	10000.0	0.60										
	10000.0	0.40										
	10000.0	1.00										
	10000.0	0.80										
	15000.0	0.00										
	15000.0	0.00										
	15000.0	0.00										
	15000.0	0.00										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
µg/L	0.0	1.00	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2009	Al-Acute 26	Qualitatively Acceptable (2)	Model: Weibull type 1, 2 para; Poor goodness of fit and large standard errors on EC estimates.	17,638	2,121	8.315
	0.0	1.00										
	0.0	1.00										
	0.0	1.00										
	1000.0	1.00										
	1000.0	0.80										
	1000.0	1.00										
	1000.0	1.00										
	3000.0	1.00										
	3000.0	0.60										
	3000.0	1.00										
	3000.0	1.00										
	5000.0	0.80										
	5000.0	1.00										
	5000.0	1.00										
	5000.0	1.00										
	10000.0	0.40										
	10000.0	0.60										
	10000.0	1.00										
	10000.0	1.00										
	15000.0	0.00										
	15000.0	0.00										
	15000.0	1.00										
	15000.0	1.00										
µg/L	0.0	1.00	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2009	Al-Acute 27	Acceptable (1)	Model: Weibull type 1, 2 para; No serious issues with this model.	24,345	2,767	8.797
	0.0	1.00										
	0.0	1.00										
	0.0	1.00										
	1000.0	1.00										
	1000.0	1.00										
	1000.0	0.80										
	1000.0	1.00										
	3000.0	1.00										
	3000.0	1.00										
	3000.0	1.00										
	3000.0	1.00										
	5000.0	0.80										
	5000.0	0.80										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
	5000.0	1.00										
	5000.0	1.00										
	10000.0	0.80										
	10000.0	0.60										
	10000.0	1.00										
	10000.0	0.80										
	15000.0	0.60										
	15000.0	0.80										
	15000.0	0.80										
	15000.0	0.40										
µg/L	0.0	1.00	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2009	Al-Acute 28	Acceptable (1)	Model: Weibull type 2, 3 para; No serious issues with this model.	10,766	8,927	1.206
	0.0	1.00										
	0.0	1.00										
	0.0	1.00										
	1000.0	1.00										
	1000.0	1.00										
	1000.0	1.00										
	1000.0	1.00										
	3000.0	1.00										
	3000.0	0.80										
	3000.0	1.00										
	3000.0	1.00										
	5000.0	1.00										
	5000.0	1.00										
	5000.0	1.00										
	5000.0	1.00										
	10000.0	0.40										
	10000.0	0.60										
	10000.0	0.80										
	10000.0	1.00										
	15000.0	0.00										
	15000.0	0.00										
	15000.0	0.20										
	15000.0	0.00										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
µg/L	0.0	1.00	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2009	Al-Acute 29	Unacceptable (3)	Model: Log Logistic type 2, 2 para; Not a great fit, one parameter not significant. Somewhat large standard errors on EC estimates. Lacking a good range of response values.	23,597	10,679	2.210
	0.0	1.00										
	0.0	1.00										
	0.0	1.00										
	1000.0	1.00										
	1000.0	1.00										
	1000.0	1.00										
	1000.0	1.00										
	3000.0	1.00										
	3000.0	1.00										
	3000.0	1.00										
	3000.0	1.00										
	5000.0	1.00										
	5000.0	1.00										
	5000.0	1.00										
	5000.0	1.00										
	10000.0	1.00										
	10000.0	1.00										
	10000.0	1.00										
	10000.0	0.80										
	15000.0	0.80										
	15000.0	1.00										
	15000.0	1.00										
	15000.0	0.60										
µg/L	0.0	1.00	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2009	Al-Acute 30	Unacceptable (3)	Model: Log Logistic type 2, 2 para; Model selection function would not work on this data set. Selected the first model able to fit. Large standard errors on EC estimates.	29,610	2,569	11.53
	0.0	1.00										
	0.0	1.00										
	0.0	1.00										
	1000.0	1.00										
	1000.0	1.00										
	1000.0	1.00										
	1000.0	1.00										
	3000.0	1.00										
	3000.0	0.80										
	3000.0	1.00										
	3000.0	0.60										
	5000.0	1.00										
	5000.0	1.00										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
	5000.0	1.00										
	5000.0	1.00										
	10000.0	0.60										
	10000.0	0.80										
	10000.0	1.00										
	10000.0	0.60										
	15000.0	0.80										
	15000.0	0.60										
	15000.0	0.60										
	15000.0	0.80										
µg/L	0	0.95	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2009	Al-Acute 40	Qualitatively Acceptable (2)	Model: Weibull type 2, 3 para; Large standard errors relative to estimates.	162.0	36.26	4.468
	62.5	0.85										
	125	0.45										
	250	0.35										
	500	0.25										
	1000	0.10										
µg/L	0.0	0.95	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2009	Al-Acute 41	Qualitatively Acceptable (2)	Model: Weibull type 1, 3 para; Large standard errors relative to estimates.	217.1	31.14	6.972
	62.5	0.85										
	125.0	0.70										
	250.0	0.35										
	500.0	0.15										
	1000.0	0.00										
µg/L	0	0.95	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2009	Al-Acute 42	Qualitatively Acceptable (2)	Model: Weibull type 2, 3 para; Large standard errors relative to estimates.	135.1	54.89	2.462
	62.5	0.90										
	125	0.50										
	250	0.15										
	500	0.10										
	1000	0.05										
µg/L	0.0	1.00	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2009	Al-Acute 43	Qualitatively Acceptable (2)	Model: Weibull type 2, 2 para; Large standard errors relative to estimates.	2,225	504.4	4.412
	400.0	1.00										
	800.0	0.85										
	1200.0	0.55										
	1600.0	0.65										
	2000.0	0.65										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
µg/L	0	1.00	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2009	Al-Acute 44	Unacceptable (3)	Model: Log Logistic type 2, 2 para; Large standard errors relative to estimates. No parameters are significant. The data set lacks a sufficient variety of response values.	13,766	1,208	11.40
	400	1.00										
	800	0.95										
	1200	0.95										
	1600	0.90										
	2000	0.95										
µg/L	0.0	1.00	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2010	Al-Acute 45	Acceptable (1)	Model: Weibull type 1, 2 para; No serious problems with this model.	309.3	53.37	5.795
	0.0	1.00										
	0.0	1.00										
	0.0	1.00										
	62.0	1.00										
	62.0	0.80										
	62.0	1.00										
	62.0	0.80										
	241.7	0.60										
	241.7	0.80										
	241.7	0.80										
	241.7	0.60										
	244.9	0.40										
	244.9	0.20										
	244.9	0.80										
	244.9	0.60										
	433.9	0.00										
	433.9	0.60										
	433.9	0.40										
	433.9	0.80										
	855.9	0.00										
	855.9	0.00										
	855.9	0.00										
	855.9	0.00										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
µg/L	0.7	1.00	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2010	Al-Acute 46	Qualitatively Acceptable (2)	Model: Log Logistic type 1, 3 para; Large standard error at the low end of the fitted curve.	139.4	110.9	1.256
	0.7	1.00										
	0.7	1.00										
	0.7	1.00										
	60.6	1.00										
	60.6	1.00										
	60.6	1.00										
	60.6	1.00										
	123.5	1.00										
	123.5	0.80										
	123.5	0.80										
	123.5	1.00										
	161.5	0.40										
	161.5	0.60										
	161.5	0.40										
	161.5	0.60										
	470.7	0.20										
	470.7	0.40										
	470.7	0.40										
	470.7	0.20										
	931.1	0.60										
	931.1	0.60										
	931.1	0.60										
	931.1	0.40										
µg/L	1.0	1.00	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2010	Al-Acute 48	Acceptable (1)	Model: Log Logistic type 1, 2 para; No problems with this model.	120.6	31.24	3.859
	1.0	1.00										
	1.0	1.00										
	1.0	1.00										
	29.9	1.00										
	29.9	1.00										
	29.9	0.80										
	29.9	1.00										
	62.6	0.80										
	62.6	0.80										
	62.6	0.80										
	62.6	0.80										
	126.6	0.60										
	126.6	0.40										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
	126.6	0.60										
	126.6	0.40										
	253.6	0.20										
	253.6	0.20										
	253.6	0.00										
	253.6	0.20										
	463.7	0.00										
	463.7	0.00										
	463.7	0.20										
	463.7	0.00										
µg/L	0.8	1.00	48 hr Survival	19 (0.8); 20 (all other conc)	Ceriodaphnia dubia	European Al Association 2010	Al-Acute 51	Unacceptable (3)	Model: Log Logistic type 1, 3 para; Large standard errors relative to estimates.	147.0	126.0	1.167
	0.8	1.00										
	0.8	1.00										
	0.8	1.00										
	34.4	1.00										
	34.4	1.00										
	34.4	1.00										
	34.4	1.00										
	78.6	1.00										
	78.6	1.00										
	78.6	1.00										
	78.6	1.00										
	178.0	0.00										
	178.0	0.00										
	178.0	0.00										
	178.0	0.20										
	353.9	0.00										
	353.9	0.00										
	353.9	0.00										
	353.9	0.00										
	718.3	0.00										
	718.3	0.00										
	718.3	0.20										
	718.3	0.00										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
µg/L	0.4	0.80	48 hr Survival	20	Ceriodaphnia dubia	European Al Association 2010	Al-Acute 52	Acceptable (1)	Model: Weibull type 2, 3 para; No serious problems with this model.	79.27	33.98	2.333
	0.4	1.00										
	0.4	1.00										
	0.4	1.00										
	34.7	1.00										
	34.7	1.00										
	34.7	1.00										
	34.7	1.00										
	52.4	0.60										
	52.4	0.60										
	52.4	0.40										
	52.4	0.80										
	111.2	0.40										
	111.2	0.20										
	111.2	0.40										
	111.2	0.20										
	231.4	0.20										
	231.4	0.20										
	231.4	0.00										
	231.4	0.40										
	424.3	0.00										
	424.3	0.00										
	424.3	0.00										
	424.3	0.00										
mg/L	0.01	1.00	96 hr Survival	20	Oncorhynchus mykiss	Gunderson et al. 1994	Al-Acute 53	Unacceptable (3)	Model: Weibull type 2, 2 para; Data suffers from a lack of response range. One overly influential observation. One parameter insignificant.	4.174	3.545	1.177
	0.81	1.00										
	1.86	1.00										
	3.73	0.85										
	11.96	0.00										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC 5 Ratio
mg/L	0.01	1.00	96 hr Survival	20	Oncorhynchus mykiss	Gunderson et al. 1994	Al-Acute 54	Qualitatively Acceptable (2)	Model: Log Logistic type 2, 2 para; Data suffer from a lack of response range. Two overly influential observations. QQ problems. – Note: Unlike Al-Acute-66 and Al-Acute-68, this salmonid curve was not retroactively considered for quantitative use because this curve was relatively weaker, as indicated by the limited partial effects and larger Cooks Distance in curve acceptability diagnostics.	5.750	3.565	1.613
	1.02	1.00										
	2.04	1.00										
	4.32	0.85										
	9.33	0.05										
mg/L	0.01	1.00	96 hr Survival	20	Oncorhynchus mykiss	Gunderson et al. 1994	Al-Acute 55	Qualitatively Acceptable (2)	Model: Log Logistic type 2, 2 para; Data suffer from a lack of response range. Two overly influential observations. QQ problems. – Note: Unlike Al-Acute-66 and Al-Acute-68, this salmonid curve was not retroactively considered for quantitative use because this curve was relatively weaker, as indicated by the limited partial effects and larger Cooks Distance in curve acceptability diagnostics.	7.110	4.194	1.695
	0.91	1.00										
	1.92	1.00										
	4.17	0.95										
	7.95	0.35										
mg/L	0.01	1.00	96 hr Survival	20	Oncorhynchus mykiss	Gunderson et al. 1994	Al-Acute 56	Unacceptable (3)	Model: Log Logistic type 2, 2 para; Lacking in response range. Large standard errors relative to estimates. One parameter insignificant. Overly influential observation.	8.589	6.808	1.262
	1.05	1.00										
	1.68	1.00										
	3.94	1.00										
	9.85	0.15										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
µg/L	0	0.95	96 hr Survival	20	Micropterus dolomieu	Kane 1984; Kane and Rabeni 1987	Al-Acute 62	Unacceptable (3)	Model: Log Logistic type 1, 3 para; One parameter not significant. Very large confidence band on fit. Poor QQ plot and an overly influential observation.	112.4	99.78	1.127
	32	0.95										
	56	0.95										
	100	0.90										
	180	0.00										
	320	0.00										
	560	0.00										
	1000	0.00										
mg/L	0.2	1.00	48 hr Survival	20	Ceriodaphnia dubia	McCauley et al. 1986	Al-Acute 63	Qualitatively Acceptable (2)	Model: Weibull type 1, 2 para; Two overly influential observations.	1.972	1.207	1.635
	1.5	0.85										
	2.6	0.05										
	5.0	0.00										
	9.6	0.00										
	16.2	0.00										
mg/L	0.2	1.00	48 hr Survival	20	Ceriodaphnia dubia	McCauley et al. 1986	Al-Acute 64	Unacceptable (3)	Model: Weibull type 1, 2 para; Poor model fit.	1.387	0.9036	1.535
	1.2	0.75										
	2.2	0.00										
	6.0	0.00										
	10.6	0.00										
	18.6	0.00										
mg/L	0.2	1.00	48 hr Survival	20	Ceriodaphnia dubia	McCauley et al. 1986	Al-Acute 65	Qualitatively Acceptable (2)	Model: Weibull type 2, 2 para; Large confidence band on fit. QQ plot not great. One observation possibly overly influential.	2.317	1.428	1.623
	1.3	1.00										
	2.1	0.50										
	3.7	0.25										
	8.5	0.00										
	17.7	0.00										
mg/L	0	1.00	96 hr Survival	30	Salvelinus fontinalis	Tandjung 1982	Al-Acute 66	Qualitatively Acceptable (2)	Model: Weibull type 1, 2 para; QQ plot has a couple of points offline, but otherwise model fit is good. – Note, model was retroactively used quantitatively for salmonids due to limited salmonid and vertebrate C-R data. Model had many partial effects along a range of responses and small Cooks Distance relative to other qualitatively-acceptable	8.180	2.934	2.788
	2	1.00										
	3.5	1.00										
	5	0.60										
	7.5	0.50										
	10	0.30										
	16	0.00										
	0	1.00										
	2	1.00										
	3.5	0.90										
	5	0.80										
	7.5	0.70										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
	10	0.60							salmonid C-R models that were not retroactively selected for quantitative use (i.e., Al-Acute-54, Al-Acute-55, Al-Acute-68).			
	16	0.00										
	0	1.00										
	2	1.00										
	3.5	1.00										
	5	0.60										
	7.5	0.50										
	10	0.40										
	16	0.00										
mg/L	0	1.00	96 hr Survival	30	Salvelinus fontinalis	Tandjung 1982	Al-Acute 67	Qualitatively Acceptable (2)	Model: Weibull type 1, 2 para; QQ plot has a couple of points offline. Note – Model contains many partial effects and small Cooks Distance; however, partial effects are not across a range of responses. No low-level effects exist (i.e., no observed acute responses less than 30% effect). Low-level effects and the shape of the pre-threshold plateau are not adequately described by exposure-response data. As a result, this salmonid curve was not retroactively used in a quantitative manner.	3.277	0.3839	8.535
	2	0.70										
	3	0.40										
	4	0.30										
	5	0.20										
	8	0.10										
	13	0.00										
	0	1.00										
	2	0.70										
	3	0.50										
	4	0.40										
	5	0.30										
	8	0.20										
	13	0.00										
	0	1.00										
	2	0.70										
	3	0.60										
	4	0.50										
	5.0	0.40										
	8	0.30										
	13	0.00										

Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability (score)	Curve Notes	LC50	LC5	LC50:LC5 Ratio
mg/L	0	1.00	96 hr Survival	30	Salvelinus fontinalis	Tandjung 1982	Al-Acute 68	Qualitatively Acceptable (2)	Model: Log Logistic type 1, 3 para; QQ plot has a couple of points offline, but otherwise model fit is good. – Note, model was retroactively used quantitatively for salmonids due to limited salmonid and vertebrate C-R data. Model had many partial effects along a range of responses and small Cooks Distance relative to other qualitatively-acceptable salmonid C-R models that were not retroactively selected for quantitative use (i.e., Al-Acute-54, Al-Acute-55, Al-Acute-68).	0.3831	0.2759	1.388
	0.1	0.90										
	0.2	1.00										
	0.3	0.80										
	0.4	0.30										
	0.5	0.00										
	1	0.00										
	0	1.00										
	0.1	1.00										
	0.2	1.00										
	0.3	0.80										
	0.4	0.60										
	0.5	0.10										
	1	0.00										
	0	1.00										
	0.1	1.00										
	0.2	1.00										
	0.3	1.00										
	0.4	0.40										
	0.5	0.10										
	1	0.00										

B.2 Test Information, C-R Data and Resulting C-R models for Chronic Aluminum Toxicity Tests Acceptable, Qualitatively Acceptable, or Unacceptable for Chronic TAF and MAF Calculation.

Dichotomous Data												
Units	Test Conc.	Response	Endpoint	n/trt.	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
µg/L	2.2	1.00	Survival	15	Pimephales promelas	OSU 2012g; Cardwell et al 2018	Al-Chronic 31	Qualitatively Acceptable (2)	Model: Weibull type 1, 3 para; This model is the best out of the top 3 AIC candidates in terms of p-values on parameter estimates. Goodness of fit test indicates poor fit. Significant variation in response at down slope of the curve. Non-constant variance in residuals.	451.5	367.4	1.229
	2.2	0.73										
	2.2	0.87										
	2.2	0.73										
	79.2	0.73										
	79.2	0.87										
	79.2	0.67										
	79.2	0.87										
	164.3	0.73										
	164.3	0.60										
	164.3	0.93										
	164.3	0.73										
	308.1	0.46										
	308.1	1.00										
	308.1	0.86										
	308.1	1.00										
	558.1	0.15										
	558.1	0.33										
	558.1	0.20										
	558.1	0.50										
	1104.6	0.00										
	1104.6	0.00										
	1104.6	0.00										
	1104.6	0.00										
µg/L	4.5	0.575	proportion adult emergence	200	Chironomus riparius	Palawski et al. 1989	Al-Chronic 43	Qualitatively Acceptable (2)	Model: Brain-Cousens, 5 para; Good p-values on parameters. Poor goodness of fit p-value. One overly influential observation.	36.95	33.88	1.090
	14.6	0.725										
	34.8	0.445										
	61.4	0.135										
	128.7	0.005										
	259.2	0.045										

Dichotomous Data												
Units	**Test Conc.**	**Response**	**Endpoint**	**n/trt.**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
µg/L	4.2	0.22	proportion adult emergence	200	Chironomus riparius	Palawski et al. 1989	Al-Chronic 44	Qualitatively Acceptable (2)	Model: Brain-Cousens, 4 para; Good p-values on parameter estimates. Standard errors on EC estimates and goodness of fit p-value are not great. Non-constant residual variance.	141.6	125.8	1.125
	15.6	0.445										
	32.5	0.43										
	56.9	0.455										
	111.4	0.165										
	235.2	0.065										

Continuous Data													
Units (x)	**Test Conc.**	**Units (y)**	**Response**	**Endpoint**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
µg/L	8	mg	280.275	Biomass	Salvelinus fontinalis	Cleveland et al. 1989	Al-Chronic 8	Unacceptable (3)	Model: Weibull type 1, 4 para; The Weibull model ranks 3rd. The two lower AIC models (2 Brain-Cousens models) were unable to calculate EC estimates. This model performs poorly on all measures.	720.7	327.2	2.203
	29		269.235									
	68		251.64									
	142		215.67									
	292		37.125									
µg/L	4	mg	359.08	Biomass	Salvelinus fontinalis	Cleveland et al. 1989	Al-Chronic 9	Qualitatively Acceptable (2)	Model: Log Logistic type 1, 3 para; Model performs well. Two observations are possibly overly influential. – Note, no other qualitatively- or quantitatively-acceptable chronic salmonid models are available. Curve was used quantitatively due to salmonid data limitations and the relatively robust fit of the modal compared to other qualitatively-acceptable models.	162.3	95.70	1.696
	57		346.704									
	88		348.365									
	169		277.42									
	350		105.06									
µg/L	0	g	0.1232	Biomass	Pimephales promelas	Kimball 1978	Al-Chronic 24	Acceptable (1)	Model: Weibull type 2, 3 para; Model performs well.	6,428	5,503	1.168
	2300		0.1144									
	4700		0.1178									
	7100		0.0784									
	11900		0.0154									
	23100		0									
	53800		0									

Continuous Data												
Units (x)	**Test Conc.**	**Units (y)**	**Response**	**Endpoint**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
µg/L	200	count	2.5	avg #young/starting adult	Ceriodaphnia dubia	McCauley et al. 1986	Al-Chronic 25	Unacceptable (3)	Model: Weibull type 2, 3 para; This model was 3rd in rank, but better AIC models produced not EC estimates. This model performs poorly on all metrics.	1,791	1,663	1.077
	1400		3.4									
	2600		0.2									
	5000		0									
	10000		0									
	17200		0									
µg/L	3	mg	85.824	Biomass	Salmo salar	McKee et al. 1989	Al-Chronic 26	Unacceptable (3)	Model: Michaelis-Menten, 3 para; This model performs poorly on all metrics.	460.7	96.99	4.750
	33		71.25									
	71		61.971									
	124		56.865									
	264		20.979									
µg/L	5	mg	32.17	Biomass	Lymnaea stagnalis	OSU 2012b; Cardwell et al. 2018	Al-Chronic 27	Unacceptable (3)	Model: Weibull type 2, 3 para; This model performs well on most metrics, but the EC estimates produce 2 negative lower bounds. This is the best model to be found in the top 5 or 6.	754.7	400.7	1.884
	5		23.94									
	5		20.02									
	5		35.07									
	5		31.45									
	5		36.11									
	5		29.77									
	5		30.06									
	5		52.9									
	175.2		8.48									
	175.2		38.05									
	175.2		31.52									
	175.2		41.98									
	175.2		50									
	175.2		36.29									
	175.2		6.04									
	175.2		0									
	175.2		33.54									
	175.2		36.18									
	309.6		26.67									
	309.6		38.19									
	309.6		11.09									
	309.6		65.3									
	309.6		42.27									
	309.6		39.71									

Continuous Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	309.6		14.37									
	309.6		19.76									
	309.6		18.8									
	309.6		40.62									
	596.3		38.8									
	596.3		22.18									
	596.3		33.48									
	596.3		43.02									
	596.3		41.5									
	596.3		0									
	596.3		29.23									
	596.3		22.31									
	596.3		42.8									
	596.3		14.36									
	1092.6		18.13									
	1092.6		17.28									
	1092.6		0									
	1092.6		0									
	1092.6		24.57									
	1092.6		0									
	1092.6		32.41									
	1092.6		24									
	1092.6		40.64									
	2099.2		22.95									
	2099.2		16.46									
	2099.2		7.35									
	2099.2		9.87									
	2099.2		18.27									
	2099.2		17.37									
	2099.2		13.48									
	2099.2		8.76									
	2099.2		23.47									
	2099.2		18.57									

Continuous Data												
Units (x)	**Test Conc.**	**Units (y)**	**Response**	**Endpoint**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
µg/L	7.5	avg. count	384	avg. # of eggs/case	Chironomus riparius	OSU 2012f; Cardwell et al. 2018	Al-Chronic 30	Qualitatively Acceptable (2)	Model: Log Logistic type 2, 3 para; One parameter estimate is not significant and the EC estimate standard errors are so large that estimates might not be practical.	3,235	488.8	6.618
	7.5		337									
	7.5		278									
	7.5		333									
	7.5		389									
	7.5		352									
	7.5		540									
	7.5		90									
	233		169									
	233		281									
	233		428									
	233		414									
	233		517									
	233		317									
	490.4		485									
	490.4		285									
	490.4		308									
	490.4		372									
	490.4		440									
	490.4		330									
	490.4		224									
	490.4		351									
	1100.2		407									
	1100.2		264									
	1100.2		258									
	1100.2		90									
	1100.2		254									
	1100.2		369									
	1100.2		380									
	2132.7		285									
	2132.7		317									
	2132.7		294									
	2132.7		334									
	2132.7		320									
	2132.7		350									
	2132.7		187									

Continuous Data												
Units (x)	**Test Conc.**	**Units (y)**	**Response**	**Endpoint**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
	4281.8		231									
	4281.8		253									
	4281.8		307									
	4281.8		230									
	4281.8		345									
	4281.8		272									
	4281.8		250									

Continuous Data												
Units (x)	**Test Conc.**	**Units (y)**	**Response**	**Endpoint**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
µg/L	2.2	mg	0.46	Biomass	Hyalella azteca	OSU 2012h; Cardwell et al. 2018	Al-Chronic 32	Qualitatively Acceptable (2)	Model: Log Logistic type 1, 3 para; EC standard errors slightly large. Goodness of fit test is marginal.	314.8	199.6	1.577
	2.2		0.517									
	2.2		0.509									
	2.2		0.307									
	2.2		0.448									
	2.2		0.488									
	2.2		0.321									
	2.2		0.514									
	30.9		0.384									
	30.9		0.276									
	30.9		0.415									
	30.9		0.415									
	30.9		0.384									
	30.9		0.445									
	30.9		0.466									
	30.9		0.485									
	53.1		0.452									
	53.1		0.528									
	53.1		0.5									
	53.1		0.528									
	53.1		0.491									
	53.1		0.442									
	53.1		0.613									
	53.1		0.503									

Continuous Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	123.2		0.468									
	123.2		0.479									
	123.2		0.507									
	123.2		0.59									
	123.2		0.621									
	123.2		0.601									
	123.2		0.193									
	123.2		0.429									
	232.6		0.255									
	232.6		0.499									
	232.6		0.464									
	232.6		0.52									
	232.6		0.449									
	232.6		0.371									
	232.6		0.329									
	232.6		0.434									
	453.8		0.233									
	453.8		0.273									
	453.8		0.238									
	453.8		0.243									
	453.8		0.314									
	453.8		0.25									
	453.8		0.254									
	453.8		0.175									
µg/L	2.8	mg	1.64	Biomass	Danio rerio	OSU 2013; Cardwell et al. 2018	Al-Chronic 33	Unacceptable (3)	Model: Weibull type 2, 3 para; No model yields non-negative EC estimates. This is the best performing model given that defect	279.7	93.06	3.006
	2.8		1.626									
	2.8		1.597									
	2.8		1.754									
	35.5		1.486									
	35.5		1.324									
	35.5		1.412									
	35.5		1.687									
	71.5		1.421									
	71.5		1.726									
	71.5		1.557									
	71.5		1.51									

Continuous Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	139.4		1.465									
	139.4		1.303									
	139.4		1.628									
	139.4		1.335									
	258		1.21									
	258		1.35									
	258		1.356									
	258		1.321									
	548.3		1.242									
	548.3		1.1									
	548.3		0.939									
	548.3		0.896									
µg/L	0.9	count	42.5	avg # of young/female	Ceriodaphnia dubia	OSU 2018	Al-Chronic 34	Unacceptable (3)	Model: Weibull type 1, 3 para; No model yields all significant parameters and non-negative EC estimates. This model performs best among many bad models.	224.3	39.77	5.639
	6.5		32.6									
	62.5		30.3									
	128.5		26.2									
	264.5		25.8									
	529		26									
	1043		21.7									
	2136		1.4									
µg/L	1.5	count	22.6	avg # of young/female	Ceriodaphnia dubia	OSU 2018	Al-Chronic 35	Qualitatively Acceptable (2)	Model: Log Logistic type 1, 3 para; Only 2 out of 3 parameters are significant. Wide confidence bands. Overly influential observation.	3,903	3,190	1.224
	315.3		27.9									
	706		27									
	1412.7		28.1									
	2801.3		32.1									
	5702.3		4.3									
µg/L	19	count	35.6	avg # of young/female	Ceriodaphnia dubia	OSU 2018	Al-Chronic 36	Qualitatively Acceptable (2)	Model: Weibull type 1, 4 para; 3 out of 4 parameters significant. Wide confidence bands. Overly influential observation.	6,735	5,407	1.246
	953.7		37.5									
	2099.3		36.9									
	4876.7		35.8									
	10536		2.9									
	23041		2.5									

Continuous Data												
Units (x)	**Test Conc.**	**Units (y)**	**Response**	**Endpoint**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
µg/L	5.5	count	35	avg # of young/female	Ceriodaphnia dubia	OSU 2018	Al-Chronic 37	Unacceptable (3)	Model: Weibull type 1, 3 para; Each model yields at least one negative EC estimate. Some overly influential observations	1,705	601.9	2.832
	690		36.3									
	1367		28.7									
	2684.7		24.1									
	5666.7		10.4									
	10933.7		2.1									
µg/L	8.3	count	34.4	avg # of young/female	Ceriodaphnia dubia	OSU 2018	Al-Chronic 38	Qualitatively Acceptable (2)	Model: Weibull type 2, 3 para; Two other models had lower AICs but they were unable to produce EC estimates. One point off QQ line and a couple overly influential observations.	6,187	4,115	1.504
	681.7		36									
	1331.3		36.7									
	2804.7		36.3									
	5406		30.8									
	10858.7		17.8									
µg/L	7.3	count	37.4	avg # of young/female	Ceriodaphnia dubia	OSU 2018	Al-Chronic 39	Unacceptable (3)	Model: Weibull type 2, 3 para; Performs poorly on all metrics.	6,600	6,255	1.055
	840		35.7									
	1618.7		38.1									
	3161.3		38.5									
	6592.3		30.1									
	12762.7		0									
µg/L	1.6	count	37.6	avg # of young/female	Ceriodaphnia dubia	OSU 2018	Al-Chronic 40	Qualitatively Acceptable (2)	Model: Weibull type 2, 3 para; This model performs just well enough to be considered for estimation.	3,809	1,810	2.104
	530.7		36.2									
	1058.7		37.5									
	2116.7		34.5									
	4491		27.8									
	8740.3		20.7									
µg/L	1.6	count	32.7	avg # of young/female	Ceriodaphnia dubia	OSU 2018	Al-Chronic 41	Unacceptable (3)	Model: Weibull type 1, 3 para; The best ranked models either produce no EC estimates or they produce EC estimates with negative lower bounds.	2,576	821.2	3.137
	1054.3		33.8									
	2127.7		28									
	4438.3		19.9									
	8949		12.7									
	17544		1.6									
µg/L	1.6	count	31.3	avg # of young/female	Ceriodaphnia dubia	OSU 2018	Al-Chronic 42	Qualitatively Acceptable (2)	Model: Log Logistic type 1, 3 para; Only 2 out of 3 parameters are significant. Wide confidence bands. Overly influential observations.	1,905	1,660	1.148
	128.3		31.3									
	267.3		31.3									
	565.3		30.9									
	1107.3		31.7									
	2212		13.3									

Continuous Data												
Units (x)	**Test Conc.**	**Units (y)**	**Response**	**Endpoint**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
µg/L	3.7	mg	21	Biomass	Lampsilis siliquoidea	Wang et al. 2016, 2018	Al-Chronic 45	Qualitatively Acceptable (2)	Model: Weibull type 1, 4 para; Wide confidence bands and overly influential observation, but model performs well enough to be considered for estimation.	182.2	103.5	1.761
	52		19.2									
	92		19.29									
	203		16.06									
	441		5.34									
	1103		3.68									

Continuous Data												
Units (x)	**Test Conc.**	**Units (y)**	**Response**	**Endpoint**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
µg/L	0	mg	4.28	Biomass	Hyalella azteca	Wang et al. 2016, 2018	Al-Chronic 46	Qualitatively Acceptable (2)	Model: Weibull type 1, 3 para; One overly influential observation but otherwise model is adequate.	586.5	340.9	1.720
	64		3.67									
	150		4.06									
	220		3.88									
	600		3.16									
	1004		1.53									

Count Data												
Units (x)	**Test Conc.**	**Units (y)**	**Response**	**Endpoint**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
mg/L	0.03	count	18	# of young/female	Ceriodaphnia dubia	CECM 2014; Gensemer et al. 2018	Al-Chronic 1	Acceptable (1)	Model: Weibull type 1, 3 para; Model performs well on all metrics.	0.2636	0.1668	1.580
	0.03		16									
	0.03		17									
	0.03		14									
	0.03		8									
	0.03		7									
	0.03		20									
	0.03		17									
	0.03		21									
	0.03		17									
	0.092		14									
	0.092		20									
	0.092		16									
	0.092		14									
	0.092		15									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	0.092		20									
	0.092		15									
	0.092		14									
	0.092		18									
	0.092		8									
	0.164		12									
	0.164		11									
	0.164		14									
	0.164		20									
	0.164		13									
	0.164		18									
	0.164		18									
	0.164		13									
	0.164		18									
	0.164		15									
	0.286		12									
	0.286		14									
	0.286		9									
	0.286		8									
	0.286		10									
	0.286		16									
	0.286		10									
	0.286		14									
	0.286		17									
	0.286		6									
	0.548		0									
	0.548		0									
	0.548		2									
	0.548		5									
	0.548		0									
	0.548		0									
	0.548		4									
	0.548		2									
	0.548		0									
	0.548		2									
	1.079		0									
	1.079		0									

Count Data													
Units (x)	**Test Conc.**	**Units (y)**	**Response**	**Endpoint**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
	1.079		0									
	1.079		0									
	1.079		0									
	1.079		0									
	1.079		0									
	1.079		0									
	1.079		0									
	1.079		0									
mg/L	0.03	count	16	# of young/female	Ceriodaphnia dubia	CECM 2014; Gensemer et al. 2018	Al-Chronic 2	Qualitatively Acceptable (2)	Model: Log Logistic type 1, 3 para; Only 2 out of 3 parameters are significant. Wide confidence bands in area of interest (use some caution), but otherwise model performs well.	0.5222	0.4750	1.099
	0.03		18									
	0.03		14									
	0.03		7									
	0.03		19									
	0.03		17									
	0.03		20									
	0.03		14									
	0.03		14									
	0.03		16									
	0.089		11									
	0.089		19									
	0.089		15									
	0.089		8									
	0.089		12									
	0.089		11									
	0.089		20									
	0.089		19									
	0.089		16									
	0.089		10									
	0.156		9									
	0.156		19									
	0.156		15									
	0.156		13									
	0.156		14									
	0.156		17									
	0.156		20									
	0.156		12									
	0.156		11									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	0.156		10									
	0.284		19									
	0.284		6									
	0.284		18									
	0.284		9									
	0.284		13									
	0.284		20									
	0.284		13									
	0.284		15									
	0.284		24									
	0.284		11									
	0.549		6									
	0.549		10									
	0.549		12									
	0.549		4									
	0.549		9									
	0.549		7									
	0.549		10									
	0.549		10									
	0.549		13									
	0.549		12									
	1.064		0									
	1.064		0									
	1.064		0									
	1.064		0									
	1.064		0									
	1.064		0									
	1.064		0									
	1.064		0									
	1.064		0									
	1.064		0									

Count Data												
Units (x)	**Test Conc.**	**Units (y)**	**Response**	**Endpoint**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
mg/L	0.04	count	17	# of young/female	Ceriodaphnia dubia	CECM 2014; Gensemer et al. 2018	Al-Chronic 3	Qualitatively Acceptable (2)	Model: Log Logistic type 1. 3 para; Only 2 out of 3 parameters are significant. Wide confidence bands in area of interest (use some caution), but otherwise model performs well.	0.2936	0.2703	1.086
	0.04		19									
	0.04		20									
	0.04		17									
	0.04		18									
	0.04		15									
	0.04		2									
	0.04		12									
	0.04		17									
	0.04		18									
	0.161		13									
	0.161		14									
	0.161		13									
	0.161		12									
	0.161		19									
	0.161		20									
	0.161		16									
	0.161		22									
	0.161		9									
	0.161		10									
	0.299		9									
	0.299		12									
	0.299		17									
	0.299		10									
	0.299		0									
	0.299		10									
	0.299		13									
	0.299		16									
	0.299		19									
	0.299		6									
	0.542		0									
	0.542		0									
	0.542		0									
	0.542		0									
	0.542		0									
	0.542		0									
	0.542		0									

Count Data												
Units (x)	**Test Conc.**	**Units (y)**	**Response**	**Endpoint**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
	0.542		0									
	0.542		0									
	0.542		0									
	1.018		0									
	1.018		0									
	1.018		0									
	1.018		0									
	1.018		0									
	1.018		0									
	1.018		0									
	1.018		0									
	1.018		0									
	1.018		0									
	2.035		0									
	2.035		0									
	2.035		0									
	2.035		0									
	2.035		0									
	2.035		0									
	2.035		0									
	2.035		0									
	2.035		0									
	2.035		0									
mg/L	0.03	count	21	# of young/female	Ceriodaphnia dubia	CECM 2014; Gensemer et al. 2018	Al-Chronic 4	Acceptable (1)	Model: Weibull type 1, 3 para; Model performs well on all metrics.	0.9313	0.5631	1.654
	0.03		19									
	0.03		20									
	0.03		17									
	0.03		19									
	0.03		19									
	0.03		26									
	0.03		20									
	0.03		11									
	0.03		13									
	0.149		19									
	0.149		16									
	0.149		18									
	0.149		17									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	0.149		14									
	0.149		17									
	0.149		21									
	0.149		19									
	0.149		16									
	0.149		18									
	0.273		18									
	0.273		18									
	0.273		17									
	0.273		19									
	0.273		18									
	0.273		14									
	0.273		22									
	0.273		18									
	0.273		17									
	0.273		16									
	0.507		9									
	0.507		21									
	0.507		19									
	0.507		18									
	0.507		20									
	0.507		16									
	0.507		20									
	0.507		17									
	0.507		18									
	0.507		17									
	0.976		15									
	0.976		17									
	0.976		19									
	0.976		11									
	0.976		10									
	0.976		16									
	0.976		15									
	0.976		8									
	0.976		18									
	0.976		10									
	1.978		4									

Count Data													
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	1.978		4									
	1.978		4									
	1.978		2									
	1.978		4									
	1.978		0									
	1.978		2									
	1.978		0									
	1.978		4									
	1.978		0									
mg/L	0.03	count	14	# of young/female	Ceriodaphnia dubia	CECM 2014; Gensemer et al. 2018	Al-Chronic 5	Acceptable (1)	Model: Weibull type 2, 3 para; Model performs well on all metrics.	0.8331	0.7096	1.174
	0.03		22									
	0.03		17									
	0.03		18									
	0.03		19									
	0.03		14									
	0.03		18									
	0.03		17									
	0.03		19									
	0.03		29									
	0.54		22									
	0.54		16									
	0.54		20									
	0.54		18									
	0.54		8									
	0.54		20									
	0.54		19									
	0.54		24									
	0.54		18									
	0.54		21									
	1.02		7									
	1.02		12									
	1.02		12									
	1.02		8									
	1.02		0									
	1.02		19									
	1.02		9									
	1.02		14									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	1.02		0									
	1.02		15									
	2.07		0									
	2.07		0									
	2.07		0									
	2.07		6									
	2.07		0									
	2.07		0									
	2.07		4									
	2.07		0									
	2.07		0									
	2.07		0									
	4.11		0									
	4.11		0									
	4.11		0									
	4.11		0									
	4.11		0									
	4.11		0									
	4.11		0									
	4.11		0									
	4.11		0									
	4.11		0									
	8.26		0									
	8.26		0									
	8.26		0									
	8.26		0									
	8.26		0									
	8.26		0									
	8.26		0									
	8.26		0									
	8.26		0									
	8.26		0									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
mg/L	0.03	count	26	# of young/female	Ceriodaphnia dubia	CECM 2014; Gensemer et al. 2018	Al-Chronic 6	Acceptable (1)	Model: Weibull type 1. 3 para	1.022	0.6149	1.661
	0.03		17									
	0.03		19									
	0.03		20									
	0.03		14									
	0.03		24									
	0.03		27									
	0.03		22									
	0.03		10									
	0.03		21									
	0.5		21									
	0.5		20									
	0.5		18									
	0.5		22									
	0.5		23									
	0.5		23									
	0.5		18									
	0.5		18									
	0.5		22									
	0.5		18									
	0.97		18									
	0.97		25									
	0.97		12									
	0.97		10									
	0.97		15									
	0.97		14									
	0.97		19									
	0.97		20									
	0.97		21									
	0.97		12									
	1.91		0									
	1.91		4									
	1.91		4									
	1.91		6									
	1.91		3									
	1.91		8									
	1.91		7									

Count Data												
Units (x)	**Test Conc.**	**Units (y)**	**Response**	**Endpoint**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
	1.91		7									
	1.91		8									
	1.91		5									
	4.15		0									
	4.15		0									
	4.15		0									
	4.15		0									
	4.15		0									
	4.15		0									
	4.15		0									
	4.15		0									
	4.15		0									
	4.15		0									
	7.92		0									
	7.92		0									
	7.92		0									
	7.92		0									
	7.92		0									
	7.92		0									
	7.92		0									
	7.92		0									
	7.92		0									
	7.92		0									
mg/L	0.03	count	20	# of young/female	Ceriodaphnia dubia	CECM 2014; Gensemer et al. 2018	Al-Chronic 7	Qualitatively Acceptable (2)	Model: Weibull type 1, 3 para; QQ plot has some outliers, but otherwise the model performs well.	0.9066	0.5339	1.698
	0.03		18									
	0.03		13									
	0.03		19									
	0.03		23									
	0.03		16									
	0.03		17									
	0.03		18									
	0.03		21									
	0.03		17									
	0.48		22									
	0.48		16									
	0.48		22									
	0.48		17									

Count Data													
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	0.48		18									
	0.48		19									
	0.48		27									
	0.48		18									
	0.48		22									
	0.48		19									
	0.98		22									
	0.98		19									
	0.98		10									
	0.98		18									
	0.98		6									
	0.98		12									
	0.98		7									
	0.98		10									
	0.98		23									
	0.98		15									
	1.95		5									
	1.95		0									
	1.95		0									
	1.95		4									
	1.95		13									
	1.95		2									
	1.95		0									
	1.95		6									
	1.95		0									
	1.95		0									
	3.87		0									
	3.87		0									
	3.87		0									
	3.87		0									
	3.87		0									
	3.87		0									
	3.87		0									
	3.87		0									
	3.87		0									
	3.87		0									
	7.48		0									

Count Data												
Units (x)	**Test Conc.**	**Units (y)**	**Response**	**Endpoint**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
	7.48		0									
	7.48		0									
	7.48		0									
	7.48		0									
	7.48		0									
	7.48		0									
	7.48		0									
	7.48		0									
	7.48		0									
mg/L	0.1	count	30	# of young/female	Ceriodaphnia dubia	ENSR 1992b	Al-Chronic 10	Qualitatively Acceptable (2)	Model: Weibull type 1, 3 para; 1 out of 3 parameters are insignificant and wide confidence band in area of interest. Otherwise model performs well.	1.617	1.255	1.288
	0.1		26									
	0.1		23									
	0.1		31									
	0.1		28									
	0.1		27									
	0.1		24									
	0.1		25									
	0.1		26									
	0.1		20									
	0.18		25									
	0.18		26									
	0.18		21									
	0.18		25									
	0.18		27									
	0.18		23									
	0.18		26									
	0.18		22									
	0.18		26									
	0.18		21									
	0.24		17									
	0.24		29									
	0.24		25									
	0.24		22									
	0.24		24									
	0.24		25									
	0.24		23									
	0.24		19									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	0.24		26									
	0.24		26									
	0.45		28									
	0.45		11									
	0.45		24									
	0.45		26									
	0.45		25									
	0.45		18									
	0.45		26									
	0.45		16									
	0.45		27									
	0.45		23									
	1.02		25									
	1.02		29									
	1.02		25									
	1.02		25									
	1.02		24									
	1.02		22									
	1.02		24									
	1.02		22									
	1.02		22									
	1.02		24									
	1.88		14									
	1.88		18									
	1.88		21									
	1.88		17									
	1.88		8									
	1.88		6									
	1.88		17									
	1.88		12									
	1.88		14									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	0.13		26									
	0.13		26									
	0.13		22									
	0.13		20									
	0.13		19									
	0.13		20									
	0.13		18									
	0.13		18									
	0.13		24									
	0.13		28									
	0.14		21									
	0.14		20									
	0.14		20									
	0.14		20									
	0.14		25									
	0.14		18									
	0.14		24									
	0.14		26									
mg/L	0.14	count	23	# of young/female	Ceriodaphnia dubia	ENSR 1992b	Al-Chronic 11	Acceptable (1)	Model: Log Logistic type 1, 3 para; Model performs well on all metrics.	0.8081	0.3946	2.048
	0.14		26									
	0.28		25									
	0.28		20									
	0.28		17									
	0.28		29									
	0.28		21									
	0.28		18									
	0.28		18									
	0.28		21									
	0.28		26									
	0.28		25									
	0.47		20									
	0.47		21									
	0.47		18									
	0.47		20									
	0.47		24									
	0.47		18									
	0.47		18									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	0.47		21									
	0.47		22									
	0.47		25									
	0.94		15									
	0.94		12									
	0.94		13									
	0.94		15									
	0.94		17									
	0.94		18									
	0.94		17									
	0.94		21									
	0.94		20									
	0.94		18									
	2.42		6									
	2.42		6									
	2.42		5									
	2.42		10									
	2.42		5									
	2.42		6									
	2.42		8									
	2.42		4									
	2.42		4									
	2.42		6									

Count Data												
Units (x)	**Test Conc.**	**Units (y)**	**Response**	**Endpoint**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
mg/L	0.05	count	24	# of young/female	Ceriodaphnia dubia	ENSR 1992b	Al-Chronic 12	Acceptable (1)	Model: Weibull type 2, 3 para; Model performs well on all metrics.	0.5968	0.4496	1.327
	0.05		25									
	0.05		28									
	0.05		32									
	0.05		12									
	0.05		31									
	0.05		28									
	0.05		31									
	0.05		24									
	0.05		14									
	0.34		30									
	0.34		27									
	0.34		28									
	0.34		27									
	0.34		26									
	0.34		28									
	0.34		29									
	0.34		23									
	0.34		13									
	0.34		13									
	0.76		10									
	0.76		19									
	0.76		17									
	0.76		22									
	0.76		19									
	0.76		12									
	0.76		12									
	0.76		19									
	0.76		24									
	0.76		13									
	1.39		7									
	1.39		5									
	1.39		4									
	1.39		2									
	1.39		1									
	1.39		8									
	1.39		2									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	1.39		1									
	1.39		4									
	3.32		0									
	3.32		2									
	3.32		1									
	3.32		0									
	3.32		1									
	3.32		1									
	3.32		2									
	3.32		2									
	3.32		2									
	3.32		3									
	7.78		0									
	7.78		0									
	7.78		0									
	7.78		0									
	7.78		0									
	7.78		0									
	7.78		0									
	7.78		0									
	7.78		2									
	7.78		0									
mg/L	0.12	count	22	# of young/female	Ceriodaphnia dubia	ENSR 1992b	Al-Chronic 13	Qualitatively Acceptable (2)	Model: Log Logistic type 1, 3 para; QQ plot has some outliers, but otherwise the model performs well.	0.7613	0.5135	1.483
	0.12		29									
	0.12		31									
	0.12		26									
	0.12		30									
	0.12		25									
	0.12		26									
	0.12		28									
	0.12		27									
	0.12		30									
	0.46		17									
	0.46		27									
	0.46		24									
	0.46		20									
	0.46		29									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	0.46		27									
	0.46		24									
	0.46		22									
	0.46		29									
	0.46		29									
	0.93		13									
	0.93		18									
	0.93		18									
	0.93		19									
	0.93		11									
	0.93		17									
	0.93		17									
	0.93		17									
	0.93		18									
	0.93		19									
	1.84		4									
	1.84		5									
	1.84		1									
	1.84		5									
	1.84		1									
	1.84		4									
	1.84		1									
	1.84		6									
	1.84		5									
	1.84		0									
	4.1		0									
	4.1		0									
	4.1		0									
	4.1		0									
	4.1		0									
	4.1		0									
	4.1		0									
	4.1		0									
	4.1		0									
	4.1		0									
	8.32		0									
	8.32		0									

Count Data												
Units (x)	**Test Conc.**	**Units (y)**	**Response**	**Endpoint**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
	8.32		0									
	8.32		0									
	8.32		0									
	8.32		0									
	8.32		0									
	8.32		0									
	8.32		0									
	8.32		0									
µg/L	5.5	count	34	# of young/female	Ceriodaphnia dubia	European Al Association 2010; Gensemer et al. 2018	Al-Chronic 14	Qualitatively Acceptable (2)	Model: Weibull type 2, 3 para; EC standard errors are higher than other models, but otherwise model performs well.	69.53	27.22	2.554
	5.5		19									
	5.5		16									
	5.5		21									
	5.5		28									
	5.5		24									
	5.5		25									
	5.5		46									
	5.5		36									
	5.5		40									
	31.8		30									
	31.8		16									
	31.8		29									
	31.8		24									
	31.8		16									
	31.8		19									
	31.8		46									
	31.8		25									
	31.8		32									
	31.8		29									
	59.8		31									
	59.8		17									
	59.8		18									
	59.8		20									
	59.8		23									
	59.8		21									
	59.8		21									
	59.8		36									
	59.8		18									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	59.8		33									
	120.3		26									
	120.3		20									
	120.3		18									
	120.3		19									
	120.3		18									
	120.3		16									
	120.3		19									
	120.3		25									
	120.3		11									
	120.3		17									
	249		18									
	249		6									
	249		16									
	249		16									
	249		9									
	249		13									
	249		20									
	249		24									
	249		15									
	249		16									
	526.6		14									
	526.6		11									
	526.6		0									
	526.6		11									
	526.6		16									
	526.6		6									
	526.6		6									
	526.6		15									
	526.6		6									
	526.6		9									

Count Data												
Units (x)	**Test Conc.**	**Units (y)**	**Response**	**Endpoint**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
µg/L	8.2	count	19	# of young/female	Ceriodaphnia dubia	European Al Association 2010; Gensemer et al. 2018	Al-Chronic 15	Qualitatively Acceptable (2)	Model: Weibull type 1, 3 para; EC standard errors are higher than other models, but otherwise model performs well	432.4	217.4	1.989
	8.2		32									
	8.2		24									
	8.2		33									
	8.2		36									
	8.2		40									
	8.2		38									
	8.2		43									
	8.2		15									
	8.2		18									
	66.3		15									
	66.3		32									
	66.3		27									
	66.3		32									
	66.3		39									
	66.3		23									
	66.3		33									
	66.3		41									
	66.3		21									
	66.3		28									
	124		13									
	124		18									
	124		24									
	124		19									
	124		33									
	124		42									
	124		19									
	124		30									
	124		41									
	124		32									
	243.3		13									
	243.3		18									
	243.3		16									
	243.3		23									
	243.3		27									
	243.3		24									
	243.3		20									

Count Data												
Units (x)	**Test Conc.**	**Units (y)**	**Response**	**Endpoint**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
	243.3		23									
	243.3		30									
	243.3		38									
	517.8		7									
	517.8		17									
	517.8		14									
	517.8		27									
	517.8		25									
	517.8		16									
	517.8		37									
	517.8		23									
	517.8		23									
	517.8		28									
	1036.7		4									
	1036.7		2									
	1036.7		4									
	1036.7		8									
	1036.7		8									
	1036.7		13									
	1036.7		5									
	1036.7		0									
	1036.7		10									
	1036.7		11									
µg/L	11.3	count	26	# of young/female	Ceriodaphnia dubia	European Al Association 2010; Gensemer et al. 2018	Al-Chronic 16	Qualitatively Acceptable (2)	Model: Weibull type 2, 3 para; EC standard errors are higher than other models, but otherwise model performs well	774.5	631.7	1.226
	11.3		29									
	11.3		39									
	11.3		21									
	11.3		27									
	11.3		25									
	11.3		35									
	11.3		39									
	11.3		39									
	11.3		32									
	128.2		34									
	128.2		39									
	128.2		32									
	128.2		31									

Count Data													
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	128.2		20									
	128.2		28									
	128.2		26									
	128.2		36									
	128.2		29									
	128.2		33									
	254.2		21									
	254.2		33									
	254.2		36									
	254.2		32									
	254.2		21									
	254.2		23									
	254.2		35									
	254.2		36									
	254.2		36									
	254.2		38									
	489.4		11									
	489.4		27									
	489.4		22									
	489.4		22									
	489.4		39									
	489.4		33									
	489.4		29									
	489.4		34									
	489.4		24									
	489.4		25									
	985.5		12									
	985.5		17									
	985.5		32									
	985.5		14									
	985.5		20									
	985.5		9									
	985.5		20									
	985.5		11									
	985.5		14									
	985.5		13									
	2163.6		0									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	2163.6		3									
	2163.6		0									
	2163.6		1									
	2163.6		0									
	2163.6		8									
	2163.6		1									
	2163.6		4									
	2163.6		1									
	2163.6		2									
µg/L	4.3	count	26	# of young/female	Ceriodaphnia dubia	European Al Association 2010; Gensemer et al. 2018	Al-Chronic 17	Acceptable (1)	Model: Weibull type 2, 3 para; Model performs well on all metrics.	185.0	111.8	1.655
	4.3		25									
	4.3		17									
	4.3		17									
	4.3		25									
	4.3		18									
	4.3		20									
	4.3		19									
	4.3		18									
	4.3		19									
	58.4		29									
	58.4		25									
	58.4		17									
	58.4		16									
	58.4		24									
	58.4		19									
	58.4		17									
	58.4		19									
	58.4		19									
	58.4		16									
	116		17									
	116		20									
	116		21									
	116		15									
	116		19									
	116		20									
	116		18									
	116		13									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	116		21									
	116		18									
	247.7		15									
	247.7		21									
	247.7		10									
	247.7		6									
	247.7		10									
	247.7		18									
	247.7		15									
	247.7		11									
	247.7		13									
	247.7		20									
	543.8		11									
	543.8		9									
	543.8		3									
	543.8		6									
	543.8		9									
	543.8		4									
	543.8		7									
	543.8		6									
	543.8		9									
	543.8		5									
	1110.5		2									
	1110.5		3									
	1110.5		3									
	1110.5		4									
	1110.5		5									
	1110.5		5									
	1110.5		5									
	1110.5		0									
	1110.5		0									
	1110.5		5									

Count Data												
Units (x)	**Test Conc.**	**Units (y)**	**Response**	**Endpoint**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
µg/L	4.1	count	23	# of young/female	Ceriodaphnia dubia	European Al Association 2010; Gensemer et al. 2018	Al-Chronic 18	Qualitatively Acceptable (2)	Model: Weibull type 1, 3 para; EC standard errors are high, but otherwise model performs well	655.9	381.5	1.720
	4.1		24									
	4.1		23									
	4.1		24									
	4.1		27									
	4.1		21									
	4.1		17									
	4.1		21									
	4.1		25									
	4.1		17									
	63.5		23									
	63.5		24									
	63.5		20									
	63.5		25									
	63.5		20									
	63.5		18									
	63.5		15									
	63.5		16									
	63.5		22									
	63.5		15									
	121.1		13									
	121.1		17									
	121.1		16									
	121.1		24									
	121.1		19									
	121.1		21									
	121.1		15									
	121.1		28									
	121.1		16									
	121.1		24									
	182		22									
	182		15									
	182		20									
	182		16									
	182		28									
	182		21									
	182		25									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	182		24									
	182		15									
	182		16									
	530.4		14									
	530.4		19									
	530.4		20									
	530.4		8									
	530.4		23									
	530.4		15									
	530.4		19									
	530.4		23									
	530.4		26									
	530.4		15									
	1004.7		11									
	1004.7		2									
	1004.7		8									
	1004.7		8									
	1004.7		13									
	1004.7		10									
	1004.7		13									
	1004.7		20									
	1004.7		11									
	1004.7		4									
µg/L	8.1	count	21	# of young/female	Ceriodaphnia dubia	European Al Association 2010; Gensemer et al. 2018	Al-Chronic 19	Qualitatively Acceptable (2)	Model: Weibull type 1, 3 para: QQ plot has some outliers but otherwise the model performs well	595.2	259.1	2.297
	8.1		24									
	8.1		14									
	8.1		27									
	8.1		18									
	8.1		18									
	8.1		22									
	8.1		22									
	8.1		17									
	8.1		19									
	365.8		26									
	365.8		23									
	365.8		23									
	365.8		25									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	365.8		13									
	365.8		17									
	365.8		21									
	365.8		23									
	365.8		22									
	365.8		13									
	1013.6		9									
	1013.6		20									
	1013.6		8									
	1013.6		13									
	1013.6		11									
	1013.6		14									
	1013.6		11									
	1013.6		12									
	1013.6		16									
	1013.6		0									
	2552.6		1									
	2552.6		0									
	2552.6		3									
	2552.6		0									
	2552.6		0									
	2552.6		0									
	2552.6		5									
	2552.6		2									
	2552.6		0									
	2552.6		1									
	4634.1		0									
	4634.1		0									
	4634.1		0									
	4634.1		0									
	4634.1		0									
	4634.1		0									
	4634.1		0									
	4634.1		0									
	4634.1		0									
	4634.1		0									
	7994.5		0									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	7994.5		0									
	7994.5		0									
	7994.5		0									
	7994.5		0									
	7994.5		0									
	7994.5		0									
	7994.5		0									
	7994.5		0									
	7994.5		0									
µg/L	0.7	count	20	# of young/female	Ceriodaphnia dubia	European Al Association 2010; Gensemer et al. 2018	Al-Chronic 20	Qualitatively Acceptable (2)	Model: Weibull type 2, 3 para: QQ plot has some outliers but otherwise the model performs well.	171.3	82.52	2.076
	0.7		22									
	0.7		26									
	0.7		20									
	0.7		20									
	0.7		25									
	0.7		20									
	0.7		21									
	0.7		23									
	0.7		21									
	44.8		21									
	44.8		22									
	44.8		22									
	44.8		22									
	44.8		25									
	44.8		22									
	44.8		19									
	44.8		23									
	44.8		23									
	44.8		29									
	86.9		16									
	86.9		20									
	86.9		24									
	86.9		24									
	86.9		19									
	86.9		28									
	86.9		22									
	86.9		23									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	86.9		22									
	86.9		30									
	174.6		20									
	174.6		19									
	174.6		11									
	174.6		2									
	174.6		17									
	174.6		0									
	174.6		16									
	174.6		22									
	174.6		23									
	174.6		31									
	359.3		18									
	359.3		19									
	359.3		19									
	359.3		0									
	359.3		10									
	359.3		13									
	359.3		13									
	359.3		18									
	359.3		14									
	359.3		17									
	795		4									
	795		10									
	795		3									
	795		13									
	795		11									
	795		5									
	795		5									
	795		10									
	795		8									
	795		9									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
µg/L	6.4	count	18	# of young/female	Ceriodaphnia dubia	European Al Association 2010; Gensemer et al. 2018	Al-Chronic 21	Acceptable (1)	Model: Weibull type 1, 3 para: Model performs well on all metrics	438.8	154.8	2.835
	6.4		16									
	6.4		17									
	6.4		26									
	6.4		14									
	6.4		26									
	6.4		25									
	6.4		28									
	6.4		27									
	6.4		26									
	158.4		19									
	158.4		17									
	158.4		22									
	158.4		25									
	158.4		26									
	158.4		18									
	158.4		24									
	158.4		27									
	158.4		24									
	158.4		27									
	314.5		18									
	314.5		17									
	314.5		23									
	314.5		24									
	314.5		26									
	314.5		22									
	314.5		18									
	314.5		18									
	314.5		25									
	314.5		18									
	1023.1		28									
	1023.1		19									
	1023.1		19									
	1023.1		23									
	1023.1		19									
	1023.1		0									
	1023.1		11									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	1023.1		19									
	1023.1		19									
	1023.1		15									
	1759.4		0									
	1759.4		0									
	1759.4		0									
	1759.4		0									
	1759.4		0									
	1759.4		2									
	1759.4		0									
	1759.4		1									
	1759.4		0									
	1759.4		3									
	3993.2		0									
	3993.2		0									
	3993.2		1									
	3993.2		0									
	3993.2		2									
	3993.2		1									
	3993.2		3									
	3993.2		0									
	3993.2		0									
	3993.2		0									
µg/L	6.6	count	35	# of young/female	Ceriodaphnia dubia	European Al Association 2010; Gensemer et al. 2018	Al-Chronic 22	Qualitatively Acceptable (2)	Model: Log Logistic type 1, 3 para; QQ plot is off but otherwise model performs well.	947.5	623.3	1.520
	6.6		22									
	6.6		34									
	6.6		34									
	6.6		28									
	6.6		33									
	6.6		22									
	6.6		26									
	6.6		35									
	6.6		23									
	318.8		27									
	318.8		35									
	318.8		20									
	318.8		36									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	318.8		29									
	318.8		40									
	318.8		28									
	318.8		34									
	318.8		26									
	318.8		24									
	748		23									
	748		20									
	748		19									
	748		37									
	748		26									
	748		27									
	748		25									
	748		29									
	748		29									
	748		18									
	1779.4		8									
	1779.4		0									
	1779.4		2									
	1779.4		16									
	1779.4		5									
	1779.4		23									
	1779.4		14									
	1779.4		6									
	1779.4		5									
	1779.4		4									
	4604.3		0									
	4604.3		2									
	4604.3		0									
	4604.3		1									
	4604.3		0									
	4604.3		0									
	4604.3		0									
	4604.3		0									
	4604.3		0									
	4604.3		0									
	7984.9		0									

Count Data												
Units (x)	**Test Conc.**	**Units (y)**	**Response**	**Endpoint**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
	7984.9		0									
	7984.9		0									
	7984.9		0									
	7984.9		0									
	7984.9		0									
	7984.9		0									
	7984.9		0									
	7984.9		0									
	7984.9		0									
µg/L	2.1	count	104	# of young/female	Daphnia magna	European Al Association 2010; Gensemer et al. 2018	Al-Chronic 23	Qualitatively Acceptable (2)	Model: Weibull type 1, 3 para; QQ plot is off and there is some uncertainty in area of interest but otherwise model performs well.	781.3	591.5	1.321
	2.1		108									
	2.1		111									
	2.1		85									
	2.1		114									
	2.1		107									
	2.1		88									
	2.1		98									
	2.1		96									
	2.1		101									
	127.5		113									
	127.5		120									
	127.5		89									
	127.5		118									
	127.5		80									
	127.5		108									
	127.5		91									
	127.5		103									
	127.5		96									
	127.5		79									
	349		129									
	349		107									
	349		104									
	349		100									
	349		87									
	349		110									
	349		93									
	349		98									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	349		99									
	349		74									
	539.3		94									
	539.3		99									
	539.3		90									
	539.3		113									
	539.3		96									
	539.3		94									
	539.3		99									
	539.3		97									
	539.3		93									
	539.3		100									
	1106.4		16									
	1106.4		12									
	1106.4		42									
	1106.4		17									
	1106.4		63									
	1106.4		22									
	1106.4		32									
	1106.4		12									
	1106.4		21									
	1106.4		10									
	2401.6		0									
	2401.6		0									
	2401.6		0									
	2401.6		0									
	2401.6		0									
	2401.6		0									
	2401.6		0									
	2401.6		0									
	2401.6		0									
	2401.6		0									

Count Data												
Units (x)	**Test Conc.**	**Units (y)**	**Response**	**Endpoint**	**Species**	**Citation**	**C-R Curve Label**	**Curve Acceptability**	**Curve Notes**	**EC20**	**EC5**	**EC20: EC5 Ratio**
µg/L	5	count	19	final # of individuals	Brachionus calyciflorus	OSU 2012c; Cardwell et al. 2018	Al-Chronic 28	Qualitatively Acceptable (2)	Model: Log Logistic type 1, 3 para; EC standard errors are a bit large but otherwise model performs well.	400.8	162.8	2.463
	5		24									
	5		27									
	5		21									
	97		20									
	97		27									
	97		17									
	97		20									
	200		32									
	200		21									
	200		18									
	405		25									
	405		16									
	405		20									
	405		21									
	820		14									
	820		8									
	820		8									
	820		11									
	1636		2									
	1636		10									
	1636		8									
	1636		7									
µg/L	0.5	count	61	final # of individuals	Aeolosoma sp.	OSU 2012e; Cardwell et al. 2018	Al-Chronic 29	Qualitatively Acceptable (2)	Model: Log Logistic type 1, 3 para; QQ plot has a few outliers, otherwise model perform well.	1,316	858.9	1.533
	0.5		64									
	0.5		73									
	0.5		63									
	84.5		68									
	84.5		76									
	84.5		46									
	84.5		74									
	480.6		73									
	480.6		75									
	480.6		73									
	480.6		92									
	962.5		46									
	962.5		76									

Count Data												
Units (x)	Test Conc.	Units (y)	Response	Endpoint	Species	Citation	C-R Curve Label	Curve Acceptability	Curve Notes	EC20	EC5	EC20: EC5 Ratio
	962.5		80									
	962.5		58									
	2156.9		19									
	2156.9		30									
	2156.9		26									
	2156.9		35									
	4460.6		2									
	4460.6		7									
	4460.6		1									
	4460.6		3									

Appendix C. Acute LC_{50}:LC_{15} and LC_{50}:LC_{10} Ratios and Chronic EC_{20}:EC_{15} and EC_{20}:EC_{10} Ratios Based on Quantitatively Acceptable C-R Curves

C.1 Acute LC_{50}:LC_{15} ratios from quantitatively-acceptable C-R models used to derive acute LC_{50}:LC_{15} adjustment factors.

Acute LC_{50}:LC_{15} adjustment factors are intended to be applied to listed species acute toxicity values (i.e., representative LC_{50} value) in the same manner as acute TAFs and the acute MAF to derive a corresponding LC_{15} value.

Order	Family	Species	LC_{50} (µg/L)	LC_{15} (µg/L)	LC_{50}: LC_{15}	C-R Curve Label[a]	Citation	Species-level TAF (LC_{50}:LC_{15})	Genus-level TAF (LC_{50}:LC_{15})
Basommatophora	Physidae	*Physa sp.*	29,267	21,718	1.348	Al-Acute 5	Call et al 1984	2.172	2.172
Basommatophora	Physidae	*Physa sp.*	61,966	17,706	3.500	Al-Acute 7	Call et al 1984		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	737.9	205.3	3.594	Al-Acute 8	ENSR 1992d	2.354	2.354
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	1,898	627.8	3.023	Al-Acute 9	ENSR 1992d		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	2,822	486.1	5.806	Al-Acute 10	ENSR 1992d		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	72.07	32.55	2.214	Al-Acute 14	European Al Association 2009		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	792.4	519.4	1.525	Al-Acute 16	European Al Association 2009		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	1,005	553.8	1.815	Al-Acute 17	European Al Association 2009		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	8,801	5,011	1.756	Al-Acute 20	European Al Association 2009		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	10,636	4,275	2.488	Al-Acute 21	European Al Association 2009		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	24,345	7,250	3.358	Al-Acute 27	European Al Association 2009		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	10,766	9,464	1.138	Al-Acute 28	European Al Association 2009		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	309.3	116.2	2.661	Al-Acute 45	European Al Association 2010		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	120.6	54.42	2.216	Al-Acute 48	European Al Association 2010		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	79.27	44.26	1.791	Al-Acute 52	European Al Association 2010		

[a] Raw empirical acute toxicity data and model output for all C-R models are provided in Appendix B.1. C-R models from two brook trout (*Salvelinus fontinalis*) acute tests (Al-Acute 66 and Al-Acute 68) that were used to derive an acute salmonid LC_{50} to LC_{15} adjustment factor are not shown in the table because they were scored to be qualitatively acceptable and were, therefore, excluded from MAF derivation. The Salmonidae family-level LC_{50} to LC_{15} acute adjustment factor is 1.466, calculated as the geometric mean of 1.770 (Al-Acute 66) and 1.213 (Al-Acute 68; see Supplemental Information A).

C.2 Acute LC_{50}:LC_{10} ratios from quantitatively-acceptable C-R models used to derive acute LC_{50}:LC_{10} adjustment factors.

Acute LC_{50}:LC_{10} adjustment factors are intended to be applied to listed species acute toxicity values (i.e., representative LC_{50} value) in the same manner as acute TAFs and the acute MAF to derive a corresponding LC_{10} value.

Order	Family	Species	LC_{50} (µg/L)	LC_{10} (µg/L)	LC_{50}: LC_{10}	C-R Curve Label[a]	Citation	Species-level TAF (LC_{50}:LC_{10})	Genus-level TAF (LC_{50}:LC_{10})
Basommatophora	Physidae	*Physa sp.*	29,267	20,507	1.427	Al-Acute 5	Call et al 1984	2.641	2.641
Basommatophora	Physidae	*Physa sp.*	61,966	12,677	4.888	Al-Acute 7	Call et al 1984		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	737.9	145.9	5.056	Al-Acute 8	ENSR 1992d	2.942	2.942
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	1,898	467.4	4.061	Al-Acute 9	ENSR 1992d		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	2,822	346.6	8.143	Al-Acute 10	ENSR 1992d		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	72.07	25.67	2.807	Al-Acute 14	European Al Association 2009		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	792.4	457.9	1.731	Al-Acute 16	European Al Association 2009		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	1,005	493.8	2.035	Al-Acute 17	European Al Association 2009		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	8,801	4,235	2.078	Al-Acute 20	European Al Association 2009		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	10,636	3,256	3.267	Al-Acute 21	European Al Association 2009		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	24,345	5,048	4.823	Al-Acute 27	European Al Association 2009		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	10,766	9,233	1.166	Al-Acute 28	European Al Association 2009		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	309.3	86.74	3.565	Al-Acute 45	European Al Association 2010		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	120.6	44.01	2.739	Al-Acute 48	European Al Association 2010		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	79.27	39.57	2.003	Al-Acute 52	European Al Association 2010		

[a] Raw empirical acute toxicity data and model output for all C-R models are provided in Appendix B.1. C-R models from two brook trout (*Salvelinus fontinalis*) acute tests (Al-Acute 66 and Al-Acute 68) that were used to derive an acute salmonid LC_{50} to LC_{15} adjustment factor are not shown in the table because they were scored to be qualitatively acceptable and were, therefore, excluded from MAF derivation. The Salmonidae family-level LC_{50} to LC_{15} acute adjustment factor is 1.638, calculated as the geometric mean of 2.100 (Al-Acute 66) and 1.277 (Al-Acute 68; see Supplemental Information A).

C.3 Chronic EC_{20}:EC_{15} ratios from quantitatively acceptable C-R models used to derive chronic EC_{20}:EC_{15} adjustment factors.

Chronic EC_{20}:EC_{15} adjustment factors are intended to be applied to listed species chronic toxicity values (i.e., representative EC_{20} value) in the same manner as chronic TAFs and the chronic MAF to derive a corresponding EC_{15} value.

Order	Family	Species	EC_{20} (µg/L)	EC_{15} (µg/L)	EC_{20}: EC_{15}	C-R Curve Label[a]	Citation	Species-level TAF (EC_{20}:EC_{15})	Genus-level TAF (EC_{20}:EC_{15})
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	263.6	238.8	1.104	Al-Chronic 1	CECM 2014; Gensemer et al. 2018	1.126	1.126
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	931.3	835.6	1.115	Al-Chronic 4	CECM 2014; Gensemer et al. 2018		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	833.1	798.5	1.043	Al-Chronic 5	CECM 2014; Gensemer et al. 2018		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	1,022	915.6	1.116	Al-Chronic 6	CECM 2014; Gensemer et al. 2018		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	808.1	688.4	1.174	Al-Chronic 11	ENSR 1992b		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	596.8	553.7	1.078	Al-Chronic 12	ENSR 1992b		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	185.0	161.9	1.143	Al-Chronic 17	European Al Association 2010; Gensemer et al. 2018		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	438.8	350.5	1.252	Al-Chronic 21	European Al Association 2010; Gensemer et al. 2018		
Cypriniformes	Cyprinidae	*Pimephales promelas*	6,428	6,169	1.042	Al-Chronic 24	Kimball 1978	1.042	1.042

[a] Raw empirical chronic toxicity data and model output for all C-R models are provided in Appendix B.2.The C-R model from a brook trout (*Salvelinus fontinalis*) chronic test (Al-Chronic-9) that was used to derive a chronic salmonid EC_{20} to EC_{15} adjustment factor is not shown in the table because the model was scored to be qualitatively acceptable and was, therefore, excluded from chronic MAF derivation. The Salmonidae family-level EC_{20} to EC_{15} chronic adjustment factor is 1.125, based on the brook trout EC_{20}:EC_{15} ratio (Al-Chronic 9; see Supplemental Information A).

C.4 Chronic EC_{20}:EC_{10} ratios from quantitatively acceptable C-R models used to derive chronic EC_{20}:EC_{10} adjustment factors.

Chronic EC_{20}:EC_{10} adjustment factors are intended to be applied to listed species chronic toxicity values (i.e., representative EC_{20} value) in the same manner as chronic TAFs and the chronic MAF to derive a corresponding EC_{10} value.

Order	Family	Species	EC_{20} (µg/L)	EC_{10} (µg/L)	EC_{20}: EC_{10}	C-R Curve Label[a]	Citation	Species-level TAF (EC_{20}:EC_{10})	Genus-level TAF (EC_{20}:EC_{10})
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	263.6	208.7	1.263	Al-Chronic 1	CECM 2014; Gensemer et al. 2018	1.317	1.317
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	931.3	720.4	1.293	Al-Chronic 4	CECM 2014; Gensemer et al. 2018		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	833.1	759.5	1.097	Al-Chronic 5	CECM 2014; Gensemer et al. 2018		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	1,022	788.4	1.296	Al-Chronic 6	CECM 2014; Gensemer et al. 2018		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	808.1	556.5	1.452	Al-Chronic 11	ENSR 1992b		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	596.8	506.9	1.177	Al-Chronic 12	ENSR 1992b		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	185.0	138.4	1.337	Al-Chronic 17	European Al Association 2010; Gensemer et al. 2018		
Diplostraca	Daphniidae	*Ceriodaphnia dubia*	438.8	257.8	1.702	Al-Chronic 21	European Al Association 2010; Gensemer et al. 2018		
Cypriniformes	Cyprinidae	*Pimephales promelas*	6,428	5,878	1.094	Al-Chronic 24	Kimball 1978	1.094	1.094

[a] Raw empirical chronic toxicity data and model output for all C-R models are provided in Appendix B.2.The C-R model from a brook trout (*Salvelinus fontinalis*) chronic test (Al-Chronic-9) that was used to derive a chronic salmonid EC_{20} to EC_{10} adjustment factor is not shown in the table because the model was scored to be qualitatively acceptable and was, therefore, excluded from chronic MAF derivation. The Salmonidae family-level EC_{20} to EC_{10} chronic adjustment factor is 1.316, based on the brook trout EC_{20}:EC_{10} ratio (Al-Chronic 9; see Supplemental Information A).

Appendix D. Appendix D: Acceptable Web-ICE Models for Aluminum Toxicity Data for Assessment

D.1 Acceptable Web-ICE models for Aluminum Assessment[a].

Common name	Scientific Name	Family	Service	
Vernal pool fairy shrimp	Branchinecta lynchi	Branchinectidae	FWS	Green shading indicates model selected
Sturgeon, green	Acipenser medirostris	Acipenseridae	NOAA Fisheries	Green shading indicates model selected
Pacific eulachon	Thaleichthys pacificus	Osmeridae	NOAA Fisheries	**No species, genus or family ICE model available**

SPECIES LEVEL ESTIMATE (Used for FWS Effects Assessment)

Prediction	Surrogate species	Surrogate Acute Value (µg/L)	Predicted Acute Value (µg/L)	95% CI LL	95% CI UL	Pred ÷ 95%CI LL	95%CI UL ÷ Pred	Intercept:	Slope:	Degrees of Freedom (N-2):	R^2:	p-value:	Average value of surrogate:	Minimum value of surrogate:	Maximum value of surrogate:
Branchinecta lynchi	Ceriodaphnia dubia	5,863	9,730	3,019.1	31,357	3.2	3.2	0.57218	0.9065	5	0.94452	0.00025	2573.99	15.7	2398168.99
Branchinecta lynchi	Daphnia magna	2,944	2728.4	1369.4	5435.83	2.0	2.0	0.310762	0.9009	5	0.98043	0.00002	5273.85	6.97	8511644.41
Branchinecta lynchi	Lampsilis siliquoidea	29,492	50760.89	20859.9	123522.3	2.4	2.4	0.003122	1.05	5	0.97505	0.00003	3018.01	19.01	3121124.59

Mean Square Error (MSE):	Sum of Squares (S_{xx}):	Cross-validation Success (%):	Taxonomic Distance:
0.264893	27.43	43	4
0.093448	28.84	100	4
0.119109	21.03	100	6

GENUS LEVEL ESTIMATE (Used for NOAA Fisheries Effects Assessment)

Prediction	Surrogate species	Surrogate Acute Value (µg/L)	Predicted Acute Value (µg/L)	95% CI LL	95% CI UL	Pred ÷ 95%CI LL	95%CI UL ÷ Pred	Intercept:	Slope:	Degrees of Freedom (N-2):	R^2:	p-value:	Average value of surrogate (log value):	Minimum value of surrogate (log value):	Maximum value of surrogate (log value):
Acipenser medirostris	Oncorhynchus mykiss	3,312	3592.81	1532.97	8420.41	2.3	2.3	-0.347756	1.1	4	0.97669	0.00021	369.95	29	95857.69
Acipenser medirostris	Pimephales promelas	22,095	9702.77	1245.39	75593.41	7.8	7.8	-1.35	1.23	3	0.94453	0.00564	1661.29	76.49	140225.29

Mean Square Error (MSE):	Sum of Squares (S_{xx}):	Cross-validation Success (%):	Taxonomic Distance:
0.066636	9.08	100	4
0.205375	6.92	60	4

[a] LC_{50} values expressed as total aluminum, normalized to pH 7, DOC of 1 mg/L and 100 mg/L hardness as $CaCO_3$; normalized using MLR equations indentified in USEPA (2018).

Appendix E. Concentration-Response Curve Fitting and Model Assessment

E.1 Concentration-Response (C-R) curve fitting methodology and C-R curve scoring system.

1. Fitting Concentration Response Data in R

Raw concentration-response data (expressed as log[treatment concentration] paired organismal responses) were obtained from quantitatively-acceptable toxicity studies that reported raw data. In many scenarios, toxicity studies reported treatment-level mean concentrations and mean organismal responses; however, individual-replicate data were also available in many scenarios (See Appendix B.1 and B.2). When fitting C-R curves, replicate-level data were preferred over treatment-level data, if both types of data were available. Within R, the drc package was employed to fit 22 mathematical models to each set of raw C-R data.

a. Fitting Acute Mortality Data

i. Dichotomous Data

Dichotomous data are binary in nature (e.g. live/dead or 0/1) and are typical of survival experiments. They are usually represented as a proportion survived.

b. Fitting Chronic Growth, Reproduction, and Survival Data

i. Continuous Data

Continuous data take on any value along the real number line (e.g. biomass).

ii. Count Data

Count data take on only integer values (e.g. number of eggs hatched).

iii. Dichotomous Data

Dichotomous data are binary in nature (e.g. live/dead or 0/1) and are typical of survival experiments. They are usually represented as a proportion survived.

2. Determining Most Robust Model Fit for Each C-R curve

The R drc package was used to fit 22 different models to each individual C-R dataset. A single model was then selected from the 22 models to serve as the representative C-R model. The selected model represented the most statistically-robust model available. To determine the most-statistically-robust model for a C-R dataset, all individual model fits were assessed on a suite of statistical metrics.

a. Selecting Candidate Models

Initially, models were ranked according to the Akaike information criteria (AIC). The AIC provides a measure of how close a model's fitted values tend to be to the true expected values, as summarized by a certain expected distance between the two. That is, the model with the lowest AIC is generally the optimal model because it is the model fit that tends to have its fitted values closest to the true outcome probabilities. In some instances, however, the model with the lowest AIC may possesses a questionable characteristic that suggests the model with the lowest AIC may not be the most appropriate. Rather than selecting a model based solely on the lowest AIC, the AIC ranking step was first used to identify several candidate models that were more closely examined before selecting a model fit for each C-R dataset

b. Assessment of Candidate Models to Determine the Most Appropriate Model

Candidate models (i.e., models with low AIC scores relative to other models produced for a particular C-R dataset) were further evaluated based on additional statistical metrics to determine a single, statistically robust curve for each quantitatively-acceptable toxicity tests. These additional statistical metrics were evaluated relative to the other candidate curve fits produced for each C-R dataset. These additional statistical metrics include:

i. Comparison of residual standard errors

As with AIC, smaller values were desirable. Residual standard errors were judged relative to other models.

ii. Width of confidence intervals for EC estimates

Confidence intervals were assessed on standard error relative to estimate and confirming that the intervals are non-negative. Judged in absolute and relative to other models.

iii. Width of confidence bands around the fitted model

General visual inspection of the confidence bands for the fitted model. Wide bands in the area of interest were undesirable. Judged in absolute and relative to other models.

iv. P-values of parameters estimates and goodness of fit tests

Hypothesis tests of parameter values determined whether an estimate was significantly different from zero. Goodness of fit tests judged the overall performance of the model fit. Typically, the level of significance was set at 0.05. There were occasional instances where the 0.05 criterion was not met, but there was little recourse for choosing another model. Judged in absolute terms.

v. Residual plots

Residuals were examined for homoskedacity and biasedness. Judged in absolute and relative to other models.

vi. Overly influential observations

Observations were judged on Cook's distance and leverage. When an observation was deemed overly influential, it was not reasonable to refit the model and exclude any overly influential observations given the limited data available. Judged in absolute terms.

Of these statistical metrics, residual standard errors, confidence intervals relative to effects concentration estimates, and confidence bands carried the most weight in determining the most appropriate model to be representative of an individual C-R dataset.

3. Determining Curve Acceptability for use in Taxonomic Adjustment Factor (TAF) or Mean Adjustment Factor (MAF) Derivation

The final curve fits that were selected for each of the quantitatively-acceptable toxicity tests were further evaluated and scored to determine whether the curves are: 1) quantitatively-acceptable for use, 2) qualitatively acceptable for use, or 3) unacceptable. To determine curve acceptability for use in deriving an acute or chronic TAF and/or MAF, each individual curve was reconsidered based on the statistical metrics described above. Instead of evaluating curves fits relative to other curve fits for the same data (as was previously done to select the most-robust curve for each test), curve fit metrics were used to assign each curve a score:

- 1 = **Quantitatively Acceptable Model**. Model performed well on most/all statistical metrics. Models that scored a 1 were used to derive TAFs and MAFs.
- 2 = **Qualitatively Acceptable Model**. Model generally performed well on statistical metrics; however, the model presented some characteristic(s) that may call estimates into question. Such models should be considered with caution. These problems consisted of any number of issues such as a parameter with a high p-value, poor goodness of fit p-value, wide confidence bands for fit or estimate interval, or residuals that indicated model assumptions are not met. Models that scored a 2 were used as supportive information and were included in TAF derivation if they provided data for listed species, or closely-related surrogates, that would otherwise not be available.
- 3 = **Unacceptable Model**. Model poorly fit to the data. Models should not be used for TAF or MAF derivation.

While the scoring system may contain a subjective component, it provides a classification mechanism to aid in evaluating models to inform their quantitative or qualitative use in a relatively repeatable manner. Individual model fits and the corresponding curve acceptability scores for each set of available C-R data are described in Appendix B.1 (acute C-R data) and B.2 (chronic C-R data).

Appendix F1. Discharger Assessment - Monte Carlo Simulation Structure

The analysis was performed on an Excel spreadsheet with 10,000 simulated events, one event per row, considering the following parameters.

- The event-specific (i.e., time-variable, random) effluent Al concentration followed the distribution of effluent concentrations that would attain the hypothetical permit limit.
- The upstream dilution flow was specified as follows (not random):
    - For the NAC discharge, the mixing zone dilution specified by the DEQ (undated) fact sheet was held constant over all events.
    - For the Fujimi discharge, one-third of trial events were assigned zero upstream flow, the DEQ (2012) dry-season dilution. The other two-thirds were assigned the DEQ (2012) wet-season mixing-zone dilution.
- The downstream Al concentration was calculated from the above parameters.
- The event-specific listed species EC_5 values were assumed to follow a lognormal distribution having the observed geometric mean and natural log standard deviation of the values calculated from observed pH, hardness, and DOC of waters representative of the discharge site. Each simulated event had three EC_5 values, one for vernal pool fairy shrimp, one for bull trout, and one for the other listed salmonids.
- The event-specific Hazard Quotients, HQ, were calculated as the ratio of the event-specific downstream Al concentration and event-specific EC_5 values.

For each event a random number, generated using the function RAND(), was used to set the effluent concentration as follows:

$$\ln(C_{eff}) = \ln(GM_{Ceff}) + \sigma_{Ceff}\text{*NORMSINV(RAND())}$$

Because the RAND() function generated decimals in the range 0-1 (in this case representing a cumulative probability value), NORMSINV(RAND()) generated a normal distribution z-value. The approach was thus applying the lognormal distribution formula,

$$\ln(x) = \mu + \sigma z$$

where μ is the mean of natural logs (i.e., ln(GM) where GM is the geometric mean of the distribution) and σ is the standard deviation of natural logs. Using relationships incorporated into the EPA (1991) permit derivation approach, the GM was calculated from the permit derivation's arithmetic mean or long-term average, LTA, as follows:

$$GM = LTA/\text{sqrt}(1 + CV^2)$$

The standard deviation of natural logs, σ, was given by

$$\sigma = \text{sqrt}(\ln(1 + CV^2))$$

Al concentration at the edge of the mixing zone – that is, the downstream concentration C_{dn}, was calculated by dividing by the DEQ Fact Sheet's specified dilution factor, Q_{dn}/Q_{eff}:

$$C_{dn} = C_{eff}/(Q_{dn}/Q_{eff})$$

For each event a second random number, again produced by the RAND() function and again representing a cumulative probability, was used to generate lognormally distributed EC_5 values, in manner corresponding to how the effluent concentration was generated:

$$\ln(EC_5) = \ln(GM_{EC5}) + \sigma_{EC5} * NORMSINV(RAND())$$

The comparison of the Al concentration at the edge of the mixing zone with the listed species EC_5 was done as Hazard Quotients, HQ:

$$HQ = C_{dn}/EC_5$$

Each of the above concentrations, EC_5, and HQ values occupies one column of the Excel spreadsheet, and their values specific to each randomly generated event occupy one row, moving down the spreadsheet. Considering the distribution of HQ over all events, various percentiles of their distribution were calculated by the Excel function PERCENTILE.EXC. This is equivalent to assigning the HQ for each event a rank and calculating percentile by the Weibull formula, rank/(N+1), in accord with past EPA practice.

The spreadsheet held 10,000 rows (10,000 events). For each condition with specified design inputs, results for five sets of 10,000 events were recorded and the median of the five was presented. Differences between the five sets were negligible.

Appendix F2. Discharger Assessment

Discharger Assessment

Abstract

A discharger assessment was completed to analyze how the aluminum aquatic life criteria (USEPA 2018) may be incorporated into regulated dischargers through the National Pollutant Discharge Elimination System (NPDES) where a facility discharge is found to have reasonable potential to cause or contribute to an excursion above the aluminum aquatic life criteria (USEPA 2018). Broadly, EPA identified facilities in Oregon whose NPDES permits contain effluent limitations or monitoring requirements for aluminum using the Integrated Compliance Information System NPDES program (ICIS-NPDES) database, examining data from the past ten years. EPA identified two existing facilities in Oregon with a NPDES permit limit for aluminum (n = 2; these permit limits are based on translating Oregon's toxics narrative criterion given that no numeric aluminum criteria for aquatic life are currently in effect for Clean Water Act purposes in Oregon). Analysis of the available data for the two facilities indicated that no exceedances of projected effluent limits are expected based on EPA's aluminum aquatic life criteria (USEPA 2018). These facilities will not have reasonable potential to cause or contribute to an exceedance above the aluminum aquatic life criteria when promulgated by EPA, and therefore, will not require water-quality based effluent limits in order to meet the promulgated criteria.

In order to conduct a hypothetical discharger assessment of EPA's aluminum aquatic life criteria as an analytical exercise for purposes of this effects assessment, EPA derived hypothetical NPDES permits assuming these two facilities were found to have reasonable potential to cause, or contribute to an exceedance above the aluminum aquatic life criteria (USEPA 2018; i.e., would require a water-quality based effluent limit, derived from and complying with the aluminum aquatic life criteria, in a NPDES permit in order to meet the promulgated criteria). EPA chose these two facilities for this hypothetical NPDES permit demonstration because facility-specific data were available to conduct this assessment. The calculation of these hypothetical NPDES permit limits was conducted to highlight, as an example, how future NPDES permit limits for facilities that are found to have reasonable potential to cause or contribute to an exceedance of EPA's aluminum aquatic life criteria could be implemented in NPDES permits.

EPA relied on receiving stream flows and representative water chemistry data (pH, DOC, and hardness) to conduct this hypothetical assessment. The protectiveness of these two hypothetical permits were examined by considering time-variable factores in a Monte-Carlo analysis to simulate receiving stream Al concentrations relative to the chronic low effect threshold values of listed species that were identified to be sensitive to chronic Al exposures (based on screening level chronic effects assessment). Simulated receiving stream Al concentrations relative to chronic low effect thresholds were used to create distributions of Hazard Quotients (HQ = Receiving stream / Al concentration/chronic low effect threshold). Hazard Quotient distributions were used to determine the probability of each permitted discharger to cause receiving stream Al to reach concentrations that may affect sensitive listed species though chronic exposures.

Northwest Aluminum Company (NAC)

Permit Considerations: NAC

This assessment shows a hypothetical calculation of a permit limit for the aluminum discharge of Northwest Aluminum Specialties - Northwest Aluminum Company (NWAS-NAC, SAPA Extrusions), on the Columbia River in Oregon. Using pH, hardness, and DOC data from the Columbia River monitoring station at Warrendale, acute and chronic values from EPA's 2018 aluminum criteria were calculated for 50 sampling events[1]. The 10th and 50th percentiles of the distribution of criteria values were considered as possible bases for effluent limits. EPA considered the 50th percentile of criteria to represent a worst-case implementation scenario and the 10th percentile to represent a scenario that is meant to capture most exposure conditions where Al may be most bioavailable/toxic.

Effluent dilution at the edge of the 30-foot acute mixing zone (also called a zone of initial dilution or ZID) and 300-foot chronic mixing zone were taken from the Oregon Department of Environmental Quality (DEQ) Permit Evaluation document, which presented the range of dilution factors measured by fluorescene dye studies at the site. Because dilution at the edge of the acute mixing zone (ZID, 30 feet) was significantly less than that at the edge of the chronic mixing zone (300 feet), permit limits based on the acute criterion were found to be substantially more limiting, such that they are expected to be used for setting the permit limits when following EPA or Oregon DEQ procedures for this discharger. Assuming the concentrations of toxic (bioavailable) forms of aluminum are negligible in upstream waters (thereby maximizing potential Al inputs from the simulated discharger), four possible effluent limits were calculated, by combining the following factors: (a) 10th or 50th percentile criteria values and (b) the lowest or average dilution factors.

Approach for Calculating Hypothetical Permit Limits

The following approach was used to explore the derivation of a hypothetical permit limit for aluminum discharged to the Columbia River by Northwest Aluminum Specialties - Northwest Aluminum Company (NWAS-NAC) at River Mile 189.

- Fifty event-specific EPA (2018a and 2018b) aluminum criteria values were calculated using simultaneously measured pH, hardness, and DOC available at the USGS station on the Columbia River at Warrendale, 40-50 miles downstream during the period 1994-2000[2]. The 10th and 50th percentile values of the distribution of criteria values were applied at the edge of their respective mixing zones.
- Mixing zone dilution factors presented in the Oregon DEQ (undated) document "NPDES Wastewater Discharge Permit Evaluation" were coupled with either the 10th or 50th percentile acute and chronic criteria values to obtain Waste Load Allocation (WLA) target effluent concentrations. For these calculations, it was assumed that the upstream

[1] The USGS NWIS at Warrendale, OR, is nearly 45 river miles downstream from the NAC discharger. Columbia River water chemistry at Warrendale was used to represent the Columbia River at the NAC discharger because: (1) only one other sample from the Columbia River was available in the RL-dataset (sample ID 35335-40052; CMC = 2,900 µg/L; CCC = 1,300) that was spatially closer to the NAC discharge and (2) the USGS NWIS data also reported flow which was used to consider relationships between flow and criterion magnitudes.

[2] The number of samples per year ranged from zero in 1995 to 15 in 1997. Although all months of the year are represented in the dataset, May and June samples were somewhat more common than other months.

concentration of toxic or bioavailable forms of aluminum was zero to maximize the influence of the simulated discharge on changing in-stream Al concentrations.

- Assuming a typical degree of effluent variability (coefficient of variation [CV] = 0.6, from EPA 1991), the Long-Term Average (LTA) concentration was calculated such that 99% of the allowable distribution of effluent concentrations would be below the acute- or chronic-based WLA concentrations, using the EPA (1991) TSD approach. Then the associated Maximum Daily Limit (MDL) and Average Monthly Limit (AML) were calculated, assuming that 99% of effluent concentrations would comply with the MDL and 95% with the AML. After comparing acute- and chronic-based effluent limitations, the more stringent would be applied, reflecting the approach of EPA (1991) and Oregon DEQ (undated).

Calculation of Criteria Values

Using the EPA (2018b) aluminum criteria calculator, acute and chronic criteria magnitudes were calculated for the 50 events for which pH, hardness, and DOC were measured in the Columbia River. **Figure F-1** shows the range of values and their relationship with streamflow.

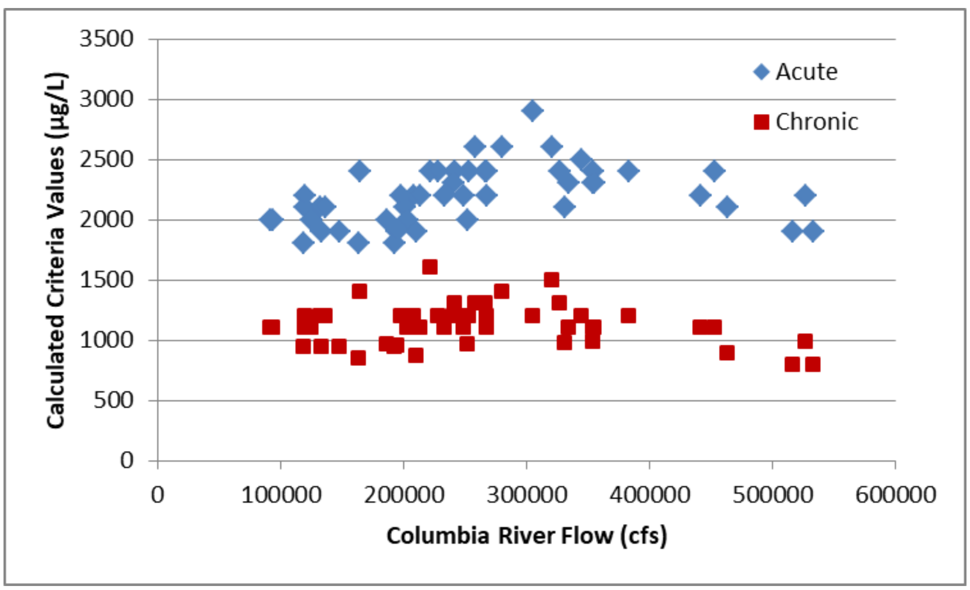

Figure F-1. Aluminum acute and chronic criteria values calculated at pH, hardness, and DOC occurring at specific Columbia River flows for 50 sample dates, 1994-2000.

NAC Aluminum Discharge

Because the flow of the NAC effluent is relatively low compared to flow of the Columbia River, the only information relevant to the hypothetical permit limit was the mixing zone dye study results. Taken from page 5 of the DEQ (undated) evaluation document, these results are shown in **Table F-1**. This analysis interpreted them as downstream dilution ratios. For illustration of hypothetical permit limit alternatives, the lowest and the average dilution factors were used.

Table F-1. NAC dye study dilution factors, measured during 84,700 cfs Columbia River flow conditions (Note: The dye study conditions completed during a period of relatively low flow to mimic worst-case dilution scenarios, 7Q10 = 74,000 cfs).

Mixing Zone Type	Observed Dilution Factors		
	Lowest	Highest	Average
Acute mixing zone (zone of initial dilution)	20:1	1,667:1	141:1
Chronic mixing zone	185:1	11,136:1	2,040:1

Hypothetical Permit Limits

The acute criterion was typically two times greater than the chronic criterion (**Figure F-1**). However, because the dilution factors at the edge of the 30-foot acute mixing zone were 9 - 14 times lower than those for the 300-foot chronic mixing zone, application of the acute criterion produced a lower long-term average (LTA) than the LTA based on the chronic criterion magnitude and chronic mixing zone. Consequently, the permit limits based on the chronic criterion were not further considered and the following hypothetical permit limits and analyses are based on the acute criterion. **Table F-2** shows the four sets of potential permit limits, based on combinations of the following options: (a) lowest or average dilution factors, and (b) 10th or 50th percentile acute criterion values.

Table F-2. Acute mixing zone dilution factors, acute criteria values corresponding to the 10th and 50th percentiles, and corresponding WLA, LTA, MDL, and AML concentrations, assuming CV=0.6, 4 samples/month, and probability targets of 0.99 for attaining the WLA, 0.99 for complying with the MDL, and 0.95 for complying with the AML in the EPA (1991) Technical Support Document procedure.

Acute mixing zone dilution factor		Criterion Percentile	Acute criterion (µg/L)	WLA (µg/L)	LTA[a] (µg/L)	MDL[b] (µg/L)	AML[c] (µg/L)
	A		*B*	*C = A*B*	*D = 0.321021*C*	*E = 3.115058*D*	*F = 1.552358*D*
Lowest	20	10%	1,900	38,000	12,199	38,000	18,937
		50%	2,200	44,000	14,125	44,000	21,927
Average	141	10%	1,900	267,900	86,002	267,900	133,505
		50%	2,200	310,200	99,581	310,200	154,585

[a] LTA values have a consistent relationship with WLA, given the 1- and 4-day averaging periods, assumed CV, and the 0.99 probability target (z=NORMSINV(0.99)):

$$LTA_{acute} = WLA_{acute} * exp(0.5\sigma^2 - z\sigma) = 0.321021\ WLA_{acute} \text{ where } \sigma^2 = ln\ (1 + CV^2)$$

[b] MDL values have a consistent relationship with the LTA (and hence WLA), given the assumed 4 samples/month, the assumed CV, the 0.99 probability target for complying with the MDL:

$$MDL_{acute} = LTA_{acute} * exp(z\sigma - 0.5\sigma^2) = 3.115058\ LTA_{acute} = WLA_{acute} \text{ with } z = NORMSINV(0.99)$$

[c] AML values have a consistent relationship with the LTA (and hence WLA), given the assumed 4 samples/month, the assumed CV, the 0.95 probability target for complying with the AML:

$$AML_{acute} = LTA_{acute} * exp(z\sigma_n - 0.5\sigma_n^2) = 1.552358\ LTA_{acute} \text{ where } \sigma_n^2 = ln\ (1 + CV^2/n), \text{ with } n = 4 \text{ samples/month and } z = NORMSINV(0.95)$$

In **Table F-2**, note the large difference in permit limits (as Maximum Daily Limits [MDL] and Average Monthly Limits [AML]) that resulted from the choice of the lowest versus average mixing zone factor, compared to the relatively minimal impact that resulted from the application of the 10^{th} versus 50^{th} percentile criterion magnitude. For example, application of the lowest mixing zone dilation factor reduced permit limits by 85.8% relative to limits based on the average mixing zone dilution factor (regardless on criterion percentile used), while permit limits based on the 10^{th} percentile criterion were 13.6% lower than permits based on the 50^{th} percentile criterion magnitude (regardless of dilution factor). Linking together multiple protection need-based assumptions to produce the least environmentally-conservative hypothetical NAC permit limits resulted from application of the lowest (presumptive worst-case) mixing zone dilution factor and the 50^{th} percentile criterion magnitude. Hypothetical limits for such a decision resulted in MDL = 44,000 µg/L and AML = 21,900 µg/L.

Approach for Assessing the Protectiveness of the Hypothetical Permit Limits

The protectiveness of the hypothetical permit limits was examined by considering time-variable factors in a Monte-Carlo analysis involving five sets of 10,000 trials for each scenario examined. The focus of this work was to evaluate the simulated aluminum concentrations at the edge of the chronic mixing zone relative to listed species chronic low-effect EC_5 threshold concentrations. The edge of the chronic mixing zone was considered the most appropriate spatial point to evaluate simulate Al concentrations relative to species EC_5 values because (1) EPA (1991) describes application of acute criteria in acute mixing zones as concerning brief exposure of organisms drifting through the mixing zone, (2) the edge of the chronic mixing zone represents the spatial point in which the Al criteria in consultation become applicable, and (3) the direct biological effects assessment indicated species are more sensitive to long-term chronic Al exposures than brief acute exposures.

This assessment considered several time-variable parameters: (1) the effluent aluminum concentration, (2) sensitive species EC_5 values, calculated from time-variable pH, hardness, and DOC of the Columbia River, and (3) the dilution at the edge of the mixing zone.

(1) Effluent Aluminum Concentration. Concentrations were assumed to be lognormally distributed, having LTA values listed in **Table F-2**, and CV = 0.6, the degree of variability used in derivation of the **Table F-2** permit limits[3].

(2) Listed Species EC_5 Values. **Table F-3** shows the estimated EC_5 values for listed species that were sensitive to long-term chronic Al exposures.

[3] The geometric mean, GM, of a lognormal distribution is given by $GM = LTA/\text{sqrt}(1 + CV^2)$. Its standard deviation of natural logs, σ, is given by $\sigma = \text{sqrt}(\ln(1 + CV^2))$. These relationships are incorporated into the EPA (1991) permit derivation approach.

Table F-3. Listed species estimated chronic EC_5 values used in the assessment.

Species	EC_5[a]
Vernal pool fairy shrimp	433.4
Bull trout	376.3
Lahontan cutthroat trout	310.4
Chum salmon	
Coho salmon	
Sockeye salmon	
Chinook salmon	
Steelhead trout	
Pacific eulachon	

[a] All values expressed as total aluminum, normalized to pH 7, DOC of 1 mg/L and 100 mg/L hardness as $CaCO_3$; normalized using MLR equations identified in USEPA (2018).

Figure F-2 shows the vernal pool fairy shrimp EC_5 value renormalized to the paired pH, hardness, and DOC values from the 50 observations taken from the Columbia River at Warrendale, plotted as cumulative probability. Similarly, **Figure F-3** shows the EC_5 values for bull trout and for the other listed salmonids renormalized to the paired pH, hardness, and DOC values from the 50 observations taken from the Columbia River at Warrendale, plotted as cumulative probability. The EC_5 distributions are consistent with lognormal distributions having the following properties:

- **Fairy shrimp**: geometric mean = 777.3 µg/L; standard deviation of natural logs = 0.116
- **Bull trout**: geometric mean = 995.8 µg/L; standard deviation of natural logs = 0.155
- **Other salmonids**: geometric mean = 821.6 µg/L; standard deviation of natural logs = 0.155.

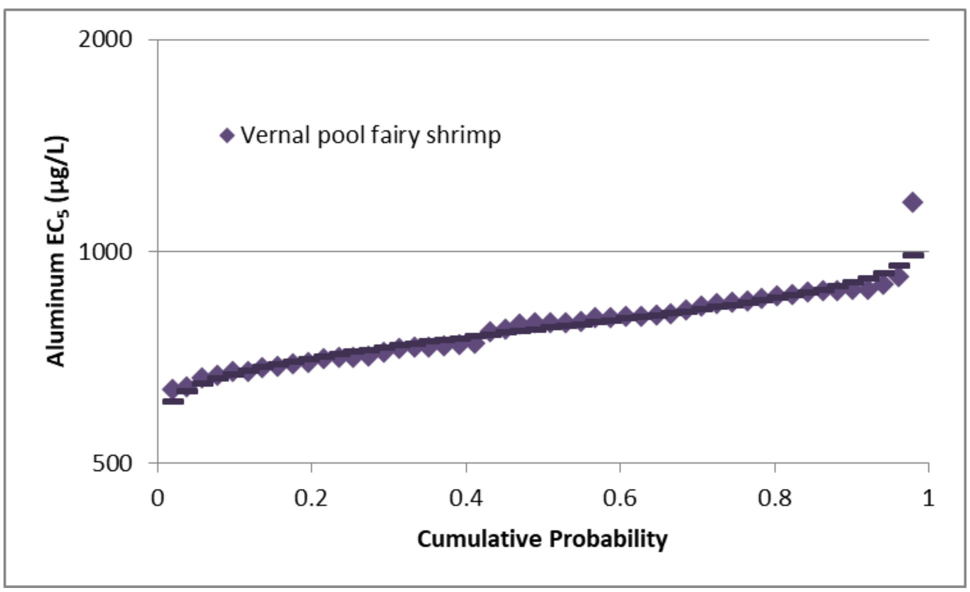

Figure F-2. Cumulative distribution of vernal pool fairy shrimp EC_5 values calculated at the pH, hardness, and DOC occurring during the 50 sample dates, 1994-2000. Darker line is the corresponding lognormal simulated distribution.

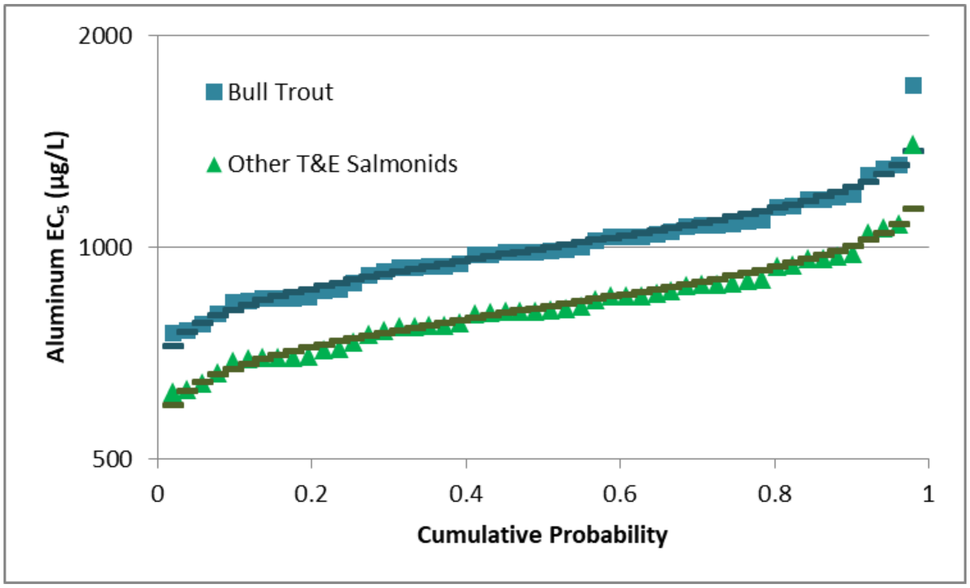

Figure F-3. Cumulative distributions of values of the bull trout EC_5 and other listed salmonids EC_5, calculated at the pH, hardness, and DOC occurring during the 50 sample dates, 1994-2000. Darker lines are the corresponding lognormal simulated distributions.

(3) Dilution at Edge of Mixing Zone. Although the dilution at the edge of the chronic mixing zone was a key factor, estimating the time variability of the dilution at the end of the mixing zone compared to the constant dilution identified from the single episode dye study in the permit fact sheet was problematic[4]. The dye study (see **Table F-1**) was performed under a relatively low flow condition (84,700 cfs) similar to the 7Q10 (74,000 cfs). Compared to the low flow conditions under which the dye study was done, it is logical to assume consideration of time-variable dilution would have provided additional dilution, thereby lowering the Al concentrations that were simulated to occur at the edge of the mixing zone in this analysis. Therefore, the assumption of time-invariant mixing-zone dilution provided an environmentally conservative outcome. The results shown below are based on applying the environmentally-conservative low and average dilution factors shown in **Table F-1** as constant conditions.

Results: Simulated Aluminum concentrations Vs. Listed Species EC_5 Values

Figures G-4, **G-5**, and **G-6** show cumulative probability curves for Al concentrations relative to species EC_5 values predicted at the edge of the chronic mixing zone. In each figure, the x-axis is the cumulative fraction of predicted values and the y-axis is chronic Hazard Quotients (HQ), expressed as the event-specific aluminum concentration at the edge of the chronic mixing zone divided by the event-specific listed species EC_5 value. **Figures G-4**, **G-5**, and **G-6** each show four curves (e.g., Hazard Quotient distributions) to correspond to each of the four possible hypothetical permit limits (see **Table F-2**). These four curves reflect combinations of the following factors: (a) criterion percentile, 10^{th} or 50^{th} (see **Table F-2**), and (b) lowest versus average observed dye study dilution (see **Table F-1**), where the permit limit is based on the acute mixing-zone dilution and the chronic HQ is based on the chronic mixing-zone dilution to

[4] Complete mixing with the vast flow of the Columbia River yielded no risk and was not considered here.

simulate effects at the point where the acute and chronic criteria are applicable. **Figure F-4** displays the vernal pool fairy shrimp Hazard Quotient distribution, **Figure F-5** displays the bull trout Hazard Quotient distribution, and **Figure F-6** displays the Hazard Quotient distribution applicable to other listed salmonids in Oregon.

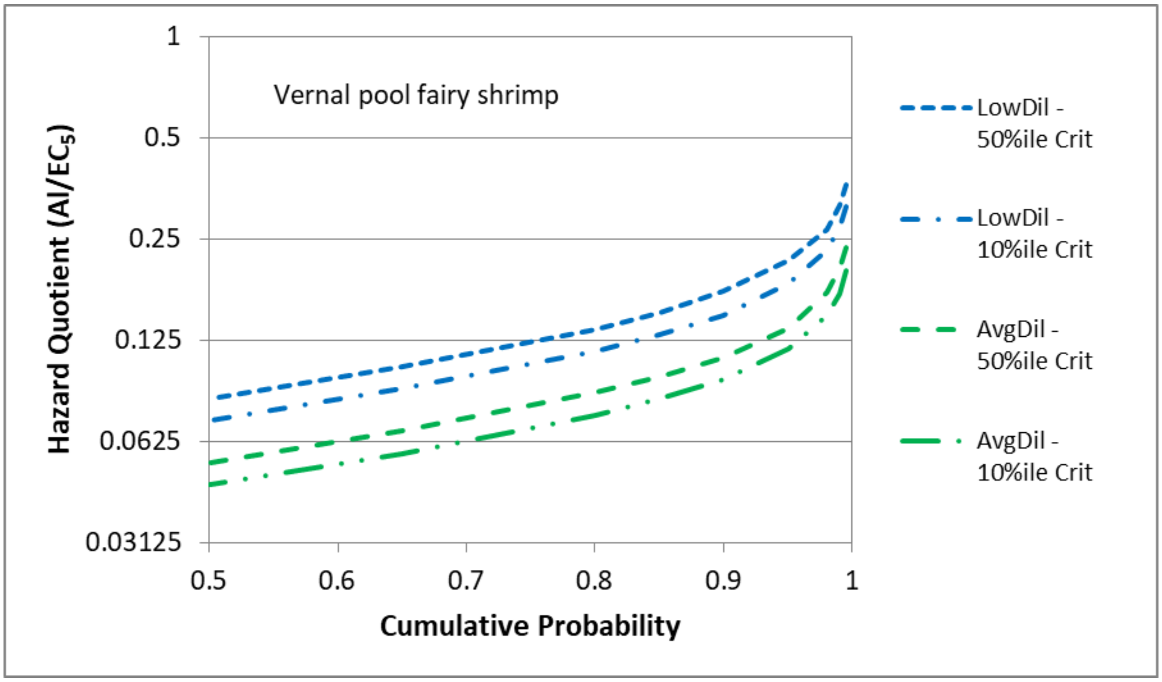

Figure F-4. Vernal pool fairy shrimp cumulative distribution (upper percentiles) of HQ predicted at the edge of the chronic mixing zone for hypothetical permit limits.

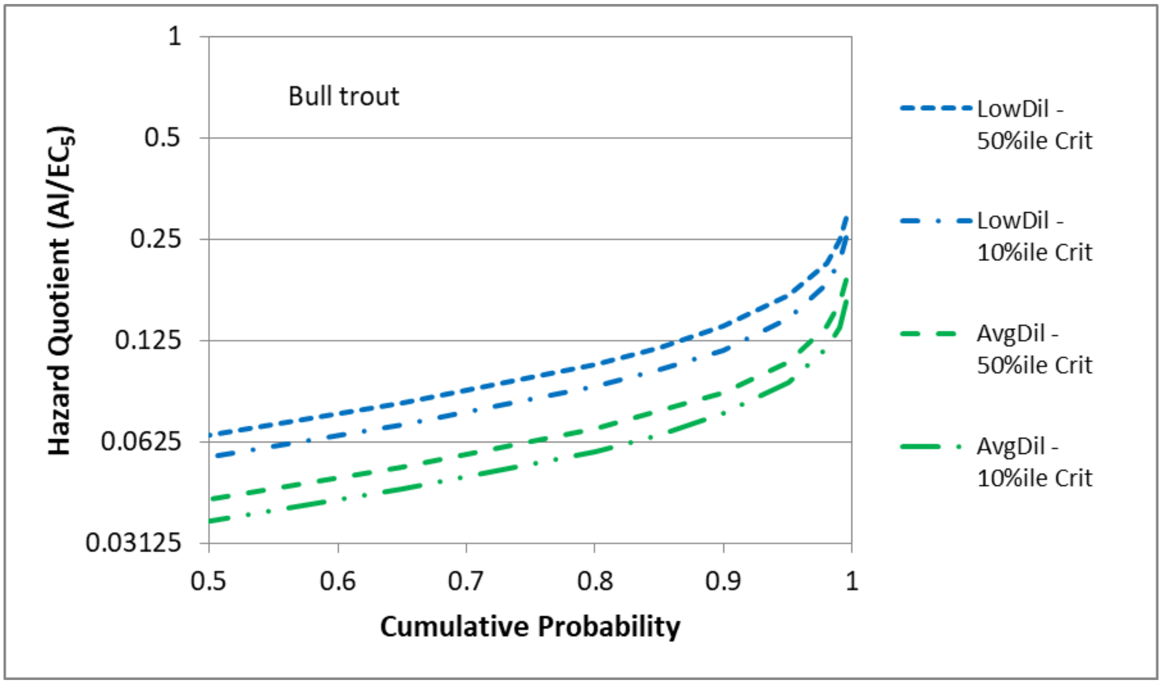

Figure F-5. Bull trout cumulative distribution (upper percentiles) of HQ predicted at the edge of the chronic mixing zone for hypothetical permit limits.

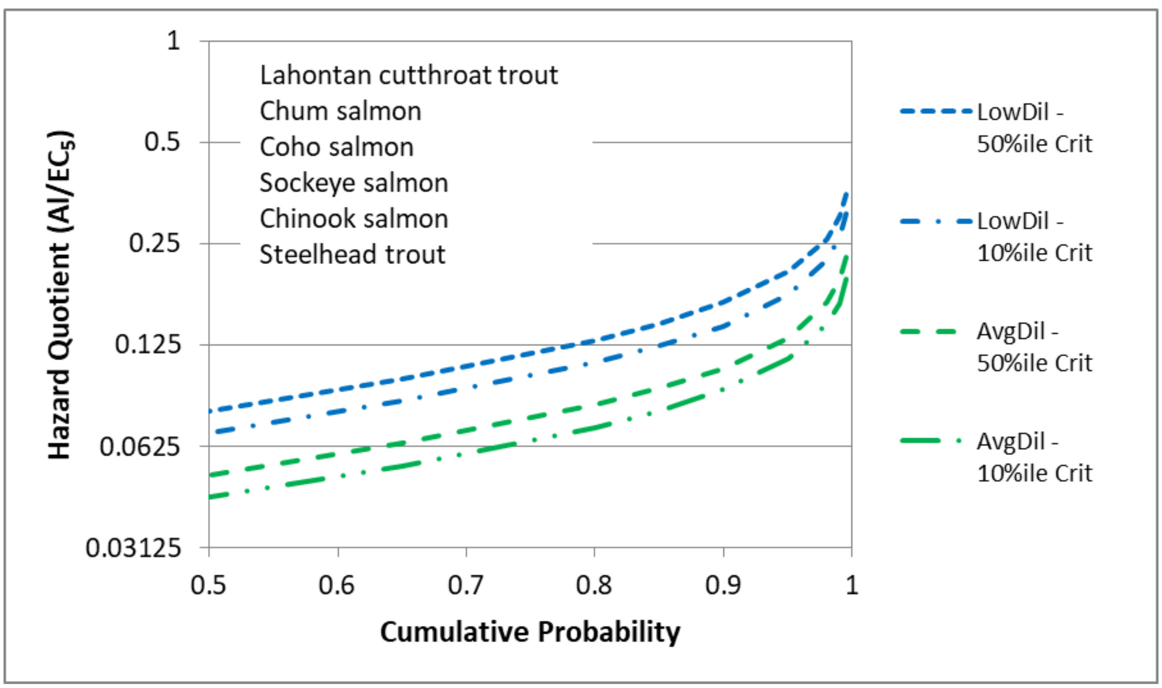

Figure F-6. Other listed salmonids cumulative distribution (upper percentiles) of HQ predicted at the edge of the chronic mixing zone for hypothetical permit limits.

The patterns are similar in all three figures. Because permit limits based on the 50th percentile criteria values are slightly higher than those based on the 10th percentile criteria values, they yield slightly higher HQ distribution. On the log scale (y axis) of the figures, the 10th and 50th percentile curves maintain a fixed distance from each other, reflecting the ratio between 10th percentile criterion (1,900 µg/L) and 50th percentile criterion (2,200 µg/L) shown in **Table F-2**. The HQ distributions predicted for low mixing-zone dilution were higher than HQ distributions based on average mixing-zone dilution. For all species, the 99th centile of the HQ distribution based on the worst-case scenario (i.e., 50th centile criterion magnitude, low dilution) never exceeded 0.5. This means that for 99 percent of the time, the hypothetical permitted discharge concentration for this facility would result in maximum aluminum ambient concentrations at the edge of the mixing zone that are less than half of the estimated EC_5 low effect level for the listed species considered, and thus are protective of the considered listed species.

No matter which option is used for the hypothetical permit limit, concentrations at the edge of the chronic mixing zone, under all water chemistry conditions, were predicted to be below the estimated EC_5 values. If the NAC aluminum discharge permit limits were to be updated to be based on EPA's 2018 Al criteria (US EPA 2018), Al concentrations at the edge of the chronic mixing zone, where the proposed criteria would be applied, would not affect sensitive listed species.

Fujimi Cooperation

Permit Considerations: Fujimi Corp.

This assessment shows a hypothetical calculation of a permit limit for the aluminum discharge of Fujimi Corporation. The Fujimi Corp. discharges Al into an unnamed drainage ditch that flows into Coffee Lake Creek, which is in turn a tributary to the Willamette River in Oregon. Paired samples of pH, hardness, and DOC data from nearby waterbodies were used to calculate acute and chronic Al criteria magnitudes for each of the 119 sampling events. The 10th and 50th percentiles of the distribution of criteria values were considered as possible bases for hypothetical effluent limits applicable to the Fujimi Corp. Effluent dilution was taken from the Oregon Department of Environmental Quality (DEQ) Permit Evaluation and Fact Sheet (DEQ 2012), which presented model-predicted effluent dilution at the end of the acute (1 m) and chronic (10 m) mixing zones under wet and dry season conditions. Hypothetical effluent limits were calculated based the 10th and 50th percentile acute and chronic criteria concentrations for both the wet and dry season dilutions, to be applied on a seasonal basis as intended by DEQ (2012). During the wet season, the permit values calculated from the acute criterion were found to be more limiting. During the dry season, the permit values based on the chronic criterion were found to be more limiting.

Approach for Calculating Hypothetical Permit Limits

Fujimi Corporation is involved with aluminum through manufacture of aluminum oxide abrasives and coatings. At the time of permit issuance, the discharge was a new source; the company was ending its discharge to the sanitary sewer and beginning its discharge directly to a drainage ditch that flows 1.6 miles to Coffee Lake Creek, which in turn flows 1.8 miles to the Willamette River. Fujimi Corp. discharges a relatively small volume, averaging 0.070-0.085

mgd, with maximum 0.125 mgd (DEQ 2012, page 4). The following approach was used to derive hypothetical permit limits for aluminum based on EPA's 2018 aluminum criteria.

- No water quality data (pH, hardness, and DOC) were available for the drainage ditch or Coffee Lake Creek; therefore, water quality data collected by Oregon Department of Environmental Quality at various locations were used to calculate acute and chronic criteria magnitudes. Water quality at these sites is expected to be reasonably representative of conditions at the discharge site:
    - Willamette River at Canby Ferry (112 observations; about 5.7 miles upstream of the confluence of Willamette River and Coffee Lake Creek)
    - Willamette River 0.5 miles downstream of I-5 (Wilsonville; 1 observation; about 9.2 miles upstream of the confluence of Willamette River and Coffee Lake Creek)
    - Willamette River at Hebb Park Boat Ramp (3 observations; about 5.2 miles upstream of the confluence of Willamette River and Coffee Lake Creek)
    - Molalla River at River Mile 0.2 (3 observations; about 7.2 miles upstream of the confluence of Willamette River and Coffee Lake Creek)

- Event-specific aluminum acute and chronic criteria magnitudes were calculated using the simultaneously measured pH, hardness, and DOC at the above Oregon DEQ sampling stations.
- Although the Fujimi facility produces aluminum oxide particles, which are insoluble, the effluent total recoverable aluminum was assumed to be in the form of aluminum hydroxides, which are the mildly soluble, floc-forming chemical species in the toxicity tests underlying the aluminum criterion. It was not clear whether the Fujimi Corp. aluminum oxide production processes actually produce the aluminum hydroxides addressed by the criterion (and that would be targeted for measurement by a milder pH 4 extraction procedure). But this assessment maintained the implicit worst-case assumption that all effluent total recoverable aluminum was in the toxic form intended to be covered by the criterion.
- Receiving water dilution was obtained from the DEQ (2012) Fact Sheet.
    - During the dry season, there is no dilution, and the criterion is to be met at the end of the pipe. Under this condition there was no assumption required about an upstream aluminum concentration.
    - During the wet season, the Fact Sheet (page 11) assigns a 1-m acute mixing zone with a dilution factor of 4, and a 10-m chronic mixing zone with a dilution factor of 14. Under this condition this analysis assumes zero upstream concentration of toxic forms of aluminum. Assuming the concentrations of toxic (bioavailable) forms of aluminum are negligible in upstream waters maximizes potential Al inputs from the simulated discharger.

- The dry and wet season dilutions were coupled with the 10^{th} and 50^{th} percentile acute and chronic criteria magnitudes to obtain Waste Load Allocation (WLA) target effluent concentrations for the eight scenarios:
    1. 10^{th} centile CCC X Dry Season Dilution
    2. 50^{th} centile CCC X Dry Season Dilution
    3. 10^{th} centile CCC X Wet Season Dilution
    4. 50^{th} centile CCC X Wet Season Dilution
    5. 10^{th} centile CMC X Dry Season Dilution
    6. 50^{th} centile CMC X Dry Season Dilution
    7. 10^{th} centile CMC X Wet Season Dilution
    8. 50^{th} centile CMC X Wet Season Dilution

- Assuming a typical degree of effluent variability (CV = 0.6, from EPA 1991), the prospective Long-Term Average (LTA) concentration was calculated such that 99% of the allowable distribution of effluent concentrations would be below the acute- or chronic-based WLA concentrations, using the EPA (1991) TSD approach. Then the associated Maximum Daily Limit (MDL) and Average Monthly Limit (AML) were calculated, assuming 99% of effluent concentrations would comply with the MDL and 95% with the AML. After comparing prospective acute- and chronic-based effluent limits, the more stringent would be incorporated into the permit, reflecting the approach of EPA (1991) and Oregon DEQ (2012).

Calculation of Criteria Values and Dilution Factors

Acute and chronic criteria magnitudes were calculated for the 119 sampling events for which pH, hardness, and DOC were measured. **Figure F-7** shows the range of values. **Table F-4** shows the dilution factors for the drainage ditch, taken from page 11 of DEQ (2012).

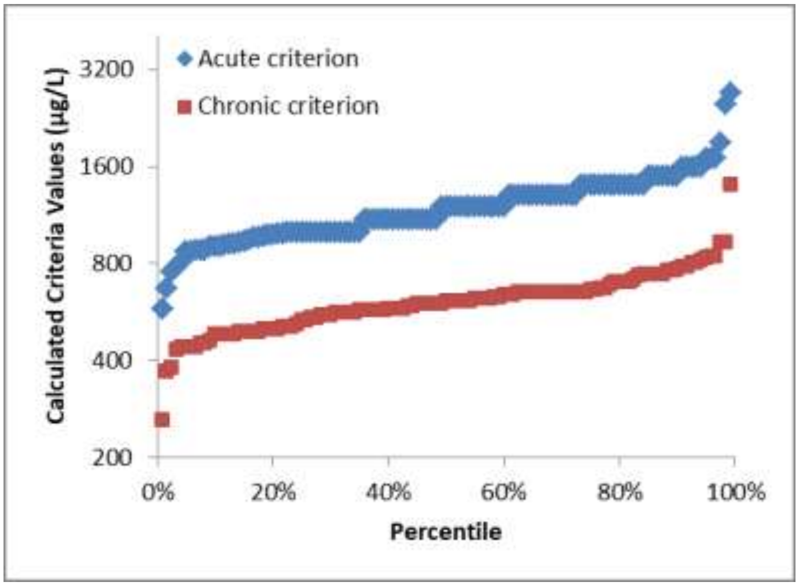

Figure F-7. Aluminum acute and chronic criterion values calculated at pH, hardness, and DOC of the available 119 sampling events in Willamette River near the confluence of Coffee Lake Creek, 2000-2016.

Table F-4. Fujimi effluent dilution factors from DEQ (2012).

Mixing Zone Type	Dilution Factors	
	Dry Season	Wet Season
Acute mixing zone (zone of initial dilution)	1	4
Chronic mixing zone	1	14

Fujimi Corp. Aluminum Discharge

Table F-5 shows potential permit limits based on the 2018 aluminum criteria, for either 10th or 50th percentile acute and chronic criteria magnitudes, coupled with dry and wet season dilution factors. Briefly, for dry-season conditions, the acute and chronic dilution factors were the same: undiluted effluent[5] in the receiving water. Therefore, governing limits for the dry season were based on the chronic criterion. For wet-season conditions, the 3.5-fold difference in the acute and chronic dilution factors (i.e., dry season dilution factor of 4 versus the wet season dilution factor of 14) outweighs the roughly 2-fold difference in the acute and chronic criteria concentrations, such that the permit limits are based on the acute criterion. Overall, choosing the 50th percentile criterion values increased the permit limit around 30 percent compared to permit limits based on the 10th percentile criteria magnitudes.

[5] Although the effluent is undiluted during the dry season, lack of information on its pH, hardness, and DOC prevents calculation of criterion concentrations based on effluent water quality. Therefore, the water chemistry collected from various sites in the Willamette River served as a surrogate measure of the undiluted effluent chemistry, even though the chemistry between the Willamette River and the Fujimi Corp. effluent are likely different from one another.

Table F-5. Acute and chronic mixing zone dilution factors, acute and chronic criteria values corresponding to the 10th and 50th percentiles, and corresponding WLA, LTA, MDL, and AML concentrations, assuming CV = 0.6, 4 samples/month, and probability targets of 0.99 for attaining the WLA, 0.99 for complying with the MDL, and 0.95 for complying with the AML in the TSD procedure. In accord with EPA (1991) and Oregon DEQ procedures, values surrounded by thick borders were the more limiting scenarios and would be used to set the permit limits during their respective seasons. Consequently, the values surrounded by thick borders remained the focus of the analysis, with the remaining values presented for comparative purposes.

Mixing Zone Dilution Factor				Based on Acute Criterion					Based on Chronic Criterion				
	Acute	Chronic	Criterion Percentile	Acute Criterion (µg/L)	WLA (µg/L)	LTA[a] (µg/L)	MDL[b] (µg/L)	AML[c] (µg/L)	Chronic Criterion (µg/L)	WLA (µg/L)	LTA[a] (µg/L)	MDL[b] (µg/L)	AML[c] (µg/L)
Season	*A*	*B*		*C*	*D = A*C*	*E = 0.321021*D*	*F = 3.115058*E*	*G = 1.552358*E*	*H*	*J = B*H*	*K = 0.52738*J*	*L = 3.115058*K*	*M = 1.552358*K*
Dry	1	1	10%	900	900	289	900	449	**480**	**480**	**253**	**789**	**393**
			50%	1,200	1,200	385	1,200	598	**610**	**610**	**322**	**1,002**	**499**
Wet	4	14	10%	**900**	**3,600**	**1,156**	**3,600**	**1,794**	480	6,720	3,544	11,040	5,502
			50%	**1,200**	**4,800**	**1,541**	**4,800**	**2,392**	610	8,540	4,504	14,030	6,992

[a] LTA values have a consistent relationship with their WLA, given the assumed CV, the 0.99 probability target (z = NORMSINV(0.99)), and the 1- and 4-day averaging periods:

$$LTA_{acute} = WLA_{acute} \times \exp(0.5\sigma^2 - z\sigma) = 0.321021\ WLA_{acute} \text{ where } \sigma^2 = \ln(1 + CV^2)$$

$$LTA_{chronic} = WLA_{chronic} \times \exp(0.5\sigma_n^2 - z\sigma_n) = 0.52738\ WLA_{chronic} \text{ where } \sigma_n^2 = \ln(1 + CV^2/n), \text{ with } n = 4 \text{ days averaging period.}$$

[b] MDL values (acute or chronic-based) have a consistent relationship with their LTA (and hence WLA), given the assumed 4 samples/month, the assumed CV, the 0.99 probability target for complying with the MDL:

$$MDL = LTA * \exp(z\sigma - 0.5\sigma^2) = 3.115058\ LTA \text{ where } z = NORMSINV(0.99)$$

[c] AML (acute or chronic-based) values have a consistent relationship with their LTA (and hence WLA), given the assumed 4 samples/month, the assumed CV, the 0.95 probability target for complying with the AML:

$$AML = LTA * \exp(z\sigma_n - 0.5\sigma_n^2) = 1.552358\ LTA \text{ where } \sigma_n^2 = \ln(1 + CV^2/n), \text{ with } n = 4 \text{ samples/month and } z = NORMSINV(0.95)$$

Approach for Assessing the Protectiveness of the Hypothetical Permit Limits

The protectiveness of the hypothetical permit limits was examined by considering time-variable factors in a Monte-Carlo analysis involving five sets of 10,000 trials for permit limits based on either the 10^{th} or 50^{th} percentile criteria concentrations. This work evaluated the aluminum concentrations calculated to occur at the edge of the chronic mixing zone relative to listed species chronic low effect EC_5 thresholds. The edge of the chronic mixing zone was considered the most appropriate spatial point to evaluate simulate Al concentrations relative to species EC_5 values because (1) EPA (1991) describes application of acute criteria in acute mixing zones as concerning brief exposure of organisms drifting through the mixing zone, (2) the edge of the chronic mixing zone represents the spatial point in which the Al criteria in consultation become applicable, and (3) the direct biological effects assessment indicated species are more sensitive to long-term chronic Al exposures than brief acute exposures.

This assessment considered three time-variable parameters: (1) the effluent aluminum concentration, (2) the dilution at the edge of the chronic mixing zone, and (3) sensitive species EC_5 values calculated from time-variable pH, hardness, and DOC representative of the receiving water.

(1) ***Effluent Aluminum Concentration.*** Concentrations are assumed to be lognormally distributed, having LTA values listed in **Table F-5** (thick-outlined), and CV = 0.6, the degree of variability used in derivation of the **Table F-5** permit limits[6].

(2) ***Dilution at the Edge of the Mixing Zone.*** Consistent with DEQ (2012), two of dilution factors were considered, corresponding to wet and dry seasons, with dilution shown in **Table F-4**. Because DEQ (2012) does not consider within-season (i.e., dry or wet) gradations in the level of dilution, no such gradations were considered here. DEQ (2012), page 19, describes the dry season as summer. Based on the monthly pattern of streamflow in this area of Oregon, shown in **Figure F-8** for the nearby Tualatin River, it was assumed that the dry-season dilution occurs in one-third of the year (June 15 – October 15), and wet-season dilution occurs for the remaining two-thirds of the year.

(3) ***Listed Species EC_5 Values.*** **Table F-6** shows the estimated EC_5 values for listed species that were sensitive to long-term chronic Al exposures.

[6] The geometric mean, GM, of a lognormal distribution is given by GM = LTA/sqrt(1 + CV^2). Its standard deviation of natural logs, σ, is given by σ = sqrt(ln(1 + CV^2)). These relationships are incorporated into the EPA (1991) permit derivation approach.

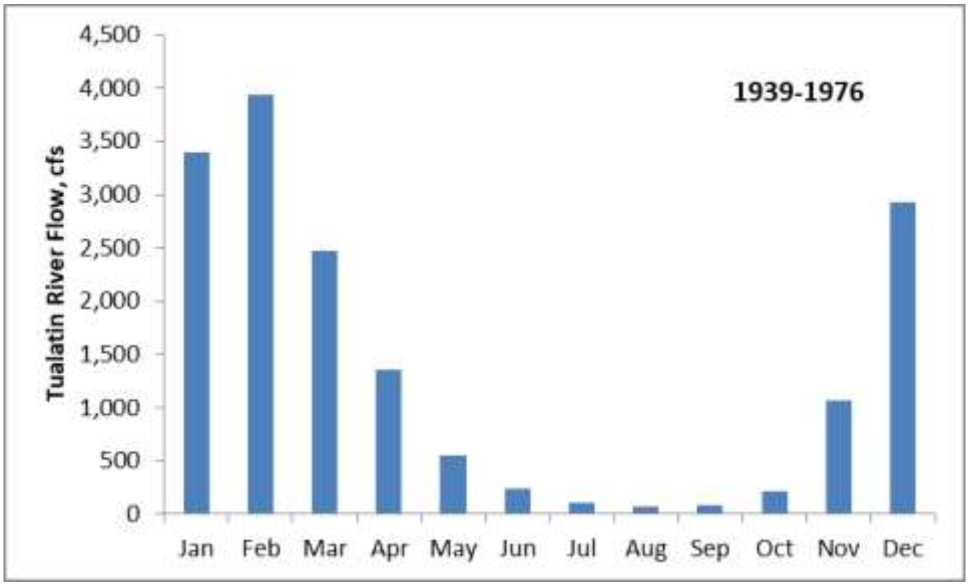

Figure F-8. Mean monthly flow pattern in the nearby Tualatin River (USGS Gage 14206500 at Farmington, Oregon), indicating portion of year with minimal flow.

Table F-6. Listed species estimated chronic EC_5 values used in the assessment. Values are for the standard condition pH=7, hardness=100 mg/L, and DOC=1 mg/L.

Species	Chronic EC_5[a]
Vernal pool fairy shrimp	433.4
Bull trout	376.3
Lahontan cutthroat trout	310.449
Chum salmon	
Coho salmon	
Sockeye salmon	
Chinook salmon	
Steelhead trout	
Pacific eulachon	

[a] All values expressed as total aluminum, normalized to pH 7, DOC of 1 mg/L and 100 mg/L hardness as $CaCO_3$; normalized using MLR equations identified in USEPA (2018).

Figure F-9 shows the vernal pool fairy shrimp EC_5 value renormalized to the paired pH, hardness, and DOC values from the 119 observations taken in the Willamette River near the confluence of Coffee Lake Creek, plotted as cumulative probability. Similarly, **Figure F-10** shows bull trout EC_5 values and EC_5 values for the other salmonids renormalized to the paired pH, hardness, and DOC values from the 119 observations taken from the Willamette River, plotted as cumulative probability. The EC_5 distributions are consistent with lognormal distributions having the following properties:

- **Fairy shrimp**: geometric mean = 414.4 µg/L; standard deviation of natural logs = 0.271
- **Bull trout**: geometric mean = 544.6 µg/L; standard deviation of natural logs = 0.215
- **Other salmonids**: geometric mean = 449.3µg/L; standard deviation of natural logs = 0.215.

The same EC_5 distributions are applied to both wet and dry seasons, consistent with the application of the same criteria values to wet and dry seasons.[7]

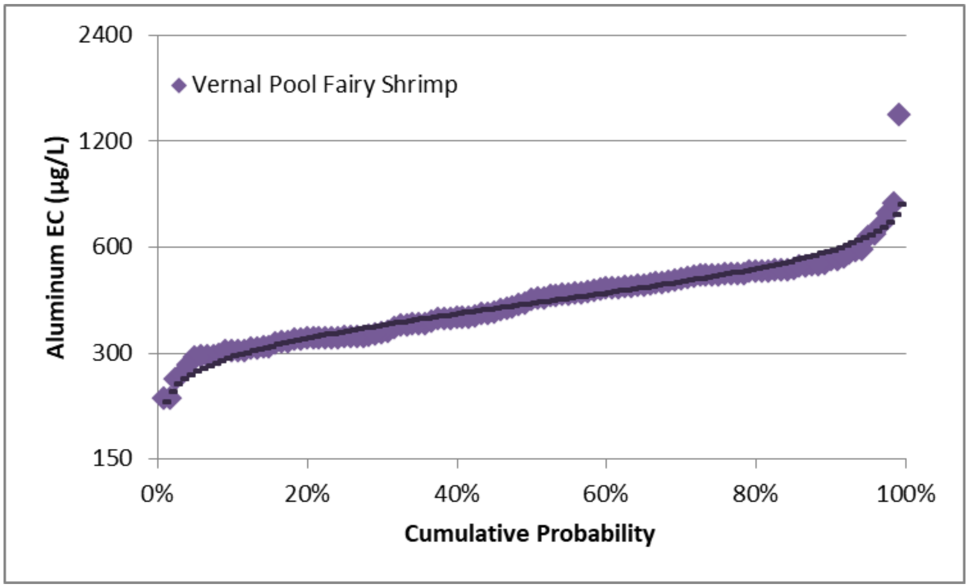

Figure F-9. Cumulative distribution of vernal pool fairy shrimp EC_5 values calculated at the pH, hardness, and DOC occurring during the 119 sample dates of waters in the general area, 2000-2016. Darker line is the corresponding simulated lognormal distribution.

[7] For the 119 water quality observations for which criterion and EC_5 values were calculated, the arithmetic mean chronic criterion was 601 µg/L among 71 wet-season observations and 631 µg/L among 48 dry-season observations. This difference is not statistically significant. Furthermore, the final results would be insensitive to whether the assessment had or had not discerned any slight differences in criteria and EC_5 values applicable to wet and dry seasons, because the slight increase in the allowed dry-season effluent concentrations would generally match the slight increase in the dry season EC_5 values.

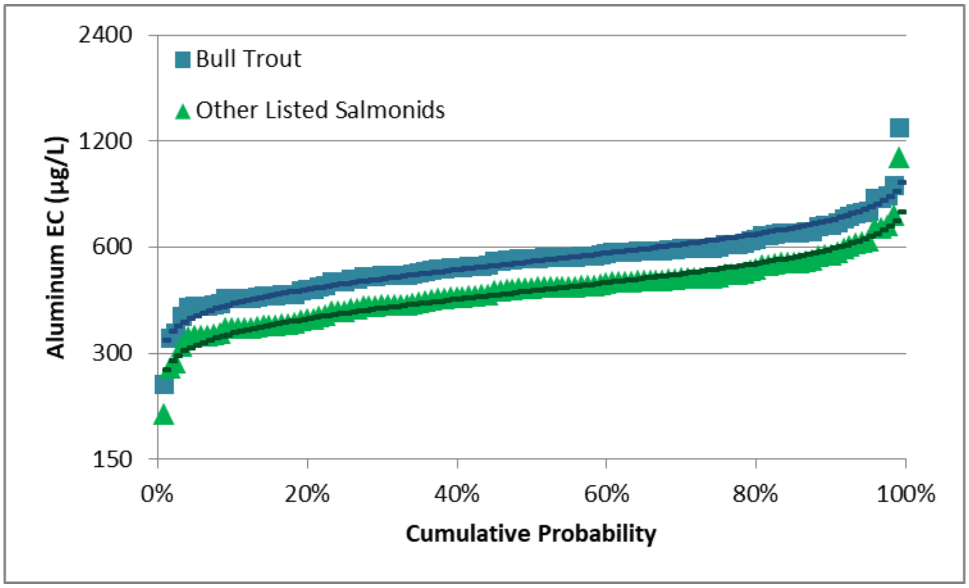

Figure F-10. Cumulative distributions of values of the bull trout EC_5 and other listed salmonids EC_5, calculated at the pH, hardness, and DOC occurring during the 119 sample dates of waters in the general area, 2000-2016. Darker lines are the corresponding lognormal simulated distributions.

Results: Simulated Aluminum concentrations Vs. Listed Species EC_5 Values

Figures G-11, **G-12**, and **G-13** show cumulative probability curves for toxicity to listed species predicted at the edge of the chronic mixing zone. In each figure the x-axis is cumulative fraction of predicted values, and the y-axis is chronic Hazard Quotient (HQ), expressed as the event-specific aluminum concentration at the edge of the chronic mixing zone divided by the event-specific listed species EC_5. Each graph shows two curves, one corresponding to the permit limit based on the 10^{th} percentile criterion, and one corresponding to the permit limit based on the 50^{th} percentile criterion. As previously discussed, the assessment assumed the following:

- One-third of time dry, applying the dry-season **Table F-5** thick-outlined limits and measuring HQ at the end of the pipe (no dilution);
- Two-thirds of time wet, applying the wet-season **Table F-5** thick-outlined limits and measuring HQ at edge of the chronic mixing zone (i.e., 14-fold dilution).

Assuming vernal pool fairy shrimp, bull trout, or other listed salmonids were to occur in the unnamed drainage ditch that the Fujimi Corp. dischargers into, then results of the discharge simulation indicates Al concentrations at the edge of the chronic mixing zone may exceed listed species chronic low effect threshold values (i.e., EC_5) under very limited circumstances, less than 10% of the time for all considered species.

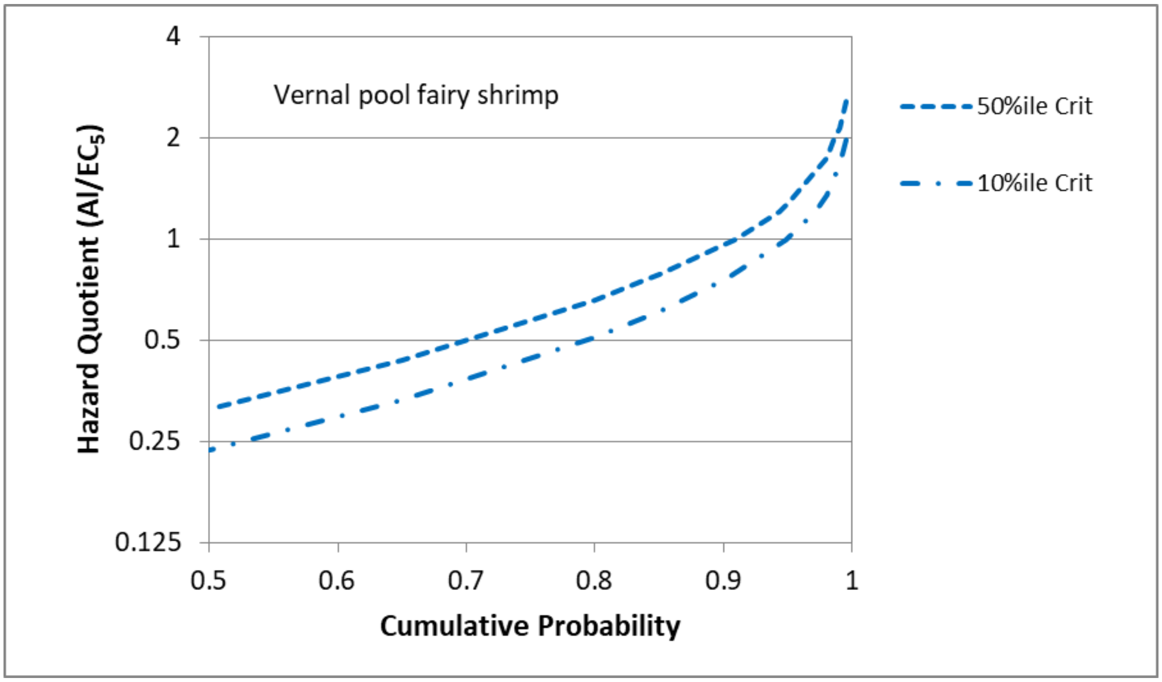

Figure F-11. Vernal pool fairy shrimp cumulative distribution (upper percentiles) of HQ predicted at point of application of the criterion (end of pipe during dry season, one-third of time; and edge of chronic mixing zone during wet season, two-thirds of time) for hypothetical permit limits based on either the 50th or 10th percentile criterion.

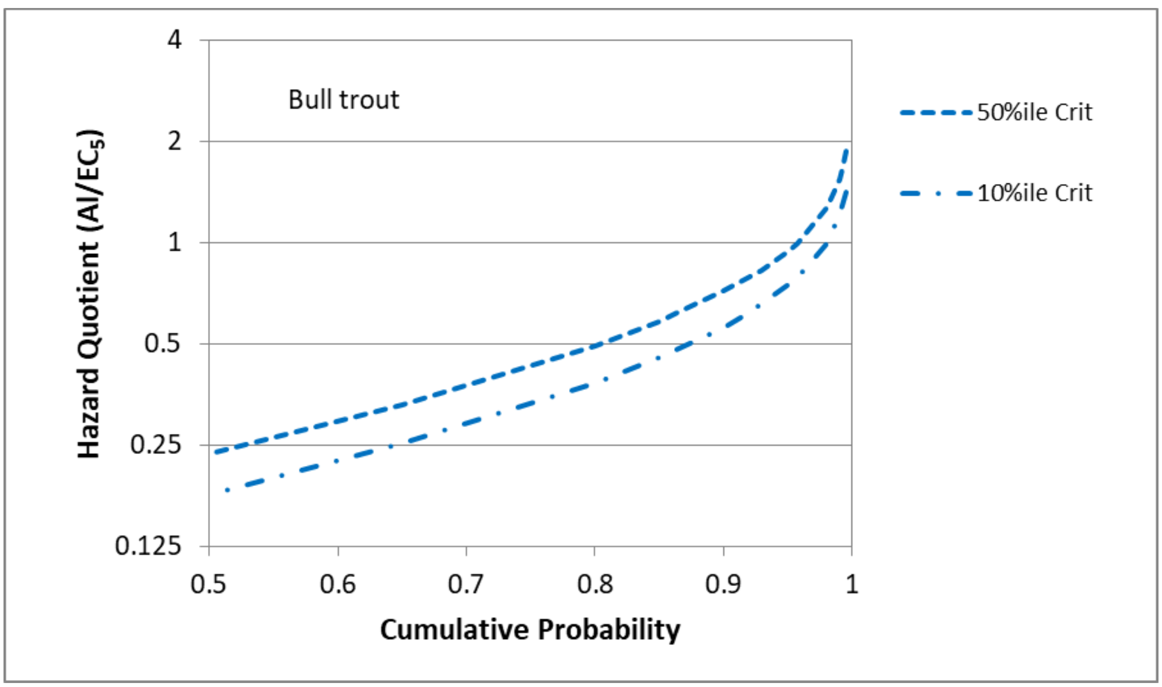

Figure F-12. Bull trout cumulative distribution (upper percentiles) of HQ predicted at point of application of the criterion (end of pipe during dry season, one-third of time; and edge of chronic mixing zone during wet season, two-thirds of time) for hypothetical permit limits based on either the 50th or 10th percentile criterion.

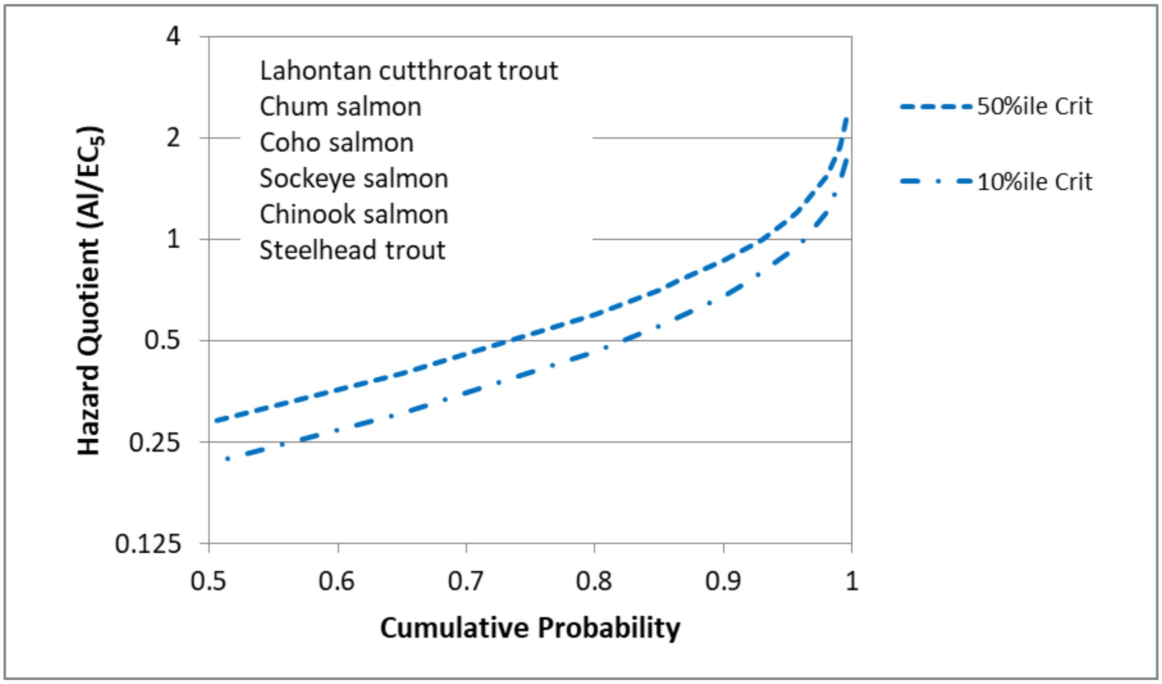

Figure F-13. Other listed salmonids cumulative distribution (upper percentiles) of HQ predicted at point of application of the criterion (end of pipe during dry season, one-third of time; and edge of chronic mixing zone during wet season, two-thirds of time) for hypothetical permit limits based on either the 50th or 10th percentile criterion.

Results of **Figures G-11**, **G-12**, and **G-13** are summarized in **Table F-7**, which presents the predicted percentage of time Al concentrations at the edge of the chronic mixing zone exceeded EC_5 values for vernal pool fairy shrimp, bull trout, and the other listed salmonids in Oregon (i.e., percentage of the time $HQ \geq 1$). The percent of the time Al exceeded listed species EC_5 values at the edge of the mixing zone does not fully imply effects are expected to occur under such circumstances. Overall, the probability that sensitive listed species occur at edge of the mixing zone, simultaneously with the low percent of time the EC_5 could possibly be exceeded, suggest an over low theoretical probability of effects.

Table F-7. Predicted percentage of time exceeding the EC_5 values for vernal pool fairy shrimp, bull trout, and the other listed salmonids.

	Predicted Percentage of Time that Hazard Quotients Exceed 1.0		
Permit limits based on:	**Vernal pool fairy shrimp**	**Bull trout**	**Other listed salmonids**
10th percentile criterion	5.0%	2.0%	3.8%
50th percentile criterion	9.1%	4.3%	7.1%

Discharger Assessment – Final Statement:

The information above provides readers with a better understanding of how discharger permitting may operate in Oregon as part of the Al criteria implementation. Because these are implementation procedures not subject to criteria promulgation, EPA did not consider this as part of its effects analysis. Moreover, EPA was not able to acquire site-specific data for the analysis. Therefore, Appendix F is provided as supplemental information and can be considered potentially representative of future permitting activities in Oregon