Appendix E

Summary of Ecotoxicity Data for Diquat Dibromide

Table E-1. Freshwater Fish Acute Toxicity of diquat expressed in mg cation/L					
Species[1,2]	***% diquat cation***	***96-hour LC_{50} (mg cation/L)***	***Toxicity Category***	***MRID No. Author, Year***	***Study Classification***
Bluegill sunfish, (*Lepomis macrochirus*)	19.8[3]	14	Slightly toxic	00138962 Thompson et. al., 1980	Supplemental (formulated product)
Rainbow trout, (*Salmo gairdneri*)	19.8[3]	15	Slightly toxic	00138961 Thompson et. al., 1980	Supplemental (formulated product)
Brown trout (*Salmo trutta*)	18[4]	18	Slightly toxic	00115858 Simonin et. al., 1977	Supplemental (formulated product, not a recommended species)
Bluegill sunfish, (*Lepomis macrochirus*)	18[4]	33[5]	Slightly toxic	00115572 McCann, 1967	Supplemental (formulated product, 72-hr test, control data not reported)
Yellow perch (*Perca flavescens*)	18[6]	32	Slightly toxic	40098001, Mayer and Ellersick, 1986	Quantitative
Bluegill sunfish (*Lepomis macrochirus*)	18[6]	79	Slightly toxic	40098001, Mayer and Ellersick, 1986	Quantitative
Bluegill sunfish (*Lepomis macrochirus*)	18[6]	92	Slightly toxic	40098001, Mayer and Ellersick, 1986	Quantitative
Black bullhead (*Ameiurus melas*)	18[6]	94	Slightly toxic	40098001, Mayer and Ellersick, 1986	Quantitative (author noted abdomen swelling and hemorrhaging in all jars)
Bluegill sunfish (*Lepomis macrochirus*)	18[6]	107	Practically non-toxic	40098001, Mayer and Ellersick, 1986	Quantitative
Bluegill sunfish (*Lepomis macrochirus*)	18[6]	227	Practically non-toxic	40098001, Mayer and Ellersick, 1986	Quantitative
Bluegill sunfish (*Lepomis macrochirus*)	18[6]	243	Practically non-toxic	40098001, Mayer and Ellersick, 1986	Quantitative
Goldfish	18[6]	>54	Slightly toxic	40098001, Mayer and Ellersick, 1986	Qualitative (24-hr study)
Rainbow trout (*Salmo gairdneri*)	18[6]	>54	Slightly toxic	40098001, Mayer and Ellersick, 1986	Quantitative
Bluegill sunfish (*Lepomis macrochirus*)	18[6]	>107	Practically non-toxic	40098001, Mayer and Ellersick, 1986	Quantitative
Bluegill sunfish (*Lepomis macrochirus*)	18[6]	>241	Practically non-toxic	40098001, Mayer and Ellersick, 1986	Quantitative
Bluegill sunfish (*Lepomis macrochirus*)	18[6]	>386	Practically non-toxic	40098001, Mayer and Ellersick, 1986	Quantitative

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Species[1,2]	***% diquat cation***	***96-hour LC_{50} (mg cation/L)***	***Toxicity Category***	***MRID No. Author, Year***	***Study Classification***

[1] In previous risk assessments for diquat dibromide, an acute toxicity study for goldfish (LC_{50} > 5000 mg/L, MRID 00059586) was listed. This study was conducted with dikegulac sodium (PC code 109601) and will not be included in this or future risk assessments for diquat dibromide.
[2] In previous risk assessments for diquat dibromide, an acute study for striped bass (*Roccus saxatilis*, MRID 00028002, Wellborn, 1969) was listed. This study is reclassified as Unacceptable (previously classified Supplemental). Reasons for the reclassification include no raw data, not recommended test species, formulated product, laboratory method concerns as study author noted issues with aquaria containing residue from previous toxicity tests.
[3] EUP was Diquat 2 Spray.
[4] Specific EUP was unspecified.
[5] This endpoint is based on a 72-hr exposure period and test. Previous EFED risk assessments indicated the LC_{50} was 64.6 mg/L; this value is correct for mg ai/L. The LC_{50} when calculated in terms of cation is 33 mg cation/L.
[6] Product tested was described as a 'Liquid Concentrate' in summary tables and as Reglone (an EUP) in some raw data sheets.

Table E-2. Early Life-Stage Toxicity of diquat (cation) to Freshwater Fish					
Species	**% cation**	**NOAEL (mg cation/L)**	**LOAEL (mg cation/L)**	**MRID No. Author/Year**	**Study Classification**
Fathead minnow (*Pimephales promelas*)	21.1 [1]	0.122	0.316	40380703 (Surprenant, 1987) D155699	Acceptable (initially classified as Supplemental, upgraded in memo (D155699). Study NOAEC based on reduction in larval wet weight.

Table E-3. Freshwater Invertebrate Acute Toxicity of diquat expressed in mg cation/L					
Species	**% diquat cation**	**96-hourEC_{50} (mg cation/L)**	**Toxicity Category**	**MRID No. Author, Year**	**Study Classification**
Crustacean amphipod (*Hyalella* spp.)	unknown (Ortho EUP)	0.14 (0 – 0.46)	Highly toxic	00115862 Nicholson et. al., 1974	Supplemental (no raw data)
Water flea (*Daphnia magna*)	18%[1]	0.77 (0.65 – 0.91)	Highly toxic	00115577 Wheeler et. al., 1978	Supplemental (no raw data)
Apple Snail	18[2]	1.1	Moderately toxic	40098001, Mayer and Ellersick, 1986	Quantitative
Water flea (*Daphnia magna*)	technical, 47% cation	1.17 (0.99 – 1.33)	Moderately toxic	00115576 Wheeler et. al., 1978	Acceptable
Water flea (*Daphnia magna*)	Technical, %ai not specified	7.1[3] (6.3 – 8.0)	Moderately toxic	05001465 Crosby et. al., 1966	Supplemental (26-hr test, no raw data, *Tween 20* added to aquaria)
Gammarus fasciatus	18[2]	>54	Practically nontoxic	40098001, Mayer and Ellersick, 1986	Quantitative

[1] EUP was Diquat Water Weed Killer.
[2] Product tested was described as a 'Liquid Concentrate' in summary tables and as Reglone (an EUP) in some raw data sheets.
[3] Based on the available information, it is not clear if the EC_{50} was reported in mg ai/L or in mg cation/L.

Table E-4. Life-cycle Toxicity of diquat (cation) to Freshwater Invertebrates					
Species	**% cation**	**NOAEC (mg cation/L)**	**LOAEC (mg cation/L)**	**MRID No. Author/Year**	**Study Classification**
Daphnia magna	21.1	0.036	0.087	MRID 403807-02 D155699	Acceptable (initially classified as Supplemental, upgraded in memo (D155699). Study NOAEC based on survival.

Table E-5. Estuarine/Marine Fish Acute Toxicity of diquat expressed in mg cation/L					
Species	***% diquat cation***	***96-hour LC_{50} (mg cation/L)***	***Toxicity Category***	***MRID No. Author, Year***	***Study Classification***
Sheepshead minnow (*Cyprinodon variegates*)	21.1	51.1	Slightly toxic	40316101	Acceptable (all test solutions were brown colored, two highest test concentrations had precipitate, not stated if test solutions were centrifuged prior to analysis)
Longnose killifish (*Fundulus similis*)	20	>20	Slightly toxic	40228401 Mayer, 1986	Supplemental (no raw data, 48-hr study)

Table E-6. Estuarine/Marine Invertebrate Acute Toxicity of diquat expressed in mg cation/L					
Species	***% diquat cation***	***Study endpoint***	***Toxicity Category***	***MRID No. Author, Year***	***Study Classification***
Mysid shrimp (*Americamysis bahia*)	21.1	LC_{50} = 0.42 mg cation/L	Highly toxic	403157-01	Acceptable
Eastern oyster (*Crassostrea virginica*)	21.1	IC_{50} >54.9 mg cation/L	Slightly toxic	403160-01 Dionne, 1987	Acceptable (28% reduction in shell growth at highest test concentration)
Pink shrimp (*Penaeus duorarum)*	21.1	EC_{50} >20 mg cation/L	Slightly toxic	402284-01	Supplemental (no raw data, 48-hr test)
Eastern oyster (*Crassostrea virginica*)	21.1	IC_{50} >0.50 mg cation/L	Highly toxic	402284-01	Supplemental (no raw data)

Table E-7. Toxicity of Diquat, expressed as mg cation/L, to Non-vascular Aquatic Plants - Tier II					
Species	*% cation*	*IC_{50} (mg cation/L)*	NOAEC *(mg cation/L)*	*MRID No. Author (Year)*	*Study Classification*
Green algae (*Kirchneria subcapitata*)	26.8	0.0094	0.0068	43532703 Smyth and Tapp, 1988	Acceptable
Marine diatom (*Isochryris galbana*)	20	7.6	NA	40228401 Mayer, 1986	Supplemental (no raw data, 240 hr test)
Marine diatom (*Phaeodactylum tricornutum*)	20	7.6	NA	40228401 Mayer, 1986	Supplemental (no raw data, 240 hr test)
Marine algae (*Dunaliella tertiolecta*)	20	16	NA	40228401 Mayer, 1986	Supplemental (no raw data, 240 hr test)
Green algae (*Chlorococcum sp.*)	20	102	NA	40228401 Mayer, 1986	Supplemental (no raw data, 240 hr test)

Table E-8. Toxicity of Diquat, expressed as mg cation/L, to Vascular Aquatic Plants - Tier II					
Species	*% ai*	Foliar application IC_{50} (lb cation/acre)	Rootzone application IC_{50} (µg cation/L)	*MRID No. Author (Year)*	*Study Classification*
Giant duckweed (*Spirodela punctata*)	35.3 ai	0.004	0.75	41883002 Bellet, 1990	Supplemental (no raw data, Florida microcosm studies, NOAEC and/or IC_{05} were not reported)
Hydrilla (*Hydrilla verticillata*)	35.3 ai	NA	9.9		
Water Hyacinth (*Eichhornia crassipes*)	35.3 ai	0.020	14.0		
Azolla (*Azolla caroliniana*)	35.3 ai	0.028	11.6		
Water Lettuce (*Pistia stratiotes*)	35.3 ai	0.11	15.8		
Watershield (*Brasenia schreberi*)	35.3 ai	3.6	NA		
Torpedograss (*Panicum repens*)	35.3 ai	3.6	3515		
Bahiagrass (*Paspalum notatum*)	35.3 ai	14.4	NA		

Table E-9. Non-target Terrestrial Plant Seedling Emergence Toxicity for Diquat Dibromide			
Crop	**Species**	**NOAEC (lb cation/A)**	**IC_{25} (lb cation/A)**
Monocots	Barnyard grass (*Echinochloa sp.)*	4.65	>4.65
	Corn (*Zea mays*)	4.65	>4.65
	Onion (*Allium cepa*)	4.65	>4.65
	Rye (*Lolium perenne)*	4.65	>4.65
Dicots	Potato (*Solanum tuberosum)*	4.65	>4.65
	Sicklepod (*Senna obtusifolia*)	4.65	>4.65
	Jimson weed *(Datura stramonium*)	4.65	>4.65
	Morning glory (*Ipomea sp*)	4.65	>4.65
	Soybean (*Glycine max*)	4.65	>4.65
	Sunflower (*Helianthus annuus*)	4.65	>4.65

Table E-10. Terrestrial Plant Toxicity (Vegetative Vigor) of diquat expressed in lbs cation/acre

Species	*% diquat cation*	*IC_{25} (lbs cation/acre*	*NOAEC (lbs cation/acre)*	*Most sensitive endpoint*	*MRID No. Author, Year*	*Study Classification*
Monocots						
Sweet corn	18[1]	0.023	0.017	Dry weight	44755601, Porch and Krueger, 1999	Supplemental (incorrect amt of surfactant added)
Wheat	18[1]	0.091	0.070	Dry weight	44755601, Porch and Krueger, 1999	Supplemental (incorrect amt of surfactant added)
Corn	22[2]	0.011	NA	Shoot height[3]	41883001 Bellet, 1990	Supplemental (no raw data, Florida field study)
Onion	22[2]	0.177	NA	Shoot height[3]	41883001 Bellet, 1990	Supplemental (no raw data, Florida field study)
Dicots						
Soybean	22[2]	0.007	NA	Dry weight[4]	41883001 Bellet, 1990	Supplemental (no raw data, Florida field study, NOAEC/IC_{05} not available)
Sunflower	22[2]	<0.020	NA	Dry weight[4]	41883001 Bellet, 1990	Supplemental (no raw data, Florida field study, NOAEC/IC_{05} not available)
Cotton	22[2]	0.005	NA	Shoot height[3]	41883001 Bellet, 1990	Supplemental (no raw data, Florida field study, NOAEC/IC_{05} not available)
Yellow nutsedge	22[2]	0.141	NA	Shoot height[3]	41883001 Bellet, 1990	Supplemental (no raw data, Florida field study, NOAEC/IC_{05} not available)

[1] EUP was Diquat 2SL.
[2] Specific EUP name was not provided, study author stated product was 35.3% diquat dibromide with 62.6% of the diquat dibromide as the cation.
[3] Calculated by reviewer based on treatment summary data.
[4] Calculated by study author using quadratic regression analysis.