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Report Title

Tier I Endangered Species Assessment for Agricultural Uses of Glyphosate and Glyphosate-Containing Herbicides

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CERTIFICATION PAGE

This report is an accurate and complete representation of the project activities.

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Table of Contents

STATEMENT OF NO DATA CONFIDENTIALITY CLAIMS 2
GOOD LABORATORY PRACTICE STATEMENT 3
CERTIFICATION PAGE 4
COPYRIGHT INFORMATION PAGE 5
1 Introduction 8
2 Product Use and Key Risk Assessment Assumptions 9
3 Endangered Species Risk Presumptions and Exposure Analysis Methods 10
4 Avian Assessment 12
4.1 Avian Exposure Estimates 12
4.2 Avian Toxicity Summary 13
4.3 Avian Risk Quotient Calculations 13
4.4 Avian Risk Discussion and Conclusions 15
5 Wild Mammal Assessment 15
5.1 Wild Mammal Exposure Estimates 15
5.2 Wild Mammal Toxicity Summary 15
5.3 Wild Mammal Risk Quotient Calculations 16
5.4 Wild Mammal Risk Discussion and Conclusions 19
6 Honeybee Assessment 20
6.1 Honeybee Toxicity Summary 20
6.2 Honeybee Risk Summary and Conclusion 20
7 Aquatic Animal Assessment 21
7.1 Aquatic Animal Exposure Estimates 21
7.2 Aquatic Animal Toxicity Summary 23
7.3 Aquatic Animal Risk Quotient Calculations 24
7.4 Aquatic Animal Risk Summary and Conclusions 26
8 Aquatic Plant Assessment 26
8.1 Aquatic Plant Exposure Estimates 26
8.2 Aquatic Plant Toxicity Summary 27
8.3 Aquatic Plant Risk Quotient Calculations 28
8.4 Aquatic Plant Assessment Summary and Conclusions 29
9 Terrestrial and Semi-Aquatic Plant Assessment 30
9.1 Terrestrial and Semi-Aquatic Plant Exposure Estimates 30
9.2 Terrestrial and Semi-Aquatic Plant Toxicity Summary 31
9.3 Terrestrial and Semi-Aquatic Plant Risk Quotient Calculations 31
9.4 Terrestrial and Semi-Aquatic Plant Risk Summary and Conclusions 32
10 Summary of Endangered Species Assessment LOC Exceedances 33
11 Overall Conclusions 33
12 References 34
Appendix 1: Calculation of the Glyphosate Foliar Half-Life in Grass 37
Appendix 2: GENEEC2 Input Parameters and Modeling Results 42

List of Tables

Table 1. Summary of Uses and Application Rates for Glyphosate Tier I Endangered Species Assessment 9
Table 2. Summary of EPA Risk Presumptions for Endangered Species Assessment 11
Table 3. Summary of Models or Methods Used to Estimate Exposure of Each Taxon to Glyphosate 12
Table 4. Estimated glyphosate acid residues on food items for birds and wild mammals. 12
Table 5. Avian Toxicity Endpoints considered for Tier I Endangered Species Assessment 13
Table 6. Acute (dose-based) risk quotients for endangered birds exposed to glyphosate 14
Table 7. Acute (diet-based) risk quotients for endangered birds exposed to glyphosate 14
Table 8. Chronic (diet-based) risk quotients for endangered birds exposed to glyphosate 15
Table 9. Mammalian toxicity values considered for the Tier I Glyphosate Endangered Species Assessment 16
Table 10. Acute (dose-based) risk quotients for endangered wild mammals exposed to glyphosate 17
Table 11. Chronic (dose-based) risk quotients for endangered wild mammals exposed to glyphosate 18
Table 12. Chronic (diet-based) risk quotients for endangered wild mammals exposed to glyphosate 18
Table 13. Honeybee toxicity values used in the Tier I Glyphosate Endangered Species Assessment 20
Table 14. Aquatic EECs of glyphosate acid following terrestrial application 21
Table 15. Aquatic EECs of glyphosate formulations following terrestrial application 22
Table 16. Aquatic animal toxicity values considered for the Tier I Glyphosate Endangered Species Assessment 23
Table 17. Acute Tier I Risk Quotients for aquatic animals assuming glyphosate acid exposure 24
Table 18. Acute Tier I Risk Quotients for aquatic animals assuming glyphosate formulation exposure 25
Table 19. Chronic Tier I Risk Quotients for aquatic animals assuming glyphosate acid exposure 25
Table 20. Summary of aquatic plant toxicity of glyphosate acid and relevant formulations to aquatic plants 27
Table 21. Tier I Risk Quotients for endangered aquatic plants assuming glyphosate acid exposure 28
Table 22. Tier I Risk Quotients for endangered aquatic plants assuming glyphosate formulation exposure 29
Table 23. Tier I EECs for terrestrial and semi-aquatic plants exposed to glyphosate 30
Table 24. Glyphosate terrestrial plant toxicity data used in Tier I endangered species assessment 31
Table 25. Tier I Risk Quotients for terrestrial and semi-aquatic Plants 32
Table 26. Glyphosate Acid: Endangered Species Level of Concern Exceedances for Terrestrial Organisms 33
Table 27. Glyphosate Acid and Formulations: Endangered Species Level of Concern Exceedances for Aquatic Organisms 33

1 Introduction

Glyphosate (Figure 1) is a broad-spectrum, nonselective, post-emergence systemic herbicide with activity on essentially all annual and perennial plants.

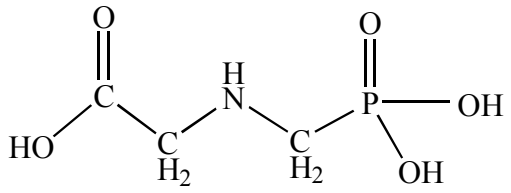

Figure 1. Glyphosate (CAS Number 1071-83-6)

This report describes a risk assessment conducted to assess the risk of direct effects of glyphosate and Roundup® agricultural herbicides to threatened and endangered animal and plant species. In addition, the risk of direct effects to non-endangered plants was also assessed.

In Roundup agricultural herbicide formulations used in the United States, glyphosate is present as either an isopropylamine (IPA), potassium, or ammonium salt. Glyphosate agricultural herbicides are generally formulated to contain either approximately 30% or 40% glyphosate acid. These two product types have different application rates when based on the formulation volume. Typically, IPA salt formulations contain 30% glyphosate acid, and potassium salt formulations contain 40% glyphosate acid. Roundup Pro® is a representative example of an IPA salt formulation with 30% glyphosate acid. Roundup WeatherMAX® and Roundup Original MAX® are representative examples of potassium salt formulations containing 40% glyphosate acid. Toxicity data from these or similar formulations are utilized in relevant parts of this risk assessment.

In the 1993 R.E.D. Facts document for glyphosate, EPA stated "EPA does not expect that most endangered terrestrial or aquatic organisms will be affected by the registered uses of glyphosate. However, many endangered plants as well as the Houston toad (due to its habitat) may be at risk." (USEPA, 1993b). Monsanto Company agrees that most animals are at low risk from exposure to glyphosate herbicides used to control weeds in field crops, whereas endangered plants may be at risk from the same uses.

This assessment follows in large measure EPA's overview document on endangered species effects determinations (USEPA, 2004) and EPA's Environmental Fate and Effects Risk Assessment for the new uses of glyphosate on bentgrass (Termes and Reider, 2006; USEPA, 2006a), from which the majority of the environmental fate input parameters and toxicity endpoints were taken to determine Risk Quotient (RQ) values for this assessment. Toxicity data for glyphosate formulations are considered where relevant.

2 Product Use and Key Risk Assessment Assumptions

This Tier I endangered species assessment for glyphosate use on crops grown in the United States evaluates glyphosate use in two different cropping systems:

- Conventional crops
- Roundup Ready® (RR) crops

For conventional crops, application of glyphosate occurs prior to crop emergence or to facilitate crop or weed senescence in a preharvest use. In Roundup Ready crops, glyphosate applications may occur before or after crop emergence although some restrictions may exist regarding in-crop application timing. Uses in these two types of cropping systems are representative of the uses for the many glyphosate formulations registered for use in U.S. crops (with the exception of sugarcane, which is a special case and is not considered here), and encompass the range of application rates and product uses. Table 1 summarizes the application scenarios considered in this assessment.

Table 1. Summary of Uses and Application Rates for Glyphosate Tier I Endangered Species Assessment

Use type	Application type	Application Rates Glyphosate a.e. (lb/A) [b]
Conventional crops	Ground (maximum single use)	3.75
	Aerial (maximum single use)	1.55
RR alfalfa	Ground or Aerial (maximum single use)	1.55
	Ground or Aerial (typical single use)	0.77
Other RR crops [a]	Ground (maximum single use) (maximum single in-crop use)	1.50 - 3.75 0.56 - 1.55
	Aerial (maximum single use)	0 - 1.55

[a] At the time of this assessment, other RR crops were corn, cotton, canola, sugar beets, and soybeans.
[b] a.e. = glyphosate acid equivalents.

Application rates of glyphosate listed in Table 1 were used in the Tier I assessment calculations. Only the maximum single use rates were considered in this assessment and not the maximum annual use rate given that glyphosate is not expected to accumulate to appreciable levels from one application to the next for the following reasons:

- The foliar half-life of glyphosate is short. Data from 22 residue trials conducted in Europe on grass yielded an average foliar half-life for glyphosate of 2.8 days (range = 0.33-10 days; see Appendix 1). Data from a magnitude of glyphosate residues trial in RR alfalfa conducted in the US (Bleeke, 2002) was used to calculate (using GraphPad for Windows, version 4.0) two additional foliar half-life values for glyphosate. Both values (1.0 and 6.8 days) fell within the range of the values observed in the 22 EU trials, thus confirming the appropriateness of the 2.8 day foliar half-life for this assessment.
- Glyphosate is rapidly metabolized in soil. Half-life values from the aerobic soil metabolism study range from 1.8 to 5.4 days (USEPA, 2006a).

- Glyphosate binds strongly to agricultural soils and sediments (mean K_{oc} = 3040; USEPA, 2006a) and therefore is rarely absorbed into plants from the soil.

There is no indication that glyphosate-containing formulations are more toxic to terrestrial organisms than technical glyphosate (see Table 5, Table 9, and Table 13); therefore, only toxicity endpoint values from toxicity studies with technical glyphosate (glyphosate acid) were used in this assessment for terrestrial animals. However, it is well known that some glyphosate-containing formulations are more toxic to some aquatic organisms; therefore, endpoint values from toxicity studies with technical glyphosate and glyphosate-containing formulations were used for the assessment of endangered aquatic organisms.

3 Endangered Species Risk Presumptions and Exposure Analysis Methods

Table 2 summarizes the risk presumptions as established by the U.S. EPA for endangered species assessment. Both acute risk and chronic risk are assessed for birds, wild mammals, and aquatic animals. For plants (aquatic, terrestrial, and semi-aquatic), EPA only assesses acute risk. Because of the conservative nature of the Tier I assessment assumptions, if the RQ value, calculated using the indicated formula, is equal to or exceeds the Level of Concern (LOC), it is presumed that there may be a risk of adverse effects to the taxonomic category being assessed. However, if the RQ value is less than the LOC, it can be concluded that there is little risk of adverse effects to that taxonomic category.

As a screening assessment for indirect effects on endangered species, EPA uses the direct effects non-endangered LOC values for taxonomic groups to make inferences concerning the potential for indirect effects upon endangered species that rely on non-endangered species in that category for critical resources (USEPA, 2004). If the non-endangered acute RQ value is below the LOC, it can be concluded there is little risk of indirect effects to wildlife categories relying on non-endangered species of that taxa.

Table 2. Summary of EPA Risk Presumptions for Endangered Species Assessment

Wildlife Category	Acute Risk		Chronic Risk	
	Risk Quotient Formula	**Level of Concern (LOC)**	**Risk Quotient Formula**	**Level of Concern (LOC)**
Direct Effects to Endangered Species				
Birds	EEC/ LD_{50} or LC_{50}	0.1	EEC/NOEC	1
Wild Mammals	EEC/LD_{50}	0.1	EEC/NOEC	1
Honeybees	NA [a]	ND	--	--
Aquatic Animals	EEC/LC_{50} (fish) EEC/EC_{50} (invertebrates)	0.05	EEC/NOEC	1
Aquatic Plants (algae, duckweed)	EEC/NOEC	1	--	--
Terrestrial and Semi-Aquatic Plants	EEC/EC_{05} or NOEC	1	--	--
Direct Effects to Non-Endangered Species				
Aquatic Animals	EEC/EC_{50}	0.5	--	--
Aquatic Vascular Plants (duckweed)	EEC/EC_{50}	1	--	--
Terrestrial Plants	EEC/EC_{25}	1	--	--

EEC: Estimated environmental concentration.
LC_{50}/EC_{50}: Exposure concentration resulting in death or immobilization of 50% of the test animals or 50% inhibition of a growth parameter for test plants.
LD_{50}: Dose resulting in death of 50% of the test organisms.
NOEC: no-observed-effect concentration.
[a] Not applicable. For honeybees, the toxicity endpoint (LD_{50}) is compared directly to a toxicity category.

The potential exposure of each taxon evaluated in this risk assessment to glyphosate was determined using standard EPA models or methods as shown in Table 3.

Table 3. Summary of Models or Methods Used to Estimate Exposure of Each Taxon to Glyphosate

Wildlife Category	Model or Method to Determine Estimated Environmental Concentration (EEC)
Birds	Glyphosate acid: T-REX version 1.3.1
Wild Mammals	Glyphosate acid: T-REX version 1.3.1
Honeybees	For honeybees, the toxicity endpoint (LD_{50}) is compared directly to a toxicity category.
Aquatic Animals	Glyphosate acid: GENEEC2 Formulations: Drift from aerial and ground applications was estimated to be 5% and 1%, respectively. [a,b]
Aquatic Plants (algae, duckweed)	Glyphosate acid: GENEEC2 Formulations: Drift from aerial and ground applications was estimated to be 5% and 1%, respectively. [a,b]
Terrestrial and Semi-Aquatic Plants	Glyphosate: Drift from aerial and ground applications was estimated to be 5% and 1%, respectively.[a]

[a] Because glyphosate has been demonstrated to bind tightly to soil and is rarely absorbed into plants from the soil, runoff is not considered in the assessment for formulations or in the terrestrial and aquatic plant assessment.
[b] A typical surfactant type used in glyphosate formulations (polyethoxylated tallow amine) has been demonstrated to have greater affinity for soil than water (Wang et al., 2005), therefore, runoff of the surfactant component of the formulation is not considered in the formulation assessments for aquatic organisms.

4 Avian Assessment

4.1 Avian Exposure Estimates

Glyphosate concentrations on food items based on data from Hoerger and Kenaga (1972), as modified by Fletcher et al. (1994), were predicted using a first-order residue decline method. The U.S. EPA Environmental Fate and Effects Division's T-REX model (USEPA, 2006b) was used to generate maximum and mean EECs resulting from a single maximum or typical application rate of glyphosate under various field use patterns (see Table 4).

Table 4. Estimated glyphosate acid residues on food items for birds and wild mammals.

TREX simulation scenario		Concentration (ppm)			
Application rate (lb a.e./A)	Number of applications	Short grass	Tall grass	Broadleaf plants/ small insects	Fruits/pods/ seeds/large insects
Maximum					
3.75	1	900	412.5	506	56.25
1.55	1	372	170.5	209	23.25
0.77	1	185	84.7	104	11.55
Mean					
3.75	1	319	135.0	169	26.25
1.55	1	132	55.8	69.75	10.85
0.77	1	65.4	27.7	34.65	5.39

4.2 Avian Toxicity Summary

Table 5 summarizes the avian toxicity data for glyphosate acid and a glyphosate herbicide. The formulation data is presented for comparison only. Glyphosate (USEPA, 2006a) and the Roundup Pro formulation are both classified as "practically nontoxic" to avian species in acute and short-term dietary studies. The acute oral and short-term dietary endpoints with glyphosate acid were used for the avian assessment.

Table 5. Avian Toxicity Endpoints considered for Tier I Endangered Species Assessment

Study	Species	LC_{50} (mg/kg feed)	NOEC (mg/kg feed)	LD_{50} (mg/kg bw)	NOEL (mg/kg bw)	Identification Number
30% Glyphosate Formulation (Roundup Pro)						
Short-term dietary	Bobwhite quail	> 5620 [a]	5620	--	--	Palmer et al., 2002a WL-97-097
	Mallard duck	> 5620 [a]	5620	--	--	Palmer et al., 2002b WL-97-101
Glyphosate acid						
Acute oral	Bobwhite quail	--	--	**> 3851**	1785 [b]	Fink et al., 1978c MRID 00108204 [e]
Short-term dietary	Bobwhite quail	**> 4640 [a]**	4640	> 1127 [d]	--	Fink, 1973b MRID 00076492 [e]
	Mallard duck	> 4640 [a]	4640	> 1241 [d]	--	Fink, 1973a MRID 00108107 [e]
One-generation reproduction	Bobwhite quail	--	**1000 [c]**	--	**96.3 [d]**	Fink and Beavers, 1978a MRID 00108207 [e]
	Mallard duck	--	1000 [a]	--	125.3 [d]	Fink and Beavers, 1978b MRID 00111953 [e]

Bold numbers are the toxicity values used in this assessment.
Values are expressed in formulation units for formulation studies and in glyphosate a.e. units for glyphosate acid studies.
[a] Highest dose tested.
[b] This NOEL value is based on the observation of transient lethargy in the 3851 mg/kg bw dose group on the day of dosing. No other adverse effects were observed at 3851 mg/kg bw.
[c] No statistically significant effect was observed on any currently used reproductive parameter, including hatchling body weight or hatchling survival, at 1000 mg/kg feed.
[d] Daily dose equivalent LD_{50} and NOEL values were calculated from the dietary dose levels, bird weights, and diet consumption data from the source studies.
[e] As cited in the Glyphosate Reregistration Eligibility Decision (USEPA, 1993a).

4.3 Avian Risk Quotient Calculations

Exposure estimates from Table 4 and toxicity endpoints from Table 5 were used as inputs in the T-REX model to calculate risk quotients (see Tables 6 through 8). A scaling factor of 1.00 was used in this assessment instead of the proposed Mineau scaling factor of 1.15 (Mineau et al., 1996), as there is no indication that glyphosate is more toxic to smaller birds than larger birds. In addition, glyphosate is not an antichlolinesterase insecticide, like the vast majority of compounds used to derive the Mineau scaling factor. A foliar half-life of 2.8 days was used in this assessment, which is the average

foliar residue half-life for glyphosate, based on residue decline data from 22 field trials conducted in European agricultural areas[1] (see Appendix 1).

Table 6. Acute (dose-based) risk quotients for endangered birds exposed to glyphosate

Food type	Weight class (g)	3.75 lb a.e./A		1.55 lb a.e./A		0.77 lb a.e./A	
		Acute RQ [a] (LOC = 0.1)					
		Max residues	Mean residues	Max residues	Mean residues	Max residues	Mean residues
Short grass	20	**Below**	<0.10	**Below**	<0.04	<0.06	<0.02
	100	**Below**	<0.06	<0.07	<0.03	<0.04	<0.02
	1000	<0.07	<0.03	<0.03	<0.01	<0.02	<0.01
Tall grass	20	**Below**	<0.04	<0.06	<0.02	<0.03	<0.01
	100	<0.07	<0.03	<0.03	<0.01	<0.02	<0.01
	1000	<0.04	<0.02	<0.02	<0.01	<0.01	<0.01
Broadleaf forage, small insects	20	**Below**	<0.05	<0.07	<0.03	<0.04	<0.02
	100	<0.09	<0.03	<0.04	<0.02	<0.02	<0.01
	1000	<0.04	<0.02	<0.02	<0.01	<0.01	<0.01
Fruit, pods, seeds, large insects	20	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01
	100	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	1000	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Below = exposure is below the dose at which no mortality occurred in the bobwhite quail oral study (see Table 5).
[a] RQ as reported by T-REX model.

Table 7. Acute (diet-based) risk quotients for endangered birds exposed to glyphosate

Food type	3.75 lb a.e./A		1.55 lb a.e./A		0.77 lb a.e./A	
	Acute RQ [a] (LOC = 0.1)					
	Max residues	Mean residues	Max residues	Mean residues	Max residues	Mean residues
Short grass	**Below**	<0.07	<0.09	<0.03	<0.04	<0.02
Tall grass	<0.09	<0.03	<0.04	<0.02	<0.02	<0.01
Broadleaf forage, small insects	**Below**	<0.04	<0.05	<0.02	<0.03	<0.01
Fruits, pods, large insects	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01

Below = exposure is below the concentration at which no mortality occurred in the bobwhite quail short-term dietary study (see Table 5).
[a] RQ as reported by T-REX model.

[1] As described in Section 2, U.S. residue data is consistent with the results of the European studies.

Table 8. Chronic (diet-based) risk quotients for endangered birds exposed to glyphosate

Food type	3.75 lb a.e./A		1.55 lb a.e./A		0.77 lb a.e./A	
	Chronic RQ [a] (LOC = 1)					
	Max residues	Mean residues	Max residues	Mean residues	Max residues	Mean residues
Short grass	0.90	0.32	0.37	0.13	0.18	0.07
Tall grass	0.41	0.14	0.17	0.06	0.08	0.03
Broadleaf forage, small insects	0.51	0.17	0.21	0.07	0.10	0.03
Fruits, pods, large insects	0.06	0.03	0.02	0.01	0.01	0.01

[a] RQ as reported by T-REX model.

4.4 Avian Risk Discussion and Conclusions

Glyphosate is classified as "practically non-toxic" to birds (USEPA, 2006a), so it can be presumed that glyphosate will not pose a risk to any birds, including federally-listed threatened or endangered birds.

While not all of the acute risk quotients are conclusively less than the LOC of 0.1 (i.e., those cells in Table 6 and Table 7 labeled "Below"), the acute risk to endangered birds from glyphosate exposure is expected to be minimal. Because all of the LD_{50} or LC_{50} values from the acute and short-term toxicology studies were greater than the highest dose tested, actual RQ values would be smaller than the values given. Also, the estimated field oral dose does not exceed the laboratory-derived dose at which no mortality is observed.

The chronic risk quotients are all less than the LOC of 1. Therefore, it can be concluded that there is low risk to endangered birds from chronic exposure to glyphosate.

5 Wild Mammal Assessment

5.1 Wild Mammal Exposure Estimates

Glyphosate concentrations on food items based on data from Hoerger and Kenaga (1972), as modified by Fletcher et al. (1994), were predicted using a first-order residue decline method. EFED's T-REX model was used to generate maximum and mean EECs resulting from a single maximum or typical application rate of glyphosate under various field use patterns (see Table 4 above).

5.2 Wild Mammal Toxicity Summary

Table 9 summarizes mammalian toxicity values for glyphosate and a glyphosate herbicide. The formulation data is presented for comparison only. Glyphosate and the Roundup WeatherMAX formulation are both classified as "practically nontoxic" to laboratory mammals in acute oral toxicity studies. Endpoints from the glyphosate acid acute oral rat study and a rabbit teratology study were used for the mammalian assessment.

Table 9. Mammalian toxicity values considered for the Tier I Glyphosate Endangered Species Assessment

Study	Species	Endpoint	Result	Reference or Monsanto report no.
40% Glyphosate Formulation (e.g. Roundup WeartherMAX)				
Acute oral	Rat	LD_{50} (mg /kg bw)	> 5000 [a]	Bonnette, 2001a MRID 45504802
	Mouse	LD_{50} (mg/kg bw)	> 5000 [a]	Bonnette, 2001b SB-2001-061
Glyphosate acid				
Acute oral	Rat	LD_{50} (mg/kg bw)	**> 5000** [a]	Blaszcak, 1988 MRID 41400601 [b]
Two-generation	Rat	NOAEL (mg/kg feed) NOAEL (mg/kg bw/day)	10,000 500 [b,c]	Reyna, 1990 MRID 41621501 [b]
Teratology study	Rabbit	NOEL (mg/kg bw/day)	**175**	Rodwell et al., 1980 MRID 00046363 [b]

Bold numbers are the toxicity values used in this assessment.
Values are expressed in formulation units for formulation studies and in glyphosate a.e. units for glyphosate acid studies.
[a] Highest dose tested.
[b] As cited in the Glyphosate Reregistration Eligibility Decision (USEPA, 1993a).
[c] The actual values determined by calculating the average test substance consumed during the study were 666 and 777 mg/kg/day (F0 males and females, respectively) and 711 and 804 mg/kg/day (F1 males and females, respectively).

5.3 Wild Mammal Risk Quotient Calculations

Exposure estimates from Table 4 and toxicity endpoints from Table 9 were used as inputs in the T-REX model version 1.3.1 to calculate risk quotients (see Tables 10 through 12). A foliar half-life value of 2.8 days was used in this assessment, which is the average foliar residue half-life for glyphosate, based on residue decline data from 22 field trials conducted in European agricultural areas[2] (see Appendix 1).

[2] As described in Section 2, U.S. residue decline data is consistent with the results of the European studies.

Table 10. Acute (dose-based) risk quotients for endangered wild mammals exposed to glyphosate

Food type	Weight class (g)	3.75 lb a.e./A		1.55 lb a.e./A		0.77 lb a.e./A	
		Acute RQ [a] (LOC = 0.1)					
		Max residues	Mean residues	Max residues	Mean residues	Max residues	Mean residues
Short grass	15	<0.08	<0.03	<0.04	<0.02	<0.02	<0.01
	35	<0.07	<0.03	<0.03	<0.01	<0.02	<0.01
	1000	<0.04	<0.02	<0.02	<0.01	<0.01	<0.01
Tall grass	15	<0.04	<0.02	<0.02	<0.01	<0.01	<0.01
	35	<0.04	<0.02	<0.02	<0.01	<0.01	<0.01
	1000	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Broadleaf forage, small insects	15	<0.05	<0.02	<0.02	<0.01	<0.01	<0.01
	35	<0.04	<0.02	<0.02	<0.01	<0.01	<0.01
	1000	<0.03	<0.01	<0.01	<0.01	<0.01	<0.01
Fruit, pods, large insects	15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	35	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	1000	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Seeds (granivore)	15	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	35	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	1000	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

[a] RQ as reported by T-REX model.

Table 11. Chronic (dose-based) risk quotients for endangered wild mammals exposed to glyphosate

Food type	Weight class (g)	3.75 lb a.e./A		1.55 lb a.e./A		0.77 lb a.e./A	
		Chronic RQ [a] (LOC = 1)					
		Max residues	Mean residues	Max residues	Mean residues	Max residues	Mean residues
Short grass	15	**2.23**	0.79	0.92	0.33	0.46	0.16
	35	**1.91**	0.68	0.79	0.28	0.39	0.14
	1000	**1.02**	0.36	0.42	0.15	0.21	0.07
Tall grass	15	**1.02**	0.33	0.42	0.14	0.21	0.07
	35	0.87	0.29	0.36	0.12	0.18	0.06
	1000	0.47	0.15	0.19	0.06	0.10	0.03
Broadleaf forage, small insects	15	**1.25**	0.42	0.52	0.17	0.26	0.09
	35	**1.07**	0.36	0.44	0.15	0.22	0.07
	1000	0.57	0.19	0.24	0.08	0.12	0.04
Fruit, pods, large insects	15	0.14	0.06	0.06	0.03	0.03	0.01
	35	0.12	0.06	0.05	0.02	0.02	0.01
	1000	0.06	0.03	0.03	0.01	0.01	0.01
Seeds (granivore)	15	0.03	0.01	0.01	0.01	0.01	<0.01
	35	0.03	0.01	0.01	0.01	0.01	<0.01
	1000	0.01	0.01	0.01	<0.01	<0.01	<0.01

[a] Bold font indicates an RQ exceedance. RQ as reported by T-REX model.

Table 12. Chronic (diet-based) risk quotients for endangered wild mammals exposed to glyphosate

Food type	3.75 lb a.e./A		1.55 lb a.e./A		0.77 lb a.e./A	
	Chronic RQ [a] (LOC = 1)					
	Max residues	Mean residues	Max residues	Mean residues	Max residues	Mean residues
Short grass	0.26	0.09	0.11	0.04	0.05	0.02
Tall grass	0.12	0.04	0.05	0.02	0.02	0.01
Broadleaf forage, small insects	0.14	0.05	0.06	0.02	0.03	0.01
Fruits, pods, large insects	0.02	0.01	0.01	<0.01	<0.01	<0.01

[a] RQ as reported by T-REX model.

5.4 Wild Mammal Risk Discussion and Conclusions

The acute and diet-based chronic risk quotients for endangered wild mammals are all less than the LOC of 0.1 or 1, respectively. Therefore, it can be concluded that there is low acute or diet-based chronic risk to endangered mammals from exposure to glyphosate.

The dose-based chronic risk LOC of 1 for endangered wild mammals is exceeded for a few use patterns at the highest use rate when continuous consumption of food containing residues at the maximum value is assumed (RQ values range from <0.1 to 2.23). This is an extremely conservative assumption for chronic exposure. When consumption of food containing mean residue values[3] is assumed, the dose-based chronic risk quotients are all less than the LOC of 1 indicating low risk to endangered wild mammals from consumption of glyphosate residues. An additional consideration is that glyphosate-treated foliage is expected to die rapidly and become unattractive as a food source, and therefore long-term exposure to mammals is unlikely (Giesy et al., 2000). Additionally, glyphosate has an average foliar half-life of 2.8 days (Appendix 1), and all RQ values will be lower than their corresponding LOC in less than 4 days after an application of the maximum use rate of 3.75 lb a.e./A. For all of these reasons, it is expected that endangered wild mammals will be at low risk from chronic dose-based exposure to glyphosate.

[3] Consumption of food containing residues at the mean value is a reasonable conservative assumption for exposure over time.

6 Honeybee Assessment

6.1 Honeybee Toxicity Summary

Table 13 summarizes the honeybee toxicity data for glyphosate acid and two glyphosate formulations.

Table 13. Honeybee toxicity values used in the Tier I Glyphosate Endangered Species Assessment

Test Material & Study Type	Endpoint	Value (µg a.e./bee)	Reference
Glyphosate acid			
Acute contact	48-hr LD_{50}	>100	Fraser and Jenkins, 1972 MRID 00026489
Acute oral	48-hr LD_{50}	100	Fraser and Jenkins, 1972 MRID 00026489
30% Glyphosate Formulation (Roundup Pro)			
Acute contact	48-hr LD_{50}	>30[a]	Palmer and Krueger, 2001a MRID 45370301
Acute oral	48-hr LD_{50}	>30 [a]	Palmer and Krueger, 2001b MRID 45370302
40% Glyphosate Formulation(similar to Roundup WeartherMAX)			
Acute contact	48-hr LD_{50}	>100	Halsall, 2002 MRID 45780204
Acute oral	48-hr LD_{50}	>95.5	Halsall, 2002 MRID 45780204

[a]Reported as 100 µg formulation/bee, which was the highest dose tested.

6.2 Honeybee Risk Summary and Conclusion

Risk to honeybees, which serve as surrogates for terrestrial invertebrates, is expected to be low as all of the honeybee LD_{50} values for glyphosate acid and glyphosate formulations are greater than 11 µg a.e./bee, the dose that is considered to be relatively non-toxic to honeybees (Atkins et al., 1981).

7 Aquatic Animal Assessment

7.1 Aquatic Animal Exposure Estimates

Using GENEEC2, the initial aquatic exposure model for screening level risk assessments (USEPA, 2001), two routes of exposure were evaluated for assessing the exposures of endangered aquatic animals to glyphosate following terrestrial application: (1) movement in water or soil from a treated area into a nearby surface waterbody; and (2) drift of spray solution from a treated area resulting in deposition onto an adjacent waterbody.

Glyphosate acid EECs were obtained from the GENEEC2 model for the standard pond, assuming application of glyphosate acid at the maximum single use rates described in Table 1. Both ground and aerial applications were modeled. Table 14 summarizes the GENEEC EEC values for glyphosate acid. Environmental fate input parameters used for the model and the results output from the model are provided in Appendix 2.

For glyphosate formulations, the primary route of exposure for glyphosate and other formulation components is by spray drift, since significant runoff after application is not expected due to the binding affinity of glyphosate and surfactant for soil (Giesy, 2000 and Wang, 2005). Therefore, glyphosate formulation EECs were obtained by assuming that 5% and 1% of the maximum single use rates from Table 1 drift into a 1-hectare pond that is 2 meters deep. Table 15 summarizes the drift EEC values for glyphosate formulations.

Table 14. Aquatic EECs of glyphosate acid following terrestrial application

Labeled Use	App Rate (lb a.e./ A)	GENEEC2 Peak or Maximum Time-Weighted Average EEC (mg glyphosate a.e./L)				
		EPA Standard Pond				
		Peak	96-hr	21-d	60-d	90-d
Crop Uses, max single, ground [a]	3.75	0.028	0.027	0.022	0.014	0.011
Crop Uses, max single, ground (RR Alfalfa) [a]	1.55	0.011	0.011	0.009	0.006	0.005
Crop uses, max aerial [a]	1.55	0.017	0.017	0.014	0.009	0.007
Crop uses, typical max aerial [a]	0.77	0.009	0.008	0.007	0.004	0.003

[a] See Appendix 2 for model output. For ground applications, high boom and medium-course droplet size were specified. For aerial applications, fine to medium droplet size was specified.

Table 15. Aquatic EECs of glyphosate formulations following terrestrial application

Labeled Use	Application Rate		Maximum EEC (mg formulation/L)	
	Volume formulation/A	lb formulation/A [a]	Ground Application	Aerial Application
40% Glyphosate Formulation (e.g. Roundup WeartherMAX)				
Crop Uses, max single, ground	3.3 qt.	9.34	0.005	--
Crop Uses, max single, ground (RR Alfalfa)	44 oz.	3.89	0.002	--
Crop uses, max single, aerial	44 oz.	3.89	--	0.011
Crop uses, typical max aerial	22 oz.	1.95	--	0.005
30% Glyphosate Formulation (e.g. Roundup Pro)				
Crop Uses, max single, ground	5 qt.	12.2	0.007	--
Crop Uses, max single, ground (RR Alfalfa)	2 qt.	4.87	0.003	--
Crop uses, max single, aerial	2 qt.	4.87	--	0.014
Crop uses, typical max aerial	1 qt.	2.44	--	0.007

[a] For the 40% glyphosate formulation, a density of 1.36 g/cm^3 was used in the conversion from formulation volume to weight. For the 30% glyphosate formulation, the density used in the calculation was 1.17 g/cm^3.

7.2 Aquatic Animal Toxicity Summary

For aquatic toxicity data, the most recent and relevant aquatic toxicity studies with glyphosate acid and glyphosate formulations were examined. The lowest endpoint value for each taxon was selected and used for risk assessment purposes.

Table 16 summarizes the glyphosate and glyphosate formulation aquatic animal toxicity data considered in this assessment.

Table 16. Aquatic animal toxicity values considered for the Tier I Glyphosate Endangered Species Assessment

Assessment type	Taxa	Species	Endpoint	Value (mg a.e. or formulation/L)	Reference
Glyphosate formulations					
Acute	Fish	Rainbow trout	96-hr LC_{50}	**3.13** [a]	Jenkins 2002a MRID 45780201 [c]
	Aquatic Invertebrate	*Daphnia magna*	48-hr EC_{50}	8	Palmer et al., 2001 WL-2000-107 [d]
	Amphibian	*Xenopus laevis*	96-hr LC_{50}	**2.84** [b]	Edginton et al., 2004 [e]
Glyphosate acid					
Acute	Fish	Bluegill sunfish	96-hr LC_{50}	**45**	Lowest value from EPA One-liner Database [f]
	Aquatic Invertebrate	*Chironomus plumosus*	48-hr EC_{50}	55	Folmar et al., 1979
Chronic	Fish	Rainbow trout	255-d NOEC	**25.7**	EG & G Bionomics 1975 MRID 00108171 [g]
	Aquatic Invertebrate	*Daphnia magna*	21-d NOEC	50	McAllister et al., 1982 MRID 00124763 [g]

[a] Endpoint value used for the 40% glyphosate formulation RQ calculations.
[b] Endpoint value used for the 30% glyphosate formulation RQ calculations.
[c] 40% Glyphosate Formulation similar to Roundup WeartherMAX.
[d] 40% Glyphosate Formulation similar to Roundup Original MAX
[e] 30% Glyphosate Formulation with toxicity similar to Roundup Pro.
[f] EPA One-liner Database. http://www.ipmcenters.org/Ecotox/index.cfm (Accessed June 2006.)
[g] As cited in the RED (USEPA, 1993a).

7.3 Aquatic Animal Risk Quotient Calculations

Risk quotient calculations for aquatic animals were calculated using the following equations:

$$RQ_{acute} = \frac{\text{Maximum EEC (mg/L)}}{EC_{50} \text{ or } LC_{50} \text{ (mg/L)}} \qquad RQ_{chronic} = \frac{\text{Maximum EEC (mg/L)}}{\text{NOEC (mg/L)}}$$

Two different exposure patterns were considered: (1) runoff and drift of glyphosate following terrestrial application; (2) drift of glyphosate formulations during ground and aerial terrestrial applications. Runoff is not considered in the formulation assessment because of the tight binding of glyphosate and surfactant to agricultural soils. Tables 17 through 19 summarize the resulting risk quotients for aquatic animals.

Table 17. Acute Tier I Risk Quotients for aquatic animals assuming glyphosate acid exposure

Application Method & Rate	Waterbody type	RQ_{acute} [LOC = 0.05 (endangered), 0.5 (non-endangered)] [a]	
		Glyphosate: EEC_{peak} (GENEEC)	
		Fish	Invert
Ground, max single, 3.75 lb a.e./A	Pond	0.0006	0.0005
Ground, max single (RR Alfalfa) 1.55 lb a.e./A	Pond	0.0003	0.0002
Aerial, max single, 1.55 lb a.e./A	Pond	0.0004	0.0003
Aerial, typical max, 0.77 lb a.e./A	Pond	0.0002	0.0002

[a] Toxicity endpoints for glyphosate studies: Bluegill LC_{50}: 45 mg a.e./L; *C. plumosus* EC_{50}: 55 mg a.e./L. The peak EEC is used for the exposure value in the RQ calculation.

Table 18. Acute Tier I Risk Quotients for aquatic animals assuming glyphosate formulation exposure

Labeled Use	Application Rate (lb formulation/A)	Risk Quotients [a] [LOC = 0.05 (endangered), 0.5 (non-endangered)]	
		Ground	Aerial
40% Glyphosate Formulation [a]			
Crop uses, max single, ground	9.34	0.002	NA
Crop uses, max single, ground (RR Alfalfa)	3.89	0.001	NA
Crop uses, max single, aerial	3.89	NA	0.003
Crop uses, typical max single, aerial	1.95	NA	0.002
30% Glyphosate Formulation [b]			
Crop uses, max single, ground	12.2	0.002	NA
Crop uses, max single, ground (RR Alfalfa)	4.87	0.001	NA
Crop uses, max single, aerial	4.87	--	0.005
Crop uses, typical max single, aerial	2.44	--	0.002

[a] Toxicity endpoint for 40% glyphosate formulation studies: Trout LC_{50}, 3.13 mg formulation/L.
[b] Toxicity endpoint for 30% glyphosate formulation studies: *Xenopus laevis* LC_{50}, 2.84 mg formulation/L.
The peak EEC is used as the exposure value in the RQ calculation.

Table 19. Chronic Tier I Risk Quotients for aquatic animals assuming glyphosate acid exposure

Application Method & Rate	Waterbody type	$RQ_{chronic}$ [LOC = 1 (endangered & non-endangered)] [a]	
		Glyphosate: $EEC_{21\text{-}d\ TWA}$ (GENEEC)	
		Fish	Invert
Ground, max single, 3.75 lb a.e./A	Pond	0.0008	0.0004
Ground, max single (RR Alfalfa), 1.55 lb a.e./A	Pond	0.0004	0.0002
Aerial, max single, 1.55 lb a.e./A	Pond	0.0005	0.0003
Aerial, typical max single, 0.77 lb a.e./A	Pond	0.0003	0.0001

[a] Toxicity endpoints for glyphosate studies: Trout NOEC: 25.7 mg a.e./L; *Daphnia magna* NOEC: 50 mg a.e./L.
The 21-day time-weighted average exposure value is used as the exposure value in the RQ calculation.

7.4 Aquatic Animal Risk Summary and Conclusions

The acute and chronic RQs for endangered and non-endangered aquatic animals exposed to glyphosate acid as estimated by GENEEC2 are all less than the LOC values described in Table 2. Additionally, all acute RQs for endangered aquatic animals exposed to glyphosate formulations due to drift are all less than the LOC of 0.05. Therefore, it can be concluded that there is low acute and chronic risk to endangered aquatic animals from exposure to glyphosate acid or glyphosate formulations.

8 Aquatic Plant Assessment

8.1 Aquatic Plant Exposure Estimates

Exposure estimates for aquatic plants potentially exposed to glyphosate acid and glyphosate formulations are the same as those for the aquatic animals (see Table 14 and Table 15).

8.2 Aquatic Plant Toxicity Summary

Table 20 summarizes the toxicity of glyphosate acid and relevant glyphosate formulations to aquatic plants (algal species and duckweed).

Table 20. Summary of aquatic plant toxicity of glyphosate acid and relevant formulations to aquatic plants

Test organism	Exposure period	Endpoint	Result (mg a.e. or formulation/L)[a]	Reference
Glyphosate Acid				
Selenastrum capricornutum green algae	4 days	$EC_{50,\ cell\ counts}$ NOEC	12.5 10.6	Hughes 1987a MRID 40236901
Navicula pelliculosa diatom	4 days	$EC_{50,\ cell\ counts}$ NOEC	39.9 33.6	Hughes 1987b MRID 40236902
Anabaena flos-aquae blue-green algae	4 days	$EC_{50,\ cell\ counts}$ NOEC	11.7 9.7	Hughes 1987d MRID 40236904
Skeletonema costatum marine algae	96 hours	$EC_{50,\ cell\ counts}$	1.3	Hollister 1978 BN-78-44
	4 days	$EC_{50,\ cell\ counts}$ NOEC	0.85 **0.28**	Hughes 1987c MRID 40236903
Lemna gibba duckweed	7 days	$EC_{50,\ frond\ no.}$ NOEC	21.5 **9.02**	Hughes 1987e MRID 40236905
40% Glyphosate Formulation				
Selenastrum capricornutum green algae	72 hours	E_bC_{50} NOEC	0.124 **0.047**	Jenkins 2002b MRID 45780202
30% Glyphosate Formulation				
Lemna gibba[b] duckweed	7 days	$EC_{50\ (frond\ number)}$ NOEC	4.7 **0.3**	Dengler 2002 GA-2002-052

Bold numbers are the toxicity values used in this assessment.
[a] EC_{50} values shown for glyphosate acid with exposure periods in days are presented in the Glyphosate RED.
[b] One formulation study with *Lemna minor* was excluded from consideration because of a lack of dose response and use of a medium not conforming with test guidelines.

8.3 Aquatic Plant Risk Quotient Calculations

For aquatic plant species, the acute risk quotient is calculated as follows:

$$\text{Aquatic Plant } RQ_{acute} = \frac{\text{Maximum initial EEC (mg/L)}}{\text{NOEC (mg/L)}}$$

EPA currently does not assess the chronic risk of aquatic plants.

Exposure values used in the RQ assessment are from Table 14 (glyphosate acid) and Table 15 (formulations). Table 21 summarizes the resulting risk quotients for endangered aquatic plants exposed to glyphosate acid and Table 22 summarizes the resulting risk quotients for endangered aquatic plants exposed to glyphosate formulations.

Table 21. Tier I Risk Quotients for endangered aquatic plants assuming glyphosate acid exposure

Application Method & Rate	Waterbody type	RQ_{acute} (LOC = 1)	
		Glyphosate [a] (EEC_{peak}:GENEEC)	
		Algae	Duckweed
Ground, max single, 3.75 lb a.e./A	Pond	0.099	0.003
Ground, max single (RR Alfalfa), 1.55 lb a.e./A	Pond	0.041	0.001
Aerial, max single, 1.55 lb a.e./A	Pond	0.061	0.002
Aerial, typical max, 0.77 lb a.e./A	Pond	0.030	0.001

[a] Toxicity endpoints for glyphosate: Algae NOEC: 0.28 mg a.e./L; Duckweed NOEC: 9.02 mg a.e./L. Exposure values are Peak EEC's from Table 14.

Table 22. Tier I Risk Quotients for endangered aquatic plants assuming glyphosate formulation exposure

Application Method & Rate	Application Rate (lb formulation/A)	RQ_{acute} (LOC = 1) [a]	
		Ground Application	Aerial Application
40% Glyphosate Formulation [b]			
Crop uses, max single, ground	9.34	0.112	--
Crop uses, max single, ground (RR Alfalfa)	3.89	0.046	--
Crop uses, max single, aerial	3.89	--	0.232
Crop uses, typical max single, aerial	1.95	--	0.116
30% Glyphosate Formulation [c]			
Crop uses, max single, ground	12.2	0.023	--
Crop uses, max single, ground (RR Alfalfa)	4.87	0.009	--
Crop uses, max single, aerial	4.87	--	0.046
Crop uses, typical max single, aerial	2.44	--	0.023

NA = Not applicable.
[a] Exposure values are from Table 15.
[b] Toxicity endpoint for 40% glyphosate formulations: *Selenastrum capricornutum* NOEC, 0.047 mg/L.
[c] Toxicity endpoint for 30% glyphosate formulations: *Lemna gibba* NOEC, 0.3 mg/L.

8.4 Aquatic Plant Assessment Summary and Conclusions

The risk quotients for endangered aquatic plants are below the LOC of 1 for all use patterns of glyphosate and glyphosate formulations, indicating a low risk to endangered aquatic plants from exposure to glyphosate following terrestrial application to crops

9 Terrestrial and Semi-Aquatic Plant Assessment

9.1 Terrestrial and Semi-Aquatic Plant Exposure Estimates

EPA uses the TerrPlant model to determine EECs for terrestrial and semi-aquatic plants from runoff and drift. However, for glyphosate, only the drift component of the TerrPlant model was used to determine exposure rates. Runoff was not considered to contribute to exposure since glyphosate binds very tightly to soil and displayed no significant herbicidal activity in the seedling emergence test (USEPA, 2006a; Bohn, 1987). In addition, the EPA has stated "…it has been determined that the use of glyphosate is not expected to cause adverse effects on seed germination/seedling emergence with the various registered use patterns" (US EPA 1993a, p. 55).

The EECs for terrestrial and semi-aquatic plants were calculated as follows:

Unincorporated ground application:
Drift = maximum application rate x 0.01

Aerial application:
Drift = maximum application rate x 0.05

Table 23. Tier I EECs for terrestrial and semi-aquatic plants exposed to glyphosate

Application Rate (lb a.e./A)	Application Method	EEC (lb a.e./A) from drift
3.75	Ground (max)	0.0375
1.55	Ground (max, RR Alfalfa)	0.0155
1.55	Aerial (max)	0.0775
0.77	Aerial (typical)	0.0385

9.2 Terrestrial and Semi-Aquatic Plant Toxicity Summary

Table 24 summarizes the terrestrial plant toxicity data used in this assessment. These data are from the vegetative vigor study conducted with a simulated glyphosate formulation (Chetram and Lucash, 1994).

Table 24. Glyphosate terrestrial plant toxicity data used in Tier I endangered species assessment

Species	Phyto-toxicity (lb a.e./A)	Survival (lb a.e./A)		Plant height (lb a.e./A)		Plant dry weight (lb a.e./A)	
	NOEC	NOEC	EC_{25}	NOEC	EC_{25}	NOEC	EC_{25}
Ryegrass	0.56	1.10	2.30	0.56	0.96	0.56	0.80
Corn	0.070	0.56	0.79	0.56	0.42	0.56	0.37
Onion	0.56	4.50	> 4.5	0.56	1.20	0.56	0.85
Oat	0.56	2.30	4.40	0.56	0.55	0.14	0.38
Soybean	0.28	4.50	> 4.5	0.56	0.57	0.28	0.42
Lettuce	0.28	1.10	1.40	0.56	0.64	0.28	0.40
Cucumber	0.14	2.30	2.60	0.28	0.46	0.28	0.41
Cabbage	0.56	1.10	2.90	0.56	0.67	0.14	0.30
Radish	0.14	0.28	0.44	0.070	0.14	**0.035**	0.14
Tomato	0.070	0.28	0.26	**0.035**	0.20	**0.035**	**0.09**

Bold numbers indicate the most sensitive NOEC (0.035 lb a.e./A) and EC_{25} (0.09 lb a.e./A) values that were used to determine RQs for endangered and non-endangered plants, respectively.

9.3 Terrestrial and Semi-Aquatic Plant Risk Quotient Calculations

For terrestrial plant species, the acute risk quotient is calculated as follows:

$$\text{Terrestrial and Semi-Aquatic Plant } RQ_{acute} = \frac{\text{EEC (lb/A)}}{\text{NOEC (lb/A; endangered plants) or } EC_{25} \text{ (lb/A; non-endangered plants)}}$$

EPA currently does not assess the chronic risk of terrestrial plants.

Table 25 summarizes the resulting risk quotients for terrestrial and semi-aquatic plant species potentially exposed to drift from terrestrial applications of glyphosate.

Table 25. Tier I Risk Quotients for terrestrial and semi-aquatic Plants

App Rate (lb a.e./A)	Application Method	Terrestrial and Semi-Aquatic Plant RQ (LOC = 1) [a]	
		Endangered	Non-Endangered
3.75	Ground (max)	**1.07**	0.42
1.55	Ground (max, RR Alfalfa)	0.44	0.17
1.55	Aerial (max)	**2.21**	0.86
0.77	Aerial (typical)	**1.10**	0.43

Bold numbers indicate a LOC exceedance.
[a] Using the EEC values from Table 23 and the NOEC and EC_{25} values summarized in Table 24.

9.4 Terrestrial and Semi-Aquatic Plant Risk Summary and Conclusions

For endangered terrestrial plants inhabiting dry areas and semi-aquatic, low-lying areas adjacent to treatment sites, the risk quotients for direct effects exceed the LOC for the ground application rate of 3.75 lb a.e./A and for the aerial use rates of 1.55 and 0.77 lb a.e./A, indicating the potential for risk to threatened or endangered species at these rates. The RQ does not exceed the LOC for the maximum ground application rate for Roundup Ready alfalfa (1.55 lb a.e./A), indicating that this rate does not pose a risk to threatened or endangered species. Using the lowest NOEC (0.035 lb a.e./A), the rates at which the LOC is not exceeded can be calculated. Acceptable RQ values for direct effects can be obtained at ground application rates of <3.5 lb a.e./A. To obtain an acceptable RQ value for aerial applications, a rate of <0.7 lb a.e./A would be necessary. However, this application rate may not be commercially acceptable.

The risk quotients for direct effects of glyphosate to non-endangered terrestrial and semi-aquatic endangered plants are below the LOC for all use patterns of glyphosate and glyphosate formulations, indicating a low risk of indirect effects to endangered species in other wildlife categories that rely on terrestrial and semi-aquatic plants for food or habitat.

10 Summary of Endangered Species Assessment LOC Exceedances

Table 26 and Table 27 summarize the risk quotient exceedances calculated in this endangered species assessment.

Table 26. Glyphosate Acid: Endangered Species Level of Concern Exceedances for Terrestrial Organisms

Taxa	Acute	Chronic
Birds	No [a]	No
Mammals	No	No [a]
Terrestrial & Semi-Aquatic Plants	**YES** [b]	--

[a] Some small exceedances were addressed by additional considerations.
[b] For ground and aerial application rates ≥ 3.5 and 0.7 lb a.e./A, respectively.

Table 27. Glyphosate Acid and Formulations: Endangered Species Level of Concern Exceedances for Aquatic Organisms

Taxa	Acute	Chronic
Aquatic Animals	No	No
Aquatic Plants	No	--

11 Overall Conclusions

- Terrestrial and aquatic threatened or endangered animals are expected to be at low risk of direct effects from exposure to glyphosate used in agriculture.
- Threatened or endangered aquatic plants are expected to be at low risk of direct effects from exposure to glyphosate used in agriculture.
- Terrestrial and semi-aquatic threatened or endangered plants are expected to be at low risk of direct effects from exposure to glyphosate used in agriculture at ground application rates less than 3.5 lb a.e./A.
- However, terrestrial and semi-aquatic threatened or endangered plants may be at risk of direct effects from exposure to glyphosate used in agriculture at ground application rates greater than or equal to 3.5 lb a.e./A and aerial application rates greater than or equal to 0.7 lb a.e./A.
- Terrestrial and aquatic threatened or endangered animals are expected to be at low risk of indirect effects from the exposure of non-endangered plants to glyphosate used in agriculture.

12 References

Atkins EL, Kellum D, Atkins KW. 1981. Reducing Pesticide Hazard to Honey Bees: Mortality Prediction Techniques and Integrated Management Strategies. University of California, Division of Agricultural Sciences, Leaflet 2883. http://bees.ucr.edu/reprints/2883.pdf

Blaszcak D. 1988. Acute Oral Toxicity Study in Rats for Glyphosate Technical (Wetcake). Monsanto Study No. BD-88-114. MRID 41400601.

Bleeke MS. 2002. Magnitude of Glyphosate Residues in Roundup Ready® Alfalfa Raw Agricultural Commodities Following Topical Application of Roundup Ultra® Herbicide. Monsanto Report No. MSL-16761. MRID 45646001.

Bohn J. 1987. An evaluation of the Preemergence Herbicidal Activity of CP 70139. Monsanto Report No. MSL-6574. MRID 40159301.

Bonnette KL. 2001a. An Acute Oral Toxicity Study in Rats with MON 78270. Monsanto Study No. SB-2001-045. MRID 45504802.

Bonnette KL. 2001b. An Acute Oral Toxicity Study in Mice with MON 78270. Monsanto Study No. SB-2001-061. (not submitted to US EPA; study available upon request)

Chetram RS, Lucash KJ. 1994. Tier 2 Vegetative Vigor Nontarget Phytotoxicity Study Using Glyphosate. Monsanto Report No. MSL-13320. MRID 43088701.

Dengler D. 2002. Assessment of toxic effects of MON 35012 on aquatic plants using the duckweed *Lemna gibba.* Monsanto Study No. GA-2002-052. (not submitted to US EPA; study available upon request)

Edginton AN, Sheridan PM, Stephenson GR, Thompson, DG, Boermans HJ. 2004. Comparative effects of pH and Vision® herbicide on two life stages of four anuran amphibian speies. *Environmental Toxicology and Chemistry* 23(4):815-822.

EG & G Bionomics. 1975. Chronic Toxicity of Glyphosate to the Fathead Minnow (Pimephales promelas, Rafinesque). Monsanto Study No. BN-75-129. MRID 00108171.

Fink R. 1973a. Eight-day Dietary LC50—Mallard Ducks: Technical CP67573. Monsanto Study No. HL-73-075. MRID 00108107.

Fink R. 1973b. Eight-day Dietary LC50—Bobwhite Quail: Technical CP67573. Monsanto Study No. HL-73-076. MRID 00076492.

Fink R, Beavers J. 1978a. One-generation reproduction study--Bobwhite Quail: Glyphosate Technical. Monsanto Study No. WL-78-052. MRID 00108207.

Fink R, Beavers J. 1978b. One-generation Reproduction Study--Mallard Duck: Glyphosate Technical. Monsanto Study No. WL-78-053. MRID 00111953.

Fink R, Beavers J, Brown R. 1978. Acute Oral LD50--Bobwhite Quail: Technical Glyphosate. Monsanto Study No. WL-78-027. MRID 00108204

Fletcher JS, Nellessen JE, Pfleeger TG. 1994. Literature review and evaluation of the EPA food-chain (Kenaga) nomogram, an instrument for estimating pesticide residues on plants. *Environmental Toxicology and Chemistry* 13(9):1383-1391.

Folmar LC, Sanders HO, Julin AM. 1979. Toxicity of the herbicide glyphosate and several of its formulations to fish and aquatic invertebrates. *Archives of Environmental Contamination and Toxicology* 8: 269-278.

Fraser WD, Jenkins G. 1972. The Acute Contact and Oral Toxicities of CP 67573 and MON 2139 to Worker Honey Bees. Monsanto Study No. HU85X094. MRID 00026489.

Giesy JP, Dobson S, Solomon KR. 2000. Ecotoxicological risk assessment for Roundup® herbicide. *Reviews of Environmental Contamination and Toxicology* 167:35-120.

Halsall N. 2002. Laboratory Bioassays to Determine Acute Oral and Contact Toxicity of MON 78273 (40% Glyphosate Acid Equivalents) to the Honeybee, *Apis mellifera*. Monsanto Study No. MT-2002-018. MRID 45780204.

Hoerger F, Kenaga EE. 1972. Pesticide residues on plants: Correlation of representative data as a basis for estimation of their magnitude in the environment. In F. Coulston and F. Korte, eds., *Environmental Quality and Safety: Chemistry, Toxicology, and Technology*, Georg Thieme Publishers, Stuttgart, West Germany, pp. 9-28.

Hollister TA. 1978. Toxicity Tests of Seven Test Materials to the marine alga, *Skeletonema costatum*. Monsanto Study No. BN-78-44C. (not submitted to US EPA; study available upon request)

Hughes J. 1987a. The Toxicity of Glyphosate Technical to *Selenastrum capricornutum.* Monsanto Study No. XX-88-412. MRID 40236901.

Hughes J. 1987b. The Toxicity of Glyphosate Technical to *Navicula pelliculosa.* Monsanto Study No. XX-88-413. MRID 40236902.

Hughes J. 1987c. The Toxicity of Glyphosate Technical to *Skeletonema costatum.* Monsanto Study No. XX-88-414. MRID 40236903.

Hughes J. 1987d. The Toxicity of Glyphosate Technical to *Anabaena flosaquae.* Monsanto Study No. XX-88-415. MRID 40236904.

Hughes J. 1987e. The Toxicity of Glyphosate Technical to *Lemna gibba.* Monsanto Study No. XX-88-416. MRID 40236905.

Jenkins CA. 2002a. MON 78273 Acute Toxicity to Fish. Monsanto Study No. HR-2002-015. MRID 45780201.

Jenkins CA. 2002b. MON 78273. Algal growth inhibition assay. Monsanto Study No. HR-2002-016. MRID 45780202

McAllister W, McKee M, Schofield M. 1982. Chronic Toxicity of Glyphosate to Daphnia magna under Flow-through Test Conditions. Monsanto Study No. AB-82-036. MRID 00124763.

Mineau P, Collins BT, Baril A**.** 1996. On the use of scaling factors to improve interspecies extrapolation to acute toxicity in birds. *Regulatory Toxicology and Pharmacology* 24:24-29.

Palmer SJ, Krueger HO. 2001a. MON 77360: An Acute Contact Toxicity Study with the Honey Bee. Monsanto Study No. WL-97-099. MRID 45370301.

Palmer SJ, Krueger HO. 2001b. MON 77360: An Acute Oral Toxicity Study with the Honey Bee. Monsanto Study No. WL-97-100. MRID 45370302.

Palmer SJ, Kendall TZ, Krueger HO. 2001. MON 77876: A 48-Hour Static Acute Toxicity Test with the Claderoceran (*Daphnia magna*). Monsanto Study No. WL-2000-107. (not submitted to US EPA; study available upon request)

Palmer SJ, Grimes, J, Beavers JB. 2002a. MON 77360: A Dietary LC50 Study with the Northern Bobwhite. Monsanto Study No. WL-97-097. (not submitted to US EPA; study available upon request)

Palmer SJ, Martin KH, Grimes, J, Beavers JB. 2002b. MON 77360: A Dietary LC50 Study with the Mallard. Monsanto Study No. WL-97-101. (not submitted to US EPA; study available upon request)

Reyna M. 1990. Two Generation Reproduction Feeding Study with Glyphosate in Sprague-Dawley Rats. Monsanto Report No. MSL-10387. MRID 41621501.

Rodwell DE, Tasker EJ, Blair M. 1980. Teratology Study in Rabbits. Monsanto Study No. IR-79-018. MRID 00046363.

Termes SC, Rieder D. 2006. Glyphosate New Use (bent-grass): Environmental Fate and Effects Risk Assessment. U.S. Environmental Protection Agency. EPA Memorandum to Jim Tompkins dated May 26, 2006. DP Barcode: D324409.

U.S. Environmental Protection Agency One-liner Database. http://www.ipmcenters.org/Ecotox/index.cfm.

U.S. Environmental Protection Agency, Office of Prevention, Pesticides and Toxic Substances, Office of Pesticide Programs. 2004. *Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs, U.S. Environmental Protection Agency, Endangered and Threatened Species Effects Determinations.* Washington, D.C.

U.S. Environmental Protection Agency. 1993a. Reregistration Eligibility Decision (RED): Glyphosate. EPA 738-R-93-014. http://www.epa.gov/oppsrrd1/REDs/old_reds/glyphosate.pdf

U.S. Environmental Protection Agency. 1993b. R.E.D. Facts: Glyphosate. EPA-738-F-93-011. http://www.epa.gov/oppsrrd1/REDs/factsheets/0178fact.pdf

U.S. Environmental Protection Agency. 2001. GENEEC: Tier I Screening Model for Pesticide Aquatic Ecological Exposure Estimate. Version 2.0. (http://www.epa.gov/oppefed1/models/water/#geneec2)

U.S. Environmental Protection Agency. 2006a. Environmental Fate and Ecological Risk Assessment, Glyphosate: New Uses on Bentgrass. Prepared by SC Termes and D Reider.

U.S. Environmental Protection Agency. 2006b. T-REX (Terrestrial Residue EXposure Model). Version 1.3.1.

Wang N, Besser JM, Buckler DR, Honegger JL, Ingersoll CG, Johnson BT, Kurtzweil ML, MacGregor J, McKee MJ. 2005. Influence of sediment on the fate and toxicity of a polyethoxylated tallowamine surfactant system (MON 0818) in aquatic microcosms. *Chemosphere* 59: 545–551.

Appendix 1: Calculation of the Glyphosate Foliar Half-Life in Grass

The methodology used to calculate the foliar half-life of glyphosate in grass foliage for the chronic avian and wild mammal risk assessments follows the procedure described in the European Commission Guidance Document on Risk Assessment for Birds and Mammals (reference 1). Residues are assumed to follow the standard pattern of first order exponential decline. The decline of glyphosate residue in grass was characterized using data from 22 residue trials each of which had a Day 0 value. Of these 22 trials, 18 of the trials were from 4 separate Monsanto reports (references 2 - 5) and 4 trials were from 2 separate Cheminova reports (references 6 and 7). MON 2139 and a comparable Cheminova formulation were used in these grass residue trials. The grass residue values from the Cheminova trials were taken directly from the European Union Glyphosate Monograph (reference 8); the Cheminova reports themselves were not reviewed.

The dissipation of glyphosate in grass was estimated using the standard first-order dissipation model:

$$C_t = C_i \times e^{-kt} \tag{1}$$

where k is the first order rate constant, C_i is the initial residue concentration, and C_t is the residue concentration at time t. Residue half life time (DT_{50}) in days for these grass land trials was calculated with equation 2.

$$DT_{50} = \frac{-\ln 0.5}{k} \tag{2}$$

In each Monsanto report, residual glyphosate in mg/kg dry matter in grass was normalized to 1 kg a.e./ha and these values were plotted against time in days. For the Monsanto residue trials, many of the later sampling intervals were taken after plant desiccation. Therefore, for the purpose of accurately characterizing glyphosate dissipation kinetics in grass, the glyphosate residues in mg/kg normalized to 100% dry matter content were used to eliminate the effect of sample weight losses during desiccation (Table 1). However, since the final sampling day in the Cheminova trials was on Day 5, when grass desiccation was negligible, correction for moisture content was not necessary (Table 2).

The dissipation of glyphosate was modeled with equation 1 using non-linear regression (9). For 20 of the 22 trials, the standard first-order dissipation model provided an adequate fit for glyphosate dissipation ($R^2 > 0.8$). The standard first-order dissipation model inadequately fit one Monsanto trial and one Cheminova trial (coefficient of determination, $R^2 \leq 0.600$). For these two trials, the DT_{50} was estimated by identifying the first day when a measured value had greater than 50% dissipation. Since the DT_{50} was estimated in this fashion for these two trials, the glyphosate residues in Tables A1-1 and A1-2 are also expressed as a percentage of the initial concentration, which was set at 100% for Day 0 after treatment. **The average DT_{50} for the 22 trials was 2.8 days.**

Table A1-1: Glyphosate residues in grass following a single treatment of Roundup® (MON 2139, SL/360). Source: Monsanto Field Residue Studies

Country, Year Trial, ID	App. Rate (kg a.e./ ha)[1]	NRG 100% of DM [2]	% of Day 0 a.e. residue	DAT[3]	R^2	k (days^{-1})	DT_{50} (days)	Glyphosate Monograph Reference; Monsanto Report No.
Great Britain, 1981								
SU 8125	1.08	101	100	1 h	0.990	0.4106	1.7	RIP95-01242 MLL 30.080
		27	26.7	3				
		12	11.9	7				
SU 8125	2.88	67	100	1 h	0.997	0.3251	2.1	
		27	40.3	3				
		5	7.5	7				
SU 30117	1.08	247	100	1 h	0.997	0.9587	0.72	
		14	5.7	3				
		8	3.2	7				
		7	2.8	9				
		6	2.4	10				
		3	1.2	14				
SU 30117	2.88	130	100	1 h	0.976	0.7063	0.98	
		14	10.8	3				
		11	8.5	7				
		9	6.9	9				
		10	7.7	10				
		3	2.3	14				
SU 30119	1.08	193	100.0	1 h	0.809	0.1456	4.8	
		175	90.7	4				
		38	19.7	9				
		9	4.7	11				
SU 30119	2.88	161	100.0	1 h	0.901	0.1550	4.5	
		123	76.4	4				
		30	18.6	9				
		13	8.1	11				
France, 1981								
811	0.72	168	100.0	0	0.976	0.4576	1.5	RIP95-01245 MLL 30.082
		9	5.4	5				
		23	13.7	8				
		5	3.0	12				
811	1.08	134	100.0	0	0.950	0.3768	1.8	
		9	6.7	5				
		27	20.1	8				
		5	3.7	12				
The Netherlands, 1982								
NL 8207	1.44	682.0	100.0	0	0.998	0.4230	1.6	RIP95-01264 MLL 30.101
		77.0	11.3	5				
		31.7	4.6	10				
Denmark, 1981								
Villbach (GE)-1981-0181Vi	1.80	162.9	100	0	0.844	0.1415	4.9	RIP95-01273 MLL 30.132
		36.0	22.1	7				
		52.6	32.3	14				
Villbach (GE)-1981-0281Vi	1.80	496.3	100	0	0.994	0.1537	4.5	
		184.4	37.2	7				
		37.0	7.5	14				

Country, Year Trial, ID	App. Rate (kg a.e./ ha)[1]	NRG 100% of DM [2]	% of Day 0 a.e. residue	DAT[3]	R^2	k (days^{-1})	DT_{50} (days)	Glyphosate Monograph Reference; Monsanto Report No.
Lettgunbrunn (GE)-1981-0981LE	1.80	437.9	100	0	0.961	0.2616	2.6	
		51.2	11.7	7				
		69.4	15.8	14				
Villbach (GE)-1981-0481Vi	1.80	190.7	100	0	0.937	0.1098	6.3	
		69.0	36.2	7				
		59.0	30.9	14				
Denmark, 1983								
Vogach (GE)-19B	1.44	158.9	100	0	0.995	0.9083	0.76	RIP95-01273 MLL 30.132
		9.9	6.2	3				
		8.3	5.2	7				
		3.3	2.1	10				
		4.4	2.8	14				
Untermehlhausen (GE)-1983	1.44	169.6	100	0	0.990	0.2852	2.4	
		16.4	9.7	7				
		16.2	9.6	10				
		13.0	7.7	14				
Schoneberg	1.44	257.2	100	0	*	*	10 [4]	
		155.8	60.6	3				
		144.6	56.2	7				
		123.9	48.2	10				
		151.0	58.7	14				
Utphe (GE)-1983	1.44	354.9	100	0	0.961	0.1718	4.0	
		78.7	22.2	7				
		62.7	17.7	14				
		39.0	11.0	21				
Meiling (GE)-1983	1.44	253.9	100	0	0.997	0.9014	0.77	
		16.6	6.5	3				
		6.0	2.4	7				
		6.3	2.5	10				
		8.3	3.3	14				

[1] a.e. = glyphosate acid. 1 kg/ha = 0.8922 lb/A.
[2] NRG 100% of DM = residual glyphosate mg/kg normalised to 1 kg a.e./ha and corrected to 100% dry matter content. Values taken directly from Monsanto reports.
[3] DAT = Days After Treatment.
[4] Estimated DT_{50} value based on time when approximately 50% dissipation was reached.
* Did not fit standard 1st order dissipation model.

Table A1-2: Glyphosate residues in grass following a single treatment of CHE 3607 (SL/360). Source: Cheminova Field Residue Studies (cited in Glyphosate Monograph)

App. Rate (kg a.e. /ha) [1]	Residue (mg a.e./ kg wet weight)	% of Day 0 a.e. Residue	DAT[2]	R^2	k ($days^{-1}$)	DT_{50} (days)	Glyphosate Monograph Reference; Cheminova Report no.
Great Britain, 1992							
2.16	237.6	100.0	4 h	0.987	1.9629	0.35	RIP95-01308 IF-93/04572-01
	45	18.9	1				
	19.6	8.2	3				
	9.6	4.0	5				
1.08	87.6	100.0	4 h	0.937	2.0879	0.33	
	14.6	16.7	1				
	14.3	16.3	3				
	8.3	9.5	5				
2.16	252.3	100.0	4 h	0.951	0.4885	1.4	RIP95-01312 IF-93/13842-01
	131	51.9	1				
	72.1	28.6	3				
	36.8	14.6	5				
1.08	90.4	100.0	4 h	*	*	3 [3]	
	142.8	158.0	1				
	39.8	44.0	3				
	17.3	19.1	5				

[1] a.e.= glyphosate acid equivalents.
[2] DAT = Days After Treatment.
[3] Estimated DT_{50} value based on time when approximately 50% dissipation was reached.
* Did not fit standard 1st order dissipation model

Appendix 1 References:

1. European Commission Guidance Document on Risk assessment for Birds and Mammals Under Council Directive 91/414/EEC, September 2002, SANCO/4145/2000.
2. Mestdagh, P. 1982. Glyphosate residues in grass, hay and silage following preharvest application of Roundup® in the United Kingdom. Monsanto report number MLL 30.080, Annex II reference no. RIP95-01242.
3. Mestdagh, P. 1982. Glyphosate residues in ray grass, hay and silage following preharvest application of Roundup® in France. Monsanto report number MLL 30.082, Annex II reference no. RIP95-01245.
4. Mestdagh, P. 1983. Residue analysis for glyphosate and AMPA in grass and silage following topical treatment with Roundup® herbicide in Holland and Denmark 1982 trials. Monsanto report number MLL 30.101, Annex II reference no. RIP95-01245.
5. Reding, MA. 1984. Glyphosate and AMPA residues in grass, hay and silage following Roundup® herbicide preharvest application in Germany and Finland trials. Monsanto report number MLL 30.132, Annex II reference no. RIP95-01273.
6. Schulz, H and Mirbach, MJ. 1994. Determination of residues of glyphosate in grass (grass and hay) – treatment with CHE 3607 – UK, season 1992. Agrisearch UK Ltd., Study plan AS/1911/CN. Cheminova report no. IF-93/04572-01, Annex II reference no. RIP95-01308. As cited in [8].[4]
7. Schulz, H and Mirbach, MJ. 1994. Determination of residues of glyphosate in grass (grass and silage) – treatment with CHE 3607 – UK, season 1992. Agrisearch UK Ltd., Study plan AS/1912/CN. Cheminova report no. IF-93/13842-01, Annex II reference no. RIP95-01312. As cited in [8].[2]
8. European Union. 1998. Glyphosate Monograph. Volume 3, B-6, Residue data, Table B.6.6.14-1.
9. Jandel Scientific. 2000. SigmaPlot Scientific graphing system, Version 6.0. San Rafael, CA, USA.

[4] Note: Glyphosate residues in grass from this study were taken directly from the EU Glyphosate Monograph; the full Cheminova reports were not reviewed.

Appendix 2: GENEEC2 Input Parameters and Modeling Results

Environmental Fate Input Parameters for GENEEC2 (USEPA, 2006a)

Chemical Constituent	Glyphosate acid
Solubility in water (mg/L)	12,000
Soil Organic Carbon Partition Coefficient (Koc; L/kg) (1)	3040
Aerobic soil metabolism half-life (days) (2)	5.4
Aerobic aquatic metabolism half-life (days) (3)	21
Photolytic half-life (days) (4)	0
Hydrolytic half-life (days) (4)	0

(1) The values for Koc were the lowest values determined from a non-sandy soil; the sources of the Koc value for glyphosate equivalents include MRID 443206-46 and a review of data performed by EFED in March 27, 1987.
(2) The value of aerobic soil metabolism half-life for glyphosate equivalents is based on the upper 90th percentile confidence interval of the mean of three values: 1.85, 2.96, and 5.4 (MRID 443206-45).
(3) The value for aerobic aquatic metabolism half-life for glyphosate equivalents is based on a single value of 7 days that was multiplied by 3 to account for uncertainty associated with having only a single value associated with this value.
(4) A value of zero indicates no significant degradation by photolysis or hydrolysis.

Appendix 2 (cont.)

```
RUN No.   1 FOR Glyphosate       ON   All_Crops     * INPUT VALUES *
-----------------------------------------------------------------------
 RATE (#/AC)   No.APPS &   SOIL  SOLUBIL   APPL TYPE NO-SPRAY INCORP
  ONE(MULT)    INTERVAL    Koc   (PPM )    (%DRIFT)   (FT)     (IN)
-----------------------------------------------------------------------
3.750(  3.750)   1   1    3040.012000.0   GRHIME(  1.2)     .0    .0

FIELD AND STANDARD POND HALFLIFE VALUES (DAYS)
-----------------------------------------------------------------------
METABOLIC  DAYS UNTIL  HYDROLYSIS   PHOTOLYSIS   METABOLIC  COMBINED
 (FIELD)   RAIN/RUNOFF   (POND)     (POND-EFF)    (POND)     (POND)
-----------------------------------------------------------------------
   5.40        2          N/A       .00-     .00    21.00     21.00

GENERIC EECs (IN MICROGRAMS/LITER (PPB))     Version 2.0 Aug 1, 2001
-----------------------------------------------------------------------
    PEAK      MAX 4 DAY     MAX 21 DAY    MAX 60 DAY    MAX 90 DAY
    GEEC      AVG GEEC       AVG GEEC      AVG GEEC      AVG GEEC
-----------------------------------------------------------------------
    27.77       26.77         21.79         14.43         11.06

RUN No.   2 FOR Glyphosate       ON   All_Crops     * INPUT VALUES *
-----------------------------------------------------------------------
 RATE (#/AC)   No.APPS &   SOIL  SOLUBIL   APPL TYPE NO-SPRAY INCORP
  ONE(MULT)    INTERVAL    Koc   (PPM )    (%DRIFT)   (FT)     (IN)
-----------------------------------------------------------------------
1.550(  1.550)   1   1    3040.012000.0   GRHIME(  1.2)     .0    .0

FIELD AND STANDARD POND HALFLIFE VALUES (DAYS)
-----------------------------------------------------------------------
METABOLIC  DAYS UNTIL  HYDROLYSIS   PHOTOLYSIS   METABOLIC  COMBINED
 (FIELD)   RAIN/RUNOFF   (POND)     (POND-EFF)    (POND)     (POND)
-----------------------------------------------------------------------
   5.40        2          N/A       .00-     .00    21.00     21.00

GENERIC EECs (IN MICROGRAMS/LITER (PPB))     Version 2.0 Aug 1, 2001
-----------------------------------------------------------------------
    PEAK      MAX 4 DAY     MAX 21 DAY    MAX 60 DAY    MAX 90 DAY
    GEEC      AVG GEEC       AVG GEEC      AVG GEEC      AVG GEEC
-----------------------------------------------------------------------
    11.48       11.06          9.01          5.96          4.57
```

Appendix 2 (cont.)

```
RUN No.   3 FOR Glyphosate       ON   All_Crops     * INPUT VALUES *
   ---------------------------------------------------------------------
    RATE (#/AC)   No.APPS &   SOIL  SOLUBIL   APPL TYPE NO-SPRAY INCORP
     ONE(MULT)    INTERVAL    Koc   (PPM )    (%DRIFT)   (FT)     (IN)
   ---------------------------------------------------------------------
  1.550(  1.550)   1   1    3040.012000.0   AERL_B( 13.0)     .0    .0

   FIELD AND STANDARD POND HALFLIFE VALUES (DAYS)
   ---------------------------------------------------------------------
   METABOLIC  DAYS UNTIL  HYDROLYSIS   PHOTOLYSIS   METABOLIC  COMBINED
    (FIELD)   RAIN/RUNOFF   (POND)     (POND-EFF)    (POND)     (POND)
   ---------------------------------------------------------------------
      5.40        2          N/A       .00-     .00    21.00     21.00

   GENERIC EECs (IN MICROGRAMS/LITER (PPB))     Version 2.0 Aug 1, 2001
   ---------------------------------------------------------------------
       PEAK      MAX 4 DAY     MAX 21 DAY    MAX 60 DAY    MAX 90 DAY
       GEEC      AVG GEEC       AVG GEEC      AVG GEEC      AVG GEEC
   ---------------------------------------------------------------------
       17.16       16.65         13.60          9.04          6.94

   RUN No.   4 FOR Glyphosate       ON   All_Crops     * INPUT VALUES *
   ---------------------------------------------------------------------
    RATE (#/AC)   No.APPS &   SOIL  SOLUBIL   APPL TYPE NO-SPRAY INCORP
     ONE(MULT)    INTERVAL    Koc   (PPM )    (%DRIFT)   (FT)     (IN)
   ---------------------------------------------------------------------
   .770(   .770)   1   1    3040.012000.0   AERL_B( 13.0)     .0    .0

   FIELD AND STANDARD POND HALFLIFE VALUES (DAYS)
   ---------------------------------------------------------------------
   METABOLIC  DAYS UNTIL  HYDROLYSIS   PHOTOLYSIS   METABOLIC  COMBINED
    (FIELD)   RAIN/RUNOFF   (POND)     (POND-EFF)    (POND)     (POND)
   ---------------------------------------------------------------------
      5.40        2          N/A       .00-     .00    21.00     21.00

   GENERIC EECs (IN MICROGRAMS/LITER (PPB))     Version 2.0 Aug 1, 2001
   ---------------------------------------------------------------------
       PEAK      MAX 4 DAY     MAX 21 DAY    MAX 60 DAY    MAX 90 DAY
       GEEC      AVG GEEC       AVG GEEC      AVG GEEC      AVG GEEC
   ---------------------------------------------------------------------
        8.53        8.27          6.76          4.49          3.45
```