Bureau of Land Management

Reno, Nevada

Diuron
Ecological Risk Assessment

Final Report

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Executive Summary

The United States Department of the Interior (USDI) Bureau of Land Management (BLM) is proposing a program to treat vegetation on up to six million acres of public lands annually in 17 western states in the continental United States (US) and Alaska. As part of this program, the BLM is proposing the use of ten herbicide active ingredients (a.i.) to control invasive plants and noxious weeds on approximately one million of the 6 million acres proposed for treatment. The BLM and its contractor, ENSR, are preparing a Vegetation Treatments Programmatic Environmental Impact Statement (EIS) to evaluate this and other proposed vegetation treatment methods and alternatives on lands managed by the BLM in the western continental US and Alaska. In support of the EIS, this Ecological Risk Assessment (ERA) evaluates the potential risks to the environment that would result from the use of the herbicide diuron, including risks to rare, threatened, and endangered (RTE) plant and animal species.

One of the BLM's highest priorities is to promote ecosystem health, and one of the greatest obstacles to achieving this goal is the rapid expansion of invasive plants (including noxious weeds and other plants not native to the region) across public lands. These invasive plants can dominate and often cause permanent damage to natural plant communities. If not eradicated or controlled, invasive plants will jeopardize the health of public lands and the activities that occur on them. Herbicides are one method employed by the BLM to control these plants.

Herbicide Description

Diuron is a broad spectrum, pre- and post-emergent herbicide for use against broad-leaf weeds and annual grasses. This chemical disrupts photosynthesis by blocking electron transport and the transfer of light energy. Diuron is used by the BLM for vegetation control in their Energy & Mineral Sites, Rights-of-Way, and Recreation programs. Ground applications are executed on foot or horseback with backpack sprayers or from all terrain vehicles or trucks equipped with spot or boom/broadcast sprayers. The application rate of diuron is typically 6.0 pounds (lbs) a.i. per acre (a.i./ac), with a maximum rate of 20.0 lbs a.i./ac.

Ecological Risk Assessment Guidelines

The main objectives of this ERA were to evaluate the potential ecological risks from diuron to the health and welfare of plants and animals and their habitats and to provide risk managers with a range of generic risk estimates that vary as a function of site conditions. The categories and guidelines listed below were designed to help the BLM determine which of the proposed alternatives evaluated in the EIS should be used on BLM-managed lands.

- Exposure pathway evaluation – The effects of diuron on several ecological receptor groups (i.e., terrestrial animals, non-target terrestrial plants, fish and aquatic invertebrates, and non-target aquatic plants) via particular exposure pathways were evaluated. The resulting exposure scenarios included the following:
  - direct contact with the herbicide or a contaminated waterbody;
  - indirect contact with contaminated foliage;
  - ingestion of contaminated food items;
  - off-site drift of spray to terrestrial areas and waterbodies;
  - surface runoff from the application area to off-site soils or waterbodies;
  - wind erosion resulting in deposition of contaminated dust; and
  - accidental spills to waterbodies.

- Definition of data evaluated in the ERA – Herbicide concentrations used in the ERA were based on typical and maximum application rates provided by the BLM. These application rates were used to predict herbicide concentrations in various environmental media (e.g., soils, water). Some of these calculations required computer models:

  - AgDRIFT® was used to estimate off-site herbicide transport due to spray drift.

  - GLEAMS was used to estimate off-site transport of herbicide in surface runoff and root-zone groundwater.

  - CALPUFF was used to predict the transport and deposition of herbicides sorbed to wind-blown dust.

- Identification of risk characterization endpoints – Endpoints used in the ERA included acute mortality; adverse direct effects on growth, reproduction, or other ecologically important sublethal processes; and adverse indirect effects on the survival, growth, or reproduction of salmonid fish. Each of these endpoints was associated with measures of effect such as the No Observed Adverse Effect Level (NOAEL) and the median lethal effect dose and median lethal concentration (LD_{50} and LC_{50}).

- Development of a CM – The purpose of the CM is to display working hypotheses about how diuron might pose hazards to ecosystems and ecological receptors. This is shown via a diagram of the possible exposure pathways and the receptors evaluated for each exposure pathway.

In the analysis phase of the ERA, EECs were identified for the various receptor groups in each of the applicable exposure scenarios via exposure modeling. Risk quotients (RQs) were then calculated by dividing the EECs by herbicide- and receptor-specific or exposure media-specific Toxicity Reference Values (TRVs) selected from the available literature. These RQs were compared to Levels of Concern (LOCs) established by the United States Environmental Protection Agency (USEPA) Office of Pesticide Programs (OPP) for specific risk presumption categories (i.e., acute high risk, acute high risk potentially mitigated through restricted use, acute high risk to endangered species, and chronic high risk).

Uncertainty

Uncertainty is introduced into the herbicide ERA through the selection of surrogates to represent a broad range of species on BLM-managed lands, the use of mixtures of diuron with other herbicides (tank mixtures) or other potentially toxic ingredients (i.e., degradates, inert ingredients, and adjuvants), and the estimation of effects via exposure concentration models. The uncertainty inherent in screening level ERAs is especially problematic for the evaluation of risks to RTE species, which are afforded higher levels of protection through government regulations and policies. To attempt to minimize the chances of underestimating risk to RTE and other species, the lowest toxicity levels found in the literature were selected as TRVs; uncertainty factors were incorporated into these TRVs; allometric scaling was used to develop dose values; model assumptions were designed to conservatively estimate herbicide exposure; and indirect as well as direct effects on species of concern were evaluated.

Herbicide Effects

Literature Review

According to the Ecological Incident Information System (EIIS) database run by the USEPA OPP, diuron has been associated with 35 reported "ecological incidents" involving damage or mortality to non-target flora or fauna. It was listed as possible (19 incidents), probable (13 incidents), or highly probable (3 incidents) that registered use of diuron was responsible.

A review of the available ecotoxicological literature was conducted in order to evaluate the potential for diuron to negatively directly or indirectly affect non-target taxa. This review was also used to identify or derive TRVs for use in the ERA. The sources identified in this review indicate that diuron is not highly toxic to most terrestrial species. In mammals, diuron is considered to have low acute oral and dermal toxicity. Adverse effects have been demonstrated in mammals from long term exposure to diuron in the diet. Diuron is slightly toxic to birds and essentially non-toxic to honeybees (*Apis* spp.). Significant adverse effects were noted in non-target terrestrial plant species after 14 days exposure to concentrations as low as 0.08 lb a.i./ac. Toxicity tests indicate that diuron is toxic to fish species at concentrations as low as 0.71 milligram per liter (mg/L). Diuron has a low to moderate potential for bioconcentration in fish tissue. Aquatic invertebrates were affected by diuron concentrations of 0.16 mg a.i./L. Aquatic plants were affected at concentrations as low as 0.0013 mg a.i./L. Amphibians were less sensitive to diuron than any other aquatic taxa.

Ecological Risk Assessment Results

Based on the ERA conducted for diuron, there is the potential for risk to ecological receptors from exposure to herbicides under specific conditions on BLM-managed lands. The following bullets summarize the risk assessment findings for diuron under each evaluated exposure scenario:

- Direct Spray – Risk to insects may occur when individuals or foliage are directly sprayed. Acute and chronic risks to terrestrial wildlife species may occur when contaminated food items are consumed. Risk to terrestrial and aquatic non-target plants, fish, and aquatic invertebrates is likely in accidental direct spray scenarios.

- Off-Site Drift – Risk to typical non-target terrestrial plant species was predicted within 100 feet (ft) of the application area (mostly at the maximum application rate), while risk to RTE terrestrial plant species may occur for any of the modeled ground application scenarios (maximum modeled distance was 900 ft). Risk to aquatic plants was predicted for all scenarios at the maximum application rate (except for acute risk in the stream with a buffer distance of 900 ft) and for distances less than or equal to 100 ft at the typical application rate (chronic risk in the pond also predicted at 900 ft for high boom application). Acute and chronic risks were predicted for fish within 25 ft of the application area (at maximum application rates). Risks were also predicted for aquatic invertebrates 25 ft from application with a low boom and 100 ft from application with a high boom. No risks were predicted for piscivorous birds.

- Surface Runoff – No risks to typical non-target terrestrial plants were predicted; risks to RTE terrestrial plants were predicted in watersheds with clay soils or clay loam soils and annual precipitation of at least 50 inches and in watersheds with loam soils and annual precipitation of at least 200 inches. Risks to aquatic species were not predicted for watersheds with very little precipitation (less than 5 inches per year). However, risks to aquatic plants and to pond-dwelling fish and aquatic invertebrates occur under most other modeled scenarios. In addition, acute risks to fish in the stream were predicted in several watersheds with at least 25 inches of rain per year (mostly at the maximum application rate), and acute risks to aquatic invertebrates were predicted at the typical and maximum application rates in watersheds with at least 10 inches of precipitation per year (effects were less likely in watersheds with loam soils). No chronic risk to fish or aquatic invertebrates were predicted in the stream, and no risks were predicted for piscivorous birds.

- Wind Erosion and Transport Off-Site – No risks were predicted for non-target terrestrial plants under any of the evaluated conditions.

- Accidental Spill to Pond – Risk to fish, aquatic invertebrates, and non-target aquatic plants occurs when herbicides are spilled directly into the pond.

In addition, species that depend on non-target species for habitat, cover, and/or food (e.g., RTE salmonids) may be indirectly impacted by possible reductions in terrestrial or aquatic vegetation or effects on terrestrial and aquatic wildlife, particularly in accidental direct spray and spill scenarios.

Based on the results of the ERA, it is unlikely RTE species would be harmed by appropriate use (see following section) of the herbicide diuron on BLM-managed lands. Adherence to certain application guidelines (e.g., defined application rates, equipment, herbicide mixture, and downwind distance to potentially sensitive habitat) can minimize the potential effects on non-target species from regular application.

Recommendations

The following recommendations are designed to reduce potential unintended impacts to the environment from the application of diuron:

- Select herbicide products carefully to minimize additional impacts from adjuvants and tank mixtures. This is especially important for application scenarios that already predict potential risk from the a.i..
- Review, understand, and conform to "Environmental Hazards" section on herbicide label. This section warns of known pesticide risks to wildlife receptors or to the environment and provides practical ways to avoid harm to organisms or the environment.
- Avoid accidental direct spray and spill conditions to reduce the most significant potential impacts.
- Use the typical application rate to reduce risk for off-site drift and surface runoff exposures.
- Establish the following buffer zones during ground applications (using the typical application rates) to reduce impacts to aquatic areas due to off-site drift.
  - Application by low boom (spray boom height set at 20 inches above the ground) – more than 100 ft from pond or stream (no risk was predicted at 900 ft).
  - Application by high boom (spray boom height set at 50 inches above the ground) – more than 100 ft from stream (no risk was predicted at 900 ft).
  - Application by high boom – more than 1,000 ft from pond (chronic risk to aquatic plants is still predicted at 900 ft; simple regression analysis predicts an RQ of 1 for aquatic plants with a buffer zone of just over 1,000 ft at the maximum application rate).
- Limit the use of diuron in terrestrial habitats if potential impacts to RTE species are of concern.
- For all ground applications of diuron, a buffer zone of more than 1,000 ft from non-target terrestrial species is necessary to limit impacts to RTE terrestrial plants (risk to RTE plants is still predicted at 900 ft; simple regression analysis predicts an RQ of 1 for RTE plants with a buffer zone of just over 1,000 ft at the maximum application rate).
  - If no RTE species are present, terrestrial plants are protected by a buffer zone of 100 ft at the typical application rate and approximately 500 ft at the maximum rate (based on regression evaluation). Less risk is predicted from the use of a low boom for ground application at the typical application rate, and risk may be reduced if diuron is applied on foot or horseback with backpack sprayers.
- Application of diuron should be carefully limited to days without predicted winds.
- Limit the use of diuron in watersheds with downgradient ponds or streams (especially at the maximum application rate) if potential impacts to aquatic species are of concern (less risk predicted in streams than ponds). Carefully evaluate watershed characteristics when RTE salmonids are present in streams (low risk is only found with larger buffer zones in watersheds with low annual precipitation and in some watersheds with loam soils).

The results from this ERA assist the evaluation of proposed alternatives in the EIS and contribute to the development of a Biological Assessment (BA), specifically addressing the potential impacts to proposed and listed RTE species on western BLM treatment lands. Furthermore, this ERA will inform BLM field offices on the proper application of diuron to ensure that impacts to plants and animals and their habitat are minimized to the extent practical.

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LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

ac	-	acres
a.i.	-	active ingredient
BA	-	Biological Assessment
BCF	-	Bioconcentration Factor
BLM	-	Bureau of Land Management
BO	-	Biological Opinion
BW	-	Body Weight
CBI	-	Confidential Business Information
CM	-	Conceptual Model
cm	-	centimeter
cms	-	cubic meters per second
CWE	-	Cumulative Watershed Effect
DPR	-	Department of Pesticide Registration
EC_{25}	-	Concentration causing 25% inhibition of a process (Effect Concentration)
EC_{50}	-	Concentration causing 50% inhibition of a process (Median Effective Concentration)
Ed.	-	Edition
EEC	-	Estimated Exposure Concentration
EIS	-	Environmental Impact Statement
EIIS	-	Ecological Incident Information System
EFED	-	Environmental Fate and Effects Division
ERA	-	Ecological Risk Assessment
ESA	-	Endangered Species Act
FIFRA	-	Federal Insecticide, Fungicide, and Rodenticide Act
FOIA	-	Freedom of Information Act
ft	-	feet
g	-	grams
gal	-	gallon
GLEAMS	-	Groundwater Loading Effects of Agricultural Management Systems
HHRA	-	Human Health Risk Assessment
HSDB	-	Hazardous Substances Data Bank
in	-	inch
IPM	-	Integrated Pest Management
IRIS	-	Integrated Risk Information System
ISO	-	International Organization for Standardization
IUPAC	-	International Union of Pure and Applied Chemistry
Kd	-	Partition coefficient
kg	-	kilogram
km	-	kilometer
K_{oc}	-	Organic carbon-water partition coefficient
K_{ow}	-	Octanol-water partition coefficient
L	-	Liters
LAI	-	Leaf Area Index
lb(s)	-	pound(s)
LC_{50}	-	Median Lethal Concentration
LD_{50}	-	Median Lethal Dose
LOAEL	-	Lowest Observed Adverse Effect Level
LOC(s)	-	Level(s) of Concern
Log	-	Common logarithm (base 10)
m	-	meters
m^3	-	cubic meter
mg	-	milligrams

LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS (Cont.)

mg/kg	-	milligrams per kilogram
mg/L	-	milligrams per liter
mmHg	-	millimeters of mercury
MRID	-	Master Record Identification Number
MSDS	-	Material Safety Data Sheet
MW	-	Molecular Weight
NASQAN	-	National Stream Quality Accounting Network
NOAA	-	National Oceanic and Atmospheric Administration
NOAEL	-	No Observed Adverse Effect Level
OPP	-	Office of Pesticide Programs
OPPTS	-	Office of Pollution Prevention and Toxic Substances
ORNL	-	Oak Ridge National Library
ppm	-	parts per million
RQ	-	Risk Quotient
RTE	-	Rare, Threatened, and Endangered
RTEC	-	Registry of Toxic Effects of Chemical Substances
SDTF	-	Spray Drift Task Force
TOXNET	-	National Library of Medicines Toxicology Data Network
TP	-	Transformation Product
TRV	-	Toxicity Reference Value
TSCA		Toxic Substances Control Act
US	-	United States
USDA	-	United States Department of Agriculture
USDI	-	United States Department of the Interior
USEPA	-	United States Environmental Protection Agency
USFWS	-	United States Fish and Wildlife Service
USLE	-	Universal Soil Loss Equation
µg	-	micrograms
>	-	greater than
<	-	less than
=	-	equal to

1.0 INTRODUCTION

The Bureau of Land Management (BLM), United States Department of the Interior (USDI), is proposing a program to treat vegetation on up to six million ac of public lands annually in 17 western states of the continental US and Alaska. The primary objectives of the proposed program include fuels management, weed control, and fish and wildlife habitat restoration. Vegetation would be managed using five primary vegetation treatment methods - mechanical, manual, biological, chemical, and prescribed fire.

The BLM and its contractor, ENSR, are preparing a *Vegetation Treatments Programmatic Environmental Impact Statement* (EIS) to evaluate proposed vegetation treatment methods and alternatives on lands managed by the BLM in the western continental US and Alaska (USDI BLM 2005). As part of the EIS, several ERAs and a Human Health Risk Assessment (HHRA; ENSR 2005a) were conducted on several herbicides used, or proposed for use, by the BLM. These risk assessments evaluate potential risks to the environment and human health from exposure to these herbicides both during and after treatment of public lands. For the ERAs, the herbicide active ingredients evaluated were tebuthiuron, diuron, bromacil, chlorsulfuron, sulfometuron-methyl, diflufenzopyr, Overdrive® (a mix of dicamba and diflufenzopyr), imazapic, diquat, and fluridone. The HHRA evaluated the risks to humans from only six active ingredients (sulfometuron-methyl, imazapic, diflufenzopyr, dicamba, diquat, and fluridone) because the other active ingredients were already quantitatively evaluated in previous EISs (e.g., BLM 1991). [Note that in the HHRA, Overdrive® was evaluated as its two separate components, dicamba and diflufenzopyr, as these two active ingredients have different toxicological endpoints, indicating that their effects on human health are not additive.] The purpose of this document is to summarize results of the ERA for the herbicide diuron.

Updated risk assessment methods were developed for both the HHRA and ERA and are described in a separate document, *Vegetation Treatments Programmatic EIS ERA Methodology* (hereafter referred to as the "Methods Document;" ENSR 2005b). The methods document provides, in detail, specific information and assumptions used in three models utilized for this ERA (exposure point modeling using GLEAMS, AgDRIFT®, and CALPUFF).

1.1 Objectives of the Ecological Risk Assessment

The purpose of the ERA is to evaluate the ecological risks of ten herbicides on the health and welfare of plants and animals and their habitats, including threatened and endangered species. This analysis will be used by the BLM, in conjunction with analyses of other treatment effects on plants and animals, and effects of treatments on other resources, to determine which of the proposed treatment alternatives evaluated in the EIS should be used by the BLM. The BLM Field Offices will also utilize this ERA for guidance on the proper application of herbicides to ensure that impacts to plants and animals are minimized to the extent practical when treating vegetation. The US Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration Fisheries Service (NOAA Fisheries), in their preparation of a Biological Opinion (BO), will also use the information provided by the ERA to assess the potential impact of vegetation treatment actions on fish and wildlife and their critical habitats.

This ERA, which provides specific information regarding the use of the terrestrial herbicide diuron, contains the following sections:

Section 1: Introduction

Section 2: BLM Herbicide Program Description – This section contains information regarding herbicide formulation, mode of action, and specific BLM herbicide use, which includes application rates and methods of dispersal. This section also contains a summary of incident reports documented with the United States Environmental Protection Agency (USEPA).

Section 3: Herbicide Toxicology, Physical-Chemical Properties, and Environmental Fate – This section contains a summary of scientific literature pertaining to the toxicology and environmental fate of diuron in terrestrial and aquatic environments, and discusses how its physical-chemical properties are used in the risk assessment.

Section 4: Ecological Risk Assessment – This section describes the exposure pathways and scenarios and the assessment endpoints, including potential measured effects. It provides quantitative estimates of risks for several risk pathways and receptors.

Section 5: Sensitivity Analysis – This section describes the sensitivity of each of three models used for the ERA to specific input parameters. The importance of these conditions to exposure concentration estimates is discussed.

Section 6: Rare, Threatened, and Endangered Species (RTE) – This section identifies RTE species potentially directly and/or indirectly affected by the herbicide program. It also describes how the ERA can be used to evaluate potential risks to RTE species.

Section 7: Uncertainty in the Ecological Risk Assessment – This section describes data gaps and assumptions made during the risk assessment process and how uncertainty should be considered in interpreting results.

Section 8: Summary – This section provides a synopsis of the ecological receptor groups, application rates, and modes of exposure. This section also provides a summary of the factors that most influence exposure concentrations with general recommendations for risk reduction.

2.0 BLM HERBICIDE PROGRAM DESCRIPTION

2.1 Problem Description

One of the BLM's highest priorities is to promote ecosystem health, and one of the greatest obstacles to achieving this goal is the rapid expansion of weeds across public lands. These invasive plants can dominate and often cause permanent damage to natural plant communities. If not eradicated or controlled, noxious weeds will jeopardize the health of public lands and the myriad of activities that occur on them. The BLM's ability to respond effectively to the challenge of noxious weeds depends on the adequacy of the agency's resources.

Millions of ac of once healthy, productive rangelands, forestlands and riparian areas have been overrun by noxious or invasive weeds. Noxious weeds are any plant designated by a federal, state, or county government as injurious to public health, agriculture, recreation, wildlife, or property (Sheley et al. 1999). Invasive plants include not only noxious weeds, but also other plants that are not native to the region. The BLM considers plants invasive if they have been introduced into an environment where they did not evolve. Invasive plants usually have no natural enemies to limit their reproduction and spread (Westbrooks 1998). They invade recreation areas, BLM-managed public lands, National Parks, State Parks, roadsides, streambanks, federal, state, and private lands. Invasive weeds can:

- destroy wildlife habitat, reduce opportunities for hunting, fishing, camping and other recreational activities;
- displace RTE species and other species critical to ecosystem functioning (e..g, riparian plants);
- reduce plant and animal diversity;
- invade following wildland and prescribed fire (potentially into previously unaffected areas), limiting regeneration and establishment of native species and rapidly increasing acreage of infested land;
- increase fuel loads and decrease the length of fire cycles and/or increase the intensity of fires;
- disrupt waterfowl and neo-tropical migratory bird flight patterns and nesting habitats; and
- cost millions of dollars in treatment and loss of productivity to private land owners.

The BLM uses an Integrated Pest Management (IPM) approach to manage invasive plants. Management techniques may be biological, mechanical, chemical, or cultural. Many herbicides are currently used by the BLM under their chemical control program. This report considers the impact to ecological receptors (animals and plants) from the use of the herbicide diuron for the management of vegetation on BLM lands.

2.2 Herbicide Description

The herbicide-specific use-criteria discussed in this document were obtained from the product label as registered with the USEPA as it applies to BLM use. Diuron application rates and methods discussed in this section are based on past and predicted BLM herbicide use and are in accordance with herbicide labels approved by the USEPA. The BLM should be aware of all state-specific label requirements and restrictions. In addition, new USEPA approved herbicide labels may be issued after publication of this report, and BLM land managers should be aware of all newly approved federal, state, and local restrictions on herbicide use when planning vegetation management programs.

Diuron, a broad-spectrum herbicide, can be applied both pre- and post-emergence for use against broad-leaf weeds and annual grasses. The mechanism of activity associated with this a.i. is the disruption of photosynthesis by blocking electron transport and the transfer of light energy. Diuron is available in both liquid and dry formulations and is used by the BLM for vegetation control in their Energy & Mineral Sites, Rights-of-Way, and Recreation programs. . It is rarely, if ever, used near estuarine or marine habitats. The majority of the land treated by BLM with herbicides is inland. Ground applications are executed on foot or horseback with backpack sprayers or from all terrain vehicles or trucks equipped with spot or boom/broadcast sprayers. The application rate of diuron is typically 6.0 lbs (a.i./ac), with a maximum rate of 20.0 lbs (a.i./ac). Details regarding expected diuron usage by the BLM are provided in Table 2-1 at the end of this section.

2.3 Herbicide Incident Reports

An "ecological incident" occurs when non-target flora or fauna is killed or damaged due to application of a pesticide. When ecological incidents are reported to a state agency or other proper authority, they are investigated and an ecological incident report is generated. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) requires product registrants to report adverse effects of their product to the USEPA.

The USEPA OPP manages a database, the EIIS, which contains much of the information in the ecological incident reports. As part of this risk assessment, USEPA was requested to provide all available incident reports in the EIIS that listed diuron as a potential source of the observed ecological damage.

The USEPA EIIS contained 35 incident reports involving diuron. Seventeen of the 35 incidents involved the use of additional pesticides. Three incident reports indicated that it was "highly probable" that the use of diuron resulted in the observed effects. One of these three incidents (taking place in 1998) implicated the registered use of both diuron and bromacil in damage to grasses as a result of drift and runoff. Another incident (in 1997) implicated the misuse of both diuron and imazapic, which resulted in the mortality of birch and willow trees from drift and direct contact. In the third incident (occurring in 1975), runoff of diuron following accidental use is believed to have caused the mortality of 1000 fish. Additionally, the USEPA lists diuron as the "probable" cause in 13 incidents and the "possible" cause in 19 incidents. Effects range from unknown and partial dieback of flora to mortality of multiple species of fish. A summary of these incidents is provided in Table 2-2 at the end of this section.

TABLE 2-1
BLM Diuron Use Statistics

Program	Scenario	Vehicle	Method	Used?	Application Rate Typical (lbs a.i./ac)	Application Rate Maximum (lbs a.i./ac)
Rangeland	Aerial	Plane	Fixed Wing	No		
		Helicopter	Rotary	No		
	Ground	Human	Backpack	No		
			Horseback	No		
		ATV	Spot	No		
			Boom/Broadcast	No		
		Truck	Spot	No		
			Boom/Broadcast	No		
Public-Domain Forest Land	Aerial	Plane	Fixed Wing	No		
		Helicopter	Rotary	No		
	Ground	Human	Backpack	No		
			Horseback	No		
		ATV	Spot	No		
			Boom/Broadcast	No		
		Truck	Spot	No		
			Boom/Broadcast	No		
Energy & Mineral Sites	Aerial	Plane	Fixed Wing	No		
		Helicopter	Rotary	No		
	Ground	Human	Backpack	Yes	6.0	20.0
			Horseback	Yes	6.0	20.0
		ATV	Spot	Yes	6.0	20.0
			Boom/Broadcast	Yes	6.0	20.0
		Truck	Spot	Yes	6.0	20.0
			Boom/Broadcast	Yes	6.0	20.0
Rights-of-way	Aerial	Plane	Fixed Wing	No		
		Helicopter	Rotary	No		
	Ground	Human	Backpack	Yes	6.0	20.0
			Horseback	Yes	6.0	20.0
		ATV	Spot	Yes	6.0	20.0
			Boom/Broadcast	Yes	6.0	20.0
		Truck	Spot	Yes	6.0	20.0
			Boom/Broadcast	Yes	6.0	20.0
Recreation	Aerial	Plane	Fixed Wing	No		
		Helicopter	Rotary	No		
	Ground	Human	Backpack	Yes	6.0	20.0
			Horseback	Yes	6.0	20.0
		ATV	Spot	Yes	6.0	20.0
			Boom/Broadcast	Yes	6.0	20.0
		Truck	Spot	Yes	6.0	20.0
			Boom/Broadcast	Yes	6.0	20.0
Aquatic				No		

TABLE 2-2
Diuron Incident Report Summary

Year	Application Area	Incident Type	Diuron Certainty	Other[1]	Dispersal	Organism	Distance[2]	Magnitude of Damage
1972	Right-of-way	Undetermined	Possible	Yes	Drift	Tomato, Squash, Pepper	Vicinity	98 tomato, 6 squash, 70 pepper
1973	Right-of-way	Accident	Probable	Yes	Drift	Pumpkin, Cantaloupe, Watermelon, Peppers	125 yds	Plant damage
1975	Municipal Operation	Accident	Highly Probable	No	Runoff	Fish	Adjacent	Mortality - 1000
1982	NA	Undetermined	Probable	NA	NA	Bass, Bream	NA	Mortality - 20 Bass, 15 Bream
1992	Pond	Accident	Possible	No	Direct	Fish	0	Mortality - large numbers
1992	Fence Row	Undetermined	Probable	Yes	Drift	Birds/Fish	2-85'	NA
1993	Pond	Accident	Possible	No	Direct	Fish	0	Mortality - 250
1995	Pond	Accident	Possible	No	Direct	Unknown	0	Mortality - unknown
1995	Pond	Undetermined	Possible	No	Direct	Catfish	0	Mortality - unknown
1995	Pond	Accident	Possible	No	Direct	Unknown	0	Mortality - unknown
1995	Pond	Accident	Possible	No	Direct	Unknown	0	Mortality - unknown
1995	Pond	Intentional Misuse	Possible	No	Direct	Bass, Trout	0	Mortality - unknown
1996	Pond	Accident	Possible	No	Direct	Unknown	0	Mortality - Unknown
1996	Pond	Accident	Possible	No	Direct	Bass, Catfish, Bream	0	Mortality - unknown
1996	Pond	Intentional Misuse	Possible	No	Direct	Bass	0	Mortality - Hundreds
1996	Agricultural	Undetermined	Probable	No	Runoff	Bass, Catfish	Adjacent	Mortality - 6 Bass, 6 Catfish
1996	Agricultural	Undetermined	Probable	Yes		Fish	Adjacent	Mortality - 3000
1997	Driveway	Misuse	Highly Probable	Yes	Drift, Direct	Birch and Willow Trees	On site	Mortality
1997	Pond	Intentional Misuse	Possible	No	Direct	Bass, Bream, Catfish	0	Mortality - unknown
1997	Pond	Intentional Misuse	Possible	No	Direct	Bass, Catfish	0	Mortality - unknown
1997	Pond	Intentional Misuse	Possible	No	Direct	Catfish	0	Mortality - 12
1997	Pond	Undetermined	Possible	No	Direct	White perch	0	Mortality - 75
1997	Plant Site	Registered Use	Probable	Yes	Runoff	Oak	50'	3 partial dieback
1997	Utility Plant	Accident	Probable	Yes	Runoff	Grass, Bullrush	Adjacent	Unknown
1997	Agricultural	Accident	Probable	Yes	Runoff	Corn	Vicinity	Unknown
1997	Pond	Accident	Probable	No	Direct	Bass, Catfish, Bluegill	Adjacent	Mortality - several
1998	Home exterior	Registered Use	Highly Probable	Yes	Drift, Runoff	Grass	Adjacent	Plant damage
1998	Utility Plant	Registered Use	Possible	Yes	NA	Catfish	Adjacent	Some - Mortality

TABLE 2-2 (Cont.)
Diuron Incident Report Summary

Year	Application Area	Incident Type	Diuron Certainty	Other[1]	Dispersal	Organism	Distance[2]	Magnitude of Damage
1998	Right-of-way	Registered Use	Possible	Yes	Drift	Evergreen	NA	Unknown
1998	Yard	Registered Use	Probable	Yes	Runoff	Grass seed	Vicinity	NA
2002	Right-of-way	Undetermined	Possible	Yes	Drift	Sugar beet	Vicinity	10 ac. Plant damage
2002	Right-of-way	Registered Use	Possible	Yes	Runoff	Grass	Vicinity	Mortality - 1/3 of backyard
2002	Cotton	Misuse	Probable	Yes	Drift	Lettuce	NA	Plant damage - 50 ac
NA	Pasture	Accident	Probable	Yes	NA	Alfalfa, Oats, Hay	Adjacent	Mortality - part of 3 ac
NA	Driveway	Intentional Misuse	Probable	Yes	Drift	Willow, Spruce	NA	Mortality - Unknown

(1) Other = other chemicals used in conjunction with diuron (yes/no)
(2) Distance = estimated distance from application area
NA = information not available

3.0 HERBICIDE TOXICOLOGY, PHYSICAL-CHEMICAL PROPERTIES, AND ENVIRONMENTAL FATE

This section summarizes available herbicide toxicology information, describes how this information was obtained, and provides a basis for the LOC values selected for this risk assessment. Diuron's physical-chemical properties and environmental fate are also discussed.

3.1 Herbicide Toxicology

A review of the available ecotoxicological literature was conducted in order to evaluate the potential for diuron to negatively effect the environment and to derive TRVs for use in the ERA (provided in italics in sections 3.1.2 and 3.1.3). The process for the literature review and the TRV derivation is provided in the Methods Document (ENSR 2005b). This review generally included a review of published manuscripts and registration documents, information obtained through a Freedom of Information Act (FOIA) request to EPA, electronic databases (e.g., EPA pesticide ecotoxicology database, EPA's on-line ECOTOX database), and other internet sources. This review included both freshwater and marine/estuarine data, although the focus of the review was on the freshwater habitats more likely to occur on BLM lands.

Endpoints for aquatic receptors and terrestrial plants were reported based on exposure concentrations (mg/L and lbs/ac, respectively). Dose-based endpoints (e.g., LD_{50}s) were used for birds and mammals. When possible, dose-based endpoints were obtained directly from the literature. When dosages were not reported, dietary concentration data were converted to dose-based values (e.g., LC_{50} to LD_{50}) following the methodology recommended in USEPA risk assessment guidelines (Sample et al. 1996). Acute TRVs were derived first to provide an upper boundary for the remaining TRVs; chronic TRVs were always equivalent to, or less than, the acute TRV. The chronic TRV was established as the highest NOAEL value that was less than both the chronic Lowest Observed Adverse Effect Level (LOAEL) and the acute TRV. When acute or chronic toxicity data was unavailable, TRVs were extrapolated from other relevant data using an uncertainty factor of 3, as described in the Methods Document (ENSR 2005b).

This section reviews the available information identified for diuron and presents the TRVs selected for this risk assessment (Table 3-1). Appendix A presents a summary of the diuron data identified during the literature review. Toxicity data are presented in the units used in the reviewed study. In most cases this applies to the a.i. itself (e.g., diuron); however, some data correspond to a specific product or applied mixture (e.g., Karmex) containing the a.i. under consideration, and potentially other ingredients (e.g., other active ingredients or inert ingredients). This topic, and others related to the availability of toxicity data, is discussed in Section 7.1 of the Uncertainty section. The review of the toxicity data did not focus on the potential toxic effects of inert ingredients (inerts), adjuvants, surfactants, and degradates. Section 7.3 of the Uncertainty section discusses the potential impacts of these constituents in a qualitative manner.

3.1.1 Overview

According to USEPA ecotoxicity classifications presented in registration materials[1], diuron is not highly toxic to most terrestrial species. In mammals, diuron is considered to have low acute oral and dermal toxicity. Adverse effects have been demonstrated in mammals from long term exposure to diuron in the diet. Diuron is slightly toxic to birds and

[1] Available at http://www.epa.gov/oppefed1/ecorisk_ders/toera_analysis_eco.htm#Ecotox

essentially non-toxic to honeybees. For terrestrial plants, vegetative vigor was the most sensitive indicator of plant toxicity. Significant adverse effects were noted in non-target plant species after 14 days exposure to concentrations as low as 0.08 lb (a.i./ac).

Diuron is classified as moderately toxic to fish and highly toxic to aquatic plants and aquatic invertebrates. Toxicity tests indicate that diuron is toxic to fish species at concentrations as low as 0.71 milligram per liter (mg/L). Diuron has a low to moderate potential for bioconcentration in fish tissue. Amphibians were less sensitive to diuron than any other aquatic taxa. Aquatic invertebrates were affected by diuron concentrations of 0.16 mg/L. Aquatic plants were affected at concentrations as low as 0.0013 mg./L (about 0.02 percent of the typical application rate).

3.1.2 Toxicity to Terrestrial Organisms

3.1.2.1 Mammals

As part of the pesticide reregistration process, several mammalian toxicological studies are required. Oral doses of diuron to male and female rats (*Rattus* spp.) resulted in LD_{50}s of 1,258 mg a.i./kilogram (kg) body weight (BW) in males and 1,182 mg a.i./kg BW in females (Gaines and Linder 1986). The reregistration reports summarized several acute oral toxicity studies conducted in small mammals. These studies found acute exposure to diuron caused adverse effects at oral doses of 1,017 mg a.i./kg BW (PIP 1993). Acute dermal exposure studies found no adverse effects to mammals exposed to 2,500 mg a.i./kg BW (Gaines and Linder 1986). However, diuron caused adverse effects in subchronic oral studies when animals were dosed during pregnancy. Fetal toxicity (bone deformities) occurred in rats exposed daily oral doses of 250 mg a.i./kg BW-day during pregnancy, while no toxic effects were reported at 125 mg a.i./kg BW-day (PIP 1996). Because fairly large single doses of diuron are required before adverse effects are noted, diuron is considered to have low acute toxicity to mammals.

In chronic dietary studies, rats fed 500 parts per million (ppm) (25 mg a.i./kg BW-day) of diuron exhibited adverse effects after 3 months of exposure, while no adverse effects were observed in rats fed 50 ppm (2.5 mg a.i./kg BW-day; Integrated Risk Information System [IRIS] 2003, Master Record Identification number [MRID] 00068036). In a longer feeding trail, rats exposed to diuron for three generations showed adverse effects (decreased pup weight) when dietary concentrations were 125 ppm (equivalent to 6.25 mg a.i./kg BW-day; IRIS 2003, MRID 00017763 and MRID 00080899).

Based on these findings, the oral LD_{50} (death of 50 percent of the test organisms; 1,017 mg a.i./kg BW) and chronic dietary NOAEL (2.5 mg a.i./kg BW-day) were selected as the dietary small mammal TRVs. The dermal small mammal TRV was established at >2,500 mg a.i./kg BW.

Data for large mammals is limited to a single study. In a two-year feeding trial, systemic effects were observed in beagle dogs (*Canis familiaris*) fed 125 ppm (equivalent to 3.125 mg a.i./kg BW-day) (IRIS 2003, MRID 00017763 and MRID 0091192). No adverse effects were observed in dogs fed 25 ppm (equivalent to 0.625 mg a.i./kg BW-day).

Since no large mammal LD_{50}s were identified in the available literature, the small mammal acute LD_{50} (1,017 mg a.i./kg BW) was used as a surrogate value. The large mammal dietary chronic NOAEL TRV was established at 0.6 mg a.i./kg BW-day.

3.1.2.2 Birds

The USEPA pesticide registration process also requires information related to avian exposure to diuron. While no adverse effects were observed in mallards (*Anas platyrhynchos*) acutely dosed with 2,000 mg/kg BW-day of a 95% diuron product (USEPA 2003a, MRID 00160000), 50 percent of the bobwhite quail (*Colinus virginianus*) dosed with 940 mg/kg BW in water died when exposed to a 92.8% diuron product (USEPA 2003a, MRID 50150170). In this same study, bobwhite quail also exhibited adverse effects when administered dose levels of 292 mg/kg BW in water, the lowest dose tested. Dietary studies documented adverse effects in large and small birds fed diets containing 1,730 ppm diuron in 8 day studies (equivalent to 173 and 1,045 mg/kg BW-day in mallards and bobwhite quail, respectively) (USEPA no date, MRID 00022923; USEPA 2003a, MRID 00022923). In these dietary tests, the test organism was presented with the dosed food for 5 days, with 3 days of additional observations after the dosed food was removed. The endpoint reported for this assay is generally an LC_{50} representing mg/kg food. This concentration-based value was converted to a dose-based value following the methodology presented in the Methods Document (ENSR 2005b). Then the dose-based value was multiplied by the number of days of exposure (generally 5) to result in an LD_{50} value representing the full herbicide exposure over the course of the test. This resulted in LD_{50} values of 5,225 mg/kg BW and 865 mg/kg BW for the bobwhite quail and mallard, respectively.

Based on these findings, the bobwhite quail dietary LD_{50} (5,225 mg/kg BW-day) and the mallard dietary LD_{50} (865 mg/kg BW-day) were selected as the small and large bird dietary TRVs. Since no chronic dietary data were available, the acute LD_{50}s were divided by an uncertainty factor of 3 to derive NOAEL TRVs of 348 and 58 mg /kg BW-day for small and large birds, respectively (based on the dietary concentrations converted to daily doses of 1,045 and 173 mg/kg BW-day). This uncertainty factor was selected based on a review of the application of uncertainty factors (Chapman et al. 1998), and the use of uncertainty factors for this assessment is described in the Methods Document (ENSR 2005b). These NOAEL TRVS are highly conservative since they are based on short term, not chronic, dietary studies.

3.1.2.3 Terrestrial Invertebrates

A standard acute contact toxicity bioassay in honeybees is required for the USEPA pesticide registration process. In this study, technical grade diuron was directly applied to the bee's thorax and mortality was assessed during a 48-hr period. The USEPA reports an LD_{50} of 145.03 µg/bee (USEPA no date, MRID 00036935).

The honeybee dermal LD_{50} TRV was set at 145.03µg/bee. Based on a honeybee weight of 0.093 g, this TRV was expressed as 1,560 mg/kg BW.

3.1.2.4 Terrestrial Plants

Toxicity tests were conducted on numerous, non-target plant species (tests were performed only on vegetable crop species and not western rangeland or forest species; USEPA 1996, 2003). Endpoints in the terrestrial plant toxicity tests were generally related to seed germination, seed emergence, and sub-lethal (i.e. growth) impacts observed during vegetative vigor assays. While no studies evaluated germination as an endpoint, seed emergence and vegetative vigor were examined. Seed emergence studies were conducted by applying the herbicide to soil containing newly sown seed. Tomato (*Lycopersicon esculentum*) plants were the most sensitive species tested, with adverse effects to 25% of the plants (i.e., the Effect Concentration [EC_{25}]) occurring in 14-days of exposure to concentrations of 0.08 lb a.i./ac (USEPA 2003a, MRID 44113401). No adverse effects on tomatoes were reported at concentrations of 0.047 lb a.i./ac. Seed emergence NOAEL values for various non-target species ranged from 0.047 to 12 lb a.i./ac (USEPA 2003a, MRID 44113401). Compared to seed emergence, vigor was a more sensitive indicator of toxicity, with EC_{50} (i.e., the concentration that causes adverse effects to 50 % of the plants) values as low as 0.002 lb a.i./ac for tomatoes. The no observed adverse effect concentration for vegetative vigor was 0.001 lb a.i./ac (USEPA 2003a, MRID 44113401).

In accordance with the Methods Document (ENSR 2005b), the lowest and highest germination-based NOAELs were selected to evaluate risk in surface runoff scenarios. Since germination data were not available for diuron, the emergence TRVs of 0.047 and 12 lb a.i./ac were selected instead. Two additional endpoints were used to evaluate other plant scenarios. These included a seed emergence EC_{25} of 0.08 lb a.i./ac and a vegetative vigor NOAEL of 0.001 lb a.i./ac.

3.1.3 Toxicity to Aquatic Organisms

3.1.3.1 Fish

The effects of diuron were examined in both cold- and warmwater fish species. In acute toxicity tests with a 95% diuron product, the 96-hour LC_{50} values were 0.71 mg/L and 2.8 mg/L for cold- and warmwater fish, respectively (USEPA 2003a, MRID 40098001). Chronic exposure of fathead minnow (*Pimephales promelas*) larvae for 64 days showed adverse impacts on survival at concentrations of 0.078 mg a.i./L, while the no observed adverse effect concentration was 0.033 mg a.i./L (Call et al. 1987). Consequently, the USEPA classifies diuron as moderately toxic to fish. No chronic toxicity tests with cold-water fish were identified.

The lower of the cold- and warmwater fish endpoints were selected as the TRVs for fish. Therefore the coldwater 96-hour LC_{50} of 0.71 mg/L was selected as the acute TRV, and the warmwater fish NOAEL of 0.033 mg a.i./L was used as the TRV for chronic effects.

Based on diuron's octanol-water coefficient (K_{ow}) and regression equations, the bioconcentration factor (BCF) was estimated to be 64. Common carp exposed for 6 weeks to diuron had experimental BCF values ranging from 3.4 to 4.9 (0.5 mg/L exposure) and from <3 to 74 (0.05 mg/L exposure) (HSDB 2003). Consequently the bioconcentration potential for diuron was considered low to moderate.

3.1.3.2 Amphibians

Numerous toxicity tests were conducted on various amphibian species with a 99.8% diuron product. Toxicity was observed after 21 days in amphibians exposed to diuron concentrations of 12.7 mg/L (Schuytema and Nebeker 1998). In chronic toxicity tests, adverse effects on growth were observed at concentrations of 14.5 mg/L, with no effects observed at 7.6 mg/L (Schuytema and Nebeker 1998).

The LC_{50} (12.7 mg./L) was selected as an amphibian acute TRV and the NOAEL (7.6 mg/L) was selected as the chronic TRV.

3.1.3.3 Aquatic Invertebrates

Diuron is considered to have relatively high toxicity to aquatic invertebrates. In 96-hour aquatic toxicity tests, acute toxicity was observed in aquatic invertebrates exposed to concentrations as low as 0.16 mg/L using a 95% diuron product (USEPA 2003a, MRID 40094602). Chronic studies were also conducted with several species of aquatic invertebrates (e.g., amphipod, midge, water fleas [*Daphnia magna*]) with no effect levels as high as 13.4 mg a.i./L (Schuytema and Nebeker 1998).

The LC_{50} (0.16 mg/L) was selected as the invertebrate acute TRV. Since none of the observed chronic NOAEL values were below the selected acute TRV, the chronic LOAEL from a 28 day daphnid assay (0.2 mg/L using a 98% diuron product; USEPA 2003a) was divided by an uncertainty factor of 3 to estimate a chronic NOAEL TRV of 0.067 mg a.i./L.

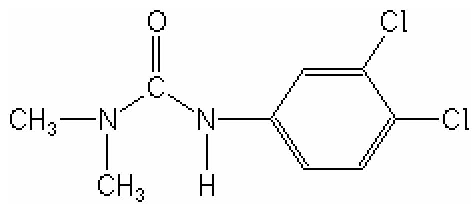
3.1.4 Aquatic Plants

Standard toxicity tests were conducted on aquatic plants, including aquatic macrophytes, algae, and diatoms. Diuron was most toxic to green algae. In studies with green algae, adverse effects to 50 percent of the algae were observed at concentrations of 0.0013 mg/L (reduced growth; Ma et al. 2001). The no observed adverse effect concentrations ranged from 0.00044 mg/L using a 96.8% diuron product to 0.01 mg/L using a 95% diuron product (USEPA 2003a, MRID 42218401; Schafer et al. 1994).

The EC_{50} (0.0013 mg/L) was selected as the aquatic plant acute TRV and the NOAEL (0.00044 mg/L) was selected as the chronic TRV.

3.2 Herbicide Physical-Chemical Properties

The chemical formula for diuron is 3-(3,4-dichlorophenyl)-1,1-dimethylurea. The chemical structure of diuron is shown below:



Diuron Chemical Structure

The physical-chemical properties and degradation rates critical to diuron's environmental fate are listed in Table 3-2 which presents the range of values encountered in the literature for these parameters. To complete Table 3-2, available USEPA literature on diuron was obtained either from the Internet or through a FOIA request. Herbicide information that had not been cleared of Confidential Business Information (CBI) was not provided by USEPA as part of the FOIA documents. Additional sources, both on-line and in print, were consulted for information about the herbicide:

- The British Crop Protection Council and the Royal Society of Chemistry. 1994. The Pesticide Manual Incorporating the Agrochemicals Handbook. Tenth Edition. 1994. Surrey and Cambridge, United Kingdom.
- Compendium of Pesticide Common Names. 2003. A website listing all International Organization for Standardization (ISO)-approved names of chemical pesticides. Available at: http://www.hclrss.demon.co.uk.
- California Department of Pesticide Registration (DPR.). 2003. USEPA/OPP Pesticide Related Database. Updated weekly. Available at: http://www.cdpr.ca.gov/docs/epa/epamenu.htm.
- Hazardous Substances Data Bank (HSDB). A toxicology data file on the National Library of Medicines Toxicology Data Network (TOXNET). Available at: http://toxnet.nlm.nih.gov.
- Hornsby, A., R. Wauchope, and A. Herner. 1996. Pesticide Properties in the Environment. Springer-Verlag, New York.
- Howard, P (ed.). 1991. Handbook of Physical Properties of Organic Chemicals. CRC Lewis Publishers. Boca Raton. Florida.
- Mackay, D., S. Wan-Ying, and M. Kuo-ching. 1997. Handbook of Environmental Fate and Exposure Data for Organic Chemicals. Volume III. Pesticides Lewis Publishers, Chelsea, Minnesota.
- Montgomery, J.H. (ed.). 1997. Illustrated Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals. Volume V. Pesticide Chemicals. Lewis Publishers, Boca Raton, Florida.
- Tomlin, C (ed.). 1994. The Agrochemicals Desk Reference 2nd Edition. Lewis Publishers, Boca Raton, Florida.

The half-life in pond water was estimated using the physical-chemical properties listed in Table 3-2 and the information reviewed concerning the environmental fate of diuron in aquatic systems. Values for foliar half-life and foliar washoff fraction were obtained from a database included in the GLEAMS computer model (United States

Department of Agriculture; USDA 1999). Residue rates were obtained from the Kenaga nomogram, as updated (Fletcher et al. 1994). Values selected for use in risk assessment calculations are shown in bold in Table 3-2.

3.3 Herbicide Environmental Fate

Diuron is a persistent chemical in the environment (Howard 1991; USEPA 2001a). In terrestrial systems, biodegradation appears to be the primary loss mechanism (USEPA 2001a; Table 3-2). Biodegradation occurs faster in aerobic soils (half-life 372 days) than under anaerobic soil conditions (half-life 1000 days) (USEPA 2001a). The K_{oc}, or organic carbon-water partitioning coefficient, measures the affinity of a chemical to organic carbon relative to water. The higher the K_{oc}, the less soluble in water and the higher affinity for organic carbon, an important constituent of soil particles. Therefore, the higher the K_{oc}, the less mobile the chemical. The estimated mobility range of diuron is wide, with K_{oc} values ranging from 15 to 1666; although, most K_{oc} values were greater than 100. The wide range of K_{oc} values indicates that, under a variety of conditions, diuron could have very high to low mobility in soils (Swann et al. 1983; Table 3-2). Diuron is stable to hydrolysis, and based on its Henry's Law constant (the ratio of the chemical's distribution at equilibrium between the gas and liquid phases), it is unlikely to volatilize from wet soils (Lyman et al. 1990; Mackay et al. 1997; USEPA 2001a). Field half-lives reported for diuron range from 73 to over 330 days (Table 3-2).

In aquatic systems, biodegradation and photodegradation appear to be the primary loss mechanisms for diuron. An aquatic biodegradation half-life of 33 days has been reported for aerobic systems, and an aquatic half-life of 5 days has been reported for anaerobic systems (USEPA 2001a). An aquatic photodegradation half-life of 43 days has been estimated from laboratory experiments (USEPA 2001a). As in terrestrial systems, diuron is stable to hydrolysis, and based on the Henry's Law constant, it is also unlikely to volatilize from aquatic systems (USEPA 2001a; Mackay et al. 1997; Lyman et al. 1990). Based on reported BCFs of <1 to 74, diuron has a low to moderate tendency to bioaccumulate in aquatic organisms (Franke et al. 1994; Mackay et al. 1997; HSDB 2003). Aquatic dissipation half-lives have been reported ranging from 3 to 10 days in anaerobic pond sediment to 177 days in a drainage ditch (Table 3-2).

TABLE 3-1
Selected Toxicity Reference Values for Diuron

Receptor	Selected TRV	Units	Duration	Endpoint	Species	Notes
RECEPTORS INCLUDED IN FOOD WEB MODEL						
Terrestrial Animals						
Honeybee	145.03	µg/bee	48 h	LD_{50}		technical grade; no % a.i. listed
Large bird	865	mg/kg bw	8 d	LD_{50}	mallard	no % a.i. listed
Large bird	58	mg/kg bw-day	8 d	NOAEL	mallard	no % a.i. listed; extrapolated from LD_{50}
Large mammal	1017	mg a.i./kg bw	NR	LD_{50}	rat	small mammal value
Large mammal	0.6	mg a.i./kg bw-day	2 y	NOAEL	dog	
Piscivorous bird	58	mg/kg bw-day	8 d	NOAEL	mallard	no % a.i. listed; extrapolated from LD_{50}
Small bird	5225	mg/kg bw	8 d	LD_{50}	bobwhite quail	no % a.i. listed
Small bird	348	mg/kg bw-day	8 d	NOAEL	bobwhite quail	no % a.i. listed; extrapolated from LD_{50}
Small mammal	2.5	mg a.i./kg bw-day	3 m	NOAEL	rat	
Small mammal - dermal	> 2500	mg a.i./kg bw	> 14 d	LD_{50}	unknown	
Small mammal - ingestion	1017	mg a.i./kg bw	NR	LD_{50}	rat	water exposure; no diet available
Terrestrial Plants						
Typical species - direct spray, drift, dust	0.08	lb a.i./ac	NR	EC_{25}	tomato	based on seed emergence
RTE species - direct spray, drift, dust	0.001	lb a.i./ac	21 d	NOAEL		vigor
Typical species – runoff	12	lb a.i./ac	14 d	NOAEL	garden pea; soybean	based on seed emergence
RTE species - runoff	0.047	lb a.i./ac	NR	NOAEL	tomato	based on seed emergence
Aquatic Species						
Aquatic invertebrates	0.16	mg/L	96 h	EC_{50}	scud (*Gammarus*)	95% a.i. product
Fish	0.71	mg/L	96 h	LC_{50}	cutthroat trout	95% a.i. product
Aquatic plants and algae	0.0013	mg/L	NR	EC_{50}	*Chlorella pyrenoidosa* (algae)	no % a.i. listed
Aquatic invertebrates	0.067	mg/L	28 d	NOAEL	daphnid	98% a.i. product; extrapolated from chronic LOAEL
Fish	0.033	mg/L	chronic	NOAEL	fathead minnow	98.6% a.i. product
Aquatic plants and algae	0.00044	mg/L	96 h	NOAEL	*Selenastrum* (algae)	98.6% a.i. product

TABLE 3-1 (Cont.)
Selected Toxicity Reference Values for Diuron

Receptor	Selected TRV	Units	Duration	Endpoint	Species	Notes
ADDITIONAL ENDPOINTS						
Amphibian	12.7	mg/L	21 d	LC_{50}	bullfrog	99.8% a.i. product
Amphibian	7.6	mg/L	21 d	NOAEL	bullfrog	99.8% a.i. product
Warmwater fish	2.8	mg/L	96 h	LC_{50}	bluegill sunfish	95% a.i. product
Warmwater fish	0.03	mg/L	chronic	NOAEL	fathead minnow	98.6% a.i. product
Coldwater fish	0.71	mg/L	96 h	LC_{50}	cutthroat trout	95% a.i. product
Coldwater fish	0.24	mg/L	96 h	NOAEL	cutthroat trout	95% a.i. product; extrapolated from LC50

Notes:

Toxicity endpoints for terrestrial animals
LD_{50} - to address acute exposure.
NOAEL - to address chronic exposure.
Toxicity endpoints for terrestrial plants
EC_{25} - to address direct spray, drift, and dust impacts on typical species.
EC_{05} or NOAEL - to address direct spray, drift, and dust impacts on threatened or endangered species.
Highest germination NOAEL - to address surface runoff impacts on typical species.
Lowest germination NOAEL - to address surface runoff impacts on threatened or endangered species.
Toxicity endpoints for aquatic receptors
LC_{50} or EC_{50} - to address acute exposure (appropriate toxicity endpoint for non-target aquatic plants will be an EC_{50}).
NOAEL - to address chronic exposure.
Value for fish is the lower of the warmwater and coldwater values.

Units represent those presented in the reviewed study.
Piscivorous bird TRV = Large bird chronic TRV
Fish TRV = lower of coldwater and warm water fish TRVs
Durations:
h – hours
d – days
w – weeks
m – months
y – years
NR – Not reported

TABLE 3-2
Physical-Chemical Properties of Diuron

Parameter	Value
Herbicide family	Phenylurea herbicide (Compendium of Pesticide Common Names 2003).
Mode of action	Disrupts plant photosynthesis (USEPA 2001a).
Chemical Abstract Service number	330-54-1 (USEPA 2001b).
Office of Pesticide Programs chemical code	035505 (DPR 2003).
Chemical class	Phenylurea herbicide (Compendium of Pesticide Common Names 2003).
Chemical name	3-(3,4-dichlorophenyl)-1,1-dimethylurea (International Union of Pure and Applied Chemistry [IUPAC]; Tomlin 1994).
Empirical formula	$C_9H_{10}Cl_2N_2O$ (USEPA 2001b).
Molecular weight (MW)	**233.1** (USEPA 2001b).
Appearance, ambient conditions	White crystal (USEPA 2001b).
Acid / Base properties	-1 to -2 (pKa) (Mackay et al. 1997).
Vapor pressure (millimeters of mercury [mmHg] at 25ºC)	2 x 10^{-7} (30ºC) (USEPA 2001b; Montgomery 1997); 6.9 x 10^{-7} (Mackay et al. 1997); 6.9 x 10^{-8} (HSDB 2003; Hornsby et al. 1996); 2.7 x 10^{-6} (Howard 1991); 8.2 x 10^{-9} (Tomlin 1994).
Water solubility (mg/L at 25ºC)	**42** (USEPA 2001b; Tomlin 1994; Hornsby et al. 1996); 40.0 (Mackay et al. 1997; Montgomery 1997); 36.4 (HSDB 2003); 37.3 (Howard 1991).
Log Octanol-water partition coefficient (log K_{OW}, unitless)	**2.68** (USEPA 2001b); 2.78 (Mackay et al. 1997); 2.84 (Tomlin 1994); 2.58 (Montgomery 1997).
Henry's law constant (atm-m^3/mole)	6.74 x 10^{-9} (Mackay et al. 1997).
Soil / Organic matter sorption coefficient (Kd / K_{oc})[1]	Chino loam (1.4% organic matter): 14 (Kd-Freundlich) 1666 (K_{oc}), Barclay silty clay loam: 7.9 (Kd-Freundlich) 468 (K_{oc}), Keyport silt loam (7.7% organic matter): 28 (Kd-Freundlich) 626 (K_{OC}) (USEPA 2001a); All values log(K_{oc}) unless specified: 2.6, 2.59 (three soil average), 2.15-2.52, 1.97 (log(Kom)), 2.58 (average 84 soils), 2.18, 2.83 (Webster soil), 2.49, 2.35, 2.57 (two OK subsurface soils), 2.94 (mucky peat), 2.68 (loam sand), 2.18, 2.48-2.49, **2.59**, 2.66, 2.68, 2.21-2.87 (Mackay et al. 1997); All K_{oc} values: 68-266 (range for aquifer sediments), 383 (average for 84 soils, standard deviation 38), 682 (Webster soil); 879 (mucky peat soil), 478 (loamy sand soil), 224 and 371 (two OK subsurface soils), 480 (HSDB 2003); 480 (K_{oc}) (Hornsby et al. 1996); 2.21-2.87 (log(K_{oc})) (Montgomery 1997); 93 K_{oc} values from various studies, K_{oc} range: 15 - 1377, average: 399 (log K_{oc} = 2.60), standard deviation: 278 (Montgomery 1997).
Bioconcentration factor (BCF)	2.16 (log(BCF), *Pimephales promelas*), 1.40 (log(BCF), species not specified) (Mackay et al. 1997); BCF values of 3.4 - 4.9 (0.5 mg diuron/L) and < 3 - **74** (0.05 mg diuron/L) were obtained from carp (*Cyprinus carpio*) after six week exposure (HSDB 2003).
Field dissipation half-life	Diuron (12 lb a.i./ac) applied once to bare ground plots in FL, MS, and CA with sand, silt loam, and silty clay loam soils, respectively. Half-lives were 73, 139, and 133 days respectively. (USEPA 2001a); 328 days, 90 days (Mackay et al. 1997; Hornsby et al. 1996). At higher application levels, diuron persisted in WY soils, under various irrigation methods, for over 15 months; mean half-life of approximately 330 days and will not leach below 5 to 10 centimeters (cm) from the surface; mean half-life 328 days with a standard deviation of 212 days (HSDB 2003).
Soil dissipation half-life[2]	7.0 months (15ºC), 5.5 months (30ºC), Adkins loamy sand: 705 days (25ºC), 414 days (30ºC), 225 days (35ºC); Seminahoo mucky peat: 3991 days (25ºC), 2164 days (30ºC), 1165 days (35ºC). (Mackay et al. 1997).

TABLE 3-2 (Cont.)
Physical-Chemical Properties of Diuron

Parameter	Value
Aquatic dissipation half-life	Diuron applied (12 lb a.i,/ac) once onto bare ground berm and slope of a channel plot of clay soil in CA and into a drainage ditch of silt loam soil in AK dissipated with half-lives of 177 days and 115 days, respectively. In CA study, calculated sediment half-life, 18.6 hours (USEPA 2001a; USEPA 2003b). In a fish pond, 90% of diuron in sediment was lost in 8 months (Howard 1991). Aerobic, organic rich pond sediment, degraded 90% of applied diuron (40 µg/ml) in 55 (25ºC) and 17 (30ºC) days (Montgomery 1997); 3-10 days (half-life, anaerobic pond sediment, 30ºC), < 17 days (half-life, pond sediment, 30ºC), ~5 days for 0.22 µg/ml to degrade (anaerobic, pond sediment) (Mackay et al. 1997).
Hydrolysis half-life	Stable to hydrolysis at pH 5, 7, and 9 (25ºC). Estimated half-life, > 500 days for all pH values (USEPA 2001a); > 120 days (half-life, pH 5-9, 20ºC) (Mackay et al. 1997).
Photodegradation half-life in water	Estimated half-life in sunlight, 43 days, based on observed 9 day half-life under continuous exposure to Xenon light. (USEPA 2001a); 2.25 hours (half-life, distilled water, 300 nm light) (Mackay et al. 1997), From a solution of 40 mg/L diuron, 42% loss in 1 hour under sunlamps and 45% loss in 25 days in natural sunlight, 84% lost from diuron solution in 135 minutes when exposed to 300 nm sunlamps at 50ºC (HSDB 2003).
Photodegradation half-life in soil	Estimated half-life, 173 days, based on degradation observed in a silt loam soil irradiated for 12 hours per day for 30 days (USEPA 2001a).
Soil biodegradation half-life	**372 days**[3] (aerobic), 1,000 days (anaerobic). Both experiments at 25ºC in a silt loam soil. (USEPA 2001a). Biodegradation in soil increased with increasing temperature and decreasing initial concentration; less than 20% of diuron (60 mg/kg) added to soil was detoxified within eight weeks, and pH (4.3 to 7.5) had little effect on the degradation rate (HSDB 2003).
Aquatic biodegradation half-life	33 days (aerobic half-life), 5 days (anaerobic half-life). Both experiments at 25ºC in a clay loam sediment (USEPA 2001a).
Other degradation rates / half-lives	Calculated volatilization half-lives from soil, 54 days and 1918 days (Mackay et al. 1997).
Foliar half-life	**30 days** (USDA 1999).
Foliar wash-off fraction	**0.45** (USDA 1999).
Half-life in pond[4]	**33 days** (estimated from herbicide's environmental behavior and values in this table).
Residue Rate for grass[5]	**197 ppm** (maximum) and **36 ppm** (typical) per lb a.i./ac
Residue Rate for vegetation[6]	**296 ppm** (maximum) and **35 ppm** (typical)
Residue Rate for insects[7]	**350 ppm** (maximum) and **45 ppm** (typical)
Residue Rate for berries[8]	**40.7 ppm** (maximum) and **5.4 ppm** (typical)

Notes:
Values presented in bold were used in risk assessment calculations.
(1) K_{oc} value used in risk assessment calculations was value selected by Mackay et al. (1997) for use in contaminant fate models. This K_{oc} value close to median K_{oc} value of 115 K_{oc}'s reported in Hornsby et al. (1996), Mackay et al. (1997), Montgomery (1997), and USEPA (2001a).
(2) Some studies listed in this category may have been performed under field conditions, but insufficient information was provided in the source material to make this determination.
(3) Value used for soil half-life in risk assessment calculations.
(4) Used in risk assessments to calculate aqueous herbicide concentration in pond water that receives herbicide-laden runoff.
(5) Residue rates selected are the high and mean values for long grass (Fletcher et al. 1994).
(6) Residue rates selected are the high and mean values for leaves and leafy crops (Fletcher et al. 1994).
(7) Residue rates selected are the high and mean values for forage such as legumes (Fletcher et al. 1994).
(8) Residue rates selected are the high and mean values for fruit (includes both woody and herbaceous; Fletcher et al. (1994).

4.0 ECOLOGICAL RISK ASSESSMENT

This section presents a screening-level evaluation of the risks to ecological receptors from potential exposure to the herbicide diuron. The general approach and analytical methods for conducting the diuron ERA were based on USEPA's Guidelines for ERA (hereafter referred to as the "Guidelines;" USEPA 1998).

The ERA is a structured evaluation of all currently available scientific data (exposure chemistry, fate and transport, toxicity, etc.) that leads to quantitative estimates of risk from environmental stressors to non-human organisms and ecosystems. The current Guidelines for conducting ERAs include three primary phases: problem formulation, analysis, and risk characterization. These phases are discussed in detail in the Methods Document (ENSR 2005b) and briefly in the following sub-sections.

4.1 Problem Formulation

Problem formulation is the initial step of the standard ERA process and provides the basis for decisions regarding the scope and objectives of the evaluation. The problem formulation phase for diuron assessment included:

- definition of risk assessment objectives;
- ecological characterization;
- exposure pathway evaluation;
- definition of data evaluated in the ERA;
- identification of risk characterization endpoints; and
- development of the CM.

4.1.1 Definition of Risk Assessment Objectives

The primary objective of this ERA was to evaluate the potential ecological risks from diuron to the health and welfare of plants and animals and their habitats. This analysis is part of the process used by the BLM to determine which of the proposed treatment alternatives evaluated in the EIS should be used on BLM-managed lands.

An additional goal of this process was to provide risk managers with a tool that develops a range of generic risk estimates that vary as a function of site conditions. This tool primarily consists of Excel spreadsheets (presented in the ERA Worksheets; Appendix B), which may be used to calculate exposure concentrations and evaluate potential risks in the risk assessment. A number of the variables included in the worksheets can be modified by BLM land managers for future evaluations.

4.1.2 Ecological Characterization

As described in Section 2.2, diuron is used by the BLM for vegetation management in their Energy & Mineral Sites, Rights-of-Way, and Recreation programs. The proposed BLM program involves the general use and application of herbicides on public lands in 17 western states in the continental US and Alaska. These applications have the potential to occur in a wide variety of ecological habitats that could include: deserts, forests, and prairie land. It is not feasible to characterize all of the potential habitats within this report; however, this ERA was designed to address generic receptors, including RTE species (see Section 6.0) that could occur within a variety of habitats.

4.1.3 Exposure Pathway Evaluation

The following ecological receptor groups were evaluated:

- terrestrial animals;
- non-target terrestrial plants; and
- aquatic species (fish, invertebrates, and non-target aquatic plants).

These groups of receptor species were selected for evaluation because they: 1) are potentially exposed to herbicides within BLM management areas; 2) are likely to play key roles in site ecosystems; 3) have complex life cycles; 4) represent a range of trophic levels; and 5) are surrogates for other species likely to be found on BLM-managed lands.

The exposure scenarios considered in the ERA were primarily organized by potential exposure pathways. In general, the exposure scenarios describe how a particular receptor group may be exposed to the herbicide as a result of a particular exposure pathway. These exposure scenarios were developed to address potential acute and chronic impacts to receptors under a variety of exposure conditions that may occur within BLM-managed lands. Diuron is a terrestrial herbicide; therefore, as discussed in detail in the Methods Document (ENSR 2005b), the following exposure scenarios were considered:

- direct contact with the herbicide or a contaminated waterbody;
- indirect contact with contaminated foliage;
- ingestion of contaminated food items;
- off-site drift of spray to terrestrial areas and waterbodies;
- surface runoff from the application area to off-site soils or waterbodies;
- wind erosion resulting in deposition of contaminated dust; and
- accidental spills to waterbodies.

Two generic waterbodies were considered in this ERA: 1) a small pond (1/4 ac pond of 1 meter [m] depth, resulting in a volume of 1,011,715 liters [L]) and 2) a small stream representative of Pacific Northwest low-order streams that provide habitat for critical life-stages of anadromous salmonids. The stream size was established at 2 m wide and 0.2 m deep with a mean water velocity of approximately 0.3 m per second, resulting in a base flow discharge of 0.12 cubic meters per second (cms).

4.1.4 Definition of Data Evaluated in the ERA

Herbicide concentrations used in the ERA were based on typical and maximum application rates provided by the BLM (Table 2-1). These application rates were used to predict herbicide concentrations in various environmental media (e.g., soils, water). Some of these calculations were fairly straightforward and required only simple algebraic calculations, but others required more complex computer models (e.g., transport from soils).

The AgDRIFT® computer model was used to estimate off-site herbicide transport due to spray drift. AgDRIFT® Version 2.0.05 (SDTF 2002) is a product of the Cooperative Research and Development Agreement between the USEPA's Office of Research and Development and the Spray Drift Task Force (SDTF, a coalition of pesticide registrants). The GLEAMS (Groundwater Loading Effects of Agricultural Management Systems) computer model was used to estimate off-site transport of herbicide in surface runoff and root-zone groundwater. GLEAMS is able to estimate a wide range of potential herbicide exposure concentrations as a function of site-specific parameters, such as soil characteristics and annual precipitation. The USEPA's guideline air quality California Puff (CALPUFF) air pollutant dispersion model was used to predict the transport and deposition of herbicides sorbed to wind-blown dust. CALPUFF "lite" version 5.7 was selected because of its ability to screen potential air quality impacts within and beyond 50 kilometers (km) and its ability to simulate plume trajectory over several hours of transport based on limited meteorological data.

4.1.5 Identification of Risk Characterization Endpoints

Assessment endpoints and associated measures of effect were selected to evaluate whether populations of ecological receptors are potentially at risk from exposure to proposed BLM applications of diuron. The selection process is discussed in detail in Methods Document (ENSR 2005b), and the selected endpoints are presented below (impacts to RTE species are discussed in more detail in Section 6.0).

Assessment Endpoint 1: Acute mortality to mammals, birds, invertebrates, non-target plants

- **Measures of Effect** included median lethal dose and median lethal concentrations (e.g., LD_{50} and LC_{50}) from acute toxicity tests on target organisms or suitable surrogates. To add conservatism to the RTE assessment, lowest available germination NOAELs were used to evaluate non-target RTE terrestrial plants, and LOC for RTE terrestrial animals were lower than for typical species (see Table 4-1).

Assessment Endpoint 2: Acute mortality to fish, aquatic invertebrates, and aquatic plants

- **Measures of Effect** included median lethal concentrations and median effective concentrations (e.g., LC_{50} and EC_{50}) from acute toxicity tests on target organisms or suitable surrogates (e.g., data from other coldwater fish to represent threatened and endangered salmonids). As with terrestrial species, lowest available germination NOAELs were used to evaluate non-target RTE aquatic plants, and LOC for RTE fish and aquatic invertebrates were lower than for typical aquatic species (see Table 4-1).

Assessment Endpoint 3: Adverse direct effects on growth, reproduction, or other ecologically important sublethal processes

- **Measures of Effect** included standard chronic toxicity test endpoints such as the NOAEL for both terrestrial and aquatic organisms. Chronic risks to RTE fish and aquatic invertebrates were evaluated using lower LOCs than for typical species. Depending on data available for a given herbicide, chronic endpoints reflect either individual impacts (e.g., growth, physiological impairment, behavior) or population-level impacts (e.g., reproduction; Barnthouse 1993). For salmonids, careful attention was paid to smoltification (i.e., development of tolerance to seawater and other indications of change of parr [freshwater stage salmonids] to adulthood), thermoregulation (i.e., ability to maintain body temperature), and migratory behavior, if such data were available.

Assessment Endpoint 4: Adverse indirect effects on the survival, growth, or reproduction of salmonid fish

- **Measures of Effect** for this assessment endpoint depended on the availability of appropriate scientific data. Unless literature studies were found that explicitly evaluated the indirect effects of diuron on salmonids and their habitat, only qualitative estimates of indirect effects were possible. Such qualitative estimates were limited to a general evaluation of the potential risks to food (typically represented by acute and/or chronic toxicity to aquatic invertebrates) and cover (typically represented by potential for destruction of riparian vegetation). Similar approaches are already being applied by USEPA OPP for Endangered Species Effects Determinations and Consultations (Available at: http://www.epa.gov/oppfead1/endanger/effects)

4.1.6 Development of the Conceptual Model

The diuron conceptual model (Figure 4-1) is presented as a series of working hypotheses about how diuron might pose hazards to the ecosystem and ecological receptors. The conceptual model indicates the possible exposure pathways for the herbicide, as well as the receptors evaluated for each exposure pathway. Figure 4-2 presents the trophic levels and receptor groups evaluated in the ERA.

The conceptual model for herbicide application on BLM lands is designed to display potential herbicide exposure through several pathways, although all pathways may not exist for all locations. The exposure pathways and ecological receptor groups considered in the conceptual model are also described in Section 4.1.3.

The terrestrial herbicide conceptual model (Figure 4-1) presents five mechanisms for the release of an herbicide into the environment: direct spray, off-site-drift, wind erosion, surface runoff, and accidental spills. These release mechanisms may occur as the terrestrial herbicide is applied to the application area by aerial or ground methods.

As indicated in the conceptual model figure, direct spray may result in herbicide exposure for wildlife, non-target terrestrial plants or waterbodies adjacent to the application area. Receptors like wildlife or terrestrial plants may be directly sprayed during the application, or herbicide exposure may be the result of contact with the contaminated water in the pond or steam (i.e., aquatic plants, fish, aquatic invertebrates). Terrestrial wildlife may also be exposed to the herbicide by brushing against sprayed vegetation or by ingesting contaminated food items.

Off-site drift may occur when herbicides are applied under normal conditions and a portion of the herbicide drifts outside of the treatment area. In these cases, the herbicide may deposit onto non-target receptors such as non-target terrestrial plants or nearby waterbodies. This results in potential direct exposure to the herbicide for terrestrial and aquatic plants, fish, and aquatic invertebrates. Piscivorous birds may also be impacted by ingesting contaminated fish from an exposed pond.

Wind erosion describes the transport mechanism in which dry conditions and wind allow movement of the herbicide from the application area as wind-blown dust. This may result in the direct exposure of non-target plants to the herbicide that is deposited on the plant itself.

Precipitation may result in the transport of herbicides via surface runoff and root-zone groundwater. The seeds of terrestrial plants may be exposed to the herbicide in the runoff or root-zone groundwater. Herbicide transport to the adjacent waterbodies may also occur through these mechanisms. This may result in the exposure of aquatic plants, fish, and aquatic invertebrates to impacted water. Piscivorous birds may also be impacted by ingesting contaminated fish from an exposed pond.

Accidental spills may also occur during normal herbicide applications. Spills represent the worst-case transport mechanism for herbicide exposure. An accidental spill to a waterbody would result in exposure for aquatic plants, fish, and aquatic invertebrates to impacted water.

4.2 Analysis Phase

The analysis phase of an ERA consists of two principal steps: the characterization of exposure and the characterization of ecological effects. The exposure characterization describes the source, fate, and distribution of the herbicide using standard models that predict concentrations in various environmental media (e.g., GLEAMS). All EECs predicted by the models are presented in Appendix B. The ecological effects characterization consisted of compiling exposure-response relationships from all available toxicity studies on the herbicide.

4.2.1 Characterization of Exposure

The BLM uses herbicides in a variety of programs (e.g., maintenance of rights of way and recreational sites) with several different application methods (e.g., vehicle, ATV-mounted, backpack/horseback sprayer). In order to assess the potential ecological impacts of these herbicide uses, a variety of exposure scenarios were considered. These scenarios, which were selected based on actual BLM herbicide usage under a variety of conditions, are described in Section 4.1.3.

When considering the exposure scenarios and the associated predicted concentrations, it is important to recall the frequency and duration of the various scenarios are not equal. For example, exposures associated with accidental spills will be very rare, while off-site drift associated with application will be relatively common. Similarly, off-site drift events will be short-lived (i.e., migration occurs within minutes), while erosion of herbicide-containing soil may occur over weeks or months following application. The ERA has generally treated these differences in a conservative manner (i.e., potential risks are presented despite their likely rarity and/or transience). Thus, tables and figures summarizing RQs may present both relatively common and very rare exposure scenarios. Additional perspective on the frequency and duration of exposures are provided in the narrative below.

As described in Section 4.1.3, the following ecological receptor groups were selected to address the potential risks due to unintended exposure to diuron: terrestrial animals, terrestrial plants, and aquatic species. A set of generic terrestrial animal receptors, listed below, were selected to cover a variety of species and feeding guilds that might be found on BLM-managed lands. Unless otherwise noted, receptor BWs were selected from the *Wildlife Exposure Factors Handbook* (USEPA 1993a). This list includes surrogate species, although not all of these surrogate species will be present within each application area:

- A pollinating insect with a BW of 0.093 grams (g). The honeybee (*Apis mellifera*) was selected as the surrogate species to represent pollinating insects. This BW was based on the estimated weight of receptors required for testing in 40CFR158.590.

- A small mammal with a BW of 20 g that feeds on fruit (e.g., berries). The deer mouse (*Peromyscus maniculatus*) was selected as the surrogate species to represent small mammalian omnivores consuming berries.

- A large mammal with a BW of 70 kg that feeds on plants. The mule deer (*Odocolieus hemionus*) was selected as the surrogate species to represent large mammalian herbivores, including wild horses and burros (Hurt and Grossenheider 1976).

- A large mammal with a BW of 12 kg that feeds on small mammals. The coyote (*Canis latrans*) was selected as the surrogate species to represent large mammalian carnivores (Hurt and Grossenheider 1976).

- A small bird with a BW of 80 g that feeds on insects. The American robin (*Turdus migratorius*) was selected as the surrogate species to represent small avian insectivores.

- A large bird with a BW of approximately 3.5 kg that feeds on vegetation. The Canada goose (*Branta canadensis*) was selected as the surrogate species to represent large avian herbivores.

- A large bird with a BW of approximately 5 kg that feeds on fish in the pond. The Northern subspecies of the bald eagle (*Haliaeetus leucocephalus alascanus*) was selected as the surrogate species to represent large avian piscivores (Brown and Amadon 1968[2]).

In addition, potential impacts to non-target terrestrial plants were considered by evaluating two plant receptors: the "typical" non-target species, and the RTE non-target species. The tomato, garden pea (*Pisum sativum*), and soybean (*Glycine max*) were the surrogate species chosen to represent typical terrestrial plants, and the tomato was used as the surrogate for RTE terrestrial plants (toxicity data are only available for vegetable crop species). According to the herbicide label, diuron products are approved for the control of annual and perennial grasses and herbaceous weeds. However, it is possible that noncropland plants and grasses are not as sensitive to diuron as the selected broadleaf surrogate plant species.

Aquatic exposure pathways were evaluated using fish, aquatic invertebrates, and non-target aquatic plants in a pond or stream habitat (as defined in Section 4.1.3). Rainbow trout (*Oncorhynchus mykiss*) and bluegill sunfish (*Lepomis*

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[2] As cited on the Virginia Tech Conservation Management Institute Endangered Species Information System website (http://fwie.fw.vt.edu/WWW/esis/).

macrochirus) were surrogates for fish, the water flea was a surrogate for aquatic invertebrates, and non-target aquatic plants and algae were represented by duckweed.

Section 3.0 of the Methods Document (ENSR 2005b) presents the details of the exposure scenarios considered in the risk assessments. The following sub-sections describe the scenarios that were evaluated for diuron.

4.2.1.1 Direct Spray

Plant and wildlife species may be unintentionally impacted during normal application of a terrestrial herbicide as a result of a direct spray of the receptor or the waterbody inhabited by the receptor, indirect contact with dislodgeable foliar residue after herbicide application, or consumption of food items sprayed during application. These exposures may occur within the application area (consumption of food items) or outside of the application area (waterbodies accidentally sprayed during application of terrestrial herbicide). Generally, impacts outside of the intended application area are accidental exposures and are not typical of BLM application practices. The following direct spray scenarios were evaluated:

<u>Exposure Scenarios Within the Application Area</u>

- Direct Spray of Terrestrial Wildlife
- Indirect Contact With Foliage After Direct Spray
- Ingestion of Food Items Contaminated by Direct Spray
- Direct Spray of Non-Target Terrestrial Plants

<u>Exposure Scenarios Outside the Application Area</u>

- Accidental Direct Spray Over Pond
- Accidental Direct Spray Over Stream

4.2.1.2 Off-site Drift

During normal application of herbicides, it is possible for a portion of the herbicide to drift outside of the treatment area and deposit onto non-target receptors. To simulate off-site herbicide transport as spray drift, AgDRIFT® software was used to evaluate a number of possible scenarios. Only boom placements for ground application scenarios were evaluated for diuron; diuron is not dispersed through aerial application by the BLM. Ground applications were modeled using either a high boom (spray boom height set at 50 inches above the ground) or a low boom (spray boom height set at 20 inches above the ground). Deposition rates vary by the height of the boom (the higher the height of the spray boom, the greater the off-site drift). Drift deposition was modeled at 25, 100, and 900 ft from the application area. The AgDRIFT® model determined the fraction of the application rate that is deposited off-site without considering herbicide degradation. The following off-site drift scenarios were evaluated:

- Off-Site Drift to Plants
- Off-Site Drift to Pond
- Off-Site Drift to Stream
- Consumption of Fish From Contaminated Pond

4.2.1.3 Surface and Groundwater Runoff

Precipitation may result in the transport of herbicides bound to soils from the application area via surface runoff and root-zone groundwater flow. This transport to off-site soils or waterbodies was modeled using GLEAMS software. It should be noted that both surface runoff (i.e., soil erosion and soluble-phase transport) and loading in root-zone groundwater were assumed to affect the waterbodies in question. GLEAMS variables include soil type, annual precipitation, size of application area, hydraulic slope, surface roughness, and vegetation type. These variables were altered to predict soil concentrations of the herbicides in various watershed types at both the typical and maximum application rates. The following surface runoff scenarios were evaluated:

- Surface Runoff to Off-Site Soils
- Surface Runoff to Off-Site Pond
- Surface Runoff to Off-Site Stream
- Consumption of Fish From Contaminated Pond

4.2.1.4 Wind Erosion and Transport Off-site

Dry conditions and wind may also allow transport of the herbicide from the application area as wind-blown dust onto non-target plants some distance away. This transport by wind erosion of the surface soil was modeled using CALPUFF software. Five distinct watersheds were evaluated to determine herbicide concentrations in dust deposited on plants after a wind event, with dust deposition estimates calculated 1.5 to 100 km from the application area.

4.2.1.5 Accidental Spill to Pond

To represent worst-case potential impacts to ponds, a spill scenario was considered. A truck spilling an entire load (200 gallon [gal] spill) of herbicide mixed for the maximum application rate into a 1/4 ac, 1 m deep pond.

4.2.2 Effects Characterization

The ecological effects characterization phase entailed a compilation and analysis of the stressor-response relationships and any other evidence of adverse impacts from exposure to diuron. For the most part, available data consisted of toxicity studies conducted in support of USEPA pesticide registration described in Section 3.1. TRVs selected for use in the ERA are presented in Table 3-1. Appendix A presents the full set of toxicity information identified for diuron.

In order to address potential risks to ecological receptors, RQs were calculated by dividing the EEC for each of the previously described scenarios by the appropriate TRV presented in Table 3-1. An RQ was calculated by dividing the EEC for a particular scenario by an herbicide specific TRV. The TRV may be a surface water or surface soil effects concentration, or a species-specific toxicity value derived from the literature.

The RQs were then compared to LOC established by the USEPA OPP to assess potential risk to non-target organisms. Table 4-1 presents the LOCs established for this assessment. Distinct USEPA LOCs are currently defined for the following risk presumption categories:

- **Acute high risk -** the potential for acute risk is high.
- **Acute restricted use -** the potential for acute risk is high, but may be mitigated through a restricted use designation.
- **Acute endangered species** – the potential for acute risk to endangered species is high.
- **Chronic risk -** the potential for chronic risk is high.

Additional uncertainty factors may also be applied to the standard LOCs to reflect uncertainties inherent in extrapolating from surrogate species toxicity data to obtain RQs (see Sections 6.3 and 7.0 for a discussion of uncertainty). A "chronic endangered species" risk presumption category for aquatic animals was added for this risk assessment. The LOC for this category was set to 0.5 to reflect the conservative two-fold difference in contaminant sensitivity between RTE and surrogate test fishes (Sappington et al. 2001). Risk quotients predicted for acute scenarios (e.g., direct spray, accidental spill) were compared to the three acute LOCs, and the RQs predicted for chronic scenarios (e.g., long term ingestion) were compared to the two chronic LOCs. If all RQs were less than the most conservative LOC for a particular receptor, comparisons against other, more elevated LOCs were not necessary.

The RQ approach used in this ERA provides a conservative measure of the potential for risk based on a "snapshot" of environmental conditions (i.e., rainfall, slope) and receptor assumptions (i.e., BW, ingestion rates) . Sections 6.3 and 7.0 discuss several of the uncertainties inherent in the RQ methodology.

To specifically address potential impacts to RTE species, two types of RQ evaluations were conducted. For RTE terrestrial plant species, the RQ was calculated using different toxicity endpoints and but keeping the same LOC (set at 1) for all scenarios. The plant toxicity endpoints were selected to provide extra protection to the RTE species. In the direct spray, spray drift, and wind erosion scenarios, the selected toxicity endpoints were an EC_{25} for "typical" species and a NOAEL for RTE species. In runoff scenarios, high and low germination NOAELs were selected to evaluate exposure for typical and RTE species, respectively.

The evaluation of RTE terrestrial wildlife and aquatic species is addressed using a second type of RQ evaluation. The same toxicity endpoint was used for both typical and RTE species in all scenarios, but the LOC was lowered for RTE species.

4.3 Risk Characterization

The ecological risk characterization integrates the results of the exposure and effects phases (i.e., risk analysis), and provides comprehensive estimates of actual or potential risks to ecological receptors. Risk quotients are summarized in Tables 4-2 to 4-5 and presented graphically in Figures 4-3 to 4-18. The results are discussed below for each of the evaluated exposure scenarios.

Box plots are used to graphically display the range of RQs obtained from evaluating each receptor and exposure scenario combination (Figures 4-3 to 4-18). These plots illustrate how RQ data are distributed about the mean and their relative relationships with LOCs. Outliers (data points outside the 90^{th} or 10^{th} percentile) were not discarded in this ERA; all RQ data presented in these plots were included in the risk assessment.

4.3.1 Direct Spray

As described in Section 4.2.1, potential impacts from direct spray were evaluated for exposure that could occur within the terrestrial application area (direct spray of terrestrial wildlife and non-target terrestrial plants, indirect contact with foliage, ingestion of contaminated food items) and outside the intended application area (accidental direct spray over pond and stream). Table 4-2 presents the RQs for the above scenarios. Figures 4-3 to 4-7 present graphic representations of the range of RQs and associated LOCs.

4.3.1.1 Terrestrial Wildlife

In general, most acute RQs for terrestrial wildlife (Figure 4-3) were below the most conservative LOC of 0.1 (acute endangered species). However, direct spray of the pollinating insect resulted in elevated RQs at both the typical and maximum application rates. In addition, at the maximum application rate, risk was also predicted for the pollinating insect from indirect contact with foliage impacted by direct spray. These are highly conservative scenarios assuming that the insect absorbs 100% of the herbicide after application with no herbicide degradation or limitations to uptake by the insect. Therefore, these scenarios may overestimate risk to the insect.

RQs for acute ingestion scenarios were below the most conservative LOC (0.1; acute risk endangered species) when herbicide is applied at the typical application rate, but above the LOC in all cases at the maximum application rate. RQs for chronic ingestion scenarios were above the associated LOC of 1.0 for three receptors (the small and large mammalian herbivores and the large mammalian carnivore) when herbicide is applied at the typical application rate. At the maximum application rate, elevated RQs were predicted for all evaluated scenarios.

This evaluation indicates that direct spray impacts may pose a risk to insects, birds, and mammals, primarily when the maximum application rate is used.

4.3.1.2 Non-target Plants – Terrestrial and Aquatic

RQs for non-target terrestrial plants (Figure 4-4) ranged from 75 to 20,000, and RQs for non-target aquatic plants (Figure 4-5) ranged from 517 to 25,474 (Table 4-2). All of the RQs were above the plant LOC of 1.0, indicating that direct spray impacts may pose a risk to plants in both aquatic and terrestrial environments, which was expected because of the mode of action of herbicides. It may be noted that the aquatic scenarios are particularly conservative because they evaluate an instantaneous concentration and do not consider flow, adsorption to particles, or degradation that may occur over time within the pond or stream.

4.3.1.3 Fish and Aquatic Invertebrates

Acute toxicity RQs for fish and aquatic invertebrates (Figure 4-6 and 4-7) in the pond and stream were above the most conservative LOC of 0.05 (acute endangered species), indicating that direct spray impacts may pose a risk to these aquatic species.

Chronic toxicity RQs were also above the LOC for chronic risk (1.0), indicating that direct spray impacts may pose a risk to these aquatic species. It may be noted that these accidental spray scenarios are conservative because they do not consider flow, adsorption to particles, or degradation that may occur over time. The herbicide concentration in the pond and stream are the instantaneous concentrations at the moment of the direct spray. The volume of the pond and the impacted segment of the stream were calculated and the mass of herbicide was calculated based on the surface area of the waterbody. There was no dilution due to degradation or stream flow. In addition, it is assumed that the pond and stream are adjacent to the herbicide application area.

4.3.2 Off-site Drift

As described in Section 4.2.1, AgDRIFT® software was used to evaluate a number of possible scenarios in which a portion of the applied herbicide drifts outside of the treatment area and deposits onto non-target receptors. Ground applications of diuron were modeled using both a low- and high-placed boom (spray boom height set at 20 and 50 inches above the ground, respectively), and drift deposition was modeled at 25, 100, and 900 ft from the application area.

Table 4-3 presents the RQs for the following scenarios: off-site drift to soils, off-site drift to ponds, off-site drift to streams, and consumption of fish from the contaminated pond. Figures 4-8 to 4-12 present graphic representations of the range of RQs and associated LOCs.

4.3.2.1 Non-target Plants – Terrestrial and Aquatic

Many of the RQs for non-target terrestrial plants affected by off-site drift to off-site soils (Figure 4-8) were above the plant LOC of 1.0. For typical terrestrial plant species, elevated RQs were predicted at the typical application rate 25 ft from application with a high boom and at the maximum application rate within 100 ft from application with a low or high boom. Elevated RQs were predicted for RTE terrestrial plant species under all off-site drift scenarios. These results indicate that terrestrial plants, particularly RTE species, located near applications areas may be impacted by herbicide drift.

The majority of the RQs for non-target aquatic plants affected by off-site drift (Figure 4-9) were above the plant LOC of 1.0. The only scenario that did not consistently predict elevated RQs was off-site drift 900 ft from the application area. More elevated RQs were predicted with application using the high boom than using the low boom. These results indicate that off-site drift may impact aquatic plants in waterbodies adjacent to application areas. It may be noted that the aquatic scenarios are particularly conservative because they do not consider flow, adsorption to particles, or degradation of the herbicide over time.

4.3.2.2 Fish and Aquatic Invertebrates

Acute toxicity RQs for fish (Figure 4-10) were below the most conservative LOC of 0.05 (acute endangered species) for all scenarios except one (off-site drift to the stream 25 ft from the maximum application with a high boom). Acute toxicity RQs for aquatic invertebrates (Figure 4-11) were generally also below the most conservative LOC of 0.05 (acute endangered species). However, off-site drift to the pond and stream within 25 ft of a low boom application or within 100 ft of a high boom application at the maximum application rate predicted elevated RQs for aquatic invertebrates. Off-site drift within 25 ft of a high boom application at the typical application rate also predicted a slightly elevated RQ (0.077) in the stream. These results indicate the potential for acute risk to fish and invertebrates due to off-site drift under selected application conditions.

Most chronic RQs were well below the LOC for chronic risk to endangered species (0.5). However, application at the maximum application rate resulted in elevated RQs for one aquatic invertebrate scenario (in the stream 25 ft from the high boom application) and three fish scenarios (in the pond 25 ft from the high boom application and in the stream 25 ft from the low and high boom applications). For fish, the only the scenario with an RQ above the chronic LOC of 1.0 was for the stream 25 ft from application at the maximum rate with a high boom. These results indicate minimal potential for chronic risk, except within 25 ft of the application area at the maximum application rate.

4.3.2.3 Piscivorous Birds

Risk to piscivorous birds was assessed by evaluating impacts from consumption of fish from a pond contaminated by off-site drift. RQs for piscivorous birds (Figure 4-12) were all well below the most conservative terrestrial animal LOC (0.1), indicating that this scenario is not likely to pose a risk to piscivorous birds.

4.3.3 Surface Runoff

As described in Section 4.2.1, surface runoff and root-zone groundwater transport of herbicides from the application area to off-site soils and waterbodies was modeled using GLEAMS software. A total of 42 GLEAMS simulations were performed with different combinations of GLEAMS variables (i.e., soil type, soil erodability factor, annual precipitation, size of application area, hydraulic slope, surface roughness, and vegetation type) to account for a wide range of possible watersheds encountered on BLM-managed lands. In 24 simulations, soil type and precipitation values were altered, while the rest of the variables were held constant in a “base watershed” condition. In the remaining 18 simulations, precipitation was held constant, while the other six variables (each with three levels) were altered.

Table 4-4 presents the RQs for the following scenarios: surface runoff to off-site soils, overland flow (runoff) to off-site ponds, overland flow to off-site streams, and consumption of fish from contaminated ponds. Figures 4-13 to 4-17 present graphic representations of the range of RQs and associated LOCs. A number of the GLEAMS scenarios, primarily those with minimal precipitation (e.g., 5 inches of precipitation per year), resulted in no predicted herbicide transport from the application area. Accordingly, these conditions do not result in associated off-site risk. RQs are discussed below for those scenarios predicting off-site transport and RQs greater than zero.

4.3.3.1 Non-target Plants – Terrestrial and Aquatic

RQs for typical non-target terrestrial plant species affected by surface runoff to off-site soil (Table 4-4) were all below the plant LOC of 1.0 (Figure 4-13), indicating that transport due to surface runoff is not likely to pose a risk to these receptors. Most RQs for RTE non-target terrestrial plant species were also below the plant LOC of 1.0. However, several scenarios did result in elevated RQs. At the typical application rate, RQs for the base watershed with clay soils and between 100 and 250 inches of rain per year (250 inches per year was the maximum rainfall modeled) ranged from 1.0 to 2.85. At the maximum application rate, RQs were elevated above 1.0 for the base watershed with clay soils and at least 50 inches of rain per year, for the base watershed with loam soils and at least 200 inches of rain per year, and for the base watershed with clay loam soil and 50 inches of rain per year (no other rainfall amounts were modeled for this scenario). This indicates the potential for risk to RTE plant species in certain watersheds (with precipitation greater than 50 inches) at the typical or maximum application rates (these scenarios are unlikely on many BLM lands because of arid and semi-arid conditions).

Acute and chronic RQs for non-target aquatic plants impacted by overland flow of herbicide (Figure 4-14) exceeded the plant LOC for nearly all pond scenarios modeled at both the typical and maximum application rates.

Acute RQs for non-target aquatic plants in the stream were also generally above the plant LOC of 1.0, indicating that this transport mechanism may pose a risk to aquatic plant species in the stream. At the typical application rate, elevated RQs occurred in 35 of the 42 scenarios. At the maximum application rate, elevated RQs occurred in 37 of the 42 scenarios. These results indicate the high potential for acute impacts to aquatic plants in the stream.

Chronic RQs in the stream at the typical application rate were generally below the plant LOC, except in the base watershed with sandy soils and precipitation of more than 25 inches per year, in the base watershed with clay or loam soils and precipitation of more than 100 inches per year, and in the 100 and 1,000 ac application areas.

Most chronic stream RQs were above the plant LOC when the maximum application rate was considered. The only scenarios below this LOC were the base application watershed with sandy soils and less than 10 inches of rain per year, the base application watershed with clay or loam soil and less than 25 inches of rain per year, the 1 ac application area, and the base watershed with silt soil and 50 inches of rain per year. These results indicate the potential for chronic impacts to aquatic plants in the stream under most conditions at the maximum application rate.

4.3.3.2 Fish and Aquatic Invertebrates

Acute toxicity RQs for fish and aquatic invertebrates (Figure 4-15 and Figures 4-16) were above the most conservative LOC of 0.05 (acute endangered species) for nearly all pond scenarios. At the typical application rate, RQs were elevated above 0.05 for fish in 35 of 42 scenarios, and for aquatic invertebrates in 36 of 42 scenarios. At the maximum application rate, this increased to 36 and 38 of 42 scenarios for fish and aquatic invertebrates, respectively. Acute RQs for aquatic invertebrates in the stream were greater than the LOC of 0.05 for most scenarios at the maximum application rate (35 of 42 scenarios) and for high precipitation scenarios at the typical application rate (18 of 42 scenarios). Acute RQs for fish in the stream were greater than the LOC for high precipitation scenarios at the maximum application rate (16 of 42 scenarios) and for high precipitation scenarios in clay soils at the typical application rate (3 of 42 scenarios). This suggests that diuron poses substantial acute risks to aquatic animals in ponds and limited acute risks to aquatic stream animals (i.e., at the maximum application rate and in wet watersheds).

Chronic toxicity RQs in the stream were well below the LOC for chronic risk to endangered species (0.5), indicating that these scenarios are not likely to result in long-term risk to fish or aquatic invertebrates. However, chronic RQs for fish and aquatic invertebrates were elevated above this LOC in several pond scenarios. At the maximum application rate, RQs were elevated above 0.5 for fish in 36 of 42 scenarios, and for aquatic invertebrates in 33 of 42 scenarios. At the typical application rate, RQs were elevated above 0.5 for fish in 30 of 42 scenarios, and for aquatic invertebrates in 10 of 42 scenarios. At the typical application rate, only 10 of the fish RQs and 3 of the aquatic invertebrate RQs were above the chronic LOC of 1 for typical species, indicating significantly less risk to non-RTE species. These results indicate the potential for risk to fish and aquatic invertebrates in the pond, especially RTE species, as a result of surface runoff.

4.3.3.3 Piscivorous Birds

Risk to piscivorous birds (Figure 4-17) was assessed by evaluating impacts from consumption of fish from a pond contaminated by surface runoff. RQs for the piscivorous bird were all well below the most conservative terrestrial animal LOC (0.1), indicating that this scenario is not likely to pose a risk to piscivorous birds.

4.3.4 Wind Erosion and Transport Off-site

As described in Section 4.2.1, five distinct watersheds were modeled using CALPUFF to determine herbicide concentrations in dust deposited on plants after a wind event with dust deposition estimates calculated at 1.5, 10, and 100 km from the application area. Deposition results for Winnemucca, NV and Tucson, AZ were not listed because the meteorological conditions (i.e., wind speed) that must be met to trigger particulate emissions for the land cover conditions assumed for these sites did not occur for any hour of the selected year. Therefore, it was assumed herbicide migration by windblown soil would not occur at those locations during that year.

The soil type assumed for Winnemucca, NV and Tucson, AZ was undisturbed sandy loam, which has a higher friction velocity (i.e., is harder for wind to pick up as dust) than the soil types of the other locations. As further explained in Section 5.3, friction velocity is a function of the measured wind speed and the surface roughness, a property affected by land use and vegetative cover. The threshold friction velocities at the other three sites (103 or 150 cm/sec) were much lower, based on differences in the assumed soil types. At these sites, wind and land cover conditions combined to predict that the soil would be eroded on several days. Soils of similar properties at Winnemucca and Tucson, if present, would also have been predicted to be subject to erosion under weather conditions encountered there.

Table 4-5 summarizes the RQs for typical and RTE terrestrial plant species exposed to contaminated dust within the three remaining watersheds at typical and maximum application rates. Figure 4-18 presents a graphic representation of the range of RQs and associated LOCs. RQs for typical and RTE terrestrial plants were all well below the plant LOC (1), indicating that wind erosion is not likely to pose a risk to non-target terrestrial plants.

4.3.5 Accidental Spill to Pond

As described in Section 4.2.1, one spill scenario was considered in which a truck spills an entire load (200 gal spill) of herbicide mixed for the maximum application rate into the 1/4 ac, 1 m deep pond. The herbicide concentration in the pond was the instantaneous concentration at the moment of the spill. The volume of the pond was determined and the volume of herbicide in the truck was mixed into the pond volume.

Risk quotients for the spill scenario (Table 4-2) were 101 for fish, 448 for aquatic invertebrates (Figure 4-6 and 4-7) and 55,180 for non-target aquatic plants (Figure 4-5). Therefore, there is the potential for risk to fish, aquatic invertebrates, and non-target aquatic plants under the scenario of a truck spill with diuron mixed for the maximum application rate. However, this scenario is highly conservative and represents unlikely and worst case conditions (limited waterbody volume, tank mixed for maximum application rate before transport to site).

4.3.6 Potential Risk to Salmonids from Indirect Effects

In addition to direct effects of herbicides on salmonids and other fish species in stream habitats (i.e., mortality due to herbicide concentrations in surface water), reduction in vegetative cover or food supply may indirectly impact individuals or populations. No literature studies were identified that explicitly evaluated the indirect effects of diuron to salmonids via effects to their food and habitat; therefore, only qualitative estimates of indirect effects are possible. These estimates were accomplished by evaluating predicted impacts to prey items and vegetative cover in the stream scenarios discussed above. These scenarios include accidental direct spray over the stream and transport to the stream via off-site drift and surface runoff. An evaluation of impacts to non-target terrestrial plants was also included as part of the discussion of vegetative cover within the riparian zone. Food items for salmonids and other potential RTE species may include other fish species, aquatic invertebrates, or aquatic plants. Additional discussion of RTE species is provided in Section 6.0.

4.3.6.1 Qualitative Evaluation of Impacts to Prey

Fish species were evaluated directly in the ERA using acute and chronic TRVs based on the most sensitive warm- or cold-water species identified during the literature search. Salmonids were included in the derivation of the fish TRVs. The selected acute fish TRV was based on a study with the cutthroat trout (*Oncorhynchus clarki*). The chronic TRV was based on a warmwater fish. This indicates that chronic direct impacts to salmonids may be overestimated in the ERA. Aquatic invertebrates were also evaluated directly using acute and chronic TRVs based on the most sensitive aquatic invertebrate species. Direct impacts on prey items (i.e., mortality to fish and aquatic invertebrates due to herbicide exposure) may result in indirect impacts on the salmonid population.

RQs in excess of the acute and chronic LOCs for fish and aquatic invertebrates were observed for the accidental direct spray scenario. However, this is an extremely conservative scenario that is unlikely to occur as a result of BLM practices, and therefore, it represents a worst-case scenario. In addition, stream flow would be likely to dilute the herbicide concentration and reduce potential impacts, but possible reductions in herbicide concentration as a result of stream flow were not evaluated in this scenario.

The off-site drift scenarios predicted elevated RQs for fish and aquatic invertebrates (mostly RTE species) under selected conditions, primarily within 25 ft of the application area. Additional risk to aquatic invertebrates is predicted within 100 ft of a high boom application at the maximum rate. Most chronic RQs for fish and aquatic invertebrates in the stream impacted by surface runoff were below the associated LOCs. The exceptions were impacts to fish or aquatic invertebrates within 25 ft of an application at the maximum rate. Acute RQs for these surface runoff scenarios were elevated above the most conservative LOC for several scenarios; most significantly for aquatic invertebrates at the maximum application rate.

Because fish and aquatic invertebrates may be directly impacted by herbicide concentrations in the stream as a result of normal applications, their availability as prey item populations may be impacted, and there may be an indirect effect on salmonids. These impacts may be minimized through the use of increased buffer zones and reduced application rates near streams.

4.3.6.2 Qualitative Evaluation of Impacts to Vegetative Cover

A qualitative evaluation of indirect impacts to salmonids due to destruction of riparian vegetation and reduction of available cover was made by considering impacts to terrestrial and aquatic plants. Aquatic plant RQs for accidental direct spray scenarios were above the plant LOC at both the typical and maximum application rates, indicating the potential for a reduction in the aquatic plant community. However, this is an extremely conservative scenario in which it is assumed that a stream is accidentally directly sprayed by a terrestrial herbicide. This is unlikely to occur as a result of BLM practices and represents a worst-case scenario. In addition, no reduction in herbicide concentration is calculated due to stream flow in this scenario. However, there is the potential for indirect impacts to salmonids due to a reduction in available cover if the stream is accidentally sprayed.

Elevated aquatic plant RQs were also observed in the stream scenarios as a result of off-site drift of the ground application of the herbicide more than 100 and less than 900 ft from the stream, indicating the potential for a reduction in cover, most significantly at the maximum application rate (chronic risk to aquatic plants are also predicted with greater than a 900-foot buffer at the maximum application rate). Elevated RQs were also predicted for many of the surface runoff scenarios. These results indicate there is the potential for indirect impacts to salmonids due to reduction in available cover due to off-site drift and surface runoff of the applied herbicide.

Terrestrial plants were evaluated for their potential to provide overhanging cover for salmonids. A reduction in the riparian cover has the potential to indirectly impact salmonids within the stream. RQs for typical and RTE terrestrial plants were elevated above the LOC for accidental direct spray scenarios at both the typical and maximum application rates, indicating the potential for a reduction in this plant community. However, as discussed above, this scenario is unlikely to occur as a result of BLM pesticide management practices and represents a worst-case scenario.

RQs for typical terrestrial plants were also observed above the plant LOC (ranging from 1.11 to 5.19) as a result of off-site drift from the ground application of the herbicide. At the typical application rate, risk was predicted at least 25 ft and less than 100 ft from the application area, and at the maximum application rate, risk was predicted at least 100 ft and less than 900 ft from the application area. Elevated RQs for RTE species were also observed for all modeled application scenarios. These results indicate the potential for a reduction in riparian cover and indirect effects to salmonids due to off-site drift under selected conditions.

No RQs in excess of the LOC were observed for typical terrestrial plant species for any of the surface runoff scenarios. Elevated RQs were predicted for RTE terrestrial plant species under selected surface runoff conditions, primarily in clay or loam soils at high precipitation levels. These results indicate the limited potential for a reduction in riparian cover due to surface runoff, primarily when RTE plant species are present.

In August 2003, the OPP evaluated the potential for diuron to impact certain Pacific anadromous salmonids (specifically Pacific salmon and steelhead) and their critical habitats in California and southern Oregon. The OPP concluded that the non-crop use of diuron has the potential to affect selected habitats. In particular, the OPP indicated the potential for acute risks to RTE fish species and the potential for indirect effects on aquatic plant cover (Turner 2003b).

4.3.6.3 Conclusions

This qualitative evaluation indicates that salmonids may be indirectly impacted by a reduction in food supply (i.e., fish and aquatic invertebrates). Indirect impacts to salmonids may also occur via a reduction in vegetative cover under some conditions. Accidental direct spray, off-site drift, and surface runoff may negatively impact terrestrial and aquatic plants, reducing the cover available to salmonids within the stream. However, increasing the buffer zones around streams, reducing the application rate, reducing the size of the application area, and avoidance of accidental application on non-target areas would reduce the likelihood of these impacts.

In addition, the effects of terrestrial herbicides in water are expected to be relatively transient, and stream flow is likely to reduce herbicide concentrations over time. In a review of potential impacts of diuron to threatened and endangered salmonids, USEPA OPP indicated that "for most pesticides applied to terrestrial environment, the effects in water, even lentic water, will be relatively transient" (Turner 2003a). Only very persistent pesticides would be expected to have effects beyond the year of their application. The OPP report indicated that if a listed salmonid is not present during the year of application, there would likely be no concern (Turner 2003a). Therefore, it is expected that potential adverse impacts to food and cover would not occur beyond the season of application.

TABLE 4-1
Levels of Concern

	Risk Presumption	RQ	LOC
Terrestrial Animals [1]			
Birds	Acute High Risk	EEC/LC_{50}	0.5
	Acute Restricted Use	EEC/LC_{50}	0.2
	Acute Endangered Species	EEC/LC_{50}	0.1
	Chronic Risk	EEC/NOAEL	1
Wild Mammals	Acute High Risk	EEC/LC_{50}	0.5
	Acute Restricted Use	EEC/LC_{50}	0.2
	Acute Endangered Species	EEC/LC_{50}	0.1
	Chronic Risk	EEC/NOAEL	1
Aquatic Animals [2]			
Fish and Aquatic Invertebrates	Acute High Risk	EEC/LC_{50} or EC_{50}	0.5
	Acute Restricted Use	EEC/LC_{50} or EC_{50}	0.1
	Acute Endangered Species	EEC/LC_{50} or EC_{50}	0.05
	Chronic Risk	EEC/NOAEL	1
	Chronic Risk, Endangered Species	EEC/NOAEL	0.5
Plants [3]			
Terrestrial/Semi-Aquatic Plants	Acute High Risk	EEC/EC_{25}	1
	Acute Endangered Species	EEC/NOAEL	1
Aquatic Plants	Acute High Risk	EEC/EC_{50}	1
	Acute Endangered Species	EEC/NOAEL	1

[1] Estimated Environmental Concentration (EEC) is in mg $_{prey}$/kg $_{BW}$ for acute scenarios and mg $_{prey}$/kg $_{BW}$/day for chronic scenarios.
[2] EEC is in mg/L.
[3] EEC is in lbs/ac.

TABLE 4-2
Risk Quotients for Direct Spray and Spill Scenarios

Terrestrial Animals	Typical Application Rate	Maximum Application Rate
Direct Spray of Terrestrial Wildlife		
Small mammal - 100% absorption	1.56E-02	5.21E-02
Pollinating insect - 100% absorption	**6.10E-01**	**2.03E+00**
Small mammal - 1st order dermal adsorption	2.26E-03	7.52E-03
Indirect Contact With Foliage After Direct Spray		
Small mammal - 100% absorption	1.56E-03	5.21E-03
Pollinating insect - 100% absorption	6.10E-02	**2.03E-01**
Small mammal - 1st order dermal adsorption	2.26E-04	7.52E-04
Ingestion of Food Items Contaminated by Direct Spray		
Small mammalian herbivore - acute exposure	1.14E-02	**2.86E-01**
Small mammalian herbivore - chronic exposure	**1.99E+00**	**5.01E+01**
Large mammalian herbivore - acute exposure	7.32E-02	**1.33E+00**
Large mammalian herbivore - chronic exposure	**2.12E+01**	**3.87E+02**
Small avian insectivore - acute exposure	2.34E-02	**6.07E-01**
Small avian insectivore - chronic exposure	1.48E-01	**3.84E+00**
Large avian herbivore - acute exposure	5.96E-02	**1.68E+00**
Large avian herbivore - chronic exposure	3.74E-01	**1.05E+01**
Large mammalian carnivore - acute exposure	3.66E-02	**1.22E-01**
Large mammalian carnivore - chronic exposure	**2.89E+00**	**9.63E+00**

TABLE 4-2 (Cont.)
Risk Quotients for Direct Spray and Spill Scenarios

Terrestrial Plants	Typical Species		RTE Species	
	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate
Direct Spray of Non-Target Terrestrial Plants				
Accidental direct spray	**7.50E+01**	**2.50E+02**	**6.00E+03**	**2.00E+04**

Aquatic Species	Fish		Aquatic Invertebrates		Non-Target Aquatic Plants	
	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate
Accidental Direct Spray Over Pond						
Acute	**9.47E-01**	**3.16E+00**	**4.20E+00**	**1.40E+01**	**5.17E+02**	**1.72E+03**
Chronic	**2.04E+01**	**6.79E+01**	**1.00E+01**	**3.35E+01**	**1.53E+03**	**5.09E+03**
Accidental Direct Spray Over Stream						
Acute	**4.74E+00**	**1.58E+01**	**2.10E+01**	**7.01E+01**	**2.59E+03**	**8.62E+03**
Chronic	**1.02E+02**	**3.40E+02**	**5.02E+01**	**1.67E+02**	**7.64E+03**	**2.55E+04**
Accidental spill						
Truck spill into pond		**1.01E+02**		**4.48E+02**		**5.52E+04**

Shading and boldface indicates terrestrial animal acute RQs greater than 0.1 (LOC for acute risk to endangered species - most conservative).
Shading and boldface indicates terrestrial animal chronic RQs greater than 1 (LOC for chronic risk).Shading and boldface indicates plant RQs greater than 1 (LOC for all plant risks).
Shading and boldface indicates acute RQs greater than 0.05 for fish and invertebrates (LOC for acute risk to endangered species - most conservative).
Shading and boldface indicates chronic RQs greater than 0.5 for fish and invertebrates (LOC for chronic risk to endangered species).
RTE – Rare, threatened, and endangered.
-- indicates the scenario was not evaluated

TABLE 4-3
Risk Quotients for Off-Site Drift Scenarios

Potential Risk to Non-Target Terrestrial Plants						
			Typical Species		Rare, Threatened, and Endangered Species	
Mode of Application	**Application Height or Type**	**Distance From Receptor (ft)**	**Typical Application Rate**	**Maximum Application Rate**	**Typical Application Rate**	**Maximum Application Rate**
Spray Drift to Off-Site Soil						
Ground	Low Boom	25	9.43E-01	**3.14E+00**	**7.54E+01**	**2.51E+02**
Ground	Low Boom	100	3.33E-01	**1.11E+00**	**2.66E+01**	**8.87E+01**
Ground	Low Boom	900	5.13E-02	1.70E-01	**4.10E+00**	**1.36E+01**
Ground	High Boom	25	**1.56E+00**	**5.19E+00**	**1.25E+02**	**4.15E+02**
Ground	High Boom	100	5.24E-01	**1.75E+00**	**4.19E+01**	**1.40E+02**
Ground	High Boom	900	6.50E-02	2.19E-01	**5.20E+00**	**1.75E+01**

TABLE 4-3 (Cont.)
Risk Quotients for Off-Site Drift Scenarios.

Potential Risk to Aquatic Receptors								
			Fish		Aquatic Invertebrates		Non-Target Aquatic Plants	
Mode of Application	Application Height or Type	Distance From Receptor (ft)	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate
Off-Site Drift to Pond Acute Toxicity								
Ground	Low Boom	25	5.76E-03	1.92E-02	2.56E-02	**8.50E-02**	**3.15E+00**	**1.05E+01**
Ground	Low Boom	100	3.15E-03	1.05E-02	1.40E-02	4.68E-02	**1.72E+00**	**5.75E+00**
Ground	Low Boom	900	6.10E-04	2.03E-03	2.71E-03	9.00E-03	3.33E-01	**1.11E+00**
Ground	High Boom	25	9.25E-03	3.08E-02	4.11E-02	**1.37E-01**	**5.05E+00**	**1.68E+01**
Ground	High Boom	100	4.87E-03	1.62E-02	2.16E-02	**7.19E-02**	**2.66E+00**	**8.85E+00**
Ground	High Boom	900	7.73E-04	2.58E-03	3.43E-03	1.14E-02	4.22E-01	**1.41E+00**

Potential Risk to Aquatic Receptors								
			Fish		Aquatic Invertebrates		Non-Target Aquatic Plants	
Mode of Application	Application Height or Type	Distance From Receptor (ft)	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate
Off-Site Drift to Pond Chronic Toxicity								
Ground	Low Boom	25	1.24E-01	4.12E-01	6.10E-02	2.03E-01	**9.30E+00**	**3.09E+01**
Ground	Low Boom	100	6.79E-02	2.27E-01	3.34E-02	1.12E-01	**5.09E+00**	**1.70E+01**
Ground	Low Boom	900	1.31E-02	4.36E-02	6.46E-03	2.15E-02	9.84E-01	**3.27E+00**
Ground	High Boom	25	1.99E-01	**6.64E-01**	9.81E-02	3.27E-01	**1.49E+01**	**4.98E+01**
Ground	High Boom	100	1.05E-01	3.48E-01	5.16E-02	1.72E-01	**7.86E+00**	**2.61E+01**
Ground	High Boom	900	1.66E-02	5.55E-02	8.19E-03	2.73E-02	**1.25E+00**	**4.16E+00**

TABLE 4-3 (Cont.)
Risk Quotients for Off-Site Drift Scenarios

Potential Risk to Aquatic Receptors								
			Fish		Aquatic Invertebrates		Non-Target Aquatic Plants	
Mode of Application	**Application Height or Type**	**Distance From Receptor (ft)**	**Typical Application Rate**	**Maximum Application Rate**	**Typical Application Rate**	**Maximum Application Rate**	**Typical Application Rate**	**Maximum Application Rate**
Off-Site Drift to Stream Acute Toxicity								
Ground	Low Boom	25	1.04E-02	3.46E-02	4.60E-02	**1.53E-01**	**5.66E+00**	**1.89E+01**
Ground	Low Boom	100	3.04E-03	1.01E-02	1.35E-02	4.49E-02	**1.66E+00**	**5.53E+00**
Ground	Low Boom	900	3.15E-04	1.05E-03	1.40E-03	4.65E-03	1.72E-01	5.72E-01
Ground	High Boom	25	1.73E-02	**5.79E-02**	**7.69E-02**	**2.57E-01**	**9.47E+00**	**3.16E+01**
Ground	High Boom	100	4.92E-03	1.64E-02	2.18E-02	**7.27E-02**	**2.69E+00**	**8.95E+00**
Ground	High Boom	900	4.16E-04	1.39E-03	1.84E-03	6.15E-03	2.27E-01	7.57E-01

Potential Risk to Aquatic Receptors								
			Fish		Aquatic Invertebrates		Non-Target Aquatic Plants	
Mode of Application	**Application Height or Type**	**Distance From Receptor (ft)**	**Typical Application Rate**	**Maximum Application Rate**	**Typical Application Rate**	**Maximum Application Rate**	**Typical Application Rate**	**Maximum Application Rate**
Off-Site Drift to Stream Chronic Toxicity								
Ground	Low Boom	25	2.23E-01	**7.43E-01**	1.10E-01	3.66E-01	**1.67E+01**	**5.58E+01**
Ground	Low Boom	100	6.53E-02	2.18E-01	3.22E-02	1.07E-01	**4.90E+00**	**1.63E+01**
Ground	Low Boom	900	6.77E-03	2.25E-02	3.34E-03	1.11E-02	5.08E-01	**1.69E+00**
Ground	High Boom	25	3.73E-01	**1.25E+00**	1.84E-01	**6.13E-01**	**2.80E+01**	**9.34E+01**
Ground	High Boom	100	1.06E-01	3.53E-01	5.21E-02	1.74E-01	**7.93E+00**	**2.64E+01**
Ground	High Boom	900	8.94E-03	2.98E-02	4.40E-03	1.47E-02	6.71E-01	**2.24E+00**

TABLE 4-3 (Cont.)
Risk Quotients for Off-Site Drift Scenarios

Potential Risk to Piscivorous Bird from Ingestion of Fish from Contaminated Pond				
Mode of Application	**Application Height or Type**	**Distance From Receptor (ft)**	**Typical Application Rate**	**Maximum Application Rate**
Ground	Low Boom	25	4.13E-04	1.37E-03
Ground	Low Boom	100	2.26E-04	7.54E-04
Ground	Low Boom	900	4.37E-05	1.45E-04
Ground	High Boom	25	6.63E-04	2.21E-03
Ground	High Boom	100	3.49E-04	1.16E-03
Ground	High Boom	900	5.54E-05	1.85E-04

Shading and boldface indicates plant RQs greater than 1 (LOC for all plant risks).
Shading and boldface indicates acute RQs greater than 0.05 for fish and invertebrates (LOC for acute risk to endangered species - most conservative).
Shading and boldface indicates chronic RQs greater than 0.5 for fish and invertebrates (LOC for chronic risk to endangered species).
Shading and boldface indicates terrestrial animal acute RQs greater than 0.1 (LOC for acute risk to endangered species - most conservative).
Shading and boldface indicates terrestrial animal chronic RQs greater than 1 (LOC for chronic risk).
RTE – Rare, threatened, and endangered.

TABLE 4-4
Risk Quotients for Surface Runoff Scenarios

Potential Risk to Non-Target Terrestrial Plants										
							Typical Species		RTE Species	
Annual Precipitation Rate (in/yr)	**Application Area (ac)**	**Hydraulic Slope**	**Surface Roughness**	**USLE Soil Erodibility Factor[1]**	**Vegetation Type**	**Soil Type**	**Typical Application Rate**	**Maximum Application Rate**	**Typical Application Rate**	**Maximum Application Rate**
Surface Runoff to Off-Site Soils										
5	10	0.05	0.015	0.401	Weeds (78)	Sand	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	10	0.05	0.015	0.401	Weeds (78)	Clay	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	10	0.05	0.015	0.401	Weeds (78)	Loam	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	10	0.05	0.015	0.401	Weeds (78)	Sand	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	10	0.05	0.015	0.401	Weeds (78)	Clay	3.45E-04	1.15E-03	8.81E-02	2.94E-01
10	10	0.05	0.015	0.401	Weeds (78)	Loam	3.31E-06	1.10E-05	8.44E-04	2.81E-03
25	10	0.05	0.015	0.401	Weeds (78)	Sand	3.89E-09	1.30E-08	9.92E-07	3.31E-06
25	10	0.05	0.015	0.401	Weeds (78)	Clay	6.63E-04	2.21E-03	1.69E-01	5.64E-01
25	10	0.05	0.015	0.401	Weeds (78)	Loam	4.88E-05	1.63E-04	1.24E-02	4.15E-02
50	10	0.05	0.015	0.401	Weeds (78)	Sand	1.15E-09	3.82E-09	2.93E-07	9.76E-07
50	10	0.05	0.015	0.401	Weeds (78)	Clay	1.54E-03	5.14E-03	3.94E-01	**1.31E+00**
50	10	0.05	0.015	0.401	Weeds (78)	Loam	1.29E-04	4.30E-04	3.29E-02	1.10E-01
100	10	0.05	0.015	0.401	Weeds (78)	Sand	3.78E-07	1.26E-06	9.66E-05	3.22E-04
100	10	0.05	0.015	0.401	Weeds (78)	Clay	3.93E-03	1.31E-02	**1.00E+00**	**3.35E+00**
100	10	0.05	0.015	0.401	Weeds (78)	Loam	3.88E-04	1.29E-03	9.91E-02	3.30E-01
150	10	0.05	0.015	0.401	Weeds (78)	Sand	1.28E-07	4.27E-07	3.27E-05	1.09E-04
150	10	0.05	0.015	0.401	Weeds (78)	Clay	5.13E-03	1.71E-02	**1.31E+00**	**4.36E+00**
150	10	0.05	0.015	0.401	Weeds (78)	Loam	8.16E-04	2.72E-03	2.08E-01	6.94E-01
200	10	0.05	0.015	0.401	Weeds (78)	Sand	4.14E-06	1.38E-05	1.06E-03	3.52E-03
200	10	0.05	0.015	0.401	Weeds (78)	Clay	8.23E-03	2.74E-02	**2.10E+00**	**7.01E+00**
200	10	0.05	0.015	0.401	Weeds (78)	Loam	1.48E-03	4.95E-03	3.79E-01	**1.26E+00**

TABLE 4-4 (Cont.)
Risk Quotients for Surface Runoff Scenarios

Potential Risk to Non-Target Terrestrial Plants										
							Typical Species		RTE Species	
Annual Precipitation Rate (in/yr)	Application Area (ac)	Hydraulic Slope	Surface Roughness	USLE Soil Erodibility Factor[1]	Vegetation Type	Soil Type	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate
Surface Runoff to Off-Site Soils (Cont.)										
250	10	0.05	0.015	0.401	Weeds (78)	Sand	4.63E-06	1.54E-05	1.18E-03	3.94E-03
250	10	0.05	0.015	0.401	Weeds (78)	Clay	1.11E-02	3.71E-02	**2.85E+00**	**9.48E+00**
250	10	0.05	0.015	0.401	Weeds (78)	Loam	2.12E-03	7.07E-03	5.41E-01	**1.80E+00**
50	1	0.05	0.015	0.401	Weeds (78)	Loam	1.18E-04	3.93E-04	3.01E-02	1.00E-01
50	100	0.05	0.015	0.401	Weeds (78)	Loam	1.18E-04	3.93E-04	3.01E-02	1.00E-01
50	1000	0.05	0.015	0.401	Weeds (78)	Loam	1.17E-04	3.91E-04	3.00E-02	9.98E-02
50	10	0.05	0.015	0.05	Weeds (78)	Loam	1.16E-04	3.86E-04	2.96E-02	9.85E-02
50	10	0.05	0.015	0.2	Weeds (78)	Loam	1.19E-04	3.98E-04	3.05E-02	1.02E-01
50	10	0.05	0.015	0.5	Weeds (78)	Loam	1.27E-04	4.22E-04	3.23E-02	1.08E-01
50	10	0.05	0.023	0.401	Weeds (78)	Loam	1.18E-04	3.94E-04	3.02E-02	1.01E-01
50	10	0.05	0.046	0.401	Weeds (78)	Loam	1.18E-04	3.92E-04	3.00E-02	1.00E-01
50	10	0.05	0.15	0.401	Weeds (78)	Loam	1.15E-04	3.84E-04	2.94E-02	9.81E-02
50	10	0.005	0.015	0.401	Weeds (78)	Loam	1.15E-04	3.84E-04	2.94E-02	9.81E-02
50	10	0.01	0.015	0.401	Weeds (78)	Loam	1.16E-04	3.85E-04	2.95E-02	9.84E-02
50	10	0.1	0.015	0.401	Weeds (78)	Loam	1.23E-04	4.12E-04	3.15E-02	1.05E-01
50	10	0.05	0.015	0.401	Weeds (78)	Silt Loam	7.00E-04	2.33E-03	1.79E-01	5.96E-01
50	10	0.05	0.015	0.401	Weeds (78)	Silt	6.63E-04	2.21E-03	1.69E-01	5.64E-01
50	10	0.05	0.015	0.401	Weeds (78)	Clay Loam	1.29E-03	4.29E-03	3.29E-01	**1.10E+00**
50	10	0.05	0.015	0.401	Shrubs(79)	Loam	1.18E-04	3.94E-04	3.02E-02	1.01E-01
50	10	0.05	0.015	0.401	Rye Grass(54)	Loam	1.18E-04	3.94E-04	3.02E-02	1.01E-01
50	10	0.05	0.015	0.401	Conifer + Hardwood (71)	Loam	1.47E-04	4.89E-04	3.75E-02	1.25E-01

TABLE 4-4 (Cont.)
Risk Quotients for Surface Runoff Scenarios

Potential Risk to Aquatic Receptors												
							Fish		Aquatic Invertebrates		Non-Target Aquatic Plants	
Annual Precipitation Rate (in/yr)	Application Area (ac)	Hydraulic Slope	Surface Roughness	USLE Soil Erodibility Factor[1]	Vegetation Type	Soil Type	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate
Overland Flow to Off-Site Pond Acute Toxicity												
5	10	0.05	0.015	0.401	Weeds (78)	Sand	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	10	0.05	0.015	0.401	Weeds (78)	Clay	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	10	0.05	0.015	0.401	Weeds (78)	Loam	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	10	0.05	0.015	0.401	Weeds (78)	Sand	6.38E-03	2.13E-02	2.83E-02	**9.44E-02**	**3.48E+00**	**1.16E+01**
10	10	0.05	0.015	0.401	Weeds (78)	Clay	**1.75E-01**	**5.85E-01**	**7.78E-01**	**2.59E+00**	**9.58E+01**	**3.19E+02**
10	10	0.05	0.015	0.401	Weeds (78)	Loam	1.61E-03	5.38E-03	7.16E-03	2.39E-02	8.81E-01	**2.94E+00**
25	10	0.05	0.015	0.401	Weeds (78)	Sand	**3.47E-01**	**1.16E+00**	**1.54E+00**	**5.13E+00**	**1.89E+02**	**6.31E+02**
25	10	0.05	0.015	0.401	Weeds (78)	Clay	**1.40E-01**	**4.65E-01**	**6.20E-01**	**2.07E+00**	**7.62E+01**	**2.54E+02**
25	10	0.05	0.015	0.401	Weeds (78)	Loam	7.09E-03	2.36E-02	3.15E-02	**1.05E-01**	**3.87E+00**	**1.29E+01**
50	10	0.05	0.015	0.401	Weeds (78)	Sand	**2.83E-01**	**9.43E-01**	**1.26E+00**	**4.18E+00**	**1.54E+02**	**5.15E+02**
50	10	0.05	0.015	0.401	Weeds (78)	Clay	**6.43E-01**	**2.14E+00**	**2.85E+00**	**9.51E+00**	**3.51E+02**	**1.17E+03**
50	10	0.05	0.015	0.401	Weeds (78)	Loam	**7.42E-02**	**2.47E-01**	**3.29E-01**	**1.10E+00**	**4.05E+01**	**1.35E+02**
100	10	0.05	0.015	0.401	Weeds (78)	Sand	**2.06E-01**	**6.85E-01**	**9.12E-01**	**3.04E+00**	**1.12E+02**	**3.74E+02**
100	10	0.05	0.015	0.401	Weeds (78)	Clay	**9.30E-01**	**3.10E+00**	**4.13E+00**	**1.38E+01**	**5.08E+02**	**1.69E+03**
100	10	0.05	0.015	0.401	Weeds (78)	Loam	**1.48E-01**	**4.92E-01**	**6.55E-01**	**2.18E+00**	**8.06E+01**	**2.69E+02**
150	10	0.05	0.015	0.401	Weeds (78)	Sand	**2.01E-01**	**6.69E-01**	**8.90E-01**	**2.97E+00**	**1.10E+02**	**3.65E+02**
150	10	0.05	0.015	0.401	Weeds (78)	Clay	**1.04E+00**	**3.45E+00**	**4.60E+00**	**1.53E+01**	**5.66E+02**	**1.89E+03**
150	10	0.05	0.015	0.401	Weeds (78)	Loam	**1.92E-01**	**6.41E-01**	**8.53E-01**	**2.84E+00**	**1.05E+02**	**3.50E+02**
200	10	0.05	0.015	0.401	Weeds (78)	Sand	**2.09E-01**	**6.96E-01**	**9.27E-01**	**3.09E+00**	**1.14E+02**	**3.80E+02**
200	10	0.05	0.015	0.401	Weeds (78)	Clay	**1.02E+00**	**3.39E+00**	**4.52E+00**	**1.51E+01**	**5.56E+02**	**1.85E+03**
200	10	0.05	0.015	0.401	Weeds (78)	Loam	**2.03E-01**	**6.77E-01**	**9.01E-01**	**3.00E+00**	**1.11E+02**	**3.70E+02**

TABLE 4-4 (Cont.)
Risk Quotients for Surface Runoff Scenarios

Potential Risk to Aquatic Receptors												
							Fish		Aquatic Invertebrates		Non-Target Aquatic Plants	
Annual Precipitation Rate (in/yr)	Application Area (ac)	Hydraulic Slope	Surface Roughness	USLE Soil Erodibility Factor[1]	Vegetation Type	Soil Type	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate
Surface Runoff to Off-Site Pond Acute Toxicity (Cont.)												
250	10	0.05	0.015	0.401	Weeds (78)	Sand	2.15E-01	7.16E-01	9.54E-01	3.18E+00	1.17E+02	3.91E+02
250	10	0.05	0.015	0.401	Weeds (78)	Clay	9.92E-01	3.31E+00	4.40E+00	1.47E+01	5.42E+02	1.81E+03
250	10	0.05	0.015	0.401	Weeds (78)	Loam	2.00E-01	6.68E-01	8.90E-01	2.97E+00	1.09E+02	3.65E+02
50	1	0.05	0.015	0.401	Weeds (78)	Loam	2.08E-02	6.94E-02	9.24E-02	3.08E-01	1.14E+01	3.79E+01
50	100	0.05	0.015	0.401	Weeds (78)	Loam	5.48E-02	1.83E-01	2.43E-01	8.10E-01	2.99E+01	9.97E+01
50	1000	0.05	0.015	0.401	Weeds (78)	Loam	5.47E-02	1.82E-01	2.43E-01	8.09E-01	2.99E+01	9.96E+01
50	10	0.05	0.015	0.05	Weeds (78)	Loam	7.05E-02	2.35E-01	3.13E-01	1.04E+00	3.85E+01	1.28E+02
50	10	0.05	0.015	0.2	Weeds (78)	Loam	7.15E-02	2.38E-01	3.17E-01	1.06E+00	3.91E+01	1.30E+02
50	10	0.05	0.015	0.5	Weeds (78)	Loam	7.35E-02	2.45E-01	3.26E-01	1.09E+00	4.01E+01	1.34E+02
50	10	0.05	0.023	0.401	Weeds (78)	Loam	7.12E-02	2.37E-01	3.16E-01	1.05E+00	3.89E+01	1.30E+02
50	10	0.05	0.046	0.401	Weeds (78)	Loam	7.10E-02	2.37E-01	3.15E-01	1.05E+00	3.88E+01	1.29E+02
50	10	0.05	0.15	0.401	Weeds (78)	Loam	7.04E-02	2.35E-01	3.12E-01	1.04E+00	3.85E+01	1.28E+02
50	10	0.005	0.015	0.401	Weeds (78)	Loam	7.04E-02	2.35E-01	3.12E-01	1.04E+00	3.85E+01	1.28E+02
50	10	0.01	0.015	0.401	Weeds (78)	Loam	7.05E-02	2.35E-01	3.13E-01	1.04E+00	3.85E+01	1.28E+02
50	10	0.1	0.015	0.401	Weeds (78)	Loam	7.26E-02	2.42E-01	3.22E-01	1.07E+00	3.97E+01	1.32E+02
50	10	0.05	0.015	0.401	Weeds (78)	Silt Loam	1.97E-01	6.57E-01	8.75E-01	2.92E+00	1.08E+02	3.59E+02
50	10	0.05	0.015	0.401	Weeds (78)	Silt	1.71E-01	5.71E-01	7.61E-01	2.54E+00	9.36E+01	3.12E+02
50	10	0.05	0.015	0.401	Weeds (78)	Clay Loam	3.13E-01	1.04E+00	1.39E+00	4.64E+00	1.71E+02	5.70E+02
50	10	0.05	0.015	0.401	Shrubs(79)	Loam	7.13E-02	2.38E-01	3.16E-01	1.05E+00	3.89E+01	1.30E+02
50	10	0.05	0.015	0.401	Rye Grass (54)	Loam	7.13E-02	2.38E-01	3.16E-01	1.05E+00	3.89E+01	1.30E+02
50	10	0.05	0.015	0.401	Conifer + Hardwood (71)	Loam	8.06E-02	2.69E-01	3.57E-01	1.19E+00	4.40E+01	1.47E+02

TABLE 4-4 (Cont.)
Risk Quotients for Surface Runoff Scenarios

Potential Risk to Aquatic Receptors												
							Fish		Aquatic Invertebrates		Non-Target Aquatic Plants	
Annual Precipitation Rate (in/yr)	Application Area (ac)	Hydraulic Slope	Surface Roughness	USLE Soil Erodibility Factor[1]	Vegetation Type	Soil Type	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate
Surface Runoff to Off-Site Pond Chronic Toxicity												
5	10	0.05	0.015	0.401	Weeds (78)	Sand	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	10	0.05	0.015	0.401	Weeds (78)	Clay	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	10	0.05	0.015	0.401	Weeds (78)	Loam	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	10	0.05	0.015	0.401	Weeds (78)	Sand	2.67E-02	8.89E-02	1.31E-02	4.38E-02	**2.00E+00**	**6.67E+00**
10	10	0.05	0.015	0.401	Weeds (78)	Clay	1.81E-01	**6.02E-01**	8.90E-02	2.97E-01	**1.36E+01**	**4.52E+01**
10	10	0.05	0.015	0.401	Weeds (78)	Loam	3.16E-03	1.05E-02	1.56E-03	5.19E-03	2.37E-01	7.90E-01
25	10	0.05	0.015	0.401	Weeds (78)	Sand	**3.70E+00**	**1.23E+01**	**1.82E+00**	**6.07E+00**	**2.77E+02**	**9.25E+02**
25	10	0.05	0.015	0.401	Weeds (78)	Clay	3.85E-01	**1.28E+00**	1.90E-01	**6.33E-01**	**2.89E+01**	**9.63E+01**
25	10	0.05	0.015	0.401	Weeds (78)	Loam	1.85E-02	6.16E-02	9.10E-03	3.03E-02	**1.39E+00**	**4.62E+00**
50	10	0.05	0.015	0.401	Weeds (78)	Sand	**4.12E+00**	**1.37E+01**	**2.03E+00**	**6.77E+00**	**2.77E+02**	**1.03E+03**
50	10	0.05	0.015	0.401	Weeds (78)	Clay	**7.63E-01**	**2.54E+00**	3.76E-01	**1.25E+00**	**5.72E+01**	**1.91E+02**
50	10	0.05	0.015	0.401	Weeds (78)	Loam	**5.82E-01**	**1.94E+00**	2.87E-01	**9.56E-01**	**4.37E+01**	**1.46E+02**
100	10	0.05	0.015	0.401	Weeds (78)	Sand	**2.39E+00**	**7.95E+00**	**1.17E+00**	**3.92E+00**	**1.79E+02**	**5.96E+02**
100	10	0.05	0.015	0.401	Weeds (78)	Clay	**8.60E-01**	**2.87E+00**	4.24E-01	**1.41E+00**	**6.45E+01**	**2.15E+02**
100	10	0.05	0.015	0.401	Weeds (78)	Loam	**1.27E+00**	**4.23E+00**	**6.25E-01**	**2.08E+00**	**9.52E+01**	**3.17E+02**
150	10	0.05	0.015	0.401	Weeds (78)	Sand	**1.73E+00**	**5.77E+00**	**8.53E-01**	**2.84E+00**	**1.30E+02**	**4.33E+02**
150	10	0.05	0.015	0.401	Weeds (78)	Clay	**6.54E-01**	**2.18E+00**	3.22E-01	**1.07E+00**	**4.91E+01**	**1.64E+02**
150	10	0.05	0.015	0.401	Weeds (78)	Loam	**1.22E+00**	**4.08E+00**	**6.02E-01**	**2.01E+00**	**9.17E+01**	**3.06E+02**
200	10	0.05	0.015	0.401	Weeds (78)	Sand	**1.73E+00**	**5.78E+00**	**8.54E-01**	**2.85E+00**	**1.30E+02**	**4.33E+02**
200	10	0.05	0.015	0.401	Weeds (78)	Clay	**5.22E-01**	**1.74E+00**	2.57E-01	**8.58E-01**	**3.92E+01**	**1.31E+02**
200	10	0.05	0.015	0.401	Weeds (78)	Loam	**1.12E+00**	**3.72E+00**	**5.50E-01**	**1.83E+00**	**8.37E+01**	**2.79E+02**

TABLE 4-4 (Cont.)
Risk Quotients for Surface Runoff Scenarios

Potential Risk to Aquatic Receptors												
							Fish		Aquatic Invertebrates		Non-Target Aquatic Plants	
Annual Precipitation Rate (in/yr)	Application Area (ac)	Hydraulic Slope	Surface Roughness	USLE Soil Erodibility Factor[1]	Vegetation Type	Soil Type	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate
Surface Runoff to Off-Site Pond Chronic Toxicity (Cont.)												
250	10	0.05	0.015	0.401	Weeds (78)	Sand	**1.75E+00**	**5.84E+00**	**8.62E-01**	**2.87E+00**	**1.31E+02**	**4.38E+02**
250	10	0.05	0.015	0.401	Weeds (78)	Clay	4.46E-01	**1.49E+00**	2.20E-01	**7.33E-01**	**3.35E+01**	**1.12E+02**
250	10	0.05	0.015	0.401	Weeds (78)	Loam	**1.02E+00**	**3.40E+00**	**5.02E-01**	**1.67E+00**	**7.65E+01**	**2.55E+02**
50	1	0.05	0.015	0.401	Weeds (78)	Loam	2.42E-01	**8.08E-01**	1.19E-01	3.98E-01	**1.82E+01**	**6.06E+01**
50	100	0.05	0.015	0.401	Weeds (78)	Loam	**6.96E-01**	**2.32E+00**	3.43E-01	**1.14E+00**	**5.22E+01**	**1.74E+02**
50	1000	0.05	0.015	0.401	Weeds (78)	Loam	**7.06E-01**	**2.35E+00**	3.48E-01	**1.16E+00**	**5.29E+01**	**1.76E+02**
50	10	0.05	0.015	0.05	Weeds (78)	Loam	**5.81E-01**	**1.94E+00**	2.86E-01	**9.54E-01**	**4.36E+01**	**1.45E+02**
50	10	0.05	0.015	0.2	Weeds (78)	Loam	**5.81E-01**	**1.94E+00**	2.86E-01	**9.55E-01**	**4.36E+01**	**1.45E+02**
50	10	0.05	0.015	0.5	Weeds (78)	Loam	**5.82E-01**	**1.94E+00**	2.87E-01	**9.56E-01**	**4.37E+01**	**1.46E+02**
50	10	0.05	0.023	0.401	Weeds (78)	Loam	**5.81E-01**	**1.94E+00**	2.86E-01	**9.54E-01**	**4.36E+01**	**1.45E+02**
50	10	0.05	0.046	0.401	Weeds (78)	Loam	**5.81E-01**	**1.94E+00**	2.86E-01	**9.54E-01**	**4.36E+01**	**1.45E+02**
50	10	0.05	0.15	0.401	Weeds (78)	Loam	**5.81E-01**	**1.94E+00**	2.86E-01	**9.54E-01**	**4.36E+01**	**1.45E+02**
50	10	0.005	0.015	0.401	Weeds (78)	Loam	**5.81E-01**	**1.94E+00**	2.86E-01	**9.54E-01**	**4.36E+01**	**1.45E+02**
50	10	0.01	0.015	0.401	Weeds (78)	Loam	**5.81E-01**	**1.94E+00**	2.86E-01	**9.54E-01**	**4.36E+01**	**1.45E+02**
50	10	0.1	0.015	0.401	Weeds (78)	Loam	**5.82E-01**	**1.94E+00**	2.87E-01	**9.55E-01**	**4.36E+01**	**1.45E+02**
50	10	0.05	0.015	0.401	Weeds (78)	Silt Loam	3.64E-01	**1.21E+00**	1.79E-01	**5.97E-01**	**2.73E+01**	**9.09E+01**
50	10	0.05	0.015	0.401	Weeds (78)	Silt	2.67E-01	**8.90E-01**	1.31E-01	4.38E-01	**2.00E+01**	**6.67E+01**
50	10	0.05	0.015	0.401	Weeds (78)	Clay Loam	**8.42E-01**	**2.81E+00**	4.15E-01	**1.38E+00**	**6.32E+01**	**2.11E+02**
50	10	0.05	0.015	0.401	Shrubs (79)	Loam	**5.82E-01**	**1.94E+00**	2.87E-01	**9.56E-01**	**4.37E+01**	**1.46E+02**
50	10	0.05	0.015	0.401	Rye Grass (54)	Loam	**5.82E-01**	**1.94E+00**	2.87E-01	**9.56E-01**	**4.37E+01**	**1.46E+02**
50	10	0.05	0.015	0.401	Conifer + Hardwood (71)	Loam	**7.83E-01**	**2.61E+00**	3.85E-01	**1.28E+00**	**5.87E+01**	**1.96E+02**

Table 4-4 (Cont.)
Risk Quotients for Surface Runoff Scenarios

Annual Precipitation Rate (in/yr)	Application Area (ac)	Hydraulic Slope	Surface Roughness	USLE Soil Erodibility Factor[1]	Vegetation Type	Soil Type	Fish: Typical Application Rate	Fish: Maximum Application Rate	Aquatic Invertebrates: Typical Application Rate	Aquatic Invertebrates: Maximum Application Rate	Non-Target Aquatic Plants: Typical Application Rate	Non-Target Aquatic Plants: Maximum Application Rate
Potential Risk to Aquatic Receptors												
Surface Runoff to Off-Site Stream — Acute Toxicity												
5	10	0.05	0.015	0.401	Weeds (78)	Sand	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	10	0.05	0.015	0.401	Weeds (78)	Clay	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	10	0.05	0.015	0.401	Weeds (78)	Loam	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	10	0.05	0.015	0.401	Weeds (78)	Sand	2.60E-04	8.65E-04	1.15E-03	3.84E-03	1.42E-01	4.72E-01
10	10	0.05	0.015	0.401	Weeds (78)	Clay	5.78E-03	1.93E-02	2.56E-02	**8.54E-02**	**3.15E+00**	**1.05E+01**
10	10	0.05	0.015	0.401	Weeds (78)	Loam	5.38E-05	1.79E-04	2.39E-04	7.96E-04	2.94E-02	9.80E-02
25	10	0.05	0.015	0.401	Weeds (78)	Sand	3.33E-02	**1.11E-01**	**1.48E-01**	**4.93E-01**	**1.82E+01**	**6.06E+01**
25	10	0.05	0.015	0.401	Weeds (78)	Clay	9.57E-03	3.19E-02	4.25E-02	**1.42E-01**	**5.22E+00**	**1.74E+01**
25	10	0.05	0.015	0.401	Weeds (78)	Loam	7.03E-04	2.34E-03	3.12E-03	1.04E-02	3.84E-01	**1.28E+00**
50	10	0.05	0.015	0.401	Weeds (78)	Sand	3.95E-02	**1.32E-01**	**1.75E-01**	**5.84E-01**	**2.16E+01**	**7.18E+01**
50	10	0.05	0.015	0.401	Weeds (78)	Clay	2.33E-02	**7.76E-02**	**1.03E-01**	**3.44E-01**	**1.27E+01**	**4.24E+01**
50	10	0.05	0.015	0.401	Weeds (78)	Loam	4.09E-03	1.36E-02	1.81E-02	**6.05E-02**	**2.23E+00**	**7.44E+00**
100	10	0.05	0.015	0.401	Weeds (78)	Sand	3.81E-02	**1.27E-01**	**1.69E-01**	**5.63E-01**	**2.08E+01**	**6.93E+01**
100	10	0.05	0.015	0.401	Weeds (78)	Clay	4.67E-02	**1.56E-01**	**2.07E-01**	**6.91E-01**	**2.55E+01**	**8.50E+01**
100	10	0.05	0.015	0.401	Weeds (78)	Loam	1.18E-02	3.92E-02	**5.22E-02**	**1.74E-01**	**6.42E+00**	**2.14E+01**
150	10	0.05	0.015	0.401	Weeds (78)	Sand	3.22E-02	**1.07E-01**	**1.43E-01**	**4.76E-01**	**1.76E+01**	**5.86E+01**
150	10	0.05	0.015	0.401	Weeds (78)	Clay	**5.86E-02**	**1.95E-01**	**2.60E-01**	**8.66E-01**	**3.20E+01**	**1.07E+02**
150	10	0.05	0.015	0.401	Weeds (78)	Loam	1.46E-02	4.88E-02	**6.50E-02**	**2.17E-01**	**7.99E+00**	**2.66E+01**
200	10	0.05	0.015	0.401	Weeds (78)	Sand	3.45E-02	**1.15E-01**	**1.53E-01**	**5.11E-01**	**1.89E+01**	**6.29E+01**
200	10	0.05	0.015	0.401	Weeds (78)	Clay	**8.72E-02**	**2.91E-01**	**3.87E-01**	**1.29E+00**	**4.76E+01**	**1.59E+02**
200	10	0.05	0.015	0.401	Weeds (78)	Loam	2.17E-02	**7.25E-02**	**9.65E-02**	**3.22E-01**	**1.19E+01**	**3.96E+01**

TABLE 4-4 (Cont.)
Risk Quotients for Surface Runoff Scenarios

Annual Precipitation Rate (in/yr)	Application Area (ac)	Hydraulic Slope	Surface Roughness	USLE Soil Erodibility Factor[1]	Vegetation Type	Soil Type	Fish: Typical Application Rate	Fish: Maximum Application Rate	Aquatic Invertebrates: Typical Application Rate	Aquatic Invertebrates: Maximum Application Rate	Non-Target Aquatic Plants: Typical Application Rate	Non-Target Aquatic Plants: Maximum Application Rate
Potential Risk to Aquatic Receptors												
Surface Runoff to Off-Site Stream Acute Toxicity (Cont.)												
250	10	0.05	0.015	0.401	Weeds (78)	Sand	3.44E-02	**1.15E-01**	**1.53E-01**	**5.09E-01**	**1.88E+01**	**6.27E+01**
250	10	0.05	0.015	0.401	Weeds (78)	Clay	**1.12E-01**	**3.72E-01**	**4.95E-01**	**1.65E+00**	**6.10E+01**	**2.03E+02**
250	10	0.05	0.015	0.401	Weeds (78)	Loam	2.73E-02	**9.10E-02**	**1.21E-01**	**4.04E-01**	**1.49E+01**	**4.97E+01**
50	1	0.05	0.015	0.401	Weeds (78)	Loam	5.78E-04	1.93E-03	2.57E-03	8.55E-03	3.16E-01	**1.05E+00**
50	100	0.05	0.015	0.401	Weeds (78)	Loam	1.88E-02	**6.28E-02**	**8.36E-02**	**2.79E-01**	**1.03E+01**	**3.43E+01**
50	1000	0.05	0.015	0.401	Weeds (78)	Loam	3.50E-02	**1.17E-01**	**1.55E-01**	**5.18E-01**	**1.91E+01**	**6.37E+01**
50	10	0.05	0.015	0.05	Weeds (78)	Loam	4.08E-03	1.36E-02	1.81E-02	**6.03E-02**	**2.23E+00**	**7.42E+00**
50	10	0.05	0.015	0.2	Weeds (78)	Loam	4.08E-03	1.36E-02	1.81E-02	**6.04E-02**	**2.23E+00**	**7.43E+00**
50	10	0.05	0.015	0.5	Weeds (78)	Loam	4.09E-03	1.36E-02	1.81E-02	**6.04E-02**	**2.23E+00**	**7.44E+00**
50	10	0.05	0.023	0.401	Weeds (78)	Loam	4.08E-03	1.36E-02	1.81E-02	**6.03E-02**	**2.23E+00**	**7.42E+00**
50	10	0.05	0.046	0.401	Weeds (78)	Loam	4.08E-03	1.36E-02	1.81E-02	**6.03E-02**	**2.23E+00**	**7.43E+00**
50	10	0.05	0.15	0.401	Weeds (78)	Loam	4.08E-03	1.36E-02	1.81E-02	**6.03E-02**	**2.23E+00**	**7.42E+00**
50	10	0.005	0.015	0.401	Weeds (78)	Loam	4.08E-03	1.36E-02	1.81E-02	**6.03E-02**	**2.23E+00**	**7.42E+00**
50	10	0.01	0.015	0.401	Weeds (78)	Loam	4.08E-03	1.36E-02	1.81E-02	**6.03E-02**	**2.23E+00**	**7.42E+00**
50	10	0.1	0.015	0.401	Weeds (78)	Loam	4.09E-03	1.36E-02	1.81E-02	**6.05E-02**	**2.23E+00**	**7.44E+00**
50	10	0.05	0.015	0.401	Weeds (78)	Silt Loam	1.07E-02	3.58E-02	4.76E-02	**1.59E-01**	**5.86E+00**	**1.95E+01**
50	10	0.05	0.015	0.401	Weeds (78)	Silt	1.01E-02	3.36E-02	4.48E-02	**1.49E-01**	**5.51E+00**	**1.84E+01**
50	10	0.05	0.015	0.401	Weeds (78)	Clay Loam	1.84E-02	**6.14E-02**	**8.17E-02**	**2.72E-01**	**1.01E+01**	**3.35E+01**
50	10	0.05	0.015	0.401	Shrubs (79)	Loam	4.09E-03	1.36E-02	1.81E-02	**6.05E-02**	**2.23E+00**	**7.44E+00**
50	10	0.05	0.015	0.401	Rye Grass (54)	Loam	4.09E-03	1.36E-02	1.81E-02	**6.04E-02**	**2.23E+00**	**7.44E+00**
50	10	0.05	0.015	0.401	Conifer + Hardwood (71)	Loam	5.19E-03	1.73E-02	2.30E-02	**7.67E-02**	**2.83E+00**	**9.44E+00**

TABLE 4-4 (Cont.)
Risk Quotients for Surface Runoff Scenarios

Potential Risk to Aquatic Receptors												
							Fish		Aquatic Invertebrates		Non-Target Aquatic Plants	
Annual Precipitation Rate (in/yr)	Application Area (ac)	Hydraulic Slope	Surface Roughness	USLE Soil Erodibility Factor[1]	Vegetation Type	Soil Type	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate
Surface Runoff to Off-Site Stream Chronic Toxicity												
5	10	0.05	0.015	0.401	Weeds (78)	Sand	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	10	0.05	0.015	0.401	Weeds (78)	Clay	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	10	0.05	0.015	0.401	Weeds (78)	Loam	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	10	0.05	0.015	0.401	Weeds (78)	Sand	8.21E-05	2.74E-04	4.05E-05	1.35E-04	6.16E-03	2.05E-02
10	10	0.05	0.015	0.401	Weeds (78)	Clay	1.02E-03	3.41E-03	5.04E-04	1.68E-03	7.68E-02	2.56E-01
10	10	0.05	0.015	0.401	Weeds (78)	Loam	9.49E-06	3.16E-05	4.68E-06	1.56E-05	7.12E-04	2.37E-03
25	10	0.05	0.015	0.401	Weeds (78)	Sand	2.49E-02	8.30E-02	1.23E-02	4.09E-02	**1.87E+00**	**6.23E+00**
25	10	0.05	0.015	0.401	Weeds (78)	Clay	3.44E-03	1.15E-02	1.69E-03	5.65E-03	2.58E-01	8.60E-01
25	10	0.05	0.015	0.401	Weeds (78)	Loam	1.91E-04	6.36E-04	9.40E-05	3.13E-04	1.43E-02	4.77E-02
50	10	0.05	0.015	0.401	Weeds (78)	Sand	4.98E-02	1.66E-01	2.45E-02	8.18E-02	**3.74E+00**	**1.25E+01**
50	10	0.05	0.015	0.401	Weeds (78)	Clay	9.91E-03	3.30E-02	4.88E-03	1.63E-02	7.43E-01	**2.48E+00**
50	10	0.05	0.015	0.401	Weeds (78)	Loam	7.00E-03	2.33E-02	3.45E-03	1.15E-02	5.25E-01	**1.75E+00**
100	10	0.05	0.015	0.401	Weeds (78)	Sand	5.88E-02	1.96E-01	2.89E-02	9.65E-02	**4.41E+00**	**1.47E+01**
100	10	0.05	0.015	0.401	Weeds (78)	Clay	2.38E-02	7.93E-02	1.17E-02	3.90E-02	**1.78E+00**	**5.95E+00**
100	10	0.05	0.015	0.401	Weeds (78)	Loam	2.66E-02	8.88E-02	1.31E-02	4.37E-02	**2.00E+00**	**6.66E+00**
150	10	0.05	0.015	0.401	Weeds (78)	Sand	5.87E-02	1.96E-01	2.89E-02	9.64E-02	**4.41E+00**	**1.47E+01**
150	10	0.05	0.015	0.401	Weeds (78)	Clay	3.05E-02	1.02E-01	1.50E-02	5.01E-02	**2.29E+00**	**7.63E+00**
150	10	0.05	0.015	0.401	Weeds (78)	Loam	3.53E-02	1.18E-01	1.74E-02	5.80E-02	**2.65E+00**	**8.83E+00**
200	10	0.05	0.015	0.401	Weeds (78)	Sand	5.99E-02	2.00E-01	2.95E-02	9.84E-02	**4.50E+00**	**1.50E+01**
200	10	0.05	0.015	0.401	Weeds (78)	Clay	3.35E-02	1.12E-01	1.65E-02	5.50E-02	**2.51E+00**	**8.38E+00**
200	10	0.05	0.015	0.401	Weeds (78)	Loam	3.97E-02	1.32E-01	1.95E-02	6.51E-02	**2.98E+00**	**9.92E+00**

TABLE 4-4 (Cont.)
Risk Quotients for Surface Runoff Scenarios

Potential Risk to Aquatic Receptors												
							Fish		Aquatic Invertebrates		Non-Target Aquatic Plants	
Annual Precipitation Rate (in/yr)	Application Area (ac)	Hydraulic Slope	Surface Roughness	USLE Soil Erodibility Factor[1]	Vegetation Type	Soil Type	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate
Surface Runoff to Off-Site Stream Chronic Toxicity (Cont.)												
250	10	0.05	0.015	0.401	Weeds (78)	Sand	6.08E-02	2.03E-01	3.00E-02	9.99E-02	**4.56E+00**	**1.52E+01**
250	10	0.05	0.015	0.401	Weeds (78)	Clay	3.51E-02	1.17E-01	1.73E-02	5.76E-02	**2.63E+00**	**8.77E+00**
250	10	0.05	0.015	0.401	Weeds (78)	Loam	4.19E-02	1.40E-01	2.06E-02	6.88E-02	**3.14E+00**	**1.05E+01**
50	1	0.05	0.015	0.401	Weeds (78)	Loam	7.86E-04	2.62E-03	3.87E-04	1.29E-03	5.89E-02	1.96E-01
50	100	0.05	0.015	0.401	Weeds (78)	Loam	4.01E-02	1.34E-01	1.98E-02	6.59E-02	**3.01E+00**	**1.00E+01**
50	1000	0.05	0.015	0.401	Weeds (78)	Loam	1.06E-01	3.53E-01	5.21E-02	1.74E-01	**7.94E+00**	**2.65E+01**
50	10	0.05	0.015	0.05	Weeds (78)	Loam	6.96E-03	2.32E-02	3.43E-03	1.14E-02	5.22E-01	**1.74E+00**
50	10	0.05	0.015	0.2	Weeds (78)	Loam	6.97E-03	2.32E-02	3.44E-03	1.15E-02	5.23E-01	**1.74E+00**
50	10	0.05	0.015	0.5	Weeds (78)	Loam	7.00E-03	2.33E-02	3.45E-03	1.15E-02	5.25E-01	**1.75E+00**
50	10	0.05	0.023	0.401	Weeds (78)	Loam	6.97E-03	2.32E-02	3.43E-03	1.14E-02	5.23E-01	**1.74E+00**
50	10	0.05	0.046	0.401	Weeds (78)	Loam	6.97E-03	2.32E-02	3.43E-03	1.14E-02	5.23E-01	**1.74E+00**
50	10	0.05	0.15	0.401	Weeds (78)	Loam	6.96E-03	2.32E-02	3.43E-03	1.14E-02	5.22E-01	**1.74E+00**
50	10	0.005	0.015	0.401	Weeds (78)	Loam	6.96E-03	2.32E-02	3.43E-03	1.14E-02	5.22E-01	**1.74E+00**
50	10	0.01	0.015	0.401	Weeds (78)	Loam	6.96E-03	2.32E-02	3.43E-03	1.14E-02	5.22E-01	**1.74E+00**
50	10	0.1	0.015	0.401	Weeds (78)	Loam	6.99E-03	2.33E-02	3.44E-03	1.15E-02	5.24E-01	**1.75E+00**
50	10	0.05	0.015	0.401	Weeds (78)	Silt Loam	4.54E-03	1.51E-02	2.24E-03	7.46E-03	3.41E-01	**1.14E+00**
50	10	0.05	0.015	0.401	Weeds (78)	Silt	3.88E-03	1.29E-02	1.91E-03	6.38E-03	2.91E-01	9.71E-01
50	10	0.05	0.015	0.401	Weeds (78)	Clay Loam	8.84E-03	2.95E-02	4.35E-03	1.45E-02	6.63E-01	**2.21E+00**
50	10	0.05	0.015	0.401	Shrubs (79)	Loam	6.98E-03	2.33E-02	3.44E-03	1.15E-02	5.24E-01	**1.75E+00**
50	10	0.05	0.015	0.401	Rye Grass (54)	Loam	6.98E-03	2.33E-02	3.44E-03	1.15E-02	5.24E-01	**1.75E+00**
50	10	0.05	0.015	0.401	Conifer + Hardwood (71)	Loam	1.00E-02	3.33E-02	4.93E-03	1.64E-02	7.50E-01	**2.50E+00**

TABLE 4-4 (Cont.)
Risk Quotients for Surface Runoff Scenarios

Potential Risk to Piscivorous Bird from Ingestion of Fish from Contaminated Pond								
Annual Precipitation Rate (in/yr)	**Application Area (ac)**	**Hydraulic Slope**	**Surface Roughness**	**USLE Soil Erodibility Factor[1]**	**Vegetation Type**	**Soil Type**	**Typical Application Rate**	**Maximum Application Rate**
5	10	0.05	0.015	0.401	Weeds (78)	Sand	0.00E+00	0.00E+00
5	10	0.05	0.015	0.401	Weeds (78)	Clay	0.00E+00	0.00E+00
5	10	0.05	0.015	0.401	Weeds (78)	Loam	0.00E+00	0.00E+00
10	10	0.05	0.015	0.401	Weeds (78)	Sand	8.88E-05	2.96E-04
10	10	0.05	0.015	0.401	Weeds (78)	Clay	6.01E-04	2.00E-03
10	10	0.05	0.015	0.401	Weeds (78)	Loam	1.05E-05	3.51E-05
25	10	0.05	0.015	0.401	Weeds (78)	Sand	1.23E-02	4.10E-02
25	10	0.05	0.015	0.401	Weeds (78)	Clay	1.28E-03	4.27E-03
25	10	0.05	0.015	0.401	Weeds (78)	Loam	6.15E-05	2.05E-04
50	10	0.05	0.015	0.401	Weeds (78)	Sand	1.37E-02	4.58E-02
50	10	0.05	0.015	0.401	Weeds (78)	Clay	2.54E-03	8.47E-03
50	10	0.05	0.015	0.401	Weeds (78)	Loam	1.94E-03	6.46E-03
100	10	0.05	0.015	0.401	Weeds (78)	Sand	7.94E-03	2.65E-02
100	10	0.05	0.015	0.401	Weeds (78)	Clay	2.86E-03	9.54E-03
100	10	0.05	0.015	0.401	Weeds (78)	Loam	4.22E-03	1.41E-02
150	10	0.05	0.015	0.401	Weeds (78)	Sand	5.77E-03	1.92E-02
150	10	0.05	0.015	0.401	Weeds (78)	Clay	2.18E-03	7.26E-03
150	10	0.05	0.015	0.401	Weeds (78)	Loam	4.07E-03	1.36E-02
200	10	0.05	0.015	0.401	Weeds (78)	Sand	5.77E-03	1.92E-02
200	10	0.05	0.015	0.401	Weeds (78)	Clay	1.74E-03	5.80E-03
200	10	0.05	0.015	0.401	Weeds (78)	Loam	3.71E-03	1.24E-02
250	10	0.05	0.015	0.401	Weeds (78)	Sand	5.83E-03	1.94E-02
250	10	0.05	0.015	0.401	Weeds (78)	Clay	1.49E-03	4.95E-03
250	10	0.05	0.015	0.401	Weeds (78)	Loam	3.40E-03	1.13E-02
50	1	0.05	0.015	0.401	Weeds (78)	Loam	8.07E-04	2.69E-03
50	100	0.05	0.015	0.401	Weeds (78)	Loam	2.32E-03	7.72E-03
50	1000	0.05	0.015	0.401	Weeds (78)	Loam	2.35E-03	7.83E-03
50	10	0.05	0.015	0.05	Weeds (78)	Loam	1.93E-03	6.45E-03
50	10	0.05	0.015	0.2	Weeds (78)	Loam	1.94E-03	6.45E-03

TABLE 4-4 (Cont.)
Risk Quotients for Surface Runoff Scenarios

Potential Risk to Piscivorous Bird from Ingestion of Fish from Contaminated Pond (Cont.)								
Annual Precipitation Rate (in/yr)	**Application Area (ac)**	**Hydraulic Slope**	**Surface Roughness**	**USLE Soil Erodibility Factor[1]**	**Vegetation Type**	**Soil Type**	**Typical Application Rate**	**Maximum Application Rate**
50	10	0.05	0.015	0.5	Weeds (78)	Loam	1.94E-03	6.46E-03
50	10	0.05	0.023	0.401	Weeds (78)	Loam	1.93E-03	6.45E-03
50	10	0.05	0.046	0.401	Weeds (78)	Loam	1.93E-03	6.45E-03
50	10	0.05	0.15	0.401	Weeds (78)	Loam	1.93E-03	6.45E-03
50	10	0.005	0.015	0.401	Weeds (78)	Loam	1.93E-03	6.45E-03
50	10	0.01	0.015	0.401	Weeds (78)	Loam	1.93E-03	6.45E-03
50	10	0.1	0.015	0.401	Weeds (78)	Loam	1.94E-03	6.46E-03
50	10	0.05	0.015	0.401	Weeds (78)	Silt Loam	1.21E-03	4.03E-03
50	10	0.05	0.015	0.401	Weeds (78)	Silt	8.88E-04	2.96E-03
50	10	0.05	0.015	0.401	Weeds (78)	Clay Loam	2.80E-03	9.35E-03
50	10	0.05	0.015	0.401	Shrubs(79)	Lam	1.94E-03	6.46E-03
50	10	0.05	0.015	0.401	Rye Grass(54)	Loam	1.94E-03	6.46E-03
50	10	0.05	0.015	0.401	Conifer + Hardwood (71)	Loam	2.60E-03	8.68E-03

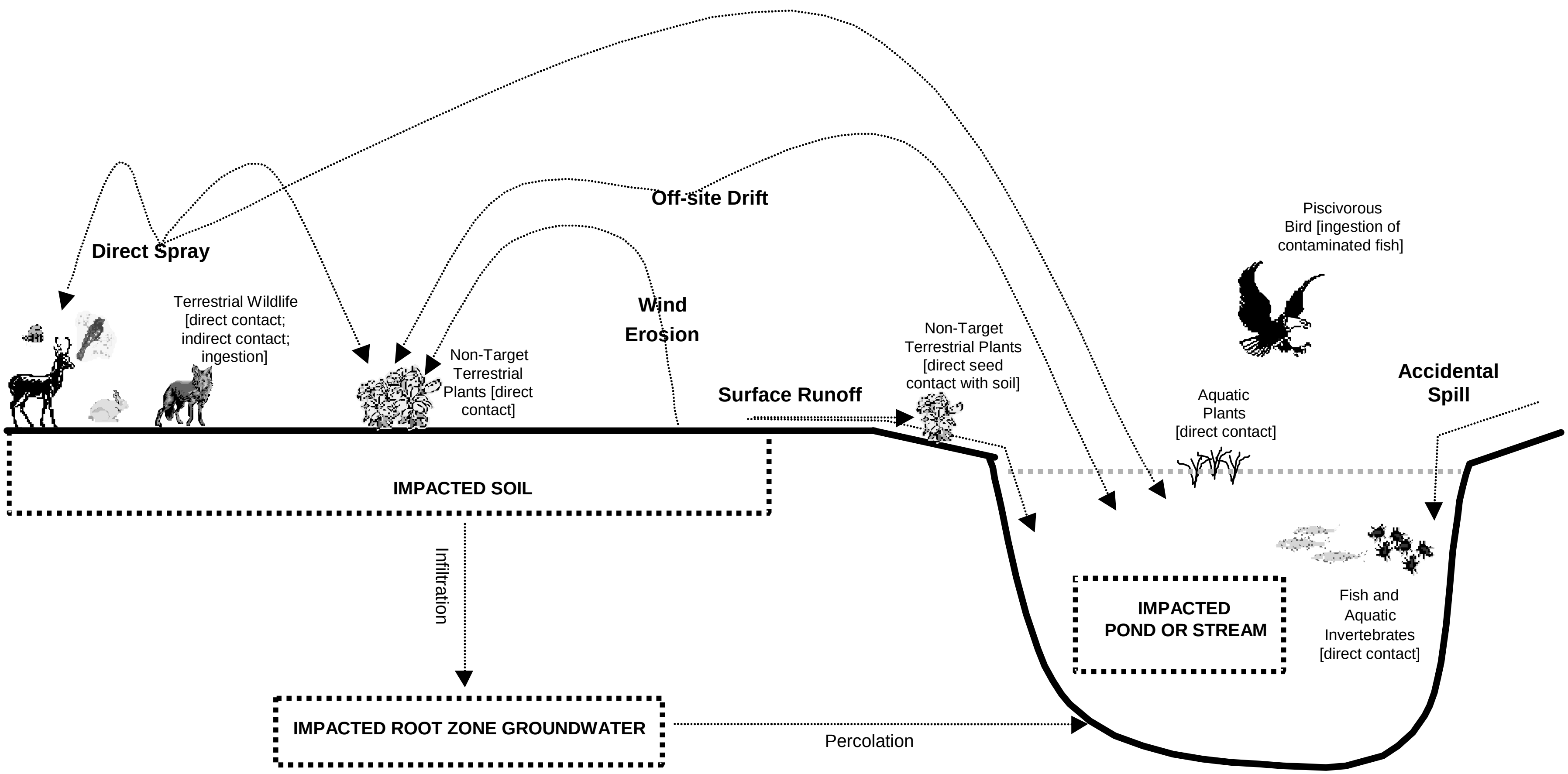
[1]Universal Soil Loss Equation.
Shading and boldface indicates plant RQs greater than 1.
Shading and boldface indicates terrestrial animal RQs greater than 0.1 (LOC for acute risk to endangered species - most conservative).
Shading and boldface indicates acute RQs greater than 0.05 for fish and invertebrates.
Shading and boldface indicates chronic RQs greater than 0.5 for fish and invertebrates

TABLE 4-5
Risk Quotients for Wind Erosion and Transport Off-Site Scenarios

Transport of wind-blown dust to off-site soil: potential risk to non-target terrestrial plants					
		Typical Species		RTE Species	
Watershed Location	**Distance from Receptor (km)**	**Typical Application Rate**	**Maximum Application Rate**	**Typical Application Rate**	**Maximum Application Rate**
Montana	1.5	4.03E-04	1.34E-03	3.22E-02	1.07E-01
Montana	10	2.28E-04	7.61E-04	1.83E-02	6.09E-02
Montana	100	2.73E-08	1.03E-07	2.19E-06	8.21E-06
Oregon	1.5	2.31E-04	7.69E-04	1.85E-02	6.15E-02
Oregon	10	8.80E-05	2.93E-04	7.04E-03	2.35E-02
Oregon	100	3.10E-08	1.03E-07	2.48E-06	8.26E-06
Wyoming	1.5	4.56E-05	1.52E-04	3.65E-03	1.22E-02
Wyoming	10	3.15E-05	1.05E-04	2.52E-03	8.39E-03
Wyoming	100	7.74E-09	2.58E-08	6.19E-07	2.06E-06

Shading and boldface indicates plant RQs greater than 1 (LOC for all plant risks).

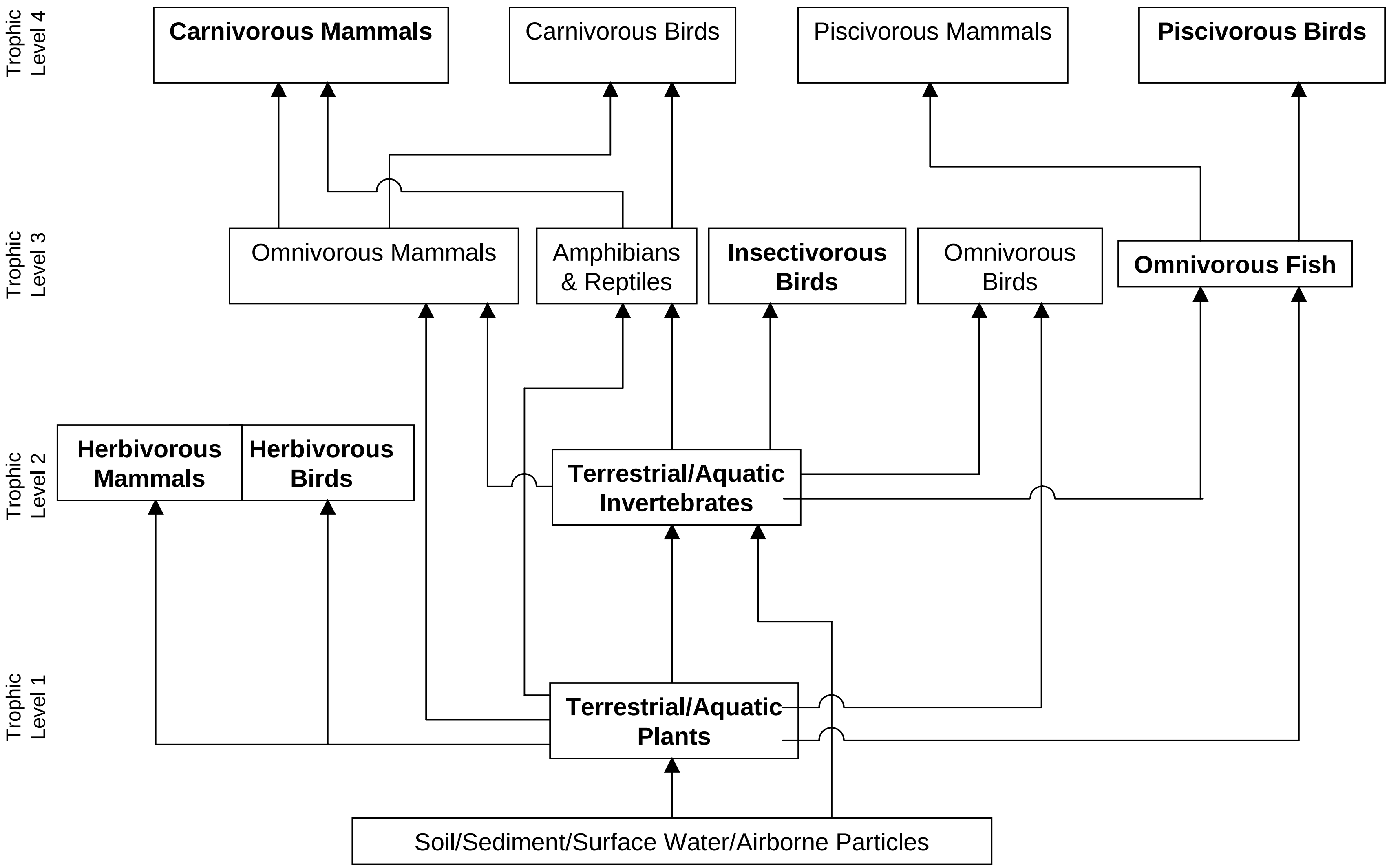
FIGURE 4-1. Conceptual Model for Terrestrial Herbicides.



Application of terrestrial herbicides may occur by aerial (i.e., plane, helicopter) or ground (i.e., truck, backpack) methods.

See Figure 4-2 for simplified food web & evaluated receptors.

FIGURE 4-2. Simplified Food Web.



Receptors in **bold** type quantitatively assessed in the BLM herbicide ERAs.

FIGURE 4-3. Direct Spray - Risk Quotients for Terrestrial Animals.

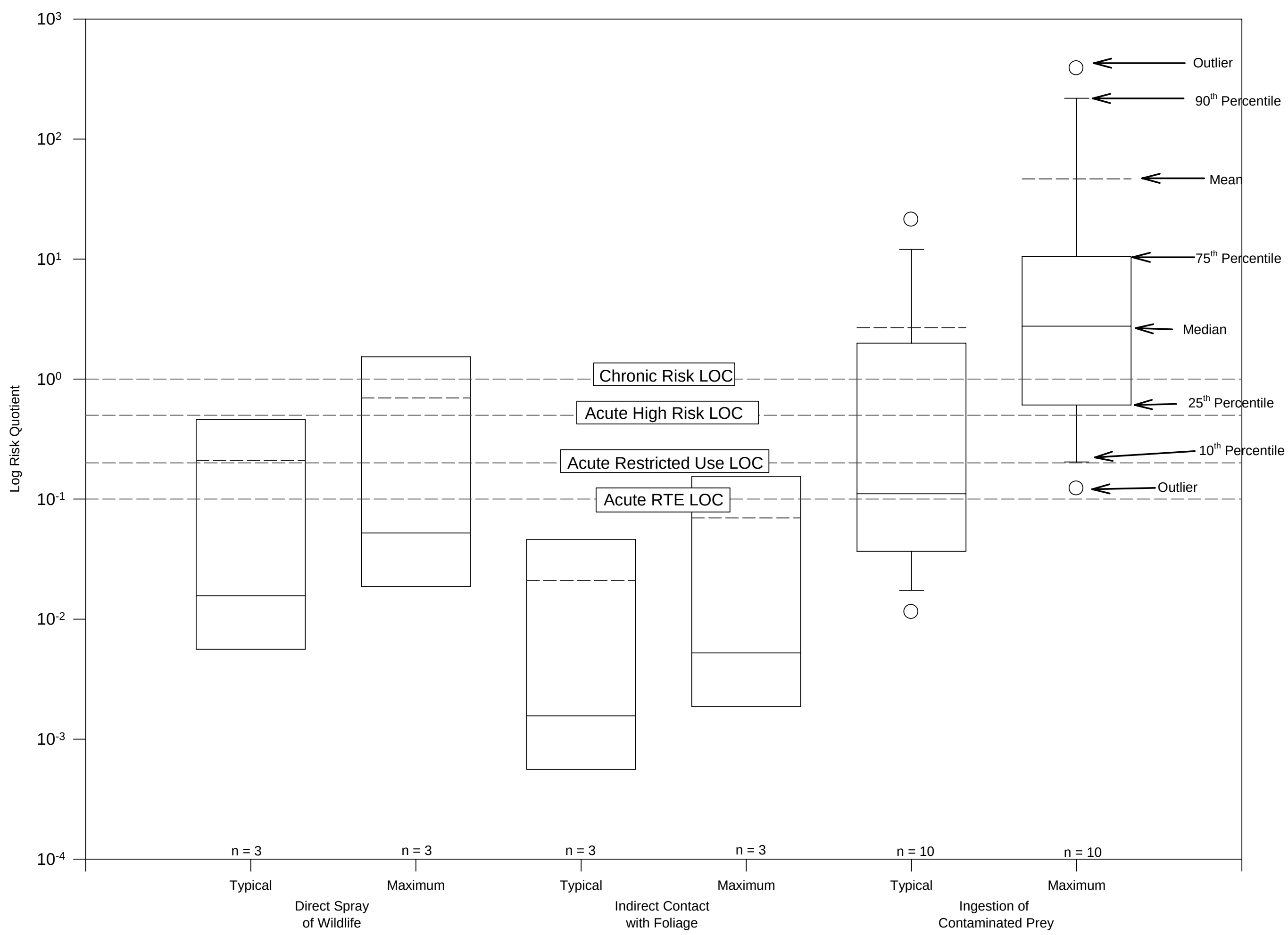


FIGURE 4-4. Direct Spray - Risk Quotients for Non-Target Terrestrial Plants.

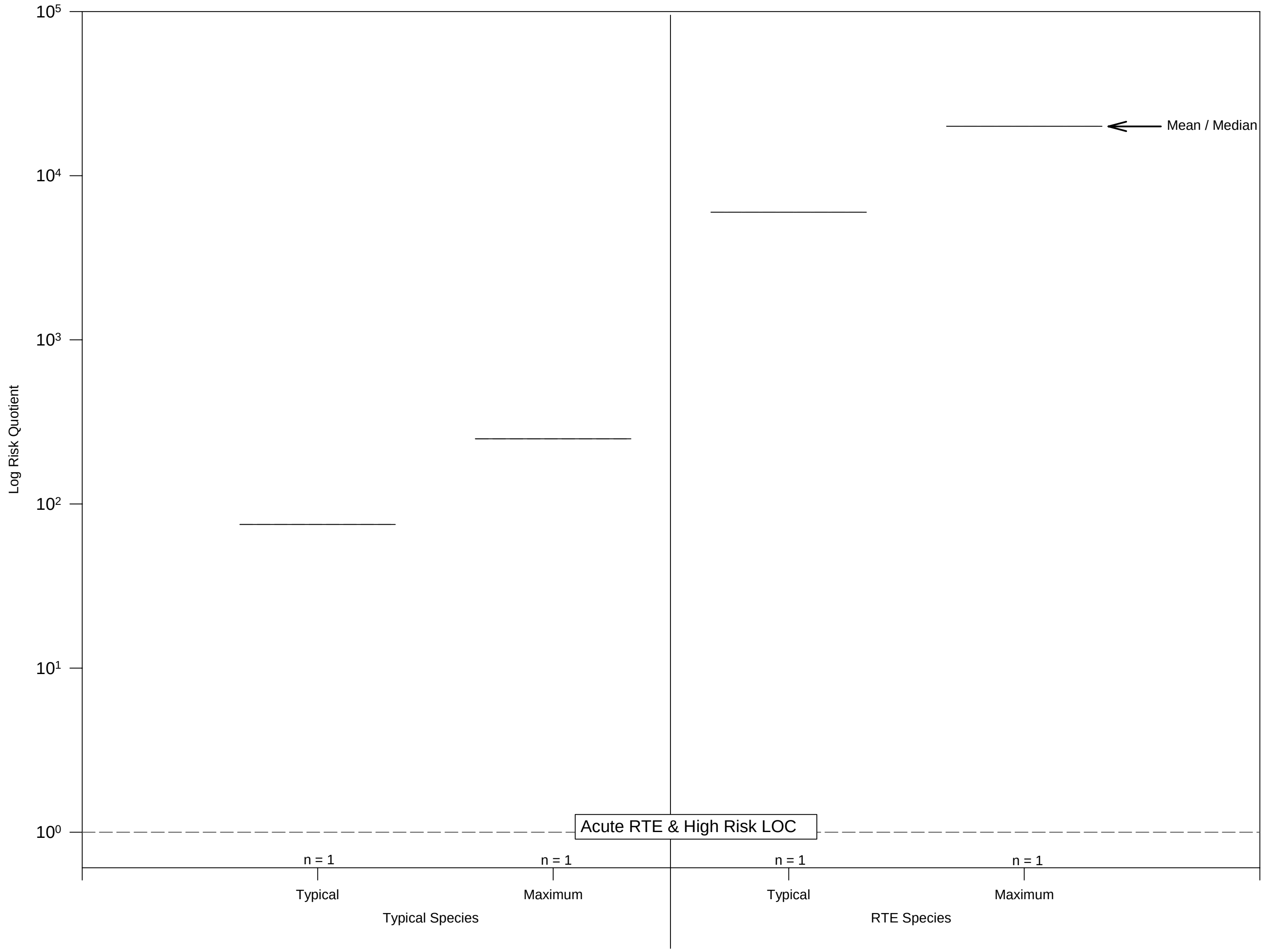


FIGURE 4-5. Accidental Direct Spray and Spills - Risk Quotients for Non-Target Aquatic Plants.

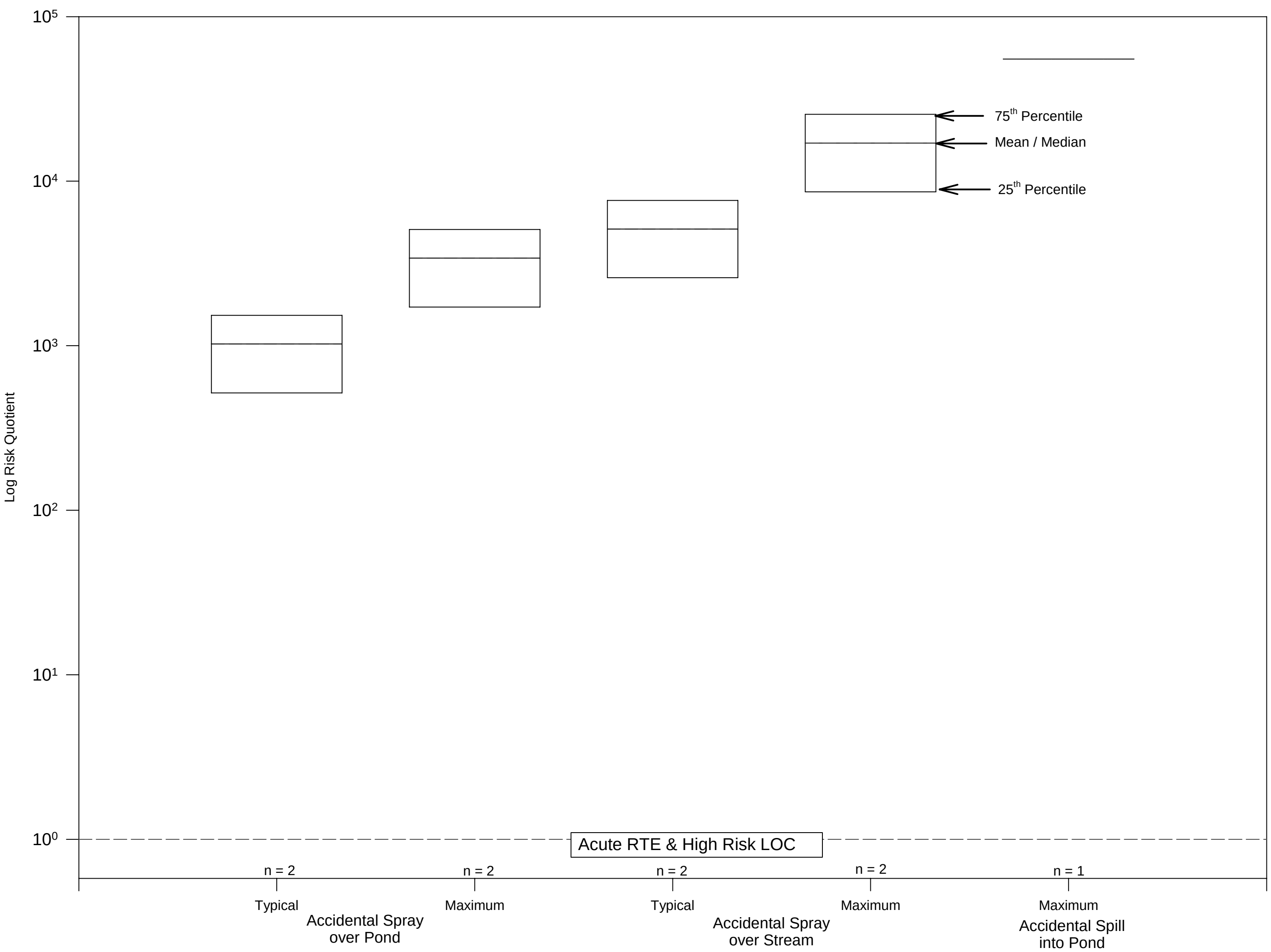


FIGURE 4-6. Accidental Direct Spray and Spills - Risk Quotients for Fish.

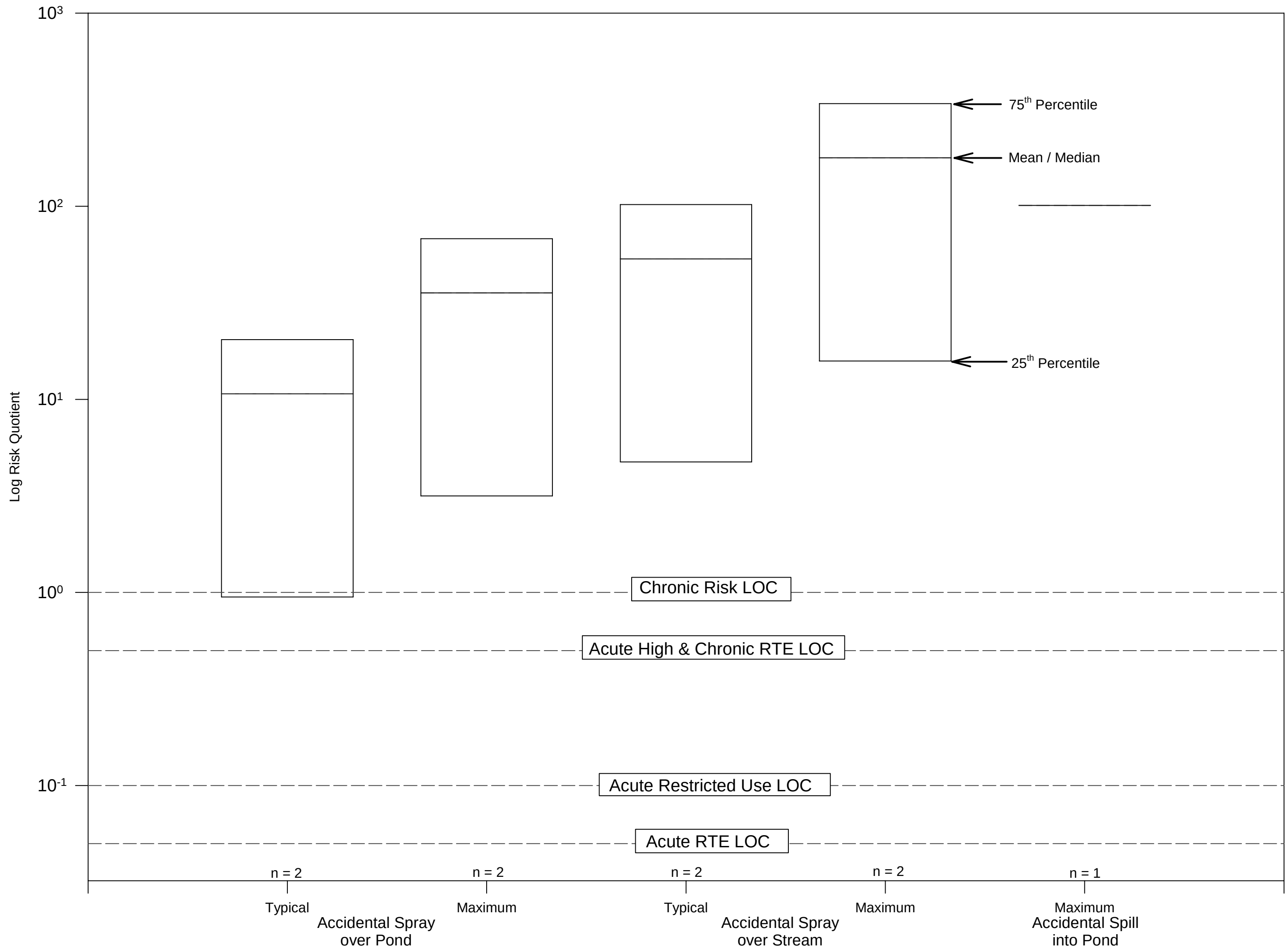


FIGURE 4-7. Accidental Direct Spray and Spills - Risk Quotients for Aquatic Invertebrates.

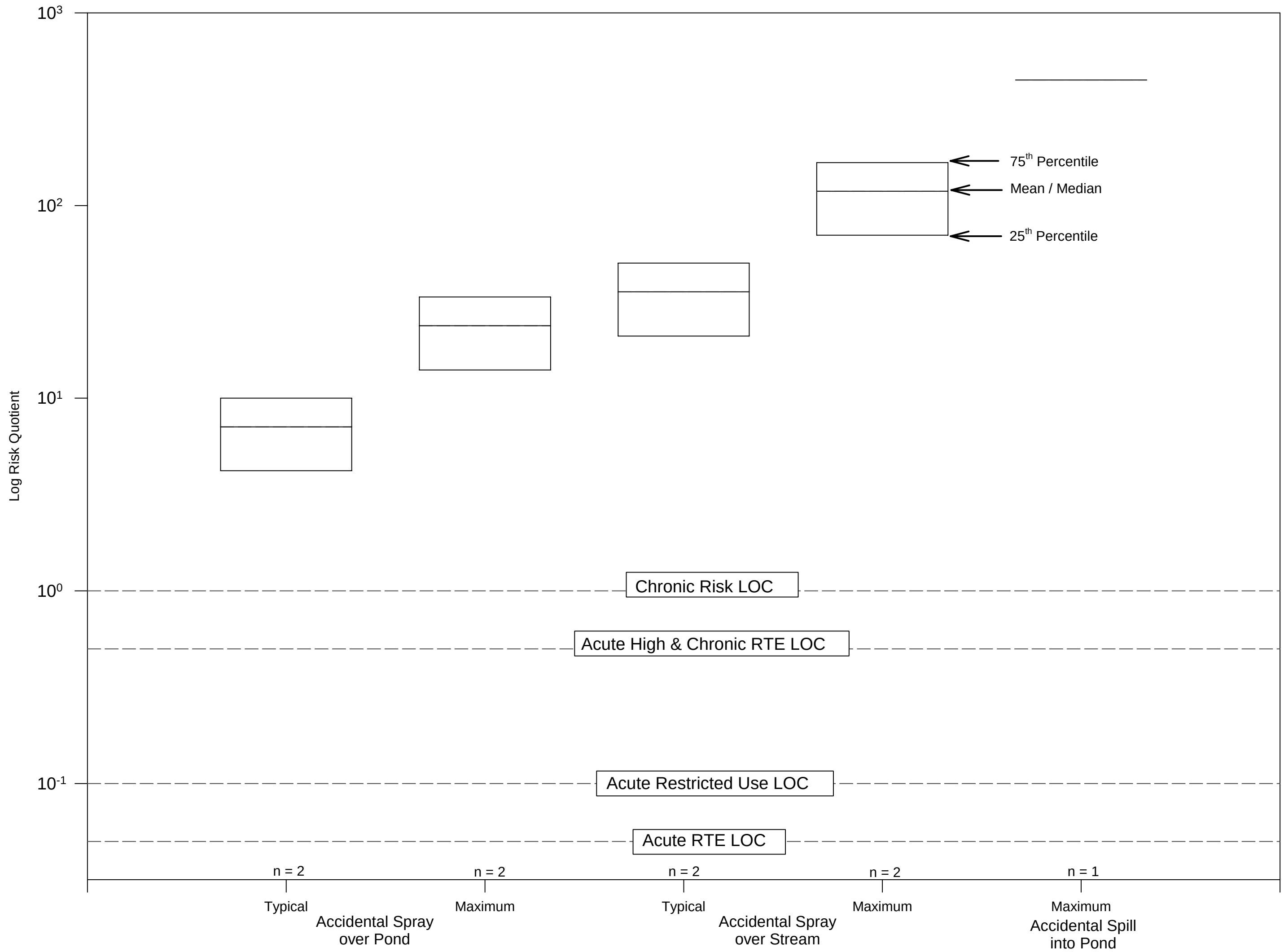


FIGURE 4-8. Off-Site Drift - Risk Quotients for Non-Target Terrestrial Plants.

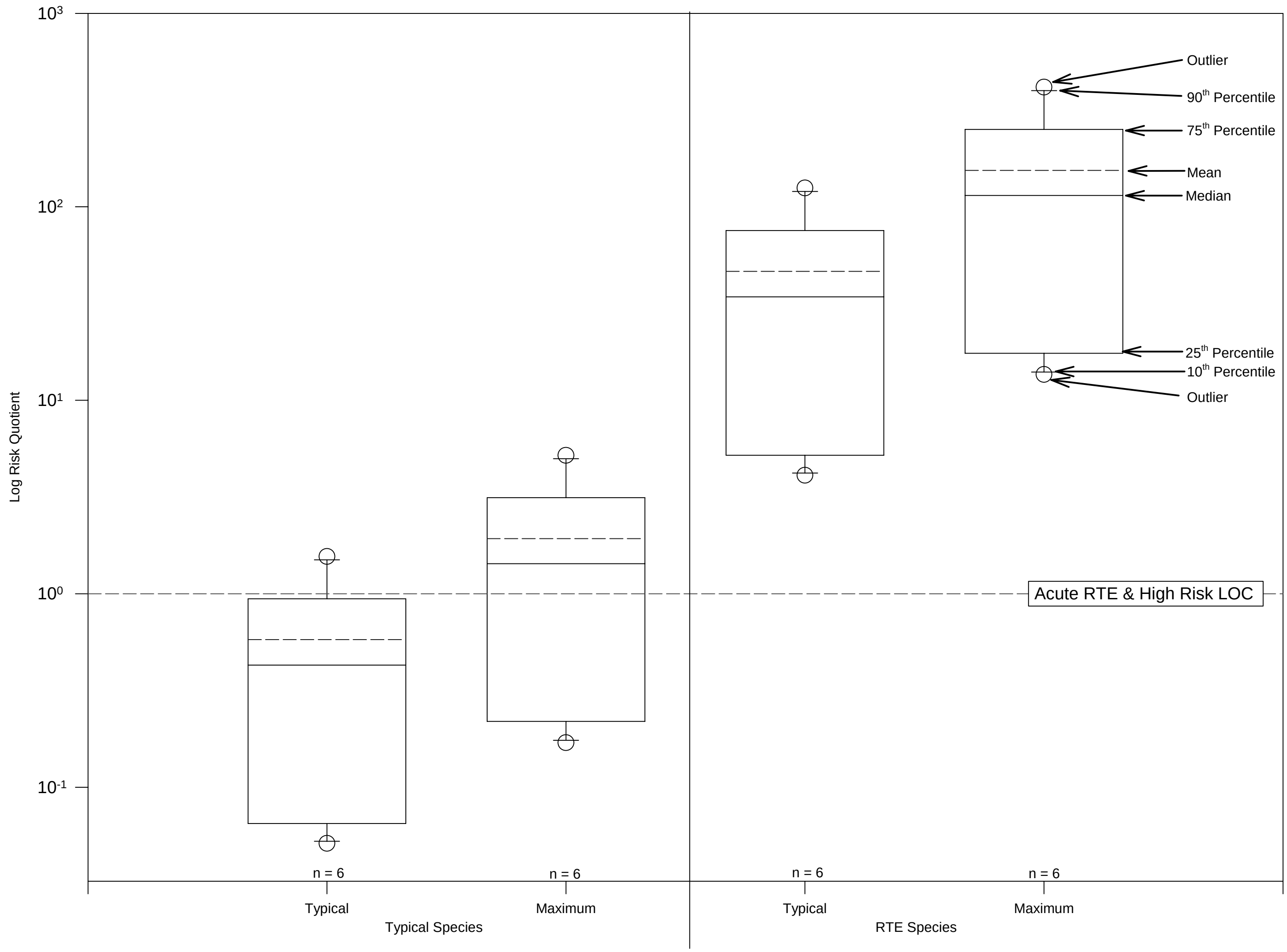


FIGURE 4-9. Off-Site Drift - Risk Quotients for Non-Target Aquatic Plants.

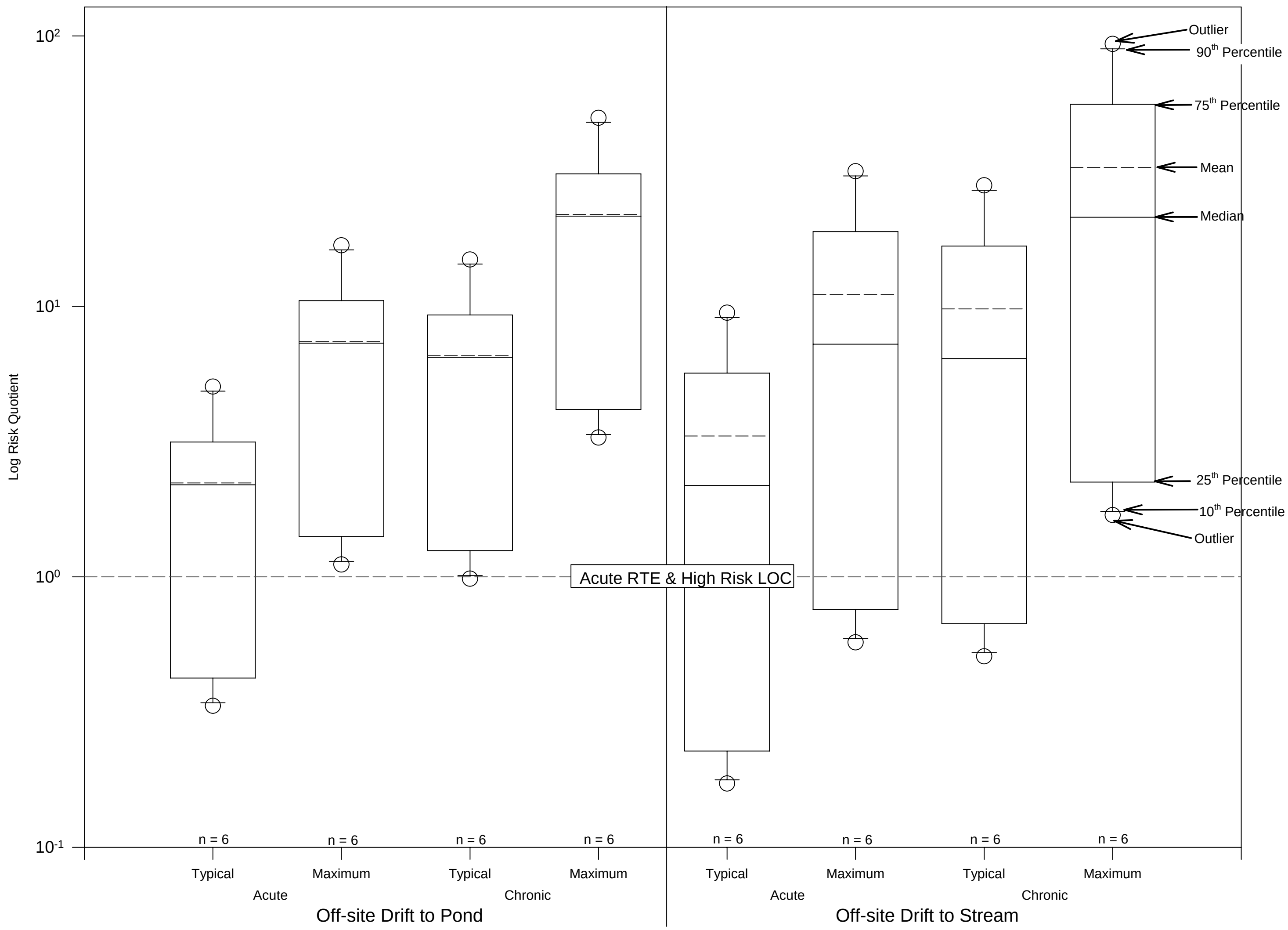


FIGURE 4-10. Off-Site Drift - Risk Quotients for Fish.

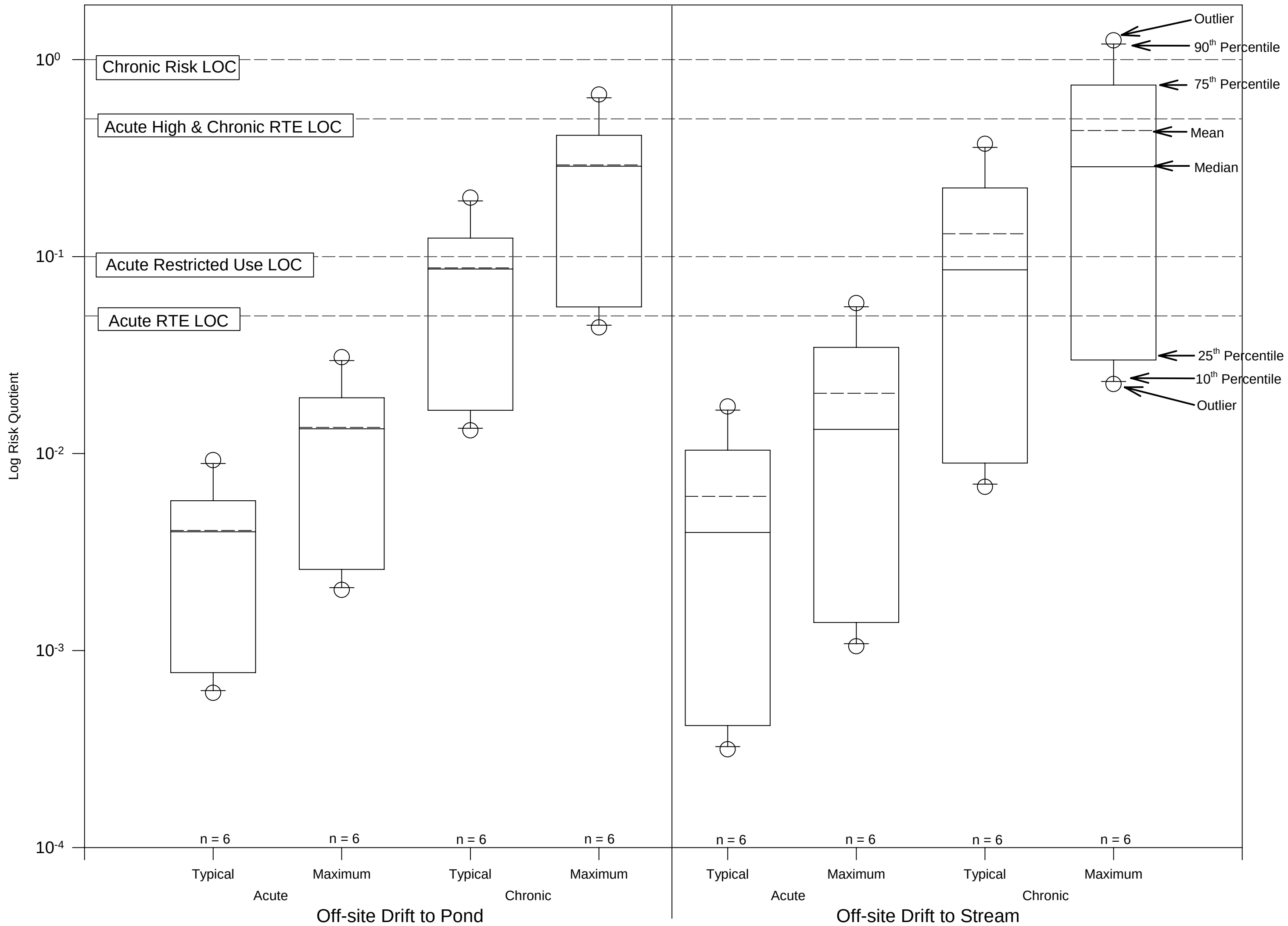


FIGURE 4-11. Off-Site Drift - Risk Quotients for Aquatic Invertebrates.

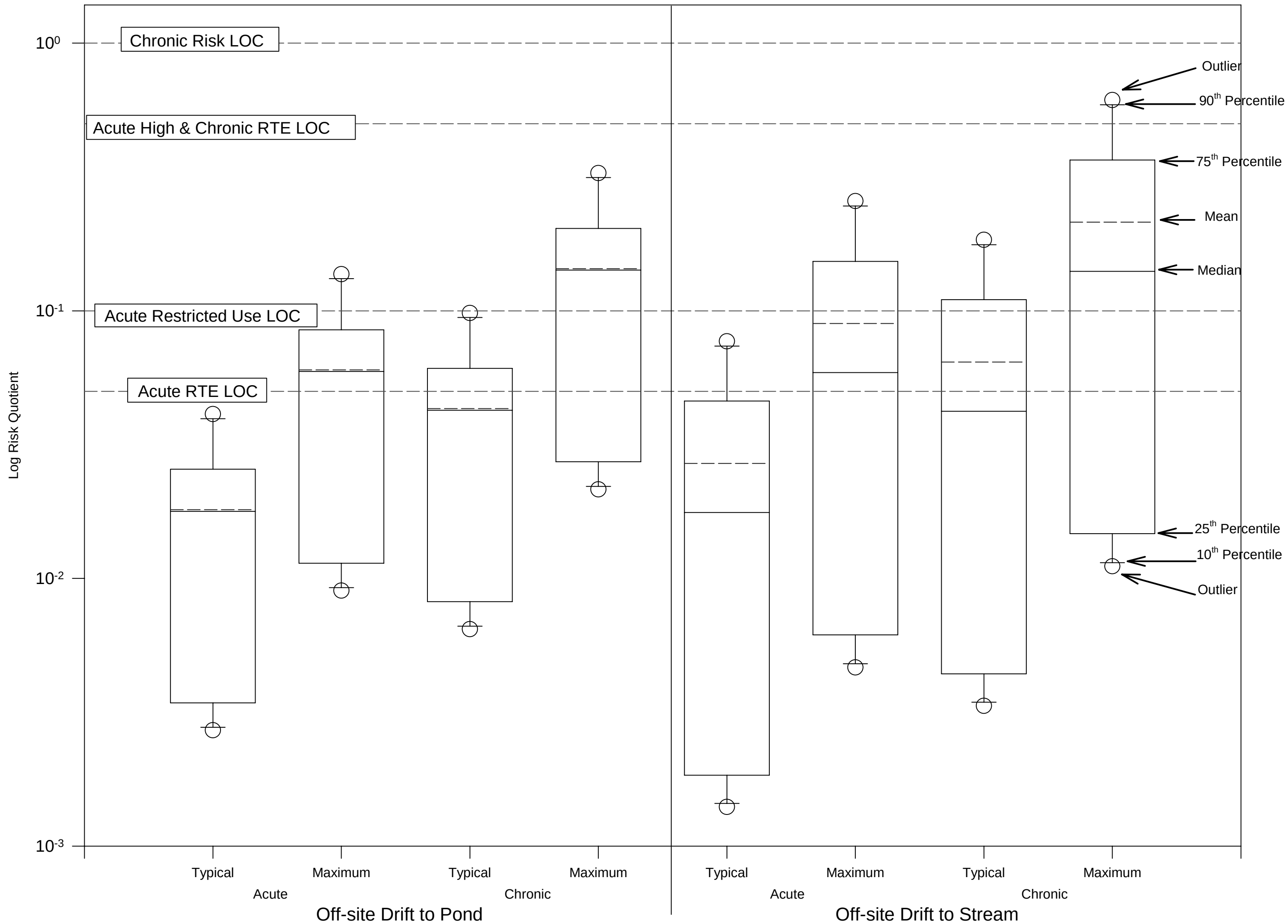


FIGURE 4-12. Off-Site Drift - Risk Quotients for Piscivorous Birds.

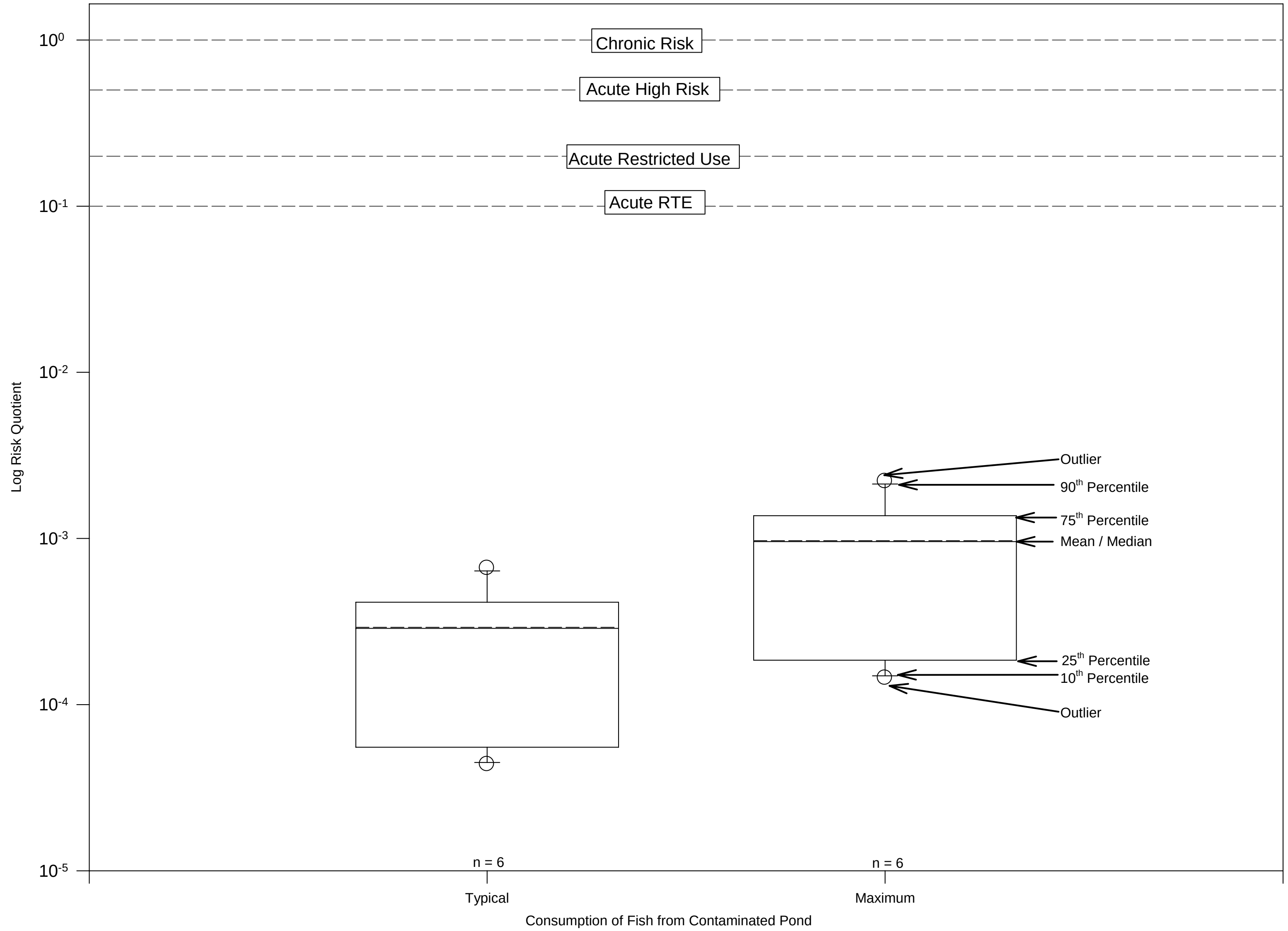


FIGURE 4-13. Surface Runoff - Risk Quotients for Non-Target Terrestrial Plants.

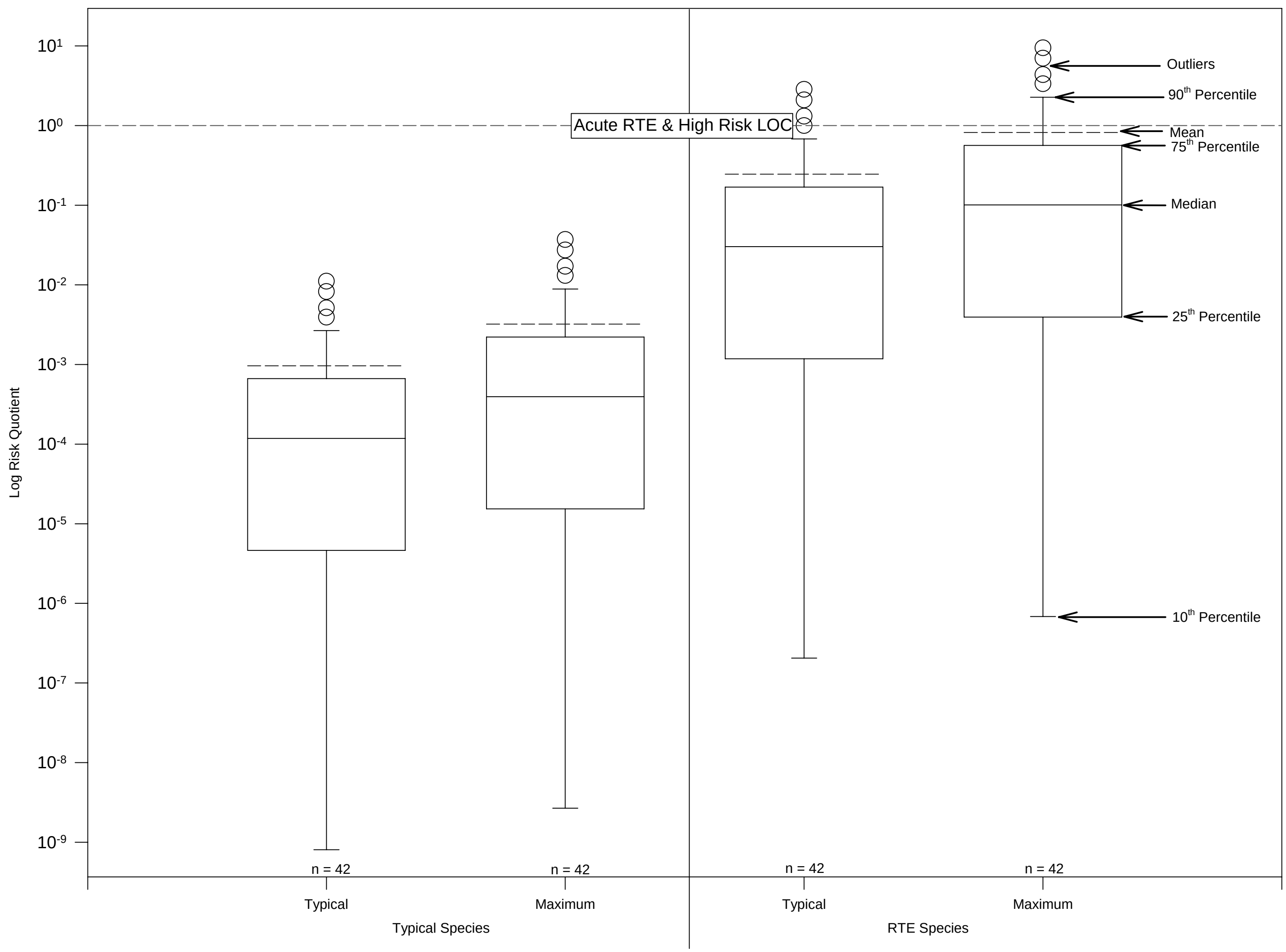


FIGURE 4-14 Surface Runoff - Risk Quotients for Non-Target Aquatic Plants.

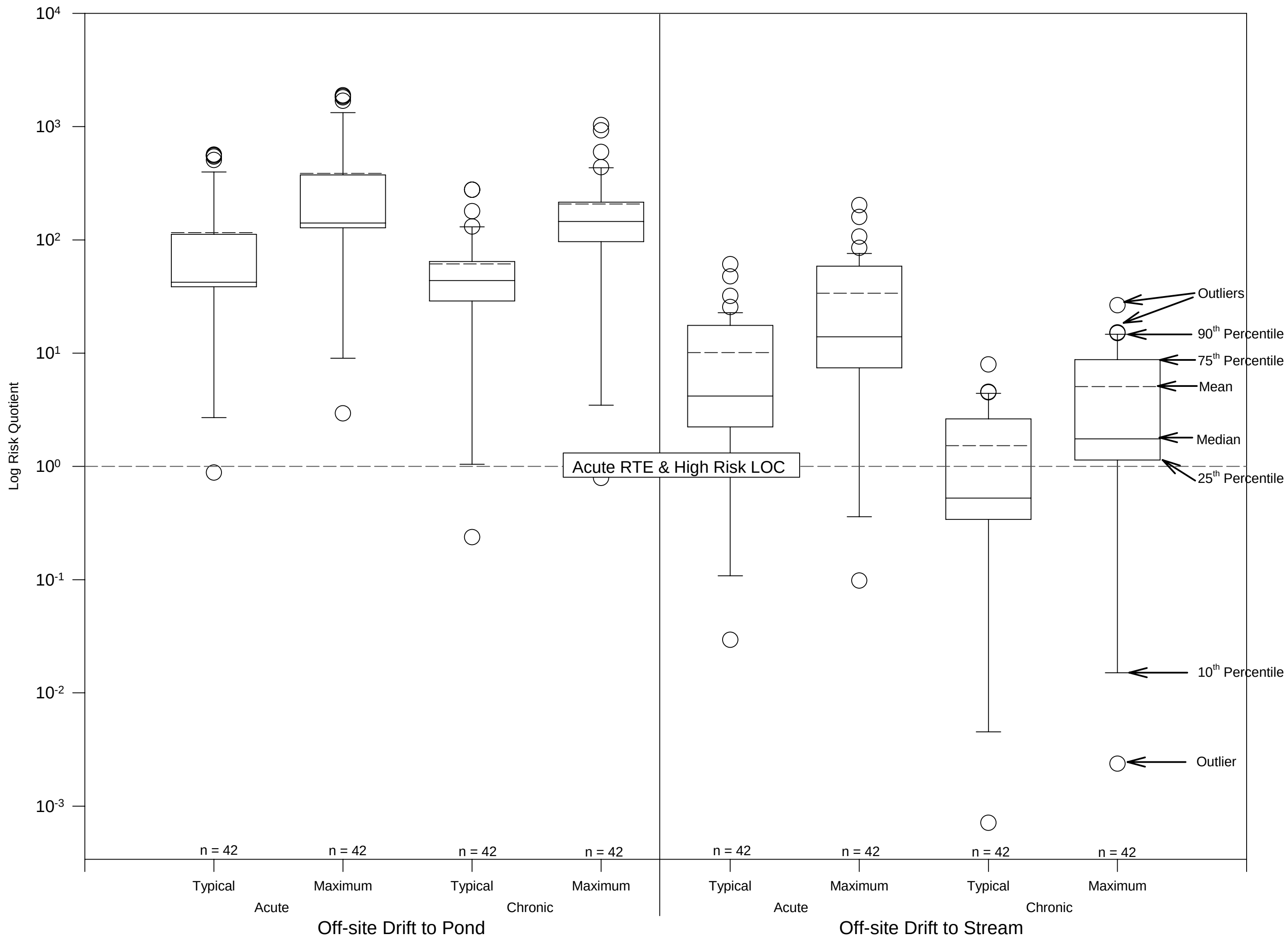


FIGURE 4-15. Surface Runoff - Risk Quotients for Fish.

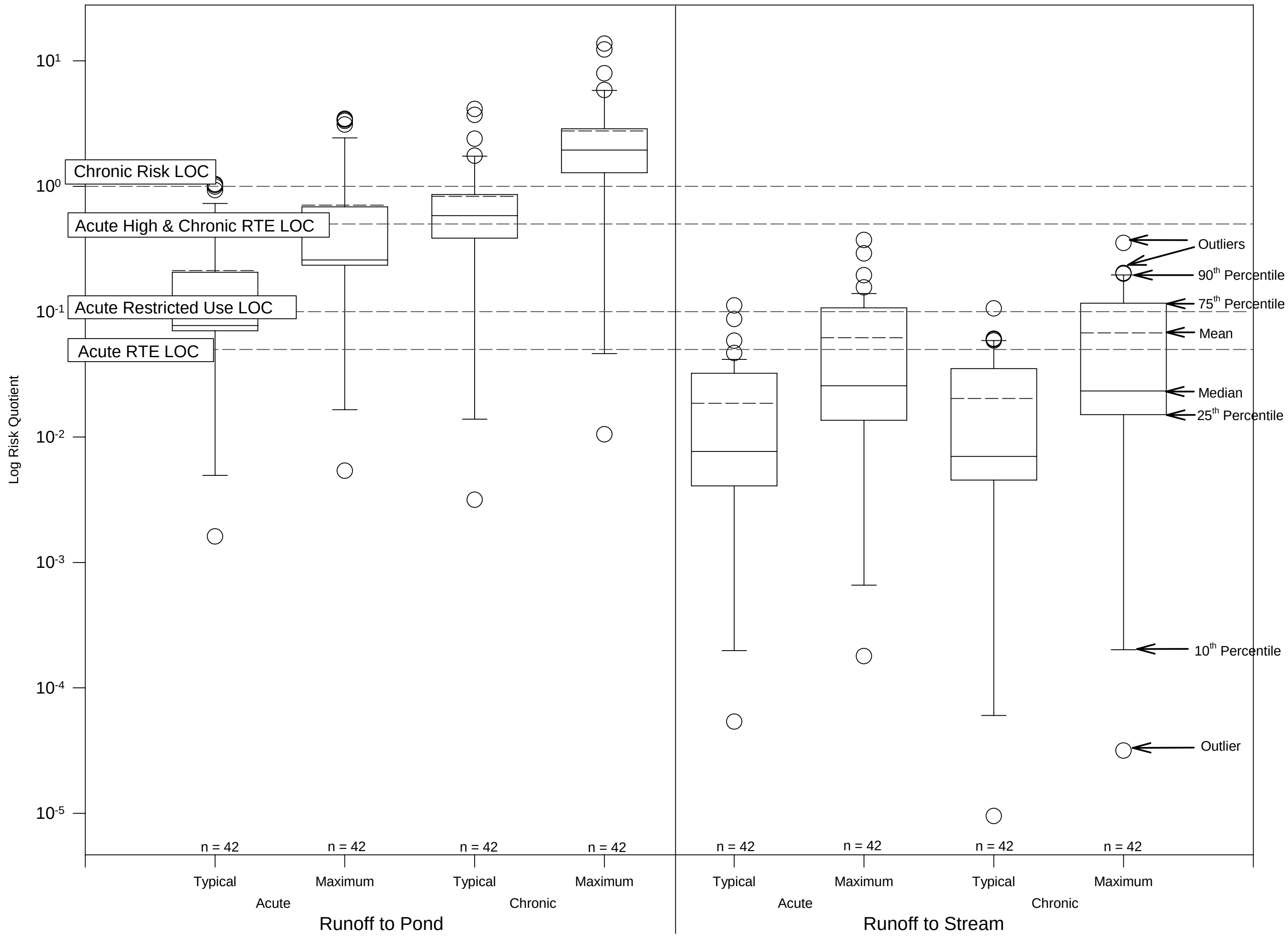


FIGURE 4-16. Surface Runoff - Risk Quotients for Aquatic Invertebrates.

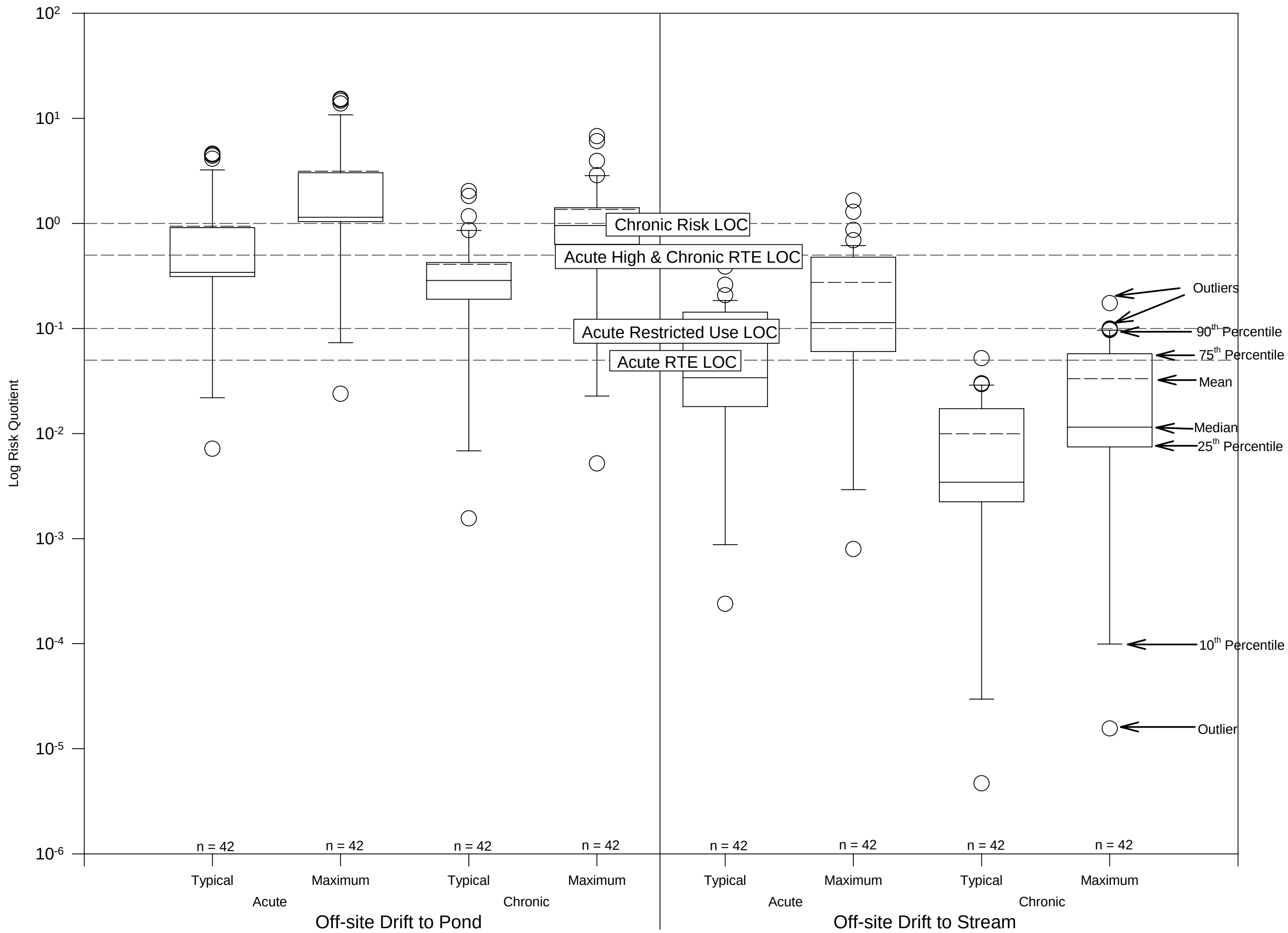


FIGURE 4-17. Surface Runoff - Risk Quotients for Piscivorous Birds.

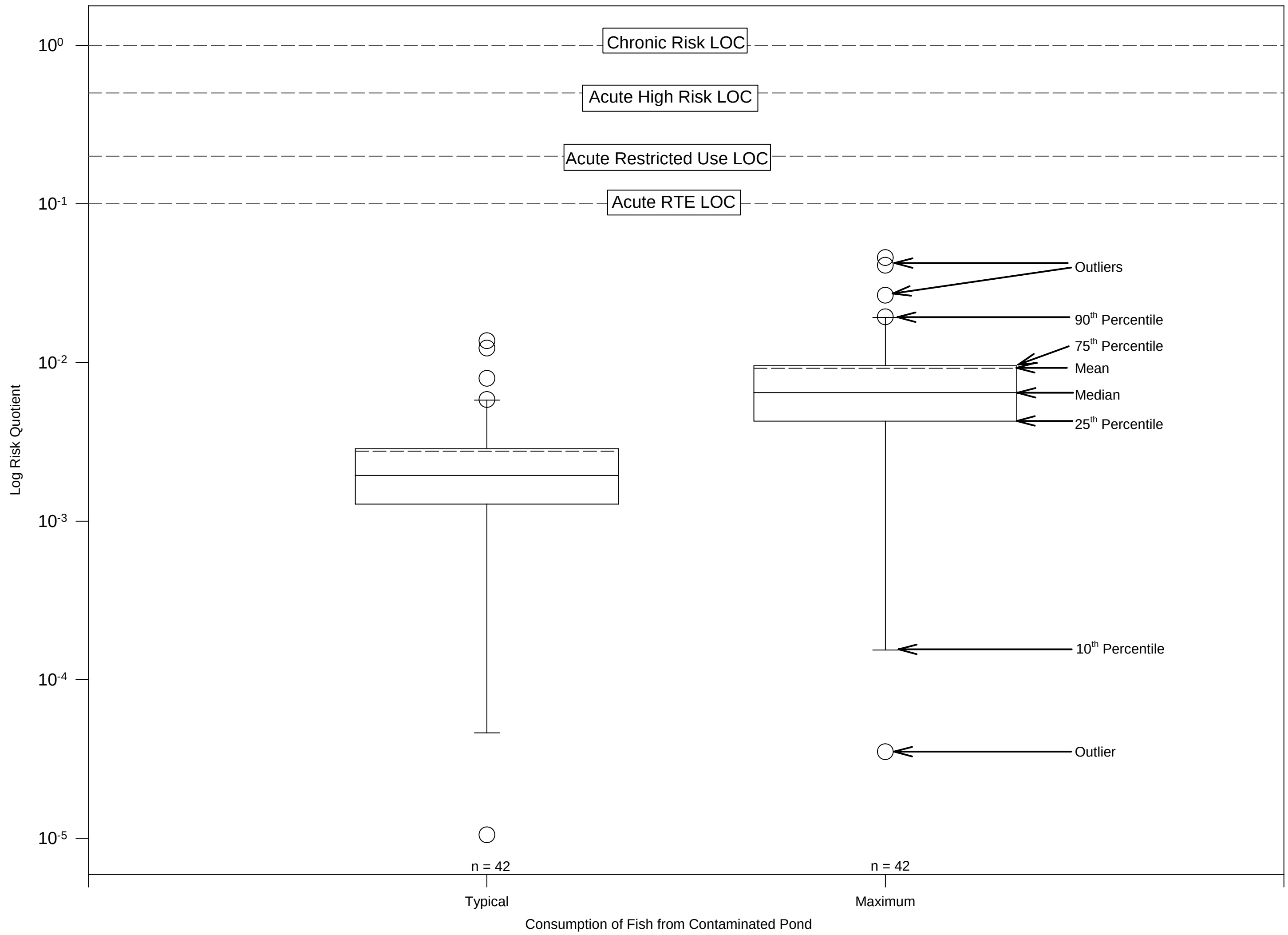
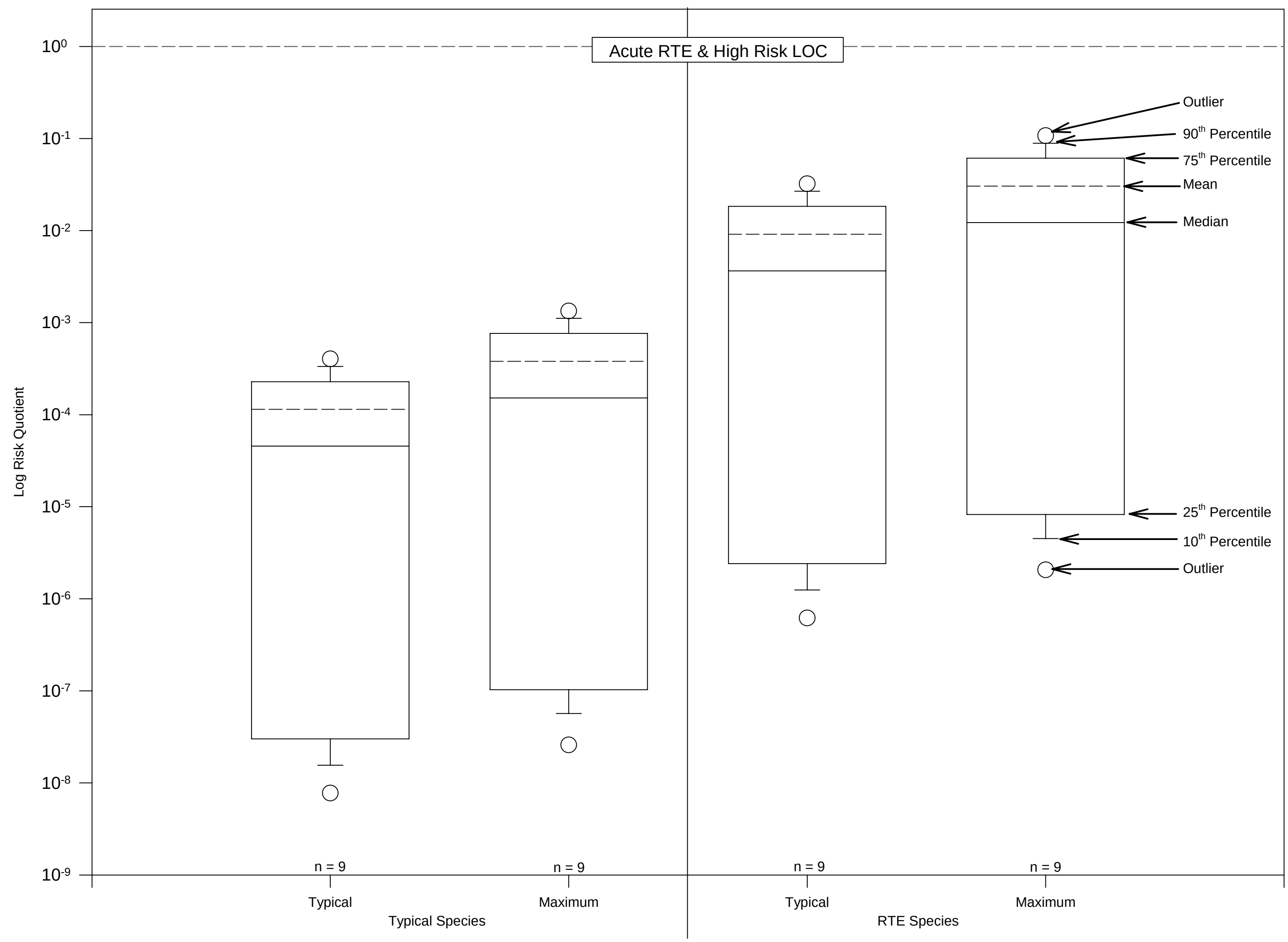


FIGURE 4-18. Wind Erosion and Transport Off-Site - Risk Quotients for Non-Target Terrestrial Plants.



5.0 SENSITIVITY ANALYSIS

The sensitivity analysis was designed to determine which factors, from three models used to predict exposure concentrations (GLEAMS, AgDRIFT®, and CALPUFF), most greatly affect exposure concentrations. A base case for each model was established. Input factors were changed independently, thereby resulting in an estimate of the importance of that factor on exposure concentrations.

Information regarding each model, their specific use and any inputs and assumptions made during the application of these models are provided in the Methods Document (ENSR 2005b). This section provides information specific to the sensitivity of each of these models to select input variables.

5.1 GLEAMS

GLEAMS is a model developed for field-size areas to evaluate the effects of agricultural management systems on the movement of agricultural chemicals within and through the plant root zone (Leonard et al. 1987). The model simulates surface runoff and ground water flow of herbicide resulting from edge-of-field and bottom-of-root-zone loadings of water, sediment, pesticides, and plant nutrients from the complex climate-soil-management interactions. Agricultural pesticides are simulated by the GLEAMS using three major components including hydrology, erosion, and pesticides. This section describes the sensitivity of model input to output variables controlling environmental conditions (i.e., precipitation, soil type). The goal of the sensitivity analysis was to investigate the control that measurable watershed variables have on the predicted outcome of a GLEAMS simulation.

5.1.1 GLEAMS Sensitivity Variables

A total of eight variables were selected for the sensitivity analysis of the GLEAMS model. The variables were selected because of their potential to affect the outcome of a simulation and the likelihood that these variables would change from site to site. These variables are generally those that have the greatest variability in field application areas. The following is list of parameters that were included in the model sensitivity analysis:

1. *Annual Precipitation* **-** The effect of variation in annual precipitation on herbicide export rates was investigated to determine the effect of runoff on predicted stream and pond concentrations. It is expected that the greater the amount of precipitation, the greater the expected exposure concentration. However, this relationship is not linear because it is influenced by additional factors, such as evapotranspiration. The lowest and highest precipitation values evaluated were 25 and 100 inches per year, respectively (this represents one half and two times the precipitation level considered in the base watershed in the ERA).

2. *Application Area* – The effect of variation in field size on herbicide export rates was investigated to determine its influence on predicted stream and pond concentrations. The lowest and highest values for application areas evaluated were 1 and 1,000 ac, respectively.

3. *Field Slope* – Variation in field slope was investigated during the sensitivity analysis to determine its effect on herbicide export. The slope of the application field affects predicted runoff, percolation, and the degree of sediment erosion resulting from rainfall events. The lowest and highest values for slope evaluated were 0.005 and 0.1 (unitless), respectively.

4. *Surface Roughness* – The Manning Roughness value, a measure of surface roughness, is used in the GLEAMS model to predict runoff intensity and erosion of sediment. The Manning Roughness value is not measured directly but can be estimated using the general surficial characteristics of the application area. The lowest and highest values for surface roughness evaluated were 0.015 and 0.15 (unitless), respectively.

5. *Erodibility* – Variation in soil erodibility was investigated during the sensitivity analysis to determine its effect on predicted river and pond concentrations. The soil erodibility factor is a lumped parameter representing an integrated average annual value of the total soil and soil profile reaction to a large number of erosive and hydrologic processes. These processes consist of soil detachment and transport by raindrop impact and surface flow, localized redeposition due to topography and tillage-induced roughness, and rainwater infiltration into the soil profile. The lowest and highest values for erodibility evaluated were 0.05 and 0.5 (tons per ac per English EI), respectively.

6. *Pond Volume or Stream Flow Rate* – The effect of variability in pond volume and stream flow on herbicide concentrations was evaluated. The lowest and highest pond volumes evaluated were 0.41 and 1,640 m^3, respectively. The lowest and highest stream flow values evaluated were 0.05 and 100 cms, respectively.

7. *Soil Type* – The influence that soil characteristics have on predicted herbicide export rates and concentration was investigated by simulating different soil types within the application area. In this sensitivity analysis, clay, loam, and sand were evaluated.

8. *Vegetation Type* – Because vegetation type strongly affects the evapotranspiration rate, this parameter was expected to have a large influence on the hydrologic budget. Plants that cover a greater proportion of the application area for longer periods of the growing season will remove more water from the subsurface, and therefore, will result in diminished percolation rates through the soil. Vegetation types evaluated in this sensitivity analysis were weeds, shrubs, rye grass, and conifers and hardwoods.

5.1.2 GLEAMS Results

The effects of the eight different input model variables were evaluated to determine the relative effect of each variable on model output concentrations. A base case was established using the following values:

- annual precipitation rate of 50 inches per year;
- application area of 10 ac;
- slope of 0.05;
- roughness of 0.015;
- erodibility of 0.401 tons per ac per English EI;
- vegetation type of weeds; and
- loam soils.

While certain parameters used in the base case for the GLEAMS sensitivity analysis may not be representative of typical BLM lands, the base case values were selected to maximize changes in the other variables during the sensitivity analysis. For each variable, Table 5-1 provides the difference in predicted exposure concentrations in the stream and the pond using the highest and the lowest input values, with all other variables held constant. Any increase in herbicide concentration results in an increase in RQs and ecological risk. The ratio of herbicide concentrations represents the relative increase/decrease in ecological risk, where values greater than 1.0 denote a positive relationship between herbicide concentration and the variable (increase in RQ) and values less than 1.0 denote a negative relationship (decrease in RQ). A similar table was created for the non-numerical variables soil and vegetation type (Table 5-2). This table presents the difference in concentration under different soil and vegetation types relative to the base case. A ratio was created by dividing the adjusted variable concentration by the base case concentration. Values farther away from 1.0, either positive or negative, indicate that predicted concentrations are more susceptible to changes within that particular variable.

Two separate results are presented 1) relative change in average annual stream or pond concentration and 2) relative change in maximum three day average concentration. Precipitation, application area, slope and erodibility are positively related to herbicide exposure concentrations; as these factors increase, so do herbicide concentrations and ecological risk. There was one exception, however, average annual pond concentrations decreased with application area. Increased roughness and flow or pond volume result in decreased herbicide concentrations and ecological risk. Changing from base case loam soils to sand, clay, clay loam, silt loam, or silt soils produced increased concentrations under all scenarios (stream/pond, average annual concentration/maximum three day average concentration) with the exception of sand soils for maximum three day average concentrations. Herbicide concentration under this scenario was predicted to be less than the base case loam scenario (i.e., ecological risk decreased). Changing from loam soils to clay soils resulted in the highest increase in concentrations of all soil types. Increasing precipitation, application area, and changing soil type result in the highest increase in herbicide exposure concentrations. The remaining variables resulted in moderate to negligible effects.

5.2 AgDRIFT®

Changes to individual input parameters of predictive models have the potential to substantially influence the results of an analysis such as that conducted in this ERA. This is particularly true for models such as AgDRIFT® which are intended to represent complex problems such as the prediction of off-target spray drift of herbicides. Predicted off-target spray drift and downwind deposition can be substantially altered by a number of variables intended to represent the herbicide application process including, but not limited to: nozzle type used in the spray application of an herbicide mixture, ambient wind speed, release height (application boom height), and evaporation. Hypothetically, any variable in the model that is intended to represent some part of the physical process of spray drift and deposition can substantially alter predicted downwind drift and deposition patterns. This section will present the changes that occur to the EEC with changes to important input parameters and assumptions used in the AgDRIFT® model. It is important to note that changes in the EEC directly affect the estimated RQ. Thus, this information is presented to help local land managers understand the factors that are likely to be related to higher potential ecological risk. Table 5-3 summarizes the relative change in exposure concentrations, and therefore ecological risk, based on specific model input parameters (e.g., mode of application, application rate).

Factors that are thought to have the greatest influence on downwind drift and deposition are: spray drop-size distribution, release height, and wind speed (Teske and Barry 1993; Teske et al. 1998; Teske and Thistle 1999, *as cited in SDTF 2002*). To better quantify the influence of these and other parameters, a sensitivity analysis was undertaken by the SDTF and documented in the AgDRIFT® user's manual. In this analysis AgDRIFT® Tier II model input parameters (model input parameters are discussed in Appendix B of the HHRA were varied by 10% above and below the default assumptions (four different drop-size distributions were evaluated). The findings of this analysis indicate the following:

- The largest variation in predicted downwind drift and deposition patterns occurred as a result of changes in the shape and content of the spray drop size distribution.
- The next greatest change in predicted downwind drift and deposition patterns occurred as a result of changes in boom height (the release height of the spray mixture).
- Changes in spray boom length resulted in significant variations in drift and deposition within 200 ft downwind of the hypothetical application area.
- Changes in the assumed ambient temperature and relative humidity resulted in small variation in drift and deposition at distances greater than 200 ft downwind of the hypothetical application area.
- Varying the assumed number of application swaths (aircraft flight lines), application swath width, and wind speed resulted in little change in predicted downwind drift and deposition.
- Variation in nonvolatile fraction of the spray mixture showed no effect on downwind drift and deposition.

These results, except for the minor to negligible influence of varying wind speed and nonvolatile fraction, were consistent with previous observations. The 10% variation in wind speed and nonvolatile fraction was likely too small to produce substantial changes in downwind drift and deposition. It is expected that varying these by a larger percentage would eventually produce some effect. In addition, changes in wind speed resulted in changes in application swath width and swath offset, which masked the effect of wind speed alone on downwind drift and deposition.

Based on these findings, and historic field observations, the hierarchy of parameters that have the greatest influence on downwind drift and deposition patterns is as follows:

1. Spray drop size distribution
2. Application boom height
3. Wind speed
4. Spray boom length
5. Relative humidity
6. Ambient temperature
7. Nonvolatile fraction

An additional limitation of the AgDRIFT® user's manual sensitivity analysis is the focus on distances less than 200 ft downwind of a hypothetical application area. From a land management perspective, distance downwind from the point of deposition may be considered to represent a hypothetical buffer zone between the application area and a potentially sensitive habitat. In this ERA, distances as great as 900 ft downwind of a hypothetical application were considered. In an effort to expand on the existing AgDRIFT® sensitivity analysis provided in the user's manual, the sensitivity of mode of application, application height or vegetation type, and application rate were evaluated. Results of this supplemental analysis are provided in Table 5-3.

The results of the expanded sensitivity analysis indicate that deposition and corresponding ecological risk decrease substantially between 25 and 900 ft downwind of hypothetical application area. Thus, from a land management perspective, the size of a hypothetical buffer zone (the downwind distance from a hypothetical application area to a potentially sensitive habitat) may be the single most controllable variable (other than the application rate, equipment and herbicide mixtures chosen) that has a substantial impact on ecological risk (Table 5-3).

The most conservative case at the typical application rate (using the smallest downwind distance measured in this ERA – 25 ft) was then evaluated using two different boom heights. Predicted concentrations were greater with high vs. low boom height (Table 5-3); therefore, ecological risk increases with boom height. The effect of application rate (maximum vs. typical) was also tested, and as expected, predicted concentrations (and ecological risk) increase with application rates (Table 5-3). Maximum application rate concentrations were approximately three times greater than concentrations using the typical application rate. Mode of application scenarios were not tested in this sensitivity analysis since only ground applications are used by the BLM to disperse diuron. In general, the evaluation presented in Table 5-3 indicates that there is a decrease in herbicide migration and associated ecological risk, with increased downward distance (i.e., buffer zone) and an increase in herbicide migration with increasing application height.

5.3 CALPUFF

To determine the downwind deposition of herbicide that might occur as a result of dust-borne herbicide migration, the CALPUFF model was used with one year of meteorological data for selected example locations: Glasgow, Montana; Medford, Oregon; and Lander, Wyoming. For this analysis, certain meteorological triggers were considered to determine whether herbicide migration was possible (ENSR 2005b). Herbicide migration is not likely during periods of sub-freezing temperatures, precipitation events, and periods with snow cover. For example, it was assumed herbicide migration would not be possible if the hourly ambient temperature was at or below 28 degrees Fahrenheit because the local ground would be frozen and would be very resistant to soil erosion. Deposition rates predicted by the model are most affected by the meteorological conditions and the surface roughness or land use at each of the sites.

Higher surface roughness lengths (a measure of the height of obstacles to the wind flow) result in higher deposition simply because deposition is more likely to occur on obstacles to wind flow (e.g., trees) than on a smooth surface. Therefore, the type of land use affects deposition as predicted by CALPUFF. In addition, a disturbed surface (e.g., through activities such as bulldozing) is more subject to wind erosion because the surface soil is exposed and loosened. The surface roughness in the CALPUFF analysis has been selected to represent bare or poorly vegetated soils. This leads to relatively high estimates of ground level wind speed in the application area. Such an assumption is likely to be reasonable in recently burned areas or sparsely vegetated rangeland. In grasslands, scrub habitat, and forests such an assumption likely leads to an over-prediction of herbicide scour and subsequent deposition.

CALPUFF uses hourly meteorological data, in conjunction with the site surface roughness, to calculate deposition velocities that are used to determine deposition rates at downwind distances. The amount of deposition at a particular distance is especially dependent on the “friction velocity.” The friction velocity is the square root of the surface shearing stress divided by the air density (a quantity with units of wind speed). Surface shearing stress is related to the vertical transfer of momentum from the air to the Earth’s surface. Shearing stress, and therefore friction velocity, increases with increasing wind speed and with increased surface roughness. Higher friction velocities result in higher deposition rates. Because the friction velocity is calculated from hourly observed wind speeds, meteorological conditions at a particular location greatly influence deposition rates as predicted by CALPUFF.

The threshold friction velocity is that ground level wind speed (accounting for surface roughness) that is assumed to lead to soil (and herbicide) scour. The threshold friction velocity is a function of the vegetative cover and soil type. Finer grained, less dense, and poorly vegetated soils tend to have lower threshold friction velocities. As the threshold friction velocity declines, wind events capable of scouring soil become more common. In fact, given the typical temporal distributions of wind speed, scour events would be predicted to be much more common as the threshold friction velocity declines from rare events to relatively common ones. The threshold wind speeds selected for the CALPUFF modeling effort are based on typical, un-vegetated soils in the example areas. In the event that very fine soils or ash are present at the site, the threshold wind speed could be lower and scouring wind events more common. This, in turn, would lead to greater soil and herbicide erosion with greater subsequent downwind deposition.

The size of the treatment area also impacts the predicted herbicide migration and deposition results. The size of the treatment area is directly proportional to the total amount of herbicide that can be moved via soil erosion. Because a fixed amount of herbicide per unit area is required for treatment, a larger treatment area would yield a larger amount of herbicide that could migrate. In addition, increased herbicide mass would lead to increased downwind deposition.

In summary:

- Herbicide migration does not occur unless the surface wind speed is high enough to produce a friction velocity that can lift soil particles into the air.

- The presence of surface “roughness elements” (buildings, trees and other vegetation) has an effect upon the deposition rate. Areas of higher roughness will result in more intense vertical eddies that can mix down suspended particles more effectively than smoother surfaces can. Thus, higher deposition of suspended soil and herbicide are predicted for areas with high roughness.

- Disturbed surfaces, such as areas recently burned, and large treatment areas will experience greater herbicide migration and deposition.

TABLE 5-1
Relative Effects of GLEAMS Input Variables on Herbicide Exposure Concentrations using Typical BLM Application Rate

Stream Scenarios

Input Variable	Units	Input Low Value (L)	Input High Value (H)	Low Value Predicted Concentration		High Value Predicted Concentration		Concentration $_H$ / Concentration $_L$		Relative Change in Concentration	
				Average Annual Stream	Maximum 3 Day Avg. Stream	Average Annual Stream	Maximum 3 Day Avg. Stream	Average Annual Stream	Maximum 3 Day Avg. Stream	Average Annual Stream	Maximum 3 Day Avg. Stream
Precipitation	inches	25	100	6.30E-06	5.01E-04	8.78E-04	8.36E-03	139.43	16.70	+	+
Area	acres	1	1000	2.60E-05	4.11E-04	3.50E-03	2.55E-02	134.39	61.96	+	+
Slope	unitless	0.005	0.1	2.30E-04	2.89E-03	2.33E-04	3.06E-03	1.016	1.058	+	+
Erodibility	tons/acre per English EI	0.05	0.5	2.30E-04	2.89E-03	2.31E-04	2.90E-03	1.005	1.002	+	+
Roughness	unitless	0.015	0.15	2.31E-04	2.90E-03	2.30E-04	2.89E-03	0.995	0.997	-	-
Flow Rate	m^3/sec	0.05	100	4.85E-04	5.82E-03	3.18E-07	5.20E-06	0.001	0.001	-	-

Pond Scenarios

Input Variable	Units	Input Low Value (L)	Input High Value (H)	Low Value Predicted Concentration		High Value Predicted Concentration		Concentration $_H$ / Concentration $_L$		Relative Change in Concentration	
				Average Annual Pond	Maximum 3 Day Avg. Pond	Average Annual Pond	Maximum 3 Day Avg. Pond	Average Annual Pond	Maximum 3 Day Avg. Pond	Average Annual Pond	Maximum 3 Day Avg. Pond
Precipitation	inches	25	100	6.09E-04	5.05E-03	4.19E-02	1.03E-01	68.73	20.48	+	+
Area	acres	1	1000	8.04E-03	1.49E-02	2.33E-02	3.95E-02	2.90	2.65	+	+
Slope	unitless	0.005	0.1	1.92E-02	5.00E-02	1.93E-02	5.69E-02	1.006	1.136	+	+
Erodibility	tons/acre per English EI	0.05	0.5	1.92E-02	5.01E-02	1.92E-02	5.22E-02	1.002	1.043	+	+
Roughness	unitless	0.015	0.15	1.92E-02	5.27E-02	1.92E-02	5.02E-02	0.998	0.953	-	-
Pond Volume	ac/ft	0.05	100	2.09E-02	4.79E-02	5.48E-05	1.08E-04	0.003	0.002	-	-

Concentrations were based on the average application rate.
+ = Increase in concentration from low to high input value = increase in RQ = increase in ecological risk.
- = Decrease in concentration from low to high input value = decrease in RQ = decrease in ecological risk.

TABLE 5-2
Relative Effects of Soil and Vegetation Type on Herbicide Exposure Concentrations using Typical BLM Application Rate

Soil Type	Predicted Concentration				Concentration X Soil Type / Concentration Loam				Relative Change in Concentration			
	Avg. Annual Stream	Max. 3 Day Avg. Stream	Avg. Annual Pond	Max. 3 Day Avg. Pond	Avg. Annual Stream	Max. 3 Day Avg. Stream	Avg. Annual Pond	Max. 3 Day Avg. Pond	Avg. Annual Stream	Max. 3 Day Avg. Stream	Avg. Annual Pond	Max. 3 Day Avg. Pond
***Loam*[1]**	***2.31E-04***	***2.90E-03***	***1.92E-02***	***5.27E-02***	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Sand	1.64E-03	2.80E-02	1.36E-01	2.01E-01	7.1132	9.6547	7.0809	3.8108	+	+	+	+
Clay	3.28E-04	1.66E-02	2.52E-02	4.59E-01	1.4177	5.7246	1.3128	8.7009	+	+	+	+
Clay Loam	3.16E-04	1.44E-02	2.98E-02	2.44E-01	1.3671	4.9473	1.5517	4.6351	+	+	+	+
Silt Loam	1.59E-04	8.21E-03	1.27E-02	1.51E-01	0.6867	2.8303	0.6591	2.8623	-	+	-	+
Silt	1.37E-04	7.81E-03	9.34E-03	1.32E-01	0.5914	2.6897	0.4858	2.5139	-	+	-	+

Vegetation Type	Predicted Concentration				Concentration X Veg Type / Concentration Weeds				Relative Change in Concentration			
	Avg. Annual Stream	Max. 3 Day Avg. Stream	Avg. Annual Pond	Max. 3 Day Avg. Pond	Avg. Annual Stream	Max. 3 Day Avg. Stream	Avg. Annual Pond	Max. 3 Day Avg. Pond	Avg. Annual Stream	Max. 3 Day Avg. Stream	Avg. Annual Pond	Max. 3 Day Avg. Pond
***Weeds*[1]**	***2.31E-04***	***2.90E-03***	***1.92E-02***	***5.27E-02***	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Conifer + Hardwood	3.31E-04	3.81E-03	2.58E-02	5.90E-02	1.4325	1.3114	1.3447	1.1202	+	+	+	+
Shrubs	2.32E-04	2.91E-03	1.93E-02	5.27E-02	1.0018	1.0023	1.0019	1.0009	+	+	+	+
Rye Grass	2.31E-04	2.91E-03	1.92E-02	5.27E-02	1.0016	1.0019	1.0016	1.0008	+	+	+	+

[1] Base Case
Concentrations were based on the average application rate.
+ = Increase in concentration from base case = increase in RQ = increase in ecological risk.
- = Decrease in concentration from base case = decrease in RQ = decrease in ecological risk.

TABLE 5-3
Herbicide Exposure Concentrations used during the Supplemental AgDRIFT® Sensitivity Analysis

Mode of Application	Application Height/Veg. Type	Minimum Downwind Distance (ft)	Maximum Downwind Distance (ft)	Minimum Downwind Distance Concentration			Maximum Downwind Distance Concentration		
				Terrestrial (lb/ac)	Stream (mg/L)	Pond (mg/L)	Terrestrial (lb/ac)	Stream (mg/L)	Pond (mg/L)
Typical Application Rate									
Plane	Forest	100	900	NA	NA	NA	NA	NA	NA
	Non-Forest	100	900	NA	NA	NA	NA	NA	NA
Helicopter	Forest	100	900	NA	NA	NA	NA	NA	NA
	Non-Forest	100	900	NA	NA	NA	NA	NA	NA
Ground	Low Boom	25	900	7.54E-02	3.75E-02	4.09E-03	4.10E-03	1.14E-03	4.33E-04
	High Boom	25	900	1.25E-01	6.28E-02	6.57E-03	5.20E-03	1.50E-03	5.49E-04
Maximum Application Rate									
Plane	Forest	100	900	NA	NA	NA	NA	NA	NA
	Non-Forest	100	900	NA	NA	NA	NA	NA	NA
Helicopter	Forest	100	900	NA	NA	NA	NA	NA	NA
	Non-Forest	100	900	NA	NA	NA	NA	NA	NA
Ground	Low Boom	25	900	2.51E-01	1.25E-01	1.36E-02	1.36E-02	3.79E-03	1.44E-03
	High Boom	25	900	4.15E-01	2.10E-01	2.19E-02	1.75E-02	5.02E-03	1.83E-03

TABLE 5-3 (Cont.)
Herbicide Exposure Concentrations used During the Supplemental AgDRIFT® Sensitivity Analysis

Effect of Downwind Distance

Mode of Application	Application Height or Vegetation Type	Minimum Buffer	Maximum Buffer	Concentration $_{900}$/Concentration $_{25}$			Relative Change in Concentration		
				Terrestrial	Stream	Pond	Terrestrial	Stream	Pond
Typical Application Rate									
Plane	Forest	100	900	NA	NA	NA	NA	NA	NA
	Non-Forest	100	900	NA	NA	NA	NA	NA	NA
Helicopter	Forest	100	900	NA	NA	NA	NA	NA	NA
	Non-Forest	100	900	NA	NA	NA	NA	NA	NA
Ground	Low Boom	25	900	0.0544	0.0304	0.1059	-	-	-
	High Boom	25	900	0.0417	0.0240	0.0836	-	-	-
Maximum Application Rate									
Plane	Forest	100	900	NA	NA	NA	NA	NA	NA
	Non-Forest	100	900	NA	NA	NA	NA	NA	NA
Helicopter	Forest	100	900	NA	NA	NA	NA	NA	NA
	Non-Forest	100	900	NA	NA	NA	NA	NA	NA
Ground	Low Boom	25	900	0.0541	0.0303	0.1059	-	-	-
	High Boom	25	900	0.0421	0.0239	0.0836	-	-	-

TABLE 5-3 (Cont.)
Herbicide Exposure Concentrations used During the Supplemental AgDRIFT® Sensitivity Analysis

Effect of Application Height (Vegetation Type or Boom Height)

Mode of Application	Application Height or Vegetation Type	Concentration Ratio[1]			Relative Change in Concentration		
		Terrestrial	Stream	Pond	Terrestrial	Stream	Pond
Typical Application Rate							
Plane	Forest/ Non-Forest	NA	NA	NA	NA	NA	NA
Helicopter	Forest/ Non-Forest	NA	NA	NA	NA	NA	NA
Ground	High/Low Boom	1.6525	1.6729	1.6064	+	+	+
Maximum Application Rate							
Plane	Forest/ Non-Forest	NA	NA	NA	NA	NA	NA
Helicopter	Forest/ Non-Forest	NA	NA	NA	NA	NA	NA
Ground	High/Low Boom	1.6526	1.6749	1.6103	+	+	+

Effect of Mode of Application Rate

	Concentration Ratio[2]			Relative Change in Concentration		
	Terrestrial	Stream	Pond	Terrestrial	Stream	Pond
Maximum vs. Typical	3.3331	3.3373	3.3333	+	+	+

(1) using minimum buffer width concentrations.
(2) using ground dispersal, minimum buffer width and high boom concentrations.
\+ = Increase in concentration = increase in RQ = increase in ecological risk.
\- = Decrease in concentration = decrease in RQ = decrease in ecological risk.

6.0 RARE, THREATENED, AND ENDANGERED SPECIES

Rare, threatened, and endangered (RTE) species have the potential to be impacted by herbicides applied for vegetation control. RTE species are of potential increased concern to screening level ERAs, which utilize surrogate species and generic assessment endpoints to evaluate potential risk, rather than examining site- and species-specific effects to individual RTE species. Several factors complicate our ability to evaluate site- and species-specific effects:

- Toxicological data specific to the species (and sometimes even class) of organism are often absent from the literature.
- The other assumptions involved in the ERA (e.g., rate of food consumption, surface-to-volume ratio) may differ for RTE species relative to selected surrogates and/or data for RTE species may be unavailable.
- The high level of protection afforded RTE species by regulation and policy suggests that secondary effects (e.g., potential loss of prey or cover), as well as site-specific circumstances that might result in higher rates of exposure, should receive more attention.

A common response to these issues is to design screening level ERAs, including this one, to be highly conservative. This includes assumptions such as 100% exposure to an herbicide by simulating scenarios where the organism lives year-round in the most affected area (i.e., area of highest concentration), or that the organism consumes only food items that have been impacted by the herbicide. The diuron screening level ERA incorporates additional conservatism in the assumptions used in the herbicide concentration models such as GLEAMS (Appendix B; ENSR 2005b). Even with highly conservative assumptions in the ERA, however, concern may still exist over the potential risk to specific RTE species.

To help address this potential concern, the following section will discuss the ERA assumptions as they relate to the protection of RTE species. The goals of this discussion are as follows:

- Present the methods the ERA employs to account for risks to RTE species and the reasons for their selection.
- Define the factors that might motivate a site- and/or species-specific evaluation[3] of potential herbicide impacts to RTE species and provide perspective useful for such an evaluation.
- Present information that is relevant to assessing the uncertainty in the conclusions reached by the ERA with respect to RTE species.

The following sections describe information used in the ERA to provide protection to RTE species, including mammals, birds, plants, reptiles, amphibians and fish (e.g., salmonids) potentially occurring on BLM-managed lands. It includes a discussion of the quantitative and qualitative factors used to provide additional protection to RTE species and a discussion of potential secondary effects of herbicide use on RTE species.

Section 6.1 provides a review of the selection of LOCs and TRVs with respect to providing additional protection to RTE species. Section 6.2 provides a discussion of species-specific traits and how they relate to the RTE protection strategy in this ERA. Section 6.2 also includes discussion of the selection of surrogate species (6.2.1), the RTE taxa of

[3] Such an evaluation might include site-specific estimation of exposure point concentrations using one or more models, more focused consideration of potential risk to individual RTE species; and/or more detailed assessment of indirect effects to RTE species, such as those resulting from impacts to habitat.

concern, and the surrogates used to represent them (6.2.2), and the biological factors that affect the exposure to and response of organisms to herbicides (6.2.3). This includes a discussion of how the ERA was defined to assure that consideration of these factors resulted in a conservative assessment. Mechanisms for extrapolating toxicity data from one taxon to another are briefly reviewed in Section 6.3. The potential for impacts, both direct and secondary, to salmonids is discussed in Section 6.4. Section 6.5 provides a summary of the section.

6.1 Use of LOCs and TRVs to Provide Protection to RTE Species

Potential direct impacts to receptors, including RTE species, are the measures of effect typically used in screening level ERAs. Direct impacts, such as those resulting from direct or indirect contact or ingestion were assessed in the diuron ERA by comparing calculated RQs to receptor-specific LOCs. As described in the methodology document for this ERA (ENSR 2005b), RQs are calculated as the potential dose or EEC divided by the TRV selected for that pathway. An RQ greater than the LOC indicates the potential for risk to that receptor group via that exposure pathway. As described below, the selection of TRVs and the use of LOCs were pursued in a conservative fashion in order to provide a greater level of protection for RTE species.

The LOCs used in the ERA (Table 4-1) were developed by the USEPA for the assessment of pesticides (LOC information obtained from Michael Davy, USEPA OPP on 13 June 2002). In essence, the LOCs act as uncertainty factors often applied to TRVs. For example, using an LOC of 0.1 provides the same result as dividing the TRV by 10. The LOC for avian and mammalian RTE species is 0.1 for acute and chronic exposures. For RTE fish and aquatic invertebrates, acute and chronic LOCs were 0.05 and 0.5, respectively. Therefore, up to a 20-fold uncertainty factor has been included in the TRVs for animal species. As noted below, such uncertainty factors provide a greater level of protection to RTE species to account for the factors listed in the introduction to this section.

For RTE plants, the exposure concentration, TRVs, and LOCs provided a direct assessment of potential impacts. For all exposure scenarios, the maximum modeled concentrations were used as the exposure concentrations. The TRVs used for RTE plants were selected based on highly sensitive endpoints, such as germination, rather than direct mortality of seedlings or larger plants. Conservatism has been built into the TRVs during their development (Section 3.1); the lowest suitable endpoint concentration available was used as the TRV for RTE plant species. Therefore, the RQ calculated for RTE plant exposure is intrinsically conservative. Given the conservative nature of the RQ, and consistent with USEPA policy, no additional levels of protection were required for the LOC (all plant LOCs are 1).

6.2 Use of Species Traits to Provide Protection to RTE Species

Over 500 RTE species currently listed under the Federal Endangered Species Act (ESA) have the potential to occur in the 17 states covered under this Programmatic ERA. These species include 287 plants, 80 fish, 30 birds, 47 mammals, 15 reptiles, 13 amphibians, 34 insects, 10 arachnids (spiders), and 22 aquatic invertebrates (12 mollusks and 10 crustaceans)[4]. Some marine mammals are included in the list of RTE species; but due to the limited possibility these species would be exposed to herbicides applied to BLM-managed lands, no surrogates specific to marine species are included in this ERA. However, the terrestrial mammalian surrogate species identified for use in the ERA include species that can be considered representative of these marine species as well. The complete list is presented in Appendix D.

Of the over 500 species potentially occurring in the 17 states, just over 300 species may occur on lands managed by the BLM. These species include 7 amphibians, 19 birds, 6 crustaceans, 65 fish, 30 mammals, 10 insects, 13 mollusks, 5 reptiles, and 151 plants[4]. Protection of these species is an integral goal of the BLM, and they are the focus of the RTE evaluation for the ERA and EIS. These species are different from one another in regards to home range, foraging

[4] The number of RTE species may have changed slightly since the writing of this document.

strategy, trophic level, metabolic rate, and other species-specific traits. Several methods were used in the ERA to take these differences into account during the quantification of potential risk. Despite this precaution, these traits are reviewed in order to provide a basis for potential site- and species-specific risk assessment. Review of these factors provides a supplement to other sections of the ERA that discuss the uncertainty in the conclusions specific to RTE species.

6.2.1 Identification of Surrogate Species

Use of surrogate species in a screening ERA is necessary to address the broad range of species likely to be encountered on BLM-managed lands as well as to accommodate the fact that toxicity data may be restricted to a limited number of species. In this ERA, surrogates were selected to account for variation in the nature of potential herbicide exposure (e.g., direct contact, food chain) as well as to ensure that different taxa, and their behaviors, are considered. As described in Section 3.0 of the Methods Document (ENSR 2005b), surrogate species were selected to represent a broad range of taxa in several trophic guilds that could potentially be impacted by herbicides on BLM-managed lands. Generally, the surrogate species that were used in the ERA are species commonly used as representative species in ERA. Many of these species are common laboratory species, or are described in USEPA (1993a, b) Exposure Factors Handbook for Wildlife. Other species were included in the California Wildlife Biology, Exposure Factor, and Toxicity Database (CA OEHHA 2003),[5] or are those recommended by USEPA OPP for tests to support pesticide registration. Surrogate species were used in two ways in the ERA: (1) TRVs were derived using surrogate species toxicity data, and (2) in exposure scenarios that involve organism size, weight, or diet, surrogate species were exposed to the herbicide in the models to represent potential impact to other mammalian and avian species that may be present on BLM lands.

Toxicity data from surrogate species were used in the development of TRVs because few, if any, data are available that demonstrate the toxicity of chemicals to RTE species. Most reliable toxicity tests are performed under controlled conditions in a laboratory, using standardized test species and protocols; RTE species are not used in laboratory toxicity testing. In addition, field-generated data, which are very limited in number but may include anecdotal information about RTE species, are not as reliable as laboratory data because uncontrolled factors may complicate the results of the tests (e.g., secondary stressors such as unmeasured toxicants, imperfect information on rate of exposure).

As described below, inter-species extrapolation of toxicity data often produces unknown bias in risk calculations. This ERA approached the evaluation of higher trophic level species by life history (e.g., large animals vs. small animals, herbivore vs. carnivores). Then surrogate species were used to evaluate all species of similar life history potentially found on BLM-managed lands, including RTE species. This procedure was not done for plants, invertebrates, and fish, as most exposure of these species to herbicides is via direct contact (e.g., foliar deposition, dermal deposition, dermal/gill uptake) rather than ingestion of contaminated food items. Therefore, altering the life history of these species would not result in more or less exposure.

The following subsections describe the selection of surrogate species used in two separate contexts in the ERA.

6.2.1.1 Species Selected in Development of TRVs

As presented in Appendix A of the ERA, limited numbers of species are used for toxicity testing of chemicals, including herbicides. Species are typically selected because they tolerate laboratory conditions well. The species used in laboratory tests have relatively well-known response thresholds to a variety of chemicals. Growth rates, ingestion rates, and other species-specific parameters are known; therefore, test duration and endpoints of concern (e.g., mortality, germination) have been established in protocols for many of these laboratory species. Data generated during a toxicity test, therefore, can be compared to data from other tests and relative species sensitivity can be compared. Of course, in the case of RTE species, it would be unacceptable to subject individuals to toxicity tests.

[5] On-line http://www.oehha.org/cal_ecotox/default.htm

The TRVs used in the ERA were selected after reviewing available ecotoxicological literature for diuron. Test quality was evaluated, and tests with multiple substances were not considered for the TRV. For most receptor groups, the lowest value available for an appropriate endpoint (e.g., mortality, germination) was selected as the TRV. Using the most sensitive species provides a conservative level of protection for all species. The surrogate species used in the diuron TRVs are presented in Table 6-1.

6.2.1.2 Species Selected as Surrogates in the ERA

Plants, fish, insects, and other aquatic invertebrates were evaluated on a generic level. That is, the surrogate species evaluated to create the TRVs were selected to represent all potentially exposed species. For vertebrate terrestrial animals, in addition to these surrogate species, specific species were selected to represent the populations of similar species. The species used in the ERA are presented in Table 6-2.

The surrogate terrestrial vertebrate species selected for the ERA include species from several trophic levels that represent a variety of foraging strategies. Whenever possible, the species selected are found throughout the range of land included in the EIS; all species selected are found in at least a portion of the range. The surrogate species are common species whose life histories are well documented (USEPA 1993 a, b; CA OEHHA 2003). Because species-specific data, including BW and food ingestion rates, can vary for a single species throughout its range, data from studies conducted in western states or with western populations were selected preferentially. As necessary, site-specific data can be used to estimate potential risk to species known to occur locally.

6.2.2 Surrogates Specific to Taxa of Concern

Protection levels for different species and individuals vary. Some organisms are protected on a community level; that is, slight risk to individual species may be acceptable if the community of organisms (e.g., wildflowers, terrestrial insects) is protected. Generally, community level organisms include plants and invertebrates. Other organisms are protected on a population level; that is, slight risk to individuals of a species may be acceptable if the population, as a whole, is not endangered. However, RTE species are protected as individuals; that is, risk to any single organism is considered unacceptable. This higher level of protection motivates much of the conservative approach taken in this ERA. Surrogate species were grouped by general life strategy: sessile (i.e., plants), water dwelling (i.e., fish), and mobile terrestrial vertebrates (i.e., birds, mammals, and reptiles). The approach to account for RTE species was divided along the same lines.

Plants, fish, insects, and aquatic invertebrates were assessed using TRVs developed from surrogate species. All species from these taxa (identified in Appendix C) were represented by the surrogate species presented in Table 6-1. The evaluation of terrestrial vertebrates used surrogate species to develop TRVs and to estimate potential risk using simple food chain models. Tables 6-3 and 6-4 present the listed birds and mammals found on BLM-managed lands and their appropriate surrogate species.

Very few laboratory studies have been conducted using reptiles or amphibians. Therefore, data specific to the adverse effects of a chemical on species of these taxa are often unavailable. These animals, being cold-blooded, have very different rates of metabolism than mammals or birds (i.e., they require lower rates of food consumption). Nonetheless, mammals and birds were used as the surrogate species for reptiles and adult amphibians because of the lack of data for these taxa. Fish were used as surrogates for juvenile amphibians. For each trophic level of RTE reptile or adult amphibian, a comparable mammal or bird was selected to represent the potential risks. Table 6-5 presents the 7 listed reptiles found on BLM-managed lands and the surrogate species chosen to represent them in the ERA. Table 6-6 presents the listed amphibians found on BLM-managed lands and their surrogate species.

The sensitivity of reptiles and amphibians relative to other species is generally unknown. Some information about reptilian exposures to pesticides, including herbicides, is available. The following provides a brief summary of the data (as cited in Sparling et al. 2000), including data for pesticides not evaluated in this ERA:

- Mountain garter snakes (*Thamnophis elegans elegans*) were exposed to the herbicide thiobencarb in the field and in the laboratory. No effects were noted in the snakes fed contaminated food or those caged and exposed directly to treated areas.

- No adverse effects to turtles were noted in a pond treated twice with the herbicide Kuron (2,4,5-T).

- Tortoises in Greece were exposed in the field to atrazine, paraquat, Kuron, and 2,4-D. No effects were noted on the tortoises exposed to atrazine or paraquat. In areas treated with Kuron and 2,4-D, no tortoises were noted following the treatment. The authors of the study concluded it was a combination of direct toxicity (tortoises were noted with swollen eyes and nasal discharge) and loss of habitat (much of the vegetation killed during the treatment had provided important ground cover for the tortoises).

- Reptilian LD_{50} values from six organochlorine pesticides were compared to avian LD_{50} values. Of the six pesticides, five lizard LD_{50}s were higher, indicating lower sensitivity. Overlapping data were available for turtle exposure to one organochlorine pesticide; the turtle was less sensitive than the birds or lizards.

- In general, reptiles were found to be less sensitive than birds to cholinesterase inhibitors.

Unfortunately, these observations do not provide any sort of rigorous review of dose and response. On the other hand, there is little evidence that reptiles are more sensitive to pesticides than other, more commonly tested organisms.

As with reptiles, some toxicity data are available describing the effects of herbicides on amphibians. The following provides a brief summary of the data (as cited in Sparling et al. 2000):

- Leopard frog *(Rana pipiens)* tadpoles exposed to up to 0.075 mg/L atrazine showed no adverse effects.

- In a field study, it was noted that frog eggs in a pond where atrazine was sprayed nearby suffered 100% mortality.

- Common frog (*Rana temporaria)* tadpoles showed behavioral and growth effects when exposed to 0.2 to 20 mg/L cyanatryn.

- Caged common frog and common toad (*Bufo bufo)* tadpoles showed no adverse effects when exposed to 1.0 mg/L diquat or 1.0 mg/L dichlobenil.

- All leopard frog eggs exposed to 2.0 to 10 mg/L diquat or 0.5 to 2.0 mg/L paraquat hatched normally, but showed adverse developmental effects. It was noted that commercial formulations of paraquat were more acutely toxic than technical grade paraquat. Tadpoles, however, showed significant mortality when fed paraquat-treated parrot feather watermilfoil (*Myriophyllum).*

- 4-chloro-2-methylphenoaxyacetic acid (MCPA) is relatively non-toxic to the African clawed frog (*Xenopus laevis)* with an LC_{50} of 3,602 mg/L and slight growth retardation at 2,000 mg/L.

- Approximately 86% of juvenile toads died when exposed to monosodium methanearsonate (ANSAR 259® HC) at 12.5% of the recommended application rate.

- Embryo hatch success, tadpole mortality, growth, paralysis, and avoidance behavior were studied in three species of ranid frogs (*Rana* sp.) exposed to hexazinone and triclopyr. No effects were noted in hexazinone exposure up to 100 mg/L. Two species showed 100% mortality at 2.4 mg/L triclopyr; no significant mortality was observed in the third species.

No conclusions can be drawn regarding the sensitivity of amphibians to exposure to diuron relative to the surrogate species selected for the ERA. Amphibians are particularly vulnerable to changes in their environment (chemical and physical) because they have skin with high permeability, making them at risk to dermal contact, and have complex life cycles, making them vulnerable to developmental defects during the many stages of metamorphosis. However, there is no evidence that the organisms evaluated in the ERA fail to provide reasonable protection as surrogates. Given the very low risks to animals in the modeled exposures, it is unlikely the concentrations of diuron predicted to occur as a result of regular herbicide usage would cause adverse effects to amphibians. Nonetheless, it should be noted that certain amphibians can be sensitive to pesticides, and site- and species-specific risk assessment should be carefully considered in the event that amphibian RTE species are present near a site of application.

Although the uncertainties associated with potential overestimates of risk to RTE mammals, birds, reptiles, and amphibians are valid, the vertebrate RQs generated in the ERA for diuron are generally low (Section 4.3). None of the piscivore (fish-eating) bird RQs exceed respective LOCs. However, there were several scenarios where RQs were elevated above LOCs. Of the four general scenarios in which vertebrate receptors were evaluated, the highest RQs were due to direct spray exposure. RQs for all of the receptors evaluated exceeded their respective LOCs for either the acute or chronic scenario at the maximum application rate. At the typical application rate, RQs for two acute exposures (large mammalian herbivore and large avian herbivore) and two chronic exposures (large mammalian herbivore and large mammalian carnivore) exceeded their respective LOCs. Fish RQ exceedances were most notable in the exposure from runoff to a pond and in the accidental direct spray or spill scenarios. (It is unknown how much of an effect the conditions creating uncertainties had on vertebrate RQs.)

6.2.3 Biological Factors Affecting Impact from Herbicide Exposure

The potential for ecological receptors to be exposed to, and affected by, herbicide is dependent upon many factors. Many of these factors are independent of the biology or life history of the receptor (e.g., timing of herbicide use, distance to receptor). These factors were explored in the ERA by simulating scenarios that vary these factors (ENSR 2005b), and these scenarios are discussed in Section 5.0 of this document. However, there are differences in life history among and between receptors that also influence the potential for exposure. Therefore, individual species have a different potential for exposure as well as response. In order to provide perspective on the assumptions made here, as well as the potential need to evaluate alternatives, receptor traits that may influence species-specific exposure and response were examined. These traits are presented and discussed in Table 6-7.

In addition to providing a review of the approach used in the ERA, the factors listed in Table 6-7 can be evaluated in order to assess whether a site- and species-specific ERA should be considered to address potential risks to a given RTE. They also provide perspective on the uncertainty associated with applying the conclusions of the ERA to a broad range of RTE species.

6.3 Review of Extrapolation Methods Used to Calculate Potential Exposure and Risk

Ecological risk assessment relies on extrapolation of observations from one system (e.g., species and toxicity endpoint) to another (see Table 6-7). While every effort has been made to anticipate bias in these extrapolations and to use them to provide an overestimate of risk, it is worth evaluating alternative approaches.

Toxicity Extrapolations in Terrestrial Systems (Fairbrother and Kaputska 1996) is an opinion paper that describes the difficulties associated with trying to quantitatively evaluate a particular species when toxicity data for that species, and/or for the endpoint of concern, are not available. The authors provide an overview of uncertainty factors and methods of data extrapolation used in terrestrial organism TRV development, and suggest an alternative approach to establishing inter-species TRVs. The following subsections summarize their findings for relevant methods of extrapolation.

6.3.1 Uncertainty Factors

Uncertainty factors are used often in both human health and ERA. The uncertainty factor most commonly used in ERA is 10. This value has little empirical basis, but was developed and adopted by the risk assessment community because it seemed conservative and was "simple to use."[6] Six situations in which uncertainty factors may be applied in ecotoxicology were identified: (1) accounting for intraspecific heterogeneity, (2) supporting interspecific extrapolation, (3) converting acute to chronic endpoints and vice versa, (4) estimating LOAEL from NOAEL, (5) supplementing professional judgment, and (6) extrapolating laboratory data to field conditions. No extrapolation of toxicity data among Classes (i.e., between birds, mammals, and reptiles) was discussed. The methods to extrapolate available laboratory toxicity data to suit the requirements of the TRVs in this ERA are discussed in Section 3. For this reason, extrapolation used to develop TRVs is discussed in this section.

Empirical data for each of the situations discussed in the Fairbrother and Kaputska paper (as applicable) are presented in Tables 6-8 through 6-12. In each of these tables, Fairbrother and Kaputska (1996) have presented the percentage of the available data that is included within a stated factor. For example, 90% of the observed LD_{50} for bird species lie within a factor of ten (i.e., the highest LD_{50} within the central 90% of the population is 10-fold higher than the lowest value). This can be compared to the approach used in this ERA. For example, for aquatic invertebrates, a LOC was defined of 0.05. This is analogous to application of an uncertainty factor 20 to the relevant TRV. In this case, the selected TRV is not the highest or the mid-point of the available values but a value at the lower end of the available range. Thus, dividing the TRV by a factor of 20 is very likely to place it well below any observed TRV. With this perspective, the ranges (or uncertainty factors) provided by Fairbrother and Kaputska (1996) generally appear to support the approach used in the ERA (i.e., select low TRVs and consider comparison to an LOC < 1.0).

6.3.2 Allometric Scaling

Allometric scaling provides a formula based on BW that allows translation of doses from one animal species to another. In this ERA, allometric scaling was used to extrapolate the terrestrial vertebrate TRVs from the laboratory species to the surrogate species used to estimate potential risk. The Environmental Sciences Division of the Oak Ridge National Laboratory (ORNL) (Opresko et al. 1994 and Sample et al. 1996) has used allometric scaling for many years to establish benchmarks for vertebrate wildlife. The USEPA has also used allometric scaling in development of wildlife water quality criteria in the Great Lakes Water Quality Initiative (USEPA 1995) and in the development of ecological soil screening levels (USEPA 2000).

The theory behind allometric scaling is that metabolic rate is proportional to body size.[7] However, assumptions are made that toxicological processes are dependent on metabolic rate, and that toxins are equally bioavailable among species. Similar to other types of extrapolation, allometric scaling is sensitive to the species used in the toxicity test selected to develop the TRV. Given the limited amount of data, using the lowest value available for the most sensitive species is the best approach[4], although the potential remains for site-specific receptors to be more sensitive to the toxin. Further uncertainty is introduced to allometric scaling when the species-specific parameters (e.g., BW, ingestion rate) are selected. Interspecies variation of these parameters can be considerable, especially among geographic regions. Allometric scaling is not applicable between classes of organisms (i.e., bird to mammal). However, given these uncertainties, allometric scaling remains the most reliable easy-to-use means to establish TRVs for a variety terrestrial vertebrate species (Fairbrother and Kaputska 1996).

[6] Section 2, Fairbrother and Kaputska 1996. Page 7.

[7] In the 1996 update to the ORNL terrestrial wildlife screening values document (Sample et al. 1996), studies by Mineau et al. (1996) using allometric scaling indicated that, for 37 pesticides studied, avian LD_{50}s varied from 1 to 1.55, with a mean of 1.148. The LD_{50} for birds is now recommended to be 1 across all species.

6.3.3 Recommendations

Fairbrother and Kaputska (1996) provided a critical evaluation of the existing, proposed, and potential means for intra-species toxicity value extrapolation. The paper they published describes the shortcomings of many methods of intra-specific extrapolation of toxicity data for terrestrial organisms. Using uncertainty factors or allometric scaling for extrapolation can often over- or underpredict the toxic effect to the receptor organism. Although using physiologically-based models may be a more scientifically correct way to predict toxicity, the logistics involved with applying them to an ERA on a large-scale make them impractical. In this ERA, extrapolation was performed using techniques most often employed by the scientific risk assessment community. These techniques included the use of uncertainty factors (i.e., potential use of LOC < 1.0) and allometric scaling.

6.4 Indirect Effects on Salmonids

In addition to the potential direct toxicity associated with herbicide exposure, organisms may be harmed from indirect effects, such as habitat degradation or loss of food. Under Section 9 of the ESA of 1973, it is illegal to take an endangered species of fish or wildlife. "Take" is defined as "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." (16 USC 1532(19)). The NOAA Fisheries (NOAA 1999) published a final rule clarifying the definition of "harm" as it relates to take of endangered species in the ESA. NOAA Fisheries defines "harm" as any act that injures or kills fish and wildlife. Acts may include "significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering." To comply with the ESA, potential secondary effects to salmonids were evaluated to ensure that use of diuron on BLM-managed lands would not cause harm to these endangered fish.

Indirect effects can generally be categorized into effects caused by biological or physical disturbance. Biological disturbance includes impacts to the food chain; physical disturbance includes impacts to habitat[8] (Freeman and Boutin 1994). NOAA Fisheries (2002) has internal draft guidance for their Section 7 pesticide evaluations. The internal draft guidance describes the steps that should be taken in an ERA to ensure salmonids are addressed appropriately. The following subsections describe how, consistent with internal draft guidance from NOAA Fisheries, the diuron ERA dealt with the indirect effects assessment.

6.4.1 Biological Disturbance

Potential direct effects to salmonids were evaluated in the ERA. Sensitive endpoints were selected for the RTE species RQ calculations, and worst-case scenarios were assumed. Few diuron RQs for fish in a stream exceeded the respective RTE LOCs (Section 4.3). RQs from spray drift at 25 ft, accidental direct spray of a stream, and acute toxicity from runoff, particularly at the maximum application rate, were the exception. Indirect effects caused by disturbance to the surrounding biological system were evaluated by looking at potential damage to the food chain.

The majority of the salmonid diet consists of aquatic invertebrates and other fish. Sustaining the aquatic invertebrate population is vital to minimizing biological damage from herbicide use. Consistent with ERA guidance (USEPA 1997, 1998), protection of non-RTE species, such as the aquatic invertebrates and fish serving as prey to salmonids, is at the population or community level, not the individual level. Sustainability of the numbers (population) or types (community) of aquatic invertebrates and fish is the assessment endpoint. Therefore, unless acute risks are present, it is unlikely the herbicide will cause harm to the prey base of salmonids from direct damage to the aquatic invertebrates and fish. As discussed in Section 4.3, aquatic invertebrate and fish, acute or chronic scenario RQs for exposure in a

[8] Physical damage to habitat may also be covered under an evaluation of critical habitat. Since all reaches of streams and rivers on BLM land may not be listed as critical habitat, a generalized approach to potential damage to any habitat was conducted. This should satisfy a general evaluation of critical habitats. Any potential for risk due to physical damage to habitat should be addressed specifically for areas deemed critical habitat.

stream exceeded respective LOCs primarily at the maximum application rate, suggesting potential direct impacts to the forage of salmonids in certain situations.

As primary producers and the food base of aquatic invertebrates, disturbance to the aquatic vegetation may affect the aquatic invertebrate population, thereby affecting salmonids. As presented in Section 4.3, the potential for risk to aquatic vegetation may occur under all exposure scenarios evaluated in the ERA. The greatest potential for risk to aquatic vegetation would occur under accidental direct spray or spill of a terrestrial herbicide into an aquatic system. RQs exceeded LOCs by up to four orders of magnitude under the spill and accidental spray scenarios. RQs in the runoff and drift to the stream scenarios exceeded LOCs by up to two orders of magnitude. This suggests that there is potential for impacts to aquatic vegetation, and potential indirect effects on salmonids, from the use of diuron.

The actual food items of many aquatic invertebrates, however, are not leafy aquatic vegetation, but detritus or benthic algae. If aquatic vegetation is affected by an accidental herbicide exposure, the detritus in the stream should increase. Benthic algae are often the principal primary producers in streams. As such, disturbance of algal communities would cause an indirect effect (via a reduction in biomass at the base of the food chain) on all organisms living in the waterbody, including salmonids. Few data are available describing the herbicide's toxicity to benthic algae. Of the algae data available for diuron, the closest species to benthic algae (*Chlorella pyrenoidosa* and *Selenastrum capricornutum*) have an EC_{50} of 0.0013 mg/L and a NOAEL of 0.00044 mg/L, respectively. It is unknown if benthic algae would be more or less sensitive than *Chlorella pyrenoidosa* or *Selenastrum capricornutum*, the species used to derive the acute and chronic aquatic plant TRVs.

As presented in Section 7.3.3.2, diuron may be used alone by BLM or in a tank mix with chlorsulfuron (Lee 2004, personal communication). However, none of the RQs for fish, aquatic invertebrates, aquatic plants, or vertebrate wildlife that were below their respective LOCs in the diuron-only calculations increased to above their respective LOCs in the tank mix calculations.

Based on an evaluation of the RQs calculated for this ERA, there is the potential that RTE fish, including salmonids, would be at indirect risk as a result of the effects of this herbicide (applied alone or in a mix with chlorsulfuron) on the aquatic food chain.

6.4.2 Physical Disturbance

The potential for indirect effects to salmonids due to physical disturbance is less easy to define that the potential for direct biological effects. Salmonids have distinct habitat requirements; any alteration to the coldwater streams in which they spawn and live until returning to the ocean as adults can be detrimental to the salmonid population. Out of the potential effects of herbicide application, it is likely the killing of instream and riparian vegetation would cause the most important physical disturbances. The potential adverse effects could include, but would not necessarily be limited to: loss of primary producers (Section 6.4.1); loss of overhead cover, which may serve as refuge from predators or shade to provide cooling to the waterbodies; and increased sedimentation due to loss of riparian vegetation.

Adverse effects caused by herbicides can be cumulative, both in terms of toxicity stress from break-down products and other chemical stressors that may be present, and in terms of the use of herbicide on lands already stressed on a larger scale. Cumulative watershed effects (CWEs) often arise in conjunction with other land use practices, such as prescribed burning[9]. In forested areas, herbicides are generally used in areas that have been previously altered, such as cut or burned, during vegetative succession when invasive species may dominate. The de-vegetation of these previously stressed areas can delay the stabilization of the substrate, increasing the potential for erosion and resulting sedimentation in adjacent waterbodies.

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[9] The following website provides a more detailed discussion of CWEs http://www.humbolt1.com/~heyenga/Herb.Drft.8_12_99.html.

Based on the results of the ERA, there is potential for non-target terrestrial and aquatic plant risk in certain circumstances, such as incidents of spills or accidental direct spray (Sections 4.3.1 and 4.3.5). In addition, potential risk to typical non-target plants is predicted in drift scenarios when the herbicide was applied 25 ft or 100 ft from the receptor. Potential risk to non-target RTE terrestrial plants may occur from drift 900 ft from the receptor, and in selected runoff scenarios. Having said this, land managers should consider the proximity of salmonid habitat to potential application areas. It may be productive to develop a more site- and/or species-specific ERA in order to assure that the proposed herbicide application will not result in secondary impacts to salmonids especially associated with loss of riparian cover.

6.5 Conclusions

The diuron ERA evaluated the potential risks to many species using many exposure scenarios. Some exposure scenarios are likely to occur, whereas others are unlikely to occur but were included to provide a level of conservatism to the ERA. Individual RTE species were not directly evaluated. Instead, surrogate species toxicity data were used to indirectly evaluate RTE species exposure. Higher trophic level receptors were also evaluated based on their life history strategies; RTE species were represented by one of several avian or mammalian species commonly used in ERAs. To provide a layer of conservatism to the evaluation, lower LOCs and TRVs were used to assess the potential impacts to RTE species.

Uncertainty factors and allometric scaling were used to adjust the toxicity data on a species-specific basis when they were likely to improve applicability and/or conservatism. As discussed in Section 3.1, TRVs were developed using the best available data; uncertainty factors were applied to toxicity data consistent with recommendation of Chapman et al. (1998).

Potential secondary effects of diuron use should be of primary concern for the protection of RTE species. Habitat disturbance and disruptions in the food chain are often the cause of declines of populations and species. For RTE species, habitat or food chain disruptions should be avoided to the extent practical. Some relationships among species are mutualistic, commensalistic, or otherwise symbiotic. For example, many species rely on a particular food source or habitat. Without that food or habitat species, the dependent species may be unduly stressed or extirpated. For RTE species, these obligatory habitats are often listed by USFWS as critical habitats. Critical habitats are afforded certain protection under the ESA. All listed critical habitat, as well as habitats that would likely support RTE species, should be avoided, as disturbance to the habitat may have an indirect adverse effect on RTE species.

Herbicides may reduce riparian zones or harm primary producers in the waterbodies. The results of the ERA indicate that non-target terrestrial and aquatic plants may be at risk from diuron, especially when accidents occur, such as spills or accidental spraying. Typical and accidental application of diuron also pose some risks to fish (including RTE salmonids) and aquatic invertebrates, both directly and indirectly via impacts to aquatic plants and other food items for fish.

In August 2003, the OPP evaluated the potential for diuron to impact certain Pacific anadromous salmonids (specifically Pacific salmon and steelhead) and their critical habitats in California and southern Oregon. The OPP concluded that the non-crop use of diuron has the potential to affect selected habitats. In particular, the OPP indicated the potential for acute risks to RTE fish species and the potential for indirect effects on aquatic plant cover (Turner 2003b). In a separate evaluation, OPP also indicated that "for most pesticides applied to the terrestrial environment, the effects in water, even lentic water, will be relatively transient" (Turner 2003a). Only very persistent pesticides would be expected to have effects beyond the year of their application.

Based on the results of the ERA, there is potential RTE species may be harmed by inappropriate and irresponsible use of the herbicide diuron on BLM-managed lands. However, certain application guidelines and restrictions (e.g., application rate, buffer distance, avoidance of designated critical habitat) for appropriate and responsible use of the herbicide on BLM-managed lands would reduce this risk (see Section 8).

TABLE 6-1
Surrogate Species Used to Derive Diuron TRVs

Species in Diuron Laboratory/Toxicity Studies		Surrogate for
Honeybee	*Apis mellifera*	Pollinating insects
Rat	*Rattus norvegicus* spp.	Mammals
Dog	*Canis familiaris*	Mammals
Mallard	*Anas platyrhynchos*	Birds
Bobwhite Quail	*Colinus virginianus*	Birds
Tomato	*Lycopersicon esculentum*	Non-target terrestrial plants
Garden pea	*Pisum sativum*	Non-target terrestrial plants
Soybean	*Glycine max*	Non-target terrestrial plants
Scud	*Gammarus fasciatus*	Aquatic invertebrates
Daphnid	*Daphnia magna*	Aquatic invertebrates
Cutthroat trout	*Oncorhynchus clarki*	Fish/Salmonids
Algae	*Chlorella pyrenoidosa*	Non-target aquatic plants
Fathead minnow	*Pimephales promelas*	Fish
Green algae	*Selanastrum capricornutum*	Non-target aquatic plants

TABLE 6-2
Surrogate Species Used in Quantitative ERA Evaluation

Species		Trophic Level/Guild	Pathway Evaluated
American robin	*Turdus migratorius*	Avian invertivore/ vermivore/ insectivore	Ingestion
Canada goose	*Branta canadensis*	Avian granivore/ herbivore	Ingestion
Deer mouse	*Peromyscus maniculatus*	Mammalian frugivore/ herbivore	Direct contact and Ingestion
Mule deer	*Odocolieus hemionus*	Mammalian herbivore/ gramivore	Ingestion
Bald eagle	*Haliaeetus leucocephalus*	Avian carnivore/ piscivore	Ingestion
Coyote	*Canis latrans*	Mammalian carnivore	Ingestion

TABLE 6-3
RTE Birds and Selected Surrogates

RTE Avian Species Potentially Occurring on BLM Lands		RTE Trophic Guild	Surrogates
Marbled murrelet	*Brachyramphus marmoratus rmoratus*	Piscivore	Bald eagle
Western snowy plover	*Charadrius alexandrinus nivosus*	Insectivore/ Piscivore	American robin
Piping plover	*Charadrius melodus*	Insectivore	American robin
Mountain plover	*Charadrius montanus*	Insectivore	American robin
Southwestern willow flycatcher	*Empidonax traillii extimus*	Insectivore	American robin
Northern aplomado falcon	*Falco femoralis septentrionalis*	Carnivore	Bald eagle Coyote
Cactus ferruginous pygmy-owl	*Glaucidium brasilianum cactorum*	Carnivore	Bald eagle Coyote
Whooping crane	*Grus Americana*	Piscivore	Bald eagle
California condor	*Gymnogyps californianus*	Carnivore	Bald eagle Coyote
Bald eagle	*Haliaeetus leucocephalus*	Piscivore	Bald eagle
Brown pelican	*Pelecanus occidentalis*	Piscivore	Bald eagle
Inyo California towhee	*Pipilo crissalis eremophilus*	Omnivore [Granivore/ Insectivore]	Canada goose American robin
Coastal California gnatcatcher	*Polioptila californica californica*	Insectivore	American robin
Stellar's eider	*Polysticta stelleri*	Piscivore	Bald eagle
Yuma clapper rail	*Rallus longirostris yumanensis*	Carnivore	Bald eagle Coyote
Spectacled eider	*Somateria fischeri*	Omnivore [Insectivore/ Herbivore]	American robin Canada goose
Least tern	*Sterna antillarum*	Piscivore	Bald eagle
Northern spotted owl	*Strix occidentalis caurina*	Carnivore	Bald eagle Coyote
Mexican spotted owl	*Strix occidentalis lucida*	Carnivore	Bald eagle Coyote
Least Bell's vireo	*Vireo bellii pusillus*	Insectivore	American robin

TABLE 6-4
RTE Mammals and Selected Surrogates

RTE Mammalian Species Potentially Occurring on BLM Lands		RTE Trophic Guild	Surrogates
Sonoran pronghorn	*Antilocapra americana sonoriensis*	Herbivore	Mule deer
Pygmy rabbit	*Brachylagus idahoensis*	Herbivore	Mule deer
Gray wolf	*Canis lupus*	Carnivore	Coyote
Utah prairie dog	*Cynomys parvidens*	Herbivore	Deer mouse
Morro Bay kangaroo rat	*Dipodomys heermanni morroensis*	Omnivore [Herbivore/ Insectivore]	Deer mouse American robin
Giant kangaroo rat	*Dipodomys ingens*	Granivore/ Herbivore	Deer mouse
Fresno kangaroo rat	*Dipodomys nitratoides exilis*	Granivore/ Herbivore	Deer mouse
Tipton kangaroo rat	*Dipodomys nitratoides nitratoides*	Granivore/ Herbivore	Deer mouse
Stephen's kangaroo rat	*Dipodomys stephensi (incl. D. cascus)*	Granivore	Deer mouse
Southern sea otter	*Enhydra lutris nereis*	Carnivore/ Piscivore	Coyote Bald eagle
Steller sea-lion	*Eumetopias jubatus*	Carnivore/ Piscivore	Coyote Bald eagle
Sinaloan jaguarundi	*Herpailurus (=Felis) yaguarundi tolteca*	Carnivore	Coyote
Ocelot	*Leopardus (=Felis) pardalis*	Carnivore	Coyote
Lesser long-nosed bat	*Leptonycteris curosoae yerbabuenae*	Frugivore/ Nectivore	Deer mouse
Mexican long-nosed bat	*Leptonycteris nivalis*	Herbivore	Deer mouse
Canada lynx	*Lynx canadensis*	Carnivore	Coyote
Amargosa vole	*Microtus californicus scirpensis*	Herbivore	Deer mouse
Hualapai Mexican vole	*Microtus mexicanus hualpaiensis*	Herbivore	Deer mouse
Black-footed ferret	*Mustela nigripes*	Carnivore	Coyote
Riparian (=San Joaquin Valley) woodrat	*Neotoma fuscipes riparia*	Herbivore	Deer mouse
Columbian white-tailed deer	*Odocolieus virginianus leucurus*	Herbivore	Mule deer
Bighorn sheep	*Ovis canadensis*	Herbivore	Mule deer
Bighorn sheep	*Ovis canadensis californiana*	Herbivore	Mule deer
Jaguar	*Panthera onca*	Carnivore	Coyote
Woodland caribou	*Rangifer tanandus caribou*	Herbivore	Mule deer
Northern Idaho ground squirrel	*Spermophilus brunneus brunneus*	Herbivore	Deer mouse
Grizzly bear	*Ursus arctos horribilis*	Omnivore [Herbivore/ Insectivore/ Piscivore]	American robin Mule deer Bald eagle
San Joaquin kit fox	*Vulpes macrotis mutica*	Carnivore	Coyote
Preble's meadow jumping mouse	*Zapus hudsonius preblei*	Omnivore [Herbivore/ Insectivore]	Deer mouse American robin

TABLE 6-5
RTE Reptiles and Selected Surrogates

RTE Reptilian Species Potentially Occurring on BLM Lands		RTE Trophic Guild	Surrogates
New Mexican ridge-nosed rattlesnake	*Crotalus willardi obscurus*	Carnivore/Insectivore	Coyote/Bald eagle American robin
Blunt-nosed leopard lizard	*Gambelia silus*	Carnivore/Insectivore	Coyote/Bald eagle American robin
Desert tortoise	*Gopherus agassizii*	Herbivore	Canada goose
Giant garter snake	*Thamnophis gigas*	Carnivore/Insectivore/Piscivore	Coyote American robin Bald eagle
Coachella Valley fringe-toed lizard	*Uma inornata*	Insectivore	American robin

Note: Five sea turtles are also listed species in the 17 states evaluated in this ERA. However, it is unlikely any exposure to herbicide would occur to marine species.

TABLE 6-6
RTE Amphibians and Selected Surrogates

RTE Amphibious Species Potentially Occurring on BLM Lands		RTE Trophic Guild	Surrogates
California tiger salamander	*Ambystoma californiense*	Invertivore[1]	Bluegill sunfish/Rainbow trout[3]
		Vermivore[2]	American robin[4]
Sonoran tiger salamander	*Ambystoma tigrinum stebbinsi*	Invertivore/Insectivore[1]	Bluegill sunfish/Rainbow trout[3]
		Carnivore/Ranivore[2]	American robin[4]
Desert slender salamander	*Batrachoseps aridus*	Invertivore	American robin[4,5]
Wyoming toad	*Bufo baxteri*	Insectivore	Bluegill sunfish/Rainbow trout[3]
			American robin[4]
Arroyo toad (=Arroyo southwestern toad)	*Bufo californicus*	Herbivore[1]	Bluegill sunfish/Rainbow trout[3]
		Invertivore[2]	American robin[4]
California red-legged frog	*Rana aurora draytonii*	Herbivore[1]	Bluegill sunfish/Rainbow trout[3]
		Invertivore[2]	American robin[4]
Chiricahua leopard frog	*Rana chiricahuensis*	Herbivore[1]	Bluegill sunfish/Rainbow trout[3]
		Invertivore[2]	American robin[4]

[1] Diet of juvenile (larval) stage.
[2] Diet of adult stage.
[3] Surrogate for juvenile stage.
[4] Surrogate for adult stage.
[5] *Bratrachoseps aridus* is a lungless salamander that has no aquatic larval stage, and is terrestrial as an adult.

TABLE 6-7
Species and Organism Traits That May Influence Herbicide Exposure and Response

Characteristic	Mode of Influence	ERA Solution
Body size	Larger organisms have more surface area potentially exposed during a direct spray exposure scenario. However, larger organisms have a smaller surface area to volume ratio, leading to a lower per body weight dose of herbicide per application event.	To evaluate potential impacts from direct spray, small organisms were selected (i.e., honeybee and deer mouse).
Habitat preference	Not all of BLM-managed lands are subject to nuisance vegetation control.	It was assumed that all organisms evaluated in the ERA were present in habitats subject to herbicide treatment.
Duration of potential exposure/ home range	Some species are migratory or present during only a fraction of year, and larger species have home ranges that likely extend beyond application areas, thereby reducing exposure duration.	It was assumed that all organisms evaluated in the ERA were present within the zone of exposure full-time.
Trophic level	Many chemical concentrations increase in higher trophic levels.	Although the herbicides evaluated in the ERA have very low potential to bioaccumulate, BCFs were selected to estimate uptake to trophic level 3 fish (prey item for the piscivores), and several trophic levels (primary producers through top-level carnivore) were included in the ERA.
Food preference	Certain types of food or prey may be more likely to attract and retain herbicide.	It was assumed that all types of food were susceptible to high deposition and retention of herbicide.
Food ingestion rate	On a mass ingested per body weight basis, organisms with higher food ingestion rates (e.g., mammals versus reptiles) are more likely to ingest large quantities of food (therefore, herbicide).	Surrogate species were selected that consume large quantities of food, relative to body size. When ranges of ingestion rates were provided in the literature, the upper end of the values was selected for use in the ERA.
Foraging strategy	The way an organism finds and eats food can influence its potential exposure to herbicide. Organisms that consume insects or plants that are underground are less likely to be exposed via ingestion than those that consume exposed food items, such as grasses and fruits.	It was assumed all food items evaluated in the ERA were fully exposed to herbicide during spray or runoff events.
Metabolic and excretion rate	While organisms with high metabolic rates may ingest more food, they may also have the ability to excrete herbicides quickly, lowering the potential for chronic impact.	It was assumed that no herbicide was excreted readily by any organism in the ERA.
Rate of dermal uptake	Different organisms will assimilate herbicides across their skins at different rates. For example, thick scales and shells of reptiles and the fur of mammals are likely to present a barrier to uptake relative to bare skin.	It was assumed that uptake across the skin was unimpeded by scales, shells, fur, or feathers.
Sensitivity to herbicide	Species respond to chemicals differently; some species may be more sensitive to certain chemicals.	The literature was searched and the lowest values from appropriate toxicity studies were selected as TRVs. Choosing the sensitive species as surrogates for the TRV development provides protection to more species.
Mode of toxicity	Response sites to chemical exposure may not be the same among all species. For instance, the presence of aryl hydrocarbon (Ah) receptors in an organism increases its susceptibility to compounds that bind to proteins or other cellular receptors. However, not all species, even within a given taxonomic group (e.g., mammals) have Ah receptors.	Mode of toxicity was not specifically addressed in the ERA. Rather, by selecting the lowest TRVs, it was assumed that all species evaluated in the ERA were also sensitive to the mode of toxicity.

TABLE 6-8
Summary of Findings: Interspecific Extrapolation Variability

Type of Data	Percentage of Data Variability Accounted for Within a Factor of:								
	2	4	10	15	20	50	100	250	300
Bird LD_{50}	--	--	90%	--	--	--	99%	100%	--
Mammal LD_{50}	--	58%	--	--	90%	--	96%	--	--
Bird and Mammal Chronic	--	--	--	--	--	94%	--	--	--
Plants	93%[(a)] 80%[(b)]	--	--	80%[(c)]	--	--	--	--	80%[(d)]

[a] Intra-genus extrapolation
[b] Intra-family extrapolation
[c] Intra-order extrapolation
[d] Intra-class extrapolation

TABLE 6-9
Summary of Findings: Intraspecific Extrapolation Variability

Type of Data	Percentage of Data Variability Accounted for Within Factor of 10	Citation from Fairbrother and Kaputska 1996
490 probit log-dose slopes	92%	Dourson and Starta, 1983 as cited in Abt Assoc., Inc. 1995
Bird LC_{50}:LC_1	95%	Hill et al. 1975
Bobwhite quail LC_{50}:LC_1	71.5%	Shirazi et al. 1994

TABLE 6-10
Summary of Findings: Acute-to-Chronic Extrapolation Variability

Type of Data	Percentage of Data Variability Accounted for Within Factor of 10	Citation from Fairbrother and Kaputska 1996
Bird and mammal dietary toxicity NOAELs (n=174)	90%	Abt Assoc., Inc. 1995

Table 6-11
Summary of Findings: LOAEL-to-NOAEL Extrapolation Variability

Type of Data	Percentage of Data Variability Accounted for Within Factor of:		Citation from Fairbrother and Kaputska 1996
	6	10	
Bird and mammal LOAELs and NOAELs	80%	97%	Abt Assoc. Inc., 1995

TABLE 6-12
Summary of Findings: Laboratory to Field Extrapolations

Type of Data	Response	Citation from Fairbrother and Kaputska 1996
Plant EC_{50} Values	3 of 20 EC_{50} lab study values were 2-fold higher than field data. 3 of 20 EC_{50} values from field data were 2-fold higher than lab study data.	Fletcher et al. 1990
Bobwhite quail	Shown to be more sensitive to cholinesterase-inhibitors when cold-stressed (i.e., more sensitive in the field).	Maguire and Williams 1987
Gray-tailed vole and deer mouse	Laboratory data overpredicted risk.	Edge et al. 1995

7.0 UNCERTAINTY IN THE ECOLOGICAL RISK ASSESSMENT

Every time an assumption is made, some level of uncertainty is introduced into the risk assessment. A thorough description of uncertainties is a key component that serves to identify possible weaknesses in the ERA analysis, and to elucidate what impact such weaknesses might have on the final risk conclusions. This uncertainty analysis lists the uncertainties, with a discussion of what bias—if any—the uncertainty may introduce into the risk conclusions. This bias is represented in qualitative terms that best describe whether the uncertainty might 1) underestimate risk, 2) overestimate risk, or 3) the bias is neutral with regard to the risk estimates, or whether it cannot be determined without additional study.

Uncertainties in the ERA process are summarized in Table 7-1. Several of the uncertainties warrant further evaluation and are discussed below. In general, the assumptions made in this risk assessment have been designed to yield a conservative evaluation of the potential risks to the environment from herbicide application.

7.1 Toxicity Data Availability

The majority of the available toxicity data was obtained from studies conducted as part of the USEPA pesticide registration process. There are a number of uncertainties related to the use of this limited data set in the risk assessment. In general, it would often be preferable to base any ecological risk analysis on reliable field studies that clearly identify and quantify the amount of potential risk from particular exposure concentrations of the chemical of concern. However, in most risk assessments it is more common to extrapolate the results obtained in the laboratory to the receptors found in the field. It should be noted, however, that laboratory studies often actually overestimate risk relative to field studies (Fairbrother and Kapustka 1996).

Thirty-five diuron incident reports were available from the USEPA's Environmental Fate and Effects Division (EFED). These reports can be used to validate both exposure models, and/or hazards to ecological receptors. These reports, described in Section 2.3, indicated diuron as the "probable" cause in 13 incidents and the "possible" cause in 19 incidents. Three incident reports indicated that it was "highly probable" that the use of diuron resulted in the observed effects. One incident implicated the registered use of both diuron and bromacil in the plant damage of grasses due to drift and runoff in 1998. One incident implicated the misuse of both diuron and imazapic, which is believed to be responsible for mortality of birch and willow trees from drift and direct contact in 1997. The third incident where diuron was implicated as a "highly probable" cause, was the accidental use of diuron, which resulted in the mortality of 1000 fish due to runoff in 1975. As described in Table 2-2, effects included partial dieback of flora and mortality of multiple species of fish. These incident reports support the elevated RQs predicted by the ERA for impacts to aquatic species and terrestrial plants due to drift, runoff, or accidental exposures (i.e., spills or direct spray). However, since the incident reports generally provide limited information (e.g., no tissue or soil concentrations), and diuron may have been mixed with other products, it is impossible to fully correlate the impacts predicted in the ERA with the incident reports.

Species for which toxicity data are available may not necessarily be the most sensitive species to a particular herbicide. These species have been selected as laboratory test organisms because they are generally sensitive to stressors, yet they can be maintained under laboratory conditions. However, the selected toxicity value for a receptor was based on a thorough review of the available data by qualified toxicologists and the selection of the most appropriate sensitive surrogate species. The surrogate species used in the registration testing are not an exact match to the wildlife receptors included in the ERA. For example, the only avian data available is for two primarily herbivorous birds: the mallard duck and the bobwhite quail. However, TRVs based on these receptors were also used to evaluate risk to insectivorous and piscivorous birds. Species with alternative feeding habits or species from different taxonomic groups may be more or less sensitive to the herbicide than those species tested in the laboratory.

As discussed previously, plant toxicity data is generally only available for crop species which may have different sensitivities than the non-crop plants occurring on BLM managed lands. According to the herbicide label, diuron products are approved for the control of annual and perennial grasses and herbaceous weeds. However, it is possible that non-cropland plants and grasses are not as sensitive to diuron as the selected broadleaf surrogate plant species.

In general, the most sensitive available endpoint for the appropriate surrogate test species was used to derive TRVs. This approach is conservative since there may be a wide range of data and effects for different species. For example, EC_{50}s or LC_{50}s were available for six species of aquatic invertebrates. These values ranged from 0.16 mg/L for an amphipod (*Gammarus fasciatus*), to 19.4 mg/L for another amphipod (*Hyalella azteca*). Accordingly, 0.16 mg /L was selected as the aquatic invertebrate TRV, even though the majority of results were well above this value. This selection criterion for the TRVs has the potential to overestimate risk within the ERA.

There is also some uncertainty in the conversion of food concentration-based toxicity values (mg herbicide per kg food) to dose-based values (mg herbicide per kg BW) for birds and mammals. Converting the concentration-based endpoint to a dose-based endpoint is dependent upon certain assumptions, specifically the test animal ingestion rate and test animal BW. Default ingestion rates for different test species were used in the conversions unless test-specific values were measured and given. The ingestion rate was assumed to be constant throughout a test. However, it is possible that a test chemical may positively or negatively affect ingestion, thus resulting in an over- or underestimation of total dose.

For the purposes of pesticide registration, tests are conducted according to specific test protocols. For example, in the case of an avian oral LD_{50} study, test guidance follows the harmonized Office of Pollution Prevention and Toxic Substances (OPPTS) protocol 850.2100, Avian Acute Oral Toxicity Test or its Toxic Substances Control Act (TSCA) or FIFRA predecessor (e.g, 40 CFR 797.2175 and OPP 71-1). In this test the bird is given a single dose, by gavage, of the chemical and the test subject is observed for a minimum of 14 days. The LD_{50} derived from this test is the true dose (mg herbicide per kg BW). However, dietary studies were selected preferentially for this ERA and historical dietary studies followed 40 CFR 797.2050, OPP 71-2, or OECD 205, the procedures for which are harmonized in OPPTS 850.2200, Avian Dietary Toxicity Test. In this test, the test organism is presented with the dosed food for 5 days, with 3 days of additional observations after the chemical-laden food is removed. The endpoint for this assay is reported as an LC_{50} representing mg herbicide per kg food. For this ERA, the concentration-based value was converted to a dose-based value following the methodology presented in the Methods Document (ENSR 2005b)[10]. Then the dose-based value was multiplied by the number of days of exposure (generally 5) to result in an LD_{50} value representing the full herbicide exposure over the course of the test.

As indicated in Section 3.1, the toxicity data within the ERAs are presented in the units used in the reviewed studies. Attempts were not made to adjust toxicity data to the % a.i. since it was not consistently provided in all reviewed materials. In most cases the toxicity data applies to the a.i. itself; however, some data corresponds to a specific product containing the a.i. under consideration, and potentially other ingredients (e.g., other active ingredients or inert ingredients). The assumption has been made that the toxicity observed in the tests is due to the a.i. under consideration. However, it is possible that the additional ingredients in the different formulations also had an effect. The OPP's Ecotoxicity Database (a source of data for the ERAs) does not adjust the toxicity data to the % a.i. and presents the data directly from the registration study in order to capture the potential effect caused by various inerts, additives, or other active ingredients in the tested product. In many cases the tested material represents the highest purity produced and higher exposure to the a.i. would not be likely.

For diuron, the % active ingredients, listed in Appendix A when available from the reviewed study, ranged from 28% to 100%. The lowest % a.i. used in the actual TRV derivation was 95% in some studies used to derive TRVs for aquatic receptors. Adjusting these TRVs to 100% of the a.i. (by multiplying the TRV by the % a.i. in the study) would reduce these TRVs slightly, resulting in slightly more elevated RQs. However, this would not result in any additional

[10] Dose-based endpoint $_{(mg/kg\ BW/day)}$ = [Concentration-based endpoint $_{(mg/kg\ food)}$ x Food Ingestion Rate $_{(kg\ food/day)}$]/BW $_{(kg)}$

LOC exceedances. The remaining TRVs are based on studies with even higher percentages of a.i. so the RQ changes would be even more minimal.

7.2 Potential Indirect Effects on Salmonids

No actual field studies or ecological incident reports on the effects of diuron on salmonids were identified during the ERA. Therefore, any discussion of direct or indirect impacts to salmonids was limited to qualitative estimates of potential impacts on salmonid populations and communities. Salmonids were included in the derivation of the fish TRVs. The acute TRV was based on salmonid data, but the chronic TRV was based on toxicity testing with a warmwater species. Therefore, chronic risks to salmonids may be overestimated by the use of the warmwater chronic TRV. A discussion of the potential indirect impacts to salmonids is presented in Section 4.3.6, and Section 6.6 provides a discussion of RTE salmonid species. These evaluations indicated that salmonids may be indirectly impacted by a reduction in food supply (i.e., fish and aquatic invertebrates) or a reduction in vegetative cover under limited conditions.

It is anticipated that these qualitative evaluations overestimate the potential risk to salmonids due to the conservative selection of TRVs for salmonid prey and vegetative cover, application of additional LOCs (with uncertainty/safety factors applied) to assess risk to RTE species, and the use of conservative stream characteristics in the exposure scenarios (i.e., low order stream, relatively small instantaneous volume, limited consideration of herbicide degradation or absorption in models).

7.3 Ecological Risks of Degradates, Inert Ingredients, Adjuvants, and Mixtures

In a detailed herbicide risk assessment, it is preferable to estimate risks not just from the a.i. of an herbicide, but also from the cumulative risks of inert ingredients, adjuvants, surfactants, and degradates. Other herbicides may also factor into the risk estimates, as many herbicides can be tank mixed to expand the level of control and to accomplish multiple identified tasks. However, using currently available models (e.g., GLEAMS), it is only practical to calculate deterministic risk calculations (i.e., exposure modeling, effects assessment, and RQ calculations) for a single a.i..

In addition, information on inerts, adjuvants, and degradates is often limited by the availability of, and access to, reliable toxicity data for these constituents. The sections below present a qualitative evaluation of potential effects for risks due to degradates, inert ingredients, adjuvants, and tank mixtures.

7.3.1 Degradates

The potential toxicity of degradates, also called herbicide transformation products (TPs), should be considered when selecting an herbicide; however, it is beyond the scope of this risk assessment to evaluate all of the possible degradates of the various herbicide formulations containing diuron. Degradates may be more or less mobile and more or less toxic in the environment than their source herbicides (Battaglin et al. 2003). Differences in environmental behavior (e.g., mobility) and toxicity between parent herbicides and TPs makes prediction of potential TP impacts challenging. For example, a less toxic, but more mobile, bioaccumulative, or persistent TP may have the potential to have a greater adverse impact on the environment due to residual concentrations in the environment. A recent study indicated that 70% of TPs had either similar or reduced toxicity to fish, daphnids, and algae than the parent pesticide. However, 4.2% of the TPs were more than an order of magnitude more toxic than the parent pesticide, with a few instances with acute toxicity values below 1.0 mg/L (Sinclair and Boxall 2003). No evaluation of impacts to terrestrial species was conducted in this study. The lack of data on the toxicity of degradates of diuron represents a source of uncertainty in the risk assessment.

7.3.2 Inerts

Pesticide products contain both active and inert ingredients. The terms “a.i.” and “inert ingredient” have been defined by Federal law—the FIFRA—since 1947. An a.i. is one that prevents, destroys, repels or mitigates the effects of a pest, or is a plant regulator, defoliant, desiccant, or nitrogen stabilizer. By law, the a.i. must be identified by name on the label, together with its percentage by weight. An inert ingredient is simply any ingredient in the product that is not intended to affect a target pest. For example, isopropyl alcohol may be an a.i. and antimicrobial pesticide in some products; however, in other products, it is used as a solvent and may be considered an inert ingredient. The law does not require inert ingredients to be identified by name and percentage on the label, but the total percentage of such ingredients must be declared.

In September 1997, the USEPA issued Pesticide Regulation Notice 97-6, which encouraged manufacturers, formulators, producers, and registrants of pesticide products to voluntarily substitute the term “other ingredients” as a heading for the inert ingredients in the ingredient statement. The USEPA made this change after learning the results of a consumer survey on the use of household pesticides. Many consumers are mislead by the term “inert ingredient,” believing it to mean “harmless.” Since neither the federal law nor the regulations define the term “inert” on the basis of toxicity, hazard or risk to humans, non-target species, or the environment, it should not be assumed that all inert ingredients are non-toxic. Whether referred to as “inerts” or “other ingredients,” these components within an herbicide have the potential to be toxic.

BLM scientists received clearance from the USEPA to review CBI on inert compounds in the following herbicides under consideration in ERAs: bromacil, chlorsulfuron, diflufenzopyr, Overdrive® (a mix of dicamba and diflufenzopyr), diquat, diuron, fluridone, imazapic, sulfometuron-methyl, and tebuthiuron. The information received listed the inert ingredients, their chemical abstract number, supplier, USEPA registration number, percentage of the formulation and purpose in the formulation. This information is confidential, and is therefore not disclosed in this document. However, a review of available data for the herbicides is included in Appendix D.

The USEPA has a listing of regulated inert ingredients at http://www.epa.gov/opprd001/inerts/index.html. This listing categorizes inert ingredients into four lists. The listing of categories and the number of inert ingredients found among the ingredients listed for the herbicides are shown below:

- List 1 – Inert Ingredients of Toxicological Concern: None.
- List 2 – Potentially Toxic Inert Ingredients: None.
- List 3 – Inerts of Unknown Toxicity. 12.
- List 4 – Inerts of Minimal Toxicity. Over 50.

Nine inerts were not found on EPA’s lists.

Toxicity information was also searched in the following sources:

- TOMES (a proprietary toxicological database including EPA’s IRIS, the Hazardous Substance Data Bank, the Registry of Toxic Effects of Chemical Substances [RTECS]).
- EPA’s ECOTOX database, which includes AQUIRE (a database containing scientific papers published on the toxic effects of chemicals to aquatic organisms).
- TOXLINE (a literature searching tool).
- Material Safety Data Sheets (MSDSs) from suppliers.
- Other sources, such as the Farm Chemicals Handbook.

- Other cited literature sources.

Relatively little toxicity information was found. A few acute studies on aquatic or terrestrial species were reported. No chronic data, no cumulative effects data and almost no indirect effects data (food chain species) were found for the inerts in the herbicides.

A number of the List 4 compounds (Inerts of Minimal Toxicity) are naturally-occurring earthen materials (e.g. clay materials or simple salts) that would produce no toxicity at applied concentrations. However, some of the inerts, particularly the List 3 compounds and unlisted compounds, may have moderate to high potential toxicity to aquatic species based on MSDSs or published data.

As a tool to evaluate List 3 and unlisted inerts in the ERA, the exposure concentration of the inert compound was calculated and compared to toxicity information. As described in more detail in Appendix D, the GLEAMS model was set up to simulate the effects of a generalized inert compound in the previously described "base-case" watershed with a sand soil type. Toxicity information from the above sources was used in addition to the work of Muller (1980), Lewis (1991), Dorn et al. (1997), and Wong et al. (1997) concerning aquatic toxicity of surfactants. These sources generally suggested that acute toxicity to aquatic life for surfactants and anti-foam agents ranged from 1 to 10 mg/L, and that chronic toxicity ranged as low as 0.1 mg/L.

Appendix D presents the following general observation for diuron: higher application rates for diuron yielded higher exposure concentrations of surfactant inerts, exceeding 1.0 mg/L for the maximum pond scenario. This indicates that inerts associated with the application of diuron may increase acute toxicity to aquatic organisms if they reach the aquatic environment. Because of the lack of specific inert toxicity data, it is not possible to state that the inerts in diuron will not result in adverse ecological impacts. It is assumed that toxic inerts would not represent a substantial percentage of the herbicide and that minimal impacts to the environment would result from these inert ingredients.

7.3.3 Adjuvants and Tank Mixtures

Evaluating the potential additional/cumulative risks from mixtures and adjuvants of pesticides is substantially more difficult than evaluating the inerts in the herbicide composition. While many herbicides are present in the natural environment along with other pesticides and toxic chemicals, the composition of such mixtures is highly site-specific, and thus nearly impossible to address at the level of the programmatic EIS.

Herbicide label information indicates whether the herbicide can be tank mixed with other pesticides. Adjuvants (e.g., surfactants, crop oil concentrates, fertilizers) may also be added to the spray mixture to improve herbicide efficacy. Without product specific toxicity data, it is impossible to quantify the potential impacts of these mixtures. In addition, a quantitative analysis could only be conducted if reliable scientific evidence allowed a determination of whether the joint action of the mixture was additive, synergistic, or antagonistic. Such evidence is not likely to exist unless the mode of action is common among the chemicals and receptors.

7.3.3.1 Adjuvants

Adjuvants generally function to enhance or prolong the activity of an a.i.. For terrestrial herbicides, adjuvants aid in the absorption of the a.i. into plant tissue. Adjuvant is a broad term and includes surfactants, selected oils, anti-foaming agents, buffering compounds, drift control agents, compatibility agents, stickers, and spreaders. Adjuvants are not under the same registration guidelines as pesticides and the USEPA does not register or approve the labeling of spray adjuvants. Individual herbicide labels identify which types of adjuvants are approved for use with that herbicide.

In reviewing the labels of several diuron formulations (for non-cropland applications), a nonionic surfactant was identified as the only adjuvant listed for use with the particular formulations. In general, adjuvants compose a relatively small portion of the volume of herbicide applied. However, it is recommended that an adjuvant with low toxic potential be selected. Potential toxicity of any material should be considered prior to its use as an adjuvant.

Following the same procedure used to address inerts in Section 7.3.2 and Appendix D, the GLEAMS model was used to estimate the potential portion of an adjuvant that might reach an adjacent waterbody via surface runoff. The chemical characteristics of the generalized inert/adjuvant compound were set at extremely high/low values to describe it as a very mobile and stable compound. The application rate of the inert/adjuvant compound was fixed at 1 lb a.i./ac; the watershed was the "base case" used in the risk assessment with sandy soil and 50 inches of precipitation per year. Under these conditions, the maximum predicted ratio of inert concentration to herbicide application rate was 0.69 mg/L per lb a.i./ac (3 day maximum in the pond).

As described in Section 7.3.2, sources (Muller 1980; Lewis 1991; Dorn et al. 1997; Wong et al. 1997) generally suggested that acute toxicity to aquatic life for surfactants and anti-foam agents ranged from 1 to 10 mg/L, and that chronic toxicity ranged as low as 0.1 mg/L. At the application rate recommended for nonionic surfactants, 0.5% v/v, and the maximum application rate for diuron, the maximum predicted concentration would be 6.9 mg/L. This value is within the range for acute toxicity to aquatic life for surfactants and anti-foam agents (1 to 10 mg/L) and above the level associated with chronic effects (0.1 mg/L). This indicates that surfactants associated with the use of diuron have the potential for negative impacts to aquatic life if they reach a downgradient waterbody.

This evaluation indicates that adjuvants may add some uncertainty to the level of risk predicted for the a.i.. However, more specific modeling and toxicity data would be necessary to define the level of uncertainty. Selection of adjuvants is under the control of BLM land managers, and it is recommended that land managers follow all label instructions and abide by any warnings. Selection of adjuvants with limited toxicity and low volumes is recommended to reduce the potential for the adjuvant to influence the toxicity of the herbicide.

7.3.3.2 Tank Mixtures

In reviewing the labels of several formulations of diuron, it is noted that this a.i. can be tank mixed with several other active ingredients, including: chlorsulfuron, imazapyr, and sulfometuron-methyl. However, it is not generally within BLM practice to tank mix diuron with these products. The use of tank mixtures of labeled herbicides, along with the addition of an adjuvant (when stated on the label) may be an efficient use of equipment and personnel. However, knowledge of both products and their interactions is necessary to avoid unintended negative effects. In general, herbicide interactions can be classified as additive, synergistic, or antagonistic:

- Additive effects occur when mixing two herbicides produces a response equal to the combined effects of each herbicide applied alone. The products neither hurt nor enhance each other.
- Synergistic responses occur when two herbicides provide a greater response than the added effects of each herbicide applied separately.
- Antagonistic responses occur when two herbicides applied together produce less control than if you applied each herbicide separately.

These types of interactions also describe the potential changes to the toxic effects of the individual herbicides and the tank mixture (i.e., the mixture may have more or less toxicity the either of the individual products). While a quantitative evaluation of all of these mixtures is beyond the scope of this ERA, a qualitative evaluation may be made if the assumption is made that the products in the tank mix will act in an additive manner. The predicted RQs for two a.i.s can be summed for each individual exposure scenario to see if the combined impacts result in additional RQs elevated over the corresponding LOCs.

In order to evaluate a common and representative tank mix scenario, the ERA evaluated a mixture with diuron and chlorsulfuron (a.i.s in the herbicide Telar DF). The RQs for these two chemicals were calculated for the ground applications described in Section 4.2.1 and combined to simulate a tank mix in Appendix E. A comparison of the RQs exceeding the LOCs for diuron applied alone and as a tank mix with chlorsulfuron is presented in Table 7-2. This comparison indicates that the tank mix does not generally predict more RQs above the associated LOCs than were predicted for diuron alone. The number of elevated RQs for typical terrestrial plant species does increase slightly with the use of the tank mix (from 6.0% to 10.3%). This indicates that the addition of chlorsulfuron in a tank mix does not generally result in any additional risks than diuron alone; however, a slight increase in risks to typical terrestrial plant species may occur with the use of the tank mix. There is some uncertainty in this evaluation because these herbicides may not interact in an additive manner. This may overestimate risk if the interaction is antagonistic, or it may underestimate risk if the interaction is synergistic. In addition, other products may also be included in tank mixes and may contribute to the potential risk.

Selection of tank mixes, like adjuvants, is under the control of BLM land managers. To reduce uncertainties and potential negative impacts, it is required that land managers follow all label instructions and abide by any warnings. Labels for both tank mixed products should be thoroughly reviewed and mixtures with the least potential for negative effects should be selected. This is especially relevant when a mixture is applied in a manner that may already have the potential for risk for an individual herbicide (e.g., runoff to ponds in sandy watersheds). Use of a tank mix under these conditions increases the level of uncertainty in risk to the environment.

7.4 Uncertainty Associated with Herbicide Exposure Concentration Models

The ERA relies on different models to predict the off-site impacts of herbicide use. These models have been developed and applied in order to develop a conservative estimate of herbicide loss from the application area to off-site locations.

As in any screening or higher-tier ERA, a discussion of potential uncertainties from fate and exposure modeling is necessary to identify potential overestimates or underestimates of risk. In particular, the uncertainty analysis focused on which environmental characteristics (e.g., soil type, annual precipitation) exert the biggest numeric impact on model outputs. The results of this uncertainty analysis have important implications not only for the uncertainty analysis itself, but also for the ability to apply risk calculations to different site characteristics from a risk management perspective.

7.4.1 AgDRIFT®

Off-target spray drift and resulting terrestrial deposition rates and waterbody concentrations (hypothetical pond or stream) were predicted using the computer model, AgDRIFT® Version 2.0.05 (SDTF 2002). As with any complex ERA model, a number of simplifying assumptions were made to ensure that the risk assessment results would be protective of most environmental settings encountered in the BLM land management program.

Predicted off-site spray drift and downwind deposition can be substantially altered by a number of variables intended to simulate the herbicide application process including, but not limited to: nozzle type used in the spray application of an herbicide mixture; ambient wind speed; release height (application boom height); and evaporation. Hypothetically, any variable in the model that is intended to represent some part of the physical process of spray drift and deposition can substantially alter predicted downwind drift and deposition patterns. Recognizing the lack of absolute knowledge about all of the scenarios likely to be encountered in the BLM land management program, these assumptions were developed to be conservative and likely result in overestimation of actual off-site spray drift and environmental impacts.

7.4.2 GLEAMS

The GLEAMS model was used to predict the loading of herbicide to nearby soils, ponds, and streams from overland runoff, erosion, and root-zone groundwater runoff. The GLEAMS model conservatively assumes that the soil, pond, and stream are directly adjacent to the application area. The use of buffer zones would reduce potential herbicide loading to the exposure areas.

7.4.2.1 Herbicide Loss Rates

The trends in herbicide loss rates (herbicide loss computed as a percent of the herbicide applied within the watershed) and water concentrations predicted by the GLEAMS model echo trends that have been documented in a wide range of streams located in the Midwestern US. A recently published study (Lerch and Blanchard 2003) recognized that factors affecting herbicide transport to streams can be organized into four general categories:

- Intrinsic factors – soil and hydrologic properties and geomorphologic characteristics of the watershed
- Anthropogenic factors – land use and herbicide management
- Climate factors – particularly precipitation and temperature
- Herbicide factors – chemical and physical properties and formulation

These findings were based on the conclusions of several prior investigations, data collected as part of the U.S. Geological Survey's National Stream Quality Accounting Network (NASQAN) program, and the results of runoff and baseflow water samples collected in 20 streams in northern Missouri and southern Iowa. The investigation concluded that the median runoff loss rates for atrazine, cyanazine, acetochlor, alachlor, metolachlor, and metribuzin ranged from 0.33 to 3.9% of the mass applied—loss rates that were considerably higher than in other areas of the US. Furthermore, the study indicated that the runoff potential was a critical factor affecting herbicide transport. Table 7-3 is a statistical summary of the GLEAMS predicted total and runoff loss rates for several herbicides. The median total loss rates range from 0.27 to 36%, and the median runoff loss rates range from 0 to 0.27%.

The results of the GLEAMS simulations indicate trends similar to those identified in the Lerch and Blanchard (2003) study. First, the GLEAMS simulations demonstrated that the most dominant factors controlling herbicide loss rates are soil type and precipitation; both are directly related to the amount of runoff from an area following an herbicide application. This was demonstrated in each of the GLEAMS simulations that considered the effect of highly variable annual precipitation rates and soil type on herbicide transport. In all cases, the GLEAMS model predicted that runoff loss rate was positively correlated with both precipitation rate and soil type.

Second, consistent with the conclusion reached by Lerch and Blanchard (2003) (i.e., that runoff potential is critical to herbicide transport) and the GLEAMS model results, estimating the groundwater discharge concentrations by using the predicted root-zone concentrations as a surrogate is extremely conservative.

For example, while the median runoff loss rates range from 0 to 0.27%, confirming the Lerch and Blanchard study, the median total loss rates predicted using GLEAMS are substantially higher. This discrepancy may be due to the differences between the watershed characteristics in the field investigation and those used to describe the GLEAMS simulations. It is probably at least in partially a result of the conservative nature of the baseflow predictions.

Based on the results and conclusions of prior investigations, the runoff loss rates predicted by the GLEAMS model are approximately equivalent to loss rates determined within the Mississippi River watershed and elsewhere in the US, and the percolation loss rates are probably conservatively high. This confirms that our GLEAMS modeling approach either approximates or overestimates the rate of loadings observed in the field.

7.4.2.2 Root-Zone Groundwater

In the application of GLEAMS, it was assumed that root-zone loading of herbicide would be transported directly to a nearby water body. This is a feasible scenario in several settings but is very conservative in situations in which the depth to the water table might be many ft. In particular, it is common in much of the arid and semi-arid western states for the water table to be well below the ground surface and for there to be little, if any, groundwater discharge to surface water features. Some ecological risk scenarios were dominated by the conservatively estimated loading of herbicide by groundwater discharge to surface waters. Again, while possible, this is likely to be an over-estimate of likely impacts in most settings on BLM lands.

7.4.3 CALPUFF

The USEPA's CALPUFF air pollutant dispersion model was used to predict impacts of the potential migration of the herbicide between 1.5 and 100 km from the application area by windblown soil (fugitive dust). Several assumptions were made that could overpredict or underpredict the deposition rates obtained from this model.

The use of flat terrain could underpredict deposition for mountainous areas. In these areas, hills and mountains would likely focus wind and deposition into certain areas, resulting in pockets of increased risk. The use of bare, undisturbed soil results in less uptake and transport than disturbed (i.e., tilled) soil. However, the BLM does not apply herbicides to agricultural areas, so this assumption may be appropriate for BLM-managed lands.

The modeling conservatively assumed that all of the herbicide would be present in the soil at the commencement of a windy event, and that no reduction due to vegetation interception/uptake, leaching, solar or chemical half-life would have occurred since the time of application. Thus, the model likely overpredicts the deposition rates unless the herbicide is taken by the wind as soon as it is applied. It is more likely that a portion of the applied herbicide would be sorbed to plants or degraded over time.

Assuming a 1-mm penetration depth is also conservative and likely overestimates impacts. This penetration depth is less than the depth used in previous herbicide risk assessments (SERA 2001) and the depth assumed in the GLEAMS model (1 cm surface soil).

The surface roughness in the vicinity of the application site directly affects the deposition rates predicted by CALPUFF. The surface roughness length used in the CALPUFF model is a measure of the height of obstacles to wind flow and varies by land-use types. Forested areas and urban areas have the highest surface roughness lengths (0.5 m to 1.3 m) while grasslands have the lowest (0.001 m to 0.10 m).

Predicted deposition rates are likely to be higher near the application area and lower at greater distances if the surface roughness in the area is relatively high (above 1 m, such as in forested areas). Therefore, overestimation of the surface roughness could overpredict deposition within about 50 km of the application area and underpredict deposition beyond 50 km. Overestimation of the surface roughness could occur if, for example, prescribed burning was used to treat a typically forested area prior to planned herbicide treatment.

The surface roughness in the vicinity of the application site also affects the calculated "friction velocity" used to determine deposition velocities, which in turn are used by CALPUFF to calculate the deposition rate. Friction velocity increases with increasing wind speed and also with increased surface roughness. Higher friction velocities result in higher deposition velocities and likewise higher deposition rates, particularly within about 50 km of the emission source.

The CALPUFF modeling assumes that the data from the selected National Weather Service stations is representative of meteorological conditions in the vicinity of the application sites. Site-specific meteorological data (e.g., from an on-site meteorological tower) could provide slightly different wind patterns, possibly due to local terrain, which could impact the deposition rates as well as locations of maximum deposition.

7.5 Summary of Potential Sources of Uncertainty

The analysis presented in this section has identified several potential sources of uncertainty that may introduce bias into the risk conclusions. This bias has the potential to 1) underestimate risk, 2) overestimate risk, or 3) be neutral with regard to the risk estimates, or be undetermined without additional study. In general, few of the sources of uncertainty in this ERA are likely to underestimate risk to ecological receptors. Risk is more likely to be overestimated or the impacts of the uncertainty may be neutral or impossible to predict.

The following bullets summarize the potential impacts on the risk predictions based on the analysis presented above:

- Toxicity Data Availability – Although the species for which toxicity data are available may not necessarily be the most sensitive species to a particular herbicide, the TRV selection methodology has focused on identifying conservative toxicity values that are likely to be protective of most species; the use of various LOCs contributes an additional layer of protection for species that may be more sensitive than the tested species (i.e., RTE species).

- Potential Indirect Effects on Salmonids - Only a qualitative evaluation of indirect risk to salmonids was possible since no relevant studies or incident reports were identified; it is likely that this qualitative evaluation overestimates the potential risk to salmonids due to the numerous conservative assumptions related to TRVs and exposure scenarios, and the application of additional LOCs (with uncertainty/safety factors applied) to assess risk to RTE species.

- Ecological Risks of Degradates, Inerts, Adjuvants, and Tank Mixtures - Only limited information is available regarding the toxicological effects of degradates, inerts, adjuvants, and tank mixtures; in general, it is unlikely that highly toxic degradates or inerts are present in approved herbicides; selection of tank mixes and adjuvants is under the control of BLM land managers and to reduce uncertainties and potential risks products should be thoroughly reviewed and mixtures with the least potential for negative effects should be selected.

- Uncertainty Associated with Herbicide Exposure Concentration Models - Environmental characteristics (e.g., soil type, annual precipitation) will impact the three models used to predict the off-site impacts of herbicide use (i.e., AgDRIFT®, GLEAMS, CALPUFF); in general, the assumptions used in the models were developed to be conservative and likely result in overestimation of actual off-site environmental impacts.

- General ERA Uncertainties – The general methodology used to conduct the ERA is more likely to overestimate risk than to underestimate risk due to the use of conservative assumptions (i.e., entire home range and diet is assumed to be impacted, aquatic waterbodies are relatively small, herbicide degradation over time is not applied in most scenarios).

TABLE 7-1
Potential Sources of Uncertainty in the ERA Process

Potential Source of Uncertainty	Direction of Effect	Justification
Physical-chemical properties of the active ingredient	Unknown	Available sources were reviewed for a variety of parameters. However, not all sources presented the same value for a parameter (e.g., water solubility) and some values were estimated.
Food chain assumed to represent those found on BLM lands	Unknown	BLM lands cover a wide variety of habitat types. A number of different exposure pathways have been included, but additional pathways may occur within management areas.
Receptors included in food chain model assumed to represent those found on BLM lands	Unknown	BLM lands cover a wide variety of habitat types. A number of different receptors have been included, but alternative receptors may occur within management areas.
Food chain model exposure parameter assumptions	Unknown	Some exposure parameters (e.g., body weight, food ingestion rates) were obtained from the literature and some were estimated. Efforts were made to select exposure parameters representative of a variety of species or feeding guilds, so that exposure estimates would be representative of more than a single species.
Assumption that receptor species will spend 100% of time in impacted terrestrial or aquatic area (home range = application area)	Overestimate	These model exposure assumptions do not take into consideration the ecology of the wildlife receptor species. Organisms will spend varying amounts of time in different habitats, thus affecting their overall exposures. Species are not restricted to one location within the application area, may migrate freely off-site, may undergo seasonal migrations (as appropriate), and are likely to respond to habitat quality in determining foraging, resting, nesting, and nursery activities. A likely overly conservative assumption has been made that wildlife species obtain all their food items from the application area.
Waterbody characteristics	Overestimate	The pond and stream were designed with conservative assumptions resulting in relatively small volumes. Larger waterbodies are likely to exist within application areas.
Extrapolation from test species to representative wildlife species	Unknown	Species differ with respect to absorption, metabolism, distribution, and excretion of chemicals. The magnitude and direction of the difference may vary with species. It should be noted, though, that in most cases, laboratory studies actually overestimate risk relative to field studies (Fairbrother and Kapustka 1996).
Consumption of contaminated food	Unknown	Toxicity to food receptors may result in sickness or mortality. Fewer prey items would be available for predators. Predators may stop foraging in areas with reduced prey populations, discriminate against, or conversely, select contaminated prey.
No evaluation of inhalation exposure pathways	Underestimate	The inhalation exposure pathways are generally considered insignificant due to the low concentration of contaminants under natural atmospheric conditions. However, under certain conditions, these exposure pathways may occur.

TABLE 7-1 (Cont.)
Potential Sources of Uncertainty in the ERA Process

Potential Source of Uncertainty	Direction of Effect	Justification
Assumption of 100% drift for chronic ingestion scenarios	Overestimate	It is unlikely that 100% of the application rate would be deposited on a plant or animal used as food by another receptor. As indicated with the AgDRIFT® model, off-site drift is only a fraction of the applied amount.
Ecological exposure concentration	Overestimate	It is unlikely any receptor would be exposed continuously to the full predicted EEC.
Over-simplification of dietary composition in the food web models	Unknown	Assumptions were made that contaminated food items (e.g., vegetation, fish) were the primary food items for wildlife. In reality, other food items are likely consumed by these organisms.
Degradation or adsorption of herbicide	Overestimate	Risk estimates for direct spray and off-site drift scenarios generally do not consider degradation or adsorption. Concentrations will tend to decrease over time from degradation. Organic carbon in water or soil/sediment may bind to herbicide and reduce bioavailability.
Bioavailability of herbicides	Overestimate	Most risk estimates assume a high degree of bioavailability. Environmental factors (e.g., binding to organic carbon, weathering) may reduce bioavailablity.
Limited evaluation of dermal exposure pathways	Unknown	The dermal exposure pathway is generally considered insignificant due to natural barriers found in fur and feathers of most ecological receptors. However, under certain conditions (e.g., for amphibians), these exposure pathways may occur.
Amount of receptor's body exposed	Unknown	More or less than ½ of the honeybee or small mammal may be affected in the accidental direct spray scenarios.
Lack of toxicity information for amphibian and reptile species	Unknown	Information is not available on the toxicity of herbicides to reptile and amphibian species resulting from dietary or direct contact exposures.
Lack of toxicity information for RTE species	Unknown	Information is not available on the toxicity of herbicides to RTE species resulting from dietary or direct contact exposures. Uncertainty factors have been applied to attempt to assess risk to RTE receptors. See Section 7.2 for additional discussion of salmonids.
Safety factors applied to TRVs	Overestimate	Assumptions regarding the use of 3-fold uncertainty factors are based on precedent, rather than scientific data.
Use of lowest toxicity data to derive TRVs	Overestimate	The lowest data point observed in the laboratory may not be representative of the actual toxicity that might occur in the environment. Using the lowest reported toxicity data point as a benchmark concentration is a very conservative approach, especially when there is a wide range in reported toxicity values for the relevant species. See Section 7.1 for additional discussion.
Use of NOAELs	Overestimate	Use of NOAELs may overestimate effects since this measurement endpoint does not reflect any observed impacts. LOAELs may be orders of magnitudes above observed literature-based NOAELs, yet NOAELs were generally selected for use in the ERA.

TABLE 7-1 (Cont.)
Potential Sources of Uncertainty in the ERA Process

Potential Source of Uncertainty	Direction of Effect	Justification
Use of chronic exposures to estimate effects of herbicides on receptors	Overestimate	Chronic toxicity screening values assume that ecological receptors experience continuous, chronic exposure. Exposure in the environment is unlikely to be continuous for many species that may be transitory and move in and out of areas of maximum herbicide concentration.
Use of measures of effect	Overestimate	Although an attempt was made to have measures of effect reflect assessment endpoints, limited available ecotoxicological literature resulted in the selection of certain measures of effect that may overestimate assessment endpoints.
Lack of toxicity information for mammals or birds	Unknown	TRVs for certain receptors were based on a limited number of studies conducted primarily for pesticide registration. Additional studies may indicate higher or lower toxicity values. See Section 7.1 for additional discussion.
Lack of seed germination toxicity information	Unknown	TRVs were based on a limited number of studies conducted primarily for pesticide registration. A wide range of germination data was not always available. Emergence or other endpoints were also used and may be more or less sensitive to the herbicide.
Species used for testing in the laboratory assumed to be equally sensitive to herbicide as those found within application areas.	Unknown	Laboratory toxicity tests are normally conducted with species that are highly sensitive to contaminants in the media of exposure. Guidance manuals from regulatory agencies contain lists of the organisms that they consider to be sensitive enough to be protective of naturally occurring organisms. However, reaction of all species to herbicides is not known, and species found within application areas may be more or less sensitive than those used in the laboratory toxicity testing. See Section 7.1 for additional discussion.
Risk evaluated for individual receptors only	Overestimate	Effects on individual organisms may occur with little population or community level effects. However, as the number of affected individuals increases, the likelihood of population-level effects increases.
Lack of predictive capability	Unknown	The RQ approach provides a conservative estimate of risk based on a "snapshot" of conditions; this approach has no predictive capability.
Unidentified stressors	Unknown	It is possible that physical stressors other than those measured may affect ecological communities.
Effect of decreased prey item populations on predatory receptors	Unknown	Adverse population effects to prey items may reduce the foraging population for predatory receptors, but may not necessarily adversely impact the population of predatory species.
Multiple conservative assumptions	Overestimate	Cumulative impact of multiple conservative assumptions predicts high risk to ecological receptors.
Predictions of off-site transport	Overestimate	Assumptions are implicit in each of the software models used in the ERA (AgDRIFT®, GLEAMS, and CALPUFF). These assumptions have been made in a conservative manner when possible. These uncertainties are discussed further in Section 7.4.
Impact of the other ingredients (e.g., inerts, adjuvants) in the application of the herbicide	Unknown	Only the a.i. has been investigated in the ERA. Inerts, adjuvants, and tank mixtures may increase or decrease the impacts of the a.i.. These uncertainties are discussed further in Section 7.3.

TABLE 7-2
Changes in RQs Exceeding LOCs for Tank Mixtures

Receptor	LOC	Number of RQs Exceeding LOC		% of Total RQs Exceeding LOC	
		Diuron RQs : Total RQs	Tank Mix RQs[1] : Total RQs	Diuron	Tank Mix[1]
Terrestrial Animals					
Birds and Wild Mammals					
Acute High	0.50	5:118	5:118	4.2	4.2
Acute Restricted	0.20	7:118	7:118	5.9	5.9
Acute RTE	0.10	8:118	8:118	6.8	6.8
Chronic	1.00	8:10	8:10	80.0	80.0
Terrestrial Plants					
Typical Species					
Acute High	1.00	7:116	12:116	6.0	10.3
Acute RTE	1.00	7:116	12:116	6.0	10.3
RTE Species					
Acute High	1.00	26:116	26:116	22.4	22.4
Acute RTE	1.00	26:116	26:116	22.4	22.4
Aquatic Receptors					
Fish and Invertebrates					
Acute High	0.50	97:394	97:394	24.6	24.6
Acute Restricted	0.10	186:394	186:394	47.2	47.2
Acute RTE	0.05	235:394	235:394	59.6	59.6
Chronic	1.00	72:392	88:392	18.4	22.4
Chronic RTE	0.50	121:392	127:392	30.9	32.4
Plants					
Acute High	1.00	172:197	172:197	87.3	87.3
Acute RTE	1.00	172:197	172:197	87.3	87.3

RQ sums include RQs for both typical and maximum application rates.
[1] Tank mix with chlorsulfuron.

TABLE 7-3
Herbicide Loss Rates Predicted by the GLEAMS Model

Herbicide	Total Loss Rate			Runoff Loss Rate		
	Median	90th	Maximum	Median	90th	Maximum
Diflufenzopyr	0.27%	22%	54%	0.27%	6.0%	22%
Diuron	4.5%	40%	79%	0.10%	4.1%	32%
Sulfometuron	0.49%	19%	37%	0.02%	1.6%	6.6%
Tebuthiuron	18%	56%	92%	0.23%	8.0%	23%
Diuron	3.7%	27%	40%	0.22%	5.0%	24%
Bromacil	36%	60%	66%	0.02%	1.7%	8.5%
Chlorsulfuron	1.9%	21%	68%	0.03%	3.9%	10%
Dicamba	26%	38%	42%	0.00%	0.0%	0.1%

8.0 SUMMARY

Based on the ERA conducted for diuron, there is the potential for risk to ecological receptors from exposure to herbicides under specific conditions on BLM-managed lands. Table 8-1 summarizes the relative magnitude of risk predicted for ecological receptors for each route of exposure. This was accomplished by comparing the RQs against the most conservative LOC, and ranking the results for each receptor-exposure route combination from 'no potential' to 'high potential' for risk. As expected due to the mode of action of terrestrial herbicides, the highest risk is predicted for non-target terrestrial and aquatic plant species, generally under accidental exposure scenarios (i.e., direct spray and accidental spills) and selected off-site transport scenarios. Risk was also predicted for fish and aquatic invertebrates under the accidental exposure scenarios.

The following bullets further summarize the risk assessment findings for diuron under evaluated exposure scenarios:

- Direct Spray – Risk to insects may occur when individuals or foliage are directly sprayed. Acute and chronic risks to terrestrial wildlife species may occur when contaminated food items are consumed. Risk to terrestrial and aquatic non-target plants, fish, and aquatic invertebrates is likely in accidental direct spray scenarios.

- Off-Site Drift – Risk to typical non-target terrestrial plant species was predicted within 100 ft of the application area (mostly at the maximum application rate), while risk to non-target RTE terrestrial plant species may occur for any of the modeled ground application scenarios. Risk to aquatic plants was predicted for all scenarios at the maximum application rate (except for acute risk in the stream with a buffer distance of 900 ft) and for distances less than or equal to 100 ft at the typical application rate (chronic risk in the pond also predicted at 900 ft for high boom application). Acute and chronic risks were predicted for fish within 25 ft of the application area (at maximum application rates). Risks were also predicted for aquatic invertebrates 25 ft from application with a low boom and 100 ft from application with a high boom. No risks were predicted to piscivorous birds.

- Surface Runoff – No risks to typical non-target terrestrial plants were predicted; risks to RTE terrestrial plants were predicted in watersheds with clay soils or clay loam soils and annual precipitation of at least 50 inches and in watersheds with loam soils and annual precipitation of at least 200 inches. Risks to aquatic species were not predicted for watersheds with very little precipitation (less than 5 inches per year). However, risks to aquatic plants and to pond-dwelling fish and aquatic invertebrates occur under most other modeled scenarios. In addition, acute risks to fish in the stream were predicted in several watersheds with at least 25 inches of rain per year (mostly at the maximum application rate), and acute risks to aquatic invertebrates were predicted at the typical and maximum application rates in watersheds with at least 10 inches of precipitation per year (effects were less likely in watersheds with loam soils). No chronic risk to fish or aquatic invertebrates were predicted in the stream, and no risks were predicted for piscivorous birds.

- Wind Erosion and Transport Off-Site – No risks were predicted for non-target terrestrial plants under any of the evaluated conditions.

- Accidental Spill to Pond – Risk to fish, aquatic invertebrates, and non-target aquatic plants occurs when herbicides are spilled directly into the pond.

In addition, species that depend on non-target species for habitat, cover, and/or food (e.g., RTE salmonids) may be indirectly impacted by possible reductions in terrestrial or aquatic vegetation or effects on terrestrial and aquatic wildlife, particularly in accidental direct spray and spill scenarios.

Based on the results of the ERA, it is unlikely RTE species would be harmed by *appropriate* use (see following section) of the herbicide diuron on BLM-managed lands. Adherence to certain application guidelines (e.g., defined application rates, equipment, herbicide mixture, downwind distance to potentially sensitive habitat, avoidance of critical habitat) can minimize the potential effects on non-target species from regular application.

8.1 Recommendations

The following recommendations are designed to reduce potential unintended impacts to the environment from the application of diuron:

- Select herbicide products carefully to minimize additional impacts from adjuvants and tank mixtures. This is especially important for application scenarios that already predict potential risk from the a.i..
- Review, understand, and conform to "Environmental Hazards" section on herbicide label. This section warns of known pesticide risks to wildlife receptors or to the environment and provides practical ways to avoid harm to organisms or the environment.
- Avoid accidental direct spray and spill conditions to reduce the most significant potential impacts.
- Use the typical application rate to reduce risk for off-site drift and surface runoff exposures.
- Establish the following buffer zones during ground applications (using the typical application rates) to reduce impacts to aquatic areas due to off-site drift.
  - Application by low boom (spray boom height set at 20 inches above the ground) – more than 100 ft from pond or stream (no risk was predicted at 900 ft).
  - Application by high boom (spray boom height set at 50 inches above the ground) – more than 100 ft from stream (no risk was predicted at 900 ft).
  - Application by high boom – more than 1,000 ft from pond (chronic risk to aquatic plants is still predicted at 900 ft; simple regression analysis predicts an RQ of 1 for aquatic plants with a buffer zone of just over 1,000 ft at the maximum application rate).
- Limit the use of diuron in terrestrial habitats if potential impacts to RTE species are of concern.
- For all ground applications of diuron, a buffer zone of more than 1,000 ft from non-target terrestrial species is necessary to limit impacts to RTE terrestrial plants (risk to RTE plants is still predicted at 900 ft; simple regression analysis predicts an RQ of 1 for RTE plants with a buffer zone of just over 1,000 ft at the maximum application rate).
  - If no RTE species are present, terrestrial plants are protected by a buffer zone of 100 ft at the typical application rate and approximately 500 ft at the maximum rate (based on regression evaluation). Less risk is predicted from the use of a low boom for ground application at the typical application rate, and risk may be reduced if diuron is applied on foot or horseback with backpack sprayers.
- Application of diuron should be carefully limited to days without predicted winds.
- Limit the use of diuron in watersheds with downgradient ponds or streams (especially at the maximum application rate) if potential impacts to aquatic species are of concern (less risk predicted in streams than ponds). Carefully evaluate watershed characteristics when RTE salmonids are present in streams (low risk is only found with larger buffer zones in watersheds with low annual precipitation and in some watersheds with loam soils).

The results from this ERA assist the evaluation of proposed alternatives in the EIS and contribute to the development of a BA, specifically addressing the potential impacts to proposed and listed RTE species on western BLM treatment lands. Furthermore, this ERA will inform BLM field offices on the proper application of diuron to ensure that impacts to plants and animals and their habitat are minimized to the extent practical.

TABLE 8-1
Typical Risk Level Resulting from Diuron Application

	Direct Spray/Spill		Off-Site Drift		Surface Runoff		Wind Erosion	
	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate
Terrestrial Animals	0	0	NA	NA	NA	NA	NA	NA
	[12: 16]	[6: 16]						
Terrestrial Plants (Typical Species)	M	H	0	L	0	0	0	0
	[1: 1]	[1: 1]	[5: 6]	[4: 6]	[42: 42]	[42: 42]	[9: 9]	[9: 9]
Terrestrial Plants (RTE Species)	H	H	M	H	0	0	0	0
	[1: 1]	[1: 1]	[3: 6]	[3: 6]	[38: 42]	[34: 42]	[9: 9]	[9: 9]
Fish In The Pond	M	H	0	0	L	L	NA	NA
	[2: 2]	[1: 2]	[12: 12]	[11: 12]	[60: 84]	[48: 84]		
Fish In The Stream	H	H	0	0	0	0	NA	NA
	[1: 1]	[1: 1]	[12: 12]	[9: 12]	[81: 84]	[68: 84]		
Aquatic Invertebrates In The Pond	M	H	0	0	0	L	NA	NA
	[2: 2]	[1: 2]	[12: 12]	[9: 12]	[38: 84]	[34: 84]		
Aquatic Invertebrates In The Stream	H	H	0	0	0	0	NA	NA
	[1: 1]	[1: 1]	[11: 12]	[8: 12]	[66: 84]	[49: 84]		
Aquatic Plants In The Pond	H	H	L	M	M	H	NA	NA
	[2: 2]	[2: 2]	[8: 12]	[6: 12]	[50: 84]	[64: 84]		
Aquatic Plants In The Stream	H	H	L	M	L	L	NA	NA
	[1: 1]	[1: 1]	[6: 12]	[6: 12]	[35: 84]	[39: 84]		
Piscivorous Bird	NA	NA	0	0	0	0	NA	NA
			[6: 6]	[6: 6]	[42: 42]	[42: 42]		

Risk Levels:
0 = No Potential for Risk (majority of RQs < most conservative LOC).
L = Low Potential for Risk (majority of RQs 1-10 times the most conservative LOC).
M = Moderate Potential for Risk (majority of RQs 10-100 times the most conservative LOC).
H = High Potential for Risk (majority of RQs >100 times the most conservative LOC).
The reported Risk Level is based on the risk level of the majority of the RQs for each exposure scenario within each of the above receptor groups and exposure categories (i.e., direct spray/spill, off-site drift, surface runoff, wind erosion). As a result, risk may be higher than the reported risk category for some scenarios within each category. The reader should consult the risk tables in Section 4 to determine the specific scenarios that result in the displayed level of risk for a given receptor group.
Number in brackets represents Number of RQs in the Indicated Risk Level: Number of Scenarios Evaluated.
NA = Not applicable. No RQs calculated for this scenario.
In cases of a tie, the more conservative (higher) risk level was selected.

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