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Diflufenzopyr Ecological Risk Assessment, Final Report

Bureau of Land Management

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Bureau of Land Management

Reno, Nevada

Diflufenzopyr
Ecological Risk Assessment

Final Report

November 2005

Bureau of Land Management Contract No. NAD010156
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Executive Summary

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 acres of public lands annually in 17 western states in the continental United States (U.S.) 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 U.S. 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 diflufenzopyr, 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

Diflufenzopyr, typically used together with dicamba, is a selective systematic herbicide used for the control of annual broad-leaf weeds post-emergence, the suppression or control of many perennial broad-leaf weeds, and the suppression of annual grasses. This chemical inhibits the transport of hormones (auxin) that regulate plant growth and development. Diflufenzopyr is a dry flowable that is mixed with water.

Diflufenzopyr is used by the BLM for vegetation control in their Energy and Mineral Sites, Rights-of-Way, and Recreation & Cultural Sites programs. Ground applications are executed on foot using backpack sprayers and from all terrain vehicles or trucks equipped with spot or boom/broadcast sprayers under the all three programs. The Recreation & Cultural Sites programs also use horseback dispersion. The BLM typically applies diflufenzopyr (without dicamba) at 0.075 pounds (lbs) a.i. per acre (a.i./ac), with a maximum rate of 0.1 lbs a.i./ac.

Ecological Risk Assessment Guidelines

The main objectives of this ERA were to evaluate the potential ecological risks from diflufenzopyr 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 lands.

- Exposure pathway evaluation – The effects of diflufenzopyr 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.
  - Groundwater Loading Effects of Agricultural Management Systems (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 conceptual model – The purpose of the conceptual model is to display working hypotheses about how diflufenzopyr might pose hazards to ecosystems and ecological receptors. This is shown via a diagram of the possible exposure pathways and the receptors for each exposure pathway.

In the analysis phase of the ERA, estimated exposure concentrations (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 lands, the use of mixtures of diflufenzopyr 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

The toxicity of diflufenzopyr is dependent upon the product tested: technical grade diflufenzopyr, manufacturing use formulation (about 93% diflufenzopyr), or the end use product—Overdrive® herbicide (a mixture of diflufenzopyr and dicamba herbicides). Toxicity data based on studies with the Overdrive® herbicide product are included in this section, but were not used to derive TRVs for diflufenzopyr.

According to the Ecological Incident Information System (EIIS) database run by the USEPA OPP, diflufenzopyr has been associated with 1 reported "ecological incident," involving damage to corn plants. The incident report indicated that because there was a variety of pesticides applied, it is possible that all played a role in the observed crop damage.

A review of the available ecotoxicological literature was conducted in order to evaluate the potential for diflufenzopyr 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 diflufenzopyr alone poses little to no acute toxicity hazard to mammals via dermal and oral exposure, while Overdrive® herbicide poses a slight toxicity hazard to mammals. Adverse effects to small mammals have been documented from long-term dietary exposure to technical grade diflufenzopyr. Diflufenzopyr is practically non-toxic to birds and causes slight toxicity to honeybees (*Apis* spp). However, adverse effects to non-target terrestrial plant species have occurred at concentrations as low as 0.0008 lbs a.i./ac. Diflufenzopyr is moderately toxic to fish and aquatic invertebrates. Diflufenzopyr is also toxic to aquatic macrophytes, with the typical herbicide formulation (containing both diflufenzopyr and dicamba) being more toxic than diflufenzopyr alone. Aquatic macrophytes are adversely affected by diflufenzopyr and its various formulations at concentrations as low as 0.00029 parts per million (ppm). There do not appear to be appreciable differences in sensitivities among aquatic macrophytes, diatoms, and algae. No toxicity studies conducted on amphibian species were found in the literature reviewed.

Ecological Risk Assessment Results

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

- Direct Spray – Risk to non-target terrestrial and aquatic plants may occur when plants or waterbodies are accidentally sprayed. No risks were predicted for terrestrial wildlife, fish, or aquatic invertebrates.
- Off-Site Drift – Risk to typical non-target terrestrial plants may occur when herbicides are applied with a buffer zone of 25 feet (ft) or less, and risk to RTE terrestrial plant species may occur within 100 ft of the application area. No risks were predicted for aquatic plants, fish, aquatic invertebrates, or piscivorous birds.
- Surface Runoff – Risk to RTE terrestrial plant species may occur in selected watersheds (primarily with clay soils and at least 25 inches of precipitation per year). No risks were predicted for typical terrestrial plant species, aquatic plants, fish, invertebrates, or 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 aquatic plants may occur when herbicides are spilled directly into the pond; no risks were predicted for fish or aquatic invertebrates.

In addition, species that depend on non-target plant species for habitat, cover, and/or food may be indirectly impacted by a possible reduction in terrestrial or aquatic vegetation. For example, accidental direct spray, off-site drift, and surface runoff may negatively impact terrestrial plants in riparian zones, reducing the cover available to RTE salmonids within the stream.

Based on the results of the ERA, it is unlikely RTE species would be harmed by appropriate use (see following section) of the herbicide diflufenzopyr on BLM lands. Although non-target terrestrial and aquatic plants have the potential to be adversely affected by application of diflufenzopyr for the control of invasive plants, adherence to certain application guidelines (e.g., defined application rates, equipment, herbicide mixture, and downwind distance to potentially sensitive habitat) would minimize the potential effects on non-target plants and associated indirect effects on species that depend on those plants for food, habitat, and cover.

Recommendations

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

- Select herbicide products carefully to minimize additional impacts from degradates, adjuvants, inert ingredients, and tank mixtures. This is especially important for application scenarios that already predict potential risk from the a.i. itself. The herbicide product Overdrive®, which contains diflufenzopyr, has been shown in some cases to be more toxic than diflufenzopyr alone.
- 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, rather than the maximum application rate, to reduce risk to non-target plants from off-site drift and surface runoff exposures.
- Because runoff to water bodies is most affected by precipitation, limit the application of diflufenzopyr during wet seasons or in high precipitation areas.
- Limit the use of diflufenzopyr within clay watersheds if annual precipitation is greater than (>) 25 inches per year and impacts to RTE terrestrial plants are a concern.
- Establish the following buffer zones during ground applications to reduce potential impacts to non-target terrestrial plants due to off-site drift:
    - Application by low boom (spray boom height set at 20 inches above the ground) at the typical application rate – 100 ft from typical or RTE terrestrial plants.
    - Application by low boom at the maximum application rate – 100 ft from typical plant species and more than 100 ft from RTE terrestrial plant species (no risk at 900 ft).
    - Application by high boom (spray boom height set at 50 inches above the ground) – 100 ft from typical and more than 100 ft from RTE terrestrial plants (no risk at 900 ft).
- Consider the proximity of potential application areas to salmonid habitat and the possible effects of herbicides on riparian vegetation. Buffer zones of 100 ft would be necessary to protect riparian vegetation and prevent any associated indirect effects on salmonids.

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 diflufenzopyr 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
°C - Degrees Celsius
CBI - Confidential Business Information
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)
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(s)
GLEAMS - Groundwater Loading Effects of Agricultural Management Systems
HHRA - Human Health Risk Assessment
HSDB - Hazardous Substances Data Bank
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
K_{oc} - Organic carbon-water partition coefficient
K_{ow} - Octanol-water partition coefficient
L - Liter(s)
lb(s) - pound(s)
LC_{50} - Concentration causing 50% mortality (Median Lethal Concentration)
LD_{50} - Dose causing 50% mortality (Median Lethal Dose)
LOAEL - Lowest Observed Adverse Effect Level
LOC(s) - Level(s) of Concern
Log - Common logarithm (base 10)
m - meters
mg - milligrams

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

mg/kg	-	milligrams per kilogram
mg/L	-	milligrams per liter
mmHg	-	millimeters of mercury
MSDS	-	Material Safety Data Sheet
MW	-	Molecular Weight
NASQAN	-	National Stream Quality Accounting Network
NMFS	-	National Marine Fisheries Service
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 Laboratory
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 acres of public lands annually in 17 western states in the continental United States (U.S.) 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 U.S. and Alaska (ENSR 2004a). As part of the EIS, several ERAs and a Human Health Risk Assessment (HHRA; ENSR 2004b) 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 a.i. 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 a.i. (sulfometuron-methyl, imazapic, diflufenzopyr, dicamba, diquat, and fluridone) because the other a.i. 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 a.i. 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 diflufenzopyr.

Updated risk assessment methods were developed for both the HHRA and ERA and are described in a separate document, *Vegetation Treatments Programmatic EIS Ecological Risk Assessment Methodology* (hereafter referred to as the "Methods Document;" ENSR 2004c). 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 U.S. 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 diflufenzopyr, 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 diflufenzopyr 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 acres 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 (Shelley 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 (Westbrook's 1998). They invade recreation areas, BLM-managed public lands, National Parks, State Parks, roadsides, stream banks, 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 diflufenzopyr 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 herbicide label as registered with the USEPA. Diflufenzopyr application rates and methods discussed in this section are based on proposed 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.

Diflufenzopyr, typically used together with dicamba, is a selective, systemic, postemergence herbicide for the management of annual, biennial, and perennial broadleaf weeds and suppression of annual grasses. The mechanism of activity associated with this herbicide is the inhibition of the movement of growth-regulating hormones, which will have an impact on the development of the targeted plant. Diflufenzopyr is formulated as a dry flowable herbicide to be mixed with water.

The BLM proposes the use of diflufenzopyr for the management of vegetation within the Rangeland, Energy and 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 will be made on foot using backpack sprayers along with horseback sprayers. Applications will also be made using ATV- or truck-mounted sprayers equipped to make spot or broadcast applications. The BLM will typically apply diflufenzopyr at 0.075 lbs a.i./ac, with a maximum application rate of 0.1 lb. a.i./ac. Details regarding expected diflufenzopyr 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, the USEPA was requested to provide all available incident reports in the EIIS that listed diflufenzopyr as a potential source of the observed ecological damage.

The USEPA EIIS contained one incident report involving diflufenzopyr. Damage to corn plants was reported after these plants were treated with a multiple pesticide mixture. The incident report indicated that because there was a variety of pesticides applied (atrazine, chlorpyrifos, dicamba, 2,4-D, and diflufenzopyr), it is possible that all played a role in the observed crop damage.

TABLE 2-1
BLM Diflufenzopyr 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	Yes	0.075	0.1
			Horseback	Yes	0.075	0.1
		ATV	Spot	Yes	0.075	0.1
			Boom/Broadcast	Yes	0.075	0.1
		Truck	Spot	Yes	0.075	0.1
			Boom/Broadcast	Yes	0.075	0.1
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 and Mineral Sites	Aerial	Plane	Fixed Wing	No		
		Helicopter	Rotary	No		
	Ground	Human	Backpack	Yes	0.075	0.1
			Horseback	Yes	0.075	0.1
		ATV	Spot	Yes	0.075	0.1
			Boom/Broadcast	Yes	0.075	0.1
		Truck	Spot	Yes	0.075	0.1
			Boom/Broadcast	Yes	0.075	0.1
Rights-of-Way	Aerial	Plane	Fixed Wing	No		
		Helicopter	Rotary	No		
	Ground	Human	Backpack	Yes	0.075	0.1
			Horseback	Yes	0.075	0.1
		ATV	Spot	Yes	0.075	0.1
			Boom/Broadcast	Yes	0.075	0.1
		Truck	Spot	Yes	0.075	0.1
			Boom/Broadcast	Yes	0.075	0.1
Recreation	Aerial	Plane	Fixed Wing	No		
		Helicopter	Rotary	No		
	Ground	Human	Backpack	Yes	0.075	0.1
			Horseback	Yes	0.075	0.1
		ATV	Spot	Yes	0.075	0.1
			Boom/Broadcast	Yes	0.075	0.1
		Truck	Spot	Yes	0.075	0.1
			Boom/Broadcast	Yes	0.075	0.1
Aquatic				No		

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. Diflufenzopyr'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 diflufenzopyr to negatively affect 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 2004c). 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 (milligrams per Liter [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 2004c).

This section reviews the available information identified for diflufenzopyr and presents the TRVs selected for this risk assessment (Table 3-1). Appendix A presents a summary of the diflufenzopyr 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., diflufenzopyr); however, some data correspond to a specific product (e.g., Overdrive®) containing the a.i. under consideration, and potentially other ingredients (e.g., other a.i. 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

The toxicity of diflufenzopyr is dependent upon the product tested: technical grade diflufenzopyr, manufacturing use formulation (about 93% diflufenzopyr), or the end use product—Distinct herbicide (a mixture of diflufenzopyr and dicamba herbicides). Toxicity data based on studies with the Distinct herbicide product are included in the discussion below, but were not used to derive TRVs for diflufenzopyr. Distinct, a corn herbicide, contains the same ratio of a.i. that is found in the herbicide Overdrive®. Overdrive® is approved for use in noncropland sites, pastures, grass hay and rangeland. However, Overdrive® cannot be used in corn and Distinct® cannot be used in pastures. A separate ERA has been prepared to address potential risk due to Overdrive®.

According to USEPA ecotoxicity classifications presented in registration materials[1],diflufenzopyr alone poses little to no acute toxicity hazard to mammals via dermal and oral exposure, while Distinct herbicide poses a slight toxicity hazard to mammals. Adverse effects to small mammals have been documented from long-term dietary exposure to technical grade diflufenzopyr. Diflufenzopyr is practically non-toxic to birds and causes slight toxicity to honeybees. However, adverse effects to non-target terrestrial plant species have occurred at concentrations as low as 0.0008 lbs a.i./ac, which is approximately 1/100 of the typical application rate.

Diflufenzopyr is moderately toxic to fish and aquatic invertebrates. No toxicity studies conducted on amphibian species were found in the literature reviewed. Diflufenzopyr is also toxic to aquatic macrophytes, with the typical herbicide formulation (containing both diflufenzopyr and dicamba) being more toxic than diflufenzopyr alone. Aquatic macrophytes are adversely affected by diflufenzopyr and its various formulations at concentrations as low as 0.00029 ppm. There do not appear to be appreciable differences in sensitivities among aquatic macrophytes, diatoms, and algae.

3.1.2 Toxicity to Terrestrial Organisms

3.1.2.1 Mammals

Based on USEPA conditional registration documents (USEPA 1999), diflufenzopyr is characterized as having low toxicity to small mammals. Supporting studies found that no adverse effects to rabbits (*Leporidae* spp.) from acute dermal exposure to a 96.4% diflufenzopyr product at 5,000 milligram (mg)/kilogram (kg) body weight (BW) (USEPA 1999). Acute oral toxicity, measured as the death of 50 percent of the test organisms (the LD_{50} value), was affected by the herbicide formulation. Technical-grade diflufenzopyr (99% a.i.) administered to rats (*Rattus* spp.) in a single oral gavage resulted in an LD_{50} value of more than 5000 mg/kg BW (USEPA 1999). When administered as the manufacturing use product (a sodium salt; 93% a.i.), the LD_{50} was 3,300 mg/kg BW in females and 4,800 mg/kg BW in males (USEPA 1999).

Subchronic reproductive toxicity was examined in small mammals. Daily doses of technical diflufenzopyr administered via gavage to rabbits during pregnancy resulted in fetal toxicity at a dose level of 300 mg/kg BW-day using a 98.1% diflufenzopyr product. This was the lowest subchronic oral LOAEL reported in the literature, independent of the herbicide formulation. In the same study in rabbits, no adverse effects were observed at 100 mg/kg BW-day (USEPA 1999).

Dietary toxicity in small mammals was evaluated in several studies. In rats, a 2-generation study evaluated dietary exposure to technical diflufenzopyr. Dietary concentrations of 2,000 ppm (equivalent to 113.1 to 175.9 mg/kg BW-day) resulted in adverse effects on BW, consumption, and seminal vesicle weights (USEPA 1999). No adverse effects were observed at concentrations of 500 ppm (equivalent to 27.3 to 42.2 mg/kg BW-day) using 98.1% technical grade diflufenzopyr. In a separate 13-week feeding trial, adverse effects (reduced weight gain) were observed in rats fed 1,000 mg/kg BW-day of technical diflufenzopyr (96.4% a.i.), while no adverse effects were observed at 75 mg/kg BW-day (USEPA 1999).

Based on these findings, the oral LD_{50} (3,300 mg./kg BW) and chronic dietary NOAEL (42.2 mg/kg BW-day) were selected as the dietary small mammal TRVs. The dermal small mammal TRV was established at >5,000 mg./kg BW.

Toxicity data for large mammals was more limited, but results were relatively comparable to those for small mammals. Chronic dietary exposure was evaluated in two studies. In a one-year feeding trial using 98% diflufenzopyr, beagle dogs (*Canis familiaris*) exhibited changes in bone marrow and liver when fed dietary concentrations of 7,500 ppm (equivalent to 299 to 301 mg/kg BW-day), but no adverse effects occurred at 750 ppm (equivalent to 26 to 28 mg/kg BW-day) (USEPA 1999). In a 13-week feeding trial, similar adverse effects to the liver

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

and bone marrow were seen in beagle dogs fed 10,000 ppm (equivalent to 403 to 423 mg/kg BW-day). No adverse effects occurred at 1,500 ppm (equivalent to 58 to 59 mg/kg BW-day) (USEPA 1999).

Since no large mammal LD_{50}s were identified in the available literature, the small mammal LD_{50} was used as a surrogate value. The large mammal dietary NOAEL TRV was established at 59 mg/kg BW-day.

3.1.2.2 Birds

Data from the available literature indicate that diflufenzopyr has low toxicity to birds. In a 14-day oral exposure, no adverse effects were observed at 2,250 mg/kg BW-day following daily oral administration of diflufenzopyr to bobwhite quail (*Colinus virginianus*) (USEPA 2003, MRID 44170132). Birds exposed to acute dietary concentrations of diflufenzopyr (containing 94.7% a.i.) for 8 days experienced no adverse effects, even at the highest dietary concentration tested, 5,620 ppm (equivalent to acute LD_{50} doses of >3,394 and >562 mg/kg BW-day for bobwhite quail and mallards [*Anas platyrhynchos*], respectively) (USEPA 2003, MRID 44170131). In this dietary test, the test organisms were 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. For this ERA, the concentration based value was converted to a dose-based value following the methodology presented in the Methods Document (ENSR 2004c). 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 >16,970 mg/kg BW and >2,810 mg/kg BW for the bobwhite quail and mallard, respectively.

Long-term exposure to 94.3% diflufenzopyr also failed to elicit adverse effects in birds. After 21 weeks, no adverse effects were observed in mallards fed 1,050 ppm, equivalent to a dose of 105 mg/kg BW-day (USEPA 2003, MRID 45310903). In bobwhite quail, dietary exposure for 20 weeks failed to cause adverse effects at dietary concentrations of 1,050 ppm, equivalent to a dose level of 634 mg/kg BW-day (USEPA 2003, MRID 45310902).

The diflufenzopyr acute small bird dietary LD_{50} was set at >16,970 mg./kg BW based on the bobwhite quail and the acute large bird dietary LD_{50} TRV was set at >2,810 mg/kg BW. The diflufenzopyr chronic small bird dietary NOAEL was set at 634 mg/kg BW-day, based on the bobwhite quail, and the large bird NOAEL was set at 105 mg/kg BW-day, based on the mallard.

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 diflufenzopyr was directly applied to the bee's thorax and mortality was assessed during a 48-hr period. The USEPA reports an LD_{50} value of more than 25 micrograms (μg)/bee for 99.5% diflufenzopyr (USEPA 2003, MRID 44307428). The no adverse effect level was 25 μg/bee.

Since a suitable LD_{50} could not be determined from the literature, the NOAEL was multiplied by an uncertainty factor of 3. The resulting honeybee dermal LD_{50} TRV was calculated to be 75 μg/bee. Based on a honeybee weight of 0.093 g, this TRV was expressed as 806 mg/kg BW.

Acute toxicity tests with earthworms reported 50 percent mortality (LC_{50}) at diflufenzopyr concentrations > 1000 mg a.i./kg soil and a no effect concentration of 50 mg a.i./kg soil (Health Canada 1999).

3.1.2.4 Terrestrial Plants

Toxicity tests were conducted on numerous, non-target plant species (plants tested were vegetable crop species—data were not available for western rangeland or forest species). While no studies evaluating germination were found in the available literature, the majority of the remaining tests evaluated seed emergence. Seed emergence studies were conducted by applying the herbicide to soil containing newly sown seed. 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.

In a 14-day study, emergence was adversely affected (25 percent of the seeds affected—Effect Concentration [EC_{25}]) in seeds exposed to concentrations as low as 0.0008 lb a.i./ac of diflufenzopyr (USEPA 1999). Turnips (*Brassica rapa*) were the most sensitive dicot tested (EC_{25} = 0.0008 lb a.i./ac), while ryegrass (*Lolium* spp.) was the most sensitive monocot (EC_{25} = 0.0055 lb a.i./ac) (USEPA 1999). No adverse effect concentrations for seed emergence ranged from 0.0001 to 0.028 lb a.i./ac of diflufenzopyr (USEPA 2003, MRID 44307421).

The lowest and highest germination-based NOAELs were selected to evaluate risk in surface runoff scenarios of the risk assessment. Emergence endpoints were used when germination data was unavailable (TRVs = 0.028 and 0.0001 lb a.i./ac). Two additional endpoints were used to evaluate other plant scenarios: an EC_{25} of 0.0008 lb a.i./ac and a NOAEL of 0.0003 lb a.i./ac (extrapolated from the EC_{25} by dividing by an uncertainty factor of 3).

3.1.3 Toxicity to Aquatic Organisms

3.1.3.1 Fish

The toxicity of diflufenzopyr to freshwater fish was evaluated by testing both cold- and warmwater fish species. A rainbow trout (*Oncorrhynchus mykiss* [coldwater species]) study with 94.7% diflufenzopyr resulted in a 96-hour LC_{50} of 106 mg/L, with no adverse effects occurring at 80 mg/L (USEPA 2003; MRID 44170134). Acute toxicity tests were also conducted in bluegill sunfish (*Lepomis macrochirus*), a warmwater fish species. In this study, the 96-hr LC_{50} was determined to be > 135 mg /L, with a no adverse effect concentration of 16 mg/L using 97.4% diflufenzopyr (USEPA 2003, MRID 44170133). Results from coldwater and warmwater fish species suggest that diflufenzopyr has relatively low toxicity to fish species.

The lower of the cold- and warmwater fish endpoints were selected as the TRVs for fish. Therefore the coldwater 96-hour LC_{50} of 106 mg/L was selected as the acute TRV and the warmwater fish NOAEL of 16 mg/L was used as the TRV for chronic effects.

Based on diflufenzopyr's octanol-water coefficient (K_{ow}) and regression equations, the bioconcentration factor (BCF) for diflufenzopyr is 3.16, indicating that diflufenzopyr would not appreciably bioconcentrate in fish tissue (HSDB 2003).

3.1.3.2 Amphibians

No toxicity studies for amphibians were found in the published literature or in USEPA registration documents.

3.1.3.3 Aquatic Invertebrates

Freshwater invertebrate toxicity tests are required for the USEPA pesticide registration process. Two acute toxicity tests using water fleas (e.g., *Daphnia magna*) were found in the literature. In these acute studies, the statistical endpoint (the Median Effective Concentration [EC_{50}]) is the concentration that immobilizes 50 percent of the test organisms after 48 hours. The lowest EC_{50} reported from these studies was 15 mg/L using a 94.7% diflufenzopyr product. In this same study, the no adverse effect concentration was 9.7 mg/L (USEPA 2003, MRID 44170135).

No chronic toxicity studies on freshwater aquatic invertebrates were found in the available literature.

The EC_{50} (15 mg/L) and NOAEL (9.7 mg/L) were selected as the invertebrate TRVs.

3.1.3.4 Aquatic Plants

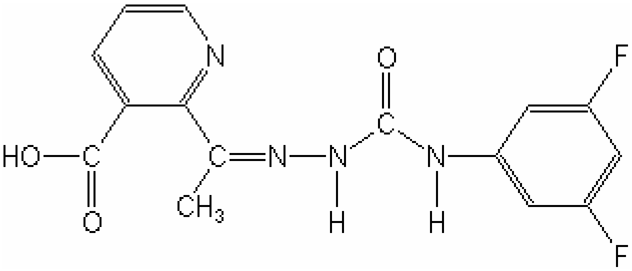
Standard toxicity tests were conducted on aquatic plants, including aquatic macrophytes, freshwater diatoms, and algae. In 14-day studies with duckweed (*Lemna* spp.), the EC_{50} for duckweed exposed to technical diflufenzopyr was > 0.35 mg a.i./L using a 99.5% diflufenzopyr product (USEPA 2003; MRID 44307422) . The lowest EC_{50} reported for aquatic plants was a value of 0.1 mg/L for green algae exposed diflufenzopyr sodium (99.5% a.i.; USEPA 2003, MRID 44307425). No adverse effect concentrations for aquatic plants ranged up to 0.0078 mg/L (diflufenzopyr-sodium; 99.5% diflufenzopyr) (USEPA 2003, and MRID 44307425).

Based on the available literature, there did not appear to be appreciable differences in sensitivities among aquatic macrophytes, diatoms, and algae.

The green algae EC_{50} *(0.1 mg./L) and NOAEL (0.0078 mg/L) were selected as the aquatic plant TRVs.*

3.2 Herbicide Physical-chemical Properties

The chemical formula for diflufenzopyr is 2-{1-[4-(3,5-difluorophyenyl)semicarbazono]ethyl}nicotinic acid. The chemical structure of diflufenzopyr is shown below:



Diflufenzopyr Chemical Structure

Diflufenzopyr is an acid; thus, it will exist as a neutral compound only at low pH values ($pK_a = 3.18$) (HSDB 2002). At pH values > 3.18, more than half the diflufenzopyr molecules will exist as deprotonated anions.

The physical/chemical properties and degradation rates critical to diflufenzopyr'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 the herbicide 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. These sources included:

- The British Crop Protection Council and The Royal Society of Chemistry. 1994. The Pesticide Manual Incorporating the Agrochemicals Handbook. Tenth Edition. Surrey and Cambridge, United Kingdom.
- 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.
- 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.
- Hazardous Substances Data Bank (HSDB). 2002. 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. P. Howard (ed.). Springer-Verlag, New York.
- 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.

Information was also obtained from the BASF label for Distinct (BASF 1999). 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 diflufenzopyr in aquatic systems. Values for foliar half-life and foliar washoff fraction were obtained from a database included in the GLEAMS computer model (U.S. 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, presented at the end of this section.

3.3 Herbicide Environmental Fate

Biodegradation, photolysis, and hydrolysis are important mechanisms in removing diflufenzopyr from soils. Soil biodegradation and photodegradation half-lives are reported to be 14 days or less (USEPA 1999). Hydrolysis may also occur in moist soils. 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 the affinity for organic carbon, an important constituent of soil particles. Therefore, the higher the K_{oc}, the less mobile the chemical. K_{oc} values reported for diflufenzopyr range from 18 to 156 indicating that diflufenzopyr, under a variety of conditions, could have very high to medium mobility in soils. Based on its vapor pressure and its Henry's Law constant [(the ratio of the chemical's distribution at equilibrium between the gas and liquid phases)], volatilization from wet or dry soil surfaces should not represent an important loss pathway (Lyman et al. 1990; HSDB 2002). The field half-life for diflufenzopyr has been reported as 4 days (USEPA 1999).

Biodegradation, photolysis, and hydrolysis are also important mechanisms in removing diflufenzopyr from aquatic systems. Half-lives for hydrolysis, photolysis, and aerobic and anaerobic aquatic biodegradation are all less than one month (USEPA 1999), and hydrolysis and photolysis rates increase in acidic environments (USEPA 1999). Based on the Henry's Law constant, volatilization from aquatic systems should not represent an important loss pathway (Lyman et al. 1990; HSDB 2002). Based on an estimated bioaccumulation factor (BCF) of 3.16, diflufenzopyr has little tendency to bioconcentrate in aquatic organisms (Franke et al. 1994). The aquatic dissipation half-life for diflufenzopyr has been reported as 25-26 days (aerobic) and 20 days (anaerobic) (USEPA 1999).

TABLE 3-1
Selected Toxicity Reference Values for Diflufenzopyr

Receptor	Selected TRV	Units	Duration	Endpoint	Species	Notes
RECEPTORS INCLUDED IN FOOD WEB MODEL						
Terrestrial Animals						
Honeybee	75	µg/bee	48 h	LD_{50}		extrapolated from NOAEL;.99.4% a.i. product
Large Bird	> 2810	mg/kg bw	8 d	LD_{50}	mallard	94.7% a.i. product
Large Bird	105	mg/kg bw-day	21 w	NOAEL	mallard	94.3% a.i. product
Piscivorous Bird	105	mg/kg bw-day	21 w	NOAEL	mallard	94.3% a.i. product
Small Bird	> 16970	mg/kg bw	8 d	LD_{50}	bobwhite quail	94.7% a.i. product
Small Bird	634	mg/kg bw-day	20 w	NOAEL	bobwhite quail	94.3% a.i. product
Small Mammal	42.2	mg/kg bw-day	2 generation	NOAEL	rat	93% a.i. product
Small Mammal - dermal	> 5000	mg/kg bw	NR	LD_{50}	rabbit	96.4% a.i. product
Small Mammal - ingestion	3300	mg/kg bw	NR	LD_{50}	rat	water exposure; no diet available; 98.1% a.i. product
Large Mammal	3300	mg/kg bw	NR	LD_{50}	rat	small mammal value
Large Mammal	59	mg/kg bw-day	1 y	NOAEL	dog	no % a.i. listed
Terrestrial Plants						
Typical Species – direct spray,drift,dust	0.0008	lb a.i./ac	14 d	EC_{25}	turnip	based on emergence
RTE Species – direct spray,drift,dust	0.0003	lb a.i./ac	14 d	NOAEL	turnip	extrapolated from EC_{25}
Typical Species – runoff	0.028	lb a.i./ac	14 d	NOAEL	tomato	no germination data; based on emergence
RTE Species – runoff	0.0001	lb a.i./ac	NR	NOAEL	turnip	no germination data; based on emergence
Aquatic Species						
Aquatic Invertebrates	15	mg/L	48 h	EC_{50}	water flea	94.7% a.i. product
Fish	106	mg/L	96 h	LC_{50}	rainbow trout	97.4% a.i. product
Aquatic Plants & Algae	0.1	mg/L	5 d	EC_{50}	green algae	99.5% a.i. product
Aquatic Invertebrates	9.7	mg/L	48 h	NOAEL	water flea	94.7% a.i. product
Fish	16	mg/L	96 h	NOAEL	bluegill sunfish	97.4% a.i. product
Aquatic Plants & Algae	0.0078	mg/L	5 d	NOAEL	green algae	99.5% a.i. product

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

Receptor	Selected TRV	Units	Duration	Endpoint	Species	Notes
ADDITIONAL ENDPOINTS						
Amphibian	no data					
Amphibian	no data					
Warmwater Fish	> 135	mg/L	96 h	LC_{50}	bluegill sunfish	97.4% a.i. product
Warmwater Fish	16	mg/L	96 h	NOAEL	bluegill sunfish	97.4% a.i. product
Coldwater Fish	106	mg/L	96 h	LC_{50}	rainbow trout	97.4% a.i. product
Coldwater Fish	80	mg/L	96 h	NOAEL	rainbow trout	97.4% a.i. product

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 & coldwater values

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
Units represent those presented in the reviewed study

TABLE 3-2
Physical-Chemical Properties of Diflufenzopyr

Parameter	Value
Herbicide family	Urea herbicide (Compendium of Pesticide Common Names 2003)
Mode of action	Auxin transport inhibitor (USEPA 1999)
Chemical Abstract Service number	109293-97-2 (parent acid), 109293-98-3 (sodium salt) (Compendium of Pesticide Common Names 2003)
Office of Pesticide Programs chemical code	005108 (DPR 2003)
Chemical name (International Union of Pure and Applied Chemistry [IUPAC])	2-{1-[4-(3,5-difluorophyenyl)semicarbazono]ethyl}nicotinic acid (Compendium of Pesticide Common Names 2003)
Empirical formula	$C_{15}H_{12}F_2N_4O_3$ (parent acid), $C_{15}H_{11}F_2N_4O_3Na$ (sodium salt) (Compendium of Pesticide Common Names 2003)
Molecular weight (MW)	**334.3** (parent acid), 356.3 (sodium salt) (HSDB 2002)
Appearance, ambient conditions	Off-white powder (USEPA 1999)
Acid / Base properties	3.18 (pKa) (HSDB 2002)
Vapor pressure (millimeters of mercury [mmHg] at 25ºC)	7.5×10^{-7} (20ºC and 25ºC) (USEPA 1999); $< 7.5 \times 10^{-8}$ (20ºC) (HSDB 2002)
Water solubility (mg/L at 25ºC)	63 (pH 5), **5850 (pH 7)**, 10,546 (pH 9) (USEPA 1999)
Octanol-water partition coefficient (K_{ow}), unitless	1.09 (average K_{ow}, pH dependent)(1) (USEPA 1999)
Henry's Law constant (atm-m^3/mole)	5.24×10^{-10} (calculated from vapor pressure and water solubility) (HSDB 2002)
Soil / Organic matter sorption coefficient (Kd / K_{oc})(2)	18 to 156 (K_{oc}) (USEPA 1999)
Bioconcentration factor (BCF)	**3.16** - Calculated from Log K_{ow} (HSDB 2002)
Field dissipation half-life	4 days (USEPA 1999)
Soil dissipation half-life(3)	4.5 days (average soil dissipation half-life) (HSDB 2002)
Aquatic dissipation half-life	not available
Hydrolysis half-life	13 days (pH 5), 24 days (pH 7), and 26 days (pH 9) (USEPA 1999)
Photodegradation half-life in water	7 days (pH 5), 17 days (pH 7), and 13 days (pH 9) (USEPA 1999)
Photodegradation half-life in soil	14 days (USEPA 1999)
Soil biodegradation half-life(4)	8-10 days aerobic soil metabolism) (USEPA 1999)
Aquatic biodegradation half-life	25-26 days (aerobic aquatic metabolism half-life), 20 days (anaerobic aquatic metabolism half-life) (USEPA 1999)
Foliar half-life	not available(5)
Foliar wash-off fraction	not available(6)
Half-life in pond (7)	**24 days** (estimated from herbicide's environmental behavior and values in this table)
Residue Rate for grass (8)	**197 ppm** (maximum) and **36 ppm** (typical) per lb a.i./ac
Residue Rate for vegetation (9)	**296 ppm** (maximum) and **35 ppm** (typical)
Residue Rate for insects (10)	**350 ppm** (maximum) and **45 ppm** (typical)
Residue Rate for berries (11)	**40.7 ppm** (maximum) and **5.4 ppm** (typical)

TABLE 3-3
Physical-Chemical Properties of Diflufenzopyr

Notes:

Values presented in bold were used in risk assessment calculations.

[1] HSDB (2002) lists Log K_{ow} = 1.09 while USEPA (1999) lists K_{ow} = 1.09.

[2] A K_{oc} value of **87** was used in risk assessment calculations. This value represents the average of the multiple K_{oc} values presented in USEPA (1999).

[3] 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.TABLE 3-2 (Cont.)

[4] A soil half-life value of **9 days** was used in risk assessment calculations. This value represents the average of aerobic soil biodegradation half-lives reported in USEPA (1999).

[5] Value for soil photodegradation half-life, **14 days**, used as a conservative estimate of foliar half-life in risk assessment calculations.

[6] A value of **1** was used as a conservative estimate of the foliar washoff fraction in risk assessment calculations.

[7] A Half-life in pond value of 24 days was used in risk assessments to calculate aqueous herbicide concentration in pond water that receives herbicide laden runoff.

[8] Residue rates selected are the high and mean values for long grass. Fletcher et al. (1994).

[9] Residue rates selected are the high and mean values for leaves and leafy crops. Fletcher et al. (1994).

[10] Residue rates selected are the high and mean values for forage such as legumes. Fletcher et al. (1994).

[11] 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 diflufenzopyr. The general approach and analytical methods for conducting the diflufenzopyr ERA were based on the 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 2004c) 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 diflufenzopyr 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 conceptual model.

4.1.1 Definition of Risk Assessment Objectives

The primary objective of this ERA was to evaluate the potential ecological risks from diflufenzopyr 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, diflufenzopyr is proposed for use by the BLM for vegetation management in their Energy and 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. Diflufenzopyr is a terrestrial herbicide; therefore, as discussed in detail in the Methods Document (ENSR 2004c), 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 acre pond of 1 meter [m] depth, resulting in a volume of 1,011,715 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 meters 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 (e.g., water concentrations from direct aerial spray), but others required more complex computer models (e.g., aerial deposition rates, 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 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 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 diflufenzopyr. The selection process is discussed in detail in Methods Document (ENSR 2004c), and the selected endpoints are presented below.

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

- **Measures of Effect** included median lethal effect concentrations (e.g., LD_{50} and LC_{50}) from acute toxicity tests on target organisms or suitable surrogates.

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

- **Measures of Effect** included median lethal effect 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).

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. 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. With the exception of non-target plants, standard acute and chronic toxicity test endpoints were used for estimates of direct herbicide effects on RTE species. To add conservatism to the RTE assessment, levels of concern for RTE species were lower than for typical species. Lowest available germination NOAELs were used to evaluate non-target RTE plants. Impacts to RTE species are discussed in more detail in Section 6.0.

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 diflufenzopyr 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 (http://www.epa.gov/oppfead1/endanger/effects).

4.1.6 Development of the Conceptual Model

The diflufenzopyr conceptual model (Figure 4-1) is presented as a series of working hypotheses about how diflufenzopyr 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 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 diflufenzopyr: 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 turnip and tomato (*Lycopersicon esculentum*) were the surrogate species chosen to represent typical terrestrial plants, and the turnip was used as the surrogate for RTE terrestrial plants (toxicity data are only available for vegetable crop species). According to the USEPA Fact Sheet for diflufenzopyr (USEPA 1999), turnips were the most sensitive dicot, so the use of turnip as a surrogate represents a very sensitive receptor. It is possible that rangeland and noncropland plants and grasses are not as sensitive to diflufenzopyr as the selected 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 and bluegill sunfish were surrogates for fish, the water flea was a surrogate for aquatic invertebrates, and non-target aquatic plants and algae were represented by duckweed.

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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/).

Section 3.0 of the Methods Document (ENSR 2004c) presents the details of the exposure scenarios considered in the risk assessments. The following subsections describe the scenarios that were evaluated for diflufenzopyr:

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:

Exposure Scenarios Within the Application Area

- 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

Exposure Scenarios Outside the Application Area

- 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 diflufenzopyr; diflufenzopyr 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-target 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. 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 feet. 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.

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.

- 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 acre, 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 diflufenzopyr. 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 diflufenzopyr.

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 LOCs 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, 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 was 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 90th or 10th percentile) were not discarded in this ERA; all RQ data presented in these plots were included in the risk assessment.

4.3.1 Accidental 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 (accidental 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

RQs for terrestrial wildlife (Figure 4-3) were all below the most conservative LOC of 0.1 (acute endangered species), indicating that direct spray impacts are not likely to pose a risk to terrestrial animals.

4.3.1.2 Non-target Plants – Terrestrial and Aquatic

RQs for non-target terrestrial plants (Figure 4-4) ranged from 93.8 to 333, and RQs for non-target aquatic plants (Figure 4-5) ranged from 0.084 to 7.19 (Table 4-2).

As expected because of the mode of action of herbicides, all of the terrestrial plant RQs were above the plant LOC of 1, indicating that direct spray impacts may pose a risk to these receptors. Aquatic plant RQs were below the plant LOC in all acute scenarios and above the plant LOC in all chronic scenarios, indicating the potential for long-term harm to these receptors. 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 (Figures 4-6 and 4-7) were below the most conservative LOC of 0.05 (acute endangered species), and all chronic toxicity RQs for fish and aquatic invertebrates were well below the LOC for chronic risk to endangered species (0.5). These results indicate that impacts from direct spray are generally not likely to pose acute or chronic risk to these aquatic species.

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 diflufenzopyr 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

The majority of the RQs for non-target terrestrial plants (Figure 4-8) affected by off-site drift to soils were below the plant LOC of 1. However, RQs did exceed the LOC (ranging from 1.13 to 7.0; Table 4-3) for several application scenarios. Off-site drift 25 ft from ground application with a low or high boom at the typical and maximum application rates resulted in RQs above the LOC for both typical and RTE species. Additional risk was also predicted for RTE species within 100 ft of a low boom application at the typical application rate and within 100 ft of a high boom application at the typical and maximum application rates. Therefore, there is potential risk to typical terrestrial plant species from off-site drift of diflufenzopyr within 25 ft of the application, and there is risk to RTE terrestrial plant species from herbicide drift within 100 ft of the application area.

All RQs for non-target aquatic plants (Figure 4-9) affected by off-site drift were below the plant LOC of 1, indicating this transport mechanism is not likely to impact these receptors.

4.3.2.2 Fish and Aquatic Invertebrates

Acute toxicity RQs for fish and aquatic invertebrates (Figures 4-10 and 4-11) were all below the most conservative LOC of 0.05 (acute endangered species), and all chronic RQs were well below the LOC for chronic risk to endangered species (0.5). These results indicate that impacts from off-site drift are not likely to pose acute or chronic risk to these aquatic species.

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 these species.

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 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 (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; however, a couple scenarios did result in elevated RQs at the typical or maximum application rate. These scenarios were surface runoff in the base watershed with clay soils and more than 25 inches of precipitation per year (250 inches per year was the maximum precipitation modeled) and runoff in the base watershed with silt loam, silt, or clay loam soils and 50 inches of precipitation per year. This indicates the potential for risk to RTE plant species in selected watersheds at the typical and maximum application rates with > 25 inches of precipitation per year.

Acute and chronic RQs for non-target aquatic plants in the pond and stream impacted by overland flow (runoff) of diflufenzopyr (Figure 4-14) were all below the plant LOC of 1. These results indicate that this transport mechanism is not likely to pose a risk to aquatic plant species under these conditions.

4.3.3.2 Fish and Aquatic Invertebrates

Acute and chronic toxicity RQs for fish and aquatic invertebrates in ponds and streams (Figures 4-15 and 4-16) were all below the most conservative LOCs (0.05 and 0.5 = acute and chronic endangered species, respectively), indicating that impacts from surface runoff are not likely to pose a risk to these aquatic species.

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 piscivorous birds 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 centimeters per second [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. A truck spilling entire load (200 gal spill) of herbicide mixed for the maximum application rate into the 1/4 acre, 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) ranged from 0.00338 for fish and 0.0239 for aquatic invertebrates (Figures 4-6 and 4-7) to 3.59 for non-target aquatic plants (Figure 4-5). Potential risk to non-target aquatic plants was indicated for the truck spill with diflufenzopyr mixed for the maximum application rate. These scenarios are highly conservative and represent unlikely, worst-case conditions (limited waterbody volume, tank mixed for maximum application).

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 direct or indirect effects of diflufenzopyr to salmonids and their 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. Prey 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 and aquatic invertebrate species were evaluated directly in the ERA using acute and chronic TRVs based on the most sensitive warm- or coldwater species identified during the literature search. Salmonid species were included in the derivation of the TRVs. The acute fish TRV was based on a rainbow trout study. The chronic fish TRV was based on a warmwater species, the bluegill sunfish. The selected chronic TRV was more than five times higher than the rainbow trout chronic indicating that chronic direct impacts to salmonids may be overestimated in the risk assessment. No RQs in excess of the appropriate acute or chronic LOCs were observed for fish or aquatic invertebrates in any of the stream scenarios. 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. Because fish and aquatic invertebrates are not predicted to be directly impacted by herbicide concentrations in the stream, salmonids are not likely to be indirectly affected by a reduction in prey.

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. Chronic 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 over time. However, this is an extremely conservative scenario in which it is assumed that a stream is accidentally directly sprayed by a terrestrial herbicide. Because such a scenario is unlikely to occur as a result of BLM practices, it represents a worst-case scenario. In addition, stream flow would be likely to dilute herbicide concentration and reduce potential impacts, but this potential reduction of diflufenzopyr concentration is not considered in this scenario. However, if the stream were accidentally sprayed, there would be the potential for indirect impacts to salmonids caused by a reduction in available cover.

No RQs in excess of the LOC were observed for stream aquatic plant species for any of the off-site drift or surface runoff scenarios.

Although not specifically evaluated in the stream scenarios of the ERA, 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 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 event is unlikely to occur as a result of BLM practices and represents a worst-case scenario.

RQs for typical terrestrial plants were also observed above the plant LOC (ranging from 1.13 to 7.00) as a result of off-site drift. Off-site drift 25 ft from ground application with a low or high boom resulted in RQs above the LOC at the typical and maximum application rates for both typical and RTE species. Additional risk was also predicted for RTE species within 100 ft of a low boom application at the typical application rate and within 100 ft of a high boom application at the typical and maximum application rates. These results indicate the potential for a reduction in riparian cover under selected conditions.

No RQs in excess of the LOC were observed for terrestrial plant species for any of the surface runoff scenarios.

4.3.6.3 Conclusions

This qualitative evaluation indicates that salmonids are not likely to be indirectly impacted by a reduction in food supply (i.e., fish and aquatic invertebrates). However, a reduction in vegetative cover may occur under limited conditions. Accidental direct spray and off-site drift during aerial applications may negatively impact terrestrial and aquatic plants, reducing the cover available to salmonids within the stream. However, increasing the buffer zone, reducing the application rate during aerial spraying, and avoiding 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 another terrestrial herbicide 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 2003). 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 2003). Therefore, it is expected that potential adverse impacts to food and cover would not occur beyond the season of application (except for cover provided by impacted riparian plants).

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 $_{body\ weight}$ for acute scenarios and mg $_{prey}$/kg $_{body\ weight}$/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	9.76E-05	1.30E-04
Pollinating insect - 100% absorption	1.47E-02	1.97E-02
Small mammal - 1st order dermal adsorption	1.63E-06	2.17E-06
Indirect Contact With Foliage After Direct Spray		
Small mammal - 100% absorption	9.76E-06	1.30E-05
Pollinating insect - 100% absorption	1.47E-03	1.97E-03
Small mammal - 1st order dermal adsorption	1.63E-07	2.17E-07
Ingestion of Food Items Contaminated by Direct Spray		
Small mammalian herbivore - acute exposure	4.39E-05	4.41E-04
Small mammalian herbivore - chronic exposure	7.64E-04	7.68E-03
Large mammalian herbivore - acute exposure	2.81E-04	2.05E-03
Large mammalian herbivore - chronic exposure	1.40E-03	1.03E-02
Small avian insectivore - acute exposure	9.02E-05	9.35E-04
Small avian insectivore - chronic exposure	5.35E-04	5.55E-03
Large avian herbivore - acute exposure	2.29E-04	2.58E-03
Large avian herbivore - chronic exposure	1.36E-03	1.53E-02
Large mammalian carnivore - acute exposure	1.83E-04	2.44E-04
Large mammalian carnivore - chronic exposure	6.94E-05	9.25E-05

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

Terrestrial Plants	**Typical Species**		**Rare, Threatened, and Endangered Species**	
	Typical Application Rate	**Maximum Application Rate**	**Typical Application Rate**	**Maximum Application Rate**
Direct Spray of Non-Target Terrestrial Plants				
Accidental direct spray	**9.38E+01**	**1.25E+02**	**2.50E+02**	**3.33E+02**

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	7.93E-05	1.06E-04	5.60E-04	7.47E-04	8.41E-02	1.12E-01
Chronic	5.25E-04	7.01E-04	8.67E-04	1.16E-03	**1.08E+00**	**1.44E+00**
Accidental Direct Spray Over Stream						
Acute	3.97E-04	5.29E-04	2.80E-03	3.74E-03	4.20E-01	5.60E-01
Chronic	2.63E-03	3.50E-03	4.33E-03	5.78E-03	**5.39E+00**	**7.19E+00**
Accidental spill						
Truck spill into pond	--	3.38E-03	--	2.39E-02	--	**3.59E+00**

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		**RTE 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	**1.13E+00**	**1.63E+00**	**3.00E+00**	**4.33E+00**
Ground	Low Boom	100	3.75E-01	5.00E-01	1.00E+00	**1.33E+00**
Ground	Low Boom	900	6.39E-02	8.53E-02	1.70E-01	2.27E-01
Ground	High Boom	25	**2.00E+00**	**2.63E+00**	**5.33E+00**	**7.00E+00**
Ground	High Boom	100	6.25E-01	8.75E-01	**1.67E+00**	**2.33E+00**
Ground	High Boom	900	8.19E-02	1.09E-01	2.18E-01	2.91E-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	4.82E-07	6.43E-07	3.41E-06	4.55E-06	5.11E-04	6.82E-04
Ground	Low Boom	100	2.64E-07	3.53E-07	1.87E-06	2.49E-06	2.80E-04	3.74E-04
Ground	Low Boom	900	5.10E-08	6.81E-08	3.61E-07	4.81E-07	5.41E-05	7.22E-05
Ground	High Boom	25	7.75E-07	1.03E-06	5.47E-06	7.27E-06	8.21E-04	1.09E-03
Ground	High Boom	100	4.08E-07	5.44E-07	2.89E-06	3.85E-06	4.33E-04	5.77E-04
Ground	High Boom	900	6.48E-08	8.64E-08	4.58E-07	6.11E-07	6.87E-05	9.16E-05
Off-Site Drift to Pond Chronic Toxicity								
Ground	Low Boom	25	3.19E-06	4.26E-06	5.27E-06	7.03E-06	6.55E-03	8.74E-03
Ground	Low Boom	100	1.75E-06	2.34E-06	2.89E-06	3.86E-06	3.59E-03	4.79E-03
Ground	Low Boom	900	3.38E-07	4.51E-07	5.58E-07	7.44E-07	6.94E-04	9.26E-04
Ground	High Boom	25	5.13E-06	6.81E-06	8.46E-06	1.12E-05	1.05E-02	1.40E-02
Ground	High Boom	100	2.71E-06	3.61E-06	4.46E-06	5.95E-06	5.55E-03	7.40E-03
Ground	High Boom	900	4.29E-07	5.73E-07	7.08E-07	9.44E-07	8.81E-04	1.17E-03
Off-Site Drift to Stream Acute Toxicity								
Ground	Low Boom	25	8.68E-07	1.16E-06	6.13E-06	8.18E-06	9.20E-04	1.23E-03
Ground	Low Boom	100	2.54E-07	3.39E-07	1.80E-06	2.40E-06	2.69E-04	3.59E-04
Ground	Low Boom	900	2.63E-08	3.51E-08	1.86E-07	2.48E-07	2.79E-05	3.72E-05
Ground	High Boom	25	1.45E-06	1.94E-06	1.03E-05	1.37E-05	1.54E-03	2.05E-03
Ground	High Boom	100	4.12E-07	5.49E-07	2.91E-06	3.88E-06	4.36E-04	5.82E-04
Ground	High Boom	900	3.48E-08	4.64E-08	2.46E-07	3.28E-07	3.69E-05	4.92E-05

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 Chronic Toxicity								
Ground	Low Boom	25	5.75E-06	7.67E-06	9.48E-06	1.26E-05	1.18E-02	1.57E-02
Ground	Low Boom	100	1.68E-06	2.25E-06	2.78E-06	3.70E-06	3.46E-03	4.61E-03
Ground	Low Boom	900	1.74E-07	2.32E-07	2.88E-07	3.83E-07	3.58E-04	4.77E-04
Ground	High Boom	25	9.63E-06	1.28E-05	1.59E-05	2.12E-05	1.98E-02	2.63E-02
Ground	High Boom	100	2.73E-06	3.64E-06	4.50E-06	6.00E-06	5.59E-03	7.46E-03
Ground	High Boom	900	2.31E-07	3.07E-07	3.80E-07	5.07E-07	4.73E-04	6.30E-04

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	1.22E-07	1.62E-07
Ground	Low Boom	100	6.66E-08	8.90E-08
Ground	Low Boom	900	1.29E-08	1.72E-08
Ground	High Boom	25	1.95E-07	2.59E-07
Ground	High Boom	100	1.03E-07	1.37E-07
Ground	High Boom	900	1.63E-08	2.18E-08

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 scenario RQs greater than 0.1 (LOC for acute risk to endangered species - most conservative).
Shading and boldface indicates terrestrial animal chronic scenario 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	1.37E-09	1.82E-09	3.82E-07	5.10E-07
10	10	0.05	0.015	0.401	Weeds (78)	Loam	0.00E+00	0.00E+00	0.00E+00	0.00E+00
25	10	0.05	0.015	0.401	Weeds (78)	Sand	0.00E+00	0.00E+00	0.00E+00	0.00E+00
25	10	0.05	0.015	0.401	Weeds (78)	Clay	3.38E-03	4.50E-03	9.45E-01	**1.26E+00**
25	10	0.05	0.015	0.401	Weeds (78)	Loam	0.00E+00	0.00E+00	0.00E+00	0.00E+00
50	10	0.05	0.015	0.401	Weeds (78)	Sand	0.00E+00	0.00E+00	0.00E+00	0.00E+00
50	10	0.05	0.015	0.401	Weeds (78)	Clay	2.16E-02	2.88E-02	**6.05E+00**	**8.07E+00**
50	10	0.05	0.015	0.401	Weeds (78)	Loam	1.05E-03	1.40E-03	2.94E-01	3.92E-01
100	10	0.05	0.015	0.401	Weeds (78)	Sand	6.83E-10	9.10E-10	1.91E-07	2.55E-07
100	10	0.05	0.015	0.401	Weeds (78)	Clay	6.42E-02	8.56E-02	**1.80E+01**	**2.40E+01**
100	10	0.05	0.015	0.401	Weeds (78)	Loam	1.90E-03	2.53E-03	5.31E-01	7.08E-01
150	10	0.05	0.015	0.401	Weeds (78)	Sand	0.00E+00	0.00E+00	0.00E+00	0.00E+00
150	10	0.05	0.015	0.401	Weeds (78)	Clay	7.72E-02	1.03E-01	**2.16E+01**	**2.88E+01**
150	10	0.05	0.015	0.401	Weeds (78)	Loam	2.13E-03	2.85E-03	5.98E-01	7.97E-01
200	10	0.05	0.015	0.401	Weeds (78)	Sand	0.00E+00	0.00E+00	0.00E+00	0.00E+00
200	10	0.05	0.015	0.401	Weeds (78)	Clay	7.70E-02	1.03E-01	**2.16E+01**	**2.87E+01**
200	10	0.05	0.015	0.401	Weeds (78)	Loam	1.68E-03	2.25E-03	4.72E-01	6.29E-01
250	10	0.05	0.015	0.401	Weeds (78)	Sand	0.00E+00	0.00E+00	0.00E+00	0.00E+00
250	10	0.05	0.015	0.401	Weeds (78)	Clay	7.46E-02	9.95E-02	**2.09E+01**	**2.79E+01**
250	10	0.05	0.015	0.401	Weeds (78)	Loam	1.20E-03	1.60E-03	3.37E-01	4.49E-01

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										
50	1	0.05	0.015	0.401	Weeds (78)	Loam	1.03E-03	1.37E-03	2.88E-01	3.84E-01
50	100	0.05	0.015	0.401	Weeds (78)	Loam	1.03E-03	1.37E-03	2.88E-01	3.84E-01
50	1000	0.05	0.015	0.401	Weeds (78)	Loam	1.03E-03	1.37E-03	2.88E-01	3.84E-01
50	10	0.05	0.015	0.05	Weeds (78)	Loam	1.02E-03	1.37E-03	2.87E-01	3.82E-01
50	10	0.05	0.015	0.2	Weeds (78)	Loam	1.03E-03	1.38E-03	2.89E-01	3.85E-01
50	10	0.05	0.015	0.5	Weeds (78)	Loam	1.05E-03	1.39E-03	2.93E-01	3.91E-01
50	10	0.05	0.023	0.401	Weeds (78)	Loam	1.03E-03	1.37E-03	2.88E-01	3.84E-01
50	10	0.05	0.046	0.401	Weeds (78)	Loam	1.03E-03	1.37E-03	2.88E-01	3.84E-01
50	10	0.05	0.15	0.401	Weeds (78)	Loam	1.02E-03	1.36E-03	2.87E-01	3.82E-01
50	10	0.005	0.015	0.401	Weeds (78)	Loam	1.02E-03	1.36E-03	2.87E-01	3.82E-01
50	10	0.01	0.015	0.401	Weeds (78)	Loam	1.02E-03	1.37E-03	2.87E-01	3.82E-01
50	10	0.1	0.015	0.401	Weeds (78)	Loam	1.04E-03	1.39E-03	2.91E-01	3.88E-01
50	10	0.05	0.015	0.401	Weeds (78)	Silt Loam	9.27E-03	1.24E-02	**2.60E+00**	**3.46E+00**
50	10	0.05	0.015	0.401	Weeds (78)	Silt	8.41E-03	1.12E-02	**2.35E+00**	**3.14E+00**
50	10	0.05	0.015	0.401	Weeds (78)	Clay Loam	1.90E-02	2.53E-02	**5.31E+00**	**7.08E+00**
50	10	0.05	0.015	0.401	Shrubs(79)	Loam	1.03E-03	1.37E-03	2.88E-01	3.84E-01
50	10	0.05	0.015	0.401	Rye Grass(54)	Loam	1.03E-03	1.37E-03	2.88E-01	3.84E-01
50	10	0.05	0.015	0.401	Conifer + Hardwood (71)	Loam	1.35E-03	1.81E-03	3.79E-01	5.06E-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**
Surface Runoff 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	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)	Clay	1.10E-11	1.47E-11	7.77E-11	1.04E-10	1.17E-08	1.55E-08
10	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
25	10	0.05	0.015	0.401	Weeds (78)	Sand	1.87E-09	2.50E-09	1.32E-08	1.77E-08	1.99E-06	2.65E-06
25	10	0.05	0.015	0.401	Weeds (78)	Clay	2.70E-05	3.61E-05	1.91E-04	2.55E-04	2.87E-02	3.82E-02
25	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
50	10	0.05	0.015	0.401	Weeds (78)	Sand	5.32E-06	7.09E-06	3.76E-05	5.01E-05	5.64E-03	7.52E-03
50	10	0.05	0.015	0.401	Weeds (78)	Clay	1.43E-04	1.91E-04	1.01E-03	1.35E-03	1.52E-01	2.02E-01
50	10	0.05	0.015	0.401	Weeds (78)	Loam	4.48E-06	5.98E-06	3.17E-05	4.23E-05	4.75E-03	6.34E-03
100	10	0.05	0.015	0.401	Weeds (78)	Sand	5.08E-05	6.77E-05	3.59E-04	4.78E-04	5.38E-02	7.18E-02
100	10	0.05	0.015	0.401	Weeds (78)	Clay	8.72E-05	1.16E-04	6.16E-04	8.21E-04	9.24E-02	1.23E-01
100	10	0.05	0.015	0.401	Weeds (78)	Loam	1.80E-06	2.40E-06	1.27E-05	1.69E-05	1.91E-03	2.54E-03
150	10	0.05	0.015	0.401	Weeds (78)	Sand	7.08E-05	9.44E-05	5.01E-04	6.67E-04	7.51E-02	1.00E-01
150	10	0.05	0.015	0.401	Weeds (78)	Clay	3.65E-05	4.86E-05	2.58E-04	3.44E-04	3.86E-02	5.15E-02
150	10	0.05	0.015	0.401	Weeds (78)	Loam	7.70E-07	1.03E-06	5.44E-06	7.25E-06	8.16E-04	1.09E-03
200	10	0.05	0.015	0.401	Weeds (78)	Sand	7.00E-05	9.33E-05	4.94E-04	6.59E-04	7.42E-02	9.89E-02
200	10	0.05	0.015	0.401	Weeds (78)	Clay	3.40E-05	4.53E-05	2.40E-04	3.20E-04	3.60E-02	4.80E-02
200	10	0.05	0.015	0.401	Weeds (78)	Loam	8.33E-07	1.11E-06	5.89E-06	7.85E-06	8.84E-04	1.18E-03

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												
250	10	0.05	0.015	0.401	Weeds (78)	Sand	7.32E-05	9.75E-05	5.17E-04	6.89E-04	7.76E-02	1.03E-01
250	10	0.05	0.015	0.401	Weeds (78)	Clay	4.43E-05	5.90E-05	3.13E-04	4.17E-04	4.69E-02	6.26E-02
250	10	0.05	0.015	0.401	Weeds (78)	Loam	1.51E-06	2.01E-06	1.06E-05	1.42E-05	1.60E-03	2.13E-03
50	1	0.05	0.015	0.401	Weeds (78)	Loam	8.14E-07	1.08E-06	5.75E-06	7.67E-06	8.63E-04	1.15E-03
50	100	0.05	0.015	0.401	Weeds (78)	Loam	1.83E-06	2.44E-06	1.29E-05	1.72E-05	1.94E-03	2.59E-03
50	1000	0.05	0.015	0.401	Weeds (78)	Loam	1.83E-06	2.44E-06	1.29E-05	1.72E-05	1.94E-03	2.58E-03
50	10	0.05	0.015	0.05	Weeds (78)	Loam	4.37E-06	5.83E-06	3.09E-05	4.12E-05	4.63E-03	6.18E-03
50	10	0.05	0.015	0.2	Weeds (78)	Loam	4.40E-06	5.87E-06	3.11E-05	4.15E-05	4.67E-03	6.22E-03
50	10	0.05	0.015	0.5	Weeds (78)	Loam	4.46E-06	5.95E-06	3.15E-05	4.21E-05	4.73E-03	6.31E-03
50	10	0.05	0.023	0.401	Weeds (78)	Loam	4.39E-06	5.86E-06	3.10E-05	4.14E-05	4.66E-03	6.21E-03
50	10	0.05	0.046	0.401	Weeds (78)	Loam	4.39E-06	5.85E-06	3.10E-05	4.13E-05	4.65E-03	6.20E-03
50	10	0.05	0.15	0.401	Weeds (78)	Loam	4.37E-06	5.82E-06	3.09E-05	4.12E-05	4.63E-03	6.17E-03
50	10	0.005	0.015	0.401	Weeds (78)	Loam	4.37E-06	5.82E-06	3.09E-05	4.12E-05	4.63E-03	6.17E-03
50	10	0.01	0.015	0.401	Weeds (78)	Loam	4.37E-06	5.83E-06	3.09E-05	4.12E-05	4.63E-03	6.18E-03
50	10	0.1	0.015	0.401	Weeds (78)	Loam	4.44E-06	5.92E-06	3.14E-05	4.18E-05	4.70E-03	6.27E-03
50	10	0.05	0.015	0.401	Weeds (78)	Silt Loam	3.95E-05	5.27E-05	2.79E-04	3.72E-04	4.19E-02	5.58E-02
50	10	0.05	0.015	0.401	Weeds (78)	Silt	3.27E-05	4.37E-05	2.31E-04	3.09E-04	3.47E-02	4.63E-02
50	10	0.05	0.015	0.401	Weeds (78)	Clay Loam	7.29E-05	9.72E-05	5.15E-04	6.87E-04	7.73E-02	1.03E-01
50	10	0.05	0.015	0.401	Shrubs(79)	Loam	4.39E-06	5.86E-06	3.10E-05	4.14E-05	4.66E-03	6.21E-03
50	10	0.05	0.015	0.401	Rye Grass(54)	Loam	4.39E-06	5.86E-06	3.10E-05	4.14E-05	4.66E-03	6.21E-03
50	10	0.05	0.015	0.401	Conifer+ Hardwood(71)	Loam	4.56E-06	6.09E-06	3.23E-05	4.30E-05	4.84E-03	6.45E-03

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	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)	Clay	3.49E-12	4.66E-12	5.76E-12	7.68E-12	7.16E-09	9.55E-09
10	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
25	10	0.05	0.015	0.401	Weeds (78)	Sand	1.46E-09	1.94E-09	2.40E-09	3.21E-09	2.99E-06	3.99E-06
25	10	0.05	0.015	0.401	Weeds (78)	Clay	1.04E-05	1.39E-05	1.72E-05	2.29E-05	2.13E-02	2.85E-02
25	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
50	10	0.05	0.015	0.401	Weeds (78)	Sand	3.93E-06	5.23E-06	6.48E-06	8.63E-06	2.99E-06	1.07E-02
50	10	0.05	0.015	0.401	Weeds (78)	Clay	2.07E-05	2.76E-05	3.42E-05	4.56E-05	4.25E-02	5.67E-02
50	10	0.05	0.015	0.401	Weeds (78)	Loam	4.71E-07	6.28E-07	7.77E-07	1.04E-06	9.66E-04	1.29E-03
100	10	0.05	0.015	0.401	Weeds (78)	Sand	3.79E-05	5.05E-05	6.25E-05	8.34E-05	7.78E-02	1.04E-01
100	10	0.05	0.015	0.401	Weeds (78)	Clay	7.39E-06	9.85E-06	1.22E-05	1.62E-05	1.52E-02	2.02E-02
100	10	0.05	0.015	0.401	Weeds (78)	Loam	1.30E-07	1.74E-07	2.15E-07	2.86E-07	2.67E-04	3.56E-04
150	10	0.05	0.015	0.401	Weeds (78)	Sand	5.26E-05	7.02E-05	8.68E-05	1.16E-04	1.08E-01	1.44E-01
150	10	0.05	0.015	0.401	Weeds (78)	Clay	3.04E-06	4.06E-06	5.02E-06	6.70E-06	6.25E-03	8.33E-03
150	10	0.05	0.015	0.401	Weeds (78)	Loam	2.55E-07	3.40E-07	4.21E-07	5.61E-07	5.23E-04	6.98E-04
200	10	0.05	0.015	0.401	Weeds (78)	Sand	4.86E-05	6.48E-05	8.01E-05	1.07E-04	9.96E-02	1.33E-01
200	10	0.05	0.015	0.401	Weeds (78)	Clay	3.03E-06	4.05E-06	5.00E-06	6.67E-06	6.22E-03	8.30E-03
200	10	0.05	0.015	0.401	Weeds (78)	Loam	7.29E-07	9.72E-07	1.20E-06	1.60E-06	1.50E-03	1.99E-03

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												
250	10	0.05	0.015	0.401	Weeds (78)	Sand	3.87E-05	5.17E-05	6.39E-05	8.52E-05	7.95E-02	1.06E-01
250	10	0.05	0.015	0.401	Weeds (78)	Clay	4.00E-06	5.34E-06	6.60E-06	8.80E-06	8.21E-03	1.09E-02
250	10	0.05	0.015	0.401	Weeds (78)	Loam	1.32E-06	1.76E-06	2.18E-06	2.91E-06	2.71E-03	3.62E-03
50	1	0.05	0.015	0.401	Weeds (78)	Loam	4.35E-07	5.80E-07	7.17E-07	9.56E-07	8.92E-04	1.19E-03
50	100	0.05	0.015	0.401	Weeds (78)	Loam	9.95E-08	1.33E-07	1.64E-07	2.19E-07	2.04E-04	2.72E-04
50	1000	0.05	0.015	0.401	Weeds (78)	Loam	9.94E-08	1.33E-07	1.64E-07	2.19E-07	2.04E-04	2.72E-04
50	10	0.05	0.015	0.05	Weeds (78)	Loam	4.59E-07	6.12E-07	7.58E-07	1.01E-06	9.42E-04	1.26E-03
50	10	0.05	0.015	0.2	Weeds (78)	Loam	4.63E-07	6.17E-07	7.63E-07	1.02E-06	9.49E-04	1.27E-03
50	10	0.05	0.015	0.5	Weeds (78)	Loam	4.69E-07	6.25E-07	7.73E-07	1.03E-06	9.62E-04	1.28E-03
50	10	0.05	0.023	0.401	Weeds (78)	Loam	4.61E-07	6.15E-07	7.61E-07	1.01E-06	9.47E-04	1.26E-03
50	10	0.05	0.046	0.401	Weeds (78)	Loam	4.61E-07	6.15E-07	7.60E-07	1.01E-06	9.45E-04	1.26E-03
50	10	0.05	0.15	0.401	Weeds (78)	Loam	4.59E-07	6.12E-07	7.57E-07	1.01E-06	9.41E-04	1.25E-03
50	10	0.005	0.015	0.401	Weeds (78)	Loam	4.59E-07	6.12E-07	7.57E-07	1.01E-06	9.41E-04	1.26E-03
50	10	0.01	0.015	0.401	Weeds (78)	Loam	4.59E-07	6.12E-07	7.57E-07	1.01E-06	9.42E-04	1.26E-03
50	10	0.1	0.015	0.401	Weeds (78)	Loam	4.66E-07	6.22E-07	7.69E-07	1.03E-06	9.56E-04	1.28E-03
50	10	0.05	0.015	0.401	Weeds (78)	Silt Loam	4.88E-06	6.50E-06	8.04E-06	1.07E-05	1.00E-02	1.33E-02
50	10	0.05	0.015	0.401	Weeds (78)	Silt	3.75E-06	5.00E-06	6.19E-06	8.25E-06	7.69E-03	1.03E-02
50	10	0.05	0.015	0.401	Weeds (78)	Clay Loam	1.11E-05	1.48E-05	1.83E-05	2.44E-05	2.28E-02	3.04E-02
50	10	0.05	0.015	0.401	Shrubs(79)	Loam	4.61E-07	6.15E-07	7.61E-07	1.01E-06	9.47E-04	1.26E-03
50	10	0.05	0.015	0.401	Rye Grass(54)	Loam	4.61E-07	6.15E-07	7.61E-07	1.01E-06	9.47E-04	1.26E-03
50	10	0.05	0.015	0.401	Conifer + Hardwood (71)	Loam	3.83E-07	5.11E-07	6.32E-07	8.43E-07	7.86E-04	1.05E-03

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 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	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)	Clay	3.68E-13	4.91E-13	2.60E-12	3.47E-12	3.90E-10	5.20E-10
10	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
25	10	0.05	0.015	0.401	Weeds (78)	Sand	6.04E-11	8.05E-11	4.27E-10	5.69E-10	6.40E-08	8.53E-08
25	10	0.05	0.015	0.401	Weeds (78)	Clay	8.99E-07	1.20E-06	6.36E-06	8.47E-06	9.53E-04	1.27E-03
25	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
50	10	0.05	0.015	0.401	Weeds (78)	Sand	2.36E-07	3.14E-07	1.67E-06	2.22E-06	2.50E-04	3.33E-04
50	10	0.05	0.015	0.401	Weeds (78)	Clay	5.19E-06	6.92E-06	3.67E-05	4.89E-05	5.50E-03	7.34E-03
50	10	0.05	0.015	0.401	Weeds (78)	Loam	2.46E-07	3.28E-07	1.74E-06	2.32E-06	2.61E-04	3.48E-04
100	10	0.05	0.015	0.401	Weeds (78)	Sand	4.38E-06	5.84E-06	3.09E-05	4.12E-05	4.64E-03	6.19E-03
100	10	0.05	0.015	0.401	Weeds (78)	Clay	1.24E-05	1.65E-05	8.77E-05	1.17E-04	1.31E-02	1.75E-02
100	10	0.05	0.015	0.401	Weeds (78)	Loam	3.52E-07	4.69E-07	2.48E-06	3.31E-06	3.73E-04	4.97E-04
150	10	0.05	0.015	0.401	Weeds (78)	Sand	9.38E-06	1.25E-05	6.63E-05	8.84E-05	9.95E-03	1.33E-02
150	10	0.05	0.015	0.401	Weeds (78)	Clay	1.24E-05	1.65E-05	8.74E-05	1.17E-04	1.31E-02	1.75E-02
150	10	0.05	0.015	0.401	Weeds (78)	Loam	3.24E-07	4.33E-07	2.29E-06	3.06E-06	3.44E-04	4.59E-04
200	10	0.05	0.015	0.401	Weeds (78)	Sand	1.20E-05	1.60E-05	8.47E-05	1.13E-04	1.27E-02	1.69E-02
200	10	0.05	0.015	0.401	Weeds (78)	Clay	1.06E-05	1.42E-05	7.52E-05	1.00E-04	1.13E-02	1.50E-02
200	10	0.05	0.015	0.401	Weeds (78)	Loam	2.21E-07	2.94E-07	1.56E-06	2.08E-06	2.34E-04	3.12E-04

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 Acute Toxicity												
250	10	0.05	0.015	0.401	Weeds (78)	Sand	1.23E-05	1.63E-05	8.67E-05	1.16E-04	1.30E-02	1.73E-02
250	10	0.05	0.015	0.401	Weeds (78)	Clay	9.27E-06	1.24E-05	6.55E-05	8.73E-05	9.83E-03	1.31E-02
250	10	0.05	0.015	0.401	Weeds (78)	Loam	1.50E-07	2.00E-07	1.06E-06	1.41E-06	1.59E-04	2.12E-04
50	1	0.05	0.015	0.401	Weeds (78)	Loam	2.73E-08	3.64E-08	1.93E-07	2.57E-07	2.90E-05	3.86E-05
50	100	0.05	0.015	0.401	Weeds (78)	Loam	1.10E-06	1.47E-06	7.79E-06	1.04E-05	1.17E-03	1.56E-03
50	1000	0.05	0.015	0.401	Weeds (78)	Loam	1.71E-06	2.29E-06	1.21E-05	1.62E-05	1.82E-03	2.42E-03
50	10	0.05	0.015	0.05	Weeds (78)	Loam	2.40E-07	3.20E-07	1.70E-06	2.26E-06	2.54E-04	3.39E-04
50	10	0.05	0.015	0.2	Weeds (78)	Loam	2.42E-07	3.22E-07	1.71E-06	2.28E-06	2.56E-04	3.41E-04
50	10	0.05	0.015	0.5	Weeds (78)	Loam	2.45E-07	3.27E-07	1.73E-06	2.31E-06	2.60E-04	3.46E-04
50	10	0.05	0.023	0.401	Weeds (78)	Loam	2.41E-07	3.21E-07	1.70E-06	2.27E-06	2.55E-04	3.41E-04
50	10	0.05	0.046	0.401	Weeds (78)	Loam	2.41E-07	3.21E-07	1.70E-06	2.27E-06	2.55E-04	3.40E-04
50	10	0.05	0.15	0.401	Weeds (78)	Loam	2.40E-07	3.20E-07	1.69E-06	2.26E-06	2.54E-04	3.39E-04
50	10	0.005	0.015	0.401	Weeds (78)	Loam	2.40E-07	3.20E-07	1.69E-06	2.26E-06	2.54E-04	3.39E-04
50	10	0.01	0.015	0.401	Weeds (78)	Loam	2.40E-07	3.20E-07	1.69E-06	2.26E-06	2.54E-04	3.39E-04
50	10	0.1	0.015	0.401	Weeds (78)	Loam	2.43E-07	3.25E-07	1.72E-06	2.29E-06	2.58E-04	3.44E-04
50	10	0.05	0.015	0.401	Weeds (78)	Silt Loam	2.17E-06	2.89E-06	1.53E-05	2.04E-05	2.30E-03	3.06E-03
50	10	0.05	0.015	0.401	Weeds (78)	Silt	1.95E-06	2.59E-06	1.37E-05	1.83E-05	2.06E-03	2.75E-03
50	10	0.05	0.015	0.401	Weeds (78)	Clay Loam	4.32E-06	5.76E-06	3.05E-05	4.07E-05	4.58E-03	6.10E-03
50	10	0.05	0.015	0.401	Shrubs(79)	Loam	2.41E-07	3.21E-07	1.70E-06	2.27E-06	2.55E-04	3.41E-04
50	10	0.05	0.015	0.401	Rye Grass(54)	Loam	2.41E-07	3.21E-07	1.70E-06	2.27E-06	2.55E-04	3.41E-04
50	10	0.05	0.015	0.401	Conifer + Hardwood (71)	Loam	3.09E-07	4.13E-07	2.19E-06	2.92E-06	3.28E-04	4.37E-04

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	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)	Clay	2.00E-14	2.67E-14	3.30E-14	4.40E-14	4.10E-11	5.47E-11
10	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
25	10	0.05	0.015	0.401	Weeds (78)	Sand	5.69E-12	7.58E-12	9.38E-12	1.25E-11	1.17E-08	1.56E-08
25	10	0.05	0.015	0.401	Weeds (78)	Clay	5.06E-08	6.75E-08	8.35E-08	1.11E-07	1.04E-04	1.38E-04
25	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
50	10	0.05	0.015	0.401	Weeds (78)	Sand	2.53E-08	3.37E-08	4.17E-08	5.56E-08	5.19E-05	6.91E-05
50	10	0.05	0.015	0.401	Weeds (78)	Clay	3.13E-07	4.18E-07	5.17E-07	6.89E-07	6.42E-04	8.57E-04
50	10	0.05	0.015	0.401	Weeds (78)	Loam	1.34E-08	1.78E-08	2.21E-08	2.94E-08	2.74E-05	3.66E-05
100	10	0.05	0.015	0.401	Weeds (78)	Sand	5.64E-07	7.52E-07	9.30E-07	1.24E-06	1.16E-03	1.54E-03
100	10	0.05	0.015	0.401	Weeds (78)	Clay	7.14E-07	9.53E-07	1.18E-06	1.57E-06	1.47E-03	1.95E-03
100	10	0.05	0.015	0.401	Weeds (78)	Loam	1.98E-08	2.64E-08	3.27E-08	4.36E-08	4.06E-05	5.42E-05
150	10	0.05	0.015	0.401	Weeds (78)	Sand	1.27E-06	1.69E-06	2.09E-06	2.79E-06	2.60E-03	3.47E-03
150	10	0.05	0.015	0.401	Weeds (78)	Clay	7.28E-07	9.71E-07	1.20E-06	1.60E-06	1.49E-03	1.99E-03
150	10	0.05	0.015	0.401	Weeds (78)	Loam	2.07E-08	2.76E-08	3.41E-08	4.55E-08	4.24E-05	5.65E-05
200	10	0.05	0.015	0.401	Weeds (78)	Sand	1.80E-06	2.39E-06	2.96E-06	3.95E-06	3.68E-03	4.91E-03
200	10	0.05	0.015	0.401	Weeds (78)	Clay	6.66E-07	8.88E-07	1.10E-06	1.46E-06	1.37E-03	1.82E-03
200	10	0.05	0.015	0.401	Weeds (78)	Loam	2.43E-08	3.24E-08	4.01E-08	5.34E-08	4.98E-05	6.64E-05

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

Potential Risk to Aquatic Receptors

Annual Precipitation Rate (in/yr)	Application Area (ac)	Hydraulic Slope	Surface Roughness	USLE Soil Erodibility Factor[1]	Vegetation Type	Soil Type	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**
Surface Runoff to Off-Site Stream Chronic Toxicity												
250	10	0.05	0.015	0.401	Weeds (78)	Sand	2.08E-06	2.78E-06	3.44E-06	4.58E-06	4.28E-03	5.70E-03
250	10	0.05	0.015	0.401	Weeds (78)	Clay	6.38E-07	8.50E-07	1.05E-06	1.40E-06	1.31E-03	1.74E-03
250	10	0.05	0.015	0.401	Weeds (78)	Loam	3.44E-08	4.59E-08	5.67E-08	7.56E-08	7.06E-05	9.41E-05
50	1	0.05	0.015	0.401	Weeds (78)	Loam	1.48E-09	1.98E-09	2.45E-09	3.26E-09	3.05E-06	4.06E-06
50	100	0.05	0.015	0.401	Weeds (78)	Loam	6.00E-08	7.99E-08	9.89E-08	1.32E-07	1.23E-04	1.64E-04
50	1000	0.05	0.015	0.401	Weeds (78)	Loam	9.32E-08	1.24E-07	1.54E-07	2.05E-07	1.91E-04	2.55E-04
50	10	0.05	0.015	0.05	Weeds (78)	Loam	1.30E-08	1.74E-08	2.15E-08	2.87E-08	2.67E-05	3.57E-05
50	10	0.05	0.015	0.2	Weeds (78)	Loam	1.31E-08	1.75E-08	2.17E-08	2.89E-08	2.69E-05	3.59E-05
50	10	0.05	0.015	0.5	Weeds (78)	Loam	1.33E-08	1.78E-08	2.20E-08	2.93E-08	2.73E-05	3.64E-05
50	10	0.05	0.023	0.401	Weeds (78)	Loam	1.31E-08	1.75E-08	2.16E-08	2.88E-08	2.69E-05	3.58E-05
50	10	0.05	0.046	0.401	Weeds (78)	Loam	1.31E-08	1.74E-08	2.16E-08	2.88E-08	2.68E-05	3.58E-05
50	10	0.05	0.15	0.401	Weeds (78)	Loam	1.30E-08	1.74E-08	2.15E-08	2.86E-08	2.67E-05	3.56E-05
50	10	0.005	0.015	0.401	Weeds (78)	Loam	1.30E-08	1.74E-08	2.15E-08	2.86E-08	2.67E-05	3.56E-05
50	10	0.01	0.015	0.401	Weeds (78)	Loam	1.30E-08	1.74E-08	2.15E-08	2.87E-08	2.67E-05	3.56E-05
50	10	0.1	0.015	0.401	Weeds (78)	Loam	1.32E-08	1.76E-08	2.18E-08	2.91E-08	2.71E-05	3.62E-05
50	10	0.05	0.015	0.401	Weeds (78)	Silt Loam	1.22E-07	1.62E-07	2.01E-07	2.68E-07	2.50E-04	3.33E-04
50	10	0.05	0.015	0.401	Weeds (78)	Silt	1.07E-07	1.43E-07	1.77E-07	2.36E-07	2.20E-04	2.94E-04
50	10	0.05	0.015	0.401	Weeds (78)	Clay Loam	2.56E-07	3.42E-07	4.23E-07	5.64E-07	5.26E-04	7.01E-04
50	10	0.05	0.015	0.401	Shrubs(79)	Loam	1.31E-08	1.75E-08	2.16E-08	2.88E-08	2.69E-05	3.58E-05
50	10	0.05	0.015	0.401	Rye Grass(54)	Loam	1.31E-08	1.75E-08	2.16E-08	2.88E-08	2.69E-05	3.58E-05
50	10	0.05	0.015	0.401	Conifer + Hardwood (71)	Loam	1.68E-08	2.24E-08	2.77E-08	3.70E-08	3.45E-05	4.60E-05

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	0.00E+00	0.00E+00
10	10	0.05	0.015	0.401	Weeds (78)	Clay	1.33E-13	1.77E-13
10	10	0.05	0.015	0.401	Weeds (78)	Loam	0.00E+00	0.00E+00
25	10	0.05	0.015	0.401	Weeds (78)	Sand	5.55E-11	7.40E-11
25	10	0.05	0.015	0.401	Weeds (78)	Clay	3.96E-07	5.28E-07
25	10	0.05	0.015	0.401	Weeds (78)	Loam	0.00E+00	0.00E+00
50	10	0.05	0.015	0.401	Weeds (78)	Sand	1.49E-07	1.99E-07
50	10	0.05	0.015	0.401	Weeds (78)	Clay	7.89E-07	1.05E-06
50	10	0.05	0.015	0.401	Weeds (78)	Loam	1.79E-08	2.39E-08
100	10	0.05	0.015	0.401	Weeds (78)	Sand	1.44E-06	1.92E-06
100	10	0.05	0.015	0.401	Weeds (78)	Clay	2.81E-07	3.75E-07
100	10	0.05	0.015	0.401	Weeds (78)	Loam	4.96E-09	6.61E-09
150	10	0.05	0.015	0.401	Weeds (78)	Sand	2.00E-06	2.67E-06
150	10	0.05	0.015	0.401	Weeds (78)	Clay	1.16E-07	1.55E-07
150	10	0.05	0.015	0.401	Weeds (78)	Loam	9.71E-09	1.30E-08
200	10	0.05	0.015	0.401	Weeds (78)	Sand	1.85E-06	2.46E-06
200	10	0.05	0.015	0.401	Weeds (78)	Clay	1.15E-07	1.54E-07
200	10	0.05	0.015	0.401	Weeds (78)	Loam	2.77E-08	3.70E-08
250	10	0.05	0.015	0.401	Weeds (78)	Sand	1.47E-06	1.97E-06
250	10	0.05	0.015	0.401	Weeds (78)	Clay	1.52E-07	2.03E-07
250	10	0.05	0.015	0.401	Weeds (78)	Loam	5.04E-08	6.71E-08
50	1	0.05	0.015	0.401	Weeds (78)	Loam	1.66E-08	2.21E-08
50	100	0.05	0.015	0.401	Weeds (78)	Loam	3.79E-09	5.05E-09
50	1000	0.05	0.015	0.401	Weeds (78)	Loam	3.78E-09	5.04E-09
50	10	0.05	0.015	0.05	Weeds (78)	Loam	1.75E-08	2.33E-08

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**
50	10	0.05	0.015	0.2	Weeds 78)	Loam	1.76E-08	2.35E-08
50	10	0.05	0.015	0.5	Weeds (78)	Loam	1.78E-08	2.38E-08
50	10	0.05	0.023	0.401	Weeds (78)	Loam	1.76E-08	2.34E-08
50	10	0.05	0.046	0.401	Weeds (78)	Loam	1.75E-08	2.34E-08
50	10	0.05	0.15	0.401	Weeds (78)	Loam	1.75E-08	2.33E-08
50	10	0.005	0.015	0.401	Weeds (78)	Loam	1.75E-08	2.33E-08
50	10	0.01	0.015	0.401	Weeds (78)	Loam	1.75E-08	2.33E-08
50	10	0.1	0.015	0.401	Weeds (78)	Loam	1.77E-08	2.37E-08
50	10	0.05	0.015	0.401	Weeds (78)	Silt Loam	1.86E-07	2.47E-07
50	10	0.05	0.015	0.401	Weeds (78)	Silt	1.43E-07	1.90E-07
50	10	0.05	0.015	0.401	Weeds (78)	Clay Loam	4.23E-07	5.64E-07
50	10	0.05	0.015	0.401	Shrubs(79)	Loam	1.76E-08	2.34E-08
50	10	0.05	0.015	0.401	Rye Grass(54)	Loam	1.76E-08	2.34E-08
50	10	0.05	0.015	0.401	Conifer + Hardwood (71)	Loam	1.46E-08	1.95E-08

[1] Universal Soil Loss Equation

Shading and boldface indicates plant RQs greater than 1.

Shading and boldface indicates acute RQs greater than 0.05 for fish and invertebrates.

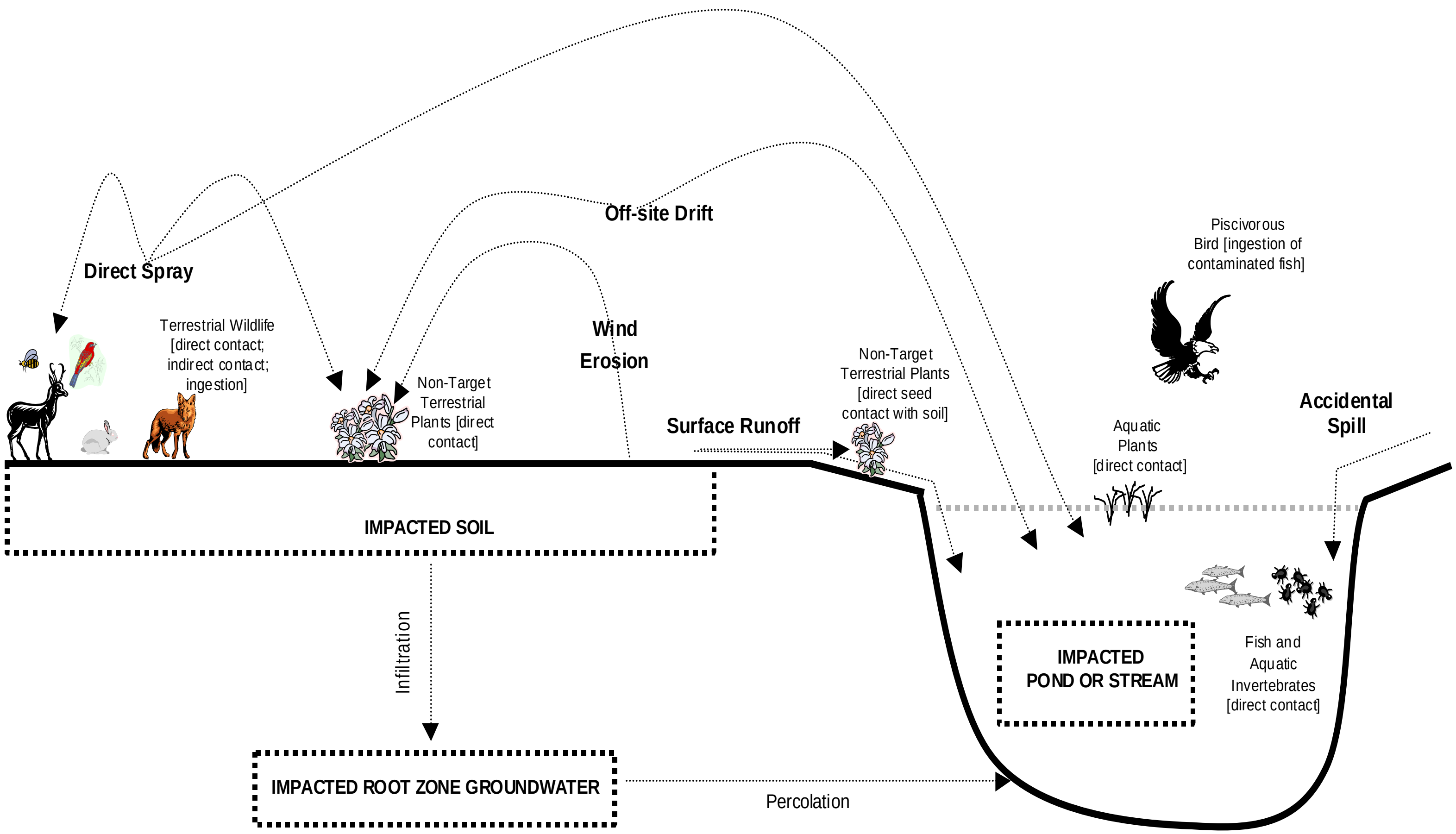
Shading and boldface indicates chronic RQs greater than 0.5 for fish and invertebrates.

Shading and boldface indicates terrestrial animal RQs greater than 0.1 (LOC for acute risk to endangered species - most conservative).

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	5.04E-04	6.72E-04	1.34E-03	1.79E-03
Montana	10	2.85E-04	3.81E-04	7.61E-04	1.01E-03
Montana	100	3.42E-08	5.13E-08	9.11E-08	1.37E-07
Oregon	1.5	2.89E-04	3.85E-04	7.69E-04	1.03E-03
Oregon	10	1.10E-04	1.47E-04	2.93E-04	3.91E-04
Oregon	100	3.87E-08	5.16E-08	1.03E-07	1.38E-07
Wyoming	1.5	5.70E-05	7.60E-05	1.52E-04	2.03E-04
Wyoming	10	3.93E-05	5.24E-05	1.05E-04	1.40E-04
Wyoming	100	9.67E-09	1.29E-08	2.58E-08	3.44E-08
Shading and boldface indicates plant RQs greater than 1 (LOC for all plant risks).					

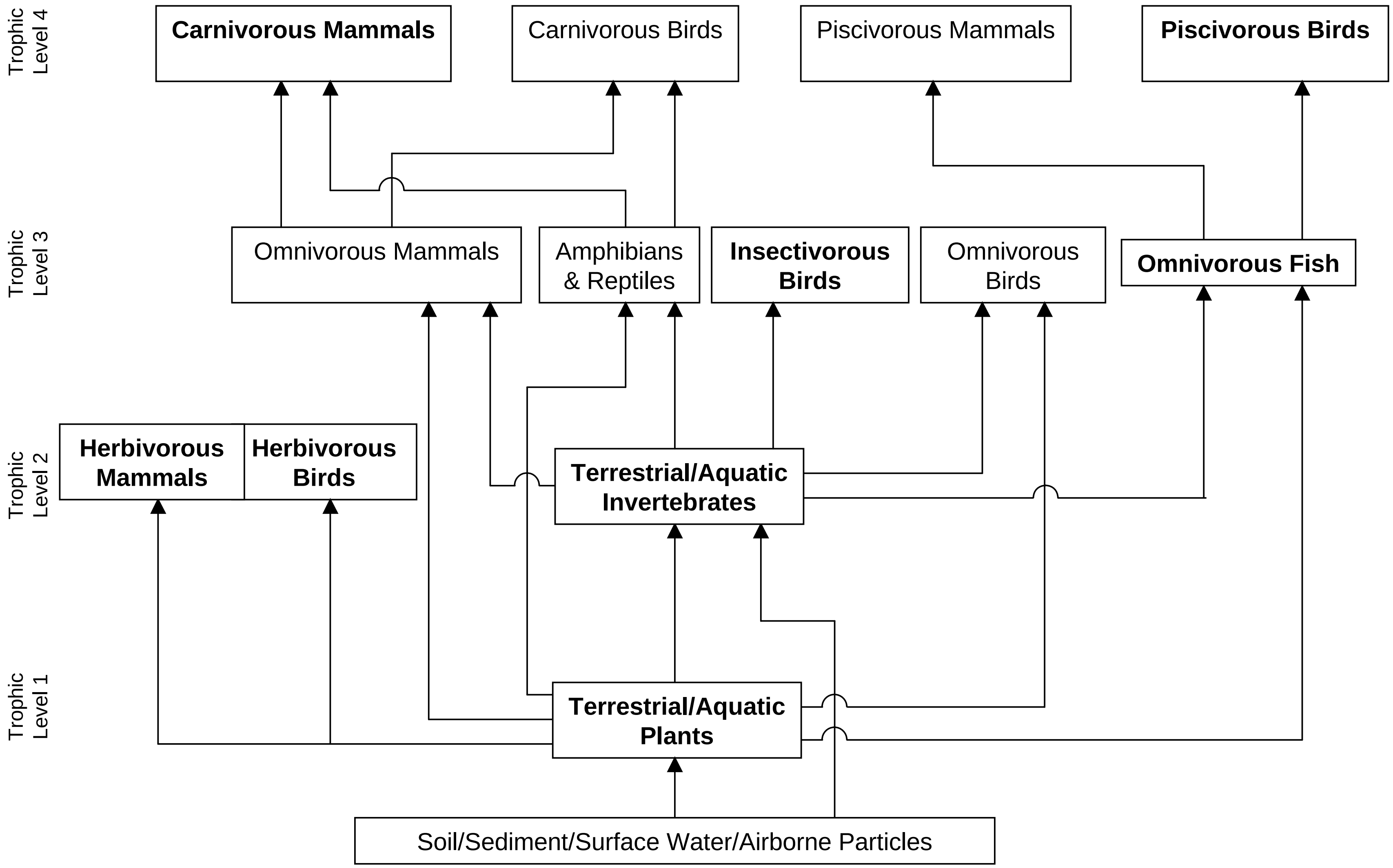
FIGURE 4-1. Conceptual Model for Terrestrial Herbicides.



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.

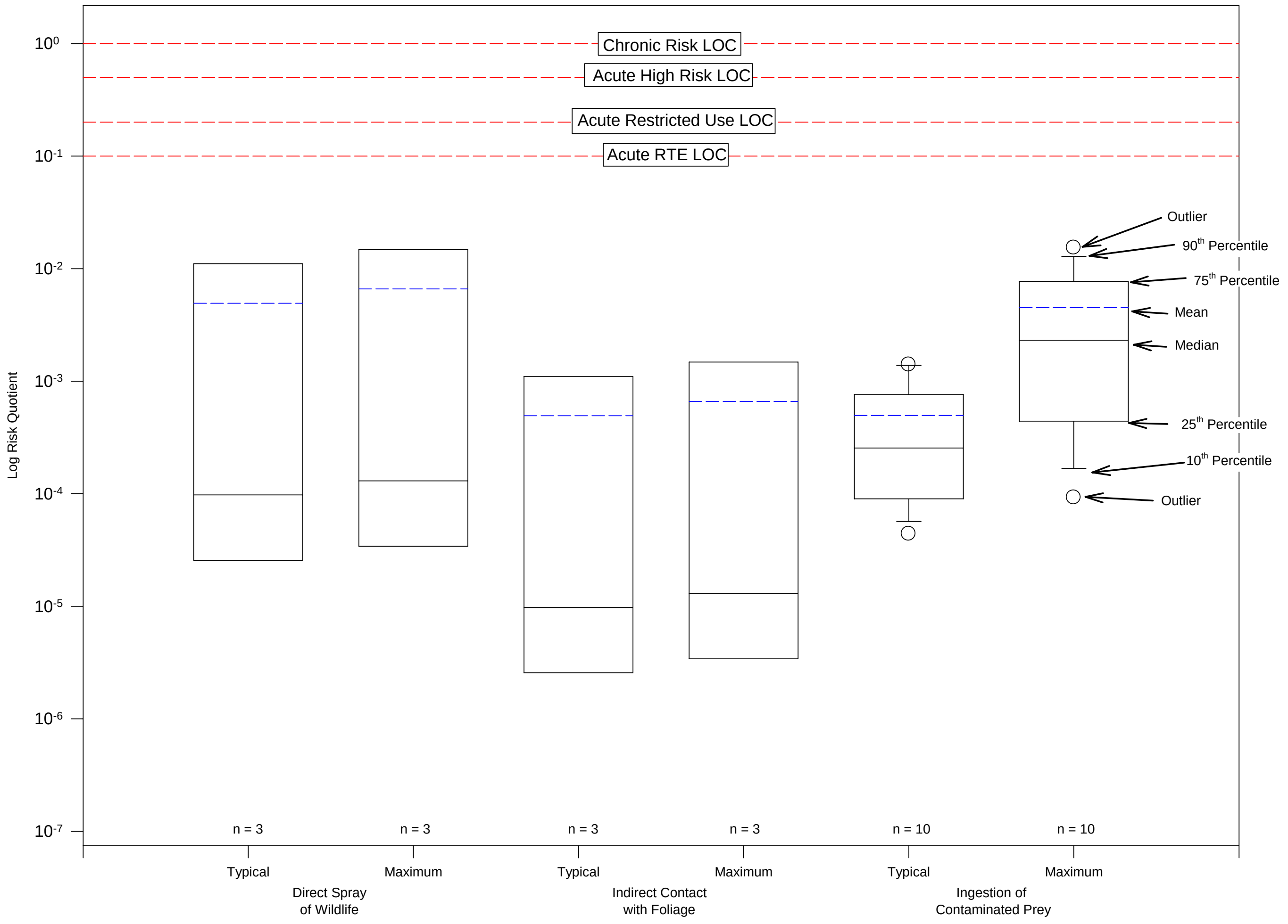


FIGURE 4-4. Direct Spray - Risk Quotients for Non-Target Terrestrial Plants.

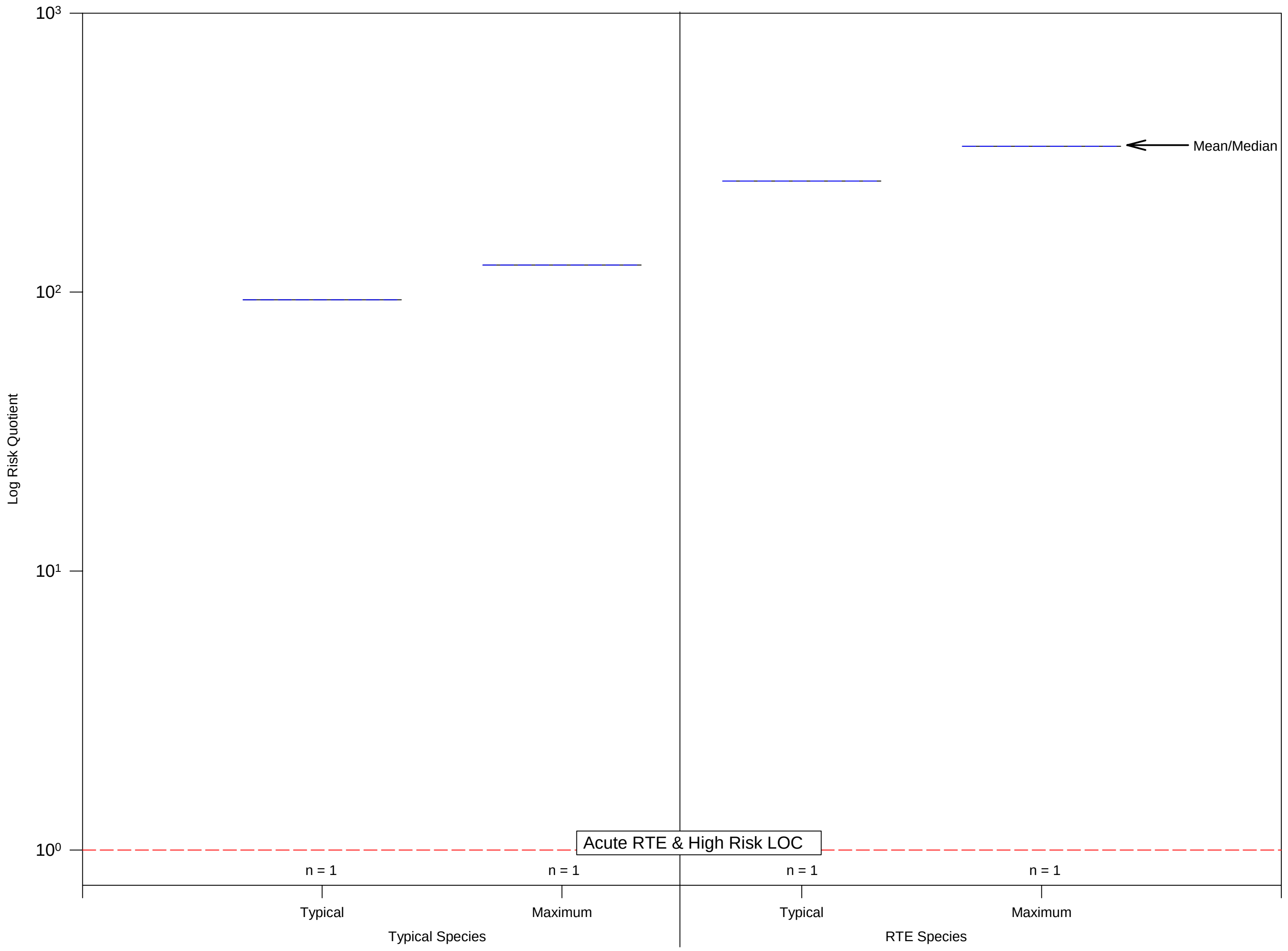


FIGURE 4-5. Accidental Direct Spray and Spills - Risk Quotients for Non-Target Aquatic Plants.

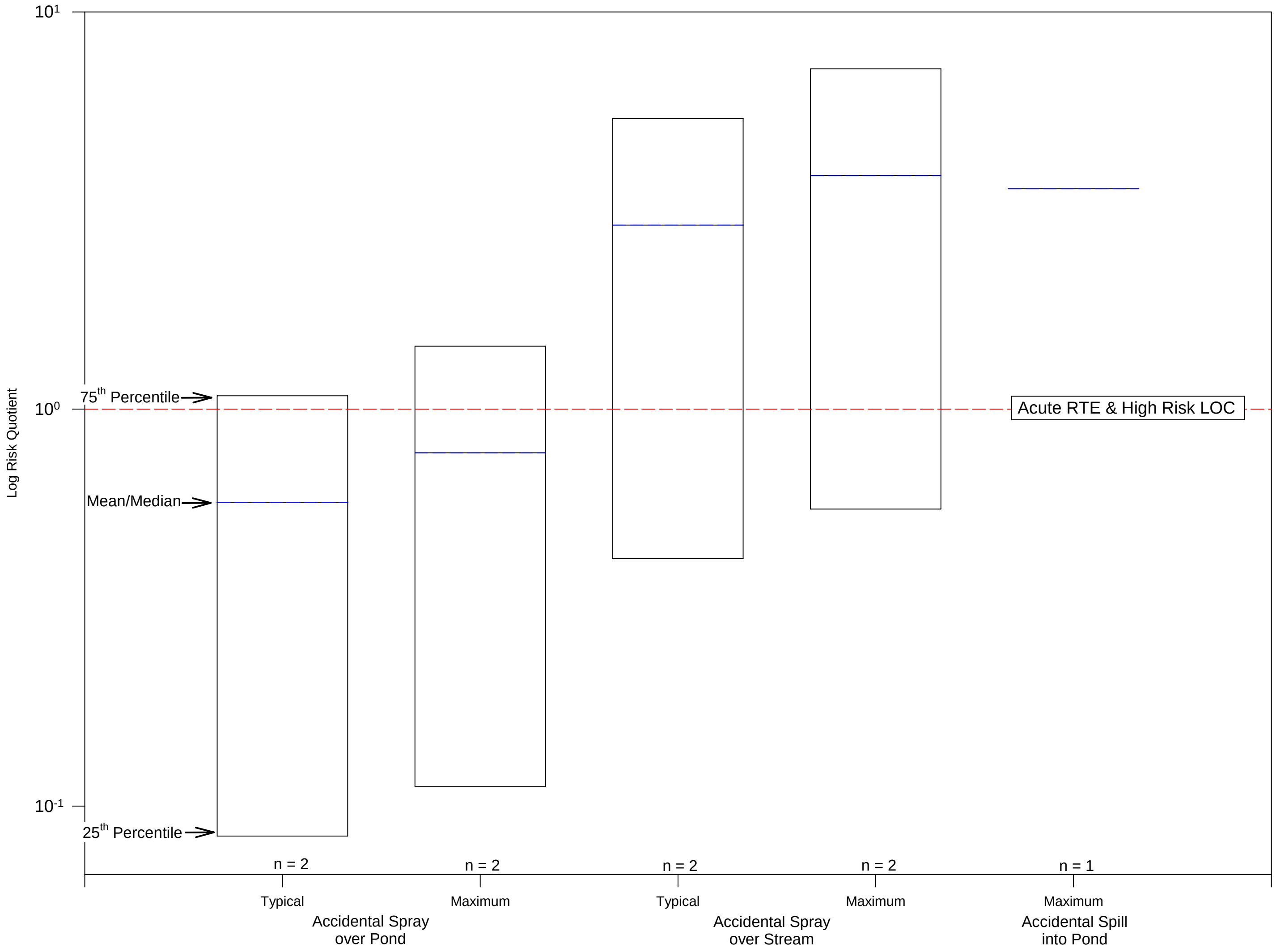


FIGURE 4-6. Accidental Direct Spray and Spills - Risk Quotients for Fish.

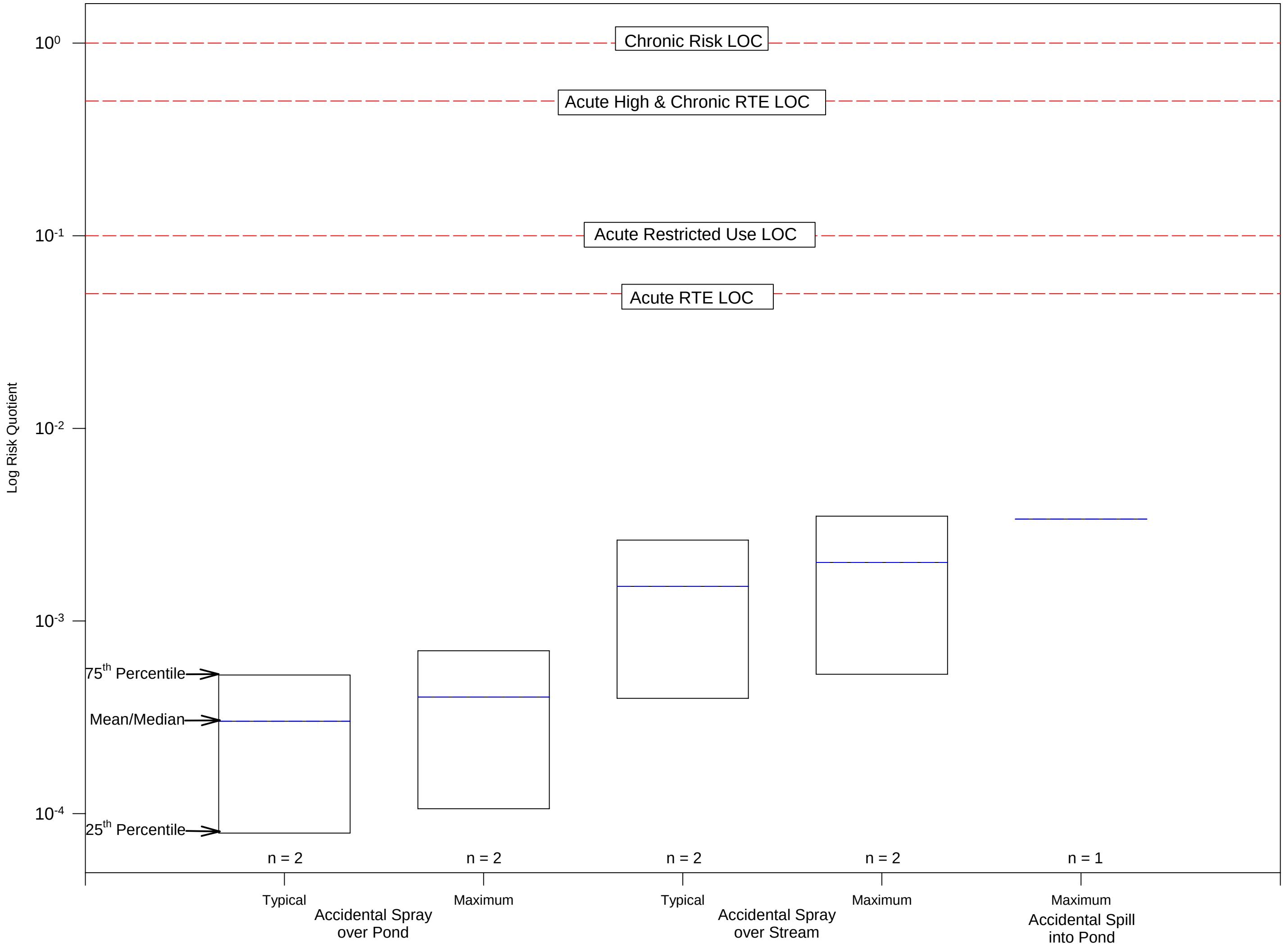


FIGURE 4-7. Accidental Direct Spray and Spills - Risk Quotients for Aquatic Invertebrates.

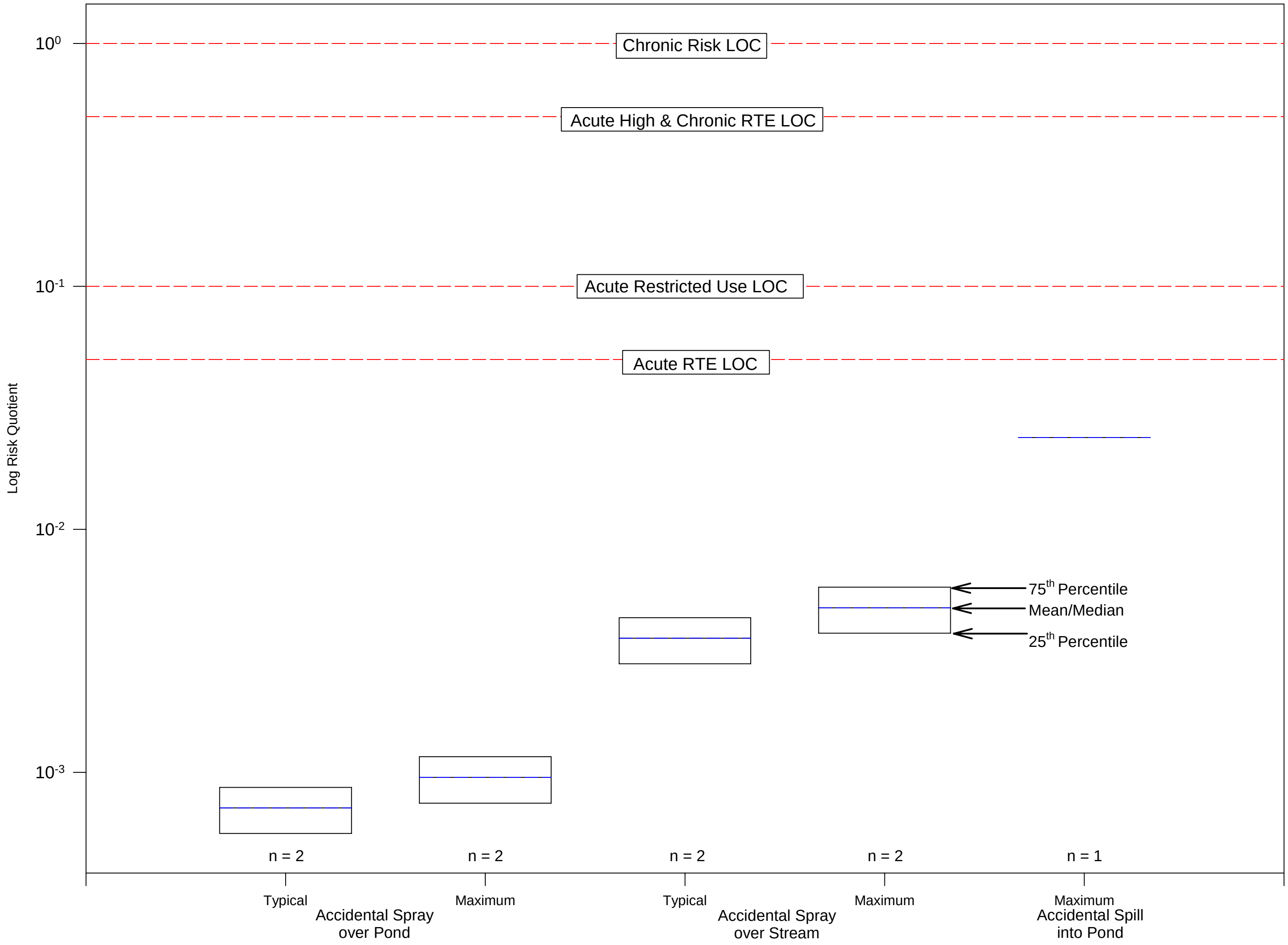


FIGURE 4-8. Off-Site Drift - Risk Quotients for Non-Target Terrestrial Plants.

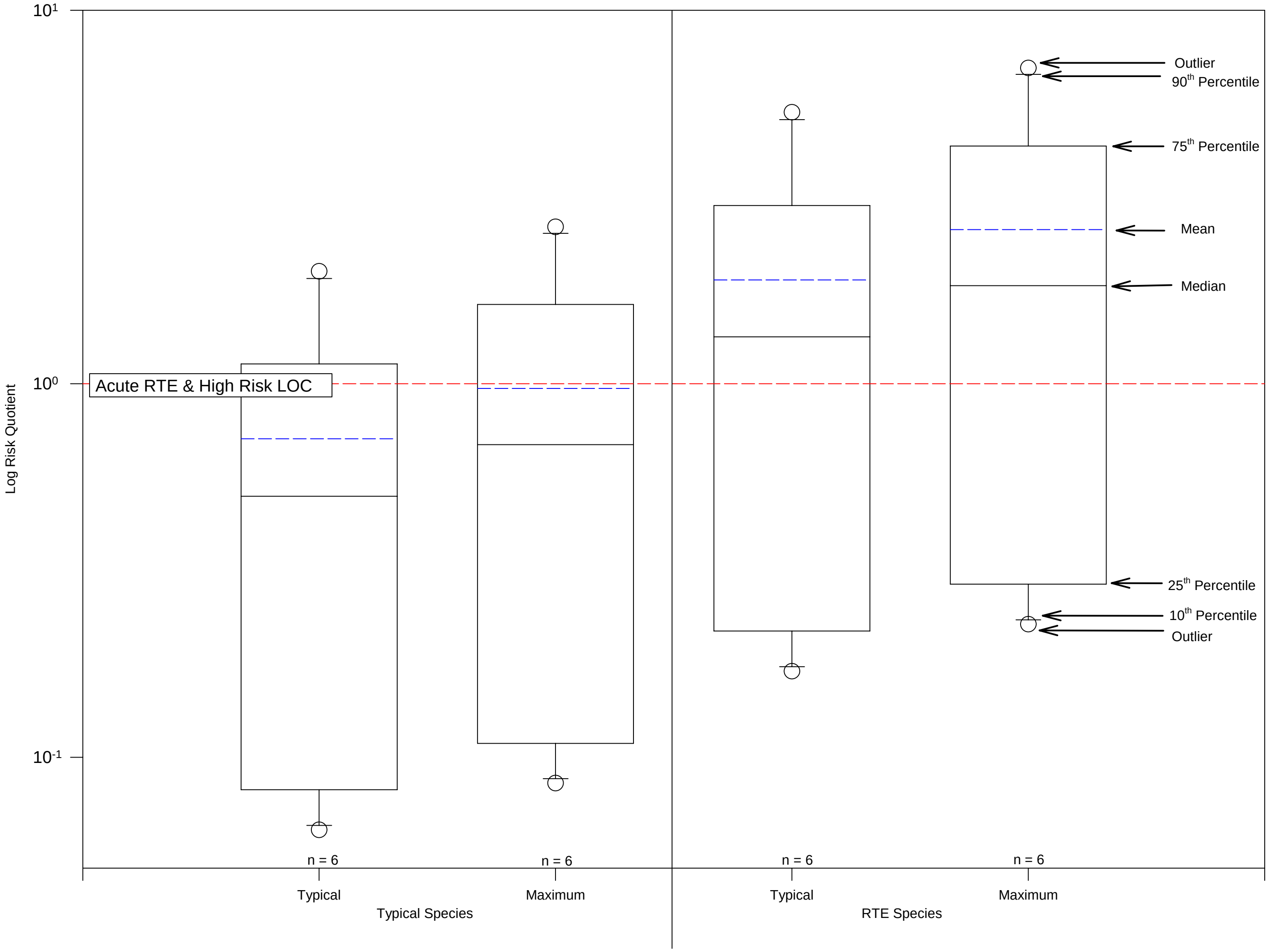


FIGURE 4-9. Off-Site Drift - Risk Quotients for Non-Target Aquatic Plants.

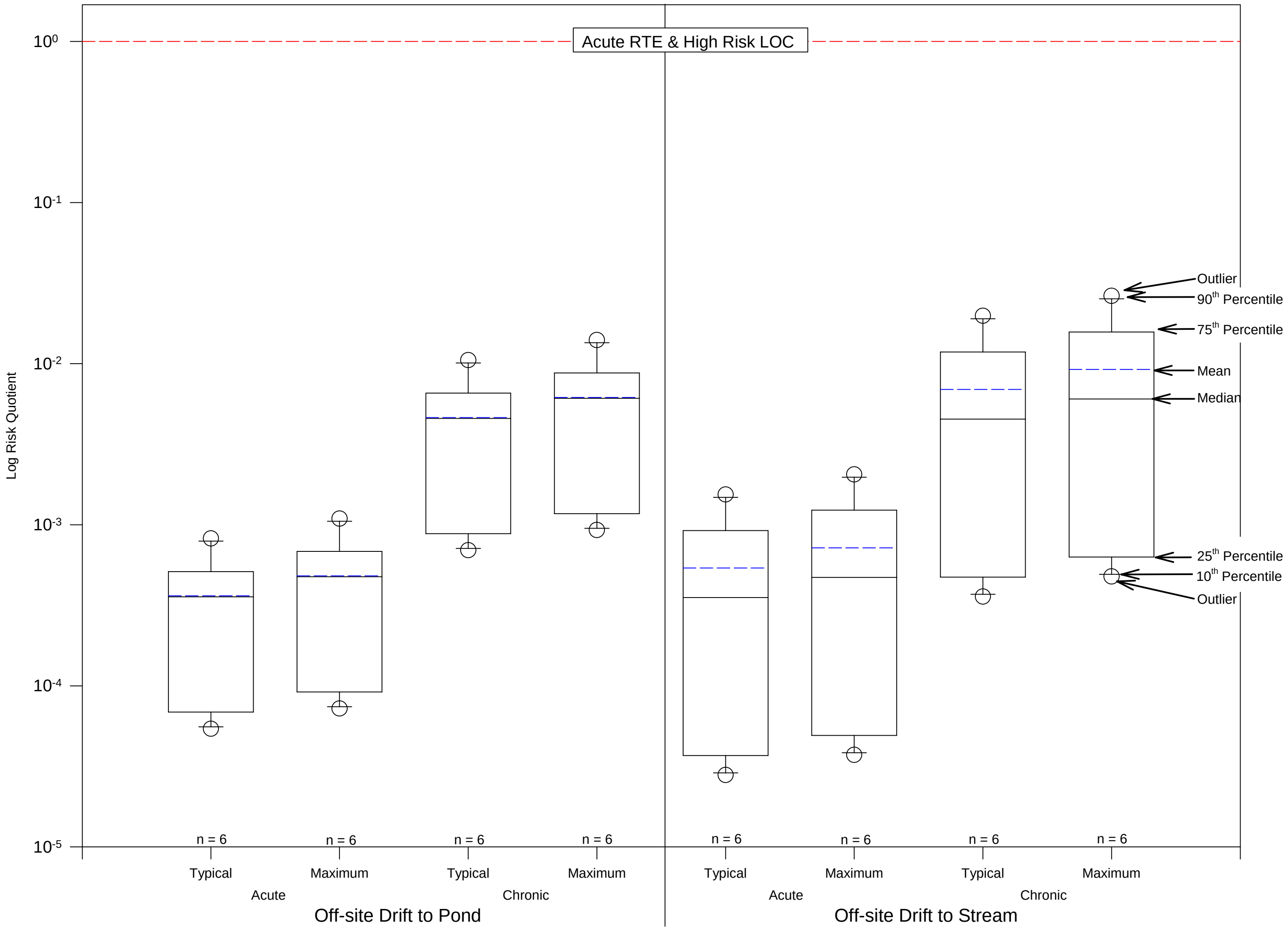


FIGURE 4-10. Off-Site Drift - Risk Quotients for Fish.

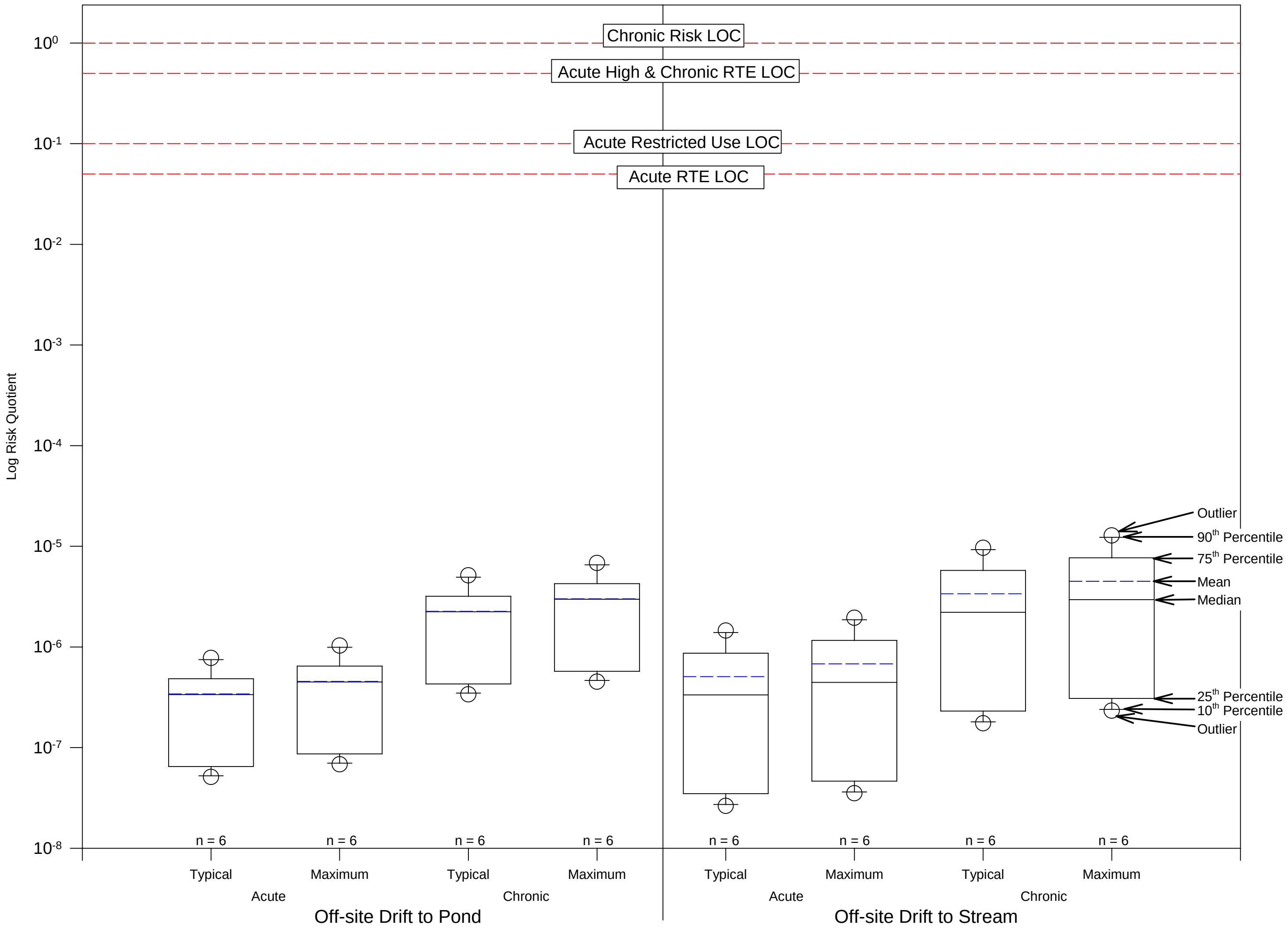


FIGURE 4-11. Off-Site Drift - Risk Quotients for Aquatic Invertebrates.

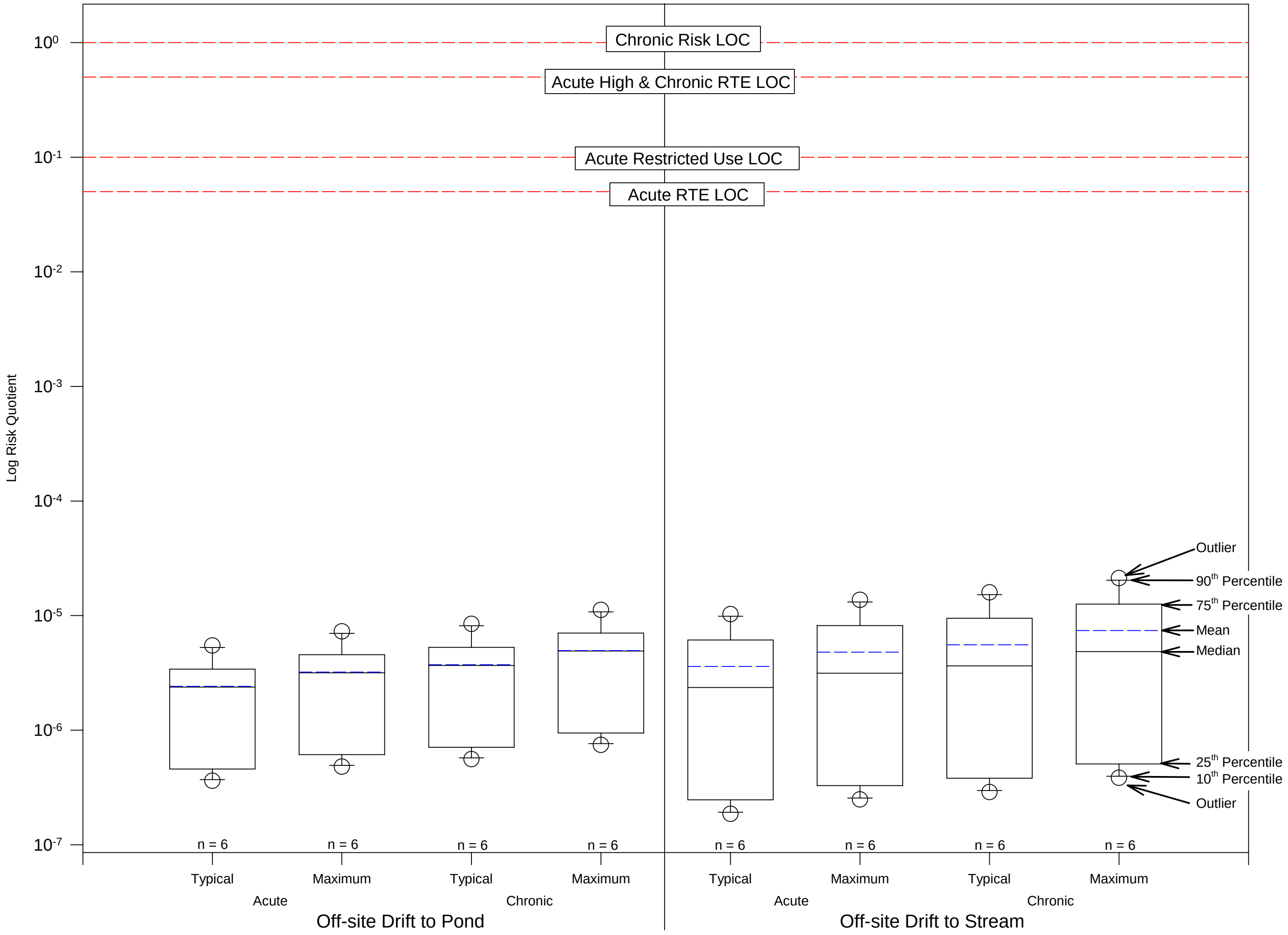


FIGURE 4-12. Off-Site Drift - Risk Quotients for Piscivorous Birds.

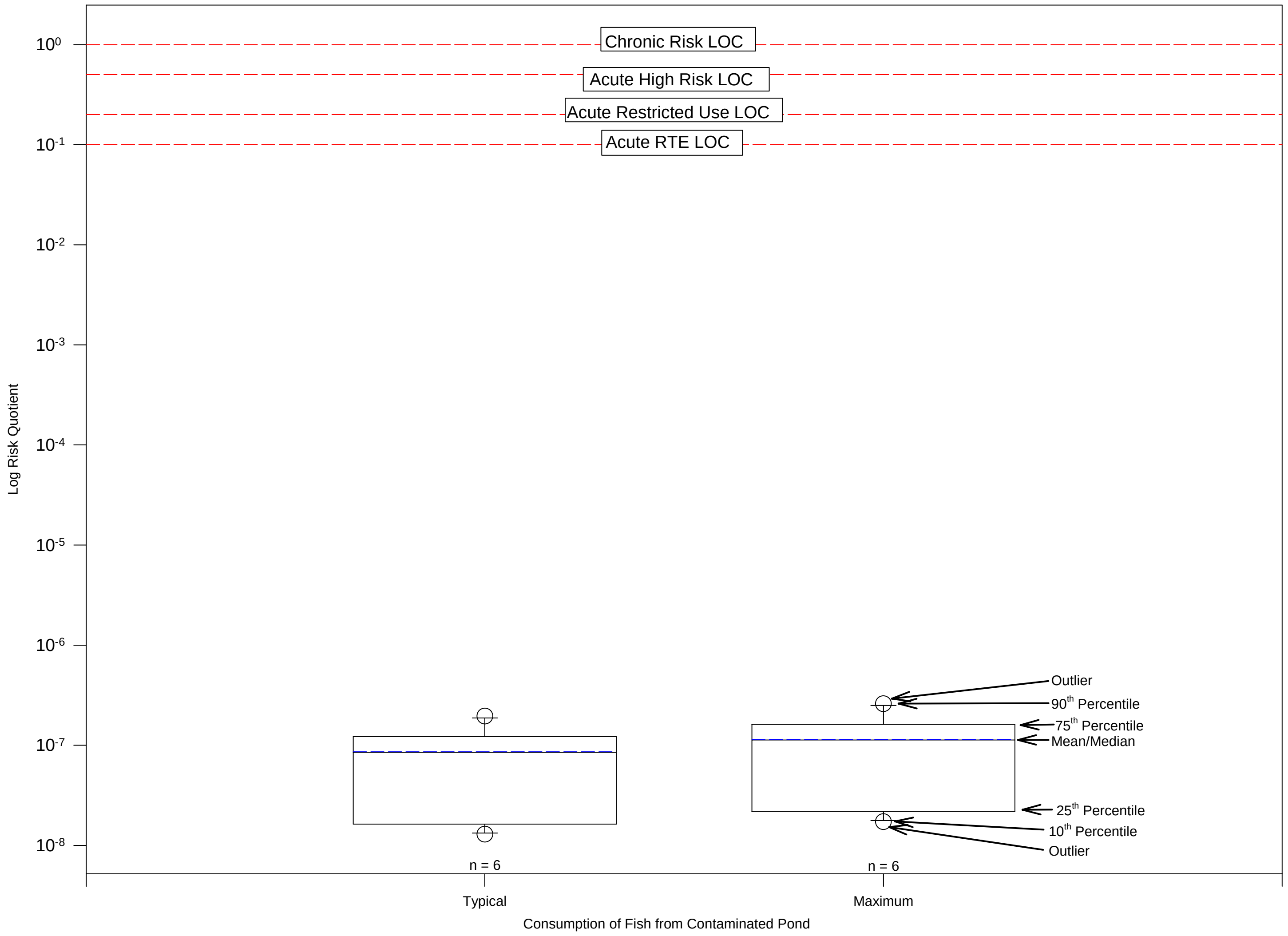


FIGURE 4-13. Surface Runoff - Risk Quotients for Non-Target Terrestrial Plants.

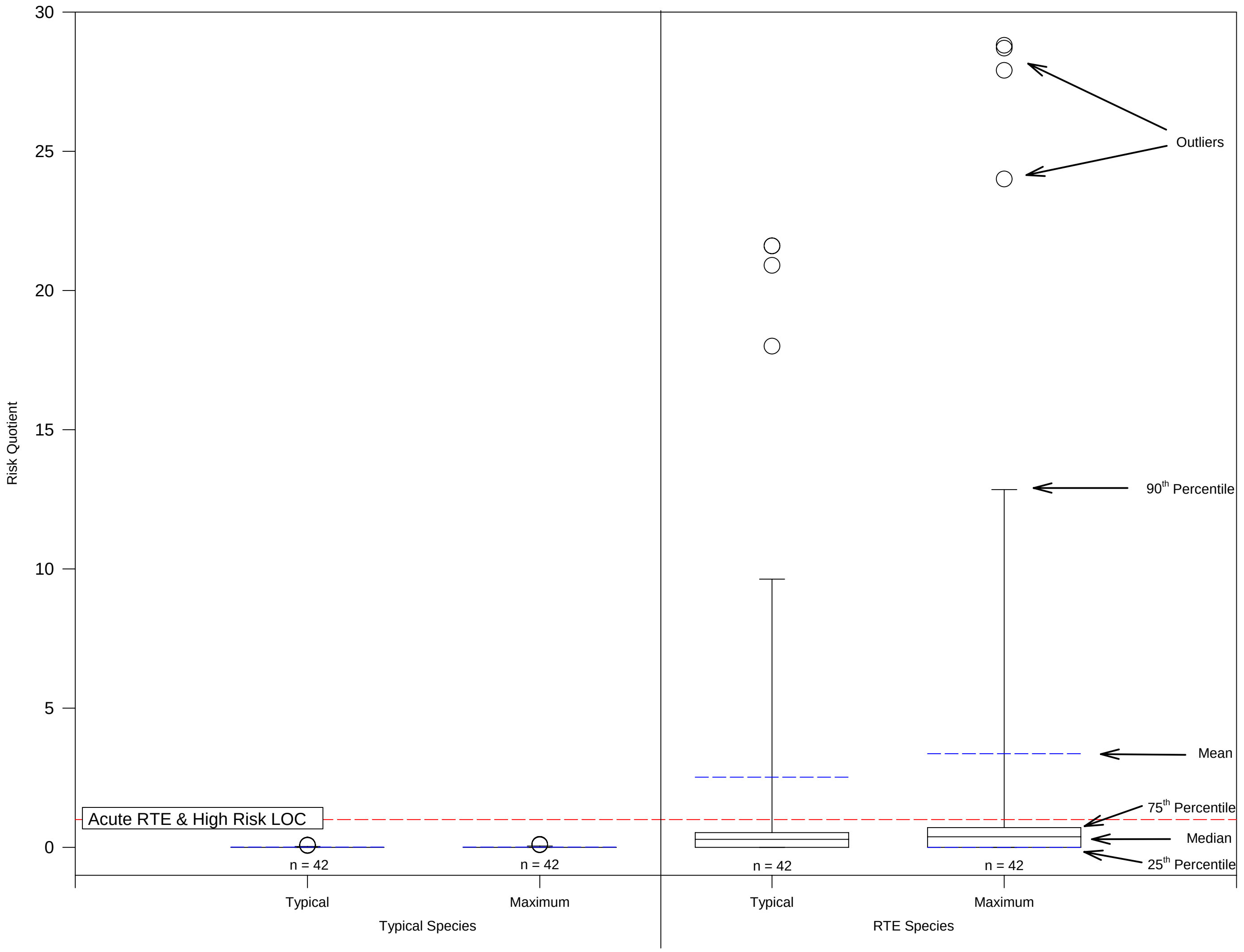


FIGURE 4-14. Surface Runoff - Risk Quotients for Non-Target Aquatic Plants.

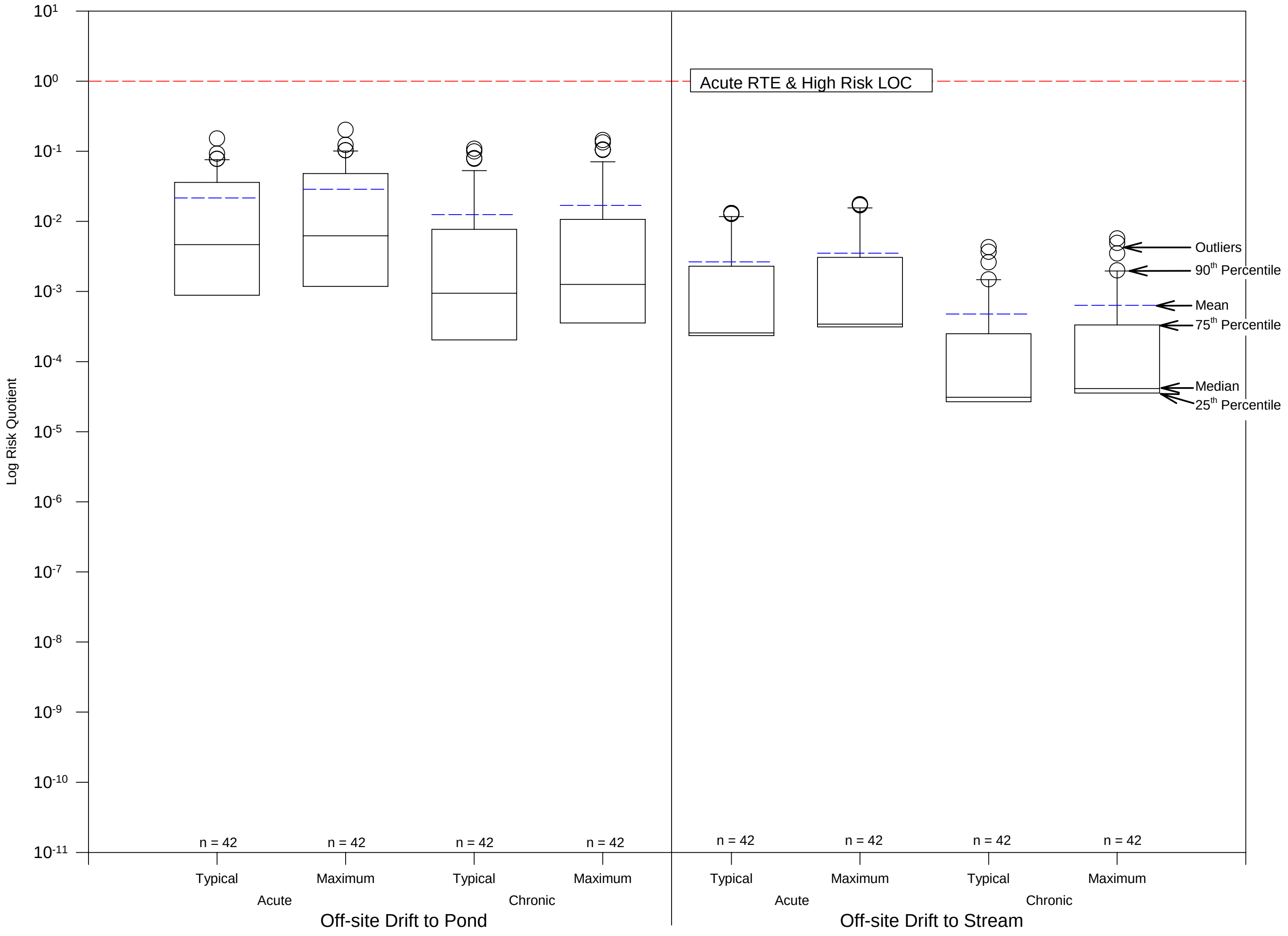


FIGURE 4-15. Surface Runoff - Risk Quotients for Fish

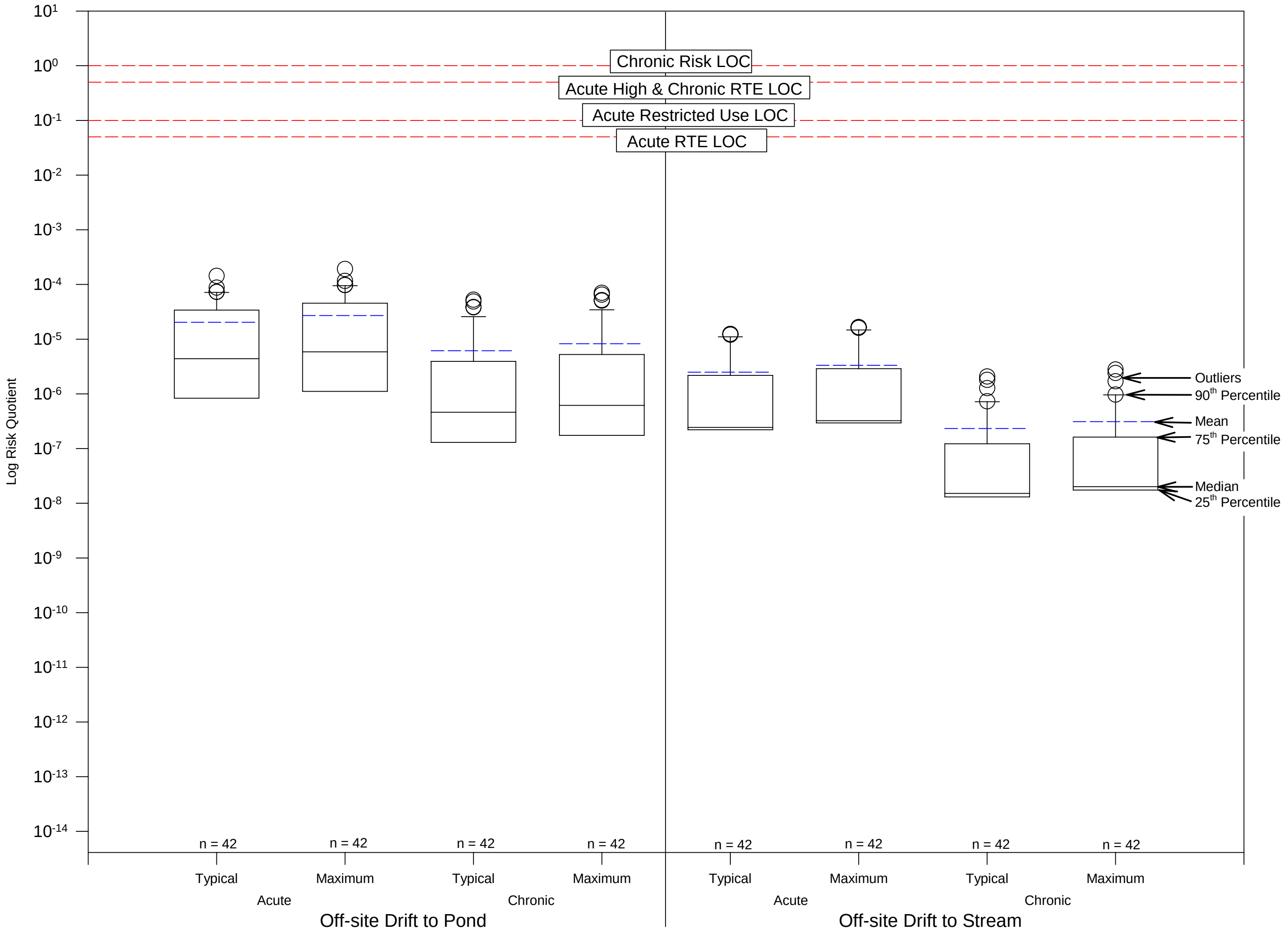


FIGURE 4-16. Surface Runoff - Risk Quotients for Aquatic Invertebrates.

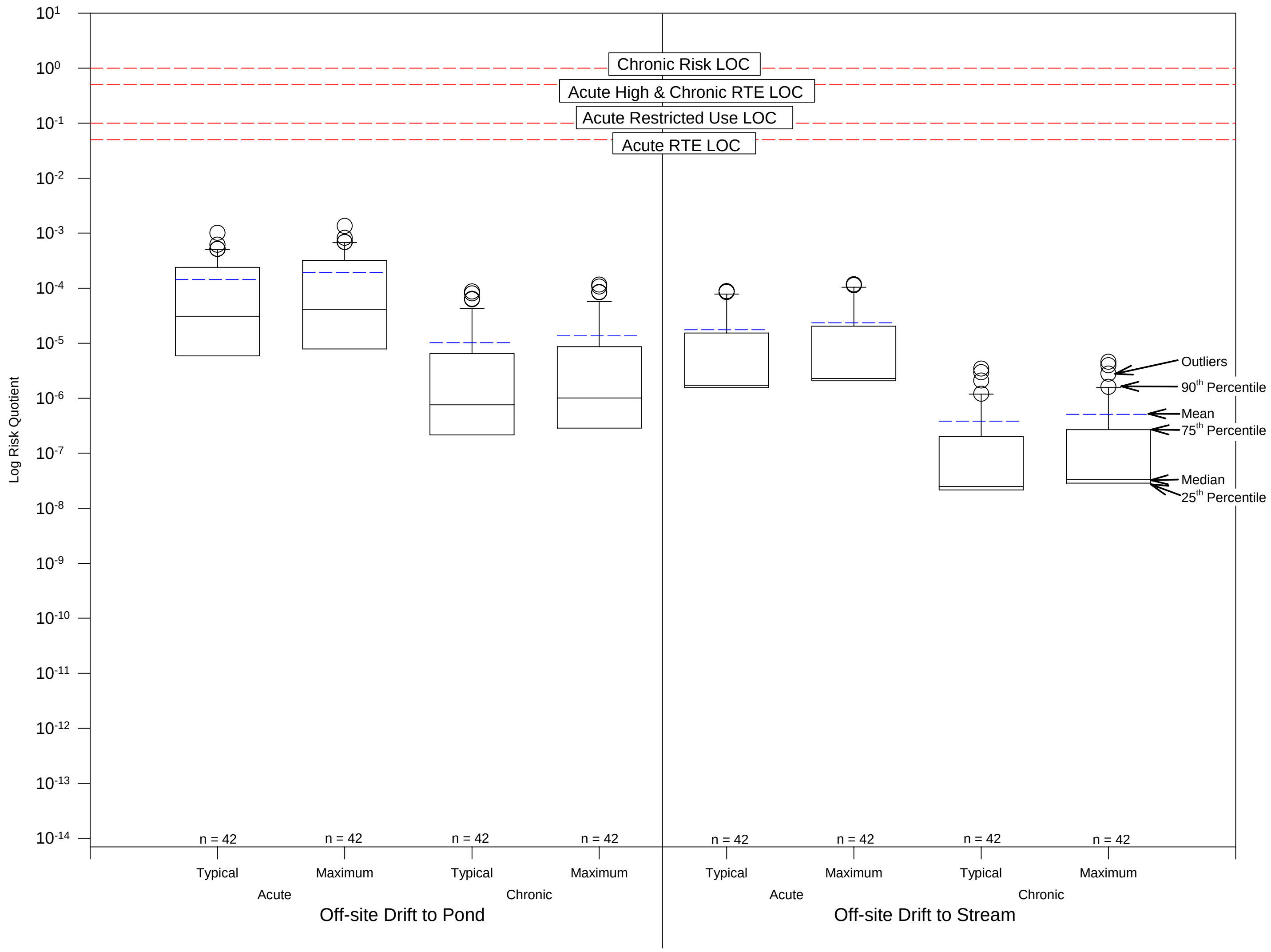


FIGURE 4-17. Surface Runoff - Risk Quotients for Piscivorous Birds.

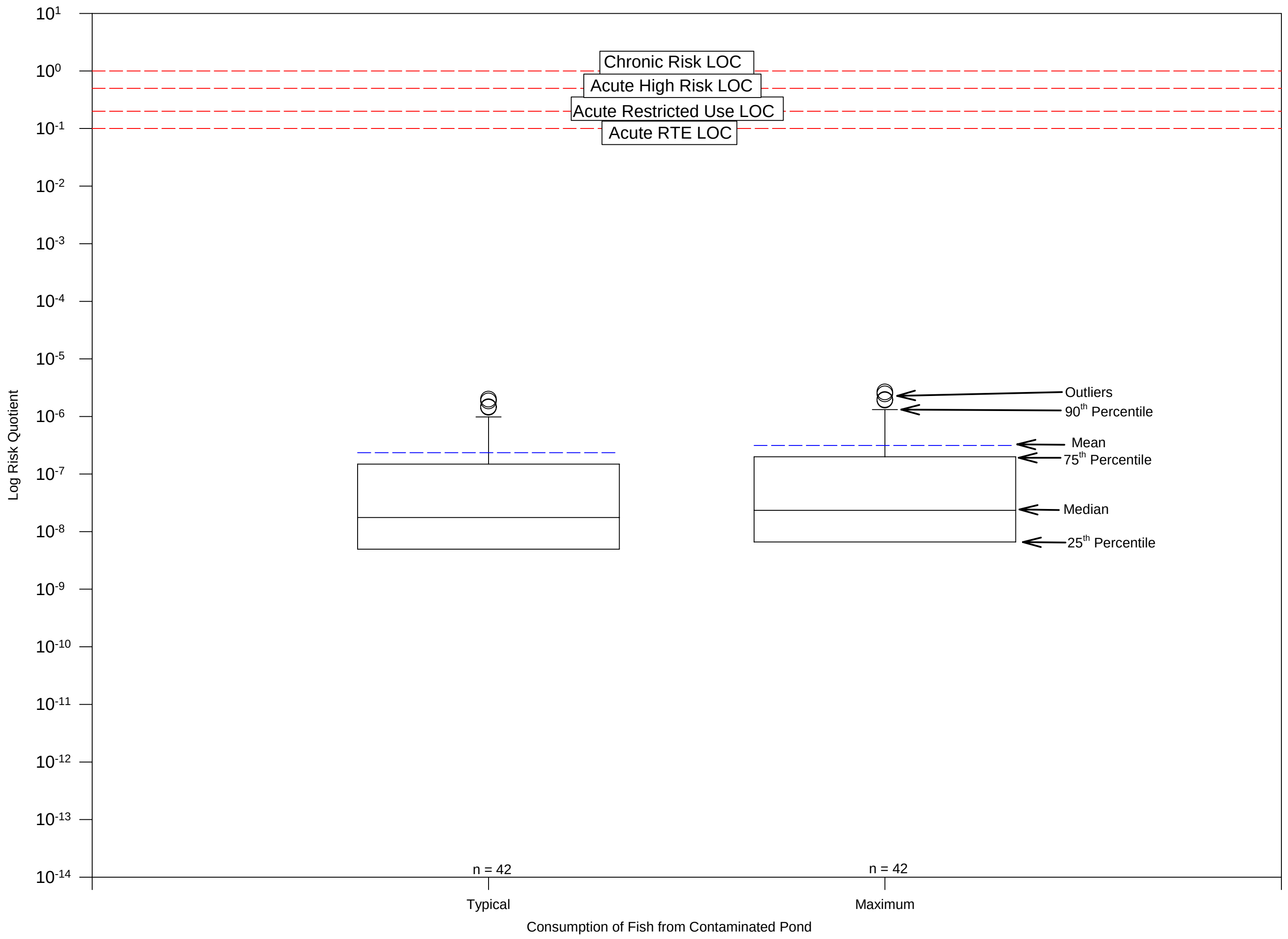
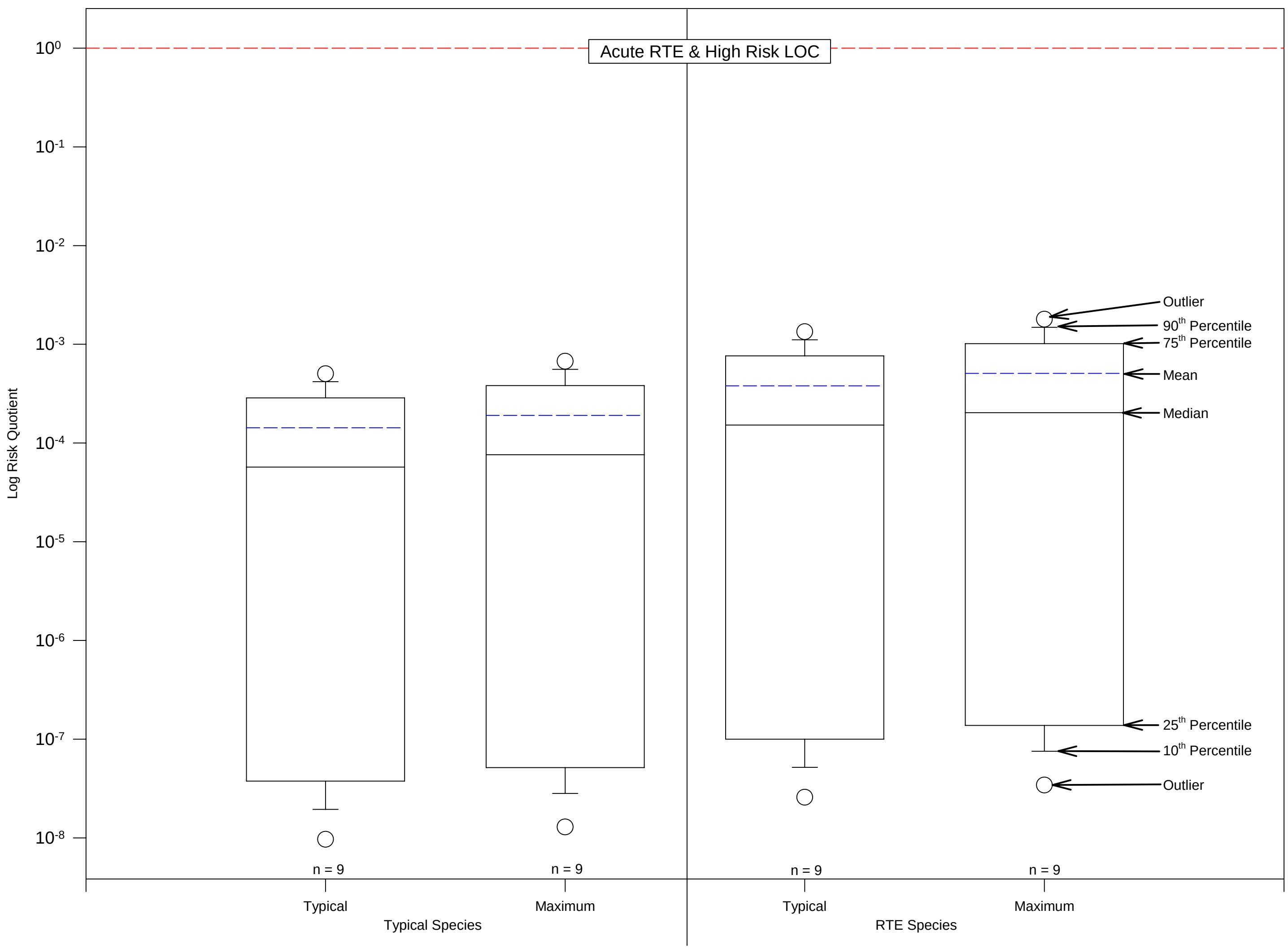


FIGURE 4-18. Wind Erosion and Transport Off-Site - Risk Quotients for Non-Target Terrestrial Plants.



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 2004c). This section provides information specific to the sensitivity of each of these models to select input variables.

5.1 GLEAMS

Groundwater Loading Effects of Agricultural Management Systems 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 groundwater 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, etc.). 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 acres, 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 acre 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 cubic meters, 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 acres;
- slope of 0.05;
- roughness of 0.015;
- erodibility of 0.401 tons per acre 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 > 1.0 denote a positive relationship between herbicide concentration and the variable (increase in RQ) and values < 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 > 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 < 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 drop off 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); 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 1.3 times greater than typical application rate concentrations. Mode of application scenarios were not tested in this sensitivity analysis since only ground applications are used by the BLM to disperse diflufenzopyr. 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 boom height and application rate.

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 2004c). 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	0.00E+00	0.00E+00	3.17E-07	3.73E-05	NA	NA	+	+
Area	acres	1	1,000	2.42E-08	2.95E-06	1.52E-06	1.85E-04	62.6162	62.5731	+	+
Slope	unitless	0.005	0.1	2.09E-07	2.54E-05	2.23E-07	2.72E-05	1.0683	1.0685	+	+
Erodibility	tons/acre per English EI	0.05	0.5	2.09E-07	2.54E-05	2.13E-07	2.60E-05	1.0216	1.0215	+	+
Roughness	unitless	0.015	0.15	2.14E-07	2.61E-05	2.09E-07	2.55E-05	0.9762	0.9761	-	-
Flow Rate	m^3/sec	0.05	100	4.34E-07	5.29E-05	2.96E-10	3.61E-08	0.0007	0.0007	-	-

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	0.00E+00	0.00E+00	2.08E-06	1.91E-04	NA	NA	+	+
Area	acres	1	1,000	7.09E-06	8.78E-05	1.61E-06	1.97E-04	0.2279	2.2408	-	+
Slope	unitless	0.005	0.1	7.34E-06	4.63E-04	7.85E-06	4.95E-04	1.0681	1.0687	+	+
Erodibility	tons/acre per English EI	0.05	0.5	7.35E-06	4.63E-04	7.51E-06	4.73E-04	1.0216	1.0215	+	+
Roughness	unitless	0.015	0.15	7.54E-06	4.76E-04	7.36E-06	4.64E-04	0.9765	0.9760	-	-
Pond Volume	ac/ft	0.05	100	4.14E-06	3.73E-04	4.42E-08	4.49E-07	0.0107	0.0012	-	-

Concentrations were based on the average application rate.
NA – not applicable; due to herbicide chemical and physical properties, there was no export of this herbicide at this low precipitation 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

	Predicted Concentration				Concentration $_{\text{X Soil Type}}$ / Concentration $_{\text{Loam}}$				Relative Change in Concentration			
Soil Type	**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]**	***2.14E-07***	***2.61E-05***	***7.54E-06***	***4.76E-04***	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Sand	4.04E-07	2.50E-05	6.28E-05	5.64E-04	1.8896	0.9575	8.3333	1.1855	+	-	+	+
Clay	5.02E-06	5.51E-04	3.32E-04	1.52E-02	23.4338	21.1153	44.0100	31.9035	+	+	+	+
Clay Loam	4.19E-06	4.68E-04	1.81E-04	7.91E-03	19.5830	17.9506	24.0199	16.6220	+	+	+	+
Silt Loam	1.98E-06	2.34E-04	7.94E-05	4.27E-03	9.2572	8.9681	10.5274	8.9686	+	+	+	+
Silt	1.75E-06	2.11E-04	6.13E-05	3.54E-03	8.1955	8.0684	8.1264	7.4531	+	+	+	+

	Predicted Concentration				Concentration $_{\text{X Veg Type}}$ / Concentration $_{\text{Weeds}}$				Relative Change in Concentration			
Vegetation Type	**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]**	***2.14E-07***	***2.61E-05***	***7.54E-06***	***4.76E-04***	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Conifer + Hardwood	2.74E-07	3.34E-05	6.25E-06	4.93E-04	1.2803	1.2805	0.8290	1.0364	+	+	-	+
Shrubs	2.14E-07	2.61E-05	7.54E-06	4.76E-04	1.0000	1.0000	1.0000	1.0000	No Change	No Change	No Change	No Change
Rye Grass	2.14E-07	2.61E-05	7.54E-06	4.76E-04	1.0000	1.0000	1.0000	1.0000	No Change	No Change	No Change	No Change

[1] ***Base Case***

Concentrations were based on the average application rate.

NA = Not applicable, no comparison.

"+" = 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

				Minimum Downwind Distance Concentration			Maximum Downwind Distance Concentration		
Mode of Application	**Application Height/Veg. Type**	**Minimum Downwind Distance (ft)**	**Maximum Downwind Distance (ft)**	**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	9.00E-04	4.69E-04	5.11E-05	5.11E-05	1.42E-05	5.41E-06
	High Boom	25	900	1.60E-03	7.86E-04	8.21E-05	6.55E-05	1.88E-05	6.87E-06
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	1.30E-03	6.26E-04	6.82E-05	6.82E-05	1.90E-05	7.22E-06
	High Boom	25	900	2.10E-03	1.05E-03	1.09E-04	8.73E-05	2.51E-05	9.16E-06

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

Effect of Downwind Distance

				Concentration $_{900}$/Concentration $_{25\text{ or }100}$			Relative Change in Concentration		
Mode of Application	**Application Height or Vegetation Type**	**Minimum Buffer**	**Maximum Buffer**	**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	0.0568	0.0303	0.1059	-	-	-
	High Boom	25	900	0.0409	0.0239	0.0837	-	-	-
				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	0.0525	0.0303	0.1059	-	-	-
	High Boom	25	900	0.0416	0.0239	0.0840	-	-	-

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	1.7778	1.6749	1.6067	+	+	+
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	1.6154	1.6749	1.5982	+	+	+

Effect of Mode of Application Rate

	Concentration Ratio[2]			Relative Change in Concentration		
	Terrestrial	Stream	Pond	Terrestrial	Stream	Pond
Maximum vs. Typical	1.3125	1.3333	1.3276	+	+	+

(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 management. 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 diflufenzopyr screening level ERA incorporates additional conservatism in the assumptions used in the herbicide concentration models such as GLEAMS (Appendix B; ENSR, 2004c). 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

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[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.

strategy in this ERA. Section 6.2 also includes discussion of the selection of surrogate species (6.2.1), the RTE taxa of 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 diflufenzopyr ERA by comparing calculated RQs to receptor-specific LOCs. As described in the methodology document for this ERA (ENSR 2004c), 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. Protection of these species is an integral goal of the BLM, and they are the focus of the

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

RTE evaluation for the ERA and EIS. These species are different from one another in regards to home range, foraging 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 2004c), 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 to derive TRVs, and 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 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.

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[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 diflufenzopyr. 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 diflufenzopyr 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 prey 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 diflufenzopyr 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. Although there are very low risks to most animals in the modeled exposures, the effects of regular usage of diflufezopyr are uncertain. 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 the potential risk to RTE mammals, birds, reptiles, and amphibians are valid, the vertebrate RQs generated in the ERA for diflufenzopyr are generally very low (Section 4.3). None of the RQs exceed respective LOCs. Of the four general scenarios in which vertebrate receptors were evaluated, the highest RQ was 0.001 (chronic exposure of large avian herbivore ingesting food contaminated by direct spray at maximum application rate). This RQ is lower than the chronic RTE LOC of 1, and lower than the lowest LOC for birds (0.1 for RTE acute exposure). Most vertebrate RQs, including fish exposure to accidental spills, were lower than respective LOCs by several orders of magnitude.

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 2004c), 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 ERAs 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

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

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., among 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 not 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, the authors have presented the percentage of the available data that is included within a stated factor. For example, 90% of the observed LD_{50}s 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 approach can be compared to the approach used in this ERA. For example, for aquatic invertebrates, a LOC of 0.05 was defined, which 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).

6.3.3 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

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[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.

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 prey. 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 National Marine Fisheries Service (NMFS, 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 diflufenzopyr 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 diflufenzopyr 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. No diflufenzopyr RQs for fish exceeded the respective RTE LOC (Section 4.3). 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 to salmonids 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, no aquatic invertebrate or fish, acute or chronic scenario RQs exceeded respective LOCs suggesting that direct impacts to the forage of salmonids is unlikely.

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, risk to aquatic vegetation may occur under selected exposure scenarios. No risks to aquatic plants were predicted due to spray drift or surface runoff. The greatest potential for risk to aquatic vegetation would occur under accidental direct spray of a terrestrial herbicide into an aquatic system. RQs exceeded LOCs by less than an order of magnitude under the accidental spray scenarios. Therefore, suggests that the potential for impacts to aquatic vegetation and potential indirect effects on salmonids are likely to be restricted to only a few scenarios including accidental direct spraying.

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[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.

The actual food items of many aquatic invertebrates, however, are not leafy aquatic vegetation, but detritus or benthic algae. Should aquatic vegetation be 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 (i.e., reduction in biomass at the base of the food chain) on all organisms living in the waterbody, including salmonids. Few data are available for the herbicide toxicity to benthic algae. Of the algae data available for diflufenzopyr, the closest species to benthic algae is green algae (*Selenastrum capricornutum*). This species was used to derive the TRVs used in the ERA (0.1 and 0.0078 mg/L for EC_{50} and NOAEL data). Since the RQs for most scenarios were lower than the LOC using a TRV based on green algae, impacts to algae and attending secondary effects are unlikely.

As presented in Section 7.3.3.2, diflufenzopyr may be used alone by BLM or in a tank mix with imazapic (Lee 2004, personal communication.). However, none of the RQs for fish or aquatic invertebrates that were below their respective LOCs in the diflufenzopyr-only calculations increased to above their respective LOCs in the tank mix calculations. Use of diflufenzopyr in a tank mix with imazapic does appear to slightly increase risk to aquatic plants, particularly when exposed to runoff to ponds (not habitat for salmonids). In the stream, slight potential risk to aquatic plants is predicted for runoff of the diflufenzopyr-imazapic tank mix from clay soils receiving 250 inches of rain annually (Appendix E; acute RQ = 1.04 vs. LOC of 1). A separate ERA has been prepared to address potential risk due to Overdrive® which contains a mixture of diflufenzopyr with dicamba.

Based on an evaluation of the RQs calculated for this ERA, it is unlikely RTE fish, including salmonids, would be at risk from the indirect effects this herbicide applied alone or in a mix with imazapic. Exceptions to this include potential acute effects to aquatic life from accidental spills, an extreme and unlikely scenario considered in this ERA to add conservatism to the risk estimates. Appropriate and careful use of diflufenzopyr should preclude such an incident.

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 4.6.1); 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.

Based on the results of the ERA, there is potential risk to non-target terrestrial and aquatic plants in extreme circumstances, such as spills or accidental direct spray (Sections 4.3.1 and 4.3.5). However, under the majority of exposure scenarios, no apparent risk to non-target aquatic plants is predicted. Terrestrial plants may be at risk from runoff and drift under certain circumstances (e.g., drift closer than 25 ft or runoff from clay soils). Use of diflufenzopyr alone may cause slight potential risk to RTE species as a result of impacts to riparian vegetation and physical habitat. Land managers should consider the proximity of salmonid habitat to potential application areas. It

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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.

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. In addition, using a tank mix of diflufenzopyr and imazapic slightly increases the predicted risks to aquatic and terrestrial plants. However, for the majority of scenarios, risks to aquatic plants in the stream were not significantly elevated relative to the LOC with the tank mix.

6.5 Conclusions

The diflufenzopyr 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 diflufenzopyr use should be of primary concern for the protection of RTE 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 diflufenzopyr, especially when accidents occur, such as spills or accidental spraying. Fish (including RTE salmonids) and aquatic invertebrates in the stream will be indirectly via impacts to aquatic and riparian plants.

In a review of potential impacts of another terrestrial herbicide 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 2003). 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 2003).

Based on the results of the ERA, it is unlikely RTE salmoninds would be harmed by appropriate and responsible use of the herbicide diflufenzopyr on BLM-managed lands; however, there is certain risk to RTE plants, which could indirectly affect other RTE species, such as salmonids. 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 Diflufenzopyr TRVs

Species in Diflufenzopyr Laboratory/Toxicity Studies		Surrogate for
Honeybee	*Apis mellifera*	Pollinating insects
Rat	*Rattus norvegicus* spp.	Mammals
Dog	*Canis familiaris*	Mammals
Rabbit	*Leporidae sp*	Mammals
Mallard	*Anas platyrhynchos*	Birds
Bobwhite Quail	*Colinus virginianus*	Birds
Turnip	*Brassica rapa*	Non-target terrestrial plants
Tomato	*Lycopersicon esculentum*	Non-target terrestrial plants
Bluegill sunfish	*Lepomis macrochirus*	Fish
Daphnid	*Daphnia magna*	Aquatic invertebrates
Rainbow trout	*Oncorhynchus mykiss*	Fish/Salmonids
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 (northern)	*Haliaeetus leucocephalus alascanus*	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 marmoratus*	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
Steller'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 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 (i.e., home range = application area).
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	Fletcher et al. 1990
	3 of 20 EC_{50} values from field data were 2-fold higher than lab study data	
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 over-predicted 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) be 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).

Only one diflufenzopyr incident report was available from the USEPA's Environmental Fate and Effects Division (EFED). Incident reports can be used to validate both exposure models and hazards to ecological receptors. This report, described in Section 2.3, indicated that damage to corn plants might be partially a result of unintended exposure to diflufenzopyr, applied as part of a multiple pesticide mixture. Risk to non-target plants was predicted in the ERA as a result of accidental direct spray and off-site drift as a result of some ground applications. However, since the incident report provides limited information and diflufenzopyr was mixed with other products (i.e., atrazine, chlorpyrifos, dicamba, 2,4-D), it is impossible to correlate the impacts predicted in the ERA with the incident report.

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 rangeland plants occurring on BLM managed lands. According to the USEPA Fact Sheet for diflufenzopyr (USEPA 1999), turnips were the most sensitive dicot, so the use of turnip as a surrogate represents a very sensitive receptor. It is possible that rangeland and non-cropland plants and grasses are not as sensitive to diflufenzopyr as the selected surrogate plant species.

Toxicity data indicates that the product Overdrive®, which is the primary diflufenzopyr-containing product used by the BLM, is generally more toxic than diflufenzopyr alone. Overdrive® contains approximately 21.4% sodium salt of diflufenzopyr, 55% of a second a.i. (sodium salt of 3,6-dichloro-o-anisic acid, also referred to as dicamba), and 23.6% inert ingredients (BASF 1999). It is possible that toxicity observed in testing with Overdrive® was due to the second a.i. and not diflufenzopyr. Therefore, Overdrive® was excluded from the TRV derivation process in order to focus on the toxicity of diflufenzopyr as an a.i. A separate ERA has been prepared to address the potential risk due to Overdrive®.

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, two EC_{50}s were available for the aquatic invertebrates. These EC_{50}s were >130 mg a.i./L and 15 mg a.i./L, both for 48 hour daphnid studies. Accordingly, 15 mg a.i./L was selected as the aquatic invertebrate TRV, even though observed results were well above this value. A similar situation occurred for terrestrial plants with EC_{25}s ranging from 0.0008 lb a.i./ac to 0.38 lb a.i./ac. In general, this selection criterion for the TRVs has the potential to overestimate risk within the ERA. In some cases (i.e., fish, aquatic invertebrates), chronic data was unavailable and chronic TRVs were derived from acute toxicity data, adding an additional level of uncertainty.

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 2004c)[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 a.i. 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 a.i. 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.

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

For diflufenzopyr, the % a.i., listed in Appendix A when available from the reviewed study, ranged from 20% to 99.6%. The studies selected for TRV derivation generally contained at least 90% a.i., so adjusting the TRV to the % a.i. would result in only minimal RQ increases.

7.2 Potential Indirect Effects on Salmonids

No actual field studies or ecological incident reports on the indirect effects of diflufenzopyr 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. As described previously, salmonid species were included in the derivation of the fish TRVs. The acute fish TRV was based on a rainbow trout study, which reduces the uncertainty in the applicability of this evaluation to salmonid species. The chronic fish TRV was based on a warmwater species, the bluegill sunfish. The selected chronic TRV was five times higher than the rainbow trout chronic TRV, indicating that risks to salmonids may be overestimated. A discussion of 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 are not likely to be indirectly impacted by a reduction in food supply (i.e., fish and aquatic invertebrates). However, a reduction in vegetative cover may occur under limited conditions, and this loss of cover might impact salmonids.

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 Tank 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 pesticides 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 compare deterministic risk calculations (i.e., exposure modeling, effects assessment, and RQ calculations) for a single a.i.

In addition, information on inerts, adjuvants, surfactants, 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 from 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 diflufenzopyr. 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 resulting from 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 of acute toxicity values below 1 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 diflufenzopyr represents a source of uncertainty in the risk assessment.

7.3.2 Inerts

Pesticide products contain both active and inert ingredients. The terms “active ingredient” 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 Integrated Risk Information System [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 (MSDS) 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 diflufenzopyr: low application rates resulted in low exposure concentrations of inerts of much < 1 mg/L in all modeled cases. Thus, inerts associated with the application of diflufenzopyr are not predicted to occur at levels that would cause acute toxicity to aquatic life. However, given the lack of specific inert toxicity data, it is not possible to state that the inerts in diflufenzopyr would 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 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 or not a particular 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 the 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 is either 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 the particular herbicide.

In reviewing the labels for Distinct® and Overdrive® (BASF 1999; 2003), the following adjuvants were identified on the labels:

- Methylated seed oil or vegetable oil concentrates – used to aid in the deposition and uptake of the herbicide on hard-to-control perennials, waxy leaf species, or plants under moisture or temperature stress. A methylated vegetable-based seed oil concentrate may be used at a rate of 1.5 to 2 pints per acre with Overdrive®, but not Distinct®.

- Nonionic surfactants – used to aid in the surface activity of the applied herbicide. The Overdrive® label (BASF 2003) recommendation is 1 quart of an 80% active nonionic spray surfactant per 100 gal of water. The Distinct® label (BASF 1999) also indicates that the nonionic surfactant (at 1 quart in 100 gal of water) should be mixed with either urea ammonium nitrate at 1.25% v/v or spray grade ammonium sulfate at 8.5 to 17 lbs per 100 gal of spray solution as a nitrogen source.

- Agriculturally approved drift-reducing additives may be used.

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 maximum application rate recommended for diflufenzopyr (0.10 lb a.i./ac) and the application rate recommended for nonionic surfactants (0.25% v/v, based on 1 quart per 100 gal), the maximum predicted concentration of the inert/adjuvant compound would be 0.0001725 mg/L. This value is well below the chronic toxicity value for nonionic surfactants (0.1 mg/L) and even the range for behavioral and physiological effects (0.002 to 40.0 mg/L; Lewis 1991).

This evaluation indicates that adjuvants may not add significant 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 the 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

According to the labels, diflufenzopyr may be mixed with several other herbicides including: Paramount, Accent, glysophate, Arsenal, Garlon 3A, MSMA, Oust, Telar, Pendulum, Redeem, Tordon, Vista, Plateau, diuron, and Escort. However, it is not generally within BLM practice to tank mix diflufenzopyr 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 effective 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. 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 mix of diflufenzopyr (as an a.i. in the herbicide Overdrive®) and imazapic (as an a.i. in the herbicide Plateau). 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 diflufenzopyr applied alone and as a tank mix with imazapic is presented in Table 7-2. This comparison indicates that the tank mix does not result in more RQs above the associated LOCs for birds, mammals, fish, or invertebrates, than were predicted for diflufenzopyr alone. Elevated RQs are predicted for both aquatic and terrestrial plants when the tank mix is applied. For aquatic plants, the percentage of RQs exceeding the LOCs increased from 1.3% for diflufenzopyr alone to 8.9% when the tank mix was applied. For terrestrial plants, the percentage of RQs exceeding the LOCs increased from 5.2% to 6.0% for typical species and from 22.4% to 24.1% for RTE species. This suggests that plant species may be particularly sensitive to tank mixes and that additional precautions (e.g., increased buffer zones, decreased application rates) should be used when tank mixes are applied near these species. 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 be included in tank mixes and may contribute to the potential risk.

For this particular tank mix, dicamba (a principal ingredient in the Overdrive® herbicide) may also impact the toxicity of the tank mix. As described in Sections 3.2 and 7.1, the Overdrive® herbicide is generally more toxic than diflufenzopyr alone. A recent draft ERA prepared for the USDA Forest Service (SERA 2003) indicates that dicamba has the potential to impact several ecological receptors. The risk assessment evaluated acute/accidental exposures and longer-term exposures for terrestrial animals, aquatic species (fish, invertebrates, plants), and non-target terrestrial plants. Exposure scenarios included impacts due to ingestion of contaminated food, ingestion of contaminated water, accidental direct spray, offsite drift and surface runoff (not all receptors were evaluated in all exposure scenarios). The dicamba report (SERA 2003) demonstrates that risk characterization is highly dependant on the application rate (evaluated rates ranged from 0.3 to 2 lbs a.i./ac). However, even the lower, typical application rate resulted in risks to large mammals and non-target terrestrial plants. The higher application rate also resulted in risks to birds. However, the methods used in the dicamba report (SERA 2003) were less conservative than in this diflufenzopyr evaluation. For example, off-site drift to waterbodies was not considered for the aquatic species; the water concentrations (three for acute scenarios and three for chronic scenarios) were selected based on a review of GLEAMS modeling results and groundwater and surface water monitoring studies. This procedure may underestimate dicamba concentrations in the water. Most notably, the dicamba report did not use the USEPA OPP list of LOCs (see Section 4.2.2) to evaluate the RQs. The dicamba evaluation only considered predicted concentrations above the associated toxicity endpoint of concern, essentially using an LOC of 1. Additional risks due to dicamba would likely be predicted if the USEPA LOCs (aquatic LOCs are as low as 0.05 and wildlife LOCs are as low as 0.1) and additional modeling were incorporated into the evaluation. However, the dicamba risk assessment does indicate that risks due to dicamba would add to the diflufenzopyr risks for any tank mix using the Overdrive® herbicide. A separate ERA has also been prepared for Overdrive® as part of this EIS.

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 have increased potential for risk (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 U.S. 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 U.S. 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 loss rates 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 (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 U.S., 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 feet. 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 from 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 aerial 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.
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 prey 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.

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

Potential Source of Uncertainty	Direction of Effect	Justification
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.
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 bioavailability.
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.

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

Potential Source of Uncertainty	Direction of Effect	Justification
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.
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.

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

Potential Source of Uncertainty	Direction of Effect	Justification
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 food item populations on predatory receptors	Unknown	Adverse population effects to food 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 active ingredient has been investigated in the ERA. Inerts, adjuvants, and tank mixtures may increase or decrease the impacts of the active ingredient. 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	
		Diflufenzopyr RQs : Total RQs	Tank Mix RQs[1] : Total RQs	Diflufenzopyr	Tank Mix[1]
Terrestrial Animals					
Birds & Wild Mammals					
Acute High	0.50	0:118	0:118	0.0	0.0
Acute Restricted	0.20	0:118	0:118	0.0	0.0
Acute RTE	0.10	0:118	0:118	0.0	0.0
Chronic	1.00	0:10	0:10	0.0	0.0
Aquatic Receptors					
Fish & Invertebrates					
Acute High	0.50	0:394	0:394	0.0	0.0
Acute Restricted	0.10	0:394	0:394	0.0	0.0
Acute RTE	0.05	0:394	0:394	0.0	0.0
Chronic	1.00	0:392	0:392	0.0	0.0
Chronic RTE	0.50	0:392	0:392	0.0	0.0
Plants					
Acute High	1.00	5:393	35:393	1.3	8.9
Acute RTE	1.00	5:393	35:393	1.3	8.9
Terrestrial Plants					
Typical Species					
Acute High	1.00	6:116	7:116	5.2	6.0
Acute RTE	1.00	6:116	7:116	5.2	6.0
RTE Species					
Acute High	1.00	26:116	28:116	22.4	24.1
Acute RTE	1.00	26:116	28:116	22.4	24.1

RQ sums include RQs for both typical and maximum application rates.
(1) Tank mix with imazapic.

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%
Imazapic	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 diflufenzopyr, 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).

The following bullets further summarize the risk assessment findings for diflufenzopyr under these conditions:

- Direct Spray – Risk to non-target terrestrial and aquatic plants may occur when plants or waterbodies are accidentally sprayed. No risks were predicted for terrestrial wildlife, fish, or aquatic invertebrates.
- Off-Site Drift – Risk to typical non-target terrestrial plant may occur when herbicides are applied with a buffer zone of 25 ft or less, and risk to RTE terrestrial plant species may occur within 100 ft of the application area. No risks were predicted for aquatic plants, fish, aquatic invertebrates, or piscivorous birds.
- Surface Runoff – Risk to RTE terrestrial plant species may occur in selected watersheds (primarily with clay soils and at least 25 inches of precipitation per year). No risks were predicted for typical terrestrial plant species, aquatic plants, fish, invertebrates, or 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 non-target aquatic plants may occur when herbicides are spilled directly into the pond; no risks were predicted for fish or aquatic invertebrates.

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. For example, accidental direct spray, off-site drift, and surface runoff may negatively impact terrestrial plants in riparian zones, reducing the cover available to RTE salmonids within the stream.

Based on the results of the ERA, it is unlikely RTE species would be harmed by appropriate use of the herbicide diflufenzopyr on BLM-managed lands. Although non-target terrestrial and aquatic plants have the potential to be adversely affected by application of diflufenzopyr for the control of invasive plants, adherence to certain application guidelines (e.g., defined application rates, equipment, herbicide mixture, and downwind distance to potentially sensitive habitat) would minimize the potential effects on non-target plants and associated indirect effects on species that depend on those plants for food, habitat, and cover.

8.1 Recommendations

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

- Select herbicide products carefully to minimize additional impacts from degradates, adjuvants, inert ingredients, and tank mixtures. This is especially important for application scenarios that already predict potential risk from the a.i. itself. The herbicide product Overdrive®, which contains diflufenzopyr and dicamba, has been shown in some cases to be more toxic than diflufenzopyr alone.

- 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, rather than the maximum application rate, to reduce risk to non-target plants from off-site drift and surface runoff exposures.

- Because runoff to water bodies is most affected by precipitation, limit the application of diflufenzopyr during wet seasons or in high precipitation areas.

- Limit the use of diflufenzopyr within clay watersheds if annual precipitation is > 25 inches per year and impacts to RTE terrestrial plants are a concern.

- Establish the following buffer zones during ground applications to reduce potential impacts to non-target terrestrial plants due to off-site drift:

    - Application by low boom (spray boom height set at 20 inches above the ground) at the typical application rate – 100 ft from typical or RTE terrestrial plants.

    - Application by low boom at the maximum application rate – 100 ft from typical plant species and more than 100 ft from RTE terrestrial plant species (no risk at 900 ft).

    - Application by high boom (spray boom height set at 50 inches above the ground) – 100 ft from typical and more than 100 ft from RTE terrestrial plants (no risk at 900 ft).

- Consider the proximity of potential application areas to salmonid habitat and the possible effects of herbicides on riparian vegetation. Buffer zones of 100 ft would be necessary to protect riparian vegetation and prevent any associated indirect effects on salmonids.

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 diflufenzopyr 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 Diflufenzopyr 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 [16: 16]	0 [16: 16]	NA	NA	NA	NA	NA	NA
Terrestrial Plants (Typical Species)	M [1: 1]	H [1: 1]	0 [4: 6]	0 [4: 6]	0 [42: 42]	0 [42: 42]	0 [9: 9]	0 [9: 9]
Terrestrial Plants (RTE Species)	H [1: 1]	H [1: 1]	L [3: 6]	L [4: 6]	0 [34: 42]	0 [33: 42]	0 [9: 9]	0 [9: 9]
Fish In The Pond	0 [2: 2]	0 [3: 3]	0 [12: 12]	0 [12: 12]	0 [84: 84]	0 [84: 84]	NA	NA
Fish In The Stream	0 [2: 2]	0 [2: 2]	0 [12: 12]	0 [12: 12]	0 [84: 84]	0 [84: 84]	NA	NA
Aquatic Invertebrates In The Pond	0 [2: 2]	0 [3: 3]	0 [12: 12]	0 [12: 12]	0 [84: 84]	0 [84: 84]	NA	NA
Aquatic Invertebrates In The Stream	0 [2: 2]	0 [2: 2]	0 [12: 12]	0 [12: 12]	0 [84: 84]	0 [84: 84]	NA	NA
Aquatic Plants In The Pond	L [1: 2]	L [2: 3]	0 [12: 12]	0 [12: 12]	0 [84: 84]	0 [84: 84]	NA	NA
Aquatic Plants In The Stream	L [1: 2]	L [1: 2]	0 [12: 12]	0 [12: 12]	0 [84: 84]	0 [84: 84]	NA	NA
Piscivorous Bird	NA	NA	0 [6: 6]	0 [6: 6]	0 [42: 42]	0 [42: 42]	NA	NA

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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