Rimsulfuron Ecological Risk Assessment

Final

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EXECUTIVE SUMMARY

The United States Department of the Interior (USDOI) Bureau of Land Management (BLM) administers about 247.9 million acres in 17 western states in the continental United States (U.S.) and Alaska. 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 an area) 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.

In 2007, the BLM published the *Vegetation Treatments Using Herbicides on Bureau of Land Management Lands in 17 Western States Programmatic Environmental Impact Statement* (17-States PEIS). The Record of Decision (ROD) for the 17-States PEIS allowed the BLM to use 18 herbicide active ingredients available for a full range of vegetation treatments in 17 western states. In the ROD, the BLM also identified a protocol for identifying, evaluating, and using new herbicide active ingredients. Under the protocol, the BLM would not be allowed to use a new herbicide active ingredient until the agency 1) assessed the hazards and risks from using the new herbicide active ingredient, and 2) prepared an Environmental Impact Statement (EIS) under the National Environmental Policy Act to assess the impacts of using new herbicide active ingredient on the natural, cultural, and social environment. A final decision on whether a new active ingredient was approved would be recorded in the EIS ROD.

The BLM is proposing to use the active ingredient rimsulfuron to treat vegetation. This Ecological Risk Assessment (ERA) evaluates the potential risks to plants and animals from the use of the herbicide rimsulfuron, including risks to rare, threatened, and endangered (RTE) plant and animal species. Information from this ERA will be used to prepare the EIS.

Herbicide Description

Rimsulfuron is a sulfonylurea herbicide that works via inhibition of acetolactate synthase. Inhibition of the enzyme leads to rapid cessation of growth and visual symptoms such as chlorosis, necrosis, and leaf malformation and discoloration. These affects appear a few days after treatment in sensitive species (United States Environmental Protection Agency [USEPA]). The BLM is proposing to use rimsulfuron for vegetation control for its Rangeland, Public-Domain Forestland, Energy and Mineral Sites, Rights-of-Way (ROW), and Recreation programs. Herbicide application may be carried out through both aerial and ground dispersal. Aerial applications may be performed using airplanes and helicopters. Ground applications may be executed on foot or on horseback with backpack sprayers or from all-terrain vehicles, utility vehicles, or trucks equipped with spot or boom/broadcast sprayers. On rangeland and public-domain forestland, the BLM typically applies rimsulfuron at 0.0469 pounds (lbs.) active ingredient (a.i.) per acre (ac), with a maximum application rate of 0.0625 lbs. a.i./ac. Rimsulfuron is applied at the maximum application rate along ROW, on recreation areas, and at energy and mineral sites.

ERA Objectives and Methods

The main objectives of this ERA are to evaluate the potential risks to the health and welfare of non-target plants and animals and their habitats from use of rimsulfuron, and to provide risk managers with a range of generic risk estimates that vary as a function of site conditions. This ERA consists of the following steps based on guidance in the *Vegetation Treatments Programmatic EIS Ecological Risk Assessment Protocol Final Report* (Methods Document). The guidance was used in conducting analyses for the 18 herbicide active ingredients evaluated in the 17-States PEIS, and was developed by the BLM in cooperation with the USEPA, National Oceanic and Atmospheric Administration National Marine Fisheries Service, and USDOI U.S. Fish and Wildlife Service.

1. Exposure pathway evaluation – The effects of rimsulfuron on several ecological receptor groups (in other words [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 water body;
    - indirect contact with contaminated foliage;
    - ingestion of contaminated food items;
    - off-site drift of spray to terrestrial areas and water bodies;
    - surface runoff from the application area to off-site soils or water bodies;
    - wind erosion resulting in deposition of contaminated dust; and
    - accidental spills to water bodies.

2. 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 (for example [e.g.], soils, water). Some of these calculations required computer models:

    - AgDRIFT® was used to estimate off-site herbicide transport due to spray drift.
    - GLEAMS was used to estimate off-site transport of herbicide in surface runoff and root zone groundwater.
    - AERMOD and CALPUFF were used to predict the transport and deposition of herbicides sorbed to wind-blown dust.

3. 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 salmonids. Each of these endpoints was associated with measures of effect such as the no observed adverse effect level and the median lethal effect dose and concentration.

4. Development of a conceptual model – The purpose of the conceptual model was to display working hypotheses about how rimsulfuron might pose hazards to ecosystems and ecological receptors. These hypotheses are shown via a conceptual model 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 established by the USEPA Office of Pesticide Programs 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 rimsulfuron with other herbicides (pre-mixes or tank mixtures) or other potentially toxic ingredients (i.e., degradates, inert [other] ingredients, and added adjuvants), and the estimation of effects via exposure concentration models. The uncertainty inherent in screening level ERAs is especially problematic for the evaluation of risks to RTE species, which are afforded higher levels of protection through government regulations and policies. To attempt to minimize the chances of underestimating risk to RTE and other species, the lowest toxicity levels found in the literature were selected as TRVs, uncertainty factors were incorporated into these TRVs, allometric scaling was used to develop dose values, model assumptions were designed to conservatively estimate herbicide exposure, and indirect as well as direct effects on species of concern were evaluated.

Herbicide Effects

Literature Review

According to the Ecological Incident Information System database prepared by the USEPA OPP, rimsulfuron has been associated with 27 reported “ecological incidents” involving damage or mortality to non-target flora or fauna. In six of these 27 incidents, it was listed as probable (5 incidents) or highly probable (1 incident) that rimsulfuron was responsible for the given incident.

A review of the available ecotoxicological literature was conducted in order to evaluate the potential for rimsulfuron to negatively directly or indirectly affect non-target taxa. This review was also used to identify or derive TRVs for use in the ERA. Peer-reviewed literature was only used in this ERA if the study conformed to specific suitability parameters related to the test material, test species, exposure route, and toxicity endpoint as described in the Methods Document. Studies were excluded if they did not meet the requirements defined in the suitable study parameters.

The sources identified in this review indicate that rimsulfuron poses little to no acute toxicity hazard to mammals via dermal and oral exposure; however, adverse chronic effects to mammals have been documented from long-term dietary exposure to rimsulfuron. Rimsulfuron also has low toxicity to birds and honeybees. In contrast, non-target plants are highly susceptible to rimsulfuron toxicity. Concentrations of rimsulfuron as low as 0.00012 lb. a.i./ac have been shown to negatively affect the vigor of non-target terrestrial plants (about 0.3% of the typical application rate). Rimsulfuron is highly toxic to aquatic plants. Aquatic macrophytes were adversely affected by concentrations as low as 0.012 parts per million. Compared to aquatic macrophytes, freshwater algae were more tolerant of rimsulfuron. No toxicity studies conducted on amphibian species were found in the literature.

ERA Results

Based on the ERA, rimsulfuron presents a potential risk to ecological receptors on BLM-administered lands under specific exposure scenarios. The following summarizes the risk assessment findings for rimsulfuron under these conditions:

1. Direct Spray – The ERA predicted risks to terrestrial and aquatic non-target plants under scenarios in which plants or water bodies are accidentally sprayed at the typical or maximum application rate. No risks were predicted for terrestrial wildlife, fish, or aquatic invertebrates.

2. Off-site Drift – The ERA predicted risks due to off-site drift for non-target terrestrial and aquatic plants. However, no risks were predicted for fish, aquatic invertebrates, or piscivorous birds in ponds or streams. The ERAs evaluated risks from off-site drift at modeled distances of 25, 100, and 900 feet (ft.) from the application site for ground applications, and at distances of 100, 300, and 900 ft. for aerial applications. The Recommendations section provides buffers for protecting non-target plants, which were extrapolated from the modeling results.

    a. The ERA predicted risks to non-target terrestrial plants (typical and RTE species) from plane applications of rimsulfuron at the largest modeled distance (900 ft.]) in forested and non-forested areas at either the typical or maximum application rate. The ERA predicted risks at 100 ft. for helicopter applications in forested areas, and at 900 ft. in non-forested areas, at both the typical or maximum application rates. The ERA predicted risks to non-target plants at 25 ft. for applications from a low boom at the typical application rate, and at 100 ft. for applications at the maximum application rate. Risks were also predicted for applications from a high boom at 100 ft., for both the typical and maximum application rates.

b. The ERA did not predict acute risks to non-target aquatic plants in ponds. The ERA predicted chronic risks to non-target aquatic plants in ponds from plane applications at the largest modeled distance (900 ft.), in forested and non-forested areas, at both the typical and maximum application rates. For helicopter application scenarios, the ERA predicted risks to aquatic plants in a forested area at 100 ft., and at 900 ft. in a non-forested area, at both the typical or maximum application rate. For applications of rimsulfuron at the typical application rate from the ground with a low or high boom, risks to aquatic plants at a distance of 25 ft. from the application area were predicted. For applications at the maximum rate from the ground with a high boom risks were predicted for aquatic plants at 100 ft. for applications at the maximum rate and at 25 ft. for applications at the typical rate.

c. The ERA did not predict acute risks to non-target aquatic plants in streams. The ERA predicted chronic risks to non-target aquatic plants in a stream at the largest modeled distance (900 ft.) under plane application scenarios in forested and non-forested areas, at both the typical and maximum application rates. For helicopter applications of rimsulfuron at the typical and maximum application rate, the ERA predicted risks to aquatic plants in forested areas at a distance of 100 ft. from the application area, and in non-forested areas at 900 ft. For ground application scenarios with a low boom, aquatic plants 25 ft. from the application area would be at risk for adverse effects as a result of applications of rimsulfuron at the typical or maximum application rate. For ground application scenarios with a high boom, aquatic plants at 25 ft. would be at risk for adverse effects as a result of applications at the typical rate, and aquatic plants at 100 ft. would be at risk for adverse effects as a result of applications at the maximum rate.

3. Surface Runoff – The ERA predicted chronic risks to non-target aquatic plants in the pond when rimsulfuron applications occur in watersheds with sandy soils and at least 25 inches of precipitation per year (RQs ranged up to 6.5 at the typical application rate and up to 8.6 at the maximum application rate), in clay or clay/loam watersheds with at least 100 inches of precipitation per year (RQs ranged up to 3.3 at the typical application rate and up to 4.4 at the maximum application rate), and in loam watersheds with at least 50 inches of precipitation per year (RQs ranged up to 2.9 at the typical application rate and up to 3.8 at the maximum application rate). However, no acute risks were predicted for non-target aquatic plants in a pond. The ERA predicted no risk for adverse effects to non-target terrestrial plants, non-target aquatic plants in a stream, fish, aquatic invertebrates, or piscivorous birds as a result of surface runoff of rimsulfuron.

4. Wind Erosion and Transport Off-site – The ERA predicted that non-target terrestrial plants (typical and RTE) would not be at risk for adverse impacts under the majority of the modeled wind erosion and transport scenarios. However, minimal risks (RQs up to 1.5) from wind erosion were predicted for non-target terrestrial plants at a distance of up to 1.5 kilometers (0.9 miles) from the application area in a watershed modeled based on conditions in Medford, Oregon.

5. Accidental Spill to Pond– The ERA predicted risks to non-target aquatic plants under a scenario of a spill of rimsulfuron directly into a pond. However, the ERA predicted no risks to fish or aquatic invertebrates under this scenario.

No direct risks to RTE fish species (e.g., salmonids) were predicted in the modeling and salmonids are not likely to be indirectly impacted by a reduction in food supply (i.e., fish and aquatic invertebrates). However, 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 and aquatic plants, reducing the cover available to RTE salmonids within a stream.

Based on the results of the ERA, it is unlikely that RTE species would be harmed by appropriate and selective use of the herbicide rimsulfuron on BLM-administered lands. Although non-target terrestrial and aquatic plants have the potential to be adversely affected by application of rimsulfuron, adherence to specific 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, such as salmonids, 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 rimsulfuron:

1. 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 active ingredient alone.
2. Review, understand, and conform to the "Environmental Hazards" section on the 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 and their environment.
3. Avoid accidental direct spray and spill conditions to reduce the most significant potential impacts.
4. Use the typical application rate, rather than the maximum application rate, to reduce risk for exposure via off-site drift (drift to soils, streams, or ponds) and surface runoff (runoff to downgradient pond).
5. If impacts to typical or RTE terrestrial plants are of concern and an aerial application is planned using the maximum application rate, establish the following buffer zones to reduce off-site drift and potential risks to terrestrial plants[1]:
   - Application by plane over forest – 1,700 ft.
   - Application by plane over non-forested land – 1,900 ft.
   - Application by helicopter over forest – approximately 300 ft. (no risks were predicted at 300 ft).
   - Application by helicopter over non-forested land – 1,600 ft.
6. If impacts to typical or RTE terrestrial plants are of concern and an aerial application is planned using the typical application rate, establish the following buffer zones to reduce off-site drift and potential risks to terrestrial plants:
   - Application by plane over forest – 1,600 ft.
   - Application by plane over non-forested land – 1,600 ft.
   - Application by helicopter over forest – approximately 300 ft. (no risks were predicted at 300 ft.).
   - Application by helicopter over non-forested land – 1,400 ft.

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[1] Note: Buffer distances provided in this section were obtained by plotting the RQs against the modeled distances, fitting a curve to the data, and then determining the distance at which the RQ was equivalent to an LOC of 1 for terrestrial plants (with an RQ based on a no observed adverse effect level for RTE species and the 25% effect concentration [EC_{25}] for typical species). The curve was extended beyond the largest modeled distance to extrapolate buffers beyond 900 feet.

7. If a ground application is planned at the maximum application rate, establish a buffer zone of 400 ft. for application with a low boom and 650 ft. for applications with a high boom to reduce off-site drift and potential risks to typical or RTE terrestrial plants. If a ground application is planned at the typical application rate, establish a buffer zone of 100 ft. for application with a low boom and 400 ft. for applications with a high boom to reduce off-site drift and potential risks to typical or RTE terrestrial plants.

8. If use of the maximum application rate is required, establish the following buffer zones during aerial and ground applications to reduce off-site drift to water bodies and potential risks to aquatic plants:

    - Application by plane over forest – 1,400 ft. from ponds and streams.
    - Application by plane over non-forested land – 1,350 ft. from ponds and streams.
    - Application by helicopter over forest – 200 ft. from ponds and 250 ft. from streams.
    - Application by helicopter over non-forested land – 1,800 ft. from ponds and 1,100 ft. from streams.
    - Application from ground by low boom – approximately 100 ft. from ponds and streams (no risks were predicted at 100 ft.).
    - Application from ground by high boom – 300 ft. from ponds and streams.

9. Consider the proximity of potential application areas to salmonid habitat and the possible effects of herbicide application on riparian vegetation. Use the preceding guidance for buffer distances to protect typical or RTE plants to protect riparian vegetation (including RTE plants) and prevent any associated indirect effects on salmonids and their habitat.

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LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

2,4-D - 2,4-dichlorophenoxyacetic acid
ac - Acres
a.i. - Active ingredient
ALS - Acetolactate synthase
Atm - Atmosphere
ATV - All-terrain Vehicle
BLM - Bureau of Land Management
BW - Body Weight
°C - Degrees Celsius
Cal EPA - California Environmental Protection Agency
CFR - Code of Federal Regulations
CM - Conceptual Model
cm - Centimeters
cms - Cubic meters per second
EC_{05} - Concentration causing 5% inhibition of a process (Effect Concentration)
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
e.g. - For example
EI - Erosion Index
EIS - Environmental Impact Statement
EIIS - Ecological Incident Information System
ERA - Ecological Risk Assessment
ESA - Endangered Species Act
F1 - First Generation
FIFRA - Federal Insecticide, Fungicide and Rodenticide Act
ft. - Feet
g - Grams
GLEAMS - Groundwater Loading Effects of Agricultural Management Systems
i.e. - that is
Kd - Partition coefficient
kg - Kilograms
km - Kilometers
K_{oc} - Organic carbon partition coefficient
K_{ow} - Octanol-water partition coefficient
L - Liter
lb. - Pound
LC50 - Concentration causing 50% mortality (Median Lethal Concentration)
LD50 - Dose causing 50% mortality (Median Lethal Dose)
LOAEL - Lowest Observed Adverse Effect Level
LOC - Level of Concern
Log - Common logarithm (base 10)
m - Meters
mg - Milligram
mg/kg - Milligrams per Kilogram

LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS (continued)

mg/L - Milligrams per Liter
MRID - Master Record Identification Number
n - Sample size
NA - Not applicable
NEPA - National Environmental Policy Act
NMFS National Marine Fisheries Service
NOAA - National Oceanic and Atmospheric Administration
NOAEL - No Observed Adverse Effect Level
NR - Not Reported
NYSDEC - New York State Department of Environmental Conservation
OPP - Office of Pesticide Programs
PEIS - Programmatic Environmental Impact Statement
PPDB Pesticide Properties Database
ppm Parts per million
ROD - Record of Decision
ROW Rights-of-Way
RQ - Risk Quotient
RTE - Rare, Threatened, and Endangered
SDTF - Spray Drift Task Force
TP - Transformation Product
TRV - Toxicity Reference Value
U.S. - United States
USDOI - United States Department of Interior
USEPA - United States Environmental Protection Agency
USFWS - United States Fish and Wildlife Service
USLE - Universal Soil Loss Equation
µg - micrograms
UTV - Utility Vehicle
yr. - year
> - greater than
< - less than
= - equal to

1.0 INTRODUCTION

The United States Department of the Interior (USDOI) Bureau of Land Management (BLM) administers about 247.9 million acres in 17 western states in the continental United States (U.S.) and Alaska. 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 an area) 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.

1.1 Background

In 2007, the BLM published the *Vegetation Treatments Using Herbicides on Bureau of Land Management Lands in 17 Western States Programmatic Environmental Impact Statement* (17-States PEIS; USDOI BLM 2007a). The Record of Decision (ROD) for the 17-States PEIS allowed the BLM to use 18 herbicide active ingredients available for a full range of vegetation treatments in 17 western states (USDOI BLM 2007b). In the ROD, the BLM also identified a protocol for identifying, evaluating, and using new herbicide active ingredients (see Appendix A of the ROD). Under the protocol, the BLM would not be allowed to use a new herbicide active ingredient until 1) the agency assessed the hazards and risks from using the new herbicide active ingredient, and 2) prepared an Environmental Impact Statement (EIS) under the National Environmental Policy Act (NEPA) to assess the impacts of using the new herbicide active ingredient on the natural, cultural, and social environment. A final decision on whether a new active ingredient was approved would be recorded in the EIS ROD.

This Ecological Risk Assessment (ERA) evaluates the potential risks to plants and animals from the use of the herbicide rimsulfuron, including risks to rare, threatened, and endangered (RTE) plant and animal species. Information from this ERA will be used to prepare the EIS. Analysis used in this ERA is based on guidance in the *Vegetation Treatments Programmatic EIS Ecological Risk Assessment Protocol Final Report* (Methods Document; ENSR 2004). The guidance was used in conducting analyses for the 18 herbicide active ingredients evaluated in the 17-States PEIS, and was developed by the BLM in cooperation with the U.S. Environmental Protection Agency (USEPA), National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS), and USDOI U.S. Fish and Wildlife Service (USFWS).Objectives of the Ecological Risk Assessment

The purpose of this ERA is to evaluate the ecological risks of rimsulfuron on the health and welfare of plants and animals and their habitats, including federally listed threatened and endangered species. The BLM will use this analysis to prepare the EIS and a Biological Assessment. The USFWS and NMFS will use this information to prepare their Biological Opinions on the risks of using rimsulfuron to RTE species and their critical habitats. This ERA contains the following sections:

Section 1: Introduction.

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

Section 3: Herbicide Toxicology, Physical-chemical Properties, and Environmental Fate – This section contains a summary of scientific literature pertaining to the toxicology and the environmental fate of rimsulfuron 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 the three ERA models to specific input parameters. The importance of these conditions to exposure concentration estimates is discussed.

Section 6: Rare, Threatened, and Endangered Species – 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

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

- destroy wildlife habitat;
- displace RTE species and other species critical to ecosystem functioning (for example [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;
- reduce opportunities for hunting, fishing, camping and other recreational activities;
- increase fuel loads and decrease the length of fire cycles and/or increase the intensity of fires;
- cost millions of dollars in treatment and loss of productivity to private land owners.

The BLM's ability to respond effectively to the challenge of noxious weeds and other invasive plants depends on the adequacy of the agency's resources. The BLM uses an Integrated Pest Management approach to manage invasive plants. Management techniques include biological, mechanical, manual, chemical, or cultural. Eighteen herbicide active ingredients are currently used by the BLM to manage vegetation under their chemical control program. The BLM is proposing to add rimsulfuron to the list of active ingredients that are available for agency use. This report considers the impact to ecological receptors (animals and plants) from the use of the herbicide rimsulfuron for the management of vegetation on BLM-administered lands.

2.2 Overview of the BLM Vegetation Treatment Program

This section identifies the land programs, application types, application vehicles, and application methods for herbicide use in the BLM vegetation treatment program.

2.2.1 Land Programs

The BLM vegetation treatment program covers six land types or programs:

- Rangeland
- Public-domain Forestland

- Energy and Mineral Sites
- Rights-of-way
- Recreation and Cultural Sites
- Aquatic Sites

Herbicides are used in rangeland improvement and silvicultural practice to improve the potential for success of desired vegetation by reducing competition for light, moisture, and soil nutrients with less desirable plant species. Herbicides are used to manage or restrict noxious plant species and to suppress vegetation that interferes with man-made structures or transportation corridors.

Herbicides are a component of the BLM's integrated weed management program, and are used in varying degrees in all land treatment categories. Herbicide use under the six land programs is discussed below.

2.2.1.1 Rangeland

Rangeland vegetation treatment operations provide forage for domestic livestock and wildlife by removing undesirable competing plant species and preparing seedbeds for desirable plants. Approximately 89% of the herbicide treated acreage in the BLM vegetation treatment program falls in the rangeland improvement category. Proposed application methods include airplane, helicopter, truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), and backpack (spot applications).

2.2.1.2 Public-domain Forestland

Public-domain forestland vegetation treatment operations, designed to ensure the establishment and healthy growth of timber crop species, are one of the BLM's least extensive programs for herbicide treatment. These operations include site preparation, plantation, maintenance, conifer release, pre-commercial thinning, and non-commercial tree removal. Site preparation treatments prepare newly harvested or inadequately stocked areas for planting new tree crops. Herbicides used in site preparation reduce vegetation that competes with conifers. In the brown-and-burn method of site preparation, herbicides are used to dry the vegetation, to be burned several months later. Herbicides are used in plantations after planting to promote the dominance and growth of already established conifers (release). Pre-commercial thinning reduces competition among conifers, thereby improving the growth rate of desirable crop trees. Non-commercial tree removal is used to eliminate dwarf mistletoe infested host trees. These latter two silvicultural practices primarily use manual applications methods. Herbicide uses in public-domain forests constitute less than 4% of the vegetation treatment operations in the BLM program. Proposed application methods include airplane, helicopter, truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), and backpack (spot applications).

2.2.1.3 Energy and Mineral Sites

Vegetation treatments in energy and mineral sites include the preparation and regular maintenance of areas for use as fire control lines or fuel breaks, and the reduction of plant species that could pose a hazard to fire control operations. More than 50% of the vegetation treatment programs at energy and mineral sites are herbicide applications. Proposed application methods include airplane, helicopter, truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), and backpack (spot applications).

2.2.1.4 Rights-of-way

Right-of-way treatments include roadside maintenance and maintenance of power transmission lines, waterways, and railroad corridors. In roadside maintenance, vegetation in ditches and on road shoulders is removed or reduced to prevent brush encroachment into driving lanes, to maintain visibility on curves for the safety of vehicle operators, to permit drainage structures to function as intended, and to facilitate maintenance operations. Herbicides have been used in nearly 50% of the BLM's roadside vegetation maintenance programs. Proposed application methods include airplane, helicopter, truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), and backpack (spot applications).

2.2.1.5 Recreation and Cultural Sites

Recreation and cultural site maintenance operations provide for the safe and efficient use of BLM facilities and recreation sites and for permittee/grantee uses of public amenities, such as, ski runs, waterways, and utility terminals. Vegetation treatments are made for the general maintenance and visual appearance of the areas and to reduce potential threats to the site's plants and wildlife, as well as to the health and welfare of visitors. The site maintenance program includes the noxious weed and poisonous plant program. Vegetation treatments in these areas are also done for fire management purposes. The BLM uses herbicides on approximately one-third of the total recreation site acreage identified as needing regular treatment operations. Proposed application methods include airplane, helicopter, truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), and backpack (spot applications).

2.2.2 Application Methods

The BLM conducts pretreatment surveys in accordance with BLM Handbook H-9011-1 (*Chemical Pest Control*) before making a decision to use herbicides on a specific land area. The herbicides can be applied by via airplane, helicopter, boat (boom/broadcast or spot applications), truck (boom/broadcast or spot applications), ATV/UTV (boom/broadcast or spot applications), horseback (spot applications), and backpack (spot applications) with the selected technique dependent upon the following variables:

- Treatment objective (removal or reduction)
- Accessibility, topography, and size of the treatment area
- Characteristics of the target species and the desired vegetation
- Location of sensitive areas in the immediate vicinity (potential environmental impacts)
- Anticipated costs and equipment limitations
- Meteorological and vegetative conditions of the treatment area at the time of treatment

Herbicide applications are scheduled and designed such that potential impacts to non-target plants and animals are minimized, while the objectives of the vegetation treatment program are kept consistent. Herbicides are applied from either the air or ground. The herbicide formulations may be in a liquid or granular form, depending on resources and program objectives. Aerial methods employ boom-mounted nozzles for liquid formulations or rotary broadcasters for granular formulations, carried by helicopters or airplanes. Ground application methods include vehicle- and boat-mounted, backpack, and horseback application techniques. Vehicle- and boat-mounted application systems use fixed-boom or hand-held spray nozzles mounted on trucks or ATVs/UTVs. Backpack systems use a pressurized sprayer to apply an herbicide as a broadcast spray directly to one or a group of individual plants.

2.2.2.1 Aerial Application Methods

Aerial application can be conducted by airplane (fixed-wing aircraft) or helicopter (rotary-wing aircraft). Between 2006 and 2011, the BLM treated 73% of its herbicide treatment sites by air. Helicopters are preferred on rangeland projects because the treatment units are numerous, far apart, and often small and irregularly shaped.

The size and type of these aircraft may vary, but the equipment used to apply the herbicides must meet specific guidelines. Contractor-operated helicopters or fixed-wing aircraft are equipped with an herbicide tank or bin (depending on whether the herbicide is a liquid or granular formulation). For aerial spraying, the aircraft is equipped with cylindrical jet-producing nozzles no less than 1/8 inch in diameter. The nozzles are directed with the slipstream, at a maximum of 45 degrees downward for fixed-wing applications, or up to 75 degrees downward for helicopter applications, depending on the flight speed. Nozzle size and pressure are designed to produce droplets with a diameter of 200 to 400 microns. For fixed-wing aircraft, the spray boom is typically ¾ of the wingspan, and for helicopters, the spray boom is often ¾ of the rotor diameter. All spray systems must have a positive liquid shut-off device that ensures that no herbicide continues to drip from the boom once the pilot has completed a swath (i.e., specific spray path). The nozzles are spaced to produce a uniform pattern for the length of the boom.

Using helicopters for herbicide application is often more expensive than using fixed-wing aircraft, but helicopters offer greater versatility. Helicopters are well adapted to areas dominated by irregular terrain and long, narrow, and irregularly shaped land patterns, a common characteristic of public lands. Various helicopter aircraft types are used, including, Bell, Sikorsky, and Hiller models. These helicopters must be capable of accommodating the spray equipment and the herbicide tank or bin, and of maintaining an air speed of 40 to 50 miles per hour at a height of 20 to 45 feet above the vegetation (depending upon the desired application rate), and they must meet BLM safety performance standards.

Fixed-wing aircraft include the typical, small “cropduster” type aircraft. Fixed-wing aircraft are best suited for smoother terrain and larger tracts of land where abrupt turning is not required. Because the fixed-wing aircraft spraying operations are used for treating larger land areas, the cost per acre is generally lower than that of helicopter spraying. Aircraft capability requirements for fixed-wing aircraft are similar to helicopter requirements, except that an air speed of 100 to 120 miles per hour is necessary, with spraying heights of 10 to 40 feet generally used to produce the desired application rates.

Batch trucks are an integral part of any aerial application operation. They serve as mixing tanks for preparing the correct proportions of herbicide and carrier, and they move with the operation when different landing areas are required.

The number of workers involved in a typical aerial spray project varies according to the type of activity. A small operation may require up to six individuals, while a complex operation may require as many as 20 to 35 workers. An aerial operations crew for range management, noxious weed management, and ROW maintenance usually consists of five to eight individuals. Typically, personnel on a large project include a pilot, a mixer/loader, who is responsible for mixing the herbicide and loading it to the tank, a contracting officer’s representative, an observer-inspector, a one- to six-member flagging crew, one or two law enforcement officers, one or two water monitors, and one or two laborers. Optional personnel include an air operations officer, a radio technician, a weather monitor, and a recorder. Workers evaluated in the HHRA for aerial applications include a pilot and a mixer/loader, as these are the receptors most likely to be exposed to herbicides. Other personnel are expected to have less or similar herbicide exposure.

2.2.2.2 Ground Application Methods

There are two types of ground application methods: human application methods (backpack and horseback) and vehicle application, which includes ATV/UTV-based application methods (spot-treatment or boom/broadcast treatment), and truck-mounted application methods (spot-treatment or boom/broadcast treatment). These are described in greater detail below.

Human Application Methods - Humans may apply herbicides by backpack or on horseback. The backpack method requires the use of a backpack spray tank for carrying the herbicide, with a handgun applicator with a single nozzle for herbicide application. Backpack and horseback spraying techniques are best adapted for very small scale applications in isolated spots and areas not accessible by vehicle. These methods are primarily used for spot treatments around signposts, spraying competing trees in public-domain forestland, delineators, power poles, scattered noxious weeds, and other areas that require selective spraying.

Backpack treatment is the predominant ground-based method for silviculture and range management. The principle hand application techniques are injection and stump treatment. Injection involves applying an herbicide with a hand-held container or injector through slits cut into the stems of target plants. Individual stem treatment by the injection method is also used for thinning crop trees or removing the undesirable trees. Stump treatment entails applying liquid herbicide directly to the cut stump of the target plant to inhibit sprouting. An herbicide can be applied by dabbing or painting the exposed cambium of a stump, or by using a squeeze bottle on a freshly cut cambium surface. Along with liquid formulations, certain active ingredients are formulated in a granular form that allows for direct application to the soil surface. Pressurized backpack treatment operations typically involve a supervisor (who may also function as a mixer/loader), an inspector, a monitor, and 2 to 12 crew members. The receptor evaluated in this risk assessment for both backpack and horseback treatments is a combined applicator/mixer/loader, because these treatments are small in scale and it is likely that the same worker would mix the herbicide as well as load and apply the herbicide.

Vehicle Application Methods - Ground-based herbicide spray treatments involve use of a truck or an ATV/UTV. A vehicle application is made using a boom with several spray nozzles (boom/broadcast treatment) or a handgun with a single nozzle (spot treatment). Ground vehicle spray equipment can be mounted on ATVs/UTVs or trucks. Because of their small size and agility, the ATVs/UTVs can be adapted to many different situations.

The boom spray equipment used for vehicle operations is designed to spray wide strips of land where the vegetation does not normally exceed 18 inches in height and the terrain is generally smooth and free of deep gullies. Ground spraying from vehicles occurs along highway rights-of-way, energy and mineral sites, public-domain forestlands, and rangeland sites.

Spot-gun spraying is best adapted for spraying small, scattered plots. It may also be used to spray signposts and delineators within highway rights-of-way, and around wooden power lines as a means of reducing fire hazards within power line rights-of-way. This technique is also used to treat scattered noxious weeds, but it is limited to areas that are accessible by vehicles.

Right-of-way maintenance projects frequently use vehicle-mounted application techniques. A truck with a mixing/holding tank uses a front mounted spray boom or a hand-held pressurized nozzle to treat roadside vegetation on varying slopes. However, using this equipment for off-road ROW projects is limited to gentle slopes (less than 20%) and open terrain. Workers typically involved include a driver/mixer/loader and an applicator. Therefore, receptors evaluated in this HHRA include an applicator, a mixer/loader, and a combined applicator/mixer/loader. The applicator receptor is evaluated both separately and combined with the mixer/loader receptor to cover both smaller scale operations conducted by one person as well as larger scale operations where more workers are involved.

2.3 Herbicide Description

Rimsulfuron is a sulfonylurea herbicide that works via inhibition of acetolactate synthase (ALS). Inhibition of the enzyme leads to rapid cessation of growth and visual symptoms such as chlorosis, necrosis, leaf malformation and discoloration. These effects appear a few days after treatment in sensitive species (USEPA 2007). Formulations of rimsulfuron include dry flowable and water soluble granules.

Rimsulfuron is proposed for use by the BLM's Rangeland, Public-Domain Forestland, Energy and Mineral Sites, ROW, and Recreation programs. It is not currently approved by the USEPA for aquatic applications. Rangeland applications are carried out through aerial and ground dispersal. Aerial applications are conducted using airplanes and helicopters. Ground applications are conducted on foot or on horseback with backpack sprayers or from ATVs, utility vehicles, or trucks equipped with spot or boom/broadcast sprayers. The BLM would typically apply rimsulfuron at 0.0469 pounds (lbs.) active ingredient (a.i.) per acre (ac), with a maximum application rate of 0.0625 lbs. a.i./ac. Details about proposed rimsulfuron application rates and methods of application are provided in Table 2-1 at the end of this section. As indicated on Table 2-1, a single application rate of 0.0625 lbs. a.i./ac is used for applications on Energy and Mineral Sites, along ROW, and in Recreation areas. For these use areas, the single application rate of 0.0625 lbs. a.i./ac represents the maximum application rate of rimsulfuron.

The herbicide-specific use criteria discussed in this document were obtained from the rimsulfuron product label (as registered with the USEPA) as it applies to the proposed BLM use. Rimsulfuron application rates and methods discussed in this section are based on proposed BLM herbicide use and are in accordance with product 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.

2.4 Herbicide Incident Reports

An “ecological incident” occurs when non-target flora or fauna are 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 Office of Pesticide Programs (OPP) manages a database, the Ecological Incident Information System (EIIS), which contains much of the information provided in the ecological incident reports. As part of this ERA, all available EIIS incident reports listing rimsulfuron as a potential source of the observed ecological damage were obtained.

A total of 27 EIIS incident reports involved rimsulfuron. Of the 27 incidents, in only one was it determined “highly probable” that rimsulfuron caused the observed damage. This incident involved the misuse of the herbicide over a total acreage of 110 acres in Illinois. Rimsulfuron was listed as the “probable” cause in 5 EIIS incidents, a “possible” cause in 11 incidents, and an “unlikely” cause in 10 incidents. A summary of these incidents as reported in the EIIS is provided in Table 2-2.

TABLE 2-1

BLM Rimsulfuron Use Statistics

					Application Rate	
Program	**Scenario**	**Vehicle**	**Method**	**Proposed for Use**	**Typical (lbs. a.i./ac)**	**Maximum (lbs. a.i./ac)**
Rangeland	Aerial	Plane	Fixed Wing	Yes	0.0469	0.0625
		Helicopter	Rotary	Yes	0.0469	0.0625
	Ground	Human	Backpack	Yes	0.0469	0.0625
			Horseback	Yes	0.0469	0.0625
		ATV/UTV	Spot	Yes	0.0469	0.0625
			Boom/Broadcast	Yes	0.0469	0.0625
		Truck	Spot	Yes	0.0469	0.0625
			Boom/Broadcast	Yes	0.0469	0.0625
Public-Domain Forestland	Aerial	Plane	Fixed Wing	Yes	0.0469	0.0625
		Helicopter	Rotary	Yes	0.0469	0.0625
	Ground	Human	Backpack	Yes	0.0469	0.0625
			Horseback	Yes	0.0469	0.0625
		ATV/UTV	Spot	Yes	0.0469	0.0625
			Boom/Broadcast	Yes	0.0469	0.0625
		Truck	Spot	Yes	0.0469	0.0625
			Boom/Broadcast	Yes	0.0469	0.0625
Energy and Mineral Sites	Aerial	Plane	Fixed Wing	Yes	0.0625	0.0625
		Helicopter	Rotary	Yes	0.0625	0.0625
	Ground	Human	Backpack	Yes	0.0625	0.0625
			Horseback	Yes	0.0625	0.0625
		ATV/UTV	Spot	Yes	0.0625	0.0625
			Boom/Broadcast	Yes	0.0625	0.0625
		Truck	Spot	Yes	0.0625	0.0625
			Boom/Broadcast	Yes	0.0625	0.0625
Rights-of-Way	Aerial	Plane	Fixed Wing	Yes	0.0625	0.0625
		Helicopter	Rotary	Yes	0.0625	0.0625
	Ground	Human	Backpack	Yes	0.0625	0.0625
			Horseback	Yes	0.0625	0.0625
		ATV/UTV	Spot	Yes	0.0625	0.0625
			Boom/Broadcast	Yes	0.0625	0.0625
		Truck	Spot	Yes	0.0625	0.0625
			Boom/Broadcast	Yes	0.0625	0.0625
Recreation	Aerial	Plane	Fixed Wing	Yes	0.0625	0.0625
		Helicopter	Rotary	Yes	0.0625	0.0625
	Ground	Human	Backpack	Yes	0.0625	0.0625
			Horseback	Yes	0.0625	0.0625
		ATV/UTV	Spot	Yes	0.0625	0.0625
			Boom/Broadcast	Yes	0.0625	0.0625
		Truck	Spot	Yes	0.0625	0.0625
			Boom/Broadcast	Yes	0.0625	0.0625
Aquatic				No		

Application rates provided by the BLM.
ac = acres.
a.e. = acid equivalent.
ATV/UTV = All-terrain vehicle/utility vehicle.
lbs. = pounds.

TABLE 2-2

Rimsulfuron Incident Report Summary

Incident #	Date	County	State	Certainty	Legal	Form	Application Method	Total Magnitude
PLANTS								
Agricultural area								
I021276-003		Grant	WA	3	U			
Corn								
I010927-044	5/5/2000	La Porte	IN	1	RU	N/R	N/R	50 acres
I010927-001	5/5/2000	Dubuque	IA	2	RU	N/R	Soil incorporation	All
I015643-001	5/1/2003	Howard	IN	2	U	G	N/R	1
I016296-001	5/16/2005	Knox	IN	2	RU	G	Spray	Small
I016813-001	6/4/2005	Grundy	IL	1	RU	WSP	Spray	80 acres corn
I016928-001	6/27/2005		NE	1	RU	WSP	Spray	75 acres
I016906-001	7/15/2005	Tippecanoe	IN	1	RU	WSP	Spray	100 acres
I016905-001	7/27/2005	Hendricks	IN	1	RU	WSP	Spray	65 acres
I016904-001	8/1/2005	Barnes	ND	1	RU	WSP	Spray	150 acres
I016941-001	8/9/2005	Wilkin	MN	1	RU	WSP		187 acres
Corn field								
I013636-025	4/23/2001	Dyer	TN	2	RU		Broadcast	80 acres
I013636-038	5/15/2002	Macoupin	IL	4	M		Broadcast	110 acres
I014702-022	6/16/2003	Rock	WI	2	RU	WSP	Broadcast	6.5 acres
I015748-031	6/8/2004	Tama	IA	3	MA		N/R	30 acres
I016926-001	5/23/2005	Jefferson	NE	2	RU	WSP	Spray	8 acres
I017153-001	6/7/2005	Gregory	SD	1	RU	DF		535 acres
I016907-001	6/16/2005	Morgan	IN	2	RU	G	Spray	20 acres
I016908-001	7/8/2005	Jay	IN	2	MA	WSP	Spray	50 acres
I016927-001	8/24/2005	Clay	MN	1	RU		Spray	179 acres field corn
I016909-001	6/15/2006	Richland	IL	1	RU	WSP	Spray	40 acres
Not reported								
I013554-024	7/1/2002	Keya Paha	NE	2	U			188 acres
Potato								
I015280-004		Grant	WA	3	MA	DF	Spray	23 acres
I015280-003		Adams	WA	2	RU	DF	Spray	Unknown
I021276-009	6/16/2004	Lincoln	WA	2	U			135 acres
I015383-001	7/13/2004	Adams	WA	3	RU	DF	Spray	Total, but unknown
TERRESTRIAL								
Soybean								
I010944-001	6/14/2000	Carroll	MO	3	MA	DF	N/R	1,600 acres

Certainty: 1 = unlikely, 2 = possible, 3 = probable, and 4 = highly probable.
Legality: RU = registered use, M = misuse, MA = misuse (accidental), and U = unknown.
Formulation: G = granular, WSP = water soluble packet, and DF = dry flowable.
N/R = not reported.
Information provided by the USEPA from the EIIS. Blank cells indicate the information was not listed in the EIIS.

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 level of concern values selected for this risk assessment. Rimsulfuron's physical-chemical properties and environmental fate are also discussed.

As discussed in the Methods Document (ENSR 2004), if the USEPA previously reviewed an available toxicology study and classified it as "acceptable," the study's findings were considered acceptable for development of toxicity reference values (TRVs). Studies classified as "supplemental" by the USEPA were only used if acceptable ("core") studies were unavailable for a certain exposure pathway/receptor. Core studies are used to support registration of a pesticide and were conducted according to accepted methodologies. Supplemental studies are scientifically sound however, they were performed under conditions that deviated from recommended protocols. These supplemental studies are generally not used for registration purposes, but are acceptable for use in a risk assessment.

3.1 Herbicide Toxicology

A review of the available ecotoxicological literature was conducted in order to evaluate the potential for rimsulfuron 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 2004). This review included a review of published manuscripts and registration documents, information obtained through electronic databases (e.g., USEPA pesticides ecotoxicology database, USEPA's online ECOTOX database), and other internet sources. This review included both freshwater and marine/estuarine data, although marine/estuarine data were not considered for TRV development, as discussed in the Methods Document.

Endpoints for aquatic receptors and terrestrial plants were reported based on exposure concentrations (milligrams per liter [mg/L] and pounds per acre [lbs./ac], respectively). Acute dose-based endpoints, such as the dose that caused the death of 50% of the test organisms (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., the concentration causing 50% mortality [LC_{50}] was converted 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 no observed adverse effect (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 were unavailable, TRVs were extrapolated from other relevant data using an uncertainty factor of 3, as described in the Methods Document (ENSR 2004).

This section reviews the available information identified for rimsulfuron and presents the TRVs selected for this ERA (Table 3-1). Appendix A presents a summary of the rimsulfuron data identified during the literature review. Toxicity data are presented in the units presented in the reviewed study, which in this case applies to the active ingredient itself (rimsulfuron). The availability of toxicity data is discussed in Section 7.1. The review of the toxicity data did not consider potential toxic effects of inert (other) ingredients, adjuvants, surfactants, and/or degradates. Section 7.3 discusses the potential impacts of these constituents in a qualitative manner.

3.1.1 Overview

According to USEPA ecotoxicity classifications presented in registration materials[2], rimsulfuron poses little to no acute toxicity hazard to terrestrial animals (mammals, birds, and honeybees [*Apis mellifera*]; USEPA 2007). The rimsulfuron mode of action is to inhibit acetolactate synthase (also known as acetohydroxyacid synthase), a key enzyme in biosynthesis of certain amino acids in plants. As this enzyme only occurs in plants, rimsulfuron has little toxic impact on mammals, birds, fish, or aquatic invertebrates.

Non-target plants are highly susceptible to rimsulfuron toxicity (New York State Department of Environmental Quality [NYSDEC] 2009). Concentrations of rimsulfuron as low as 0.00012 lb. a.i./ac have been shown to negatively affect the vigor of non-target terrestrial plants (about 0.3% of the typical application rate). Based on vegetative vigor as an endpoint, wheat (*Triticum aestivum;* a monocotyledon) was the most sensitive species tested. Based on seedling emergence, rape (*Brassica* sp.; a dicotyledon) was the most sensitive species tested.

Rimsulfuron is highly toxic to aquatic plants. Aquatic macrophytes were adversely affected by concentrations as low as 0.012 parts per million (ppm). Compared to aquatic macrophytes, green algae (*Selenastrum capricornutum*) and the freshwater diatom (*Navicula pelliculosa*) were more tolerant of rimsulfuron. Rimsulfuron was practically non-toxic to fish.

3.1.2 Toxicity to Terrestrial Organisms

3.1.2.1 Mammals

Based on a review of available ecotoxicological literature, rimsulfuron is characterized as not acutely toxic via dermal or oral routes of exposure to mammals. Rimsulfuron administered to rats (*Rattus* spp.) in a single gavage caused the death of 50% of the test organisms at an estimated dose in excess of 5,000 mg a.i./kilogram (kg) body weight (BW; USEPA 2007, Master Record Identification Number [MRIDs] 41356311, 41356310, 41931634). A similar study in mice (*Mus* spp.) estimated an LD_{50} value in excess of 5,000 mg a.i./kg-BW (USEPA 2007, MRID 41931623). An acute dermal exposure study found no adverse effects to rabbits (*Leporidae* sp.) from exposures in excess of 2,000 mg a.i./kg-BW (USEPA 2007; MRIDs 41356312, 41356313, 41931624, 41931635).

Subchronic reproductive toxicity was examined in small mammals. Daily doses of rimsulfuron resulted in toxicity (weight loss) in rats at a dose level of 375 mg a.i./kg BW-day (USEPA 2007; MRID 41356321). In the same study, no adverse effects were observed at 75 mg a.i./kg BW-day. In male mice, daily doses of rimsulfuron resulted in toxicity (increased red blood cells and hemoglobin and decreased weight gain) at a dose level of 225 mg a.i./kg BW-day (USEPA 2007; MRID 41356323). In the same study, no adverse effects were observed at 56.25 mg a.i./kg BW-day (in females it was greater than 1,125 mg a.i./kg BW-day).

Reproduction and fertility effects in the rat were examined over a 2-generation dietary study. In offspring, decreased mean body weight in first-generation (F1) males, decreased body weight gain in F1 females, and decreased daily food consumption in F1 males was observed at a dose level of 1,316 mg a.i./kg BW-day, but adverse effects were not observed in males at a dose level of 217 mg a.i./kg BW-day (USEPA 2007; MRID 41931644). In the same study, decreased body weight gain in male parents was observed at a dose level of 830 mg a.i./kg BW-day, while the NOAEL was determined to be 165 mg a.i./kg BW-day in males.

In a chronic study, rimsulfuron was administered to rats for 2 years at dietary concentrations ranging from 25 to 10,000 ppm (1 to 414 mg a.i./kg BW-day for males; 1.38 to 568 mg a.i./kg BW-day for females). The LOAEL for males and females is based on decreased body weight gain and liver effects. The LOAEL for males was determined to be 121 mg a.i./kg BW-day and the NOAEL was determined to be 11.8 mg a.i./kg BW-day. The LOAEL for females

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

was determined to be 568 mg a.i./kg BW-day, with a corresponding NOAEL of 163 mg a.i./kg BW-day (USEPA 2011a; MRID 42047701). In a second chronic study, rimsulfuron was administered to mice for 18 months at dietary concentrations ranging from 25 to 7,500 ppm (3.47 to 1,127 mg a.i./kg BW-day for males; 4.99 to 1,505 mg a.i./kg BW-day for females). The LOAEL for males and females is based on decreased mean body weight, increased incidence of dilation and cysts in the glandular stomach and degeneration of the testicular artery and tunica albuginea in males. The LOAEL for males was determined to be 1,127 mg a.i./kg BW-day and the NOAEL was determined to be 351 mg a.i./kg BW-day. The LOAEL for females was determined to be 1,505 mg a.i./kg BW-day, with a corresponding NOAEL of 488 mg a.i./kg BW-day (USEPA 2011a; MRID 41931642). In both chronic studies the males were more susceptible to rimsulfuron toxicity than the females.

Based on these findings, the oral LD_{50} *(>5,000 mg a.i./kg-BW) and chronic NOAEL (11.8 mg a.i./kg BW-day) were selected as the dietary small mammal TRVs. The dermal small mammal TRV was established at >2,000 mg a.i./kg BW.*

Toxicity data for large mammals were more limited. Chronic dietary exposure was evaluated in two studies. In the first, a 1-year feeding trial, beagle dogs (*Canis lupus familiaris*) had increased liver and kidney weights when fed 342.4 mg a.i./kg BW-day, but no adverse effects occurred at 81.8 mg a.i./kg BW-day (USEPA 2007; MRID 41931643). In the second 90-day oral toxicity study, dogs had altered urinary volume and osmolarity when fed 125 mg a.i./kg BW-day, but no adverse effects occurred at 6.25 mg a.i./kg BW-day (USEPA 2007; MRID 41356322). An LD_{50} value for large mammals was not identified in the literature.

The small mammal LD_{50} *was used as a surrogate value for large mammals (>5,000 mg a.i./kg-BW). The large mammal dietary NOAEL TRV was established at 81.8 mg a.i./kg BW-day.*

3.1.2.2 Birds

Data from the literature indicate that rimsulfuron has low toxicity to birds. Acute dietary exposure did not result in toxic effects at 5,620 ppm (equivalent to 3,394 mg a.i./kg BW-day in bobwhite quail [*Colinus virginianus*]) of a 98.8% rimsulfuron product (MRID 41356305). In this dietary test, the test organism was presented with the dosed food for 5 days, with 3 days of additional observations after the dosed food was removed. The endpoint reported for this assay is generally an LC_{50} representing mg/kg food. For this ERA, the concentration-based value was converted to a dose-based value following the methodology presented in the Methods Document (ENSR 2004).[3] The dose-based value was multiplied by the exposure duration (generally 5 days) to result in an LD_{50} value representing the full herbicide exposure over the course of the test. This resulted in an LD_{50} value of >16,969 mg a.i./kg BW for the quail. Exposure via gavage for 14 days did not result in toxic effects in the bobwhite quail at a concentration equivalent to 14,610 ppm (2,250 mg a.i./kg-BW; MRID 41356304).

In a 14-day gavage study, an LD_{50} value for the mallard (*Anas platyrhynchos*) was estimated as being in excess of 2,000 mg a.i./kg-BW for a 98.8% rimsulfuron product (MRID 41931630). In the same study, no adverse effects were observed at a dose level of 1,000 mg a.i./kg BW (equivalent to 71.4 mg a.i./kg BW-day for the mallard). In a dietary study, daily exposure to rimsulfuron for 5 days resulted in an LC_{50} value in excess of 5,620 ppm (equivalent to >2,810 mg a.i./kg BW for the mallard; MRID 41356306). Data for piscivorous birds were not identified in the literature.

Based on these findings, the bobwhite quail dietary LD_{50} *(> 16,969 mg a.i./kg BW) and chronic NOAEL (3,394 mg a.i./kg BW-day) were selected as the small bird dietary TRVs. The mallard dietary* LD_{50} *(>2000 mg a.i./kg BW) and NOAEL (1,000 mg a.i./kg BW-day) were selected as the large bird dietary TRVs. The large bird NOAEL was selected as a surrogate value for the piscivorous bird.*

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

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, a 98.8% rimsulfuron product was directly applied to the bee's thorax, and mortality was assessed during a 48-hr period. The USEPA reports a LD_{50} value of more than 100 micrograms (µg) per bee, as the no effect level was 100 µg/bee (MRID 41356331).

The honeybee dermal LD_{50} *TRV was set at >100 µg a.i./bee.*

3.1.2.4 Terrestrial Plants

Toxicity tests were conducted on several terrestrial plant species (plants tested were vegetable crop species rather than rangeland or forest species). The highest germination based NOAEL was reported for sorghum (*Sorghum bicolor*) and is equal to 0.5 ounce a.i./ac (MRID 42471304). The lowest germination based NOAEL was reported for rape and is equal to <0.002 ounce a.i./ac (MRID 42471304).

In a 14-day seedling emergence study, the 25% effect concentration (EC_{25}) was determined to be 0.002 ounce a.i./ac for rape (MRID 42471304). The EC_{25} is the concentration that affects 25% of the tested population. This was the lowest 25% effect concentration reported for terrestrial plants; EC_{25} values for other species ranged up to >0.5 ounce a.i./ac for tomato (*Lycopersicon esculentum*) vegetative vigor in a 21-day exposure and >0.5 ounce a.i./ac for sorghum germination in a 5-day exposure (MRID 42471304).

Two studies evaluating vegetative vigor in non-target terrestrial plant species observed no adverse effects after 21 days at concentrations ranging from 0.00195 ounce a.i./ac for wheat to >0.5 ounce a.i./ac for tomato (MRIDs 42471304, 43539201). Supplemental vegetative vigor results were available for an additional three species (rape, garden pea [*Pisum sativum*], and cucumber [*Cucumis sativum*]). These studies observed no adverse effects after 21 days at concentrations ranging from <0.0005 to 0.002 ounce a.i./ac (MRIDs 42471304, 43539201).

The lowest and highest germination-based NOAELs were selected to evaluate risk in surface runoff scenarios to RTE and typical species, respectively. The selected TRVs were 0.50 ounce a.i./ac (0.03125 lb. a.i./ac) and <0.002 ounce a.i./ac (0.000125 lb. a.i./ac). Two additional endpoints were used to evaluate other plant scenarios. These included an EC_{25} *of 0.002 ounce a.i./ac (0.000125 lb. a.i./ac) and a NOAEL of 0.00195 ounce a.i./ac (0.00012 lb. a.i./ac).*

3.1.3 Toxicity to Aquatic Organisms

3.1.3.1 Fish

The toxicity of rimsulfuron to freshwater fish was evaluated by testing both coldwater and warmwater fish species, and the lowest toxicity result was selected as the TRV for fish. One study examined the acute toxic effects of rimsulfuron on rainbow trout (*Oncorhynchus mykiss*), a coldwater species. This study found that no adverse effects occurred after 96 hours of exposure to 390 mg/liter (MRID 41356307). The LC_{50} from this study was determined to be in excess of 390 mg/L.

Acute toxicity tests were also conducted with warmwater fish species, namely the bluegill sunfish (*Lepomis macrochirus*). Two studies determined that no adverse effects occurred after 96 hours of exposure to 390 mg/L. The LC_{50}s from these studies were also in excess of 390 mg/L (MRIDs 41356308, 41931620). These results suggest that coldwater and warmwater fish species may have comparable sensitivity to rimsulfuron. No chronic tests were identified.

Given that the coldwater and warmwater fish endpoints were the same, it was not possible to select the lower of the two as the TRV for fish. The LC_{50} *of >390 mg a.i./L was selected as the acute TRV. In the absence of chronic data, the acute NOAEL of 390 mg a.i./L was divided by an uncertainty factor of 3 to extrapolate to a chronic NOAEL of 130 mg a.i./L and this value was used as the NOAEL TRV for chronic effects.*

Based on rimsulfuron's octanol-water coefficient (K_{ow}) and regression equations, rimsulfuron is not likely to bioconcentrate in fish tissue (California Environmental Protection Agency [CalEPA]1997).

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 core acute toxicity tests using water fleas (*Daphnia magna)* were reviewed. In these acute studies, the statistical endpoint (the EC_{50}) is the concentration that causes an effect in 50% of the test organisms after 48 hours. The lowest EC_{50} reported from these studies was >50 mg/L using a 99.5% rimsulfuron product (Martins et al. 2001). The second test reported an EC_{50} value of >360 mg/L using a 98.8% rimsulfuron product (MRID 41356309).

A supplemental acute study using water fleas was also identified during the literature review. This study reported an EC_{50} value of 1,000 mg/L, but no adverse effects were observed at a concentration of 800 mg/L (MRID 41931621).

A *Daphnia* life-cycle test to assess chronic toxicity to aquatic invertebrates was not found in the literature.

The lowest EC_{50} *>50 mg a.i./L) was selected as the invertebrate acute TRV. In the absence of chronic data, the acute NOAEL value of 50 mg a.i./L was divided by an uncertainty factor of 3 to extrapolate to a chronic NOAEL of 16.7 mg a.i./L, and this value was used as the NOAEL TRV for chronic effects.*

3.1.3.4 Aquatic Plants

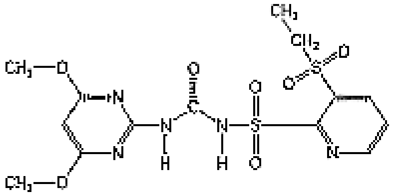
Standard toxicity tests were conducted on aquatic plants, including aquatic macrophytes and algae. Rimsulfuron was most toxic to aquatic macrophytes, particularly duckweed (*Lemna gibba*). In the duckweed study, plants were adversely affected (based on reduced growth) by concentrations as low as 0.0116 mg/L after 14 days of exposure (MRID 42471308). The NOAEL for duckweed in this same study was 0.00009 mg/L. The no adverse effect concentrations for green algae (*Selenastrum capricornutum*) and the freshwater diatom (*Navicula pelliculosa*) were 0.029 and <0.030 mg/L, respectively, after 5 days of exposure (MRIDs 42471305, 42471307).

No chronic tests using aquatic plants were found in the available literature.

Since the 14-day duckweed test is considered to be an acute test, the EC_{50} *(0.0116 mg a.i./L) was selected as the aquatic plant acute TRV. In the absence of a chronic NOAEL, the acute NOAEL from this study was divided by an uncertainty factor of 3 to extrapolate to a chronic NOAEL of 0.00003 mg a.i./L, which was selected as the chronic TRV.*

3.2 Herbicide Physical-Chemical Properties

The chemical formula for rimsulfuron is N-((4,6-dimethyoxypyrimidin-2-yl)aminocarbonyl)-3-(ethylsulfonyl)-2-pyridine-sulfonamide. The chemical structure of rimsulfuron is shown below:



Rimsulfuron Chemical Structure

The physical-chemical properties and degradation rates critical to rimsulfuron'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, USEPA literature on rimsulfuron was obtained from published manuscripts and registration documents. Additional sources, both on-line and in print, were consulted for information about the herbicide, and included:

California Environmental Protection Agency (CalEPA). 1997. Assessment of the Tolerances for Section 3 Registration of Shadeout™ (Rimsulfuron) on Tomatoes. Department of Pesticide Regulation. October 21, 1997.

Juraske, R., A. Anton, and F. Castells. 2008. Estimating Half-lives of Pesticides in/on Vegetation for use in Multimedia Fate and Exposure Models. Chemosphere 70(10):1748-1755.

Kegley, S.E., B.R. Hill, S. Orme, and A.H. Choi. 2010. PAN Pesticide Database, Pesticide Action Network, North America. Available at URL: www.pesticideinfo.org.

Knisel W.G., and F.M. Davis. 2000. GLEAMS (Groundwater Loading Effects of Agricultural Management Systems), Version 3.0, User Manual. U.S. Department of Agriculture, Agricultural Research Service, Southeast Watershed Research Laboratory, Tifton, Georgia. Publication Number SEWRL-WGK/FMD-050199. Report Dated May 1, 1999 and Revised August 15, 2000. 194 pp.

New York State Department of Environmental Conservation (NYSDEC). 2009. Re: Registration of a Major Change in Labeling for DuPont Matrix FNV Herbicide (USEPA Registration Number 352-671) Containing the Active Ingredient Rimsulfuron (Active Ingredient Code 129009).

Pesticide Properties DataBase (PPDB). 2010. University of Hertfordshire. Available at URL: http://sitem.herts.ac.uk/aeru/projects/ppdb/index.htm.

USEPA Pesticide Fate Database. 2011b. Available at: http://cfpub.epa.gov/pfate/home.cfm.

The foliar wash-off fraction for rimsulfuron was estimated based on the closely related chlorsulfuron and nicosulfuron herbicides (Knisel and Davis 2000). The foliar half-life, based on an analysis for 41 pesticides, was estimated as ¼ the soil half-life (Juraske et al. 2008). Residue rates were obtained from the Kenaga nomogram, as updated (Fletcher et al. 1994). Values selected for use in risk assessment calculations are shown in bold in Table 3-2.

3.3 Herbicide Environmental Fate

Rimsulfuron is non-persistent in the environment (CalEPA 1997, NYSDEC 2009, PPDB 2010). The reported half-life of rimsulfuron in soil is 24.3 days at 20 degrees Celsius [^{o}C] and 21.3 days at 25 ^{o}C (CalEPA 1997, PPDB 2010, USEPA 2011b). In terrestrial systems, photodegradation and biodegradation appear to be the primary loss mechanisms. The photodegradation half-life in soil is between 11 and 12 days in sandy loam soil. The biodegradation half-life in soil is around 18 days in anaerobic environments, while the half-life ranges from 5 to 40 days in aerobic environments (NYSDEC 2009).

The K_{oc}, or organic carbon-water partitioning coefficient, measures the affinity of a chemical to organic carbon relative to water. A high K_{oc} indicates that the chemical is not very soluble in water and has a high affinity for organic carbon, an important constituent of soil particles. Therefore, the higher the K_{oc}, the less mobile the chemical is expected to be. K_{oc} values for rimsulfuron range from 19 to 74 indicating that rimsulfuron's mobility in soil varies according to the specific soil conditions (NYSDEC 2009, Kegley et al. 2010, PPDB 2010). Hydrolysis occurs with the following half-lives at the following soil pH levels: 4.5 to 4.7 days (pH=5), 7.1 to 7.3 days (pH=7), and 4.2 to 10.9 hours (pH=9; NYSDEC 2009, USEPA 2011b). Given rimsulfuron's Henry's Law constant (the ratio of the chemical's distribution at equilibrium between the gas and liquid phases), it is unlikely to volatilize from wet soils (PPDB 2010). Field half-lives reported for rimsulfuron range from 5 to 18 days (CalEPA 1997, NYSDEC 2009, PPDB 2010).

As in terrestrial systems, biodegradation and photodegradation appear to be the primary loss mechanisms for rimsulfuron in aquatic environments. An aquatic biodegradation half-life of 10 days was observed in aerobic systems. In anaerobic systems, an aquatic half-life of less than 2 days occurred at 25 ^{o}C, and a half-life of between 48 and 59 days was reported at 5 ^{o}C (Table 3-2; NYSDEC 2009, USEPA 2011b). Aquatic photodegradation occurs with the following half-lives at the following water pH levels: 1.1 days (pH=5), 11.0 to 12.4 days (pH=7), and 10.2 to 12 hours (pH=9; NYSDEC 2009, USEPA 2011b). The reported half-life of rimsulfuron in water is 4 days. The reported half-life of rimsulfuron in aquatic sediment is 6 days. Based on rimsulfuron's Henry's Law constant, it is unlikely to volatilize from aquatic systems (PPDB 2010). Bioaccumulation is not anticipated to occur in aquatic organisms and as such, a bioconcentration factor of 1 is assumed (CalEPA 1997).

TABLE 3-1

Selected Toxicity Reference Values for Rimsulfuron

Receptor	Selected TRV	Units	Duration	Endpoint	Species	Notes
RECEPTORS INCLUDED IN FOOD WEB MODEL						
Terrestrial Animals						
Honeybee	>100	µg a.i./bee	NR	LD_{50}	honeybee	98.8% a.i. product
Large Bird	>2,000	mg a.i./kg bw	14 d	LD_{50}	mallard	98.8% a.i. product
Large Bird	1,000	mg a.i./kg bw-day	14 d	NOAEL	mallard	98.8% a.i. product
Piscivorous Bird	1,000	mg a.i./kg bw-day	14 d	NOAEL	mallard	large bird value used
Small Bird	>16,969	mg a.i./kg bw	8 d	LD_{50}	bobwhite quail	98.8% a.i. product
Small Bird	3,394	mg a.i./kg bw-day	8 d	NOAEL	bobwhite quail	98.8% a.i. product
Large Mammal	>5,000	mg a.i./kg bw	NR	LD_{50}	rat, mouse	small mammal study used
Large Mammal	81.8	mg a.i./kg bw-day	1 y	NOAEL	dog	dietary study
Small Mammal	11.8	mg a.i./kg bw-day	2 y	NOAEL	rat	dietary study
Small Mammal - dermal	>2,000	mg a.i./kg bw	NR	LD_{50}	rabbit	--
Small Mammal - ingestion	>5,000	mg a.i./kg bw	NR	LD_{50}	rat, mouse	--
Terrestrial Plants						
Typical Species-direct spray, drift, dust	0.000125	lb. a.i./ac	2 w	EC_{25}	rape	98.8% a.i. product
RTE Species-direct spray, drift, dust	0.00012	lb. a.i./ac	3 w	NOAEL	wheat	vegetative vigor
Typical Species-runoff	0.03125	lb. a.i./ac	5 d	NOAEL	sorghum	germination
RTE Species-runoff	0.000125	lb. a.i./ac	2 w	NOAEL	rape	emergence
Aquatic Species						
Aquatic Invertebrates	>50	mg a.i./L	48 hr	EC_{50}	water flea	99.5% a.i. product
Fish	>390	mg a.i./L	96 hr	LC_{50}	multiple	98.8% a.i. product
Aquatic Plants and Algae	0.0116	mg a.i./L	14 d	EC_{50}	duckweed	--
Aquatic Invertebrates	16.7	mg a.i./L	48 hr	NOAEL	water flea	extrapolated from acute NOAEL
Fish	130	mg a.i./L	96 hr	NOAEL	multiple	extrapolated from acute NOAEL
Aquatic Plants and Algae	0.00003	mg a.i./L	14 d	NOAEL	duckweed	extrapolated from acute NOAEL

TABLE 3-1 (Cont.)

Selected Toxicity Reference Values for Rimsulfuron

Receptor	Selected TRV	Units	Duration	Endpoint	Species	Notes
ADDITIONAL ENDPOINTS						
Amphibian	no data					
Warmwater Fish	>390	mg a.i./L	96 hr	LC_{50}	multiple	98.8% a.i. product
Warmwater Fish	390	mg a.i./L	96 hr	NOAEL	multiple	98.8% a.i. product
Coldwater Fish	>390	mg a.i./L	96 hr	LC_{50}	multiple	98.8% a.i. product
Coldwater Fish	390	mg a.i./L	96 hr	NOAEL	multiple	98.8% 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.

.NOAEL - to address direct spray, drift, and dust impacts on threatened or endangered species.

Highest germination NOAEL - to address surface runoff impacts on typical species.

Lowest germination NOAEL - to address surface runoff impacts on threatened or endangered species.

Toxicity endpoints for aquatic receptors;

LC_{50} or EC_{50} - to address acute exposure (appropriate toxicity endpoint for non-target aquatic plants will be an EC_{50}).

NOAEL - to address chronic exposure.

Value for fish is the lower of the warmwater and coldwater values.

TRVs preceded by a greater than symbol (>) were applied at the specified value in the ERA. However, it should be noted that the specified effect was not observed at the highest tested concentration in these studies and therefore these values may over-estimate risks.

Piscivorous bird TRV = Large bird chronic TRV.

Fish TRV = lower of coldwater and warmwater fish TRVs.

NR – Not reported

Durations:

hr - hours
d - days
w - weeks
m - months
y - years

-- indicates no notes are applicable to this scenario

> - greater than

TABLE 3-2

Physical-Chemical Properties of Rimsulfuron

Parameter	Value
Herbicide family	Sulfonylurea (CalEPA 1997).
Mode of action	Inhibits acetolactate synthase, a key enzyme in biosynthesis of certain amino acids in plants (NYSDEC 2009).
Chemical Abstract Service number	122931-48-0 (CalEPA 1997).
Office of Pesticide Programs chemical code	129009 (PPDB 2010).
Chemical name (International Union of Pure and Applied Chemistry)	N-((4,6-dimethyoxypyrimidin-2-yl)aminocarbonyl)-3-(ethylsulfonyl)-2-pyridine-sulfonamide (CalEPA 1997).
Empirical formula	$C_{14}H_{17}N_5O_7S_2$ (CalEPA 1997).
Molecular weight	**431.44** (CalEPA 1997).
Appearance, ambient conditions	White solid, with a paste-like odor (CalEPA 1997).
Acid / base properties (acid dissociation constant)	4.0 (NYSDEC 2009).
Vapor pressure (millimeters mercury at 25 ºC)	1.1×10^{-8} (CalEPA 1997); 6.7×10^{-9} (PPDB 2010).
Water solubility (mg/L at 25 ºC)	135 (pH 5), **7,300** (pH 7), 5,560 (pH 9; CalEPA 1997); 3,750 (Kegley et al. 2010).
Log octanol-water partition coefficient (log [K_{ow}]), unitless	1.96 (pH 5), **0.0345** (pH 7; CalEPA 1997).
Henry's Law constant (atmosphere per cubic meter/mole)	8.2×10^{-13} (8.30×10^{-8} Pa-m^3/mole; PPDB 2010).
Soil partition coefficient/organic matter sorption coefficient(K_d/K_{oc})	K_d: 0.23 and 0.32 (sandy loam), 1.36 (clay loam), 1.57 (silt loam; NYSDEC 2009). K_{oc}: **19** to 74 (NYSDEC 2009), 47 (PPDB 2010), 49.0 (Kegley et al. 2010).
Bioconcentration factor	Not likely to bioconcentrate (CalEPA 1997). Bioconcentration factor of **1** used in risk assessment.
Foliar wash-off fraction[1]	**0.75** (estimated, Knisel and Davis 2000).
Half-life – aquatic sediment	**6 days** (water-sediment; PPDB 2010).
Half-life – foliar [2]	**6 days** (estimated).
Half-life – soil	**24.3 days** (lab at 20 ºC; PPDB 2010); 21.3 days (CalEPA 1997; at 25 ºC; PPDB 2010; MRID 41356334).
Half-life – water	**4 days** (PPDB 2010).
Half-life – hydrolysis	4.5 to 4.7 days (pH 5), 7.1 to 7.3 days (pH 7), 4.2 to 10.9 hours (pH 9; 25 ºC; NYSDEC 2009); 4.6 days (pH 5), 7.2 days (pH 7), 7.55 days (pH 9; at 25 ºC; PPDB 2010; MRID 41356333).
Half-life – photodegradation in water (photolysis)	1.1 days (pH 5), 12.4 days (pH 7), 12 hours (pH 9; for the pyridine label), 1.1 days (pH 5), 11.0 days (pH 7), 10.2 hours (pH 9; for the pyrimidine labeled ring; NYSDEC 2009; at 25 ºC; PPDB 2010; MRID 41931608).
Half-life – photodegradation in soil (photolysis)	11 to 12 days in sandy loam soil (pH 6.7, 1.1% organic matter; NYSDEC 2009; at 25ºC; PpDB 2010; MRID #AMD-1219-88).
Half-life – soil biodegradation	18.1 days (calculated, pyridine label), 17.9 days (calculated, pyrimidine label) in anaerobic environments. In aerobic environments, half-life ranges from 5 to 40 days (NYSDEC 2009); 17.9 and 18.1 days in sandy loam (PPDB 2010; MRID 41356335).

TABLE 3-2 (Cont.)

Physical-Chemical Properties of Rimsulfuron

Parameter	Value
Half-life – aquatic biodegradation	10 days (observed), 21.3 days (calculated) in a sandy loam soil (pH 6.7, 1.1% organic matter) in aerobic environments (NYSDEC 2009). In anaerobic environments half-lives were less than 2 days (non-sterile sample) and 1 day (sterile sample; NYSDEC 2009); 2 and 2.1 days at 25 ºC; 48 and 59 days at 5ºC (pyridine and pyrimidine rings; USEPA Pesticide Fate Database; MRID 43288502).
Half-life – field dissipation (degradation and dissipation)	5 to 18 days (geometric mean of 9 days; NYSDEC 2009); 10.8 days (PPDB 2010); 5.4 to 17.7 days (CalEPA 1997).
Residue rate for grass [3]	197 ppm (maximum) and 36 ppm (typical) per lb. a.i./ac.
Residue rate for vegetation [4]	296 ppm (maximum) and 35 ppm (typical) per lb. a.i./ac.
Residue rate for insects [5]	350 ppm (maximum) and 45 ppm (typical) per lb. a.i./ac.
Residue rate for berries [6]	40.7 ppm (maximum) and 5.4 ppm (typical) per lb. a.i./ac.

Notes:

Values presented in bold were used in risk assessment calculations.

[1] Estimated based on closely related chlorsulfuron and nicosulfuron (Knisel and Davis 2000).

[2] Based on an analysis for 41 pesticides (Juraske et al. 2008). Estimate foliar residues as ¼ the soil half-life.

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

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

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

[6] 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 rimsulfuron. The general approach and analytical methods for conducting the rimsulfuron ERA were based on USEPA's *Guidelines for Ecological Risk Assessment* (USEPA 1998).

The ERA is a structured evaluation of 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 USEPA 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 2004) 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 rimsulfuron 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 rimsulfuron to the health and welfare of plants and animals and their habitats. 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 (see Appendix B), which may be used to calculate exposure concentrations and evaluate potential risks in the ERA. 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, rimsulfuron is proposed for use by the BLM for vegetation management in their Rangeland, Public-Domain Forestland, Energy and Mineral Sites, ROW, and Recreation programs on public lands in 17 western states in the continental U.S. 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. This ERA, however, 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 in this evaluation:

- 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-administered 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-administered 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 on BLM-administered lands. Rimsulfuron is a terrestrial herbicide; therefore, as discussed in detail in the Methods Document (ENSR 2004), the following exposure scenarios were considered:

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

Two generic water bodies were considered in this ERA: 1) a small pond (¼- ac pond of 1-meter [m] depth, with 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 m per second, and a base flow discharge of 0.12 cubic m 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., soil, 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 (Spray Drift Task Force [SDTF] 2002) is a product of the Cooperative Research and Development Agreement between the USEPA's Office of Research and Development and the SDTF (a coalition of pesticide registrants). The GLEAMS (Groundwater Loading Effects of Agricultural Management Systems) computer model was used to estimate off-site transport of herbicide in surface runoff and root zone groundwater. GLEAMS is able to estimate a wide range of potential herbicide exposure concentrations as a function of site-specific parameters, such as soil characteristics and annual precipitation.

The American Meteorological Society/USEPA's guideline air quality dispersion model (AERMOD version 11103) was used to determine potential herbicide migration due to wind-blown dust in the near-field for receptors located up to 50 kilometers (km; 31 miles) from the herbicide application locations. AERMOD is currently USEPA's preferred model for use at distances up to 50 km from an emission source. For receptors located between 50 and 100 km (31 and 62 miles) from an herbicide application area, the USEPA's California Puff (CALPUFF) air pollutant dispersion model was used to predict the transport and deposition of herbicides sorbed to wind-blown dust. The current USEPA approved version, CALPUFF version 5.8, was used with the single-station meteorological data used for the AERMOD modeling. Thus, for consistency, the near-field (AERMOD) modeling and the far-field (CALPUFF) modeling used the same set of 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 rimsulfuron. The selection process is discussed in detail in the Methods Document (ENSR 2004), and the selected endpoints are presented below.

<u>Assessment Endpoint 1: Acute mortality to mammals, birds, invertebrates, and non-target plants:</u>

- **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.

<u>Assessment Endpoint 2: Acute mortality to fish, aquatic invertebrates, and aquatic plants:</u>

- **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).

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

- **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., seed germination, growth, physiological impairment, or behavior), or population-level impacts (e.g., reproduction; Barnthouse 1993). For salmonids, careful attention was paid to smoltification (in other words [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 those 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.

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

- **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 rimsulfuron on salmonids and their habitat, only qualitative estimates of indirect effects were possible. Such qualitative estimates were limited to a general evaluation of the potential risks to food (typically represented by acute and/or chronic toxicity to aquatic invertebrates) and cover (typically represented by potential for destruction of riparian vegetation). Similar approaches are already being applied by USEPA OPP for Endangered Species Effects Determinations and Consultations (Available at URL: http://www.epa.gov/oppfead1/endanger/effects).

4.1.6 Development of the Conceptual Model

The rimsulfuron conceptual model (Figure 4-1) is presented as a series of working hypotheses about how rimsulfuron 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.

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). The ecological effects characterization consists 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 rangeland, oil and gas sites, ROW, and recreational sites) with several different application methods (e.g., vehicle, ATV-mounted, backpack sprayer, and aerial application). 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 that the frequency and duration of the various scenarios are not equal. For example, exposures associated with accidental spills are very rare, while off-site drift associated with application is relatively common. Similarly, off-site drift events are 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 risk quotients 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 rimsulfuron: 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-administered lands. Unless otherwise noted, receptor body weights were selected from the *Wildlife Exposure Factors Handbook* (USEPA 1993a). This list includes surrogate species, although not all of these surrogate species would be present within each application area.

- A pollinating insect with a body weight of 0.093 grams (g). The honeybee was selected as the surrogate species to represent pollinating insects. This body weight was based on the estimated weight of receptors required for testing in 40 CFR 158.590.
- A small mammal with a body weight of 20 g (0.7 ounces) 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 body weight of 70 kg (155 lbs.) that feeds on plants. The mule deer (*Odocolieus hemionus*) was selected as the surrogate species to represent large mammalian herbivores, including wild horses (*Equus ferus*) and burros (*Equus asinus*; Hurt and Grossenheider 1976).

- A large mammal with a body weight of 12 kg (27 lbs.) 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 body weight of 80 g (3 ounces) 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 body weight of approximately 3.5 kg (8 lbs.) 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 body weight of approximately 5 kg (11 lbs.) 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[4]).

In addition, potential impacts to non-target terrestrial plants were considered by evaluating two types of plant receptors: the “typical” non-target species, and the RTE non-target species. Rape and sorghum were the surrogate species chosen to represent typical terrestrial plants, and rape was used as a surrogate for RTE terrestrial plants (toxicity data are only available for vegetable crop species). According to the herbicide label, mustards are a class of plants that are controlled by rimsulfuron, so the use of rape (a member of the mustard [*Brassicaceae*] family) as a surrogate represents a very sensitive receptor. Rimsulfuron provides selective control of certain broadleaf weeds and grasses. However, it is possible that rangeland and noncropland plants and grasses are not as sensitive to rimsulfuron 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 selected as surrogates for fish, the water flea was a surrogate for aquatic invertebrates, and non-target aquatic plants and algae were represented by duckweed.

Section 3.0 of the Methods Document (ENSR 2004) presents the details of the exposure scenarios considered in the risk assessments. The following sub-sections describe the scenarios that were evaluated for rimsulfuron.

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 water body inhabited by the receptor, indirect contact with dislodgeable foliar residue after herbicide application, or consumption of food items sprayed during ground application. These exposures may occur within the application area (consumption of food items) or outside of the application area (water bodies accidentally sprayed during application of terrestrial herbicide). Generally, impacts outside of the intended application area are accidental exposures that are not typical of BLM application practices. The following direct spray scenarios were evaluated:

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

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

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[4] As cited on the Virginia Tech Conservation Management Institute Endangered Species Information System website available at URL: http://fwie.fw.vt.edu/WWW/esis/.

- Direct Spray of Non-Target Terrestrial Plants

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

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

4.2.1.2 Off-site Drift

During normal application of herbicides, it is possible for a portion of the herbicide to drift outside of the treatment area and deposit onto non-target receptors. To simulate off-site herbicide transport as spray drift, AgDRIFT® software was used to evaluate a number of possible scenarios. Depending on actual BLM herbicide practices, ground applications were modeled using a low- or high-placed boom, and aerial applications were modeled from either a helicopter or a fixed-wing plane over forested (20 feet [ft.] above the forest canopy) and non-forested (10 ft. above the ground) lands. 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 application (the higher the application, the greater the off-site drift). Drift deposition was modeled at 25, 100, and 900 ft. from the application area for ground applications, and 100, 300, and 900 ft. from the application area for aerial applications. 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 water bodies 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 water bodies 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 much of the arid and semi-arid western states, in particular, it is common 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 rimsulfuron soil concentrations 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 AERMOD and 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 up to 100 km (62 miles) from the application area. The models assumed that the herbicide was applied on a specific area (1,000 acres) of undisturbed soil in each of the watersheds.

4.2.1.5 Accidental Spill to Pond

To represent worst-case potential impacts to ponds, two spill scenarios were considered. These scenarios consist of a truck or a helicopter spilling entire loads (200-gallon spill and 140-gallon spill, respectively) of herbicide mixed for the maximum application rate into a ¼-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 rimsulfuron. For the most part, available data consisted of the toxicity studies conducted in support of USEPA pesticide registration described in Section 3.1. As described in the Methods Document (ENSR 2004), the toxicity endpoint for most acute studies was mortality, immobilization, or failure to germinate, as assessed during a short-term exposure. The toxicity endpoint for most chronic studies was growth or reproduction, effects that were assessed over a long-term exposure. TRVs selected for use in the ERA are presented in Table 3-1. Appendix A presents the full set of toxicity information identified for rimsulfuron.

In order to address potential risks to ecological receptors, risk quotients (RQs) were calculated by dividing the estimated exposure concentration (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 Levels of Concern (LOC) established by the USEPA OPP to assess potential risk to non-target organisms. Table 4-1 presents the LOCs established for this assessment. Distinct USEPA LOCs are currently defined for the following risk presumption categories:

- **Acute high risk -** the potential for acute adverse effects is high.
- **Acute restricted use -** the potential for acute adverse effects is high, but may be mitigated through restricted use.
- **Acute endangered species** – the potential for acute adverse effects to endangered species is high.
- **Chronic risk -** the potential for chronic adverse effects 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., body weight, 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 included 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 as discussed in Section 4.2.2.

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. As indicated in Table 2-1, a single application rate of 0.0625 lbs. a.i./ac is used for applications on energy and mineral sites, along ROW, and in recreation areas. Typical and maximum application rates of 0.0469 lbs. a.i./ac and 0.0625 lbs. a.i./ac, respectively, are used for applications on rangeland and public-domain forestland. Risk characterization results are presented for both application rates. Only the results for the maximum application rate are applicable for energy and mineral sites, ROW, and recreation areas.

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 the data are distributed about the mean and their relative relationships with LOCs. Outliers (data points outside the 90th or 10th percentiles) were not discarded in this ERA; all risk quotient data presented in these plots were included in the risk assessment.

4.3.1 Direct Spray

As described in Section 4.2.1, potential impacts from direct spray were evaluated for exposure that could occur within the terrestrial application area (direct spray of terrestrial wildlife and non-target terrestrial plants, indirect contact with foliage, ingestion of contaminated food items) and outside the intended application area (accidental direct spray over a pond or 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 were all below the most conservative LOC of 0.1 (acute endangered species), indicating that direct spray is not likely to pose a risk to terrestrial animals (Figure 4-3).

4.3.1.2 Non-target Plants – Terrestrial and Aquatic

The RQs for non-target terrestrial plants were high, ranging from 375 to 521, and RQs for non-target aquatic plants ranged from 0.45 to 1,170 (Figures 4-4 and 4-5; Table 4-2). For terrestrial plants the lowest RQs were calculated for typical species at the typical application rate, and the highest RQs were calculated for RTE species impacted at the maximum application rate. Most of the RQs were above the plant LOC of 1, indicating that direct spray of rimsulfuron poses a risk to plants in both aquatic and terrestrial environments. The only exception is the accidental direct spray over a pond at the typical and maximum application rates. 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

All of the RQs for fish and aquatic invertebrates were below the most conservative LOC of 0.05 (acute endangered species), indicating that direct spray is not likely to pose a risk to these aquatic receptors (Figures 4-6 and 4-7).

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 rimsulfuron were modeled using both a low- and high-placed boom (spray boom height set at 20 and 50 inches above the ground, respectively), and aerial applications were modeled from both a helicopter and a plane over forested (20 ft. above the forest canopy) and non-forested (10 ft. above the ground) lands. Drift deposition was modeled at 25, 100, and 900 ft. from the application area for ground applications and 100, 300, and 900 ft. from the aerial application area.

Table 4-3 presents the RQs for the following scenarios: off-site drift to soil, off-site drift to pond, off-site drift to stream, 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 affected by off-site drift to soil were above the plant LOC of 1 (Figure 4-8). These results indicate the potential for impacts to off-site non-target terrestrial plants due to drift. The only RQs below the plant LOC were off-site drift 300 and 900 ft. from the helicopter application site in a forested area at the typical and maximum application rate, off-site drift 100 ft. from ground application with a low boom at the typical application rate, or off-site drift 900 ft. from ground application with a low or high boom at the typical and maximum application rate.

The majority of the RQs for non-target aquatic plants affected by off-site drift were below the plant LOC of 1 (Figure 4-9). None of the acute toxicity scenarios exceeded the LOC of 1 (Table 4-3) However, chronic toxicity RQs were above the LOC for some aerial and ground application scenarios. For scenarios involving off-site drift into a pond, chronic toxicity RQs were elevated for all applications by plane at the typical and maximum application rates, for most applications by helicopter at the typical and maximum application rates, for ground applications at 25 ft. with a high boom at the typical and maximum application rate, and for ground applications at 100 ft. with a high boom at the maximum application rate only. However, the aquatic scenarios are particularly conservative because they do not consider flow, adsorption to particles, or degradation of the herbicide over time.

4.3.2.2 Fish and Aquatic Invertebrates

Acute toxicity RQs for fish and aquatic invertebrates were all below the most conservative LOC of 0.05 (acute endangered species; Figures 4-10 and 4-11). All chronic RQs were well below the LOC for chronic risk to endangered species (0.5). These results indicate that off-site drift of rimsulfuron is not likely to pose an 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 the piscivorous bird were all well below the most conservative terrestrial animal LOC (0.1), indicating that this scenario is not likely to pose a risk to piscivorous birds (Figure 4-12).

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 water bodies 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-administered 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 an off-site pond, overland flow to an off-site stream, and consumption of fish from a contaminated pond. Figures 4-13 to 4-17 present graphic representations of the range of RQs and associated LOCs. In several scenarios, primarily those with low precipitation (e.g., 5 inches of precipitation per year), GLEAMS predicted no herbicide transport from the application area. Accordingly, there is no off-site risk associated with these scenarios. RQs are discussed below for scenarios predicting off-site transport and RQs greater than zero.

4.3.3.1 Non-target Plants – Terrestrial and Aquatic

RQs for non-target terrestrial plants affected by surface runoff to off-site soil were all below the plant LOC of 1 (Figure 4-13 and Table 4-4), indicating that transport due to surface runoff is not likely to pose a risk to typical or RTE terrestrial plant species.

Acute and chronic RQs for non-target aquatic plants in streams impacted by surface runoff of herbicide were all below the plant LOC of 1, indicating that this transport mechanism is not likely to pose a risk to aquatic plant species in the stream (Figure 4-14).

The acute RQs for non-target aquatic plants in a pond impacted by surface runoff of herbicide were all below the plant LOC of 1. However, RQs exceeded the LOC for several chronic pond scenarios at both typical and maximum application rates. Elevated chronic RQs based on the typical application rate ranged from 1.39 to 6.49 as a result of surface runoff through sandy soil in the base watershed with annual precipitation above 25 above inches, through clay in the base watershed with annual precipitation above 100 inches, through loam in the base watershed with annual precipitation above 50 inches, and through 14 of the 15 variations of the base watershed with 50 inches of rain per year. Elevated chronic RQs based on the maximum application rate ranged from 1.05 to 8.65 as a result of surface runoff through sandy soil in the base watershed with annual precipitation above 25 inches, through clay in the base watershed with annual precipitation above 100 inches, through loam in the base watershed with annual precipitation above 50 inches, and through all 15 variations of the base watershed with 50 inches of rain per year. Of the 42 scenarios modeled for the pond, chronic RQs were elevated above the LOC for 29 scenarios at the typical application rate and 30 scenarios at the maximum application rate.

4.3.3.2 Fish and Aquatic Invertebrates

Acute toxicity RQs for fish and aquatic invertebrates were all below the most conservative LOC of 0.05 (acute endangered species) for all pond and stream scenarios (Figures 4-15 and 4-16). All chronic RQs were well below the LOC for chronic risk to endangered species (0.5). These results indicate that surface runoff is not likely to pose a risk to these aquatic species.

4.3.3.3 Piscivorous Birds

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

4.3.4 Wind Erosion and Transport Off-site

As described in Sections 4.2.1.4 and 5.3, five distinct watersheds were modeled using AERMOD and 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 (0.9, 6.2, and 62 miles) from the application area. These watersheds were located in Winnemucca, Nevada; Tucson, Arizona; Glasgow, Montana; Medford, Oregon; and Lander, Wyoming.

Deposition results for Winnemucca, Nevada, and Tucson, Arizona, are not included in the analysis 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 and risks due to dust deposition were not evaluated in these two locations.

The soil type assumed for Winnemucca, Nevada, and Tucson, Arizona, 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 at the other locations (Glasgow and Lander have loamy sand, and Medford has loam soil). 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 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. Similar predictions would have been made for soils of similar properties at Winnemucca and Tucson, if present, 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 watersheds with the potential for wind erosion (Glasgow, Montana; Medford, Oregon; and Lander, Wyoming) following applications of rimsulfuron at typical and maximum application rates. Figure 4-18 presents a graphic representation of the range of RQs and associated LOCs. Most RQs for typical and RTE terrestrial plants were all well below the plant LOC (1). The only scenario that could pose a risk to non-target typical or RTE terrestrial plant species is wind erosion in the Medford, Oregon, watershed following an application of rimsulfuron at a distance of 0.5 km (0.3 miles). Under this scenario, the typical application rate resulted in RQs of 1.08 and 1.12 for typical and RTE plant species, respectively. The maximum application rate resulted in RQs of 1.44 and 1.50 for typical and RTE plant species, respectively. The results indicate that under most scenarios, wind erosion is not likely to pose a risk to non-target terrestrial plants.

In cases where rimsulfuron applications occur in areas that have been denuded by a prescribed burn, lower deposition of herbicide-treated windblown soil would occur because the lack of vegetation within the application area would reduce wind resistance. In these cases, all RQs may be less than 1.

4.3.5 Accidental Spill to Pond

As described in Section 4.2.1, two spill scenarios were considered: a truck or a helicopter spilling entire loads (200-gallon spill and 140-gallon spill, respectively) of herbicide prepared for the maximum application rate into a ¼-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 scenarios were elevated for non-target aquatic plants, while RQs for fish and aquatic invertebrates were below the identified LOC (Table 4-2). These scenarios are highly conservative and represent unlikely and worst-case conditions (limited water body volume, tank mixed for maximum application). Potential risk to non-target aquatic plants was indicated for both the truck and helicopter spills mixed for the maximum application rate.

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 rimsulfuron 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 warmwater or coldwater species identified during the literature search. No RQs in excess of the appropriate acute or chronic LOCs were observed for fish or aquatic invertebrates for any of the stream scenarios. Because the ERA did not predict direct impacts to fish and aquatic invertebrates in a stream as a result of rimsulfuron applications, 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. Aquatic plant RQs for accidental direct spray scenarios were above the plant LOC at both the typical and maximum application rates, indicating the potential for a reduction in the aquatic plant community. However, this is an extremely conservative scenario in which it is assumed that a stream is accidentally directly sprayed by a terrestrial herbicide. Because such a scenario is unlikely to occur as a result of BLM practices, it represents a worst-case scenario. In addition, although stream flow would be likely to dilute herbicide concentrations and reduce potential impacts, such a reduction in concentration is not considered in this scenario. However, if the stream were accidentally sprayed, salmonids could potentially be indirectly impacted as a result of a reduction in available cover.

Elevated aquatic plant chronic RQs (RQs of 1.21 to 33.3) were observed under scenarios of off-site drift from selected aerial and ground applications of rimsulfuron, indicating the potential for a reduction in plant cover over time. No elevated aquatic plant acute RQs were predicted due to drift. No RQs in excess of the LOC were observed for aquatic plant species in the stream for any of the 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. For accidental direct spray scenarios at both the typical and maximum application rates, RQs for terrestrial plants were above the LOC, 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 1.60 to 72.8) for nearly all scenarios as a result of off-site drift. No RQs in excess of the LOC were observed for terrestrial plant species for any of the surface water scenarios. These results indicate the potential for a reduction in riparian cover under selected conditions.

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 some conditions. Accidental direct spray and off-site drift during aerial and ground applications of rimsulfuron may negatively impact terrestrial and aquatic plants, reducing the cover available to salmonids within the stream. However, increasing the buffer zone or reducing the application rate during aerial spraying, and avoiding application on non-target vegetation, 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, the 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. Therefore, it is expected that potential adverse impacts to food and cover would not occur beyond the season of application.

TABLE 4-1

Levels of Concern

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

TABLE 4-2

Risk Quotients for Direct Spray and Spill Scenarios

Terrestrial Animals	Typical Application Rate	Maximum Application Rate
Direct Spray of Terrestrial Wildlife		
Small mammal - 100% absorption	1.53E-04	2.03E-04
Pollinating insect - 100% absorption	6.91E-03	9.21E-03
Small mammal - 1st order dermal adsorption	3.66E-07	4.87E-07
Indirect Contact With Foliage After Direct Spray		
Small mammal - 100% absorption	1.53E-05	2.03E-05
Pollinating insect - 100% absorption	6.91E-04	9.21E-04
Small mammal - 1st order dermal adsorption	3.66E-08	4.87E-08
Ingestion of Food Items Contaminated by Direct Spray		
Small mammalian herbivore - acute exposure	5.03E-06	3.13E-05
Small mammalian herbivore - chronic exposure	2.06E-04	1.28E-03
Large mammalian herbivore - acute exposure	2.97E-04	4.73E-04
Large mammalian herbivore - chronic exposure	7.16E-04	1.14E-03
Small avian insectivore - acute exposure	4.13E-05	9.68E-05
Small avian insectivore - chronic exposure	1.99E-05	4.66E-05
Large avian herbivore - acute exposure	2.01E-04	9.58E-04
Large avian herbivore - chronic exposure	3.87E-05	1.84E-04
Large mammalian carnivore - acute exposure	7.56E-05	1.01E-04
Large mammalian carnivore - chronic exposure	4.51E-06	6.02E-06

TABLE 4-2 (Cont.)

Risk Quotients for Direct Spray and Spill Scenarios

Terrestrial Plants	Typical Species		RTE Species	
	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate
Direct Spray of Non-Target Terrestrial Plants				
Accidental direct spray	**3.75E+02**	**5.00E+02**	**3.91E+02**	**5.21E+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	1.35E-05	1.80E-05	1.05E-04	1.40E-04	4.53E-01	6.04E-01
Chronic	4.04E-05	5.39E-05	3.15E-04	4.19E-04	**1.75E+02**	**2.34E+02**
Accidental Direct Spray Over Stream						
Acute	6.74E-05	8.98E-05	5.26E-04	7.01E-04	**2.27E+00**	**3.02E+00**
Chronic	2.02E-04	2.69E-04	1.57E-03	2.10E-03	**8.76E+02**	**1.17E+03**
Accidental spill						
Truck spill into pond	--	5.75E-04	--	4.48E-03	--	**1.93E+01**
Helicopter spill into pond	--	2.01E-03	--	1.57E-02	--	**6.76E+01**

Typical and maximum application rates are used for applications on rangeland and public-domain forestland. Only the results for the maximum application rate are applicable for energy and mineral sites, ROW, and recreation areas (single rate is used).
Shading and boldface indicates plant RQs greater than 1 (LOC for all plant risks).
RTE – Rare, threatened, and endangered.
-- indicates the scenario was not evaluated.

TABLE 4-3

Risk Quotients for Off-site Drift Scenarios

Potential Risk to Non-target Terrestrial Plants						
			Typical Species		Rare, Threatened, and Endangered Species	
Mode of Application	**Application Height or Type**	**Distance From Receptor (ft.)**	**Typical Application Rate**	**Maximum Application Rate**	**Typical Application Rate**	**Maximum Application Rate**
Spray Drift to Off-site Soil						
Plane	Forested	100	**5.76E+01**	**7.28E+01**	**6.00E+01**	**7.58E+01**
Plane	Forested	300	**2.08E+01**	**2.64E+01**	**2.17E+01**	**2.75E+01**
Plane	Forested	900	**6.40E+00**	**8.00E+00**	**6.67E+00**	**8.33E+00**
Plane	Non-Forested	100	**1.36E+01**	**1.92E+01**	**1.42E+01**	**2.00E+01**
Plane	Non-Forested	300	**6.40E+00**	**9.60E+00**	**6.67E+00**	**1.00E+01**
Plane	Non-Forested	900	**3.20E+00**	**4.80E+00**	**3.33E+00**	**5.00E+00**
Helicopter	Forested	100	**4.80E+00**	**6.40E+00**	**5.00E+00**	**6.67E+00**
Helicopter	Forested	300	7.35E-01	8.00E-01	7.66E-01	8.33E-01
Helicopter	Forested	900	1.13E-01	1.42E-01	1.18E-01	1.48E-01
Helicopter	Non-Forested	100	**1.12E+01**	**1.52E+01**	**1.17E+01**	**1.58E+01**
Helicopter	Non-Forested	300	**4.80E+00**	**7.20E+00**	**5.00E+00**	**7.50E+00**
Helicopter	Non-Forested	900	**2.40E+00**	**3.20E+00**	**2.50E+00**	**3.33E+00**
Ground	Low Boom	25	**1.60E+00**	**2.40E+00**	**1.67E+00**	**2.50E+00**
Ground	Low Boom	100	8.00E-01	**1.60E+00**	8.33E-01	**1.67E+00**
Ground	Low Boom	900	2.29E-01	3.06E-01	2.38E-01	3.18E-01
Ground	High Boom	25	**2.40E+00**	**1.04E+01**	**2.50E+00**	**1.08E+01**
Ground	High Boom	100	**1.60E+00**	**3.20E+00**	**1.67E+00**	**3.33E+00**
Ground	High Boom	900	2.89E-01	4.37E-01	3.01E-01	4.55E-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**					
Plane	Forested	100	1.46E-06	1.85E-06	1.14E-05	1.44E-05	4.91E-02	6.22E-02
Plane	Forested	300	6.39E-07	8.06E-07	4.99E-06	6.28E-06	2.15E-02	2.71E-02
Plane	Forested	900	2.05E-07	2.59E-07	1.60E-06	2.02E-06	6.89E-03	8.71E-03
Plane	Non-Forested	100	6.33E-07	8.66E-07	4.94E-06	6.76E-06	2.13E-02	2.91E-02
Plane	Non-Forested	300	2.70E-07	3.76E-07	2.10E-06	2.93E-06	9.07E-03	1.26E-02
Plane	Non-Forested	900	1.27E-07	1.79E-07	9.88E-07	1.40E-06	4.26E-03	6.02E-03
Helicopter	Forested	100	8.62E-08	1.10E-07	6.72E-07	8.61E-07	2.90E-03	3.71E-03
Helicopter	Forested	300	2.21E-08	2.83E-08	1.72E-07	2.21E-07	7.41E-04	9.52E-04
Helicopter	Forested	900	3.54E-09	4.44E-09	2.76E-08	3.46E-08	1.19E-04	1.49E-04
Helicopter	Non-Forested	100	5.20E-07	5.41E-06	4.05E-06	4.22E-05	1.75E-02	1.82E-01
Helicopter	Non-Forested	300	1.98E-07	1.56E-06	1.55E-06	1.22E-05	6.66E-03	5.25E-02
Helicopter	Non-Forested	900	9.17E-08	6.62E-07	7.15E-07	5.16E-06	3.08E-03	2.23E-02
Ground	Low Boom	25	8.20E-08	1.03E-12	6.39E-07	8.00E-12	2.76E-03	3.45E-08
Ground	Low Boom	100	4.49E-08	5.99E-08	3.51E-07	4.67E-07	1.51E-03	2.01E-03
Ground	Low Boom	900	8.67E-09	1.16E-08	6.76E-08	9.02E-08	2.91E-04	3.89E-04
Ground	High Boom	25	1.32E-07	1.75E-07	1.03E-06	1.37E-06	4.43E-03	5.90E-03
Ground	High Boom	100	6.94E-08	9.24E-08	5.41E-07	7.21E-07	2.33E-03	3.11E-03
Ground	High Boom	900	1.10E-08	1.47E-08	8.60E-08	1.14E-07	3.71E-04	4.93E-04

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 Chronic Toxicity								
Plane	Forested	100	4.38E-06	5.55E-06	3.41E-05	4.32E-05	**1.90E+01**	**2.41E+01**
Plane	Forested	300	1.92E-06	2.42E-06	1.49E-05	1.88E-05	**8.31E+00**	**1.05E+01**
Plane	Forested	900	6.15E-07	7.77E-07	4.79E-06	6.05E-06	**2.66E+00**	**3.37E+00**
Plane	Non-Forested	100	1.90E-06	2.60E-06	1.48E-05	2.02E-05	**8.23E+00**	**1.13E+01**
Plane	Non-Forested	300	8.09E-07	1.13E-06	6.30E-06	8.78E-06	**3.51E+00**	**4.89E+00**
Plane	Non-Forested	900	3.80E-07	5.37E-07	2.96E-06	4.18E-06	**1.65E+00**	**2.33E+00**
Helicopter	Forested	100	2.59E-07	3.31E-07	2.01E-06	2.58E-06	**1.12E+00**	**1.43E+00**
Helicopter	Forested	300	6.62E-08	8.49E-08	5.15E-07	6.61E-07	2.87E-01	3.68E-01
Helicopter	Forested	900	1.06E-08	1.33E-08	8.26E-08	1.04E-07	4.60E-02	5.77E-02
Helicopter	Non-Forested	100	1.56E-06	1.62E-05	1.21E-05	1.26E-04	**6.76E+00**	**7.03E+01**
Helicopter	Non-Forested	300	5.94E-07	4.69E-06	4.63E-06	3.65E-05	**2.58E+00**	**2.03E+01**
Helicopter	Non-Forested	900	2.75E-07	1.99E-06	2.14E-06	1.55E-05	**1.19E+00**	**8.61E+00**
Ground	Low Boom	25	2.46E-07	3.28E-07	1.91E-06	2.55E-06	**1.07E+00**	**1.42E+00**
Ground	Low Boom	100	1.35E-07	1.80E-07	1.05E-06	1.40E-06	5.84E-01	7.79E-01
Ground	Low Boom	900	2.60E-08	3.47E-08	2.02E-07	2.70E-07	1.13E-01	1.50E-01
Ground	High Boom	25	3.95E-07	5.26E-07	3.07E-06	4.10E-06	**1.71E+00**	**2.28E+00**
Ground	High Boom	100	2.08E-07	2.77E-07	1.62E-06	2.16E-06	9.02E-01	**1.20E+00**
Ground	High Boom	900	3.31E-08	4.40E-08	2.57E-07	3.43E-07	1.43E-01	1.91E-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 Stream Acute Toxicity								
Plane	Forested	100	2.02E-06	2.56E-06	1.57E-05	2.00E-05	6.78E-02	8.60E-02
Plane	Forested	300	7.35E-07	9.25E-07	5.73E-06	7.21E-06	2.47E-02	3.11E-02
Plane	Forested	900	2.14E-07	2.70E-07	1.67E-06	2.11E-06	7.20E-03	9.09E-03
Plane	Non-Forested	100	9.21E-07	1.23E-06	7.18E-06	9.63E-06	3.10E-02	4.15E-02
Plane	Non-Forested	300	2.96E-07	4.10E-07	2.31E-06	3.20E-06	9.95E-03	1.38E-02
Plane	Non-Forested	900	1.29E-07	1.83E-07	1.00E-06	1.43E-06	4.32E-03	6.16E-03
Helicopter	Forested	100	1.36E-07	1.73E-07	1.06E-06	1.35E-06	4.57E-03	5.82E-03
Helicopter	Forested	300	2.54E-08	3.27E-08	1.98E-07	2.55E-07	8.55E-04	1.10E-03
Helicopter	Forested	900	3.96E-09	5.00E-09	3.09E-08	3.90E-08	1.33E-04	1.68E-04
Helicopter	Non-Forested	100	7.68E-07	1.06E-06	5.99E-06	8.27E-06	2.58E-02	3.57E-02
Helicopter	Non-Forested	300	2.22E-07	3.06E-07	1.73E-06	2.39E-06	7.46E-03	1.03E-02
Helicopter	Non-Forested	900	9.39E-08	1.30E-07	7.32E-07	1.01E-06	3.16E-03	4.36E-03
Ground	Low Boom	25	1.52E-07	2.02E-07	1.18E-06	1.58E-06	5.10E-03	6.80E-03
Ground	Low Boom	100	4.46E-08	5.95E-08	3.48E-07	4.64E-07	1.50E-03	2.00E-03
Ground	Low Boom	900	4.46E-09	5.95E-09	3.48E-08	4.64E-08	1.50E-04	2.00E-04
Ground	High Boom	25	2.47E-07	3.29E-07	1.93E-06	2.57E-06	8.31E-03	1.11E-02
Ground	High Boom	100	7.00E-08	9.32E-08	5.46E-07	7.27E-07	2.35E-03	3.13E-03
Ground	High Boom	900	5.91E-09	7.88E-09	4.61E-08	6.15E-08	1.99E-04	2.65E-04

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								
Plane	Forested	100	6.05E-06	7.67E-06	4.71E-05	5.97E-05	**2.62E+01**	**3.33E+01**
Plane	Forested	300	2.20E-06	2.77E-06	1.72E-05	2.16E-05	**9.55E+00**	**1.20E+01**
Plane	Forested	900	6.42E-07	8.11E-07	5.00E-06	6.31E-06	**2.78E+00**	**3.52E+00**
Plane	Non-Forested	100	2.76E-06	3.70E-06	2.15E-05	2.88E-05	**1.20E+01**	**1.60E+01**
Plane	Non-Forested	300	8.88E-07	1.23E-06	6.91E-06	9.58E-06	**3.85E+00**	**5.33E+00**
Plane	Non-Forested	900	3.86E-07	5.49E-07	3.00E-06	4.28E-06	**1.67E+00**	**2.38E+00**
Helicopter	Forested	100	4.08E-07	5.19E-07	3.18E-06	4.04E-06	**1.77E+00**	**2.25E+00**
Helicopter	Forested	300	7.63E-08	9.80E-08	5.94E-07	7.63E-07	3.30E-01	4.25E-01
Helicopter	Forested	900	1.19E-08	1.50E-08	9.25E-08	1.17E-07	5.15E-02	6.50E-02
Helicopter	Non-Forested	100	2.30E-06	3.18E-06	1.79E-05	2.48E-05	**9.98E+00**	**1.38E+01**
Helicopter	Non-Forested	300	6.66E-07	9.19E-07	5.18E-06	7.15E-06	**2.88E+00**	**3.98E+00**
Helicopter	Non-Forested	900	2.82E-07	3.89E-07	2.19E-06	3.03E-06	**1.22E+00**	**1.69E+00**
Ground	Low Boom	25	4.55E-07	6.07E-07	3.54E-06	4.72E-06	**1.97E+00**	**2.63E+00**
Ground	Low Boom	100	1.34E-07	1.78E-07	1.04E-06	1.39E-06	5.80E-01	7.73E-01
Ground	Low Boom	900	1.34E-08	1.78E-08	1.04E-07	1.39E-07	5.80E-02	7.73E-02
Ground	High Boom	25	7.41E-07	9.88E-07	5.77E-06	7.69E-06	**3.21E+00**	**4.28E+00**
Ground	High Boom	100	2.10E-07	2.80E-07	1.63E-06	2.18E-06	9.10E-01	**1.21E+00**
Ground	High Boom	900	1.77E-08	2.37E-08	1.38E-07	1.84E-07	7.69E-02	1.02E-01

TABLE 4-3 (Cont.)

Risk Quotients for Off-site Drift Scenarios

Potential Risk to Piscivorous Bird from Ingestion of Fish from Contaminated Pond				
Mode of Application	**Application Height or Type**	**Distance From Receptor (ft.)**	**Typical Application Rate**	**Maximum Application Rate**
Plane	Forested	100	4.51E-08	5.71E-08
Plane	Forested	300	1.97E-08	2.48E-08
Plane	Forested	900	6.32E-09	7.98E-09
Plane	Non-Forested	100	1.95E-08	2.67E-08
Plane	Non-Forested	300	8.32E-09	1.16E-08
Plane	Non-Forested	900	3.90E-09	5.52E-09
Helicopter	Forested	100	2.66E-09	3.40E-09
Helicopter	Forested	300	6.80E-10	8.73E-10
Helicopter	Forested	900	1.09E-10	1.37E-10
Helicopter	Non-Forested	100	1.60E-08	1.67E-07
Helicopter	Non-Forested	300	6.11E-09	4.82E-08
Helicopter	Non-Forested	900	2.83E-09	2.04E-08
Ground	Low Boom	25	2.53E-09	3.37E-09
Ground	Low Boom	100	1.39E-09	1.85E-09
Ground	Low Boom	900	2.67E-10	3.57E-10
Ground	High Boom	25	4.06E-09	5.41E-09
Ground	High Boom	100	2.14E-09	2.85E-09
Ground	High Boom	900	3.40E-10	4.52E-10

ft = feet.
RTE – Rare, threatened, and endangered.
Typical and maximum application rates are used for applications on rangeland and public-domain forestland. Only the results for the maximum application rate are applicable for energy and mineral sites, ROW, and recreation areas (single rate is used).
Shading and boldface indicates plant RQs greater than 1 (LOC for all plant risks).

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**	**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	7.84E-06	1.05E-05	1.96E-03	2.61E-03
10	10	0.05	0.015	0.401	Weeds (78)	Loam	1.49E-08	1.99E-08	3.73E-06	4.97E-06
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	8.17E-06	1.09E-05	2.04E-03	2.72E-03
25	10	0.05	0.015	0.401	Weeds (78)	Loam	1.61E-08	2.14E-08	4.02E-06	5.35E-06
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	6.06E-05	8.07E-05	1.51E-02	2.02E-02
50	10	0.05	0.015	0.401	Weeds (78)	Loam	3.54E-08	4.72E-08	8.85E-06	1.18E-05
100	10	0.05	0.015	0.401	Weeds (78)	Sand	0.00E+00	0.00E+00	0.00E+00	0.00E+00
100	10	0.05	0.015	0.401	Weeds (78)	Clay	2.63E-04	3.51E-04	6.58E-02	8.77E-02
100	10	0.05	0.015	0.401	Weeds (78)	Loam	7.62E-07	1.02E-06	1.91E-04	2.54E-04
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	6.07E-04	8.09E-04	1.52E-01	2.02E-01
150	10	0.05	0.015	0.401	Weeds (78)	Loam	3.21E-07	4.28E-07	8.02E-05	1.07E-04
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	1.36E-03	1.81E-03	3.40E-01	4.53E-01
200	10	0.05	0.015	0.401	Weeds (78)	Loam	2.58E-07	3.43E-07	6.44E-05	8.58E-05

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	Vegetation Type	Soil Type	Typical Application Rate	Maximum Application Rate	Typical Application Rate	Maximum Application Rate
Surface Runoff to Off-site Soils										
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	2.09E-03	2.79E-03	5.23E-01	6.97E-01
250	10	0.05	0.015	0.401	Weeds (78)	Loam	3.09E-06	4.12E-06	7.72E-04	1.03E-03
50	1	0.05	0.015	0.401	Weeds (78)	Loam	3.54E-08	4.72E-08	8.85E-06	1.18E-05
50	100	0.05	0.015	0.401	Weeds (78)	Loam	3.54E-08	4.72E-08	8.85E-06	1.18E-05
50	1000	0.05	0.015	0.401	Weeds (78)	Loam	3.54E-08	4.72E-08	8.85E-06	1.18E-05
50	10	0.05	0.015	0.05	Weeds (78)	Loam	3.52E-08	4.69E-08	8.80E-06	1.17E-05
50	10	0.05	0.015	0.2	Weeds (78)	Loam	3.52E-08	4.69E-08	8.80E-06	1.17E-05
50	10	0.05	0.015	0.5	Weeds (78)	Loam	3.54E-08	4.72E-08	8.85E-06	1.18E-05
50	10	0.05	0.023	0.401	Weeds (78)	Loam	3.54E-08	4.72E-08	8.85E-06	1.18E-05
50	10	0.05	0.046	0.401	Weeds (78)	Loam	3.52E-08	4.69E-08	8.80E-06	1.17E-05
50	10	0.05	0.15	0.401	Weeds (78)	Loam	3.52E-08	4.69E-08	8.80E-06	1.17E-05
50	10	0.005	0.015	0.401	Weeds (78)	Loam	3.52E-08	4.69E-08	8.80E-06	1.17E-05
50	10	0.01	0.015	0.401	Weeds (78)	Loam	3.52E-08	4.69E-08	8.80E-06	1.17E-05
50	10	0.1	0.015	0.401	Weeds (78)	Loam	3.56E-08	4.74E-08	8.89E-06	1.19E-05
50	10	0.05	0.015	0.401	Weeds (78)	Loam	7.43E-06	9.90E-06	1.86E-03	2.47E-03
50	10	0.05	0.015	0.401	Weeds (78)	Loam	6.73E-06	8.97E-06	1.68E-03	2.24E-03
50	10	0.05	0.015	0.401	Weeds (78)	Loam	7.49E-05	9.98E-05	1.87E-02	2.49E-02
50	10	0.05	0.015	0.401	Shrub (79)	Loam	3.54E-08	4.72E-08	8.85E-06	1.18E-05
50	10	0.05	0.015	0.401	Rye Grass (54)	Loam	3.54E-08	4.72E-08	8.85E-06	1.18E-05
50	10	0.05	0.015	0.401	Conifer +Hardwood (71)	Loam	8.03E-09	1.07E-08	2.01E-06	2.68E-06

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**	**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	7.26E-09	9.68E-09	5.67E-08	7.55E-08	2.44E-04	3.25E-04
10	10	0.05	0.015	0.401	Weeds (78)	Clay	2.66E-10	3.55E-10	2.08E-09	2.77E-09	8.95E-06	1.19E-05
10	10	0.05	0.015	0.401	Weeds (78)	Loam	2.56E-12	3.42E-12	2.00E-11	2.66E-11	8.62E-08	1.15E-07
25	10	0.05	0.015	0.401	Weeds (78)	Sand	1.69E-07	2.25E-07	1.32E-06	1.75E-06	5.67E-03	7.55E-03
25	10	0.05	0.015	0.401	Weeds (78)	Clay	4.85E-10	6.47E-10	3.79E-09	5.05E-09	1.63E-05	2.18E-05
25	10	0.05	0.015	0.401	Weeds (78)	Loam	2.22E-08	2.96E-08	1.73E-07	2.31E-07	7.47E-04	9.96E-04
50	10	0.05	0.015	0.401	Weeds (78)	Sand	2.20E-07	2.93E-07	1.71E-06	2.29E-06	7.39E-03	9.85E-03
50	10	0.05	0.015	0.401	Weeds (78)	Clay	6.06E-09	8.08E-09	4.73E-08	6.30E-08	2.04E-04	2.71E-04
50	10	0.05	0.015	0.401	Weeds (78)	Loam	1.17E-07	1.56E-07	9.14E-07	1.22E-06	3.94E-03	5.25E-03
100	10	0.05	0.015	0.401	Weeds (78)	Sand	3.84E-07	5.12E-07	3.00E-06	3.99E-06	1.29E-02	1.72E-02
100	10	0.05	0.015	0.401	Weeds (78)	Clay	1.07E-07	1.42E-07	8.32E-07	1.11E-06	3.59E-03	4.78E-03
100	10	0.05	0.015	0.401	Weeds (78)	Loam	1.52E-07	2.02E-07	1.18E-06	1.58E-06	5.11E-03	6.80E-03
150	10	0.05	0.015	0.401	Weeds (78)	Sand	4.99E-07	6.65E-07	3.89E-06	5.19E-06	1.68E-02	2.24E-02
150	10	0.05	0.015	0.401	Weeds (78)	Clay	1.64E-07	2.19E-07	1.28E-06	1.71E-06	5.51E-03	7.35E-03
150	10	0.05	0.015	0.401	Weeds (78)	Loam	1.85E-07	2.46E-07	1.44E-06	1.92E-06	6.22E-03	8.29E-03
200	10	0.05	0.015	0.401	Weeds (78)	Sand	4.36E-07	5.81E-07	3.40E-06	4.53E-06	1.47E-02	1.95E-02
200	10	0.05	0.015	0.401	Weeds (78)	Clay	2.17E-07	2.89E-07	1.69E-06	2.25E-06	7.29E-03	9.71E-03
200	10	0.05	0.015	0.401	Weeds (78)	Loam	2.04E-07	2.72E-07	1.59E-06	2.12E-06	6.87E-03	9.15E-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**	**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	3.37E-07	4.49E-07	2.63E-06	3.50E-06	1.13E-02	1.51E-02
250	10	0.05	0.015	0.401	Weeds (78)	Clay	2.54E-07	3.38E-07	1.98E-06	2.64E-06	8.53E-03	1.14E-02
250	10	0.05	0.015	0.401	Weeds (78)	Loam	2.21E-07	2.95E-07	1.73E-06	2.30E-06	7.44E-03	9.91E-03
50	1	0.05	0.015	0.401	Weeds (78)	Loam	2.51E-08	3.34E-08	1.96E-07	2.61E-07	8.43E-04	1.12E-03
50	100	0.05	0.015	0.401	Weeds (78)	Loam	1.79E-07	2.39E-07	1.40E-06	1.86E-06	6.02E-03	8.03E-03
50	1,000	0.05	0.015	0.401	Weeds (78)	Loam	1.90E-07	2.53E-07	1.48E-06	1.97E-06	6.37E-03	8.49E-03
50	10	0.05	0.015	0.05	Weeds (78)	Loam	1.17E-07	1.56E-07	9.14E-07	1.22E-06	3.94E-03	5.25E-03
50	10	0.05	0.015	0.2	Weeds (78)	Loam	1.17E-07	1.56E-07	9.14E-07	1.22E-06	3.94E-03	5.25E-03
50	10	0.05	0.015	0.5	Weeds (78)	Loam	1.17E-07	1.56E-07	9.14E-07	1.22E-06	3.94E-03	5.25E-03
50	10	0.05	0.023	0.401	Weeds (78)	Loam	1.17E-07	1.56E-07	9.14E-07	1.22E-06	3.94E-03	5.25E-03
50	10	0.05	0.046	0.401	Weeds (78)	Loam	1.17E-07	1.56E-07	9.14E-07	1.22E-06	3.94E-03	5.25E-03
50	10	0.05	0.15	0.401	Weeds (78)	Loam	1.17E-07	1.56E-07	9.14E-07	1.22E-06	3.94E-03	5.25E-03
50	10	0.005	0.015	0.401	Weeds (78)	Loam	1.17E-07	1.56E-07	9.14E-07	1.22E-06	3.94E-03	5.25E-03
50	10	0.01	0.015	0.401	Weeds (78)	Loam	1.17E-07	1.56E-07	9.14E-07	1.22E-06	3.94E-03	5.25E-03
50	10	0.1	0.015	0.401	Weeds (78)	Loam	1.17E-07	1.56E-07	9.14E-07	1.22E-06	3.94E-03	5.25E-03
50	10	0.05	0.015	0.401	Weeds (78)	Silt Loam	5.73E-08	7.63E-08	4.47E-07	5.95E-07	1.93E-03	2.57E-03
50	10	0.05	0.015	0.401	Weeds (78)	Silt	6.06E-08	8.08E-08	4.73E-07	6.30E-07	2.04E-03	2.72E-03
50	10	0.05	0.015	0.401	Weeds (78)	Clay Loam	2.90E-08	3.86E-08	2.26E-07	3.01E-07	9.75E-04	1.30E-03
50	10	0.05	0.015	0.401	Shrubs (79)	Loam	1.17E-07	1.56E-07	9.14E-07	1.22E-06	3.94E-03	5.25E-03
50	10	0.05	0.015	0.401	Rye Grass (54)	Loam	1.17E-07	1.56E-07	9.14E-07	1.22E-06	3.94E-03	5.25E-03
50	10	0.05	0.015	0.401	Conifer + Hardwood (71)	Loam	1.32E-07	1.76E-07	1.03E-06	1.37E-06	4.44E-03	5.91E-03

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	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 Pond Chronic Toxicity												
5	10	0.05	0.015	0.401	Weeds (78)	Sand	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	10	0.05	0.015	0.401	Weeds (78)	Clay	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	10	0.05	0.015	0.401	Weeds (78)	Loam	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	10	0.05	0.015	0.401	Weeds (78)	Sand	2.18E-08	2.90E-08	1.70E-07	2.26E-07	9.44E-02	1.26E-01
10	10	0.05	0.015	0.401	Weeds (78)	Clay	7.98E-10	1.06E-09	6.21E-09	8.28E-09	3.46E-03	4.61E-03
10	10	0.05	0.015	0.401	Weeds (78)	Loam	7.69E-12	1.02E-11	5.98E-11	7.98E-11	3.33E-05	4.44E-05
25	10	0.05	0.015	0.401	Weeds (78)	Sand	5.06E-07	6.74E-07	3.94E-06	5.25E-06	**2.19E+00**	**2.92E+00**
25	10	0.05	0.015	0.401	Weeds (78)	Clay	1.46E-09	1.94E-09	1.13E-08	1.51E-08	6.31E-03	8.41E-03
25	10	0.05	0.015	0.401	Weeds (78)	Loam	6.67E-08	8.88E-08	5.19E-07	6.92E-07	2.89E-01	3.85E-01
50	10	0.05	0.015	0.401	Weeds (78)	Sand	6.59E-07	8.79E-07	5.13E-06	6.84E-06	**2.19E+00**	**3.81E+00**
50	10	0.05	0.015	0.401	Weeds (78)	Clay	1.82E-08	2.42E-08	1.42E-07	1.89E-07	7.88E-02	1.05E-01
50	10	0.05	0.015	0.401	Weeds (78)	Loam	3.51E-07	4.68E-07	2.74E-06	3.64E-06	**1.52E+00**	**2.03E+00**
100	10	0.05	0.015	0.401	Weeds (78)	Sand	1.15E-06	1.54E-06	8.97E-06	1.20E-05	**4.99E+00**	**6.65E+00**
100	10	0.05	0.015	0.401	Weeds (78)	Clay	3.20E-07	4.26E-07	2.49E-06	3.32E-06	**1.39E+00**	**1.85E+00**
100	10	0.05	0.015	0.401	Weeds (78)	Loam	4.56E-07	6.07E-07	3.55E-06	4.73E-06	**1.97E+00**	**2.63E+00**
150	10	0.05	0.015	0.401	Weeds (78)	Sand	1.50E-06	2.00E-06	1.17E-05	1.55E-05	**6.49E+00**	**8.65E+00**
150	10	0.05	0.015	0.401	Weeds (78)	Clay	4.92E-07	6.56E-07	3.83E-06	5.10E-06	**2.13E+00**	**2.84E+00**
150	10	0.05	0.015	0.401	Weeds (78)	Loam	5.55E-07	7.39E-07	4.32E-06	5.76E-06	**2.40E+00**	**3.20E+00**
200	10	0.05	0.015	0.401	Weeds (78)	Sand	1.31E-06	1.74E-06	1.02E-05	1.36E-05	**5.67E+00**	**7.56E+00**
200	10	0.05	0.015	0.401	Weeds (78)	Clay	6.50E-07	8.67E-07	5.06E-06	6.75E-06	**2.82E+00**	**3.76E+00**
200	10	0.05	0.015	0.401	Weeds (78)	Loam	6.13E-07	8.17E-07	4.77E-06	6.36E-06	**2.66E+00**	**3.54E+00**

TABLE 4-4 (Cont.)

Risk Quotients for Surface Runoff Scenarios

Potential Risk to Aquatic Receptors												
							Fish		**Aquatic Invertebrates**		**Non-target Aquatic Plants**	
Annual Precipitation Rate (in/yr.)	**Application Area (ac)**	**Hydraulic Slope**	**Surface Roughness**	**USLE Soil Erodibility Factor**	**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	1.01E-06	1.35E-06	7.87E-06	1.05E-05	**4.38E+00**	**5.84E+00**
250	10	0.05	0.015	0.401	Weeds (78)	Clay	7.62E-07	1.01E-06	5.93E-06	7.90E-06	**3.30E+00**	**4.40E+00**
250	10	0.05	0.015	0.401	Weeds (78)	Loam	6.64E-07	8.85E-07	5.17E-06	6.89E-06	**2.88E+00**	**3.83E+00**
50	1	0.05	0.015	0.401	Weeds (78)	Loam	7.53E-08	1.00E-07	5.86E-07	7.81E-07	3.26E-01	4.35E-01
50	100	0.05	0.015	0.401	Weeds (78)	Loam	5.38E-07	7.16E-07	4.18E-06	5.58E-06	**2.33E+00**	**3.10E+00**
50	1,000	0.05	0.015	0.401	Weeds (78)	Loam	5.69E-07	7.58E-07	4.43E-06	5.90E-06	**2.46E+00**	**3.28E+00**
50	10	0.05	0.015	0.05	Weeds (78)	Loam	3.51E-07	4.68E-07	2.74E-06	3.64E-06	**1.52E+00**	**2.03E+00**
50	10	0.05	0.015	0.2	Weeds (78)	Loam	3.51E-07	4.68E-07	2.74E-06	3.64E-06	**1.52E+00**	**2.03E+00**
50	10	0.05	0.015	0.5	Weeds (78)	Loam	3.51E-07	4.68E-07	2.74E-06	3.64E-06	**1.52E+00**	**2.03E+00**
50	10	0.05	0.023	0.401	Weeds (78)	Loam	3.51E-07	4.68E-07	2.74E-06	3.64E-06	**1.52E+00**	**2.03E+00**
50	10	0.05	0.046	0.401	Weeds (78)	Loam	3.51E-07	4.68E-07	2.74E-06	3.64E-06	**1.52E+00**	**2.03E+00**
50	10	0.05	0.15	0.401	Weeds (78)	Loam	3.51E-07	4.68E-07	2.74E-06	3.64E-06	**1.52E+00**	**2.03E+00**
50	10	0.005	0.015	0.401	Weeds (78)	Loam	3.51E-07	4.68E-07	2.74E-06	3.64E-06	**1.52E+00**	**2.03E+00**
50	10	0.01	0.015	0.401	Weeds (78)	Loam	3.51E-07	4.68E-07	2.74E-06	3.64E-06	**1.52E+00**	**2.03E+00**
50	10	0.1	0.015	0.401	Weeds (78)	Loam	3.51E-07	4.68E-07	2.74E-06	3.64E-06	**1.52E+00**	**2.03E+00**
50	10	0.05	0.015	0.401	Weeds (78)	Silt Loam	1.72E-07	2.29E-07	1.34E-06	1.78E-06	7.45E-01	9.92E-01
50	10	0.05	0.015	0.401	Weeds (78)	Silt	1.82E-07	2.42E-07	1.42E-06	1.89E-06	7.88E-01	**1.05E+00**
50	10	0.05	0.015	0.401	Weeds (78)	Clay Loam	8.70E-08	1.16E-07	6.77E-07	9.02E-07	3.77E-01	5.02E-01
50	10	0.05	0.015	0.401	Shrubs (79)	Loam	3.51E-07	4.68E-07	2.74E-06	3.64E-06	**1.52E+00**	**2.03E+00**
50	10	0.05	0.015	0.401	Rye Grass (54)	Loam	3.51E-07	4.68E-07	2.74E-06	3.64E-06	**1.52E+00**	**2.03E+00**
50	10	0.05	0.015	0.401	Conifer + Hardwood (71)	Loam	3.96E-07	5.27E-07	3.08E-06	4.11E-06	**1.71E+00**	**2.29E+00**

TABLE 4-4 (Cont.)

Risk Quotients for Surface Runoff Scenarios

Potential Risk to Aquatic Receptors												
							Fish		Aquatic Invertebrates		Non-target Aquatic Plants	
Annual Precipitation Rate (in/yr.)	**Application Area (ac)**	**Hydraulic Slope**	**Surface Roughness**	**USLE Soil Erodibility Factor**	**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	1.27E-10	1.70E-10	9.94E-10	1.33E-09	4.29E-06	5.71E-06
10	10	0.05	0.015	0.401	Weeds (78)	Clay	5.21E-12	6.94E-12	4.06E-11	5.42E-11	1.75E-07	2.33E-07
10	10	0.05	0.015	0.401	Weeds (78)	Loam	4.10E-14	5.46E-14	3.20E-13	4.26E-13	1.38E-09	1.84E-09
25	10	0.05	0.015	0.401	Weeds (78)	Sand	4.24E-09	5.66E-09	3.31E-08	4.41E-08	1.43E-04	1.90E-04
25	10	0.05	0.015	0.401	Weeds (78)	Clay	1.12E-11	1.49E-11	8.71E-11	1.16E-10	3.75E-07	5.00E-07
25	10	0.05	0.015	0.401	Weeds (78)	Loam	4.79E-10	6.39E-10	3.74E-09	4.98E-09	1.61E-05	2.15E-05
50	10	0.05	0.015	0.401	Weeds (78)	Sand	7.17E-09	9.55E-09	5.59E-08	7.45E-08	2.41E-04	3.21E-04
50	10	0.05	0.015	0.401	Weeds (78)	Clay	1.25E-10	1.66E-10	9.73E-10	1.30E-09	4.19E-06	5.59E-06
50	10	0.05	0.015	0.401	Weeds (78)	Loam	3.65E-09	4.86E-09	2.85E-08	3.79E-08	1.23E-04	1.64E-04
100	10	0.05	0.015	0.401	Weeds (78)	Sand	1.43E-08	1.90E-08	1.11E-07	1.48E-07	4.80E-04	6.39E-04
100	10	0.05	0.015	0.401	Weeds (78)	Clay	3.31E-09	4.41E-09	2.58E-08	3.44E-08	1.11E-04	1.48E-04
100	10	0.05	0.015	0.401	Weeds (78)	Loam	7.04E-09	9.38E-09	5.49E-08	7.32E-08	2.37E-04	3.16E-04
150	10	0.05	0.015	0.401	Weeds (78)	Sand	2.02E-08	2.69E-08	1.58E-07	2.10E-07	6.80E-04	9.06E-04
150	10	0.05	0.015	0.401	Weeds (78)	Clay	5.37E-09	7.16E-09	4.19E-08	5.58E-08	1.81E-04	2.41E-04
150	10	0.05	0.015	0.401	Weeds (78)	Loam	9.64E-09	1.29E-08	7.52E-08	1.00E-07	3.24E-04	4.32E-04
200	10	0.05	0.015	0.401	Weeds (78)	Sand	2.35E-08	3.13E-08	1.83E-07	2.44E-07	7.90E-04	1.05E-03
200	10	0.05	0.015	0.401	Weeds (78)	Clay	7.18E-09	9.57E-09	5.60E-08	7.47E-08	2.41E-04	3.22E-04
200	10	0.05	0.015	0.401	Weeds (78)	Loam	1.15E-08	1.54E-08	8.99E-08	1.20E-07	3.88E-04	5.16E-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**	**Vegetation Type**	**Soil Type**	**Typical Application Rate**	**Maximum Application Rate**	**Typical Application Rate**	**Maximum Application Rate**	**Typical Application Rate**	**Maximum Application Rate**
Overland Flow to Off-site Stream Acute Toxicity												
250	10	0.05	0.015	0.401	Weeds (78)	Sand	2.47E-08	3.30E-08	1.93E-07	2.57E-07	8.32E-04	1.11E-03
250	10	0.05	0.015	0.401	Weeds (78)	Clay	8.46E-09	1.13E-08	6.60E-08	8.80E-08	2.84E-04	3.79E-04
250	10	0.05	0.015	0.401	Weeds (78)	Loam	1.30E-08	1.73E-08	1.01E-07	1.35E-07	4.37E-04	5.83E-04
50	1	0.05	0.015	0.401	Weeds (78)	Loam	4.18E-10	5.56E-10	3.26E-09	4.34E-09	1.40E-05	1.87E-05
50	100	0.05	0.015	0.401	Weeds (78)	Loam	2.10E-08	2.80E-08	1.64E-07	2.18E-07	7.06E-04	9.40E-04
50	1,000	0.05	0.015	0.401	Weeds (78)	Loam	5.68E-08	7.57E-08	4.43E-07	5.91E-07	1.91E-03	2.55E-03
50	10	0.05	0.015	0.05	Weeds (78)	Loam	3.65E-09	4.86E-09	2.85E-08	3.79E-08	1.23E-04	1.64E-04
50	10	0.05	0.015	0.2	Weeds (78)	Loam	3.65E-09	4.86E-09	2.85E-08	3.79E-08	1.23E-04	1.64E-04
50	10	0.05	0.015	0.5	Weeds (78)	Loam	3.65E-09	4.86E-09	2.85E-08	3.79E-08	1.23E-04	1.64E-04
50	10	0.05	0.023	0.401	Weeds (78)	Loam	3.65E-09	4.86E-09	2.85E-08	3.79E-08	1.23E-04	1.64E-04
50	10	0.05	0.046	0.401	Weeds (78)	Loam	3.65E-09	4.86E-09	2.85E-08	3.79E-08	1.23E-04	1.64E-04
50	10	0.05	0.15	0.401	Weeds (78)	Loam	3.65E-09	4.86E-09	2.85E-08	3.79E-08	1.23E-04	1.64E-04
50	10	0.005	0.015	0.401	Weeds (78)	Loam	3.65E-09	4.86E-09	2.85E-08	3.79E-08	1.23E-04	1.64E-04
50	10	0.01	0.015	0.401	Weeds (78)	Loam	3.65E-09	4.86E-09	2.85E-08	3.79E-08	1.23E-04	1.64E-04
50	10	0.1	0.015	0.401	Weeds (78)	Loam	3.65E-09	4.86E-09	2.85E-08	3.79E-08	1.23E-04	1.64E-04
50	10	0.05	0.015	0.401	Weeds (78)	Silt Loam	1.56E-09	2.08E-09	1.22E-08	1.62E-08	5.24E-05	6.98E-05
50	10	0.05	0.015	0.401	Weeds (78)	Silt	1.69E-09	2.25E-09	1.32E-08	1.75E-08	5.67E-05	7.55E-05
50	10	0.05	0.015	0.401	Weeds (78)	Clay Loam	7.25E-10	9.66E-10	5.65E-09	7.54E-09	2.44E-05	3.25E-05
50	10	0.05	0.015	0.401	Shrubs (79)	Loam	3.65E-09	4.86E-09	2.85E-08	3.79E-08	1.23E-04	1.64E-04
50	10	0.05	0.015	0.401	Rye Grass (54)	Loam	3.65E-09	4.86E-09	2.85E-08	3.79E-08	1.23E-04	1.64E-04
50	10	0.05	0.015	0.401	Conifer + Hardwood (71)	Loam	4.34E-09	5.78E-09	3.38E-08	4.51E-08	1.46E-04	1.94E-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**	**Vegetation Type**	**Soil Type**	**Typical Application Rate**	**Maximum Application Rate**	**Typical Application Rate**	**Maximum Application Rate**	**Typical Application Rate**	**Maximum Application Rate**
Overland Flow to Off-site 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	3.82E-10	5.10E-10	2.98E-09	3.97E-09	1.66E-03	2.21E-03
10	10	0.05	0.015	0.401	Weeds (78)	Clay	1.56E-11	2.08E-11	1.22E-10	1.62E-10	6.77E-05	9.03E-05
10	10	0.05	0.015	0.401	Weeds (78)	Loam	1.23E-13	1.64E-13	9.57E-13	1.28E-12	5.33E-07	7.10E-07
25	10	0.05	0.015	0.401	Weeds (78)	Sand	1.27E-08	1.70E-08	9.91E-08	1.32E-07	5.52E-02	7.35E-02
25	10	0.05	0.015	0.401	Weeds (78)	Clay	3.35E-11	4.46E-11	2.61E-10	3.48E-10	1.45E-04	1.93E-04
25	10	0.05	0.015	0.401	Weeds (78)	Loam	1.44E-09	1.92E-09	1.12E-08	1.49E-08	6.23E-03	8.31E-03
50	10	0.05	0.015	0.401	Weeds (78)	Sand	2.15E-08	2.87E-08	1.67E-07	2.23E-07	9.32E-02	1.24E-01
50	10	0.05	0.015	0.401	Weeds (78)	Clay	3.74E-10	4.99E-10	2.91E-09	3.88E-09	1.62E-03	2.16E-03
50	10	0.05	0.015	0.401	Weeds (78)	Loam	1.09E-08	1.46E-08	8.52E-08	1.14E-07	4.74E-02	6.32E-02
100	10	0.05	0.015	0.401	Weeds (78)	Sand	4.28E-08	5.70E-08	3.33E-07	4.44E-07	1.85E-01	2.47E-01
100	10	0.05	0.015	0.401	Weeds (78)	Clay	9.93E-09	1.32E-08	7.73E-08	1.03E-07	4.30E-02	5.73E-02
100	10	0.05	0.015	0.401	Weeds (78)	Loam	2.11E-08	2.82E-08	1.64E-07	2.19E-07	9.15E-02	1.22E-01
150	10	0.05	0.015	0.401	Weeds (78)	Sand	6.06E-08	8.08E-08	4.72E-07	6.29E-07	2.63E-01	3.50E-01
150	10	0.05	0.015	0.401	Weeds (78)	Clay	1.61E-08	2.15E-08	1.25E-07	1.67E-07	6.98E-02	9.30E-02
150	10	0.05	0.015	0.401	Weeds (78)	Loam	2.89E-08	3.86E-08	2.25E-07	3.00E-07	1.25E-01	1.67E-01
200	10	0.05	0.015	0.401	Weeds (78)	Sand	7.05E-08	9.39E-08	5.48E-07	7.31E-07	3.05E-01	4.07E-01
200	10	0.05	0.015	0.401	Weeds (78)	Clay	2.15E-08	2.87E-08	1.68E-07	2.24E-07	9.34E-02	1.24E-01
200	10	0.05	0.015	0.401	Weeds (78)	Loam	3.46E-08	4.61E-08	2.69E-07	3.59E-07	1.50E-01	2.00E-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**	**Vegetation Type**	**Soil Type**	**Typical Application Rate**	**Maximum Application Rate**	**Typical Application Rate**	**Maximum Application Rate**	**Typical Application Rate**	**Maximum Application Rate**
Overland Flow to Off-site Stream Chronic Toxicity												
250	10	0.05	0.015	0.401	Weeds (78)	Sand	7.42E-08	9.89E-08	5.78E-07	7.70E-07	3.22E-01	4.29E-01
250	10	0.05	0.015	0.401	Weeds (78)	Clay	2.54E-08	3.38E-08	1.98E-07	2.63E-07	1.10E-01	1.47E-01
250	10	0.05	0.015	0.401	Weeds (78)	Loam	3.90E-08	5.20E-08	3.04E-07	4.05E-07	1.69E-01	2.25E-01
50	1	0.05	0.015	0.401	Weeds (78)	Loam	1.25E-09	1.67E-09	9.75E-09	1.30E-08	5.43E-03	7.23E-03
50	100	0.05	0.015	0.401	Weeds (78)	Loam	6.30E-08	8.39E-08	4.90E-07	6.53E-07	2.73E-01	3.64E-01
50	1,000	0.05	0.015	0.401	Weeds (78)	Loam	1.70E-07	2.27E-07	1.33E-06	1.77E-06	7.39E-01	9.84E-01
50	10	0.05	0.015	0.05	Weeds (78)	Loam	1.09E-08	1.46E-08	8.52E-08	1.14E-07	4.74E-02	6.32E-02
50	10	0.05	0.015	0.2	Weeds (78)	Loam	1.09E-08	1.46E-08	8.52E-08	1.14E-07	4.74E-02	6.32E-02
50	10	0.05	0.015	0.5	Weeds (78)	Loam	1.09E-08	1.46E-08	8.52E-08	1.14E-07	4.74E-02	6.32E-02
50	10	0.05	0.023	0.401	Weeds (78)	Loam	1.09E-08	1.46E-08	8.52E-08	1.14E-07	4.74E-02	6.32E-02
50	10	0.05	0.046	0.401	Weeds (78)	Loam	1.09E-08	1.46E-08	8.52E-08	1.14E-07	4.74E-02	6.32E-02
50	10	0.05	0.15	0.401	Weeds (78)	Loam	1.09E-08	1.46E-08	8.52E-08	1.14E-07	4.74E-02	6.32E-02
50	10	0.005	0.015	0.401	Weeds (78)	Loam	1.09E-08	1.46E-08	8.52E-08	1.14E-07	4.74E-02	6.32E-02
50	10	0.01	0.015	0.401	Weeds (78)	Loam	1.09E-08	1.46E-08	8.52E-08	1.14E-07	4.74E-02	6.32E-02
50	10	0.1	0.015	0.401	Weeds (78)	Loam	1.09E-08	1.46E-08	8.52E-08	1.14E-07	4.74E-02	6.32E-02
50	10	0.05	0.015	0.401	Weeds (78)	Silt Loam	4.68E-09	6.23E-09	3.64E-08	4.85E-08	2.03E-02	2.70E-02
50	10	0.05	0.015	0.401	Weeds (78)	Silt	5.06E-09	6.74E-09	3.94E-08	5.25E-08	2.19E-02	2.92E-02
50	10	0.05	0.015	0.401	Weeds (78)	Clay Loam	2.17E-09	2.90E-09	1.69E-08	2.26E-08	9.42E-03	1.26E-02
50	10	0.05	0.015	0.401	Shrubs (79)	Loam	1.09E-08	1.46E-08	8.52E-08	1.14E-07	4.74E-02	6.32E-02
50	10	0.05	0.015	0.401	Rye Grass (54)	Loam	1.09E-08	1.46E-08	8.52E-08	1.14E-07	4.74E-02	6.32E-02
50	10	0.05	0.015	0.401	Conifer + Hardwood (71)	Loam	1.30E-08	1.73E-08	1.01E-07	1.35E-07	5.64E-02	7.51E-02

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**	**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	2.24E-10	2.98E-10
10	10	0.05	0.015	0.401	Weeds (78)	Clay	8.21E-12	1.09E-11
10	10	0.05	0.015	0.401	Weeds (78)	Loam	7.90E-14	1.05E-13
25	10	0.05	0.015	0.401	Weeds (78)	Sand	5.20E-09	6.93E-09
25	10	0.05	0.015	0.401	Weeds (78)	Clay	1.50E-11	1.99E-11
25	10	0.05	0.015	0.401	Weeds (78)	Loam	6.85E-10	9.13E-10
50	10	0.05	0.015	0.401	Weeds (78)	Sand	6.78E-09	9.03E-09
50	10	0.05	0.015	0.401	Weeds (78)	Clay	1.87E-10	2.49E-10
50	10	0.05	0.015	0.401	Weeds (78)	Loam	3.61E-09	4.81E-09
100	10	0.05	0.015	0.401	Weeds (78)	Sand	1.18E-08	1.58E-08
100	10	0.05	0.015	0.401	Weeds (78)	Clay	3.29E-09	4.38E-09
100	10	0.05	0.015	0.401	Weeds (78)	Loam	4.68E-09	6.24E-09
150	10	0.05	0.015	0.401	Weeds (78)	Sand	1.54E-08	2.05E-08
150	10	0.05	0.015	0.401	Weeds (78)	Clay	5.06E-09	6.74E-09
150	10	0.05	0.015	0.401	Weeds (78)	Loam	5.70E-09	7.60E-09
200	10	0.05	0.015	0.401	Weeds (78)	Sand	1.34E-08	1.79E-08
200	10	0.05	0.015	0.401	Weeds (78)	Clay	6.69E-09	8.91E-09
200	10	0.05	0.015	0.401	Weeds (78)	Loam	6.30E-09	8.39E-09
250	10	0.05	0.015	0.401	Weeds (78)	Sand	1.04E-08	1.38E-08
250	10	0.05	0.015	0.401	Weeds (78)	Clay	7.83E-09	1.04E-08
250	10	0.05	0.015	0.401	Weeds (78)	Loam	6.82E-09	9.09E-09
50	1	0.05	0.015	0.401	Weeds (78)	Loam	7.73E-10	1.03E-09
50	100	0.05	0.015	0.401	Weeds (78)	Loam	5.52E-09	7.36E-09
50	1,000	0.05	0.015	0.401	Weeds (78)	Loam	5.84E-09	7.79E-09
50	10	0.05	0.015	0.05	Weeds (78)	Loam	3.61E-09	4.81E-09
50	10	0.05	0.015	0.2	Weeds (78)	Loam	3.61E-09	4.81E-09

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**	**Vegetation Type**	**Soil Type**	**Typical Application Rate**	**Maximum Application Rate**
50	10	0.05	0.015	0.5	Weeds (78)	Loam	3.61E-09	4.81E-09
50	10	0.05	0.023	0.401	Weeds (78)	Loam	3.61E-09	4.81E-09
50	10	0.05	0.046	0.401	Weeds (78)	Loam	3.61E-09	4.81E-09
50	10	0.05	0.15	0.401	Weeds (78)	Loam	3.61E-09	4.81E-09
50	10	0.005	0.015	0.401	Weeds (78)	Loam	3.61E-09	4.81E-09
50	10	0.01	0.015	0.401	Weeds (78)	Loam	3.61E-09	4.81E-09
50	10	0.1	0.015	0.401	Weeds (78)	Loam	3.61E-09	4.81E-09
50	10	0.05	0.015	0.401	Weeds (78)	Silt Loam	1.77E-09	2.35E-09
50	10	0.05	0.015	0.401	Weeds (78)	Silt	1.87E-09	2.49E-09
50	10	0.05	0.015	0.401	Weeds (78)	Clay Loam	8.94E-10	1.19E-09
50	10	0.05	0.015	0.401	Shrubs (79)	Loam	3.61E-09	4.81E-09
50	10	0.05	0.015	0.401	Rye Grass (54)	Loam	3.61E-09	4.81E-09
50	10	0.05	0.015	0.401	Conifer + Hardwood (71)	Loam	4.07E-09	5.42E-09

USLE - Universal Soil Loss Equation.
ac = acres.
in/yr. = inches per year.
Values in parentheses represent number assigned in GLEAMS for that variable.
Typical and maximum application rates are used for applications on rangeland and public-domain forestland. Only the results for the maximum application rate are applicable for energy and mineral sites, ROW, and recreation areas (single rate is used).
Shading and boldface indicates plant RQs greater than 1.
Values of zero indicate that GLEAMS did not predict herbicide transport from the application area; therefore, the resulting risk quotient is zero.

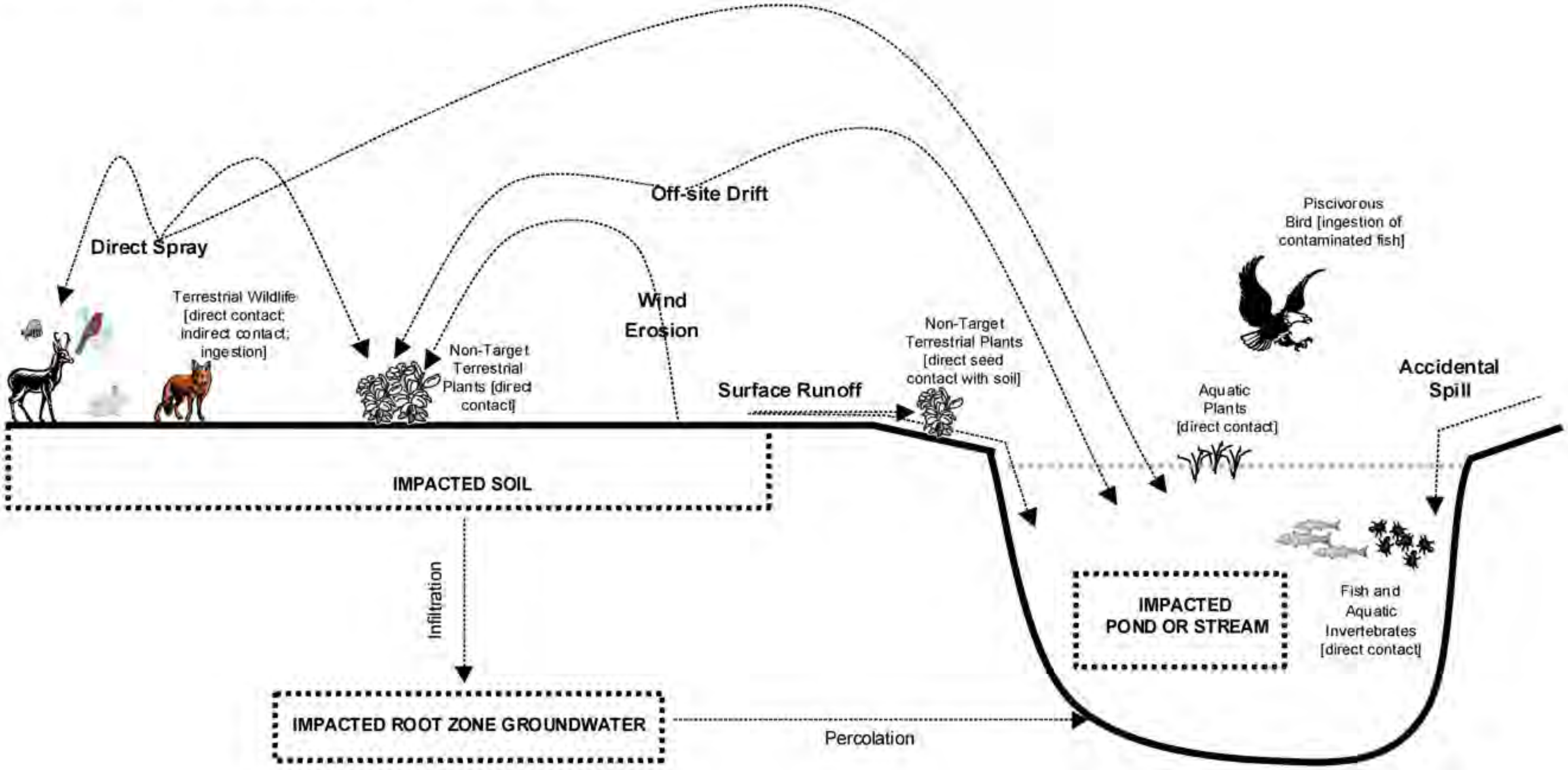
TABLE 4-5

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	9.37E-02	1.25E-01	9.76E-02	1.30E-01
Montana	10	2.75E-03	3.66E-03	2.86E-03	3.82E-03
Montana	100	9.61E-05	1.28E-04	1.00E-04	1.33E-04
Oregon	1.5	**1.08E+00**	**1.44E+00**	**1.12E+00**	**1.50E+00**
Oregon	10	2.88E-02	3.84E-02	3.00E-02	4.00E-02
Oregon	100	7.03E-04	9.37E-04	7.33E-04	9.76E-04
Wyoming	1.5	5.54E-01	7.38E-01	5.77E-01	7.69E-01
Wyoming	10	1.98E-02	2.64E-02	2.07E-02	2.75E-02
Wyoming	100	6.32E-04	8.42E-04	6.59E-04	8.78E-04

km = kilometers; 1.5 km = 0.9 miles, 10 km = 6.2 miles, and 100 km = 62 miles.
RTE = Rare, threatened, and endangered.
Typical and maximum application rates are used for applications on rangeland and public-domain forestland. Only the results for the maximum application rate are applicable for energy and mineral sites, ROW, and recreation areas (single rate is used).
Shading and boldface indicates plant RQs greater than 1 (LOC for all plant risks).

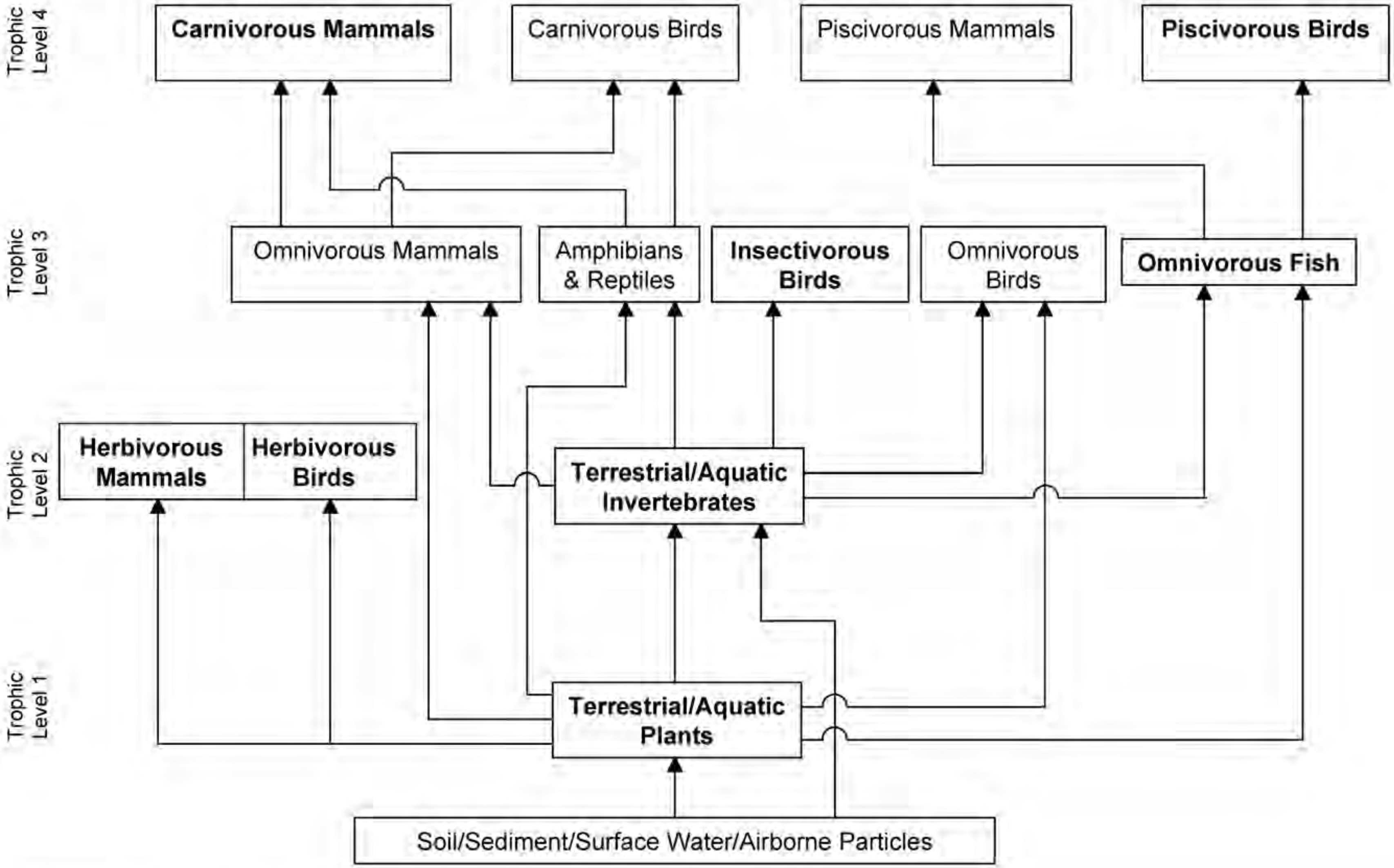
FIGURE 4-1. Conceptual Model for Terrestrial Herbicides.



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.

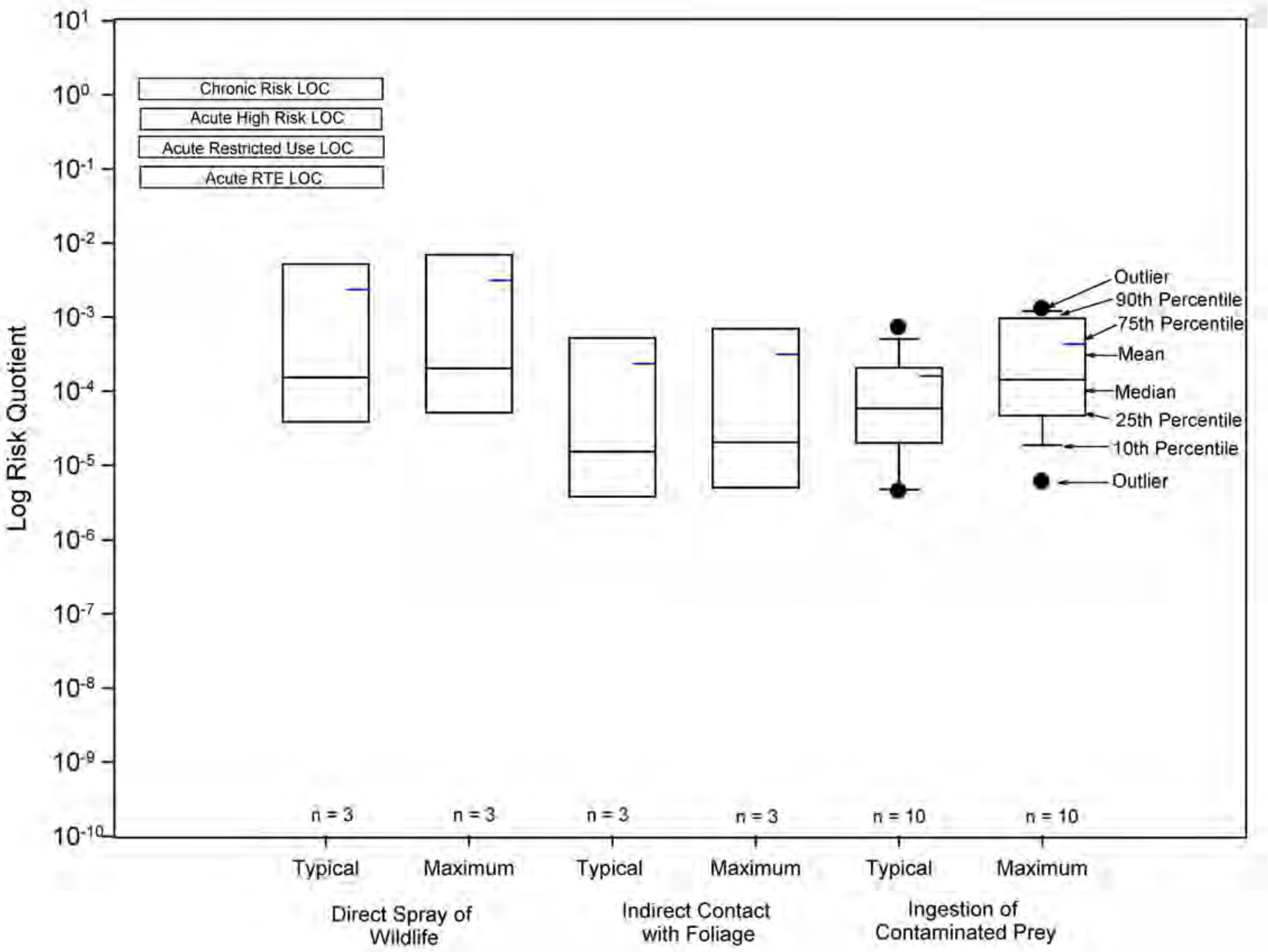


FIGURE 4-4. Direct Spray - Risk Quotients for Non-target Terrestrial Plants.

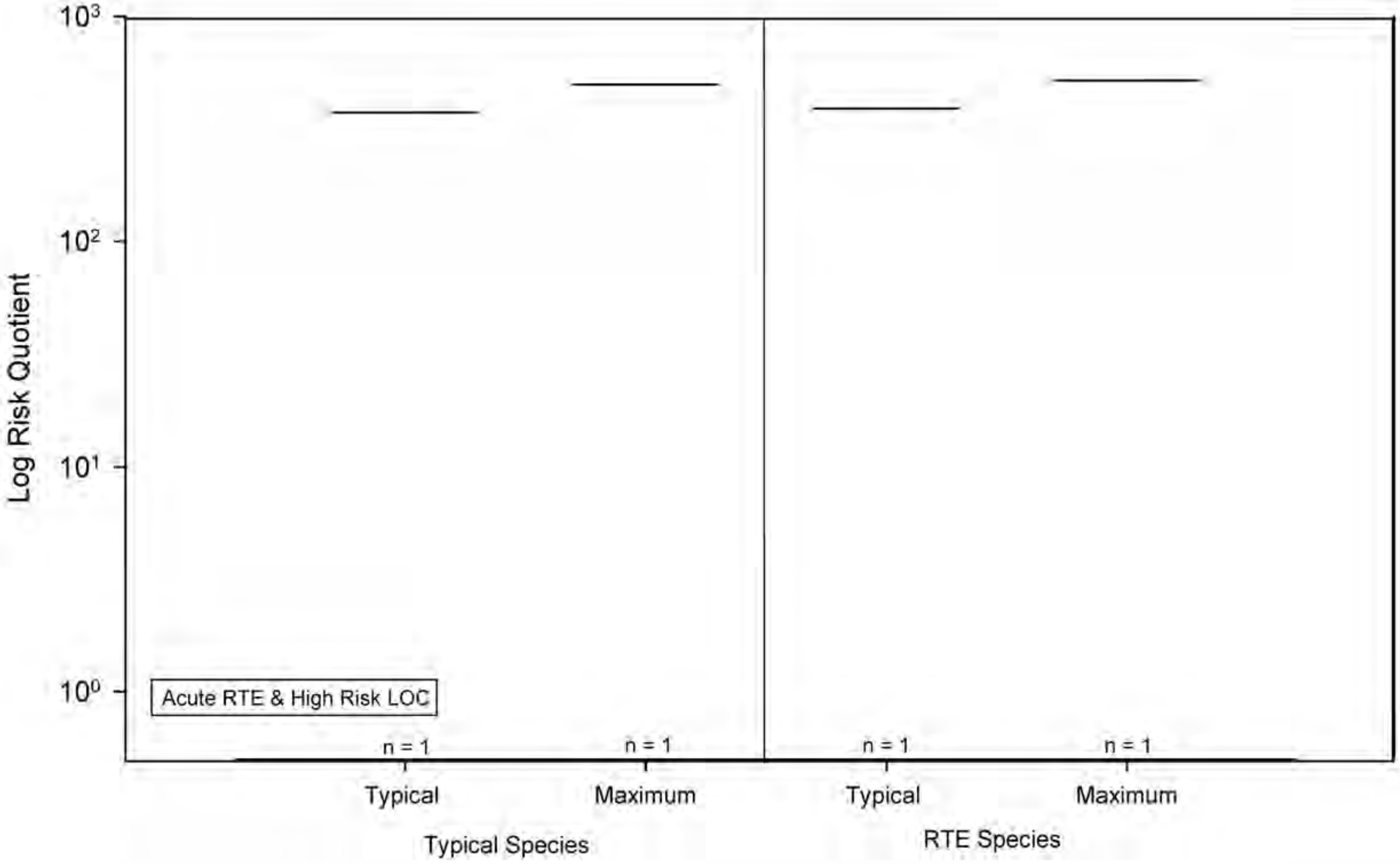


FIGURE 4-5. Accidental Direct Spray and Spills - Risk Quotients for Non-target Aquatic Plants.

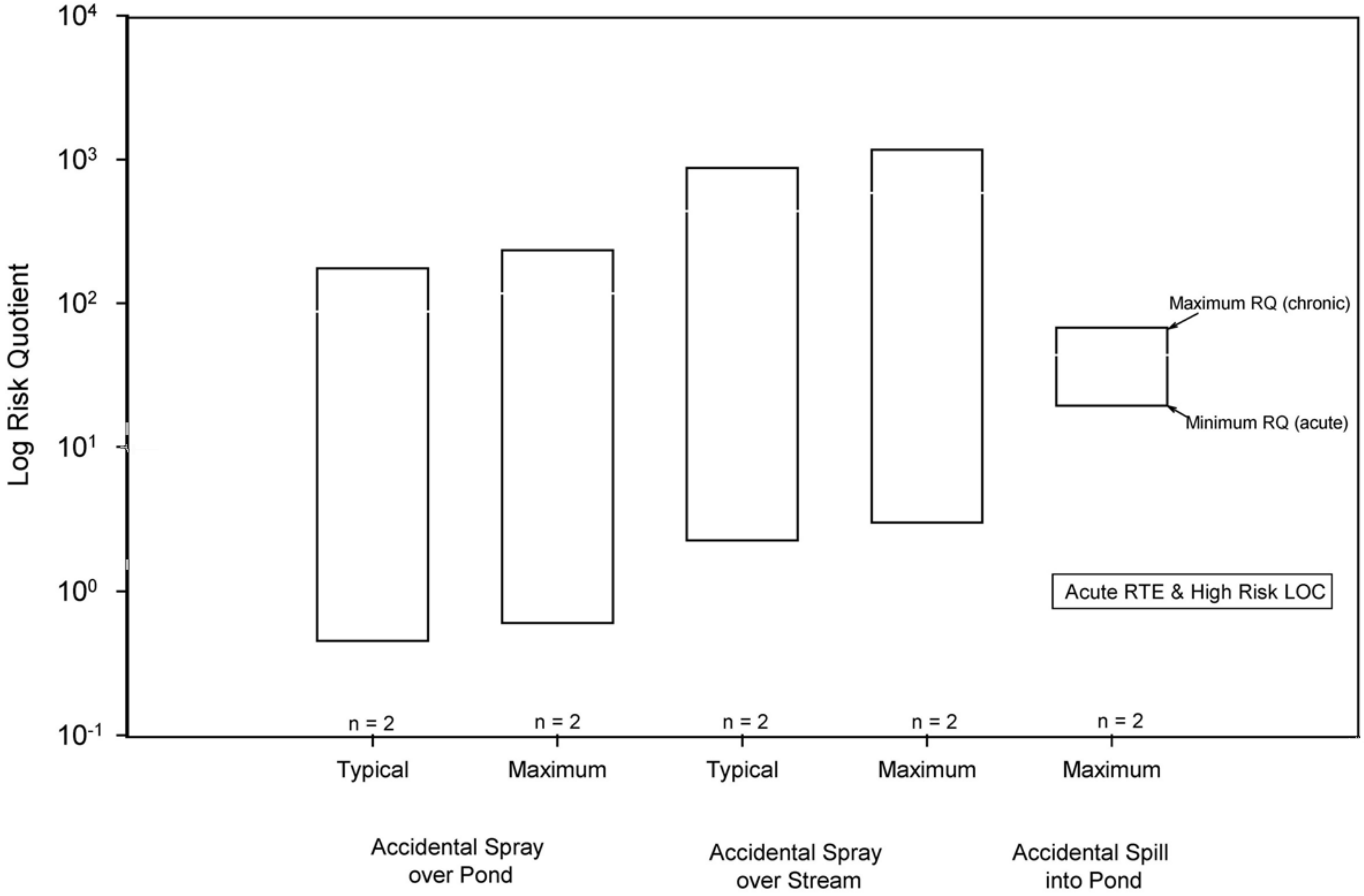


FIGURE 4-6. Accidental Direct Spray and Spills - Risk Quotients for Fish.

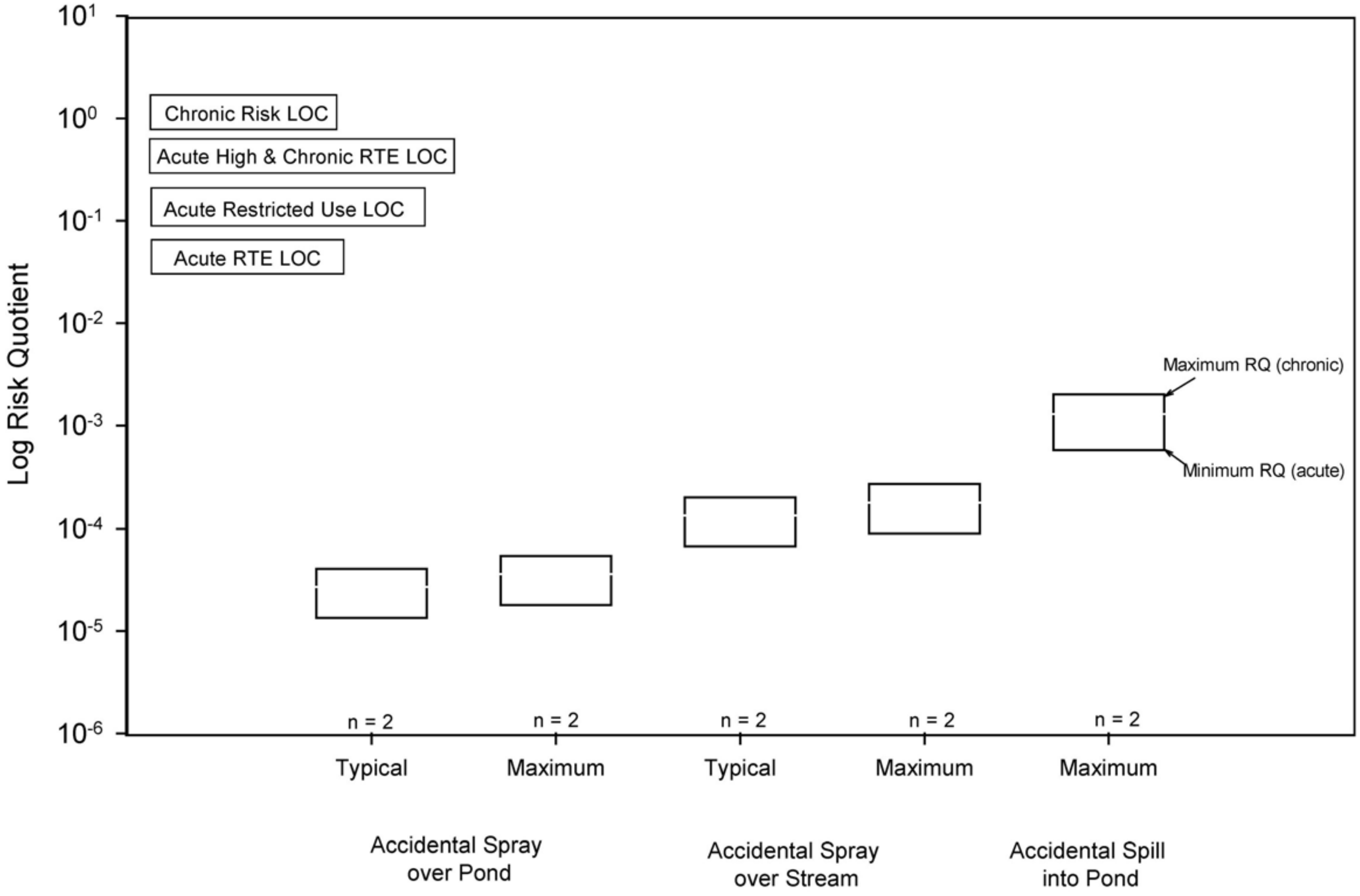


FIGURE 4-7. Accidental Direct Spray and Spills - Risk Quotients for Aquatic Invertebrates.

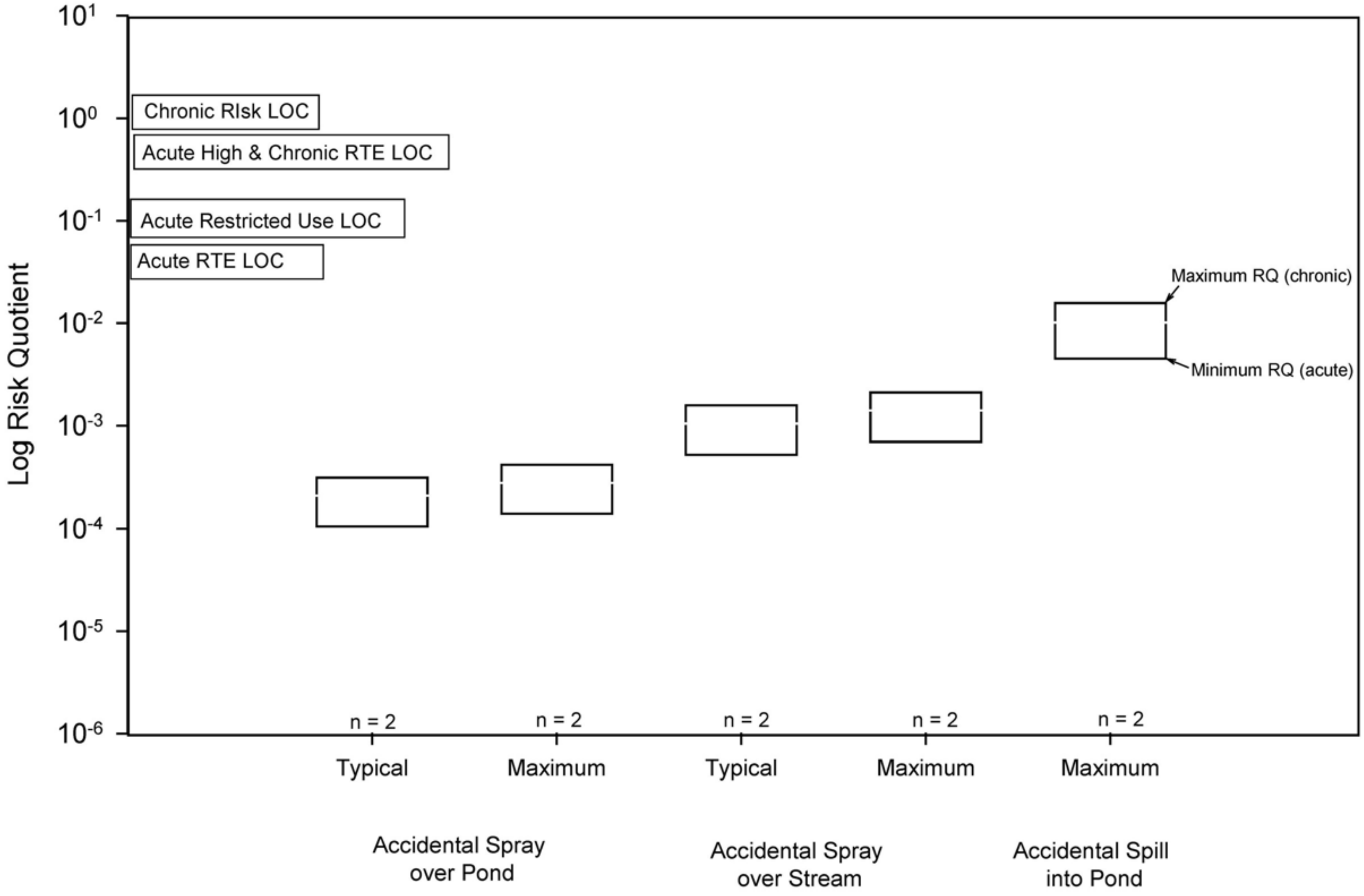


FIGURE 4-8. Off-Site Drift - Risk Quotients for Non-target Terrestrial Plants.

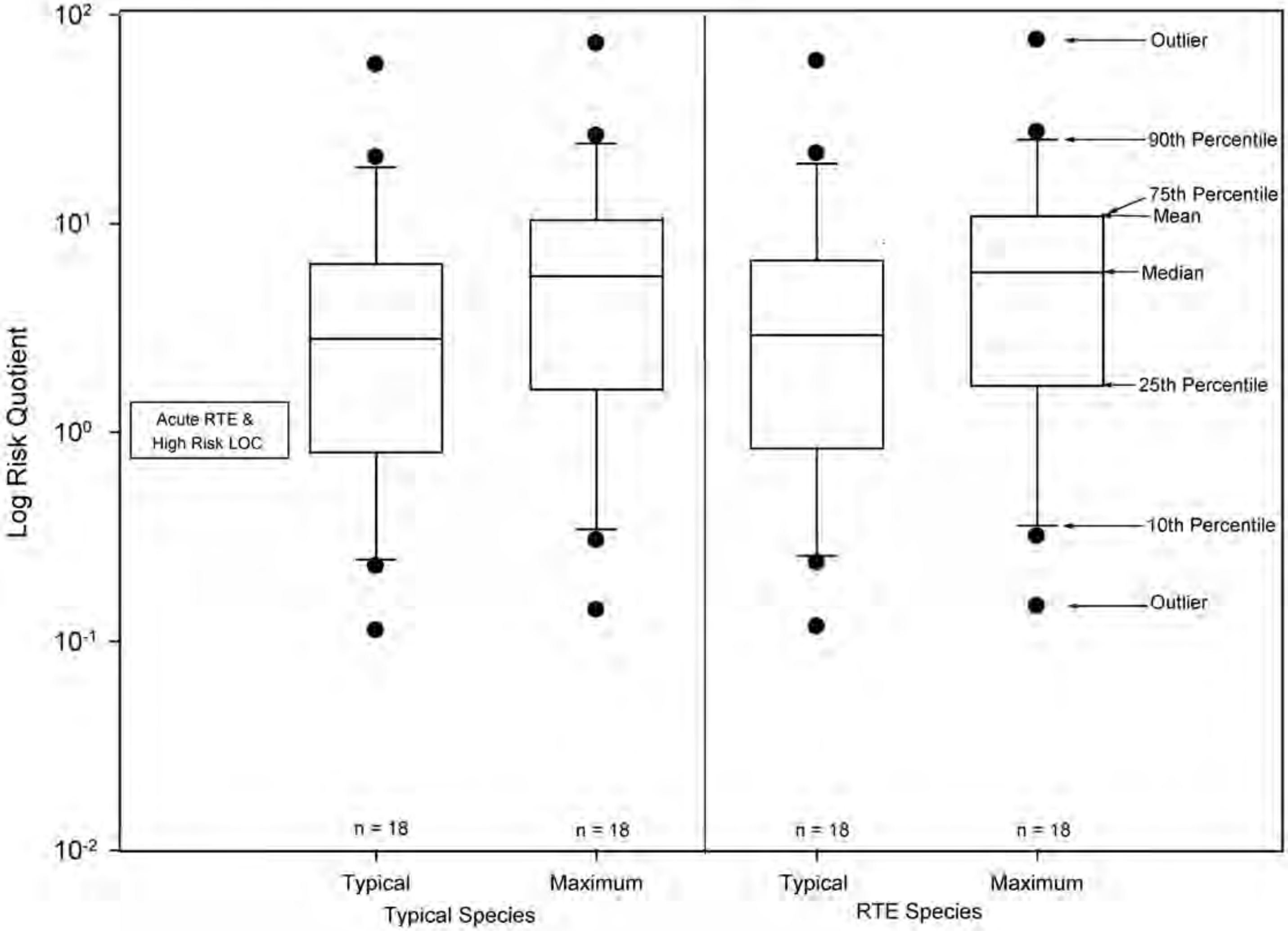


FIGURE 4-9. Off-site Drift - Risk Quotients for Non-target Aquatic Plants.

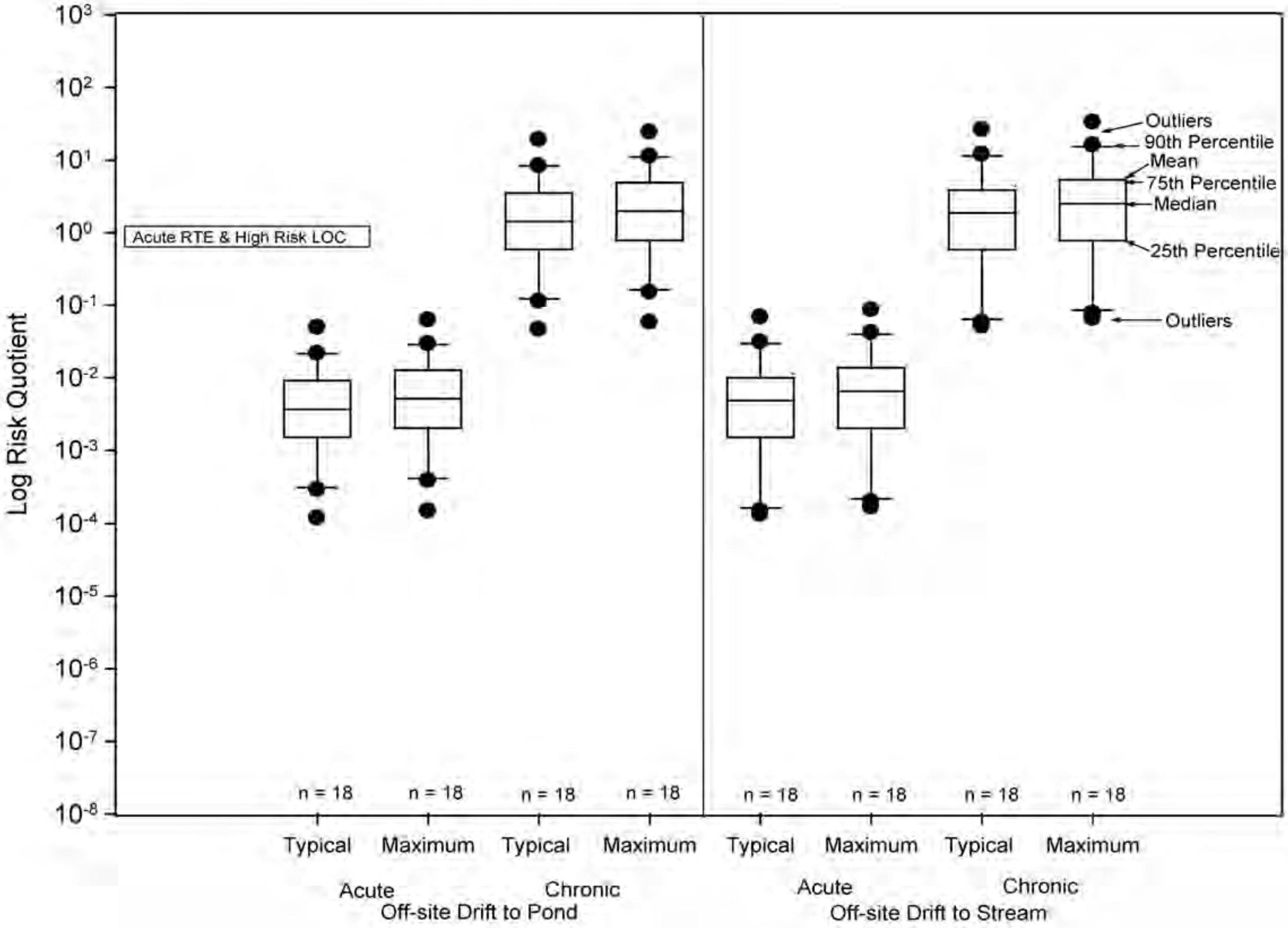


FIGURE 4-10. Off-site Drift - Risk Quotients for Fish.

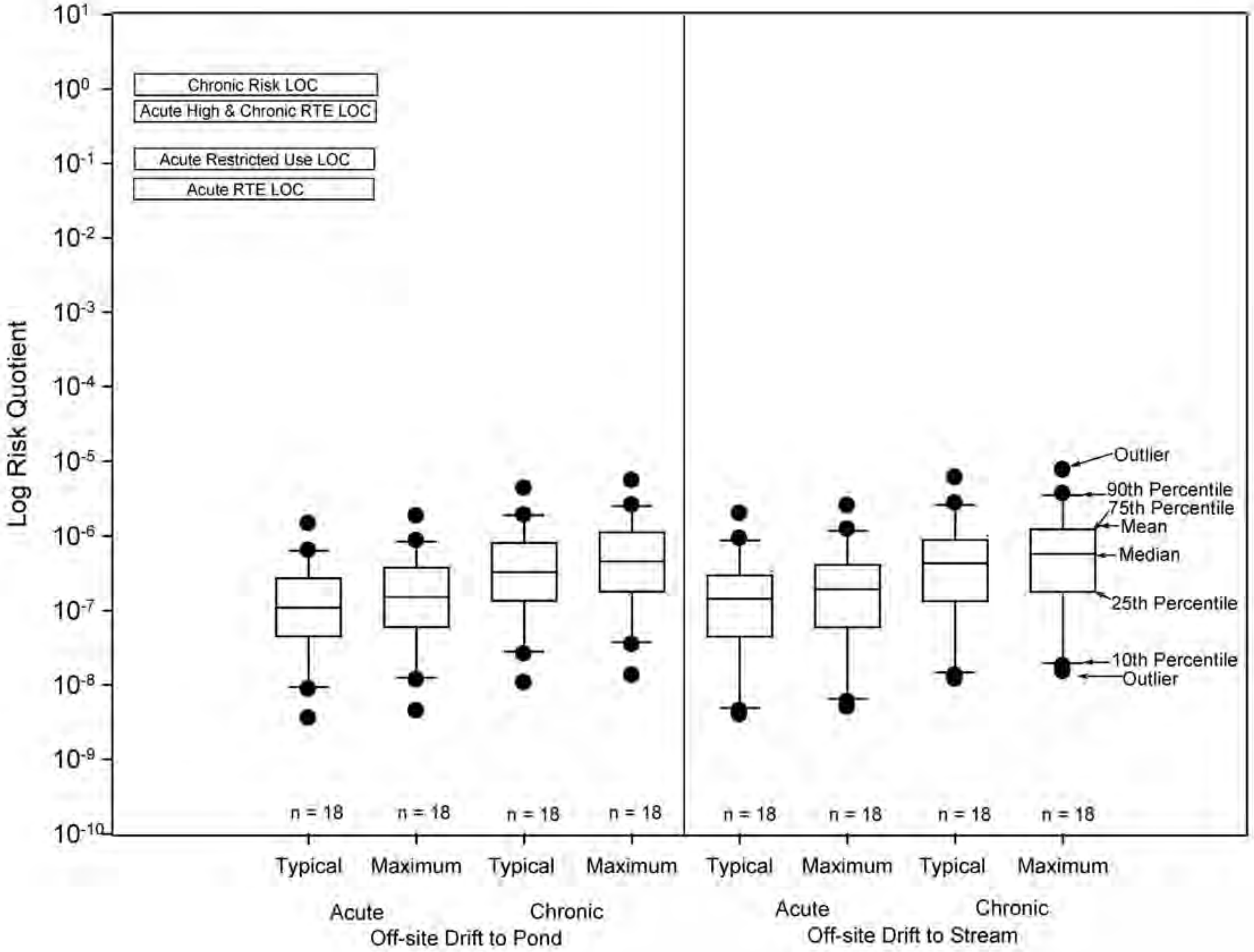


FIGURE 4-11. Off-site Drift - Risk Quotients for Aquatic Invertebrates.

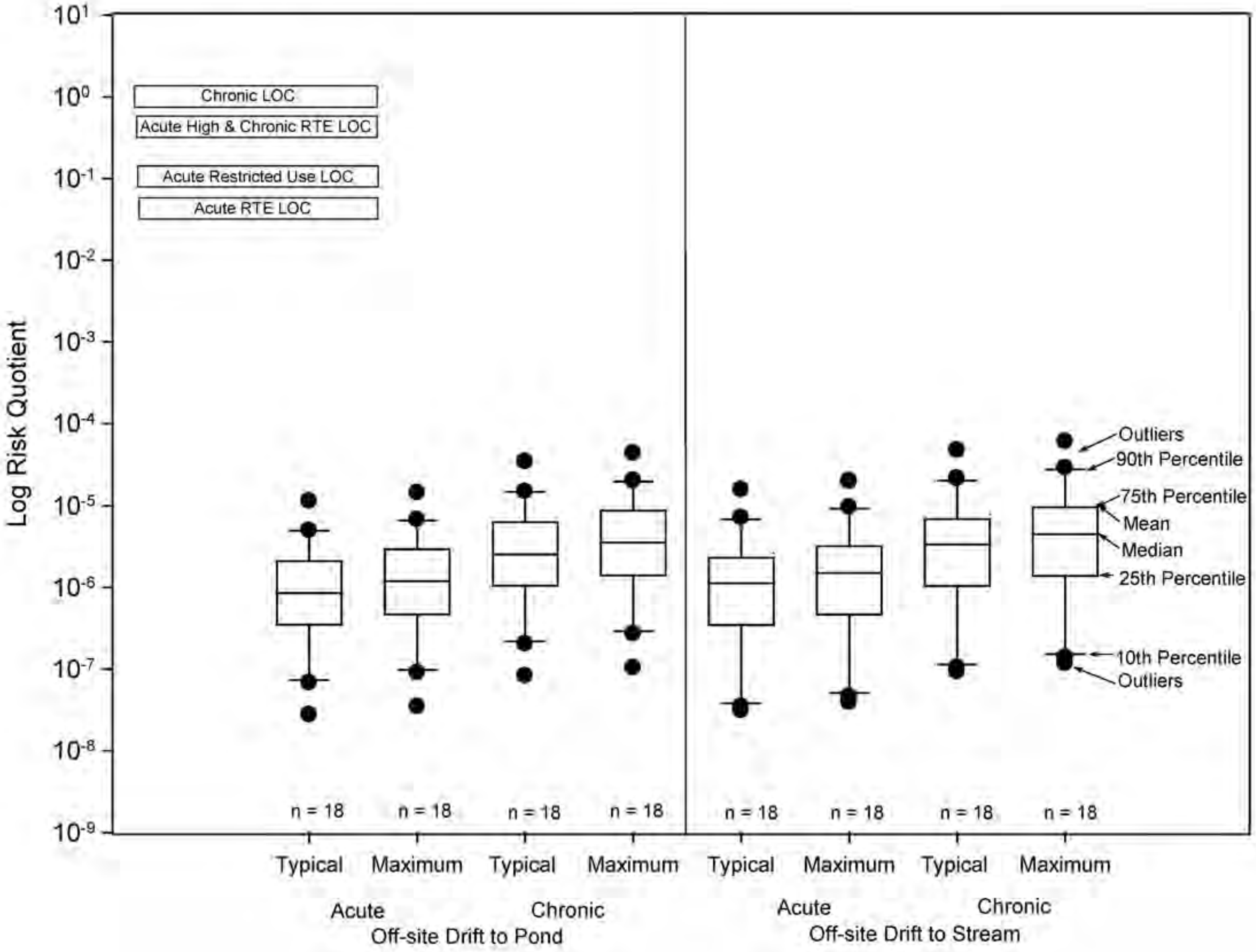


FIGURE 4-12. Off-site Drift - Risk Quotients for Piscivorous Birds.

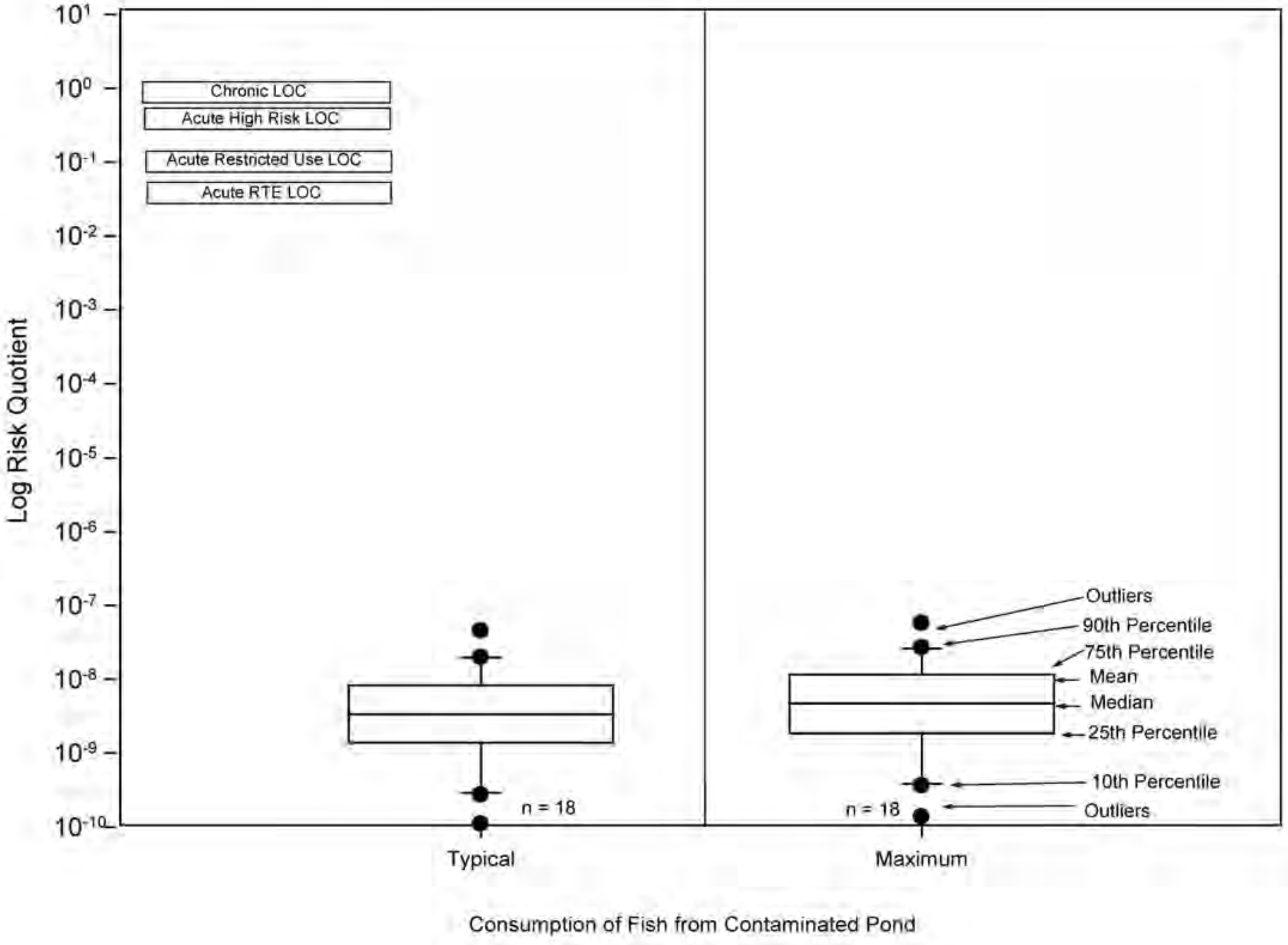


FIGURE 4-13. Surface Runoff - Risk Quotients for Non-target Terrestrial Plants.

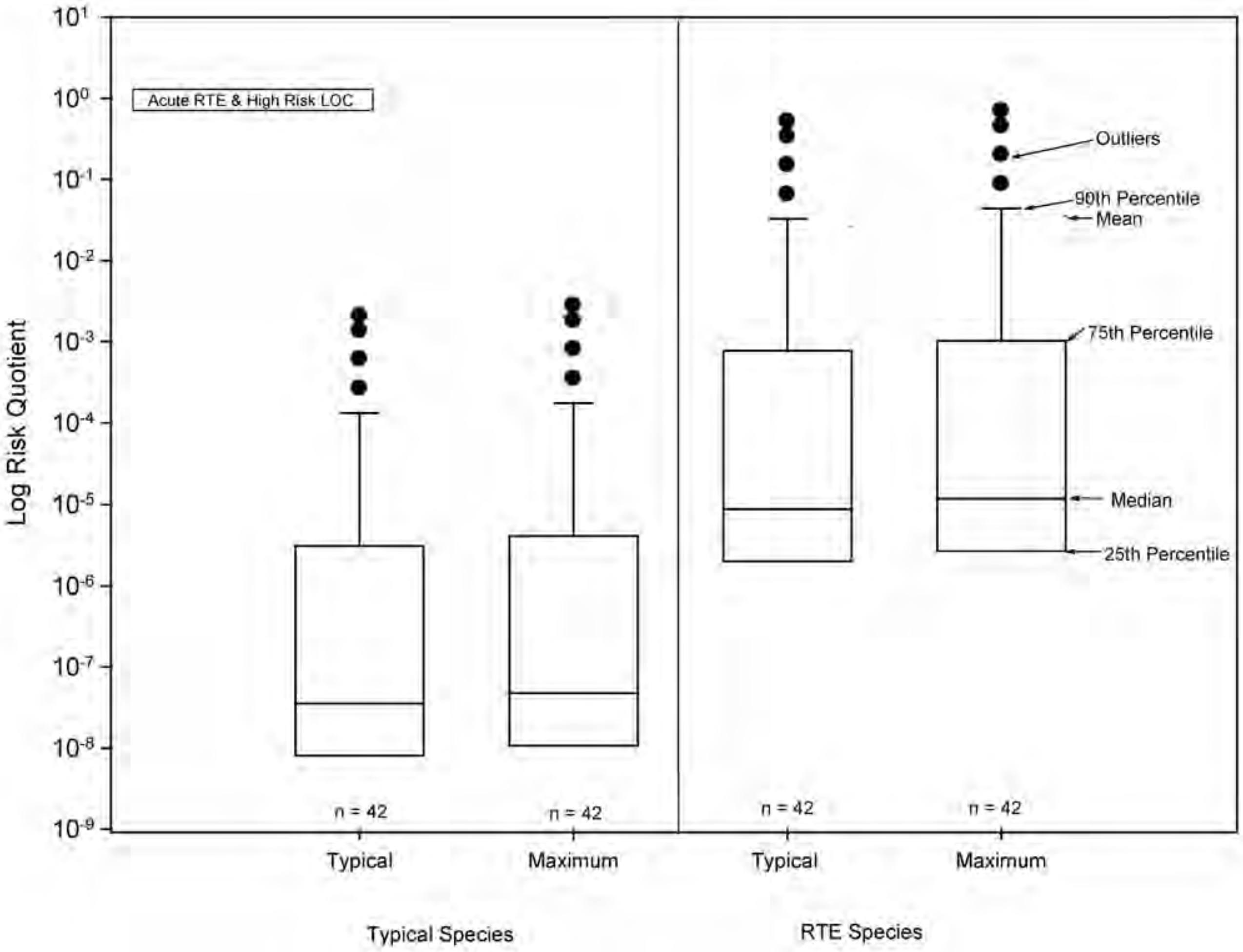


FIGURE 4-14. Surface Runoff - Risk Quotients for Non-target Aquatic Plants.

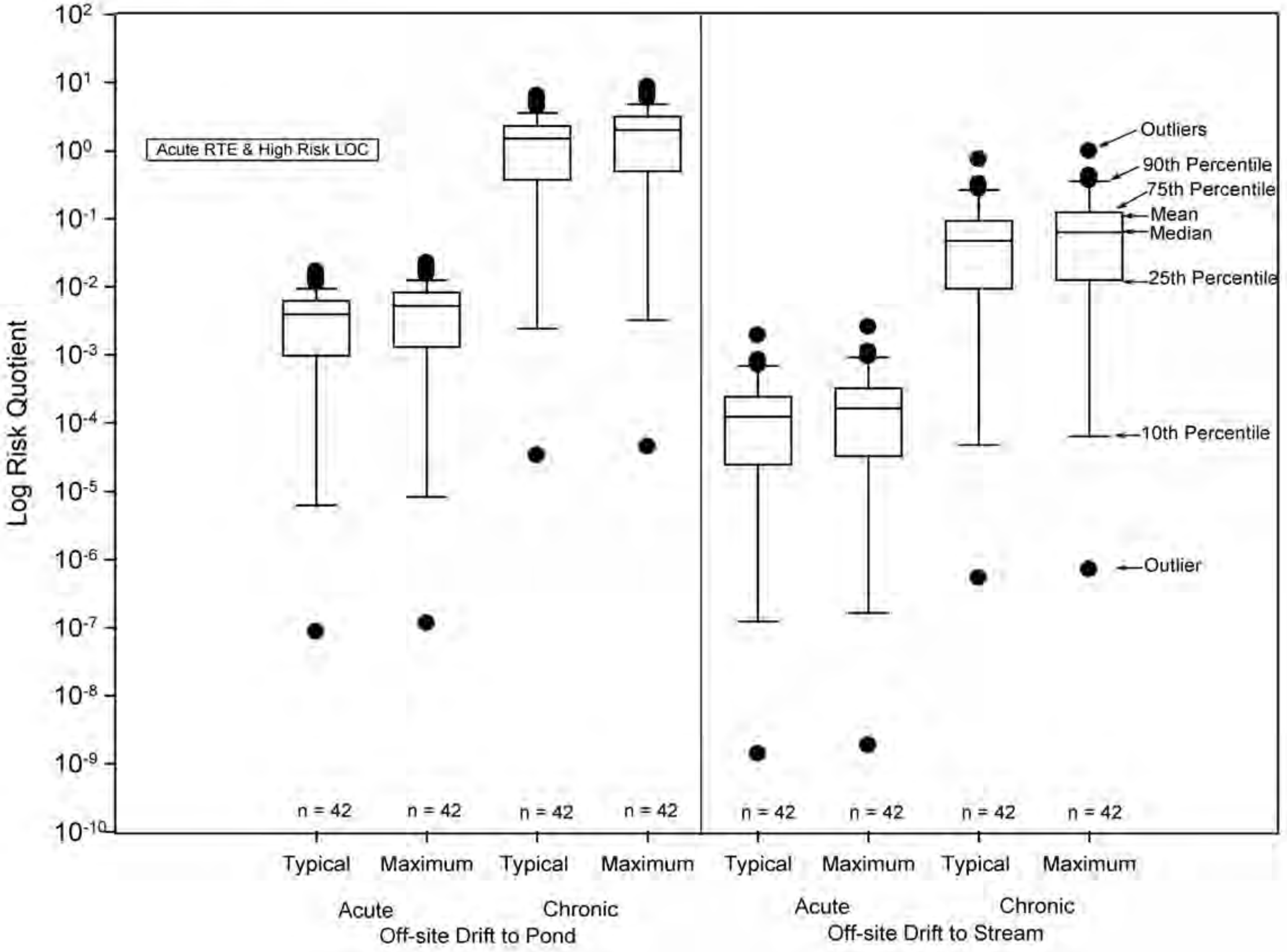


FIGURE 4-15. Surface Runoff - Risk Quotients for Fish.

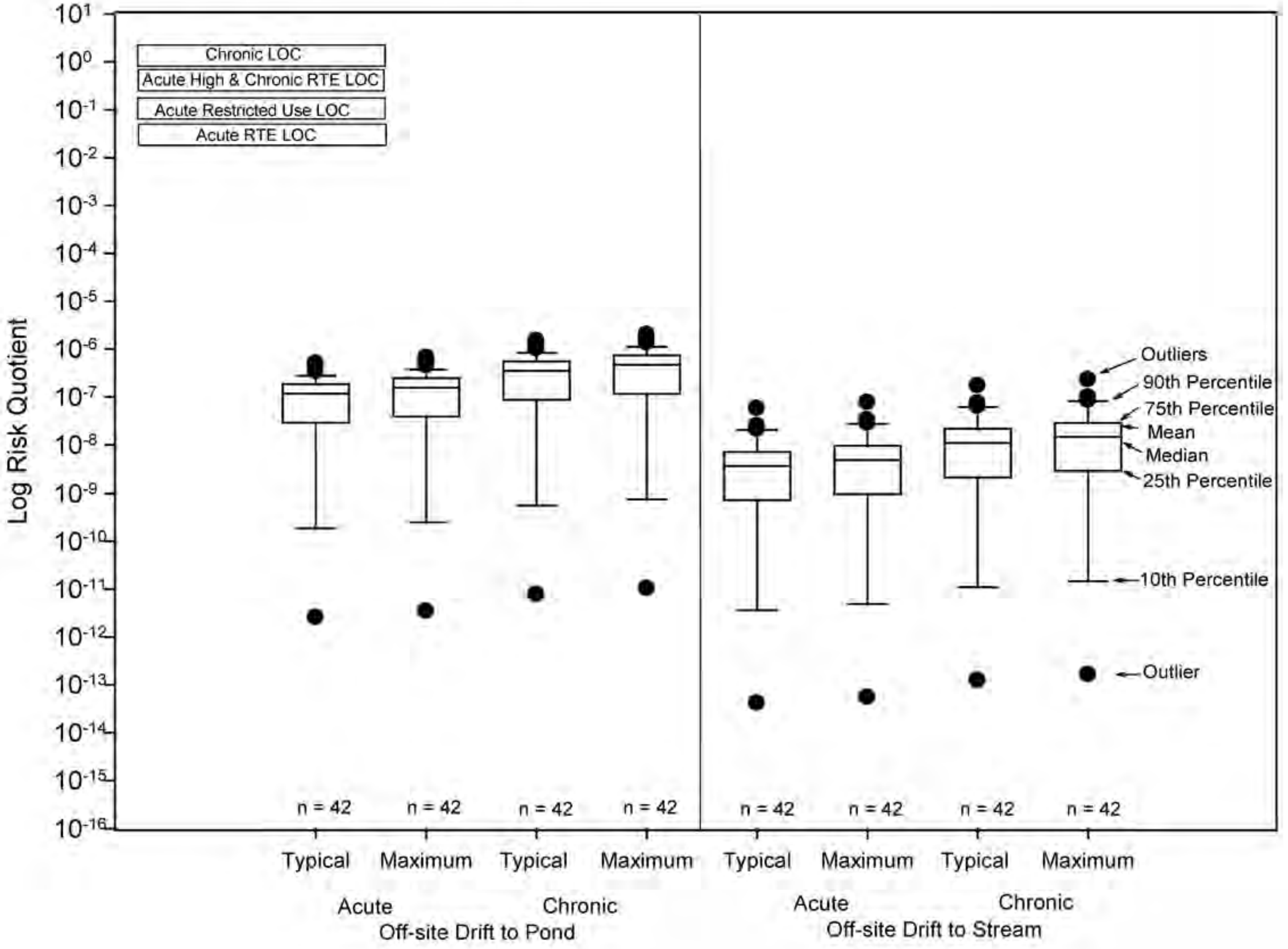


FIGURE 4-16. Surface Runoff - Risk Quotients for Aquatic Invertebrates.

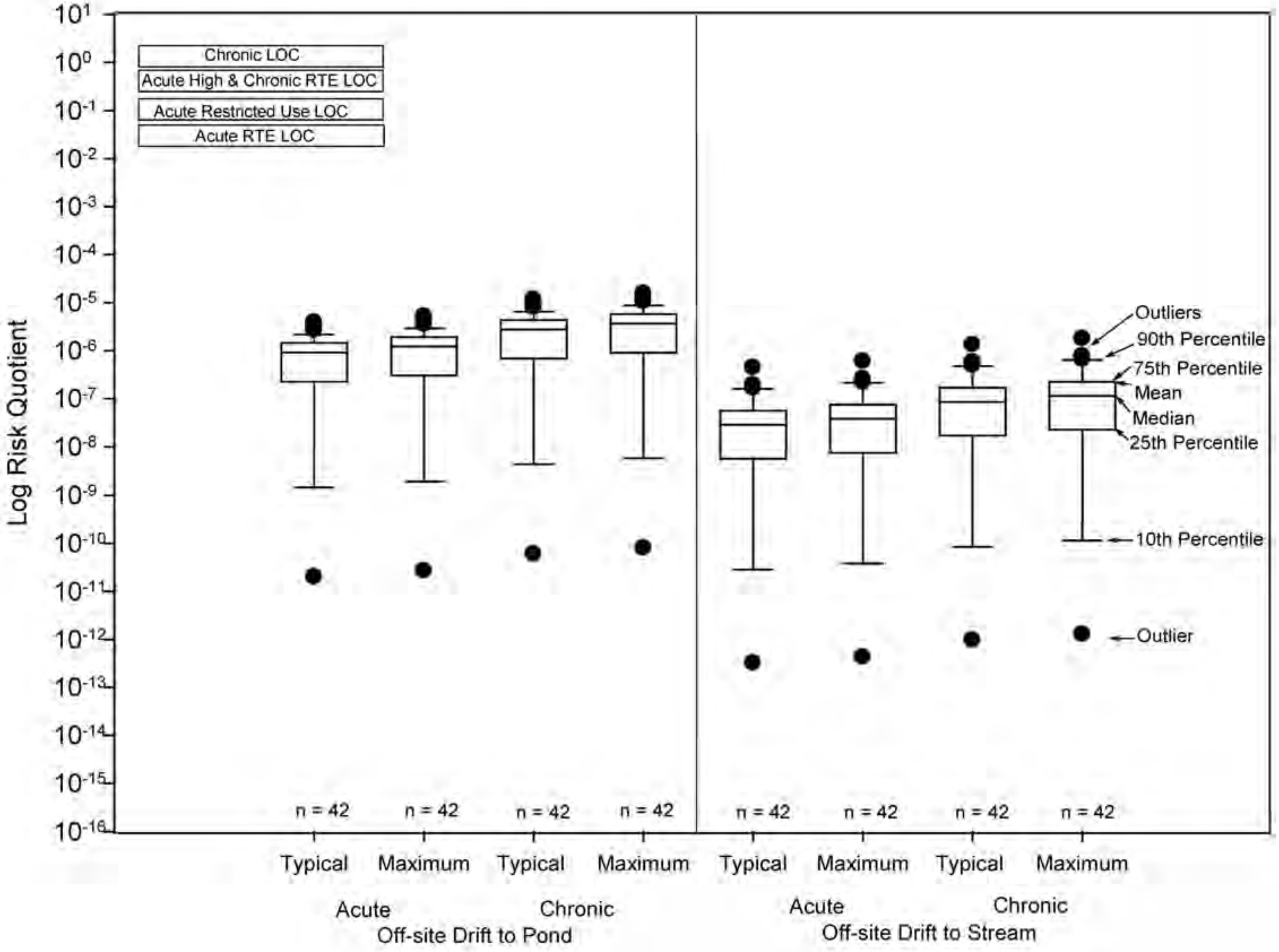


FIGURE 4-17. Surface Runoff - Risk Quotients for Piscivorous Birds.

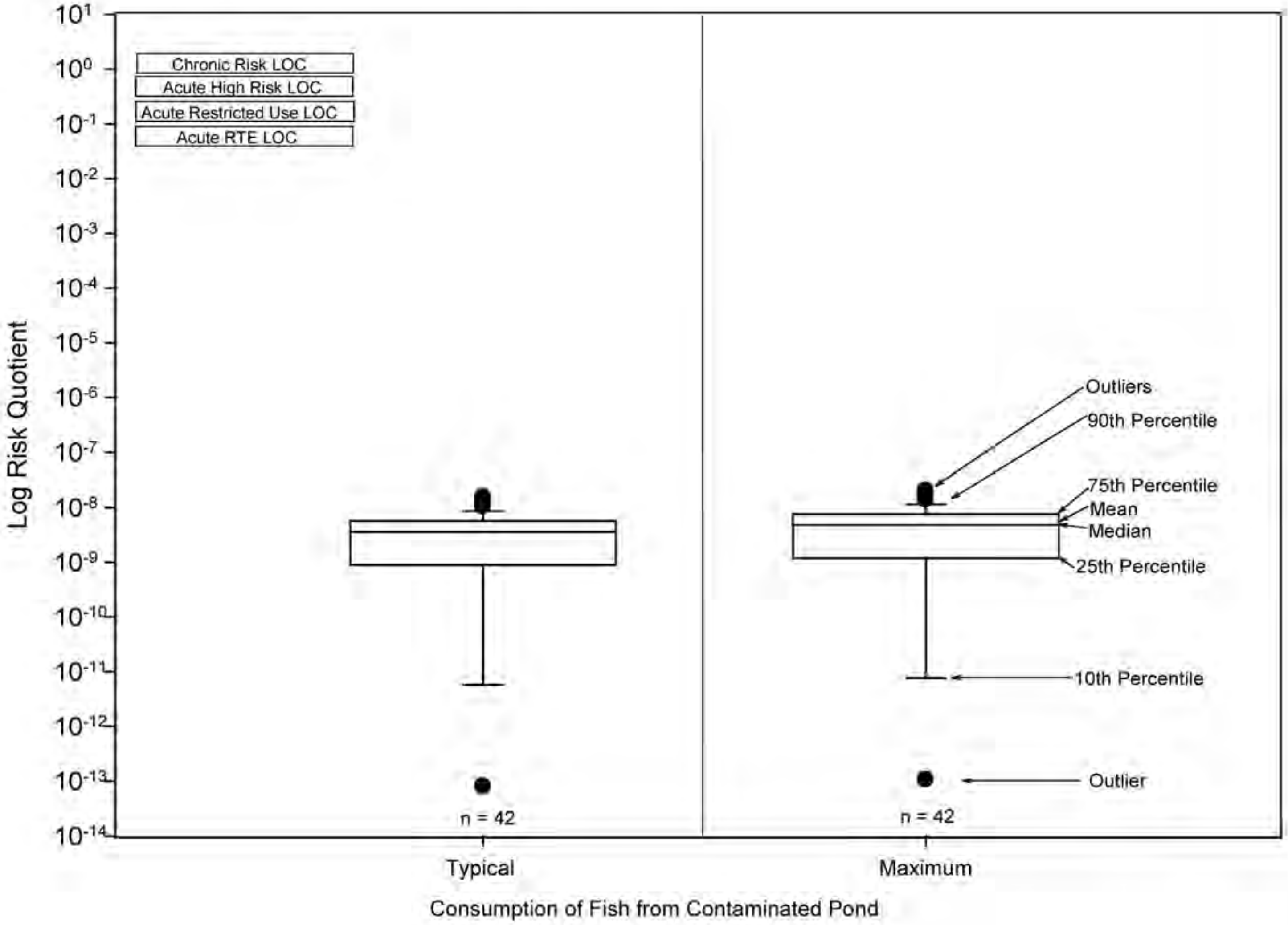
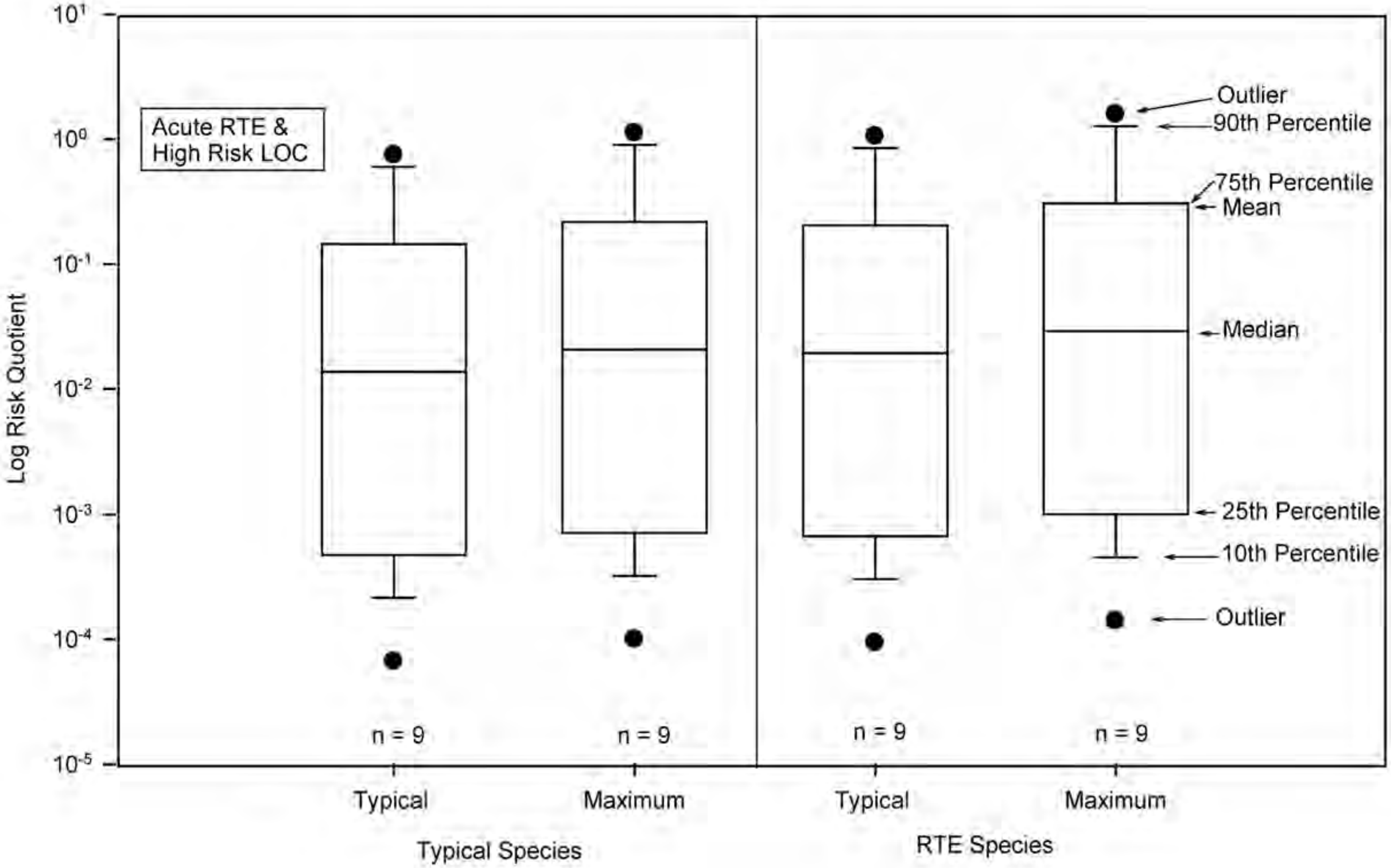


FIGURE 4-18. Wind Erosion and Transport Off-site - Risk Quotients for Non-target Terrestrial Plants.



5.0 SENSITIVITY ANALYSIS

A sensitivity analysis was designed to determine which factors used to predict exposure concentrations most greatly affect exposure concentrations. A base case for each model used (GLEAMS, AgDRIFT®, AERMOD, and CALPUFF) was established. Input factors were changed independently, allowing the importance of each factor to be estimated separately. This section provides information specific to the sensitivity of each model to select input variables. This section provides information specific to the sensitivity of each model to select input variables.

5.1 GLEAMS

GLEAMS (**G**roundwater **L**oading **E**ffects of **A**gricultural **M**anagement **S**ystems) is a model developed for field-sized 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 from edge-of-field and bottom-of-root-zone loadings of water, sediment, pesticides, and plant nutrients as a result of the complex climate-soil-management interactions. Agricultural pesticides are simulated by GLEAMS using model input parameters that characterize three major components of the system: hydrology, erosion, and pesticides. This section describes the sensitivity of the model output to input variables controlling environmental conditions (i.e., precipitation, soil type). The goal of the sensitivity analysis was to investigate the control that measurable watershed variables have on the predicted outcome of a GLEAMS simulation.

5.1.1 GLEAMS Sensitivity Variables

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

1. <u>Annual Precipitation</u> – 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 250 inches per year, respectively (this represents one half and two times the precipitation level considered in the base watershed in the ERA).

2. <u>Application Area</u> – Variation in field size was investigated to determine its influence on herbicide export rates and predicted stream and pond concentrations. The lowest and highest values for application areas evaluated were 1 and 1,000 acres, respectively.

3. <u>Field Slope</u> – Variation in field slope was investigated 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 (equivalent to slopes of 0.5% and 10%).

4. <u>Surface Roughness</u> – The Manning Roughness value, a measure of surface roughness, was 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. <u>Erodibility</u> – Variation in soil erodibility was investigated to determine its effect on predicted river and pond concentrations. The soil erodibility factor is a composite parameter representing an integrated average annual value of the total soil and soil profile reaction to numerous erosive and hydrologic processes. These processes

include 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 erosion index [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 of soil characteristics 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 remove more water from the subsurface, and therefore result in diminished percolation rates through the soil. Vegetation types evaluated in this sensitivity analysis were weeds, shrubs, rye grass, 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 ft./ft.;
- 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 greater than 1.0 denote a positive relationship between herbicide concentration and the variable (increase in RQ), and values less than 1.0 denote a negative relationship (decrease in RQ). A similar table was created for the non-numerical variables soil and vegetation type (Table 5-2). This table presents the difference in concentration under different soil and vegetation types relative to the base case. A ratio was created by dividing the adjusted variable concentration by the base case concentration. Values further 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 3-day average concentration. Precipitation and application area are positively related to herbicide exposure concentrations; as these factors increase, so do herbicide concentrations and ecological risk. Conversely, increased flow or pond volume decreases herbicide concentrations and decreases ecological risk. Changing from loam to sand, clay, or clay loam soils increased stream and pond concentrations. Changing to silt loam and silt soils produced mixed results: average annual concentrations (decreased) and maximum 3-day average concentrations (increased). Changing from weeds to other vegetation types resulted in increased concentrations under conifer and hardwood cover only. All other scenarios resulted in no change in concentration (no change in ecological risk).

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 estimated exposure concentration, 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 in order 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 (i.e., 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 human health risk assessment; AECOM 2014) 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 a small variation in drift and deposition at distances greater than 200 ft. downwind of the hypothetical application area.

- Varying the assumed number of application swaths (aircraft flight lines), application swath width, and wind speed resulted in little change in predicted downwind drift and deposition.

- Variation in the nonvolatile fraction of the spray mixture had no effect on downwind drift and deposition.

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

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

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

An additional limitation of the AgDRIFT® user's manual sensitivity analysis is the focus on distances less than 200 ft. downwind of a hypothetical application area. From a land management perspective, distance downwind from the point of deposition can 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 in this ERA. 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 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 higher with high vs. low boom height (Table 5-3). Vegetation types for aerial applications were not evaluated, since aerial applications are only used by the BLM in their Rangeland program at this time, which contains only non-forested areas. Using the minimum downwind distance, non-forest vegetation, and high boom heights, a comparison was made to determine the effect of mode of application. Concentrations resulting from plane applications were highest and concentrations from ground applications were lowest, with helicopter concentrations falling between the two. The final variable analyzed was application rate (maximum vs. typical), and, as expected, predicted concentrations increased with application rates. Maximum application rate increased exposure concentrations by a factor of three for ground applications. In general, the evaluation presented in Table 5-3 indicates that herbicide migration and associated ecological risk decreases with increased downward distance (i.e., buffer zone). Herbicide migration increases with increasing application height and rate.

5.3 AERMOD and CALPUFF

To determine the downwind deposition of herbicide that might occur as a result of dust-borne herbicide migration, the AERMOD and CALPUFF models were used with 1 year of meteorological data for Glasgow, Montana, Medford, Oregon, and Lander, Wyoming. As indicated in Section 4.3.4, the meteorological conditions (i.e., minimum wind speed) that must be met to trigger particulate emissions were not met for watersheds in Winnemucca, Nevada, or Tucson, Arizona, so dust deposition was not modeled for these two locations.

For this analysis, certain meteorological triggers were considered to determine whether herbicide migration was possible (ENSR 2004). Herbicide migration is not likely during periods of sub-freezing temperatures, precipitation events, and periods with snow cover. For example, it was assumed that 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 very resistant to soil erosion. Deposition rates predicted by the model were 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 AERMOD and CALPUFF. For the three sites evaluated, deposition computations assumed that vegetation typical of the area was in place, rather than being burned off by prescribed burning or removed by other methods prior to the application of the herbicide. For the closest distances in areas with lush vegetation (e.g., Medford, Oregon, and to a lesser extent, Lander, Wyoming), this assumption would cause AERMOD to overestimate herbicide deposition if the vegetation were instead denuded by fire or other methods near the herbicide application area.

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 AERMOD and CALPUFF analysis has been selected to represent typical vegetation (1.3 m in Oregon due to forest cover, but much lower in Wyoming at 0.26 m and only 0.04 m in Montana, depicting little vegetation). The AERMOD and CALPUFF modeling is conservative in that it assumes that herbicide was applied just before each day during the full year modeled that had sufficient wind to cause windblown dust. In actual practice, it is unlikely that more than one herbicide application would be made in a given year at a specific site, and it is very possible that rainfall would activate the herbicide and leach it into the soil surface before a high wind event. Therefore, running the model with multiple windblown dust events can conservatively produce a potentially high frequency of herbicide transport events, and the worst-case modeled event is used for summarizing the predicted herbicide deposition as a function of transport distance.

AERMOD and CALPUFF use hourly meteorological data, in conjunction with the site surface roughness, to calculate the 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 AERMOD and CALPUFF.

The threshold friction velocity is the 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 relatively low 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 AERMOD and CALPUFF modeling effort are based on typical vegetation 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, but the vegetation available for capturing the windblown dust would likely be removed, thus lowering the actual deposition rate for any given windblown soil event. Since the AERMOD and CALPUFF modeling evaluated numerous potential windblown dust events (very unlikely in actual practice due to infrequent herbicide applications), the modeling approach very likely identifies the worst-case deposition event, provided the actual friction velocity exceeds the threshold value at least a few times during the modeled year.

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 off site. 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. However, the modeling considers herbicide transport for every single hour in the course of a year in which the friction velocity exceeds the threshold value and the surface is not wet or frozen.

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

- Disturbed surfaces, such as areas recently burned and large treatment areas, experience greater herbicide migration, but if the vegetation is burned off, the deposition rate per unit emissions in these areas is lower due to the lack of vegetation surfaces to intercept the airborne soil 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	3.08E-08	7.36E-07	3.29E-06	3.92E-05	106.82	53.23	+	+
Area	acres	1	1,000	1.71E-04	2.91E-03	2.39E-02	1.70E-01	139.90	58.51	+	+
Slope	unitless	0.005	0.1	9.29E-07	1.38E-05	9.29E-07	1.38E-05	1.000	1.000	No Change	No Change
Erodibility	tons/acre per English EI	0.05	0.5	9.29E-07	1.38E-05	9.29E-07	1.38E-05	1.000	1.000	No Change	No Change
Roughness	unitless	0.015	0.15	9.29E-07	1.38E-05	9.29E-07	1.38E-05	1.000	1.000	No Change	No Change
Flow Rate	m^3/sec	0.05	100	1.96E-06	2.39E-05	1.28E-09	2.49E-08	0.001	0.001	-	-

Pond Scenarios

Input Variable	Units	Input Low Value (L)	Input High Value (H)	Low Value Predicted Concentration		High Value Predicted Concentration		Concentration $_H$ / Concentration $_L$		Relative Change in Concentration	
				Average Annual Pond	Maximum 3 Day Avg. Pond	Average Annual Pond	Maximum 3 Day Avg. Pond	Average Annual Pond	Maximum 3 Day Avg. Pond	Average Annual Pond	Maximum 3 Day Avg. Pond
Precipitation	inches	25	100	8.59E-06	2.29E-05	1.65E-04	3.61E-04	19.27	15.80	+	+
Area	acres	1	1,000	1.34E-01	1.61E-01	2.01E-01	2.19E-01	1.50	1.36	+	+
Slope	unitless	0.005	0.1	9.59E-05	1.90E-04	9.59E-05	1.90E-04	1.000	1.000	No Change	No Change
Erodibility	tons/acre per English EI	0.05	0.5	9.59E-05	1.90E-04	9.59E-05	1.90E-04	1.000	1.000	No Change	No Change
Roughness	unitless	0.015	0.15	9.59E-05	1.90E-04	9.59E-05	1.90E-04	1.000	1.000	No Change	No Change
Pond Volume	ac/ft.	0.05	100	1.00E-04	1.95E-04	4.02E-07	8.25E-07	0.004	0.004	-	-

EI = Erosion index.
m^3/sec = cubic meters per second.
ac/ft. – acre feet.
Avg. = Average.
Concentrations were based on the average application rate.
+ = Increase in concentration from low to high input value = increase in RQ = increase in ecological risk.
- = Decrease in concentration from low to high input value = decrease in RQ = decrease in ecological risk.
Concentration $_H$ / Concentration $_L$ = Ratio of high value concentration to low value concentration.

TABLE 5-2

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

Soil Type	Predicted Concentration				Concentration$_{\text{X Soil Type}}$ / Concentration$_{\text{Loam}}$				Relative Change in Concentration			
	Avg. Annual Stream	**Max. 3 Day Avg. Stream**	**Avg. Annual Pond**	**Max. 3 Day Avg. Pond**	**Avg. Annual Stream**	**Max. 3 Day Avg. Stream**	**Avg. Annual Pond**	**Max. 3 Day Avg. Pond**	**Avg. Annual Stream**	**Max. 3 Day Avg. Stream**	**Avg. Annual Pond**	**Max. 3 Day Avg. Pond**
Loam[1]	***9.29E-07***	***1.38E-05***	***9.59E-05***	***1.90E-04***	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Sand	5.97E-06	1.08E-04	8.42E-04	2.50E-03	6.4271	7.8423	8.7800	13.1476	+	+	+	+
Clay	2.08E-06	2.21E-04	1.65E-04	6.21E-03	2.2348	15.9667	1.7227	32.7390	+	+	+	+
Clay Loam	1.47E-06	1.57E-04	9.80E-05	2.68E-03	1.5876	11.3184	1.0220	14.1283	+	+	+	+
Silt Loam	5.89E-07	4.23E-05	5.01E-05	7.84E-04	0.6341	3.0605	0.5228	4.1332	-	+	-	+
Silt	6.06E-07	4.65E-05	4.41E-05	7.96E-04	0.6528	3.3605	0.4601	4.1951	-	+	-	+

Vegetation Type	Predicted Concentration				Concentration$_{\text{X Veg Type}}$ / Concentration$_{\text{Weeds}}$				Relative Change in Concentration			
	Avg. Annual Stream	**Max. 3 Day Avg. Stream**	**Avg. Annual Pond**	**Max. 3 Day Avg. Pond**	**Avg. Annual Stream**	**Max. 3 Day Avg. Stream**	**Avg. Annual Pond**	**Max. 3 Day Avg. Pond**	**Avg. Annual Stream**	**Max. 3 Day Avg. Stream**	**Avg. Annual Pond**	**Max. 3 Day Avg. Pond**
Weeds[1]	***9.29E-07***	***1.38E-05***	***9.59E-05***	***1.90E-04***	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Conifer + Hardwood	1.29E-06	1.88E-05	1.13E-04	2.14E-04	1.3902	1.3585	1.1744	1.1293	+	+	+	+
Shrubs	9.29E-07	1.38E-05	9.59E-05	1.90E-04	1.0000	1.0000	1.0000	1.0000	No Change	No Change	No Change	No Change
Rye Grass	9.29E-07	1.38E-05	9.59E-05	1.90E-04	1.0000	1.0000	1.0000	1.0000	No Change	No Change	No Change	No Change

Avg. = Average.

NA = Not an applicable comparison.

[1] ***Base Case***

Concentrations were based on the average application rate.

+ = Increase in concentration from base case = increase in RQ = increase in ecological risk.

- = Decrease in concentration from base case = decrease in RQ = decrease in ecological risk.

Concentration$_{\text{X Soil Type}}$ / Concentration$_{\text{Loam}}$ = Ratio of concentration in indicated soil type to concentration in loam model.

Concentration$_{\text{X Veg Type}}$ / Concentration$_{\text{Weed}}$ = Ratio of concentration in indicated vegetation type to concentration in weed model.

TABLE 5-3

Herbicide Exposure Concentrations used during the Supplemental AgDRIFT® Sensitivity Analysis

Mode of Application	Application Height or Vegetation Type	Minimum Downwind Distance (ft.)	Maximum Downwind Distance (ft.)	Minimum Downwind Distance Concentration			Maximum Downwind Distance Concentration		
				Terrestrial (lb. a.i./ac)	Stream (mg/L)	Pond (mg/L)	Terrestrial (lb. a.i./ac)	Stream (mg/L)	Pond (mg/L)
Typical Application Rate									
Plane	Forest	100	900	7.20E-03	4.01E-03	5.70E-04	8.00E-04	4.26E-04	7.99E-05
	Non-Forest	100	900	1.70E-03	1.83E-03	2.47E-04	4.00E-04	2.56E-04	4.94E-05
Helicopter	Forest	100	900	6.00E-04	2.71E-04	3.36E-05	1.41E-05	7.88E-06	1.38E-06
	Non-Forest	100	900	1.40E-03	1.53E-03	2.03E-04	3.00E-04	1.87E-04	3.58E-05
Ground	Low Boom	25	900	2.00E-04	3.02E-04	3.20E-05	2.86E-05	8.87E-06	3.38E-06
	High Boom	25	900	3.00E-04	4.91E-04	5.13E-05	3.61E-05	1.18E-05	4.30E-06
Maximum Application Rate									
Plane	Forest	100	900	9.10E-03	5.09E-03	7.22E-04	1.00E-03	5.38E-04	1.01E-04
	Non-Forest	100	900	2.40E-03	2.46E-03	3.38E-04	6.00E-04	3.64E-04	6.98E-05
Helicopter	Forest	100	900	8.00E-04	3.44E-04	4.30E-05	1.77E-05	9.94E-06	1.73E-06
	Non-Forest	100	900	1.90E-03	2.11E-03	2.75E-04	4.00E-04	2.58E-04	5.04E-05
Ground	Low Boom	25	900	3.00E-04	4.02E-04	4.26E-05	3.82E-05	1.18E-05	4.51E-06
	High Boom	25	900	1.30E-03	6.55E-04	6.84E-05	5.46E-05	1.57E-05	5.72E-06

Effect of Downwind Distance

Mode of Application	Application Height or Vegetation Type	Minimum Downwind Distance (ft.)	Maximum Downwind Distance (ft.)	Concentration $_{900}$/ Concentration $_{25\text{ or }100}$			Relative Change in Concentration		
				Terrestrial	Stream	Pond	Terrestrial	Stream	Pond
Typical Application Rate									
Plane	Forest	100	900	0.1111	0.1061	0.1402	-	-	-
	Non-Forest	100	900	0.2353	0.1397	0.2000	-	-	-
Helicopter	Forest	100	900	0.0235	0.0291	0.0411	-	-	-
	Non-Forest	100	900	0.2143	0.1223	0.1765	-	-	-
Ground	Low Boom	25	900	0.1430	0.0294	0.1057	-	-	-
	High Boom	25	900	0.1203	0.0239	0.0838	-	-	-
Maximum Application Rate									
Plane	Forest	100	900	0.1099	0.1057	0.1400	-	-	-
	Non-Forest	100	900	0.2500	0.1484	0.2067	-	-	-
Helicopter	Forest	100	900	0.0221	0.0289	0.0402	-	-	-
	Non-Forest	100	900	0.2105	0.1224	0.1830	-	-	-
Ground	Low Boom	25	900	0.1273	0.0294	0.1058	-	-	-
	High Boom	25	900	0.0420	0.0239	0.0836	-	-	-

TABLE 5-3 (Cont.)

Herbicide Exposure Concentrations used during the Supplemental AgDRIFT® Sensitivity Analysis

Effect of Application Height (Vegetation Type or Boom Height)

Mode of Application	Application Height or Vegetation Type	Concentration Ratio[1]			Relative Change in Concentration		
		Terrestrial	Stream	Pond	Terrestrial	Stream	Pond
Typical Application Rate							
Plane	Forest/ Non-Forest	4.2353	2.1907	2.3089	+	+	+
Helicopter	Forest/ Non-Forest	0.4286	0.1772	0.1658	-	-	-
Ground	High/Low Boom	1.5000	1.6276	1.6059	+	+	+
Maximum Application Rate							
Plane	Forest/ Non-Forest	3.7917	2.0718	2.1364	+	+	+
Helicopter	Forest/ Non-Forest	0.4211	0.1631	0.1562	-	-	-
Ground	High/Low Boom	4.3333	1.6276	1.6057	+	+	+

Effect of Mode of Application

	Concentration Ratio[2]			Relative Change in Concentration		
	Terrestrial	Stream	Pond	Terrestrial	Stream	Pond
Typical Application Rate						
Plane vs. Helicopter	1.2143	1.1995	1.2181	+	+	+
Plane vs. Ground	5.6667	3.7274	4.8085	+	+	+
Helicopter vs. Ground	4.6667	3.1074	3.9476	+	+	+
Maximum Application Rate						
Plane vs. Helicopter	1.2632	1.1638	1.2264	+	+	+
Plane vs. Ground	1.8462	3.7501	4.9372	+	+	+
Helicopter vs. Ground	1.4615	3.2223	4.0259	+	+	+

TABLE 5-3 (Cont.)

Herbicide Exposure Concentrations used during the Supplemental AgDRIFT® Sensitivity Analysis

Effect of Mode of Application Rate

	Concentration Ratio[3]			Relative Change in Concentration		
	Terrestrial	**Stream**	**Pond**	**Terrestrial**	**Stream**	**Pond**
Maximum vs. Typical	4.3333	1.3326	1.3327	+	+	+

ft. = feet.
mg/L = milligrams per liter.
lb. a.i./ac = pounds active ingredient per acre.
Concentration $_{900}$ / Concentration $_{25 \text{ or } 100}$ = Ratio of concentration at 900 ft. to concentration at 25 or 100 ft..

[1] Using concentrations modeled at minimum distance from application area.

[2] Using concentrations modeled at minimum distance from application area and non-forest aerial or high boom ground applications.

[3] Using concentrations modeled at minimum distance from application area and high boom ground applications.

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

- Toxicological data specific to the species (and sometimes even class) of organism are often absent from the literature.
- The other assumptions involved in the ERA (e.g., rate of food consumption, surface-to-volume ratio) may differ for RTE species relative to selected surrogates, and/or data for RTE species may be unavailable.
- The high level of protection afforded RTE species 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. Such a design 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 in which the organism consumes only food items that have been impacted by the herbicide. Other conservative assumptions are incorporated into the herbicide concentration models such as GLEAMS (Appendix B; ENSR 2004). Even with these highly conservative assumptions, 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[5] of potential herbicide impacts to RTE species and provide perspective useful for such an evaluation.
- Present information that can be used to assess uncertainty in the ERA's conclusions about risks to RTE species.

The following sections describe information used in the ERA to provide protection to RTE species, including mammals, birds, reptiles, amphibians, fish (e.g., salmonids), and plants potentially occurring on BLM-administered 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 to provide additional protection to RTE species. Section 6.2 provides a discussion of species-specific traits and how they relate to the RTE protection strategy in this ERA. Section 6.2 also includes a discussion of the selection of surrogate species (see Section 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

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[5] 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.

response of organisms to herbicides (6.2.3). This discussion includes information about 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

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 rimsulfuron ERA by comparing calculated RQs to receptor-specific LOCs. As described in the methodology document for this ERA (ENSR 2004), 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 impacts 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 June 13, 2002). In essence, the LOCs act as uncertainty factors often applied to TRVs. For example, using an LOC of 1.0 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 are 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 the 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 was 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. Given the conservative nature of the RQ, and consistent with USEPA policy, no additional levels of protection were required for the LOC (i.e., 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 have the potential to occur in the 17 states covered under this Programmatic ERA. Some marine mammals are included in the list of RTE species, but given the low likelihood that these species would be exposed to herbicides applied to BLM-administered 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 C.

Of the over 500 species potentially occurring in the 17 states, over 300 species may occur on lands administered by the BLM. Protection of these species is an integral goal of the BLM, and they are the focus of the RTE evaluation for the ERA and EIS. These species are different from one another in regards to home range, foraging 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-administered 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 2004), surrogate species were selected to represent a broad range of taxa in several trophic guilds that could be potentially impacted by herbicides on BLM-administered lands. Generally, the surrogate species that were used in the ERA are species commonly used as representative species in ecological risk assessment. Many of these species are common laboratory species, or are described in *Exposure Factors Handbook for Wildlife* (USEPA 1993 a, b). Other species were included in the *California Wildlife Biology, Exposure Factor, and Toxicity Database* (California Office of Environmental Health Hazard Assessment and University of California at Davis 2003), [6] or have been 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 used to model herbicide exposure scenarios to represent potential impact to other species that may be present on BLM-administered lands.

Toxicity data from surrogate species were used in the development of TRVs for RTE species 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, and 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-administered 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 for the development of TRVs and to represent all potentially exposed receptors on a generic level.

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.

The TRVs used in the ERA were selected after reviewing available ecotoxicological literature for rimsulfuron. 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 rimsulfuron TRVs are presented in Table 6-1.

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[6] Available at URL: http://www.oehha.org/cal_ecotox/default.htm.

6.2.1.2 Species Selected as Surrogates in the ERA

Plants, fish, insects, and 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 as surrogates 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; and 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 1993a, b, California Office of Environmental Health Hazard Assessment and University of California at Davis 2003). Because species-specific data, including body weight 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 and mammals). 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 federally listed birds and mammals found on BLM-administered 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 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 federally listed reptiles found on BLM-administered lands and the surrogate species chosen to represent them in the ERA. Table 6-6 presents the federally listed amphibians found on BLM-administered 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 (see 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 than the avian LD_{50}s, 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 describing the effects of herbicides on amphibians are available. The following provides a brief summary of the data (see 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* sp.).

- 4-chloro-2-methylphenoaxyacetic acid 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 rimsulfuron 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 rimsulfuron are uncertain. It should be noted that certain amphibians can be sensitive to pesticides, and site- and species-specific risk assessments 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, amphibians, and insects are valid, the vertebrate RQs generated in the ERA for rimsulfuron 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 0.0013 (chronic exposure of small mammalian herbivore ingesting food contaminated by direct spray at maximum application rate). This RQ is lower than the lowest LOC for mammals (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, an 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 2004), which are discussed in Section 5.0 of this document. However, differences in life history among and between receptors 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 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, 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 ecological risk assessment. 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."[7] Six situations in which uncertainty factors may be applied in ecotoxicology were identified: (1) accounting for intraspecific heterogeneity, (2) supporting interspecific extrapolation, (3) converting acute to chronic endpoints and vice versa, (4) estimating LOAEL from NOAEL, (5) supplementing professional judgment, and (6) extrapolating laboratory data to field conditions. No extrapolation of toxicity data among Classes (i.e., among birds, mammals, and reptiles) was discussed. The methods

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[7] Section 2, Fairbrother and Kaputska (1996:7).

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 Fairbrother and Kaputska (1996; 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, an 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 body weight 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 (Opresko et al. 1994, Sample et al. 1996) has used allometric scaling for many years to establish benchmarks for vertebrate wildlife. USEPA has also used allometric scaling in development of wildlife water quality criteria in the Great Lakes Water Quality Initiative 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.[8] 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, 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., body weight, 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 of 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 of 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 under-predict the toxic effect to the receptor organism. Although using physiologically-based models may be a more scientifically correct way to predict toxicity, the logistics involved with applying them to an ERA on a large scale make them impractical. In this ERA, extrapolation was performed using techniques most often employed by the scientific risk assessment community. These techniques included the use of uncertainty factors (i.e., potential use of LOC < 1.0) and allometric scaling.

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

6.4 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 Endangered Species Act (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 United States Code 1532(19)). The NMFS (NOAA 1999) published a final rule clarifying the definition of "harm" as it relates to take of endangered species in the ESA. The NMFS 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 rimsulfuron on BLM-administered lands would not cause harm to salmonids.

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[9] (Freeman and Boutin 1994). The NMFS has internal draft guidance for their ESA Section 7 pesticide evaluations (NOAA 2002). 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 NMFS, the rimsulfuron 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 rimsulfuron 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 for 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 are unlikely.

Nonetheless, aquatic vegetation may be at risk, and disturbance to the aquatic vegetation (as primary producers and the food base of aquatic invertebrates) may affect the aquatic invertebrate population, thereby affecting salmonids. As presented in Section 4.3, the potential for risk to aquatic vegetation may occur under a variety of exposure scenarios. Elevated aquatic plant chronic RQs were observed under scenarios of off-site drift from selected aerial and ground applications of rimsulfuron, indicating the potential for a reduction in cover over time. Acute risks to aquatic plants due to spray drift were not predicted under any application scenario. The greatest risk for impacts to aquatic vegetation would occur under a scenario of accidental direct spray or spill of a terrestrial herbicide into an aquatic system. RQs exceeded LOCs by up to three orders of magnitude under the spill and accidental spray scenarios, and under the runoff and drift scenarios RQs exceeded LOCs by a factor of 9 and 70, respectively. These results suggest

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[9] 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.

that the potential for impacts to aquatic vegetation and potential indirect effects to salmonids are likely to be restricted to only a few scenarios including accidental spills and direct spraying.

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 water body, including salmonids. Few data indicating the toxicity of herbicides to benthic algae are available. Of the algae data available for rimsulfuron, the closest species to benthic algae (green algae, *Selenastrum capricornutum*) has an EC_{50} of > 0.029 mg/L, which is twice as high as the acute TRV used in the ERA and three orders of magnitude higher than the chronic TRV used in the ERA (0.0116 and 0.00003 mg/L for EC_{50} and NOAEL data, based on duckweed exposure). RQs for most scenarios would be lower than the LOC using a TRV based on green algae, suggesting that impacts to algae and attending secondary effects are unlikely.

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 rimsulfuron may have on the aquatic food chain. One exception would be the risk for acute effects to aquatic life from accidental spills, an extreme and unlikely scenario that was considered in this ERA to add conservatism to the risk estimates. Appropriate and careful use of rimsulfuron 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 than 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. Among the effects of herbicide application, harm to instream and riparian vegetation would be of greatest concern. 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 water bodies; 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 often arise in conjunction with other land use practices, such as prescribed burning.[10] In forested areas, herbicides are generally used in areas that have been previously altered, such as by cutting or burning, 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 water bodies.

Based on the results of the ERA, non-target terrestrial and aquatic plants are at risk for impacts under extreme circumstances, such as spills or accidental direct spray, spray drift, runoff, or dust exposure scenario (Sections 4.3.1 and 4.3.5). However, it is unlikely that responsible use of rimsulfuron by BLM land managers would indirectly affect salmonids through the killing of in-stream or riparian vegetation. Land managers should consider the proximity of salmonid habitat to potential application areas.

6.5 Conclusions

The rimsulfuron ERA evaluated the potential risks to many species using many exposure scenarios. Some exposure scenarios would be likely to occur, whereas others would be unlikely to occur but were included to provide a level of

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[10] The following website provides a more detailed discussion of cumulative watershed effects at URL: http://www.humbolt1.com/~heyenga/Herb.Drft.8_12_99.html.

conservatism to the ERA. Individual RTE species were not directly evaluated; instead, toxicity data for surrogate species 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 rimsulfuron use should be of primary concern for the protection of RTE species. Habitat disturbance and disruptions in the food chain are often the cause of declines of populations and species. Herbicides may reduce riparian zones or harm primary producers in the water bodies. The results of the ERA indicate that non-target terrestrial and aquatic plants may be at risk from rimsulfuron under extreme circumstances, such as spills or accidental direct spray, spray drift, runoff, or dust exposure scenarios.

In a review of potential impacts of another terrestrial herbicide to threatened and endangered salmonids, the USEPA OPP indicated that “for most pesticides applied to terrestrial environment, the effects in water, even lentic water, will be relatively transient”. 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 salmonids would be harmed by appropriate and responsible use of the herbicide rimsulfuron on BLM lands; however, there is certain risk to RTE plants, which could indirectly affect other RTE species, such as salmonids. There is the opportunity to minimize the risk to RTE plants if certain application recommendations are followed (see Section 8). Managers can further decrease risks to RTE species and non-target populations and communities by increasing buffer zones between application areas and areas of concern, particularly if rimsulfuron is applied aerially.

TABLE 6-1

Surrogate Species Used to Derive Rimsulfuron TRVs

Species in Rimsulfuron Laboratory/Toxicity Studies		
Species	**Scientific Name**	**Surrogate for**
Honeybee	*Apis mellifera*	Pollinating insects
Rat	*Rattus norvegicus* spp.	Mammals
Mouse	*Mus musculus*	Mammals
Dog	*Canis familiaris*	Mammals
Rabbit	*Leporidae* sp.	Mammals
Bobwhite quail	*Colinus virginianus*	Birds
Mallard	*Anas platyrhynchos*	Birds
Rape	*Brassica* sp.	Non-target terrestrial plants
Wheat	*Triticum aestivum*	Non-target terrestrial plants
Sorghum	*Sorghum bicolor*	Non-target terrestrial plants
Water flea	*Daphnia magna straus*	Aquatic invertebrates
Rainbow trout	*Oncorhynchus mykiss*	Fish/salmonids
Bluegill sunfish	*Lepomis macrochirus*	Fish/salmonids
Duckweed	*Lemna gibba*	Non-target aquatic plants

TABLE 6-2

Surrogate Species Used in Quantitative ERA Evaluation

Species	**Scientific Name**	**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/granivore	Ingestion
Bald eagle (northern)	*Haliaeetus leucocephalus alascanus*	Avian carnivore/piscivore	Ingestion
Coyote	*Canis latrans*	Mammalian carnivore	Ingestion

Guild definitions –

Carnivore – Feeding on flesh.
Frugivore – Feeding on fruit.
Granivore – Feeding on grain and seeds.
Herbivore – Feeding on plant material.
Insectivore – Feeding on insects.
Invertivore – Feeding on invertebrates.
Piscivore – Feeding on fish.
Vermivore – Feeding on worms.

TABLE 6-3

Federally Listed Birds and Selected Surrogates

Federally Listed Avian Species Potentially Occurring on BLM-administered Lands			
Species	**Scientific Name**	**RTE Trophic Guild**	**Surrogates**
Marbled murrelet	*Brachyramphus marmoratus marmoratus*	Piscivore	Bald eagle
Gunnison sage-grouse	*Centrocercus minimus*	Omnivore [Insectivore/ herbivore]	American robin Canada goose
Greater sage-grouse (Bi-State DPS)	*Centrocercus urophasianus*	Omnivore [Insectivore/ herbivore]	American robin Canada goose
Western snowy plover	*Charadrius alexandrinus nivosus*	Insectivore	American robin
Piping plover	*Charadrius melodus*	Insectivore	American robin
Mountain plover	*Charadrius montanus*	Insectivore	American robin
Yellow-billed cuckoo (Western DPS)	*Coccyzus americanus*	Insectivore	American robin
Southwestern willow flycatcher	*Empidonax traillii extimus*	Insectivore	American robin
Streak horned lark	*Eremophila alpestris strigata*	Insectivore	American robin
Northern aplomado falcon	*Falco femoralis septentrionalis*	Carnivore	Bald eagle Coyote
			Coyote
Whooping crane	*Grus Americana*	Piscivore	Bald eagle
California condor	*Gymnogyps californianus*	Carnivore	Bald eagle Coyote
Inyo California towhee	*Pipilo crissalis eremophilus*	Omnivore [Granivore/insectivore]	Canada goose American robin
Coastal California gnatcatcher	*Polioptila californica californica*	Insectivore	American robin
Stellar's eider	*Polysticta stelleri*	Piscivore	Bald eagle
Yuma clapper rail	*Rallus longirostris yumanensis*	Carnivore	Bald eagle Coyote
Spectacled eider	*Somateria fischeri*	Omnivore [Insectivore/ herbivore]	American robin Canada goose
Least tern	*Sterna antillarum*	Piscivore	Bald eagle
Northern spotted owl	*Strix occidentalis caurina*	Carnivore	Bald eagle Coyote
Mexican spotted owl	*Strix occidentalis lucida*	Carnivore	Bald eagle Coyote
Lesser prairie-chicken	*Tympanachus pallidicinctus*	Omnivore [Insectivore/ herbivore]	American robin Canada goose
Least Bell's vireo	*Vireo bellii pusillus*	Insectivore	American robin

TABLE 6-4

Federally Listed Mammals and Selected Surrogates

Federally Listed Mammalian Species Potentially Occurring on BLM-administered Lands			
Species	**Scientific Name**	**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
San Bernardino Merriam's kangaroo rat	*Dipodomys merriami parvus*	Granivore/herbivore	Deer mouse
Fresno kangaroo rat	*Dipodomys nitratoides exilis*	Granivore/herbivore	Deer mouse
Tipton kangaroo rat	*Dipodomys nitratoides nitratoides*	Granivore/herbivore	Deer mouse
Stephens' kangaroo rat	*Dipodomys stephensi (*incl. *D. cascus)*	Granivore	Deer mouse
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* ssp. *nelsoni*	Herbivore	Mule deer
Bighorn sheep	*Ovis canadensis* ssp. *sierrae*	Herbivore	Mule deer
Jaguar	*Panthera onca*	Carnivore	Coyote
Woodland caribou	*Rangifer tanandus caribou*	Herbivore	Mule deer
Buena Vista Lake ornate shrew	*Sorex ornatus relictus*	Granivore/herbivore	Deer mouse
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
New Mexico meadow jumping mouse	*Zapus hudsonius luteus*	Omnivore [herbivore/ insectivore]	American robin Deer mouse
Preble's meadow jumping mouse	*Zapus hudsonius preblei*	Omnivore [herbivore/ insectivore]	American robin American robin

Note: Several marine mammals (e.g., whales, seals, sea otters, sea lions) 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 6-5

Federally Listed Reptiles and Selected Surrogates

Federally Listed Reptile Species Potentially Occurring on BLM-administered Lands			
Species	**Scientific Name**	**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
Northern Mexican garter snake	*Thamniphis eques megalops*	Carnivore/insectivore/piscivore	Coyote Bald eagle American robin
Giant garter snake	*Thamnophis gigas*	Carnivore/insectivore/piscivore	American robin Bald eagle Bald eagle
Narrow-headed garter snake	*Thamniphis rufipunctatus*	Carnivore/insectivore/piscivore	Coyote Bald eagle American rob
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

Federally Listed Amphibians and Selected Surrogates

Federally Listed Amphibian Species Potentially Occurring on BLM-administered Lands Species	Scientific Name	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]
Mountain yellow-legged frog (Northern DPS)	*Rana muscosa*	Herbivore[1]	Bluegill sunfish Rainbow trout[3]
		Invertivore[2]	American robin[4]
Oregon spotted frog	*Rana pretiosa*	Herbivore[1]	Bluegill sunfish Rainbow trout[3]
		Invertivore[2]	American robin[4]
Sierra Nevada yellow-legged frog	*Rana sierrae*	Herbivore[1]	Bluegill sunfish Rainbow trout[3]
		Invertivore[2]	American robin[4]
Mountain yellow-legged frog (Northern DPS)			

[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-administered lands are subject to nuisance vegetation control.	It was assumed that all organisms evaluated in the ERA were present in habitats subject to herbicide treatment.
Duration of potential exposure/ home range	Some species are migratory or present during only a fraction of year, and larger species have home ranges that likely extend beyond application areas, thereby reducing exposure duration.	It was assumed that all organisms evaluated in the ERA were present within the zone of exposure full-time.
Trophic level	Many chemical concentrations increase in higher trophic levels.	Although the herbicides evaluated in the ERA have very low potential to bioaccumulate, bioconcentration factors 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 prey 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 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 aryl hydrocarbon 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[1] 80[2]	--	--	80[3]	--	--	--	--	80[4]

[1] Intra-genus extrapolation.
[2] Intra-family extrapolation.
[3] Intra-order extrapolation.
[4] Intra-class extrapolation.

TABLE 6-9

Summary of Findings - Intraspecific Extrapolation Variability

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

TABLE 6-10

Summary of Findings - Acute-to-Chronic Extrapolation Variability

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

TABLE 6-11

Summary of Findings - LOAEL-to-NOAEL Extrapolation Variability

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

TABLE 6-12

Summary of Findings - Laboratory to Field Extrapolations

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

7.0 UNCERTAINTY IN THE ECOLOGICAL RISK ASSESSMENT

Every time an assumption is made, some level of uncertainty is introduced into the risk assessment. A thorough description of uncertainties is a key component that serves to identify possible weaknesses in the ERA analysis, and to elucidate what impact such weaknesses might have on the final risk conclusions. This uncertainty analysis lists the uncertainties, with a discussion of what bias, if any, the uncertainty may introduce into the risk conclusions. This bias is represented in qualitative terms that best describe whether the uncertainty might 1) underestimate risk, 2) overestimate risk, or 3) 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 toxicity data were obtained from studies conducted as part of the USEPA pesticide registration process. There are a number of uncertainties related to the use of this data set in the risk assessment. In general, it is preferable to base any ecological risk analysis on reliable field studies that clearly identify and quantify the amount of potential risk associated with 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 overestimate risk relative to field studies (Fairbrother and Kapustka 1996).

Twenty-seven rimsulfuron EIIS reports were available from the USEPAs Environmental Fate and Effects Division. These reports can be used to validate exposure models and/or hazards to ecological receptors. These reports, described in Section 2.3, indicated that damage to crops might be, in part, due to unintended exposure to rimsulfuron. The incident reports listed the probability that rimsulfuron caused the observed damage as “highly probable” in one incident, “probable” in 5 incidents, “possible” in 11 incidents, and “unlikely” in 10 incidents. It was “highly probable” that the misuse of rimsulfuron over a total acreage of 110 acres in Illinois using the broadcast application method resulted in adverse effects to non-target plants. These reports support the risk assessment’s prediction of risk to non-target plants under various exposure scenarios inside and outside of the application area. However, since the incident reports provide limited information, it is impossible to fully correlate the impacts predicted in the ERA with the incident reports.

Species for which toxicity data are available may not necessarily be the most sensitive species to a particular herbicide. These species have been selected as laboratory test organisms because they are generally sensitive to stressors, yet they can be maintained under laboratory conditions. Furthermore, the selected toxicity value for each receptor was based on a thorough review of the available data by qualified toxicologists and the selection of the most appropriate sensitive surrogate species. Because of the selection limitations, surrogate species are not exact matches to the wildlife receptors included in the ERA. For example, the only avian data available are 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 may be more or less sensitive to the herbicide than species tested in the laboratory. As discussed previously, plant toxicity data are generally only available for crop species, which may have different sensitivities than the rangeland plants occurring on BLM-administered lands. Data from toxicity testing with rape likely represent toxicity to sensitive species, since members of the mustard family are controlled by rimsulfuron. The use of toxicity data based on the mustard species may overestimate risks to rangeland and noncropland species.

In general, the most sensitive available endpoint for the appropriate surrogate test species was used to derive TRVs. This approach is conservative since there may be a wide range of data and effects for different species. For example, two studies evaluating vegetative vigor in several non-target terrestrial plant species observed NOAELs after 21 days at concentrations ranging from 0.00195 to >0.5 ounce a.i./ac. Accordingly, 0.00195 ounce a.i./ac was selected as the chronic NOAEL value for terrestrial plants. In general, this selection criterion for the TRVs has the potential to overestimate risk within the ERA. In some cases, chronic effects data were unavailable and chronic TRVs were derived from acute effects toxicity data, adding an additional level of uncertainty.

In some toxicological studies, a response was not observed at the highest tested concentration or dose. In these cases, the toxicological endpoint was recorded as being greater than (>) a given concentration or dose (see Section 3.1 and Table 3-1). For example, some of the avian LC_{50} studies result in mortality for 50% of the test organisms at the highest tested concentration; therefore the LC_{50} was reported as being greater than the highest concentration tested (i.e., it takes more than that concentration to result in mortality for 50% of test organisms). In the ERA, TRVs preceded by a greater than symbol were applied at the specified value, which is conservative and may lead to an overestimation of risk because a higher concentration or dose is needed to reach the specified effect.

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 body weight) for birds and mammals. Converting the concentration-based endpoint to a dose-based endpoint is dependent on certain assumptions, specifically the test animal ingestion rate and test animal body weight. 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 or FIFRA predecessor (e.g., 40 Code of Federal Regulations [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 body weight). However, dietary studies were selected preferentially for this ERA, and historical dietary studies followed 40 CFR 797.2050, OPP 71-2, or Organisation for Economic Co-operation and Development 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 2004).[11] 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 ERA are presented in the units reported in the reviewed studies. Attempts were not made to adjust toxicity data to the percent active ingredient, since it was not consistently provided in all reviewed materials. In most cases the toxicity data apply to the active ingredient itself; however, some data correspond to a specific product containing the active ingredient under consideration, and potentially other ingredients (e.g., other active ingredients or inert ingredients). It is assumed that the toxicity observed in the tests is attributable to the active ingredient 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 percent active ingredient , and presents the data directly from the registration study in order to capture the potential effect caused by various inert ingredients, additives, or other active ingredients in the

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

tested product (USEPA 2010). In many cases the tested material represents the highest purity produced, and higher exposure to the active ingredient would not be likely.

For rimsulfuron, the percent active ingredients, listed in Appendix A when available from the reviewed study, ranged from 25% to 99.5%. The lowest percent active ingredient used in the actual TRV derivation was 98.6% in the studies used to derive some of the aquatic plant TRVs. Adjusting the TRV to 100% of the active ingredient (by multiplying the TRV by the percent active ingredient in the study) would lower these TRVs slightly and increase the associated RQs slightly. However, this would not result in any additional LOC exceedances. The remaining TRVs are based on studies with even higher percentages of active ingredient so the RQ changes would be even more minimal.

7.2 Potential Indirect Effects on Salmonids

No actual field studies or ecological incident reports on the effects of rimsulfuron 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. The acute fish TRV used in the risk assessment was based on laboratory studies conducted with a salmonid, the rainbow trout, reducing the uncertainties in this evaluation. A discussion of the potential indirect impacts to salmonids is presented in Section 4.3.6, and Section 6.4 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, which 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 active ingredient of an herbicide, but also from the cumulative risks of inert ingredients, adjuvants, surfactants, and degradates. Other herbicides may also factor into the risk estimates, as many herbicides can be tank-mixed to expand the level of control and to accomplish multiple identified tasks. However, it is only practical, using currently available models (e.g., GLEAMS), to compare deterministic risk calculations (i.e., exposure modeling, effects assessment, and RQ calculations) for a single active ingredient.

In addition, information on inert ingredients, 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 the potential risk for adverse effects due to exposure to degradates, inert ingredients, adjuvants, and tank mixes.

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 rimsulfuron. 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 potentially have a greater adverse impact on the environment than a more toxic, less mobile TP, as a result of 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 rimsulfuron represents a source of uncertainty in the risk assessment.

7.3.2 Inert Ingredients

Herbicides, like all pesticides, contain both “active” and “inert” or “other” ingredients, as stated on the label. The active ingredients are responsible for the pest management activity, while the inert ingredients are included in the formulation as solvents that may improve the active ingredient’s ability to move through the leaf surface, to improve the shelf-life of the formulation, to reduce the degradation of the active ingredient, or to provide a color to the formulation. It is important to note that the term “inert” does not imply that the ingredients that that make up this portion of the formulation are nontoxic.

Unlike the active ingredient, federal law does not require that the individual ingredients be identified by name or percentage on the label, but the law does require that the total percentage of the formulation associated with the inert ingredients be stated on the label.

In the 17-States PEIS, the BLM took advantage of the List Category policy, created in 1987, for the purpose of prioritizing inert ingredients in pesticide products. The prioritization process involved the establishment of four categories of “toxicological concern.” As stated on the web site (http://www.epa.gov/opprd001/inerts/) now that reassessment of food tolerances/tolerance exemptions under the Food Quality Protection Act is complete, there are no longer inert ingredients classified as List 1, 2, or 3. The “4A” category is still being used for the purposes of FIFRA Section 25(b), and USDA is still utilizing “List 4” for their National Organic Program. For non-food inert ingredients, the List Category policy remains pertinent (including labeling) for those identified as “List 1” (toxicological concern).”

For the purpose of pesticides, there are now two categories of inert ingredients approved for use in pesticides: Nonfood Use Only and Food and Nonfood Use. The BLM requires that inert ingredients found in herbicide formulations and adjuvants be listed in one of these two categories.

Nonfood Use Only – Inert ingredients permitted solely for use in pesticide products applied to nonfood use sites, such as ornamental plants, highway right-of-ways, rodent control, etc. These inert ingredients may not be applied to food.

Food and Nonfood Use – Inert ingredients approved for use in pesticide products applied to food. These inert ingredients have either tolerances or tolerance exemptions in 40 CFR Part 180 (the majority are found in Sections 180.910 – 960) or their residues are not found in food. All food use inert ingredients are also permitted for nonfood use.

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 inert ingredients 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 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 herbicide efficacy. Without product-specific toxicity data, it is impossible to quantify the potential impacts of these mixtures. In addition, a quantitative analysis could only be conducted if reliable scientific evidence allowed a determination of whether the joint action of the mixture was additive, synergistic, or antagonistic. Such evidence is not likely to exist unless the mode of action is common among the chemicals and receptors.

7.3.3.1 Adjuvants

Adjuvants generally function to enhance or prolong the activity of an active ingredient. For terrestrial herbicides, adjuvants may aid in the absorption of the active ingredient into plant tissue. Adjuvant is a broad term that 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 of rimsulfuron formulations, several types of spray adjuvants (e.g., nonionic surfactant, petroleum crop oil concentrate, modified seed oil, ammonium nitrogen fertilizer, and combination adjuvant products) were identified as being compatible for use with rimsulfuron products. 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.

The GLEAMS model was used to estimate the potential portion of an adjuvant that might reach an adjacent water body 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, respectively. The application rate of the inert/adjuvant compound was fixed at 1 lb. a.i./ac; the test 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 ingredient concentration to herbicide application rate was 0.69 mg/L per lb. a.i./ac (3-day maximum in the pond).

Several sources (Muller 1980, Lewis 1991, Dorn et al. 1997, Wong et al. 1997) generally suggest that acute toxicity to aquatic life for surfactants and anti-foam agents range from 1 to 10 mg/L, and that chronic toxicity can be as low as 0.1 mg/L. At the application rate recommended for nonionic surfactants, 0.25% to 0.5% volume to volume (v/v), and the maximum ground application rate for rimsulfuron (0.0625 lb. a.i./ac), the maximum predicted concentration of the inert/adjuvant compound would be 0.011 mg/L. This value is well below the chronic toxicity value for nonionic surfactants (0.1 mg/L) and in the low end of 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 active ingredient. 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

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 each herbicide applied 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 than either of the individual products). A quantitative evaluation of potential rimsulfuron tank mixtures is beyond the scope of this ERA.

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 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 predicting risk to the environment.

7.4 Uncertainty Associated with Herbicide Exposure Concentration Models

This 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 water body 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 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 rimsulfuron to nearby soils, ponds, and streams from overland and surface 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 United States. 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 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 United States. Furthermore, the study indicated that the runoff potential was a critical factor affecting herbicide transport. Table 7-2 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 to 77%, and the median runoff loss rates range were all equal to 0%.

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

Second, consistent with the conclusion reached by Lerch and Blanchard (2003; i.e., that runoff potential is critical to herbicide transport) and the GLEAMS model results, estimating the groundwater discharge concentrations by using the predicted root zone concentrations as a surrogate is extremely conservative. For example, while the median runoff loss rates were all equal to 0%, 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 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 United States, 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 scenario is feasible in several settings, but is very conservative in situations in which the depth to the water table is 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 overestimate of likely impacts in most settings on BLM-administered lands.

7.4.3 AERMOD and CALPUFF

The USEPA's AERMOD and CALPUFF air pollutant dispersion models were used to predict impacts from the potential migration of the herbicide between 1.5 and 100 km (0.9 and 62 miles) from the application area by windblown soil (fugitive dust). Several assumptions were made that could over predict or under predict the deposition rates obtained from this model.

The use of flat terrain could under predict 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-administered 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, or solar or chemical half-life would have occurred since the time of aerial application. Thus, the model likely over predicts 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-millimeter penetration depth is also conservative and likely overestimates impacts. This penetration depth is less than the depth used in previous herbicide risk assessments (Syracuse Environmental Research Associates 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 AERMOD and CALPUFF. The surface roughness length used in the models 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 (31 miles) of the application area and under predict 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 the models 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 AERMOD and 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. It is more likely that risk is overestimated, or that the impacts of the uncertainty are 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 because no relevant studies or incident reports were identified. It is likely that this qualitative evaluation overestimates the potential risk to salmonids as a result of 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, Inert Ingredients, Adjuvants, and Tank Mixtures – Only limited information is available regarding the toxicological effects of degradates, inert ingredients, adjuvants, and tank mixtures. In general, it is unlikely that highly toxic degradates or inert ingredients are present in approved herbicides. Also, 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) impact the models used to predict the off-site impacts of herbicide use (i.e., AgDRIFT®, GLEAMS, AERMOD, 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 because of its conservative assumptions (i.e., entire home range and diet is assumed to be impacted, aquatic water bodies are relatively small, and 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-administered lands	Unknown	BLM-administered 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-administered lands	Unknown	BLM-administered 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.
Water body characteristics	Overestimate	The pond and stream were designed with conservative assumptions resulting in relatively small volumes. Larger water bodies 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.
No evaluation of inhalation exposure pathways	Underestimate	The inhalation exposure pathways are generally considered insignificant due to the low concentration of contaminants under natural atmospheric conditions. However, under certain conditions, these exposure pathways may occur.

TABLE 7-1 (Cont.)

Potential Sources of Uncertainty in the ERA Process

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

TABLE 7-1 (Cont.)

Potential Sources of Uncertainty in the ERA Process

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

TABLE 7-1 (Cont.)

Potential Sources of Uncertainty in the ERA Process

Potential Source of Uncertainty	Direction of Effect	Justification
Predictions of off-site transport	Overestimate	Assumptions are implicit in each of the software models used in the ERA (AgDRIFT®, GLEAMS, AERMOD, 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., inert ingredients, adjuvants) in the application of the herbicide	Unknown	Only the active ingredient has been investigated in the ERA. Inert ingredients, 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

Herbicide Loss Rates Predicted by the GLEAMS Model

Herbicide	Total Loss Rate			Runoff Loss Rate		
	Median	90th	Maximum	Median	90th	Maximum
2,4-D acid	0.00	0.14	1.8	0.00	0.01	1.8
2,4-D ester	0.00	0.46	1.5	0.00	0.04	1.5
2, 4-D acid/W*	0.00	0.15	1.8	0.00	0.01	1.8
2,4-D ester/W*	0.00	0.46	1.5	0.00	0.04	1.5
Aminopyralid	77	85	89	0.00	0.08	0.34
Clopyralid	5.7	18	28	0.00	0.01	0.06
Fluroxypyr	0.00	4.8	22	0.00	0.13	2.9
Rimsulfuron	3.0	11	22	0.00	0.09	1.5

* "W" denotes model runs with woody vegetation.

8.0 SUMMARY

8.1 Summary of ERA Results

Ecological receptors would potentially be at risk from exposure to rimsulfuron under specific conditions on BLM-administered lands. Table 8-1 summarizes the relative magnitude of risk predicted for ecological receptors for each route of exposure. Risk levels were determined 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 given the mode of action of terrestrial herbicides, the highest risk level is predicted for non-target terrestrial and aquatic plant species, generally under accidental exposure scenarios (i.e., direct spray and accidental spills). The ERA predicted no risks for the terrestrial animals, fish, and aquatic invertebrates included in the models. The potential for risks to salmonids is discussed separately below.

Based on the ERA, rimsulfuron presents a potential risk to ecological receptors on BLM-administered lands under specific exposure scenarios. The following summarizes the risk assessment findings for rimsulfuron under these conditions:

1. Direct Spray – The ERA predicted risks to terrestrial and aquatic non-target plants under scenarios in which plants or water bodies are accidentally sprayed at the typical or maximum application rate. No risks were predicted for terrestrial wildlife, fish, or aquatic invertebrates.

2. Off-site Drift – The ERA predicted risks due to off-site drift for non-target terrestrial and aquatic plants. However, no risks were predicted for fish, aquatic invertebrates, or piscivorous birds in ponds or streams. The ERAs evaluated risks from off-site drift at modeled distances of 25, 100, and 900 ft. from the application site for ground applications, and at distances of 100, 300, and 900 ft. for aerial applications. The Recommendations section provides buffers for protecting non-target plants, which were extrapolated from the modeling results.

    a. The ERA predicted risks to non-target terrestrial plants (typical and RTE species) from plane applications of rimsulfuron at the largest modeled distance (900 ft.) in forested and non-forested areas at either the typical or maximum application rate. The ERA predicted risks at 100 ft. for helicopter applications in forested areas, and at 900 feet in non-forested areas, at both the typical or maximum application rates. The ERA predicted risks to non-target plants at 25 ft. for applications from a low boom at the typical application rate, and at 100 ft. for applications at the maximum application rate. Risks were also predicted for applications from a high boom at 100 ft., for both the typical and maximum application rates.

    b. The ERA did not predict acute risks to non-target aquatic plants in ponds. The ERA predicted chronic risks to non-target aquatic plants in ponds from plane applications at the largest modeled distance (900 ft.), in forested and non-forested areas, at both the typical and maximum application rates. For helicopter application scenarios, the ERA predicted risks to aquatic plants in a forested area at 100 ft., and at 900 ft. in a non-forested area, at both the typical or maximum application rate. For applications of rimsulfuron at the typical application rate from the ground with a low or high boom, risks to aquatic plants at a distance of 25 ft. from the application area were predicted. For applications at the maximum rate from the ground with a high boom risks were predicted for aquatic plants at 100 ft. for applications at the maximum rate and at 25 ft. for applications at the typical rate.

    c. The ERA did not predict acute risks to non-target aquatic plants in streams. The ERA predicted chronic risks to non-target aquatic plants in a stream at the largest modeled distance (900 ft.) under plane application scenarios in forested and non-forested areas, at both the typical and maximum application rates. For helicopter applications of rimsulfuron at the typical and maximum application rate, the ERA predicted risks to aquatic plants in forested areas at a distance of 100 ft. from the application area, and in non-forested areas at 900 ft.. For ground application scenarios with a low boom, aquatic plants 25 ft. from the application area would be at risk for adverse effects as a result of applications of rimsulfuron at the typical or maximum application rate. For ground application scenarios with a high boom, aquatic plants at 25 ft. would be at risk for adverse effects as a result of applications at the typical rate, and aquatic plants at 100 ft. would be at risk for adverse effects as a result of applications at the maximum rate.

3. Surface Runoff – The ERA predicted chronic risks to non-target aquatic plants in the pond when rimsulfuron applications occur in watersheds with sandy soils and at least 25 inches of precipitation per year (RQs ranged up to 6.5 at the typical application rate and up to 8.6 at the maximum application rate), in clay or clay/loam watersheds with at least 100 inches of precipitation per year (RQs ranged up to 3.3 at the typical application rate and up to 4.4 at the maximum application rate), and in loam watersheds with at least 50 inches of precipitation per year (RQs ranged up to 2.9 at the typical application rate and up to 3.8 at the maximum application rate). However, no acute risks were predicted for non-target aquatic plants in a pond. The ERA predicted no risk for adverse effects to non-target terrestrial plants, non-target aquatic plants in a stream, fish, aquatic invertebrates, or piscivorous birds as a result of surface runoff of rimsulfuron.

4. Wind Erosion and Transport Off-site – The ERA predicted that non-target terrestrial plants (typical and RTE) would not be at risk for adverse impacts under the majority of the modeled wind erosion and transport scenarios. However, minimal risks (RQs up to 1.5) from wind erosion were predicted for non-target terrestrial plants at a distance of up to 1.5 kilometers (0.9 miles) from the application area in a watershed modeled based on conditions in Medford, Oregon.

5. Accidental Spill to Pond– The ERA predicted risks to non-target aquatic plants under a scenario of a spill of rimsulfuron directly into a pond. However, the ERA predicted no risks to fish or aquatic invertebrates under this scenario.

No direct risks to RTE fish species (e.g., salmonids) were predicted in the modeling and salmonids are not likely to be indirectly impacted by a reduction in food supply (i.e., fish and aquatic invertebrates). However, 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 and aquatic plants, reducing the cover available to RTE salmonids within a stream.

Based on the results of the ERA, it is unlikely that RTE species would be harmed by appropriate and selective use of the herbicide rimsulfuron on BLM-administered lands. Although non-target terrestrial and aquatic plants have the potential to be adversely affected by application of rimsulfuron, adherence to specific 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, such as salmonids, 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 rimsulfuron:

1. 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 active ingredient alone.

2. Review, understand, and conform to the “Environmental Hazards” section on the 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 and their environment.

3. Avoid accidental direct spray and spill conditions to reduce the most significant potential impacts.

4. Use the typical application rate, rather than the maximum application rate, to reduce risk for exposure via off-site drift (drift to soils, streams, or ponds) and surface runoff (runoff to downgradient pond).

5. If impacts to typical or RTE terrestrial plants are of concern and an aerial application is planned using the maximum application rate, establish the following buffer zones to reduce off-site drift and potential risks to terrestrial plants[12]:

    - Application by plane over forest – 1,700 ft.
    - Application by plane over non-forested land – 1,900 ft.
    - Application by helicopter over forest – approximately 300 ft. (no risks were predicted at 300 ft.).
    - Application by helicopter over non-forested land – 1,600 ft.

6. If impacts to typical or RTE terrestrial plants are of concern and an aerial application is planned using the typical application rate, establish the following buffer zones to reduce off-site drift and potential risks to terrestrial plants:

    - Application by plane over forest – 1,600 ft.
    - Application by plane over non-forested land – 1,600 ft.
    - Application by helicopter over forest – approximately 300 ft. (no risks were predicted at 300 ft.).
    - Application by helicopter over non-forested land – 1,400 ft.

7. If a ground application is planned at the maximum application rate, establish a buffer zone of 400 ft. for application with a low boom and 650 ft. for applications with a high boom to reduce off-site drift and potential risks to typical or RTE terrestrial plants. If a ground application is planned at the typical application rate, establish a buffer zone of 100 ft. for application with a low boom and 400 ft. for applications with a high boom to reduce off-site drift and potential risks to typical or RTE terrestrial plants.

8. If use of the maximum application rate is required, establish the following buffer zones during aerial and ground applications to reduce off-site drift to water bodies and potential risks to aquatic plants:

    - Application by plane over forest – 1,400 ft. from ponds and streams.
    - Application by plane over non-forested land – 1,350 ft. from ponds and streams.
    - Application by helicopter over forest – 200 ft. from ponds and 250 ft. from streams.
    - Application by helicopter over non-forested land – 1,800 ft. from ponds and 1,100 ft. from streams.
    - Application from ground by low boom – approximately 100 ft. from ponds and streams (no risks were predicted at 100 ft.).

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[12] Note: Buffer distances provided in this section were obtained by plotting the RQs against the modeled distances, fitting a curve to the data, and then determining the distance at which the RQ was equivalent to an LOC of 1 for terrestrial plants (with an RQ based on a no observed adverse effect level for RTE species and the 25% effect concentration [EC_{25}] for typical species). The curve was extended beyond the largest modeled distance to extrapolate buffers beyond 900 feet.

- Application from ground by high boom – 300 ft. from ponds and streams.

9. Because runoff to water bodies is most affected by precipitation, limit the application of rimsulfuron in areas adjacent to water bodies during wet seasons or in high precipitation areas (RQs were consistently below LOCs in areas with precipitation of 10 inches per year or less). The risk of rimsulfuron entering a water body can be reduced or eliminated by retaining an untreated buffer between the treatment area and water body (see Section 7.4.2).

    - To reduce the impacts of surface runoff to aquatic plants in the pond, limit the use of rimsulfuron to clay watersheds with 50 inches per year or less of precipitation, to sandy watersheds with low annual precipitation (10 inches per year or less), or to loam watersheds with 25 inches per year or less of precipitation for treatments near ponds. For remaining watersheds, maintain an untreated buffer between the treatment area and water body to reduce the likelihood of rimsulfuron entering ponds (see Section 7.4.2). RQs for aquatic plants in ponds were above LOCs in these watersheds above the specified precipitation levels.

10. Consider the proximity of potential application areas to salmonid habitat and the possible effects of herbicide application on riparian vegetation. Use the preceding guidance for buffer distances to protect typical or RTE plants to protect riparian vegetation (including RTE plants) and prevent any associated indirect effects on salmonids and their habitat.

TABLE 8-1

Typical Risk Level Resulting from Rimsulfuron 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)	H [1: 1]	H [1: 1]	L [9: 18]	L [9: 18]	0 [42: 42]	0 [42: 42]	0 [8: 9]	0 [8: 9]
Terrestrial Plants (RTE Species)	H [1: 1]	H [1: 1]	L [9: 18]	L [8: 18]	0 [42: 42]	0 [42: 42]	0 [8: 9]	0 [8: 9]
Fish In The Pond	0 [2: 2]	0 [4: 4]	0 [36: 36]	0 [36: 36]	0 [84: 84]	0 [84: 84]	NA	NA
Fish In The Stream	0 [2: 2]	0 [2: 2]	0 [36: 36]	0 [36: 36]	0 [84: 84]	0 [84: 84]	NA	NA
Aquatic Invertebrates In The Pond	0 [2: 2]	0 [4: 4]	0 [36: 36]	0 [36: 36]	0 [84: 84]	0 [84: 84]	NA	NA
Aquatic Invertebrates In The Stream	0 [2: 2]	0 [2: 2]	0 [36: 36]	0 [36: 36]	0 [84: 84]	0 [84: 84]	NA	NA
Aquatic Plants In The Pond	H [1: 2]	M [2: 4]	0 [24: 36]	0 [23: 36]	0 [55: 84]	0 [54: 84]	NA	NA
Aquatic Plants In The Stream	H [1: 2]	H [1: 2]	0 [24: 36]	0 [23: 36]	0 [84: 84]	0 [84: 84]	NA	NA
Piscivorous Bird	NA	NA	0 [18: 18]	0 [18: 18]	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).

NA = Not applicable. No RQs calculated for this scenario.

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.
In cases of a tie, the more conservative (higher) risk level was selected.

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