Attachment E – Notice of Intent

WATER QUALITY ORDER NO. 2013-0002-DWQ
GENERAL PERMIT NO. CAG990005

STATEWIDE GENERAL NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT FOR RESIDUAL AQUATIC PESTICIDE DISCHARGES TO WATERS OF THE UNITED STATES FROM ALGAE AND AQUATIC WEED CONTROL APPLICATIONS

I. NOTICE OF INTENT STATUS (see Instructions)

Mark only one item (A.) New Applicator B. Change of Information: WDID# _____

C. ☐ Change of ownership or responsibility: WDID# _____

II. DISCHARGER INFORMATION

A. Name Klamath Basin NWR Complex			
B. Mailing Address 4009 Hill road			
C. City Tulelake	D. County Siskiyou / Modoc	E. State CA	F. Zip 96134
G. Contact Person Dustin Taylor	H. E-mail address dustin_taylor@fws.gov	I. Title IPM Specialist	J. Phone 530-667-8312

III. BILLING ADDRESS (Enter Information *only* if different from Section II above)

A. Name			
B. Mailing Address			
C. City	D. County	E. State	F. Zip
G. E-mail address	H. Title	I. Phone	

IV. RECEIVING WATER INFORMATION

A. Algaecide and aquatic herbicides are used to treat (check all that apply):

1. ☒ Canals, ditches, or other constructed conveyance facilities owned and controlled by Discharger.
   Name of the conveyance system: canal system w/in Lower Klamath NWR
2. ☒ Canals, ditches, or other constructed conveyance facilities owned and controlled by an entity other than the Discharger.
   Owner's name: Bureau of Reclamation
   Name of the conveyance system: canal system w/in Tule Lake NWR
3. Directly to river, lake, creek, stream, bay, ocean, etc.
   Name of water body: Managed wetlands in Lower Klamath & Tule Lake NWRs.

B. Regional Water Quality Control Board(s) where treatment areas are located (REGION 1, 2, 3, 4, 5, 6, 7, 8, or 9): Region 1
(List all regions where algaecide and aquatic herbicide application is proposed.)

V. ALGAECIDE AND AQUATIC HERBICIDE APPLICATION INFORMATION

A. Target Organisms: purple loosestrife, yellow flag iris, cattails, bulrush, and Early Detection Rapid Response (EDRR) species

B. Algaecide and Aquatic Herbicide Used: List Name and Active ingredients

Glyphosate (e.g. Roundup Custom, Aquaneat, Rodeo)

Imazapyr (e.g. Arsenal, Polaris, Habitat)

Imazamox (e.g. Clearcast)

C. Period of Application: Start Date May End Date September

D. Types of Adjuvants Used: Agridex (CA Reg. # 5905-50094-AA)

VI. AQUATIC PESTICIDE APPLICATION PLAN

Has an Aquatic Pesticide Application Plan been prepared and is the applicator familiar with its contents?
☒ Yes ☐ No

If not, when will it be prepared? _____

VII. NOTIFICATION

Have potentially affected public and governmental agencies been notified? ☒ Yes ☐ No

VIII. FEE

Have you included payment of the filing fee (for first-time enrollees only) with this submittal?
☐ YES ☒ NO ☐ NA

IX. CERTIFICATION

"I certify under penalty of law that this document and all attachments were prepared under my direction and supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine or imprisonment. Additionally, I certify that the provisions of the General Permit, including developing and implementing a monitoring program, will be complied with."

A. Printed Name: Dustin Taylor

B. Signature: Dustin Taylor **Date:** 5/10/19

C. Title: IPM Specialist

XI. FOR STATE WATER BOARD STAFF USE ONLY

WDID:	**Date NOI Received:**	**Date NOI Processed:**
Case Handler's Initial:	**Fee Amount Received:** $	**Check #:**
☐ **Lyris List Notification of Posting of APAP**	**Date** _____	**Confirmation Sent** _____

Aquatic Pesticide Application Plan

for Invasive/Undesirable Species

Treatment on Lower Klamath and Tule Lake NWRs

Submitted by:

Klamath Basin National Wildlife Refuge Complex
U.S. Fish and Wildlife Service
May 2019

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SECTION 1: Description of Water System

Tule Lake NWR. Tule Lake Refuge (Figure 1) receives primarily return flows from private agricultural lands north and east of the refuge. The primary water-bodies are Sumps 1A and 1B, which act as collecting basins for agricultural return flows during the spring/summer irrigation season and runoff during winter and spring precipitation events. Sumps 1A and 1B (13,021 acres) receive water from the Lost River via Anderson Rose Dam spills; N Canal spills; return flow pumps adjacent to the lake; and precipitation. Most of the irrigation diversions go to Sump 2, followed by Sump 3. Excess water in Sumps 1A and 1B is removed via a tunnel (D Plant) through Sheepy Ridge to Lower Klamath Refuge. D Plant pumping was historically the largest source of outflow from the lake (84,186 acre-feet annually and 51,321 acre-feet April–October). However, due to rising power costs D Plant has rarely been used over the last 5 years. Evaporation is the second largest source of outflow at 50,055 acre-feet annually.

Farm lands in Sump 2 (5,657 acres) are served by the Q and R Canals. The average annual inflow to Sump 2 is 22,364 acre-feet and the average annual outflow is 15,844 acre-feet. Almost all of the inflow and outflow (94%) occurs during the April through October irrigation season. Farm lands in Sump 3 (11,275 acres) are served by the North N Canal, which serves both public and private lands. The total supply to the N Canal averages 83,330 acre-feet annually and 74,567 acre-feet in April through October. Water not used to irrigate crops, or that is lost to evapotranspiration, is returned to Sumps 1A and 1B. Average annual crop evapotranspiration in Sump 3 averages 20,490 acre-feet during the April through October irrigation season. This network of canals and drains is illustrated in *Figure 2*.

Lower Klamath NWR. Lower Klamath Refuge (Figure 1) receives most of its water from two sources: direct project diversions from the Klamath River through the Ady Canal, and project return flows from Tule Lake sumps via the D Plant. Klamath Drainage District installed infrastructure to recirculate drain water. An estimated 7,953 acre-feet of drain water from the north side of the district is recycled back into Ady Canal at the Westside Pumping Plant during the irrigation season. In contrast to the 1980s and 1990s, in the six drought years in the last half of the record (1998–2015), the refuge has been nearly dry, only receiving an average of 13,000 acre-feet from the Ady Canal, as contrasted with refuge water needs and historical deliveries of over 100,000 acre-feet annually.

Discharge to the Klamath River from Lower Klamath NWR is primarily thru flows in KSD at the F-FF Pumps. From 2007 through 2016, average flow exiting Lower Klamath Refuge at Stateline was only approximately 12% of average flow entering the Klamath River through KSD at F-FF Pumps (compared to 34% of average flow from 1999 to 2006). These waters, in addition to drainage waters from the Klamath Drainage District, contribute return flows to KSD. From 1999 through 2006 approximately 82% of the average flow at the F-FF Pumps could be contributed to water exiting the Area K lease lands at the E-EE Pumps, while from 2007 through 2016 only 44% could be contributed to this water (Figure 3). The average flow at the E-EE Pumps from 2007 through 2016 was approximately 35% of the average flow at the E-EE Pumps from 1999 through 2006.

SECTION 2: Treatment Area

Treatment areas may include seasonal wetlands, semi-permanent wetlands, canals, and drains throughout Tule Lake and Lower Klamath NWRs. Depending on water availability, seasonally flooded wetlands cover up to one-third of the Lower Klamath Refuge land area or up to 16,000 acres (however since 1998 the majority of these wetlands have been dry). Seasonally flooded wetlands are characterized by a flooding regime extending less than year-round, but greater than 6 months (of which 2 months must be

during the growing season). Management of seasonally flooded wetlands requires flooding during the early fall (September through November) and de-watering in late spring to early summer by gradually

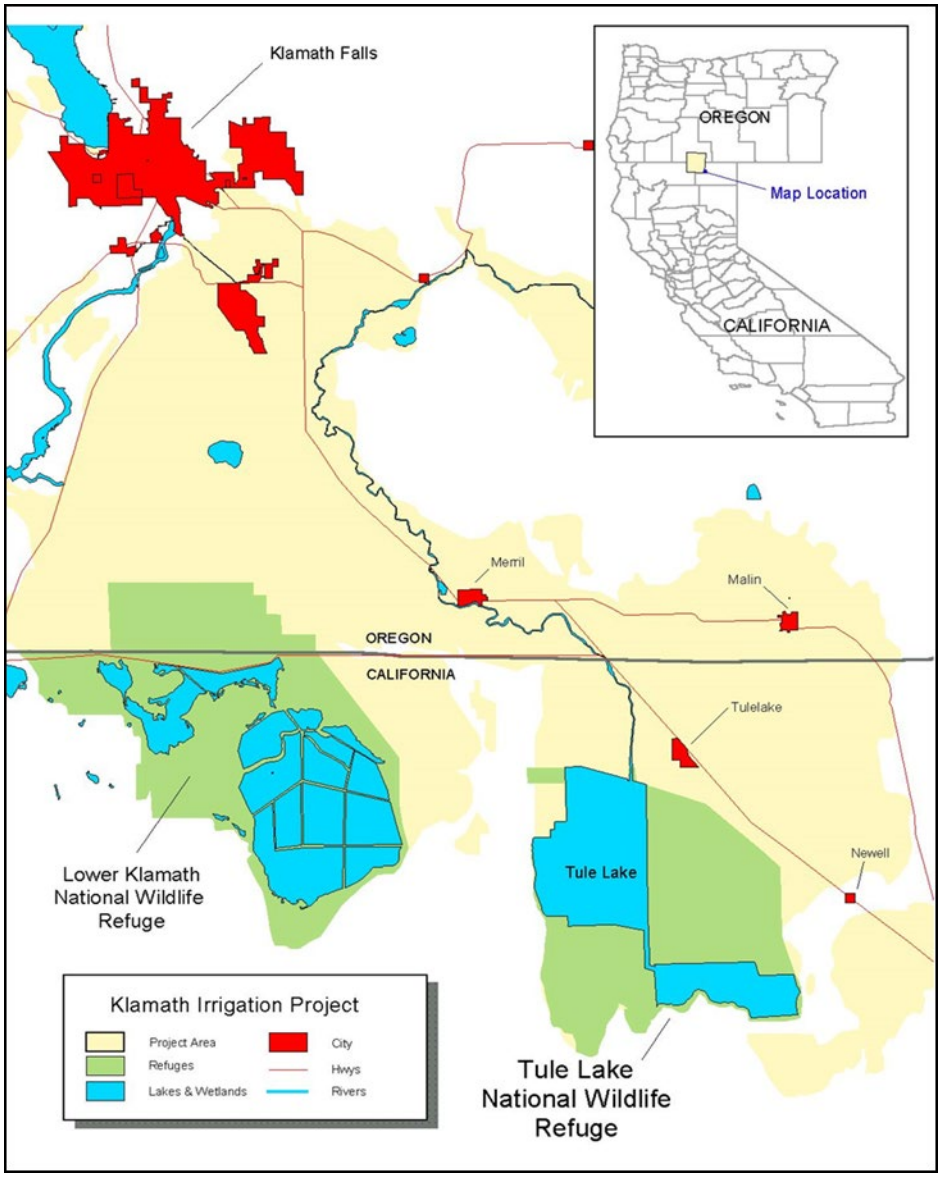

Figure 1. Map of Tule Lake National Wildlife and Lower Klamath National Wildlife Refuges.

lowering the water level either by draining, or by evaporation, or a combination of both. On Tule Lake NWR, Sumps 1A and 1B total around 13,240 acres, and consist of semi-permanent wetlands and open-water habitat. Semi-permanent wetland habitat is characterized by flooding periods of 10-12 months. Depending on water availability, up to 10,000 acres of semi-permanent wetlands were historically maintained on Lower Klamath Refuge. Locations of canals and drains within the refuges are described in *Section 1*.

SECTION 3: Description of Target Weed Species

3.1 Pest Problem Description

Cattails & Bulrush

Broad-leaved cattail (*Typha latifolia*), alkali bulrush (*Scirpus maritimus*), and Tule bulrush (*Scirpus acutus*) (hereafter referred to as cattails and bulrush) are found throughout the Klamath Basin in areas where semi-permanent wetland conditions exist and disturbance is infrequent. Cattails and bulrush are considered to be desirable, however if they becomes too dense they will reduce waterbird use and habitat availability. Therefore, periodic control with herbicide, prescribed fire, and mechanical application is required.

Yellow flag iris

Yellow flag iris *(Iris pseudacorus)* may displace native vegetation along streambanks, wetlands, and ponds. It may reduce stream width and sedimentation. Seedlings spread by water and typically germinates after the water recedes along the edges of the shore. The flowering period in the Klamath Basin spans from May thru July. Most transport and spread is likely through water movement along the river system and through irrigation systems. This pest species is found throughout greater Klamath Basin irrigation systems. Currently it is found in Sump 1a on Tule Lake NWR.

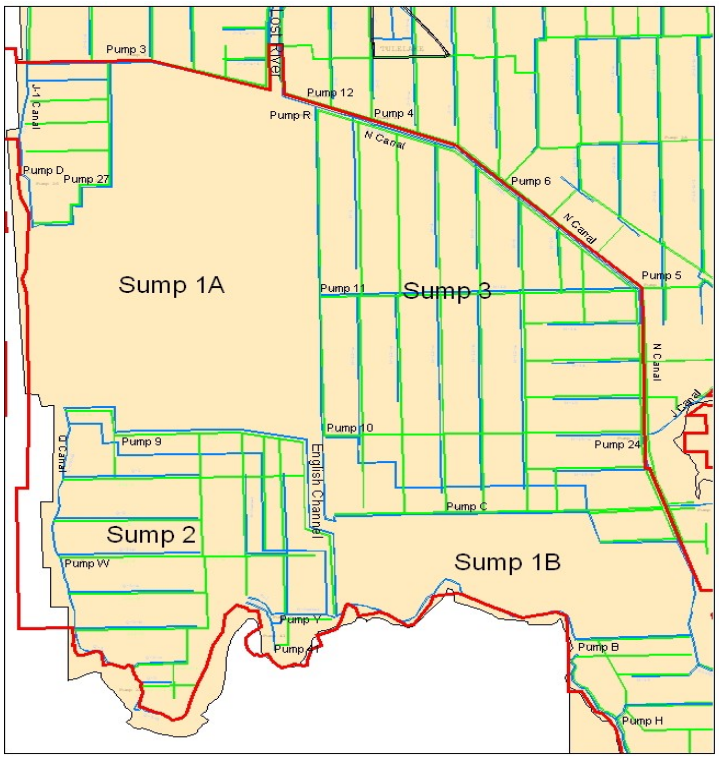

Figure 2. Map of Tule Lake National Wildlife Refuge Federal Lease Lands illustrating the network of irrigation canals (blue) and drains (green) and pumping stations.

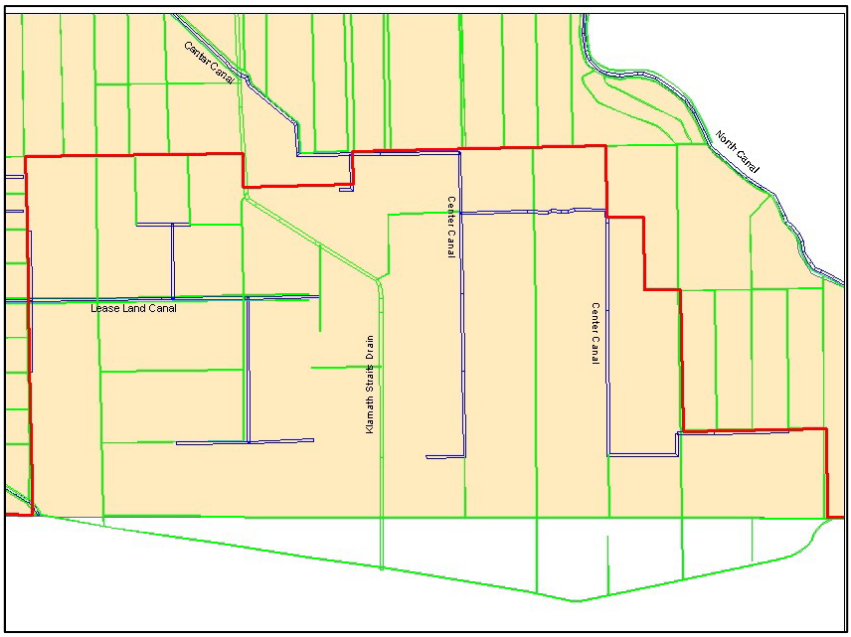

Figure 3. Map of Lower Klamath National Wildlife Refuge Federal Lease Lands illustrating the network of irrigation canals (purple) and drains (green).

Phragmites

Phragmites (*Phragmites australis*) is presently found on a few locations in Lower Klamath NWR. Spread of this species may be through rhizomes and seed. However, heavy equipment and maintenance activities may facilitate its' spread.

Reed Canary Grass

Reed Canary Grass (*Phalaris arundinacea*) is abundant throughout the Klamath Basin and is a common plant within the Basin's irrigation systems. Established populations can survive drought and year-long flooding. Established populations can effectively compete and exclude almost all native plant species. Seeds can be spread by equipment, people, and animals. The most common means of spread is rhizome fragments dispersed by water.

Purple Loosestrife

Loosestrife (*Lythrum salicaria*) is found in wetlands, wet meadows, streams, lake sides, and river banks. In the Klamath Basin known populations are in Sump 1a of Tule Lake, Unit 3a in Lower Klamath NWR, and a few scattered populations in the Barnes and Agency unit at Upper Klamath NWR. Spread of purple loosestrife can occur by root fragmentation and seed. This plant may be transported by human activities, wildlife, and maintenance equipment.

Early Detection Rapid Response (EDRR)

EDRR is considered a critical second defense against the establishment of invasive populations, and is recommended by the National Invasive Species Council. EDRR is intended to increase the likelihood that localized invasive populations will be found, contained, and eradicated before they become widely established. A prompt and coordinated response can reduce environmental and economic impacts, and can reduce long-term pesticide usage. Species that receive EDRR treatment may be grasses, broadleaf, and emergent types of vegetation.

3.2 Action Threshold(s)

Target Pest: Cattails & Bulrush

Pest Management Objective: Cattails and bulrush are desirable native species, however, if populations become too dense they may reduce waterfowl use and forage availability. The goal is to either set back succession at 3-5 year intervals if possible by mechanical methods (e.g. disking, plowing, mowing, burning, etc.). However, in areas where mechanical disturbance is not possible, the objective may be to reduce total coverage using herbicides.

Action Threshold: Treatment may be considered if cattails and bulrush comprise greater than 50% of a management unit/area.

Basis for the action threshold: At a high density (approximately > 75%) persistent emergent vegetation (e.g. cattail, bulrush) reduces waterbird use; reducing the density of persistent emergent vegetation resulting in a higher amount and diversity of waterbird usage.

Method to determine when the action threshold has been met: Current ocular estimates and aerial imagery are sufficient methods to estimate density.

Target Pest: Yellow Flag Iris

Pest Management Objective: Yellow-flag iris is abundant throughout the irrigation system within the Klamath Basin. Sump 1a and the ditch networks surrounding the sump have the highest density of yellow-flag iris within the refuge complex.

Action Threshold: Eliminate Iris from existing areas, prevent spread. Plants found in new areas may be chemically treated.

Basis for the action threshold: The primary focus on yellow-flag iris is to treat satellite populations and reduce spread. However, effort will be taken to remove iris from existing areas, if feasible.

Method to determine when the action threshold has been met: Ocular estimate occurring during green-up (Iris becomes green in the summer before cattail and bulrush) or during flowering.

Target Pest: Phragmites

Pest Management Objective: Phragmites is an aggressive invasive species. However, phragmites is not abundant within the refuge boundaries. The objective is to reduce existing populations and inhibit satellite populations.

Action Threshold: Populations of phragmites are currently less than 5 acres in size. Treatment will occur on existing populations on Lower Klamath NWR with the goal of eradication. Satellite populations on other refuges will be treated when detected.

Basis for the action threshold: Phragmites populations are at a low density, threshold is based on goal of elimination and prevention.

Method to determine when the action threshold has been met: Ocular estimate of presence/absence. Thresholds may be re-evaluated if a population's size is > 10 acres in one location.

Target Pest: Reed Canary Grass

Pest Management Objective: Maintain amount to < 10% of a total management unit. Prevent new infestations from becoming established. Reed canary grass is abundant throughout all of the irrigation system in the Klamath Basin, and eliminating existing populations from the irrigation system is not an objective.

Action Threshold: Satellite populations will be treated in new areas where it is not already abundant.

Basis for the action threshold: Reed Canary Grass is an aggressive competitor and quickly takes over natural systems. The objective is to prevent satellite populations from becoming established and to reduce presence if larger populations begin to take over a management unit.

Method to determine when the action threshold has been met: Ocular estimates and aerial imagery will be used to make this determination.

Target Pest: Purple Loosestrife

Pest Management Objective: Prevent spread and establishment of satellite populations and to contain existing populations within Sump 1a.

Action Threshold: Satellite populations will be treated when found. Focus on treatment of the main population in Sump 1a of Tule Lake NWR is containment.

Basis for the action threshold: Loosestrife is an aggressive invasive species, it outcompetes and displaces native vegetation and spreads rapidly. Reducing establishment into new areas is a priority. Existing populations in Sump 1a are large, and may exceed 200 acres in size.

Method to determine when the action threshold has been met: Ocular determinations of presence will be used to treat satellite populations and for containing the spread of the plant. The optimal detection period is in July and August during the flowering period.

Target Pest: EDRR

Pest Management Objective: Use EDRR to detect populations of new species that are considered priority invasive species within the continental, regional, state, or county level so that they can be treated before they spread.

Action Threshold: Populations of new species that are considered priority invasive species within the continental, regional, state, or county level may be treated. EDRR species are expected to be found early in the infestation and are assumed to be less than an acre in size (and is usually only a few plants).

Basis for the action threshold: The concept of EDRR depends on finding invasive species threats early, to prevent a future problem (and to reduce long-term herbicide use). Threshold is any EDRR species that is found will be treated.
Method to determine when the action threshold has been met: *See EDRR guidance outlined by the Center for Invasive Species and Ecosytem Health (http://www.invasive.org/edrr/).*

SECTION 4: Aquatic herbicides and application methods

Section 4.1. Pesticide Properties

Two things may happen to pesticides when they are released into the environment. They may be broken down, or degraded, by the action of sunlight, water or other chemicals, or microorganisms, such as bacteria. Generally pesticides have four properties that determine the tendency of pesticides to move off-target. The most important of these properties are persistence, soil adsorption, and vapor pressure. Solubility also is involved, but to a lesser extent than the others. Appendices A-C include, chemical profiles developed by the USFWS for our proposed active ingredients. Below we summarize the pesticides properties found within the Appendices (*also see Table 1*).

Fish LC_{50}: For test freshwater or marine species listed in the scientific literature, Service personnel record an LC_{50} in ppm or mg/L. Most common test species available in the scientific literature are the bluegill, rainbow trout, and fathead minnow (marine). Test results for many game species may also be available. The lowest LC_{50} value found for a freshwater fish species is used as a toxicological endpoint for RQ calculations to assess acute risk. Acute toxicity ratings were the following: super toxic < 0.01, extremely toxic 0.01-0.1, highly toxic 0.1-1, moderately toxic 1-10, slightly toxic 10-100, practically non-toxic 100-1000, and relatively harmless > 1000 (USFWS 1984). The lowest LC_{50} values found in the Chemical Profiles (*see Appendices A-C*) are listed below:

- Imazapyr: rainbow trout, 96-hr LC_{50} = 6.7 ppm; moderately toxic.
- Glyphosate: bluegill, 96-hr LC_{50} > 24 ppm; slightly toxic.
- Imazamox: rainbow trout, 28-day NOEL, 122 ppm a.e.; practically non-toxic.

Fish Early Life Stage (ELS)/Life Cycle: For test freshwater or marine species available in the scientific literature, Service personnel record test results (e.g., LOEC, NOAEL, NOAEC, LOAEC) in ppm for test procedure(s) (e.g., early life cycle, life cycle). Most common test species available in the scientific literature are bluegill, rainbow trout, and fathead minnow. Test results for other game species may also be available. The lowest test value found for a fish species (preferably freshwater) is used as a toxicological endpoint for RQ calculations to assess chronic risk. The lowest LOEC, NOAEL, NOAEC, or LOAEC values found in the Chemical Profiles (*see Appendices A-C*) are listed below:

- Imazapyr: rainbow trout, 96 hr NOEC = 1.36 ppm a.e.
- Glyphosate: fathead minnow, av. wt. 0.3-0.7g creek 96hr LC_{50} = 22 ppm.
- Imazamox: 28 day NOEL, age unknown = 122 ppm.

***Water Solubility*:** Service personnel record values for water solubility (S_w), which describes the amount of pesticide that dissolves in a known quantity of water. S_w is expressed as mg/L (ppm). Pesticide S_w values are categorized as one of the following: insoluble <0.1 ppm, moderately soluble = 100 to 1000 ppm, highly soluble >10,000 ppm (USGS, 2000). As pesticide S_w increases, there is greater potential to degrade water quality through runoff and leaching. Sw is used to evaluate potential for bioaccumulation in aquatic species [see Octanol-Water Partition Coefficient (K_{ow}) below]. The highest water solubility values found in the Chemical Profiles (*see Appendix A-C*) are listed below:

- Imazapyr: 6,500,000 ppm; highly soluble.
- Glyphosate: 900,000 ppm; highly soluble.
- Imazamox: 626,000 ppm; highly soluble.

***Soil Mobility*:** Service personnel record available values for soil adsorption coefficient (K_{oc} [µg/g]). This value provides a measure of a chemical's mobility and leaching potential in soil. K_{oc} values are directly proportional to organic content, clay content, and surface area of the soil. K_{oc} data for a pesticide may be available for a variety of soil types (e.g., clay, loam, sand). K_{oc} values are used in evaluating the potential to degrade groundwater by leaching (see Potential to Move to Groundwater below). K_{oc} values are categorized as the following: very high 0-50, high 50-150, medium 150-500, low 500-2000, slight 2000-5000, and immobile < 5000. The lowest soil mobility values found in the Chemical Profile (*see Appendix A-C*) are listed below:

- Imazapyr: 15 ppm in loamy sand; very highly mobile.
- Glyphosate: 3,100 ppm in sandy loam; slightly mobile.
- Imazamox: 5 ppm; very highly mobile.

***Soil Dissipation*:** Dissipation time (DT_{50}) represents the time required for 50% of the deposited pesticide to degrade and move from a treated site; whereas, soil $t_{½}$ describes the rate for degradation only. As for $t_{½}$, units of dissipation time are usually expressed in days. Field dissipation times are the preferred data for use to estimate pesticide concentrations in the environment because they are based upon field studies, compared to soil $t_{½}$, which is derived in a laboratory. However, soil $t_{½}$ are the most common persistence data available in the published literature. If field dissipation data are not available, soil half-life data are used in a Chemical Profile. The average or representative half-life value of the most important degradation mechanism is selected for quantitative analysis for both terrestrial and aquatic environments. Based upon the DT_{50} value, environmental persistence in the soil is categorized as one of the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days (Kerle et al. 1996). The highest soil DT_{50} values found in the Chemical Profile (*see Appendix A-C*) are listed below:

- Imazapyr: 180 days; persistent.
- Glyphosate: 13.9 days; non-persistent.

- Imazamox: 207 days; persistent.

***Aquatic Dissipation*:** Dissipation time (DT_{50}) represents the time required for 50% of the deposited pesticide to degrade or move (dissipate); whereas, aquatic $t_{½}$ describes the rate for degradation only. As for $t_{½}$, units of dissipation time are usually expressed in days. Based upon the DT_{50} value, environmental persistence in aquatic habitats is categorized as one of the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days (Kerle et al. 1996). The highest aquatic DT_{50} values found in the Chemical Profile (*see Appendix A-C*) are listed below:

- Imazapyr: 700 days; persistent.
- Glyphosate: 120 days; persistent.
- Imazamox: 192 days; persistent.

***Potential to Move to Groundwater*:** Groundwater Ubiquity Score (GUS) = $\log_{10}$(soil $t_{½}$) x [4 – $\log_{10}(K_{oc})$]. If a DT_{50} value is available, it is used rather than a $t_{½}$ value to calculate a GUS score. Based upon the GUS value, the potential to move toward groundwater is recorded as one of the following categories: extremely low potential<1.0, low - 1.0 to 2.0, moderate - 2.0 to 3.0, high -3.0 to 4.0, or very high > 4.0 (USFWS 2017). The highest GUS values found in the Chemical Profile (*see Appendix A-C*) are listed below:

- Imazapyr: 1.98; moderate potential to move to groundwater.
- Glyphosate: low potential to move to groundwater.
- Imazamox: 6.76; very high potential to move to ground water.

***Volatilization*:** Pesticides may volatilize (evaporate) from soil and plant surfaces and move off- target into the atmosphere. The potential for a pesticide to volatilize is a function of its vapor pressure that is affected by temperature, sorption, soil moisture, and the pesticide's water solubility. Vapor pressure is often expressed in mm Hg. To make these values easier to compare, vapor pressure is recorded by Service personnel in exponential form ($I \times 10^{-7}$), where I represents a vapor pressure index. In general, pesticides with I<10 have low potential to volatilize; whereas, pesticides with I >1,000 have a high potential to volatilize (Oregon State University, 1996). The highest vapor pressure values found in the Chemical Profile (*see Appendix A-C*) are listed below:

- Imazapyr: $0.997 < 10^{-7}$ ppm @ 60 degrees C; low potential to volatize.
- Glyphosate: 1.84×10^{-7} ppm @ 45 degrees C; low potential to volatize.
- Imazamox: 16.5×10^{-7} ppm @ 20 degrees C; low potential to volatize.

***Bioaccumulation/Bioconcentration*:** The physiological process where pesticide concentrations in tissue would increase in biota because they are taken and stored at a faster rate than they are metabolized or excreted. The potential for bioaccumulation is evaluated through bioaccumulation factors (BAFs) or bioconcentration factors (BCFs). Based upon BAF or BCF values, the potential to

bioaccumulate is recorded as one of the following: low – 0 to 300, moderate – 300 to 1,000, or high >1,000 (Calabrese and Baldwin, 1993). The highest BCF found in the Chemical Profile (*see Appendix A-C*) are listed below:

- Imazapyr: low potential for bio-concentration.
- Glyphosate: BCF = 0.5; low potential for bio-concentration.
- Imazamox: BCF = 0.14; low potential for bio-concentration.

Table 1. Summary of environmental fate and toxicity data for imazapyr, glyphosate, imazamox.

	Imazapyr	Glyphosate	Imazamox
Acute Toxicity Fish	***moderately toxic****	slightly toxic	practically non-toxic
Acute RQ (Fish)	< 0.01 [0.05]	***0.03 [0.05] ****	< 0.01 [0.05]
Chronic RQ (Fish)	0.03 [1]	0.03 [1]	0.26 [1]
Water Solubility	highly soluble	highly soluble	highly soluble
Soil Mobility	***very highly mobile****	slightly mobile	***very highly mobile****
Soil Dissipation	***persistent****	non-persistent	***persistent****
Aquatic Dissipation	***persistent****	***persistent****	***persistent****
Potential to Move to Groundwater	low potential	low potential	***very high***

Volatilization	low potential	low potential	low potential
Bio-concentration	low potential	low potential	low potential

*BMPs are implemented to address these specific pesticide properties.

Worst-Case Ecological Risk Assessment

Ecological Risk Assessment

Currently, ecological risk assessments are used to evaluate pesticides use on the leaselands of Lower Klamath and Tule Lake NWRs (see Biological Evaluation and Opinion for Pesticide use on Lease Lands 2006 and 2007, respectively) and are used by the USFWS to develop Chemical Profiles that are available to all FWS employees on the Pesticide Use Proposal System (PUPS) website. The ecological risk assessment process evaluates the likelihood that adverse ecological effects may occur to endangered, threatened or candidate wildlife species and other Refuge wildlife resources as a result of pesticide usage. This process is used to systematically organize and evaluate data, information, assumptions, and uncertainties in order to understand and predict relationships between pesticide use patterns, and ecological effects in a manner that is useful for environmental risk decision-making. The ecological risk assessment process integrates this information into prescribed protocols that have been developed through scientific research and adopted by the U.S. Environmental Protection Agency (2004), and determined by U.S. Fish and Wildlife Service and National Marine Fisheries Service (2004) to "produce effects determinations that reliably assess the effects of pesticides on listed species and critical habitat pursuant to section 7 of the ESA and implementing regulations". Below, we use the same process to evaluate the proposed use of the following active ingredients: glyphosate, imazapyr and imazamox.

Max Application Rates (acid equivalent): Service personnel use the highest potential application rate for the ecological risk assessment. The proposed maximum application rate as derived from pesticide labels is:

- Glyphosate: 2 lbs a.e./acre; based on Aquaneat Specimen Label max 0.5 gal/ac rate for treating poison hemlock and purple loosestrife (Nufarm Americas Inc. 2015) .
- Imazapyr: 0.5 lbs a.e./acre; based on Polaris Specimen Label at a max. 0.25 gal/ac rate (Nufarm Americas Inc. 2011).
- Imazamox: 0.5 lbs a.e./acre; based Clearcast Specimen Label rate of 0.5 gal/ac (SePro Coorporation 2016).

EECs: An estimated environmental concentration (EEC) represents potential exposure to fish and wildlife (birds and mammals) from using a pesticide. EECs are calculated using an USEPA screening-level approach (USEPA, 2004).

For the worst-case exposure scenario to non-target aquatic habitats, EECs (Table 2) would be would be derived from Urban and Cook (1986) that assumes an intentional overspray to an entire, non-target water body (1-foot depth) from a treatment <25 feet from the high water mark using the max application rate (acid basis [see above]). If there would be unacceptable (acute or chronic) risk to fish and wildlife with the simulated 100% overspray (RQ>LOC), then the proposed pesticide use may be disapproved or the PUP would be approved at a lower application rate to minimize/eliminate unacceptable risk to aquatic organisms (RQ=LOC).

Table 2. Estimated Environmental Concentrations (ppb) of pesticides in aquatic habitats (1 foot depth) immediately after direct application (Urban and Cook 1986).

Lbs/acre	EEC ppb)
0.10	36.7
0.20	73.5
0.25	91.9
0.30	110.2
0.40	147.0
0.50	183.7
0.75	275.6
1.00	367.5
1.25	459.7
1.50	551.6
1.75	643.5
2.00	735.7
2.25	827.6
2.50	919.4
3.00	1103.5
4.00	1471.4
5.00	1839
6.00	2207
7.00	2575
8.00	2943
9.00	3311
10.00	3678

We used the following EECs for evaluating risk based on maximum application rates:

- Glyphosate: 0.736 ppm.
- Imazapyr: 0.184 ppm.
- Imazamox: 0.184 ppm.

Presumption of Unacceptable Risk/Risk Quotients:

The potential for pesticides to cause direct adverse effects in Lost River and shortnose suckers, bull trout, and Oregon spotted frogs, is assessed using methods consistent with EPA's Ecological Risk Assessment Process (USEPA, 2004). This method integrates the results of exposure estimates (i.e., estimated environmental concentration and toxicological endpoints to evaluate the likelihood of adverse ecological effects to subject species. The means of this integration is called the risk quotient (RQ). Risk quotients are calculated by dividing the Estimated Environmental Concentration (EEC) by acute and chronic toxicity values selected from standardized toxicological endpoints or published effect data.

Estimated Environmental Concentration (EEC) ÷ Toxicological Endpoint = Risk Quotient (RQ)

The level of risk of direct effects of a pesticide is characterized by comparing the resulting risk quotients to EPA's numeric Level of Concern (LOC) for acute and chronic exposure scenarios (Table 3). The LOC ratio describes whether or not adverse effects may occur to wildlife resources when a pesticide is used under specific conditions. Two different categories are used to identify potential for unacceptable risk. One category is for effects at the individual level (i.e., listed species). Listed species are those species whose population levels have decreased to such an extent that any further decline could result in the extirpation of the species. Therefore, protection from adverse effects is analyzed at the individual level with the assumption that the loss of individuals from a population could jeopardize species sustainability. For example, the level of concern for acute risk is 0.05 for listed or candidate aquatic species, and is 10 times less restrictive (i.e., LOC = 0.5) for unlisted aquatic species. Risk quotients exceeding a Level of Concern are an indicator of unacceptable ecological risk.

For aquatic assessments associated with habitat management treatments, RQ calculations are based upon selected acute and chronic toxicological endpoints for fish and the EEC is derived from Urban and Cook (1986) assuming 100% overspray to an entire 1-foot deep water body using the maximum application rate (a.e. or a.i. basis [see above]). Our calculated RQ values were as followed:

- Glyphosate: acute RQ = 0.03; chronic RQ = 0.03.
- Imazapyr: acute RQ = 0.03; chronic RQ = 0.14.
- Imazamox: acute RQ < 0.01; chronic RQ < 0.01.

Table 3. Presumption of unacceptable risk for birds, fish and mammals (USEPA, 2004).

Risk Presumption		Level of Concern	
		Endangered, Threatened or Candidate Species	All Other Species
Aquatic Animals	Acute	0.05	0.5
	Chronic	1.0	1.0

A. Explanation of Actions to be Implemented to Reduce Adverse Effects

In Table 4, we list actions that would be implemented to reduce potential adverse effects based environmental fate and toxicity data acquired during our analysis (*see next page*).

The following Best Management Practices would be used for all pesticide usage:

- Do not apply pesticides when wind velocity exceeds 7 mph or when inversion conditions exist. Assess wind direction, wind speed, and inversion conditions using measurement devices such anemometers and windsocks.
- Select nozzles and operate application equipment such that spray droplets produced are ASAE droplet spectrum category medium (i.e., Volume Median Diameter = 250-350 microns) or coarser.
- Whenever practical use drift reduction nozzles and strive for boom pressures that produce droplets with median diameters no less than 500 microns (ASAE Droplet Size Category = Very Coarse).
- Do not allow boom height to exceed 20 inches above target canopy (for ground based applications only).
- Where possible, use a dye for non-crop spot treatment to indicate treated areas.
- Ground-based application only (e.g., ground-propelled hydraulic sprayers, backpack sprayers, hand sprayers, wick applicators, etc.).

These following additional Best Management Practices would be used for all aerial applications:

- Shut off discharges over surface water bodies including wetlands, canals, drains, Sumps1A & 1B, and English Channel, and whenever raising equipment over obstacles such as poles. Aircraft shall shut off discharges immediately before rotation to exit a treatment site.

- Control liquid flow to aircraft nozzles by a positive shutoff system. Equip each individual nozzle with a check valve and control flow by a suckback or boom pressure release device, or use individual nozzles with positive action valves.
- It is preferred aircraft equipped with nozzles orifices directed backward parallel to the horizontal axis of the aircraft in flight.
-

Table 4. Actions to be implemented to reduce potential effects of imazapyr, glyphosate, and imazamox on listed species. Based on toxicity and environmental fate data.

Active Ingredient	Pesticide Properties of Concern	Best Management Practices (BMPs)
Imazapyr	**Acute RQ for Fish below but Relatively near Risk Threshold**	Do not exceed 1 application per site per year.
		Use only adjuvants that are practically non-toxic to aquatic animals.
		Reduce maximum application rate to 0.25 gal/ac from label recommended maximum rate of 1 gal/ac.
		When feasible, treat wetlands during periods when they are seasonally non-inundated.
	Persistent in Soil and Water + Very Highly Mobile in Soil + Very High Potential to Move to Groundwater + Shallow Groundwater Depth	Do not use if substantial rainfall is expected within 24-hrs.
		Reduce maximum application rate to 0.25 gal/ac from label recommended maximum rate of 1 gal/ac.
		Limited to 1 application per year (except for spot applications).
Glyphosate	**Persistent in Water + Acute RQ for Fish below but Relatively near Risk Threshold + Shallow Groundwater Depth**	Use only adjuvants that are practically non-toxic to aquatic animals within 25-ft of standing water.
		Do not use if substantial rainfall is expected within 24-hrs.
		Limited to 1 application per year (except for spot applications).
		Low potential for movement to groundwater, no additional BMPs added.
Imazamox	**Persistent in Soil and Water + Very Highly Mobile in Soil + Very High Potential to Move to Groundwater + Shallow Groundwater Depth**	Do not use if substantial rainfall is expected within 24-hrs.
		Limited to 1 application per year (except for spot applications).
		Reduce maximum application rate to 0.5 gal/ac from label recommended maximum rate of 1 gal/ac.
		Use only adjuvants that are practically non-toxic to aquatic animals.

- Whenever possible, use flight paths parallel to, rather than perpendicular to, adjacent water bodies, avoid paths over Tule Lake Sump 1A & 1B and the English Channel or standing water, if present.
- Implement all additional precautions or recommendations in the Section 3 label or the supplemental label of the State of California to prevent environmental harm.

Section 4.2. Application Methods

All pesticide use will follow the pesticide label and all relevant state and federal laws. Applications may occur using ground spot application techniques, and aerial application (including fixed winged aircraft if the pesticide label allows for this use). Application rates will be in accordance with the product label for each specific target species and will not exceed the rates, intervals, and number of applications described in this document.

SECTION 5: Adjuvants

Only adjuvants that are considered practically non-toxic (LC_{50} > 100 ppm) to both aquatic invertebrates and fish will be used in aquatic environments. Toxicity data will be derived from the adjuvant's Safety Data Sheets (SDSs). Nonylphenol will be included in the monitoring if adjuvants were used containing the ingredient.

SECTION 6: Factors Influencing Choice to use Herbicide

A detailed evaluation of alternative control methods is presented in Section 10. Using chemical methods is the only feasible control method for many of our target pests. For all, species except purple loosestrife there is no approved (or pending) bio-control agent. Biocontrol options will be attempted for purple loosestrife, however previous biocontrol releases have not been effective. Mechanical extraction is costly and not feasible due to the location of the plants. EDRR treatment methods will be a focus of our efforts in order to prevent future infestations and to reduce potential herbicide use. In seasonal wetland units, when feasible mechanical methods will be utilized either by itself or in conjunction with herbicides when wetlands are dry.

SECTION 7: Gates and Control Structures

The Refuge operates a number of water control structures within the refuges. Nearly all wetland units have an inflow and outflow on their water control structures. On seasonal wetland units, water releases occur in late-spring and early summer and any applications that would occur would happen after water was removed. The project also has several pumping stations that can move water across elevational gradients (*see Section 1*).

SECTION 8: Water Quality Monitoring Plan

All monitoring of the effects of aquatic herbicide applications to control target weed species in Tule Lake and Lower Klamath NWRs will be conducted according to the Monitoring Reporting

Program (MRP) requirements summarized in Water Quality Order No. 2013-0002-DWQ. Samples will be collected and analyzed per MRP guidelines (Table 5).

Section 8.1 Monitoring Frequency and Locations, Sample Collections, Reports

On each refuge, samples will be collected from a minimum of six application events for each active ingredient per year, within each habitat type (e.g. seasonal or semi-permanent). If there are less than six application events in a year, we will collect samples during each application event for each active ingredient. With the exception being glyphosate which only 1 sample will be collected each year within each habitat type. If the results from six consecutive sampling events show concentrations that are less than the receiving water limitation/trigger for an active ingredient, sampling shall be reduced to one application event per year for that active ingredient. If the yearly sampling event shows exceedance of the receiving water limitation/trigger for an active ingredient in an environmental setting, then sampling shall return to six application events for that active ingredient. If areas are dry during treatment or during the post-treatment time-frame no sampling will be conducted. We will follow the schedule set forth by the NPDES general permit to characterize receiving waters for: (1) background monitoring, (2) event monitoring (e.g. immediately after application), and (3) post-event monitoring. Post-event monitoring will occur within 3-7 days of initial application. Background samples will be collected within the treatment areas, and event and post-event samples will be collected between 100-200m “down-stream” from the treatment area or in the direction that water movement is most likely (water movement is minimal in wetland environments). Environmental parameters to be recorded during sampling include: visual appearance of application site, water temperature, dissolved oxygen, pH, turbidity, and electrical conductivity. Concentration of active ingredient for the herbicides will be determined through laboratory analysis. Field measurements will be recorded on the field data sheet form (Table 6).

Water samples for laboratory analyses and other environmental parameters for the MRP will be collected by staff. Laboratory analysis will be conducted by a private analytical laboratory and certified for such analysis by the California Department of Health Services. All laboratory analyses will be conducted according to U.S. EPA Guidelines. Sample collections sites are less than 6 feet in depth, and all collections will be done at mid-depth. An annual report summarizing treatments and monitoring will be submitted to the Regional Water Quality Control Board by March 1 of the year following treatment.

Section 8.2. ***Sample Contamination Prevention***

Equipment will be cleaned with a non-phosphate cleaner and triple rinsed after sampling is complete and prior to moving to a new sample location. Gloves will be changed between collection sites. Samples will be tightly sealed at the point of collection and placed upright in an ice chest dedicated solely for transporting samples.

Section 8.3. Receiving Water Monitoring Triggers

Receiving water monitoring triggers will be in compliance with those provided in Statewide NPDES Permit for Aquatic Weed Control (#CAG990005) and other supplementary water monitoring triggers provided by the State Water Resources Control Board.

Table 5. Monitoring requirements per NPDES General Permit

Sample Type	Constituent/Parameter	Units	Sample Method	Minimum Sampling Frequency	Sample Type Required	Requird Analytical Test Method
Visual	1. Monitoring area description (pond, lake, open waterway, channel, etc.)	Not applicable	Visual Observation	All applications at all sites [1]	Background, Event and Post-event monitoring	Not applicable
	2. Appearance of waterway (sheen, color, clarity, etc.)					
	3. Weather conditions (fog, rain, wind, etc.)					
Physical	1. Temperature[2]	°F	Grab [4]	See 5 below	Background, Event and Post-event monitoring	6
	2. pH[3]	Number				
	3. Turbidity[3]	NTU				
	4. Electric Conductivity[3] @ 25 °C	µmhos/cm				
Chemical	1. Active Ingredient[7]	µg/L	Grab [4]	See 5 below	Background, Event and Post-event monitoring	6
	2. Nonylphenol	µg/L				
	3. Hardness (if copper is monitored)	mg/L				
	4. Dissolved Oxygen[2]	mg/L				

1 All applications at all sites.
2 Field testing.
3 Field or laboratory testing.
4 Samples shall be collected at three feet below the surface of the water body or at mid water column depth if the depth is less than three feet.
5 Collect samples from a minimum of six application events for each active ingredient per year, per habitat type (e.g. seasonal or semi-permanent), per refuge (e.g. Lower Klamath and Tule Lake NWRs). If there are less than six application events in a year, we will collect samples immediately after each application event for each active ingredient and nonylphenol, if applicable. If the results from six consecutive sampling events show concentrations that are less than the receiving water limitation/trigger for an active ingredient, sampling shall be reduced to one application event per year for that active ingredient. If the yearly sampling event shows exceedance of the receiving water limitation/trigger for an active ingredient in an environmental setting, then sampling shall return to six application events for that active ingredient. For glyphosate, collect samples from one application event from each environmental setting per year.
6 Pollutants shall be analyzed using the analytical methods described in 40 C.F.R. part 136.
7 Glyphosate, imazamox, and imazapyr.

Table 6. NPDES Monitoring Data Sheet

NPDES Monitoring Data Sheet

Site Name:	Collector:	Target Veg:	Herbicide/Surfactant:

Background Monitoring : Upstream at time of the application event or in application area just prior to (up to 24 hours in advance of) the application event.

Date:	GPS/Waypt:		H_2O Spd (ft/sec)	%Veg	Photo
Time:	Altitude:				☐
OBSERVATIONS – Circle and provide description, if applicable					
Weather: Clear / Partly Cloudy / Cloudy / Overcast / Other:				Wind:	
Water Clarity: Clear / Cloudy / Milky / Muddy / Other:					
Water Color: Clear / Brown / Red/ Green / Other:					
Visible: Films / Sheens / Coatings	Bottom Deposits: Yes / No		Fungi / Slimes / Objectionable Growth:		
Floating/ Suspended Material (algae, trash, etc.):					
Aquatic Life: Yes / No					
Potential Nuisance Conditions: Yes / No					
WATER TESTING					
Temp(°C):	**DO(mg/L):**	**EC(µs/cm):**	**Sal (ppt):**	**pH:**	

Event Monitoring: Immediately downstream of treatment area in flowing waters or immediately outside of treatment area in non-flowing waters.

Date:	GPS/Waypt:		H_2O Spd (ft/sec)	%Veg	Photo
Time:	Altitude:				☐
OBSERVATIONS – Circle and provide description, if applicable					
Weather: Clear / Partly Cloudy / Cloudy / Overcast / Other:				Wind:	
Water Clarity: Clear / Cloudy / Milky / Muddy / Other:					
Water Color: Clear / Brown / Red/ Green / Other:					
Visible: Films / Sheens / Coatings	Bottom Deposits: Yes / No		Fungi / Slimes / Objectionable Growth:		
Floating/ Suspended Material (algae, trash, etc.):					
Aquatic Life: Yes / No					
Potential Nuisance Conditions: Yes / No					
WATER TESTING					
Temp(°C):	**DO(mg/L):**	**EC(µs/cm):**	**Sal (ppt):**	**pH:**	

Post-Event Monitoring : Within the treatment area within one week after application

Date:	GPS/Waypt:		H_2O Spd (ft/sec)	%Veg	Photo
Time:	Altitude:				☐
OBSERVATIONS – Circle and provide description, if applicable					
Weather: Clear / Partly Cloudy / Cloudy / Overcast / Other:				Wind:	
Water Clarity: Clear / Cloudy / Milky / Muddy / Other:					
Water Color: Clear / Brown / Red/ Green / Other:					
Visible: Films / Sheens / Coatings	Bottom Deposits: Yes / No		Fungi / Slimes / Objectionable Growth:		
Floating/ Suspended Material (algae, trash, etc.):					
Aquatic Life: Yes / No					
Potential Nuisance Conditions: Yes / No					
WATER TESTING					
Temp(°C):	**DO(mg/L):**	**EC(µs/cm):**	**Sal (ppt):**	**pH:**	

SECTION 9: Applicable Water Quality Best Management Practices

9.1 Spill Response Procedures

Spill Prevention. When possible, treatments will occur during periods when wetlands are dry (which may occur between May-October). The risk of an over-water spill effecting water quality or non-target organisms will be minimized by conducting all herbicide mixes on dry land. Equipment will be calibrated at the beginning of each season. Equipment will be inspected each morning prior to conducting the types of applications listed in this plan. Inspections will include: checking for equipment leaks, wear, proper nozzles, and so forth.

Authorization to Conduct Response Operations

When possible, cleanup will be accomplished using Refuge personnel and equipment. If the cleanup effort exceeds the capabilities of the Refuge, a warranted Contracting Officer may, on an emergency basis, award a contract to begin cleanup. If the Officer's warrant authority is not sufficient to allow for completion of the cleanup, the Spill Coordinator will obtain Regional Office approval to award a contract to continue cleanup operations.

Containment, Recovery, & Storage.

In the event of a spill, Refuge personnel will use absorbent material and/or booms, pillows, and pads to contain the release (specific actions are described in Section 5.2.1). Contaminated soils will be excavated and containerized for subsequent management. Eliminating routes of transport between the spill and water-bodies and drains is a priority. A tarp will be used to cover any spill site until retrieval of the spilled material, or cleanup of the site occurs. If the spill cannot be cleaned and contained immediately, additional spill response personnel will be contacted (see Section 5.2.2).

Tools and PPE are located in the LK shop, absorbent pads located in the Haz-Stor (right side), other spill equipment can be located next to the LK or TL fuel tanks.

Spill containment supplies and/or spill response equipment is checked on a quarterly basis to ensure that adequate supplies are available. Spill protection equipment includes the following:

- Hydrocarbon sorbent booms, pillows, and pads
- Dry sorbent material (Spag-Sorb® or equivalent)
- Tools (shovels, rakes, pitch forks, clamps, etc.)
- Overpack / Recovery drums
- Personal protective equipment (PPE) (e.g., gloves, coveralls, and safety glasses)

Waste Characterization /Disposition.

Federal, State, and local permits required to transport or dispose of recovered product contaminated soil, personal protective equipment, and absorbents as well as the Refuge's ability to handle the disposal will vary depending on the contaminants and concentrations involved in the spill and cleanup. Information and guidance regarding compliance requirements and disposal options can be obtained by contacting the USFWS Regional Spill Response Coordinator, USFWS Regional Compliance Coordinator, Environmental and Facility Compliance Office (Denver, CO), and/or other regulatory personnel listed in Section 5.2.2. Site personnel should channel as many of these requests as possible through the appropriate Regional Coordinator or Environmental and Facility Compliance Officer.

Personnel Training

Spill prevention training will be scheduled and conducted for operating personnel at intervals frequent enough to assure adequate understanding of this plan. Seasonal employees should be included in this training schedule.

9.2 Maintenance Schedule

Daily

- Inspect hoses, nozzles, and other spray equipment for wear and leaks.
- Check Calibration Spray Pattern: 1) clean nozzles if there is an abnormal angle or heavy stream, 2) If cleaning does not fix problem, replace worn nozzles, and 3) collect the amount of flow for 60 seconds and measure water for each nozzle to make sure they are all equal.

Monthly (or as needed)

- Cleaning Sprayer: 1) Check pesticide label for any specific cleaning instructions, 2) drain all pesticide solution from the sprayer, 3) flush sprayer with clean water, 4) fill sprayer with water plus one cup of trisodium phosphate for each 10 gallons of water, 5) wash tank and pump parts by running the sprayer for about 5 minutes with the nozzles closed, and 6) discharge the mixture from the tank and nozzles
- Cleaning Sprayer Parts: 1) remove dirt and pesticide solids from screen, and 2) use soft brush to clean nozzles

Annually (or as needed)

- Calibration: 1) fill sprayer tank at least half full of water to simulate spraying conditions, 2) measure distance, in inches, between nozzles, 3) locate width in the bullet below and note corresponding course distance, 4) mark off this distance in a field to be sprayed, 5) record gear, speed, sprayer pressure, and throttle setting, 6) travel marked distance at least 3 times, 7) collect water from a nozzle for same number of seconds it took to drive test course, 8) ounces of water collected will equal the sprayer output in gallons/acre for

that nozzle, 9) repeat for all nozzles, and 10) divide total volume collected of all nozzles by number of nozzles to get average output.

9.3 Spill Notification

In the case of a spill, the on-site Refuge Spill Coordinator should be immediately contacted. If he cannot be reached the alternate Refuge Spill Coordinator should be contacted. The National Spill Response Center should be contacted if the spill cannot be readily contained and cleaned by refuge staff and/or the spill may enter a water-body. The next person to be contacted is the USFWS Regional Spill coordinator and FWS Field Spill Coordinator. A list of emergency response agencies and regulatory agencies are included in *Section 10.2.3.*

9.4 Adverse Incident Response Procedures

Effects Monitoring. Pesticide applicators are required to conduct spot checks in the area in and around where pesticides are applied for possible and observable adverse impacts caused by an application of pesticides. Adverse impacts may include, but are not limited to, the unanticipated death or distress of non-target organisms, disruption of fish or wildlife habitat and disruption of recreational or municipal water use. Visual assessments will occur: 1) during the application when considerations for safety and feasibility allow, and 2) during any post-application surveillance or efficacy check that is conducted. The applicator(s) are responsible for monitoring, and will monitoring will supplemented by other refuge staff.

An operator must contact the California Office of Environmental Health Hazard Assessment (OEHHA) if the operator observes or is otherwise made aware of an adverse incident that may have resulted from a discharge from the pesticide application. The contact must occur no later than 24 hours after the operator becomes aware of the adverse incident. The OEHHA phone number is (800) 852-7550.

The following information will be included on an incident notification: 1) name and telephone number, 2) location and description of affected area, 3) operator name and contact information, 4) NPDES File #, 5) name of contact person, 6) date and time incident was discovered, 7) description of adverse species and name of affected species, 8) EPA registration # of product, 9) description of steps taken to mitigate adverse effects, an 10) reason why notification was made 24 hours later, if applicable.

Operator is not required to report an adverse incident if it was not related to toxic effects or expose from pesticide application.

Responding to an Adverse Incident

PRIORITY	SPILL RESPONSE ACTION	DESCRIPTION
1	Decontamination of any personnel involved	Personnel will be provided with opportunity to wash up and decontaminate as thoroughly needed.
2	Ensure adequate ventilation	Personnel should move upwind, open doors and windows, keep out of low areas, etc.
2	Stop the flow/spill	If the flow/spill can be stopped safely, personnel should act quickly to close the source of the spill.

PRIORITY	SPILL RESPONSE ACTION	DESCRIPTION
3	Warn personnel	Enforce safety and security measures. If possible, one employee should remain at the spill. The Refuge Spill Coordinator or alternate Refuge Spill Coordinator should be notified (*see Section 5.1.2*). If the spill cannot be cleaned and contained immediately, additional spill response personnel will be contacted (*see Section 5.2.2*).
4	Initiate containment	Place containment boom around the tank and/or in the water. Pick up with earth, sand, or suitable absorbent material. Place into suitable and properly labeled containers for reuse or disposal in a licensed facility.
5	Make required notifications	The National Spill Response Center should be contacted if the spill cannot be readily contained and cleaned by refuge staff and/or the spill may enter a water-body (*See Section 10.2.3*)

SPILL NOTIFICATION PHONE LIST

ORGANIZATION	INDIVIDUAL	PHONE NUMBER
Klamath Basin NWR Complex Spill Prevention Coordinator	Dustin Taylor	(530) 667-8312
Klamath Basin NWR Complex Spill Prevention Coordinator (*Alternate*)	Stacy Freitas	(530) 667-8308
National Response Center	24-Hour Spill Response Hotline	(800) 424-8802
California Dept. of Fish & Wildlife (spills on water)	On-call Responder	(530) 598-0059
California Hwy. Patrol (spills on land)	On-call Responder	(530) 223-2919
California Office of Emergency Services (Redding)	On-call Responder	(800) 852-7550
EPA Spill Report (California)	On-call Responder	(415) 744-1500
Cascade Earth Sciences (Medford, OR)	On-call Responder	(541) 779-2280
Nielsen Research (Medford, OR)	On-call Responder	(800) 600-5227
E, C, and A Inc. (Klamath Falls, OR)	On-call Responder	(541) 885-4917
Ed Staub & Sons Inc. (Klamath Falls, OR)	On-call Responder	(541) 798-5215
Porter Geotechnical (Sparks, NV)	On-call Responder	(775) 849-0668

Contact information last updated / verified: February 2017

Section 9.5. Prevention of Fish Kills from Pesticide Application

All herbicide applications will be done by licensed staff or contractors according to the pesticide label which includes practices to reduce impacts to fish. These practices include spraying half of large concentrations of invasives if they comprise the majority of plant types within a given unit. This would be done to reduce depleting the oxygen levels under vegetation as the plants decay. Refuge applicators will alter the spray of the nozzle depending on the size and number of plants being treated to reduce the amount of pesticide entering the water. Applicators also minimize drift by monitoring the wind direction and speed, remaining within prescriptions for applying pesticides at all times.

SECTION 10: Evaluation of Alternate, Non-Chemical Methods

Section 10.1. Evaluation of Alternatives and Non-Chemical Methods.

Target Pest: Cattail

- No Action: Employing a "no action" alternative would allow Cattail and Bulrush to continue spreading, and invading managed seasonal herbaceous wetlands. If not treated this plant would continue to occur at a density that discourages use by waterfowl, wading birds, and shorebirds, and therefore is expected to have moderate-high effects on wildlife diversity. This alternative would result in increased Cattail and Bulrush populations, which may result in moderate-high future treatment costs.
- Prevention: Cattail and Bulrush expand rapidly in stabilized water conditions, and in wetland areas that receive high nutrient inputs. Cattail and bulrush also represent a late-successional stage for wetlands in the Klamath Basin and are tremendously important as breeding and molting habitat for waterfowl and other wetland dependent species. As cattails are generally desirable, except at high densities, prevention is not considered an option.
- Mechanical/Physical Methods: There are a variety of mechanical/physical methods that may control cattails, including: 1) water level control; 2) cutting, crushing, shearing, and disking; 3) grazing; and 4) prescribed burning.
    - Water Level Control: In general, 3-4 ft (0.9-1.2m) of water over the tops of existing shoots in spring, will provide the depth necessary to kill the plant. However, if the dead leaves are removed (via cutting or burning) and soil condition are anaerobic, cattail can be controlled by as little as a few inches above the top of the growing shoots and standing dead leaves. However, this control method is not possible due to levee limitations and adjacent agricultural land.
    - Cutting, Crushing, Shearing, and Disking: This management prescription can be used to impede starch storage in the growing season. These treatments are effective if done during a 3-week window from 1 week before to 1 week after the pistillate spike is lime green. Deep disking combined with continued drying and freezing in fall decreases plant survival, and can retard shoot formation and damage the rhizomes. Management success increases if the wetland can be kept sufficiently dry and disking is repeated during the next 2-3 growing seasons. Success increases further, if a wetland is disked in fall and again in the following spring and summer. In contrast, little effect is realized from disking alone for 3 consecutive falls. This is generally not a viable option at the refuge, because in areas where cattail is present

the wetland cannot be kept sufficiently dry. Setting back wetlands with agriculture is often viewed as a desirable and cost effective method of setting back succession.

  - Grazing: Grazing by cows can remove entire plants, particularly when cattail populations do not have extensive rhizomes. To minimize starch storage, heavy grazing should be centered around the period when the pistillate spike is lime green.
  - Prescribed Burning: Burning can affect the ability of cattails to store starches, particularly when done in conjunction with water level control (see above). Because cattails are difficult to burn in the growing season, winter (or in spring before significant growth) burns are often the most effective. This is generally not a viable option at the refuge, because in areas where cattail is present the wetland cannot be kept sufficiently dry, or alternatively 2" of water cannot be held over the cattails during the growing season.

- Cultural Methods: Cultural methods are not expected to improve the control of this species.
- Biological Control Agents: Muskrats may decrease the density of Cattails and other persistent emergent species and are regarded as an ecosystem engineer in South-Eastern Forested Wetlands. Seedling and young cattails are particularly sensitive to grazing, and muskrats can potentially thin dense stands. Future introductions may be considered, but are not currently viewed as a viable alternative for the control of cattails or other persistent emergent vegetation.

Target Pest: Yellow-Flag Iris

- No Action: Employing a "no action" alternative would allow Yellow-Flag Iris to continue spreading. A no action alternative may result in displacement of other persistent emergent plants (e.g. cattails, bulrush, etc.). This alternative may result in increased Iris populations, which may result in moderate-high future treatment costs.
- Prevention: *see cultural methods*
- Mechanical/Physical Methods: Repeated mowing or cutting may keep iris contained and can potentially kill the plant by depleting energy in the rhizomes. Also, removing the rhizome via mechanical equipment may be effective as well. However this plant is present in areas that are not accessible by heavy machinery, and populations may be too large for manual removal, therefore this option is not likely viable.
- Cultural Methods: This plant is available via the horticulture trade. Educating the public regarding the effect of this plant on native communities might discourage its' future purchase. The cost of educating the public on this species, would likely be moderate-high as it requires the education of private citizens in surrounding rural and metropolitan areas. However, education may benefit native species, by reducing the upstream seed source. Prescribed fire is not recommended as seeds germinate and grow well after a late summer burning, and plants have a strong tendency to re-sprout from rhizomes after burning.;
- Biological Control Agents: No biological control agents are presently known, and no research is currently being conducted, to our knowledge.

Target Pest: Phragmites

- No Action: Employing a "no action" alternative may result in the spread and stand expansion of phragmites. Currently, phragmites is at a low density; however this may change if left alone. In a "no action" alternative the effects to non-target organisms would range from minor-high, and

presence of phragmites may affect quality of breeding habitat, sedimentation, and wetland seed and tuber production.

- Prevention: This plant may also be spread and introduced by hunters and fishermen. Educating hunters and fishermen about this risk, and encouraging them to clean their equipment prior before entering or after leaving the refuge may reduce spread.
- Mechanical Methods: Disking is not recommended as a mechanical control method for Phragmites, since it results in the spread of rhizomes and the production of new plants. Mowing may be a useful tool for removing biomass following an herbicide application or in cases where stands are very dense and tall, mowing prior to herbicide treatment may increase effectiveness. Plants should be allowed to grow for at least 4 weeks before an herbicide application occurs. Mowing without an herbicide may provide some suppression. In this situation mowing should occur in winter, to improve native vegetation competition early in the season. Mowing during the wrong time a year may trigger growth and stand expansion.
- Cultural Methods: Use of prescribed fire without first treating with herbicide may encourage rhizome growth and cause phragmites to become more vigorous. If conducted the year following herbicide treatment in either late summer or winter, prescribed fire may provide opportunities for native plant regrowth. Water control management may be used to discourage its' spread. For example, rotation through a semi-permanent water regime may reduce its' presence, or late summer drawdown may help to promote native vegetation and discourage establishment of phragmites.
- Biological Control Agents: To our knowledge, there are no known biological control agents.

Target Pest: Reed Canary Grass

- No Action: Employing a "no action" alternative may allow reed canary grass to continue spreading, and may result in new populations within the refuge complex. This alternative would result in increased reed canary grass populations, which may result in moderate-high future treatment costs.
- Prevention: Prevention strategies may include: maintaining a healthy community of native or otherwise desirable plants; taking care to not disperse seeds or propagules; carefully monitoring your managed area periodically (especially along roadside ditches and other disturbed areas); and eradicating small populations as soon as possible.
- Mechanical/Physical Methods: Mowing by itself will not kill reed canary grass, and if mowing only occurs once or twice per year, it will stimulate additional stem production. Mowing 5+ times each year for 5-10 years is reported as successful in controlling reed canary grass. Additionally, mowing prior to or at the onset of flowering can eliminate seed set for that year. Mowing can be used as a pre-treatment for tillage, since it will remove or break up the thick layer of dead litter. The use of large tillage machinery can successfully eliminate the grass if combined with a proper flooding regime. This method requires the ability to manipulate water levels. The initial tillage may require several passes of the equipment, since the sod layer may be thick and tough. To be successful the exposed stems and rhizomes must be allowed to dry-out. Tillage would need to occur several times during the field season to break-up and dry all rhizome fragments. In winter or fall the area should be inundated at least 18 inches deep through late spring (late May-June) the following year.
- Cultural Methods: Burning generally does not kill reed canary grass, and similar to occasional mowing, actually appears to stimulate additional stem production unless the fire burns through the entire sod layer. Herbicide treatment prior to burning can facilitate a prescribed fire,

especially outside of typical "fire seasons." Prescribed fire can however, be used as a pretreatment to tillage, or prior to herbicide application for good results, since the fire will remove the aboveground dead litter and standing vegetation. Similarly, grazing alone does not control reed canary grass. Cattle prefer reed canary grass when stems and leaves are young and succulent, but do not prefer it once stems become old and tough. Goats and sheep may be less selective. Grazing can be combined with another treatment method (followed by tillage, herbicide), for good control.

- Biological Control Agents: There are no known biological control agents for RCG.

Target Pest: Purple Loosestrife

- No Action: Employing a "no action" alternative would allow purple loosestrife to continue to expand within Sump 1a and Barnes Agency potentially comprising the refuge's ability to provide wildlife habitat. Satellite populations may become established in new areas. This alternative would result in increased loosestrife populations, which may result in moderate-high future treatment costs.
- Prevention: This plant may also be spread and introduced by hunters and fishermen. Educating hunters and fishermen about this risk, and encouraging them to clean their equipment prior to entering or after leaving the refuge may reduce spread.
- Mechanical/Physical Methods: Hand-removal is recommended for small populations and isolated stems. Ideally, the plants should be pulled out before they have set seed. The entire rootstock must be pulled out since regeneration from root fragments is possible. Mowing is not recommended for Purple Loosestrife because it can further spread by distributing plant stems that can sprout vegetatively. If possible, native plants should be restored or promoted in the control area by seeding or planting. This will deter new loosestrife seedling development.
- Cultural Methods: Burning is thought to not be an effective control method because purple loosestrife is typically found in a wet soil condition and the rootstock of the plant is well-protected. Further research is needed to determine the effects of prescribed burns for purple loosestrife control.
- Biological Control Agents: As of 1997, three insect species from Europe have been approved by the U.S. Department of Agriculture for use as biological control agents. These plant eating insects include a root-mining weevil (*Hylobius transversovittatus*), and two leaf-feeding beetles (*Galerucella calmariensis* and *Galerucella pusilla*). Bio-control has been proven to be successful for purple loosestrife. In the Klamath Basin there is uncertainty on how well these insects can survive winter and fall conditions.

Target Pest: EDRR species

- No Action: Employing a "no action" alternative would not allow for EDRR techniques to be employed. This alternative may result in new infestations and new invasive species problems.
- Prevention: To prevent the spread of any of these plants, trailers, boats and fishing gear should be carefully inspected to avoid transporting plant materials between water bodies. Education would encourage fisher-men to carefully monitor their equipment, and may discourage private citizens from planting certain EDRR species, or from dumping aquariums that possibly contain the species within public waterways. Education (signage, pamphlets, and verbal communication) may decrease the transportation of certain EDRR species within and outside the refuge boundaries. We would expect that this method would minimize spread, which will beneficially affect a variety of

wetland and aquatic dependent wildlife species. Minimizing its' spread will also reduce pesticide use in the future. Costs associated with this method could range from minor-moderate. However, this method by itself will not control EDRR species or effectively stop its' spread.

- Mechanical/Physical Methods: Mechanical and physical methods for EDRR species may be different depending the specific species. If possible hand pulling would be employed if the populations were small.
- Cultural Methods: *see prevention*
- Biological Control Agents: Bio control agents would be considered depending on the EDRR species. However, the purpose of EDRR control would be to quickly stop infestations before they became a large enough problem to warrant bio control.

Section 10.2. Recommended Action.

Cattail and Bulrush: The primary method to control cattails and bulrush is mechanical control. When feasible, the refuge will use the cooperative farming program to setback wetland succession. Herbicides (e.g. imazapyr, imazamox) will only be used if mechanical means are not feasible due to saturated or inundated soils. Herbicides may be used to control cattail and bulrush. Herbicides are expected to only have minor effects on non-target organisms and water quality (*see Section 4.1*).

Yellow-Flag Iris: The objective for yellow-flag iris is containment and if feasible eradication. Herbicides may be used to treat iris. Glyphosate, imazamox, and imazapyr based herbicides are expected to only have minor effects on non-target organisms and water quality (*see Section 4.1*).

Phragmites: Populations of phragmites are currently less than 5-10 acres in size. Treatment will occur on existing populations on Lower Klamath NWR with the goal of eradication. Satellite populations on other refuges will be treated when detected. Timing of treatments will correspond with periods that wetlands are seasonally dry, when possible. An effort will be made to not make applications on or near water, thus minimizing any potential effects. Herbicides (e.g. imazapyr, glyphosate) are expected to only have minor effects on non-target organisms and water quality (*see Section 4.1*).

Reed Canary Grass: The current objective is to prevent new infestations from becoming established. Reed canary grass is abundant throughout all of the irrigation system in the Klamath Basin, and eliminating existing populations from the irrigation system is not an objective. Timing of treatments will correspond with periods that wetlands are seasonally dry, when possible. An effort will be made to not make applications on or near water, thus minimizing any potential effects. Herbicides (e.g. imazapyr, glyphosate) are expected to only have minor effects on non-target organisms and water quality (*see Section 4.1*).

Purple Loosestrife: Purple Loosestrife is an aggressive invasive species, it outcompetes and displaces native vegetation and spreads rapidly. The current objectives are to prevent the spread and establishment of satellite populations and to contain existing populations. Satellite populations will be treated when found, and the focus on treatment of the main population in Sump 1a of Tule Lake NWR will be containment. Reducing establishment into new areas is a priority. Biocontrol will be explored as a control option, hopefully reducing the reliance on herbicide applications. Herbicides (e.g. imazapyr, glyphosate) are expected to only have minor effects on non-target organisms and water quality (*see Section 4.1*).

EDRR species: EDRR will be used to reduce the need for future herbicide treatments for new invasive species. The concept of EDRR depends on finding invasive species threats early, to prevent a future problem. Herbicides (e.g. imazapyr, imazamox, glyphosate) are expected to only have minor effects on non-target organisms and water quality (*see Section 4.1*).

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Appendix A: Glyphosate Profile

Toxicological endpoint and environmental fate data listed in this chemical profile will be periodically reviewed and updated. New information, including, but not limited to, completion of national section 7consultation in accordance with the federal Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Stat. 884), as amended, between the U.S. Fish and Wildlife Service and the U.S. Environmental Protection Agency on individual pesticide registrations and all federally listed and proposed species and proposed and designated critical habitat, may change ecological risk assessments, pesticide use patterns, best management practices, and/or justification for use. Consultations occur now at the local level for listed and proposed species and proposed and designated critical habitat on specific use of individual pesticides in specific project areas.

Justification for Use:	Efficacious non-selective annual, biannual and perennial broadleaf and grass weed control. 1.5 lbs a.e./acre may be applied up to 5 times with 30 day intervals. Also, in accordance with product labels: 2 applications per year at 2.25 lbs a.e./acre or a single application at up to 3.75lbs a.e./acre once a year may be allowed. For areas with listed mammals and birds, complete ESA consultation including a toxicological analysis before use at these higher rates and more frequent applications.
Specific Best Management Practices (BMPs):	• Do not treat within 25 feet of surface water because of aquatic plant toxicity unless specifically using a product labelled for aquatic use. • Use caution where sensitive non-target plants are present. • Apply aquatic labeled glyphosate formulations to aquatic habitats and to riparian habitats within 25 feet of surface water resources; ensure that surfactants are classified as practically non-toxic or slight acute toxicity (>10 ppm) to aquatic organisms. Slight acute toxicity surfactants include but are not limited to, Level 7, AgriDex, Class Act Next Generation, Competitor, Hasten EA, Modified Vegetable Oil, Breeze, Bronc Plus, NIS-EA, Rainier EA, Superb HC, Kinetic. Combination products used on Service lands: **Implement the most restrictive BMPs**. *EsplAnade EZ* = Indaziflam + Diquat bromide + Glyphosate *Extreme, Tackle* = Imazethapyr + Glyphosate *Flexstar* = Glyphosate + Fomesafen *Groundclear, OneStep* = Glyphosate + Imazapyr *Halex GT* = s-Metolachlor + Glyphosate + Mesotrione *Journey* = Imazapic + Glyphosate *Landmaster II* = Glyphosate + 2,4-D amine *QuikPRO, Roundup Weed & Grass Killer Concentrate Plus* = Glyphosate + Diquat bromide *Roundup Concentrate Extended Control* = Glyphosate + Imazapic + Ammonium salt + Diquat bromide *Roundup Ready-to-Use Extended Control Weed Preventer II* = Glyphosate + Pelargonic acid + Imazapic *Roundup Ready-to-Use Plus* = Glyphosate + Pelargonic acid *Spartan Advance* = Sulfentrazone + Glyphosate
Resistance:	• If you think you may be seeing resistance: 1) contact the county extension agent or Regional USFWS IPM Coordinator; 2) check your timing of application, choice/use of adjuvant, plant growth stage at time of application, and application rate. These can influence efficacy. **Check the list below for weeds with known resistance.** • If resistance is noted, use a broad spectrum herbicide with a Mechanism of Action that differs from glyphosate. • Difficult to control weeds may require sequential applications of herbicides with alternative Mechanisms of Action. • If used in crop fields, rotate crops to allow the use of herbicides with alternative Mechanisms of Action. • Consider increasing rates within the label recommended range for difficult to control weeds (full rate of this herbicide may be required for the most difficult to control weed in the field). • Applications should be made when weeds are at the correct size (see the label) to minimize weed escapes. • Do not use more than two applications of glyphosate or an herbicide with the same Mechanism of Action within a single growing season unless mixed with another

	Mechanism of Action herbicide with overlapping spectrum for the difficult to control weeds. • Report incidence of non-performance of this product against a particular weed species to the registrant, county extension agent, & Regional FWS IPM Coordinator.
Endangered Species Compliance:	• Before use, a section 7 ESA consultation must be completed, including an ecotoxicological analysis. Additional best management practices, conservation recommendations, or terms and conditions for use near listed species may be required based on site-specific consultation.
Known Resistance:	• If you are treating one of the following weeds, consult the list at the end of this document to determine if resistance is documented in the state: annual bluegrass, common ragweed, common sunflower, giant ragweed, goosegrass, hairy fleabane. horseweed, Italian ryegrass, Johnsongrass, junglerice, kochia, Palmer amaranth, ragweed parthenium, rigid ryegrass, Russian thistle, spiny amaranth, and tall waterhemp. • For the most current status, please go to: http://weedscience.org/Summary/ResistbyActive.aspx :

Date:	9/20/17				
Pesticide Class:	EPSP synthase inhibitor	**Common Chemical Name(s):**	Glyphosate	**Pesticide Type:**	Herbicide Group 9
Trade Name(s):	Abundit Edge, Abundit Extra, Accord Concentrate, Accord SP, Accord XRT, Accord XRT II, Alecto 41S, Aqua Star, AquaMaster, AquaNeat, AquaPro, Buccaneer, Buccaneer Plus, Bullzeye, Cornerstone, Cornerstone 5 Plus, Cornerstone Plus, Cornerstone Plus with Advanced Surfactant, Credit 41 Extra, Credit Systemic Extra, CropSmart Glyphosate 41% Extra, CropSmart Glyphosate 41 Plus, Durango DMA, Eliminator Weed & Grass Killer Super Concentrate, Envy, Eraser AQ,	**EPA Registration Number:**	524-549, 71368-20, 62719-324, 62719-322, 62719-517, 62719-556, 9468-33, 42750-59, 524-343, 228-365, 62716-324, 524-445, 55467-9, 4787-23, 524-445, 1381-241, 1381-192, 74530-43, 71368-20, 71368-20, 85945-1, 42750-61, 62719-556, 71995-7, 89168-17, 42750-59,	**CAS Number:**	70907-12-1, 38641-94-0, 38641-94-0, 38641-94-0, 38641-94-0, 34494-04-7, 38641-94-0, 38641-94-0, 38641-94-0, 38641-94-0, 38641-94-0, 38641-94-0, 38641-94-0, 38641-94-0, 38641-94-0, 38641-94-0, 38641-94-0, 38641-94-0, 38641-94-0, 38641-94-0, 38641-94-0, 38641-94-0, 34494-04-7, 38641-94-0, 38641-94-0, 38641-94-0,

	Eraser Systemic Weed & Grass Killer,		53883-59,		38641-94-0,
	Extra Credit 5,		71368-43,		38641-94-0,
	EZ-Ject Diamondback Herbicide Shells,		83220-1,		38641-94-0,
	Farmworks 41% Glyphosate Grass & Weed Killer,		86068-4,		38641-94-0, 38641-94-0,
	Foresters' Non-selective Herbicide,		228-381,		38641-94-0,
	Gly Star 5 Extra,		42750-59,		38641-94-0,
	Gly Star Original,		42750-60,		38641-94-0,
	Gly Star Plus,		42750-61,		38641-94-0,
	Gly Star Pro,		42750-61,		38641-94-0,
	Glyfos Aquatic,		4787-34,		38641-94-0,
	Glyfos X-TRA,		4787-23,		38641-94-0,
	GlyphoMate 41,		2217-847,		38641-94-0,
	Glyphosate 4 Plus,		81927-9		38641-94-0,
	Glyphosate 5.4,		81927-8,		38641-94-0,
	Glyphosate Plus,		66222-176,		38641-94-0,
	Glyphosate Pro 4,		72112-4,		38641-94-0,
	Glyphosate T&O,		73220-6,		38641-94-0,
	Glypro,		62719-324,		38641-94-0,
	Glypro Plus,		62719-322,		38641-94-0,
	Helosate Plus Advanced,		74530-43,		38641-94-0,
	Hi-Yield Kill-Zall II,		19713-526,		38641-94-0,
	Honcho,		524-445,		38641-94-0,
	Honcho Plus,		524-454,		38641-94-0,
	Imitator Plus,		19713-526,		38641-94-0,
	KleenUp 41% Concentrate,		4-484,		38641-94-0,
	KleenUp Pro,		34704-890,		38641-94-0,
	Mad Dog,		34704-889,		38641-94-0,
	Mad Dog Plus,		34704-890,		38641-94-0,
	Makaze,		34704-890,		38641-94-0,
	Mirage,		524-445,		38641-94-0,
	Mirage Plus,		524-454,		38641-94-0,
	Misty Glypho Kill 2,		2217-844,		38641-94-0,
	Pronto Big N' Tuf,		42750-6,		38641-94-0,
	Prosecutor,		228-366,		38641-94-0,
	Ranger Pro,		524-517,		38641-94-0,
	RapidFire,		62719-556,		38641-94-0,
	Rascal Plus,		1381-192,		38641-94-0,
	Razor,		228-366,		38641-94-0,
	Razor Pro,		228-366,		38641-94-0,
	Refuge,		100-1362,		39600-42-5,
	Remuda Full Strength,		228-366,		38641-94-0,
	Rodeo,		62719-324,		38641-94-0,
	Roundup Custom,		524-343,		38641-94-0,
	Roundup Original,		524-445,		38641-94-0,
	Roundup Original MAX,		524-539,		70901-12-1,
	Roundup Power MAX,		524-549,		70901-12-1,
	Roundup Pro,		524-475,		38641-94-0,
	Roundup PRO Concentrate,		524-529,		38641-94-0,
	Roundup ProMax,		524-579,		70901-12-1,

	Roundup Ultra, Roundup UltraDry, Roundup WeatherMAX, Roundup Weed & Grass Killer Super Concentrate, RT 3, Showdown, StrikeOut Extra, Tomahawk 4, Tomahawk 5, Touchdown, Touchdown HiTech, Touchdown Pro, Touchdown Total, Traxion		524-475, 524-504, 524-537, 71995-25, 524-544, 71368-25, 81142-3, 33270-18, 33270-15, 100-1117, 100-1182, 100-1121, 100-1169, 100-1169		38641-94-0, 114370-14-8, 70901-12-1, 70901-12-1, 38641-94-0, 38641-94-0, 38641-94-0, 38641-94-0, 38641-94-0, 1071-83-6, 39600-42-5, 1071-83-6, 1071-83-6, 1071-83-6
Other Ingredients:	**Abundit Edge (glyphosate N-(phosphonomethyl) glycine, potassium salt (K)):** 48.7% K, 51.3% other ingredients (1a); **Abundit Extra (glyphosate N-(phosphonomethyl) glycine, isopropylamine salt (IPA)):** 41% IPA, 59% other (1b); **Accord Concentrate:** 53.8% IPA, 46.2% other (1c); **Accord SP:** 41% IPA, 59% other (1d); **Accord XRT:** 53.6% IPA, 46.4% other (1e); **Accord XRT II (glyphosate N-(phosphonomethyl) glycine, dimethylamine salt (DMA):** 50.2% DMA, 49.8% other (1f); **Alecto 41S:** 41% IPA, 59% other (1g); **Aqua Star:** 53.8% IPA, 46.2% other (1h); **AquaMaster:** 53.8% IPA, 46.2% water (1i); **AquaNeat:** 53.8% IPA, 46.2% other (1j); **AquaPro:** 53.8% IPA, 46.2% water (1k); **Buccaneer:** 41.0% IPA, 59.0% other (1l); **Buccaneer Plus:** 41.0% IPA, 59.0% other (1m); **Bullzeye:** 41.0% IPA, 59.0% other (1n); **Cornerstone:** 41.0% IPA, 59.0% other (1o); **Cornerstone 5 Plus:** 53.8% IPA, 46.2% other (1p); **Cornerstone Plus:** 41.0% IPA, 59.0% other (1q); **Cornerstone Plus with Advanced Surfactant:** 41.0% IPA, 59.0% other (1r); **Credit 41 Extra:** 41.0% IPA, 59.0% other (1s); **Credit Systemic Extra:** 41.0% IPA, 59.0% other (1t); **CropSmart Glyphosate 41 Extra:** 41.0% IPA, 59.0% other (1u); **CropSmart Glyphosate 41 Plus:** 41.0% IPA, 59.0% other (1v); **Durango DMA:** 50.2% DMA, 49.8% other (1w); **Eliminator Weed & Grass Killer Super Concentrate:** 41.0% IPA, 59.0% other (1x); **Envy:** 41.0% IPA, 59.0% other (1y); **Eraser AQ:** 41.0% IPA, 59.0% other (1z); **Eraser Systemic Weed & Grass Killer:** 41.0% IPA, 59.0% other (1aa; **Extra Credit 5:** 50.6% IPA, 49.4% other (1bb); **EZ-Ject Diamondback Herbicide Shells:** 83.5% IPA, 16.5% other (1cc); **Farmworks 41% Glyphosate Grass & Weed Killer:** 41.0% IPA, 59.0% other (1dd); **Foresters' Non-selective Herbicide:** 53.8% IPA, 46.2% other (1ee); **Gly Star 5 Extra:** 53.8% IPA, 46.2% other (1ff); **Gly Star Original:** 41.0% IPA, 59.0% other (1gg); **Gly Star Plus:** 41.0% IPA, 59.0% other (hh); **Gly Star Pro:** 41.0% IPA, 59.0% other (1ii); **Glyfos Aquatic:** 53.8% IPA, 46.20% other (1jj); **Glyfos XTRA:** 41.0% IPA, 59% other (1kk); **GlyphoMate 41:** 41.0% IPA, 59.0% other (1ll); **Glyphosate 4 Plus:** 41.0% IPA, 59.0% other (1mm); **Glyphosate 5.4:** 53.8% IPA, 46.2% other (1nn); **Glyphosate Plus:** 41.0% IPA, 59.0% other (1oo); **Glyphosate Pro 4:** 41.0% IPA, 59.0% other (1pp); **Glyphosate T&O:** 41.0% IPA, 59.0% other (1qq); **Glypro:** 53.8% IPA, 46.2% other (1rr); **Glypro Plus:** 41.0% IPA, 59.0% other (1ss); **Helosate Plus Advanced:** 41.0% IPA, 59.0% other (1tt); **Hi-Yield Kill-Zall II:** 41.0% IPA, 59.0% other (1uu); **Honcho:** 41.0% IPA, 59.0% other (1vv); **Honcho Plus:** 41.0% IPA, 59.0% other (1ww); **Imitator Plus:** 41.0% IPA, 59.0% other (1xx); **KleenUp 41% Concentrate:** 41.0% IPA, 59.0% other (1yy); **KleenUp Pro:** 41.0% IPA, 59.0% other (1zz); **Mad Dog:** 41.0% IPA, 59.0% other (1ba); **Mad Dog Plus:** 41.0% IPA, 59.0% other (1bc); **Makaze:** 41.0% IPA, 59.0% other (1bd); **Mirage:** 41.0% IPA, 59.0% other (1be); **Mirage Plus:** 41.0% IPA, 59.0% other (1bf); **Misty Glypho Kill 2:** 2% IPA, 98% other (1bg); **Pronto Big N' Tuf:** 41.0% IPA, 59.0% other (1bh); **Prosecutor:** 41.0% IPA, 59.0% other (1bi); **Ranger Pro:** 41.0% IPA, 59.0% other (1bj); **RapidFire:** 50.2% DMA, 49.8% other (1bk); **Rascal Plus:** 41.0% IPA, 59.0% other (1bl); **Razor:** 41.0% IPA, 59.0% other (1bm); **Razor Pro:** 41.0% IPA, 59.0% other (1bn); **Refuge:** 52.3% K, 47.7% other (1bo); **Remuda Full Strength:** 41.0% IPA, 59.0% other (1bp); **Rodeo:** 53.8% IPA, 46.2% other (1bq); **Roundup Custom:** 53.8% IPA,				

	46.2% other (1br); **Roundup Original:** 41.0% IPA, 59.0% other (1bs); **Roundup Original MAX:** 48.7% K, 51.3% other (1bt); **Roundup Power MAX:** 48.7% K, 51.3% other (1bu); **Roundup Pro:** 41.0% IPA, 59.0% other (1bv); **Roundup PRO Concentrate:** 50.2% IPA, 49.8% other (1bw); **Roundup ProMax:** 48.7% K, 51.3% other (1bx); **Roundup Ultra:** 41.0% IPA, 59.0% other (1by); **Roundup UltraDry(glyphosate N-(phosphonomethyl) glycine, ammonium salt (NH3):** 71.4% NH3, 28.6% other (1bz); **Roundup WeatherMAX:** 48.8% K, 51.2% other (1ca); **Roundup Weed & Grass Killer Super Concentrate:** 50.2% IPA, 49.8% other (1cb); **RT 3:** 48.8% K, 51.2% other (1cd); **Showdown:** 37.54% IPA, 3.42 (NH3), 59.04% other (1ce); **StrikeOut Extra:** 41.0% IPA, 59.0% other (1cf); **Tomahawk 4:** 41.0% IPA, 59.0% other (1cg); **Tomahawk 5:** 53.8% IPA, 46.2% other (1ch); **Touchdown:** 28.3% NH3, 71.7% other (1ci); **Touchdown HiTech:** 52.3% K, 47.7% other (cj); **Touchdown Pro:** 28.3% NH3, 71.7% other (1ck); **Touchdown Total:** 44.9% K, 55.1% other (1cl); **Traxion:** 36.5% glyphosate acid, 63.5% other (1mn).

Toxicological Endpoints	Endpoints highlighted yellow are selected for use in a screening-level ecological risk assessment. Endpoints selected are typically the most toxic endpoint for the most sensitive species listed in following summaries.
Mammalian LD_{50}:	**Glyphosate Tech 95.0-98.7%**: *Dog*: NOEL = 500 mg/kg/day (11). *Goat* (female): 96-h = 3,500 mg/kg bw (3). *Mice*: 96-h = 1,568 mg/kg bw (3); NOAEL = 3,125 mg/kg diet (10). *Rabbit*: 96-h = 3,800 mg/kg bw (3); 21-d NOAEL = 175 mg ae/kg/day (20). *Rat*: 96-h >4,320 mg/kg (2,7,11); 96-h = 4,873 mg/kg bw (3); 96-h >2000 mg/kg (6); 96-h >4,770 mg ae/kg bw (8), NOAEL <3,125 mg/kg diet (10); Systemic Toxicity LOEL males = 940 mg/kg/day, females = 1,183 mg/kg/day (11); Systemic Toxicity NOELs: males = 362 mg/kg/day, females = 457 mg/kg/day (11); = 2,047 mg ae/kg/day (20). **Glyphosate Tech 88.0%:** *Rat*: 96-h >4,440 mg ae/kg bw (8). **Glyphosate Tech 76.0%:** *Rat*: 96-h >3,800 mg ae/kg bw (8). **AMPA 95.4-97.2%**: *Dog*: 90-d NOEL = 263 mg/kg/day (20). *Rat*: >1,920 mg ae/kg bw (3); >4,750 mg ae/kg bw (3); >4,770 mg ae/kg bw (3); >4,800 mg ae/kg bw (3); >4,860 mg ae/kg bw (3); 90-d NOEL = 400 mg/kg/day, LOEL = 1,200 mg/kg/day (20). **AMPA 88.0%**: *Rat*: >4,400 mg ae/kg bw (3). **AMPA 76.0%**: *Rat*: >3,800 mg ae/kg bw (3). **IPA 62.0%:** *Rat*: >5,000 mg/kg (1c); Mouse: >5,000 mg/kg (1c). **IPA 53.8%**: *Rat*: >5,000 mg/kg (1a). **IPA 41.0%**: *Rat*: >5,000 mg/kg (1i,m,o,r), = 5,108 mg/kg bw (1t).

	K: No information in references.
Mammalian LC_{50}:	**Glyphosate Tech (95.0-98.7%):** *Rat*: NOEL (diet) = 150 ppm (6).
Mammalian Reproduction:	**Glyphosate Tech:** *Rabbit*: Maternal toxicity NOEL = 175 mg/kg/day, LOEL = 350 mg/kg/day (2,8,10); Developmental toxicity NOEL >175 mg/kg/day (1c,e,f,h,m,n,r-v,2,8). *Rat*: Maternal & developmental toxicity NOEL = 1,000 mg/kg/day, LOEL = 3,500 mg/kg/day (2,3); 3-generation: Systemic & reproductive toxicity NOEL < 30 mg/kg/day (1c,e,f,2,8,10,20); Developmental toxicity NOEL = 10 mg/kg/day, LOEL = 30 mg/kg/day (2); 2-generation: Systemic & developmental toxicity NOEL = 500 mg/kg/day, LOEL = 1,500 mg/kg/day (2,3,8); Reproduction NOEL = 1,500 mg/kg/day (1m,n,r-v,2,3); 21-d dietary NOEL = 400 mg/kg/day (20). **AMPA 98.7%**: *Rat*: Systemic & Reproductive NOEL = 740 mg/kg/day, LOEL = 2,268 mg/kg/day (3). **IPA:** No information in references. **K:** No information in references.
Avian LD_{50}:	**Glyphosate Tech 95.6-99.0%:** *Bobwhite*: >3,851 mg ae/kg diet (1c,s,v,20); 96-h >1,912 mg/kg bw, NOAEL = 1,912 mg/kg bw (8); 8-d dietary = 4,000 ppm (11); 8-d dietary > 4,640 mg ae/ kg diet (7,20). *Mallard*: 8-d dietary = 4,000 ppm (11); 8-d dietary >4,640 mg ae/kg diet (7,20). **Glyphosate Tech 83.0%**: *Bobwhite*: 96-h >2,000 mg/kg (2,11); 96-h >3,196 mg ae/kg bw (8). **AMPA:** *Bobwhite*: >3,800 mg/kg (1b,i); >1,912 mg ae/kg bw (3); 8-d dietary >5,620 mg/kg diet, NOEC = 5,620 mg/kg diet (20); (Single Dose LC50) >2,250 mg ae/kg diet (20). *Mallard*: 8-d dietary >5,620 mg/kg diet, NOEC = 5,620 mg/kg diet (20). **AMPA 87.8%**: *Bobwhite*: 96-h >1,976 mg ae/kg, NOAEL = 1,185 mg ae/kg (8). **IPA 41.0%**: *Bobwhite*: >3,800 mg/kg (1g). *Japanese Quail*: 5-d dietary >5,000 ppm (1k,4). **K:** No information in references.
Avian LC_{50}:	**Glyphosate (95.6-98.5%)**: *Bobwhite*: 5-d >5,620 ppm diet (1t); 8-d >4,500 ppm (1d,p); 96-h >4,570 ppm ae, NOAEC = 4,570 ppm ae (3,8); 96-h >4,971.2 ppm ae, NOAEC = 4,971.2 ppm ae (3); 5-d LC50 (14-d old) >4,640 ppm (22). *Mallard*: 5-d >5,620 ppm diet (1t); 8-d >4,500 ppm (1d,p); 96-h > 4,570.4 ppm ae, NOAEC = 4,770.4 ppm ae (3,8); 96-h >4,971.2 ppm ae, NOAEC = 4,971.2 ppm ae (3); 5-d LC50 (14-d old) >4,640 ppm, NOEL = 1,000 ppm (22). **AMPA (87.8%)**: *Bobwhite*: >4,934 ppm, NOAEC = 4,934 ppm (3,8). *Mallard*: > 4,934 ppm, NOAEC = 4,934 ppm (3,8). **IPA (Unk. %AI)**: *Mallard*: 8-d LC50 >4,640 ppm (4). *Bobwhite*: 8-d LC50 >4,640 ppm (4).

	K: No information in references.
Avian Reproduction:	**Glyphosate Tech (94.4-98.5%):** *Bobwhite*: 8-d >4,640 ppm diet (1c,s,v,2). *Mallard*: 5-d > 4,640 ppm diet (1c,s,v,2). **Glyphosate Tech (90.4%)**: *Mallard*: No effects up to 30 ppm (2); NOAEC = 27 ppm, LOAEC >27 ppm (3,8). **Glyphosate Tech (83.0%)**: *Mallard*: No effects up to 1,000 ppm (2,11); NOAEC = 830 ppm (3,8), LOAEC >830 ppm (8). *Bobwhite*: No effects up to 1,000 ppm (2); NOAEC = 830 ppm (3,8), LOAEC >830 ppm (8). **IPA:** No information in references. **K:** No information in references. **AMPA:** No information in references.
Fish LC_{50}:	**Glyphosate Tech. (95.4-99.7%)**: *Bluegill*: 96-h >24 ppm (2,20); 96-h = 43 ppm ae (3,5,8), NOAEC = 30.6 ppm (3,8); 96-h LC50 (pH 6.5 @ 22°C) = 140 ppm (3,4,5,14); 96-h LC50 (pH 9.5 @ 22°C) = 220 ppm (4,5,14); 96-h = 78 ppm (7); 96-h = 100.2 ppm ae (8); 96-h, static water = 34.0 ppm (10); 96-h flow-through water = 5.8 ppm (10); 96-h = 150 ppm (11); 96-h = 120 ppm (12,20). *Channel Catfish*: 48-h = 140 ppm (2); 96-h LC50 @ 22°C = 130 ppm (4,5,11,14); 96-h = 93 ppm ae (8); 96-h = 39 ppm (10). *Chinook*: 96-h = 20 ppm (10). *Coho*: 96-h = 22 ppm (10). *Fathead Minnow*: 48-h = 97 ppm (2,11); 96-h LC50 @ 22°C = 97 ppm (4,5,14), NOAEC = 25.7 ppm ae (8); 96-h = 69.4 ppm ae (8); 96-h = 23 ppm (10). *Pink*: 96-h = 14 to 33 ppm (10). *Rainbow Trout*: 96-h >1,000 ppm (1b); 96-h = 128.1 ppm, NOAEC = 30.6 ppm (dark coloration observed at 53.6 ppm) (3,8); 96-h LC50 (pH 6.5 @ 12°C) = 140 ppm (3,4,5,11,14); 96-h LC50 (pH 9.5 @ 12°C) = 240 ppm (4,5,14); 96-h LC50 = 38 ppm (6,7); 21-d NOEC = 25 ppm (6); 96-h = 100.2 ppm ae (8); 96-h = 128.1 ppm ae (8); 96-h (static water) = 15 to 26 ppm (10); 96-h (flow-through water) = 8.2 ppm (10). **Glyphosate Tech (83.0-87.3%)**: *Bluegill*: 96-h = 99.6 ppm, NOAEC = 83 ppm (3,8); 96-h = 120 ppm (1d,5); 48-h = 120 ppm (2). *Fathead Minnow*: 48-h = 84.9 ppm (2). *Rainbow Trout*: 96-h = 86 ppm (1d,3,5,12,20); 96-h NOEC = 42 ppm (20); 96-h = 71.4 ppm ae (8). **AMPA (94.4-95.6% AI)**: *Species Unknown*: 96-h = 499 ppm, NOAEC = 174 ppm (3,8); 96-h LC50 = 520 ppm, NOEC = 33 ppm (20). *Bluegill*: 96-h >1,000 ppm (1b). **IPA (%AI Unk):** *Rainbow Trout*: 21-d NOEC = 52 ppm (20). **IPA (62.0%)**: *Bluegill*: 96-h >461.8 ppm ae (3). *Rainbow Trout*: 96-h >461.8 ppm ae (3).

	IPA (53.6-53.8%): *Channel Catfish*: 96-h = 130 ppm (4,14,20). *Fathead Minnow*: 96-h NOEC = 1,000 ppm (3,5); 96-h =97 ppm (4,14,20). *Rainbow Trout*: 96-h >2,500 ppm (1a,l,q), NOEC = 1,000 ppm (3,20). **IPA (41% w/ 15% POEA surfactant)**: *Bluegill*: 96-h @ 22°C = 5 ppm (5,14); 96-h @ 17°C = 7.5 ppm (5,14); 96-h @ 22°C = 5 ppm (14); 96-h @ pH 6.5 = 4.2 ppm (14); 96-h pH 7.5 = 2.4 ppm (4,5,14); 96-h = 6.4 ppm (11). *Channel Catfish*: 96-h @ 22°C = 13 ppm (11,14). *Fathead Minnow*: 96-h @ 22°C = 2.3 ppm (5,14); 96-h = 2.4 ppm (11). *Rainbow Trout*: 96-h @12°C = 8.3 ppm (4,5,11,14); 96-h @ 7°C = 14 ppm (4,5,14); 96-h @ 12°C = 7.5 ppm (4,5,14); 96-h @ pH 6.5 = 7.6 ppm (4,5,14); 96-h @ pH 7.5 = 1.6 ppm (4,5,14); behavioral LOEC = 13.5 ppm (4,5); 21-d NOEC = 2.4 ppm (20). **K:** No information in references.
Fish ELS/Life Cycle:	**Glyphosate Tech (%AI unk.)**: *Coho*: NOEC (15.5-16.9 g smolts, plasma Na concentrations) = 2.78 ppm ae (3). **Glyphosate Tech (87.3-99.7%)**: *Bluegill*: Av. wt. 0.4-0.9g @ 22°C, = 44 ppm $CaCO_3$; LC50s: @ pH 6.5: 24-h = 240 ppm; 96-h = 140 ppm (4,5); @ pH 7.4: 24-h = 150 ppm; 96-h = 135 ppm (4,5); @ pH 9.5: 24-h = 230 ppm; 96-h = 220 ppm (4,5). *Channel Catfish*: Av. wt. 2.2g @ 22°C: 24 & 96-h = 130 ppm (4,5). *Chinook*: Av. wt. 0.3-0.7g: creek (soft) water LC50s: 24-h = 55 ppm; 96-h = 30 ppm (4,5,15,20): lake (hard) water LC50s: 24-h = 220 ppm; 96-h = 211 ppm (4,5,15,20). *Chum*: Av. wt. 0.3-0.7g: creek (soft) water LC50s: 24-h = 26 ppm; 96-h = 22 ppm (4,5,15,20); lake (hard) water LC50s: 24-h = 202 ppm; 96-h = 148 ppm (4,5,15,20). *Coho*: Av. wt. 0.3-0.7g: creek (soft) water LC50s: 24-h = 55 ppm; 96-h = 36 ppm (4,5,15,20); lake (hard) water LC50s: 24-h = 210 ppm; 96-h = 174 ppm (4,5,15,20). *Fathead Minnow*: MATC >25.7 mg/l (2); Av. wt. 0.6g @ 20C, LC50s: 24 & 96-h = 97 ppm (4,5). *Pink*: Av. wt. 0.3-0.7g: creek (soft) water LC50s: 24-h = 63 ppm; 96-h = 23 ppm (4,5,15,20); lake (hard) water LC50s: 24-h = 380 ppm; 96-h = 190 ppm (4,5,15,20). *Rainbow Trout*: Av. wt. 0.3-0.7g: creek (soft) water LC50s: 24-h = 32 ppm; 96-h = 22 ppm (4,5,15,20); lake (hard) water LC50s: 24-h = 220 ppm; 96-h = 197 ppm (4,5,15,20); Av. Wt. 0.7-0.8 g @12C, soft water, LC50s: @ pH 6.5: 24-h = 240 ppm; 96-h = 140 ppm (4,5); @ pH 7: 24 & 96-h = 130 ppm (4,5); @ pH 9.5: 24 & 96-h = 240 ppm (4,5). **Glyphosate Tech (41.%AI):** *Bluegill*: Av. wt. 0.7g @ 22°C @ pH 7.4 @ 44 ppm $CaCO_3$, LC50s: 24-h = 6.8 ppm; 96-h = 5.6 ppm (4,5); Av. wt. 0.5g @ pH 7.4 @ 44 ppm $CaCO_3$, LC50s: @17°C: 24-h = 9.6 ppm; 96-h = 7.5 ppm (4,5): @22°C: 24-h = 6.4 ppm; 96-h = 5 ppm (4,5); @27°C: 24-h = 4.3 ppm; 96-h = 4 ppm (4,5); Av. wt. 0.3g @ 22°C @ 44 ppm $CaCO_3$, LC50s: @pH 6.5: 24-h =7.6 ppm; 96-h = 4.2 ppm (4,5); @pH 7.5 24-h = 4 ppm; 96-h = 2.4 ppm (4,5); @pH 8.5: 24-h = 3.9 ppm; 96-h = 2.4 ppm (4,5); @pH 9.5: 24-h = 2.4 ppm; 96-h = 1.8 ppm (4,5); degradation (degr.) study (av. wt. 0.5g, 12°C, pH 7.4, 44 ppm $CaCO_3$): LC50s: 0-d degr.: 24-h = 4.3 ppm; 96-h = 4 ppm (4,5); 1-d degr.: 24-h = 6.6 ppm; 96-h = 6 ppm (4,5); 3-d degr.: 24-h = 8 ppm; 96-h = 7 ppm, (4,5); 7-d degr.: 24-h = 6.2 ppm; 96-h = 5.6 ppm (4,5); Av. wt. 1.3g, 20°C, 272 ppm $CaCO_3$: LC50: 96-h = 5.5 ppm (4,5). *Channel Catfish*: Av. wt. 0.2g, 20°C: 24 & 96-h = 4.4 ppm (4,5); Av. wt. 0.6 g, 22°C: 24 & 96-h = 13 ppm (4,5); Eyed eggs (20°C): LC50 96-h = 43 ppm (4,5); 225°C, LC50s: swim-up fry: 24-h = 3.7 ppm 96-h = 3.3 ppm (4,5); yolk-sac fry: 24 & 96-h = 4.3 ppm (4,5). *Fathead Minnow*: Av. wt. 0.6-0.9 g, pH 7.4, 44 ppm $CaCO_3$, LC50s: @15°C: 24-h = 7 ppm; 96-h = 4.8 ppm (4,5); @20°C: 24-h = 4.1 ppm; 96-h = 2.9 ppm (4,5); @22°C: 24-h = 2.4 ppm; 96-h = 2.3 ppm (4,5); @25°C: 24-h = 6.4 ppm: 96-h = 4.3 ppm (4,5).

	Rainbow Trout: @12°C, pH 7.4, 44 ppm CaCO3, LC50s: Av. wt. 0.4 g: 24-h = 12 ppm; 96-h = 7.6 ppm (4,5); Av. wt. 0.5 g: 24-h = 5.2 ppm; 96-h = 1.3 ppm (4,5); Av. wt. 1.0 g: 24 & 96-h = 8.3 ppm (4,5); Av. wt. 0.7g @pH 7.4, 44 ppm CaCO3, LC50s: @7°C: 24 & 96-h = 14 ppm (4,5); @12°C: 24-h = 14 ppm; 96-h = 7.5 ppm (4,5); @17°C: 24-h = 7.5 ppm; 96-h = 7.4 ppm (4,5); Av. wt. 0.4g, @12°C, 44 ppm CaCO3, LC50s: @pH 6.5: 24-h = 14 ppm; 96-h = 7.6 ppm (4,5); @pH 7.5: 24-h = 2.4 ppm; 96-h = 1.6 ppm (4,5); @pH 8.5 & 9.5: 24-h = 2.4 ppm; 96-h = 1.4 ppm (4,5); degradation (degr.) study (av. wt. 0.5g, 12°C, pH 7.4, 44 ppm $CaCO_3$, LC50s: 0-d degr.: 24-h = 19 ppm; 96-h = 9 ppm (4,5); 1-, 3- & 7-d degr.: 24-h = 14 ppm; 96-h = 7.6 ppm (4,5); yolk-sac fry (10°C), LC50s: 24-h = 11 ppm; 96-h = 3.4 ppm (4,5). **AMPA:** *Fathead Minnow*: NOEC (life-cycle) = 25.7 ppm (3). **IPA (96.7%):** *Bluegill*: 96-h LC50, av. wt. 1g = 120 ppm, NOEL = 100 ppm (22). *Channel Catfish*: 96-h LC50, av. wt. 2.2g = 130 ppm (22). *Fathead Minnow*: 96-h LC50, av. wt. 0.6g = 97 ppm (22). **IPA (83.0-87.3%):** *Fathead Minnow*: Life Cycle (LOEL) >25.7 ppm, (NOEL) = 25.7 ppm (22). *Rainbow Trout*: 96-h LC50, av. wt. 0.8g = 140 ppm (22). **IPA (62.4%):** *Rainbow Trout*: 96-h LC50, av. wt. 0.22) >1,000 ppm (22). **IPA (53.6-53.8%):** *Striped Bass*: Av. wt 1g: 1-h = 131 ppm, 6-h = 50 ppm, 96-h = 23.5 ppm (4,5). **IPA (40.7-41.8%)**: *Bluegill*: 96-h LC50, av. wt. 0.45g = 14 ppm, NOEL = 8.7 ppm (22); 96-h LC50, av. wt. <2.5g = 2.4 ppm (22); 96-h LC50, av. wt. 0.25g = 5.8 ppm, NOEL = 2.2 ppm (22); 96-h LC50, av. wt. 0.11g = 134 ppm, NOEL <100 ppm (22); 96-h LC50, av. wt. 0.5g = 4.0 ppm (22). *Channel Catfish*: 96-h LC50, av. wt. 0.6g = 13 ppm (22); 96-h LC50, av. wt. 3.0g = 16 ppm, NOEL = 9.4 ppm (22). *Fathead Minnow*: 96-h LC50, av. wt. 0.6g = 9.4 ppm, NOEL = 5.6 ppm (22). *Rainbow Trout*: 21-d NOEC = 0.43-0.81 ppm (1k); 96-h LC50, av. wt. 0.5g = 1.3 ppm (22); 96-h LC50, fingerling = 8.3 ppm (22); 96-h LC50, av. wt. 0.4g = 150 ppm, NOEL = 100 ppm (22); 96-h LC50, av. wt. 2.4g = 8.2 ppm, NOEL = 5.8 ppm (22); 96-h LC50, av. wt. 0.5g = 120 ppm (22). **IPA (7.03%):** *Bluegill*: 96-h LC50, av. wt. 0.18g = 830.8 ppm, NOEL = 180 ppm (22). *Rainbow Trout*: 96-h LC50, av. wt. 1.0g = 240 ppm, NOEL =180 ppm (22). **IPA (41% w/10% POEA surfactant)**: *Coho*: Av. wt. 0.3-0.7g: creek (soft) water: 24-h = 54 ppm, 96-h = 51 ppm (4,5,15), lake (hard) water: 24 & 96-h = 25 ppm (4,5,15). *Chum*: Av. wt. 0.3-0.7g: creek (soft) water: 24-h = 62 ppm, 96-h = 58 ppm (4,5,15), lake (hard) water: 24-h = 25 ppm, 96-h = 23 ppm (4,5,15); Av. wt. 0.3-0.7g: creek (soft) water: 24-h = 31 ppm, 96-h = 19 ppm (4,5,15), lake (hard) water: 24-h = 17 ppm, 96-h = 11 ppm (4,5,15). *Rainbow Trout*: Av. wt. 0.3-0.7g: creek (soft) water: 24-h = 33 ppm, 96-h = 31 ppm (4,5,15), lake (hard) water: 24-h = 31 ppm, 96-h = 17 ppm (4,5,15), 96-h (av. wt 0.37 g): (dechlorinated city water, pH 6.1) = 26 ppm, (lake water, pH 7.7) = 15 ppm (4,20).

	IPA (41% w/ 15% POEA surfactant): *Channel Catfish*: 96-h, sac fry = 4.3 ppm (4,14), swim-up fry = 3.3 ppm (4,14), Av. wt 2.2g) = 13 ppm (14). *Chinook*: Av. wt. 0.3-0.7g: Creek (soft) water: 24-h = 41 ppm, 96-h = 27 ppm (4,5,15,20), Lake (hard) water: 24 & 96-h = 17 ppm (4,5,15,20), Av. wt. 4.6g, dechlorinated city water, pH 6.1: 96-h = 20 ppm (4,20). *Chum*: Av. wt. 0.3-0.7g: creek (soft) water: 24-h = 31 ppm, 96-h = 19 ppm (4,5,15,20), lake (hard) water: 24-h = 17 ppm, 96-h = 11 ppm (4,5,15,20). *Coho*: Av. wt. 0.3-0.7g: Creek (soft) water: 24 & 96-h = 27 ppm (4,5,15,20), lake (hard) water: 24-h = 14 ppm, 96-h =13 ppm (4,5,15,20), 96-h, av. wt. 0.3g @ 15°C = 42 ppm (4,5,16,20); Av. wt. 11.8g, dechlorinated city water @ pH 6.2: 96-h = 22 ppm (4,20). *Pink*: Av. wt. 0.3-0.7g: creek (soft) water: 24-h = 33 ppm, 96-h = 31 ppm (4,5,15,20), lake (hard) water: 24-h =17 ppm, 96-h =14 ppm (4,5,15,20). *Rainbow Trout*: 96-h, eyed eggs = 16 ppm (4,5,14), sac fry = 3.4 ppm, swim-up fry = 2.4 ppm (4,5,14); 96-h, av. wt. 1g = 1.3 ppm (4,5,14), 96-h, av. wt. 2g = 8.3 ppm (4,5,14); Av. wt. 0.3-0.7g: creek (soft) water: 24-h =21 ppm, 96-h =15 ppm (4,5,15,20), lake (hard) water: 24-h = 17 ppm, 96-h = 14 ppm (4,5,15,20); 96-h, av. wt. 0.33g, 15°C = 28 ppm, av. wt. 0.6g, 14.5°C = 25.5 ppm (4,5,16). *Sockeye*: 96-h, av. wt. 3.8 g, 4.2°C) = 26.7 ppm (4,5,16,20), Av. wt. 0.25 g, 4.5°C = 28.8 ppm (4,5,16).
Amphibians/ Reptiles:	**Glyphosate Tech (95.0% +):** *Gray Tree Frog*: 26-d NOEL, metamorphosis, growth & survival = 0.0069 ppm (4,5). *Green Frog*: 24-h & 96-h LC50s, embryo >38.9 ppm (4,11);7-d & 14-d NOEL, mortality =3.7 ppm (4,5); 15-d LOEL, immunological = 3.7 ppm (4,5). *Leopard Frog*: 40 to 45-d NOEL, metamorphosis, growth & survival = 0.0069 ppm (4,5); NOAEC =1.8 ppm ae (8). *Xenopus laevis*: 96-h LC50 @ pH 7.6 = 7,297 ppm ae; 96-h LC05 @ pH 7.6 = 5,516 ppm ae (3). **AMPA:** No data in references. **IPA (53.8%)**: *African Clawed Frog*: 96-h LC50, embryo = 7,296.8 ppm ae (4,5); 96-h LC10, embryo = 5,867.2 ppm ae (4); 96-h LC05, embryo = 5,515.5 ppm ae (4); 96-h LOEL, growth = 6,000 ppm ae (4,5), NOEL, growth 4,000 ppm ae (4,5); 96-h LC50, embryo @ pH 6.5 = 4,341.6 ppm ae (4,5); 96-h LC10, embryo @ pH 6.5 = 3,023.4 ppm ae (4); 96-h LC50, embryo @ pH 8.0 = 645.2 ppm ae (4,5); 96-h LC10, embryo @ pH 8.0 = 395.2 ppm ae (4). **IPA (25.2%)**: *American Bullfrog*: 16-d NOEL, growth & survival = 1 ppm (4,5), LOEL growth & survival = 2 ppm (4,5); 16-d LC50 = 2.07 ppm (5,17). *American Toad*: 16-d NOEL growth & survival =1 ppm (4,5), LOEL = 2 ppm (4,5); 16-d LC50 = 2.52 ppm (5,17). *Gray Tree Frog*: 16-d NOEL growth & survival = 2 ppm (4,5); 16-d LC50 = 1.35 ppm (5,17). *Green Frog*: 16-d NOEL growth & survival = 1 ppm (4,5), LOEL = 2 ppm (4,5); 16-d LC50 = 2.17 ppm (5,17). *Leopard Frog*: 16-d NOEL growth & survival = 2 ppm (4,5); 16-d LC50 = 2.46 ppm (5,17). *Wood Frog*: 16-d NOEC = 1 ppm (4,5); 16-d LC50 w/o predator = 1.32 ppm (5,17), LC50 w/ predator [red-spotted newt (RSN)] 0.55 ppm (5,17). **IPA (13.0%)**: *Leopard Frog*: 23-d LOEL, 29% reduction in survival w/out predation by red-spotted newts (RSN) = 1.3 ppm (4), (23-d LOEL, w/ predation by RSN, additional 21% reduction in survival = 1.3 ppm (4,5).

	Gray Tree Frog: 23-d NOEL 0% reduction in survival = 1.3 ppm (4,5), LOEL 0% survival = 1.3 ppm (4); red-spotted newt: 23-d NOEL, survival =1.3 ppm (4,5). **IPA (41.0% w/15% POEA surfactant):** *African Clawed Frog*: 96-h LC50, embryo = 9.3 ppm ae (4,5); 96-h LC10, embryo = 8.0 ppm ae (4); 96-h LC05, embryo = 7.7 ppm ae (4); 96-h LC50, embryo @ pH 6 15.6 ppm ae (4,5,8); 96-h LC10, embryo @ pH 6 = 6.2 ppm ae (4); 96-h LC50, embryo @ pH 7.5 = 7.9 ppm ae (4,5,8); 96-h LC10 embryo @ pH 7.5 = 4.0 ppm ae (4); 96-h LC50, larvae @ pH 6 = 2.1 ppm ae (4,5,8); 96-h LC10 larvae @ pH 6 = 1.99 ppm ae (4); 96-h LC50 larvae @ pH 7.5 = 0.88 ppm ae (4,5,8); 96-h LC10 larvae @ pH 7.5 = 0.85 ppm ae (4); 96-h LOEL growth = 10 ppm ae (4), NOEL growth) = 8 ppm ae (4). *American Bullfrog*: 96-h LC50 larvae = 1.55 ppm ae (9). *American Toad*: 24-h LC50 embryo = 13.5 ppm (4); 96-h LC50 embryo <12.9 ppm (3,4,5,8); 96-h LC50 embryo @ pH 6 = 4.8 ppm ae (4,5,8,9); 96-h LC10 embryo @ pH 6 = 2.2 ppm ae (4); 96-h LC50 embryo @ pH 7.5 = 6.4 ppm ae (4,5,8,9); 96-h LC10 embryo @ pH 7.5 = 4.3 ppm ae (4); 96-h LC50 larvae @ pH 6 = 2.9 ppm ae (4,5,8,9); 96-h LC10 larvae @ pH 6 = 2.1 ppm ae (4); 96-h LC50 larvae @ pH 7.5 = 1.7 ppm ae (4,5,8,9); 96-h LC10 larvae @ pH 7.5 = 1.2 ppm ae (4); 96-h LC50 larvae <4 ppm ae (9); 16-d LC50 larvae = 1.89 ppm ae (9). *Gray Tree Frog*: 96-h LC50 larvae = 1.0 ppm ae (9). *Green Frog*: 96-h LC50 embryo = 6.5 ppm (3,4,5,8); 96-h LC10 larvae = 3.9 ppm (4); 96-h LC50 larvae = 8.7 ppm (4); 96-h LC50 embryo @ pH 6 = 5.3 ppm ae (4,5,8,9); 96-h LC10 embryo @ pH 6 = 2.6 ppm ae (4); 96-h LC50 embryo @ pH 7.5 = 4.1 ppm ae (4,5,8,9); 96-h LC10 embryo @ pH 7.5 = 2.8 ppm ae (4); 96-h LC50 larvae @ pH 6 = 3.5 ppm ae (4,5,8,9); 96-h LC10 larvae @ pH 6 = 2.1 ppm ae (4); 96-h LC50 larvae @ pH 7.5 = 1.4 ppm ae (4,5,8,9); 96-h LC10 larvae @ pH 7.5 = 0.89 ppm ae (4); 96-h LC50 larvae = 2.0 ppm ae (4,5,9); 16-d LC50 = 1.63 ppm ae (4,5,9); field enclosure studies (tadpoles) 96-h LC50s: Site A = 4.34 ppm ae (4,5,9), Site B = 2.70 ppm ae (4,5,9). *Northern Leopard Frog*: 24-h LC50 embryo = 11.9 ppm (4); 96-h LC50 embryo = 9.2 ppm (3,4,5,8); 96-h LC10 larvae = 10.5 ppm (4); 96-h LC50 larvae = 13.7 ppm (4); 96-h LC50 embryo @ pH 6 = 15.1 ppm ae (4,5,8,9); 96-h LC10 embryo @ pH 6 = 13.1 ppm ae (4); 96-h LC50 embryo @ pH 7.5 = 7.5 ppm ae (4,5,8,9); 96-h LC10 embryo @ pH 7.5 = 6.7 ppm ae (4); 96-h LC50 larvae @ pH 6 = 1.8 ppm ae (4,5,8,9); 96-h LC10 larvae @ pH 6 = 1.1 ppm ae (4); 96-h LC50 larvae @ pH 7.5 = 1.1 ppm ae (4,5,8,9); 96-h LC10 larvae @ pH 7.5 = 0.83 ppm ae (4); 96-h LC50 larvae = 2.9 ppm ae (4,5,9); 16-d LC50 = 1.85 ppm ae (9); field enclosure studies (tadpoles) 96-h LC50s: Site A = 11.47 ppm ae (4,5,9), Site B= 4.25 ppm ae (4,5,9). *Wood Frog*: 24-h LC50 embryo = 18.1 ppm (4); 96-h LC50 embryo = 16.5 ppm (4,5,8); 96-h LC50 larvae = 16.5 ppm (3,5); 96-h LC50 larvae = 5.1 ppm ae (9); 16-d LC50, w/o predator = 1.0 ppm ae (9); 16-d LC50 w/predator = 0.41 ppm ae (9). **K (48.8%):** <u>Roundup WeatherMAX</u>: New Mexico spadefoot & Great Plains toad: 48-h NOEC survival = 1.301 L/acre (21). **K (48.7% AI w/unk % POEA surfactant – <u>Roundup Original MAX</u>:** *American Bullfrog*: 96-h LC50 larvae = 0.8 ppm ae (3,18); 96-h LC10 & LC90 larvae = 0.5 & 1.2 ppm ae (18). *American Toad*: 96-h LC50 larvae = 1.6 ppm ae (3,18); 96-h LC10 & LC90 larvae = 1.2 & 2.1 ppm ae (18). *Blue-spotted Salamander*: 96-h LC50 larvae = 3.2 ppm ae (3,18); 96-h LC10 & LC90 larvae = 2.7 & 3.7 ppm ae (18). *Cascades Frog*: 96-h LC50 larvae = 1.7 ppm ae (3,18); 96-h LC10 & LC90 larvae = 1.2 & 2.1 ppm ae (18). *Gray Tree Frog*: 96-h LC50 larvae = 1.7 ppm ae (3,18); 96-h LC10 & LC90 larvae = 1.4 & 2.0 ppm ae (18). *Green Frog*: 96-h LC50 larvae = 1.4 ppm ae (3,18); 96-h LC10 & LC90 larvae = 1.0 & 1.8

	ppm ae (18). *Leopard Frog*: 96-h LC50 larvae = 1.5 ppm ae (3,18); 96-h LC10 & LC90 larvae = 1.2 & 1.8 ppm ae (18). *Northwestern Salamander*: 96-h LC50 larvae = 2.8 ppm ae (3,18); 96-h LC10 & LC90, larvae = 2.4 & 3.3 ppm ae (18). *Spotted Salamander*: 96-h LC50 larvae = 2.8 ppm ae (3,18); 96-h LC10 & LC90 larvae = 2.4 & 3.3 ppm ae (18). *Spring Peeper*: 96-h LC50 larvae = 0.8 ppm ae (3,18); 96-h LC10 & LC90 larvae = 0.1 & 1.6 ppm ae (18). *Red-spotted Salamander*: 96-h LC50 larvae = 2.7 ppm ae (3,18); 96-h LC10 & LC90, larvae = 2.3 & 3.1 ppm ae (18). *Western Toad*: 96-h LC50 larvae = 2.0 ppm ae (3,18); 96-h LC10 & LC90 larvae = 1.7 & 2.4 ppm ae (18). *Wood Frog*: 96-h LC50 larvae = 1.9 ppm ae (3,18); 96-h LC10 & LC90 larvae = 1.3 & 2.8 ppm ae (18).
Invertebrates/ Plants:	**Glyphosate Tech (95.0-99.7%)**: *Daphnia magna*: (48-h EC50) = 930 ppm (1c,7), (48-h EC50, immobilization) = 40 ppm (6), (21-d NOEC) = 30 ppm (6), NOAEC = 49.9 ppm ae (8), (48-h EC50, w/aeration) = 37 ppm (10), (48-h EC50, w/o aeration) = 24 ppm (10), (48-h EC50) = 13 ppm (10). *Duckweed*: 7-d EC50 phytotoxicity = 21.5 ppm (2); 7-d EC50 biomass = 12 ppm (6); 7-d EC50 = 10 ppm ae (20); 14-d EC50 growth = 25.5 ppm ae, NOEC = 16.6 ppm ae (20). *Earthworm*: 14-d LC50 >5,000 mg kg dry soil (1c); 14-d LC50 >480 mg/kg (6), NOEC reproduction >28.8 mg/kg (6); 14-d LC50 >3,750 mg/kg soil, NOEC = 118.7 (20). *Eastern Oyster, eggs*: 48-h LC or EC50 >10 ppm ae (20). *Fatmucket Clam*: 48-h LC50, larvae >200 ppm ae (3,4,5); 96-h LC50 juvenile >200 ppm ae (3,4,5); 21-d LC50 >200 ppm ae (3,4,5). *Fiddler Crab*: 96-h LC50 = 934 ppm (2,11,20). *Grass Shrimp*: 96-h LC50 = 281 ppm (2,11,20). *Green Algae*: 96-h EC50 phytotoxicity = 12.5 ppm (2); 72-h EC50 growth inhibition = 166 ppm (1c); 72-h EC50 growth = 4.4 ppm (6). *Honeybee*: 48-d contact LD50 >100 µg/bee (1c,2,4); 48-h LD50, oral & contact ≥100 µg/bee (6,7,8,10,11,20). *Midge*: 48-h LC50 = 55 ppm (2,3,5); 48-h LC50 = 53.2 ppm ae (8); 48-h LC50 = 53.2 ppm ae (8). *Mysid Shrimp*: 96-h LC or EC50 >1,000 ppm ae (20). **Glyphosate Tech (83.0%)**: *Daphnia magna:* 48-h LC50 = 780 ppm (1d,2); 21-d, life cycle NOEC = 49.9 ppm, LOEC = 95.7 ppm (3). **Glyphosate Tech (41.0% AI):** *Buzzer midge*: 3rd instar, 22°C, hard water, LC50s: (48-h) >10 ppm @ pH 7.4); (48-h) = 55 ppm @ pH 7.4; 48-h >56 @ pH 6.6 (4,5). *Daphnia magna*: 1st instar, 22°C, hard water, LC50s: (24-h) = 5.3 ppm; 48-h = 2.95 ppm (4,5). **AMPA (94.4-98.5%):** *Daphnia magna*: 48-h EC50 = 683 ppm, NOAEC = 320 ppm (3,8); 48-h LC or EC50 = 690 ppm (20). *Duckweed*: 7-d EC50 growth = 46.9 ppm ae (3); 7-d EC10 growth = 3.78 ppm ae (3). *Honeybee*: 48-h LD50 contact >100 µg/bee (3). *Green Algae*: 48-h EC50 growth = 270 ppm (3); 48-h EC10 growth = 92.5 ppm (3); 96-h EC50 growth = 55.9 ppm ae (3); 96-h IC50 growth = 24.7 ppm (3). **AMPA (83.0%)**: *Ceriodaphnia dubia*: 48-h LC50 = 147 ppm ae (3).

	Daphnia magna: 48-h EC50 = 647.4 ppm ae, NOAEC = 464.8 ppm ae (3,8); 48-h EC50 = 128.1 ppm ae, NOAEC = 95.6 ppm ae (3). **IPA (Unk %AI):** *Daphnia pulex*: 48-h EC50 < 24 h old = 7.9 ppm (22). *Duckweed*: 48-h EC50 growth = 2.0 ppm (22); 48-h EC50 growth >16.91 ppm, NOEL = 16.91 ppm (22). *Honeybee*: 48-h LD50 contact >100 µg/bee (22). **IPA (95.0-99.7%)**: *Daphnia magna*: 21-d early life LOEC = 96 ppm, NOEL = 50 ppm (22). *Eastern Oyster*: 48-h LC50 embryo-larvae >10 ppm (22). *Fatmucket Clam*: 48-h LC50 larvae = 5.0 ppm ae (4,5); 96-h LC50 juvenile = 7.2 ppm ae (4,5). *Fiddler Crab*: 96-h LC50 = 934 ppm, NOEL = 650 ppm (22). *Midge*: 48-h LC50 4th instar = 55 ppm (22); 48-h LC50 juvenile = 18 ppm (22). *Shore Shrimp*: 96-h LC50 = 281 ppm, NOEL = 210 ppm (22). **IPA (83.0%):** *Daphnia magna*: 48-h EC50 = 780 ppm, NOEL = 560 ppm (22). **IPA (62.4%):** *Daphnia magna*: 48-h EC50 = 401.3 ppm ae, NOAEC = 147.8 ppm ae (3); 48-h LC50 1st instar = 869 ppm, NOEL = 320 ppm (22). **IPA (53.5-56.8%)**: *Ceriodaphnia dubia*: 48-h LC50 = 415 ppm ae (3,4,5); 24-h LC50 = 707 ppm ae (4). *Daphnia magna*: 48-h LC50 = 218 ppm (3,4,5); 48-h LC50 = 35.5 ppm, NOEC immobility = 13 ppm (3); 48-d LC50 = 130 ppm (4). *Duckweed*: growth inhibition = 24.4 ppm (1a,l,q). *Earthworm*: LC50 >1,000 ppm (1a,l,q). *Fatmucket Mussel*: 48-h EC50 larvae >148 ppm ae (3,4,5); 96-h LC50 juvenile >148 ppm ae (3,4,5); 28-d LC50 = 43 ppm ae (3,4,5). *Green Algae*: growth inhibition = 127 ppm (1a,1l,1q); 96-h IC50 growth = 41.0 ppm (3). *Honeybee* contact LD50: >100 µg/bee (1a,l,q). *Midge*: 48-h EC50 immobilization = 5,600 ppm (3,4,5,20); 48-h LC50 = 1,216 ppm (3,5); 24-h EC50 immobilization = 5,900 ppm (4,5). **IPA (40.7-41.4% AI):** *Crayfish*: Adult, 22°C, hard water, 96-h LC50 = 7 ppm (4,5,22). *Daphnia magna*: 48-h EC50 = 21.6 ppm (1k); 48-h LC50 = 11.0 ppm (1t); 21-d NOEC = 1.5 ppm (1k,5); 48-h EC50 immobility, first instar, w/o suspended sediments @ 22°C = 3 ppm (5,19); 48-h EC50, 1st instar = 3 ppm (22); 48-h EC50, <24-h old = 310 ppm, NOEL = 56 ppm (22); 48-h EC50, <24-h old = 72 ppm (22); 48-h EC50 <24-h old = 5.3 ppm, NOEL = 1.9 ppm (22). *Daphnia pulex*: 48-h EC50 immobility, w/o suspended sediments @ 15°C = 7.9 ppm (4,5,19); 48-h EC50 immobility, w/suspended sediments (50 mg clay/L) @ 15°C = 3.2 ppm (5,19**);** 48-h EC50 <24 h old = 242 ppm, NOEL <60 ppm (22). *Duckweed*: 7-d EC50 = 27.0 ppm (1k). *Earthworm*: 14-d EC50 >1,000 ppm (dry soil) (1k); 14-d EC50 >1,250 mg/kg soil (1t). *Green Algae*: 72-h IC50 = 17.4 ppm (1k); 96-h IC50 = 2.2 ppm (1k). *Honeybee*: 24-h LD50 contact) >20 µg/bee (1k). **IPA (25.2%)**: *Pouch Snail*: 13-d NOEL = 3.8 ppm (4,5). *Marsh Pond Snail*: 13-d NOEL = 3.8 ppm (4,5).

	Marsh Rams-Horn: 13-d NOEL = 3.8 ppm (4,5). **IPA (7.03%):** *Daphnia magna*: 48-h EC50 1st instar >1,000 ppm, NOEL = 560 ppm (22). **IPA (41% w/ 10-20% POEA surfactants)**: *Ceriodaphnia dubia*: (24-h LC50) = 6.0 ppm ae (4,5), (48-h LC50) = 5.7 ppm ae (4,5). **IPA (41% w/ 15% POEA surfactants)**: *Daphnia pulex*: 96-h EC50 = 25.5 ppm (4,5,12,16). *Duckweed*: 7-d EC50 growth = 15.1 ppm ae (20); 14-d EC50 growth = 4.9 ppm ae (20). *Earthworm*: 14-d LC50 >5,000 mg ae/kg soil (20), NOEC = 500 mg ae/kg soil (20). *Midge*: 48-h LC50 = 16 ppm (11). **K:** No information in references.
Other:	**Glyphosate Tech:** Carcinogenic: Negative (2,6,11); Teratogenic: Negative (10,11); Mutagenic: Slightly, but not in mammals (3,11); Genotoxic: Potential; however, the research that raised the largest concerns involved the use of a formulation marketed in S. America (w/ EPA Registration No. 524-424) (3); Endocrine disruption: Unknown (5,6), Negative in mammals (11). **AMPA:** Unknown (5); Teratogenic: Negative (10,11); Mutagenic: Negative (10); Endocrine disruption: Unknown (5), Negative in mammals (11).

Glyphosate: 1st-order degradate of glyphosate salts (e.g. isopropylamine (IPA) and potassium (K)) (1d);
Aminomethylphosphonic Acid (AMPA): 2nd-order degradate of glyphosate salts (7,12).

Ecological Incident Reports

No incident reports in references.

Environmental Fate

Water solubility (S_w):	**Glyphosate:** Highly water soluble (2,12); = 11,600 ppm at 25°C (7); = 12,000 ppm at 25°C (8); = 10,500 ppm at 20°C (10); = 10,500 ppm at pH 1.9 (11); = 900,000 ppm (12); = 1.2 x 10^4 at 25°C (13); = 10,000 to 15,700 mg/L at 25°C (20). **IPA:** =786,000 ppm at pH 4.06 (11).
Soil Mobility (K_{oc}):	**Glyphosate:** =884-60,000 L/kg, absorbs strongly to soil (1c,e,f,h,m,n,r-v,2); = 1435 (slightly mobile) (6); sand = 58,000 mL/g (8); sandy loam = 3,100 – 13,000 mL/g (8), silty clay loam = 33,000 – 47,000 mL/g (8); = 2,640; 2,100 & 500 (12).
Soil Persistence ($t_{½}$):	**Glyphosate:** Primary degradation mechanism is biotic metabolism to AMPA (2,7,11,12). *Aerobic degradation*: sandy loam = 1.85 d (2), silt loam = 2.06 d (2); = 96.4 d (7); sandy loam = 1.8 & 5.4 d, silt loam = 2.6 d (8), remained in pond sediments at ≥1 ppm at 1 year post-treatment (8); = 2 to 197 d (11), Av. = 47 d (11,12); Av. = 0.9 d (0.6 to 1.1 d) (13). *Anaerobic degradation*: = 22.1 d (7). *Photolysis*: Stable to photodegradation on soil (2); = stable (for at least 30 d) (8). **AMPA:** *Aerobic degradation*: = max. of 29% at 40 d (8).
Soil Dissipation (DT_{50}):	**Glyphosate:** = 2-174 d (1c,1e,1f,1h,1m,1n,1r- v,13); Av. =13.9 days (2.6 d in TX to 140.6 d in IA) (2), half-lives are longer in colder climes (28.7 d in MN, 127.8 d in NY) (2), = av. 100 d (35 – 158 d) (2); field (aerobic) = 12 d (6), lab at 20°C = 49 d (6); =44 to 60 d (7); =7.3 d (OH), = 1.7 d (TX), = 17 d (AZ), = 114 d (NY), = 25 d (MN), = 8.3 d (GA), = 13 d (CA)

	(8); forest soil = 14.8 & 24.2 (13); = 27.3 to 55.5 d (20); = 1.7 to 141.9 d (20). **AMPA:** = 119 d (OH), = 131 d (TX), = 142 d (AZ), = 240 d (NY), = 302 d (MN), = 958 d (GA), = 896 d (CA) (2,8); = av. 118 d (71 to 165 d) (2).
Aquatic Persistence ($t_{½}$):	**Glyphosate:** <7 d (1c,1e,1f,1h,1m,1n,1r- v). *Aerobic degradation*: Silty clay loam incubated in dark at ~25°C for 30 days = 7 d (2); water-silty clay loam = 14.1 d (8); = 3 to 91 d (11). *Anaerobic degradation*: Silty clay loam sediment = 8.1 d (2); water-silty clay loam = 208 d (8). *Hydrolysis*: Stable to hydrolysis at pH 3, 6, and 9 @ 5 & 35°C. *Photolysis*: Stable to photodegradation in pH 5, 7, and 9 under natural sunlight (2,7,10,11); = stable (for at least 30 d) (8). **AMPA:** *Aerobic degradation*: = 19-25% at 7-30 d (8), = 7 to 14 d (20), considered comparable to glyphosate (20). *Anaerobic degradation*: = max. of 25% at 15 d (8).
Aquatic Dissipation (DT_{50}):	**Glyphosate:** = 7.5 d (irrigation water) (2,8); = 120 d (pond in MO) (2); >35 d (av. across several temperatures and pH levels) (7); = stable at pH 5 to 8 at 25°C (6); water-sediment DT50 = 87 d (6); = 7 & 14 d (20). *Hydrolysis*: DT50 = stable at pH 7, 20°C (6). *Photolysis*: DT50 = 33 d (pH 5), = 69 d (pH 7), 77 d (pH 9) (6).
Potential to Move to Groundwater (GUS score):	**Glyphosate:** Low potential (2,7,11,12). **AMPA:** Low potential (2).
Vapor Pressure (mm Hg):	**Glyphosate:** Low (2,7), = 7.5×10^{-8} (6), = 1.84×10^{-7} at 45°C (11). **IPA:** = 1.58×10^{-8} at 25°C (11).
Octanol-Water Partition Coefficient (K_{ow}):	**Glyphosate:** Low (2,7), = 6.31×10^{-4} at pH 7, 20°C, low, (6), = 0.00033, very low (7), <6×10^{-4} at pH 5, 7 & 9 (10), = 0.02512 (12), = 2.57×10^{-5} to 0.01995 (20).
Bioaccumulation/ Biocentration:	**Glyphosate:** BCF (Bluegill) <1 for whole fish (1c,e,f,h,m,n,r-v), = 0.52x (whole fish) (2), BCF = 0.5 (6).

Worst Case Ecological Risk Assessment

Max Application Rate (ai lbs/acre – ae basis)	**Habitat Management:** 1.5 lb. a.e./acre, 30 day interval with maximum 5 applications/ 2.25 a.e./acre, 30 day interval with maximum 2 applications/3.75 a.e./acre with 1 application.* **Croplands/Facilities Maintenance:** 1.5 lb. a.e./acre, 30 day interval with maximum 5 applications/ 2.25 a.e./acre, 30 day interval with maximum 2 applications/3.75 a.e./acre with 1 application.* *Broadcast at these rates; cut-stump and targeted treatment at higher rates acceptable.
EECs	**Terrestrial (Habitat Management):** 463.67 ppm/567.1 ppm/933 ppm **Terrestrial (Croplands/Facilities Maintenance):** 463.67 ppm/567.1 ppm/933 ppm **Aquatic (Habitat Management):** 0.5516 ppm/ 0.8276 ppm/1.3795 ppm; no buffer for aquatic use labelled formulations. **Aquatic (Croplands/Facilities Maintenance):** 0.00503 ppm/0.00754 ppm/0.01257 ppm**;** assumes 25 ft buffer for non-aquatic labelled formulations.

Habitat Management Treatments:*

Presumption of Unacceptable Risk		Risk Quotient (RQ)	
		Listed (T&E) Species	Nonlisted Species
Acute	Birds	=0.1/0.12/0.2 [0.1]	=0.1/0.12/0.2 [0.5]
	Mammals	=0.11/0.13/0.21 [0.1]	=0.11/0.13/0.21 [0.5]
	Fish	<0.02/<0.02/<0.02 [0.05]	<0.02/<0.02/<0.02 [0.5]
Chronic	Birds	=0.5/0.68/1.08 [1]	=0.5/0.68/1.08 [1]
	Mammals	=0.03/0.3/0.6 [1]	=0.03/0.3/0.6 [1]
	Fish	<0.02/<0.02/<0.02 [1]	<0.02/<0.02/<0.02 [1]

*Calculations for mammal RQs using acute values for glyphosate acid and chronic values for the metabolite AMPA; for birds, only glyphosate acid values used as no metabolite information available. Glyphosate technical acute and chronic values used to for fish because formulations labelled for aquatic do not contain the surfactants used in crop formulations that are toxic to aquatic life.

Cropland/Facilities Maintenance Treatments:*

Presumption of Unacceptable Risk		Risk Quotient (RQ)	
		Listed (T&E) Species	Nonlisted Species
Acute	Birds	=0.1/0.12/0.2 [0.1]	=0.1/0.12/0.2 [0.5]
	Mammals	=0.11/0.13/0.21 [0.1]	=0.11/0.13/0.21 [0.5]
	Fish	<0.02 [0.05]	<0.02 [0.5]
Chronic	Birds	=0.5/0.68/1.08 [1]	=0.5/0.68/1.08 [1]
	Mammals	=0.03/0.3/0.6 [1]	=0.03/0.3/0.6 [1]
	Fish	<0.02 [1]	<0.02 [1]

*Calculations for mammal RQs using acute values for glyphosate acid and chronic values for the metabolite AMPA; for birds, only glyphosate acid values used as no metabolite information available. Acute and chronic values of glyphosate with surfactants used to calculate RQs for fish because crop formulations are more toxic to aquatic life.

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Known Resistance:

- If you are treating a weed listed below in a state that is listed, we recommend you contact the local county extension agent to determine if resistance is known in the county in which you'll be working and follow the resistance BMPs. As of May 2017, the following plants in the United States have been reported as resistant to glyphosate. For the most current status, please go to: http://weedscience.org/Summary/ResistbyActive.aspx :

Common Name	Species	State	Year	Other Herbicides*
Annual Bluegrass	*Poa annua*	CA	2013	NR
Annual Bluegrass	*Poa annua*	TN	2011	NR
Common Ragweed	*Ambrosia artemisiifolia*	AL	2013	NR
Common Ragweed	*Ambrosia artemisiifolia*	AR	2004	NR
Common Ragweed	*Ambrosia artemisiifolia*	IN	2007	NR
Common Ragweed	*Ambrosia artemisiifolia*	KS	2007	NR
Common Ragweed	*Ambrosia artemisiifolia*	KY	2006	NR
Common Ragweed	*Ambrosia artemisiifolia*	MO	2004	NR
Common Ragweed	*Ambrosia artemisiifolia*	MN	2010	Y
Common Ragweed	*Ambrosia artemisiifolia*	MS	2014	NR
Common Ragweed	*Ambrosia artemisiifolia*	NC	2015	Y
Common Ragweed	*Ambrosia artemisiifolia*	ND	2007	NR
Common Ragweed	*Ambrosia artemisiifolia*	NE	2013	NR
Common Ragweed	*Ambrosia artemisiifolia*	NJ	2013	NR
Common Ragweed	*Ambrosia artemisiifolia*	OH	2006	Y
Common Ragweed	*Ambrosia artemisiifolia*	PA	2008	NR
Common Ragweed	*Ambrosia artemisiifolia*	SD	2007	NR
Common Sunflower	*Helianthus annuus*	TX	2015	NR
Giant Ragweed	*Ambrosia trifida*	AR	2005	NR
Giant Ragweed	*Ambrosia trifida*	IA	2009	NR
Giant Ragweed	*Ambrosia trifida*	IN	2005	NR
Giant Ragweed	*Ambrosia trifida*	KS	2006	NR
Giant Ragweed	*Ambrosia trifida*	KY	2005	NR
Giant Ragweed	*Ambrosia trifida*	MN	2008	Y
Giant Ragweed	*Ambrosia trifida*	MO	2011	Y
Giant Ragweed	*Ambrosia trifida*	MS	2010	NR
Giant Ragweed	*Ambrosia trifida*	NE	2010	NR
Giant Ragweed	*Ambrosia trifida*	OH	2006	Y
Giant Ragweed	*Ambrosia trifida*	OH	2004	NR
Giant Ragweed	*Ambrosia trifida*	TN	2007	NR
Giant Ragweed	*Ambrosia trifida*	WI	2011	NR

Goosegrass	*Eleusine indica*	MS	2010	NR
Goosegrass	*Eleusine indica*	TN	2011	NR
Hairy Fleabane	*Conyza bonariensis*	CA	2009	Y
Horseweed	*Conyza canadensis*	AL	2013	NR
Horseweed	*Conyza canadensis*	AR	2003	NR
Horseweed	*Conyza canadensis*	CA	2014	Y
Horseweed	*Conyza canadensis*	DE	2010	Y
Horseweed	*Conyza canadensis*	IA	2011	NR
Horseweed	*Conyza canadensis*	IL	2005	NR
Horseweed	*Conyza canadensis*	IN	2002	NR
Horseweed	*Conyza canadensis*	KS	2005	NR
Horseweed	*Conyza canadensis*	KY	2001	NR
Horseweed	*Conyza canadensis*	MD	2002	NR
Horseweed	*Conyza canadensis*	MI	2007	NR
Horseweed	*Conyza canadensis*	MO	2002	NR
Horseweed	*Conyza canadensis*	MS	2007	Y
Horseweed	*Conyza canadensis*	MT	2015	NR
Horseweed	*Conyza canadensis*	NC	2003	NR
Horseweed	*Conyza canadensis*	NE	2006	Y
Horseweed	*Conyza canadensis*	NJ	2002	NR
Horseweed	*Conyza canadensis*	OH	2003	Y
Horseweed	*Conyza canadensis*	OK	2009	NR
Horseweed	*Conyza canadensis*	PA	2003	NR
Horseweed	*Conyza canadensis*	SD	2010	NR
Horseweed	*Conyza canadensis*	TN	2001	NR
Horseweed	*Conyza canadensis*	VA	2005	NR
Horseweed	*Conyza canadensis*	WI	2013	NR
Horseweed	*Conyza canadensis*	WV	2007	NR
Italian Ryegrass	*Lolium perenne ssp. multiflorum*	AR	2008	NR
Italian Ryegrass	*Lolium perenne ssp. multiflorum*	CA	2015	Y
Italian Ryegrass	*Lolium perenne ssp. multiflorum*	LA	2014	NR
Italian Ryegrass	*Lolium perenne ssp. multiflorum*	MS	2005	NR
Italian Ryegrass	*Lolium perenne ssp. multiflorum*	NC	2009	NR
Italian Ryegrass	*Lolium perenne ssp. multiflorum*	OR	2010	Y

Italian Ryegrass	*Lolium perenne ssp. multiflorum*	TN	2012	NR
Johnsongrass	*Sorghum halepense*	AR	2007	NR
Johnsongrass	*Sorghum halepense*	LA	2010	NR
Johnsongrass	*Sorghum halepense*	MS	2008	NR
Junglerice	*Echinochloa colona*	CA	2008	NR
Kochia	*Kochia scoparia*	CO	2012	NR
Kochia	*Kochia scoparia*	ID	2014	NR
Kochia	*Kochia scoparia*	KS	2013	Y
Kochia	*Kochia scoparia*	MT	2013	Y
Kochia	*Kochia scoparia*	ND	2012	NR
Kochia	*Kochia scoparia*	NE	2011	NR
Kochia	*Kochia scoparia*	OK	2013	NR
Kochia	*Kochia scoparia*	OR	2014	NR
Kochia	*Kochia scoparia*	SD	2009	NR
Kochia	*Kochia scoparia*	WY	2014	NR
Palmer Amaranth	*Amaranthus palmeri*	AL	2008	NR
Palmer Amaranth	*Amaranthus palmeri*	AR	2006	NR
Palmer Amaranth	*Amaranthus palmeri*	AZ	2012	Y
Palmer Amaranth	*Amaranthus palmeri*	CA	2015	NR
Palmer Amaranth	*Amaranthus palmeri*	DE	2014	Y
Palmer Amaranth	*Amaranthus palmeri*	FL	2013	Y
Palmer Amaranth	*Amaranthus palmeri*	GA	2010	Y
Palmer Amaranth	*Amaranthus palmeri*	IL	2016	Y
Palmer Amaranth	*Amaranthus palmeri*	IN	2012	NR
Palmer Amaranth	*Amaranthus palmeri*	KS	2011	NR
Palmer Amaranth	*Amaranthus palmeri*	KY	2010	NR
Palmer Amaranth	*Amaranthus palmeri*	LA	2010	NR
Palmer Amaranth	*Amaranthus palmeri*	MD	2014	Y
Palmer Amaranth	*Amaranthus palmeri*	MI	2011	NR
Palmer Amaranth	*Amaranthus palmeri*	MO	2008	NR
Palmer Amaranth	*Amaranthus palmeri*	MS	2008	Y
Palmer Amaranth	*Amaranthus palmeri*	NC	2005	NR
Palmer Amaranth	*Amaranthus palmeri*	NE	2016	Y
Palmer Amaranth	*Amaranthus palmeri*	NJ	2014	NR
Palmer Amaranth	*Amaranthus palmeri*	NM	2007	NR
Palmer Amaranth	*Amaranthus palmeri*	OH	2010	NR

Palmer Amaranth	*Amaranthus palmeri*	PA	2013	NR
Palmer Amaranth	*Amaranthus palmeri*	SC	2010	Y
Palmer Amaranth	*Amaranthus palmeri*	TN	2015	Y
Palmer Amaranth	*Amaranthus palmeri*	TX	2011	NR
Palmer Amaranth	*Amaranthus palmeri*	VA	2011	NR
Palmer Amaranth	*Amaranthus palmeri*	WI	2013	NR
Ragweed Parthenium	*Parthenium hysterophorus*	FL	2014	NR
Rigid Ryegrass	*Lolium rigidum*	CA	1998	NR
Russian-thistle	*Salsola tragus*	MT	2015	NR
Russian-thistle	*Salsola tragus*	OR	2016	NR
Spiny Amaranth	*Amaranthus spinosus*	MS	2012	NR
Tall Waterhemp	*Amaranthus tuberculatus (=A. rudis)*	AR	2015	NR
Tall Waterhemp	*Amaranthus tuberculatus (=A. rudis)*	IA	2011	Y
Tall Waterhemp	*Amaranthus tuberculatus (=A. rudis)*	IL	2009	Y
Tall Waterhemp	*Amaranthus tuberculatus (=A. rudis)*	IN	2009	NR
Tall Waterhemp	*Amaranthus tuberculatus (=A. rudis)*	LA	2015	NR
Tall Waterhemp	*Amaranthus tuberculatus (=A. rudis)*	KS	2006	NR
Tall Waterhemp	*Amaranthus tuberculatus (=A. rudis)*	KY	2010	NR
Tall Waterhemp	*Amaranthus tuberculatus (=A. rudis)*	MN	2016	Y
Tall Waterhemp	*Amaranthus tuberculatus (=A. rudis)*	MO	2009	Y
Tall Waterhemp	*Amaranthus tuberculatus (=A. rudis)*	MS	2010	NR
Tall Waterhemp	*Amaranthus tuberculatus (=A. rudis)*	ND	2010	NR
Tall Waterhemp	*Amaranthus tuberculatus (=A. rudis)*	NE	2012	NR
Tall Waterhemp	*Amaranthus tuberculatus (=A. rudis)*	OH	2008	NR
Tall Waterhemp	*Amaranthus tuberculatus (=A. rudis)*	OK	2011	NR
Tall Waterhemp	*Amaranthus tuberculatus (=A. rudis)*	SD	2010	NR
Tall Waterhemp	*Amaranthus tuberculatus (=A. rudis)*	TN	2011	NR

Tall Waterhemp	*Amaranthus tuberculatus (=A. rudis)*	TX	2006	NR
Tall Waterhemp	*Amaranthus tuberculatus (=A. rudis)*	WI	2013	NR

***Other Herbicides** – Y=Resistance to other herbicides, NR=Resistance to other herbicides not reported. Other herbicides listed at: http://weedscience.org/Summary/ResistbyActive.aspx. Heap, I. The International Survey of Herbicide Resistant Weeds. Online. Internet. Tuesday, March 21, 2017. Available at: http://weedscience.org

Appendix B: Imazamox Profile

Toxicological endpoint and environmental fate data listed in this chemical profile will be periodically reviewed and updated. New information, including, but not limited to, completion of national section 7consultation in accordance with the federal Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Stat. 884), as amended, between the U.S. Fish and Wildlife Service and the U.S. Environmental Protection Agency on individual pesticide registrations and all federally listed and proposed species and proposed and designated critical habitat, may change ecological risk assessments, pesticide use patterns, best management practices, and/or justification for use. Consultations occur now at the local level for listed and proposed species and proposed and designated critical habitat on specific use of individual pesticides in specific project areas.

Justification for Use:

Low risk herbicide for control of a wide variety of annual and perennial broadleaf and grass weeds. Predominately a broadleaf herbicide.

Specific Best Management Practices (BMPs):

- One application per year.
- Ground application only.
- Highly soluble in water, degrades slowly in soil, is persistent, and has a highly leaching potential which may contaminate groundwater. Cannot be use on sandy soil or sandy loamy soils and/or where distance to groundwater is <10 ft. (GUS = 6.76 = very high potential for movement to groundwater).

Endangered Species Compliance:

- Before use a section 7 ESA consultation must be completed, including an ecotoxicological analysis. Additional best management practices, conservation recommendations, or terms and conditions for use near listed species may be required based on site-specific consultation.

Known Resistance:

As of May 2017, the following plant(s) in the United States have been reported as resistant to imazamox. For the most current status, please go to: http://weedscience.org/Summary/ResistbyActive.aspx

Common Name	Species	State	Year	Other Herbicides*
Smooth Pigweed	*Amaranthus hybridus (syn: quitensis)*	MI	2002	Y
Redroot Pigweed	*Amaranthus retroflexus*	PA	1998	Y
Tall Waterhemp	*Amaranthus tuberculatus (=A. rudis)*	IL	2002	Y
Tall Waterhemp	*Amaranthus tuberculatus (=A. rudis)*	MO	2005	Y
Common Ragweed	*Ambrosia artemisiifolia*	MI	1998	Y
Common Ragweed	*Ambrosia artemisiifolia*	OH	1998	Y
Common Ragweed	*Ambrosia artemisiifolia*	DE	2005	Y
Giant Ragweed	*Ambrosia trifida*	OH	1998	Y
Giant Ragweed	*Ambrosia trifida*	WI	2013	Y
Japanese Brome	*Bromus japonicus*	KS	2007	Y
Cheat (Rye Brome)	*Bromus secalinus*	KS	2007	Y
Cheat (Rye Brome)	*Bromus secalinus*	OK	2009	Y
Downy Brome (Cheatgrass)	*Bromus tectorum*	OR	1997	Y

Downy Brome (Cheatgrass)	*Bromus tectorum*	MT	2016	Y
Common Lambsquarters	*Chenopodium album*	MI	2001	Y
Rice Flatsedge	*Cyperus iria*	AR	2010	Y
Flixweed	*Descurainia sophia*	KS	2006	Y
Barnyardgrass	*Echinochloa crus-galli var. crus-galli*	MS	2011	Y
Bushy Wallflower	*Erysimum repandum*	KS	2005	Y
Marshelder	*Iva xanthifolia*	ND	2003	Y
Kochia	*Kochia scoparia*	MI	2005	Y
Italian Ryegrass	*Lolium perenne ssp. multiflorum*	AR	2003	Y
Italian Ryegrass	*Lolium perenne ssp. multiflorum*	NC	2007	Y
Red Rice	*Oryza sativa var. sylvatica*	AR	2002	Y
Giant Foxtail	*Setaria faberi*	PA	2004	Y
Green Foxtail	*Setaria viridis*	WI	1999	NR
Eastern Black Nightshade	*Solanum ptycanthum*	WI	1999	Y
Eastern Black Nightshade	*Solanum ptycanthum*	ND	1999	Y
Eastern Black Nightshade	*Solanum ptycanthum*	IL	1999	Y
Spiny Sowthistle	*Sonchus asper*	WA	2000	Y
Shattercane	*Sorghum bicolor*	PA	2001	Y

***Other Herbicides** – Y=Resistance to other herbicides, NR=Resistance to other herbicides not reported. Other herbicides listed at: http://weedscience.org/Summary/ResistbyActive.aspx. Heap, I. The International Survey of Herbicide Resistant Weeds. Online. Internet. Tuesday, March 21, 2017. Available at: http://weedscience.org

Date:	7/25/17				
Pesticide Class:	Imidazolinone	**Common Chemical Name(s):**	Imazamox	**Pesticide Type:**	Herbicide
Trade Name(s):	Beyond, Clearcast, Raptor	**EPA Registration Number:**	241-441, 241-437, 241-379	**CAS Number:**	247057-22-3, 247057-22-3, 247057-22-3
Other Ingredients:	**Beyond (ammonium salt of Imazamox):** 12.1% IZM, 87.9% proprietary ingredients (1a); **Clearcast:** 12.1% IZM, 87.9% proprietary ingredients (1b); **Raptor:** 12.1% IZM, 87.9% proprietary ingredients (1c)				

Toxicological Endpoints

Mammalian LD_{50}:	**IZM (%AI Unk):** *Rat*: Single oral dos: females = 2,121 mg/kg bw, males = 2,313 mg/kg bw (2). **IZM (97.1-98.2% AI):** *Rat*: Single dose, 14-d observation period: > 5,000 mg ai/kg bw (highest dose tested) (3,8); 90-d feeding study: NOEL = 20,000 ppm (1,661 mg/kg bw/day) (3,8), (LOEL) = not established (3).

	Dog: 13-week feeding study NOAEL > 40,000 ppm (males = 1,300 mg/kg bw/day, females = 1,400 mg/kg bw/day) (3,9). *Mouse*: 18-mo feeding study NOAEL = 7,000 ppm (males = 1,053 mg/kg bw/day, females = 1,348 mg/kg bw/day), (LOEL) = not established (3,9). **IZM (11.83% AI):** *Rat*: acute oral, age unk > 5,000 mg/kg bw (1a,b,c,3,7,9).
Mammalian LC_{50}:	**IZM:** No information in references (see LD50 data).
Mammalian Reproduction:	**IZM (97.1-98.2AI):** *Rabbit*: Reproductive study, time unk: maternal NOAEL = 300 mg/kg bw/day, LOEL = 600 mg/kg bw/day; developmental NOAEL = 900 mg/kg bw/day (3,8,9). *Rat*: 2-generation reproductive study NOEL > 20,000 ppm (females = 1,705 mg/kg bw, males = 1,469 mg/kg bw), highest dose tested, LOEL = not observed (2,3,8,9); Reproductive study, time unk: Maternal NOAEL = 500 mg/kg bw/day, LOEL = 1,000 mg/kg bw/day (9); Developmental NOAEL = 1,000 mg/kg bw/day, LOEL = not achieved (3,9).
Avian LD_{50}:	**IZM (98.2% AI):** *Bobwhite*: Single dose, 14-d observation period, 20 weeks old > 1,846 mg/kg bw (2,3,4,6,7,8), (14-d NOEL) = 1,846 mg/kg bw (3,4,6). *Mallard*: Single dose, 14-d observation period, 20 weeks old > 1,950 mg/kg bw (2,3,4,6,8,9), (14-d NOEL) = 1,950 mg/kg bw (4,6).
Avian LC_{50}:	**IZM (97.1% AI):** *Bobwhite*: 5-d, 10 d old > 5,572 ppm (2,3,4,6,7,8,9), 5-d NOEL = 5,572 ppm (3,4,6). *Mallard*: 5-d, 10 d old > 5,572 ppm (1a,b,c,2,3,4,6,8,9), 5-d NOEL = 5,572 ppm (3,4,6).
Avian Reproduction:	**IZM (97.1% AI):** *Bobwhite*: 10 week reproductive study, 24 weeks old LOEL > 2,000 ppm (2,3,6,9), NOEL = 2,000 ppm (3,6). *Mallard*: 10 week reproductive study, 18 weeks old LOEL > 2,000 ppm (2,3,6,9), NOEL = 2,000 ppm (3,6).
Fish LC_{50}:	**IZM (%AI Unk):** *Rainbow Trout*: 28-d NOEL, age unk = 122 ppm (3,8), 96-day NOEL, age unk = 11.8 ppm (3,8), 21-d NOEL, age unk > 122 ppm (7).
Fish ELS/ Life Cycle:	**IZM (97.1% AI):** *Bluegill*: 96-h LC50, av. wt. 0.33 g > 119 ppm (2,3,4,5,6,8,9), 96-h NOEL = 119 ppm (3,6). *Rainbow Trout*: 96-h LC50, av. wt. 0.64 g > 122 ppm (1a,b,c,2,3,4,5,6,7,8,9), 96-h NOEL = 122 ppm (3,6). *Sheepshead Minnow*: 96-h LC50, av. wt. 0.28 g > 94.2 ppm (2,3,6), 96-h NOEL = 94.2 ppm (3,6).
Amphibians/ Reptiles:	**IZM:** No information in references.
Invertebrates/ Plants:	**IZM (%AI Unk):** *Daphnia magna*: (21-d NOE) = 137 ppm (3,7,8). *Duckweed*: 7-d EC50, biomass = 0.011 ppm (7). *Earthworm*: 14-d LC50 > 901 mg/kg dry soil (7,8). *Green Algae*: 5-d EC50, biomass > 0.144 ppm (4,5); 5-d EC50, growth > 0.04 ppm (3). *Honey Bee*: 48-h LD50, ora) > 40 µg/bee (7,8), 48-h LD50, contact > 58 µg/bee (8), 72-h LD50, contact > 25 µg/bee (8).

	(97.1-98.2% AI): *Daphnia magna*: 48-h EC50, < 24 h old > 122 ppm (1a,b,c,2,3,4,5,6,7,8,9), 48-h NOEL = 122 ppm (3,6). *Dicot* (most sensitive species is tomato) 21-d study, EC25s: Seedling emergence = 0.0041 lbs ai/acre, NOEL = 0.0015 lbs ai/acre; Vegetative vigor = 0.001 lbs ai/acre, NOEL = 0.00075 lbs ai/acre (2,3). *Duckweed*: 14-d EC50, growth = 0.011 ppm (2,3,4,5,6), 14-d NOEL = 0.0045 ppm (2,3,6). *Green Algae*: Single dose, 5-d observation period (EC50) > 0.037 ppm (1a,b,c,2,6,7,8), (5-d NOEL) < 0.037 ppm (6); *Honey Bee*: 48-h LD50, adult, contac) > 24-25 µg/bee (2,4,6,9), 48-h NOEL = 24 µg/bee (4,6). *Monocot* (most sensitive species is oat) 21-d study, EC25s: Seedling emergence = 0.0026 lbs ai/acre, NOEL = 0.0015 lbs ai/acre; Vegetative vigor = 0.0016 lbs ai/acre, NOEL = 0.0015 lbs ai/acre (2,3). *Mysid Shrimp*: 96-h LC50 > 100 ppm (2,6), 96-h NOEL = 94.3 ppm (3,6).
Other:	**IZM:** Neurotoxic: Negative (3,7,8); Carcinogenic: Negative (3,7,8); Teratogenic: Negative (7); Mutagenic: Negative (1a,b,c,3); Genotoxic: Negative (1a,b,c,8); Endocrine disruption: Negative (3)

Imazamox [IZM]: Dissolution product of ammonium salt of imazamo and the herbicidal active ingredient; **NOTE:** No toxicological or fate data are available for ammonium salt of imazamox.

Ecological Incident Reports

No reports in references.

Environmental Fate

Water solubility (S_w):	**IZM:** = 4,413 mg/L (2,3,9); @ 20°C = 4,160 mg/L (3), = 4,410 mg/L (3); @ 20°C = 626,000 mg/L (3,7); @ pH 5, 25°C = 116,000 mg/L (8), @ pH 7 & 9, 25°C > 626,000 mg/L (8).
Soil Mobility (K_{oc}):	**IZM:** loamy sand, AR = 17.2 mL/g (3), clay loam, AR = 144.1 mL/g (3), silt loam, IN = 136.2 mL/g (3), silt loam, NJ = 35.3 mL/g (3), silty clay loam, ND = 5 mL/g (3), loam, WI = 17.5 mL/g (2,3); Av. = 67 d (range 2 – 374) (8).
Soil Persistence ($t_{½}$):	**IZM:** *Aerobic metabolism*: sandy loam = 27 d (2); = 30 d (3). *Anaerobic metabolism*: = Stable (3,8). *Photolysis*: = 65 d (2).
Soil Dissipation (DT_{50}):	**IZM:** *Mechansim not specified*: Av. = 25.9 d (range 21.1 to 34.7) (3), = 15 to 130 d (3). *Aerobic degradation*: typical = 25 d (7), lab at 20°C = 70 d (7), field = 17 d (7); sandy loam, pH 6.8, 20°C, 1.5% organic carbon = 45 d (8), sandy loam, 20°C, pH Unk, 1.7% organic carbon in lab = 40 d (8), silt loam, 20°C, pH 5.8, 0.8% organic carbon in lab = 207 d (8), silt loam, 20°C, pH 6.5, 0.8% organic carbon in lab = 44 d (8), silty clay loam, 20°C, pH 8.1, 1.1% organic carbon in lab = 12 d (8), silt loam, 10°C, pH 6.5, 0.8% organic carbon, aerobic in lab = 113 d (8), silty clay loam, 10°C, pH 8.1, 0.8% organic carbon, aerobic in lab = 42 d (8), 20°C, anaerobic in lab = Stable (8); Field, autumn testing Av. = 13.3 d (range 6.2 – 7.1) at pHs 7.5 – 8.7 (8), Field, spring testing Av. = 16.5 d (range 4.5 – 41) at pHs 6.0 – 8.1 (8), Field, autumn testing Av. = 14.9 d (range 8 – 23.7) at pHs 7.2 – 8.2 (8), Field, spring testing Av. = 12.1 d (range 12 – 12.2) at pHs 5.7 – 8.0 (8).
Aquatic Persistence ($t_{½}$):	**IZM:** *Anaerobic metabolism*: in laboratory, extrapolated = 761 d (2,3), = Stable (3). *Hydrolysis*: = Stable at pHs 5, 7 & 9 (2,3,8,9). *Photolysis*: @ pH 5, 7 & 9 = 6.8 hrs (2,3,9).

Aquatic Dissipation (DT_{50}):	**IZM:** *Hydrolysis*: @ pHs 4 - 9, 20°C) = Stable (7); Water-sediment = 142 d (7), water only = 38 d (7); @ pH 4 & 7= stable (8), @ pH 9, 25°C = 192 d (8), @ pH 5 = 6.8 hrs (8), @ pH 9 = 7.1 hrs (8). *Photolysis*: @ pH 7 = 6.7 hrs (3,8); pH 7 = 0.3 d (7); estimated to be 6.4 d in winter and 2 d in summer (8); water-sediment study: water only = 61 d, whole system = 129 to 154 d (8).
Potential to Move to Groundwater (GUS score):	**IZM:** = 6.76 (7)
Vapor Pressure (mm Hg):	**IZM:** (25°C) = 9.97 x 10^{-8} (2,3,7,8), Not significant (9)
Octanol-Water Partition Coefficient (K_{ow}):	**IZM:** = 5.4 (2), (pH 7, 20°C) = 2.29 x 10^{5} (7), (pH 5 & 6, 25°C) = 5.36 (3,8,9)
Bioaccumulation/ Biocentration:	**IZM:** **BAF:** No significant accumulation in bluegill (2); No evidence of accumulation (8). **BCF:** Concentrations in whole fish and edible tissue were below the minimal quantifiable limit, Inedible tissue < 1x (2,3), = 0.13 mg/kg on day 14, = 0.11 mg/kg on day 21, = 0.14 mg/kg on day 28 (3), = 0.1x (7).

Worst Case Ecological Risk Assessment

Max Application Rate (ai lbs/acre – ae basis)	**Habitat Management:** 0.5 lb. a.e./acre **Croplands/Facilities Maintenance:** 0.047 lb. a.e./acre
EECs	**Terrestrial (Habitat Management):** 120 ppm **Terrestrial (Croplands/Facilities Maintenance):** 11.3 ppm **Aquatic (Habitat Management):** 0.1873 ppm **Aquatic (Croplands/Facilities Maintenance):** 0.0000775 ppm

Habitat Management Treatments:

Presumption of Unacceptable Risk		**Risk Quotient (RQ)**	
		Listed (T&E) Species	**Nonlisted Species**
Acute	Birds	=0.02 [0.1]	=0.02 [0.5]
	Mammals	=0.01 [0.1]	=0.01 [0.5]
	Fish	<0.01 [0.05]	<0.01 [0.5]
Chronic	Birds	=0.06 [1]	=0.06 [1]
	Mammals	=0.02 [1]	=0.02 [1]
	Fish	<0.01 [1]	<0.01 [1]

Cropland/Facilities Maintenance Treatments:

Presumption of Unacceptable Risk		**Risk Quotient (RQ)**	
		Listed (T&E) Species	**Nonlisted Species**
Acute	Birds	<0.01 [0.1]	<0.01 [0.5]
	Mammals	<0.01 [0.1]	<0.01 [0.5]
	Fish	<0.01 [0.05]	<0.01 [0.5]
Chronic	Birds	=0.01 [1]	=0.01 [1]
	Mammals	<0.01 [1]	<0.01 [1]
	Fish	<0.01 [1]	<0.01 [1]

References:

[1a] _____. 2011 & 2009, respectively. Beyond label and SDS, BASF Corporation. Florham Park, NJ. 23 & 8 pp., respectively.

[1b] _____. 2009 & 2008, respectively. Clearcast label and SDS. BASF Corporation. Florham Park, NJ. 12 & 8 pp., respectively.

[1c] _____. 2009. Raptor label and SDS. BASF Corporation. Florham Park, NJ. 24 & 8 pp., respectively.

[2] Abdel-Saheb, I. *et al*. 2008. Memo: Ecological risk assessment evaluating Imazamox (PC 129171) for the proposed new use for the control of vegetation in and around aquatic and noncropland sites. Office of Prevention, Pesticides, and Toxic Substances. Washington D.C. 87 pp.

[3] Durkin, PR. 2010. Imazamox: Human Health and Ecological Risk Assessment – Final Report. Prepared for the USDA Forest Service by Syracuse Environmental Research Associates, Inc (Forest Service Contract#: AG-3187-C-06-0010). 169 pp.

[4] US Environmental Protection Agency. Office of Pesticide Program's Pesticide Ecotoxicity Database: http://www.ipmcenters.org/ecotox/DataAccess.cfm; Last accessed 21 April 2012.

[5] _____. 2011. Kegley, S.E., B.R. Hill, S. Orme, and A.H. Choi. PAN Pesticide Database. Pesticide Action Network. San Francisco, CA. Last Accessed 21 April 2012.

[6] US Environmental Protection Agency. Office of Pesticide Program's Pesticide Ecotoxicity Database: http://www.ipmcenters.org/ecotox/DataAccess.cfm; Last accessed 21 April 2012.

[7] _____. 2009. Pesticide properties database. Agricultural & Environmental Research Unit. Science and Technology Research Institute. University of Hertfordshire. Hatfield, UK. Last accessed 17 May 2012.

[8] European Commission. 2002. Review report for the active substance imazamox. Health and Consumer Protection Directorate-General, Directorate E – Food Safety. Available at: http://ec.europa.eu/food/plant/protection/evaluation/newactive/imazamox.pdf, Last accessed: 30 July 2012.

[9] USEPA. 1997. Pesticide Fact Sheet: Imazamox (Raptor Herbicide). Office of Prevention, Pesticides, and Toxic Substances. Washington D.C. 6 pp.

Table CP.1 Pesticide Name
Active Ingredient = Imazamox

Trade Name[a]	Treatment Type[b,c]	Max Product Rate – Single Application (lbs/acre or gal/acre)	Max Product Rate - Single Application (lbs/acre - AI on acid equiv basis)	Max Number of Applications Per Season	Max Product Rate Per Season (lbs/acre/season or gal/acre/season)	Minimum Time Between Applications (Days)
Beyond	H	0.5 gal/acre	0.5 lb. a.e./acre	1	0.5 gal/acre	0
Beyond	CF	0.047 gal/acre	0.047 lb. a.e./acre	1	0.047 gal/acre	0
Clearcast	H	0.5 gal/acre	0.5 lb. a.e./acre	1	0.5 gal/acre	0
Clearcast	CF	0.047 gal/acre	0.047 lb. a.e./acre	1	0.047 gal/acre	0
Raptor	H	0.5 gal/acre	0.5 lb. a.e./acre	1	0.5 gal/acre	0
Raptor	CF	0.047 gal/acre	0.047 lb. a.e./acre	1	0.047 gal/acre	0

[a]From each label for a pesticide identified in pesticide use proposals (PUPs), Service personnel would record application information associated with possible/known uses on Service lands.
[b]Treatment type: H – habitat management or CF – cropland/facilities maintenance. If a pesticide is labeled for both types of treatments (uses), then record separate data for H and CF applications.
[c]Treatment type is for ecological risk assessment purposes only. The product label will determine whether or not the treatment type is permissible under Section 3 of the Federal Insecticide, Fungicide and Rodenticide Act.

Appendix C: Imazapyr Chemical Profile

Toxicological endpoint and environmental fate data listed in this chemical profile will be periodically reviewed and updated. New information, including, but not limited to, completion of national section 7consultation in accordance with the federal Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Stat. 884), as amended, between the U.S. Fish and Wildlife Service and the U.S. Environmental Protection Agency on individual pesticide registrations and all federally listed and proposed species and proposed and designated critical habitat, may change ecological risk assessments, pesticide use patterns, best management practices, and/or justification for use. Consultations occur now at the local level for listed and proposed species and proposed and designated critical habitat on specific use of individual pesticides in specific project areas.

Justification for Use:

Reduced risk herbicide active ingredient that may be used in upland, riparian and aquatic habitats.

Specific Best Management Practices (BMPs):

- Apply only aquatic labeled imazapyr formulations to aquatic and riparian habitats or habitats within 25 feet of surface water resources. Limit application rate = 1.0 a.i./ac.
- Tank mix aquatic imazapyr formulations with surfactants classified as practically non-toxic or slight acute toxicity to aquatic organisms (>10 ppm). Surfactants include, but not necessarily limited to: LI-700, AgriDex, Activate Plus, Big Sur 90, Sil Energy, Dyne-Amic, Freeway, Sun-Wet, Hasten Modified Vegetable Oil, Kinetic or Class Act Next Generation.
- Maximum application rate = 1.0 lb. a.i./acre for aquatic and riparian treatment sites within 25 feet of surface water resources.

Combination products used on Service lands: U**se the more restrictive BMPs**.
Groundclear Vegetation Killer Concentrate, OneStep = Glyphosate + Imazapyr
Imazuron, Mohave 70EG, Sahara DG = Imazapyr + Diuron
Lightning = Imazapyr + Imazethapyr
Lineage Clearstand = Imazapyr + Metsulfuron-methyl
Viewpoint = Imazapyr + Aminocyclopyrachlor + Metsulfuron-methyl

Endangered Species Compliance:

- Before use a section 7 ESA consultation must be completed, including an ecotoxicological analysis. Additional best management practices, conservation recommendations, or terms and conditions for use near listed species may be required based on site-specific consultation. Some products are phytotoxic at extremely low concentrations.

Known Resistance:

As of May 2017, the following plant(s) in the United States have been reported as resistant to imazpyr. For the most current status, please go to: http://weedscience.org/Summary/ResistbyActive.aspx

Common Name	Species	State	Year	Other Herbicides
Common Cocklebur	*Xanthium strumarium*	NC	1999	Y
Common Ragweed	*Ambrosia artemisiifolia*	DE	2005	Y
Common Ragweed	*Ambrosia artemisiifolia*	MN	2010	Y
Red Rice	*Oryza sativa var. sylvatica*	AR	2002	Y
Shattercane	*Sorghum bicolor*	VA	2003	Y
Tall Waterhemp	*Amaranthus tuberculatus* (= *A. rudis*)	MN	2007	Y

***Other Herbicides** – Y=Resistance to other herbicides, NR=Resistance to other herbicides not reported. Other herbicides listed at: http://weedscience.org/Summary/ResistbyActive.aspx. Heap, I. The International Survey of Herbicide Resistant Weeds. Online. Internet. Tuesday, March 21, 2017. Available at: http://weedscience.org

Date:	7/26/17				
Pesticide Class:	Imidazolinone	**Common Chemical Name(s):**	Imazapyr	**Pesticide Type:**	Herbicide Group 9
Trade Name(s):	AquaPier, Arsenal, Arsenal AC, Arsenal Powerline, Chopper, Chopper Gen2, Ecomazapyr 2 SL (Alligare), EZ-JECT Copperhead, Habitat, Imazapyr 2 SL, Imazapyr 4 SL, Imazapyr E Pro 2, Polaris, Polaris AC, Polaris AC Complete, Polaris AQ, Polaris SP, Rotary 2 SL, Stalker	**EPA Registration Number:**	74477-6, 241-346, 241-299, 241-431, 241-296, 241-430, 81927-22, 83220-2, 241-426, 81927-23, 81927-24, 81959-8, 228-534, 228-480, 228-570, 241-426, 228-536, 81927-6, 241-398	**CAS Number:**	81510-83-0, 81510-83-0, 81510-83-0, 81510-83-0, 81510-83-0, 81510-83-0, 81510-83-0, 81510-83-0, 81510-83-0, 81510-83-0, 81510-83-0, 81510-83-0, 81510-83-0, 81510-83-0, 81510-83-0, 81510-83-0, 81510-83-0, 81510-83-0
Other Ingredients:	**AquaPier (isopropylamine [IPA]) salt of imazapyr):** 27.8% IPA, 72.2% propriety ingredients (1a); **Arsenal:** 28.7% IPA, 71.3% propriety ingredients (1b); **Arsenal AC:** 53.1% IPA, 46.9% proprietary ingredients (1c); **Arsenal Powerline:** 26.7% IPA, 73.3% proprietary ingredients (1d); **Chopper:** 27.6% IPA, 72.4% proprietary ingredients (1e); **Chopper Gen2:** 26.7% IPA, 73.3% proprietary ingredients (1f); **Ecomazapyr 2 SL (Alligare):** 27.8% IPA, 72.2% proprietary ingredients (1g); **EZ-JECT Copperhead Herbicide Shells:** 83.5% IPA, 16.5% proprietary ingredients (1h); **Habitat:** 28.7% IPA, 71.3% proprietary ingredients (1i); **Imazapyr 2 SL:** 27.8% IPA, 72.2% proprietary ingredients (1j); **Imazapyr 4 SL:** 52.6% IPA, 47.4% proprietary ingredients (1k); **Imazapyr E Pro 2:** 28.7% IPA, 71.3% proprietary ingredients (1l); **Polaris:** 27.7% IPA, 72.3% proprietary ingredients (1m); **Polaris AC:** 53.1% IPA, 46.9% proprietary ingredients (1n); **Polaris AC Complete:** 53.1% IPA, 46.9% proprietary ingredients (1o); **Polaris AQ:** 28.7% IPA, 71.3% proprietary ingredients (1p); **Polaris SP:** 27.6% IPA, 72.4% proprietary ingredients (1q); **Rotary 2 SL:** 27.8% IPA, 72.2% proprietary ingredients (1r); **Stalker:** 27.6% IPA, 72.4% proprietary ingredients (1s).				

Toxicological Endpoints

Endpoints highlighted yellow are selected for use in a screening-level ecological risk assessment. Endpoints selected are typically the most toxic endpoint for the most sensitive species listed in following summaries.

Mammalian LD_{50}:	**Acid:** No information in references. **IPA (<u>Arsenal</u>):** *Rat*: Single dose, 14-d observation period > 5,000 ppm (1a-b,d,f-j,3,8). **IPA (99.5% AI):** *Dog*: 1-year NOEL = 10,000 ppm (3). **IPA (26.7% AI):** *Rat*: > 2,000 mg/kg (1c).

Mammalian LC_{50}:	**Acid:** No information in references. **IPA:** No information in references.
Mammalian Reproduction:	**Acid (99.5% AI):** *Rat*: Reproductive: NOAEL, males = 738 mg/kg bw/day, NOAEL, females = 933.3 mg/kg bw/day (9). **Acid (93.0% AI):** *Rat*: Developmental: NOAEL = 300 mg/kg bw/day, LOAEL = 1,000 mg/kg bw/day (9). **IPA: (Arsenal):** *Rat*: Reproductive Study NOEL: = 300 mg/kg/day (10); 2 generation study NOEL = 738 mg/kg/day (10). *Rabbit*: Reproductive Study NOEL: = 400 mg/kg/day (10).
Avian LD_{50}:	**Acid (93.0+% AI):** *Bobwhite*: 21-d, 28-32 week old > 2,150 ppm (1h,i,3,4,6,8,9). *Mallard*: 21-d, 24-28 week old > 2,150 ppm (1h,i,3,4,6,7,8,9). **IPA:** No information in references.
Avian LC_{50}:	**Acid: (93.0% AI):** *Bobwhite*: 5-d, 16-d old > 5,000 ppm (3,4,6,10). *Mallard*: 5-d, 11-d old > 5,000 ppm (3,4,6,10). **Acid (49.7% AI):** *Bobwhite*: 5-d, 15-d old > 5,000 ppm (4,6), 5-d NOEL = 5,000 ppm (6). **IPA (22.6% AI):** *Mallard*: 5-d, 5 d old > 5,000 ppm, 5-d NOEL = 1,250 ppm (6). **IPA (49.7% AI, Arsenal AC):** *Bobwhite*: 5-d, 15 d old > 5,000 ppm (1b,4,6), 5-d NOEL = 5,000 ppm (6). **IPA (22.6% AI, Arsenal):** *Mallard*: 21-d, 27 week old > 2,150 ppm, 21-d NOEL = 2,150 ppm (6).
Avian Reproduction:	**Acid (99.0+% AI):** *Bobwhite*: 21-week reproductive study LOEL > 1,670 ppm, NOEL = 1,670 ppm (6,9); 18-week reproductive study NOEL < 2,000 ppm, NOEL = 2,000 ppm (3,6,9); 18-week reproductive study LD50 > 1,890 mg/kg, NOEL = 1,890 mg/kg (10). *Mallard*: 18-week reproductive study LD50 > 1,890 ppm, NOEL = 1,890 ppm (6,9,10). **IPA:** No information in reference.
Fish LC_{50}:	**Acid:** See Fish ELS/Life Cycle data. **IPA:** See Fish ELS/Life Cycle data.
Fish ELS/ Life Cycle:	**Acid (93.0+% AI):** *Atlantic Silverside*: 96-h LC50, juvenile > 184 ppm (3,4,5,6,10), NOEL = 184 ppm (6). *Bluegill*: 96-h LC50, av. wt. 0.18 g > 100 ppm (1h,i,3,4,5,6,9,10), NOEL = 100 ppm (6). *Channel Catfish*: 96-h LC50, av. wt. 1.3 g > 100 ppm (3,4,5,6,9,10), NOEL = 100 ppm (6). *Fathead Minnow*: 8-month, life cycle LOEC > 120 ppm, NOEC = 120 ppm (3,6,9);

	32-d LOEC, early life > 118 ppm, NOEC = 118 ppm (3,6,9). *Rainbow Trout*: 96-h LC50, av. wt. 0.48 g > 100 ppm (1a-c,f-i,4,5,6,7,9,10), 96-h NOEL = 100 ppm (6); 28-d early life stage LOEC= 92.4 ppm, NOEC = 43.1 ppm (3,6,9). **Acid (49.7% AI):** *Bluegill*: 96-h LC50, av. wt. 0.32 g > 100 ppm (4,6), NOEL = 100 ppm (6). **Acid (21.5% AI):** *Rainbow Trout*: 96-h LC50, av. wt. 3.8 g > 110 ppm (3,6), NOEL = 110 ppm (6). **IPA (49.7-53.1% AI, Arsenal AC):** *Bluegill*: 96-h LC50, av. wt. 0.32 g > 1,000 ppm (3,4,5,6), NOEL = 1,000 ppm (6). *Rainbow Trout*: 96-h LC50, av. wt. 0.36) = 43,947 ppm (11). **IPA (30.8% AI):** *Bluegill*: 96-h, av. wt. 1.1 g. = 24 ppm (4,6); 96-h, av. wt 0.76 g = 75 ppm (4,6). *Rainbow Trout*: 96-h, av. wt. 1.5 g = 6.7 ppm (4,5,6). **IPA (28.6% AI, Arsenal):** *Rainbow Trout*: 96-h LC50, av. wt. 0.21 g = 77,716 ppm (11). **IPA (22.6% AI):** *Rainbow Trout*: 96-h LC50, av. wt. 0.81 g = 112 ppm, NOEL = 56 ppm (6,9).
Amphibians/ Reptiles:	**Acid (Tech.):** *Bullfrog*: 96-h LC50, tadpoles = 799.6 ppm (12). **IPA (27.6% AI, Stalker):** *Bullfrog*: 96-h LC50, tadpoles = 14.7 ppm (12). **IPA (28.7% AI, Habitat):** *Bullfrog*: 96-h LC50, tadpoles = 1,739 ppm (12). Note: Previous research has demonstrated that bullfrog tadpoles and other ranid species are similar in sensitivity to pesticides (12).
Invertebrates/ Plants:	**Acid (Tech.):** *Honey Bee*: 96-h LD50 > 100 µg/bee (1a-c,f-i,3,6). **Acid (93.0+% AI):** *Daphnia magna*: 48-h EC50, immobility > 100 ppm (1a,c,f-i,3,4,5,6,7,9); 21-d LOEL => 97.1 ppm (3,6,9,10). *Duckweed*: 14-d, growth EC25 = 0.013 ppm (3); EC50 = 0.024 ppm (3,4,5,6,7,9); 14-d NOEL = 0.01 ppm (6,9). *Eastern Oyster*: 96-h EC50, spat > 132 ppm, NOEL = 132 ppm (6,10); 96-h EC50, 40 mm > 173 ppm (3,4,5,6), NOEL = 109 ppm (6). *Green Algae*: 7-d EC50, growth = 71 ppm (1c,f,h,4,5,6,7,9), NOEL = 50.9 ppm (6,9). *Pink Shrimp*: 96-h LC50, wt. 0.3 – 1 g > 189 ppm (4,5,6,10), NOEL = 189 ppm (6,10). **IPA (49.7% AI, Arsenal AC):** *Daphnia magna*: 48-h EC50, immobility, < 24 h old = 750 ppm (1b,4,5,6), NOEL = 560 ppm (6). **IPA (30.8% AI):**

	Daphnia magna: 48-h EC50, immobility, < 24 old = 6.6 ppm (4,5,6). **IPA (23.3-22.6% AI):** *Daphnia magna*: 48-h EC50, immobility, < 24 h old = 350 ppm (3,6), NOEL = 180 ppm (6). *Duckweed*: 14-d EC50, growth = 21.5 ppm, NOEL = 13.0 ppm (6). *Green Algae*: 120-h EC50, growth = 14.1 ppm, NOEL = 8.75 ppm (6).
Other:	**Acid:** Neurotoxic: Negative (2,7); Carcinogenic: Unlikely (2,5); Teratogenic: Negative (1b-c,f-j,2,7); Mutagenic: Negative (1b-c,f-j,8); Genotoxic: Negative (1b-c,f-j,8); Endocrine disruption: Negative (2). **IPA:** Neurotoxic: Negative (2); Carcinogenic: Unlikely (2,5); Teratogenic: Negative (2); Mutagenic: Negative (8); Genotoxic: Negative (8); Endocrine disruption: Negative (2).

Imazapyr Acid: 1st- order degradate of imazapyr salts (2)

Ecological Incident Reports

As of 2004, 12 incidents - Four incidents involved aquatic resources including fish kills. One report agricultural runoff to a pond resulting in a possible fish kill from imazapyr, but could not definitively determine mortalities were directly related to imazapyr exposure. Two other reports involved a mixture of herbicides, one of which was imazapyr. Because a mixture was involved it could not be definitively determined the mortalities were due to imazapyr exposure. A fourth report involved a goldfish kill from suspected runoff following aerial application of imazapyr, but could not be definitively determined (2,9).

Environmental Fate

Water solubility (S_w):	**Acid:** =11,000 mg/L (3), = 13,100 mg/L (at 25ºC) (3), = 110,000 to 150,000 mg/L (3), = 9,740 mg/L (20ºC) (7), = 11,272 ppm (8). **IPA:** = 6,500,000 mg/L (3).
Soil Mobility (K_{oc}):	**Acid:** (sand sediment, Florida) = 31 mL/g (9), (silt loam, Missouri) = 100 mL/g (9), (loamy sand) = 15 mL/g (9), (silt loam) = 82 mL/g (9), (sandy loam) = 8.2 mL/g (9), (loam) = 17 mL/g (9), (pond sediment) = 150 mL/g (9), (sandy loam, Princeton) = 110 mL/g (9), (loamy sand, Delaware) = 100 mL/g (9), (clay loam, North Dakota) = 18 mL/g (9), (silt loam, Wisconsin) = 52 mL/g (9). **IPA:** = 100 mL/g (3), = 46 mL/g (3), = 30.6 mL/g (sand) (3,9), = 99.8 mL/g (silt loam) (3,9), (sand sediment, Florida) = 31 mL/g (9), (silt loam, Missouri) = 100 mL/g (9), (loamy sand) = 15 mL/g (9), (silt loam) = 82 mL/g (9), (sandy loam) = 8.2 mL/g (9), (loam) = 17 mL/g (9), (pond sediment) = 150 mL/g (9), (sandy loam, Princeton) = 110 mL/g (9), (loamy sand, Delaware) = 100 mL/g (9), (clay loam, North Dakota) = 18 mL/g (9), (silt loam, Wisconsin) = 52 mL/g (9).
Soil Persistence ($t_{½}$):	**Acid:** = 25 to 141 d (8). *Aerobic degradation*: Loamy sand = stable (9), Loamy sand = approx. 5.9 years, > 296 d (9). *Anaerobic degradation*: Loamy sand = stable, > 60 d (9). **IPA:** *Aerobic degradation*: = 210 d (3), = 5.9 yrs (3), = 313 d (3), Loamy sand = stable

	(9), Loamy sand = approx. 5.9 years, > 296 d (9). *Anaerobic degradation*: Loamy sand = stable, > 60 d (9). *Photolysis*: At soil surface= 149 d (3,9); Degraded primarily by microbial metabolism, little to no photodegradation in soil and not readily by other chemical processes (8), = 1 to 7 months (dependent on soil type, temperature, and moisture) (8), half-life shorter at cooler temperatures and in sandier (versus clay loam) soils (8), up to 50 months in loam and clay loam soils with pH 7-8 (8), At above pH 5, does not bind strongly with soil particles and can remain available in the environment (8).
Soil Dissipation (DT_{50}):	**Acid:** Aerobic degradation: Typical = 11 d (7), (lab) = 11 d (20ºC) (7); Bare ground, silt loam, Hillsboro, OR = 143 d (9), bare ground/sandy loam soil, North Carolina) = 64 d (9). **IPA:** = 90 d (3), = 138 d (3), = 30 d (3), = 34 to 65 d (3), = 70 to 155 d (3), = 150 d (Oregon) (3), = 180 d (North Carolina) (3), = 94 d (3), = 25 to 58 d (3); = 143 d (9), bare ground/sandy loam soil, North Carolina = 64 d (9).
Aquatic Persistence ($t_{½}$):	**Acid:** *Anaerobic degradation*: > 120 d (9). **IPA:** *Aerobic degradation*: Surface water = 3 to 5 d (2); Water/sediment = 17 months (3). *Anaerobic degradation*: = > 120 d (9); = 14.1 & 14.5 d (MO ponds) (10), = 3.9 & 8.4 d (FL ponds) (10). *Hydrolysis*: = 325 d at pH 7 (3). *Photolysis*: = 3.7 d at pH 7 (3); = 2.5 to 5.3 d (9); Quickly undergos photodegradation in aqueous solutions (photohydrolysis) (8), photodegradation = 2 d (8).
Aquatic Dissipation (DT_{50}):	**Acid:** = 300 to 700 d (under more typical aquatic field conditions) (9). *Hydrolysis*: = 30 d (pH 7, 20ºC) (7), *Photolysis*: = 2.1 d (pH 7) (7). **IPA:** = 300 to 700 d (under more typical aquatic field conditions) (9).
Potential to Move to Groundwater (GUS score):	**Acid:** Potential (5), = 1.98 (7), Increased potential for transport to ground and surface waters due to low sorption and long residence times in soil (9). **IPA:** Increased potential for transport to ground and surface waters due to low sorption and long residence times in soil (9).
Volatilization (mm Hg):	**Acid:** < 10^{-7} at 60ºC (9). **IPA:** < 10^{-7} at 60ºC (9).
Octanol-Water Partition Coefficient (K_{ow}):	**Acid:** = 1.3 (22ºC) (3), = 1.29 (7). **IPA:** No information in references
Bioaccumulation/ Bioconcentration:	**BAF:** Does not appreciably bioaccumulate (9).

	BCF: Does not bioconcentrate (9).

Worst Case Ecological Risk Assessment

Max Application Rate (ai lbs/acre – ae basis)	**Habitat Management:** 1.5 lbs. a.e./acre – terrestrial 1.0 lb. a.e./acre – aquatic[1] **Croplands/Facilities Maintenance:** 1.5 lbs. a.e./acre
EECs	**Terrestrial (Habitat Management):** 360 ppm **Terrestrial (Croplands/Facilities Maintenance):** 360 ppm **Aquatic (Habitat Management):** 0.368 ppm **Aquatic (Croplands/Facilities Maintenance):** 0.00503 ppm

[1]Aquatic overspray and riparian areas within 25 feet of surface water resources.

Habitat Management Treatments:

Presumption of Unacceptable Risk		**Risk Quotient (RQ)**	
		Listed (T&E) Species	**Nonlisted Species**
Acute	Birds	=0.07 [0.1]	=0.07 [0.5]
	Mammals	=0.08 [0.1]	=0.08 [0.5]
	Fish	=0.05 [0.05][1]	=0.05 [0.5][1]
Chronic	Birds	=0.22 [1]	=0.22 [1]
	Mammals	=0.06 [1]	=0.06 [1]
	Fish	=0.05 [1][1]	=0.05 [1][1]

[1]Screening-level ecological risk assessment assumes an application rate = 1.0 a.e./acre.

Cropland/Facilities Maintenance Treatments:

Presumption of Unacceptable Risk		**Risk Quotient (RQ)**	
		Listed (T&E) Species	**Nonlisted Species**
Acute	Birds	=0.07 [0.1]	=0.07 [0.5]
	Mammals	=0.08 [0.1]	0.08 [0.5]
	Fish	<0.01 [0.05]	<0.01 [0.5]
Chronic	Birds	=0.07 [1]	=0.07 [1]
	Mammals	=0.08 [1]	=0.08 [1]
	Fish	<0.01 [1]	<0.01 [1]

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