UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D. C. 20460

OFFICE OF
PREVENTION, PESTICIDES
AND TOXIC SUBSTANCES

Chemical: Imazapyr
PC Code: 128821
DP Barcode: D275562

MEMORANDUM

DATE: 3 September 2003

CHEMICALS: Section 3 request for additional terrestrial uses and first time aquatic uses of imazapyr (PC 128821, CAS Reg. No. 81334-34-1, AC 243997, CL 243997) and its isopropyl amine salt (PC 128829, CAS Reg. No. 81510-83-0, AC 252925, CL 252925) and sold as the herbicide product ARSENAL® (EPA Reg. No. 241-346, BASF/American Cyanamid, Co. No. 000241)

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Attached please find the Environmental Fate and Effects Division's (EFED) screening level environmental risk assessment for the proposed registration of new aquatic uses for the formulated product ARSENAL® (EPA Reg. No. 241-346; active ingredient: imazapyr as isopropyl amine salt). In accordance with the agreement with Registration Division, **the additional terrestrial uses requested by the registrant will not be considered at this time.** Based on the proposed new product label, imazapyr is intended to control emerged and floating vascular plants on non-crop bodies of freshwater that may be flowing, non-flowing, or transient. The non-crop freshwater aquatic sites encompass all manner of wetlands and transitional areas. The label lists "lakes, rivers, streams, ponds, seeps, drainage ditches, canals, reservoirs, swamps, bogs, marshes, transitional areas between terrestrial and aquatic sites, seasonal wet areas, and similar non-crop areas."

The ARSENAL® label specifies a maximum single application rate of 6 pints/acre of product, which is formulated as a concentrated solution of the isopropyl amine salt of the parent acid imazapyr. This application rate corresponds to 1.5 lb/acre of acid equivalents (a.e.) of imazapyr. However, the label does not explicitly specify a maximum number of applications per season/year or a maximum seasonal rate for these proposed uses. In lieu of these maximums, EFED chose to use the maximum single application rate of 1.5 lb a.e./acre of imazapyr as the annual maximum input for use in model estimates of potential exposure. This adds uncertainty to the results and conclusions of this assessment. In addition, because of imazapyr's persistence, splitting applications while maintaining a total of 1.5 lb a.e./acre annually would not result in meaningful alteration of exposure concentrations or risk conclusions. Potential risks to aquatic organisms (fish, invertebrates, and plants) and terrestrial organisms (birds, mammals, and plants) are assessed based on modeled Expected Environmental Concentrations (EECs). This document also includes an assessment of potential imazapyr residues in drinking water.

Key findings of this risk assessment are as follows:

- Levels of Concern (LOCs) are exceeded for non-target endangered and non-endangered vascular aquatic plants. Thus, the proposed aquatic uses of imazapyr present a potential risk to endangered and non-endangered aquatic vascular plants. Since imazapyr is persistent in water and soil, the potential risk to these vascular plants could last for a relatively long time, perhaps as long as several years.

- Levels of Concern (LOCs) are exceeded for non-target endangered and non-endangered terrestrial plants. Thus, the proposed aquatic uses of imazapyr on use sites described as "transitional areas between terrestrial and aquatic sites" pose potential risks to non-target endangered and non-endangered terrestrial plants. EFED considers applications to these sites equivalent to applications to terrestrial non-crop sites. In addition, drift from ground and aerial applications to the proposed aquatic sites also poses potential risks to non-target endangered and non-endangered terrestrial plants.

- Levels of Concern (LOCs) are not exceeded for aquatic and terrestrial animals and aquatic non-vascular plants (e.g., algae). Available studies suggest that the proposed aquatic uses of imazapyr are not likely to pose risks to these non-target organisms; however, additional information is needed to conclusively rule out chronic risks to birds.

- Risks to honey bees from technical imazapyr are not expected and precautionary labeling is not required.

- Estimated concentrations in drinking water are based on direct application of imazapyr at the maximum single aerial application rate of 1.5 lb a.e./acre to the entire surface of the Index Reservoir. This yields an annual estimated peak concentration (acute) of **61 μg/L** (part per billion, or ppb). Applying this result to the FIRST model, which for this case considers only aquatic degradation and outflow dilution, the model yields an annual mean concentration (chronic) of **36 μg/L**.

- EFED also recommends a number of changes to the proposed label to reduce the potential risk to non-target plants.

Data Requirements

Ecological Effects

Avian Reproduction:

EFED recommends that the avian reproduction toxicity test using the mallard duck (71-4b) as the test species be repeated. The current mallard reproduction study is scientifically invalid due to bacterial contamination and high embryonic mortality in the control group. Typically, testing using two avian species (bobwhite quail and mallard duck) are required to fulfill Subdivision E Guideline 71-4, and to complete a characterization of the chronic risk of imazapyr to birds. Because the proposed use is for aquatic sites, toxicity testing with an aquatic bird is especially needed. In addition, the invalid study submitted for mallard ducks indicated there might be reproductive effects. Nevertheless, given that imazapyr was practically nontoxic to the bobwhite quail, the value added of repeating this study is medium.

Terrestrial plant:

EFED recommends that the Tier II Seedling Emergence (123-1a) be repeated. After reevaluation with the use of a newer model for a dose-response regression analysis, it was determined that the data in the current vegetative vigor study (MRID 40811801)) were inadequate for determining the EC25 and NOAEC values. In addition, there were numerous guideline deviations according to today's standard protocols. The study does not fulfill the guideline requirements because each species was subjected to overcrowding and excessive competition, especially larger seedlings, wherein ten seeds of each species were planted in a 4-in diameter dixie cup and grown (tested) to 28 days. The area of the pot container may have restricted seedling growth and thereby overestimated EC25 and NOAEC. The study is classified as supplemental for this use. This study should be repeated with a full set of 10 species with appropriate area of the pot container to allow unrestricted growth and reduce competition of the plants. The use of TEP (typical end-use product) instead of technical grade active ingredient is required for all terrestrial nontarget plant tests with the highest percent active ingredient used.

Because of the potential for runoff to adjacent areas from application sites to cause adverse effects on nontarget plants, the value added by repeating this study is high.

EFED also recommends that the Tier II vegetative vigor test (123-1b) be repeated. After reevaluation with the use of a newer model for a dose-response regression analysis, it was determined that the data in the current vegetative vigor study (MRID 40811801) were inadequate for determining the EC25 and NOAEC values. In addition there were numerous guideline deviations according to today's standard protocols. The study is scientifically sound in that it establishes that imazapyr is highly toxic to terrestrial plants, but it does not fulfill the guideline requirements because insufficient dose levels were used in the portion of the 14-day study using young plants to calculate reliable EC25 and NOAEC levels. In addition, the toxicity values generated from the portion of the 28-day study using older plants could be underestimated since the plants were tested at a less sensitive stage of growth. This study is required to be repeated with a full set of 10 species with appropriate concentration levels for reliable EC25 values with plants applied at the second or third true leaf stage. The use of TEP (typical end-use product) instead of technical grade active ingredient is required for all terrestrial nontarget plant tests with the highest percent active ingredient used. Because of the potential for spray drift from application areas to cause adverse effects on non-target plants, the value added by repeating this study is high.

Submerged aquatic vascular plants (SAVs):

Results of the duckweed test (GLN 123-2) suggest that aquatic vascular plants are significantly less sensitive than terrestrial plants to the effects of imazapyr. It has been postulated by the registrant that imazapyr does not affect SAVs. Confirmation of this point with concrete evidence would allow EFED to further refine our assessment of impacts in aquatic areas. To address this uncertainty, EFED recommends a Tier II aquatic vascular toxicity test with a submerged aquatic vascular plant (SAV) to observe any adverse effects to SAVs from imazapyr applications. The value added by requesting this study is high. EFED recommends that, before beginning the study, the registrant consult with EFED for the appropriate protocols and species used for the submerged aquatic vascular toxicity test.

Environmental Fate:

Aquatic field dissipation (GLN 164-2):

Aquatic field dissipation data could provide evidence to are needed to refute the expected routes and rates of dissipation of imazapyr which EFED has developed based on the results of numerous laboratory studies. However, given the uncertainty frequently associated with such tests, any new data may not change EFED's characterization.

Analytical chemical methods (OPPTS 850.7100):

The present estimated limits of quantitation (LOQs) for the analytical chemical methods for imazapyr in soil and water are each 5 parts per billion (ppb). It is difficult to specify what level of method improvement might be necessary until EFED has satisfactory determination of final plant toxicity endpoints. For the most sensitive plant for which there is satisfactory data (cucumber), the toxicity endpoint corresponded to an application rate for imazapyr of 0.000064 lb a.e./acre. The present cucumber endpoint corresponds to a minimum LOQ in soil, assuming a 15 cm incorporation, of approximately 35 parts per trillion (ppt). For water, at least an equivalent sensitivity would be required. Consequently, a method with detection capability in the 10 ppt or less range would appear warranted before terrestrial uses of imazapyr are contemplated.

Recommended Label Language

EFED recommends that the label be rewritten to specify that the use is for aquatic uses only. References to terrestrial use should be deleted from the label. In addition, the aquatic use sites listed on the label provided for review are too broad and all inclusive. EFED recommends that the label be split into parts dealing with direct application to emerged aquatic plants in water bodies and direct application to plants in other areas.

Currently, there is no seasonal/annual maximum application rate on the proposed label. EFED recommends that such a rate be included on the label.

The following statements should be included on the ARSENAL® (EPA Reg. No. 241-346) label:

Spray Drift

Because of the high toxicity of imazapyr to plants, there is the potential for nontarget plants to be harmed by spray drift from treated areas. Potential product label language that is consistent with the modeling conducted and risks presented in the EFED assessment is shown below:

> For aerial applications, the boom width must not exceed 75% of the wingspan or 90% of the rotary blade. Use upwind swath displacement and apply only when wind speed is between 3 and 10 mph. Use "coarse" or coarser spray according to ASAE 572 definition for standard nozzles.

Endangered Species Statement

As was stated in the Risk Characterization Section of the main document, the broad definition of potential use sites on the proposed label makes an assessment of the possible adverse effects of imazapyr on endangered and threatened aquatic vascular plants difficult. An addendum to the Section 3 document will follow, in which recommendations that would help reduce this problem will be made.

9/3/2003

Environmental Fate and Ecological Risk Assessment for the Registration of Imazapyr Use on Aquatic Non-Crop Sites

PC Code 128821

EXECUTIVE SUMMARY

Imazapyr Proposed Usage

Imazapyr is an imidazolinone ALS inhibitor, which has a mode of action similar to that of the sulfonylurea class of herbicides. It has been proposed for a new use for control of emergent and floating aquatic weeds in a wide range of aquatic and semi-aquatic/wetland sites (including non-flowing waters, bogs, swamps, marshes, etc.). EFED has considered available information on imazapy's toxicity, potential aquatic use areas, fate properties, and application methods in characterizing ecological risks related to labeled uses. After review and analysis of the available information, EFED believes the proposed aquatic uses of imazapyr may present a potential risk to aquatic vascular plants inhabiting open freshwater bodies and to terrestrial plants inhabiting semi-aquatic areas.

Beyond these points, the lack of a seasonal maximum use rate on the proposed label, the use of a less accurate and reliable measurement endpoint (shoot fresh weight) in a key terrestrial plant toxicity test, and the potential for indirect effects on aquatic and terrestrial plant populations and communities are important sources of uncertainty in this risk assessment.

When imazapyr, a non-selective herbicide, is directly applied to emergent or floating aquatic plants in aquatic areas at the proposed maximum application rate of 1.5 lb ae/acre, it will damage or kill those plants. Levels of concern (LOCs) are exceeded for non-target vascular plants, with risk quotients ranging from 4 (if imazapyr were applied to static water 2 meters deep) to 23 (if applied to static water one foot deep); the corresponding range for endangered aquatic vascular plants is 9 to 55. Furthermore, as plants in semi-aquatic areas (such as those found in wetlands) are much more like terrestrial plants (i.e. more sensitive to the effects of imazapyr), there is potential for more severe impacts if imazapyr is applied to wetlands.

Aquatic modeling suggests that imazapyr reaching the water may be persistent with an estimated half-life of 300 - 700 days. It is uncertain if submerged aquatic vegetation (SAV) is sensitive to predicted concentrations of imazapyr. If it is, the persistence could pose a potential indirect threat to fish due to loss of cover or food sources. EFED is not able to quantitatively evaluate these effects with the available information.

When imazapyr is applied to semiaquatic areas which can be periodically dry at the proposed maximum application rate of 1.5 lb ae/acre, it has the potential to damage or kill terrestrial plants growing in adjacent areas due to runoff or spray drift. Assuming unincorporated ground application is represented by one percent spray drift combined with five percent runoff, and coupling this with the most sensitive plant endpoint from among the valid Seedling Emergence tests (sugarbeets), results in levels of concern (LOCs) excedances for non-endangered and endangered non-target vascular plants, with risk quotients of 38 and 529, respectively. Under the assumption of aerial application (five percent runoff coupled with five percent drift), the respective non-endangered and endangered terrestrial plant risk quotients were 50 and 706. These numbers would be considerably reduced if application is restricted to aquatic sites where runoff would not be a factor (i.e. more permanent water bodies).

When the above points are reassessed using the most sensitive of the valid Vegetative Vigor tests (cucumber), only spray drift is considered. In addition, it is important to note that the cucumber value is based on a 28-day test, rather than a 14-day test. Nevertheless, once again, using the one and five percent drift assumptions for ground and aerial application results in levels of concern (LOCs) excedances. For ground application, the risk quotients for non-endangered and endangered terrestrial plants, are 17 and 234, respectively. For aerial application, the corresponding risk quotients were 83 and 1172. In all of these case, it clearly points out the value of reducing spray drift.

LOCs <u>are not</u> exceeded for aquatic and terrestrial animals and aquatic non-vascular plants (e.g., algae). Thus, the proposed aquatic uses of imazapyr are not likely to pose direct risks to these non-target organisms. Further, risks to honey bees from technical imazapyr are not expected, and no restrictive labeling is required.

Drinking Water Summary

For direct application to surface water, EFED used as our reference or benchmark water body the standard EFED Index Reservoir used for drinking water assessments for chemicals applied terrestrially. Description of the Index Reservoir, including its geometry, volume, and conditions for water flow, is given in the Water Resource Assessment section and Appendix 4 of this document. By simple calculation, direct application of imazapyr at the maximum rate of 1.5 lb a.e./acre to the entire surface area of the Index Reservoir yields a peak concentration of 61 parts per billion (ppb). Based on the fate properties of imazapyr and Index Reservoir dynamics, the average annual (chronic) concentration for direct application is 36 ppb. Exposure concentrations would vary depending on the unique dimensions/volume, hydrology, episodic climatic events, and other characteristics of a water body.

The registrant has indicated[1] that the aquatic application will usually be targeted at emerged and floating vegetation found at the margins of water bodies. If only "margins" were treated, then for the particular geometry of the Index Reservoir (see Appendix 4), and with the assumptions of 1) an arbitrary vegetated margin of two meters (representing approximately 5% of the total surface area) and 2) the maximum application rate, the hypothetical peak concentration would be approximately 3 ppb. The corresponding chronic concentration is approximately 2 ppb.

Endangered Species

The highly generalized description of the proposed use sites for imazapyr suggests the potential for application to a myriad of locations across the country. However, refinements to the geographical scope of the proposed uses is not possible, given the current information on the proposed use-sites of the compound. Nevertheless, endangered plant species frequently are located in wetlands. Given the magnitude of the screening risk assessment numbers presented, it is unlikely that the numbers could be reduced below levels of concern through changes to

[1]Registrant's letter of 17 April 2000.

application practices.

TABLE OF CONTENTS

APPENDIX 5 - GENEEC Model Output (*.wpd)
APPENDIX 6 - New Fate DER Summaries (*.wpd)
APPENDIX 7 - EEC Calculations for Birds and Mammals (*.xls)
APPENDIX 8 - Imazapyr Toxicity Studies (*.wpd)
APPENDIX 9 - Imazapyr RQs (*.wpd)
APPENDIX 10 - Spray Drift Analysis (*.wpd)
APPENDIX 11 - Terrestrial Plant RQ Calculations (*.xls)
APPENDIX 12 - Drift Calculations (*.xls)

I. ENVIRONMENTAL RISKS OF IMAZAPYR

Problem Formulation

After reviewing the proposed label (which included rangeland and grass pasture uses) and noting the many missing pieces of information with respect to terrestrial plant risk, the Environmental Fate and Effects Division (EFED)decided to focus this assessment on aquatic uses. EFED has evaluated all available information on imazapyr's toxicity, potential use areas, environmental behavior, and application methods to perform a screening level risk assessment for the proposed aquatic use. Based on the screening level risk assessment, imazapyr is not expected to pose risks to non-target aquatic and terrestrial animals. However, because levels of concern (LOCs) are exceeded for vascular plants, the proposed use presents a potential risk to endangered and non-endangered, non-target aquatic and terrestrial plants. Because imazapyr poses a potential threat primarily to plants, the particular focus of this document is on explaining the bases for developing the risk assessment for plants. In addition, because the proposed treatment sites include all manner of wetlands and transitional areas, as well as application to flowing, non-flowing, or transient bodies of fresh water, it was necessary to develop separate risk assessments for plants growing in aquatic and semi-aquatic/wetland areas.

Conceptual Model for Screening Risk Assessments of Plants

It is important to note that imazapyr is being considered for use on emergent and floating plants in sites that include all manner of wetlands and transitional areas, as well as application to flowing, non-flowing, or transient bodies of fresh water. The label lists "lakes, rivers, streams, ponds, seeps, drainage ditches, canals, reservoirs, swamps, bogs, marshes, transitional areas between terrestrial and aquatic sites, seasonal wet areas, and similar non-crop areas." Therefore, direct application to aquatic plants inhabiting deep or shallow freshwater bodies and applications to terrestrial plants inhabiting semi-aquatic areas were separately evaluated to estimate exposure to vascular plants. The potential for effects on terrestrial plants inhabiting dry land areas due to spray drift from aerial application was assessed.

There are particular routes by which imazapyr, when used as proposed, may inadvertently affect non-target plant populations in aquatic areas: drift during application, particularly downwind drift; dispersion of contaminated water from treated areas to untreated areas; and, contamination of surface waters by cleaning of spray equipment after application. In semi-aquatic areas, the routes are: drift during application, particularly downwind drift; runoff events (off-site movement of contaminated water); and wind erosion of contaminated soil particles. Since imazapyr is designed to kill unwanted plants or weeds, there may be exposure to non-target terrestrial plants adjacent to treated areas via drift and runoff from transitional sites or wetlands which may be dry during certain periods, or via wind-blown treated soil particles from those dry areas.

Because of the toxicity of imazapyr to vascular plants, analytical chemistry methods to quantitate residues in water, soil, and plant matrices need to be evaluated for adequacy.

Use, Application Information, and Herbicidal Effects (as presented on the proposed product label)

ARSENAL® (EPA Reg. No. 241-346) is a systemic, non-selective herbicide used for control of annual and perennial weeds, and is currently registered for non-food uses. It is toxic to a broad spectrum of grass and broadleaf plants (including vines, brush, and trees). The label states that the herbicide is translocated rapidly throughout a plant, with accumulation in the meristematic regions. Uptake may be from exposed foliage or from the soil by plant roots.

Proposed uses: Based on the proposed new use label, imazapyr may be sprayed on non-cropped, flowing, non-flowing, or transient bodies of freshwater. The non-crop freshwater aquatic sites encompass all manner of wetlands and transitional areas. The label lists "lakes, rivers, streams, ponds, seeps, drainage ditches, canals, reservoirs, swamps, bogs, marshes, transitional areas between terrestrial and aquatic sites, seasonal wet areas, and similar non-crop areas." For aquatic use, the label specifies application to plants that are floating or otherwise emerged with most of their foliage above water. The herbicide is said to be most effective on emerged, vigorously growing plants.

Application mixtures: ARSENAL® is always used with either an appropriate surfactant (non-ionic or silicone-based) or, alternatively, an oil (methylated seed oil or vegetable oil concentrate). Fertilizers may also be blended with the spray mixtures of product and adjuvants. A variety of other pesticides may also be included in the spray tank mixture.

Application Rates: For this assessment, all exposure estimates are based on a single, direct surface application at a maximum rate of 1.5 lb a.e./acre. This rate derives from the maximum of 6 pints/acre of product stipulated on the label. Inspection of the label shows single application rates are typically 2 to 6 pints/acre.

As stated in the first section of this document, since the proposed label does not explicitly specify a maximum number of applications or maximum seasonal rate for any use, EFED has implicitly assumed that use will be limited to a maximum of 1.5 lb a.e./acre annually. Because of imazapyr's persistence, split applications totaling no more than 1.5 lb a.e./acre annually do not result in meaningful reduction of estimated concentrations within time periods of interest. EFED also implicitly assumes that, within a given watershed, there will be no co-occurrence of terrestrial and aquatic use.

Methods of application: Aerial and surface spray applications are specified on the proposed label. However, the label does not explicitly describe the types of equipment to be used, etc.

Herbicidal effects: As with other imidazolinones, exposed plants first show signs of chlorosis in newest growth (apical meristem), followed by gradual spreading of tissue necrosis. Herbicidal symptoms may not appear in susceptible plants for two weeks, and kill may not occur for several weeks. In perennials, translocation to underground or underwater storage organs prevents regrowth. If rain or boat backwash does not wash imazapyr from exposed plant surfaces within one hour after application, there is said to be sufficient translocation into tissue for effective herbicidal action.

Rotational Crop Intervals: As discussed in the Environmental Fate Assessment section below and elsewhere in this document, fate studies show imazapyr to be persistent in soil (laboratory half-lives of approximately 3 years). Rotational crop intervals also serve as a practical measure of persistence and effective residual toxicity in soil. Since the proposed label for "aquatic" uses of imazapyr includes "dry" sites, the rotational interval is relevant. For an application rate of 0.75 a.e./acre, the maximum rate for some proposed terrestrial uses, the label specifies a rotational crop interval of one year, followed by a successful bioassay before planting any crop following ARSENAL® application. Presumably, for other uses at the maximum annual rate of 1.5 lb a.e./acre, the crop rotational interval would be correspondingly longer, followed by a successful bioassay. For another imazapyr-containing product, Lightning®, a co-formulation of imazapyr with imazethapyr (another imidazolinone), stipulated rotational intervals for a much lower application rate are as long 40 months (3.3 years), followed by a safe bioassay. The persistence indicated by crop rotational intervals is in good agreement with submitted fate studies.

Chemical and Product Identification

The active ingredient imazapyr is an organic acid (pKa ≈ 3.8, more acidic than acetic acid, less than citric acid), and is in the imidazolinone family of herbicides (see chemical structural formula and table of physical/chemical properties of imazapyr in a separate section below). Because of its acidity, at typical environmental pHs imazapyr is mostly in anionic form (61% ionized at pH 4, 94% ionized at pH 5, greater than 99% ionized at pH 6 and higher). Its mode of action is inhibition of the acetolactase synthase enzyme (ALS, also called acetohydroxyacid synthase (AHAS)). (This enzymatic pathway involves the biosynthesis of the branched chain amino acids leucine, isoleucine, and valine.)

The herbicidal product ARSENAL® (EPA Reg. No. 241-346) is formulated as a concentrated aqueous solution of the isopropyl amine salt of imazapyr. (Note: Imazapyr has the EPA PC Code 128821; the amine salt has the EPA PC Code 128829. Also note that other products share the same name ARSENAL®. Therefore, to avoid confusion among these products, registration numbers and general use should be given explicitly when referring to a specific product.) The amine salt comprises 28.7% of the weight of ARSENAL®, which corresponds to an imazapyr acid equivalent (a.e.) composition of 22.6% by weight or *2.0 lbs of imazapyr a.e. per gallon of product.* Herein, all exposure concentrations and toxicity values are expressed on the basis of imazapyr a.e..

Physical and Chemical Properties of Imazapyr

Imazapyr's chemical structural formula, chemical names or other designations, and a table of selected physicochemical properties are given in sequence below. (Alternative chemical names, even under the same naming conventions, are possible and in use.)

Common Name

IMAZAPYR
(CAS No. 81334-34-1, Company Designations AC 243997 and CL 243997)

IUPAC Name

2-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)nicotinic acid.

CAS Name

2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-3-pyridinecarboxylic acid.

Table 1. Physical and Chemical Properties for Imazapyr (Source: Data issued by registrant representatives J. Arthur on 31 Jan 2001 and by Jeffrey Birk on 26 Feb 2003. Accuracy of information has not been verified. Values are generally consistent with chemical structure modeling and available published literature values.)

Guideline	Property	Result
830.6302	Color	White to tan
830.6303	Physical state	Solid (powder)
830.6304	Odor	No odor or slight odor of acetic acid
N/A	Molecular weight	261.28 Daltons

Table 1. Physical and Chemical Properties for Imazapyr (Source: Data issued by registrant representatives J. Arthur on 31 Jan 2001 and by Jeffrey Birk on 26 Feb 2003. Accuracy of information has not been verified. Values are generally consistent with chemical structure modeling and available published literature values.)

Guideline	Property	Result
N/A	Empirical formula	$C_{13}H_{15}N_3O_3$
830.7000	pH of water solutions or suspensions	1% Solution: 2.7 0.1% Solution: 3.1
830.7200	Melting point/melting range	167-173 ^{0}C
830.7300	Bulk density	0.35-0.37 g/mL (tapped)
830.7370	Dissociation constant in water	pKa of 3.6-3.8 (other reported pKa or polyacidic pKa values are not consistent with structure or measured pHs of 1% and 0.1% solutions) (Temp. unknown)
830.7550	n-octanol/water partition coefficient	P_{ow}: 1.3 to 1.7; log P_{ow}: 0.11 to 0.22 (pH and Temp. unknown)
830.7840	Water solubility (sol.)	11.1 x 10^3 mg/L (11100 ppm) at 25 ^{0}C
830.7950	Vapor pressure (v.p.)	< 10^{-7} mm Hg (< 1.3 x 10^{-5} Pa) at 60 ^{0}C (method limit)
N/A	Henry's Law constant (reviewer-calculated from sol. and v.p.)	< 10^{-11} atm m^3/mole (< 10^{-6} Pa m^3/mole) Unitless Kh = Kaw < 10^{-10}

Assessment Endpoints and Analysis Plan

Laboratory toxicity tests indicate that imazapyr is practically nontoxic to terrestrial and aquatic animals. However, the toxicity tests for non-target terrestrial plants (Tier II Vegetative Vigor and Seedling Emergence) and aquatic vascular plants (Tier II Aquatic Plant Growth) indicate that imazapyr is toxic to terrestrial and aquatic vascular plants. Because imazapyr is being considered for use on emergent and floating plants in sites that include all manner of wetlands and transitional areas, as well as application to flowing, non-flowing, or transient bodies of fresh water, direct application to aquatic plants inhabiting aquatic areas and applications to terrestrial plants inhabiting semi-aquatic areas must be separately evaluated to estimate exposure. Therefore, the purpose of this analysis was to assess the impact of imazapyr on the diversity and growth of non-target and endangered terrestrial and aquatic plant communities[2] resulting from

[2]Because there are no current plant testing guidelines for assessing chronic (reproductive) effects of herbicides, this screening level assessment focuses only on endpoints related to acute effects to plants (terrestrial; aquatic).

use in aquatic areas.

Imazapyr is not currently registered for use on aquatic sites; therefore, no water monitoring data exist for this use. Exposure concentrations and spray drift effects were estimated with models.

Peak exposure to aquatic animals and plants in water bodies was estimated by using a direct application to the standard pond; chronic exposure to invertebrates and fish was estimated by using the standard pond from GENEEC2. Parent imazapyr was the only modeled chemical species.

TerrPlant was used to estimate deposition of imazapyr to terrestrial plants inhabiting semi-aquatic areas adjacent to treated areas as a result of spray drift and runoff from a single application. The AgDRIFT model for aerial conditions was used to refine TerrPlant downwind deposition estimates as a function of distance from the application site from spray drift only.

The Food Quality Protection Act (FQPA) mandates that exposure concentrations of a pesticide in drinking water be included in the dietary risk assessment. For the drinking water assessment, the peak concentration in surface water bodies used as drinking water sources was estimated by using a direct application to the standard Index Reservoir at the maximum label rate. Chronic exposure to drinking water was estimated by using the Index Reservoir from FIRST.

Tier I SCI-GROW was used to estimate concentrations in ground water. Estimates were performed using the maximum single application rate; there is no specification on the label of a maximum seasonal application rate, or whether repeat applications are permitted. Parent imazapyr was the only modeled chemical species.

Environmental fate and physical and chemical data served to describe the transformation, persistence, and transport of imazapyr and its products in soil and water (i.e., the behavior of the chemical in the environment). The data served to select the appropriate input parameters for modeling and to provide the Health Effects Division information on the chemical nature of the transformation products, their routes of exposure, and the amount in different environmental media.

II. ENVIRONMENTAL AND ECOLOGICAL RISK CHARACTERIZATION

As previously stated, laboratory toxicity tests indicate that imazapyr is practically nontoxic to terrestrial and aquatic animals. The screening level assessment (Appendix 9) showed that the proposed aquatic uses of imazapyr are not likely to pose a potential acute or chronic risk to birds, mammals, fish, or invertebrates. Although imazapyr did not adversely affect aquatic non-vascular plants (algae and diatoms), terrestrial and aquatic vascular plants were sensitive to imazapyr.

Because of the broad definition of potential use sites for imazapyr, direct application to aquatic and semi-aquatic areas were separately evaluated to estimate exposure. The following is a characterization of the impact of imazapyr on non-target and endangered aquatic and terrestrial plant communities.

1) *Risks to Vascular Plants in Aquatic Areas*

When imazapyr, a non-selective herbicide, is directly applied to emergent or floating aquatic plants in aquatic areas at the proposed maximum application rate of 1.5 lb ae/acre, it has the potential to damage or kill those plants. Levels of concern (LOCs) are exceeded for non-target vascular plants, with risk quotients ranging from 4 (if imazapyr were applied to static water 2 meters deep) to 23 (if applied to static water one foot deep); the corresponding range for endangered aquatic vascular plants is 9 to 55. Furthermore, in semi-aquatic settings (such as those found in wetlands) plants are expected to respond much more like terrestrial plants (i.e. more sensitive to the effects of imazapyr). Consequently, there is potential for more severe impacts if imazapyr is applied to wetlands.

The registrant has indicated (letter to OPP dated 17 April 2000) that imazapyr will most often be used on the margins of the water body, which are the shallowest; therefore, the potential for plant damage in those areas is high.

Imazapyr salt that reaches the water without intercepting plant surfaces will dissociate to anionic imazapyr acid. While imazapyr near the surface of clear waters will be degraded fairly quickly by photolysis, in deeper or turbid waters where light cannot significantly penetrate, degradation will be significantly slower. Aquatic modeling suggests that imazapyr can be persistent with an estimated half-life in water ranging from 300 - 700 days.

Uncertainties

The duckweed plant is the only surrogate plant tested to representative the entire aquatic vascular plant population that is emerged, floating, or submerged in freshwater bodies.

The proposed label is not specific on whether repeat applications are allowed, or what the maximum seasonal application is. The potential for risk will increase as the application rate increases.

The predicted persistence of imazapyr in natural waters could result in long duration exposure of submerged aquatic vascular plants (SAVs) to greater-than-ppb concentrations. While the proposed label states specifically: "ARSENAL herbicide does not control plants which are completely submerged or have a majority of their foliage under water," the registrant has not submitted data to support this statement. If SAVs are sensitive to predicted concentrations of imazapyr, there is a possible indirect effect for fish due to loss of cover or food sources. The magnitude of this potential risk depends on whether SAVs are affected by imazapyr or not.

The modeled numbers presume perfect mixing and application to one hundred percent of the surface area of the water body. In well-mixed water bodies, where imazapyr is applied only along the margins as suggested by the registrant, concentrations will be much lower. Because little is known about imazapyr's effect on SAV's and time to effect, it is hard to evaluate the potential impact of this factor.

Herbicide use may also result in structural changes in the aquatic plant communities due to variable species sensitivity and resistance. This could result in changes further up the aquatic food chain. Simulated and actual field testing and chemical monitoring are not available to evaluate these potential indirect effects for imazapyr. Thus, EFED is not able to quantitatively evaluate these effects.

2) *Risks to Plants in Semi-aquatic Areas*

When imazapyr, a non-selective herbicide, is applied to semiaquatic areas which can be periodically dry at the proposed maximum application rate of 1.5 lb ae/acre, it has the potential to damage or kill plants growing in adjacent areas. Based on toxicity to sugarbeet (the most sensitive species tested in the seedling emergence study), the risk quotients for non-endangered and endangered terrestrial plants inhabiting semi-aquatic areas were 38 and 529, respectively, if imazapyr were applied at the maximum rate by ground; if applied aerially, the corresponding risk quotients were 50 and 706.

Although the proposed use sites for imazapyr are aquatic and semi-aquatic areas, imazapyr which drifts off-site to terrestrial areas could damage or kill plants growing there. Based on toxicity to cucumber (the most sensitive species tested in the vegetative vigor study), the risk quotients for non-endangered and endangered terrestrial plants were 17 and 234, respectively, if imazapyr were applied at the maximum rate by ground or boat; if applied aerially, the corresponding risk quotients were 83 and 1172.

Tests with the some herbicides in this class indicate that they can cause reduction in yield for some tested crops. In wild plants, this may translate to reduction in the production of fruit and seeds on which wildlife depend for food as well as the degradation of wildlife habitat.

Uncertainties

The lack of a seasonal maximum use rate on the proposed label and the potential for indirect effects on plant populations and communities are important sources of uncertainty in this risk assessment. Simulated and actual field testing and chemical monitoring are not available to evaluate these potential indirect effects for imazapyr. Thus, EFED is not able to quantitatively evaluate these effects.

The toxicity values could be underestimated since the study was tested with older plants in the 28D test at a less sensitive stage of growth (timing of application). In addition, toxicity values used in the risk assessment are based on shoot 'fresh weight' instead of 'dry weight' as the measurement endpoint for toxic effect. Since this measurement endpoint can vary due to plant moisture content, the toxicity value is less accurate and reliable. If anything, an endpoint based on "dry weight" is likely to be lower than the current toxicity values.

3) Risk to Terrestrial Plants

The Ag DRIFT Spray Drift model (see Appendix 10, Figure 1) estimates that, with an aerial application with a coarse spray, a 10% or more reduction in one of the endpoints would be expected for all tested species 500 feet downwind of imazapyr under the assumed conditions.

If application conditions occurred under higher release heights or in higher wind speeds than those modeled, risks to non-target plants would increase beyond the levels shown in this assessment. Thus the results of this assessment suggest that mandatory restrictions on droplet size, release height, and wind speed may reduce risks to non-target plants.

III. ENVIRONMENTAL FATE ASSESSMENT SUMMARY

Basis of Fate Assessment

This assessment is based on an integration of 1) environmental fate study data from previously reviewed studies and from the current review of new fate studies submitted to support both the proposed new uses and existing uses of imazapyr, 2) intrinsic physical/chemical properties, and 3) product label statements. As with all EFED fate assessments, it does not take into consideration any alteration of the environmental fate properties of imazapyr that may be associated with the addition of co-formulated ingredients (other pesticides and/or "inert" ingredients); tank mixtures with other pesticides; or adjuvants (for example, surfactants or oils).

For a fuller discussion of environmental fate, a better understanding of limitations, and more quantitative information (including selection of model input parameters), refer to Appendix 2. Another appendix, Appendix 6, gives the scientific conclusions from the individual Data Evaluation Reports (DERs) for the new fate studies submitted to support both the old and proposed new uses.

Use Context of Fate Assessment

As stated previously, the proposed uses of imazapyr for freshwater weed control are virtually all inclusive. Applications would be to non-crop bodies of freshwater that may be flowing, non-flowing, or transient. Label-listed areas of application include lakes, rivers, streams, ponds, seeps, drainage ditches, canals, reservoirs, swamps, bogs, marshes, transitional areas between terrestrial and aquatic sites, seasonal wet areas, and similar non-crop areas.

Considering these diverse habitats and possible extent of plant cover, the degree to which imazapyr spray is intercepted by plants (or ratio of leaf area to exposed water surface) would typically be a small fraction when weeds are under regular control; in out-of-control areas with heavy weed infestations, plant interception could be a relatively large fraction. However, regardless of the degree of interception, it is reasonable to assume that applied imazapyr will, directly or indirectly, be released into surface water or soil through foliar wash-off or by subsequent release of absorbed imazapyr by affected plants.

Environmental Fate Summary

Abstract: Imazapyr is an anionic, organic acid that is non-volatile, persistent, and mobile in soil. Its nature is similar to compounds known to runoff to surface water and leach to groundwater. Field study observations are consistent with its intrinsic ability to move with water. Imazapyr does not bioconcentrate. The only major transformation products identified are the aqueous photolysis products CL 119060 and CL 9140. Minor soil metabolites were separated in some lab studies (see Appendix 2), but most were not identified.

As can be seen from its chemical formula and table of physicochemical properties given above, imazapyr is a water-soluble, weak acid with a pKa of 3.8. Consequently, at pHs found in most aquatic and terrestrial environments, imazapyr is mainly in anionic form (61% ionized at pH 4, 94% ionized at pH 5, greater than 99% ionized at pH 6 and higher). Imazapyr's calculated Henry's Law constant, anionic nature, and collateral data showing the absence of imazapyr in collection traps for volatile products in various laboratory degradation/metabolism studies indicate that imazapyr is essentially non-volatile.

Upon direct application or indirect release into water, photolysis, as discussed below, is the only identified route of degradation for imazapyr applicable to aquatic use. Laboratory studies show imazapyr is essentially stable to hydrolysis and aerobic and anaerobic aquatic metabolism.

Direct photolysis in laboratory water under ideal exposure conditions occurred with half-lives of approximately three to five days (adjusted from 24-hours of continuous daily xenon irradiation to twelve hours of sun per day, MRID 00131617). These laboratory photolysis half-lives translate to an effective aquatic field half-lives of approximately 300 to 700 days under the aquatic field conditions (water depth, clarity, other factors) used in current EFED modeling scenarios.

The major aqueous photolysis products ($\geq$ 10% in parent equivalents) were CL 119060 and CL 9140 (see Appendix 1 for chemical structures), and their pattern of formation is reasonably consistent with parallel production from imazapyr. CL 119060 and CL 9140 each retain the pyridine ring, and are formed when the joined rings of the imazapyr molecule are severed with the opening of the imidazol ring moiety. CL 119060 and CL 9140 reached respective broad maxima in parent equivalent concentrations of approximately 32% and 23% within the last half of the 10-day study (24-hour daily irradiation). There are no data for photolysis on plant surfaces treated with imazapyr. Imazapyr is stable to photolysis on soil.

The two major aqueous photodegradates were separately tested for aquatic metabolism under aerobic conditions. In a 14-day study, their aerobic aquatic metabolism half-lives were in the range of three to eight days in two different sediment/water systems. Nicotinic acid was a metabolite of CL 119060, and reached a maximum equivalent of approximately 10% of parent. CL 9140, based on its structural similarity to CL 119060, would likewise be expected to form nicotinic acid; however, for unclear reasons, it apparently did not. None of these compounds, because of their dissimilarity to parent and/or projected environmental concentrations, have an influence on the risk assessment. Mineralization, as evidenced carbon dioxide production, was significant for each photodegradate in both sediment/water systems, with a range of production amounting to approximately 20% to 50% of photodegradate equivalents.

Imazapyr that reaches soil surfaces through direct application or spray drift will be persistent. Extrapolated laboratory aerobic soil metabolism half-lives in three soils averaged approximately three years (2.8 years with an upper 90% confidence interval on the mean of 5.6 years); this estimate is supported by multi-year crop rotational intervals specified on the product label and subsequent field bioassay before planting. Imazapyr was essentially stable to anaerobic soil metabolism and, as previously stated, within laboratory study conditions and durations, imazapyr was essentially stable (half-lives indeterminately long because of little or no transformation during study periods) to hydrolysis, photolysis in soil, and aerobic and anaerobic aquatic metabolism. However, minor concentrations of identified and unidentified transformation products were detected in of some of the aforementioned processes (see Appendices 2 and 1). Slow production and accumulation of relatively low residual concentrations of imazapyr byproducts (identified or unidentified) could be responsible, at least in part, for the long rotational crop intervals and the need for bioassays before planting.

Imazapyr applied to soil will also be mobile. Imazapyr has little affinity for soil/sediment, as evidenced by low batch/bulk equilibrium soil/sediment-adsorption coefficients that ranged from 0.04 to 3.4 mL/g in 11 soils/sediments (median of 0.6 mL/g). There was no apparent correlation with soil organic matter. Since pH dependent complex equilibria generally influence sorption, the variation in sorption coefficients among different soils for the acid imazapyr is understandable. However, the standard battery of environmental fate study data, which we have for imazapyr, are insufficient in number and diversity of soils to demonstrate or correlate systematically the direction and magnitude of any possible pH effects on sorption or other characteristics, such as degradation and metabolism rates. Generally speaking, other factors being the same, sorption would tend to diminish with increasing pH for acidic/anionic compounds. Batch/bulk equilibrium sorption coefficients for the two major aqueous photolysis products, CL 119060 and CL 9140, were compared with those of parent imazapyr in two sediments. Their equilibrium sorption coefficients in these sediments were approximately five to ten times higher than parent.

The long crop rotational intervals previously mentioned may seem inconsistent with the imazapyr's mobility (low bulk soil-sorption coefficients) in that one may think that all imazapyr would typically leach below rooting depths within less time. However, movement or elution through soil is not equivalent to piston displacement of water from rainfall or irrigation, and even trace quantities of residual, persistent parent in near-surface soil are sufficient to cause plant toxicity. Also, preferential sorption in some soils by specific minor or trace soil components could sequester enough phytotoxic imazapyr (or transformation products) to contribute to the long residual soil bioactivity. Additionally, variable local weather conditions, different soils, plant/soil evapotranspirational demands, and different agricultural practices always affect the temporal and spacial behavior of pesticides and plant/soil water balance.

Supplemental bare ground and cropped terrestrial field dissipation studies are disparate and inconclusive about routes of dissipation. Because of key deficiencies common to these field studies, only limited, qualitative observations can be made. However, it is not unreasonable to conclude, and in basic agreement with laboratory tests and previous reviews summarizing runoff and leaching data from forestry studies, that imazapyr is mobile under field soil conditions.

Judging from imazapyr's persistence, low sorption coefficients, intrinsic anionic nature, and evidence from forestry and terrestrial field data, it is prone to leach and runoff. The combination of low sorption and long residence time in soil offers increased opportunities for transport to ground and surface waters. Estimated potential exposure concentrations in water for the purposes of aquatic and drinking water assessments are presented in separate sections of this document.

A laboratory bioconcentration study with bluegill sunfish (limit of quantitation (LOQ) of approximately 550 ppb) and another with eastern oyster and grass shrimp (LOQ of 72-128 ppb) indicate that parent imazapyr, even though long-lived in the environment, is not subject to bioconcentration (bioconcentration factor (BCF) less than one). The BCF in caged fish and crayfish species was also measured in an aquatic field dissipation study. The reported LOQ for imazapyr in tissues of the caged animals (three fish and one crayfish species at each of two sites, total of seven different species) was 50 parts per billion (ppb). Thus, within a relatively high 50 ppb limit, it is not unreasonable to conclude that parent imazapyr does not bioconcentrate. There was no attempt to analyze for metabolites or degradates in any of the species tested. Imazapyr's relatively high solubility in water and low n-octanol to water partitioning ratio is also consistent with little likelihood of bioconcentration.

IV. DRINKING WATER EXPOSURE ASSESSMENT

To assess exposure concentrations for direct application of imazapyr to control aquatic weeds, EFED used as a reference or benchmark water body the standard EFED Index Reservoir used for drinking water assessments for chemicals applied terrestrially. The Index Reservoir allows for water flow and other dissipative or degradative processes. A complete description of the Index Reservoir, including its dimensions, volume, and conditions for water flow are given in the general description for the EFED FIRST surface water model, which is available at the EPA internet site:

http://www.epa.gov/oppefed1/models/water/first_description.htm#index drinking

Appendix 4 describes the essential geometry and water flow of the Index Reservoir. Of course, every water body to which imazapyr may be applied will have its own unique dimensions/volume, hydrology, episodic climatic events, and other characteristics; therefore, estimations of exposure concentrations would vary accordingly.

By simple calculation, direct application of imazapyr at the maximum rate of 1.5 lb a.e./acre to the entire surface area of the Index Reservoir (dimensions above) yields a *maximum concentration of 61 parts per billion (ppb)*. (For this peak concentration, we assume that there are no attenuating factors such as interception or uptake by emerged plants or absorption or uptake by floating or submerged microorganisms. Sorption to suspended or bottom sediment is not a significant factor for imazapyr because of its solubility and low partitioning to sediment.)

Upon application to water, photolysis is the only identified degradative process for imazapyr, as discussed in the environmental fate assessment. Water flow through the Index Reservoir is also included in our assessment; and serves to dilute concentrations of imazapyr. Beginning with the initial maximum concentration of 61 ppb in the Index Reservoir, and using only the aquatic portion of the FIRST model with chemical-specific inputs for imazapyr, yields the corresponding average annual concentration of 36 ppb.

Tabulated results for a direct application of imazapyr at the rate of 1.5 lb a.e./acre to the Index Reservoir are:

Table 2. Surface Water Concentrations from Simple, Direct Application to Index Reservoir (application rate of 1.5 lb a.e./acre)	
Acute: 61 µg/mL (ppb)	**Chronic: 36 µg/mL (ppb)**

It bears repeating that: 1) the assessment uses a single maximum, application rate of 1.5 lb a.e./acre as representative of a reasonable, generic, upper bound for labeled uses, and that 2) the screening concentrations given above are in units of imazapyr acid equivalents (a.e.), the units upon which ecological exposures and toxicity tests should be compared.

As an additional consideration, according to the registrant's letter of 17 April 2000, the aquatic application will usually be targeted at emerged and floating vegetation found at the margins of water bodies. However, the proposed label does not preclude greater coverage. If only "margins" were treated, then for the particular geometry and volume of the Index Reservoir (see Appendix 4), and with the assumptions of 1) an arbitrary vegetated margin of two meters (representing approximately 5% of the total surface area) and 2) the maximum application rate, the hypothetical peak concentration would be approximately 3 ppb. The corresponding attenuated chronic concentration is approximately 2 ppb. Again, depending upon the size (geometry and nature of the water body and "margin" width), these values would vary widely.

V. AQUATIC EXPOSURE AND RISK ASSESSMENT SUMMARY

Toxicity to Aquatic Organisms

For aquatic organisms, imazapyr is practically non-toxic to freshwater and marine fish (LC_{50} range: >100 mg/L), to freshwater and marine invertebrates (EC_{50} range: >100 mg/L). On a chronic exposure basis, the early life-stage and full life cycle testing in fish (NOAEC range: 118 - 120 mg/L) showed no significant effects. Chronic toxicity testing in freshwater invertebrates (NOAEC = 97.1 mg/L) showed no significant effects.

Toxicity to Aquatic Plants

Aquatic plant Tier II toxicity testing was conducted with the most sensitive vascular plant, duckweed, and the most sensitive non-vascular plant, blue-green algae. The resultant EC50s are 0.024 mg/L and 12.2 mg/L, respectively.

Estimated Environmental Concentrations for Aquatic Organisms and Plants

Aquatic EECs of imazapyr in surface waters resulting from a single direct application of 1.5 lb ae/acre were determined using simple direct calculations (SDC) and the GENeric Expected Environmental Concentration model, Version 2 (GENEEC2). Two different EEC calculations were used to estimate exposure to aquatic organisms and emerged or floating plants inhabiting shallow and deep water bodies.

The aquatic concentrations used to estimate acute risks from exposures of aquatic fish, invertebrates to imazapyr are based on estimated peak values from simple direct calculations in water. Concentrations used to estimate risks to fish and invertebrates are based on water depths of 1 foot and 2 meters; estimates for aquatic vascular and non-vascular plants are based on water depths of 1 ft, 3 ft, and 2 meters. The SDC and peak values are presented in Table 3.

Table 3. Estimated Environmental Concentrations (ug/L) of Imazapyr Residues in Surface Water Using Simple Direct Calculation.

Water Depths	1 foot	3 feet	2 meters
Peak Values (Day 0)	550	180	84

Aquatic concentrations used to estimate chronic risks to aquatic invertebrates are based on estimated 21-day average values; estimates for chronic risks to aquatic fish are based on estimated 60-day average values. The GENEEC2 model and average values are discussed in Table 4 and detailed in Appendix 5.

Table 4. Estimated Environmental Concentrations (ug/L) of Imazapyr Residues in Surface Water Using GENEEC2 model

21-day	60-day	90-day
83.6	82.6	81.9

Estimates of Risks to Aquatic Organisms and Plants

A means of integrating the results of exposure (EEC) and toxicity data is called the quotient method. For this method, risk quotients (RQs) are calculated by dividing exposure estimates by toxicity values, both acute and chronic.

RQ = EXPOSURE/TOXICITY

The toxicity test values (i.e., measurement endpoints) used in the acute and chronic risk quotients are derived from the results of required studies. The EEC, toxicity, and risk quotient values are provided below in Table 5.

Table 5. Toxicity, Exposure, and Risk Quotient Values of Imazapyr

Species	Toxicity (ppm)	Water Depth	Exposure (ppm)	Risk Quotient (RQ)
Trout/Sunfish/Catfish/Silversides –Acute	>100	1 foot	0.55	<0.01
		2 meters	0.0841	<0.01
Daphnia magna–Acute	>100	1 foot	0.55	<0.01
		2 meters	0.0841	<0.01
Daphnia magna–Chronic	97.1	2 meters	0.0836	<0.01
Sheepshead minnow–Full Life Cycle	120	2 meters	0.0826	<0.01
Fathead minnow--Early Life Stage	118	2 meters	0.0826	<0.01
Shrimp –Acute	>189	1 foot	0.55	<0.01
		2 meters	0.0841	<0.01
Eastern Oyster--Shell deposition	>132	1 foot	0.55	<0.01
		2 meters	0.0841	<0.01
Aquatic Plants–Duckweed	0.024(EC50) / 0.01 (NOAEC)	1 foot	0.55	23[4] / 55[4]
		3 feet	0.18	8[4] / 18[4]
		2 meters	0.0841	4[4] / 9[4]
Aquatic Plants–Green algae	71	2 meters	0.0841	<0.01
Aquatic Plants–Navicula pelliculosa	>41	2 meters	0.0841	<0.01
Aquatic Plants–Skeletonema costatum	92	2 meters	0.0841	<0.01
Aquatic Plants--Blue-green algae	12.2	1 foot	0.55	0.05
		3 feet	0.18	0.01
		2 meters	0.0841	<0.01

[4] exceeds the LOC for risk to aquatic plants ($RQ \geq 1$)

Summary of Risks to Aquatic Organisms and Plants

Aquatic vascular plants are likely to be exposed to imazapyr as a result of its use from direct applications in shallow and deep water bodies. In standard water bodies of 2 meters water depth where emerged or floating plant inhabit, the risk quotient of 9 exceeds the LOC for potential risk to endangered aquatic vascular plants and the RQ of 4 exceeds the LOC for potential risk to non-target aquatic vascular plants. However, emerged and floating aquatic vascular plants are also found at the edges of water bodies, where water will be much shallower; based on a water depth of 1 foot, the RQ of 55 exceeds the LOC for endangered vascular plants and the RQ of 23 exceeds the LOC for non-target vascular plants. LOCs are not exceeded for aquatic non-vascular plants; thus, the proposed aquatic uses of imazapyr are not likely to pose risks to aquatic non-vascular plants.

For fish and aquatic invertebrates exposed to imazapyr, neither acute nor chronic LOCs were exceeded; thus, the proposed aquatic uses of imazapyr are not likely to pose direct risks to fish and invertebrates.

VI. TERRESTRIAL EXPOSURE AND RISK ASSESSMENT SUMMARY

Toxicity to Terrestrial Animals

Data submitted to the Agency show imazapyr is practically non-toxic to non-target animals. Based on the EFED review dated May 1997 (D227667) and the studies reviewed for this report (D275562), imazapyr is practically nontoxic to birds on both an acute exposure (LD_{50} > 2,150 mg/kg) and subacute dietary exposure (LC_{50} > 5,000 mg/kg of diet) basis. On a chronic exposure basis, no adverse effects were obsserved (NOAEC = 1670 ppm). Imazapyr is practically nontoxic (LD_{50} = >5000 mg/kg) to mammals on an acute exposure basis, and on a chronic exposure basis (NOAEC = 10,000 ppm) showed no significant effects. Imazapyr is practically nontoxic to bees (LD_{50} > 100 ug/bee) on an acute exposure basis.

Estimated Environmental Concentrations for Birds and Mammals

Terrestrial estimated environmental concentrations (EECs) of imazapyr in potential bird and mammal food items from single or multiple applications were determined using the ELL-FATE model. The EECs from the ELL-FATE model are based on predicted day-0 maximum residues following a single application of 1 pound of active ingredient per acre. These initial concentrations are based on work done by Hoerger and Kenaga (1972) as modified by Fletcher et al. (1994). The ELL-FATE model adjusts these predicted maximum residue values by the application rate and annual frequency of application for the use sites being modeled and assumes exponential decay following each application of pesticide at a rate based on the half-life data provided for the pesticide being modeled. These initial adjusted values, based on a single maximum annual application rate of 1.5 pounds of imazapyr per acre, are tabulated in the exposure column of Table 6. Details of the ELL-FATE model and EECs are presented in Appendix 7.

TABLE 6. Initial EECs on Avian and Mammalian Food Items Following a Single Application of Imazapyr at 1.5 lb ae/A

Food Items	EEC (ppm) Predicted Maximum Imazapyr EEC[1]
Short grass	360

Tall grass	165
Broadleaf/forage plants and insects	203
Fruits, pods, seeds, and large insects	23

Estimates of Risks to Birds and Mammals

A means of integrating the results of exposure (EEC) and toxicity data is called the quotient method. For this method, risk quotients (RQs) are calculated by dividing exposure estimates by toxicity values, both acute and chronic.

$$RQ = \text{EXPOSURE/TOXICITY}$$

The toxicity test values (i.e., measurement endpoints) used in the acute and chronic risk quotients are derived from the results of required studies. The EEC, toxicity, and risk quotient values are provided below in Table 7.

Table 7. Toxicity, Exposure, and Risk Quotient Values of Imazapyr

Species	**Toxicity**	**Exposure (ppm)**	**Risk Quotients (RQ)**
Northern bobwhite/ Mallard duck–Oral	>2150 mg/kg	360	<0.01
Bobwhite/Mallard–Dietary	>5000 ppm	360	<0.01
Northern bobwhite–Reproduction	>1670 ppm	360	≤0.22
Mammals–Oral and Reproduction	>5000 mg/kg / 10000 ppm	360	<0.01 / 0.04

Acute LOC for endangered species: $RQ \geq 0.05$
Chronic LOC for endangered species $RQ \geq 1$

Bird and Mammal Risk Assessment Summary

The acute and chronic RQs for imazapyr did not exceed the LOCs; thus, the proposed aquatic uses of imazapyr are not likely to pose acute or chronic risks to birds and mammals.

Assessment of Risks to Insects

Toxicity results for the honeybee are used for recommending appropriate label precautions. Because imazapyr is practically non-toxic to honeybees (LD50 >100 ug/bee) on an acute contact basis, precautionary labeling is not required..

Assessment of Risks to Terrestrial Plants

Toxicity to Terrestrial Plants

The tested terrestrial plants exhibited a wide range of sensitivity to imazapyr (see Appendix 8, Table 15). Seedling emergence EC25 values ranged from 0.093 (pea, shoot weight) to 0.0024 lbs ae/A (sugarbeet, shoot fresh weight), while seedling emergence NOAEC/EC05 values ranged from 0.0624 (pea, shoot height) to 0.000005 lbs ae/A (cucumber, shoot fresh weight). However, these toxicity values are less accurate and reliable because: 1) the seedlings were subjected to overcrowding and excessive competition since the area of the pot container may restrict seedling growth (4-inch diameter dixie cups were used to plant 10 seeds each cup); and 2) 'fresh weight' instead of 'dry weight' as the measurement endpoint for toxic effect which can vary due to plant moisture content.

In the first study (14D) with young plants, vegetative vigor EC25 values based on useful results from two species out of 10 species tested were 0.022 lbs ae/A (pea, shoot height), while NOAEC/EC05 values ranged from 0.0156 (pea, shoot height) to 0.00195 lbs ae/A (onion, shoot weight). However, the toxicity values are less accurate and reliable because the concentrations used in the 14 day study were not low enough to produce reliable results. Nine of the species lacked a sufficient dose response to calculate EC25 values and 8 of the species lacked a sufficient dose response to calculate NOAEC values.

In the second study (28D) with older plants, vegetative vigor EC25 values based on useful results from 7 species out of 10 species tested ranged from >0.0156 lb ae/A (corn, shoot weight) to 0.0009 lb ae/A (cucumber, shoot height), while NOAEC/EC05 values ranged from 0.0078 lb ae/A (corn, shoot weight) to 0.000064 lb ae/A (cucumber, shoot height). However, the toxicity values could be underestimated since the study was tested with older plants at a less sensitive stage of growth (timing of application) and based on 'fresh weight' instead of 'dry weight' as the measurement endpoint for toxic effect. Since this measurement endpoint can vary due to plant moisture content, the toxicity value is less accurate and reliable. Thus, an uncertainty is added to the risk assessment.

The sugarbeet and cucumber EC25 and NOAEC/EC05 toxicity values are used in the terrestrial plant risk assessment since both species were estimated to be the most sensitive species in the seedling emergence and vegetative vigor tests, respectively. The sugarbeet values were used in the seedling emergence test to measure the response of plants subjected to runoff into adjacent areas while cucumber values were used in the vegetative vigor test to measure the response of plants subjected to spray drift to adjacent areas. Thus, there is an uncertainty for the terrestrial plant risk assessment for potential risks to terrestrial plants inhabiting semi-aquatic areas from runoff and drift based on insufficient dose responses and unreliable toxicity values due to plant moisture content.

Estimated Environmental Concentrations for Terrestrial Plants

Terrestrial plant EECs of imazapyr from single or multiple applications were determined using the TerrPlant model (V.1.0). Details of the TerrPlant model and EECs are presented in Tables 8 and 9 and Appendix 11. The EECs from the model are based on the application rate and solubility of the pesticide in water and drift characteristics which depend on ground or aerial applications. The amount of imazapyr that runs off is a proportion of the application rate and is assumed to be 1%, 2%, or 5% for water solubility values of <10 ppm, 10-100 ppm, and >100 ppm, respectively. For imazapyr, a runoff value of 5% is assumed, based on its solubility of >100 ppm in water. Drift from ground and aerial applications are assumed to be 1% and 5%, respectively, of the application rate. An application efficiency of 60% is assumed for aerial application. In addition to considering where plants grow, exposure must be estimated to compare with results from two kinds of plant tests - a seedling emergence study and a vegetative vigor study. The seedling emergence study involves treating the soil in which seedlings grow, thus exposing the growing plant to the pesticide. The vegetative vigor study involves exposing only the foliage of actively growing plants off site to spray drift. Both spray drift and runoff are assumed to reach off-site soil.

Normally, for terrestrial use patterns when applications are occurring on land, runoff to semi-aquatic areas is assumed from 10 treated acres to a distant low-lying acre (10:1 ratio). However, this assessment is based on use patterns in semi-aquatic areas that terrestrial plants inhabit which could be periodically dry; therefore, runoff from a treated acre to an adjacent acre (1:1 ratio) is estimated instead of from 10 treated acres to a distant low-lying acre. The range of semi-aquatic areas apparently allowed by this broad proposed label represent much different exposure scenarios than open water bodies. These might include areas that go dry at times, which could lead to the potential for runoff at times.

Table 8. Estimated Environmental Concentrations (EECs) for Imazapyr spray applications (1.5 lbs ae/acre)

Application Rate	**Total Loading to Semi-Aquatic Area (EEC = Sheet Runoff + Drift)**	**Drift EEC (for ground: application rate x 0.01); (for aerial: application rate x 0.05)**
Ground Unincorporated	0.09	0.015
Aerial	0.12	.075

Estimates of Risks to Terrestrial Plants

A means of integrating the results of exposure (EEC) and toxicity data is called the quotient method. For this method, risk quotients (RQs) are calculated by dividing exposure estimates by toxicity values, both acute and chronic.

RQ = EXPOSURE/TOXICITY

The toxicity test values (i.e., measurement endpoints) used in the acute and chronic risk quotients are derived from the results of required studies. The EEC, toxicity, and risk quotient values are provided below in Table 9.

Table 9. Toxicity, Exposure, and Risk Quotient Values of Imazapyr

Species	Toxicity Values		Exposure (lbs ae/A)	Risk Quotients in Semi-Aquatic Areas (RQ)		
	Seedling emergence (lb ae/A)	Vegetative vigor (lb ae/A)		Runoff from ground application	Runoff from aerial application	drift from aerial/ground applications
Non-Endangered Terrestrial plants	0.0024	0.0009	see Table 2	38*	50*	83* / 17*
Endangered Terrestrial plants	0.00017	0.000064	see Table 2	529*	706*	1172* / 234*

* exceeds the LOC for risk to terrestrial or aquatic plants (RQ $\geq$ 1)

Terrestrial Plant Risk Assessment Summary

Considering the proposed aquatic uses of imazapyr in semi-aquatic areas, the LOC for potential risk to non-endangered and endangered terrestrial plants (LOC = 1) is exceeded for terrestrial plants for both ground and aerial application. Based on the seedling emergence study, the runoff EECs exceed the sugarbeet EC25 by greater than 50 times (RQs range from 38 to 50 for non-endangered terrestrial plants) and exceed the NOAEC/EC05 by up to 700 times (RQs range from 529 to 706 for endangered terrestrial plants) due to runoff from a semi-aquatic treated acre to an adjacent acre which would include wetlands and transitional areas, both of which can be periodically dry. Based on the vegetative vigor study, drift alone from the proposed aquatic use sites also presents a potential risk to both non-endangered and endangered terrestrial plants. The EECs exceed the vegetative vigor EC25 by up to 80 times (RQs range from 17 to 83 for non-endangered terrestrial plants) and exceed the NOAEC/EC05 by greater than 1100 times (RQs range from 234 to 1172 for endangered terrestrial plants) from drift alone. Thus, the proposed aquatic uses of imazapyr pose a potential risk to terrestrial plants.

Currently, EFED does not perform chronic risk assessments for terrestrial plants. Therefore no chronic RQ values for terrestrial plants are presented.

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