MIDPENINSULA REGIONAL OPEN SPACE DISTRICT
REQUEST FOR PROPOSALS & QUALIFICATIONS

August 11, 2017

INVITATION

The Midpeninsula Regional Open Space District is pleased to announce the opportunity to provide environmental review services under the California Environmental Quality Act (CEQA) for the addition of three new pesticides and two new amphibian species of special concern to the District's Integrated Pest Management Program and associated Environmental Impact Report.

PROJECT DESCRIPTION

Introduction

1. **Location.**
   The District is a public agency created in 1972 that has successfully protected and managed over 62,000 acres of diverse open space land and manages 26 open space preserves for low-intensity recreational use by the public. The District's boundary extends from San Carlos to Los Gatos and to the Pacific Ocean from south of Pacifica to the Santa Cruz County line. District lands provide permanently protected wildlife habitat, natural resources, watershed, and a variety of ecosystems.

2. **Brief Description of the Project.**
   Midpeninsula Regional Open Space District's Natural Resources Department is seeking online proposals to establish a contract through a competitive process for CEQA services. The overall goal of this proposal is to engage a consultant to prepare an analysis and an Addendum to the Environmental Impact Report (EIR) (or other appropriate CEQA document) on three new pesticides that the District is evaluating for potential inclusion on the Approved Pesticide list of the Integrated Pest Management Program. In addition, two species of special concern have recently been listed by the California Department of Fish and Wildlife and the District wishes to analyze potential impacts to these species which was not done in the EIR.

3. **Background.**
   The Midpeninsula Regional Open Space District (District) undertakes management activities to control noxious and invasive weeds and mobile vectors such as mosquitoes, wasps, and hornets that are a nuisance or risk to human and ecological health on District lands. Because of the importance of providing new methods of weed and vector control without causing undue adverse impacts to human and ecological health, the District intends to modify its Integrated Pest Management (IPM) Program with the most effective, least toxic, suite of new treatment options.

   Please see our EIR for the Integrated Pest Management Program:
   www.openspace.org/sites/default/files/IPM_EIR.pdf

A new toxicological analysis on the proposed new pesticides has been conducted and the report is provided as an attachment. Although this toxicological analysis reviewed four pesticides, the District has determined only three will be evaluated for CEQA: Garlon 4 Ultra, Capstone, and Wasp Freeze II. Python Dust Bags will not be evaluated and will not be included in the District's Approved Pesticides List.

Project Design Objectives and Requirements

While the IPM approach to land management can provide safer, more effective approaches to controlling unwanted vegetative and pest vectors, it is essential to understand the physical and chemical characteristics, relative toxicity, and possible adverse impacts to non-target receptors (i.e., humans, domestic pets, non-target wildlife and vegetation) of any pesticides that may be used. Under the District's IPM Program, the following objectives will be evaluated:

- Provide the most effective treatment of unwanted vectors with the safe and least toxic application techniques
- Reduce the potential for human and non-target animal exposure to chemicals
- Reduce the potential adverse impacts to humans, animals, and non-target vegetation
- Reduce the potential for human and non-target animal discomfort or injury from applications and from exposure to non-vegetative vectors.

Estimated Budget

The estimated budget for this project is projected at approximately $32,000.

Scope of Work

Provide consulting services for preparation of an Addendum and related findings and Notice of Determination (NOD) to the previously adopted 2014 Final EIR for the Midpeninsula Regional Open Space District Integrated Pest Management Program. If, after further review for consistency with the EIR, it is determined that a different form of CEQA documentation would be appropriate, consultant will notify the District and will coordinate to determine the appropriate approach.

Element 1: Develop a Project Description that documents and explains the minor modifications to the approved project, which would include the potential areas of change for environmental impact minimization or avoidance.

- Task 1: Develop a Project Description of the modifications to the approved project for evaluating the potential environmental impacts.
- Task 2: Attend a Project Coordination Meeting to evaluate the additions of three proposed pesticides and the inclusion of two new species of concern: California Giant Salamander and the Santa Cruz Black Salamander.
- Task 3: Analyze potential environmental impacts associated with these minor modifications to the project and evaluate the applicability of the mitigation measures identified for the originally proposed project analyzed in the NOP/IS for the EIR are still applicable to the modified project.
- Task 4: Determine whether the modified project would result in any new significant environmental impacts, substantial increases in the significance of previously identified

effects, or necessitate implementation of additional or considerably different mitigation or improvement measures than those identified in the Final EIR.

Element 2: Prepare Addendum to the Final EIR and support the District in preparations of Findings of Fact.

- Task 1: Administrative Draft Addendum for District staff and Legal review.
- Task 2: Screen-check Addendum for District staff and Legal review.
- Task 3: Public Draft Addendum (for Board action)
- Task 4: Findings of Fact for District staff and Legal review.
- Task 5: Attend Board public hearing to assist District staff with questions of environmental analysis and findings
- Task 6: File Notice of Determination (NOD) at the State Clearinghouse within five days after the project decision (assuming project approval). Submittal of the NOD initiates the 30-day Statute of Limitations.

SUBMISSION REQUIREMENTS

Please keep proposals to no more than twelve pages, not including qualifications.

Proposed Approach

Provide a description of how the project team intends to complete the work, including a detailed list of the necessary tasks to complete the project

Team Description

Provide a description of the team that addresses the following:

Project team structure. Provide an organizational chart or description of the probable team including subconsultants. Include all key project team members and explain their role and responsibility throughout the project. Identify the project team members who are the daily contacts.

Prior experience. Provide a summary of the background and specific pertinent expertise of key personnel, as well as a statement of their time commitment to the project. Include examples of the project team's previous experience with comparable projects. Include descriptive information such as the character of the project, the scope of involvement, location of the project, and the completion of the project. Project teams are encouraged to include illustrations or photographs of work designed and/or developed by team members. Provide a description of the firm's method of, and experience in, controlling project costs and schedules.

References. Provide a list of at least three current references that have relevant knowledge concerning the project team's ability to manage similar projects. Names, affiliations, addresses, and current telephone numbers of all references must be provided.

Qualifications

Provide a biography describing the project team members' individual qualifications and history, years in business, location(s), legal structure, ownership, organizational structure and key staff who would be committed to this project.

Project Fee

Provide a detailed estimated fee proposal that is divided by phase. The fee proposal should include all anticipated reimbursable expenses as a separate line item, the charge rates of the people who would perform the work (please identify tasks to be performed by sub-consultants), and a standard hourly rate schedule. Provide a description of the key assumptions used to calculate the project fee. If appropriate, identify cost saving strategies as well.

Insurance Requirements

Provide a statement of the firm's acceptance of the District's insurance and indemnification requirements, or any reservations the firm has with the requirements. Please see attached Midpeninsula Regional Open Space *District Professional Services Agreement Template*.

SELECTION PROCESS

This Request for Proposals is being distributed to firms who have come to our attention based on the quality of their work, and it is posted on the District website for wider dissemination in order to elicit proposals from interested and qualified firms. Proposers may be asked to make a general presentation of their plan to a selection committee and/or attend an interview. The selection committee reserves the right to have discussions with any or all of the proposers. The District will make a recommendation to the Board of Directors for approval of the consultant contract.

Evaluation Criteria

The goal for each firm should be to prepare a proposal that is comprehensive. The proposal should describe how the proposing firm would fulfill both the goals as explained in the scope of work, as well as the financial requirements and overall business approach. Once the proposals are received, the selection committee may require clarification and additional information. The proposals will be evaluated according to the criteria listed and described below. The order of the criteria listed below does not reflect a hierarchy for the final selection.

1. **Quality of Proposal**
    - Consistency with the objectives
    - Demonstrating an understanding of the project
    - Fulfilling proposal requirements as described in this RFP
    - Overall presentation

2. **Implementation Approach**
    - Organization, structure and responsibilities of the project team
    - Proposed approach
    - Proposed strategies to reduce time and costs

3. **Implementation Expertise**
    - Proven track record, the technical ability of the team to accomplish the District's goals
    - Background, qualifications, experience and expertise of the firm (including subconsultants) in similar projects
    - Project Fee

The selection of the team will not be based solely on the "lowest bid." Instead, the District intends select the best overall proposal package to achieve the project goals.

RFP and Contract Award Schedule
The following is a tentative schedule that is subject to change. The District will inform all teams of changes in the schedule by fax and correspondence.

8/21/2017	Deadline to submit Questions to District Representative
9/7/2017	Deadline to receive Proposals via e-mail: csifuentes@openspace.org
9/12/2017	Selection committee ranks proposers
9/14/2017	Begin negotiations towards executing a professional services agreement

STIPULATIONS

Interviews and Requests for Additional Information from the District
The District reserves the right to conduct personal interviews or require presentations of any or all proposers prior to the selection. The District reserves the right to request more detailed information from one or more proposers to provide for a reliable comparison between proposals.

General Stipulations
The District is not responsible for any expenses which proposers may incur in preparing and submitting the proposal. The District will not be liable for any costs incurred by the proposers that are related to the RFP process; this includes production of the proposal, interviews/presentations, travel and accommodations. The District reserves the right to request or negotiate modifications to the proposals that are deemed appropriate. All proposals received from proposers in response to this Request for Proposal will become the property of the District and will not be returned to the proposers. In the event of contract award, all documentation produced as part of the contract will become the exclusive property of the District. The District reserves the right to reject any and all proposals and to waive minor irregularities. The District also reserves the right to seek new proposals or re-advertise if responses have not been satisfactory or for any other reason.

Requests for Additional Information and Questions
Specific questions related to the RFP must be addressed in writing to the District. Answers will then be distributed to all teams. Additional and updated information will be provided to the teams via fax or email and correspondence. Please submit all requests to:

Coty Sifuentes-Winter
csifuentes@openspace.org
Midpeninsula Regional Open Space District
330 Distel Circle
Los Altos, CA 94022

PROPOSAL DEADLINE

Final proposal are to be submitted via e-mail by ***Thursday, 9/7/2017 at 2:00pm***, **to *Coty Sifuentes-Winter, IPM Coordinator, csifuentes@openspace.org***. The District at its sole discretion may grant an extension to all candidates if circumstances require additional time. Responding teams should assume that the District may initiate discussions simultaneously with all respondents.

PRE-PROPOSAL CONFERENCE

At this time, a pre-proposal conference has not been scheduled. Upon review of this Request for Proposal and Qualifications, a pre-proposal conference may be scheduled at the request of a firm. If a pre-proposal conference will be held, notification will be given to all interested firms.

PUBLIC RECORDS AND PROPRIETARY INFORMATION, INDEMNIFICATION

The District recognizes that proposers will occasionally believe that all or portions of their proposals are confidential or proprietary. This can present problems in participating in a public agency RFP process. All proposals, strategies, supporting information, rate schedules and other information and documents are presumptively public records under the California Public Records Act (Gov't Code section 6250 et seq.), subject to prompt disclosure upon request by any member of the public.

The District is not soliciting, does not wish to receive, and will not treat any information received under this proposal as proprietary or confidential information, unless specifically called for or expressly accepted by the District General Counsel in writing, and will be accepted and considered only when, in the sole discretion of the District it is necessary to serve the public purpose of the project. If the inclusion of confidential or proprietary information is determined to be necessary to the proposal, proposers must identify each and every specific item and each and every page, and segregate the information into a separate envelope or electronic file labeled conspicuously as confidential, with a cover page describing the information and applicable law exempting the same from disclosure. Any material marked or claimed as confidential or proprietary may be returned to the proposer by the District or destroyed and may not be considered in the review of proposals if the claim does not appear justified or would inhibit the public purposes of the project proposed.

If the documents have been properly marked and expressly accepted as confidential and proprietary in writing by the District General Counsel, the District will make its best effort to advise the proposer of any Public Records Act request, should any be received, seeking documents claimed to be confidential or proprietary, to give the proposer an opportunity to take legal steps to protect such property from disclosure to third-party requester. The District

expressly disclaims any duty and will not defend the confidentiality or proprietary nature of any information submitted. **By submitting any confidential or proprietary information to the District, the proposer agrees to holds harmless and indemnify and defend the District and its officers, employees, and agents for any and all costs, including attorneys fees,** incurred by the District or awarded to a Public Records Act requester relating to a request for release of proposer's data should the proposer ask the information to be handled as proprietary or confidential.

LIST OF ATTACHMENTS

1) District Professional Services Agreement Template
2) Pesticide Technical Background Information

Appendix D

Pesticide Technical Background Information

Appendix D

Pesticide Technical Background Information

June 13, 2017

Prepared for:

Midpeninsula Regional Open Space District
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Los Altos, CA 94022

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1 Introduction

The Midpeninsula Regional Open Space District (District) evaluates, recommends, and implements weed and vector control strategies based on currently available, effective, and least toxic pest management techniques. The District's modified Integrated Pest Management (IPM) Plan is intended to minimize risks associated with exposure to pesticide products that may adversely impact non-target receptors or the environment.

This appendix serves as a supplement to the pesticide technical background information presented in Appendix A and reviews the active ingredients of four candidate pesticides currently under consideration for use by the District. In a similar manner to that of Appendix A, each active ingredient is reviewed for its human and ecological toxicity, reported environmental fate and transport, and potential to impact water quality. Basic use information and exposure considerations for the candidate pesticides are also discussed.

Tables 1-1 and 1-2 summarize some of the characteristics of each new active ingredient for quick reference. Additional summary tables for human and ecological toxicity and for fate and transport in the environment are also presented at the beginning of each pesticide category chapter (Chapters 2 and 3) and the environmental fate chapter (Chapter 4), respectively. The references used in this evaluation are presented in Chapter 5. For a list of commonly used acronyms, abbreviations, and terms, see Chapter 6.

Refer to Chapter 1 (Introduction) of Appendix A for additional information on the District's IPM Plan and candidate pesticide review and evaluation process.

Table 1-1 Summary of Herbicides under Consideration for Use by the District

The table below provides a general overview of the characteristics of each herbicide being considered for use by the District. The categories in this table are supplemented in greater detail in the text. This table is intended for a "quick look" evaluation of the potential effects and toxicity to humans, wildlife, and some physiochemical characteristics of each candidate pesticide.

Active Ingredient, Product, and Manufacturer	***Mode of Action***	***Purpose***	***Toxicity Rank (Humans)***	***Toxicity (Non-Target Wildlife and Vegetation)***	***Solubility and Half-Life in Water***	***Persistence and Half-Life in Soil***	***Food Web Issues and Bioaccumulation Potential***	***Toxicity to Children***	***SDS Flags and Cautions***
Triclopyr Butoxyethyl Ester (Triclopyr BEE) *Garlon 4 Ultra* (Dow Agro)	Auxin growth hormone mimic	Selective post-emergent ***woody plant and broadleaf weed control***	Low to very low toxicity. No evidence of carcinogenicity, neurotoxicity, immunotoxicity	Low toxicity to birds, mammals, insects. Moderate toxicity to freshwater invertebrates. High toxicity to fish, estuarian/ marine invertebrates	Insoluble in water (solubility = 7.4 mg/L). Hydrolytic half-life @ 0.5 days	Low persistence and high binding affinity (K_{OC} = 640 to 1650). Aerobic half-life < 0.2 days	No bioaccumulation or food web impact expected due to rapid degradation. Concentrations in fish similar to concentrations in water	Toxicity in children similar to toxicity in adults	Warning-potential skin sensitization
Triclopyr Triethylamine Salt (Triclopyr TEA) *Capstone* (Dow Agro) (See Notes 1 and 2)	Auxin growth hormone mimic	Selective pre- and post-emergent ***broadleaf weed and woody plant control***	Low to very low toxicity. No evidence of carcinogenicity, neurotoxicity, immunotoxicity	Low to very low toxicity to birds, mammals, insects, fish, aquatic invertebrates	High water solubility (solubility = 412,000 mg/L). Dissipation within one minute in aqueous environment	Mobile but not persistent in soil (K_{OC} = 24 to 144). Average aerobic half-life @ 9.7 days	Very little potential for bioaccumulation or food web impact	Toxicity in children similar to toxicity in adults	Warning-potential eye irritation. Flammable

Note 1: Capstone contains both triclopyr TEA and aminopyralid. In contrast, triclopyr TEA is the sole active ingredient in products such as Garlon 3A. For example, as compared to Capstone, use limitations for products such as Garlon 3A are not as restrictive regarding use on or near water. When the use of Capstone is considered, information on both triclopyr TEA and aminopyralid should be reviewed.

Note 2: Triclopyr TEA found in products such as Garlon 3A has significantly different toxicity, environmental fate, and transport characteristics as compared to triclopyr BEE, which is the active ingredient in products such as Garlon 4 Ultra. Triclopyr TEA should not be confused with triclopyr BEE. Always read and follow product label instructions. Refer to Table 4-1 for a summary of the environmental fate and transport properties of each form of triclopyr.

Table 1-2 Summary of Insecticides under Consideration for Use by the District

The table below provides a general overview of the characteristics of each insecticide being considered for use by the District. The categories in this table are supplemented in greater detail in the text. This table is intended for a "quick look" evaluation of the potential effects and toxicity to humans, wildlife, and some physiochemical characteristics of each candidate pesticide.

Active Ingredient, Product, and Manufacturer	***Mode of Action***	***Purpose***	***Toxicity Rank (Humans)***	***Toxicity (Non-Target Wildlife and Vegetation)***	***Solubility and Half-Life in Water***	***Persistence and Half-Life in Soil***	***Food Web Issues and Bioaccumulation Potential***	***Toxicity to Children***	***SDS Flags and Cautions***
Zeta-Cypermethrin *Python Dust* (Y-Tex)	Disruption of voltage-gated sodium channels	Livestock insecticide. ***General insect control***	Moderate to low toxicity. Limited to no evidence of immunotoxicity. Possible human carcinogen	Low toxicity to mammals and birds. High toxicity to fish, aquatic invertebrates, honeybees	Negligible water solubility (solubility = 7.6 µg/L). Hydrolytic half-life >50 days	Binds strongly to organic carbon (K_{OC} = 20,800 to 385,000). Aerobic half-life @ 6 to 60 days	May bioconcentrate or bioaccumulate in biota	Toxicity in children similar to toxicity in adults	Danger-harmful if inhaled. May cause long-lasting harmful effects to aquatic life
Piperonyl Butoxide *Python Dust* (Y-Tex)	Micro-somal enzyme inhibitor	Pyrethrin and pyrethroid ***insecticide synergist***	Low toxicity. Skin and eye irritation possible. No evidence of neurotoxicity, mutagenicity. Some evidence of carcinogenicity	Non-toxic to birds and honey bees. Moderately toxic to fish. Moderately to highly toxic to aquatic invertebrates, amphibians	Low water solubility (solubility = 14.3 mg/L). Photolytic half-life @ 8.4 hours	Moderate sorption to soil and sediment (K_{OC} = 399 to 830). Aerobic half-life @ 14 days	Low potential for bioconcentration of parent compound or food web issues	Toxicity in children similar to toxicity in adults	Danger-Harmful if inhaled. May cause long-lasting harmful effects to aquatic life
Prallethrin *Wasp Freeze II* (BASF)	Disruption of voltage-gated sodium channels	***Wasp and hornet insecticide***	Moderate to low toxicity. Limited to no evidence of carcinogenicity, immunotoxicity. May be neurotoxic in high concentrations	Low to moderate toxicity to mammals. Low toxicity to birds. Highly toxic to fish, aquatic invertebrates, honeybees	Low water solubility (solubility = 8.03 mg/L). Photolytic half-life @ 0.57 days. Stable in neutral to acidic water	Strong affinity to sorb onto soil and sediment (K_{OC} = 3082). Aerobic half-life @ 9 days	Bioaccumulates moderately in fish (BCF = 1150)	Toxicity in children similar to toxicity in adults	Danger-may be fatal if swallowed and enters airways

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2 Herbicides

Table 2-1 Human Toxicity Summary of Herbicide Active Ingredients

Active Ingredient	Mammalian Oral LD50 (mg/kg)[A]	Mammalian Dermal LD50 (mg/kg)[B]	Mammalian Inhalation LC50 (mg/L)[A]	USEPA Toxicity Rating	Carcinogenic	Reproductive or Developmental Toxicity	Neurotoxic	Immunotoxic	Endocrine Disruption
Triclopyr butoxyethyl ester	803	>2,000	>4.8	Oral and dermal (III), inhalation (IV)	Not classifiable	No	No	No	No
Triclopyr triethylamine salt	1,847	>2,000	>2.6	Oral and dermal (III), inhalation (IV)	Not classifiable	No	No	No	No

Table 2-2 Ecotoxicity Summary of Herbicide Active Ingredients

Active Ingredient	Mammalian Oral LD50 (mg/kg)[A]	Mammalian Dermal LD50 (mg/kg)[B]	Mammalian Inhalation LC50 (mg/L)[A]	Avian LD50 (mg/kg)[C]	Fish LC50 (mg/L)[D]	Aquatic Invert EC50 (mg/L)[E]	Honeybee LD50 (µg/bee)	Other Receptors
Triclopyr butoxyethyl ester	803	>2,000	>4.8	735	0.36	12	>100	Dog NOAEL = 10 mg/kg/day
Triclopyr triethylamine salt	1,847	>2,000	>2.6	2,055	240	1,496	>100	Dog NOAEL = 10 mg/kg/day

A. Unless otherwise specified, values are for rats.
B. Unless otherwise specified, values are for rabbits.
C. Unless otherwise specified, values are for mallard duck or bobwhite quail.
D. Unless otherwise specified, values are for rainbow trout or bluegill sunfish
E. Values are for *Daphnia magna* or similar species.

2.1 Triclopyr Butoxyethyl Ester (Triclopyr BEE)

TRICLOPYR BUTOXYETHYL ESTER (TRICLOPYR BEE)

Example Product: *Garlon 4 Ultra* (60.45% Triclopyr Butoxyethyl Ester)

- **Signal Word:** CAUTION
- **Human Toxicity:** Low to very low toxicity. May cause skin sensitization and eye irritation. Not classified as to human carcinogenicity. No evidence of neurotoxicity, immunotoxicity, or endocrine disruption. Developmental and reproductive toxicity only at maternally toxic doses.
- **Ecological Toxicity:** Low to very low toxicity to birds and mammals. Very low toxicity to insects. Moderate to high toxicity to freshwater and estuarian/marine fish and estuarian/marine invertebrates. Low to moderate toxicity to freshwater invertebrates.
- **Water Pollution Potential:** Nearly insoluble in water and largely immobile in soil. Parent compound unlikely to contaminate groundwater or persist in surface runoff waters with proper application techniques.
- **Other Considerations:** Degradants may be more toxic than parent compound to mammals and chronically exposed aquatic life and have increased persistence and potential to impact groundwater or surface water quality.

2.1.1 Basic Use Information

> Example Product: *Garlon 4 Ultra*

> Typical Target Pests: Woody plants (e.g. blackberry, Scotch broom, French broom, tree-of-heaven), annual and perennial broadleaf weeds (e.g. mustard, purple loosestrife, ragweed, stinkwort)

> Signal Word: Caution – Avoid contact with skin, eyes, or clothing. See product label and SDS for additional information regarding safety precautions.

> Environmental Hazards: This pesticide is toxic to fish and has properties and characteristics associated with chemicals detected in groundwater. Do not apply directly to water, to areas where surface water is present, or to intertidal areas below the mean high water mark. Refer to product label and SDS for additional information on use restrictions.

> Application Rates: See specific product label for application rates, target plants, and methods of application.

> Application Locations: Non-crop areas, including industrial manufacturing and storage sites, rights-of-way such as electrical power lines, communication lines, pipelines, roadsides, railroads, fence rows, non-irrigation ditch banks, forests, and in the establishment and maintenance of wildlife openings. Use within these sites may include application to grazed areas.

> **Note:** Triclopyr BEE in products such as Garlon 4 Ultra has significantly different toxicity, environmental fate, and transport characteristics as compared to triclopyr TEA, which is the active ingredient in products such as Garlon 3A. Triclopyr BEE should not be confused with triclopyr TEA. Always read and follow product label instructions. Information on triclopyr TEA is presented in section 2.1 of Appendix D.

Triclopyr butoxyethyl ester (triclopyr BEE) is a selective, post-emergent, and systemic herbicide registered for use in agricultural and nonagricultural areas (Dow AgroSciences, 2008). It is applied to rangelands and pastures, rights-of-way, forestry, and turf. Triclopyr BEE is a plant growth regulator that functions by mimicking the auxin growth hormone in plants and disrupting

normal growth. It is used to control annual and perennial broadleaf weeds and woody plants and has low phytotoxicity to grasses (Dow AgroSciences, 2008). Triclopyr BEE is a pyridine herbicide and has low toxicity in humans (HSDB, 2010a). Based on the percent composition, there are several formulations of triclopyr BEE including: emulsifiable concentrate (e.g. Garlon 4 Ultra), formulation intermediate, and ready-to-use liquid (USEPA, 1998). In the environment, triclopyr BEE rapidly converts to triclopyr acid (triclopyr) and butoxyethanol. The primary degradant of triclopyr is 3,5,6-trichloro-2-pyridinol (TCP). Because triclopyr BEE, triclopyr acid, and TCP behave differently in the environment and may have varying degrees of toxicity in exposed organisms, each form will be included in the following discussion as necessary.

2.1.2 Exposure Considerations

Products containing triclopyr BEE are harmful when swallowed and can cause eye and skin irritation in exposed individuals. Applicators must comply with label-specific requirements for PPE when handling this chemical. Product-specific PPE may include but is not limited to: long-sleeved shirts, long pants, chemical-resistant gloves ≥14 mils in thickness, eye protection, shoes, and socks.

Nontarget receptors may be exposed to triclopyr and its degradants via direct application, spray drift, and runoff. Direct sprays may harm conifer trees. Triclopyr BEE is toxic to fish; therefore, care should be taken to avoid contamination of surface and groundwater during application or when cleaning application equipment.

USEPA (2009) made a May Affect determination for the endangered California Red Legged Frog based on direct effects of triclopyr use and a Likely to Adversely Affect determination based on indirect effects such as reduction in prey items and habitat. To minimize potential for drift into sensitive areas such as water bodies, residential areas, and habitats for endangered species, products containing triclopyr BEE should be applied when wind velocity is low and blowing away from the sensitive areas. Drift can also be reduced by using application equipment that produces large droplets, thickened spray mixtures, or high viscosity invert systems. With ground equipment, low spray boom positioning is recommended. **Always read and follow the product label instructions.**

2.1.3 Human Toxicity

USEPA (1998) classifies triclopyr BEE as Category III (low toxicity) for oral and dermal toxicity and as Category IV (very low toxicity) for inhalation toxicity. Exposure to triclopyr BEE during application may result in some eye irritation (Category III) and dermal sensitization. It is not irritating to the skin (Category IV). In humans, acute toxicity associated with oral exposure to triclopyr BEE is slightly lower than that of triclopyr acid. The LD50 for acute oral exposure to triclopyr BEE in male and female rats is 803 mg/kg; the oral LD50 for technical grade triclopyr is 729 mg/kg in male rats and 630 mg/kg in female rats (USEPA, 2002). Triclopyr BEE is slowly absorbed through the skin. The dermal LD50 for both triclopyr BEE and triclopyr acid in rabbits is >2,000 mg/kg (USEPA, 2002). In rats, the LC50 for inhalation of triclopyr BEE is >4.8 mg/L (USEPA, 2002).

The kidney and liver are the most sensitive organs to triclopyr exposure. The subchronic NOAEL for rats orally exposed to triclopyr BEE is 7 mg/kg/day in males and <7 mg/kg/day for females based on adverse hepatic effects reported at the 28 mg/kg/day dose level (USEPA, 2002). For triclopyr acid, a systemic LOAEL was established at 20 mg/kg/day based on a dietary subchronic exposure of Fischer rats to triclopyr technical (USEPA, 1998, 2002). No observable adverse effects were reported at the 5 mg/kg/day dose level. In a chronic toxicity study of beagle dogs orally administered triclopyr, a NOAEL of 10 mg/kg/day was established based on the decreased body weight gain and hematological parameters (male dogs), changes in clinical chemistry (male and female dogs), and liver histopathology (male and female dogs) observed at the 20 mg/kg/day dose level (USEPA, 1998, 2002).

Triclopyr is rapidly eliminated (average urinary excretion rate = 0.3 $hour^{-1}$) and has low potential to accumulate in humans (USFS, 2011). In rats exposed to repeated low oral doses of ^{14}C-triclopyr, >90% of the compound remained unmetabolized and was excreted in the urine within 24 hours (USEPA, 1998). Minimal but measurable levels of triclopyr residue were observed in perirenal fat tissues (male and female rats) and ovaries (female rats) in a dose-related manner.

Triclopyr is classified as a Group D chemical: not classifiable as to human carcinogenicity. This

classification was based on chronic toxicity/carcinogenicity studies in mice and rats orally dosed with triclopyr that resulted in only marginal evidence of carcinogenic potential. This classification is supported by assays demonstrating that both triclopyr BEE and triclopyr acid are non-mutagenic *in vivo* and *in vitro* (USEPA, 1998).

Developmental and reproductive toxicity may occur at dose levels that cause visible maternal toxicity. The developmental NOAEL of triclopyr BEE technical is 30 mg/kg, based on a developmental toxicity study in New Zealand White rabbits reporting decreased total live fetuses, increased total fetal deaths, and increased incidence of fetal and/or litter skeletal malformations at the 100 mg/kg dose level (USEPA, 1998, 2002). In a two-generation reproduction study in Sprague-Dawley rats, a parental systemic toxicity NOAEL of 5 mg/kg/day was determined based on the adverse effects observed in the kidney at the next dose level (LOAEL = 25 mg/kg/day; USEPA, 1998). Based on this study, USEPA's Reference Dose (RfD) Peer Review Committee established a chronic dietary RfD for triclopyr acid at 0.05 mg/kg/day (USEPA, 2002). The reproductive/systemic LOAEL is 250 mg/kg/day, based on decreased litter size, decreased body weight and weight gain, and decreased survival in both generations (NOAEL = 25 mg/kg/day; USEPA, 1998; USFS, 2011).

Similarly, developmental and reproductive studies have been used to develop acute dietary RfDs. For the general population, including infants and children, an acute RfD of 1 mg/kg/day was established based on a developmental toxicity study of rats exposed to triclopyr BEE (USEPA, 2002; USFS, 2011). In the study, fetal toxicity was reported at the 300 mg/kg/day dose level, while no observable adverse effects were reported at the 100 mg/kg/day dose level. For females of childbearing age (13-50 years), a two-generation reproductive study on rats exposed to triclopyr acid was used to develop the acute RfD of 0.05 mg/kg/day (USEPA, 2002). This value corresponds to the NOAEL of 5 mg/kg/day and is based on the increased incidence of rare malformations in second-generation pups observed at the 25 mg/kg/day dose level. USEPA (2002) also uses a modification of the acute and chronic RfD referred to as the aPAD and cPAD, respectively, to describe acceptable dietary exposures to TCP (aPAD = 0.025 mg/kg/day, cPAD = 0.012 mg/kg/day). The smaller aPAD and cPAD values for TCP relative to the greater acute and chronic RfD values for triclopyr products indicate that the degradant TCP is more toxic to humans than the parent compound triclopyr.

A summary of human toxicity associated with triclopyr BEE is presented in Table 2-1.

2.1.4 Ecological Toxicity

Acute contact with triclopyr is practically non-toxic to honeybees (LD50 > 100 µg/bee; USEPA, 1998). Results from toxicological studies indicate that triclopyr BEE is slightly toxic to birds on an acute oral basis (northern bobwhite quail LD50 = 735 mg/kg) and practically non-toxic on a subacute dietary basis (northern bobwhite quail LC50 = 5,401 mg/L; USEPA, 1998). In the mallard duck, triclopyr acid is also slightly toxic from acute oral exposure (LD50 = 1,698 mg/kg); it is slightly toxic to moderately toxic to avian species from subacute dietary exposure (northern bobwhite quail LC50 = 2,934 mg/L; mallard duck LC50 = 5,620 mg/L; USEPA, 1998). Similarly, TCP has low to very low toxicity to birds on an acute oral basis and low toxicity on a subacute dietary basis. In birds subject to repeated or continuous exposure to triclopyr (e.g. during breeding season or via animal feed), concentrations greater than 100 mg/L may adversely affect the number of surviving offspring; the mallard duck LOAEC for reproduction is 200 mg/L (USEPA, 1998).

USEPA (1998) used oral and reproductive rat studies to assess the acute and chronic toxicity of triclopyr to wild mammals (herbivores, insectivores, and granivores). Based on the oral LD50 of 729 mg/kg in male rats and 630 mg/kg in female rats, triclopyr is considered practically non-toxic to small mammals on an acute oral basis. At dose levels greater than 25 mg/kg/day, adverse reproductive/systemic effects have been observed in rats. These effects include decreases in litter size, body weight and weight gain, and litter survival rates spanning two generations (LOAEL = 250 mg/kg/day).

Triclopyr is not expected to bioaccumulate in aquatic organisms. Triclopyr BEE is moderately to highly toxic to freshwater fish on an acute basis. The LC50s for rainbow trout and bluegill sunfish acutely exposed to triclopyr BEE are 0.65 mg/L and 0.36 mg/L, respectively, indicating high toxicity (USEPA, 1998). Formulated triclopyr BEE products are moderately toxic to freshwater fish;

the most sensitive species to triclopyr BEE is the rainbow trout (LC50 = 1.29 mg/L; USEPA, 1998). Technical grade triclopyr is practically non-toxic to acutely exposed freshwater fish; the LC50 is 117 mg/L for rainbow trout and 148 mg/L for bluegill sunfish (USEPA, 1998). While less toxic than triclopyr BEE, the degradant TCP is more toxic than triclopyr acid to some aquatic organisms (USFS, 2011). The LC50 for rainbow trout exposed to 99.7% TCP is 1.5 mg-a.i./L and 12.6 mg-a.i./L for exposures to 99.9% TCP (USEPA, 1998). Triclopyr BEE is slightly to moderately toxic to freshwater aquatic invertebrates on an acute basis. The EC50 for triclopyr BEE in waterfleas has been reported at 12 mg/L (USEPA, 1998). Triclopyr acid (EC50 = 132.9 mg/L) and TCP have very low and low acute toxicities in freshwater invertebrates, respectively (USEPA, 1998).

Triclopyr BEE is highly toxic to estuarian/marine fish on an acute basis. In the tidewater silverside fish, the LC50 for triclopyr BEE exposure is 0.45 mg/L (USEPA, 1998). Moderate to high toxicity is expected in marine/estuarian invertebrates acutely exposed to triclopyr BEE. The LC50 associated with formulated triclopyr BEE products is 0.32 mg/L for the eastern oyster and 1.7 mg/L for the estuarian shrimp (USEPA, 1998). While chronic effects are not expected from a single application of triclopyr BEE, TCP may persist in aqueous environments at concentrations greater than 1% of the LC50 and may therefore have adverse impacts on fish species subject to repeated or prolonged exposures.

Exposure levels exceeding 0.88 mg/L may significantly impact the growth and reproduction of non-target vascular aquatic plants exposed to triclopyr BEE (*Lemna gibba* EC50 = 0.88 mg/L, NOAEC ≤ 0.16 mg/L; USEPA, 1998). Adverse effects on algae or diatoms may occur from exposure levels greater than 0.10 mg/L triclopyr BEE (*Navicula pelliculosa* EC50 = 0.1 mg/L, NOAEC = 0.002 mg/L) or 32.45 mg/L triclopyr acid (*Selenastrum capricornutum* EC50 = 32.5 mg/L, NOAEC = 7 mg/L; USEPA, 1998).

A summary of the ecological toxicity values discussed above is presented in Table 2-2.

2.1.5 Physical Properties/Environmental Fate and Transport

Compared to triclopyr TEA (vapor pressure < $1x10^{-8}$ mmHg), triclopyr BEE is more volatile with a vapor pressure of $3.6x10^{-6}$ mmHg (DPR, 1997; USEPA, 1998, 2009). Based on its low Henry's Law constant of $2.47x10^{-7}$ atm-m^3 mol^{-1}, triclopyr BEE is not expected to be found in air when label-specific application techniques are employed (DPR, 1997; USEPA, 1998). However, under certain circumstances that include high ambient air temperatures, triclopyr BEE may volatilize and drift to non-target plants. Drift can be mitigated by a number of practices including adjusting nozzle pressure and increasing droplet size. Always read and follow label directions.

Although triclopyr BEE is only slightly soluble in water (solubility = 7.4 mg/L; USEPA, 2009), solubility increases upon conversion to triclopyr acid (solubility = 440 mg/L; USEPA, 2009) and subsequent metabolism to TCP (solubility = 49,100 mg/L; USFS, 2011). In natural water (pH 6.7), triclopyr BEE is rapidly hydrolyzed to triclopyr with a half-life of 0.5 days (USEPA, 1998). This rate increases with increasing pH. Conversely, triclopyr acid is stable to hydrolysis and is primarily degraded by photolysis (half-life = 1.7 days in river water; USEPA, 2009). The half-life of TCP via photolysis is 2 hours (USFS, 2011). USEPA (1998) reports that in sterile aqueous buffer solutions at pH 5, triclopyr BEE is photodegraded with a half-life of 6.6 days. In many instances, reported values describing the environmental fate of triclopyr BEE, triclopyr acid, and its degradants are variable. By way of aerobic aquatic metabolism, the half-life of triclopyr acid has been reported at 142 days and 426 days (USEPA, 2009). While the high K_{OW} of triclopyr BEE (K_{OW} = 20,000) suggests its tendency to accumulate in fish, bioaccumulation is not expected to occur based on its rapid conversion to triclopyr acid (K_{OW} = 0.35; USEPA, 2009). The rate of triclopyr degradation is greatly reduced in anaerobic aquatic conditions. A half-life of 26.45 days and 1,300 days for triclopyr BEE and triclopyr acid, respectively, has been reported for anaerobic aquatic conditions (DPR, 1997; USEPA, 2009).

In soil, triclopyr BEE quickly hydrolyzes to triclopyr acid with a half-life of about 3 hours (DPR, 1997; USEPA, 1998). The foliar wash off fraction of triclopyr BEE is 70% (USFS, 2011). Triclopyr is readily absorbed by plant roots and is more persistent in soil than in water. Its major dissipation pathway in soil is aerobic microbial degradation. The half-life of triclopyr BEE has been reported at 0.9 hours in sandy loam soil and 1.4 hours in silt loam soil (USFS, 2011). Triclopyr

acid (half-life = 8 to 18 days) and TCP (half-life = 40 to 95 days) do not degrade as readily in this medium (USFS, 2011). In aquatic field dissipation studies, half-lives of triclopyr acid were reported at 0.5 to 3.5 days in lake water and 5 days in pond water; the half-life in pond sediment was 24 days (USEPA, 1998). Terrestrial field dissipation studies have indicated that the half-life of triclopyr BEE in bare-ground sandy loam soil is 1.1 days, while the half-life of total triclopyr (triclopyr BEE and triclopyr acid) is 10.6 days (USEPA, 1998). In bare-ground and vegetated loam plots treated with triclopyr BEE, total triclopyr half-lives were reported at about 2 weeks and 33 days, respectively (USEPA, 1998). The degradant TCP appears to be much more persistent in terrestrial environments. In forest soil, the half-lives of total triclopyr and TCP have been reported at 26 days and 85 days, respectively (USEPA, 1998).

Refer to Table 4-1 for a summary of the environmental fate characteristics described for triclopyr BEE above.

2.1.6 Water Pollution Potential

Improper use in areas where soils are permeable and/or where shallow groundwater is present may result in groundwater contamination. While triclopyr BEE has moderate sorption to organic material in soil (K_{OC} = 640 to 1650), triclopyr acid and TCP are expected to be more mobile based on their K_{OC} values of 25 to 134 and 81 to 242, respectively (DPR, 1997; USEPA, 2009). Sorption to soil increases with time. Because triclopyr is not particularly persistent, TCP has the most potential to contaminate groundwater. In field dissipation studies, triclopyr BEE was detected only in the top 7.5 cm of a bare-ground plot of sandy loam soil (USEPA, 1998). In general, neither triclopyr acid nor TCP were detected below the 45-cm or 30-cm soil depths, respectively. In a short grass loam soil plot, vertical movement of triclopyr acid and its degradants were typically limited to the upper 16 cm of soil. Persistence and likelihood of groundwater contamination will increase if triclopyr or TCP reach deeper soil levels with anaerobic conditions, but they are not expected to occur in concentrations high enough to induce toxicity; therefore, USEPA (1998) does not consider triclopyr a concern for drinking water that is derived from groundwater sources. In a groundwater monitoring survey of 379 wells in four states, low but detectable levels of triclopyr were reported in 5 wells (maximum concentration = 0.58 µg/L; USEPA, 1998).

Since neither triclopyr acid nor TCP adsorb strongly to soil and sediment particles, they may contaminate surface water due to runoff from treated fields. Rice field dissipation studies indicate that TCP may persist in flood waters due to triclopyr's rapid photolytic degradation in aquatic environments (USEPA, 1998). In California surface water samples collected from 1993 to 2006, 102 out of 583 samples had detectable levels of triclopyr (USEPA, 2009). The highest concentration reported was 14.5 µg/L.

2.2 Triclopyr Triethylamine Salt (Triclopyr TEA)

TRICLOPYR TRIETHYLAMINE SALT (TRICLOPYR TEA)

Example Product: *Capstone* (16.22% Triclopyr Triethylamine Salt, 2.22% Aminopyralid Triisopropanolamine Salt*)

- **Signal Word:** CAUTION
- **Human Toxicity:** Low to very low toxicity. May cause skin sensitization and severe eye irritation. Not classified as to human carcinogenicity. No evidence of neurotoxicity, immunotoxicity, or endocrine disruption. Developmental and reproductive toxicity only at maternally toxic doses.
- **Ecological Toxicity:** Very low toxicity to birds, mammals, insects, freshwater invertebrates, and fish. Low to very low toxicity to estuarian/marine invertebrates.
- **Water Pollution Potential:** Very soluble in water and mobile in soil. Parent compound unlikely to contaminate groundwater or persist in surface runoff waters with proper application techniques due to rapid dissipation.
- **Other Considerations:** Degradants may be more toxic than parent compound to mammals and chronically exposed aquatic life and have increased persistence and potential to impact groundwater or surface water quality.

*For information on aminopyralid, refer to section 2.2 of Appendix A

2.2.1 Basic Use Information

> Example product: *Capstone*

> Typical target pests: Annual and perennial broadleaf weeds (e.g. teasel, tansy ragwort, mullein), woody plants and vines (e.g. blackberry, locust, Scotch broom)

> Signal word: Caution – Avoid contact with eyes, skin, or clothing. See product label and SDS for additional user safety recommendations.

> Environmental hazards: This product has properties and characteristics associated with chemicals detected in groundwater. Do not apply directly to water, to areas where surface water is present, or to intertidal areas below the mean high water mark. Refer to product label and SDS for additional information on use restrictions.

> Application rates: See specific product label for application rates, target plants, and methods of application.

> Application locations: Rangeland, permanent grass pastures, Conservation Reserve Program (CRP), forests, and non-cropland areas. Use within the above sites may include applications to seasonably dry wetlands (flood plains, marshes, swamps, bogs), dry transitional areas between upland and lowland sites, and around standing water (deltas, riparian areas).

> **Important Notes:**

> Capstone contains both triclopyr TEA and aminopyralid. In contrast, triclopyr TEA is the sole active ingredient in products such as Garlon 3A. For example, as compared to Capstone, use limitations for products such as Garlon 3A are not as restrictive regarding use on or near water. When the use of Capstone is considered, information on both triclopyr TEA and aminopyralid should be reviewed.

> Triclopyr TEA found in products such as Garlon 3A has significantly different toxicity, environmental fate, and transport characteristics as compared to triclopyr BEE, which is the active ingredient in products such as Garlon 4 Ultra. Triclopyr TEA should not be confused with triclopyr BEE. Always read and follow product label instructions. Information on triclopyr BEE is presented in section 2.1 of Appendix D.

Triclopyr triethylamine salt (triclopyr TEA) is a selective, pre- and post-emergent, and systemic herbicide registered for use in agricultural and nonagricultural areas (Dow AgroSciences, 2015a). Triclopyr TEA is a plant growth regulator that functions by mimicking the auxin growth hormone in plants, thereby disrupting plant growth. It is used to control annual and perennial broadleaf weeds and woody plants and vines (Dow AgroSciences, 2015a). Triclopyr TEA is a pyridine herbicide and has low toxicity in humans (HSDB, 2010a). It is available in a variety of formulations including: soluble concentrate, emulsifiable concentrate, liquid (pressurized and ready to use), granular, formulation intermediate, wettable powder, and pelleted (USEPA, 1998). In the environment, triclopyr TEA rapidly dissociates to triclopyr acid (triclopyr) and triethanolamine. The major degradant of triclopyr is 3,5,6-trichloro-2-pyridinol (TCP). Because triclopyr TEA, triclopyr acid, and TCP each have a unique environmental fate and may have different toxicological effects in exposed organisms, each form will be included in the following discussion as necessary.

2.2.2 Exposure Considerations

Products containing triclopyr TEA are harmful when swallowed and can cause eye and skin irritation in exposed individuals. Based on label-specific requirements, applicators may be required to wear long-sleeved shirts, long pants, chemical-resistant gloves ≥14 mils in thickness, eye protection, shoes, and socks when handling this pesticide.

Nontarget receptors may be exposed to triclopyr and its degradants via direct application, spray drift, and runoff. To minimize potential for drift into sensitive areas such as water bodies, residential areas, and habitats for endangered species, triclopyr TEA products should be applied when wind velocity is low and blowing away from the sensitive areas. This is particularly important for the endangered California Red Legged Frog, for instance, since USEPA (2009) made a May Affect determination based on direct effects of triclopyr use and a Likely to Adversely Affect determination based on indirect effects such as reduction in prey items and habitat for this species.

Triclopyr TEA is highly effective against may broadleaf plant species; therefore, precautions must be taken to protect nontarget plants from spray drift. With ground equipment, low spray boom positioning is recommended. Keeping spray pressures low also minimizes drift by providing coarse spray droplets. In aqueous environments, triclopyr TEA rapidly degrades to triclopyr acid, which can be carried in runoff waters and may injure susceptible crops and other plants, such as grapes, soybeans, tobacco, and sensitive ornamentals. To minimize runoff potential, products containing triclopyr TEA should not be applied during periods of heavy rainfall, to impervious surfaces, or to soils saturated with water or not readily penetrated by rainfall. Care should be taken to prevent contamination of water intended for irrigation or domestic purposes. **Always read and follow the product label instructions.**

2.2.3 Human Toxicity

USEPA (1998) classifies triclopyr TEA as Category III (low toxicity) for oral and dermal toxicity and as Category IV (very low toxicity) for inhalation toxicity. While triclopyr TEA is not a dermal irritant (Category IV), it is corrosive to the eye (Category I) and may cause dermal sensitization. The LD50 for acute oral exposure to triclopyr TEA in male and female rats is 1,847 mg/kg (USEPA, 2002). Because this value is higher than the oral LD50s for male and female rats exposed to technical grade triclopyr acid (male rat LD50 = 729 mg/kg, female rat LD50 = 630 mg/kg), triclopyr acid is considered more toxic to humans than triclopyr TEA via this route of exposure (USEPA, 2002). Based on acute dermal exposure to either triclopyr acid or TEA in rabbits, the dermal LD50 for both forms is >2,000 mg/kg; the acute inhalation LC50 in male and female rats is >2.6 mg/L (USEPA, 2002).

The kidney and liver are the most sensitive organs to triclopyr exposure. A systemic LOAEL was established at 20 mg/kg/day based on effects in the kidney reported after a dietary subchronic exposure of Fischer rats to triclopyr technical (USEPA, 1998, 2002). The NOAEL in this study was 5 mg/kg/day. In a chronic toxicity study of beagle dogs orally administered triclopyr, decreased body weight gain and hematological parameters (male dogs), changes in clinical chemistry (male and female dogs), and liver histopathology (male and female dogs) was reported at the 20 mg/kg/day dose level (NOAEL = 10 mg/kg/day; USEPA, 1998, 2002). Triclopyr is rapidly eliminated (average urinary excretion rate = 0.3 $hour^{-1}$) and has low potential to accumulate in humans (USFS, 2011). In rats

exposed to repeated low oral doses of ^{14}C-triclopyr, >90% of the compound remained unmetabolized and was excreted in the urine within 24 hours (USEPA, 1998). Minimal but measurable levels of triclopyr were observed in perirenal fat tissues (male and female rats) and ovaries (female rats) in a dose-related manner.

Triclopyr is classified as a Group D chemical – not classifiable as to human carcinogenicity – based on chronic toxicity/carcinogenicity studies in mice and rats orally dosed with triclopyr that resulted in only marginal evidence of carcinogenic potential. This classification is supported by assays demonstrating that triclopyr is non-mutagenic both *in vivo* and *in vitro* (USEPA, 1998).

Developmental and reproductive toxicity may occur at dose levels that cause visible maternal toxicity. The developmental NOAEL for triclopyr TEA is 30 mg/kg, based on a developmental toxicity study in New Zealand White rabbits reporting based on the decreased number of live implants, decreased live fetuses, and increased embryonic deaths at the 100 mg/kg dose level (USEPA, 1998, 2002). In a two-generation reproduction study in Sprague-Dawley rats, a parental systemic toxicity LOAEL of 25 mg/kg/day was determined for triclopyr acid based on the adverse effects observed in the kidney at this next dose level (NOAEL = 5 mg/kg/day; USEPA, 1998, 2002). Based on this study, USEPA's Reference Dose (RfD) Peer Review Committee established a chronic dietary RfD for triclopyr at 0.05 mg/kg/day (USEPA, 1998, 2002). The reproductive/systemic LOAEL is 250 mg/kg/day, based on decreased litter size, decreased body weight and weight gain, and decreased survival in both generations (NOAEL = 25 mg/kg/day; USEPA, 1998; USFS, 2011).

Developmental and reproductive studies have also been used as the basis for the acute dietary RfDs for the general population, including infants and children, and for females of childbearing age (13 to 50 years). An acute RfD of 1 mg/kg/day was established for the general population based on a developmental toxicity study in rats exposed to the ester form of triclopyr (USEPA, 2002; USFS, 2011). This value corresponds to the NOAEL of 100 mg/kg/day and is protective of the fetal toxicity reported at the 300 mg/kg/day dose level. A two-generation reproductive study on rats exposed to triclopyr acid was used to determine the acute RfD of 0.05 mg/kg/day for women aged 13 to 50 (USEPA, 2002). The NOAEL of 5 mg/kg/day was determined based on the increased incidence of rare malformations in second-generation pups observed at the 25 mg/kg/day dose level. USEPA (2002) also uses a modification of the acute and chronic RfD referred to as the aPAD and cPAD, respectively, to describe acceptable dietary exposures to TCP. For both acute and chronic exposures, the RfD analogs for TCP (aPAD = 0.025 mg/kg/day, cPAD = 0.012 mg/kg/day) are lower than the RfDs established for triclopyr acid, indicating that the degradant TCP is more toxic to mammals than the parent compound triclopyr (USEPA, 2002).

A summary of human toxicity associated with triclopyr TEA is presented in Table 2-1.

2.2.4 Ecological Toxicity

Triclopyr TEA is relatively acutely non-toxic to honeybees (LD50 > 100 µg/bee; USEPA, 1998). Triclopyr TEA is practically non-toxic to birds on an acute and subacute oral basis. The acute oral LD50 in the mallard duck is 2,055 mg/kg; the subacute LC50 is > 10,000 mg/L in the mallard duck and 11,622 mg/L in the northern bobwhite quail (USEPA, 1998). Triclopyr acid is slightly toxic to birds with acute oral exposure (mallard duck LD50 = 1,698 mg/kg) and slightly toxic to moderately toxic with subacute dietary exposure (northern bobwhite quail LC50 = 2,934 mg/L; mallard duck LC50 = 5,620 mg/L; USEPA, 1998). TCP has low to very low toxicity to birds on an acute oral basis and low toxicity on a subacute dietary basis. Concentrations greater than 100 mg/L may adversely affect the number of surviving offspring in birds chronically exposed to triclopyr (mallard duck reproduction LOAEC = 200 mg/L; USEPA, 1998).

USEPA (1998) used oral and reproductive rat studies to assess the acute and chronic toxicity of triclopyr to wild mammals (herbivores, insectivores, and granivores). Based on the oral LD50 of 729 mg/kg in male rats and 630 mg/kg in female rats, triclopyr is considered practically non-toxic to small mammals on an acute oral basis; however, chronic effects may occur at dose levels greater than 25 mg/kg/day. In rats chronically exposed to 250 mg/kg/day, adverse reproductive/systemic effects such decreases in litter size, body weight and weight gain, and litter survival rates spanning two generations have been reported.

Triclopyr is not expected to bioaccumulate in aquatic organisms. Triclopyr TEA is practically non-toxic to freshwater fish on an acute basis. The most sensitive species to acute flow-through exposure to triclopyr TEA is the rainbow trout (LC50 = 240 mg/L; USEPA, 1998). The LC50s for fathead minnows in flow-through and static tests are 279 mg/L and 544 mg/L, respectively. Similarly, triclopyr acid is practically non-toxic to acutely exposed freshwater fish (rainbow trout LC50 = 117 mg/L; USEPA, 1998). Relative to triclopyr TEA and triclopyr acid, TCP has higher toxicity in aquatic organisms; the LC50 for rainbow trout exposed to TCP is 1.5 mg/L (USEPA, 1998). Results from freshwater fish early life stage toxicity tests indicate that triclopyr TEA may affect fish lengths at concentrations exceeding 104 mg/L (fathead minnow NOAEC > 104 mg/L, LOAEC < 162 mg/L; USEPA, 1998). Triclopyr TEA is practically non-toxic to freshwater aquatic invertebrates on an acute basis. The EC50 for waterfleas acutely exposed to triclopyr TEA is 1,496 mg/L (USEPA, 1998). Aquatic invertebrate reproductive impairment has been reported at dose levels greater than 80.7 mg/L (waterflea NOAEC = 80.7 mg/L, LOAEC = 149 mg/L; USEPA, 1998). In addition, the degradant TCP may persist in aqueous environments at concentrations greater than 1% of the LC50 and may adversely impact fish species subject to repeated or prolonged exposures.

Triclopyr TEA is practically non-toxic to estuarian/marine fish on an acute basis. In the tidewater silverside fish, the LC50 from triclopyr TEA exposure is 13 mg/L (USEPA, 1998). Low to very low toxicity is expected in marine/estuarian invertebrates acutely exposed to triclopyr TEA. The eastern oyster is the most sensitive species to acute triclopyr TEA exposure with an LC50 of 58 mg/L; the LC50 for grass shrimp is 326 mg/L (USEPA, 1998).

Results from non-target aquatic plant toxicity tests indicate that exposure levels of 8.80 mg/L triclopyr TEA or greater may adversely impact the growth and reproduction of vascular aquatic plant species (*Lemna gibba* EC50 = 8.8 mg/L, NOAEC = 3.5 mg/L; USEPA, 1998). Algae or diatoms may be affected at levels greater than 5.9 mg/L triclopyr TEA (*Anabaena flos-aquae* NOAEC = 2 mg/L) or 32.45 mg/L triclopyr (*Selenastrum capricornutum* EC50 = 32.5 mg/L, NOAEC = 7 mg/L; USEPA, 1998).

A summary of the ecological toxicity values discussed above is presented in Table 2-2.

2.2.5 Physical Properties/Environmental Fate and Transport

Compared to triclopyr BEE (vapor pressure = 3.6×10^{-6} mmHg), triclopyr TEA is significantly less volatile with a vapor pressure of $<1 \times 10^{-8}$ mmHg (USEPA, 1998). Based on its low Henry's Law constant of 1.15×10^{-14} atm-m^3 mol^{-1}, triclopyr TEA is not expected to be found in air when label-specific application techniques are employed (USFS, 2011).

Triclopyr TEA is very soluble in water (solubility = 412,000 mg/L); however, it rapidly transforms into the moderately soluble triclopyr acid (solubility = 440 mg/L; USEPA, 2009). Degradation of triclopyr then yields the more-soluble metabolite TCP (solubility = 49,100 mg/L; USFS, 2011). Triclopyr TEA transforms rapidly (<1 minute) to triclopyr acid and triethanolamine in aqueous conditions; therefore, its behavior in water reflects that of triclopyr acid (DPR, 1997; USEPA, 1998). The major route of triclopyr degradation in water is photolysis. In river water, its half-life is 1.7 days (USEPA, 2009). The half-life of TCP via photolysis is 2 hours (USFS, 2011). Neither triclopyr TEA nor triclopyr acid are expected to accumulate in fish (triclopyr TEA K_{OW} = 1.23, triclopyr acid K_{OW} = 0.35; DPR, 1997; USFS, 2011). In anaerobic conditions, the degradation rate of triclopyr is greatly reduced (half-life = 1,300 days; USEPA, 2009).

Triclopyr is readily absorbed by plant roots. Although reported values describing the environmental fate of triclopyr TEA, triclopyr, and its degradants are variable, study results indicate that persistence in soil exceeds that in water. In sandy loam soil and silt loam soil, half-lives for triclopyr TEA have been reported at 5.6 days and 13.7 days, respectively (USFS, 2011). Soil half-lives range from 8 to 18 days for triclopyr and from 40 to 95 days for TCP (USEPA, 2009; USFS, 2011). In field dissipation studies of rice water flood plots treated with triclopyr TEA, the half-life of residual triclopyr was calculated at <8 days in water and <12 days in soil (USEPA, 1998). In another study, the half-life of triclopyr in pond water was reported at 5 days; the half-life in pond sediment was 24 days (USEPA, 1998). In lake water treated with triclopyr TEA, triclopyr has a reported half-life of 0.5 to 3.5 days; TCP was not detected after 1 day (USEPA, 1998).

Refer to Table 4-1 for a summary of the environmental fate characteristics described for triclopyr TEA above.

2.2.6 Water Pollution Potential

Since triclopyr TEA, triclopyr acid, and TCP are soluble and have comparable K_{OC} values (triclopyr TEA K_{OC} = 24 to 144, triclopyr acid K_{OC} = 25 to 134, TCP K_{OC} = 81 to 242), they are all expected to be mobile in soil (DPR, 1997; USEPA, 2009). The foliar wash off fraction of triclopyr TEA is 95%; however, triclopyr TEA will not persist as the TEA salt under normal environmental conditions (USFS, 2011). Since triclopyr and TCP are very mobile in soil, groundwater contamination may occur if products containing triclopyr TEA are improperly used in areas where soils are permeable, especially where the water table is shallow.

Triclopyr sorption to soil increases with time. In field dissipation studies, triclopyr and TCP residues were generally limited to the upper 45-cm and 30-cm soil depths, respectively (USEPA, 1998). In a short grass loam soil plot, triclopyr and its degradants typically remained in the upper 16 cm of soil. Although persistence and likelihood of groundwater contamination will increase if triclopyr or TCP reach deeper soil levels with anaerobic conditions, they are not expected to be occur in concentrations high enough to induce toxicity; therefore, USEPA (1998) does not consider triclopyr a concern for drinking water that is derived from groundwater sources. A maximum concentration of 0.58 µg/L was detected in a groundwater monitoring survey of 379 wells in four states (USEPA, 1998). In total, triclopyr residues were found in five wells. Since neither triclopyr nor TCP adsorb to soil and sediment particles, they may contaminate surface runoff waters; however, triclopyr is not expected to persist. Concentrations of triclopyr up to 14.5 µg/L have been detected in some California surface water samples collected in six counties from 1993 to 2006 (USEPA, 2009).

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3 Insecticides

Table 3-1 Human Toxicity Summary of Insecticide Active Ingredients

Active Ingredient	Mammalian Oral LD50 (mg/kg)[A]	Mammalian Dermal LD50 (mg/kg)[B]	Mammalian Inhalation LC50 (mg/L)[A]	USEPA Toxicity Rating	Carcinogenic	Reproductive or Developmental Toxicity	Neurotoxic	Immunotoxic	Endocrine Disruption
Zeta-cypermethrin	247 – 309	2460	>2.5	Oral (II), dermal (III), inhalation (IV)	Possible human carcinogen	No	Yes	Little to no evidence	Little to no evidence
Piperonyl butoxide	4,570 – 7,220	>2,000	>5.9	Oral and dermal (III), inhalation (IV)	Possible human carcinogen	No	No	Little to no evidence	No
Prallethrin	460 – 640	>5,000	0.658 – 0.855	Oral and inhalation (II), dermal (IV)	No	No	Yes	No	Little to no evidence

Table 3-2 Ecotoxicity Summary of Insecticide Active Ingredients

Active Ingredient	Mammalian Oral LD50 (mg/kg)[A]	Mammalian Dermal LD50 (mg/kg)[B]	Mammalian Inhalation LC50 (mg/L)[A]	Avian LD50 (mg/kg)[C]	Fish LC50 (mg/L)[D]	Aquatic Invert EC50 (mg/L)[E]	Honeybee LD50 (µg/bee)	Other Receptors
Zeta-cypermethrin	247 – 309	2460	>2.5	>20,000	0.00082	0.00026	0.023	Sheepshead minnow LC50 = 0.95 µg/L
Piperonyl butoxide	4,570 – 7,220	>2,000	>5.9	>2,250	1.9	0.51	>25	Western Chorus frog tadpole LC50 = 0.21 mg/L
Prallethrin	460 – 640	>5,000	0.658 – 0.855	1171	0.012	0.0062	0.028	Mysid shrip LC50 = 3.9 µg/L

A. Unless otherwise specified, values are for rats.
B. Unless otherwise specified, values are for rabbits.
C. Unless otherwise specified, values are for mallard duck or bobwhite quail.
D. Unless otherwise specified, values are for rainbow trout or bluegill sunfish
E. Values are for *Daphnia magna* or similar species.

3.1 Zeta-Cypermethrin

ZETA-CYPERMETHRIN

Example Product: Python Dust (0.075% Zeta-Cypermethrin, 0.15% Piperonyl Butoxide*)

- **Signal Word:** CAUTION
- **Human Toxicity:** Moderately toxic through oral route. Low toxicity through dermal and inhalation routes. Skin and eye irritation possible. Developmental and reproductive toxicity only at doses that cause maternal toxicity. Possible Human Carcinogen.
- **Ecological Toxicity:** Low toxicity in mammals and birds. Very high toxicity in fish and aquatic invertebrates, terrestrial invertebrates, and honeybees.
- **Water Pollution Potential:** Low water solubility, but strongly adsorbs to soil. Not often found in surface and groundwater. Slow degradation in water.
- **Other Considerations:** Not to be used in or near aquatic systems due to high fish and aquatic invertebrate toxicity. To protect the environment, do not allow the pesticide to run off into storm drains, drainage ditches, or surface waters.

*For information on piperonyl butoxide, refer to section 3.2 of Appendix D

3.1.1 Basic Use Information

> Example Product: *Python Dust*

> Typical target pests: Horn flies, lice, ticks, keds, face flies, stable flies, and other nuisance flies

> Signal word: Caution – Harmful if absorbed through the skin. Avoid contact with eyes, skin, or clothing. Wash thoroughly with soap and water after handling. See product label and SDS for additional information regarding safety precautions.

> Environmental hazards: This pesticide is extremely toxic to aquatic organisms. Do not contaminate water by cleaning of equipment or disposal of wastes. Do not allow the pesticide to enter or run-off into storm drains, drainage ditches, gutters, or surface waters.

> Application rates: See specific product label for application rates, target pests, and methods of application.

Zeta-cypermethrin is a non-selective insecticide and synthetic pyrethroid, used in both agricultural and non-agricultural settings. In residential settings, it is typically for used for control of ants, cockroaches, fleas, and control of subterranean termites and other insect pests (USEPA, 2006a, 2012). In agricultural settings, it is used primarily on cotton crops, and is also used on pecans, peanuts, broccoli, cabbage, lettuce, citrus, peppers, sweet corn, and livestock. Zeta-cypermethrin alters nerve function by modifying the normal biochemistry and physiology of nerve membrane voltage-gated sodium channels (USEPA, 2006a). Zeta-cypermethrin also works by inhibiting ATPase enzymes from maintaining an ion balance between membranes. Zeta-cypermethrin is a specific S-enantiomer of cypermethrin, which has the same toxicological endpoints regarding human health and environmental fate (USEPA, 2006a). Therefore, data for the two compounds cypermethrin and zeta-cypermethrin are considered interchangeable.

3.1.2 Exposure Considerations

Zeta-cypermethrin is extremely toxic to aquatic organisms, including fish and invertebrates (Y-Tex, 2011, 2014). To protect sensitive species, do not allow the pesticide to run off into storm drains, drainage ditches, gutters, or surface waters, or where habitat can occur (USEPA,

2006a). Do not apply near storm drains, rivers, fish ponds, lakes, streams, reservoirs, marshes, estuaries, bays, or oceans. Apply the pesticide in calm weather, when rain is not predicted to fall after application to ensure the pesticide is not washed off the treatment area. Do not apply when windy. After application, do not over-water the treated area to the point of runoff.

Applicators and handlers of this pesticide should wear appropriate personal protective equipment (PPE), including chemical resistant gloves and baseline attire, including a long-sleeved shirt, long pants, shoes, and socks (USEPA, 2006a). Handlers should wash their hands before eating, drinking, chewing gum, using tobacco, or using the toilet. Users should remove clothing immediately if the pesticide is inside the clothing. Users should also remove PPE immediately after handling the product, and as soon as possible wash thoroughly and change into clean clothing (Y-Tex, 2011, 2014). Users should keep and wash PPE according to the manufacturer's instructions. If instructions do not exist, PPE should be washed in detergent, separate from other clothing.

To reduce spray drift, use decreased application rates and increased application intervals. A constructed and maintained vegetative barrier may prevent spray drift into other fields. Specified minimum allowable droplet size, maximum allowable wind speed, release height, and buffer zone instructions on labels should be followed (USEPA, 2006a). **Always read and follow the product label instructions.**

3.1.3 Human Toxicity

Zeta-cypermethrin is a neurotoxin that acts by damaging voltage-gated sodium channels, causing the channels to stay open for prolonged periods of time and producing trains of repetitive nerve impulses (DPR, 1999). Zeta-cypermethrin also inhibits ATPase enzymes, disrupting the ability to maintain ion balances (DPR, 1999).

Zeta-cypermethrin has low to very low acute toxicity through dermal and inhalation routes, and is moderately toxic through the oral route (USEPA, 2006a). The acute oral LD50 for rats is 247 mg/kg for males, and 309 mg/kg for females, classifying it as moderately toxic (Category II) through the oral route (USEPA, 2006a). After human ingestion, initial symptoms typically occur within 60 minutes post-exposure, involving prominent digestive symptoms such as epigastric pain, nausea, and vomiting (USEPA, 2006a). Large doses may cause symptoms such as convulsions, coma, or pulmonary edema. Through acute dermal exposure, the LD50 is 2,460 mg/kg for rabbits (Category III, low toxicity), which is an accepted surrogate for testing for human dermal toxicity. In rats, the dermal toxicity is even higher at 4920 mg/kg (USEPA, 2006a). The LC50 for acute inhalation in rats has not been estimated, but toxicity tests indicate that it is higher than 2.5 mg/L, classifying it as a Category IV chemical with very low toxicity (USEPA, 2006a).

When tested for primary eye irritation, exposure to zeta-cypermethrin resulted in slight redness of conjunctivae and chemosis coupled with discharge (USEPA, 2006a). When tested, the effect persisted to day 7, categorizing it Category III, low toxicity for primary eye irritation. In toxicological tests for primary skin irritation, zeta-cypermethrin caused slight to mild erythema on intact and abraded skin, which typically subsided within 48 hours (USEPA, 2006a). Zeta-cypermethrin is classified as practically non-toxic for primary skin irritation and is not a dermal sensitizer (USEPA, 2006a).

The NOAEL for reproductive toxicity is 375 mg/kg in rats. The developmental NOAEL based on lower mean pup body weights in rats is 100 mg/kg (DPR, 2016). The harmful effect as a reproductive toxin is reduced consumption of food for the parents, leading to lower birth weights in the pups and excessive pup mortality (DPR, 2016). Newborn pups also had lower mean weight gains in comparison to controls.

Zeta-cypermethrin and all other forms of cypermethrin are classified as Group C: Possible Human Carcinogens (USEPA, 2006a, 2016a). Cypermethrin has also been found to have mutagenic activity in Swiss Albino Mice (HSDB, 2012). The acute dietary Reference Dose (RfD) from the USEPA (2012) Federal Register is 0.07 mg/kg/day for all age groups.

For a summary of the human toxicity values for zeta-cypermethrin, see Table 3-1.

3.1.4 Ecological Toxicity

Zeta-cypermethrin is effective on a wide range of insect pests, but mammals and birds are less vulnerable to their toxic effects (DPR, 1999). In toxicological studies, cypermethrin is moderately toxic to mammals on an acute oral basis. The

oral LD50 for rats is 247 mg/kg in male rats and 309 mg/kg in female rats (DPR, 1999). Some symptoms from various rat toxicity studies include subdued behavior, loss of muscle control, excessive salivation, urinary incontinence, fecal incontinence, dehydration, ataxia, unsteady gait, clonic convulsions (i.e. involuntary muscle contractions), and piloerection. The acute dermal LD50 for rabbits is 2460 mg/kg (low toxicity), and symptoms of exposure include subdued behavior, unsteady gait, urinary incontinence, ungroomed appearance, piloerection and nervous shaking (DPR, 2016). Zeta-cypermethrin is practically non-toxic to birds, with an oral LC50 > 20,000 mg/L for mallard ducks and bobwhite quails (DPR, 1999).

In contrast, zeta-cypermethrin is highly toxic to freshwater fish and invertebrates on an acute basis. The LC50 for rainbow trout is 0.82 µg/L, and the LC50 for *Daphnia magna*, a small planktonic crustacean, is 0.26 µg/L (DPR, 1999). Estuarian/marine fish and invertebrates are similarly vulnerable to zeta-cypermethrin (sheepshead minnow LC50 = 0.95 µg/L, mysid shrimp LC50 = 0.00475 µg/L; USEPA, 2006a).

Zeta-cypermethrin can also present acute toxic risk to other invertebrates and beneficial non-target insects such as honeybees (LD50 = 0.023 µg/bee) and earthworms (USEPA, 2006a). Toxicity data are not available for terrestrial plants, but due to the zeta-cypermethrin mode of action, toxicity to plants is not expected.

Table 3-2 provides a summary of the ecological toxicity values for zeta-cypermethrin described above.

3.1.5 Physical Properties/Environmental Fate and Transport

Cypermethrin has a low Henry's Law constant of $2.5x10^{-7}$ atm-m^3/mol, indicating that it is not readily volatilized into the atmosphere from water (DPR, 1999). Therefore, it is not likely to be found in the air except for minor spray drift. Zeta-cypermethrin also has a very low vapor pressure ($1.3x10^{-9}$ mmHg); therefore, it has a low volatility and does not prefer to move from most media into the air (DPR, 1999).

The water solubility of zeta-cypermethrin at 25°C is reported at 7.6 µg/L, indicating that it is not very soluble in water (USEPA, 2006a). Zeta-cypermethrin in water is expected to hydrolyze in >50 days and photolyze in >100 days (DPR, 1999). Zeta-cypermethrin is also degraded more quickly in basic water than in water with a neutral pH. Cypermethrin is reported to have an aerobic and anaerobic metabolic half-life in water of 9 to 17 days (USEPA, 2006a). Due to its non-polar nature, zeta-cypermethrin has a large octanol-water coefficient (K_{OW} = $3.98x10^6$), and may therefore bioconcentrate in aquatic organisms (DPR, 1999).

When released into the environment, zeta-cypermethrin preferentially moves to soil and sediment. In these media, zeta-cypermethrin is moderately persistent and primarily degrades by biodegradation (USEPA, 2006a). When in aerobic soil, zeta-cypermethrin is reported to degrade aerobically with a half-life ranging from 6 to 60 days (DPR, 1999; USEPA, 2006a). When the soil is anaerobic, the half-life is reported to be <14 days to 2 months (DPR, 1999; USEPA, 2006a). Zeta-cypermethrin also photodegrades in soil rapidly with a half-life of 8 to 16 days (DPR, 1999).

Cypermethrin tends to bind strongly to organic matter, giving it little mobility in the soil. Its reported K_{OC} values range from 20,800 to 385,000 (USEPA, 2006a). Thus, zeta-cypermethrin is expected to persist longer in soils with high organic matter, high clay content, and anaerobic conditions. The breakdown products PBA and DCVA are organic acids and more mobile than the parent compound, particularly in neutral to alkaline soils (DPR, 1999). These major metabolites are largely immobile in very acidic soils. Once adsorbed into the soil, bioavailability is reduced and the chemical becomes less of a hazard to aquatic organisms (DPR, 1999).

Refer to Table 4-1 for a summary of the environmental fate characteristics described for zeta-cypermethrin above.

3.1.6 Water Pollution Potential

Due to its high K_{OC} of 20,800 to 385,000, zeta-cypermethrin has a strong affinity to bind to soil and is therefore expected to have little mobility (USEPA, 2006a). For this reason, it is not likely to leach into groundwater. Current evidence shows that cypermethrin is estimated to be at concentrations in drinking water that are not at levels that are hazardous to humans (3.6 ng/L; Health Canada, 2016; USEPA, 2006a). Because of its strong affinity for soil, cypermethrin may be carried to nearby bodies of water via erosion while suspended in sediment (DPR, 1999).

Because cypermethrin has relatively low mobility, it is most likely to reach bodies of water via spray drift, through runoff events accompanied by soil erosion, or in runoff from outdoor impervious surfaces (USEPA, 2006a). For example, non-agricultural applications of cypermethrin such as perimeter treatments around buildings and applications to lawns may result in surface water contamination. In surface water runoff from non-agricultural uses and suburban developments, cypermethrin has been found at levels of toxicological significance to aquatic organisms (USEPA, 2006a). The highest concentration of cypermethrin estimated by USEPA (2006a) to be present in drinking water in surface water is 1.04 µg/L.

The use of a spray buffer may reduce water pollution potential under typical conditions (USEPA, 2006a). However, conditions more conducive to spray drift could result in unacceptable exposure from drift alone, regardless of the spray buffer.

3.2 Piperonyl Butoxide (PBO) (Synergist)

PIPERONYL BUTOXIDE (PBO)

Example Product: Python Dust (0.150% Piperonyl Butoxide, 0.075% Zeta-Cypermethrin*)

- **Signal Word:** CAUTION
- **Human Toxicity:** Low toxicity. Skin and eye irritation possible. No evidence of neurotoxicity, mutagenicity. Some evidence of carcinogenicity. Developmental toxicity at maternally toxic doses.
- **Ecological Toxicity:** Practically non-toxic to birds and honeybees. Moderately toxic to fish. Moderately to highly toxic to freshwater invertebrates. Highly toxic to estuarine/marine invertebrates and amphibians.
- **Water Pollution Potential:** Slow migration to groundwater. Higher leaching potential in sandy soil than loam soil.
- **Other Considerations:** PBO does not have pesticidal activity of its own and acts as an insecticide synergist.

* For information on zeta-cypermethrin, refer to section 3.1 of Appendix D.

3.2.1 Basic Use Information

> Example Product: *Python Dust*

> Typical target pests: Horn flies, lice, face flies, stable flies, ticks, and keds

> Signal Word: Caution – Harmful if absorbed through skin. Avoid contact with eyes, skin or clothing. Refer to the specific product label and Safety Data Sheet (SDS) for more information.

> Environmental Hazards: This synergist is extremely toxic to aquatic organisms. Do not allow it to enter or run off into storm drains, drainage ditches, gutters or surface waters. Refer to the specific product label and SDS for more information.

> Application rates: See the product label for application rates, target plants, and methods of application.

Piperonyl butoxide (PBO) is a synergist used to enhance the activity of insecticides and is applied as a component of formulated insecticide products. It is commonly used in combination with other active ingredients such as pyrethrins and synthetic pyrethroids to control a variety of flying and crawling insects and arthropods (USEPA, 2006b). As a synergist, it lacks pesticidal

properties of its own and instead increases the toxicity of insecticide active ingredients by prolonging the effects of the insecticide. It functions by inhibiting the microsomal enzymes in susceptible pests, thereby hindering pests' ability to detoxify the pesticide (JMPR, 2002; USEPA, 2006b).

There are about 1,500 registered pesticide products in the United States that use PBO as a synergist for agricultural and residential use (USEPA, 2006b). PBO is used in a variety of settings including: pre- and post-harvest agricultural crops, livestock and premises, industrial and commercial facilities and storage areas where food and/or feed commodities are being processed or stored, and mosquito abatement areas. It currently has 69 tolerances set by USEPA for residues on commodities.

For the purposes of this report, discussion of formulated products containing PBO will refer only to those containing PBO and pyrethrins or pyrethoids.

3.2.2 Exposure Considerations

Products that contain PBO as an insecticide synergist may be harmful when absorbed through skin, so care should be taken to avoid skin, eye, and clothing contact, and applicators must wash thoroughly with water and soap after handling and before eating, drinking, chewing gum, or using tobacco or the toilet (Y-Tex, 2014). Applicators and handlers are required to wear proper Personal Protective Equipment (PPE) as indicated on the product label, which may consist of items such as a long-sleeved shirt and long pants, chemical-resistant gloves made of any waterproof material, eye protection, and shoes and socks.

PBO is toxic to aquatic organisms. Do not allow products containing PBO to run off into storm drains, drainage ditches, gutters, or surface waters. It is also important not to contaminate water, food, and feedstuffs with the pesticide when cleaning equipment or during storage and disposal (Y-Tex, 2011, 2014).

Exposure considerations for PBO products vary based on formulation type. Dust formulations, for example, may be unintentionally inhaled if not applied according to label instructions. For this reason, aerial and power duster applications of such products may be prohibited (Y-Tex, 2011; USEPA, 2006b). Certain meteorological conditions may not be suitable for applications of dust formulations of products containing PBO. Applications in calm weather where no rain is expected are recommended to ensure that neither wind nor rain will blow or wash pesticide products containing PBO away from the treatment areas. Following an application, allow the dust to settle before allowing reentry into the treated area.

Other safety precautions should be observed when using products containing PBO. For example, following space spray applications, individuals must exit the treated area immediately and remain outside the treated area until aerosols, vapors, and/or mists have dispersed. In plant and article spray applications, do not allow the product to drip off from treated plants and articles or runoff into surface water. To prevent excessive dermal exposure, do not use the treated article until spray has dried. When using products containing PBO in wettable powder formulations, do not apply the product as a dust or in forestry areas (USEPA, 2006b). **Always read and follow the product label instructions.**

3.2.3 Human Toxicity

PBO has low acute toxicity via oral and dermal routes; USEPA (2006b) classifies PBO as Category III (low toxicity) for oral and dermal exposures. These determinations are based on an acute oral study in rats (male rat LD50 = 4,570 mg/kg; female rat LD50 = 7,220 mg/kg) and an acute dermal study in rabbits (LD50 > 2,000 mg/kg), respectively. PBO has very low toxicity (Category IV) via inhalation exposure. In an acute inhalation study conducted on rats, the LC50 was determined to be >5.9 mg/L (USEPA, 2006b). PBO is minimally irritating to the eyes and skin; USEPA (2006b) classifies it as Category IV for primary eye and skin irritation based on a study in rabbits. Based on an exposure study in guinea pigs, however, PBO may act as a dermal sensitizer for some individuals.

The liver is the main target organ of PBO. In a one-year study of dogs treated with PBO, concentrations above the NOAEL of 15.5 mg/kg/day resulted in effects on the liver such as enlargement of liver cells and increases in liver weight and enzyme activity (USEPA, 2006b). Similar findings have been reported in PBO-treated rats and mice (USEPA, 2006b). Based on the study in dogs described above, a chronic dietary RfD of 0.16 mg/kg/day has been

established for the general population, including sensitive subpopulations.

PBO is classified as a Group C chemical: possible human carcinogen (USEPA, 2006b). This determination was made based on conflicting results from a combined chronic/carcinogenicity study in rats and a 1979 National Toxicology Program study in rats and mice that reported both positive and negative carcinogenic effects. The International Agency for Research on Cancer has similarly classified PBO as Group 3: not classifiable as to its carcinogenicity to humans (IARC, 2016). PBO is not expected to be neurotoxic, mutagenic, or an endocrine disruptor (USEPA, 2006b).

Developmental toxicity from exposure to PBO is not expected to occur unless extremely high doses are administered (USEPA, 2006b). In a two-generation reproduction study in rats exposed to PBO, a NOAEL of 89 mg/kg/day was established based on a decrease in body weight gain of the maternal rats and offspring reported at the next dose level. A separate developmental toxicity study in rats was used to develop the acute dietary RfD of 6.3 mg/kg/day for the general population (USEPA, 2006b). In this study, no observable adverse effects were noted at the 630 mg/kg/day dose level, while a decrease in maternal body weight gain was reported at higher doses.

Refer to Table 3-1 for a summary of the human toxicity properties discussed above.

3.2.4 Ecological Toxicity

PBO is expected to have very low toxicity in terrestrial organisms (USEPA, 2006b). USEPA (2006b) used rats to evaluate ecological toxicity in wild mammals. Results from an acute oral study in rats suggest that PBO is practically non-toxic in wild mammals (LD50 = 4,570 mg/kg-bw). In birds with acute oral and subacute dietary exposures, no mortalities were reported at the highest test concentrations; the acute oral LD50 for the northern bobwhite quail was estimated to be 2,250 mg a.i./kg-bw. PBO is similarly practically non-toxic to honeybees on an acute oral basis (LD50 > 25 µg/bee).

In contrast to toxicity data on terrestrial organisms, ecotoxicity studies reported by USEPA (2006b) indicate that aquatic organisms are more likely to be adversely affected by exposure to PBO. In an acute toxicity study of rainbow trout, PBO was determined to be moderately toxic to freshwater fish based on reported mortality occurring in 50% of fish at the 1.9 mg/L dose level. PBO is also moderately to highly toxic to freshwater invertebrates on an acute basis (waterflea LC50 = 0.51 mg/L).

While PBO is considered moderately toxic to estuarine/marine fish (sheepshead minnow LC50 = 3.94 mg/L), the most sensitive aquatic organisms to PBO exposure appear to be estuarine/marine invertebrates and amphibians. Based on the LC50s of 0.49 mg/L and 0.21 mg/L in mysid shrimp and the Western chorus frog tadpole, respectively, PBO is expected to be highly toxic for similar receptors.

For a summary of the ecological toxicity values described above for PBO, see Table 3-2.

3.2.5 Physical Properties/Environmental Fate and Transport

PBO is relatively nonvolatile from water surfaces due to its its Henry's Law constant of $8.9x10^{-11}$ atm-m^3/mole (HSDB, 2010b; USEPA, 2006b, 2012). Due to its vapor pressure of $<1x10^{-7}$ mmHg at 25°C, PBO exists in vapor and particulate phases in air (HSDB, 2010b). The vapor phase of PBO degrades at a moderate rate in the atmosphere by reacting with hydroxyl radicals produced in sunlight (half-life = 3.4 to 3.6 hours) (HSDB, 2010b; USEPA, 2006b, 2012). Alternatively, particulate PBO in air is removed from the atmosphere by wet or dry deposition (HSDB, 2010b).

PBO is slightly soluble in water based on an estimated solubility of 14.3 mg/L at 25°C (USEPA, 2006b). The primary route of PBO degradation in aqueous environments is photolysis (half-life = 8.4 hours); it is stable to hydrolysis at pH 5, 7, and 9 under sterile dark conditions (HSDB, 2010b; JMPR, 2002; USEPA, 2006b). This finding is supported by a degradation study in a sandy loam soil water-sediment system in which PBO incubated in the dark under aerobic conditions degraded at a slower rate than PBO exposed to sunlight (JMPR, 2002). The degradation rate of PBO is also greatly reduced in anaerobic environments. Based on its low log K_{OW} of 4.95 and estimated bioconcentration factor (BCF) of 27, PBO in its unmetabolized form has a low potential for accumulation in aquatic organisms (HSDB, 2010b).

PBO is also considered non-persistent in soil (USEPA, 1982). In aerobic soil, PBO is metabolized by microorganisms with an aerobic degradation half-life of about 14 days (HSDB, 2010b). PBO has low to moderate mobility in soil with K_{OC} values ranging from 399 to 830 based on the soil type (HSDB 2010b; USEPA, 2006b). PBO typically adsorbs to soil and sediment, and studies show that PBO is more mobile in sandy soil than in loam soil (HSDB, 2010b; JMPR, 2002).

A summary of PBO's fate and transport in the environment is presented in Table 4-1.

3.2.6 Water Pollution Potential

USEPA (2006b) used environmental models to evaluate the risk of exposure to PBO in drinking water via groundwater and surface water contamination. While acute and chronic exposures in food and water are not considered to be of concern, model outputs suggest that PBO has the potential to contaminate surface and groundwater. Although it moderately adsorbs to soil and sediment, environmental models indicate that PBO may slowly migrate to groundwater (HSDB, 2010b; USEPA, 2006b, 2012). The likeliness of groundwater contamination varies by soil type. PBO in sandy soil, for example, is more mobile than in loam soil, and therefore has a greater leaching potential in soils made up of larger particles than in those made up of smaller particles (JMPR, 2002).

If used in a manner inconsistent with the label, the use of some pesticides may lead to surface water contamination. Because it is commonly formulated with pyrethrins and pyrethroids, it is reasonable to anticipate that PBO residues may be present in surface water runoff or spray drift when such products are applied. In a field dissipation study referenced by USEPA (2006b), the environmental fate of several pesticides that characteristically bind almost completely to soil in an agricultural setting was evaluated. While the study did not sample for PBO, transport of pyrethroids to streambed sediment was reported. Based on this finding, the possibility remains that PBO was also present in the sample since the product applied contained both active ingredients.

Degradants of PBO (e.g. PBO-alcohol, -aldehyde, and -acid) are more soluble in water and therefore more mobile in soil-water systems (USEPA, 2006b). Further, they have a lower tendency to sorb to soil relative to PBO. Based on these properties, the aforementioned degradants likely have a higher potential to leach into groundwater and run off into surface waters.

3.3 Prallethrin

PRALLETHRIN

Example Product: Wasp Freeze II (0.1% Prallethrin)

- **Signal Word:** CAUTION
- **Human Toxicity:** Moderately toxic through oral and inhalation route. Low toxicity through dermal routes. Not irritating to the skin. Minimally irritating to the eye. Not likely to be a carcinogen to humans. Developmental and reproductive toxicity only at maternally toxic doses.
- **Ecological Toxicity:** Low toxicity in mammals and birds. Very high toxicity in fish, aquatic invertebrates, and honeybees.
- **Water Pollution Potential:** Low water solubility and strong adsorption to soil. Not often found in groundwater. Quickly degrades in water through photolysis. Degrades quickly via hydrolysis in alkaline waters, but is stable in neutral to acidic waters.
- **Other Considerations:** May not be used in or near aquatic systems due to high fish and aquatic invertebrate toxicity. Do not allow the pesticide to run off into storm drains, drainage ditches, or surface waters.

3.3.1 Basic Use Information

> Example Product: *Wasp Freeze II*

> Typical target pests: Wasps, hornets, yellowjackets, bees, and spiders

> Signal Word: Caution – Causes moderate eye irritation. Avoid contact with eyes, skin, or clothing. Wash thoroughly with soap and water after handling. Refer to the product label and SDS for more information on safety precautions.

> Environmental hazards: This pesticide is toxic to bees exposed to direct treatment on blooming crops or weeds. Do not apply this product or allow it to drift to blooming crops or weeds while bees are actively visiting the treatment area. Do not apply directly to water or areas where surface water is present, or to intertidal areas below the mean high water mark. Do not contaminate water by cleaning of equipment or disposal of equipment wash waters. Refer to the product label and SDS for additional information on use restrictions.

> Application rates: See the specific product label for application rates, target pests, and methods of application.

Prallethrin is a synthetic pyrethroid insecticide. In residential settings, prallethrin is commonly used on ants, cockroaches, fleas, and ticks (USEPA, 2003). In agricultural settings, prallethrin is registered for use for applications over, near, and around agricultural areas as a wide-area mosquito adulticide (USEPA, 2014a). As a pyrethroid, prallethrin modulates sodium channels by disrupting nerve impulses in target insects and subsequently causing paralysis (USEPA, 2014a).

Prallethrin is used to control bees, hornets, yellowjackets, spiders, and wasps. It is highly toxic to fish and aquatic invertebrates, and therefore should not be applied on or near water, or where in areas where there is a high possibility of drift from wind (BASF, 2013).

3.3.2 Exposure Considerations

Prallethrin is very toxic to aquatic organisms, including fish and invertebrates. To protect sensitive species, do not allow the pesticide to run off into storm drains, drainage ditches, gutters, or surface waters (BASF, 2013). Do not apply directly to water, or below the mean high water mark. Efforts should be taken to reduce spray drift, such as applying the pesticide in calm weather and using appropriate application rates and label-specified application intervals. Do not contaminate water by cleaning of equipment or disposal of equipment wash waters (BASF, 2013).

This pesticide is toxic to bees exposed to direct treatment on blooming crops or weeds. Do not apply this product or allow it to drift to crops or weeds while bees are actively visiting the treatment area (BASF, 2013).

Prallethrin can cause moderate eye irritation. Avoid contact with eyes, skin, and clothing. Wash thoroughly with soap and water after handling prallethrin, and before eating, drinking, and using the toilet. Remove contaminated clothing and launder before reuse. **Always read and follow the product label instructions.**

3.3.3 Human Toxicity

Prallethrin is a member of the pyrethroid class of insecticides that acts by damaging voltage-gated sodium channels, causing the channels to stay open for prolonged periods of time and producing trains of repetitive nerve impulses (USEPA, 2016b). Furthermore, Type I pyrethroids including prallethrin produce a tremor associated with a large increase in metabolic rate, which can lead to hyperthermia and exhaustion (HSDB, 2014).

Clinical signs of prallethrin neurotoxicity include decreased exploratory behavior, reduced motor activity, tremors, convulsions, and gait and postural abnormalities when given at a high dose to rats (oral NOAEL = 100 mg/kg/day; USEPA, 2016b). After chronic oral exposures in dogs, more pronounced clinical signs were seen, including tremors, convulsions, salivation, postural changes, and rapid eye blinking (NOAEL = 2.5 mg/kg/day; USEPA, 2016b).

USEPA (2016b) classifies prallethrin as moderately acutely toxicity via the oral and inhalation routes (Category II). According to the World Health Organization (WHO), the LD50 for oral exposure in rats is 640 mg/kg-bw for male rats, and 460 mg/kg-bw for female rats (WHO, 2004). The LC50 for inhalation exposure is 0.855 mg/L for male rats, and 0.658 mg/L for female rats (WHO, 2004). Prallethrin is of low acute toxicity via the dermal route (LD50 > 5,000 mg/kg, Category IV) (USEPA, 2016b; WHO, 2004). It is not irritating to the skin (Category IV) and is minimally irritating to the eye (Category III). It is not a dermal sensitizer (USEPA, 2016b; WHO, 2004).

The acute dietary Reference Dose (RfD) is 0.025 mg/kg/day for adults and children ≥6 years old, and 0.008 mg/kg/day for children <6 years old (USEPA, 2016b). The activity of enzymes associated with the metabolism of pyrethroids increases with age, therefore younger age groups may be more susceptible than older age groups. However, in the context of normal dietary and residential exposure, exposure to prallethrin is expected to happen at levels that are not harmful to juveniles or adults (USEPA, 2016b). The acute dietary NOAEL for all age groups for humans is 2.5 mg/kg/day for clinical signs of neurotoxicity. The dermal short-term NOAEL for humans is 30 mg/kg/day for fixation, abnormal gait, tremors, sensitivity to abnormal stimuli, vocalization, twitching, and writhing spasms. The inhalation NOAEL for humans of all ages is 0.001 mg/L for irregular respiration, decreased spontaneous activity, salivation, incontinence, and nasal discharge (USEPA, 2014b).

According to USEPA (2016b), prallethrin is classified as "Not Likely to be Carcinogenic to Humans." There is limited to no evidence of developmental toxicity to humans. No fetal effects were observed in developmental studies, and offspring effects were seen in the presence of comparable maternal toxicity (USEPA, 2016b).

Refer to Table 3-1 for a summary of human toxicity reference values discussed above.

3.3.4 Ecological Toxicity

Prallethrin is of low to moderate toxicity in mammals. In oral toxicology studies, the ocute LD50s in male and female rats 640 mg/kg and 460 mg/kg, respectively (WHO, 2004). Prallethrin is classified as Category II to III for oral toxicity, signifying it has moderate to low toxicity through the oral route (NPIC, 2008). In comparison, the acute dermal LD50 of prallethrin in rats could not be identified even at the highest dose tested (NOAEL > 5000 mg/kg), indicating that it is of very low toxicity through the dermal route (WHO, 2004; NPIC, 2008). In rabbit studies, prallethrin has not been shown to be a dermal irritant (WHO, 2004). Prallethrin was found to have an acute inhalation LD50 of 0.855 mg/L in male rats, and 0.658 mg/L in female rats, categorizing prallethrin as low toxicity (Category III) through the inhalation route (WHO, 2004; NPIC, 2008).

Prallethrin is of low toxicity to birds, with an oral LD50 of >2000 mg/kg for mallard ducks, and an oral LD50 of 1171 mg/kg for bobwhite quails (WHO, 2004; USEPA, 2014a). However, prallethrin is highly toxic to both fish and aquatic invertebrates. Rainbow trout has an LC50 of 0.012 mg/L, and bluegill sunfish has a toxicity of 0.022 mg/L (USEPA, 2014a). Prallethrin is highly toxic to the representative test organism for freshwater aquatic invertebrates, *Daphnia magna,* which has an EC50 of 6.2 µg/L (WHO, 2004). Similarly, prallethrin is highly toxic to estuarine/marine invertebrates, for which the surrogate species mysid shrimp (*Mysidopsis bahia)* has an LC50 of 3.9 µg/L (USEPA, 2014a). Prallethrin is very highly toxic to marine and estuarian fish, with a LC50 of 26 µg/L for the surrogate species sheepshead minnow. Prallethrin can also present acute toxic risk to honeybees. The LC50 for honeybees is 0.028 µg/bee. (USEPA, 2014a).

A summary of the ecological toxicity values discussed in this section is presented in Table 3-2.

3.3.5 Physical Properties/Environmental Fate and Transport

Prallethrin is a relatively unstable compound which mainly dissipates through the pathways of photodegradation in aqueous environments and microbially-mediated degradation in terrestrial environments (USEPA, 2014a). When released into the environment, prallethrin will mostly be found in soil.

Prallethrin has a very low Henry's Law constant of 4.92×10^{-9}, indicating it is unlikely to volatilize readily from water into air (USEPA, 2012, 2014a). Prallethrin has a vapor pressure of 3.2×10^{-5} mmHg which is considered relatively low (USEPA, 2016b). However, since the vapor pressure of prallethrin is significantly higher than

other pyrethroids, it has an increased tendency to exist in both the vapor and particulate phases (USEPA, 2012).

Prallethrin is only slightly soluble in water, with a solubility of 8.03 mg/L (USEPA, 2012, 2014a). In water, prallethrin degrades through hydrolysis fairly quickly in alkaline environments, with a half-life of 4.9 days in water that is pH 9; however, prallethrin is stable and will not degrade quickly through hydrolysis in acidic or neutral pH waters (half-life > 10 years at pH 7; USEPA, 2014a). If in a sunny area, prallethrin will degrade in water via photolysis very quickly with a half-life of 0.57 days. In anaerobic environments, its aquatic metabolism half-life is 37 days, and in aerobic environments, its aquatic metabolism half-life is 18 days (USEPA, 2014a).

The log K_{OW} for prallethrin has been estimated at 4.49, which is considered relatively high (USEPA, 2012, 2016b). This high log K_{OW} indicates that prallethrin is hydrophobic and not very soluble in water. When in water, prallethrin prefers to partition and move towards non-polar or fatty substances, and will stick to sediment and be bound in soil (USEPA, 2014a). The K_{OC} for prallethrin of 3,082 is high, indicating that it will have strong affinity to sorb onto soil and sediment (USEPA, 2012, 2014a).

In aerobic soil environments, prallethrin degrades due to microbial populations (half-life = 3 to 9 days). By way of photolysis at the surface level of soil, the half-life of prallethrin is reported at 29 days (USEPA, 2014a). Once bound and adsorbed onto sediment, bioavailability is reduced and prallethrin becomes less of a hazard to aquatic organisms. The BCF for prallethrin is 1150, and the value is indicative of moderate bioconcentration potential (USEPA, 2012, 2014a). If bioaccumulated into fish, the rate at which the chemical leaves the body is represented by the depuration half-life, estimated at 1.3 to 2.5 days (USEPA, 2014a).

See Table 4-1 for a summary of the environmental fate characteristics for prallethrin described above.

3.3.6 Water Pollution Potential

Because prallethrin has moderately high sorption to organic material in the soil (K_{OC} = 3,082), it is expected to bind strongly to organic carbon and will have little mobility once adsorbed to the soil (USEPA, 2012, 2014a). Given its high affinity to bind to soil organic matter and its low water solubility, prallethrin will have little migration to groundwater, and concentrations in drinking water are anticipated to be very low (USEPA, 2012, 2016b).

The estimated environmental concentrations in surface water were determined by modeling to be 0.591 µg/L for acute concentrations, and 0.0375 µg/L for chronic concentrations (USEPA, 2003). Surface water estimates were greater than ground water estimates of 1.04 ng/L (USEPA, 2003). When used according to label instructions, prallethrin is not expected to be present in drinking water at concentrations that are harmful to humans.

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4 Fate and Transport Summary

Table 4-1 Environmental Fate and Transport of Active Ingredients Under Consideration for Use by the District

Active Ingredient	Air	Water	Soil
Triclopyr butoxyethyl ester	> Relatively nonvolatile (vapor pressure = $3.6x10^{-6}$ mmHg)	> Relatively insoluble (solubility = 7.4 mg/L) > Rapid degradation via hydrolysis ($t_{1/2} \approx 0.5$ days) > Degradant is stable to hydrolysis	> Moderate sorption to soil; remains in upper 7.5 cm of soil (K_{OC} = 640 to 1650) > Primarily degraded by microbes under aerobic conditions ($t_{1/2} < 0.2$ days) > Degradants are likely more persistent and mobile in soil
Triclopyr triethylamine salt	> Nonvolatile (vapor pressure = $1x10^{-8}$ mmHg)	> Very soluble (solubility = 412,000 mg/L) > Dissipation within 1 minute > Degradant is stable to hydrolysis	> Mobile in soil (K_{OC} = 24 to 144) > Average aerobic $t_{1/2}$ = 9.7 days > Degradants are also persistent and mobile in soil
Zeta-cypermethrin	> Nonvolatile (vapor pressure = $1.3x10^{-9}$ mmHg)	> Largely insoluble (solubility = 7.6 µg/L) > Aerobic and anaerobic $t_{1/2}$ = 9 to 17 days > Hydrolysis $t_{1/2}$ > 50 days > Photolysis $t_{1/2}$ > 100 days	> High sorption and low mobility in soil (K_{OC} = 20,800 to 385,000) > Microbial degradation $t_{1/2} \leq 60$ days
Piperonyl butoxide	> Relatively nonvolatile (vapor pressure < $1x10^{-7}$ mmHg)	> Slightly soluble (solubility = 14.3 mg/L) > Rapid degradation via photolysis ($t_{1/2}$ = 8.4 hours) > Stable to hydrolysis at pH 5, 7, 9 under sterile dark conditions	> Low to moderate mobility in soil (K_{OC} = 399 to 830) > Microbial degradation under aerobic conditions ($t_{1/2}$ = 14 hours) > More mobile in sandy soil than loam soil
Prallethrin	> Slightly volatile (vapor pressure = $3.2x10^{-5}$ mmHg)	> Slightly soluble (8.03 mg/L) > Very rapid degradation via photolysis ($t_{1/2}$ = 0.57 days) > Rapid degradation in basic waters ($t_{1/2}$ = 4.9 days) > Slow degradation in neutral to acidic water	> High sorption and low mobility in soil (K_{OC} = 3082) > Microbial degradation under aerobic conditions ($t_{1/2}$ = 3 to 9 days)

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6 List of Abbreviations/Acronyms/Definitions

a.i.	Active ingredient. Used to describe chemicals in pesticide products that kill, repel, or control pests.
atm-m^3/mole	Atmosphere-cubic meters per mole
BCF	Bioconcentration factor. A unitless value indicative of the potential for a chemical to increase in concentration of the test substance in an organism (specified tissues thereof) relative to the concentration of test substance in the surrounding medium. Used as a surrogate for bioaccumulation in higher trophic levels of the food web.
BEE, triclopyr	Triclopyr butoxyethyl ester
bw	Body weight
cm	Centimeter
DCVA	3-(2,2-dichlorovinyl)-2,2-dimethyl cyclopropanecarboxylic acid. Degradant of zeta-cypermethrin.
EC50	Median effective concentration. A statistically derived concentration of a substance that can be expected to induce 50% of the maximal response in test organisms.
K_{OC}	Organic carbon partitioning coefficient, or soil adsorption coefficient. A dimensionless concentration ratio whose magnitude expresses the tendency of a compound to bind to soil organic carbon.
K_{OW}	Octanol-water partitioning coefficient. A dimensionless concentration ratio whose magnitude expresses the distribution of a compound between equal volumes of n-octanol and water.
LC50	Median lethal concentration. A statistically derived concentration of a substance that can be expected to cause death in 50% of the test organisms when administered by the indicated route (inhalation or drinking water). Usually expressed as the amount of substance per amount of solution (e.g., mg/L).
LD50	Median lethal dose. A statistically derived concentration of a substance that can be expected to cause death in 50% of test organisms when administered by the indicated route (oral or dermal). Usually expressed as a weight of substance per unit weight of animal (e.g., mg/kg).
LOAEC	Lowest Observed Adverse Effect Concentration. The lowest concentration of a compound that causes a significant predetermined adverse effect in an experimental population.
LOAEL	Lowest Observed Adverse Effect Level. The lowest dose of a compound that causes a significant predetermined adverse effect in an experimental population.
µg	Micrograms
mg/kg	Milligrams per kilogram of body weight
mg/L	Milligrams per liter
mmHg	Millimeter of mercury
mph	Miles per hour

ng	Nanograms
NOAEC	No Observed Adverse Effect Concentration. The highest concentration of a compound that causes no significant predetermined adverse effects in an experimental population.
NOAEL	No Observed Adverse Effect Level. The highest dose of a compound that causes no significant predetermined adverse effects in an experimental population.
OP	Organophosphate pesticide
PAD	Population Adjusted Dose (a = acute, c = chronic prefixes). A modification of the reference dose (RfD) that incorporates safety factors for sensitive subpopulations.
PBA	3-phenoxybenzoic acid. Degradant of zeta-cypermethrin.
PBO	Piperonyl butoxide
PPE	Personal Protective Equipment
RfD	Reference Dose. An estimate of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.
SDS	Safety Data Sheet
t½	Half-life. The period of time required for the amount of a substance undergoing decay to decrease by half.
TCP	3,5,6-trichloro-2-pyridinol. Degradant of triclopyr acid.
TEA, triclopyr	Triclopyr triethylamine salt
USEPA	United States Environmental Protection Agency
WHO	World Health Organization