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

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OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

**MEMORANDUM**

OCT - 4 1999

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Reregistration Branch II
Special Review and Reregistration Division - 7508W

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**Thru:** Tom Bailey, Chief
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**Subject:** Reregistration Eligibility Document for Temephos
(D240786; Case No. 818974; Chemical No. 059001)

Attached to this memorandum is the revised EFED RED chapter for Temephos. This revision was based on the review of several field studies submitted by the Lee County (Florida) Mosquito Control District and literature studies submitted by the registrant, Clarke Mosquito Control Products, Inc. A number of laboratory data requirements that were previously required have now been dropped as a result of the review of these field studies. This transmittal memo summarizes EFED's findings.

## 1. Introduction

Temephos is an organophosphate insecticide registered for the control of the aquatic insect larvae, which is an outdoor, non-food use. There are no agricultural crop uses.



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Temephos is manufactured by American Cyanamid Company. It is marketed in the United States by Clarke Mosquito Control Products, Inc. under license from American Cyanamid.

Temephos is used for the control of the aquatic larvae of mosquitoes, midges, gnats, punkies, and sandflies. Most of the data used in this RED was generated by American Cyanamid when they were the primary registrant. They held the registrations for the technical grade active ingredient (TGAI) (EPA Registration Number 241-220) and for four end-use products (241-174, -151, -150, and -132). In September 1997 these registrations were transferred to Clarke Mosquito Control Products, Inc. (as 8329-56, -57, -58, -59, and -60 respectively). Clarke also holds four other temephos end-use registrations (8329-15, -16, -17, and -30). There are two §24 registrations: NJ 940004 (which is the same as American Cyanamid's (241-132)) and NJ 940005 (241-150).

## 2. Use Characterization

Formulations include a granular and an emulsifiable concentrate. Temephos is applied to water to kill the aquatic larvae of certain pestiferous diptera, especially mosquitos, but gnat, pinkies, and sandflies as well. Sites are listed on labels as standing water, shallow ponds, lakes, woodland pools, tidal waters, marshes, swamps, waters high in organic content, highly polluted water, catch basins and similar areas where mosquitos may breed, margins of streams, and intertidal zones of sandy beaches.

## 3. Environmental Fate Assessment

The presence of microorganisms in aquatic environments and exposure to sunlight are likely to be the predominant routes of transformation/dissipation of temephos. In the absence of microorganisms or sunlight, temephos does not react significantly with water. The effect of sunlight on temephos is decreased by the presence of dense vegetation which may commonly shade temephos treated waters.

Temephos can bind strongly to soils and sediments and is unlikely to volatilize from either under most conditions. However, temephos could potentially volatilize from shallow water due to its air-water partition coefficient. Transformation products of temephos, such as "temephos sulfoxide", "temephos sulfone", "temephos sulfide and sulfone phenols" do not bind to soil as strongly as temephos and are, therefore, more likely to migrate to and remain dissolved in the water.

Temephos, being a hydrophobic chemical and thus more likely to bind to fatty substances, has the potential to bioconcentrate. Temephos bioaccumulated in fish exposed to



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temephos for 28 days. However, more than 75% temephos was eliminated after 14-days of non-exposure.

The major transformation products of temephos are "temephos sulfoxide" and "temephos sulfone." "Temephos sulfide and sulfone phenols" have also been identified in water/sediments under anaerobic and aerobic conditions. The only major degradate of temephos identified in irradiation-exposed samples was "temephos sulfoxide".

## 4. Water Resources Assessment

Temephos is a larvacide that is applied directly to shallow, stagnant, brackish and polluted waters. Exposure to temephos and its degradation products is limited to these aquatic environments, where mosquito breeding occurs. These waters are unsuitable as a source of drinking water. When applied, if at all, to water that may be used as a source of drinking water, e.g., reservoirs and ox-bow lakes, dilution and residence time will reduce exposures to temephos at the drinking water intake. Temephos degrades relatively rapidly in natural water. Model concentrations indicate that there is little effect of repeat applications on peak concentrations of temephos; however, longer-term concentrations in woodland pools increase when temephos treatments reoccur at intervals of 7 or 15 days. In estuarine environments where tidal flushing occurs repeat applications are not expected to result in accumulation of temephos.

Temephos is not likely to reach ground water that would be used for drinking water due to lack of transport in typical temephos use areas (which are characterized by low hydraulic gradients) and its relatively short half-life in natural waters. It was therefore determined that there was no need to further evaluate temephos occurrence in ground water or surface water used for drinking.

## 5. Ecological Risk Characterization

### Terrestrial animals

Because Temephos is only applied directly to water, it is not expected to have a direct impact upon terrestrial animals. EFED modeled the possibility of terrestrial animals being exposed to temephos via drinking water using an avian species (a duck), but found that there was no cause for concern.

Additionally, due to the tendencies for temephos to bioconcentrate, a piscivorous bird scenario was modeled to assess the risk to fish-eating birds. This assessment was based on the comparison of the bioconcentration factor (BCF) and resulting residues in fish viscera, to an avian subacute dietary $LC_{50}$. It was concluded that residue levels are expected to be lower than the avian subacute dietary $LC_{50}$. This assessment indicates that only endangered species may be affected in the 15 cm pond depth scenario if the same presumptions for risks to non-piscivorous birds are applied.



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There is no data on the effect of the chronic intake of food by waterfowl or upland gamebirds. In EFED's response to Cyanamid's low volume/minor use data waiver request, Maciorowski (1993) recommended avian reproduction testing, "information contained within the submission indicates that reproductive effects to waterfowl (mallard duck) may be expected at concentrations as low as 1 ppm (Fransen, et al., 1983). Nesting waterfowl are expected to be directly exposed to temephos from spraying operations. EEB is interested in reviewing this study as possible useable data for satisfaction of avian reproductive testing which is now required." An acceptable study has not been submitted, however field data that have been submitted for review indicate that there is very little, if any, impact on birds. Therefore, EFED will not require a chronic bird study at this time. In addition, since birds are not expected to be affected by direct applications to water and no effects were noted in the field data, EFED will not require acute testing on the formulated product.

**Aquatic animals**

Temephos is "slightly toxic to very highly toxic" to aquatic freshwater vertebrates. It is "highly toxic" to "very highly toxic" to freshwater and marine/estuarine aquatic invertebrates. The emulsifiable concentrate appears to be much more toxic than the granular formulation in laboratory studies, however this conclusion is based on a single valid study with a 5% granular formulation.

The Risk Quotients derived from the current freshwater fish acute toxicity studies exceed the levels of concern for the liquid formulation only for restricted use and endangered species, the risk quotients for the granular formulation do not exceed the levels of concern. EFED has no data on acute testing of any marine fish species. Since the liquid formulation appears to be more toxic and exposure to marine/estuarine fish is likely given the current use pattern, acute toxicity testing for marine fish will be required for the liquid formulation only.

Chronic testing was reserved in the 1981 Registration Standard pending results of lower tier testing. In 1993 SRRD required that a freshwater invertebrate life cycle chronic toxicity and fish early life stage chronic toxicity studies (Guideline 72-4) be submitted within one year. Acceptable chronic studies have not been submitted.

Chronic studies were triggered because the labels allow repeated applications to water. $LC_{50}$ values of less than 1 ppm have been demonstrated for both aquatic invertebrates and fish. However, a number of field studies have been submitted which show that even after ten applications of the granular 2G formulation no chronic effects to fish were observed. Growth retarding effects in fish were observed in one study after 4 applications of the liquid Abate 4E formulation, but details of the studies were not given and EFED does not have a high level of confidence in the results of this study. Review of the extensive field data submitted negates the need for chronic fish studies and they will not be required at this time.

Some field data for freshwater invertebrates show that non-target aquatic invertebrate populations tend to reestablish their original population levels within three weeks after application, however, other field data show that recovery patterns are altered. Additionally, laboratory studies show *Daphnia magna* to be extremely sensitive resulting in risk quotients being exceeded by many orders of magnitude for the liquid formulation. Due to this incongruence of results, an aquatic freshwater invertebrate life-cycle test will be required to better characterize chronic risk.

Chronic risk to the estuarine environment was difficult to characterize due to the lack of marine/estuarine invertebrate chronic data. The risk quotients on the acute data based on the TGAI did not greatly exceed the levels of concern. However, levels of concern are greatly exceeded for the liquid formulated product. Although no acceptable chronic studies have been submitted for marine/estuarine invertebrates, a number of field studies have been submitted which have demonstrated that adverse effects to aquatic ecosystems are minimized when temephos is used at the lower application rate. At present, the guideline (72-4) is not fulfilled. However, limiting the application rate to 0.5 fl. oz./A for the liquid formulation, would eliminate the need for this study.

The low solubility of 0.030 mg/L and the relatively high $K_{oc}$ of 16, 250 might suggest some laboratory sediment toxicity testing be performed. However, measurements of residues in sediment from field studies submitted by the registrant generally concluded that temephos tends to rapidly adsorb to organic media and further degrade to low or undetectable concentrations. The most recent field study which monitored the temephos sediment over a three year period (1995-1997) did not detect temephos in the sediment after 24 hours. As a result of this field data, a sediment toxicity study will not be required at this time.

**Non-target plants**

Seed germination/seedling emergence and vegetative vigor (Tier 1), and growth and reproduction of plants (Tier 1) were required in the 1981 Registration Standard. Seed germination/seedling emergence and vegetative vigor (Tier 1) was subsequently waived (Bushong, 1982). In 1993, SRRD required aquatic plant growth Tier 1 testing (Guideline 122-2) be submitted within one year. A literature search for phytotoxicity to aquatic plants was conducted by EFED. The results of this search revealed that there are no phytotoxic concerns and aquatic plant data will not be required at this time.

**Non-target insects**

A honey-bee acute contact $LD_{50}$ was not requested in the 1981 RS, but was required in 1993. An acceptable study has not been submitted. However, the requirement has been waived because current temephos use is not likely to result in exposure to honey bees.

## 6. Status of Data Requirements/Data Gaps

Acceptable studies have not been submitted for the following guidelines requirements:

72-3(d) Estuarine/Marine Toxicity Fish/TEP-EC

72-4(b) Life Cycle Aquatic Invertebrate - *Daphnia magna*

72-4(b) Life Cycle Aquatic Invertebrate - Mysid Shrimp

**Adequacy of Toxicity Data and Waivers:**

EFED's preliminary assessment listed 15 outstanding data requirements. During the public comment period, the registrant and others submitted a number of field monitoring and literature studies. While the field studies do not meet current guideline requirements, they have provided enough information for the Agency to conduct an ecological risk assessment and waive most of the study requirements. The three studies listed above are not waived.

The registrants, users, and other commentors including USDA and HHS, have noted that temephos is needed because it is the least expensive and most efficacious pesticide to control larval mosquitos, there are currently no adequate alternatives, and it is important in resistance management.

EFED had previously recommended against data waivers (C. Bushong, 1982; Maciorowski, 1993). EFED has used EPA published data (MRID 40228401) to satisfy some testing requirements including data generated before 1982. EFED has considered this data despite its policy to not accept data generated prior to 1984.

## 7. Peer Reviewers

This chapter was peer-reviewed by Jim Felkel, Biologist and R. David Jones, Environmental Engineer.

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Environmental Risk Assessment

There is sufficient core environmental fate data to complete an environmental fate assessment for a low volume/minor use chemical. The core environmental fate data are: hydrolysis (161-1); direct photolysis in water (161-2); anaerobic aquatic metabolism (162-3); aerobic aquatic metabolism (162-4); mobility in soil/sediments (163-1) and bioaccumulation in fish (165-4). There are insufficient guideline ecotoxicity data available. However, numerous field monitoring studies and studies from the open literature have been submitted to address the guideline requirements. Therefore, the assessment which follows is an ecological risk assessment based on an inadequate guideline toxicological laboratory data base supplemented by field studies.

## 1. Use Characterization

Temephos is an organophosphate insecticide used for the control of aquatic larvae of mosquitoes, midges, gnats, punkies, and sandflies. It is primarily applied to salt marshes and mangrove swamps. Primary use areas are coastal Lee County, Florida, coastal New Jersey and the mid West. Mosquito breeding sites include swamps, shallow woodland pools, polluted waters and brackish coastal wetlands. There are no indoor domestic or agricultural uses. Temephos is formulated as an emulsifiable concentrate and a granular, including one end use granular product that is applied to tire piles.

Most of the data used in this RED were generated by American Cyanamid when they were the primary registrant. They held the registrations for the technical grade active ingredient (TGAI) (EPA Registration Number 241-220) and for four end-use products (241-174, -151, -150, and -132). In September 1997 these registrations were transferred to Clarke Mosquito Control Products, Inc. (as 8329-56, -57, -58, -59, and -60 respectively). Clarke also holds four other temephos end-use registrations (8329-15, -16, -17, and -30). There are two §24 registrations: NJ 940004 (which is the same as American Cyanamid's (241-132)) and NJ 940005 (241-150).

Sites and application rates are listed on labels as follows:

Standing water, shallow ponds, lakes, and woodland pools:

2 lb/A of 5% G (0.1 lb ai/A).
Repeat as necessary (No interval stated on current label).

2.5-5 lb/A of 2% G (0.05-0.10 lb ai/A). Repeat as necessary

0.5-1.5 fluid oz. of 45.1% (by weight) Emulsifiable Concentrate.
0.015-0.047 lb ai/A)
Repeat as necessary.

5-10 lb/A 1% G (0.05-0.1 lb ai/A). Repeat as necessary.

Tidal waters, marshes, swamps, and waters high in organic content:

4 lb/A 5% G (0.2 lb ai/A). .

10 lb/A 2% G (0.2 lb ai/A). Repeat as necessary.

10-20 lb/A 1% G (0.1-0.2 lb ai/A).

10 lb/A 1% G (0.1 lb ai/A). .

Highly-polluted water:

10 lbs/A 5% G (0.5 lb ai/A). .

25 lb/A 2% G (0.5 lb ai/A). Repeat as necessary.

20-50 lb/A 1% G (0.2-0.5 lb ai/A). Repeat as necessary.

Standing water, shallow ponds, swamps, marshes, catch basins, and similar areas where mosquitos breed:

0.5-1.5 fluid oz. 4EC (0.015-0.047 lb ai/A). Repeat as necessary.

5-10 lb/A 1% G (0.05-0.1 lb ai/A). .

2½-5 lb/A 2%G (0.05-1.0 lb ai/A).

Marshlands, margins of streams, intertidal zones of sandy beaches:

5-10 lb/A 2% G (0.1-0.2 lb ai/A). .



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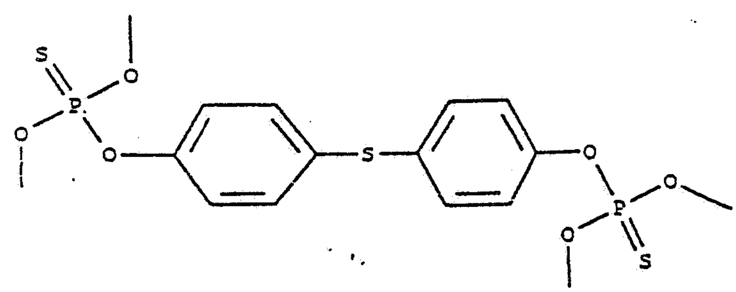
2. Exposure Characterization

a. Chemical Profile

*Common name:* Temephos
*Chemical name:* Phosphorothioic acid,
O,O'-(thiodi-4,1-phenylene)bis(O,O'-dimethyl) phosphorothioate
*Chemical Abstracts Service Number:* 3383-96-8
*Chemical Abstracts name*: Phosphoric acid
O,O'-(thiodi,1,4-phenylene) O,O,O',O'-tetramethyl ester
*Trade name:* Abate®
*Physical and chemical properties:*
Molecular formula: $C_{16}H_{20}O_6P_2S_3$
Molecular weight: 446.46
Physical state: Crystalline Solid
Henry's Law Constant: 1.47 x $10^{-6}$ atm.$m^3$.$mol^{-1}$
Boiling point: Not applicable
Vapor pressure: 7.17 x $10^{-8}$ mmHg (torrs; 2.23 x $10^{-11}$ atm;
9.5 x $10^{-6}$ Pa) at 25°C
Melting point" 30.0 - 30.5° C
Solubility: 30 $\mu$g/l at 25°C
Kow= 80,900 (log Kow= 4.91)

*Chemical Structure:*




Temephos is composed of two dimethylphosphorothiate groups attached at the fourth carbon of two benzene rings linked by a sulfide bridge (-S-) at the *para*-position with respect to the phophorothioate groups.

The sulfur in the sulfide linkage, S(-II), can oxidize to S(IV) and S(VI) to yield the sulfoxide and sulfone analog of Temephos, respectively. The sulfur in the phosphorothioate groups can be replaced by oxygen but usually elimination of one or both of the phosphorothioate groups are observed with or without replacement by oxygen. This results in free dimethyl phosphorothioate or dimethylphosphate ions and Temephos phenols. Temephos phenols, with or without oxidation of the sulfide



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linkage, have been identified in aquatic metabolism study (Temephos sulfone phenol and Temephos sulfide phenol).

The *n*-octanol/water partition coefficient, $K_{ow}$ is 80,900 (log $K_{ow}$=4.91). This relatively high *n*-octanol/water partition coefficient indicates that Temephos is a hydrophobic compound and, thus, will have a tendency to remain at the water/air interface. Temephos has the potential to bioconcentrate.

The vapor pressure of Temephos is reported as $7.17 \times 10^{-8}$ mmHg. The estimated Henry's Law constant is $1.47 \times 10^{-6}$ $atm.m^3.mol^{-1}$, which suggests that Temephos may volatilize slowly from water, but volatilization may be more significant in shallow rivers and water bodies.

Temephos has an aquatic use pattern and is applied directly to water. Thus, exposure to Temephos and its degradation products is primarily associated with treated aquatic environments where mosquitos breed. Terrestrial exposure is expected to be minimal. Aquatic sites in which Temephos is used as a mosquito larvicide are presumably not suitable drinking water sources and, therefore, a drinking water assessment was not conducted.

## b. Environmental Fate Assessment Summary

Direct photolysis and biodegradation in water/sediment systems are the major routes of transformation and dissipation of temephos in the environment with half-lives of 15 and 17.2 to 29 days, respectively. However, the effect of solar irradiation will be reduced by dense tree canopies, grasses and tannins present in sites where temephos is applied (for example, mangroves and marshes). Abiotic hydrolysis does not contribute to the transformation of temephos at relevant environmental pHs; half-lives greater than 30 days.

In water/sediment systems under anaerobic conditions, a primary half-life of 12.2 days was reported for the first 29 days and a secondary half-life of 27.2 days from days 30 to 121. Under aerobic conditions, the half-life of transformation/dissipation is 17.2 days.

Parent temephos adsorbs strongly to soils and sediments, with Freundlich adsorption coefficients ranging from 73 to 541 L/kg and appears to be dependent on the organic matter content of the soil or sediment. Concentrations of temephos adsorbed to sediments is less under anaerobic then under aerobic conditions, a maximum adsorbed occurred after 2-days in aerobically incubated samples.

Volatilization of temephos from soils is not likely to be a major dissipation route, because temephos has a low vapor pressure and is not applied directly to soils. However,



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due to temephos' Henry's Law constant (1.47 x $10^{-6}$ atm.m$^3$.mol$^{-1}$) volatilization from water, especially shallow water due to potentially higher surface roughness, may be more significant.

The major transformation products of temephos are the oxidation products "temephos sulfoxide" and "temephos sulfone" and were identified in the photolysis and biodegradation in water/sediments studies. There is evidence that "desorption" of temephos is the result of formation of degradates that do not adsorb strongly to sediments, as indicated by the increasing concentration of degradates in the water phase. Other degradates that have been identified in the aqueous phase are "temephos sulfide phenol" and "temephos sulfone phenol". Neither of these degradates contain the organophosphate group.

Temephos is primarily applied to salt marshes and mangrove swamps. Seasonal variations in dissolved oxygen concentration, redox potential, pH, salinity, temperature, or tidal fluctuations are likely to influence the rate of degradation/dissipation of temephos and the chemical nature of its degradation products. In these sites, the contribution of direct photolysis in water is likely to be reduced by vegetation, such as dense tree canopies, grasses, and high organic matter in the water column.

### c. Environmental Fate and Transport

#### I. Degradation

***Abiotic hydrolysis (§161-1):*** Abiotic hydrolysis is not a major degradative pathway for temephos. Buffered solutions of $^{14}$C-temephos at pH 5, 7, and 9 at a concentration of 30 $\mu$g/l (ppb) and 25° C did not hydrolyze significantly over the 30-day duration of the study. However, there is evidence that there is a pH-related trend in the reported, extrapolated half-lives and pseudo first-order rate constants, with the half-lives decreasing with increasing pH. The reported half-lives and rate constants (in parentheses) are: pH 5, 1030 days (k = 6.7 x $10^{-4}$ day$^{-1}$); pH 7, 460 day (k = 1.5 x $10^{-3}$ days$^{-1}$); pH 9 86 days (k = 8.1 x $10^{-3}$ day$^{-1}$). However, there is much uncertainty in these calculated half-lives because they are extrapolated well beyond the 30-day duration of the study. The only major degradate identified was the oxidation product temephos sulfoxide at less than 10% and only at pH 9.

***Direct photolysis in water (§161-2):*** Direct photolysis is an important degradation route for temephos in water. The reported calculated half-life of $^{14}$C-temephos under 24 hours of continuous irradiation (xenon arc lamp) is 15 days (k = 4.3 x $10^{2}$ days), at a concentration of 30 $\mu$g/l (ppb) in unbuffered solutions at pH 6.5 to 7.0 and 25° C. The major degradate identified was temephos sulfoxide at 11% maximum from 3-days after



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exposure and throughout the 14-days, in contrast to less than 4% in dark control solutions. There was a total of 12 unknowns in the irradiated samples, at a total of 15% of applied. However, none of the individual components exceeded 10% of the applied.

*Anaerobic aquatic metabolism (§162-3):*

Kinetics and Experimental Conditions: Radiolabeled ($^{14}C$-)

Temephos applied at a concentration of 29.4 $\mu g/g$ to anaerobic water/sediment underwent degradation. The initial degradation/dissipation half-life was calculated as 12.2 days (first phase: 0 to 29 days) and the terminal, longer degradation/dissipation half-life of 27.2 days (30 to 121 days and beyond).

The 10-to-1 ratio water/sediment samples were incubated for five months under a nitrogen atmosphere prior to fortification. The temperature of the samples throughout the 373-days duration of the study was maintained between 23.3 and 26.7 degrees Celsius and were continuously purged with oxygen-filtered nitrogen. The water and sediment were collected from Lake Mendota, WI. The collected water had a pH of 8.0 and a dissolved oxygen concentration of 10 mg/l. The sand sediment (96% sand, 2% silt, and 2% clay) had a pH of 8, a cation exchange capacity of 7 meq/100g, and 0.3% organic matter. However, dissolved oxygen concentration, redox potential, and pH of the water phase were not measured prior to addition of Temephos nor monitored during the study. Test systems were fitted with traps to collect volatile products.

Transformation of Temephos under Anaerobic Aquatic Conditions

Mean total radioactivity recovered from the water/sediment systems ranged between 89 to 103 percent of the applied. In the aqueous phase, parent Temephos decreased from 59.9% at "day 0" (2 hours after application) to 7.9% by one week and below 1.6% after 90 days. In the sediment phase, Temephos decreased from 31.4% at "day 0" to 2.8% at day 90. Formation of $CO_2$ was not detected at any time during the course of the study.

In the aqueous phase, Temephos sulfoxide increased from 1.3% at "day 0," then decreased to below 1.0% but reached 3.4% after 205 days. Temephos sulfone increased from 0.9% at "day 0," reached a maximum of 3.3% by 7-days and remained below 1% throughout the duration of the study. In the sediment phase, these two degradates were detected at below 1% of the applied at all times.

The major identified degradates were Temephos sulfide phenol and Temephos sulfone phenol. None of these two degradates bear the organophosphate group. In the aqueous phase, Temephos sulfide phenol increased steadily from non-detected at "day 0" to a maximum of 13.8% after 373-days. In the sediment phase, this degradate was not



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detected until 29-days at 1.8% maximum and declined to non-detected afterwards. Temephos sulfone phenol increased steadily from 0.2% at "day 0" to 28.9% by day 61 and declined steadily to below 10% after 121 days. In the sediment phase, Temephos sulfide phenol was not present until 29 days after application of Temephos (maximum 1.7%), declining to 1% or less after 29 days. Temephos sulfone phenol was not detected until 7 days post-fortification (3.0%) and reached a maximum of 4.2% by day 15 but steadily declined afterwards to 2.2% and 1.8% by days 90 and 121, respectively.

There is a major uncertainty in the identity of three degradation products labeled as "Metabolite A," "Metabolite B," and "Metabolite C." These degradation products partitioned predominantly to the aqueous phase, where none of them were detected at concentrations greater than 1.1% of the applied at all times.

*Aerobic aquatic metabolism (§162-4):*

Kinetics and Experimental Conditions- Degradation/dissipation of $^{14}C$

Temephos applied at a concentration of 31.7 $\mu$g/g to aerobic water/sediment followed first-order kinetics, with a half-life of 17.2 days. The water and sediment were collected from Lake Mendota, WI. The 10-to-1 ratio water/sediment samples were incubated in the dark at 25°C under air. A continuous flow of air was maintained throughout the duration of the study. The collected water had a pH of 8.0. The sand sediment (96% sand, 3% silt and 1% clay) had a pH of 7, a cation exchange capacity of 6 meq/100g, and 0.7% organic matter. However, dissolved oxygen concentration, redox potential, and pH of the water phase were not measured prior to addition of Temephos nor monitored during the study. Test systems were fitted with traps to collect volatile products. The duration of the study was 39 days.

Transformation of Temephos Under Aerobic Aquatic Conditions

Mean total radioactivity ranged from 91 to 101 percent of the applied. In the aqueous phase, Temephos decreased from 33.5% of the applied at day 0 to 0.3% at 30 days. In contrast, Temephos in the sediment phase increased from 51.9% at day 0 to a maximum of 72.9% at day 2, decreasing to 21.7% by day 30. Decrease of Temephos in the aqueous phase parallels partition to the sediment phase and increase in degradation.

Temephos sulfoxide, Temephos sulfide phenol, and Temephos sulfone phenol were identified in both the water and sediment phases. Temephos sulfoxide was found at a maximum of 5.4% in the sediment (day 4) and 3.6% in the water by day 2. The maximum Temephos sulfone phenol detected in the water phase was 6.3% (day 14) and 5.4% in the sediment (day 1). Temephos sulfide phenol in the sediment increased steadily, reaching a maximum 4.8% at day 30 but remained at 1.7% or below in the water phase at all sampling times shorter than 30 days.

An unknown metabolite ("Unknown 1") in the sediment reached a maximum of 13.2% on day 14. Uncharacterized degradates in the aqueous phase increased steadily to 17% by day 30 and are presumed to be highly polar, weakly adsorbing products. Volatile organic compounds and $^{14}CO_2$ reached 0.2% and 4.6%, respectively, by day 30.

## d. Mobility

### i. Mobility in Soil

Batch-equilibrium adsorption/desorption conducted with $^{14}$C-Temephos in four different soils indicate that parent Temephos adsorbs strongly to soils as indicated by the Fruendlich adsorption coefficients $K_{ads,F.}$. Adsorption is dependent on the organic matter content of the soil. In the concentration range used in the study (5, 8, 11, and 26 ppb), adsorption was not linear as indicated by the deviation of 1/n from 1. The results of the study are summarized below:

Adsorption in soils

| | Loamy Sand (Delaware) | Sandy Loam (Princeton) | Silt Loam (Nebraska) | Loam (Ontario) |
|---|---|---|---|---|
| pH | 6.0 | 6.4 | 6.9 | 7.0 |
| CEC | 5.3 | 8.4 | 13.3 | 39.4 |
| %OM | 1.0 | 1.6 | 2.4 | 7.0 |
| %Sand | 77.6 | 55.6 | 24.0 | 38.0 |
| %Silt | 15.2 | 33.2 | 58.0 | 46.0 |
| %Clay | 7.2 | 11.2 | 18.0 | 16.0 |
| $K_{ads,F.}$ | 7.3 | 130.0 | 244. | 541. |
| 1/n | 0.58 | 0.62 | 0.72 | 0.78 |
| $K_{OC}$ | 18,250 | 16,250 | 31,800 | 22,800 |

The correlation coefficients ($r^2$) were poor, ranging from 0.51 to 0.81. If outliers in the Fruendlich isotherms are considered, $r^2$ improves to 0.90 or higher.



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Although a desorption study was conducted, the desorbed radioactivity was equal or below the background label to allow adequate calculations of Freundlich desorption coefficients.

No targeted mobility data are available on the major degradation products of Temephos but data from the aquatic metabolism studies suggest that oxidized, polar products of Temephos may be weakly adsorbed to sediments as these degradates tend to partition into the water phase.

### ii. Volatility from soil and water

Temephos has a low tendency to volatilize from soil (vapor pressure 7.17 X 10-6 mmHg at 20°C). The estimated Henry's Law constant (1.47 X $10^6$ atm.$m^3$ .$mol^1$ ) suggests that temephos may volatilize slowly from water, but that volatilization of temephos may be more significant in shallow rivers.

### e. Bioaccumulation in Fish

A 28-day dynamic exposure of 120 acclimated fish to a concentration of $^{14}$C-Temephos of 0.65 $\pm$ 0.12 $\mu$g/l indicated rapid uptake of radioactivity by the fish. Daily bioconcentration factors for fillet, whole fish, and viscera ranged from 63-970, 99-2300, and 150-3900, respectively. The uptake concentrations of $^{14}$C-Temephos in tissues ranged from 50-630 ppb, 78-1500 ppb, and 120-2500 ppb for fillet, whole fish, and viscera, respectively. No mortality or abnormalities were observed in the Temephos-exposed fish.

The 14-depuration phase indicated 75, 75, and 78 percent depuration from fillet, whole fish and viscera, respectively and indicated a gradual decrease through the depuration phase. The $^{14}$C-Temephos residues in the 28-day uptake phase dropped from 630 ppb to 160 ppb (fillet), 1500 ppb to 380 ppb (whole fish), and 2500 ppb to 560 ppb by the end of the 14-day depuration period.

The uptake rate constant ($K_1$), the depuration rate constant ($K_2$) the depuration half-life ($t_{1/2}$), the [steady state] bioconcentration factor (BCF), and the time to reach 90% of steady state were calculated using the non-linear BIOFAC kinetic modeling program. The standard deviation of each estimated parameter was use as a measure of variability. The results are summarized as follows:

$K_{1(uptake)} = 200(\pm 16)$;
$K_{2(depuration)} = 0.086(\pm 0.0073)$;
$t_{1/2(depuration)} = 8(\pm 0.68)$ days
$BCF_{steady\ state} = 2300(\pm 270)$
Steady $state_{90\%} = 27(\pm 2.3)$days



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The metabolic fate of $^{14}C$-temephos in the fish was determined by characterizing the chemical nature of residues in fillet, whole fish, and viscera at 21 and 28 days exposure. The extracted residues (methanol:methylene chloride, 1:1 v/v; 95% extraction efficiency) were co-chromatographed (2-dimensional thin layer chromatography) with authentic standards of parent and suspected metabolites.

Parent Temephos was the major residue identified in fillet, whole fish, and viscera in 21 and 28 day samples. In fillet, whole fish and viscera Temephos was found at 490, 1700, and 1000 ppb, respectively in 21-day samples. In 28-day samples, 630, 2500, and 1500 ppb were respectively present in fillet, whole fish and viscera. The percent of applied Temephos found as intact Temephos was: (1) fillet, 79% at 21 days and 86% at 28 days; (2) whole fish, 73.6% at 21 and 28 days; viscera, 82% at 21 days and 59% at 28 days.

Temephos sulfoxide was the major metabolite. In terms of applied radioactivity, Temephos sulfoxide accounted for: (1) fillet, 5.1% at 21 days, and 4.5% at 28 days; whole fish, 6.8% at 21 and 28 days; viscera, 9.2% at 21 days and 12.8% at 28 days. Other minor hydrolytic and oxidative metabolites, each at equal or less than 4%, were also found. One of the metabolites, 4,4'-thiodiphenol, are the result of losing both phosphorothioate groups from the parent metabolite. The two other metabolites, phosphorothioic acid,O-*p*-(*p*-hydroxyohenylthio) phenyl, O,O'-dimethyl ester and phosphoric acid, O-*p*-(*p*-hydroxyphenylthio)phenyl dimethyl ester, contains only one organophosphate group; in the latter metabolite, the sulfur group in the phosphorothioate group was replaced by oxygen. All of these three metabolites preserve the sulfide linkage, that is, they are not a sulfoxide or a sulfone. Non-identified metabolites (2 to 9) were present at 4 to 13% and were mostly present in the viscera.

**d. Water Resource Assessment Summary.**

Temephos is a larvicide that is applied directly to shallow, stagnant, brackish and polluted waters. Exposure to temephos and its degradation products is limited to these aquatic environments, where mosquito breeding occurs. These waters are unsuitable as a source of drinking water. Temephos degrades relatively rapidly in natural water. Model concentrations indicate that there is little effect of repeat applications on peak concentrations of temephos; however, longer-term concentrations in woodland pools increase when temephos treatments reoccur at intervals of 7 or 15 days. In estuarine environments where tidal flushing occurs repeat applications are not expected to result in accumulation of temephos.

Temephos is not likely to reach ground water that would be used for drinking water due to lack of transport in typical temephos use areas (which are characterized by low hydraulic gradients) and its relatively short half-life in natural waters. It was therefore determined that there was no need to further evaluate temephos occurrence in ground water or surface water used for drinking. Therefore, only an aquatic exposure assessment is presented here.

### i. Modeling for Temephos Concentration in Tidal Waters

Primary use areas include coastal Lee County, Florida, and coastal New Jersey. Mosquito breeding sites include swamps, shallow woodland pools, polluted waters and brackish coastal wetlands. Liquid temephos is applied by air directly to tidal marshes to control heavy infestations of mosquito larva. The concentration in the water is determined by the amount of chemical which reaches the surface primarily at the time of application but also secondarily by material applied earlier which may be washed off of leaf surfaces by rainfall. The amount of chemical is a function of both the application rate and the amount which is intercepted by vegetation such as mangroves growing in the water.

There is no standard scenario available to simulate direct application of a pesticide to tidal marshes. Therefore, in this assessment we have developed a scenario to calculate the resulting concentrations in a shallow tidal marsh as a result of the aerial treatment with temephos. We assumed that the water depth in the marsh area varies from 1 to 20 centimeters (one-half to eight inches), based on conversations with the Lee County, FL Mosquito Control District. We assumed complete mixing of temephos with the water and that 100% of the application reaches the water (that is, it is not intercepted by vegetation).

Calculations are included for application rates of 0.5, 1.0, and 1.5 ounces of product (43% active ingredient). The 0.5 and 1.0 rates are currently used and the 1.5 oz. rate is to be held in reserve in case resistence develops in the future. It is also assumed that these are potential maximum concentrations and that tidal flushing does not typically allow accumulation of temephos from multiple applications. This is supported by monitoring data (Wichterman, George, 1999) which has not shown any cases of measurable concentrations (detection limit 0.05 $\mu$g/L) in open water 24 hours after application.

The following equation was used to estimate temephos concentrations in a tidal pool:

$$\text{temephos conc. } [\mu g/L] = \frac{\text{application rate } [\#a.i./A] * 1.123\ [\#/A \text{ to } Kg/Ha] * 10^{9}\ [\mu g/Kg]}{10^{4}\ [m^{2}/Ha] * \text{water depth}/1000\ [l/m^{3}]}$$

Calculated concentrations at these application rates [in ounces of temephos (liquid formulation) per acre] and these water depths are shown in the table below.

**Initial Temephos Concentration Values in Tidal Flats ($\mu$g/L)$^{\dagger}$**

| Application Rate (oz./A) | Water Depth (centimeters/inches) | | | | |
|---|---|---|---|---|---|
| | 1/0.4 | 2/0.8 | 5/2 | 10/4 | 20/8 |



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| | | | | | |
|---|---|---|---|---|---|
| 0.5 | 151 | 76 | 30 | 15 | 8 |
| 1.0 | 302 | 151 | 60 | 30 | 15 |
| 1.5 | 453 | 227 | 90 | 45 | 23 |

† (A concentration of approximately 1.0 μg/L is needed for 100% mortality of Aedes mosquito larva).

Monitoring data indicates that temephos is stratified in the water column, measured in standing water up to ten times higher in the surface layer than at a depth of 10 centimeters. Therefore, we have modified the above scenario to simulate this stratification effect. Such an effect might be seen in tidal flats between flushes of the incoming tide, for example in standing water. The values in the table below represent a recalculation of the values in the previous table to reflect these findings. These values represent the maximum concentrations in the top centimeter only. It is assumed that the concentration in the top centimeter is ten times that of the water below.

**Initial Temephos Concentrations in Top Centimeter of Tidal Flat Water for a Given Depth (μg/L)**

| Application Rate (oz./A) | Water Depth (centimeters/inches) | | | | |
|---|---|---|---|---|---|
| | 1/0.4 | 2/0.8 | 5/2 | 10/4 | 20/8 |
| 0.5 | 151 | 137 | 108 | 79 | 52 |
| 1.0 | 302 | 274 | 216 | 159 | 104 |
| 1.5 | 453 | 412 | 324 | 238 | 156 |

In most cases, a portion of the chemical is deposited on the surface of mangrove leaves above the water reducing this initial concentration by the fraction which is deposited there Data show that from 15% to 70% of the chemical reaches the water surface depending on rainfall (Wichterman, 1999). The values in the table below assume that 40% of the applied material reaches the water surface (or 60% is removed). These values represent median concentration; these numbers will vary with the actual amount which is intercepted by vegetation. These values are presented to demonstrate the potential magnitude of this effect only and are not used in the risk assessment.



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**Initial Temephos Concentration Values in Top Centimeter of Tidal Flat Water ($\mu$g/L)[†††] assuming 60% removal by mangrove vegetation**

| Application Rate (oz./A) | Water Depth (centimeters/inches) 1/0.4 | 2/0.8 | 5/2 | 10/4 | 20/8 |
|---|---|---|---|---|---|
| 0.5 | 60 | 55 | 43 | 32 | 21 |
| 1.0 | 120 | 110 | 86 | 64 | 42 |
| 1.5 | 180 | 165 | 129 | 95 | 62 |

††† Assuming concentration in top centimeter is ten times higher than that in the water below and 40% of the application reaches the water.

### ii. Modeling for Temephos Concentration Applied to Non-tidal Fresh Water

Application of granular temephos applied as a mosquito larvicides was modeled using the Exposure Analysis Modeling System (EXAMS) version 2.97.5. The EXAMS program can be used to simulate direct application to water which is the case with temephos. This modeling assumes conditions that are believed to occur, for example, where temephos (granular) is applied to non-tidal fresh water in coastal New Jersey. Examples of mosquito breeding sites include: swamps, shallow woodland pools, polluted waters, and brackish coastal wetlands. The EXAMS modeling setting chosen as a high exposure scenario is a shallow (30 centimeters) woodland pool. This scenario was chosen because it is believed to accurately represent environments where mosquitos will breed. To ensure that the physical scenario we are modeling is conservative we have assumed that the pond will not be influenced by stream flow, which would remove temephos by tidal action thereby diluting temephos concentrations. The model takes into account other mechanisms of temephos dissipation, for example, volatilization and direct photolysis. The scenario utilizes all of the same input parameters as the EFED standard pond with the exception of the depth (see EXAMS input parameters in Appendix B). This scenario assumes a 30 centimeter (12 inch) water depth for this shallow woodland pond.

Temephos is typically applied in one or two treatments per year depending upon need (levels of breeding mosquitos). Application rates for the 5%, 2%, and 1% granular products vary from 0.05 - 0.5 pounds of active ingredient per acre (the higher rate is for highly polluted waters). The tables below represent estimated concentrations resulting from treatment at the lowest rate and at the highest rate. Also, temephos may be applied multiple times (on



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an as needed basis). The results below represent a single application as well as a double application with intervals between treatment varying from 7 to 90 days.

Temephos Mosquito Larvicides
Thirty Centimeter Static Pond
Lowest Application Rate (0.05 #ai/A)
(EXAMS 2.97.5)

Concentration ($\mu$g/L)

| No. Appl. | Interval (days) | Peak | 96 Hour | 21 Day | 60 Day | 90 Day | Annual |
|---|---|---|---|---|---|---|---|
| 1 | N/A | 2.4 | 0.5 | 0.15 | 0.07 | 0.05 | 0.02 |
| 2 | 7 | 2.5 | 0.6 | 0.28 | 0.14 | 0.10 | 0.03 |
| 2 | 15 | 2.5 | 0.6 | 0.26 | 0.13 | 0.09 | 0.03 |
| 2 | 90 | 2.4 | 0.5 | 0.15 | 0.07 | 0.05 | 0.03 |

Temephos Mosquito Larvicides
Thirty Centimeter Static Pond
Highest Application Rate (0.5 #ai/A)
(EXAMS 2.97.5)

Concentration ($\mu$g/L)

| No. Appl. | Interval (days) | Peak | 96 Hour | 21 Day | 60 Day | 90 Day | Annual |
|---|---|---|---|---|---|---|---|
| 1 | N/A | 24.4 | 5.0 | 1.5 | 0.7 | 0.5 | 0.15 |
| 2 | 7 | 25.2 | 5.8 | 2.8 | 1.4 | 1.0 | 0.30 |
| 2 | 15 | 25.0 | 5.6 | 2.6 | 1.3 | 0.9 | 0.30 |
| 2 | 90 | 24.4 | 5.0 | 1.5 | 0.7 | 0.5 | 0.03 |

The modeling results given in the two tables above indicate that peak concentrations estimated are largely a function of the application rate, and do not vary substantially as a result of repeat application regardless of the interval between treatment. Longer-term concentrations (for example, 90-day concentrations) appear to reflect the influence of treatment interval. Concentrations resulting from two treatments are approximately double those resulting from a single treatment for intervals of 7 and 15 days. The cumulative effect of temephos treatments is not observed for a 90 day treatment interval. Peak concentrations estimated for the non-standard tidal scenario are roughly equivalent to the concentrations estimated in this EXAMS-based woodland pond scenario, reflecting the assumption that the depth of water in tidal flats is shallower than it is in woodland ponds and the lower application rates for the liquid temephos formulation.

## 3. Ecological Effects Toxicity Assessment

### a. Toxicity to Terrestrial Animals

#### i. Birds, Acute and Subacute

An acute oral toxicity study using the technical grade of the active ingredient (TGAI) is required to establish the toxicity of Temephos to birds. The preferred test species is either mallard duck (a waterfowl) or bobwhite quail (an upland gamebird). Results of this study are tabulated below.

Avian Acute Oral Toxicity

| Species | % ai | LD50 (mg/kg) | Toxicity Category | MRID No. Author/Year | Study Classification[1] |
|---|---|---|---|---|---|
| Northern bobwhite quail *(Colinus virginianus)* | 94.7 | 27.4 | Highly toxic | 470167035 (157841) Fletcher, 1986 | Core |

[1] Core (study satisfies guideline). Supplemental (study is scientifically sound, but does not satisfy guideline)

Since the LD50 falls in the range of 10-50 mg/kg, Temephos is categorized as Highly toxic to avian species on an acute oral basis. The guideline 71-1a is fulfilled (MRID 470167035).

Two subacute dietary studies using the TGAI are required to establish the toxicity of Temephos to birds. The preferred test species are mallard duck and bobwhite quail. Results of these studies are tabulated below.

Avian Subacute Dietary Toxicity

| Species | % ai | 5-Day LC50 (ppm)[1] | Toxicity Category | MRID No. Author/Year | Study Classification |
|---|---|---|---|---|---|
| Bobwhite quail (*Colinus virginianus*) | 86.9 | 92 | Highly toxic | 22923 Hill, 1975 | Core |
| Mallard duck (*Anas platyrhynchos*) | 86.9 | 894 | Moderately toxic | 22923 Hill, 1975 | Core |

[1] Test organisms observed an additional three days while on untreated feed.

Since the LC50 falls in the range of 50-500 ppm, Temephos is categorized as being Highly toxic to avian species on a subacute dietary basis. The guideline 71-2 is fulfilled (MRID 22923). In addition, since birds are not expected to be affected by direct applications to water and no effects were noted in the field data, EFED will not require acute testing on the formulated product.

### ii. Birds, Chronic

Avian reproduction studies using the TGAI are required for Temephos because birds will be subject to repeated exposure to the pesticide, especially preceding or during the breeding season. No acceptable reproductive studies have been submitted, however, field data that has been submitted for review indicate that there is very little, if any, impact on birds. Therefore, EFED will not require a chronic bird study at this time.

### iii. Mammals

Wild mammal studies are required on a case-by-case basis, depending on the results of lower tier laboratory mammalian studies, intended use pattern and pertinent environmental fate characteristics. In most cases, rat or mouse toxicity values obtained from the Agency's Health Effects Division (HED) substitute for wild mammal studies. These toxicity values are reported below.

Mammalian Oral Acute Toxicity

| Species | % ai | Toxicity Category | LD50 (mg/kg) | MRID |
|---|---|---|---|---|
| Laboratory rat *(Rattus norvegicus)* | 86.9 | Highly toxic | 444 | 1902 |

An analysis of the results indicates that Temephos is categorized as being highly toxic to small mammals on an acute oral basis.

### iv. Insects

No acceptable studies have been reviewed. The requirement for a honey bee acute contact study has been waived, because the current limited use of temephos is not likely to result in exposure to honey bees.

### b. Toxicity to Freshwater Aquatic Animals

#### i. Freshwater Fish, Acute

Two freshwater fish toxicity studies using the TGAI are required to establish the toxicity of Temephos to fish. The preferred test species are rainbow trout (a coldwater fish) and bluegill sunfish (a warmwater fish). When it is believed that the formulation will affect the results, a study for that formulation may be required. Results of these studies are tabulated below.

Freshwater Fish Acute Toxicity

| Species/ | % ai | 96-hour LC50 (ppm) | Toxicity Category | MRID No. Author/Year | Study Classification |
|---|---|---|---|---|---|
| Rainbow trout *(Oncorhynchus mykiss)* | 86.2 | 3.49 | Moderately toxic | 40098001 McCann, 1971 | Core |
| | 43%EC | 0.158 | Very highly toxic | 1337 Kennedy, 1970 | Core |
| Bluegill sunfish *(Lepomis macrochirus)* | 86.2 | 21.8 | Slightly toxic | 40098001 McCann, 1971 | Core |
| | 43% EC | 1.14 | Slightly toxic | 40098001 McCann, 1971 | Core |

Since the $LC_{50}$ of Temephos TGAI falls in the range of 1-100 ppm, it is categorized as being Slightly to Moderately toxic to freshwater fish on an acute basis. Since the LC50s of Temephos EC fall in the range of <0.1 to 10 ppm, it is categorized as being Very highly to Moderately toxic to freshwater fish on an acute basis. The guideline (72-1) is fulfilled (MRID 40098001 and 1337).

#### ii. Freshwater Fish, Chronic

Chronic studies were triggered because the labels allow repeated applications to water. $LC_{50}$ values of less than 1 ppm have been demonstrated for both aquatic invertebrates and fish. However, a number of field studies have been submitted which show that even after ten applications of the granular 2G formulation no chronic effects were observed. Growth retarding effects were observed in one study after 4 applications of the liquid Abate 4E formulation, but details of the studies are not given and EFED does not have a lot of



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confidence in the results of this study. In view of the extensive field data submitted and reviewed, chronic fish studies will not be required at this time.

### iii. Freshwater Invertebrates, Acute

A freshwater aquatic invertebrate toxicity study using the TGAI is required to establish the toxicity of Temephos to aquatic invertebrates. The preferred test species is *Daphnia magna*. When the formulation is expected to affect the toxicity, studies with the formulated product may also be required. Results of these studies are tabulated below.

Freshwater Invertebrate Acute Toxicity

| Species/Static or Flow-through | % ai | 48-hour LC50/ EC50 (ppm) | Toxicity Category | MRID No. Author/Year | Study Classification |
|---|---|---|---|---|---|
| Scud (*Gammarus lacustris*) | 86.2 | 0.082 | Very highly toxic | 40098001 McCann, 1971 | Core |
| Stone fly (*Pteronarcs* spp.) | 86.2 | 0.01 | Very highly toxic | 40098001 McCann, 1971 | Core |
| Waterflea *Daphnia magna* | 43% EC Abate* | 0.000011 NOEC = 0.00003 | Very highly toxic | 470177012 Forbis, 1986 | Core |
| Waterflea (*Daphnia magna*) | 5% G | 0.00054 | Very highly toxic | 40098001 McCann, 1971 | Core |

Since the LC50 is <0.1 ppm in a TGAI study, Temephos is categorized as being very highly toxic to aquatic invertebrates on an acute basis. The guideline (72-2a) is fulfilled (MRID 40098001). Since the LC50 is <0.1 ppm in TEP (EC and G) studies, Temephos EC is categorized as being very highly toxic to aquatic invertebrates on an acute basis. The guideline (72-2b) is fulfilled (MRID 470177012).

### iv. Freshwater Invertebrate, Chronic

A freshwater aquatic invertebrate life-cycle study using the TGAI is required for Temephos since the end-use product will be applied directly to water and : (1) the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent regardless of toxicity, (2) any aquatic acute LC50 or EC50 is less than 1 mg/l, or, (3) the EEC in water is equal to or greater than 0.01 of any acute EC50 or LC50 value, or, (4) the pesticide is persistent in water (*i.e.*, half-life greater than 4 days). The preferred test species is *Daphnia magna*. No acceptable studies have been reviewed. The guideline (72-4) is not fulfilled.



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Some field data for freshwater invertebrates shows that non-target aquatic invertebrate populations tend to reestablish to their original population levels within three weeks after application, however, other field data show that recovery patterns are altered. On the other hand, laboratory studies show *Daphnia magna* as extremely sensitive and risk quotients are exceeded by many magnitudes for the liquid formulation. Due to these extreme exceedances an aquatic life-cycle test will be required.

### c. Toxicity to Estuarine and Marine Animals

#### i. Estuarine and Marine Fish, Acute

The risk quotients derived from the current freshwater fish acute toxicity studies exceed the levels of concern for restricted use and endangered species only for the liquid formulation, the risk quotients for the granular formulation do not exceed the levels of concern. EFED has no data on acute testing of any marine fish species. Since levels of concern are exceeded for the liquid formulation of freshwater fish, acute testing for marine fish will be required for the liquid formulation only. The preferred test species is sheepshead minnow.

#### ii. Estuarine and Marine Fish, Chronic

Chronic studies were triggered because the labels allow repeated applications to water. $LC_{50}$ values of less than 1 ppm have been demonstrated for both aquatic invertebrates and fish. However, a number of field studies have been submitted which show that even after ten applications of the granular 2G formulation no chronic effects were observed. Growth retarding effects were observed in one study after 4 applications of the liquid Abate 4E formulation, but details of the studies are not given and EFED does not have a lot of confidence in the results of this study. In view of the extensive field data submitted and reviewed chronic fish studies will not be required at this time.

#### iii. Estuarine and Marine Invertebrates, Acute

Acute toxicity testing with estuarine/marine invertebrates using the TGAI and the emulsifiable concentrate and the granular end use products are required for Temephos because



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the end-use product is intended for direct application to the marine/estuarine. The preferred test species are the mysid and eastern oyster.

Estuarine/Marine Invertebrate Acute Toxicity

| Species/Static or Flow-through | % ai. Formulation | 96-hour EC50 (ppm) | Toxicity Category | MRID Author/Year | Study Classification |
|---|---|---|---|---|---|
| Eastern oyster *(Crassostrea virginica)* | 86.2 TGAI | 0.22 | Highly toxic | 40228401 Mayer, 1986 | Core |
| | 43 EC | 0.17 | Highly toxic | 40228401 Mayer, 1986 | Core |
| Pink shrimp *(Penaeus duorum)* | 43 EC* | 0.0053 | Very highly toxic | 470231012, McCann, 1975 | Supplemental |

*Note: The results of this test are based on a 48-hour EC50

Since the EC50 for the Eastern oyster falls in the range of 0.1 - 1 ppm for the TGAI, Temephos TGAI is categorized as being highly toxic to Eastern oysters on an acute basis. The guideline 72-3b is fulfilled (MRID 40228401).

### iv. Estuarine and Marine Invertebrate, Chronic

An estuarine/marine invertebrate life-cycle toxicity study using the TGAI is required for Temephos because the end-use product will be applied directly to the estuarine/marine environment and: (1) the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent regardless of toxicity, (2) any aquatic acute LC50 or EC50 is less than 1 mg/l, (3) the EEC in water is equal to or greater than 0.01 of any acute LC50 or EC50 value, or, (4) the pesticide is persistent in water (*e.g.*, half-life greater than 4 days). The preferred test species is the mysid. Although no acceptable studies have been submitted, a number of field studies have been submitted which have demonstrated that adverse effects to aquatic ecosystems are minimized when temephos is used at the lower application rate. If the registrant is agreeable to reducing the label rate to the lower application rate of 0.5 fl. oz./A for the liquid formulated product, this chronic study will not be required. At present, the guideline (72-4) is not fulfilled.

## d. Toxicity to Sediment Dwelling Organisms

### i. Freshwater and Marine, Acute

The aerobic aquatic metabolism study suggests that Temephos sediment concentrations increase from day zero to a maximum at day 2, but steadily decreases to 21% by day 30. Thus, there is uncertainty in the amount of Temephos associated with the soil phase beyond 30 days. However, the study indicates that temephos transforms to the sediment phase with



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partitions of transformed products to the water phase. Some chemical properties which might suggest that sediment toxicity testing be performed include the following:

Solubility ≤ 0.1 mg/L
$K_{oc}$ ≥ 50,000
Persistence ≥ 10 days
$K_d$ ≥ 1000
$K_{ow}$ ≥ 1000

and concentration in pore water equals or exceeds the LC50 concentration for *D. magna.*

The low solubility of 0.030 mg/L and the relatively high $K_{oc}$ of 16,250 of temephos might suggest some laboratory toxicity testing be performed. However, measurements of residues in sediment from field studies submitted by the registrant generally concluded that temephos tends to rapidly adsorb to organic media and further degrade to low or undetectable concentrations. The most recent field study which monitored the temephos sediment over a three year period (1995-1997) did not detect temephos in the sediment after 24 hours. As a result of this field data a sediment toxicity study will not be required at this time.

### e. Freshwater Field Studies

A number of field studies were submitted by the registrant and the Lee County (Florida) Mosquito Control District as part of the comments to an earlier version of the EFED RED chapter in support of waiving acute and chronic toxicity guideline data requirements. These studies were reviewed and found to be inadequate to fulfil the guideline requirements. However, many of the studies were found to have limited use in the current risk assessment and characterization. The following tables list the studies and their results:

### Temephos Field Data

**Abate: Effects of the Organophosphate Insecticide on Bluegills and Invertebrates in Ponds†**

| Product Tested (% ai) | Rate/Method Application | Objective of Study | Results and Conclusions |
|---|---|---|---|
| Abate EC (45.1%) | Three applications were applied at 40 and 4 μg ai/L at intervals approximately one month intervals between applications | To determine if Bluegill and aquatic invertebrates are adversely effected | - No acute bluegill mortality |

### Objective and Description of Study:



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The objective of this study was to determine if Bluegill and aquatic invertebrates are adversely affected. Six 0.04 ha earthen ponds were used in this study, and had an average depth and volume of 0.88 m and 311 $m^3$ , respectively. Three applications were applied at 40 and 4 $\mu g$ ai/L at approximately one month intervals between applications.

† *Sanders, Herman O. and Walsh, David O., and Campbell. 1981.; Abate: Effects of the Organophosphate Insecticide on Bluegills and Invertebrates in Ponds. U.S. Fish and Wildlife Service. Technical Bulletin 104.*

**Effects of Abate® (Temephos) on Non-Target Aquatic Organisms in a Natural Pond Undergoing Mosquito Control Treatment†**

| Product Tested (% ai) | Rate/Method Application | Objective of Study | Results and Conclusions |
|---|---|---|---|
| Abate EC 45.1% Abate 1% gra0nular | One application of 0.1 lb ai/A + one application of 0.1 1 b ai/A (14 day interval) | To validate and/or improve the ecological hazard assessment procedures | - No bluegill mortality<br>- Fewer fry at higher rates (40$\mu$g ai/L)<br>- AchE (acetylcholinesterase activity) not effected<br>- Not detected in sediment from 1 hr to 14 days<br>- Lab tests suggest acute toxicity 5-20X greater than TGAI<br>- Several changes in zooplankton community. Recovery occurred, but growth patterns altered.<br>- Macro invertebrates increased in densities<br>- Cladocerans and Chaoborus very sensitive<br>- Short-lived in water and toxic at detection limit (<0.7 ppb) |

## Objective and Description of Study:

Two reference ponds (1.4 and 1.8 A) and one treatment pond (1 A) were monitored to obtain field data on the effects of mosquito larvicide applications to non-target aquatic organisms. Environmental conditions including dissolved oxygen, temperature, pH, precipitation, rainfall, and outlet stream flow were monitored prior to, during and after the study. Water and sediment samples were also collected and analyzed.

† ***Siefert, et. al. 1986. Effects of Abate® (Temephos) on Non-Target Aquatic Organisms in a Natural Pond Undergoing Mosquito Control Treatment. U.S. EPA Environmental Research Laboratory Progress Report, Duluth. 105 pp.***

Residues of CL 52,160 [temephos] in Water and Mud from Streams and Ponds†

| Product Tested (% ai) | Rate/Method Application | Objective of Study | Results and Conclusions |
|---|---|---|---|
| CL 52,160 (% ai not given) | One appl. of 1.0 lb/A and 10 appl. of 0.1 lb/A at weekly intervals | To measure rate of disappearance of CL 52, 160 in water and mud from streams and ponds in CA and NJ | - Residues in surface water ranged from 100 - 300 ppb and dropped to less than 50 ppb in 24 h.<br>- No detectable residues in mud<br>-- Limits of detection not given |

## Objective and Description of Study:

Samples of water and mud were taken from streams at the point of application and 500 and 1,500 feet downstream. Water samples were taken at the surface and at a 5-8 foot depths. Only the Scope and the Results sections of the report were submitted for review and details about the methods used are extremely sketchy. Specific sites and their descriptions were not reported.

† Residues of CL 52,160 [temephos] in Water and Mud from Streams and Ponds. American Cyanamid company, Report No. C-74, March 1965.

**Abate®: Abate and Abate Sulfoxide Residues in Environmental Samples - Water, Sediment and Four Aquatic Species (Chrisfield, MD and Newark, DE)†**

| Product Tested (% ai) | Rate/Method Application | Objective of Study | Results and Conclusions |
|---|---|---|---|
| Abate 4EC (45.1%) | MD: Five appl. at intervals of 14, 28, 28.and 14 days respectively at rates of 0.015, 0.03, 0.09, 0.18, and 0.36 lb ai/A<br>DE: Four appl. at intervals of 14 and 28 days respectively at a rate of 0.09 lb ai/A | To determine the effect of Abate on marine organisms in relation to the ecological food chain. Measurement of residue data was used to give insight into persistence. | - Highest residue accumulation in oysters (concentrations not reported)<br>- Crab residues from 0.06 to 3.11 ppm after 2nd treatment<br>- Maximum Abate sediment concentrations was 0.53 ppm<br>- Maximum Abate Sulfoxide concentration was 0.4 ppm<br>- Rapid adsorbing to sediment and conversion to Abate Sulfoxide |

## Objective and Description of Study:

Four marine species (killifish, grass Shrimp, Blue Claw Crab, and American oyster) were exposed to dosages of 0.5, 1.0, 3.0, 6.0, and 12 fluid oz of Abate® 4E per acre (0.15, 0.3, 0.09, 0.18, and 0.36 lb ai/A) under field conditions in the Chrisfield, MD study. Samples were taken 3 days after treatment for the first three treatments and daily for two weeks after the final treatment. Sizes of treatment areas (test plots) were not reported. In addition, raw data and tables were not included. The Newark, DE site conducted experiments in "micro-



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marsh" testing pools in which natural salt-marsh conditions were simulated. (Details not given). Killifish and grass shrimp composite samples were taken 7 days after the final treatment. Water and sediment samples were taken for 4 weeks after treatment.

†Abate®: Abate and Abate Sulfoxide Residues in Environmental Samples - Water, Sediment and Four Aquatic Species (Chrisfield, MD and Newark, DE). American Cyanamide Company, Report No. C-333, November, 1972.

**Abate® Residues in Salt Marsh Substrates†**

| Product Tested (% ai) | Rate/Method Application | Objective of Study | Results and Conclusions |
|---|---|---|---|
| Abate 2CG<br>Abate 4EC<br>(45.1%) | Ten granular appl. at a rate of 0.1 lb ai/A at 2 week intervals. Four liquid applications at 0.032 lb ai/A at 2 week intervals. | A three year study of the ecological impact of chemicals used in mosquito control. | - Granular applications result in very low subsurface water concentrations<br>- Abate 4EC applied to the surface is transferred to surfaces of plant, algae, and other available materials within 24 hours.<br>- *S. Alterniflora*, a sparse grass which was subjected to flooding had greater soil exposer than *S. patens*, a dense grass not subjected to flooding. |

## Objective and Description of Study:

This study was conducted as a field study to measure residues of Abate in salt marsh substrates. In 1973 a 1.5 acre plot near Tuckerton, New Jersey was treated at 2-week intervals with 10 granular applications of Abate 2CG as described above. In addition, in 1974 a 7.5 acre salt marsh plot near Manahawkin was treated with 4 liquid applications of Abate 4E at 0.032 lb ai/A at 2-week intervals. At the Tuckerton site water was monitored on an hourly basis for Abate residues in 5 potholes. The following year 3 of the 5 potholes were monitored. Three potholes were monitored at the Manahawkin site after the applications. Algae, grass, and soil samples were taken at the same potholes on day 1 and weeks 1 and 2 after application. Samples were also collected at control plots where Abate was not detected.

†Carey, W.E. and R. Iadevaia. 1976. Abate Residues in Salt Marsh substrates. Proceedings of the 63rd Annual Meeting of the NJ Mosquito Control Commission, pp. 186-193.

## A Summary of Studies of the Impact of Temephos and Chlorpyrifos on the Salt Marsh Environment†

| Product Tested (% ai) | Rate/Method Application | Objective of Study | Results and Conclusions |
|---|---|---|---|
| Abate 2CG<br>Abate 4EC<br>(45.1%) | Ten granular appl.. At a rate of 0.1 lb ai/A at 2 week intervals. Four liquid applications at 0.032 lb ai/A at 2 week intervals. | To determine the impact of temephos (Abate) on a salt marsh ecosystem. | -Salt marsh grasses (*S alterniflor* and *S. patens*), isopods, amphipods, and snails, and birds species tested not affected.<br>-Did not appear to effect survival, growth, or behavior in fish for Abate 2G.<br>-- Growth retarding effects to fish observed with Abate 4EC<br>- Abate 2G reduces the density of natural fiddler crab populations<br>- Crab activity was impaired by sublethal doses making larvae susceptible to bird predatation. |

### Objective and Description of Study:

This study was conducted as a field study to determine the impact of temephos (Abate on a salt marsh ecosystem. In 1973, 4 one acre plots (2 treated and 2 control) near Tuckerton, New Jersey were marked out for the measurement of effects of temephos to bird species. Two additional plots (1 treatment and 1 control) were marked for grass productive, non-target organisms, and .residues studies. Ten granular applications of Abate 2CG were applied as described above. In addition, in 1974, five 7.5 acre salt marsh plots near Manahawkin were treated with 4 liquid applications of Abate 4E at 0.032 lb ai/A at 2-week intervals. Two of the five plots were used as controls, one for the Abate 4EC treatment, one for a Dursban (Chlorpyrifos) treatment, and one as a bird control plot. Although the details of the studies are not given, observations and measurements were said to be made at frequent, periodic intervals before, during and after treatment.

†Forgash, A.J. 1976. A Summary of Studies of the Impact of Temephos and Chlorpyrifos on the Salt Marsh Environment. Proceedings of the 63rd Annual Meeting of the NJ Mosquito Control Commission, pp. 94-98.

## A Study of the Effects of Abate, Applied For Mosquito Larvae Control on Non-Target Organisms in a Maryland Tidal Marsh†

| Product Tested (% ai) | Rate/Method Application | Objective of Study | Results and Conclusions |
|---|---|---|---|
| Abate 4EC<br>(45.1%) | One applications at 0.048 lb ai/A. | To determine the acute toxicity of Abate 4EC to estuarine organisms found to be most sensitive under laboratory conditions. | - Negligible 48-hour mortality to the four salt marsh organisms tested. |

### Objective and Description of Study:

This study was conducted in August 1977 on the salt marshes at the Deal Island Wildlife Management Area on the Eastern Shore of Maryland. Abate 4EC was applied to 250 acres at a rate of 0.048 lb ai/A. An additional control plot about 2 miles south was not treated. The



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selected four test species of non-target organisms indigenous to salt marshes included the eastern oysters (70 individuals), the blue crab (10 individuals), the grass shrimp (140 individuals) and the mallard duck (10 individuals). Observations were made for mortality prior to and 24 and 48 hours after application.

†MD Department of Agriculture. A Study of the Effects of Abate, Applied for Mosquito Larvae Control on Non-Target Organisms in a Maryland Tidal Marsh. 1977. Unpublished Report. 9 pp.

**Effects of Abate 2G and Abate 4E Mosquito Larvicides on Selected Non-Target Organisms Coexisting with Mosquito Larvae in Woodland Depressions†**

| Product Tested (% ai) | Rate/Method Application | Objective of Study | Results and Conclusions |
|---|---|---|---|
| Abate 2G<br>Abate 4EC<br>(45.1%) | One application Abate 2G at 5.0 lb/A and one application of Abate 4EC at 0.031 lb ai/A. | To study the effects of granular and flowable temephos formulations on non-target organisms under field conditions. | - Most non-target populations returned to original population levels after 48 hours of application. Cladocerans we most susceptible (7 days for recovery needed) |

## Objective and Description of Study:

The non-target organisms used in this study were representatives of the cladocerans, copepods, ostracods, and damselfly. The breeding sites were observed daily and 10 dips of water were taken at each site and poured through a plankton net. Population estimates were determined and recorded for a period of 5 days before treatment and 10 days after the treatment. The pre-treatment dips were used as the controls to record the natural development of untreated populations.

†Liem, K.K., and R.N. LaSalle. 1976. Effects of Abate 2G® and Abate 4E® Mosquito Larvicides on Selected Non-Target Organisms Coexisting with Mosquito Larvae in Woodland Depressions. Mosquito New 36(2): 202-203.

**The Residual Effect of Temephos (Abate 4E) on Non-Target Communities†**

| Product Tested (% ai) | Rate/Method Application | Objective of Study | Results and Conclusions |
|---|---|---|---|
| Abate 4EC<br>(45.1%) | One application Abate 4EC at 2.5 lb ai/A | To study the impact of temephos on non-target organism in relation to the time of recovery of these populations. | - Non-target populations recovered 3 weeks after the application.<br>- Temephos did not persist in treated water |

## Objective and Description of Study:

Three manmade ponds were treated to assess the impact of temephos (Abate 4E) on non-target organisms. The first pond was untreated and served as a control pond, while the second and third were treated at a rate of 2.5 lb ai/A on May 14, 1982. The first and the third pond contained about the same water volume, shape, surface area, and depth, while the second pond



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differed enough to have a direct effect on the thermal regimen of the ponds. Three samples of 5 liters were collected at predetermined transects at each pond, filtered, and fixed in a 5% formaldehyde solution. Beginning on May 4, 1982, the ponds were sampled 3 times prior to application, then at 3 or 4 day intervals for the 2 weeks after application, then on a weekly basis throughout the season. The ponds were also sampled 5 times the following summer. Physicochemical characteristics were also measured at each sampling time.

†Fortin, C., A. Maire, and R. LeClair. 1987. The Residual Effect of Temephos (Abate® 4E) on Non-Target Communities. Journal of the American Mosquito Control Association. 3(2): 282-288.

**Impact Assessment of Mosquito Larvicides on Non-target Organisms in Coastal Wetlands†**

| Product Tested (% ai) | Rate/Method Application | Objective of Study | Results and Conclusions |
|---|---|---|---|
| Abate 4EC (45.1%) | Three appl. at 2-week intervals at a rate of 0.031 lb ai/A. | To measure the impact of Abate (temephos) and Altosid (methoprene) applications on coastal shorebird populations and their prey under field conditions | - No acute toxicity was observed in adult fiddler crabs<br>- Tidal water did not retain larvicides in detectable amount for greater than 24 hours<br>- Mussels did not accumulate Abate in detectable quantities<br>- Fiddler crabs retained Abate in concentrations similar to that found in leaf litter . Possible internal bioaccumulation or physical adsorption to the crab shell<br>- Abate residues found in leaf litter persisted up to 96 hours after application<br>- Sediment samples contained a small but consistent amount of Abate for up to 168 hours<br>- At least 13 species of listed birds were observed at or near the habitat typically sprayed<br>- In total, 115 bird species were documented during the study period<br>- Most wading birds make heavy use of the isolated ponds upland of the saltern habitat, as well as the salterns, when standing water is present. |

## Objective and Description of Study:

The purpose of this study was to measure the impact of Abate (temephos) applications on coastal shorebird populations and their prey under field conditions. Three aerial applications of Abate were made on 8/27/88, 9/10/88, and 10/28/99 at an average rate of 0.031 lb ai/A (the maximum label rate is 0.047 lb ai/A) to 3 sites plus 1 control site. Crabs and mussels were collected from the St. Jude area of Lee County, Florida up to 24 hours after application. Larvicide residue field collections included residue monitoring on mangrove leaves, water pools, leaf littler/detritus, fiddler crabs, and mussels. Residues on mangrove leaves were determined by collecting 30 leaves from each site. Leaf litter/detritus were obtained by collecting a composite sample from each site. Residues in water were collected in a 1-L water sample at each site. Residues in mussels and fiddler crabs were determined by collecting at least 12 individuals from each site.



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Three sites were also chosen for bird study sites. An additional control site was located in the mangrove and salt marsh fringes of Charlotte Harbor. The method used to monitor birds was to routinely visit predetermined points and recording bird species seen and/or heard for three 5-minute intervals. The primary purpose of these recordings were to provide insight into the within group variation between observational periods at each point.

†Pierce, R.H., Henry, M.S., Proffitt, L.S., and Evans, R.K. 1989. Impact Assessment of Mosquito Larvicides on Non-Target Organisms in Costal Wetlands. Mote Marine Laboratory, Sarasota, Fl.

**Impact Assessment of Mosquito Larvicides on Non-target Organisms in a Salt Marsh Community and on Selected Listed Species of Marsh and Shore Birds of the Southwest Florida Coast†**

| Product Tested (% ai) | Rate/Method Application | Objective of Study | Results and Conclusions |
|---|---|---|---|
| Abate 4EC (45.1%) | Three appl. at 2-week intervals at a rate of 0.031 lb ai/A. | 1) To assess the impact of temephos on larvae and juveniles of non-target salt marsh organisms during a 15-month period (July 1, 1989 to September 30, 1990).<br><br>2) Determine what levels of temephos were in the eggs and/or young of selected species at various distances from the study area; and determine where these birds were feeding. | - Temephos residues in water after application ranged from 0.6 to 108 µg/L (ppb).<br>- Small concentrations of temephos were recovered from both the *Uca* and *Aratus* crabs as well as the coffee bean snail, ribbed mussel, and sheepshead minnow, indicating a potential for accumulation in the food chain.<br>- Temephos was observed to be almost 10 times more concentrated at the water's surface. Indicated that organisms in contact with the water surface are more vulnerable.<br>- The 1990 studies concluded that there was a 30% mortality of *Uca* crabs and a 20% mortality of *Aratus* crabs 6 hours after application. However, the mosquito larvae experienced a 100% mortality.<br>- The crab larvae were not frequently present when mosquito larvae are developing. Better timing of temephos applications could avoid exposure to crab larvae. |

## Objective and Description of Study:

The objective of the first study was to assess the impact of temephos on larvae and juveniles of non-target salt marsh organisms during a 15-month period (July 1, 1989 to September 30, 1990). Five field applications were made with temephos (Abate 4-E) at the rate of 0.031 lb ai/A (the maximum label rate is 0.047 lb ai/A) on 7/21/89, 8/18/89, 9/14/89, 8/7/90, and 9/7/90. The primary organism of study was the larvae of the marsh fiddler crab (*Uca rapax*). However, the mangrove tree crab (*Aratus pisonii*) and the marsh crab (*Sesarma sp.*) were also tested as well as the snook fry (*Centropomus undecimalis*), the adult specimens of the invertebrate (*Mysidopsis bahia*), and the sheepshead minnow (*Cyprinodon variegatus*). In addition, two field sites were monitored on July 7 and September 6, 1990 as field controls without a temephos application to assess the survival of the marsh fiddler crab (*Uca rapax*), the mangrove tree crab (*Aratus pisonii*), and snook fry (*Centropomus undecimalis*) larvae. All were compared to the mortality rate of the target salt marsh mosquito larvae *Aedes taeniarhynchus*. To measure temephos distribution and persistence at the surface glass fiber filter pads were placed at ground level and collected one hour after application. Water



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samples were also taken before and after application to measure exposure to aquatic organisms. The amount of temephos remaining in the mangrove canopy was established by analysis of mangrove leaves at various time intervals after application.

The second study was a follow-up of a previous avian one year study in which over 115 bird species were documented as having used the marsh study areas. Thirteen of these species were listed species. The objective of this study was to 1) determine what levels of temephos were in the eggs and/or young of selected species at various distances from the study area; and 2) determine where these birds were feeding. Key bird species and rookery sites were selected for the study in accordance with availability and abundance as well as their likelihood of representing the top level of the food web. (It was pointed out that a limited number of osprey and possibly great blue heron eggs were collected and broader geographic coverage of colonies were limited because many of the key species occupied the centers of the colonies and were, therefore, unobservable.) Eggshell thicknesses for collected eggs were measured, and the only conclusion that could be made was that temephos could not be detected in any of the 40 eggs or 8 prey items that were analyzed.

†Pierce, R.H., Henry, M.S., Levi, M.R., and Lincer, J.L. 1990. Impact Assessment of Mosquito Larvicides on Non-target Organisms in a Salt Marsh Community and on Selected Listed Species of Marsh and Shore Birds of the Southwest Florida Coast. Mote Marine Laboratory, Sarasota, Fl.

**Fate and Toxicity of Abate® Applied to an Estuarine Environment†**

| Product Tested (% ai) | Rate/Method Application | Objective of Study | Results and Conclusions |
|---|---|---|---|
| Abate 4EC (45.1%) | Five appl. in 3 episodes at a rate of 0.031 lb ai/A for each application:<br>1) Two appl. at 4-day interval<br>2) One appl.<br>3) Two appl. at 3-day interval. | 1) To investigate the fate and toxicity of Abate (temephos in a mangrove system following mosquito larvicide application to intertidal mangrove-fringed estuarine areas. | - Brown shrimp an pinfish not acutely affected.<br>- 14% mortalities in mysid shrimp. No acute toxicities for sheepshead minnows, snook, and grass shrimp.<br>- Temephos not detected in oysters after 72 hours.<br>- No residues observed after in water 1-2 hrs due to tidal flushing<br>- Temephos remained on leaf surfaces and tidal pools up to 72 hrs.<br>- Negligible amounts of temephos found in sediment samples<br>- Potential problems in static pools and upper salt marshes due to lack of tidal flushing in these areas. |

## Objective and Description of Study:

One control and one test area were studied. Three separate application episodes of Abate® 4EC were monitored at a rate of 0.031 lb ai/A . The first episode was a 96-hour period where 2 applications were applied at 4 day interval (June 13 and June 17) with sample collections for residue analysis and toxicity monitoring of caged organisms at intervals of 1 hr, 6 hrs, 24 hrs, and 48 hrs after each application. The second episode was a 24-hour period where 1



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application was applied on July 24 with sample collections and toxicity monitoring at 1 hr, 3 hrs, and 24 hrs after application. The final episode was a 96-hour period where 2 applications were applied at a 3-day interval (September 29 and October 2) with sample collection and toxicity monitoring at 1 hr, 2 hrs, 4 hrs, 7 hrs, 24 hrs, and 72 hrs after the first application, and 1 hr, 2 hrs, 4 hrs, 7 hrs, and 24 hrs after the second application. The objective of the study was "determining the distribution and persistence of temephos applied to an estuarine environment during routine applications and to establish the acute toxicity to select marine organisms under normal larvicide application conditions."

Residue data was collected on the surface water, mangrove leaves, sediment, and oysters. For field toxicity tests, 6 estuarine species were observed for behavior and mortality. These species are *Ampelisca abdita, Eohaustorius estuarius, Leptocheirus plumulosus, or Rhepoxynius abronius*. The six species tested in this field test were the mysid shrimp (*Mysidopsis bahia,* snook (*Centropomis undeimalis*), brown shrimp (*Panaeus aztecus*), grass shrimp (*Palaemonetes pugio*), sheepshead minnow (*Cyprinodon variegatus*), and pinfish (*Lagodon rhombiodes*).

†Pierce, R.H., Brown, R.C., Henry, M.S., Hardman, K.R., and Palmer, C.L.P. 1988. Fate and Toxicity of Abate® Applied to an Estuarine Environment. Mote Marine Laboratory, Sarasota, Fl.

**Effects of the Mosquito Larvicide, Temephos, to Non-Target Organisms in a Salt Marsh Community†**

| Product Tested (% ai) | Rate/Method Application | Objective of Study | Results and Conclusions |
|---|---|---|---|
| Abate 4EC (45.1%) | Two series of five appl. at a rate of 0.015 lb ai/A for each application. (Each series were sprayed at different locations.)<br><br>First Series:<br>3 appl .with 4 week interval between appl.<br><br>Second Series:<br>About 6 weeks after last appl. of first series 2 more appl. with 7 day interval. | To assess the impact of temephos on non-target salt marsh organisms with an ultimate goal to determine whether the use of temephos creates an unacceptable risk to non-target organisms within a south Florida salt marsh. | - Temephos concentrations in salt marsh water of 0.031 lb ai/A (1 fl oz/A) is suspected of having adverse effects on *Aratus spp.* and *Uca spp.* larvae.<br>- Reduction of temephos to 0.015 lb ai/A reduced field concentrations below acute toxicity levels for Aratus spp.<br>- Lab tests showed temephos more highly toxic to *Aratus* than *Uca*.<br>- *Uca spp* present in the mid-marsh, and therefore not as susceptible as *Aratus spp.*<br>- 48 hr LC50 ranged from 6.4 to 49.8 μg/L for *Aratus spp.*<br>- *Uca* 96 hour $LC_{50}$s ranged from 5.6 to 14.9 μg/L. 48-hour $LC_{50}$s ranged from 56 to >67μg/L. |

## Objective and Description of Study:

One control and one test area were studied for mortality monitoring at the St. Jude area site. Three applications of Abate® 4EC were applied at a rate of 0.015 lb ai/A on 6/5, 7/31, and 8/28/92. Ten *Aratus spp.* Crab larvae were placed in each of 6 cylinders in a floating trays. Additionally, 10 mosquito larvae were placed in each of three nytex cylinders. Two trays were used at each site, one with a cylinder of mosquito larvae and 3 cylinders of *Aratus* larvae



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and the other with 2 cylinders of mosquito larvae and 3 of *Aratus* larvae. Two cylinders at each site were used to return to the lab for long-term observation after the 6-hour field exposure period.

The second test site at Bonita Springs area was similarly set up to study the effect of a reduced larvicide dosage on mortality of the freshwater mosquito larvae, *Culex migripalpas*. Applications were made on 10/16 and 10/23/92.

Temephos concentrations were analyzed from the surface and mid-depth water to assess the distribution and persistence of temephos. Filter pads were also placed at the larval exposure sites, the control site, and in the open marsh area and collected 1 hour after application to measure the amount of temephos settling in the marsh.

The laboratory toxicity tests were conducted for the *Aratus* crabs using both static and water exchanges systems on 4/21/92, 5/4/92, 5/19/92, and 6/9/92. The *Uca* crabs were tested on 7/15/92, 9/4/92, and 9/29/92. These studies were said to follow EPA protocols, but complete details and the raw data of these studies did not appear in the report.

†Pierce, R.H. 1993. Effects of the Mosquito Larvicide, Temephos, to Non-target Organisms in a Salt marsh Community. Mote Marine Laboratory, Sarasota, Fl.

**Temephos Distribution and Toxicity in a South Florida Salt Marsh Community†**

| Product Tested (% ai) | Rate/Method Application | Objective of Study | Results and Conclusions |
|---|---|---|---|
| Abate 4EC (45.1%) | Two appl. at a rate of 0.015 lb ai/A with 15 day interval between appl. | To determine if aerial application of temephos is detrimental to non-target organisms in a South Florida mangrove fringing salt marsh community. | - Temephos concentration after 1 hour ranged from 3 to 10 µg/L at the low tide mid-marsh *Uca* site. The concentrations ranged from 1.0 to 1.8 µg/L temephos at high tide five hours after application. None was detected in the lower marsh<br>- After second application to upper marsh area only, no temephos was detected in middle or lower marshes during out-going tide.<br>- Lab tests showed no difference in crab larvae toxicity between the technical and Abate.<br>- 1992 field test concluded no immediate concern, but significant mortality through first molt<br>- 1993 field test showed increased mortality during first molt for *Uca* larvae in mid-marsh, but no effect for Aratus in lower marsh.<br>- Study concludes that when applications are restricted to upper marsh areas risks to crab larvae is reduced or eliminated. |

## Objective and Description of Study:



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The experimental approach was to assess the environmental exposure and follow-up with an evaluation of the environmental hazard to representative salt marsh organisms based on laboratory toxicity tests. The final outcome was to propose application conditions which would reduce the risk to non-target organisms while providing effective control of mosquito larvae.

To assess the environmental exposure an aerial application of temephos was applied to upper and mid-marsh areas on September 2, 1993 where the most abundant crab species (*Uca rapax* and *Aratus pisonii*) were known to occur. The application rate was not specified in the actual body of the report, however, the summary indicated a rate of 0.5 fl. oz./A (0.015 lb ai/A). Water samples at the surface and mid-level depths were collected prior to and at 1 and 5 hours after application. A second application was applied on September 17 to the upper marsh area only at low tide and water samples were collected prior to and at 1, 4, 5, and 6 hours after application. Samples were again collected at surface and mid-depth at the upper, middle, and lower marsh sites.

The environmental hazard evaluation was determined by comparing the EECs from the field studies to the Estimated Toxic Threshold (ETT) determined from both laboratory and field toxicity tests. The ETT was defined as the concentration of temephos exposure at which there was no difference in percent survival between test and control larvae through two days past the first molt. Laboratory toxicity tests for determination of the ETT were performed for both the *Uca* and *Aratus* crab larvae with both the technical form of the active ingredient and the product formulation (Abate®).

The larvae for the toxicity tests were used 1 to 2 days after enclosure, and to simulate tidal flushing the exposure water was exchanged at 70% at 6 hours, 50% at 24 hours and 50% every 48 hours thereafter. Three replicate sets of 20 larvae at 5 concentrations and 2 replicate sets of controls, one in salt marsh water and one set in water plus methanol which was used as a dispersant. The test concentration levels for temephos were 2.5, 5, 10, 15, and 20 $\mu$g/L. For the Abate formulation the test concentrations were 2.5, 5, 7.5, and 10 $\mu$g/L, based on the amount of temephos in the water.

Field toxicity tests were also conducted in the salt marshes by exposing mosquito and crab larvae (*Aratus ppisonii*) for 6 hours (5 hours for the 1993 study), then removing them from the marshes. They were promptly returned to the laboratory and monitored for a period of 12 days. The objective of these tests was to establish effects on survival through the first molt. The tests run in 1992 utilized *Aratus* crab larvae and mosquito larvae. The 1993 tests run the *Uca* crab larvae and the saltwater mosquito larvae, *Aedes thaeniorhynchus*.



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Ecological Impact Assessment of Abate® on Florida State Lands/Salt Marsh Communities†

| Product Tested (% ai) | Rate/Method Application | Objective of Study | Results and Conclusions |
|---|---|---|---|
| Abate 4EC (45.1%) | Applied 3 times in 1995, 1996, and 1997 at a rate of 0.015 lb ai/A with 15-22 day intervals between appl. | To address the concern for possible adverse effects from applications of the mosquito larvicide abate (temephos) on State-owned salt marsh lands along the intertidal regions of Cape Coral, Florida. | - 1995 data conclude that no temephos was detected at the surface water and very little in mid-depth after 96 hours. None detected in sediment surface water after 24 hours.<br>- 1996 data showed no detectable levels of temephos residue in sediment.<br>- 1997 data concluded that no detectable temephos levels were found in control areas. Temephos not detected in surface sediment samples.<br>- 1995 benthic data concluded no long-term exposure or accumulation. Greater species diversity at control sites.<br>- 1996 benthic data showed high level of temporal<br>†Pierce, R.H. Henry, M.S., and Culter, J.K. 1998. Ecological Impact Assessment of Abate® on Florida State Lands/Salt Marsh communities. Mote Marine Laboratory, Sarasota, Fl.<br>and spatial variation. |

†Pierce, R.H. 1993. Temephos Distribution and Toxicity in a South Florida Salt marsh Community. Mote Marine Laboratory, Sarasota, Fl.

## Objective and Description of Study:

Both control and application areas were designated for monitoring the benthic infauna and temephos concentrations before and after the applications benthic macroinfauna were monitored to account for the extreme environmental conditions due to the monthly variations from wet to dry. Another component to the study was the application of adulticides (malathion or baytex) over residential areas as needed after adult mosquitoes emerged. Therefore, the drift from these adulticides was also monitored.

Temephos was aerially applied three times in 1995 (5/1, 5/22, and 6/6), 1996 (6/14, 7/3, and 7/20), and 1997 (5/14, 6/25, and 7/17) at a rate of 0.5 fl. oz./A (0.015 lb ai/A). For adequate replication of samples the number of test and control sites were increased from two to four pairs of sites for 1996 and 1997. Samples were collected at each site at the water (surface micro layer and mid-depth), surface sediment, and at glass-fiber filter pads to monitor the amount of larvicide deposition to the marsh surface. The monitoring included collections at pre-application, 2 hours, 24 hours, and 96 hours post-application for the 1995 applications. Filter pads were retrieved 1 hour post-application for 1996 and 1997. Invertebrate samples were collected pre-application and 96 hours post-application at each study site, and a Hester Dendy invertebrate settlement collector was added in 1996 and 1997 sampling to reduce the natural habitat variability from one site to another. Snail mesocosm studies were also established to assess the impact on natural populations of marsh invertebrates. One control site and one test site was used and monitored 96 hours after the 6/1/95 application and during final field collection on 10/11/95.

Although these studies do not yield toxic endpoints required under EPA Guidelines, they have a benefit in that they show results under more realistic field conditions. Although these field studies were not requested by EPA, and no protocol was submitted to EPA for approval, a conscientious and sustained effort was evident in developing these field studies, especially the Lee County, Florida monitoring studies. The data summarized in these aquatic field studies have demonstrated the following conclusions regarding risk to non-target aquatic organisms.

1. Non-target aquatic invertebrate populations tend to reestablish to their original population levels within three weeks after application (Fortin, et. al., 1976). In another study, (Liem, et. al., 1976) Cladocerans appeared to be the most sensitive taking 7 days to recover after two applications. The other three representatives tested (copepods, ostracods, and damselflies) reestablished after 48 hours. In another study, (Siefert, et. al., 1986) observed recovery to the zooplankton community, but growth patterns were altered.

2. Ten applications of the granular 2G formulation did not appear to affect survival, growth, or behavior in fish, but growth retarding effects were observed after 4 applications of the liquid Abate 4E formulation (Forgash, et. al., 1976). No acute mortality, growth effects, or acetylcholinesterase inhibition was observed in bluegill (Siefert, et.al., 1981). No acute effects were observed in pinfish, sheepshead minnows, or snook (Pierce, et. al., 1988).

3. A Florida salt marsh field study conducted in 1989 concluded that there was no acute toxicity to adult fiddler crabs when salt marsh areas were treated three times at 2-week intervals at a rate of 0.031 lb ai/A (Pierce, et. al., 1989). However, continued work in 1990 concluded that there was a 30% mortality of the fiddler crab larvae (*Uca rapax*) and a 20% mortality of the mangrove tree crab larvae (*Aratus pisonii*) six hours after application (Pierce, et. al., 1990). A further 1993 study concluded that concentrations in salt marsh water resulting from an application rate of 0.031 lb ai/A (1 fl. oz/A) is suspected of having adverse effects on the fiddler crab and the mangrove tree crab. Laboratory studies revealed that the mangrove tree crab with a 48-hour LC50 range of 6.4 to 49.8 ug/L was found to be more sensitive than the fidler crab (LC50 = 56 to >67 ug/L). The mangrove tree crab inhabits the lower marsh areas which are not being treated, and exposure to this species was greatly reduced. Further, when the



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application was reduced to 0.015 lb ai/A and sprayed in the upper and mid-marsh areas where the fiddler crab is found, the exposure concentrations were reduced to below the fiddler crab acute toxicity level while still killing 100% of the mosquito larvae (Pierce, et. al., 1993). Further field toxicity studies were conducted to establish the effects of larval survival through the first molt (Pierce, et. al., 1993). The results of the 1992 study showed significant mortality through the first molt (almost 50% in one test). The 1993 study showed increased mortality for the *Uca rapax* (fiddler crab) in the mid-marsh, but no effect to the *Aratus pisonii* (mangrove tree crab) in the lower marsh. The net conclusions of these studies are when minimum application rates of 0.015 lb ai/A are restricted to upper marsh areas, risk to crab lavae are reduced or eliminated. It is also interesting to note that the laboratory results showed no difference in crab larvae sensitivity between the technical temephos and the formulated product (Abate 4EC). In contrast, the acute toxicity data available for fish indicate that the formulated product is much more toxic than the technical. The rainbow trout $LC_{50}$ for the technical is 3,490 ppb, and 158 ppb for the formulated product. We have no data on the technical for the *Daphnia magna*.

4. A number of the conducted field studies relating to the fate of temephos under field conditions have verified much of the laboratory data that EFED has reviewed. In addition, much information concerning residue concentrations in various media has been obtained.

Some field studies confirm the laboratory data which characterizes temephos as not persisting in the water column. According to one study temephos was not detectable in tidal waters for more than 24 hours (Pierce, et. al., 1989). In a 1990 study residues in water after application ranged from 0.6 to 108 $\mu$g/L (Pierce et. al., 1990). Temephos concentration after 1 hour ranged from 3 to 10 $\mu$/L at low tide in a mid-marsh site and 1.0 to 1.8 $\mu$g/L at high tide 5 hours after application in a 1993 study (Pierce, et. al., 1993). A 1972 study by American Cyanamide concluded that temephos was rapidly adsorbed to sediment and converted to Abate sulfoxide. The measured concentration of Abate sulfoxide was 400 $\mu$g/L. There was also evidence to show that the liquid temephos formulation was up to 10 times more concentrated at the water's surface (Pierce et. al., 1990). Although not quantified, granular applications resulted in very low sub-surface concentrations (Carey, et. al., 1976).

Residues detected in sediment showed a wide range of results. A 1981 study did not detect temephos in sediment from 1 hour to 14 days (Siefert, et. al., 1986). A study from 1972 showed Abate sediment concentrations of 530 $\mu$g/L (American Cyanamide, 1972). Another study showed a small but consistent amount of Abate in sediment for up to 168 hours (Pierce, et. al., 1989). The most recent study which monitored



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temephos sediment over a three year period (1995-97), did not detect temephos in the sediment after 24 hours (Pierce, et. al., 1998).

Temephos was detected in various media substrates as well as sediment in many of the studies. A 1976 study found that Abate was transferred to surfaces of plant, algae, and other available materials within 24 hours (Carey et. al, 1976). Abate was also found to remain on leaf surfaces and tidal pools for up to 72 hours, most, however, was dissipated into the estuary by tidal flushing (Pierce, et. al., 1988). Abate residues found in leaf litter persisted up to 96 hours after application (Pierce, et. al., 1989). Small concentrations of temephos were also recovered from the fiddler crab and mangrove tree crab as well as the coffee bean snail, ribbed mussel, and sheepshead minnow, however quantities were not given (Pierce, et. al., 1990). Temephos residues in Crab ranged from 60 to 3,110 ppb after 2$^{nd}$ treatment (American Cyanamide, 1972). In a 1988 study temephos was not detected in oysters 72 hours after treatment (Pierce, et. al., 1988). Mussels did not accumulate in detectable quantities 24 hours after application in a 1989 study (Pierce, et. al., 1989).

### f. Toxicity to Nontarget Plants

Seed germination/seedling emergence, vegetative vigor (Tier 1), and growth and reproduction of plants (Tier 1) were required in the 1981 RS. Seed germination/seedling emergence and vegetative vigor (Tier 1) were subsequently waived (Bushong, 1982). In 1993, SRRD required that aquatic plant growth (Tier 1) testing (Guideline 122-2) be submitted within one year. A literature search for aquatic plant phytotoxicity was conducted by EFED. The results of this search revealed that there are no phytotoxic concerns for Temephos, and therefore aquatic plant data will not be required at this time.

## 4. Ecological Risk Assessment

Risk characterization integrates the results of the exposure and ecotoxicity data to evaluate the likelihood of adverse ecological effects. The result of this calculation is called the quotient method. Risk quotients (RQs) are calculated by dividing exposure estimates by acute and chronic ecotoxicity values.

RQ = EXPOSURE/TOXICITY

RQs are then compared to OPP's levels of concern (LOCs). These LOCs are used by OPP to analyze potential risk to nontarget organisms and the need to consider regulatory action. The criteria indicate that a pesticide used as directed has the potential to cause adverse effects on nontarget organisms. LOCs currently address the following risk presumption categories: (1) **acute high** -- potential for acute risk is high; regulatory action may be warranted in addition to restricted use classification, (2) **acute restricted use** -- the potential



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for acute risk is high, but may be mitigated through restricted use classification, (3) acute endangered species - endangered species may be adversely affected, and (4) chronic risk - the potential for chronic risk is high regulatory action may be warranted. Currently, EFED does not perform assessments for chronic risk to plants, acute or chronic risks to nontarget insects, or chronic risk from granular/bait formulations to birds or mammals.

Risk presumptions and the corresponding RQs and LOCs, are tabulated below.



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Risk Presumptions for Aquatic Animals

| Risk Presumption | RQ | LOC |
|---|---|---|
| Acute High Risk | EEC[1]/LC50 or EC50 | 0.5 |
| Acute Restricted Use | EEC/LC50 or EC50 | 0.1 |
| Acute Endangered Species | EEC/LC50 or EC50 | 0.05 |
| Chronic Risk | EEC/MATC or NOEC | 1 |

[1] EEC = (ppm or ppb) in water

a. **Exposure and risk to nontarget terrestrial animals**

Temephos is applied directly to water and is not expected to affect terrestrial animals. Therefore, LOCs have not been calculated for exclusively terrestrial animals.

**I. Acute exposure and risk.**

Some animals are primarily terrestrial but swim in and drink from water that may be sprayed with Temephos. The Mallard duck fits this category and EFED has data on Temephos' toxicity to it.

EPA's "Wildlife Exposure Factors Handbook" gives an equation to calculate the amount of water intake for a bird:

$$W.I. = 0.059 \times wt^{0.67} = 0.06 \text{ liters/day}$$

Where W.I. is the water intake, wt is the bird's weight in KG, and 0.059 and 0.67 are experimentally derived numbers. The average weight of a Mallard is 1.1 kg.

The Food Intake equation is:

$$F.I. = 0.0582 \times wt^{0.651} = 0.062 \text{ kg/day}$$

Where F.I. is the food intake, wt is the bird's weight in KG, and 0.0582 and 0.651 are experimentally derived numbers.

The dietary $LC_{50}$ for a Mallard is 894 ppm, *i.e.*, 894 mg of Temephos per kilogram of food. If a Mallard eats 0.062 kg/day, it receives 55.4 mg of Temephos per day in an $LC_{50}$. The acute $LD_{50}$ is 27.4 mg per kilogram of bird for Bobwhite quail (there is no acceptable Mallard $LC_{50}$), *i.e.*, 30.1 mg of Temephos per 1.1 kg bird. This value is below the level of concern.

The W.I. equation predicts that a Mallard will drink 0.06 liters of water per day. The highest "Peak Concentration" for application of Temephos is 50 ppb or 0.05 mg Temephos per liter of water. Therefore, a Mallard duck would be expected to take in 0.003 mg Temephos per day by drinking water. This expected intake is below the level of concern.



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Another route of exposure for birds and mammals may be via the ingestion of aquatic organisms. Fish and other aquatic organisms may bioaccumulate pesticide residues from water, sediment, and/or their food. Some piscivores, like egrets, herons, kingfishers, pelicans, cormorants, water snakes, and turtles may swallow fish whole. Other piscivores species, like mink, river otter, osprey, bald eagle, gulls and terns may feed largely on the viscera which may have higher pesticide residue levels.

This risk assessment is limited to bioconcentration (i.e., residue uptake from water only), and does not address bioaccumulation of pesticide residues (i.e., residue uptake from diet and water exposures). In aquatic habitats, pesticides with certain properties are taken by organisms directly from water and sediments. Predatory species also take up pesticides in their diet. While the residues in food may increase residue levels higher than the amounts taken up from water, for most pesticides, aquatic organisms will obtain the largest portion of the pesticide residue directly from the water via absorption through the gills and skin. Since long-term, cumulative concentration of Temephos in an aquatic ecosystem does not allow assessment of residues potentially taken-up at levels that these organisms can be exposed. To assist aquatic bioaccumulation data are unavailable, the risks to piscivores are based on BCF values which may be an underestimation of risks to piscivorous species.

Gross estimates of the dietary exposures for piscivorous mammals and birds can be made by multiplying the average water concentration for the time it takes for a steady-state to be reach in bioconcentration test times the bioconcentration factor (BCF). Temephos BCF values used in this risk assessment are 970X for whole fish and 2300X for viscera. Aquatic bioaccumulation data from actual environmental concentrations (i.e. from monitoring data) are not available for Temephos. EXAMS generated concentrations were used to roughly estimate the uptake and bioconcentration in piscivorous mammals and birds. These residue levels in fish were estimated by multiplying the 21-day EEC from EXAMS generated concentrations times the BCF values for whole fish and viscera. Risks to piscivores can be estimated by comparing the estimated residue levels in fish to the subacute dietary $LC_{50}$ and reproductive NOECs for mammals and birds. The resulting residue levels and resulting risk quotients are presented in the table below.

Risk Quotients for Piscivorus Birds Based On an Avian Subacute Dietary Bobwhite Quail $LC_{50}$ of 92 ppm on the TGAI (86.2%) at a maximum rate of 0.5 lb ai/A for the granular formulation.

| Site/Application Method/Rate in lbs ai/A (No. of Apps.) | LC50 (ppm) 86.2% ai | Residues (Fish Viscera) 21-day EEC (ppm) x BCF | | Acute RQ (EEC/LC50) | |
|---|---|---|---|---|---|
| | | 15 cm | 30 cm | 15 cm | 30 cm |
| Intermittent Ponds/aerial & ground/ 0.5(1) | 92 | 6.9 | 3.5 | 0:08 | 0:04 |
| 0.5(2) at 7 day intervals | 92 | 12.9 | 6.5 | 0:14 | 0:07 |
| 0.5(2) at 15 day intervals | 92 | 11.9 | 6.0 | 0:13 | 0:07 |
| 0.5(2) at 90 day intervals | 92 | 11.5 | 5.8 | 0:13 | 0:06 |

Based on the above table, Temephos residue levels calculated from Bioconcentration Factors (BCF) in fish viscera, residue levels are expected to be lower than the avian subacute dietary $LC_{50}$. Although EFED has not established LOC criteria for presumption of risk to piscivorous birds, if the same presumptions for risks to non-piscvorous birds are applied, only endangered species may be affected in the 15 cm pond depth scenario.

### ii. Reproductive risk to nontarget terrestrial animals

Birds are expected to be exposed Temephos during the breeding season. No studies on reproductive effects have been submitted for either the Mallard duck or the Bobwhite quail.

## b. Exposure and Risk to Nontarget Freshwater Aquatic Animals

EFED uses environmental fate and transport computer models to calculate refined EECs. The Exposure Analysis Modeling System (EXAMS 2.97.5) simulates pesticide fate and transport in an aquatic environment (one hectare body of water, two meters deep). Since Temephos is directly applied as a mosquito larvicide to intermittent ponds and drainage ditches, it was concluded that the use of this exposure scenario with pond depths of 15 and 30 cm. The resulting EECs are presented under Section 2.f.

### I. Risk quotients for freshwater Fish

Acute risk quotients are tabulated below based on pond depths of 15 and 30 cm for the 0.5 lb ai/A application rate for the granular formation, and 0.046875 lb ai/A for the EC formulation. Chronic data are unavailable for freshwater fish.

Risk Quotients for Freshwater Fish Based On a Rainbow trout LC50 of 3490 ppb ($\mu$g/l) on the TGAI (86.2%) at a maximum rate of 0.5 lb ai/A for the granular formulation.

| Site/Application Method/Rate in lbs ai/A (No. of Apps.) | LC50 (ppb) 86.2% ai | EEC Initial/Peak (ppb) | | Acute RQ (EEC/LC50) | |
|---|---|---|---|---|---|
| | | 15 cm | 30 cm | 15 cm | 30 cm |
| Intermittent Ponds/aerial & ground/ 0.5(1) | 3490 | 48.8 | 24.4 | 0:01 | 0:01 |
| 0.5(2) at 7 day intervals | 3490 | 50.4 | 25.2 | 0:01 | 0:01 |
| 0.5(2) at 15 day intervals | 3490 | 50.0 | 25.0 | 0:01 | 0:01 |
| 0.5(2) at 90 day intervals | 3490 | 48.8 | 24.4 | 0:01 | 0:01 |

Risk Quotients for Freshwater Fish Based On a Rainbow trout LC50 of 158 ppb ($\mu$g/l) on the EC Formulation (43% ai) at a maximum rate of 0.047 lb ai/A.

| Site/Application Method/Rate in lbs ai/A (No. of Apps.) | LC50 (ppb) 86.2% ai | EEC Initial/Peak (ppb) | | Acute RQ (EEC/LC50) | |
|---|---|---|---|---|---|
| | | 15 cm | 30 cm | 15 cm | 30 cm |
| Intermittent Ponds/aerial & ground/ 0.5(1) | 158 | 48.8 | 24.4 | 0.31 | 0.15 |
| 0.5(2) at 7 day intervals | 158 | 50.4 | 25.2 | 0.32 | 0.16 |
| 0.5(2) at 15 day intervals | 158 | 50.0 | 25.0 | 0.32 | 0.16 |
| 0.5(2) at 90 day intervals | 158 | 48.8 | 24.4 | 0.31 | 0.15 |

An analysis of the results indicate that aquatic acute high risk, restricted use, and endangered species levels of concern are not exceeded for granular applications to freshwater fish at a registered maximum application rates of 0.5 lb ai/A. Only restricted use and endangered species levels of concerns are exceeded for the liquid formulation at a maximum rate of 0.047 lb ai/A.

**ii. Risk Quotients for Freshwater Invertebrates**

The acute risk quotients are tabulated below. Chronic data on freshwater aquatic invertebrates are not available.



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Risk Quotients for Freshwater Invertebrates Based on a Stonefly *Pteronarcs* spp. EC50 of 10 ppb (μg/l) for the TGAI (86.2%) at a maximum rate of 0.5 lb ai/A for the granular formulation.

| Site/Application Method/ Rate in lbs ai/A(No. of Apps.) | EC50 (ppb) 86.2% ai | EEC Initial/Peak (ppb) | | Acute RQ (EEC/LC50) | |
|---|---|---|---|---|---|
| | | 15 cm | 30 cm | 5 cm | 30 cm |
| Intermittent Ponds/aerial & ground/ 0.5 (1) | 10 | 48.8 | 24.4 | 4:88 | 2:44 |
| 0.5 (2) at 7 day intervals | 10 | 50.4 | 25.2 | 5:04 | 2:52 |
| 0.5 (2) at 15 day intervals | 10 | 50.0 | 25.0 | 5:00 | 2:50 |
| 0.5 (2) at 90 day intervals | 10 | 48.8 | 24.4 | 4:88 | 2:44 |

Risk Quotients for Freshwater Invertebrates Based on a *Daphnia magna* EC50 of 0.011 ppb (μg/l) for the EC Formulation (43% ai) at a maximum application rate of 0.047lb ai/A.

| Site/Application Method/ Rate in lbs ai/A(No. of Apps.) | EC50 (ppb) 86.2% ai | EEC Initial/Peak (ppb) | | Acute RQ (EEC/LC50) | |
|---|---|---|---|---|---|
| | | 15 cm | 30 cm | 5 cm | 30 cm |
| Intermittent Ponds/aerial & ground/ 0.5 (1) | 0.011 | 48.8 | 24.4 | 4,436.36 | 2,218.18 |
| 0.5 (2) at 7 day intervals | 0.011 | 50.4 | 25.2 | 4,581.82 | 2,290.91 |
| 0.5 (2) at 15 day intervals | 0.011 | 50.0 | 25.0 | 4,545.45 | 2,272.73 |
| 0.5 (2) at 90 day intervals | 0.011 | 48.8 | 24.4 | 4,436.36 | 2,218.18 |

An analysis of the results indicate that aquatic acute high risk, restricted use, and endangered species levels of concern are exceeded for freshwater invertebrates at a registered maximum application rate at 0.5 lb ai/A for granular formulations. All aquatic acute high risk, restricted use, and endangered species levels of concern are exceeded by many folds at for the liquid formulation at a maximum application rate of 0.047 lb ai/A.

### c. Exposure and Risk to Estuarine and Marine Animals

The acute risk quotients for marine/estuarine invertebrates are tabulated below. Marine/estuarine exposure is based upon tidal flats with between one and twenty centimeters of water. This range of water depths was chosen based on personal communication with George Wichterman of the Lee County Mosquito Control District of Florida. Acute and chronic data are not available for marine/estuarine fish are not available. Chronic data on marine/estuarine invertebrates are not available.

*Risk Quotients for Marine/Estuarine Invertebrates Based on a Pink Shrimp EC50 of 220 ppb (µg/l) for the TGAI (86.2%) at a maximum rate of 0.5 lb ai/A for the granular formulation where tidal flushing occurs.*

| Rate in lbs ai/A | EC50 (ppb) 86.2% ai | EEC Initial/Peak (ppb) | | Acute RQ (EEC/LC50) | |
|---|---|---|---|---|---|
| | | 1 cm | 20 cm | 1 cm | 20 cm |
| 0.015 | 220 | 151 | 8 | 0.69 | 0.04 |
| 0.030 | 220 | 302 | 15 | 1.37 | 0.07 |
| 0.047 | 220 | 435 | 23 | 1.98 | 0.10 |

*Risk Quotients for Marine/Estuarine Invertebrates Based on a Pink Shrimp EC50 of 5.3 ppb (µg/l) for the EC Formulation (43% ai) where tidal flushing occurs.*

| Rate in lbs ai/A | EC50 (ppb) 86.2% ai | EEC Initial/Peak (ppb) | | Acute RQ (EEC/LC50) | |
|---|---|---|---|---|---|
| | | 1 cm | 20 cm | 1 cm | 20 cm |
| 0.015 | 5.3 | 151 | 8 | 28.5 | 1.5 |
| 0.030 | 5.3 | 302 | 15 | 57.0 | 2.8 |
| 0.047 | 5.3 | 453 | 23 | 85.5 | 4.3 |

*Risk Quotients for Marine/Estuarine Invertebrates Based on a Pink Shrimp EC50 of 5.3 ppb (µg/l) for the EC Formulation (43% ai) in standing water (tidal pools).*

| *Rate in lbs ai/A* | *EC50 (ppb) 86.2% ai* | *EEC Initial/Peak (ppb)* | | *Acute RQ (EEC/LC50)* | |
|---|---|---|---|---|---|
| | | *1 cm* | *20 cm* | *1 cm* | *20 cm* |
| *0.015* | *5.3* | *151* | *52* | *28:5* | *9:8* |
| *0.030* | *5.3* | *302* | *104* | *57:0* | *19:6* |
| *0.047* | *5.3* | *453* | *156* | *85:5* | *29:4* |

An analysis of the results indicate that aquatic acute high risk, restricted use and endangered species levels of concern are exceeded for marine/estuarine invertebrates at a registered maximum application rate at 0.5 lb ai/A in 1cm deep water bodies. Only endangered species are exceeded in 20 cm deep water bodies. Aquatic acute high risk, restricted use, and endangered species levels of concern are exceeded at 1 - 20 cm pond depths at the registered EC application rates.

## 5. Endangered Species

The Agency has developed a program (the "Endangered Species Protection Program") to identify pesticides whose use may cause adverse impacts on endangered and threatened species, and to implement mitigation measures that will eliminate the adverse impacts.

At present, the program is being implemented on an interim basis as described in a *Federal Register* notice (54 FR 27984-28008, July 3, 1989), and is providing information to pesticide users to help them protect these species on a voluntary basis. As currently planned, the final program will call for label modifications referring to required limitations on pesticide uses, typically as depicted in county-specific bulletins or by other site-specific mechanisms as specified by state partners. A final program, which may be altered from the interim program, will be described in a future *Federal Register* notice.

The Agency is not imposing label modifications at this time through the RED. Rather, any requirements for product use modifications will occur in the future under the Endangered Species Protection Program.

## 6. Risk Characterization

### a. Characterization of the Fate and Transport of Temephos to Water

#### I. Environmental Fate

The major dissipation/degradation pathways of temephos, photolysis and biodegradation, suggest that it may not be persistent enough to impact aquatic resources; however, actual use conditions are such that half-lives may be longer than those predicted by the laboratory studies. Therefore, impact to aquatic resources cannot be ruled out. Degradation rates were not substantially different between aerobic and anaerobic conditions. No significant abiotic degradation processes were identified. Studies show that parent temephos strongly adsorbs to soils and sediments, especially under aerobic conditions where sorption was stronger than under anaerobic conditions in the early phases of the studies. This characteristic of temephos may reduce aquatic exposures under aerobic conditions during the immediate period following application. Although volatilization is not a likely dissipation pathway from soil, volatilization from water may be significant due to it's water air partition coefficient (Henry's law constant).

The two major temephos degradates formed by the oxidation of temephos are temephos sulfoxide and temephos sulfone. There is an incomplete fate database for both of these degradates. However, there is evidence in the biodegradation studies that these degradation products do not strongly sorb to sediments, in comparison to parent temephos. Hence they appear to be more mobile. The sulfoxide and sulfone degradates of other organophosphate pesticides have been shown to be more persistent than parent compounds. However, no information is available to compare the persistence of temephos degradates to that of parent temephos. Several other degradates were observed but not fully identified.

Temephos is primarily applied to salt marshes and mango swamps. Seasonal variations in dissolved oxygen concentrations, redox potential, pH, salinity, or temperature are likely to influence the rate of degradation and dissipation of temephos and the chemical nature of it's degradation products. In these sites, the contribution of direct photolysis in water is likely to be reduced by vegetation and high dissolved organic matter in the water column.

#### II. Water Resources

None of the model scenarios simulated concentrations of degradates, due to the lack of environmental fate data for these compounds. Degradates concentrations would likely be more significant in the woodland pond scenario than in the tidal flat scenario because the chemical is not dissipated by tidal action and thus remains longer in the system.



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Overall, we believe the model scenarios are designed to be conservative, but the following is an assessment of how model assumptions could affect concentrations estimated.

Tidal flat scenario: We have assumed that there is no accumulation as a result of tidal flushing based on monitoring results. Both peak and chronic concentrations could be higher if this were not the case. We are fairly confident that our assumptions about the depth of water in tidal pools is conservative, because we have simulated concentrations occurring in waters as shallow as 1 - 20 cm. In deeper water, concentrations would be lower than those predicted. Based on our understanding of current practices, we have only modeled treatment with the liquid formulation. If the granular formulation were used in tidal flats, acute concentrations would be substantially higher. Monitoring results indicate that concentrations are up to ten times higher in the top centimeter of the water column than in lower layers. This is also likely to be the cause of the lack of detections of temephos in sediment samples. One of the model scenarios presented simulates the effect of those higher concentrations that might be observed in the surface layer. Another factor contributing to the conservative nature of this assessment is the assumption that no temephos is intercepted by vegetation. In fact, this would lead to lower concentrations than those estimated.

Woodland pool scenario: The scenario modeled is assumed to be a static environment, with no temephos removed or added by streamflow. This is a realistic assumption because it characteristic of the environments in which mosquitos breed; residues introduced by direct application are not removed from the system. We have modeled the effect of two repeat applications based on information provided by the registrant; however, the label does not limit the number of applications or the interval between applications. Our modeling results indicate that peak temephos concentrations do not increase when temephos is applied at weekly intervals. We have not modeled the effect of less than weekly applications, or the impact resulting from more than two applications per year. More than two applications would likely increase the longer-term concentrations (90-days or greater). The impact of stratification in this scenario would be comparable to that described in the tidal flat scenario above. Model estimates are conservative in this case, because the effect of applying a liquid rather than granular formulation would be to decrease the concentration predicted, as a result of the lower application rates associated with the liquid formulation.

The woodland pool scenario is based on the EFED standard Georgia pond scenario. Parameters for this scenario differ from that of a woodland pond in the following ways. The pH of the woodland pond would be lower than that of the standard pond. However, this is not a major degradation pathway and would not likely affect the modeling results. The winter temperature would be lower in the woodland pond scenario than the standard pond, reducing the rate of degradation. However, since application occur primarily in the summertime, this would not likely affect model estimates. The effect of photolysis would be similar in the standard pond and the woodland pond because light attenuation with depth is similar in these environments.

### III. Drinking Water

Temephos is a larvicide that is applied directly to shallow, stagnant, brackish and polluted waters. We are assuming that exposure to temephos and its degradation products is limited to these aquatic environments, and that these waters are unsuitable as a source of drinking water. At this time there is no indication that temephos is applied directly to drinking water sources. If this were the case, residues may be available for a short period of time at elevated levels. In addition, this exposure assessment does not evaluate the effect of temephos degradates on drinking water, not do we have information on the effect of treatment on parent temephos concentrations.

Temephos is not likely to reach ground water that would be used for drinking water due to lack of transport in typical temephos use areas (which are characterized by low hydraulic gradients) and its relatively short half-life in natural waters. Therefore, it is unlikely that temephos will occur in ground water used for drinking.

## b. Characterization of Risk to Nontarget Species

### i. Terrestrial

It is not believed that Temephos poses a threat to terrestrial animals. The only Incident Report (17 sandpipers killed during mosquito control operation) was from 1973 in which neither the formulation nor the use pattern were reported. Malathion was used simultaneously with temephos as well as other insecticides and it could not be established which insecticide was responsible for the incident.

It is possible that a terrestrial animal, such as a wading bird, using water sprayed with temephos, might be exposed and weaken by the temephos in the water. But any risk resulting from this pathway seems unlikely given that the expected intake of water by a wading bird is well below that required to achieve impact. Based on temephos residue levels calculated from Bioconcentration Factors (BCF) in fish viscera, residue levels are expected to be lower than the avian subacute dietary $LC_{50}$. Although EFED has not established LOC criteria for presumption of risk to piscivorous birds, if the same presumptions for risks to non-piscvorous birds are applied, only endangered species may be affected in 15 cm bodies of water.

Although EFED lacks chronic laboratory data for temephos, several field studies submitted for review show that bird species which frequent salt marsh areas were not affected. In one study (Forgash,et. al., 1976) ten granular and four liquid applications of temephos were applied and monitored for effects on a salt marsh ecosystem. No effects were noted to the bird



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species tested, even though they gorged themselves on treated immobilized crab larva. Further studies conducted in Florida (Pierce, et. al. 1990) salt marsh areas showed almost no impact to the more than 115 shore birds that were observed in the study areas. Of the over 40 eggs and 8 prey items collected from rookeries no temephos was detected.

Although these toxic studies yielded no NOAEC (an EPA Guideline study requirement), they have limited benefit in that they show results under variable and in some cases extreme field conditions. In the case of temephos, since no measurable effects were observed in the field studies, it is uncertain whether a laboratory chronic study used to generate risk quotients would result in a vastly different risk conclusion. Furthermore, it should be noted that there is uncertainty associated with these field studies due to the variability of the field conditions.

### ii. Aquatic

Since application to turf or agricultural crops are no longer supported, aquatic animals will not be exposed to temephos from run-off. The need for repeated applications of temephos is subject to interpretation by government mosquito control abatement units or by privately owned companies (POCs) under contract to them.

An analysis of the aquatic laboratory toxicity studies indicate that aquatic acute high risk, restricted use, and endangered species levels of concern are not exceeded for freshwater fish at the registered maximum application rate of 0.5 lb ai/A. However, acute high risk, restricted use, and endangered species are just exceeded for the liquid formulations in standing water. The LOCs were exceeded for freshwater invertebrates exposed to the granular formulation and exceeded by several orders of magnitude for the liquid formulations. Chronic laboratory toxicity data are unavailable for freshwater fish or invertebrates.

An analysis of the estuarine/marine mollusk studies indicate that restricted use and endangered species levels of concern are exceeded for estuarine invertebrates at registered maximum granular application rates equal to or above 0.5 lb ai/A. Acute high risk, restricted use, and endangered species are well exceeded for the liquid formulation in tidal pools and where tidal flushing occurs. Acute laboratory toxicity data are not available for marine/estuarine fish. Chronic laboratory toxicity data are not available for marine/estuarine mollusks and marine/estuarine fish are not available.

Although the lack of laboratory data would lead EFED to conclude a high level of uncertainty of the risk to aquatic non-target organisms, several field studies which were submitted by the registrant to substitute for the lack of laboratory data on temephos have demonstrated that adverse effects to non-target organisms are minimal. No acute effects to either freshwater or marine fish were shown in any of the studies, and even after ten applications of the granular 2G formulation no chronic effects were observed in fish. Again, it should be noted that there is a certain amount of uncertainty associated with these field studies due to the variability of the field conditions.

The general conclusion from these field studies is that they demonstrate that adverse effects to marine ecosystems are minimized when temephos is used at the lower rates. Non-target organisms appear to recover to original population levels very quickly (in less than three weeks) after an application. Temephos tends to rapidly adsorb to organic media and further degrade to low or undetectable levels. In marine/estuarine ecosystems the field studies have demonstrated that tidal flushing also plays a significant role in exposure. In many cases temephos was not detected within hours after application. Due to the results of these field studies, EFED has minimal concern for aquatic risk from applications of temephos.

Characterization of risk in the sediment compartment is limited by a lack of laboratory toxicity data. Environmental fate and field data suggest that temephos tends to rapidly adsorb to organic media and further degrade to low or undetectable concentrations. However, a low level of certainty is associated with the dismissal of risk in the sediment compartment due to the inherent variability in the field data.

**iii. Nontarget Plants**

A literature search for phytotoxicity to aquatic plants was conducted by EFED. The results of this search revealed that there are no phytotoxic concerns, therefore no aquatic plant data will be required at this time. EFED has a high level of certainty that risk to aquatic non-target plants is low.



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# 7. Appendices/Supporting documentation



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## APPENDIX A

Data requirements for Temephos

| GUIDELINES | DATA REQUIREMENTS | FULFILLS REQUIREMENTS (Y/N/W/R[1]), % ai | STUDIES REVIEWED: RESULTS (ppm or mg/l) | STUDIES REVIEWED: MRID, AUTHOR, & YEAR | STATUS |
|---|---|---|---|---|---|
| 71-1(a) | Acute Avian Oral Quail | Yes, 94.7 | $LD_{50}$ =27.4 ht | 470167035 (157841, 1357, 1354), Fletcher, 1986 | Core |
| 71-2(a) | Avian Dietary Quail | Yes, 86.9 | "$LC_{50}$" + 92, ht | 22923, Hill, 1975 | Core |
| 71-2(b) | Avian Dietary- Mallard | Yes, 86.9 | "$LC_{50}$" = 894, mt | 22923, Hill, 1975 | Core |
| 71-1(b) | Acute Avian Oral Quail or Duck/TEP | N | | | |
| 71-4(a) | Avian Reproductive/Quail | N | | | |
| 71-4(b) | Avian Reproductive/Duck | N | | | |
| 72-1(a) | Fish Toxicity Bluegill | Yes, 86.2 | $LC_{50}$ = 21.8, st | 40098001 (4602), McCann (USDA), 1971 | Core |
| 72-1(b) | Fish Toxicity Bluegill/TEP-G | Yes, 43% EC | $LC_{50}$ = 1.14, ht | 40098001, McCann (USDA), 1971 | Core |
| 72-1(c) | Fish Toxicity Rainbow Trout | Yes, 86.2 | $LC_{50}$ = 3.49, mt | 40098001, McCann (USDA), 1971 | Core |
| 72-1(d) | Fish Toxicity Rainbow Trout/TEP | Yes, 43% EC | $LC_{50}$ = 0.158 ppm, vht | 1337, Kennedy, 1970 | Core |
| 72-2(a) | Invertebrate Toxicity- scud | Yes, 86.2 | $LC_{50}$ = 0.082, vht | 40098001 (4602), McCann (USDA), 1971 | Core |
| 72-2(a) | Invertebrate Toxicity- Stonefly | Yes, 86.2 | $LC_{50}$ = 0.01, vht | 40098001 (4602), McCann (USDA), 1971 | Core |



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Data requirements for Temephos

| | | FULFILLS REQUIREMENTS | STUDIES REVIEWED | | |
|---|---|---|---|---|---|
| 72-2(b) | Invertebrate Toxicity/TEP-EC Daphnid | Yes, Abate 4E | $LC_{50}$ = 0.011 $\mu$g/l NOEC = 0.0032 $\mu$g/l, vht | 470177012, (158327, 1534, 1357), Forbis, 1986 | Core |
| 72-2(b) | Invertebrate Toxicity/TEP-G Daphnid | Yes, 5G | $LC_{50}$ = 0.54 $\mu$g/l, ht | (5002680, 4602), McCann (USDA), 1975 | Supplemental |
| 72-3(a) | Estuarine/Marine Toxicity Fish | No | | | |
| 72-3(b) | Estuarine/Marine Toxicity Mollusk | Yes, TGAI | $LC_{50}$ = 0.22, ht | 40228401 | Core |
| 72-39(c) | Estuarine/Marine Toxicity Shrimp | No | | | |
| 72-3(d) | Estuarine/Marine Toxicity Fish/TEC-EC | No | | | |
| 72-3(d) | Estuarine/Marine Toxicity Fish/TEP-G | No | | | |
| 72-3(e) | Estuarine/Marine Toxicity Mollusk/TEP-EC | Yes | $LC_{50}$ = 0.32, ht | 40228401 | Core |
| 72-3(e) | Estuarine/Marine Toxicity Mollusk/TEP-G | No | | | |
| 72-3(f) | Estuarine/Marine Toxicity Shrimp/ TEP-EC, Pink shrimp *Penaeus duorum* | No | $LC_{50}$ = 5.3 ppb, NOEC = 0.6 ppb, vht | 470231012, (161090, 1357) | Supplemental, (can be upgraded) |
| 72-3(f) | Estuarine/Marine Toxicity Shrimp/TEP-G | No | | | |
| 72-4(a) | Early Life Stage Fish | No | | | |
| 72-4(b) | Life Cycle Aquatic Invertebrate | No | | | |
| 72-5 | Life Cycle Fish | R | | | |



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Data requirements for Temephos

| | | FULFILLS REQUIREMENTS | STUDIES REVIEWED | | |
|---|---|---|---|---|---|
| 72-6 | Aquatic Organisms Accumulation | Y | Fillet, 79% at 21 days and 86% at 28 days; Whole fish, 73.6% at 21 and 28 days; Viscera, 82% at 21 days and 59% at 28 days. | 165027 Fobis, 1986 | Core |
| 81-1 | Mammalian (mouse, HED study) | Yes, TGAI | $LD_{50}$ range, "770-130000" | 1354, 1365, 1368, 5000974, pnt | Core |
| 122-2 | Aquatic Plant Growth | No | | | |
| 123-1(a) | Seed Germ/Seedling Emergency | W | | | |
| 123-1(b) | Vegetative Vigor | W | | | |
| 141-1 | Honey Bee Acute Contact | No | | | |

Y = Data requirement fulfilled    X = Not applicable
N = Data requirement *not* fulfilled, study required
R = Test reserved    W = Waived
pnt = practically nontoxic, st = slightly toxic, mt = moderately toxic, ht = highly toxic, vht = very highly toxic

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APPENDIX B

## EXAMS Input Chemical Variables

| Name | Description | Value | Units | Source |
|---|---|---|---|---|
| HENRY | Henry's law rate | | $atm\text{-}m^3 mole^{-1}$ | Registrant data |
| KBACW | Water col bact rate | | $(cfu/ml)^{-1} hr^{-1}$ | Registrant data via EFED |
| KBACS | Benthic bact rate | | $(cfu/ml)^{-1} hr^{-1}$ | Registrant data via EFED |
| KDP | Direct photol rate | | $hour^{-1}$ | Registrant data via EFED - based on 24 hours light |
| KBH | Base hydrol rate con | N/A | $mole^{-1} hour^{-1}$ | Registrant data via EFED |
| KNH | Neutral hydrol rate | N/A | $hour^{-1}$ | Registrant data via EFED |
| KAH | Acid hydrol rate con | N/A | $mole^{-1} hour^{-1}$ | Registrant data via EFED |
| KOC | Partition coef. | 16250 | liter/kg-fOC | Registrant data via EFED |
| KOW | Octanol water part. | | $lit_{wat}/lit_{oct}$ | Registrant data via EFED |
| KPS | Sediment part. coef. | 130 | liter/kg | Registrant data via EFED |
| MWT | Molecular weight | | grams/mole | Registrant data |
| QTBAS | Sediment bacteria temperature coef. | 2 | dimensionless | STANDARD |
| QTBAW | Water bact temp coef | 2 | dimensionless | STANDARD |
| SOL | Solubility | 30 | mg/liter | Registrant data; SOL is Max EEC |
| QUAINT | Quantum Yield | Measured | dimensionless | Use only with adsorp spectra |
| VAPR | Vapor pressure | | torr | Registrant data |
| PCTWA | Percent Water benthic | 137 | Percent | Georgia Pond |

## EXAMS Input Geometry Variables

| Name | Description | Value | Units | Source |
|---|---|---|---|---|
| AREA | Segment area | 10,000 | $meter^2$ | Standard |
| CHARL | Mixing length | 0.175 | meter | Georgia Pond |
| DEPTH | Segment thickness | 2 | meter | Standard |
| KOUNT | Number of segments | 2 | N/A | Standard |
| WIDTH | Segment width | 63.61 | meter | Standard |
| LENG | Segment length | 157.2 | meter | Standard |
| VOL | Segment volume | 3,000 | $meter^3$ | Standard |

***EXAMS Input Flow and Loading Variables***

| | | | | |
|---|---|---|---|---|
| ADVPR | Part flow advected | 0.0 | Proportion | |
| DRFLD | Drift loadings | 0.0 | Kg/hour | |
| EVAP | Evaporation | 0.0 | Mm/month | |
| IMASS | Pulse load | | Kilogram | Spray Drift in PRZM2EXA files |



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| | | | |
|---|---|---|---|
| NPSED | Nonpoint sed load | 0.0 | Kg/hour |
| NPSFL | Nonpoint flow | 0.0 | ***meter$^3$/hour*** |
| NPSLD | Nonpoint chem load | | ***Kg/hour*** |
| PCPLD | Precipation load | 0.0 | Kg/hour |
| SEEPS | Seepage flow | 0.0 | ***meter$^3$/hour*** |
| STFLO | Stream flow | 0.0 | meter$^3$/hour |

EXAMS Input Environmental Variables.

| Name | Description | Value | Units | Source |
|---|---|---|---|---|
| ATURB | Atmospheric turb | 2.0 | kilometer | GEORGIA POND |
| BACPL | Plankton Population | 1.0 | cfu/ml | GEORGIA POND |
| BNBAC | Benthic bacteria | 37 | cfu/100 gr | GEORGIA POND |
| BNMAS | Benthic biomass | 6.0e-3 | gr/m$^2$ | GEORGIA POND |
| BULKD | Bulk density | 1.85 | gr/cm$^3$ | GEORGIA POND |
| CEC | Cation exchange cap | 1.0e-2 | meq/100 gr | GEORGIA POND |
| DFAC | Distribution factor | 1.19 | dimensionless | GEORGIA POND |
| DISO2 | Disolved oxygen | 5.0 | mg/liter | GEORGIA POND |
| DOC | Dissolved org carb | 5.0 | mg/liter | GEORGIA POND |
| DSP | Dispersion coef. | 3.0e-5 | m$^2$/hour | GEORGIA POND |
| FROC | Frac. organic carbon | 0.04 | dimensionless | GEORGIA POND |
| OZONE | Mean monthly ozone | 0.3 | cm NTP | GEORGIA POND |
| PH | Log hydrogen ion con | 7.0 | pH units | GEORGIA POND |
| POH | Log hydroxid ion con | 7.0 | pOH units | GEORGIA POND |
| RAIN | Ave monthly rainfall | N/A | mm/month | GEORGIA POND |
| RHUM | Relative Humidity | N/A | % saturation | GEORGIA POND |
| SUSED | Suspended sediment | 30 | mg/liter | GEORGIA POND |
| TCEL | Temperature celsius | variable | C° Max=30 C° | Monthly average at site |

Y = Data requirement fulfilled    X = Not applicable
N = Data requirement *not* fulfilled, study required
R = Test reserved    W = Waived
pnt = practically nontoxic, st = slightly toxic, mt = moderately toxic, ht = highly toxic, vht = very highly toxic

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END