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

OFFICE OF
PREVENTION, PESTICIDES AND TOXIC
SUBSTANCES

MEMORANDUM

DATE: July 31, 2006

SUBJECT: Finalization of Interim Reregistration Eligibility Decisions (IREDs) and Interim Tolerance Reassessment and Risk Management Decisions (TREDs) for the Organophosphate Pesticides, and Completion of the Tolerance Reassessment and Reregistration Eligibility Process for the Organophosphate Pesticides

FROM: Debra Edwards, Director
Special Review and Reregistration Division
Office of Pesticide Programs

TO: Jim Jones, Director
Office of Pesticide Programs

As you know, EPA has completed its assessment of the cumulative risks from the organophosphate (OP) class of pesticides as required by the Food Quality Protection Act of 1996. In addition, the individual OPs have also been subject to review through the individual-chemical review process. The Agency's review of individual OPs has resulted in the issuance of Interim Reregistration Eligibility Decisions (IREDs) for 22 OPs, interim Tolerance Reassessment and Risk Management Decisions (TREDs) for 8 OPs, and a Reregistration Eligibility Decision (RED) for one OP, malathion.[1] These 31 OPs are listed in Appendix A.

EPA has concluded, after completing its assessment of the cumulative risks associated with exposures to all of the OPs, that:

(1) the pesticides covered by the IREDs that were pending the results of the OP cumulative assessment (listed in Attachment A) are indeed eligible for reregistration; and

[1] Malathion is included in the OP cumulative assessment. However, the Agency has issued a RED for malathion, rather than an IRED, because the decision was signed on the same day as the completion of the OP cumulative assessment.

(2) the pesticide tolerances covered by the IREDs and TREDs that were pending the results of the OP cumulative assessment (listed in Attachment A) meet the safety standard under Section 408(b)(2) of the FFDCA.

Thus, with regard to the OPs, EPA has fulfilled its obligations as to FFDCA tolerance reassessment and FIFRA reregistration, other than product-specific reregistration.

The Special Review and Reregistration Division will be issuing data call-in notices for confirmatory data on two OPs, methidathion and phorate, for the reasons described in detail in the OP cumulative assessment. The specific studies that will be required are:

- 28-day repeated-dose toxicity study with methidathion oxon; and
- Drinking water monitoring study for phorate, phorate sulfoxide, and phorate sulfone in both source water (at the intake) and treated water for five community water systems in Palm Beach County, Florida and two near Lake Okechobee, Florida.

The cumulative risk assessment and supporting documents are available on the Agency's website at www.epa.gov/pesticides/cumulative and in the docket (EPA-HQ-OPP-2006-0618).

Attachment A:

Organophosphates included in the OP Cumulative Assessment

Chemical	Decision Document	Status
Acephate	IRED	IRED completed 9/2001
Azinphos-methyl (AZM)	IRED	IRED completed 10/2001
Bensulide	IRED	IRED completed 9/2000
Cadusafos	TRED	TRED completed 9/2000
Chlorethoxyphos	TRED	TRED completed 9/2000
Chlorpyrifos	IRED	IRED completed 9/2001
Coumaphos	TRED	TRED completed 2/2000
DDVP (Dichlorvos)	IRED	IRED completed 6/2006
Diazinon	IRED	IRED completed 7/2002
Dicrotophos	IRED	IRED completed 4/2002
Dimethoate	IRED	IRED completed 6/2006
Disulfoton	IRED	IRED completed 3/2002
Ethoprop	IRED	IRED completed 9/2001 IRED addendum completed 2/2006
Fenitrothion	TRED	TRED completed 10/2000
Malathion	RED	RED completed 8/2006
Methamidophos	IRED	IRED completed 4/2002
Methidathion	IRED	IRED completed 4/2002
Methyl Parathion	IRED	IRED completed 5/2003
Naled	IRED	IRED completed 1/2002
Oxydemeton-methyl	IRED	IRED completed 8/2002
Phorate	IRED	IRED completed 3/2001
Phosalone	TRED	TRED completed 1/2001
Phosmet	IRED	IRED completed 10/2001
Phostebupirim	TRED	TRED completed 12/2000
Pirimiphos-methyl	IRED	IRED completed 6/2001
Profenofos	IRED	IRED completed 9/2000
Propetamphos	IRED	IRED completed 12/2000
Terbufos	IRED	IRED completed 9/2001
Tetrachlorvinphos	TRED	TRED completed 12/2002
Tribufos	IRED	IRED completed 12/2000
Trichlorfon	TRED	TRED completed 9/2001

United States Environmental Protection Agency
Prevention, Pesticides and Toxic Substances (7508P)
EPA 738-R-06-030
July 2006

Reregistration Eligibility Decision (RED) for Malathion

REREGISTRATION ELIGIBILITY

DECISION

for

Malathion

Case No. 0248

Approved by:

/S/

Debra Edwards, Ph.D.
Director, Special Review and
Reregistration Division

July 31, 2006

Date

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Glossary of Terms and Abbreviations

ai	Active Ingredient
aPAD	Acute Population Adjusted Dose
APHIS	Animal and Plant Health Inspection Service
ARTF	Agricultural Re-entry Task Force
BCF	Bioconcentration Factor
CDC	Centers for Disease Control
CDPR	California Department of Pesticide Regulation
CFR	Code of Federal Regulations
ChEI	Cholinesterase Inhibition
cPAD	Chronic Population Adjusted Dose
CSFII	USDA Continuing Surveys for Food Intake by Individuals
CWS	Community Water System
DCI	Data Call-In
DEEM	Dietary Exposure Evaluation Model
DL	Double layer clothing {i.e., coveralls over SL}
EC	Emulsifiable Concentrate Formulation
EDSP	Endocrine Disruptor Screening Program
EDSTAC	Endocrine Disruptor Screening and Testing Advisory Committee
EEC	Estimated Environmental Concentration. The estimated pesticide concentration in an environment, such as a terrestrial ecosystem.
EP	End-Use Product
EPA	U.S. Environmental Protection Agency
EXAMS	Tier II Surface Water Computer Model
FDA	Food and Drug Administration
FFDCA	Federal Food, Drug, and Cosmetic Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FOB	Functional Observation Battery
FQPA	Food Quality Protection Act
FR	Federal Register
IDFS	Incident Data System
IPM	Integrated Pest Management
RED	Reregistration Eligibility Decision
LADD	Lifetime Average Daily Dose
LC_{50}	Median Lethal Concentration. Statistically derived concentration of a substance expected to cause death in 50% of test animals, usually expressed as the weight of substance per weight or volume of water, air or feed, e.g., mg/l, mg/kg or ppm.
LD_{50}	Median Lethal Dose. Statistically derived single dose causing death in 50% of the test animals when administered by the route indicated (oral, dermal, inhalation), expressed as a weight of substance per unit weight of animal, e.g., mg/kg.
LOAEC	Lowest Observed Adverse Effect Concentration
LOAEL	Lowest Observed Adverse Effect Level
LOC	Level of Concern
LOEC	Lowest Observed Effect Concentration
mg/kg/day	Milligram Per Kilogram Per Day
MOE	Margin of Exposure
MP	Manufacturing-Use Product
MRID	Master Record Identification (number). EPA's system of recording and tracking studies submitted.
MRL	Maximum Residue Level
N/A	Not Applicable
NASS	National Agricultural Statistical Service
NAWQA	USGS National Water Quality Assessment
NMFS	National Marine Fisheries Service
NOAEC	No Observed Adverse Effect Concentration

NOAEL	No Observed Adverse Effect Level
NPIC	National Pesticide Information Center
NR	No respirator
OP	Organophosphorus
OPP	EPA Office of Pesticide Programs
ORETF	Outdoor Residential Exposure Task Force
PAD	Population Adjusted Dose
PCA	Percent Cropped Area
PDCI	Product Specific Data Call-In
PDP	USDA Pesticide Data Program
PF10	Protections factor 10 respirator
PF5	Protection factor 5 respirator
PHED	Pesticide Handler's Exposure Data
PHI	Preharvest Interval
ppb	Parts Per Billion
PPE	Personal Protective Equipment
PRZM	Pesticide Root Zone Model
RBC	Red Blood Cell
RED	Reregistration Eligibility Decision
REI	Restricted Entry Interval
RfD	Reference Dose
RPA	Reasonable and Prudent Alternatives
RQ	Risk Quotient
RTU	(Ready-to-use)
RUP	Restricted Use Pesticide
SCI-GROW	Tier I Ground Water Computer Model
SF	Safety Factor
SL	Single layer clothing
SLN	Special Local Need (Registrations Under Section 24(c) of FIFRA)
TEP	Typical End-Use Product
TGAI	Technical Grade Active Ingredient
TTRS	Transferable Turf Residues
UF	Uncertainty Factor
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WPS	Worker Protection Standard

Abstract

The Environmental Protection Agency (EPA or the Agency) has completed the human health and environmental risk assessments for malathion and is issuing its risk management decision and tolerance reassessment. The risk assessments, which are summarized below, are based on the review of the required target database supporting the use patterns of currently registered products and additional information received through the public docket. After considering the risks identified in the revised risk assessments, comments received, and mitigation suggestions from interested parties, the Agency developed its risk management decision for uses of malathion that pose risks of concern. As a result of this review, EPA has determined that malathion-containing products are eligible for reregistration, provided that risk mitigation measures are adopted and labels are amended accordingly. That decision is discussed fully in this document.

Malathion is a broad-spectrum organophosphate (OP) insecticide first registered in 1956. It is used widely in agriculture for various food and feed crops, homeowner outdoor uses, ornamental nursery stock, building perimeters, pastures and rangeland, and regional pest eradication programs. Previous risk assessments indicated some drinking water, occupational handler and post-application, residential bystander, and ecological risks of concern. Drinking water and residential bystander risk estimates were revised based on refinements to the assessments and/or mitigation measures, such as reduced maximum application rates and number of application permitted per year for many use sites. Occupational risks have been mitigated through personal protective equipment or engineering control requirements on the labels and extending re-entry intervals for some sites, and ecological risks have been addressed through adding buffer zone and spray drift requirements to the labels, and amending use patterns for many uses.

I. Introduction

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) was amended in 1988 to accelerate the reregistration of products with active ingredients registered prior to November 1, 1984. The amended Act calls for the development and submission of data to support the reregistration of an active ingredient, as well as a review of all submitted data by the U.S. Environmental Protection Agency (referred to as EPA or "the Agency"). Reregistration involves a thorough review of the scientific database underlying a pesticide's registration. The purpose of the Agency's review is to reassess the potential hazards arising from the currently registered uses of the pesticide, to determine the need for additional data on health and environmental effects, and to determine whether or not the pesticide meets the "no unreasonable adverse effects" criteria of FIFRA.

On August 3, 1996, the Food Quality Protection Act (FQPA) was signed into law. This Act amends FIFRA and the Federal Food, Drug, and Cosmetic Act (FFDCA) to require reassessment of all existing tolerances for pesticides in food. FQPA also requires EPA to review all tolerances in effect on August 2, 1996, by August 3, 2006. In reassessing these tolerances, the Agency must consider, among other things, aggregate risks from non-occupational sources of pesticide exposure, whether there is increased susceptibility of infants and children, and the cumulative effects of pesticides with a common mechanism of toxicity. Malathion belongs to a group of pesticides called organophosphates (OPs), which share a common mechanism of toxicity by affecting the nervous system via cholinesterase inhibition. When the Agency concludes that there is a reasonable certainty of no harm from aggregate exposure, and the cumulative risks for pesticides which share a common mechanism of toxicity, such as the OPs, are below the Agency's level of concern, the tolerances are considered reassessed. EPA decided that, for those chemicals that have tolerances and are undergoing reregistration, tolerance reassessment will be accomplished through the reregistration process.

As mentioned above, FQPA requires EPA to consider available information concerning the cumulative effects of a particular pesticide's residues and "other substances that have a common mechanism of toxicity." Potential cumulative effects of chemicals with a common mechanism of toxicity are considered because low-level exposures to multiple chemicals causing a common toxic effect by a common mechanism could lead to the same adverse health effect as would a higher level of exposure to any one of these individual chemicals. Malathion is a member of the OP class of pesticides, which share a common mechanism of toxicity by affecting the nervous system via cholinesterase inhibition. A cumulative risk assessment, which evaluates exposures based on a common mechanism of toxicity, was conducted to evaluate the risk from food, drinking water, residential, and other non-occupational exposures resulting from registered uses of OP pesticides, including malathion. EPA has concluded that the cumulative risks associated with OP pesticides are below the Agency's level of concern. For additional information, refer to the *OP Cumulative Assessment* (2006 Update), which is available in EPA docket EPA-HQ-OPP-2006-0618 and on EPA's website at http://www.epa.gov/pesticides/cumulative/.

This document presents EPA's revised human health and ecological risk assessments, its tolerance reassessment, and reregistration eligibility decision (RED) for malathion. The document consists of six sections. Section I contains the regulatory framework for reregistration/tolerance reassessment; Section II provides an overview of the chemical and a profile of its use and usage; Section III gives an overview of the human health and environmental effects risk assessments;

Section IV presents the Agency's decision on reregistration eligibility and risk management; and Section V summarizes the label changes necessary to implement the risk mitigation measures outlined in Section IV. Finally, the Appendices list related information, supporting documents, and studies evaluated for the reregistration decision. The revised risk assessments for malathion and all other supporting documents are available in the Office of Pesticide Programs (OPP) public docket (http://www.regulations.gov.) under docket number EPA-HQ-OPP-2004-0348.

II. Chemical Overview

A. Regulatory History

Malathion is a broad spectrum organophosphate insecticide and miticide first registered in 1956. Malathion has numerous commercial agricultural, industrial, governmental, and homeowner uses. In 2000, approximately 11-13 million pounds of malathion were used annually; currently, approximately 15 million pounds are used annually.

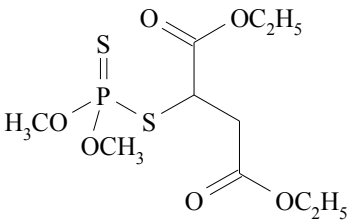
In February 1988, the Guidance for the Reregistration of Pesticide Products Containing Malathion (*Malathion Registration Standard*) was issued. The Registration Standard summarized the human health and ecological risk findings based on the data available at that time, and required other studies to complete the malathion data base. The Registration Standard also imposed label restrictions to reduce exposure resulting from indoor applications of malathion, and updated environmental hazard statements on malathion product labels. Numerous data requirements needed to complete the Agency's reassessment of malathion were imposed through Data Call-In (DCI) Notices issued as part of the reregistration process of malathion. DCIs on malathion were issued in 1992, 1993, 1994, 1995, 1999, and 2004.

In February 2000, EPA issued its *Preliminary Risk Assessment for the Reregistration Eligibility Decision Document*. The Preliminary Risk Assessment reflected the conclusion of the OPP Hazard Identification Assessment Review Committee (HIARC), and the FQPA Safety Factor Committee, as well as the OPP Cancer Assessment Review Committee. A preliminary ecological risk assessment was also issued at that time. In September 2000, EPA issued a *Revised Malathion Risk Assessment.* The revised assessment reflected comments received during the public comment period, and incorporated new data the Agency received regarding exposure to agricultural workers. The 2000 *Revised Malathion Risk Assessment* also included a revised cancer classification of malathion. The *2000 Revised Ecological Risk Assessment* changed little from the *Preliminary Ecological Risk Assessment*.

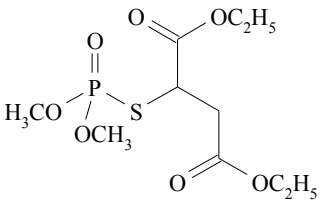
In 1999, EPA required a developmental neurotoxicity study along with a comparative cholinesterase study. These data were submitted to the Agency in 2002, and were assessed as part of the Agency's revised risk assessment, which was issued for public comment in September 2005. The *2005 Revised Human Health Risk Assessment* also contained other changes, including a toxicity adjustment factor for the primary metabolite malaoxon, and addressed the pharmaceutical use of malathion. As no new data were received with respect to ecological fate or hazard of malathion, the ecological risk assessment remained unchanged between 2000 and 2005.

B. Chemical Identification

Malathion is a colorless to amber liquid with a mercaptan odor and boiling point of 156-157^{0}C. Malathion is soluble in water and is readily soluble in most alcohols, esters, aromatic solvents, and ketones, and is only slightly soluble in aliphatic hydrocarbons. Below is a summary of the chemical compound malathion.

Malathion Test Compound Nomenclature		
Chemical Structure		
Empirical Formula	$C_{10}H_{19}O_6PS_2$	
Common name	Malathion	
IUPAC name	O,O-dimethyl dithiophosphate of diethyl mercaptosuccinate	
CAS Registry Number	121-75-5	
Chemical Class	Organophosphate	
Known Impurities of Concern	Empirical Formula:	$C_{10}H_{19}O_6PS_2$
	Common Name:	Isomalathion
	IUPAC Name:	Butanedioic acid, [[methoxy(methylthio)phosphinyl]thio]-, diethylester
	CAS Registry Number:	3344-12-5

Malaoxon is the primary metabolite of malathion and, under certain conditions, is formed as an environmental breakdown product of malathion making it available for direct human exposure. Below is a summary of the chemical compound malaoxon.

Malaoxon Test Compound Nomenclature	
Chemical Structure	
Empirical Formula	$C_{10}H_{19}O_7PS$
Common name	Malaoxon (the active ChE inhibiting metabolite of malathion)
IUPAC name	O,O-dimethyl thiophosphate of diethyl mercaptosuccinate
CAS Registry Number	1634-78-2
Chemical Class	Organophosphate

A number of impurities have been reported to be present in representative technical formulations of malathion. Isomalathion is an impurity known to be present at very low levels in both technical grade and end-use product samples of malathion. These low levels of isomalathion may be formed during the manufacturing process of malathion, and low levels of isomalathion may also be formed if malathion undergoes chemical rearrangement (isomerization) during product storage. Data provided by the registrant indicate that Fyfanon® Technical (EPA Reg. No. 4787-5) is stable for up to 1 year when stored under warehouse conditions (20-23°C), although a small amount of isomalathion accumulated (increase from <0.01% to about 0.1%). Storage of malathion at 54°C for 2 weeks resulted in an increase of isomalathion from about 0.05% to 0.2%.

C. Use Profile

Malathion is a broad-spectrum organophosphorous (OP) insecticide, used widely in agriculture and regional pest eradication programs. The following use sites and crops are being supported and were included in this risk assessment. A detailed table of the uses of malathion eligible for reregistration is available in Appendix A.

Food and Feed Crops - Alfalfa; apricot; asparagus; avocado; barley; bean (succulent and dry); beets (table); birdsfoot trefoil; blackberry; blueberry; boysenberry; broccoli; broccoli raab; Brussels sprout; cabbage (including Chinese); carrot; cauliflower; celery; chayote; cherry; chestnut; clover; collards; corn (field; sweet; and pop); cotton; cucumber; currant; dandelion; date; dewberry; eggplant; endive; escarole; potato; fig; garlic; gooseberry; grape; grapefruit; guava; hay grass; hops; horseradish; kale; kohlrabi; kumquat; leek; lemon; lespedeza; lettuce (head and leaf); lime; loganberry; lupine; macadamia nut; mango; melon; mint; mushroom; mustard greens; nectarines; oats; okra; onion; orange; papaya; parsley; parsnip; passion fruit; pea; peach; pear; pecan; pepper; pineapple; pumpkin; radish; raspberry; rice; rutabaga; rye; salsify; shallot; sorghum; spinach; spring wheat; squash; strawberry; sweet potato; Swiss chard; tangelo; tangerine; tomato (including tomatillo); turnip; vetch; walnut; watercress; watermelon; wheat (spring, and winter); wild rice; and yam; indoor stored commodity treatment and empty storage facilities for barley, corn, oats, rye, and wheat.

Other Uses - Homeowner outdoor uses: ornamental flowering plants, ornamental lawns, ornamental turf, vegetable gardens and fruit trees; ornamental flowers, shrubs, and trees; Christmas tree plantations; slash pine; ornamental nursery stock; woody plants; building perimeters (domestic dwellings as well as commercial structures); uncultivated nonagricultural areas; outdoor garbage dumps; intermittently flooded areas; irrigation systems; pastures; and rangeland.

Regional Pest Eradication Programs - Boll Weevil eradication (USDA sponsored program), Medfly control (USDA), and mosquito control (public health).

Pharmaceutical Malathion - There is a pharmaceutical use of malathion as a pediculicide for the treatment of head lice and their ova, which is regulated by the Food and Drug Administration (FDA).

Types/Formulations Registered - Malathion is formulated as an emulsifiable concentrate (EC), dust

(D), wettable powder (WP), ready-to-use (RTU) liquid, and as a pressurized liquid (PrL). The EC and RTU formulations may contain up to 82% and 96.8% active ingredient (ai), respectively. Several of the 96.8% ai RTU liquids are intended for ultra-low-volume (ULV) application with the use of aerial or ground equipment. Malathion is typically applied as multiple foliar treatments as needed to control various pest species.

Application Equipment - Aircraft (fixed wing, and rotary), duster, fogger, ground boom, irrigation, shaker can, sprayer, and spreader.

Target Pests - Ants, aphids, apple mealybug, armyworm, bagworm, beetle, borer, casebearer, blackheaded fireworm, blueberry maggot, cadelle, caterpillars, cattle lice, cherry fruitworm, cockroaches, corn earworm, corn rootworms, cotton fleahopper, cotton leaf perforator, cotton leafworm, cranberry fruitworm, crickets, currant cutworm, earwigs, European fruit lecanium, fall cankerworm, fleahoppers, fleas, flies, fruit flies, fungus gnats, garden webworm, grain borer, grape phylloxera, grasshoppers, green cloverworm, greenbug, groundpearls, hornets, imported cabbageworm, imported currantworm, ked, leafhoppers, leafrollers, leafminer, looper, millipedes, mites, mosquitoes (adult, larvae), moths, kermes, mushroom flies, omnivorous leaftier, onion maggot, orange tortrix, orangeworms, pear psylla, pecan phylloxera, pepper maggot, pickleworm, pillbugs, pine needle sheathminer, plant bugs, plum curculio, poultry lice, rose chafer, sawflies, scales, scorpions, silverfish, sorghum midge, sowbugs, spiders, spittlebugs, springtails, strawberry leafroller, sugarbeet root maggot, tadpole shrimp, thrips, ticks, tingids, tomato fruitworm, vetch bruchid, wasps, weevil, whiteflies, and wild rice worm.

Application Rate Ranges

General Agriculture:	0.175 – 6.25 lb ai/A
Home and Garden:	0.000085 – 0.0003 lb ai/ft^2
Boll Weevil Eradication Program:	0.3 – 1.22 lb ai/A
Fruit Fly Treatment:	0.09 – 0.18 lb ai/A
Public Health Adulticide:	0.11 – 0.23 lb ai/A

Typical Usage - An average annual estimate of total domestic usage of malathion is approximately 15 million pounds of malathion as active ingredient (ai). Approximately 10.2 million pounds ai are applied through the USDA Boll Weevil Eradication Program, 1.5 million pounds are applied to agricultural crops, and 300,000 pounds are applied as postharvest grain treatment to corn, wheat, and oats. Approximately 500,000 pounds ai are used on non-agricultural sites, such as around buildings, roads, and ditches. Approximately 1.5 million pounds are applied in quarantine programs and public health (adulticide) programs, and 1 million pounds are used in the residential/home owner market.

Percent crop treated - For the majority of the agricultural sites for which malathion is registered and the Agency has use data, less than 1% of the crop is typically treated with malathion; however on several agricultural crops, malathion is applied to 10% of the crop or more.

Percent Crop Treated Range	*Crops*
>10	blueberries, raspberries, strawberries, limes, cotton, cherries, garlic, greens, dates, celery.
5 – 10	okra, walnuts, lettuce, avocados, onions, carrots, squash, asparagus, cantaloupes, cabbage, collards, kale.
1 - 5	alfalfa, pecans, wheat, rice, oranges, almonds, corn, peaches, apples, pears, tomatoes, potatoes, sorghum, grapes, beets, lemons, broccoli, cucumbers, grapefruit, pumpkins, sunflowers, watermelons, peas, corn, beans, peppers, plums, prunes, spinach, apricots, cauliflower.
<1	Approximately 54 crops make up this category, but are not listed here.

III. Summary of Malathion Risk Assessment

The following is a summary of EPA's revised human health and ecological risk assessments for malathion, as presented fully in the documents *Malathion: Revised Human Health Risk Assessment for the Reregistration Eligibility Decision Document (RED)*, dated July 31, 2006, and *Revised EFED RED Chapter for Malathion*, dated October, 2000. The purpose of this summary is to assist the reader by identifying the key features and findings of these risk assessments, and to help the reader better understand the conclusions reached in the assessments.

The human health and ecological risk assessment documents and supporting information listed in Appendix C were used to reach the safety finding and regulatory decision for malathion. While the risk assessments and related addenda are not included in this document, they are available from the OPP Public Docket EPA-HQ-OPP-2004-0348 and may also be accessed on the internet at http://www.regulations.gov

A. Human Health Risk Assessment

The human health risk assessment incorporates potential exposure risks from all sources, which include food, drinking water, residential (if applicable), and occupational scenarios. Aggregate assessments combine food, drinking water, and any residential or other non-occupational (if applicable) exposures to determine potential exposures to the U.S. population. The Agency's human health assessment is protective of all U.S. populations, including infants and young children. The Agency's use of human studies in the malathion risk assessment is in accordance with the Agency's Final Rule promulgated on January 26, 2006, related to Protections for Subjects in Human Research, which is codified in 40 CFR Part 26.

The EPA released its revised risk assessments for malathion for public comment on September 23, 2005 for a 60-day public comment period (and additional Phase 5 of the public participation process). In response to comments received and additional data submitted during

Phase 5, the risk assessments were updated. The revised risk assessments may be found in the OPP public docket at the address given above and in EPA's electronic docket under docket number EPA-HQ-OPP-2004-0348. Major revisions to the malathion human health risk assessment include the following:

- Revised Toxicity Adjustment Factor: revision based on recalculation of the doses administered to the test animals in the original data set.
- New chronic dietary endpoint: revised chronic dietary endpoint also based on the recalculation of the doses administered to the test animals in the original data set.
- New dermal toxicity endpoint: new data were voluntarily submitted by the technical registrant, reviewed by the Agency, and incorporated into the current assessment.

For more information on the malathion revised human health risk assessment, see *Malathion: Revised Human Health Risk Assessment for the Reregistration Eligibility Decision Document (RED)*, dated July 31, 2006.

1. Toxicity Summary

The toxicity (hazard) assessment is designed to predict whether a pesticide could cause adverse health effects in humans, including short-term (acute) effects, or lifetime (chronic) effects at the level or dose which is expected to occur through the labeled use. The Agency has reviewed all the toxicity data submitted for the reregistration of malathion and has determined that the toxicological database is sufficient to assess potential hazard to all population subgroups, including infants and children, under various exposure scenarios and time durations. The only toxicity data gaps for malathion are a special acute and repeated dose comparative cholinesterase assay with malathion and malaoxon, the environmental degradate of malathion, in juvenile rats, and an immunotoxicity study. The Agency issued a Data Call-In in October, 2004 requiring the special cholinesterase assay. The immunotoxicity study will be required as part of this RED.

Malathion (O,O-dimethyl thiophosphate of diethyl mercaptosuccinate) is an organophosphorous insecticide, which targets the nervous system and, like all members of this class, displays its mode of toxic action through inhibition of cholinesterase (ChE). Malathion is converted to its metabolite, malaoxon (via oxidation of the P=S moiety to P=O), in insects and mammals. The oxon is the active ChE inhibiting metabolite of malathion. When administered to animals directly, malaoxon is a more potent ChE inhibitor than malathion. Cholinesterase inhibition (ChEI) in the nervous system, from exposure to malathion, has been measured in various compartments and observed in multiple species (rat, mouse, rabbit, and dog), following oral, dermal, and inhalation routes of administration. Other treatment related effects of malathion include histopathologic lesions of the nasal cavity and larynx, following inhalation. For a complete discussion on the toxicological database on malathion, see *Malathion: Revised Human Health Risk Assessment for the Reregistration Eligibility Decision Document (RED)*, dated July 31, 2006.

Data from chronic studies revealed ChEI effects at the lowest doses tested. In standard guideline prenatal developmental toxicity studies, no developmental toxicity was observed in rats. The weight of evidence from guideline studies and open literature does not support a mutagenic

concern for malathion. Published literature studies have shown that malathion can affect immune function, depending on route, magnitude, and frequency of administration. This information has prompted the requirement for a guideline immunotoxicity study to better characterize the potential effects of malathion on the immune system, which will be required as part of this RED.

a. Acute Toxicity Profile

Malathion exhibits low acute toxicity via the oral, dermal, and inhalation routes (Toxicity Category III or IV). It exhibits only slight eye and dermal irritation and is not a dermal sensitizer. Table 1 provides a summary of the toxicity categories for malathion.

Table 1. Malathion Acute Toxicity Profile

Guideline Number	Type of Study - Species	MRID (Date)	Results	Toxicity Category
870.110	Acute Oral - Rat	00159876 (1986)	LD_{50}= 5400(M)/5700(F) mg/kg	IV
870.1200	Acute Dermal - Rat	00159877 (1986)	LD_{50} >2000 mg/kg (M)(F)	III
870.1300	Acute Inhalation - Rat	00159878 (1986)	LC_{50}> 5.2 mg/L (M)(F)	IV
870.2400	Eye Irritation - Rabbit	00159880 (1985)	Slight conjunctival irritation; Clear by 7 days	III
870.2500	Skin Irritation - Rabbit	00159879 (1985)	Slight dermal irritation (PIS=1.1)	IV
870.2600	Dermal Sensitization - Guinea pig	00159881 (1986)	Not a skin sensitizer	N/A

LD_{50} or LC_{50}; Median Lethal Dose or Concentration, statistically derived single dose or concentration that can be expected to cause death in 50% of the test animals when administered by the route indicated (oral, dermal, inhalation).

b. FQPA Safety Factor Considerations

The Federal Food, Drug, and Cosmetic Act (FFDCA), as amended by FQPA, directs the Agency to use an additional tenfold (10x) safety factor (SF) to account for potential pre- and post-natal toxicity and completeness of the data with respect to exposure and toxicity to infants and children. FFDCA authorizes the Agency to reduce the 10x FQPA SF only if reliable data demonstrate that the resulting margin of exposure is adequate to protect infants and children. The toxicology database for malathion is adequate although data gaps remain: a guideline immunotoxicity study and a special comparative ChEI study for acute and repeated exposures in juvenile animals with malaoxon and malathion.

The data the Agency used to address potential differences between young and adult animals are the following guideline studies: pre-natal developmental toxicity in rats and rabbits; a two-generation reproductive toxicity study in rats; an acute neurotoxicity study in rats ; a sub-chronic neurotoxicity study in rats; and a developmental neurotoxicity study in rats (with a supplemental range-finding study). Additionally, a comparative ChE study with malathion in adult and immature rats for acute and repeated exposures is also available. Consistent with its mode of action, ChE inhibition provides the critical effect for determining the point of departure for the oral, dermal and inhalation (aggregate only) routes of exposure. The comparative ChE in the young demonstrate that juvenile animals are more sensitive than adults.

In order to account for the increased toxicity due to exposure from malaoxon, the Agency is applying a Toxicity Adjustment Factor (TAF) of 61x to malaoxon exposures. The Agency has data on malaoxon (including a 14-day and 2-year feeding study in rats) for repeated exposures which shows malaoxon to be 61x more toxic to adults than malathion. This TAF is, in the absence of data, assumed to be health protective in assessing single (acute) exposures to malaoxon in adults as well as both acute and repeated exposures to the young. The Agency will be receiving confirmatory acute and repeated dose toxicity data for the young in the near future, as discussed earlier.

The Agency has determined that there is evidence that following acute or repeated dose exposures to malathion, young animals exhibit adverse effects more readily than adults. The Agency has oral data for this most sensitive subpopulation and is using it to determine the appropriate point of departure (PoD) for use in assessing risk for acute and chronic dietary and incidental oral scenarios. In those instances where the Agency is using a PoD derived on pup data, the FQPA SF is reduced to 1x. The Agency has decided to retain the FQPA SF (10x) for those scenarios where the PoD does not already reflect the most sensitive population (i.e., the PoD is derived from adult animal studies). Consequently, for dermal exposure scenarios, where the PoD is derived from adult animals and children are expected to be exposed, the FQPA SF of 10x has been retained. Similarly, for inhalation exposure scenarios where the endpoint selected is ChE inhibition (in order to aggregate non-occupational exposures) and the PoD is based on adult animals, the FQPA SF of 10x has also been retained. Finally, the Agency has retained the FQPA SF of 10x for the bystander inhalation scenario in order to account for the lack of a NOAEL, severity of effect, as well as any differential in susceptibility in the young.

Although the immunotoxicity study is identified as a data gap, it is not considered important to the quantification of risk from malathion. Rather it will be used to further characterize the hazard from malathion in terms of its effects on the immune system, and it is not expected to have an effect on the hazard values used in the risk assessment. Therefore, no additional safety factor is necessary to account for the lack of a guideline immunotoxicity study.

FQPA also requires that the completeness of the exposure data base be considered in deciding whether to retain, reduce or remove the FQPA SF. The Agency is confident that the

risk assessment for each potential exposure scenario will not underestimate dietary or non-occupational exposures to infants and children.

c. Dose-Response and Benchmark Dose Analysis

A means of refinement to the use of no observed adverse effect levels (NOAELs) and lowest observed adverse effect levels (LOAELs) to describe the relationship between dose and response is the use of benchmark dose (BMD) modeling. BMD modeling is a statistically more robust approach, which better incorporates all the data from the test animals at all doses, thus characterizing response (from 0% - 100% inhibition) along the dose continuum.

For malathion, BMD modeling was utilized for the malathion comparative ChE study, (used for endpoint selection for the acute and chronic dietary, and incidental oral scenarios), and 21-day dermal studies (used for endpoint selection for the dermal occupational and non-occupational exposure scenarios). In the past, the Agency has selected the point at which 10% ChEI is observed (BMD_{10}) as the point of departure (PoD) i.e, the point of biological and statistically significant response to a chemical exposure. The Agency then determines the 95% lower confidence limit associated with the PoD to select the toxicity endpoint value, which is termed the BMDL. Thus the $BMDL_{10}$ is the lower 95% confidence interval associated with the dose determined to cause 10% inhibition in the test animals. Although previous PoDs were based upon the BMD_{10}, the Agency may consider alternative benchmark response levels (greater or lower than 10% inhibition) on a chemical by chemical basis, provided there is sufficient information to ensure that the appropriate and protective response level is chosen.

The technical registrant provided comments and analysis to the Agency suggesting that the 20% response level (20% ChEI) was both statistically and biologically more appropriate than the 10% ChEI level, due to the variability associated with ChEI measurements in the red blood cell (RBC) compartment. The Agency reviewed the relevant data and concluded that a 20% RBC ChEI (BMD_{20}) in the malathion adult animal is protective of obvious clinical signs in adult animals, and an appropriate PoD for dermal exposure. Therefore, the Agency selected the $BMDL_{20}$ dose (127 mg/kg/day) from the data set as the dermal toxicity endpoint. The Agency also considered the technical registrant's analysis regarding a BMD_{20} for dietary exposure. However, after reviewing the relevant data, the Agency determined that the BMD_{20} for dietary exposure was not protective, and that the $BMDL_{10}$ is the appropriate and protective endpoint for dietary and incidental oral exposure. Further information on BMD modeling is contained in the *Malathion: Revised Human Health Risk Assessment for the Reregistration Eligibility Decision Document (RED)*, dated July 31, 2006

d. Toxicological Endpoints

The toxicological endpoints used in the human health risk assessment for malathion are listed in Table 2, below. The uncertainty factors (UF) which account for interspecies

extrapolation (10x), intraspecies variability (10x), and the FQPA SF used to account for susceptibility of infants and children, are also described in Table 2.

Table 2. Summary of Toxicological Endpoints

Exposure Scenario and Population	Dose (mg/kg/day) and Uncertainty Factor or FQPA Safety Factor	Level of Concern (LOC) as either Population Adjusted Dose (PAD) or Margin of Exposure (MOE)	Study and Toxicological Effects
Dietary Exposure			
Acute Dietary Females 13-49	There is no increased susceptibility expected to females of child-bearing age. Effects observed in the rat and rabbit developmental studies showed reduced body weight gains with NOAELs of 400 and 25 mg/kg/d, respectively. The aRfD for the general population is lower and, thus, would be protective of this population group.		
Acute Dietary General population, including infants and children	Oral $BMDL_{10}$ = 13.6 mg/kg/d UF = 100^2 FQPA SF = 1x	RfD = dose/UF Acute RfD = 0.14 mg/kg/day aPAD = acute RfD/FQPA SF aPAD = 0.14 mg/kg/day	$BMDL_{10}$ = 13.6 mg/kg/day based on RBC ChEI in male pups from the comparative ChE acute oral study in the rat. FQPA SF = 1x since dose is taken from pup data, susceptibility of young is accounted for.
Chronic Dietary All populations	Oral $BMDL_{10}$ = 7.1 mg/kg/d UF = 100 FQPA SF = 1X	RfD = dose/UF Chronic RfD = 0.07 mg/kg/day cPAD = chronic RfD/FQPA cPAD = 0.07 mg/kg/day	$BMDL_{10}$ = 7.1 mg/kg/d based on RBC ChEI in offspring from the comparative ChE multiple dose oral study in the rat. FQPA SF = 1x since dose is taken from the pup data, susceptibility of young is accounted for.
Non-Dietary Exposure			
Incidental Oral Short- (1-30 days) and Intermediate-Term (1-6 months) Children	Oral $BMDL_{10}$ = 7.1 mg/kg/d UF = 100 FQPA SF = 1x	Residential LOC = UF x FQPA SF Residential (Short-term only) LOC for MOE = 100 Occupational = N/A	$BMDL_{10}$ = 7.1 mg/kg/d based on RBC ChEI in offspring from the comparative ChE multiple dose oral study in the rat. FQPA SF = 1x since dose is taken from pup data, susceptibility of young is accounted for.
Dermal Short- (1-30 days) and Intermediate-Term (1-6 months) Children	Dermal $BMDL_{20}$ = 127 mg/kg/d UF = 100 FQPA SF = 10x	Residential LOC = UF x FQPA SF Residential (Short-term only) LOC for MOE = 1000^3 Occupational = N/A	$BMDL_{20}$ = 127 mg/kg/d based on RBC ChEI (%) in two separate 21-day dermal studies in rabbits FQPA SF = 10x since dose is taken from adult data.

Exposure Scenario and Population	Dose (mg/kg/day) and Uncertainty Factor or FQPA Safety Factor	Level of Concern (LOC) as either Population Adjusted Dose (PAD) or Margin of Exposure (MOE)	Study and Toxicological Effects
Dermal Short- (1-30 days) and Intermediate-Term (1-6 months) Adults	Dermal $BMDL_{20}$ = 127 mg/kg/d UF = 100 FQPA SF = 1x[1]	Residential LOC = UF x FQPA SF Residential (Short-term only) LOC for MOE = 100 Occupational LOC for MOE = 100	$BMDL_{20}$ = 127 mg/kg/d based on RBC ChEI (%) in two separate 21-day dermal studies in rabbits FQPA SF =1x since population of concern is adults
Inhalation Short- (1-30 days) and Intermediate-Term (1-6 months) All populations	Inhalation LOAEL = 0.1 mg/L (25.8 mg/kg/day) UF = 100 FQPA SF = 10x	Residential LOC = UF x FQPA SF Residential (Short-term only) LOC for MOE = 1000	LOAEL = 0.1 mg/L (25.8 mg/kg/d) based on histopathology in respiratory epithelium 90-day inhalation study in rats. FQPA SF = 10x to account for LOAEL to NOAEL extrapolation and severity of effect (due to concern for exposure to infants and children)
	Inhalation LOAEL = 0.1 mg/L (25.8 mg/kg/day) UF = 1000[4]	Occupational LOC for MOE = 1000	LOAEL = 0.1 mg/L (25.8 mg/kg/d) based on histopathology in respiratory epithelium 90-day inhalation study in rats.
Inhalation Short- (1-30 days) and Intermediate-Term (1-6 months) Children - Aggregate Only	Inhalation NOAEL= 0.1 mg/L (25.8 mg/kg/day) based on ChEI UF = 100 FQPA SF = 10x	Residential LOC = UF x FQPA SF Residential (Short-term only) LOC for MOE = 1000[3] Occupational = N/A	LOAEL = 0.45 mg/L (115 mg/kg/day) based on plasma and RBC ChEI 90-day inhalation study in rats. FQPA SF = 10x since the dose is taken from adult animals.

Exposure Scenario and Population	Dose (mg/kg/day) and Uncertainty Factor or FQPA Safety Factor	Level of Concern (LOC) as either Population Adjusted Dose (PAD) or Margin of Exposure (MOE)	Study and Toxicological Effects
Inhalation Short- (1-30 days) and Intermediate-Term (1-6 months) Adults - Aggregate Only	Inhalation NOAEL = 0.1 mg/L (25.8 mg/kg/day) based on ChEI UF = 100 FQPA SF = 1x[1]	Residential LOC = UF x FQPA SF Residential (Short-term only) LOC for MOE = 100 Occupational LOC for MOE = 100	LOAEL = 0.45 mg/L (115 mg/kg/day) based on plasma and RBC ChEI 90-day inhalation study in rats. FQPA SF = 1x since population of concern is adults.
Cancer	**Classification:** Suggestive evidence of carcinogenicity		

UF = uncertainty factor, FQPA SF = FQPA safety factor, NOAEL = no observed adverse effect level, LOAEL = lowest observed adverse effect level, PAD = population adjusted dose (a = acute, c = chronic), RfD = reference dose, MOE = margin of exposure, LOC = level of concern, NA = Not Applicable, RBD = red blood cell, ChEI = cholinesterase inhibition, $BMDL_{10}$ = Benchmark Dose Lower Limit (lower 95% confidence limit on the RBC ChEI 10% effect level, $BMDL_{20}$ = Benchmark Dose Lower Limit (lower 95% confidence limit on the RBC ChEI 20% effect level)

[1]: The FQPA SF has not been retained for women of child-bearing age following dermal and/or inhalation exposure because: (i) the observed susceptibility differences between young and old are a result of postnatal exposures and ChEI data from gestational only exposures which indicate that fetuses are less sensitive than the mother at birth; (ii) the dermal toxicity endpoint is based on the more sensitive species (rabbit); (iii) in dermal and inhalation studies, females were neither more sensitive nor responded differently than males; and, (iv) oral studies indicate that there is no enhanced sensitivity of pregnant animals versus non-pregnant animals to malathion, and there is no reason to believe that this is route-specific.

[2]: UF = 100 [10x for interspecies and a 10x for intraspecies variations].

[3]: MOE = 1000 [10x for interspecies extrapolation, 10x for intraspecies variations, and 10x for known susceptibility of the young based on the malathion comparative ChE study].

[4]: UF = 1000 [10x for interspecies extrapolation, 10x for intraspecies variations, and 10x for a LOAEL to NOAEL extrapolation and for the severity of the effect.]

e. Toxicity Adjustment Factor for Malaoxon

Under certain environmental conditions, humans may be directly exposed to malaoxon following applications of malathion (i.e., when malathion undergoes oxidation and the P=S moiety is converted to a P=O moiety). As the oxon metabolite, malaoxon is a more potent ChE inhibitor. The Agency characterizes the toxicity of the metabolite in terms of its degree of potency in comparison to the parent compound. The ratio of relative toxicity between the parent and the oxon is termed the Toxicity Adjustment Factor (TAF).

To calculate the ratio of toxicity between malathion and malaoxon, the Agency utilized BMD modeling of the data. Ideally, a separate TAF for acute/short-term and chronic/long-term exposures would be determined. At the present time, the Agency does not have sufficient data to calculate an acute TAF, but sufficient data with which to estimate a chronic TAF does exist (i.e., 14-day rat study and 2-year chronic rat study). The Agency issued a Data Call-In in October,

2004 which will result in the submission of a special acute and repeat dose comparative cholinesterase assay with malaoxon and malathion in juvenile animals, which will be used to determine the acute TAF. In the absence of an acute TAF, the Agency has applied the chronic TAF to acute exposure scenarios. Based on BMD modeling, the chronic TAF is 61x, meaning malaoxon is estimated to be 61 times more toxic than malathion. Therefore, in the absence of an acute TAF, the chronic TAF of 61x calculated from oral studies is applicable to residues of malaoxon for risk assessment of all exposure durations, routes, and scenarios and is considered to be health protective.

f. Carcinogenicity

Malathion has been classified as having "suggestive evidence of carcinogenicity" in accordance with the EPA *Proposed Guidelines for Carcinogen Risk Assessment* (July 1999). A quantitative cancer dose-response assessment is not indicated for pesticides in the "suggestive" category.

The classification is based on the following evidence: 1) the occurrence of liver tumors in mice and rats only at excessive doses; 2) the presence of a few rare tumors in rats, which cannot be distinguished as either treatment related or due to random occurrence; 3) the evidence for mutagenicity is not supportive of a mutagenic concern in carcinogenicity; and 4) malaoxon, a structurally related chemical, is not carcinogenic in rats. The carcinogenic potential of malathion was also reviewed by the FIFRA Scientific Advisory Panel (SAP) on August 17-18, 2000. The Panel report, *"A Consultation on the EPA Health Effects Division's Proposed Classification of the Human Carcinogenic Potential of Malathion*," dated December 14, 2000, offers an overall equivocal recommendation on the Agency's classification of malathion as "suggestive." The Agency subsequently considered the SAP recommendations and concluded that the cancer classification should remain as "suggestive." Additionally, the CARC recently evaluated a publication by Cabello et al. (2001) and concluded that the paper provided insufficient basis for revising the cancer classification for malathion. Furthermore, the chronic dietary risk assessment is considered protective of any potential carcinogenic effects.

2. Endocrine Disruption

EPA is required under the FFDCA, as amended by FQPA, to develop a screening program to determine whether certain substances (including all pesticide active and other ingredients) "may have an effect in humans that is similar to an effect produced by a naturally occurring estrogen, or other such endocrine effects as the Administrator may designate." Following recommendations of its Endocrine Disruptor and Testing Advisory Committee (EDSTAC), EPA determined that there was a scientific basis for including, as part of the program, the androgen and thyroid hormone systems, in addition to the estrogen hormone system. EPA also adopted EDSTAC's recommendation that the Program include evaluations of potential effects in wildlife. For pesticide chemicals, EPA will use FIFRA and, to the extent that effects in wildlife may help determine whether a substance may have an effect in humans,

FFDCA authority to require the wildlife evaluation. As the science develops and resources allow, screening of additional hormone systems may be added to the Endocrine Disruptor Screening Program (EDSP). When additional appropriate screening and/or testing protocols being considered under the Agency's EDSP have been developed, malathion may be subject to further screening and/or testing to better characterize effects related to endocrine disruption.

In the available toxicity studies on malathion, there was no estrogen or androgen mediated toxicity. Thyroid effects were observed in the combined chronic/carcinogenicity study in rats, which included an increase in parathyroid hyperplasia in male and female rats, and a significant trend in thyroid follicular cell adenomas and/or carcinomas and thyroid c-cell carcinomas (all in males). However, the FIFRA SAP did not consider the thyroid effects of concern or necessarily related to malathion exposure (SAP, 2000).

3. Dietary Exposure from Malathion and Malaoxon in Food

EPA conducted highly refined acute (probabilistic) and chronic dietary (food) risk assessments for malathion using Dietary Exposure Evaluation Model software with the Food Commodity Intake Database (DEM-FCID™, Version 2.03), which uses food consumption data from the U.S. Department of Agriculture's Continuing Survey of Food Intakes by Individuals (CSFII) from 1994-1996, and 1998. The acute and chronic dietary risk assessment was conducted for all supported malathion food uses.

Malathion dietary residue estimates reflect use of monitoring data, processing factors, and percent crop treated. Pesticide residue data are drawn from several sources: USDA's Pesticide Data sampling Program (PDP) between 1999-2003; FDA's surveillance program; the FOODCONTAM database (designated FODC) between 1992-1998; and field trial data for malathion and malaoxon. The four residue data sources analyzed for both malathion and malaoxon provide EPA with residue data on more than 40,000 food sample items. Residue data is combined with consumption data to estimate potential dietary exposure on an acute (one-time), and chronic basis.

As the major metabolite, malaoxon is to be regulated in plant commodities. The formation of malaoxon can occur via oxidation during water treatment processes (discussed below), or through reaction with the ambient air. Data suggest though, that the oxidation of malathion to malaoxon via ambient air does not readily occur on biologically active material (plant surfaces). Indeed, within the more than 40,000 residue samples collected between 1992-2003, only 43 detections of malaoxon were made. Although detections of malaoxon in or on food commodities are infrequent, they are accounted for in the Agency's dietary assessment by multiplying each malaoxon detection by the TAF (61x) and adding this value to the malathion dietary residue values.

a. Population Adjusted Dose

The dietary risk assessment incorporates both exposure and toxicity of a given pesticide. For acute and chronic dietary assessments, the risk is expressed as a percentage of a level of concern (i.e., the dose predicted to result in no unreasonable adverse health effects to any human sub-population, including sensitive members of such sub-populations). This level of concern is referred to as the Population Adjusted Dose (PAD). Dietary risk is characterized in terms of the PAD, which reflects the Reference Dose (RfD), either acute or chronic, that has been adjusted to account for the FQPA SF. The Agency reduced the FQPA SF to 1x where the endpoint is derived from data using juvenile animals, i.e., for both the aPAD and cPAD. Both the acute and chronic PADs for malathion are protective of all population subgroups including all infants, children, and women of child bearing age.

Estimated dietary risks less than 100% of the PAD, either acute (aPAD) or chronic (cPAD), are below the Agency's level of concern (LOC). The aPAD is the dose at which a person could be exposed at any given day with no adverse health effects expected. The cPAD is the dose at which an individual could be exposed over the course of a lifetime with no adverse health effects expected.

b. Acute and Chronic Dietary (Food) Risk

The estimated acute and chronic dietary risks from malathion and malaoxon, in food alone, are less than 100% of both the aPAD and the cPAD and, therefore, are below the Agency's LOC. Acute dietary exposure to malathion and malaoxon in food at the 99.9th percentile is 5% of the aPAD for the general U.S. population, and 11% of the aPAD for infants (<1 yr old), the most highly exposed population subgroup. The chronic dietary (food) exposure to malathion and malaoxon is less than 1% of the cPAD for all population subgroups. Tables 3 and 4 below summarize the acute and chronic dietary (food only) risks, respectively, from dietary exposure to food alone.

Table 3. Acute Dietary Exposure and Risk at the 99.9th Percentile - Food Only

Population Subgroup	aPAD (mg/kg/day)	Exposure (mg/kg/day)	Percent of the aPAD
General U.S Population	0.14	0.006975	5
All Infants < 1 year old	0.14	0.015734	11
Children 1 – 2 years old	0.14	0.013100	9
Children 3 – 5 years old	0.14	0.012432	9

Table 4. Chronic Dietary Exposure and Risk - Food Only

Population Subgroup	cPAD (mg/kg/day)	Exposure (mg/kg/day)	Percent of the cPAD
General U.S Population	0.07	0.000148	< 1
All Infants < 1 year old	0.07	0.000219	< 1
Children 1 – 2 years old	0.07	0.000343	< 1
Children 3 – 5 years old	0.07	0.000334	< 1

c. Drinking Water Exposure

Exposure to pesticides from drinking water can occur through surface and groundwater contamination. The Agency considers both acute (one day) and chronic (long-term) drinking water risks and uses either modeling or actual monitoring data, if available. EPA has assessed potential dietary risk from exposure to concentrations of malathion and malaoxon in surface water and groundwater sources of drinking water, using both modeling and available monitoring data.

Although malathion has some mobility characteristics which suggest it may leach into groundwater, its short soil persistence in conjunction with its relatively quick degradation reduces this potential exposure. EPA's groundwater database (EPA Pesticides in Ground Water Data Base 1971-1991, National Summary) identified very few wells with positive detections of malathion (12 of 990 sampled). Based upon its review of the monitoring data, EPA selected 3.17 ppb to be used for dietary exposure for malathion and malaoxon via groundwater in earlier assessments. The selected value of 3.17 ppb is considered to be a much more conservative value than concentrations predicted through EPA's Tier I SCI-GROW model (0.142 ppb).

Malathion's solubility gives it the potential to dissolve in rainwater and be transported in runoff from the application site. Surface water monitoring data on malathion has been collected in connection with the Boll Weevil Eradication Program and the Mediterranean fruit fly (Medfly) control programs, and is consistent with the fate data. These monitoring data indicate that malathion is mobile, but also that concentrations of malathion in surface water runoff decrease as distance from the application site increases. This result was expected since a greater distance (from the application site) allowed malathion to penetrate soil, adsorb to soil particles, or break/down via hydrolysis and/or aquatic metabolism. Both the fate and the monitoring data indicate that potential runoff of malathion in agricultural settings is affected by numerous variables, including soil type, soil half-life, the amount of time between rainfall events, the amount of rainfall, and the vegetation.

To model potential runoff concentrations from agricultural uses of malathion, EPA used the Tier II Pesticide Root Zone Model (PRZM), and Exposure Analysis Modeling System (EXAMS). EPA selected 16 separate crop scenarios for PRZM-EXMS in order to represent the

100+ commercial agricultural sites for which malathion is registered. EPA selected the 16 crop surrogates based upon: geographic location, use information, percent crop treated, and crop type. The modeling reflected the "Index Reservoir" (IR), a modeled water body with physical dimensions drawn from an actual reservoir, and Percent Cropped Area (PCA) refinements. PCA factors are used in pesticide drinking water assessments to account for the fact that the entire area of an individual watershed is not devoted to growing crops. In addition, other refinements were also considered in the models, including a refined aerobic soil half-life and an adjusted first application date. In addition, mitigated application values were modeled. Mitigated application values reflect a lower application rate (lb ai/A), and/or a reduction in the number of applications per year. Table 5 below summarizes selected input parameters used in estimating EDWCs. The Agency generated estimated drinking water concentrations (EDWCs) using both default and refined model inputs. Since the estimated residues of malathion in surface water are greater than those predicted or measured in groundwater, the Agency is only presenting dietary exposure to malathion/malaoxon via the surface water route, as this will be protective of any potential groundwater exposure to malathion.

Table 5. Selected Input Parameters for Drinking Water Modeling

	Soil Half-Life	**Percent Cropped Area (PCA)**	**Application Method**	**First Application Date**	**Use Pattern (app. rate and no. of appls./year)**
Default	3 day	National default (0.87)	Ground and Aerial	Rainiest part of the year, depending upon scenario modeled[3]	Maximum supported
Refined	1 day[1]	Regional PCAs[2]	Ground and Aerial	Typical first application date[4]	Proposed (reduced) application values

[1]: Under certain soil conditions, malathion aerobic half-life may be 24 hours.
[2]: Regional PCAs used: Southeast (0.38); Central (0.80); Western (0.56); and, North West (0.63).
[3]: Default *first application date* is intended to reflect month with heaviest rainfall in the modeled area: southeast (May 1); central (Jan. 1); northwest (Jan. 1).
[4]: "*First application date*" was needed only to refine the model scenario for strawberry grown in CA (May 1).

Refined Input Parameters

The drinking water models used in this analysis require the input of a single aerobic soil metabolism half-life for the entire modeled period. A 1-day aerobic soil metabolism half-life was modeled along with the 3-day half-life to evaluate the effect of a shorter soil half-life. Malathion has a wide range of measured soil half-lives which roughly correlate with soil microbial activity and moisture. On moist, microbially active soils, malathion is expected to degrade faster than on dryer, less microbially active soils. The drinking water modeling using a 1-day half-life may represent more typical water concentrations than the default 3-day half-life, because agricultural soils would be expected to commonly be moist and microbially active in order to support crop growth. For all but one scenario (WA cherry), estimated acute dietary risks were below the Agency's LOC, when the mitigated application values and the Regional PCAs were used to model EDWCs. For the WA cherry scenario, the Agency used the refined 1-day

soil half-life, because it appropriately represents the northwest region where rainfall and soil moisture is higher.

PCA factors are used in pesticide drinking water assessments to account for the fact that the entire area of an individual watershed is not devoted to growing crops. The default national PCA of 0.87 is based on the most heavily-cropped watershed in the entire United States, which is located in the Midwest. However, many crops to which malathion is applied are grown in less extensively cropped areas. For this reason, regional PCAs, which represent a refinement of national PCAs, were also used in this assessment. Even when considered on a regional scale, regional PCA factors are still likely to be conservative, as they represent the percentage of the most heavily-cropped watershed that is planted to any crop, not just the crop considered in a particular drinking water scenario. PCAs also do not take into account the percentage of a particular crop that is actually treated with malathion. State-level usage data indicate that malathion is generally used on a relatively small portion of any given crop (<5%); thus, the probability that malathion is applied to a large portion of a watershed is decreased.

In the absence of information on the time of year when malathion is used for pest control on a particular crop, the rainiest season for a site was chosen to reflect high-end runoff and exposure values. The Agency can also consider alternate application timings if information is available that indicates the rainiest season for a particular site does not coincide with malathion use. In this instance, a refined first application date for malathion was used for strawberries grown in California, because specific information about its use pattern and timing of application was available to the Agency.

Malathion Conversion to Malaoxon in Drinking Water

As mentioned above, malaoxon is formed during the water treatment process. The rate of conversion during water treatment is efficient, but may vary depending on the type of water process used in disinfection. Limited monitoring information indicates that conversion from malathion to malaoxon may be as high as 100%; data collected by the FL Dept. of Agriculture and Consumer Services Bureau of Pesticides (1997) showed only concentrations of malathion entering the Hillsboro Water Treatment Plant and, following the treatment process, only concentrations of malaoxon exiting the plant. Once converted, malaoxon may remain stable in treated water long enough to be available at the tap for direct consumption. Recently received hydrolysis data indicates that malaoxon may remain stable for 72 hours, which is within delivery times for some publicly owned treatment works (POTWs).

Therefore, in assessing dietary risk to malathion from drinking water, the Agency conservatively assumes that all estimated concentrations of malathion which enter surface water from agricultural runoff are converted to malaoxon and are available for dietary exposure via drinking water. EPA incorporated malathion/malaoxon EDWCs into the acute and chronic dietary assessments by applying the TAF (61x) to the concentrations and including this exposure with the malathion (and malaoxon) food residue values in the DEEM model.

The drinking water assessment contains various refined and conservative assumptions. Overall though, the Agency believes that estimated dietary risk via drinking water is not underestimated. The Agency notes that certain assumptions in its assessment potentially overestimate the dietary exposure to malathion/malaoxon. First, both environmental fate data and monitoring data indicate the malathion breaks down as it moves farther from the application source; however, the Agency has assumed that 100% of the predicted concentration value at the "edge of the field" reaches the POTW. Second, the Agency has little data to fully characterize the conversion of malathion to malaoxon in the water treatment process. While the Agency has data to support the upper-bound conversion of malathion to malaoxon as 100%, it lacks data to characterize a lower-bound rate of conversion which, under certain conditions, the Agency believes would be less than the assumed 100% conversion. Thirdly, the Agency's drinking water model is designed to predict surface water runoff from large portions of a watershed treated with a compound at the same time. However, State level malathion usage data indicates that malathion is generally used on a relatively small portion of any given crop. Therefore, even EDWCs generated with a refined regional PCA may be an overestimate. Finally, the Agency's TAF (61x), derived from chronic toxicity data could be an overestimate since acute toxicity data on malaoxon is outstanding. Table 6 presents the acute EDWCs and the types of refinements used for the malathion drinking water assessment. For more information on EDWCs refer to *Drinking Water Exposure Modeling Evaluating the Effect of Varying Crop Scenarios, Application Rate, Application Interval, Spray Drift Levels, Soil Half Life* (June 15, 2006).

Table 6. Summary of Acute EDWCs for Selected[1] Malathion Model Scenarios

Site	EDWCs (ppb): Default Input Parameters and Maximum Use Patterns	EDWCs (ppb): Refined Input Parameters and Mitigated Use Patterns	Refinements Applied to Default EDWC
Lettuce, CA	141	12.5	Default estimate was refined with: - proposed application values, - regional PCA, and, - 1 day half-life.
Peach, TX	185	25.4	Default estimate was refined with: - proposed application values, - regional PCA[2]
Citrus, FL	154	14	Default estimate was refined with: - proposed application values
Strawberry, CA	107	3.9	Default estimate was refined with: - first application date, and, - regional PCA
Cherry, WA	44	19.5	Default estimate was refined with: - regional PCA - 1 day soil half life
Asparagus, WA	23	17.1	Default estimate was refined with: - regional PCA

[1]: EPA modeled 16 crop scenarios to assess drinking water exposure. Only those which exceeded the Agency's LOC when default input parameters were used are shown here, and refinements implemented.
[2]: An adequate Peach, TX modeling scenario was unavailable; therefore, EPA combined southcentral PCA with GA Peach modeling scenario.

Chronic EDWCs for Malathion

The chronic EDWC used to assess malathion/malaoxon in surface water sources of drinking water was also estimated using the PRZM/EXAMS screening-level model. Based on the CA lettuce scenario, with a 3-day default half-life at the current maximum application rate, the 1-in-10 year annual concentration of 3.62 ppb was used in the chronic dietary exposure assessment.

4. Residential Exposure and Risk

Residential exposure assessments consider all potential non-occupational pesticide exposure, other than exposure due to residues in foods or in drinking water. Exposures to malathion may result from outdoor residential uses on vegetable gardens, home orchards, ornamentals and perimeter residential treatments. Residential exposure also may occur from use of malathion in wide-area treatments for adult mosquito control, spray drift from agricultural uses and fruit fly (Medfly) control.

The Agency has determined that there is a potential for exposure to malathion in residential settings for homeowners who handle (mix, load, and apply) products containing malathion. The Agency has also determined that there are potential post-application exposures to residents contacting residues while performing work associated with treating home vegetable gardens and fruit/nut trees, harvesting strawberries in commercial "pick-your-own" fields, and following outdoor fogger use.

Because of the unique circumstances regarding the special uses of malathion in public health mosquito abatement programs, the USDA's Boll Weevil Eradication Program, and fruit fly (Medfly) control, potential residential bystander exposure from these uses are assessed in separate sections later in this document. The greatest potential for malaoxon formation occurs when malathion residues deposit on hard, dry surfaces which can be inadvertently contaminated during wide area applications. For these reasons, the Agency believes that residential contact with outdoor hard surfaces following wide area aerial application of malathion presents the most relevant and worst-case scenario for assessing the risk from malaoxon exposure. Specifically, the Agency has estimated toddler post-application exposures from potential contact with malaoxon residues on wood decks and playground equipment following aerial ULV sprays for public health mosquito treatment, boll weevil eradication, and fruit fly treatment.

To estimate residential dermal and inhalation risks, the Agency calculates a margin of exposure (MOE), which is the ratio of the point of departure (PoD) selected for risk assessment to the exposure. The MOE is compared to a level of concern which is the same value as the uncertainty and safety factors (UF) applied to a particular toxicity study. For a summary of doses, UFs and FQPA SFs used to assess residential exposures, please refer to Table 2.

Residential Use Patterns

The technical registrant (Cheminova) has indicated the following residential use sites will not be supported for reregistration and are therefore not assessed: all pet uses for all formulations; all indoor uses; all greenhouse uses; all pressurized can formulations; all broadcast turf uses; and all residential dust formulation uses.

Potential residential and non-occupational uses where exposure may occur include home gardens (flower and vegetables), home orchards, building perimeters, and back yard foggers. Additional non-occupational exposure may occur from exposure to wood decks and playground equipment following aerial ULV sprays for public health mosquito treatment, boll weevil eradication, and fruit fly treatment. For ease and brevity, the residential use sites have been grouped as shown in Table 7.

Table 7. Residential Use Sites

Use Site	Target Crops or Pests	Maximum Rates	Application Equipment
Homeowner Fruit Trees	Includes apples, cherries, grapes, peaches, plums, oranges and tangerines	0.034 lb ai/gallon	Low pressure hand wand, hose end sprayer, and backpack sprayer.
Homeowner Ornamentals	Includes shade trees, evergreens, and roses	0.034 lb ai/gallon	Low pressure hand wand, hose end sprayer and backpack sprayer.
Homeowner Vegetables/Small Fruits	Includes beans, beets, broccoli, cabbage, collards, cucumbers, melons, tomatoes, peas, peppers and strawberries	0.023 lb ai/gal	Low pressure hand wand, hose end sprayer and backpack sprayer.
Homeowner Outdoor Building Perimeter Treatments	Treatment for outdoor household pests (i.e., roaches, ants, clover mites, spiders, silverfish, crickets, earwigs)	0.1547 lb ai/gal (0.011 lb ai/gal for hose end sprayer)	Low pressure hand wand, hose end sprayer, backpack sprayer.
Outdoor Yard	Mosquito and flying insect pests	0.1 lb ai/acre	Handheld fogger

a. Residential Handler Risks

The Agency determined that exposure to homeowners handling (mixing/loading/applying) a malathion product is likely to occur via dermal (skin) and inhalation routes during the residential use of malathion on the use sites shown in Table 7 above. The risk assessment considered 5 major residential exposure scenarios, based on use patterns and current labeling, types of equipment, formulations, and techniques that can potentially be used to make applications of malathion around residential settings. The use patterns assessed are intended to

be representative of the vast majority of the residential uses of malathion. These scenarios include:

(1a) mixing/loading/applying liquid with a low pressure hand wand;
(1b) mixing/loading/applying wettable powder with a low pressure hand wand;
(2) loading/applying liquid with a hose-end sprayer;
(3) mixing/loading/applying liquid with a backpack sprayer; and
(4) mixing/loading liquid for fogger.

The Agency considered residential handler exposure scenarios to be short-term (1-30 days), as homeowner applications are not expected to result in continuous exposure duration greater than 30 days. The residential risk assessment is also based on standard estimates of what and how much homeowners would typically treat, such as the size of a garden. For more information on assumptions about the daily volume handled and the area treated used in each residential handler scenarios, please refer to *Malathion: Residential Exposure and Risk Assessment for the Interim Reregistration Eligibility Decision Document*, dated July 6, 2006.

Estimated dermal and inhalation risks for homeowners handling malathion products are below the Agency's LOC for all handling scenarios. The combined (dermal and inhalation) MOEs for all scenarios assessed are greater than 100 (ranging from 250 to 13000) based on a ChE endpoint. All inhalation MOEs based on histopathologic lesions exceed 1000. Although not tabulated in this document, details on these risk estimates are available in the document referenced above.

b. Residential Post-Application Risks

The Agency refers to the term "post-application" to describe exposures to individuals that occur as a result of being in an environment that has been previously treated with a pesticide. Malathion can be used in areas that can be frequented by the general population including residential outdoor areas. The Agency has determined that there are potential post-application exposures to individuals while performing work with treated home vegetable gardens and fruit/nut trees, and while harvesting strawberries in commercial "pick-your-own" fields. While the inhalation component of post-application exposure is usually considered to be negligible and, therefore, not included in most determinations, the potential inhalation exposure following use of an outdoor fogger is a primary route of exposure and, therefore, has been assessed.

Because of the unique circumstances regarding the special uses of malathion in public health mosquito abatement control, the USDA's Boll Weevil Eradication Program, and fruit fly (Medfly) control, potential residential bystander exposure from these uses is assessed in separate sections later in this document.

Unlike residential handler exposure, where the EPA assumed only adults will be handling and applying malathion products, individuals of varying ages can potentially be exposed to

malathion when reentering or performing activities in areas that have been previously treated. The exposure pathway, residential population, and use patterns that were considered in the risk assessment include:

- Dermal exposure from residues on vegetable/small fruit gardens (adult);
- Dermal exposure from residues on fruit trees (adult);
- Dermal exposure from "pick your own" strawberries (adult);
- Dermal and inhalation (adults and toddlers) and incidental oral (toddlers only) exposure following handheld fogger use at residential, park and school settings.

Post-application exposure following building perimeter treatment is considered to be negligible, and was not assessed. However, existing label language (e.g., EPA Reg. 239-739) for outdoor household pest control gives a range of directions for perimeter house applications which includes directions for application to building foundations and wood piles, and application to the ground surrounding the perimeter of the house in a swath up to 10 feet wide.

EPA considers application of a 10-foot wide swath around most residential structures to be equivalent to a broadcast turf treatment, a use for which the technical registrant has requested voluntary cancellation (letter dated July 25, 2006). In addition, data indicates that application of malathion at the rate intended for residential pest control (0.1547 lb ai/gallon) may be phytotoxic to some ornamental species. Therefore, final label directions for perimeter house treatment will be required which permit application only to structural foundations and to wood piles, and the 2-foot wide path surrounding them.

For all post-application scenarios listed above, estimated dermal and inhalation risks from post-application exposure to malathion are below the Agency's LOC (MOEs ranged from 270 - 7800 for adults and 4000 for toddlers) at the residential setting and, therefore, are not tabulated in this document. A full discussion of assumptions and estimates of residential post-application exposure is available in *Malathion: Residential Exposure and Risk Assessment for the Interim Reregistration Eligibility Decision Document*, dated July 6, 2006.

Residential Post-Application Co-Exposure

The Agency also combines risk values from separate handler and post-application exposure scenarios when it is likely that they can occur simultaneously, and the toxicity endpoint is the same. Simultaneous exposure may refer to scenarios where the same individual handles (mixes/loads) malathion, treats a residential site, and performs post-application activities at that site on the same day. Table 8 below presents combined residential handler and post-application risks based on several malathion use patterns.

Table 8. Combined Handling and Post-Application Risks from Residential Malathion Uses (Adults)

Scenario	Total Dermal Daily Dose (mg/kg/day)	Total Dermal MOE[1]	Total Inhal. Daily Dose (mg/kg/day)	Total Inhal. MOE[1]	Total Combined MOE[2]
Mixing, loading and applying **wettable powder** with low-pressure handwand **on vegetable gardens** plus post-application activities **with home fruit trees.**	0.47	270	0.0014	18,000	260
Mixing, loading and applying **wettable powder** with low-pressure handwand **on vegetable gardens** plus post-application activities **with vegetable gardens.**	0.37	340	0.0014	18,000	330
Mixing, loading and applying **liquids** with low-pressure handwand **on fruit trees** plus post-application activities **with home fruit trees**.	0.29	440	0.00001	2,600,000	440
Mixing, loading and applying **liquids** with low-pressure handwand **on vegetable gardens** plus post-application activities **with fruit trees**.	0.24	530	0.00001	2,600,000	530
Mixing, loading and applying **liquids** with low-pressure handwand **on fruit trees** plus post-application activities **with vegetable gardens**.	0.19	670	0.00001	2,600,000	670

1. Total MOE = NOAEL/Total Daily Dose, where:
BMDL = 127 mg/kg/day, for dermal, with an LOC of 100 (cholinesterase effects)
NOAEL = 25.8 mg/kg/day, for inhalation, with an LOC of 100 (cholinesterase effects)
2 Total Combined MOE = 1/[(1/MOEdermal) + (1/MOEinhalation)]

The total combined MOEs for all assessed residential handler and post-application scenarios assumed to potentially occur the same day are all greater than 100 and, therefore, do not exceed the Agency's LOC.

c. Residential Bystander Assessment

The Agency has determined that there is potential for post-application exposures to adults and children contacting residues of malathion on turf resulting from wide area ULV applications (public health mosquito control, USDA's Boll Weevil Eradication Program, and fruit fly uses). Inhalation exposure usually does not factor significantly into post-application risk for home and garden uses. However, due to the use of malathion in ULV aerial and truck fogger applications to control mosquitoes (adulticide), its wide use in USDA's Boll Weevil Eradication Program, and fruit fly (Medfly) control, potential risk from the inhalation route of exposure has been assessed for both the aerial ULV and ground-based applications. In addition, potential dermal and non-dietary oral (hand-to-mouth) exposures have been estimated because of the concern for the residues that may be deposited during the ultra low volume (ULV) aerial and ground-based fogger applications in the vicinity of residential dwellings and other recreational areas (e.g., school playgrounds, parks, athletic fields). The dermal, inhalation, and hand-to-mouth

components of post-application exposure to adults and toddlers have been included for public health mosquito control, boll weevil eradication, and fruit fly (Medfly) uses.

For a more detailed review of the assumptions and underlying data used to assess the residential bystander exposures and risks from these uses see the *Malathion: Residential Exposure and Risk Assessment for the Interim Reregistration Eligibility Decision (RED) Document*, dated July 6, 2006.

Public Health Mosquito Control - Malathion

EPA has determined that there are potential post-application exposures to adults and children from the ULV aerial and ground-based fogger applications for public health mosquito control uses in the vicinity of residential dwellings. The assessment was developed to ensure that the potential exposures are not underestimated, and to represent a conservative model that encompasses potential exposures received in recreational settings, such as schools, playgrounds, parks, or athletic fields. The scenarios likely to result in post-application exposures are:

- dermal exposure from residues deposited on turf at residential, park, and school sites (adult and toddler);
- incidental non-dietary ingestion of residues deposited on turf at residential, park, and school sites from hand-to-mouth transfer (toddler);
- incidental non-dietary ingestion of residues deposited on turf at residential, park, and school sites from object-to-mouth transfer (toddler);
- incidental ingestion of soil from treated areas (toddler); and
- inhalation exposure (adult and toddler).

Adult combined risks based on RBC ChEI as the endpoint are calculated using the Total MOE approach where 100 is the target MOE. For toddlers, however, combined risk was estimated by calculating an aggregate risk index (ARI) because, while oral, dermal and inhalation endpoint effects are the same (ChEI), they have different associated target MOEs or levels of concern (i.e., for dermal and inhalation exposure, the LOC = 1000; for incidental oral exposure, the LOC = 100). Calculated ARIs equal to or greater than 1 are below the Agency's LOC. Combined inhalation and dermal short-term risk estimates for adults resulted in MOEs ranging from 22,000 to 74,000. In addition, the combined dermal, inhalation and incidental oral risk estimates for toddlers from post-application exposure to malathion following public health mosquito treatment resulted in ARIs ranging from 9-20. Therefore, estimated combined short-term risks to adults and toddlers, from all routes of exposure to malathion following both ground and aerial malathion public health mosquito control treatments, do not exceed the Agency's LOC. Additionally, inhalation risks based on histopathological lesions exceeded the Agency's target MOE of 1000 for all scenarios for adults and toddlers (23,000 to 500,000).

Boll Weevil Eradication Program - Malathion

The Boll Weevil Eradication Program (BWEP) is a special project under the direction of the United States Department of Agriculture designed to systematically eradicate the boll weevil pest in cotton-growing regions of the US. The Agency has determined that there is potential for non-occupational post-application exposure to malathion residues from spray drift associated with the use of malathion in the BWEP. Potential exposure may result from off target drift resulting from aerial applications in the vicinity of residential dwellings. The assessment has been developed to ensure that the potential exposures are not underestimated and to represent a conservative model that encompasses potential exposures received in residential and other recreational settings such as schools, playgrounds, parks, and athletic fields.

The Agency's assessment of the BWEP considers the potential for inhalation exposure (adults and children), dermal contact with residues (adults and children), and incidental ingestion (children only) of residues deposited on turf and soil. The Agency believes it is reasonable to expect that the BWEP application scenario may result in dermal, inhalation, and incidental oral exposure to a single individual within a single day.

The scenarios likely to result in dermal and inhalation (adult and child), and incidental ingestion (child) post-application exposures resulting from boll weevil control uses are as follows:

- dermal exposure from residues deposited on turf at residential, park, and school sites (adult and toddler);
- incidental non-dietary ingestion of residues deposited on turf at residential, park, and school sites from hand-to-mouth transfer (toddler);
- incidental non-dietary ingestion of residues deposited on turf at residential, park, and school sites from object-to-mouth transfer (toddler);
- incidental non-dietary ingestion of residues deposited on soil at residential, park, and school sites from treated areas (toddler);
- inhalation (adult and toddler); and
- inhalation exposure from airborne spray drift (adult and toddler).

Combined risk based on RBC ChEI endpoint for adults were estimated using the Total MOE approach, while combined risk for toddlers used the ARI methodology previously described. Combined adult dermal and inhalation exposures from malathion only result in a risk (total MOE = 3000) that does not exceed the LOC. Likewise, combined toddler exposures from malathion only result in a risk (total ARI = 1.3) that does not exceed the LOC for post-application residential (bystander) exposure in areas nearby fields being treated for boll weevil. Inhalation risks based on histopathological lesions exceeded the Agency's target MOE of 1000 for all scenarios for adults and toddlers (20,000 to 99,000)

Fruit Fly (Medfly) Eradication Treatment - Malathion

Various fruit fly species exist, which when found in areas of fruit and vegetable production trigger eradication efforts because of the potential economic damage they can inflict. Malathion, mixed with a protein-hydrolase bait which attracts the flies and applied by air or ground equipment as a ULV, has been used as part of the fruit fly eradication efforts. Treatment programs to control fruit fly pests have been undertaken in California, Florida and Texas.

As with the ULV uses of malathion for public health mosquito control and the BWEP, fruit fly treatments lead to a potential for non-occupational (residential bystander) post-application exposures. Potential exposures occur as a result from (i) direct deposition to residential areas when applications are made in residential areas; and, (ii) from off target drift in residential areas from applications made to nearby agricultural fields and orchards. The assessment has been developed to ensure that potential exposures are not underestimated and to represent a conservative model that encompasses potential exposures received in residential and public places (e.g., school playgrounds, parks, athletic fields).

This assessment considers the potential for inhalation (adults and children), dermal contact with residues on residential turf (adults and children), and incidental ingestion (children only) of malathion residues on residential turf and soil, following application of malathion to control fruit flies. The Agency believes it is reasonable to expect that the fruit fly application scenario may result in dermal, inhalation, and incidental oral exposure to a single individual within a single day.

The scenarios likely to result in dermal and inhalation (adult and child), and incidental non-dietary ingestion (child) exposures resulting from fruit fly control uses are as follows:

- dermal exposure from residues deposited on turf at residential, park, and school sites (adult and toddler);
- incidental non-dietary ingestion of residues deposited on turf at residential, park, and school sites from hand-to-mouth transfer (toddler);
- incidental non-dietary ingestion of residues deposited on turf at residential, park, and school sites from object-to-mouth transfer (toddler);
- incidental non-dietary ingestion of residues deposited on soil at residential, park, and school sites from treated areas (toddler); and
- inhalation exposure from airborne spray drift (adult and toddler).

Combined risk for adults based on RBC ChEI endpoint were estimated using the Total MOE approach, while combined risk for toddlers is expressed using the ARI methodology previously described. The Agency expects potential exposures and risks associated with aerial application to be greater than those associated with ground application. Therefore, the Agency did not assess ground application of fruit fly treatments with malathion. Based on the most conservative exposure estimates drawn from monitoring data, combined adult dermal and inhalation exposures following aerial fruit fly treatment result in a risk (total MOE = 5500) that

does not exceed the LOC. Likewise, combined exposure to toddlers from dermal, inhalation, and incidental oral routes result in a risk (total ARI = 1.7) that does not exceed the LOC. Inhalation risks based on histopathological lesions exceeded the Agency's target MOE of 1000 for all scenarios for adults and toddlers (4.5×10^7 to 1.7×10^8)

Combined Residues of Malathion and Malaoxon

In vivo, malaoxon is the active ChEI, of malathion. Under certain conditions, malaoxon is formed as an environmental breakdown product of malathion and is available for direct human exposure. Monitoring data gathered following aerial application of malathion data indicated malaoxon presence in air, soil, sand and hard surfaces, but minimal to no presence on foliage. These data further indicated that the greatest potential for malaoxon formation occurs when malathion residues deposit on hard, dry (anthropogenic) surfaces such as pavement, metal or wood. For these reasons, the Agency believes that residential contact with outdoor hard surfaces following aerial application of malathion presents the most relevant and worst case scenario for assessing the risk from potential malaoxon exposure.

The Agency has estimated toddler exposures from potential contact with malaoxon residues on wood decks and playground equipment following wide area applications of (ULV) malathion. The full risk from these scenarios must include not only potential malaoxon exposure, but also the exposure to the residues of malathion that remain untransformed (to malaoxon). Therefore, the Agency estimated potential risks to toddlers from the combined exposure to malathion and malaoxon. Because toddler risks from this scenario are believed to represent the worst case for all residential populations engaged in any activity on outdoor hard surfaces, adult exposures and risks were not assessed.

Only limited data exists on the rate of transformation from malathion to malaoxon on hard surfaces. The data which the Agency does have indicates a range of potential transformation rates (1%, 5% or 10%), and the Agency has decided to estimate the risk using the full range. Data on the transformation of malathion to malaoxon will be required as part of the RED. Further, the Agency received information on the dissipation and breakdown of malathion to malaoxon, such that when 5% malaoxon is formed, only 40% of untransformed malathion is present, as opposed to 95% untransformed malathion.

To account for and assess the greater toxicity of malaoxon in residential bystander settings, the Agency applied the TAF (61x) to estimated residues of malaoxon and combined this estimated dose with the estimated dose of malathion. Because both chemicals present the same toxic effect (i.e., cholinesterase inhibition), exposure to both malaoxon and untransformed malathion residues can be directly added together.

Post-application exposures of toddlers to malathion/malaoxon residues on hard surfaces following public health mosquitocide, boll weevil eradication treatment, and fruit fly treatment have been calculated and the details of these can be found in the *Malathion: Residential*

Exposure and Risk Assessment for the Interim Reregistration Eligibility Decision (RED) Document, dated July 31, 2006. The calculated exposures in this assessment are not considered to underestimate risk because they include conservative assumptions, maximum application rates and conservative deposition estimates.

Risks from individual routes of exposure (dermal and incidental oral) are combined using an aggregate risk index (ARI) and are presented in Table 9 below. The ARI approach is used because, while dermal and incidental oral toxicity endpoint effects are the same, they occur at different dose levels and have different associated levels of concern (i.e., for dermal, the LOC = 1000; for incidental oral, the LOC = 100). Calculated ARIs of greater than or equal to 1 are not of concern to the Agency.

Table 9. Aggregate Risk Index (ARI) for Residential Toddler Bystanders from Combined Residues of Malathion and Malaoxon

Use Pattern	Appl. Method	ARIs Based on Malathion-to-Malaoxon Transformation Rates		
		1% Rate	5% Rate	10% Rate
Public Health, adulticide	Aerial	20	12	6
	Ground	340	150	90
Fruit Fly Treatment	Aerial	12	9	5
Boll Weevil Eradication Program	Aerial at 1.2 lb ai/A	2.6	1.2	0.8
	Aerial at 0.9 lb ai/A	3.6	1.6	1.0

5. Aggregate Risk Assessment for Malathion

The FQPA amends the FFDCA (FFDCA, Section 408(b)(2)(A)(ii)) to require "that there is a reasonable certainty that no harm will result from aggregate exposure to the pesticide chemical residue, including all anticipated dietary exposures and other exposures for which there is reliable information." Aggregate exposure will typically include exposures from food, drinking water, residential uses of a pesticide, and other non-occupational sources of exposure.

For malathion, EPA conducted a highly refined aggregate risk assessment that combines exposures across all pathways including food, drinking water, and residential exposure, where appropriate, resulting from agricultural and non-agricultural uses of malathion. When aggregating risk from various sources, the Agency considers both the route and duration of exposure. For malathion, aggregate risk assessments were conducted for acute, chronic and short-term exposures. The Agency's aggregate assessment accounts for exposure to both malathion and the oxygen analogue, malaoxon. Results of the aggregate assessment are summarized here, and are discussed more extensively in the *Malathion: Revised Human Health Risk Assessment for the Reregistration Eligibility Decision Document (RED)*, dated July 31, 2006

a. Acute Aggregate Risk

The acute aggregate risk assessment for malathion considers exposures from food and drinking water only, as there are no other pathways of acute exposure. Dietary estimates to all population subgroups were based on a highly refined (probabilistic) assessment using DEEM software. Drinking water exposure was assessed using the full distribution of estimated residues in surface water generated by the PRZM-EXAMS model. All estimated malathion residues in drinking water were converted to malaoxon residues, multiplied by the TAF (61x), and combined with the estimated food residues. Total dietary exposure from food and drinking water was then compared to the aPAD for malathion.

Acute aggregate risk estimates, based on various default input parameters and maximum registered use patterns (rates and number of applications) from food and drinking water were above the Agency's LOC (>100% aPAD) at the 99.9th percentile of exposure. The CA lettuce maximum aerial scenario resulted in the highest drinking water concentration estimates, and consequently the highest dietary (food + drinking water) exposure estimates. Acute aggregate (food and drinking water) exposure to malathion, based on the CA lettuce scenario at the maximum aerial application rate, at the 99.9th percentile was estimated at 144% of the aPAD for the U.S. population and 520% of the aPAD for all infants (<1 yr old), the most highly exposed population subgroup.

Based on exposure estimates using refined input parameters (e.g., regional PCAs and 1-day half-lives) and mitigated use patterns, all acute aggregate (food + drinking water) risk estimates are below the Agency's LOC (< 100% of the aPAD) for all population subgroups including all infants. Because total dietary exposure from malathion/malaoxon is less than 100% aPAD, acute aggregate exposure from malathion is below the Agency's LOC. Table 10 below summarizes those acute aggregate (food + drinking water) risk estimates for malathion which were refined; other acute aggregate (food + drinking water) risk estimates for malathion which were below the Agency's LOC when default inputs were used, are not presented.

Table 10. Selected[1] Acute Aggregate Exposure and Risk Estimates (Food and Drinking Water)

Site	Population	% aPAD (Default Inputs and Maximum Use Patterns)	% aPAD (Refined Inputs and Mitigated Use Patterns)	Comments
Acute Aggregate Dietary Estimate at the 99.9th Percentile				
Lettuce, CA	U.S Population	144	19	Default estimates were refined with: - proposed application values - regional PCA - 1 day half-life
	All Infants (< 1 yr)	520	63	
	Children 1-2 yrs	218	29	
	Children 3-5 yrs	200	27	

Site	Population	% aPAD (Default Inputs and Maximum Use Patterns)	% aPAD (Refined Inputs and Mitigated Use Patterns)	Comments
Acute Aggregate Dietary Estimate at the 99.9th Percentile				
Peach, TX	U.S Population	146	22	Used GA Peach as surrogate model Default estimate was refined with: - proposed application values - regional PCA[1]
	All Infants (< 1 yr)	485	73	
	Children 1–2 yrs	222	34	
	Children 3-5 yrs	201	30	
Citrus, FL	U.S Population	123	11	Default estimate was refined with: - proposed application values
	All Infants (< 1 yr)	430	37	
	Children 1–2 yrs	184	20	
	Children 3-5 yrs	166	17	
Tomato, FL	U.S Population	115	-	Default exposure estimates refined with: - proposed revised application rates - regional PCA All population subgroups have lower estimated exposure than all infants, therefore other populations were not modeled
	All Infants (< 1 yr)	410	72	
	Children 1–2 yrs	177	-	
	Children 3-5 yrs	162	-	
Strawberry, CA	U.S Population	102	20	Default estimate was refined with: - first application date - regional PCA This scenario was also run with the more conservative 3 day half-life, which resulted in aPAD for all children of 99%.
	All Infants (< 1 yr)	370	59	
	Children 1–2 yrs	153	30	
	Children 3-5 yrs	140	28	
Cotton, MS	U.S Population	73	7	Default estimates refined with - proposed revised application rates
	All Infants (< 1 yr)	262	19	
	Children 1–2 yrs	111	13	
	Children 3-5 yrs	101	11	
Cherry, WA	U.S Population	62	29	Default estimate was refined with: - proposed application values - regional PCA - 1 day soil half-life
	All Infants (< 1 yr)	207	94	
	Children 1–2 yrs	91	43	
	Children 3-5 yrs	81	39	
Cabbage, FL	U.S Population	57	13	Default estimates refined with: - proposed revised application rates
	All Infants (< 1 yr)	195	46	
	Children 1–2 yrs	83	22	
	Children 3-5 yrs	76	20	
Sorghum, TX	U.S Population	39	5	Default estimates refined with: - proposed revised application rates
	All Infants (< 1 yr)	128	12	
	Children 1–2 yrs	58	9	

Site	Population	% aPAD (Default Inputs and Maximum Use Patterns)	% aPAD (Refined Inputs and Mitigated Use Patterns)	Comments
Acute Aggregate Dietary Estimate at the 99.9th Percentile				
	Children 3-5 yrs	53	9	
Asparagus, WA	U.S Population	38	-	Default estimate was refined with: - proposed application values - regional PCA All population subgroups have lower estimated exposure than all infants (<1), therefore, other populations were not modeled
	All Infants (< 1 yr)	123	94	
	Children 1–2 yrs	55	-	
	Children 3-5 yrs	51	-	

[1]: EPA modeled 16 crop scenarios to assess drinking water exposure. Only those which exceeded the Agency's LOC when default input parameters were used are shown here, and refinements implemented.
[2]: An adequate Peach, TX modeling scenario was unavailable; therefore, EPA combined south central PCA with GA peach modeling scenario.

b. Chronic Aggregate Risk

The chronic aggregate exposure to malathion from food and drinking water is below the Agency's LOC for the U.S. general population and all population subgroups. For all drinking water scenarios assessed, including the worst-case aerial CA lettuce scenario with maximum application rates, all chronic aggregate dietary exposure from food and drinking water for the U.S. population and all infants <1 yr, the most highly exposed population subgroup, was <1% of the cPAD. Table 11 provides a summary of chronic aggregate exposure estimates and risk estimates for food and drinking water.

Table 11. Chronic Aggregate Dietary Exposure and Risk (Food + Drinking Water)

Population Subgroup	cPAD (mg/kg/day)	Exposure (mg/kg/day)	Percent of the cPAD
General U.S Population	0.07	0.000224	< 1
All Infants < 1 year old	0.07	0.000469	< 1
Children 1 – 2 years old	0.07	0.000456	< 1
Children 3 – 5 years old	0.07	0.000441	< 1

c. Short-Term Aggregate Risk

Aggregate short-term (1-30 days) risk estimates include the contribution from chronic (average) dietary sources (food + drinking water) and short-term residential sources. Several short-term residential exposure scenarios exist that could be aggregated with the chronic dietary exposure sources. Short-term residential exposure (dermal + inhalation + incidental oral)

scenarios include adult residential handler, adult and toddler bystander exposure to the home and garden uses of malathion, and toddler bystander exposure to the wide area uses of malathion (BWEP, public health, and Medfly control). Since the estimated exposures resulting from the wide area use assessments incorporate potential exposure to malaoxon, they are more conservative than the estimated exposures resulting from the residential uses and, therefore, have been chosen for the aggregate assessment. Among the wide area uses of malathion, the Agency believes that aerial application of public health use of malathion represents the most likely, and wide spread co-occurring exposure pathway for the general U.S. population. To be conservative, the Agency assessed this scenario at the 10% conversion rate of malathion to malaoxon.

Short-term bystander exposure from public health use considered incidental oral (hand to mouth), and dermal exposure to both malathion and malaoxon. MOEs for incidental oral exposure are 1,900, and for dermal are 9,100. Chronic aggregate dietary exposures for all infants (< 1 yr old), the most highly exposed population subgroup, is < 1% of the cPAD. The Agency combined these risks using the Aggregate Risk Index (ARI) method, since the target LOC for oral exposure (hand to mouth, and dietary) differs from that of dermal exposure. When using the ARI method, the Agency considers risks equal to or greater than 1 to be not of concern. As presented in Table 12, when chronic dietary (food + drinking water) is added to the oral and dermal exposure components, the total aggregate ARI is 6 and, therefore, below the Agency's LOC.

While the Agency believes that the public health use of malathion is the most appropriate scenario for short-term aggregate risk characterization, it is not the most conservative; rather toddler bystander exposure from the BWEP represents the most conservative residential exposure scenario. There are several reasons why EPA believes that the BWEP scenario is not the most appropriate co-exposure scenario for aggregation. First, the BWEP is a time limited program. The USDA Animal and Plant Health Inspection Service (APHIS) has projected that the eradication phase of the program will end by 2009. Thereafter, USDA/APHIS intends to control the boll weevil by applying malathion only where outbreaks occur, which will result in a significant reduction of malathion applied and, therefore, a significant reduction of potential exposure. The BWEP is also very targeted, being managed and administered in only those states and counties currently active in the eradication phase of the program. As of March 2006, USDA/APHIS reports that boll weevil has already been successfully eradicated in 10 states with active eradication efforts currently underway in 7 states and Mexico. In contrast, the public health use of malathion is national (on a yearly basis) and is broadcast over wider areas (including residential), not just to agricultural fields as malathion is used in the BWEP. Finally, the BWEP has a community outreach and notification component which helps reduce potential exposure from off target drift to bystanders. For these reasons, EPA believes that the BWEP is a less appropriate scenario for aggregation, than the public health use of malathion. Nonetheless, the Agency aggregated this use with the chronic dietary exposure as a worst-case scenario. When estimating risk from the BWEP, the Agency considered both the maximum application rate as well as the typical application rate. Based on information provided by USDA/APHIS which indicates that the predominantly used typical rate in the BWEP is 0.9 lb ai/A (greater than

99% of the acreage is treated at this rate or below), the Agency assessed the predominantly used typical rate (0.9 lb ai/A) for aggregate short-term risk as well as the maximum rate (1.2 lb ai/A). At the maximum application rate, and at the maximum 10% malaoxon conversion rate the estimated aggregate risk, combining the bystander BWEP scenario with chronic dietary (food + drinking water), results in an ARI of 0.8 and, therefore, above the Agency's level of concern. However, based on the predominantly used typical rate of 0.9 lb ai/A, and at the maximum 10% malaoxon conversion rate, the estimated ARI is 1 and, therefore, below the Agency's LOC. Table 12 summarizes short-term aggregate risk to children 1-2 years of age for public health mosquitocide and BWEP.

Table 12. Short-term Aggregate Risk to Children 1 – 2 Years

Use Scenario	ARI Food + Water[1]	ARI Oral[1]	ARI Dermal[1]	Aggregate ARI[2]
Public Health Mosquito Control (10% malaoxon conversion)	160	19	9.1	6.0
BWEP at Max App. Rate (1.2 lb ai/A) (10% malaoxon conversion)	160	3.6	1.4	0.8
BWEP at Typ App Rate (0.9 lb ai/A) (10% malaoxon conversion)	160	3.6	1.6	1.0

[1] $ARI = [MOE_{CALCULATED} \div MOE_{ACCEPTABLE}]$ (Note: Target ARI = 1)

[2] Aggregate ARI $= \dfrac{1}{\frac{1}{ARI_{FOOD+WATER}} + \frac{1}{ARI_{ORAL}} + \frac{1}{ARI_{DERMAL}}}$

d. Malathion Pesticide and Pharmaceutical Use Co-Exposure Assessment

As indicated above, in determining the risk to human health, the Agency examines more than just dietary exposures. Section 408 of FFDCA requires EPA to consider potential sources of exposure to a pesticide and related substances in addition to the dietary sources expected to result from a pesticide use subject to the tolerance. In order to determine whether to maintain a pesticide tolerance, EPA must "determine that there is a reasonable certainty of no harm. . . ." Under FFDCA section 505, the Food and Drug Administration reviews human drugs for safety and effectiveness and may approve a drug notwithstanding the possibility that some patients may experience adverse side effects. EPA does not believe that, for purposes of the section 408 dietary risk assessment, it is compelled to treat a pharmaceutical patient the same as a non-patient, or to assume that combined exposures to pesticide and pharmaceutical residues that lead to a physiological effect in the patient constitutes "harm" under the meaning of section 408 of the FFDCA.

Rather, EPA believes the appropriate way to consider the pharmaceutical use of malathion in its risk assessment is to examine the impact that the additional non-occupational pesticide exposures would have to a pharmaceutical patient exposed to a related (or, in some cases, the same) compound. Where the additional pesticide exposure has no more than a

minimal impact on the pharmaceutical patient, EPA could make a reasonable certainty of no harm finding for the pesticide tolerances of that compound under section 408 of the FFDCA. If the potential impact on the pharmaceutical user as a result of co-exposure from pesticide use is more than minimal, then EPA would not be able to conclude that pesticide residues were safe and would need to discuss with FDA appropriate measures to reduce exposure from one or both sources. The Agency provided its preliminary findings with respect to malathion to FDA in a letter dated August 10, 2005, which is available on the public docket (EPA-HQ-OPP-2004-0348).

The exposure estimates used in the determination of malathion pharmaceutical and pesticide co-exposure assessment, Attachments 1 and 2 to the July 25, 2005 letter, referenced above, reflects the external dermal dose of malathion a patient treated with a pharmaceutical malathion product would receive in a reasonable worst-case scenario. EPA's pesticide exposure assessment has taken into consideration the appropriate population, exposure route, and exposure duration for comparison with exposure to the pharmaceutical use of malathion. Using the malathion (Ovide® Lotion 0.05%) registered pharmaceutical label, EPA estimated exposure from a typical treatment of that product, and compared that to the potential exposure an individual would receive from the pesticide uses of malathion. Because the Ovide® Lotion is indicated for use over an 8 - 12 hour period, EPA considers the pharmaceutical use as a short-term exposure. To estimate combined pesticide exposure for a short-term scenario, EPA integrated average dietary exposure estimates (food + drinking water) with one of the non-occupational exposure scenarios (i.e. post-application to malathion residues from wide area public health applications). EPA chose the wide area public health exposure scenario because this application is a reasonable high-end scenario, and is likely to result in a large number of individuals potentially exposed to malathion pesticide residues.

In connection to its Revised Malathion Human Health Risk Assessment, issued September 2005, EPA worked with FDA to determine whether the additional malathion exposure from the pesticide uses would pose a safety concern to a patient using Ovide® Lotion. In a letter dated August 26, 2005, FDA stated that based on EPA calculations of potential high-end pesticide exposure (0.27 mg/kg/day), such exposure in patients receiving Ovide® Lotion treatment would fall within the expected upper range of exposure following Ovide® Lotion use alone, and would not present an increased safety risk.

As discussed above, comments were received in connection with the issuance of the Revised Malathion Human Health Risk Assessment that has resulted in a recalculation of the average dietary exposure and non-occupational exposure (wide area public health use) estimates. The recalculated combined pesticide exposure is within the dose range considered by FDA in its August 26, 2005 letter and below the high-end pesticide exposure estimate that FDA concluded would not increase risk beyond the range expected for the pharmaceutical use alone. Therefore, because the pesticide exposure has no more than a minimal impact on the pharmaceutical patient, the Agency believes that there is a reasonable certainty that the potential pesticide exposure will result in no harm to a patient also receiving Ovide® Lotion.

6. Occupational Exposure and Risk

Workers can be exposed to a pesticide through mixing, loading, and/or applying the pesticide, or re-entering a treated site. The Agency assessed risk to occupational handlers and workers in the same fashion as it used to assess risks to residential bystanders, i.e., by using the Margin of Exposure (MOE) approach. The MOE reflects how close an occupational exposure comes to the No Observed Adverse Effect Level (NOAEL) or some other PoD, the dose considered to result in no adverse health effects. The Agency is not concerned if the estimated exposure is 100x less than the PoD (the difference equal to the UF which accounts for the intra-species and inter-species variation). Please see Table 2 for the summary of toxicological endpoints used in this assessment. Both short- and intermediate-term exposures are expected to occur to handlers from registered malathion use patterns. The risk assessment for short-term (1-30 days) and intermediate-term (1-6 months) occupational exposures are similar because the toxicity endpoints, the PODs and the target MOE, are the same for both durations. Chronic exposure (> 6 months) is not expected for handlers and, therefore, is not assessed. Even though the Agency selected separate endpoints for dermal exposure versus inhalation exposures (ChEI as the toxicity endpoint for dermal exposure and histopathologic lesions as the toxicity endpoint for inhalation exposure), the contribution of inhalation exposure to the ChE endpoint was also considered. Therefore, in calculating the short- and intermediate-term risks for ChEI, total MOEs were estimated for combined dermal and inhalation exposures, as well as MOEs for inhalation only to address risk from histopathological lesions.

For malathion, total MOEs that are greater than 100 generally do not exceed the Agency's LOC. However, when occupational MOEs are less than 100, EPA strives to reduce worker cancer risks through the use of personal protective equipment, engineering controls, or Restricted-Entry Intervals (REIs). MOEs for inhalation (histopathological lesions) greater than 1000 do not exceed the Agency's LOC.

a. Occupational Handler Exposure and Risk

Exposure to malathion by pesticide handlers (mixers, loaders, applicators and flaggers) is likely during the use of malathion based on the type of equipment and techniques that can potentially be used. Twenty-six occupational exposure scenarios were assessed based on registered labels, equipment, and techniques that could be used for malathion applicators. Due to the scope of the various malathion occupational uses (there are over 200 registered malathion products), it would be difficult to assess each individual exposure scenario. Therefore, the following selected scenarios are representative of the worse-case exposure scenarios to represent the major ways malathion can be handled in the occupational environment. The scenario numbers correspond to the non-cancer risk estimate tables presented in the *Malathion: Occupational Exposure and Risk Assessment for the Interim Reregistration Eligibility Decision (IRED) Document,* dated July 6, 2006.

The labeled use patterns indicate a number of exposure scenarios based on the types of equipment and activities used to make malathion applications. These scenarios include:

1) mixing/loading liquids for chemigation application;
2) mixing/loading liquids for groundboom application;
3) mixing/loading liquids for aerial application;
4) mixing/loading liquids for airblast sprayer;
5) mixing/loading liquids for dipping;
6) mixing/loading liquids for a fogger;
7) mixing/loading liquids for handgun sprayer;
8) mixing/loading liquids for truck mounted ULV sprays;
9) applying liquids via groundboom;
10) applying liquids via airblast;
11) applying liquids via aerial;
12) applying liquids via handgun sprayer;
13) applying liquids via truck mounted sprayer;
14) applying liquids via dip;
15) mixing/loading/applying liquids via handgun sprayer;
16) mixing/loading/applying liquids via low pressure handwand;
17) mixing/loading/applying liquids via backpack sprayer;
18) mixing loading/applying liquids via paint brush;
19) mixing/loading/applying liquids via dip;
20) flagging for aerial spray application;
21) mixing/loading wettable powders for aerial;
22) mixing/loading wettable powders for chemigation application;
23) mixing/loading wettable powders for groundboom application;
24) mixing/loading wettable powders for airblast application;
25) loading dusts for power duster; and
26) applying dusts with a power duster.

The level of personal protective equipment (PPE) varies on the numerous malathion labels. Some labels only require the minimum level of PPE, while others require additional PPE, such as chemical-resistant gloves, respirators, etc., depending on the labeled handler activity. Therefore, the Agency considered the following levels of PPE or engineering controls in the occupational exposure assessments:

- Baseline, or long-sleeved shirt, long pants, no gloves, and no respirator. (Baseline)
- Baseline plus chemical-resistant gloves, and no respirator. (PPE-G-NR)
- Coveralls worn over long-sleeved shirt and long pants, chemical-resistant gloves, and no respirator. (PPE-G-DL-NR)
- Baseline plus chemical-resistant gloves and an 80% PF (quarter-face dust/mist) respirator. (PPE-G-80%R)
- Coveralls worn over long-sleeved shirt and long pants, chemical-resistant gloves, and

an 80% PF (quarter-face dust/mist) respirator. (PPE-G-DL-80%R)
- Engineering Controls, or closed mixing/loading system, enclosed cab, or enclosed cockpit. (EC)

Except for malathion handlers and applicators using closed mixing/loading systems to support aerial application to cotton and dust application to dates, no chemical-specific handler exposure data were submitted in support of the reregistration of malathion. Therefore, an exposure assessment for most scenarios was developed, where appropriate data are available, using the Pesticide Handlers Exposure Database (PHED) Version 1.1. PHED is a generic database containing measured exposure data for workers involved in the handling or the application of pesticides in the field (i.e., currently contains data for over 2,000 monitored exposure events).

For each of the 26 handler scenarios above, the Agency considered numerous crops or target use sites with various application rates and daily treated area to reflect the way in which malathion can be applied (approximately 555 various use patterns were assessed). Additionally, due to the broad spectrum use of malathion, the Agency believes that occupational exposure can occur over a single day or up to a week's time for many use-patterns, and intermittent exposure over several weeks are also anticipated. Therefore, the risk assessment considers both short- (1-30 days) and intermediate-term (1-6 months) exposure to malathion; combining dermal and inhalation exposures to assess risks from ChEI and evaluating inhalation exposures alone to assess histopathological lesions.

Handler Risks

The majority of the risk estimates were below the Agency's LOC, with MOEs ranging from 100 to 490,000 when baseline PPE and chemical-resistant gloves were applied and are, therefore, not tabulated in this document. However, 17 of the over 500 use patterns assessed either had no data available for conducting an assessment, or required additional PPE or engineering controls before the risk estimates were below the Agency's LOC, and are listed in Table 13. One scenario, however, mixing/loading/applying (M/L/A) liquid concentrates with a low pressure handwand to overhead/fruit trees, was assessed but no data were available to estimate MOEs with anything other than baseline clothing, which exceeded the LOC. This scenario is very similar to another low pressure handwand M/L/A scenario which has data available to calculate MOEs with baseline PPE and chemical-resistant gloves and which is not of concern with that level of protection. This scenario effectively serves as a surrogate for the overhead/tree fruit scenario with no data and is, therefore, not tabulated in Table 13 below.

Table 13. Summary of Malathion Occupational Handler Risk Estimates (MOEs) Requiring PPE greater than Baseline and Gloves

Exposure Scenario	Crop or Use	Application Rate	Max. Area Treated Daily	Base-line	PPE-G-NR	PPE-G-80%R	PPE-G-DL-80%R	EC
Mixer/Loader (M/L)								
M/L Liquids for ULV Aerial Application	Field & Row Crop (Rice, Barely , Oats, Rye, and Wild Rice)	0.61 lb ai/A	7500 A	1	67	ND	110	NA
	Field & Row Crops (Cotton)	1.22 lb ai/A	7500 A	0	34	ND	53	110
M/L Wettable Powders for Aerial Application	Blueberries (Low)	1.25 lb ai/A	350 A	5	53	96	120	NA
		0.76 lb ai/A	350 A	9	88	160	NA	NA
	Blueberries (Vine/Trellis)	1.25 lb ai/A	350 A	5	53	96	120	NA
		0.76 lb ai/A	350 A	9	88	160	NA	NA
	Blackberry, Boysenberry, Dewberry, Loganberry, and Raspberry	2 lb ai/A	350 A	3	33	60	74	1,200
M/L Wettable Powder for Chemigation	Blueberries (Low)	1.25 lb ai/A	350 A	5	53	96	120	NA
		0.76 lb ai/A	350 A	9	88	160	NA	NA
	Blueberries (Vine/Trellis)	1.25 lb ai/A	350 A	5	53	96	120	NA
		0.76 lb ai/A	350 A	9	88	160	NA	NA
	Strawberries	2 lb ai/A	350 A	3	33	60	74	1,200
	Blackberry, Boysenberry, Dewberry, Loganberry, and Raspberry	2 lb ai/A	350 A	3	33	60	74	1,200
Application Only								
Liquids via Aerial Application	All 77 crop scenarios assessed	0.175 to 8 Lb ai/A	350 to 7500 A	ND	ND	ND	ND	180 to 27,000
Dust Via Mechanical Duster	Tree Fruit: Evergreens (Tropical)	4.25 lb ai/A	5 A	ND	ND	ND	ND	ND
		2.75 lb ai/A	5 A	ND	ND	ND	ND	ND
Mixing/Loading/Applying (M/L/A)								
Mixing/Loading/Applying Dip	Grape root	0.019 lb ai/gallon	100 gallons	ND	ND	ND	ND	NF

ND= No Data
NF= Not Feasible
NA=Not Assessed

b. Occupational Post-Application Exposure and Risk

EPA uses the term "post-application" to describe exposure to an individual which occurs as a result of entering into an environment that has been previously treated with a pesticide (also

referred to as reentry exposure). Many crops (or other pesticide treated environments) require distinct job functions which must occur in an environment, following the application of a pesticide product. The job requirements, the nature of the environment, or target that was treated, and how the chemical residues degrade in the environment can cause exposure levels to differ over time. Each factor has been considered in this assessment in determining the safety of persons who are subject to post-application pesticide exposure.

In estimating post-application exposure and risk, transfer coefficient data, which is a measure of the residue transferred from a treated surface to a person who is performing an activity in a treated area, are used in conjunction with dislodgeable foliar residue (DFR) data. DFR data is a unique measurement of the amount of pesticide residue on a treated surface which is available for transfer. DFR data is specific to a compound and describes (by algorithmic function) the dissipation of that chemical over time. EPA has six separate DFR studies on malathion. All agricultural occupational post-application scenarios for malathion were evaluated using one of these six DFR studies.

Occupational post-application exposure (for a given activity/crop combination) is calculated by multiplying the DFR data by the transfer coefficient(s) for that activity/crop combination. The calculation takes into account the application rate for each specific crop, and is normalized by body weight and adjusted for dermal absorption (if necessary). The frequency and duration of post-application occupational exposure is also considered in EPA's estimates of post-application exposure and risk. Short-term exposure durations (1-30 days) are typically considered, and intermediate-term exposure durations (1-6 months) are appropriate for exposures scenarios where the pesticide is reapplied several times over a growing season, or the pesticide residues persist for relatively long periods of time. For malathion, the exposure durations for noncancer post-application risk assessment were short-term and intermediate-term. The dermal toxicological endpoint of concern is the same for both exposure durations, i.e., ChEI. Since malathion has a very low vapor pressure, inhalation exposures are considered to be negligible in outdoor post-application scenarios. DFR data multiplied by the appropriate transfer coefficient yields an estimated dose. The estimated dose is then compared to the selected PoD endpoint (see Table 2), with a target MOE of 100.

EPA does not consider the use of personal protective equipment (PPE), or other types of equipment as a viable option to reduce occupational post-application exposures. However, the Restricted-Entry Interval (REI) is considered an acceptable risk mitigation approach for occupational post-application scenarios. The REI is the required time period, following a pesticide application, during which entry into the treated area is prohibited for workers performing conventional tasks. The Agency sets the REI equal to the time required for the estimated risk to be above the Agency's LOC (i.e., the REI is set equal to the time required for the MOE to be equal to or greater than 100). Currently, all malathion labels specify a 12-hour REI.

For this assessment, the Agency assessed not only the current maximum supported application rate, but also the proposed revised application rate. Based on a revised dermal toxicological endpoint of 127 mg/kg/day, and the proposed revised application rates, the vast majority of occupational post-application scenarios result in MOEs greater than 100 at 12 or 24 hours following application. In several cases a 2-day REI is required to reach the target MOE of 100, and for detasseling corn and tying grapes, a 4-day REI is required. Table 14 provides a summary of occupational post-application REIs for those use sites that require more than the current 12 hour REI based on the maximum supported application rate and, where appropriate, the recalculated REI based on the proposed revised application rate.

Table 14. Summary of Use Sites that Require More than 12 Hour REI

Use Site	Application Rate (lb ai/A)	Application Rate Source	REI
Cotton	2.5	Current	2 days
	1.22	Current	24 hrs
Peanuts	2.5	Current	24 hrs
Peas	2.5	Current	2 days
	1.0	Amended	12 hrs
Corn (field, seed, sweet and pop)	1.0	Amended	4 days for detasseling and hand harvesting; 12 hrs for all other activities
	0.61	Current	3 days for detasseling and hand harvesting; 12 hrs for all other activities
Apricots	3.75	Current	12 hrs for med expos; 2 days for high expos
	1.5	Amended	12 hrs
Nectarine, peach	3.75	Current	2 days
	3.0	Amended	24 hrs
Figs	2.5	Current	24 hrs
	2.0	Amended	24 hrs
Cherries (sweet and tart)	3.75	Current	2 days
	1.75	Amended	12 hrs
Grapefruit, Lemon, lime, orange, tangelo, tangerine,	6.25	Current	3 days
	CA: 7.5	Amended	3 days
	Rest of US: 4.5	Amended	2 days
Avocado	4.70	Current	3 days
	4.7	Amended	2 days
Kumquat	6.25	Current	3 days
	4.5	Amended	2 days
Dates	4.25	Current	2 days
Pine seed orchards, Christmas tree plantations, slash pine	2.5	Current	24 hrs

Use Site	Application Rate (lb ai/A)	Application Rate Source	REI
plantations, forest trees			
Chestnuts	5	Current	2 days
	2.5	Amended	24 hrs
Pecans	2.5	Current	24 hrs
	8.0	Amended	3 days
Walnuts	2.5	Current	24 hrs
Forest trees	2.5	Current	24 hrs
Garden beets, carrot, horseradish, parsnip, radish, rutabaga, salsify, turnip	1.25	Current	24 hrs
Chayote root, yams	1.56	Current	24 hrs
Garlic, leeks, green onion, shallots	1.56	Current	24 hrs
Chayote fruit, cucumber	1.88	Current	24 hrs
Summer squash	1.88	Current	24 hrs
	1.75	Amended	24 hrs
Eggplant	3.43	Current	24 hrs
	1.56	Amended	12 hrs
Tomato (fresh and processed), tomatillo	3.43	Current	24 hrs
	1.56	Amended	12 hrs
Broccoli (raab, Chinese), Brussels sprouts, cabbage, cauliflower	1.25	Current	2 days
Celery, kohlrabi	1.25	Current	24 hrs
Collard, kale, mustard green, Chinese greens	1.25	Current	24 hrs
Dandelion	2	Current	2 days
	1.25	Amended	24 hrs
Parsley	2	Current	2 days
	1.5	Amended	24 hrs
Spinach	2	Current	2 days
Swiss chard	2	Current	2 days
Endive and escarole	1.88	Current	24 hrs
	1.24	Amended	12 hrs
Lettuce	1.88	Current	24 hrs
Chives	1.56	Current	24 hrs
Watercress	1.25	Current	24 hrs
Pineapples	5	Current	2 days
Grape (wine, table, raisin)	1.88	Current	3 days for girdling and cane turning; 12 hrs for all other activities

c. Incident Reports

The number of malathion exposures and poisonings has declined in recent years; however, most of this decline has occurred in the residential setting and there are no usage surveys to determine whether all or most of this decline is due to less use or safer handling. Likely, some of the decline is due to less widespread use of malathion due to Medfly outbreaks and as a choice for use against carriers of West Nile Virus. Although agricultural use has declined slightly in California in recent years, it does not explain most of the decline in poisonings reported from that State.

Symptoms commonly reported for malathion exposure cover the spectrum normally associated with organophosphate exposure, and include headache, nausea, dizziness, muscle weakness, drowsiness, difficult breathing, diarrhea, excess secretions, agitation, confusion, blurred vision and, death from accidental or intentional ingestions (i.e., suicides). The most recent five years of data (1999-2003) from California show a marked decline of 59% (from 27.5 to 11.2) in total illnesses attributed to malathion from the 1982-1998 time span. There were 79 cases reported from 1999-2003 and, of these, malathion was determined to be the primary cause of illness in 55 cases. As before, cases were included if malathion was considered a possible, probable, or definite cause of the reported illness. Only 5 of the 55 cases were related to use in agriculture and 4 of the 5 were systemic poisonings. On average, there were 14,846 agriculturally-related applications of malathion from 1999 through 2003 in California. Thus, there were 0.27 systemic poisonings per 1,000 applications from 1999-2003, which compares favorably with much older data from 1982 through 1989, which found a median of 0.41 poisonings per 1,000 applications. However, the earlier data did not have a requirement that all agricultural applications be reported, just commercial and applications by a licensed pesticide applicator. Therefore, it is not clear whether the current rate of poisoning per thousand applications is due to a real decline or an artifact of use reporting. Still, the decline in systemic poisonings from 1990-96 (20.4 per year) to 1999-2003 (8.2 per year) demonstrates a 60% decline in all systemic poisonings, which appears to be not solely a result of the decline in malathion use.

The pattern of incidents was similar to previous years. There were three suicides (ingestions of concentrate: 6-8 ounces, over a cup, and an unknown quantity) and 3 attempted suicides (one case ingested about 8 ounces of 0.125% malathion). Also, a number of rescue personnel attending the suicide victims were also poisoned by the strong odor and from contact with contamination. There were four such individuals in one case, and nine persons sick from attending another suicide victim. Fourteen of the cases became sick from applications that occurred nearby (e.g., from drift). Some of these were due to highly concentrated applications that had not been diluted properly. Five cases involved the applicators themselves, and in six cases there was mention of a leaking or broken bottle.

Much of the information presented above has inherent limitations, including inadequate documentation of exposure and effects, reporting biases and absence of denominator information

on the population at risk. However, certain consistent patterns of risk factors can be identified. The large majority of malathion incidents appear to involve minor symptoms, which in many cases may be a reaction to the odor rather than cholinergic poisoning. Nonetheless, symptoms brought on by odor effects are poisonings by definition. Broken bottles and other inadequate packaging accounted for over a quarter of the cases in California from 1982 through 1995. Drift and exposure to odors was another common cause of incidents in California. These latter incidents typically resulted in mild and transient symptoms. In many cases it appears that symptoms are brought on by the offensive odor of the compound alone (i.e., ChE depression need not be present). More serious malathion cases typically involve application by hand or backpack sprayer and direct exposure to concentrate. Often, serious exposures result from equipment failure, such as hose breaks or failure to exercise minimal precautions during maintenance or clean-up. Though less hazardous than other OPs and carbamates on most measures, malathion has a higher incidence of life-threatening cases in Poison Control Center data. Extensive exposure to concentrates appears to be a likely risk factor in these cases.

B. Environmental Fate and Effects Assessment

A summary of the EPA's environmental fate and ecological effects of malathion is presented below. The full assessment, *Revised EFED RED Chapter for Malathion* (May, 2000) and response to public comments are available on the internet and in the public docket (EPA-HQ-OPP-2004-0348). Updates to the risk assessment include the following:

- incorporation of malaoxon fate data (hydrolysis and conversion data);
- refinement to surface water concentration estimates using typical application information, regional percent cropped area values, and crop specific application information;
- consideration of buffer zones to reduce off target drift from EC/WP formulation and ULV formulation applications;
- reassessment of off target drift resulting from the Boll Weevil Eradication Program; and
- revision to the public health use parameters based on the provision of the PR Notice 2005-1 for Public Health Use Pesticides.

1. Environmental Fate and Transport

The primary routes of dissipation of malathion in surface soils appear to be microbially mediated soil metabolism and hydrolysis. Malathion is generally nonpersistent; but open literature studies suggest that its persistence is longer on soil that is of dry, sandy, low nitrogen, low carbon, and acidic quality. Aerobic soil metabolism data indicate that half-life values for malathion range from several hours to nearly 11 days. The persistence of malathion is decreased with microbial activity, moisture, and high pH. While malathion exhibits short soil persistence, which reduces the likelihood it will leach to groundwater, its low Kd value, and data from various leaching studies, and groundwater detections in three states (CA, MS, and VA) indicate that malathion does have potential to leach to groundwater. Other important routes of dissipation from soil, suggested by the data, include leaching, plant uptake, and surface runoff.

In general, malathion and its degradates are soluble and do not adsorb strongly to soils, and, therefore, are likely to be mobile. Guideline studies and open literature show that malathion is unstable under alkaline conditions and increasingly stable under acidic conditions. While malathion is stable under sunlight, it photodegrades slowly in natural and distilled water (reported half lives ranging from 0.67 to 42 days). Open literature in conjunction with registrant submitted studies suggest that malathion is unlikely to persist in anaerobic aquatic conditions. Aerobic aquatic metabolism data indicate that malathion's half-life can vary from 1 day to two weeks. Malathion has a relative low vapor pressure, indicating that gas phase reactions are only minor routes of degradation

EPA has limited data on malaoxon, the oxon analogue, and the other impurities/degradates of malathion. However, based upon the chemical similarity between malathion and malaoxon, it is expected that malaoxon will have similar fate properties as its parent. As discussed earlier in this document, malaoxon is shown to form under dry and microbially inactive environmental conditions, such as on dry soil, concrete, or roofing material, where oxidation can occur.

2. Ecological Exposure and Risk

To estimate potential ecological risk, EPA integrates the results of exposure and ecotoxicity studies using the risk quotient method. Risk quotients (RQs) are calculated by dividing acute and chronic estimated environmental concentrations (EECs), based on environmental fate characteristics and pesticide use data, by ecotoxicity values for various wildlife and plant species. RQs are then compared to levels of concern (LOCs), and when the RQ exceeds the level of concern for a particular category, the Agency presumes a risk of concern to that category. See Table 15 for the Agency's LOCs. Risk characterization provides further information on potential adverse effects and the possible impact of those effects by considering the fate of the chemical and its degradates in the environment, organisms potentially at risk, and the nature of the effects observed. To the extent feasible, the Agency seeks to reduce environmental concentrations in an effort to reduce the potential for adverse effects to non-target organisms.

Table 15. EPA's Levels of Concern (LOCs) and Risk Presumptions

If a calculated RQ is greater than the LOC presented, then the Agency presumes that…	**LOC terrestrial animals**	**LOC aquatic animals**	**LOC Plants**
Acute Risk …there is potential for acute risk; regulatory action may be warranted	0.5	0.5	1.0
Acute Listed (Endangered and Threatened) Species …listed species may be adversely affected	0.1	0.05	1.0
Chronic Risk …there is potential for chronic risk	1	1	NA

In general, ecotoxicity data reveal that on an acute basis, malathion is moderately toxic to birds and only slightly toxic to mammals through dietary exposure. Malathion has shown to be more acutely toxic to aquatic species (including freshwater as well as estuarine marine species). On a chronic basis, malathion is moderately toxic to avian species and less toxic to mammals. Conversely, malathion is highly toxic to aquatic organisms.

Malathion's mode of action is through acetylcholinesterase (AChE) inhibition which disrupts nervous system function. Inhibiting this enzyme leads to accumulation of the neurotransmitter, thus causing signals in the nervous system to persist longer than normal. While these effects are intended for control of target insects, the toxicological effects of malathion also occur in other non-targeted organisms exposed to malathion.

The Agency does not believe that the conditions necessary for the formation of malaoxon exist such that residues of malaoxon will be found in or on the food sources for terrestrial wildlife. Malaoxon can enter surface water via urban runoff when malathion converts to malaoxon and is washed off by rainfall. However, the Agency does not expect malaoxon to be a significant component of the ecological hazard of malathion to non-target organisms. While other degradates and impurities of malathion exist, they too are not expected to be present in the environment at concentrations high enough to contribute to the toxicity of malathion to non-target organisms.

a. Terrestrial Organisms

Birds and Mammals

Residues of malathion from single and multiple application scenarios are expected to occur on avian and mammalian food items. Predicted maximum and mean concentrations of pesticide residues from single and multiple applications of malathion are based on the Kenaga nomogram as modified by Fletcher et al. (1994). Multiple applications of malathion lead to higher estimated environmental concentrations (EECs) and, therefore, these EECs were employed in the Agency's screening-level analyses. In cases where estimated RQs exceed the Agency's LOC, the Agency may refine its assessment by using mean foliar residue concentrations in estimating exposure. However, because the estimated RQs for terrestrial non-target organisms are relatively low, the Agency did not refine its assessment.

In estimating foliar residues from multiple applications, EPA employed first order dissipation calculations and based scenarios on maximum application rates, minimum application intervals, and maximum number of applications as reported in field trial data submitted by the technical registrant. The Agency estimated numerous EECs for various food sources, (grass, fruit and seed) associated with many of the registered malathion use sites.

Acute and chronic terrestrial organism toxicity studies are required to establish the hazard of malathion to non-target species. Malathion displays low to moderate acute and subacute oral

toxicity to birds. To estimate acute avian risk, the Agency chose to use the toxicity endpoint from the subacute dietary study with the Ring-necked pheasant. To calculate chronic avian RQs, the Agency chose the reproduction study in Bobwhite quail as the toxicity reference value.

The Agency requires wild mammal acute toxicity testing on a case-by-case basis, depending upon the results of lower tier laboratory mammalian studies, intended use pattern, and pertinent environmental fate characteristics. In the case of malathion, the Agency estimated acute mammalian risk, using a toxicity reference value (LD_{50}) from the acute toxicity study with rat. To calculate chronic mammalian RQs, the Agency selected the NOEL from the 2-year mouse feeding study as the toxicity reference value. Table 16 summarizes the terrestrial toxicity reference values for malathion.

A number of non-guideline laboratory and field studies, available through open literature, evaluated the effects of malathion to birds following commercial agricultural applications. Summaries of study findings are included in the *Revised EFED RED Chapter for Malathion* (2000). In addition, several non-guideline, and field monitoring studies with other non-target terrestrial organisms (mammals, reptiles, and insects) are also included in the *Revised EFED RED Chapter for Malathion* (2000).

Table 16. Terrestrial Toxicity Reference Values for Malathion

Exposure Scenario	Species	Exposure Duration	Toxicity Reference Value	Toxicity Category/Effect
Avian				
Acute	Ring-necked pheasant	8-day dietary	LC_{50} = 2369 ppm	Slightly toxic
Chronic	Bobwhite quail	21-week dietary	LOEL = 2400 ppm	Growth and viability
Mammalian				
Acute	Rat	32-day dietary	LD_{50} = 390 mg/kg	ChE reduction, reduced bodyweight, reduced pup survival
Chronic	Mice	2-year chronic growth study	500 ppm	

Based on estimated avian acute RQs, the LOC for non-endangered birds is only slightly exceeded. However, the acute endangered LOC for birds is exceeded. The chronic RQs for birds and mammals slightly exceed the LOC of 1.0, which applies to both endangered and non-endangered species. For mammals, both non-endangered and endangered, acute and chronic RQs only slightly exceed the LOC. RQs were estimated for many sites. The range of acute and chronic RQs are presented in Tables 17 and 18, respectively, below. The tables present both lower and upper bound for malathion use in a commercial agricultural setting using label recommended application parameters. The lower bound estimate represents the labeled application rate for a single ULV application to citrus, and the upper bound represents a multiple EC/WP application to chestnuts (for birds) and to citrus (for mammals).

Table 17. Terrestrial Organism Acute Risk Ranges

Species	Food Source	EEC (ppm)	Toxicity Reference Value	RQ
Avian	Short grass[1]	42 – 1987	LC_{50} = 2639 mg/kg	0.01 – 0.75
	Seed	1.2 - 119		0.0004 – 0.04
Mammal	Short grass	43 – 1500	LD_{50} = 390 mg/kg	0.07 – 3.65
	Fruit	2.7 - 44		0.005 – 0.16

[1]: estimated concentration of malathion residues on terrestrial short grass, following multiple applications is representative of foliar food items such as short grass, tall grass, and broadleaf plants.

Table 18. Terrestrial Organism Chronic Risk Ranges

Species	Food Source	EEC (ppm)	Toxicity Reference Value	RQ
Avian	Short grass[1]	42 – 1535	NOEC = 110 ppm	0.4 – 18.1
	Seed	1.2 – 46		0.01 – 1.1
Mammal	Short grass	43 – 1500	NOEL 500 ppm	0.09 – 3.0
	Fruit	2.7 - 44		0.005 – 0.13

[1]: estimated concentration of malathion residues on terrestrial short grass, following multiple applications is representative of foliar food items such as short grass, tall grass, and broadleaf plants.

Amphibians and Reptiles

Exposure to amphibians may occur either through surface water contamination from runoff or drift, or through dermal absorption that may occur from spray drift. EPA has limited amphibian aquatic toxicity data, and limited data on the possible effects to amphibians from dermal adsorption of malathion residues. Possible exposure may occur through ingestion or absorption of water contaminated with malathion. However, acute risk to reptiles is not expected as they, like mammals, are relatively efficient at detoxifying malathion.

Non-Target Plants and Non-Target Insects

Malathion has been shown to be systemically absorbed into plant tissues. However, the Agency does not expect malathion to pose a serious risk to terrestrial plants or aquatic algae, as its mode of action (effects on the nervous system) would not apply. Indeed the Agency has no reports of adverse reactions of crops or plants to malathion.

Malathion, however, has been shown to be lethal to many species of beneficial insects. Routes of exposure may either be through direct contact, contact through foliar residues, and contact with residue coated pollen transported back to nests or hives. A honeybee foliar residue

contact toxicity study indicated that malathion is highly toxic to bees on an acute basis. In addition several toxicity studies with aquatic insect larvae were conducted by the USFWS which showed that malathion is highly to very highly toxic to non-target insects with aquatic early life stages.

b. Aquatic Organisms

Freshwater and Estuarine Fish and Invertebrates

As noted above, malathion is mobile, and can move from application sites into surface water and groundwater. Contamination of surface water from commercial agricultural uses results from both runoff and from off-target drift. Surface water contamination can also occur from urban runoff from residential uses and wide area applications, i.e., quarantine and public health mosquitocide uses.

The Agency used a tier two (PRZM-EXAMS model) assessment, on selected crops, to assess potential risks to aquatic organisms. The PRZM-EXAMS model is used for both ecological exposure and drinking water concentration exposure. Unlike the drinking water assessment described in the human health risk assessment section of this document, the exposure values used in the ecological risk assessment are neither based upon the Index Reservoir (IR), nor incorporate percent cropped area (PCA) factors, but rather are based upon the "standard pond" scenario. The "standard pond" scenario is intended to better represent the spatial and physical qualities of habitats relevant to risk assessment for aquatic non-target organisms such as ponds, or streams in, and adjacent to, treated agricultural fields. Therefore, the EEC values used to assess potential exposure and risk to aquatic animals are not the same as those used to assess exposure and risk to humans from pesticides in drinking water.

The tier two, PRZM-EXAMS water exposure assessment was conducted on four malathion crops and several non-agricultural use sites. The Pesticide Root Zone Model (PRZM) simulates the movement of a chemical in unsaturated soil just below the plant root zone. The Exposure Analysis Modeling System (EXAMS II) is a model that works with the PRZM model and predicts pesticide concentrations in a simulated pond. Because malathion is registered for use on over 100 different commercial agricultural crops, tier two EECs could not be generated on all registered use sites. In choosing crop surrogates for estimating surface water concentrations, the Agency considered crop location, application parameters, percent crop treated, and percent of total malathion use on that crop.

Application rates, number of applications and minimum retreatment intervals were based upon the maximum supported values identified by the technical registrant in residue field trials. Estimated water concentrations for selected crops are listed below in Table 19.

Table 19. Maximum and Typical EECs for Selected Crops

Site	Appl	Application Rate			Estimate Environmental Concentration (ppb)		
		lbs ai/A	no. of app	Retreatment Interval	21 day avg.	60 day avg.	Peak
Citrus	Max	6.25	3	30	23.2	10.7	156
	Typ	2.5	1	-	7.38	2.59	47.3
Cotton[1]	Max	2.5	25	3	67.4	47.7	291
	Typ	0.3	4	3	1.48	0.5	7.9
Sorghum	Max	1.25	3	7	5.0	26.7	26.7
	Typ	0.8	1	-	0.5	0.18	2.94
Lettuce	Max	1.88	6	5	6.3	2.98	15.4
	Typ	2.0	1	-	1.58	0.56	5.63

[1]: application values for cotton modeled represent old maximum supported values; current maximum supported use rate for the Boll Weevil Eradication Program is 1.2 lb ai/A, and current typical application rate is 0.9 lb ai/A.

Numerous acute and chronic toxicity studies for freshwater and estuarine/marine fish have been reviewed by EPA. Depending upon species tested, malathion toxicity to freshwater fish is classified as very highly toxic. Acute and chronic toxicity data for freshwater and estuarine invertebrates were also required. Based upon these data, malathion is categorized as highly toxic to freshwater invertebrates. Table 20 summarizes the aquatic toxicity reference values for malathion.

Table 20. Aquatic Toxicity Reference Values for Malathion

Exposure Scenario	Species	Exposure Duration	Toxicity Reference Value	Toxicity Category/Effect
Freshwater Fish				
Acute	Bluegill sunfish	69 hr	LC_{50} = 30 ppb	Very highly toxic
Chronic	Rainbow trout	97 day	NOEC 21 ppb	LOEC = 44 ppb
Freshwater Invertebrates				
Acute	Water flea, *Daphnia magna*	48 hr	EC_{50} = 1.0 ppb	Highly toxic
Chronic	Water flea, *Daphnia magna*	21 day	NOEC = 0.06 ppb	LOEC = 0.01 ppb

Similar to RQs calculated for terrestrial organisms, aquatic acute and chronic RQs are derived by dividing the EEC by the LC_{50} or EC_{50} (for acute hazard) and the EEC by the NOEC (for chronic hazard). Based on actual monitored concentrations, predicted modeling results, and actual fish kill incidents, there is acute hazard from contamination of aquatic habitats adjacent to, or within target application areas. Tables 21 and 22 list acute and chronic RQs, respectively, for selected crops.

Many non-guideline laboratory and field studies on malathion's toxicity to aquatic non-target organisms have been conducted. These studies report behavioral and biologic effects

which are not investigated or reflected in the guideline studies required by EPA. Summaries of these studies are included in the *Revised EFED RED Chapter for Malathion,* (2000).

Currently, the Agency does not have a model with which to predict concentrations of malathion in surface water, from home/garden applications, or urban uses. Runoff from these uses is expected to move over lawns, and impervious surfaces to storm sewers and then to surface water. Monitoring data from the USGS National Water Quality Assessment program (NAWQA) between 1992 and 2001 analyzed for malathion in 903 samples from urban streams, and found malathion at a maximum concentration of 0.648 ppb. Since the NAWQA data is not targeted, by location or time, it cannot be reliably considered representative of acute concentrations of malathion that may occur from urban uses. However, the magnitude of the concentrations sampled in NAWQA suggests that the acute concentrations from agricultural uses predicted by PRZM/EXAMS modeling is sufficiently conservative to be protective of potential concentrations from urban uses.

Table 21. Acute Risk Quotient Ranges for Aquatic Fish and Invertebrates

Site	Appl	EEC (ppb) (peak concentration)	Toxicity Reference Value		Risk Quotient	
			Fish	Invert	Fish	Invert
Cotton[1]	Max	291	Bluegill sunfish LC_{50} = 30 ppb	Daphnia magna EC_{50} = 1.0 ppb	9.7	291
	Typ	7.9			0.26	8
Sorghum	Max	26.7			0.9	27
	Typ	2.94			0.09	3
Citrus	Max	162			5.4	162
	Typ	47.3			1.57	47
Lettuce	Max	15.4			0.5	15
	Typ	5.63			0.18	6

[1]: RQs for cotton represent rates used in the BWEP. EEC of 291 is an overestimate as it is based on the old maximum application rate of 2.5 lb ai/A. Current maximum application rate for cotton (BWEP) is 1.2 lb ai/A, and typical rate is 0.9 lb ai/A.

Table 22. Chronic Risk Quotient Ranges for Aquatic Freshwater Fish and Invertebrates

Site	Appl	EEC (ppb)		Toxicity Reference Value		Risk Quotient	
		21 day (used with invert.)	60 day (used with fish)	Fish	Invert	Fish	Invert[2]
Cotton[1]	Max	67.4	47.7	Rainbow trout NOEC = 21 ppb	Daphnia magna NOEC = 0.06 ppb	2.3	1123
	Typ	1.48	0.5			0.02	25
Sorghum	Max	5.0	1.95			0.09	83
	Typ	0.5	0.18			0.01	8.3
Citrus	Max	25.2	11.1			0.5	416
	Typ	7.38	2.59			0.12	121
Lettuce	Max	6.26	2.98			0.14	104
	Typ	1.58	0.56			0.02	26

[1]: RQs for cotton represent rates used in the BWEP. EECs of 67.4, and 47.7 are overestimates as they are based on old maximum application rates of 2.5 lb ai/A. Current maximum application rate for cotton (BWEP) is 1.2 lb ai/A, and typical rate is 0.9 lb ai/A.
[2]: Chronic invertebrate RQs cited in the *Revised EFED RED Chapter for Malathion* (2000) were incorrectly calculated using the LOEC (0.1), instead of the NOEC value (0.06), which was used in this table.

RQs used to evaluate risk to all aquatic organisms were based on toxicity data for bluegill sunfish and *Daphnia magna*, which are both freshwater species. The risk assessment uses these organisms to represent both freshwater and estuarine/marine fish and invertebrates, because AChE inhibition is the same toxic mode of action for all of these taxa. Although there is a wide range of sensitivity to malathion exposure among aquatic organisms, the data do not indicate a difference attributable to the type of water body in which the animals live.

Were RQs to be calculated for estuarine/marine fish and invertebrates from estuarine/marine toxicity data, the finding of potential acute risk would be the same. The LC_{50} of 33 ppb for the most sensitive estuarine/marine fish tested, the sheepshead minnow, is essentially equivalent to the bluegill sunfish LC_{50} of 30 ppb used in the risk assessment to calculate acute RQs for all fish. The EC_{50} of 2.2 ppb for the estuarine/marine invertebrate *Mysidopsis bahia* is not as low as the *Daphnia magna* EC_{50} of 1.0 ppb used to calculate the acute RQs for all aquatic invertebrates. However, the peak EECs from PRZM/EXAMS scenarios representing crops most likely to be grown in estuarine watersheds (such as cotton, citrus and lettuce) would result in RQs that exceed the acute LOC for all four of these species, whether from a maximum or typical application rate.

A similar comparison of the chronic toxicity of malathion to freshwater and estuarine/marine animals is more difficult, due to a scarcity of laboratory toxicity data. There is only a single submitted chronic toxicity study for estuarine/marine fish, and no such data for estuarine/marine invertebrates. As with the assessment of acute risk, freshwater RQs are used to represent all aquatic organisms because of the equivalence of the mode of toxicity to freshwater and estuarine/marine fish and invertebrates.

c. Spray Drift

Monitoring results indicate that spray drift can be a significant source of aquatic contamination, and reducing off-target drift reduces aquatic EECs. Drifting malathion applications carried by air movement will reach unintended sites. Droplet size, wind speed, and release height tend to be the most important parameters in determining how much of a pesticide application will deposit off-target. Applications of nonvolatile oils, as in ULV formulations, do not evaporate rapidly and, therefore, settle more quickly than ULV formulations that may use water as a carrier. The AgDRIFT model used by the Agency to estimate buffer zones contains a sophisticated evaporation algorithm to account for evaporation during droplet's time in the air. The speed by which droplets fall is exponentially related to their size such that small droplets fall very slowly, resulting in more nontarget deposition. Application rate is also an important determinant for off-target spray drift exposure. The application rates EPA modeled were representative of the range of rates supported by the technical registrant. Spray drift field studies show considerable variability in deposition under essentially the same conditions. Therefore, model estimates used for dissipation distances reflect mean values.

EPA modeled several combinations of wind speed, boom width, and formulation types to determine distances and related pesticide loading into a "standard pond" from aerial applications of malathion. The Agency estimated buffer zones that would result in concentrations less than 4 ug/L, the lowest LC_{50} value for fish, and in concentrations less than 20 ug/L, the lower 95^{th} percentile LC_{50} for a freshwater species reported in EPA's *Revised EFED RED Chapter for Malathion* (2000). Model results showed that smaller buffer zones were required when wind speed is low, boom width is reduced, and non-ULV formulations are used. Model results also showed that buffer zones for ULV and non-ULV formulations were not necessary to prevent concentrations at or above 20 ug/L and, therefore, are not presented here. Results of model estimates of buffer zones, based on varying conditions and at the estimated concentration of 4 ug/L, are summarized below in Table 23.

Table 23. Dissipation Distances from Various Aerial Applications

Wind Speed (mph)	Boom Width (% of wing span)	ULV	Non-ULV Formulations (formulations using water carriers)
Most Sensitive Freshwater fish – Rainbow trout: LC_{50} = 4 ug/L			
10	60 ft	0	25 ft
	75 ft	0	100 ft
15	60 ft	0	50 ft
	75 ft	50 ft	150 ft

d. Wide Area Treatments with Malathion

Public Health Mosquito Treatment

EPA also conducted a screening-level ecological assessment of the public health use of malathion as a mosquito adulticide. The malathion mosquito abatement product is only formulated as an ULV product and is applied either aerially or by truck mounted sprayer. The Agency calculated aquatic EECs from off-target drift using the Agricultural Dispersal (AGDISP) model, which estimates the deposition of a compound into a "standard pond" (i.e., one hectare pond that is two meters deep next to a ten hectare plot).

Input parameters for the AGDISP model are chosen to reflect environmental conditions under which the mosquitocide product is applied (such as temperature and relative humidity), application practices (boom width, droplet size, and application rate), and physical characteristics of the compound (such as the evaporation rate or the volatilization fraction of the compound). Instead of using existing mosquitocide labels, which vary between manufacturers, the Agency relied upon labels recently submitted by the malathion technical registrant in connection with Pesticide Registration (PR) Notice 2005-1. The PR Notice 2005-1 recommended specific label statements and organization principles intended to improve the lot of existing public health adult mosquitocide labels by clarifying language regarding environmental hazards posed by mosquitocide products, and by standardizing use direction and instructions for mosquitocide applicators.

Several variables drawn from the updated mosquitocide label (in compliance with PR 2005-1) include the proposed minimum release height of 100 feet. The updated labels, in line with the PR Notice also specify a droplet size of 60 ug. Finally, PR 2005-1 discusses that a buffer zone around aquatic habitat may not be warranted, noting that protecting human health from mosquito-borne diseases with pesticides often involves some degree of ecological risk, and that an aquatic buffer zone may require leaving potentially infested areas untreated. Therefore, in estimating ecological risk from the mosquitocide application scenario, the Agency assumed a zero foot buffer zone.

The Agency calculated a worst-case RQ for fish and invertebrates from the wide area public health use by assuming 100% of product (on a per area basis) drifts into a six foot deep pond. Estimated acute RQs for fish are 38 and 1.9 for freshwater invertebrates.

Fruit Fly (Quarantine) Treatment

Malathion is also used in liquid bait applications, such as for wide-area quarantine uses to control the Mediterranean and other fruit fly species. Non-target organisms may be exposed to the bait formulation of malathion as it is similar to granules foraged by wildlife. Based upon the current maximum Med-Fly application rate (0.18 lb ai/A), acute RQs are well below the LOC (<

0.00001) for both mammals and avian species. Chronic RQs were not calculated, since they too are likely to be below the Agency's LOC.

Other Non-Agricultural Uses

Other wide area, non-agricultural use sites include rangeland/pasture as well as commercial tree production. In these scenarios, EPA estimated acute RQs for freshwater fish to range from 36 to 190 for rangeland/pastures and commercial tree farms, respectively. Acute RQs for freshwater invertebrates ranged from 1.8 to 3.8. Similar to exposure estimates made in connection with the public health adulticide use, these RQs are considered very conservative as EPA estimated RQs assuming 100% of the applied product (on a per area basis) deposits into a subject water body. Wide area uses are intended to disperse and, therefore, 100% deposition is very unlikely to occur.

e. Down-the-Drain Assessment

The Agency also estimated potential exposure from malathion released into domestic wastewater which may eventually be introduced into Publicly Owned Treatment Works (POTWs) from the pharmaceutical use of malathion. The Agency used the consumer product exposure model, Exposure and Fate Assessment Screening Tool (E-FAST) (Versar 1999) developed by OPPT.

The screening-level assessment assumes that in a given year the entire production volume of malathion pharmaceutical product is parceled out on a daily basis across the U.S. population, and is then converted to a mass release per capita. This mass is then diluted into the average daily volume of wastewater released per person per day to arrive at an estimated concentration of malathion in wastewater prior to entering a treatment facility. The concentration of malathion in untreated wastewater is then reduced by the fraction removed during the treatment process before it is released into a river or stream. The remaining pesticide is discharged into surface water where it is instantaneously diluted and no further removal is assumed.

Based on 2000-2001 production volume of Ovide®, EPA estimates the high-end acute surface water concentration to be 3.55×10^{-5} ppb, and chronic surface water concentration to be approximately 2.73×10^{-6}. Since Ovide® production has increased since 2000-2001 by approximately 3-fold, estimated environmental concentrations from down-the-drain sources are not expected to be greater than 1.0×10^{-4} ppb. Because E-FAST is a screening tool, and the estimated removal of malathion in wastewater of 3% may be an underestimate based on laboratory data, the estimated surface water concentrations from down-the-drain release of malathion from the pharmaceutical use remain very low and significantly less than predicted exposures from agricultural uses of malathion. Therefore, estimated RQs to non-target aquatic organisms from down-the-drain exposure to malathion is expected to be very low and not of concern to the Agency.

f. Endangered Species

Based upon the screening-level assessment conducted on malathion, the Agency has identified several exceedences of the acute and chronic endangered LOC in certain cases for birds, mammals, fish and invertebrates should exposures actually occur at modeled levels.

Terrestrial Organisms

- Mammals
  - Acute RQs for small mammals feeding on short grass exceeded the Agency's acute endangered LOC for sites with multiple applications at an application rate ≥ 0.175 lb ai/A.
  - Chronic RQs for small mammals exceeded the Agency's acute endangered LOC for sites with multiple applications at an application rate ≥ 0.61 lb ai/A.
- Birds
  - Acute endangered LOC is exceeded for grass-eating birds at use sites with single and multiple applications at an application rate ≥ 1.25 lb ai/A. The Agency's acute endangered LOC was not exceeded for seed-eating birds.
  - Chronic RQs exceed the endangered LOC for grass-eating birds at use sites with single and multiple applications at an application rate ≥ 0.175 lb ai/A and for seed-eating birds with multiple applications at rates ≥ 0.61 lb ai/A or with single applications at rates ≥ 1.56 lb ai/A.
- Insects and Plants
  - Data indicate that malathion may be highly toxic to bees, and has been shown to be lethal to many species of beneficial insects when used near or over non-agricultural areas containing beneficial insect populations. However, the Agency does not yet have a method to estimate risk to bees and other non-target insect organisms. Therefore, the Agency cannot preclude possible adverse effects to beneficial and listed insect species. In addition, the Agency does have data with which to assess the malathion risk to non- target terrestrial plants or aquatic algae, and while the Agency has no data or reports of adverse reactions of crops or plants to malathion, it cannot preclude potential adverse effects to non-target terrestrial plant species.

Aquatic Organisms

- Fish and Invertebrates (fresh water and estuarine/marine)
  - The Agency's acute endangered LOC is exceeded for both fish and invertebrates in all sites modeled with PRZM-EXAMS. However, when typical use parameters were used to model these five sites, several RQs for fish fell below the Agency's acute endangered LOC.

The conclusions stated in this document are based solely on EPA's screening-level assessment and do not constitute "may effect" findings under the Endangered Species Act for any listed species. Further, potential indirect effects to any species dependent upon a species that

experiences effects from use of malathion can not be precluded based on the screening level ecological risk assessment.

3. Ecological Incidents

Wildlife incidents which involve aquatic organisms are reported to the Agency by local, state, other federal agencies, or at times, submitted under FIFRA sec. 6(a)(2). Eighteen of the twenty two ecological incidents reported to the Agency were related to fish kills, with most incidents having occurred since 1970 through the present. The highest rate of incidents is associated with the high volume and heavily monitored Boll Weevil Eradication Program (BWEP). Mosquito control and Mediterranean Fruit fly control are also associated with several incident reports. Incidents ranged in magnitude from just 2 fish to over 10,000 fish. The Agency expects the occurrence of aquatic incidents to decline over time, as the BWEP is a time limited program. The Agency has only two reported incidents involving terrestrial organisms. In one incident (1985), extensive mortality to honeybees was recorded and may have been associated with large area treatment of alfalfa. The second terrestrial incident involved waterfowl and was considered only to be possibly linked to a wide area (Medfly) treatment with malathion.

IV. Risk Management, Reregistration, and Tolerance Reassessment

A. Determination of Reregistration Eligibility

Section 4(g)(2)(A) of FIFRA calls for the Agency to determine, after submission of relevant data concerning an active ingredient, whether or not products containing the active ingredient are eligible for reregistration. The Agency has previously identified and required the submission of the generic (technical or manufacturing-use grade) data required to support reregistration of products containing malathion as an active ingredient.

The Agency has completed its review of submitted data and its assessment of the dietary, residential, occupational, and ecological risks associated with the use of pesticide products containing the active ingredient malathion. Based on these data, the Agency has sufficient information on the human health and ecological effects of malathion to make its decisions as part of the tolerance reassessment process under FFDCA and the reregistration process under FIFRA, as amended by FQPA. The Agency has determined that products containing malathion will be eligible for reregistration provided that: (i) the risk mitigation measures outlined in this document are adopted; and (ii) label amendments are made to reflect these measures. Needed label changes and language are listed in Section V. Appendix A is a detailed table listing all malathion uses that are eligible for reregistration, or uses which require tolerances or tolerance consideration. Appendix B identifies generic data requirements that the Agency reviewed as part of its determination of the reregistration eligibility of malathion, and lists the submitted studies the Agency found acceptable. Data gaps are identified as either outstanding generic data

requirements that have not been satisfied with acceptable data, or additional data necessary to confirm the decision presented here.

Based on its evaluation of malathion, the Agency has determined that malathion products, unless labeled and used as specified in Sections IV and V this document, would present risks inconsistent with FIFRA and FFDCA. Accordingly, should a registrant fail to implement any of the risk mitigation measures identified in this document, the Agency may take regulatory action to address the risk concerns from the use of malathion. If all changes outlined in this document are incorporated into the product labels, then all current risks for malathion will be adequately mitigated for the purposes of this determination under FIFRA. Additionally, once an endangered species assessment is completed, further changes to these registrations may be necessary, as explained in Section IV.C.4. of this document.

B. Public Comments and Responses

Through the Agency's public participation process, EPA worked with stakeholders and the public to reach the regulatory decisions for malathion. EPA released its revised malathion risk assessments for public comment on September 23, 2005, for a 60-day public comment period (an additional Phase 5 of the public participation process). During the public comment period on the risk assessments, which closed on November 22, 2005, the Agency received comments from the technical registrant, American Mushroom Institute, Natural Resources Defense Council, Armed Forces Pest Management Board, University of Hawaii, U.S. Department of Agriculture, various water quality associations and mosquito control districts, and others. These comments in their entirety, responses to the comments, as well as the preliminary and revised risk assessments, are available in the public docket (EPA-HQ-OPP-2004-0348) and on the internet at http:www.regulations.gov.

C. Regulatory Position

1. Food Quality Protection Act Findings

a. "Risk Cup" Determination

As part of the FQPA tolerance reassessment process, EPA assessed the risks associated with this pesticide, as well as cumulative risks from total exposure to registered uses of OP pesticides. FQPA requires the Agency to evaluate food tolerances on the basis of cumulative risk from substances sharing a common mechanism of toxicity, such as the toxicity expressed by the OPs through a common biochemical interaction with the cholinesterase enzyme. The Agency has determined that, if the mitigation described in this document is adopted and labels are amended, aggregate human health risks as a result of exposures to malathion are within acceptable levels. In other words, EPA has concluded that the tolerances for malathion meet FQPA safety standards. In reaching this determination, EPA has considered the available information on the special sensitivity of infants and children, as well as exposures to malathion

from all possible sources. In addition, the Agency has concluded that cumulative risks associated with OP pesticides, including malathion, are also below the Agency's level of concern.

b. Determination of Safety to U.S. Population

The Agency has determined that the established tolerances for malathion, with amendments and changes as specified in this document, meet the safety standards under the FQPA amendments to section 408(b)(2)(D) of the FFDCA, and that there is a reasonable certainty no harm will result to the general population or any subgroup from the use of malathion. In reaching this conclusion, the Agency has considered all available information on the toxicity, use practices and exposure scenarios, and the environmental behavior of malathion. As discussed in this document, aggregate risks from malathion are below the Agency's level of concern. In addition, the Agency has concluded that cumulative risks associated with OP pesticides, including malathion, are also below the Agency's level of concern.

c. Determination of Safety to Infants and Children

EPA has determined that the established tolerances for malathion, with amendments and changes as specified in this document, meet the safety standards under the FQPA amendments to section 408(b)(2)(C) of the FFDCA, that there is a reasonable certainty of no harm for infants and children. The safety determination for infants and children considers factors on the toxicity, use practices and environmental behavior noted above for the general population, but also takes into account the possibility of increased dietary exposure due to the specific consumption patterns of infants and children, as well as the possibility of increased susceptibility to the toxic effects of malathion residues in this population subgroup. In addition, the Agency has concluded that cumulative risks associated with OP pesticides, including malathion, are also below the Agency's level of concern.

In determining whether or not infants and children are particularly susceptible to toxic effects from exposure to residues of malathion, the Agency considered the completeness of the hazard database for developmental and reproductive effects, the nature of the effects observed, and other information. The Agency has determined that there is evidence that following acute or repeated dose exposures to malathion, young animals exhibit adverse effects more readily than adults. The Agency has oral data for this most sensitive subpopulation and is using it to determine the appropriate point of departure (PoD) for use in assessing risk for acute and chronic dietary and incidental oral scenarios. In those instances where the Agency is using a PoD derived on pup data, the FQPA SF is reduced to 1x. The Agency has decided to retain the FQPA SF (10x) for those scenarios where the PoD does not already reflect the most sensitive population (i.e., the PoD is derived from adult animal studies). Consequently, for dermal exposure scenarios, where the PoD is derived from adult animals and children are expected to be exposed, the FQPA SF of 10x has been retained. Similarly, for inhalation exposure scenarios where the endpoint selected is ChE inhibition (in order to aggregate non-occupational exposures)

and the PoD is based on adult animals, the FQPA SF of 10x has also been retained. Finally, the Agency has retained the FQPA SF of 10x for the bystander inhalation scenario in order to account for the lack of a NOAEL, severity of effect, as well as any differential in susceptibility in the young.

2. Endocrine Disruptor Effects

EPA is required under the FFDCA, as amended by FQPA, to develop a screening program to determine whether certain substances (including all pesticide active and other ingredients) "may have an effect in humans that is similar to an effect produced by a naturally occurring estrogen, or other endocrine effects as the Administrator may designate." Following recommendations of its Endocrine Disruptor Screening and Testing Advisory Committee (EDSTAC), EPA determined that there was a scientific basis for including, as part of the program, the androgen and thyroid hormone systems, in addition to the estrogen hormone system. EPA also adopted EDSTAC's recommendation that EPA include evaluations of potential effects in wildlife. For pesticides, EPA will use FIFRA and, to the extent that effects in wildlife may help determine whether a substance may have an effect in humans, FFDCA authority to require the wildlife evaluations. As the science develops and resources allow, screening for additional hormone systems may be added to the Endocrine Disruptor Screening Program (EDSP).

In the available toxicity studies on malathion, there was no estrogen or androgen mediated toxicity. However, thyroid effects were observed in the combined chronic/carcinogenicity study in rats, which included an increase in parathyroid hyperplasia in male and female rats, and a significant trend in thyroid follicular cell adenomas and/or carcinomas and thyroid c-cell carcinomas (all in males). However, the FIFRA SAP did not consider the thyroid effects of concern or necessarily related to malathion exposure (SAP, 2000).

3. Cumulative Risks

Section 408(b)(2)(D)(v) of FIFRA requires that, when considering whether to establish, modify, or revoke a tolerance, the Agency consider "available information" concerning the cumulative effects of a particular pesticide's residues and "other substances that have a common mechanism of toxicity." Other substances are considered to account for the possibility that low-level exposures to multiple chemical substances that cause a common effect by a common mechanism could lead to the same adverse health effect as would a higher level of exposure to each individual substance.

Malathion is a member of the OP class of pesticides, which share a common mechanism of toxicity by affecting the nervous system via cholinesterase inhibition. A cumulative risk assessment, which evaluates exposures based on a common mechanism of toxicity, was conducted to evaluate the risk from food, drinking water, residential, and other non-occupational exposures resulting from registered uses of OP pesticides, including malathion. EPA has

concluded that the cumulative risks associated with OP pesticides are below the Agency's level of concern. For additional information, refer to the *OP Cumulative Assessment* (2006 Update), which is available in EPA docket EPA-HQ-OPP-2006-0618 and on EPA's website at http://www.epa.gov/pesticides/cumulative/.

4. Endangered Species

The Endangered Species Act required federal agencies to ensure that their actions are not likely to jeopardize listed species or adversely modify designated critical habitat. The Agency has developed the Endangered Species Protection Program to identify pesticides whose use may cause adverse impacts on federally listed endangered and threatened species, and to implement mitigation measures that address these impacts. To assess the potential of registered pesticide uses that may affect any particular species, EPA puts basic toxicity and exposure data developed for the REDs into context for individual listed species and considers ecological parameters, pesticide use information, the geographic relationship between specific pesticide uses and species locations and biological requirements and behavioral aspects of the particular species. When conducted, these analyses take into consideration any regulatory changes recommended in this RED being implemented at that time. A determination that there is a likelihood of potential effects to a listed species may result in limitations on the use of the pesticide, other measures to mitigate any potential effects, and/or consultations with the Fish and Wildlife Service or National Marine Fisheries Service, as necessary. If the Agency determines use of malathion "may affect" listed species or their designated critical habitat, EPA will employ the provisions in the Services regulations (50 CFR Part 402).

The ecological assessment that EPA conducted for this RED does not, in itself, constitute a determination as to whether specific species or critical habitat may be harmed by the pesticide. Rather, this assessment serves as a screen to determine the need for any species specific assessment that will evaluate whether exposure may be at levels that could cause harm to specific listed species and their critical habitat. That assessment refines the screening-level assessment to take into account the geographic area of pesticide use in relation to the listed species, the habits and habitat requirements of the listed species, etc. If the Agency's specific assessments for malathion result in the need to modify use of the pesticide, any geographically specific changes to the pesticide's registration will be implemented through the process described in the Agency's Federal Register Notice (54 FR 27984) regarding implementation of the Endangered Species Protection Program. Until that species specific analysis is completed, the risk mitigation measures being implemented through this RED will help to reduce the likelihood that endangered and threatened species may be exposed to malathion at levels of concern.

D. Tolerance Reassessment Summary

Tolerance Definition

Tolerances have been established for the residues of malathion *per se* in/on food/feed commodities, meat, milk poultry and eggs [40CFR§ 180.111]. Because animal metabolism data indicate that there is little likelihood of residue transfer to meat, milk, poultry and eggs, tolerances for malathion residues in these commodities may be revoked.

Tolerances for residues of malathion in/on plant and animal commodities, food commodities, and feed commodities are currently expressed in terms of malathion *per se*. Based on available plant metabolism data, the Agency has determined that the malathion residues of concern in plants consist of malathion and its metabolite, malaoxon. In vivo, malaoxon is the active ChE-inhibiting oxon metabolite of malathion, and under certain conditions, malaoxon can be formed as an environmental breakdown product of malathion. Monitoring data indicate malaoxon's presence in food. Therefore, tolerance expression should be revised to include malathion and malaoxon. The tolerance expression for plant commodities needs to be revised in order to reflect the Agency's determination that the residues of concern are malathion [*O,O*-dimethyl dithiophosphate of diethyl mercaptosuccinate] and its metabolite malaoxon [*O,O*-dimethyl thiophosphate of diethyl mercaptosuccinate]. Table 24 summarizes the metabolites and degradate included in the malathion risk assessment and tolerance expression.

Table 24. Metabolites and Degradates Included in the Risk Assessment and Tolerance Expression

Matrix		Residues Included in Risk Assessment	Residues included in Tolerance Expression
Plants	Primary Crop	Malathion and malaoxon	Malathion and malaoxon
	Rotational Crop	Malathion and malaoxon	Malathion and malaoxon
Livestock	Ruminant	180.6(a)(3)	180.6(a)(3)
	Poultry	180.6(a)(3)	180.6(a)(3)
Drinking Water		Malathion and malaoxon	Not applicable

The established tolerances for animal commodities should be revoked. The Agency published a Notice of Request for Deletion of Certain Uses and Directions for Use (FR vol. 56, No. 52, FRL-3874-4) in 1991 in which all direct application to livestock was requested for deletion from malathion labels. No comments have been received by the Agency in support of these uses, and this use has been removed from almost all labels. Remaining labels with direct animal treatment will be amended as part of the RED. Since neither malathion nor malaoxon were observed in eggs, milk, and animal tissues, there is no need for tolerances in these commodities based on dietary exposure to malathion.

The Agency has recently updated the list of raw agricultural and processed commodities and feedstuffs derived from crops (Table 1, OPPTS GLN 860.1000). As a result of changes to

Table 1, malathion tolerances for certain raw agricultural commodities (RACs) which have been removed from the livestock feeds table need to be revoked. Also, some commodity definitions must be corrected. A summary of malathion tolerance reassessments is presented in Table 25, below.

Tolerances Listed Under 40 CFR §180.111:

Sufficient data have been submitted (or were translated when appropriate) to reassess the established tolerances for the following commodities, pending label amendments for some crops: alfalfa; apricots; asparagus; avocados; barley, grain (postharvest); beans; beets (including tops); Birdsfoot trefoil, forage ; Birdsfoot trefoil, hay; blackberries; blueberries; boysenberries; carrots; chayote fruit; chayote roots; cherries; chestnuts; clover; corn, forage; corn, fresh (including sweet K + CWHR); corn, grain (postharvest); cottonseed; cucumbers; currants; dewberries; eggplants; figs; flax seed; garlic; grapefruit; gooseberries; grapes; grass; grass, hay; guavas; hops; horseradish; kumquats; leeks; lemons; lespedeza, hay; lespedeza, straw; limes; loganberries; lupine, seed; macadamia nuts; mangos; melons; mushrooms; nectarines; oats, grain (postharvest); okra; onions (including green onions); oranges; papayas; parsnips; passion fruit; peaches; pears; peas; pecans; peppermint; peppers; pineapples; potatoes; pumpkins; radishes; raspberries; rice, grain (postharvest); rice, wild; rutabagas; rye, grain (postharvest); salsify (including tops); shallots; sorghum, grain (postharvest); spearmint; squash, summer and winter; strawberries; sweet potatoes; tangerines; tomatoes; turnips (including tops); vegetables, leafy, *Brassica* (cole); vetch, hay; vetch, straw; walnuts and wheat, grain (postharvest).

Confirmatory data are required to support the reassessed following commodities: apples; dates; quinces; sorghum, forage; and vegetables, leafy (except *Brassica*).

No registrants have committed to support malathion uses on any greenhouse-grown crops. Therefore, the registered greenhouse uses of malathion on cucumber, endive, lettuce, radish, tomato, and watercress should be deleted from all malathion end-use product labels. The reassessment of tolerances has been conducted with the assumption that only field-grown cucumber, endive, lettuce, radish, tomato, and watercress are supported for reregistration.

Due to a lack of support for reregistration, the established tolerances for the following commodities should be revoked concomitant with the deletion of respective crops from all malathion product labels: almond hulls; almonds; almonds, shells; beets, sugar, roots; beets, sugar, tops; cowpea, forage; cowpea, hay; cranberries; filberts; lentils; peanut, forage; peanut, hay; peanuts; peavine, hay; peavines; plums; prunes; safflower, seed; soybeans (dry and succulent); soybean, forage; soybean, hay; sunflower seeds.

The tolerances for the following commodities should be revoked because they are no longer considered significant livestock feed items and have been deleted from Table 1 (OPPTS GLN 860.1000): flax straw; lespedeza, seed (PRE-H); and vetch, seed (PRE-H).

The tolerances for the following animal commodities should be revoked because the technical registrant(s) have voluntarily requested cancellation of direct animal treatment uses of malathion to poultry and other livestock including: cattle, fat (PRE-S); cattle, mbyp (PRE-S); cattle, meat (PRE-S); eggs (from application to poultry; goats, fat (PRE- S); goats mbyp (PRE-S); goats, meat (PRE-S); hogs, fat (PRE-S); hogs mbyp (PRE-S); hogs, meat (PRE-S); horses, fat (PRE-S); horses, mbyp (PRE-S); horses, meat (PRE-S); milk, fat (from application to dairy cows); poultry, fat (PRE-S); poultry, mbyp (PRE-S); poultry, meat (PRE-S); sheep, fat (PRE-S); sheep, mbyp (PRE-S); and sheep, meat (PRE-S).

Tolerances To Be Proposed Under 40 CFR §180.111:

Tolerances are required and must be proposed, based on available field trial data, for the following RACs: aspirated grain fractions; barley, straw; corn, field, stover; oats, forage; oats, straw; radish tops; rice, straw; rye, forage; rye, straw; watercress; wheat, forage; and wheat, straw. Tolerances are required and must be proposed for the following RACs after adequate data have been submitted and evaluated: barley, hay; stover; corn, sweet, stover; cotton, gin byproducts; oats, hay; sorghum, stover; and wheat, hay.

Tolerances need to be proposed on certain processed commodities which showed significant concentration of residues based on the results of acceptable processing studies. The results of processing studies which trigger the need for tolerances for the combined residues of malathion and malaoxon are briefly presented below.

The processing data for apple indicate that the combined residues of malathion and malaoxon concentrated 3.8x in wet pomace, but did not concentrate in apple juice processed from apples bearing detectable residues of malathion. A tolerance for apple wet pomace needs to be proposed once adequate field trial data are available for reassessment of the established tolerance on apples.

The processing data for preharvest-treated field corn grain indicate that the combined residues of malathion and malaoxon did not concentrate above the limit of detection (0.01 ppm) in starch, grits, meal, flour, dry- and wet-milled crude oil, dry- and wet-milled refined oil, and dry- and wet-milled bleached and deodorized oil processed from field corn grain bearing nondetectable residues of malathion and malaoxon (<0.01 ppm each) following three preharvest foliar treatments at 5x the maximum single application rate.

The processing data for postharvest-treated field corn grain indicate that the combined residues of malathion and malaoxon concentrated 1.8x in meal and 2.0x in flour processed from field corn grain bearing detectable combined residues of malathion and malaoxon following a series of postharvest treatments according to the use pattern the registrant wishes to support. The combined residues did not concentrate in grits, starch and dry- and wet-milled bleached and deodorized oil. The highest average field trial (HAFT) (combined residues) from trials reflecting postharvest treatment is 6.79 ppm. Based on this HAFT and the observed concentration factors,

the maximum expected combined residues are 12.2 ppm for meal (6.79 x 1.8) and 13.6 ppm for flour (6.79 x 2.0). These maximum expected combined residues are higher than the reassessed tolerance of 8.0 ppm for field corn grain. Therefore, tolerances for the combined residues of malathion and malaoxon in corn meal and flour at 14.0 ppm must be proposed. Since residues did not concentrate in dry- and wet-milled bleached and deodorized oil, a tolerance for this commodity need not be proposed.

The available data for stored field corn processed commodities may be translated to stored sorghum processed commodities. A tolerance for the combined residues of malathion and malaoxon in/on sorghum flour need not be established at this time since sorghum flour is used exclusively in the United States as a component for drywall, and not as either a human food or a feedstuff.

The processing data for fig indicate that the combined residues of malathion and malaoxon concentrated 2.9x in dried fig processed from fresh fig bearing detectable residues and treated at 1x. A tolerance of 2 ppm should be appropriate for dried fig based on the concentration factor and the highest average field trial.

The mint processing data indicate that the combined residues of malathion and malaoxon concentrated up to 12.7x in mint oil processed from mint tops bearing detectable residues following applications at 5x. The HAFT (combined residues) from mint field trials reflecting the maximum proposed use pattern is 1.1 ppm. Based on this HAFT and the observed concentration factor, the maximum expected combined residues are 13.97 ppm for mint oil. These maximum expected combined residues are higher that the reassessed tolerance of 2.0 ppm for peppermint and spearmint tops. Therefore, tolerances for the combined residues of malathion and malaoxon in peppermint and spearmint at 15.0 ppm must be proposed.

The processing data for preharvest-treated oranges indicate that the combined residues of malathion and malaoxon concentrated in oil (>208x) and dried pulp (9.5x) but reduced in juice (<0.1x) following processing of oranges bearing detectable residues. Based on the results of this study, and a HAFT of 1.9 ppm, a tolerance of 400 ppm must be proposed for citrus oil and a tolerance of 20 ppm must be proposed for citrus dried pulp.

The processing data submitted for cottonseed, potatoes, and tomatoes indicate that the combined residues of malathion and malaoxon did not concentrate in the respective processed commodities; therefore, tolerances are not required for the processed commodities of these crops. Additional processing studies remain outstanding for flax and postharvest-treated wheat.

Tolerances Listed Under 40 CFR §180.111(a)(2):

The established tolerance for raisins resulting from drying of grapes on treated trays should be revoked since adequate supporting data are not available and this use is not being supported for reregistration. An acceptable grape processing study reflecting preharvest

treatment has been submitted and evaluated. The grape processing data indicate that the combined residues of malathion and malaoxon did not concentrate in raisin and juice processed from grapes bearing detectable residues following treatment with the 5 lb/gal EC formulation at 5x the maximum single application rate.

Tolerances Listed Under 40 CFR §180.111(a)(3):

The established tolerance for refined safflower oil should be revoked since no registrants have committed to support malathion use on safflower.

Tolerances Listed Under 40 CFR §180.111(a)(4):

The conditions listed in 40 CFR §180.111 (a)(4) allowing malathion use for the control of insects during the drying of grapes (raisins) should be deleted unless the registrant(s) submits supporting data.

Tolerances Listed Under 40 CFR §180(a)(5):

The tolerances for the following commodities should be revoked because the technical registrant(s) have voluntarily requested cancellation of animal feed uses: dehydrated citrus pulp (for cattle feed) and non-medicated cattle feed concentrate blocks.

A summary of malathion tolerance reassessment and recommended modifications in commodity definitions are presented in Table 25, below.

Table 25: Tolerance Summary for Malathion

Commodity	Tolerance Listed Under 40 CFR §180.111	Reassessed Tolerance[1]	Comment [*correct commodity definition*]
Tolerances Listed Under 40 CFR §180.111 (2)(1)			
Alfalfa	135	125	[*Alfalfa, forage*]
		185	[*Alfalfa, hay*]
Almond, hulls	50	Revoke	Not supported under reregistration
Almonds, postharvest	8	Revoke	Not supported under reregistration
Almonds, shells	50	Revoke	Not supported under reregistration
Apple	8	TBD [2]	Additional apple field trial data are required as confirmatory data
Apricot	8	1.0	
Asparagus	8	2.0	
Avocado	8	0.2	
Barley, grain, postharvest	8	8.0	[*Barley, grain (PRE- and POST-H)*] Translated from wheat data.
Beans	8	2.0	[*Bean, dry*]
		2.0	[*Bean, succulent*]

Commodity	Tolerance Listed Under 40 CFR §180.111	Reassessed Tolerance[1]	Comment [*correct commodity definition*]
Beets (including tops)	8	4.0	[*Beet, garden, tops*] translated from turnip tops data.
		0.5	[*Beet, garden, roots*] Translated from turnip root data.
Beet, sugar, roots	1	Revoke	Not supported under reregistration
Beets sugar, tops	8	Revoke	Not supported under reregistration
Blackberry	8	6	
Blueberry	8	8	
Boysenberry	8	6.0	Translated from blackberry and raspberry data.
Carrots, roots	8	1	[*Carrot*]
Cattle, fat (PRE-S)	4	Revoke	Contingent upon cancellation of direct animal treatment uses.
Cattle, meat byproducts (PRE-S)	4	Revoke	Contingent upon cancellation of direct animal treatment uses.
Cattle, meat (PRE-S)	4	Revoke	Contingent upon cancellation of direct animal treatment uses.
Chayote fruit	8	0.2	Translated cucumber data.
Chayote roots	8	0.1	Translated potato data.
Cherry	8	3.0	
Chestnut	1	1.0	
Clover	135	125	[*Clover, forage*]
		125	[*Clover, hay*]
Corn, forage	8	5.0	[*Corn, field, forage*]
		45.0	[*Corn, sweet, forage*]
Corn, fresh (including sweet, kernel plus cob with husks removed)	2	0.1	[*Corn, sweet (K + CWHR)*]
Corn, grain, post harvest	8	8.0	[*Corn, field, grain (PRE- and POST- H)*]
Cotton, undelinted seed	2	20	
Cowpea, forage	135	Revoke	Not supported under reregistration
Cowpea, hay	135	Revoke	Not supported under reregistration
Cranberry	8	Revoke	Not supported under reregistration
Cucumber	8	0.2	
Currant	8	8.0	Translated from blueberry data.
Dates	8	TBD[2]	Further confirmatory data required (data under review)
Dewberry	8	6.0	Translated from blackberry data.
Eggplant	8	2.0	Translated from tomato data.
Eggs (from application to poultry)	0.1	Revoke	Contingent upon cancellation of direct animal treatment uses.
Fig	8	1.0	
Filbert	1	Revoke	Not supported under reregistration
Flax seed	0.1	0.10	[*Flax, seed*]
Flax straw	1	Revoke	Not a significant RAC of flax.
Garlic	8	1.0	Translated from onion bulb data.
Goat, fat (PRE-S)	4	Revoke	Contingent upon cancellation of direct

Commodity	Tolerance Listed Under 40 CFR §180.111	Reassessed Tolerance[1]	Comment [*correct commodity definition*]
			animal treatment uses.
Goat, meat byproducts (PRE-S)	4	Revoke	Contingent upon cancellation of direct animal treatment uses.
Goat, meat (PRE-S)	4	Revoke	Contingent upon cancellation of direct animal treatment uses.
Gooseberry	8	6.0	Translated from blackberry and raspberry data.
Grapefruit	8	4.0	Translated from orange data.
Grape	8	4.0	
Grass	135	200	[*Grass, forage*]
Grass, hay	135	270	
Guava	8	1.0	
Hog, fat (PRE-S)	4	Revoke	Contingent upon cancellation of direct animal treatment uses.
Hog, meat byproduct (PRE-S)	4	Revoke	Contingent upon cancellation of direct animal treatment uses.
Hog, meat (PRE-S)	4	Revoke	Contingent upon cancellation of direct animal treatment uses.
Hop	1	1.0	[*Hops, dried*]
Horseradish	8	0.5	Translated from turnip root data.
Horse, fat (PRE-S)	4	Revoke	Contingent upon cancellation of direct animal treatment uses.
Horse, meat byproduct (PRE-S)	4	Revoke	Contingent upon cancellation of direct animal treatment uses.
Horse, meat (PRE-S)	4	Revoke	Contingent upon cancellation of direct animal treatment uses.
Kumquat	8	4.0	Translated from orange data.
Leek	8	6	Translated from green onion data.
Lemon	8	4.0	Translated from orange data.
Lentil, seed	8	Revoke	Not supported under reregistration
Lespedeza, hay	135	185	Translated from alfalfa hay data.
Lespedeza, seed	8	Revoke	Not a significant RAC of lespedeza
Lespedeza, straw	135	Revoke	Not a significant RAC of lespedeza
Lime	8	4.0	Translated from orange data.
Loganberry	8	6.0	Translated from blackberry and raspberry data.
Lupine, seed	8	2.0	Translated from dry beans data
Mango	8	0.2	
Melon	8	1.0	
Milk, fat (from application to dairy cows)	0.5	Revoke	Contingent upon cancellation of direct animal treatment uses.
Mushroom	8	0.2	
Nectarine	8	1.0	Translated from apricot data.
Nut, macadamia	1	0.2	
Oat, grain, postharvest	8	8.0	[*Oats, grain (PRE- and POST-H)*] Translated from wheat grain data.
Okra	8	3.0	

Commodity	Tolerance Listed Under 40 CFR §180.111	Reassessed Tolerance[1]	Comment [*correct commodity definition*]
Onions (including green onion)	8	1.0	[*Onion, bulb*]
		6.0	[*Onion, green*]
Orange, sweet	8	4.0	[*Orange*]
Papaya	1	1	
Parsnip	8	0.5	Translated from turnip root data.
Passion fruit	8	0.2	[*Passion fruit*]
Peach	8	6.0	
Peanut, forage	135	Revoke	Not supported under reregistration
Peanut, hay	135	Revoke	Not supported under reregistration
Peanut, postharvest	8	Revoke	Not supported under reregistration
Pear	8	3.0	[Pear]
Pea	8	2.0	[*Pea, succulent*] Dry peas not being supported under reregistration.
Pea vine, hay	8	Revoke	Not supported under reregistration
Pea vines	8	Revoke	Not supported under reregistration
Pecans	8	0.20	[*Pecan*] Translated from walnut data.
Peppermint	8	2.0	[*Peppermint*]
Pepper	8	0.5	[*Pepper*]
Pineapple	8	0.2	[*Pineapple*]
Plum	8	Revoke	Not supported under reregistration
Potato	8	0.1	[*Potato*]
Poultry, fat (PRE-S)	4	Revoke	Contingent upon cancellation of direct animal treatment uses.
Poultry, meat byproduct (PRE-S)	4	Revoke	Contingent upon cancellation of direct animal treatment uses.
Poultry, meat (PRE-S)	4	Revoke	Contingent upon cancellation of direct animal treatment uses.
Plum, prune	8	Revoke	Not supported under reregistration.
Pumpkin	8	1.0	Translated from melon data.
Quince	8	TBD[2]	Translate from apple data. Further confirmatory data on apple required.
Radish	8	0.5	Translated from turnip root data.
Raspberry	8	6.0	
Rice, grain, postharvest	8	30	[*Rice, grain (PRE-H)*] Postharvest use on rice not supported under reregistration.
Rice, wild	8	30	[*Rice, wild*] Translated from rice grain data.
Rutabaga	8	0.5	[*Rutabaga*] Translated from turnip root data.
Rye, grain, postharvest	8	8.0	[*Rye, grain (PRE- and POST-H)*] Translated from wheat grain data.
Safflower, seed	0.2	Revoke	Not supported under reregistration
Salsify (including tops)	8	4.0	*[Salsify, tops (leaves)]* Translated from turnip tops data.
		0.5	*[Salsify, root]* Translated from turnip root data.

Commodity	Tolerance Listed Under 40 CFR §180.111	Reassessed Tolerance[1]	Comment [*correct commodity definition*]
Shallots	8	6.0	[*Shallot*]Translated from green onion data.
Sheep, fat (PRE-S)	4	Revoke	Contingent upon cancellation of direct animal treatment uses.
Sheep, meat byproduct (PRE-S)	4	Revoke	Contingent upon cancellation of direct animal treatment uses.
Sheep, meat (PRE-S)	4	Revoke	Contingent upon cancellation of direct animal treatment uses.
Sorghum, forage	8	TBD[2]	[*Sorghum, forage*] Additional data are required.
Sorghum, grain, postharvest	8	8.0	[*Sorghum, grain (PRE- and POST-H)*] Postharvest data translated from field corn grain data.
Soybean (dry and succulent)	8	Revoke	Not supported under reregistration
Soybean, forage	135	Revoke	Not supported under reregistration
Soybean, hay	135	Revoke	Not supported under reregistration
Spearmint, tops	8	2.0	[*Spearmint*]
Squash, summer and winter	8	0.2	[*Squash, summer*] Translated from cucumber data.
		1.0	[*Squash, winter*] Translated from winter squash data.
Strawberry	8	1	
Sunflower, seed (POST-H)	8	Revoke	Not supported under reregistration
Sweet potato, roots	1	0.1	[*Sweet potato*] Translated from potato data.
Tangerine	8	4.0	Translated from orange data.
Tomato	8	2.0	
Trefoil, birdsfoot, forage	135	125	[trefoil, forage] Translate alfalfa and clover data
Trefoil, birdsfoot, hay	135	185	[trefoil, forage] Translate alfalfa and clover data
Turnip (including tops)	8	4.0	[*Turnip, tops*]
		0.5	[*Turnip, roots*]
Vegetables, Brassica, leafy, group 5	8	8.0	[*Brassica (cole) leafy vegetables group*]
Vegetables, leafy (except *Brassica*)	8	TBD[2]	[V*egetables, leafy, except Brassica group 4*] Further data required on representative commodity, celery.
Vetch, hay	135	185	Based on alfalfa data
Vetch, seed	8	Revoke	Not a RAC of vetch
Vetch, straw	135	Revoke	Not a RAC of vetch
Walnut	8	0.2	[*Walnut*]
Wheat, grain, postharvest	8	8	[*Wheat, grain (PRE- and POST-H)*]
Tolerance To Be Proposed Under 40 CFR §180.111 (a)(1)			
Apple, wet pomace	None	TBD[2]	Level will be determined when RAC tolerance reassessed. Further data are

Commodity	Tolerance Listed Under 40 CFR §180.111	Reassessed Tolerance[1]	Comment [*correct commodity definition*]
			required on RAC.
Barley, hay	None	TBD[2]	Translate from wheat hay data when adequate data have been reviewed.
Barley, straw	None	50	Translated from wheat straw data.
Citrus, pulp, dried	None	20	
Citrus, oil	None	400	
Corn, field, stover	None	30.0	
Corn, sweet, stover	None	TBD[2]	Sweet corn stover data are required.
Corn, flour	None	14.0	
Corn, meal	None	14.0	
Cotton, gin byproducts	None	TBD[2]	Cotton gin byproducts data required.
Fig, dried	None	2.0	
Grain, aspirated, grain fractions	None	700	Based on postharvest treated corn grain; the highest value measured in aspirated grain fractions.
Lespedeza, forage	None	125	Translated from alfalfa and clover data.
Oats, forage	None	4.0	Translated from wheat forage data.
Oat, hay	None	TBD[2]	Translate from wheat hay data when adequate data reviewed.
Oat, straw	None	50	Translated from wheat straw data.
Pineapple, process residue	None	0.40	
Peppermint, oil	None	15.0	
Radish, tops	None	4.0	Translated from turnip tops data
Rice, hulls	None	150	
Rice, straw	None	60	
Rye, forage	None	4.0	Translated from wheat forage data.
Rye, straw	None	50	Translated from wheat straw data.
Sorghum, grain, stover	None	TBD[2]	
Spearmint, oil	None	15.0	
Vetch, forage	None	125	Translated from alfalfa and clover data
Watercress	None	0.2	
Wheat, forage	None	4.0	
Wheat, hay	None	TBD[2]	Field trial data are required for wheat hay.
Wheat, straw	None	50	
Tolerances Listed Under 40 CFR §180.111 (a)(2)			
Raisins	12	Revoke	Not supported under reregistration
Tolerances Listed Under 40 CFR §180.111 (a)(3)			
Safflower, refined oil	0.6	Revoke	Not supported under reregistration
Tolerances Listed Under 40 CFR §180.111 (a)(4)			
Raisins	exempt	Revoke	Not supported under reregistration

Commodity	Tolerance Listed Under 40 CFR §180.111	Reassessed Tolerance[1]	Comment [*correct commodity definition*]
Tolerances Listed Under 40 CFR §180. 111 (a)(5)			
Dehydrated citrus pulp [post-H]	50	Revoke	Not supported under reregistration
Non-medicated cattle feed concentrate blocks.	10	Revoke	Not supported under reregistration

[1]: The reassessed tolerance levels are contingent upon the recommended label revisions outlined in the *Residue Chemistry Chapter for the Malathion Reregistration Eligibility Decision (RED) Document*, (April 14, 1999)

[2]: TBD = To be determined

Codex Harmonization

The Codex Aliment Arius Commission has established several maximum residue limits (Marls) for residues of malathion in/on various raw agricultural and processed commodities. The Codex MRLs are expressed in terms of malathion *per se*. Reassessed U.S. tolerances include both residues of malathion and the metabolite malaoxon. A numerical comparison of the Codex MRLs and the corresponding reassessed U.S. tolerances is presented in Table 26.

Table 26: Codex MRLs and Applicable U.S. Tolerances for Malathion.

Codex			**Reassessed U.S. Tolerance, ppm**
Commodity, As Defined	**MRL (mg/kg)**	**Step**	
Apple	2.0	CXL	TBD[1]
Beans, (dry)	8.0 Po[2]	CXL	2.0
Blackberries	8.0	CXL	6.0
Blueberries	0.5	CXL	8.0
Broccoli	5.0	CXL	8.0
Cabbages, Head	8.0	CXL	8.0
Cauliflower	0.5	CXL	8.0
Celery	1.0	CXL	TBD
Cereal grains	8.0 Po [2]	CXL	Corn (field), sorghum, barley, oats, rye, wheat grains = 8.0 (POST-H)
Chard	0.5	CXL	TBD
Cherries	6.0	CXL	3.0
Citrus fruits	4.0	CXL	4.0
Common bean (pods and/or immature seeds)	2.0	CXL	2.0
Dried fruits	8.0	CXL	--
Egg plant	0.5	CXL	2.0
Endive	8.0	CXL	TBD

Codex			Reassessed U.S. Tolerance, ppm
Commodity, As Defined	MRL (mg/kg)	Step	
Grapes	8.0	CXL	4.0
Kale	3.0	CXL	TBD
Kohlrabi	0.5	CXL	TBD
Lentil (dry)	8.0	CXL	Revoke
Lettuce, Head	8.0	CXL	TBD
Nuts (whole in shell)	8.0	CXL	--
Peach	6.0	CXL	6.0
Pear	0.5	CXL	3.0
Peas (pods and succulent=immature seeds)	0.5	CXL	2.0
Peppers	0.5	CXL	0.5
Plums (including prunes)	6.0	CXL	Revoke
Raspberries, Red, Black	8.0	CXL	6
Root and tuber vegetables	0.5 [3]	CXL	Potato, Sweet potato, beet, garden, roots; carrots; horseradish; parsnip; radish; rutabaga; and turnip = 0.1
Rye bran, Unprocessed	20.0 PoP [4]	CXL	--
Rye flour	2.0 PoP [4]	CXL	--
Rye wholemeal	2.0 PoP [4]	CXL	--
Spinach	8.0	CXL	TBD
Strawberry	1.0	CXL	1.0
Tomato	3.0	CXL	2.0
Turnip, Garden	3.0	CXL	4 tops 0.5 roots
Wheat bran, Unprocessed	20.0 PoP [4]	CXL	--
Wheat flour	2.0 PoP [4]	CXL	--
Wheat wholemeal	2.0 PoP [4]	CXL	--

[1] TBD = To be determined; residue data remain outstanding.
[2] Po = Postharvest treatment of the commodity.
[3] (Except Turnip, Garden)
[4] PoP = Postharvest treatment of the primary food crop.

E. Regulatory Rationale

The following is a summary of the rationale for mitigation measures necessary for managing risks associated with the use of malathion for malathion products to be eligible for reregistration. Where labelling revisions are warranted, specific language is set forth in the summary table of Section V.

1. Human Health Risk Management

a. Acute and Chronic Dietary (Food Only) Mitigation

The estimated acute and chronic dietary risks from malathion, and malaoxon in food alone, are less than 100% of both the aPAD, and the cPAD and, therefore, are below the Agency's LOC. Acute dietary exposure to malathion and malaoxon in food at the 99.9th percentile is 5% of the aPAD for the general U.S. population, and 11% of the aPAD for all infants (<1 yr old), the most highly exposed population subgroup. The chronic dietary (food) exposure to malathion and malaoxon is less than 1% of the cPAD for all population subgroups. No mitigation is required to address either acute or chronic dietary risks from food alone.

b. Residential Risk Mitigation

Residential Handlers and Post-Application

Estimated dermal and inhalation risks for homeowners handling malathion products are below the Agency's LOC for all handling scenarios. The combined (dermal and inhalation) MOEs for all scenarios assessed are greater than 100 (ranging from 250 to 13000).

For all post-application scenarios, estimated dermal and inhalation MOEs for adults and toddlers are all greater than 100 (ranging from 270 to 7800) and, therefore, do not exceed the Agency's LOC.

The total combined MOEs for all assessed residential handler and post-application scenarios assumed to potentially occur the same day are all greater than 100 (ranging from 260 to 670) and, therefore, do not exceed the Agency's LOC. No mitigation is necessary to address residential handler or post-application risks.

Residential Bystander – Malathion Only

Public Health Mosquito Control. Combined inhalation and dermal short-term risk estimates for adults (MOEs ranging from 22,000 to 74,000), and combined dermal, inhalation and incidental oral risk estimates for toddlers (ARIs ranging from 9-20) from post-application exposure to malathion following public health mosquito treatment with malathion do not exceed the Agency's LOC. Therefore, no mitigation is necessary.

Boll Weevil Eradication Program. Combined risks from post-application dermal contact, inhalation and incidental ingestion of malathion residues in areas nearby fields being treated for boll weevil with the predominant application rate do not exceed the Agency's LOC for adults (MOE = 3000) or toddlers (ARI = 1.3); therefore, no mitigation is necessary.

Fruit Fly Eradication Treatment. Adult risk from combined dermal and inhalation exposure following aerial fruit fly treatment does not exceed the Agency's LOC (MOE = 5500). Likewise, combined exposure to toddlers from dermal, inhalation and incidental oral routes results in a risk that does not exceed the Agency's LOC (ARI =1.7); therefore, no mitigation is necessary.

Residential Bystander – Combined Residues of Malathion and Malaoxon

Post-application exposures of toddlers to combined residues of malathion and malaoxon on hard surfaces following public health mosquitocide, boll weevil eradication treatment, and fruit fly treatment have been estimated. Risks from individual routes of exposure (dermal and incidental oral) were combined using an aggregate risk index (ARI) and are not of concern to the Agency; therefore, no mitigation measures are necessary.

At the maximum 10% malaoxon conversion rate, the estimated ARI from the maximum use rate (1.2 lb ai/A) for malathion in the BWEP is above the LOC (ARI = 0.8); however, the estimated exposures at the predominantly used typical rate (0.9 lb ai/A) resulted in an ARI = 1, which is below the Agency's LOC. All other assessed malaoxon conversion scenarios at the maximum application rate resulted in ARIs that were also below the Agency's LOC. Information provided by the USDA/APHIS boll weevil eradication program managers indicate that the maximum use rate (1.2 lbs ai/A) is used on less than 1% of the acreage currently in the active phase of the program. Recognizing that such a small percentage of acres may actually receive a malathion treatment at the maximum BWEP rate, the likelihood of playground equipment and/or decks being found within the estimated drift distance used in the assessment (75 feet) from a field edge is negligible. Furthermore, the BWEP is a time limited program and is expected to be largely completed by 2009, with each interim year seeing a substantial reduction in the overall number of cotton acres being treated with malathion.

c. Acute Aggregate Risk Mitigation

To estimate acute aggregate (food + drinking water) risk from malathion, EPA combined peak EDWCs, which included predicted concentrations of malaoxon, with food residues and consumption data, and compared this to the acute aPAD. The Agency assessed 16 separate screening-level model scenarios (PRZM-EXAMS) to evaluate acute aggregate risk for the 100+ agricultural use sites for which malathion is registered. When EPA estimated acute aggregate risks based on current maximum supported application values, many risks were above the Agency's LOC (see Table 10). However, when mitigated application values are used in conjunction with refinements to the drinking water model, the EDWCs are substantially reduced, and all acute aggregate risk estimates are below the Agency's LOC (<100% of the aPAD) for all population subgroups, including the highest exposed population subgroup, all infants.

The mitigated application values used to reduce peak EDWCs and, thus, acute aggregate risks below the Agency's LOC represent either a lower maximum application rate (lb ai/A),

and/or a reduced number of applications per year. These values were developed in cooperation with users and growers, Regional Integrated Pest Management (IPM) Centers, USDA, and the technical registrant. Therefore, the Agency does not believe the mitigated application values, when implemented, will have an adverse impact on users. Tables 27 and 28 below summarize the mitigated application rates (lbs ai/A) and maximum number of applications per year for non-ULV and ULV applications, respectively, which will be required on all malathion product labels. Tables 27 and 28 lists only those sites where application values have changed from the currently supported maximum application values.

For several reasons the Agency believes that even the acute aggregate risk estimates, based on mitigated application values and refined inputs, do not underestimate risk, since several assumptions associated with the EDWC may overestimate potential residues in drinking water. First, the Agency has assumed that 100% of the predicted concentration value at the "edge of the field" reaches the POTW. However, monitoring data indicates that concentrations of malathion are likely to decrease as distance from the application site increases. Second, based on laboratory data and monitoring data, the Agency assumed 100% conversion of malathion to malaoxon during the water treatment process. However, the Agency lacks data on the conversion of malathion to malaoxon under varying treatment processes, or under different water qualities and, therefore, while the assumption of 100% conversion to malaoxon clearly is a reasonable upper bound estimate, the Agency lacks the data with which to establish a lower bound rate of conversion. Third, the Agency's drinking water model is designed to predict surface water runoff as if a large portion of an entire watershed is treated with a compound at the same time, and in temporal proximity to a major rainfall event. However, multiple-year data indicates that malathion is used on a relatively small percent of almost all crops (< 5%), thereby reducing the probability of large "spikes" of malathion residues in drinking water. Finally, because acute comparative ChEI data remains outstanding, some uncertainty regarding the malaoxon TAF (61x) also remains. Upon receipt of the required comparative ChEI data, the Agency will review the malaoxon TAF, and the associated dietary (food + drinking water) risks if necessary.

Table 27: Current and Amended Agricultural Use Patterns for Non-ULV Applications

Crop	Application Values: Max. Appl. Rate (lb ai/A) x Max. No. of Appls. Per Year x Retreatment Interval (Days)	
	Current Maximum Supported Application Values	**Mitigated Application Values**
Apricots	3.75 x 4 x 7	1.5 x 2 x 7
Asparagus	1.25 x 9 x 7	1.25 x 2 x 7
Barley	1.25 x 3 x 7	1.25 x 2 x 7
Beets, garden	1.25 x 5 x 7	1.25 x 3 x 7
Blackberry	2.0 x 4 x 7	2.0 x 3 x 7
Blueberry	1.25 x 4 x 4	1.25 x 3 x 4

Crop	Application Values: Max. Appl. Rate (lb ai/A) x Max. No. of Appls. Per Year x Retreatment Interval (Days)	
	Current Maximum Supported Application Values	**Mitigated Application Values**
Broccoli	1.25 x 5 x 7	1.25 x 1 x 7
Broccoli Chinese	1.25 x 5 x 7	1.25 x 1 x 7
Broccoli raab	1.25 x 5 x 7	1.25 x 1 x 7
Brussels sprouts	1.25 x 4 x 7	1.25 x 1 x 7
Cabbage	1.25 x 10 x 7	1.25 x 6 x 7
Cantaloupe	1.0 x 6 x 7	1.0 x 2 x 7
Carrots	1.25 x 7 x 7	1.25 x 2 x 7
Cauliflower	1.25 x 5 x 7	1.25 x 1 x 7
Chayote fruit	1.88 x 3 x 7	1.75 x 2 x 7
Cherries (sweet)	3.75 x 6 x 7	1.75 x 4 x 3[2]
Cherries (tart)	3.75 x 6 x 7	1.75 x 4 x 3[2]
Chestnut	5.0 x 4 x 7	2.5 x 3 x 7
Chinese greens (Chinese cabbage)	1.25 x 10 x 7	1.25 x 2 x 7
Collards	1.25 x 10 x 7	1.25 x 3 x 7
Corn, field	1.25 x 3 x 7	1.0 x 2 x 7
Corn, sweet	1.25 x 5 x 5	1.0 x 2 x 5
Cucumber	1.88 x 3 x 7	1.75 x 2 x 7
Dandelion	2 x NS	1.25 x 2 x 7
Dates	4.25 x 6 x 7	4.25 x 5 x 7
Eggplant	3.43 x 5 x 5 1.56 x 5 x 5	1.56 x 4 x 5
Eggplant, oriental	3.43 x 5 x 5 1.56 x 5 x 5	1.56 x 5 x 5
Endive	1.88 x NS x NS	1.25 x 2 x 7
Flax	0.5 x 1	0.5 x 3 x 7[2]
Figs	2.5 x 3 x 5	2.0 x 2 x 5
Garlic	1.56 x 5 x 7	1.56 x 3 x 7
Grapefruit	6.25 x 3 x 30	Rest of US: 4.5 x 1 CA: 7.5 x 1[1]
Horseradish	1.25 x 5 x 7	1.25 x 3 x 7
Kale	1.25 x 10 x 7	1.25 x 3 x 5[2]

Crop	Application Values: Max. Appl. Rate (lb ai/A) x Max. No. of Appls. Per Year x Retreatment Interval (Days)	
	Current Maximum Supported Application Values	**Mitigated Application Values**
Kohlrabi	1.25 x 10 x 7	1.25 x 2 x 7
Kumquats	6.25 x 3 x 30	4.5 x 1 x 30
Leeks	1.56 x 5 x 7	1.56 x 2 x 7
Lemons	6.25 x 3 x 30	FL: 4.5 x 1 CA: 7.5 x 1[1]
Lettuce, head	1.88 x 6 x 6	1.88 x 2 x 6
Lettuce, leaf	1.88 x 6 x 5	1.88 x 2 x 5
Limes	6.25 x 3 x 30	Rest of US: 4.5 x 2 x 30 CA: 7.5 x 1[1]
Loganberry	2.0 x 4 x 7	2.0 x 2 x 7
Macadamia Nut	0.94 x 7 x 7	0.94 x 2 x 7
Melons	1.0 x 6 x 7	1.0 x 2 x 7
Nectarines	3.75 x 4 x 7	3 x 3 x 7
Mustard greens	1.25 x 6 x 7	1.25 x 3 x 5[2]
Oats	1.25 x 3 x 7	1 x 2 x 7
Okra	1.5 x 6 x 7	1.2 x 5 x 7
Onions, bulb	1.56 x 6 x 7	1.56 x 2 x 7
Onion green	1.56 x 6 x 7	1.56 x 2 x 7
Oranges	6.25 x 3 x 30	Rest of US: 4.5 x 1 CA: 7.5 x 1[1]
Papaya	1.25 x 13 x 3	1.25 x 4 x 3
Parsnip	1.25 x 5 x 7	1.25 x 3 x 7
Passion Fruit	1.25 x 8 x 7	1 x 8 x 7
Peaches	3.75 x 5 x 11	3.0 x 3 x 11
Pears	1.25 x 5 x 7	1.25 x 2 x 7
Peas, succulent	2.5 x 5 x 7	1.0 x 2 x 7
Pecans	2.5 x 3 x 7	2.5 x 2 x 7
Peppers	1.56 x 5 x 5	1.56 x 2 x 5
Pineapple	5.0 x 3 x 7	2.0 x 3 x 7
Pumpkin	1.0 x 6 x 7	1.0 x 2 x 7
Radishes	1.25 x 5 x 7	1.25 x 3 x 7
Raspberry	2.0 x 4 x 7	2.0 x 2 x 7

Crop	Application Values: Max. Appl. Rate (lb ai/A) x Max. No. of Appls. Per Year x Retreatment Interval (Days)	
	Current Maximum Supported Application Values	Mitigated Application Values
Rice	1.25 x 3 x 7	1.25 x 2 x 7
Rutabagas	1.25 x 5 x 7	1.25 x 3 x 7
Rye	1.25 x 3 x 7	1.0 x 2 x 7
Salsify	1.25 x 5 x 7	1.25 x 3 x 7
Shallots	1.56 x 5 x 7	1.56 x 2 x 7
Spinach	2.0 x 3 x 7	2.0 x 2 x 7
Squash, summer	1.88 x 3 x 7	1.75 x 3 x 7
Squash, winter	1.0 x 6 x 7	1.0 x 3 x 7
Strawberry	2.0 x 6 x 7	2.0 x 4 x 7
Tangelos	6.25 x 3 x 30	Rest of US: 4.5 x 1 CA: 7.5 x 1[1]
Tangerines	6.25 x 3 x 30	Rest of US: 4.5 x 1 CA: 7.5 x 1[1]
Tomatoes	3.43 x 5 x 5 1.56 x 5 x 5	1.56 x 4 x 5
Tomatillo	3.43 x 5 x 5 1.56 x 5 x 5	1.56 x 4 x 5
Turnip, greens, roots	1.25 x 5 x 7	greens: 1.25 x 3 x 5[2] roots: 1.25 x 3 x 7
Watermelons	1.0 x 6 x 7	1.5 x 4 x 7
Wheat, spring	1.25 x 3 x 7	1.0 x 2 x 7
Wheat, winter	1.25 x 3 x 7	1.0 x 2 x 7
Wild rice	1.25 x 3 x 7	1.25 x 2 x 7

NS: Not specified

[1]: Although the single maximum application rate is increased, the number of applications permitted per year decreased; thus, the overall potential exposure from this use is lower.

[2]: Retreatment intervals were shortened or additional applications are allowed for these uses based on grower comments and are supported by existing field trial data.

Table 28: Current and Amended Agricultural Use Patterns for ULV Applications

Crop	Application Values: Max. Appl. Rate (lb ai/A) x Max. No. of Appls. Per Year x Retreatment Interval (Days)	
	Current Maximum Supported Application Values	Amended Application Values
Barley	0.61 x 3 x 7	0.61 x 2 x 7
Beans, dry, lima	0.61 x 3 x 7	0.61 x 2 x 7
Beans, snap	0.61 x 3 x 7	0.61 x 2 x 7

Crop	Application Values: Max. Appl. Rate (lb ai/A) x Max. No. of Appls. Per Year x Retreatment Interval (Days)	
	Current Maximum Supported Application Values	Amended Application Values
Blueberry	0.77 x 5 x 10	0.77 x 3 x 10
Cherries, sweet	1.22 x 6 x 7	1.22 x 4 x 7
Corn, field	0.61 x 3 x 7	0.61 x 2 x 7
Corn, sweet	0.61 x 5 x 5	0.61 x 2 x 5
Grapefruit	0.175 x 10 x 7	0.175 x 3 x 7
Kumquats	0.175 x 10 x 7	0.175 x 2 x 7
Lemons	0.175 x 10 x 7	0.175 x 2 x 7
Limes	0.175 x 10 x 7	0.175 x 1 x 7
Lupine	0.61 x 3 x 7	0.61 x 1 x 7
Oats	0.61 x 3 x 7	0.61 x 2 x 7
Oranges	0.175 x 10 x 7	0.175 x 2 x 7
Rice	0.61 x 3 x 7	0.61 x 2 x 7
Rye	0.61 x 3 x 7	0.61 x 1 x 7
Sorghum	0.61 x 3 x 7	0.61 x 2 x 7
Tangelos	0.175 x 10 x 7	0.175 x 2 x 7
Tangerines	0.175 x 10 x 7	0.175 x 2 x 7
Wheat, spring	0.61 x 3 x 7	0.61 x 2 x 7
Wheat, winter	0.61 x 3 x 7	0.61 x 2 x 7
Wild rice	0.61 x 3 x 7	0.61 x 2 x 7

d. Chronic Aggregate Risk Mitigation

Chronic aggregate risk for malathion and malaoxon from food and drinking water is below the Agency's LOC for the U.S. general population and all population subgroups. For all drinking water scenarios assessed, including the worst-case aerial CA lettuce scenario with maximum application rates, all chronic aggregate dietary exposure from food and drinking water for the U.S. population and all infants <1 yr, the most highly exposed population subgroup, was <1% of the cPAD. No mitigation is required for chronic aggregate exposures to malathion.

e. Short-Term Aggregate Risk Mitigation

Short-term aggregate risk combines chronic dietary (food + drinking water) exposure with short-term residential exposure. Several malathion uses, such as home fogger, or the wide

area treatments, result in short-term residential exposure which could be aggregated with the chronic dietary to estimate short-term aggregate risk. Among the malathion residential exposure scenarios, the Agency believes that aerial application of public health use of malathion represents the most likely and wide spread co-occurring exposure pathway for the general U.S. population. To be conservative, the Agency assessed this scenario at the 10% conversion rate of malathion to malaoxon. For more information regarding the transformation of malathion to malaoxon in the residential exposure and risk analysis, refer to *Malathion: Residential Exposure and Risk Assessment for the Interim Reregistration Eligibility Decision (RED) Document*, dated July 6, 2006.

The Agency aggregated the estimated risks from acute aggregate dietary with the estimated risks from the wide area public health uses of malathion using the Aggregate Risk Index (ARI) method, since the target MOE for oral exposure (hand to mouth, and dietary) differs from that of dermal exposure. When using the ARI method, the Agency considers risks equal to or above 1 to be not of concern. When chronic dietary (food + drinking water) exposure is added to the residential bystander oral and dermal exposure components from the public health use of malathion, the total aggregate ARI is 6. The estimated ARI of 6 is below the Agency's LOC and, therefore, no mitigation is necessary.

While the Agency believes the wide area use of malathion as a public health pesticide is the most reasonable scenario to aggregate for short-term aggregate risk, it is not the most conservative. Rather, the highest estimated risk to a residential bystander from the Boll Weevil Eradication Program (BWEP). For the BWEP bystander scenario, the Agency estimated risks using the maximum supported application rate of 1.2 lb ai/A, and the typical rate of 0.9 lb ai/A. When the Agency combined chronic aggregate dietary (food + drinking water) with the BWEP bystander scenario, using the maximum supported application rate of 1.2 lb ai/A, the ARI is 0.8 which indicates exposure slightly above the Agency's LOC. However, when the Agency estimated short-term aggregate risk from the BWEP at the typical rate of 0.9 lb ai/A, the ARI is 1, which indicates exposure below the Agency's LOC.

The Agency estimated aggregate short-term risks from the BWEP using the 1.2 lb ai/A, because it is Agency policy to characterize risk using the maximum supported rate. However, based on communications with USDA/APHIS, which sponsors the BWEP, the Agency believes that the typical application rate of 0.9 lb ai/A is predominantly used and, therefore, the appropriate rate at which to asses potential residential risk from the BWEP. USDA/APHIS provided information which characterized the 0.9 lb ai/A rate (or lower) as the predominant rate used in the BWEP, as it provides the optimum combination of efficacy, and cost effectiveness. The 1.2 lb ai/A rate was mainly used prior to 1997, and is currently maintained by the BWEP for select situations, such as finishing up the active phase of the program in a certain area with the objective of preventing boll weevil survival into another season. On an annual basis, the 1.2 lb ai/A rate is used on less than 1% of the active program acreage. Therefore, the Agency has a high degree of confidence that short-term aggregate exposures, using the wide area BWEP exposure scenario, are below the Agency's LOC, and no mitigation is necessary.

While the short-term aggregate risk incorporating the BWEP is below the Agency's LOC, the Agency has taken steps to strengthen malathion product labeling for the BWEP. The Agency has worked with the technical registrant and USDA to develop spray drift label language for the BWEP. The additional label language will assist program operators to convey more information on application requirements and potentially reduce spray drift (see Table 30 in Section V).

f. Occupational Risk Mitigation

A wide range of factors is considered in making risk management decisions for worker risks. These factors include, in addition to the estimated MOEs, incident data, the nature and severity of adverse effects observed in the animal studies, uncertainties in the risk assessment, alternative registered pesticides, the importance of the chemical in integrated pest management (IPM) programs, and other factors. Mitigation measures may include reducing application rates, adding personal protective equipment (PPE) to end-product labels, requiring the use of engineering controls, extending the post-application re-entry period, and other measures.

Handler Risk Mitigation

Occupational handler (mixers, loaders and applicators) exposure assessments are completed by the Agency considering the use of baseline PPE and, if warranted, increasing levels of PPE and engineering controls in order to estimate the potential impact on exposure and risk. The combined dermal and inhalation target MOE for malathion is 100. When estimated MOEs for handler risk are less than 100, EPA strives to reduce worker risks through the use of PPE and engineering controls or other mitigation measures. In some cases, the Agency may accept MOEs less than 100 when all mitigation measures that are feasible and practical have been applied, particularly when there are critical pest management needs associated with the use of the pesticide.

To address handler risks of concern, the Agency is requiring the following PPE and/or engineering controls be specified on product labels for formulations and use patterns of malathion, in addition to the use pattern changes identified in Tables 27 and 28, to be eligible for reregistration. Following the implementation of these formulation specific and activity specific risk mitigation measures, handler risks for malathion will no longer be of concern to the Agency.

- For all malathion formulations and use patterns, flaggers and applicators using motorized ground equipment are required to wear baseline PPE (long-sleeved shirt, long pants, and shoes);
- For all malathion formulations and use patterns—except those identified below—baseline PPE plus chemical-resistant gloves are required for mixers and loaders;

- Closed mixing/loading systems are required for all ULV applications and mixers and loaders are required to wear baseline PPE, chemical-resistant gloves, and chemical-resistant apron;
- All wettable powder (WP) formulations must be packaged in water soluble packaging;
- Mixers, loaders and applicators of dust (D) formulations are required to wear coveralls over long-sleeve shirt and long pants, chemical-resistant gloves, and an 80% PF (quarter-face dust/mist) respirator;
- For all dip applications, mixers, loaders and applicators are required to wear baseline PPE plus chemical-resistant gloves, and chemical-resistant apron;
- For all airblast applications applicators are required to wear baseline PPE, chemical-resistant gloves, and chemical-resistant hat; and
- Enclosed cockpits are required for all aerial applications.

Two formulation specific scenarios assessed lacked data in PHED for evaluation: loading/applying dusts with a power duster to treat dates and stored grain, and mixing/loading and applying dips.

Loading and Applying Dusts

The Agency used surrogate data for WP formulations for handlers loading dust formulations in mechanical dusters for use on stored grain and dates, but has no data available for assessing individuals who apply or load/apply dusts. A published study, "Malathion Deposition, Metabolite Clearance, and Cholinesterase Status of Date Dusters and Harvesters in California," (2000) authored by Krieger and Dinoff. *Arch. Environ. Contam. Toxicol*. Volume 38, Pages 546-553, was submitted by the USDA for consideration in this malathion assessment. The study reports estimated daily exposure doses of from 0.4 - 1.0 mg malathion/kg/day (i.e., MOEs ranged from 130 to 3200, if the total dose is attributed to dermal exposure) for handlers who load/operate power dusters to treat dates with malathion 5% dust. Workers in this study were already wearing coveralls over baseline attire, gloves and dust/mist respirators. It is not expected that engineering controls would be feasible to the operator of the power-duster. Thus, dust formulations are eligible for reregistration provided handlers wear coveralls over long-sleeved shirt and long pants, chemical-resistant gloves, and an 80% PF (quarter-face dust/mist) respirator. No additional data will be required by the Agency for this scenario.

Mixing/Loading and Applying Dips

Exposure data is not available to assess potential occupational risks associated with mixing, loading and applying dip applications. Currently the dip application method is only registered for use on grape roots. The Agency believes the same individual typically mixes, loads and applies the dip to the grape roots rather than multiple workers being involved in the operation. The Agency believes that based on the risk estimates for occupational handlers using the liquid formulation of malathion for agricultural crop uses, which involve much higher volume of product, baseline PPE and chemical-resistant gloves will be adequately protective for

all dip applications as well. However, to reduce additional exposure that may result from potential splashing of product onto the individual during the dip application, the Agency is also requiring chemical-resistant aprons to be worn. Therefore, for dip applications to be eligible for reregistration, handlers must wear baseline PPE, chemical-resistant gloves and chemical-resistant aprons. No additional data will be required by the Agency for this scenario.

Post-Application Risk Mitigation

Based on the post-application scenarios assessed, the number of days estimated to reach the target MOE following applications of malathion exceed the current label REI of 12 hours established under the Worker Protection Standard for some uses. Considering refinements to the risk assessment, including the use pattern changes identified in Tables 27 and 28**,** the Agency has determined that extension of some REIs is needed in order to mitigate risks to workers entering previously treated areas to conduct various activities.

Generally, occupational post-application risks to workers were not a concern (MOEs >100) by 24 hours after treatment for the vast majority of malathion use sites, based on the mitigated use rates and other refinements to the assessment. In general, when application rates were 4.5 lb ai/A and higher, the REI needed to achieve risks that are not a concern increased to two or three days (24 to 72 hours after treatment), depending on the application rate associated with the crop and the transfer coefficient associated with the post-application activity. For two tasks with very high transfer coefficients (detasseling/hand harvesting corn with a TC of 17,000 cm^2/hr and girdling/cane turning grapes with a TC of 10,000 cm^2/hr), the REI needed to achieve risks that are not of concern is three days even though the application rates are 2.0 lb ai/acre or less.

The Agency, through its regulatory partner, USDA, Office of Pest Management Policy, contacted land grant universities, regional IPM centers, and grower groups to obtain additional information about malathion use patterns and post-application worker activities and maximum feasible REIs. The goal of this exercise was to determine when high contact, high exposure, and high risk activities were performed relative to malathion application and to collect other information about malathion use that might factor into the regulatory decision on REIs for this RED. Based on information provided through this effort, the Agency is confident the extended REIs necessary to avoid risks of concern will not adversely impact malathion users. Table 29 lists those crops and specific activities (where appropriate) which require REIs of 24 hours or greater. All other use sites eligible for reregistration not listed in these tables are required to have a 12 hour REI. Following the implementation of these REIs, post-application risks for malathion will no longer be of concern to the Agency

Table 29. Use Sites Which Require REIs Longer than 12 Hours

Use Sites that Require a 24 Hour REI		
Carrot	Horseradish	Pineapple
Celery	Kale	Radish

Chayote (root, fruit)	Kohlrabi	Rutabaga
Chestnut	Leeks	Salsify
Chinese greens	Lettuce (head, leaf)	Shallots
Collards	Mustard greens	Spinach
Cucumber	Nectarines	Summer squash
Dandelion	Parsley	Swiss chard
Endive	Parsnip	Turnips
Figs	Peach	Walnuts
Garlic	Pecan	Yams
Use Sites that Require a Two Day (48 hour) REI		
Avocado	Cabbage	Dates
Broccoli	Cauliflower	Kumquats (if not w/ citrus)
Broccoli raab	Chinese broccoli	
Brussels sprouts	Citrus crops @ 4.5 lb ai/A	
Use Sites that Require a Three Day (72 hour) REI		
Citrus crops @ 7.5 lb ai/A	Corn (field, seed, sweet, and pop) detasseling and hand harvesting only[1]	Grapes (table, wine, raisin) girdling and cane turning only[1]

[1] All other reentry activities for corn and grapes require a 12 hour REI

2. Non-Target Organism (Ecological) Risk Management

a. Terrestrial Organisms

Birds and Mammals

EPA's screening-level ecological assessment resulted in estimated acute risks to birds and mammals which only slightly exceeded the Agency's LOC. The highest acute and chronic RQ for avain species was associated with malathion use on chestnut (0.75 and 18, respectively), and the highest acute and chronic RQs for mammals was associated with malathion use on citrus (3.6 and 3, respectively). RQ estimates were based on maximum concentrations of pesticide residues on animal feed items from multiple applications, and reflect maximum number of applications and maximum labeled use rates for malathion.

However, through comments and feedback from the user community, and communication with USDA and the technical registrant, EPA has received agreement to reduce the maximum application use and number of applications for numerous agricultural uses (see Tables 27 and 28 for summary of amended use rates). Reductions to the use patterns (lbs ai/A and the maximum number of applications) will significantly reduce potential malathion residues on food and feed items through which non-target terrestrial organisms are exposed to malathion. The Agency expects that while the acute and chronic RQs to both avian and mammalian species will be

greatly reduced when reduced application rates are used, the estimated RQs may not fall entirely below the Agency's LOC.

In addition, instructions are to be added to the malathion product labels to reduce the potential for off target spray drift; thus reducing the potential exposure to non-target terrestrial organisms. Specific label language aimed at reducing off target drift is contained in Table 30.

Non-Target Plants and Non-Target Insects

As stated above, since the mode of action for malathion is well defined (effects nervous system), and the Agency has no reports of adverse effects to plants, the Agency has no risk concerns and is not proposing any mitigation measures for exposure to non-target plants.

The Agency has classified malathion as highly toxic to bees; therefore, a precautionary statement is required on malathion product labels to limit the exposure to honeybees and other beneficial insects during applications of malathion (see Table 30).

b. Aquatic Organisms

Agricultural Uses

As stated above, numerous reductions to application rates are to be implemented for malathion; however, the majority of changes to be made to malathion labels are for reducing the maximum number of applications per year. Revised exposure assessments indicate that reducing the number of applications may have a greater impact on reducing potential exposure to non-target aquatic organisms than a reduction in the application rate. Moreover, a reduction in the number of applications not only reduces potential accumulation of malathion that may be transported in surface run-off, but also reduces occurrences of off-target drift.

To further reduce potential exposure to both non-target fish and aquatic invertebrates, the technical registrant has agreed to add instructions to product labels to reduce potential off-target drift to aquatic areas, including requirements for a 25 foot buffer zone along aquatic areas for all non-ULV aerial applications, and a 50 foot buffer zone along aquatic areas for all ULV aerial agricultural applications. These buffer zones were determined by considering typical application speed, boom width, and a representative application rate (see Table 23) and are considered to be protective of the most sensitive freshwater fish species (bluegill sunfish). By imposing language on product labels to reduce off-target drift and the use of buffer zones, potential exposure to non-target invertebrates is further reduced.

In addition, since the toxicological response between freshwater fish and estuarine fish is similar, the Agency expects that the risk reduction being realized for non-target freshwater organisms will also be seen for non-target estuarine organisms.

Aquatic Risks

Aquatic toxicity data indicates that on an acute basis malathion is classified as highly toxic to non-target aquatic invertebrates, and very highly toxic to non-target fish. EPA conducted a Tier II risk assessment using PRZM-EXAMS modeling on several crops to represent the 100+ agricultural crops for which malathion is registered. For the several agricultural crop scenarios modeled, the Agency estimated RQs based on both maximum application values (lbs ai/A, and maximum number of applications) as well as typical application values, which better reflect actual field application practices and will be required on product labels (see Tables 27 and 28). When assessed with maximum application values, most scenarios resulted in RQs above the Agency's LOC. However, the Agency expects that acute and chronic RQs to aquatic organisms will be greatly reduced, with RQs for some scenarios being below the Agency's LOC, when reduced application rates are assessed.

Estimated acute RQs for non-target fish, using maximum application values for commercial agricultural sites ranged from 0.5 - 5.4, with the highest RQ based on applications to citrus. When typical application values were used, the range of estimated acute RQs for non-target fish was from 0.09 - 1.57. Acute RQs for invertebrates were also estimated using both maximum and typical application values. Estimated acute RQs for invertebrates, based on maximum application values ranged from 15 - 162, and when typical application values were used, RQs ranged from 3 - 47, again with the highest RQ based on application to citrus.

Based on maximum application rates, estimated chronic RQs for non-target fish ranged from 0.09 - 0.5; however, when typical application values were used, chronic RQs ranged from 0.01 - 0.12. Estimated chronic RQs for invertebrates ranged from 83 - 416 when maximum application values were used, and ranged from 8.3 - 121 when typical application values were used.

Public Health Uses

The Agency conducted a screening-level ecological assessment for the wide area uses of malathion including public health, fruit fly, and BWEP uses. For public health uses, the Agency estimated that the acute RQ for freshwater fish is 38, and the acute RQ for invertebrates is 1.9. However, when the Agency estimated these RQs, it assumed 100% deposition into a six foot deep pond, which may overestimate potential exposure since modeling information indicates that some applied material remains aloft and disperses to such a degree, it does not reach the target site. In addition, the current maximum application rate for public health adulticide is 0.23 lb ai/A, which is approximately three times less than the rate assessed in EPA's screening-level assessment of 2000. Further, comments received during the Phase 5 public comment period indicate that mosquito control officials typically use rates lower than the current maximum of 0.23 lb ai/A. Therefore, while the Agency did not revise non-target RQs to reflect more appropriate application rates, the Agency believes that risks to non-target aquatic organisms from adult adulticide applications will be lower than those reflected above. However, while the

estimated RQs associated with the public health use of malathion are be lower than 38 and 1.9, respectively, for fish and invertebrates, some level of risk to non-target aquatic organisms from this use likely remain.

Malathion, like other adult mosquitocide products, was the subject of PR Notice 2005-1 which aimed to improve current adult mosquitocide labeling to reduce ecological risks and improve the handling and use of these products. In addition, the Agency has required additional measures be added to labels for public health mosquito abatement to further reduce potential bystander and ecological exposure. These measures, listed below, are being required of other public health mosquito abatement products as well.

- Specify droplet size for aerial and ground applications (see Table 30 for details);
- Specify minimum release height of 100 ft for planes, and 75 feet for helicopter;
- Specify wind speed for applications; and
- Specify use pattern by setting a single maximum application, and yearly maximum application rate. (However, public health labels also permit more frequent applications to be made to prevent or control a threat to public and/or animal health under certain conditions.)

Wide Area Fruit Fly Treatment

Based on a screening-level analysis of the fruit fly treatment use, estimated acute RQs were very low (< 0.00001) and, therefore, below the Agency's LOC. While chronic RQs were not calculated, the Agency believes them to be similarly low and below the Agency's LOC. Therefore no mitigation action is required for this use.

Boll Weevil Eradication Program

Based on maximum application rates, the estimated acute RQs for the BWEP were 9.7 for non-target fish and 291 for non-target invertebrates. Estimated chronic RQs ranged from 2.3 for fish to 1123 for invertebrates. For several reasons, the Agency believes that these estimates are overestimated. First, estimated RQs were based on maximum application values (2.5 lb ai/A applied 25 times per year). Currently, the maximum application rate is 1.2 lb ai/A, and the predominantly used typical rate is 0.9 lb ai/A (>99% of treated acreage). Also, based on communications with USDA/APHIS far fewer applications are typically made in a year. Secondly, while the BWEP is an eradication program and, therefore, cannot support buffer zones, it does however require operators to identify natural water bodies as "sensitive areas," and make efforts to protect sensitive areas from off-target drift. For example, operators are advised to use ground applications to treat the edge of a field when sensitive areas are adjacent to application sites.

In addition, the Agency also recognizes that the BWEP is a time limited program, with a goal of completing the eradication phase by 2009. After such time, the use of malation through BWEP will be greatly reduced, and so to will potential exposure to non-target organisms. Reduction to potential exposure is also realized through the BWEP as the National Cotton Council estimates that areas where the boll weevil has been eradicated via the BWEP have realized a 40% – 90% reduction in insecticide use on cotton, which is in part because of the reduction in the use of malathion. For additional information on the direct and indirect benefits of the BWEP, see section section IV.E.3, Benefits of Malathion to Users.

Urban Uses

One of the risk assessment goals of the Agency is to estimate pesticide exposure through all significant routes of exposure from both agricultural and non-crop uses. However, the ecological risk assessment for malathion pesticides focuses primarily on the agricultural and wide area uses, because pesticide transport models are available to estimate potential aquatic exposure from these uses. Based on laboratory toxicity tests with aquatic animals, aquatic exposure could cause adverse effects in the environment.

Malathion is used for a number of non-crop pesticidal uses, including use as a garden insecticide and as a building perimeter treatment. As described earlier, malathion is used as a wide-area spray as a mosquito adulticide and by prescription for head-lice control.

The ecological risk assessment evaluates the head-lice control use with the "down-the-drain" model E-FAST 2.0. In these simulations, wastewater containing malathion flows from buildings in which it is used and passes through sanitary sewers and publicly owned treatment works (POTW) before being discharged to surface water. The E-FAST model uses the total national production of a pesticide and distributes it among all households in the nation. The amount of malathion produced for this use was estimated at 100 kg. The assessment uses a malathion removal efficiency at the POTW of 3%, which was estimated using the model EPISuite.

Predicted concentrations from E-FAST indicate that the head-lice control use should not pose a risk to fish and invertebrates. An acute EEC of 3.55×10^{-5} ppb was estimated based on a high-end stream dilution factor (i.e., upper 10^{th} percentile), and a chronic EEC of 2.73×10^{-6} ppb was estimated based on a median stream dilution factor (i.e., 50^{th} percentile). These EECs result in acute and chronic RQs several orders-of-magnitude below the acute, chronic and endangered species LOCs.

For outdoor urban uses, the Agency assumes that runoff water from rain and/or lawn and garden watering may transport pesticides to storm sewers and then directly to surface water. Although malathion use on lawns is not supported, it can be used on ornamentals plants, including fruit trees, and gardens. Malathion transported by runoff or erosion in an urban setting would take a path not only over lawns, but also impervious surfaces such as walkways,

driveways and streets. The Agency is unaware of any model which can simulate the different application methods for urban use and the physical representation of the urban landscape, storm sewer and receiving water configuration.

There are models available which can be calibrated to simulate sites and pesticides for which extensive flow and pollutant data have been collected in advance. The HSPF/NPSM model, for instance, which is included in the EPA's BASINS shell, has been used to calibrate stream flow and malathion pesticide use data to simulate loading of these pesticides consistent with concentrations measured in surface water monitoring. Risk assessors with the California Department of Environmental Protection confirmed in conversations with the Agency that they also have used watershed models to calibrate previously collected flow and pesticide monitoring data, but that they did not know of any models capable of predicting concentrations of pesticides that might occur because of outdoor urban uses.

Development of a screening model which could simulate the fate and transport of pesticides applied in an urban setting would require a large body of data which is currently unavailable. For instance, an urban landscape cannot be simulated as easily as an agricultural field. The PRZM model simulates runoff from an agricultural field using readily available data describing surface soil characteristics and laboratory data detailing the persistence and mobility of pesticides in these soils. The agricultural field simulated is homogenously planted to a single crop, and soil and water are transported from the field to a receiving water body with dimensions consistent with USDA farm-pond construction guidelines.

By contrast, an urban landscape or suburban housing development consists of impervious surfaces such as streets and sidewalks, and pervious surfaces such as lawns and parkland. One could expect much greater mobility for pesticides applied to impervious surfaces, but laboratory soil metabolism studies may not provide an accurate measure of the persistence of pesticides on these surfaces. The path runoff water and eroded sediment might take is less obvious for an urban setting than an agricultural field. First, an urban landscape cannot be considered homogeneous, as the proportion of impervious and pervious surfaces varies for different locations. In addition, the flow path of runoff water and sediment is not necessarily a direct path over land, but can pass below ground through storm sewer networks, be directed, or slowed by pumping stations or temporary holding ponds. Finally, the timing and magnitude of urban uses is less well defined for urban uses than agricultural uses. While agricultural uses would occur within a predictable window during the growing season, urban uses of malathion, either from home owner or from different wide area uses may the occur at different times each year, and might occur at different times within the same watershed.

The apparent difficulties in accurately characterizing surface water contamination via urban pesticide use also make it difficult to develop an urban pesticide transport model as well as identify meaningful mitigation at this time. The next opportunity to assess malathion will be through the new Registration Review program, which is expected to begin in 2007. The purpose of Registration Review is to ensure the periodic review of all pesticides to make sure they

continue to meet current scientific and regulatory requirements, with the goal of reviewing each pesticide every fifteen years. The Agency expects to begin malathion within the first several years of the Registration Review. During the interim, several actions are planned which should improve the Agency's ability to assess the level of aquatic exposure to pesticides from urban use. First, research is currently underway which is aimed at defining the conditions of urban pesticide use that may lead to greater transport. While this research is being conducted on pyrethroids, it may be applicable to malathion as well. In addition, further investigation into the dominant urban uses and application practices of malathion, as well as other pesticides, may help contribute to understanding the contribution malathion may have as a contaminant in urban runoff. Finally, the Agency will also continue in its efforts to develop a screening-level model for urban pesticide uses. Advances in the resolution of GIS databases may allow better representation of the impervious and pervious portions of a typical urban landscape. As information regarding urban pesticide use and transport becomes clearer, the conceptual model of how urban transport should be simulated will also become clearer.

Runoff from urban uses of malathion are likely to occur from either outdoor residential uses (home garden, or home perimeter), or from wide area treatments such as the public health use, or fruit fly (quarantine) uses. While it is possible that the residential use of malathion contributes to urban runoff, wide area applications are likely to result in greater deposition on impervious surfaces, such as roof tops, roads, and driveways and, therefore, lead to larger concentrations of malathion in urban runoff. While the wide area uses of malathion may be a larger contributor to urban runoff compared to the home garden uses, the benefits of the wide area uses are significant.

3. Benefits of Malathion to Users

FIFRA provides for the Agency to consider the economic, societal, and environmental costs and benefits of pesticidal use when weighing the risks associated with occupational (handler and post-application) and ecological exposures. The mitigation measures required for malathion are based on EPA's review of comments received; direct consultation with other federal departments, knowledgeable experts, and growers; close evaluation of malathion's use patterns and user pest management needs; refinements to the risk assessments where appropriate; and other information available to the Agency.

Based on Agency data, approximately 15 million pounds of malathion active ingredient are used annually in the US. A large percent of that use, almost 70%, is used on cotton as part of the USDA Boll Weevil Eradication Program. The program, which began in the late 1970s, has been the largest consumer of malathion for the past decade or so. In 2006, less than 3,000,000 acres (or approx. 20% of the US cotton acreage) remain in the active eradication phase, with 12,000,000 acres now considered weevil-free and in the post-eradication phase. The program is expected to be largely complete by 2009 with essentially 100% of US cotton acreage to be weevil-free and in the post-eradication phase. Malathion use will decline dramatically as the remaining acres in the active eradication phase of the program are declared weevil-free.

According to the National Cotton Council, in the Southeast, where the weevil has been eradicated, the combined annual direct economic benefits from increased yields, reduced insect damage and lower insect control costs are more than $80 million. Additionally, the Council estimates that by eradicating the boll weevil from the remaining infested areas, cotton growers in those states will see annual insect control costs reduced by $30 per acre and yield increases of more than 10%. Eradicated areas have realized a 40% to 90% reduction in insecticide use on cotton, which in large part is because of the reduction in the use of malathion (http://www.cotton.org/tech/pest/bollweevil/index.cfm).

For the remainder of malathion uses, two of the most frequently identified reasons it is used is its low cost when compared to alternatives and the broad spectrum of pests controlled. Further, for some use sites, malathion is perhaps the only insecticide registered, or one of only a few. According to comments received from various stakeholders, the broad spectrum of pests that malathion targets makes its use highly beneficial since the agricultural industry has been losing a number of insecticides, and the newer insecticides replacing them have chemistries that target specific insects and are narrow in their spectrum. Additionally, malathion is registered for use on over 100 crops, most of which are classified as minor crops (grown on <300,000 acres), while many of the alternative pest control options are registered on fewer crops.

Risks were identified for malathion which exceeded the Agency's LOC for certain terrestrial and aquatic organisms. With the reductions in malathion use rates and number of applications allowed per year to such a large percentage of the crop uses, combined with spray drift buffers, the Agency believes, on balance, that the benefits of malathion outweigh remaining terrestrial and aquatic organism risks. Therefore, malathion-containing products are eligible for reregistration, provided the risk mitigation measures are adopted and labels are amended accordingly.

4. Isomalathion

Isomalathion is a known impurity present as a component of malathion during the manufacturing process. The current upper certified limit of isomalathion in the technical product is 0.2% by weight. Data submitted by the technical registrant indicate that the presence of isomalathion, as a percent of the product, increases when malathion is stored under high temperatures, for long periods of time, or a combination of these two variables. Current guideline data indicate that malathion is stable for one year, at 25^0C (77^0 F) and under these conditions, the percent of isomalathion remains below the certified limit. The current storage statement recommends against product storage in temperatures above 25^0C (77^0 F). In 2004, the EPA's Office of Enforcement and Compliance Monitoring collected and analyzed product samples collected from two primary Cheminova distribution centers and found that all samples were within certified limits. However, since malathion is used in numerous markets on a national basis, storage conditions are likely to vary greatly once products leave the distribution center, and depend upon the type of product, and state or region where the product is ultimately used.

The Agency has limited toxicity data on either isomalthion alone or products containing elevated levels of isomalathion. The limited data suggests that isomalathion increases the toxicity of malathion. It is assumed, however, that the current toxicological data base on malathion reflects the presence of isomalathion up to the certified limit.

To better understand the presence and effect of isomalathion in malathion products, the Agency is requiring data and/or information to characterize the storage conditions and general life cycle of malathion products. In addition, the technical registrant has agreed to submit to the Agency existing data on the formation of isomalathion as well as a 2-year storage stability study, currently being conducted by the technical registrant to fulfill a FAO/WHO requirement. The Agency is currently reviewing a battery of acute toxicity data submitted by the technical registrant on malathion spiked with 0.4% isomalathion. Pending its review of the acute toxicity data, the Agency may require additional toxicity data on isomalathion, if necessary.

The technical registrant has also agreed to add to malathion product labels an amended storage stability statement. The amended storage statement differs from the current statement by advising against storing malathion products for long periods of time and in conditions where the temperatures are in excess of 25^0C (77^0 F).

5. Summary of Mitigation Measures

The following mitigation measures are necessary for malathion products to be eligible for reregistration:

- Reduce maximum use patterns for a large number of agricultural crops (see Tables 27 and 28):
    - 4 crop uses require reduced maximum application rates only,
    - 69 crop uses require reduced maximum allowed number of applications per year only, and
    - 29 crop uses require both reduced maximum application rates and maximum number of applications allowed per year;
- For all malathion formulations and use patterns, flaggers and applicators using motorized ground equipment are required to wear baseline PPE (long-sleeved shirt, long pants, and shoes);
- For all malathion formulations and use patterns—except those identified below—baseline PPE plus chemical-resistant gloves are required for mixers and loaders;
- Closed mixing/loading systems are required for all ULV applications and mixers and loaders are required to wear baseline PPE, chemical-resistant gloves, and chemical-resistant apron;
- All wettable powder (WP) formulations must be packaged in water soluble packaging;

- Mixers, loaders and applicators of dust (D) formulations are required to wear coveralls over long-sleeve shirt and long pants, chemical-resistant gloves, and an 80% PF (quarter-face dust/mist) respirator;
- For all dip applications, mixers, loaders and applicators are required to wear baseline PPE plus chemical-resistant gloves, and chemical-resistant apron;
- For all airblast applications applicators are required to wear baseline PPE, chemical-resistant gloves, and chemical-resistant hat;
- Enclosed cockpits are required for all aerial applications;
- REIs are extended for 46 agricultural crops (although most are 12-24 hours) (see Table 29);
- Buffer zones of 25 feet for all non-ULV applications and 50 feet for all ULV agricultural applications are required for aerial applications along all water bodies;
- Spray drift management language specific to BWEP and non-BWEP product labels are to be added; and
- An amended storage stability statement is to be added to product labels advising against storing malathion products for long periods of time and in conditions where the temperatures are in excess of 25^0C (77^0 F).

Unsupported Use Sites

The following use sites have not been included in the revised risk assessments. The Agency received and published a request from the technical registrants to delete the following uses from malathion product labels (FRL-3874-4, p. 11420). Following the publication announcing the request for use deletion, the Agency subsequently received comments indicating that the uses listed below would not be supported by any interested party. Therefore, the following uses must be removed from all end-use product labels.

- stored commodity treatment for almonds
- field or garden seeds
- feed rooms
- manure piles
- rabbits on wire
- human clothing (woolens and other fabrics)
- mattresses
- commercial and industrial uses for bagged flour
- cereal processing plants
- edible and inedible commercial establishments
- edible and inedible eating establishments
- edible and inedible food processing plants
- packaged cereals
- pet foods and feed stuff
- dairies/cheese processing plant equipment (food contact)

- forest trees (including Douglas fir, eastern pine, hemlock, larch, pines, red pine, spruce, and true fir)
- cattle feed concentrate blocks (non-medicated)
- cats
- dogs
- all direct animal and livestock treatments including (goats, hog, horse, poultry, fowl, sheep and cattle: dairy, non-dairy, lactating and non-lactating)
- animal premise and barns used for dairy and livestock
- tobacco
- stables and pens
- poultry houses
- animal kennels/sleeping quarters (commercial)
- cattle feedlots and holding pens

In addition, the following use sites/formulations have been requested for deletion by the technical registrant in a letter to the Agency dated July 25, 2006. The Agency intends to announce this request in the Federal Register in the near future.

- apples
- commercial shipping containers –feed/food- empty
- commercial storages/ warehouses premises
- commercial transportation facilities –feed/food –empty
- commercial transportation facilities –nonfeed/nonfood
- commercial/institutional/industrial premises/equipment (outdoor)
- commercial/institutional/industrial premises/equipment (indoor)
- golf course turf
- greenhouse –empty
- greenhouse –in use
- lentils
- quince
- residential lawns (broadcast)
- sewage systems
- residential pressurized can formulations
- residential dust formulations

F. Other Labeling Requirements

To be eligible for reregistration, various use and safety information will be included in the labeling of all end-use products containing malathion. For the specific labeling statements and a list of outstanding data, refer to Section V of this RED document.

1. Endangered Species Considerations

At this time, the Agency is not requiring label changes specific to the protection of listed species for malathion. If, in the future, specific measures are necessary for the protection of listed species, the Agency will implement them through the Endangered Species Protection Program. While RQs exceeded the Agency's endangered species LOC for several taxa (see Section III), these results were based on a screening-level assessment and do not constitute "may affect" findings under the Endangered Species Act.

The Agency has developed 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 address these impacts. The Endangered Species Act (ESA) requires federal agencies to ensure that their actions are not likely to jeopardize listed species or adversely modify designated critical habitat. To analyze the potential of registered pesticide uses that may affect any particular species, EPA uses basic toxicity and exposure data developed for the REDs and considers it in relation to individual species and their locations by evaluating important ecological parameters, pesticide use information, geographic relationship between specific pesticide uses and species locations, and biological requirements and behavioral aspects of the particular species, as part of a refined species-specific analysis. When conducted, this species-specific analysis will take into consideration any regulatory changes recommended in this RED being implemented at that time.

Following this future species-specific analysis, a determination that there is a likelihood of potential impact to a listed species or its critical habitat may result in: limitations on the use of malathion; other measures to mitigate any potential impact; or consultations with the Fish and Wildlife Service or the National Marine Fisheries Service as necessary. If the Agency determines that use of malathion "may affect" listed species or their designated critical habitat, EPA will employ the provisions in the Services regulations (50 CFR Part 402). Until that species-specific analysis is completed, the risk mitigation measures being implemented through this RED will reduce the likelihood that endangered and threatened species may be exposed to malathion at levels of concern. EPA is not requiring specific malathion label language at the present time relative to threatened and endangered species. If, in the future, specific measures are necessary for the protection of listed species, the Agency will implement them through the Endangered Species Protection Program.

2. Spray Drift Management

The Agency has been working closely with stakeholders to develop improved approaches for mitigating risks to human health and the environment from pesticide spray and dust drift. As part of the reregistration process, EPA will continue to work with all interested parties on this important issue.

From its assessment of malathion, as summarized in this document, the Agency concludes that certain drift mitigation measures are needed to address the risks from off-target drift for malathion, including requirements for medium to coarse droplet size, not applying when wind velocity exceeds 15 mph or into areas of temperature inversions, and other measures. Label statements implementing these measures are listed in the "spray drift management" section of the label table (Table 30) in Section V of this RED document. In the future, malathion product labels may need to be revised to include additional or different drift label statements.

In addition to generic spray drift management language to the malathion label, the Agency has required, and the technical registrant has agreed to include on non-BWEP malathion product labels the requirement of buffer zones along all water bodies of 25 feet for all non-ULV applications and a 50 feet for all ULV agricultural applications.

Finally, the Agency has worked with UDSA/APHIS to develop spray drift management language specific to the BWEP, including specifications on droplet size, wind velocity, boom length, and other measures, for inclusion on the malathion label. The full list of spray drift measures for the BWEP are listed in Table 30.

V. What Registrants Need to Do

The Agency has determined that malathion is eligible for reregistration provided that the risk mitigation measures outlined in this document are adopted and label amendments are made to reflect these measures. To implement the risk mitigation measures, the registrants will be required to amend their product labeling to incorporate the label statements set forth in the Label Summary Table in Section C below. In the near future, the Agency intends to issue Data Call-In (DCI) Notices requiring label amendments, product-specific data and additional generic (technical grade) data. Generally, registrants will have 90 days from receipt of a DCI to complete and submit response forms or request time extension and/or waiver requests with a full written justification. For product-specific data, the registrant will have eight months to submit data and amended labels. For generic data, due dates can vary depending on the specific studies being required. Below are tables of additional generic data and label amendments that the Agency intends to require for malathion to be eligible for reregistration.

A. Manufacturing-Use Products

1. Generic Data Requirements

The generic data base supporting the reregistration of malathion has been reviewed and determined to be substantially complete. However, the Agency has identified data necessary to confirm the reregistration eligibility decision for malathion. These studies are listed below and will be included in the generic DCI for this RED, which the Agency intends to issue at a future date.

Guideline No.	Study Title
870.7800	Immunotoxicity study with malathion
835.4300	Aerobic aquatic metabolism with malathion
835.4300	Aerobic aquatic metabolism with malaoxon
Special study:	Conversion of malathion to malaoxon on hard dry surfaces
81-8-SS	Comparative ChE study with malathion and malaoxon (previously required 10/2004)
860.1500	Field crop trials (various crops where data are necessary to support the established tolerance)

2. Labeling for Manufacturing-Use Products

To ensure compliance with FIFRA, manufacturing-use product (MP) labeling should be revised to comply with all current EPA regulations, PR Notices, and applicable policies. The MP labeling should bear the labeling contained in Table 30.

B. End-Use Products

1. Additional Product-Specific Data Requirements

Section 4(g)(2)(B) of FIFRA calls for the Agency to obtain any needed product-specific data regarding the pesticide after a determination of eligibility has been made. Registrants must review previous data submissions to ensure that they meet current EPA acceptance criteria and, if not, commit to conduct new studies. If a registrant believes that previously submitted data meet current testing standards, then the study MRID numbers should be cited according to the instructions in the Requirement Status and Registrants Response Form provided for each product. The Agency intends to issue a separate product-specific data call-in (PDCI), outlining specific product-specific data requirements.

2. Labeling for End-Use Products

To be eligible for reregistration, labeling changes are necessary to implement measures outlined in Section IV above. Specific language to incorporate these changes is specified in Table 30. Generally, conditions for the distribution and sale of products bearing old labels/labeling will be established when the label changes are approved. However, specific existing stocks time frames will be established case-by-case, depending on the number of products involved, the number of label changes, and other factors.

C. Labeling Changes Summary Table

For malathion to be eligible for reregistration, all malathion labels must be amended to incorporate the risk mitigation measures outlined in Section IV. Table 30 describes specific label amendments.

Table 30. Labeling Changes Summary Table.

To Be Developed