Risks of Metam Sodium Use to Federally Listed Threatened California Red Legged Frog
(*Rana aurora draytonii*)

Pesticide Effects Determination

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1.0 Executive Summary

The purpose of this assessment is to evaluate potential direct and indirect effects on the California red-legged frog *(Rana aurora draytonii*) (CRLF) arising from FIFRA regulatory actions regarding use of metam sodium on agricultural and non-agricultural sites. In addition, this assessment evaluates whether these actions can be expected to result in the destruction or adverse modification of the species' designated critical habitat. This assessment was completed in accordance with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) *Endangered Species Consultation Handbook* (USFWS/NMFS, 1998 and procedures outlined in the Agency's Overview Document (U.S. EPA, 2004).

The CRLF was listed as a threatened species by USFWS in 1996. The species is endemic to California and Baja California (Mexico) and inhabits both coastal and interior mountain ranges. A total of 243 streams or drainages are believed to be currently occupied by the species, with the greatest numbers in Monterey, San Luis Obispo, and Santa Barbara counties (USFWS 1996) in California.

Metam sodium (sodium-N-methyl dithiocarbamate) degrades rapidly in soil to generate methyl isothiocyanate (MITC), a volatile biocide active product to control weeds, nematodes and various soil-borne pathogens. The high vapor pressure and low affinity for sorption on soil of MITC suggest that volatilization is the most important environmental route of dissipation. Once MITC volatilizes into the atmosphere, it degrades rapidly due to direct photolysis. MITC is also highly soluble in water and has low adsorption in soil, it can potentially leach into ground water and transport to surface water through runoff under a flooded condition. It is registered for use on all crops and on many non-crop areas. Metam sodium is typically applied once per growing season through soil injection or irrigation to fumigate the upper six to twelve inches of soil a number of weeks prior to planting annual crops. For perennial trees, metam sodium is applied only once per life cycle of tree.

Environmental fate and transport models were used to estimate high-end exposure values expected to occur in the CRLF action area as a result of agricultural and non-agricultural metam sodium use in accordance with label directions. Since CRLF exist within aquatic and terrestrial habitats, exposures to the CRLF, its prey and its habitats are assessed separately for the two habitats. Two application methods are assessed to determine the effects of MITC on the CRLF in the aquatic environment. The methods are subsurface fumigation via shank injection, or drip irrigation and surface application using sprinkler irrigation. The effects of MITC on CRLF due to surface and subsurface fumigations will be evaluated.

Since metam sodium degrades rapidly to MITC upon application to the soil, the risk assessment is based on organism exposure to off-gassed MITC and aquatic MITC residues in surface water. Comparison of available toxicity information for MITC indicates greater aquatic toxicity than the metam sodium parent for freshwater invertebrates, and aquatic plants. Pesticide Root Zone Model/Exposure Analysis Modeling System (PRZM/EXAMS) modeled concentrations of MITC provide the estimates of exposure in a static water body, which are intended to represent metam sodium and MITC concentrations transported with runoff water to potential CRLF aquatic habitat. Industrial Source Complex: Short-Term Model (ISCST3) estimated downwind air concentrations of MITC from metam sodium application which are used for terrestrial organisms.

Due to the environmental fate properties of MITC, the focus for terrestrial exposure is inhalation. Due to the absence of amphibian toxicity data, birds are used as a surrogate for the terrestrial phase CRLF. Although birds are more protective of the CRLF, no acceptable bird inhalation toxicity data is available, therefore mammals are used as a surrogate for CRLF to estimate the inhalation risks to the terrestrial phase CRLF and as surrogates for small mammals in their diet. Indirect risks to terrestrial-phase CRLF for their potential habitats can not be estimated due to lack of terrestrial plant data as studies prepared under OPPTS test guidelines or open literature for MITC. Since MITC is a volatile chemical, the dietary exposure of terrestrial-phase CRLF is considered to be sufficiently low to be of no risk.

The CRLF direct toxic effects include survival, growth and reproduction assessment endpoints. Freshwater fish are generally used as an amphibian surrogate for direct effects in the aquatic habitat, so toxicity information for freshwater fish will be used in this assessment. Only acute freshwater fish data is available. Due to unacceptable open literature studies, no growth or reproductive effects will be determined for this assessment.

Birds are usually used as an amphibian surrogate for direct effects in the terrestrial habitat due to the higher level of protection provided. However, no MITC bird data is available, including no inhalation studies. This assessment will use inhalation mammal studies to assess terrestrial phase CRLF direct effects of MITC exposure.

This assessment will also determine indirect effects of prey and habitat modification from MITC exposure in both aquatic and terrestrial habitats. Aquatic phase CRLF prey items are dependent on fish, aquatic invertebrates and non-vascular aquatic plants. Toxicity information for acute studies from aquatic invertebrates and plants will be discussed. Terrestrial phase CRLF indirect effects for prey are assessed by considering effects to terrestrial insects and small mammals.

Indirect effects for the CLRF are determined by assessing modification of critical habitat as an indirect effect for the CRLF. Primary constituent elements (PCEs) are used to describe modifications to critical habitat. PCEs include, but are not limited to, space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements, cover or shelter, sites for breeding, reproduction, rearing/development of offspring; and habitats that are protected from disturbance or are representative of the historic geographical and ecological distribution of a species. The designated critical habitat areas for the CRLF are considered to have the following PCEs that justify critical habitat designation:

Breeding aquatic habitat;
Non-breeding aquatic habitat;
Upland habitat; and
Dispersal habitat.

Aquatic phase CRLF critical habitat is dependent on aquatic plants. Vascular and non-vascular plant registrant studies have been submitted and are used to determine modification of CRLF critical habitat.

Terrestrial phase CRLF indirect effects for modification of critical habitat are characterized by available data for monocots and dicots. No terrestrial plant guideline studies are available.

Risk quotients (RQs), quantitative estimates of potential high risk, are derived from available registrant submitted studies or acceptable open literature studies used quantitatively. Acute and chronic RQs are compared to the Agency's levels of concern (LOCs) for Federally-listed threatened species and non-listed species to identify if metam sodium use within the action area has direct or indirect effects on the CRLF.

For those effects with a "may affect" determination", further refinements are estimated using the probit slope model for individual effects and GIS modeling for overlapping areas. Aquatic habitat overlapping areas are determined from the GIS downstream model. Terrestrial habitat overlapping areas are determined from GIS use data.

Table 1.1 describes the risk conclusions for direct and indirect effects for the aquatic and terrestrial phase CRLF. Two application methods are described for each assessment endpoint.

Table 1.1 Effects Determination Summary for Direct and Indirect Effects of MITC on the California Red-legged Frog

Assessment Endpoint	Effects Determination		Basis
Aquatic-Phase Effects (Eggs, Larvae, Tadpoles, Adults)			
	Application Methods		
	Sprinkler Irrigation	Shank Injection	
Direct Effects of MITC on the Aquatic Phase CRLF			
Survival of CRLF individuals via direct effects on aquatic phases (Surrogate Fish)	Aquatic vertebrates (fish) May affect, LAA: Six modeled crops (strawberry, tomato, lettuce, turf,	Aquatic vertebrates (fish) No Effect: Modeled crops (strawberry, tomato, lettuce, turf, nursery,	*Sprinkler Application*: For the sprinkler irrigation application method the risk conclusion is supported by listed species LOC exceedence for "May affect". LAA based on individual effects results and exposure overlap from the downstream model for the surrogate fish for six modeled crops.

Table 1.1 Effects Determination Summary for Direct and Indirect Effects of MITC on the California Red-legged Frog			
Assessment Endpoint	Effects Determination		Basis
	nursery and onion) No Effect; Three modeled crops (potato, row crops and melon)	onion, potato, row crops and melon	RQs of three modeled crops (potato, row crops and melon) do not exceed listed species LOC. *Shank Injection Application:* For the shank injection application method, the risk conclusion is based on no LOC exceedence for any of the nine modeled crops.
Reproduction (Embryos)	No Effect	No Effect	No Effect conclusion supported by MITC physio-chemical characteristics, volatilization and fate transport for chronic exposure. Due to absence of prey and vegetation to provide shelter and predator protection, CRLF not anticipated to be at application site, which has highest concentration.
Growth	No Effect	No Effect	No Effect conclusion supported by MITC physio-chemical characteristics, volatilization and fate transport for chronic exposure. Due to absence of prey and vegetation to provide shelter and predator protection, CRLF not anticipated to be at application site, which has highest concentration. .
Reduction of Prey as Indirect Effects of MITC on the Aquatic Phase CRLF			
Survival, growth, and reproduction of CRLF individuals via effects on prey (*i.e., aquatic* vertebrates and amphibians)	Aquatic vertebrates (fish): May affect: Modeled crops: strawberry, tomato, lettuce, turf, nursery and onion LAA Effect: strawberry, tomato,	Aquatic vertebrates (fish) No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon	*Sprinkler Application:* Risk conclusion supported by listed species LOC exceedence for fish and aquatic invertebrates for "May affect". LAA based on individual effects results and downstream model exposure results for the surrogate fish for four modeled crops. LOCs for nursery and onion fall between listed species and acute LOCs. NLAA for nursery supported by RQ resulting in 5.9% effect. lack of food

Table 1.1 Effects Determination Summary for Direct and Indirect Effects of MITC on the California Red-legged Frog			
Assessment Endpoint	Effects Determination		Basis
	lettuce, turf NLAA: nursery and onion No Effects: potato, row crops and melon		item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. NLAA for onion supported by RQ resulting in a low probability of 1 in 9.88 x 10^6, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. No effect for potato, row crops and melon based on no LOC exceedence. *Shank Injection Application:* For the shank injection application method, the risk conclusion is based on no LOC exceedence for the fish for all nine of the modeled crops
Survival, growth, and reproduction of CRLF individuals via effects to food supply (*i.e.,* freshwater invertebrates, non-vascular plants)	Aquatic invertebrates: May Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery and onion) LAA for strawberry, tomato, lettuce and turf. NLAA for nursery and onion. No effect for potato, row crops and melon	Aquatic invertebrates: No Effect Modeled crops (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon	*Sprinkler Irrigation Application:* Risk conclusion supported by listed species LOC exceedence for aquatic invertebrates for “May affect”. LAA based on individual effects results and downstream model exposure results for the aquatic invertebrates for four modeled crops. LOCs for nursery and onion fall between listed species and acute LOCs. NLAA for nursery supported by RQ resulting in 4.5% effect, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. NLAA for onion supported by RQ resulting in a low probability of 1 in 2,510,000, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC.

Table 1.1 Effects Determination Summary for Direct and Indirect Effects of MITC on the California Red-legged Frog			
Assessment Endpoint	Effects Determination		Basis
	Aquatic non-vascular plants: No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon	Aquatic non-vascular plants: No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon	No Effect for potato, row crops and melon based on no LOC exceedence. For the sprinkler irrigation application method, the risk conclusion is based on no LOC exceedence for aquatic plants. *Shank Injection Application*: For the shank injection application method, the risk conclusion is based on no LOC exceedence for aquatic invertebrates and aquatic plants.
Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat, cover, and/or primary productivity (*i.e.,* aquatic plant community)	Aquatic plants No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon)	Aquatic plants No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon)	Risk conclusion supported by no LOC exceedence for aquatic plants for both application methods for all nine modeled crops.
Habitat as Indirect Effect of MITC on the Aquatic Phase CRLF			
Survival, growth, and reproduction of CRLF individuals via effects to riparian vegetation, required to maintain acceptable water quality and habitat in ponds and streams comprising the species' current range	Aquatic Plants No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row	Aquatic Plants No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row	Risk conclusion supported by no LOC exceedence for aquatic plants for both application methods for all nine modeled crops.

<table>
<tr><td colspan="4">Table 1.1 Effects Determination Summary for Direct and Indirect Effects of MITC on the California Red-legged Frog</td></tr>
<tr><td>Assessment Endpoint</td><td colspan="2">Effects Determination</td><td>Basis</td></tr>
<tr><td></td><td>crops and melon

Terrestrial Plants:

May Effect, LAA</td><td>crops and melon

Terrestrial Plants:

May affect, LAA</td><td>No terrestrial plant guideline studies have been submitted. No open literature is available to calculate RQs. Risk determination of may affect is due to the uncertainty from the limited data as the most conservative determination for both application methods.
.</td></tr>
<tr><td colspan="4">Terrestrial Phase Effects Using Both Shank Injection and Sprinkler Irrigation Application Methods (Juveniles and adults)</td></tr>
<tr><td rowspan="2"></td><td colspan="2">Application Methods</td><td rowspan="2"></td></tr>
<tr><td>Sprinkler Irrigation</td><td>Shank Injection</td></tr>
<tr><td colspan="4">Direct Effects of MITC on Terrestrial Phase CRLF</td></tr>
<tr><td>Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles</td><td>Terrestrial vertebrates (mammals)

No Effect</td><td>Terrestrial vertebrates (mammals)

No Effect</td><td>MITC inhalation RQs do not exceed LOCs for direct effects using mammals as a surrogate. Risk conclusions supported by RQs for mammal inhalation for both application methods</td></tr>
<tr><td colspan="4">Reduction of Prey as Indirect Effects of MITC on the terrestrial Phase CRLF</td></tr>
<tr><td>Survival, growth, and reproduction of CRLF individuals via effects on prey (i.e., small terrestrial vertebrates, including mammals and terrestrial phase amphibians)</td><td>Terrestrial vertebrates (mammals)

No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon</td><td>Terrestrial vertebrates (mammals)

No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon</td><td>MITC inhalation RQs do not exceed LOCs for terrestrial vertebrates. Risk conclusions supported by RQ for terrestrial vertebrates (mammals) for both application methods.</td></tr>
<tr><td>Survival, growth, and reproduction of CRLF individuals via effects on prey (i.e., terrestrial invertebrates)</td><td>Terrestrial invertebrates:

May affect, LAA</td><td>Terrestrial invertebrates:

May affect, LAA</td><td>No terrestrial invertebrate guideline studies have been submitted. No open literature is available to calculate RQs. Risk determination of may affect is due to the uncertainty from limited data as the most conservative determination for both application methods.
.</td></tr>
</table>

Table 1.1 Effects Determination Summary for Direct and Indirect Effects of MITC on the California Red-legged Frog			
Assessment Endpoint	Effects Determination		Basis
Habitat as Indirect Effect of MITC on the Terrestrial Phase CRLF			
Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat (*i.e.,* riparian vegetation)	Terrestrial plants: May affect, LAA	Terrestrial plants: May affect, LAA	No terrestrial plant guideline studies have been submitted. No open literature is available to provide data for RQs. Risk determination of May affect, Likely to Adversely Affect is due to the uncertainty from limited data as the most conservative determination.

Table 1.2 Effects Determination Summary for the Critical Habitat Impact Analysis

Assessment Endpoint	Effects Determination		Basis
Aquatic Phase Primary Constituent Elements (PCEs) Using Sprinkler Irrigation and Shank Injection Application Methods (Aquatic breeding Habitat and Aquatic Non-breeding Habitat)			
	Application Methods		
	Sprinkler Irrigation	Shank Injection	
Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond: aquatic habitat (including riparian vegetation) provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs.	Aquatic Plants: No Habitat Modification Terrestrial plants: Habitat Modification	Aquatic Plants: No Habitat Modification Terrestrial plants: Habitat Modification	Aquatic plant RQs for both application methods do not exceed LOCs for any of the nine modeled crops. Risk determination is based on no LOC exceedence. No registrant terrestrial plant guideline studies have been submitted for MITC. No open literature is available for determining RQs for terrestrial plants. Habitat modification risk conclusion is based on the uncertainty due to limited data for MITC for both application methods.

Table 1.2 Effects Determination Summary for the Critical Habitat Impact Analysis

Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source[1].	Aquatic vertebrates (fish): Habitat Modification: Modeled crops: (strawberry, tomato, lettuce, turf) No Habitat modification: nursery and onion No habitat modification: potato, row crops and melon	Aquatic vertebrates (fish): No Habitat Modification : Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon)	*Sprinkler Application:* Risk conclusion supported by listed species LOC exceedence for fish. Habitat modification based on individual effects results and downstream model exposure results for the surrogate fish for four modeled crops. LOCs for nursery and onion fall between listed species and acute LOCs. No habitat modification for nursery supported by RQ resulting in 5.9% effect, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. No habitat modification for onion supported by RQ resulting in a low probability of 1 in 9.88×10^6, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. No habitat modification for potato, row crops and melon based on no LOC exceedence. *Shank Injection Application:* For the shank injection application method, the risk conclusion is based on no LOC exceedence for the fish for all nine of the modeled crops

Table 1.2 Effects Determination Summary for the Critical Habitat Impact Analysis

	Aquatic invertebrates: Habitat Modification Modeled crops: (strawberry, tomato, lettuce and turf.) No Habitat Modification for nursery and onion. No Habitat Modification for potato, row crops and melon	Aquatic invertebrates: No Habitat Modification Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon	*Sprinkler Irrigation Application:* Risk conclusion supported by listed species LOC exceedence for aquatic invertebrates. Habitat modification based on individual effects results and downstream model exposure results for the aquatic invertebrates for four modeled crops. LOCs for nursery and onion fall between listed species and acute LOCs. No habitat modification for nursery supported by RQ resulting in 4.5% effect, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. No habitat modification for onion supported by RQ resulting in a low probability of 1 in 2,510,000, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. No habitat modification for potato, row crops and melon based on no LOC exceedence. *Shank Injection Application*: For the shank injection application method, the risk conclusion is based on no LOC exceedence for aquatic invertebrates and plants.

Table 1.2 Effects Determination Summary for the Critical Habitat Impact Analysis

	Aquatic non-vascular plants: No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon)	Aquatic non-vascular plants: No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon)	*Sprinkler Application* For the sprinkler irrigation application method, the risk conclusion is based on no LOC exceedence for aquatic plants. *Shank Injection Application*: For the shank injection application method, the risk conclusion is based on no LOC exceedence for aquatic plants for both application methods.

Table 1.2 Effects Determination Summary for the Critical Habitat Impact Analysis

Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source. Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.*, algae)	Aquatic vertebrates (fish): Habitat Modification: Modeled crops: (strawberry, tomato, lettuce, turf) No Habitat Modification: nursery and onion No Habitat Modification: potato, row crops and melon	Aquatic vertebrates (fish) No Habitat Modification: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon)	*Sprinkler Application:* Risk conclusion supported by listed species LOC exceedence for fish. Habitat modification based on individual effects results and downstream model exposure results for the surrogate fish for four modeled crops. LOCs for nursery and onion fall between listed species and acute LOCs. No habitat modification for nursery supported by RQ resulting in 5.9% effect, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. No habitat modification for onion supported by RQ resulting in a low probability of 1 in 1 in 9.88×10^6, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. No habitat modification for potato, row crops and melon based on no LOC exceedence. *Shank Injection Application:* For the shank injection application method, the risk conclusion is based on no LOC exceedence for the fish for all nine of the modeled crops

Table 1.2 Effects Determination Summary for the Critical Habitat Impact Analysis

	Aquatic invertebrates: Habitat Modification: Modeled crops: (strawberry, tomato, lettuce and turf.) No Habitat Modification for nursery and onion. No Habitat Modification for potato, row crops and melon	Aquatic invertebrates: No Habitat Modification Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon	*Sprinkler Irrigation Application:* Risk conclusion supported by listed species LOC exceedence for aquatic invertebrates. Habitat modification based on individual effects results and downstream model exposure results for the aquatic invertebrates for four modeled crops. LOCs for nursery and onion fall between listed species and acute LOCs. No habitat modification for nursery supported by RQ resulting in 4.5% effect, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. No habitat modification for onion supported by RQ resulting in a low probability of 1 in 2,510,000, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. No habitat modification for potato, row crops and melon based on no LOC exceedence. *Shank Injection Application*: For the shank injection application method, the risk conclusion is based on no LOC exceedence for aquatic invertebrates and plants.

Table 1.2 Effects Determination Summary for the Critical Habitat Impact Analysis

	Aquatic non-vascular plants: No Habitat Modification: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon)	Aquatic non-vascular plants: No Habitat Modification Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon)	*Sprinkler Irrigation Application* For the sprinkler irrigation application method, the risk conclusion is based on no LOC exceedence for aquatic plants. *Shank Injection Application*: For the shank injection application method, the risk conclusion is based on no LOC exceedence for aquatic plants for both application methods.
Terrestrial Phase Primary Constituent Elements (PCEs) (Upland Habitat and Dispersal Habitat)			
	Application Methods		
	Sprinkler Irrigation	Shank Injection	
Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs: Upland areas within 200 ft of the edge of the riparian vegetation or dripline surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that provides the CRLF shelter, forage, and predator avoidance	Terrestrial plants: Habitat Modification	Terrestrial plants Habitat Modification	No terrestrial plant guideline studies have been submitted. No open literature is available to calculate RQs. Risk determination of habitat modification is due to the uncertainty from limited data as the most conservative determination. .
Elimination and/or disturbance of dispersal habitat: Upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal	Terrestrial plants: Habitat Modification	Terrestrial plants: Habitat Modification	No terrestrial plant guideline studies have been submitted. No open literature is available to calculate RQs. Risk determination of habitat modification is due to the uncertainty from limited data as the most conservative determination.
Terrestrial Phase PCEs Base (Upland Habitat and Dispersal Habitat)			
Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source. Reduction and/or	Terrestrial Vertebrate: No Habitat Modification	Terrestrial Vertebrate: No Habitat Modification	The MITC RQ for small mammals does not exceed the LOC. Risk conclusions for aquatic invertebrate and the terrestrial mammal prey are based on the RQs for both

Table 1.2 Effects Determination Summary for the Critical Habitat Impact Analysis

modification of food sources for terrestrial phase juveniles and adults.	Terrestrial invertebrates: Habitat Modification Terrestrial plants: Habitat Modification	Terrestrial invertebrates: Habitat Modification Terrestrial plants: Habitat Modification	application methods. No terrestrial invertebrate guideline studies have been submitted. No open literature is available to calculate RQs. Risk determination of habitat modification is due to the uncertainty from limited data as the most conservative determination for both application methods. No terrestrial plant guideline studies have been submitted. No open literature is available to calculate RQs. Risk determination of habitat modification, is due the uncertainty from the limited data for both application methods.
[1] Physico-chemical water quality parameters such as salinity, pH, and hardness are not evaluated because these processes are not biologically mediated and, therefore, are not relevant to the endpoints included in this assessment.			

1.1 Direct Survival Effects and Indirect Effects on Prey for Metam Sodium Exposure:

Table 1.1 summarizes both direct effects of survival and indirect effects on prey based on estimated environmental concentrations from MITC exposure for the CRLF. Both aquatic and terrestrial phase CRLF effects are represented by two currently registered application methods for metam sodium, sprinkler irrigation and shank injection.

1.1.1 Direct Survival and Indirect Effects of Prey for Metam Sodium Sprinkler Irrigation Application Method:

There are no anticipated chronic effects of reproduction or growth based on the short- term exposure period anticipated from the physio-chemical properties of MITC for both application methods and for aquatic and terrestrial phase CRLF. No detected MITC residues in soil after 14 days. Due to the volatility and photodegradation properties of MITC the concentration is anticipated to decrease over time. Although the study is limited by information that is not reported, it indicates no notochord damage from a sample of 60 developing embryos for *Xenopus* after 10 days at MITC concentrations ranging from 1-50 µg/L. Severe notochord damage was reported for concentration ranging from 100-500 µg/L. (Birch and Prahlad, 1986). The peak modeled concentration EEC for shank injection was 0.6 µg/L and for sprinkler irrigation was 59.4. µg/L.

Aquatic Phase Effects:

Direct Effects on the Aquatic Phase CRLF (Surrogate Fish):

The risk conclusions for survival of the aquatic phase CRLF for the nine modeled crops described below are described in Table 1.1. Aquatic phase direct survival effect RQs for the surrogate fish do not exceed the listed species LOC set by the Agency for three of the modeled crops, potato, row crops and melon. The "may affect" conclusion is based on the LOC exceedence for six of the nine modeled crops (strawberry, tomato, lettuce, turf, nursery and onion). The downstream high concentrations overlapping the species habitat are estimated from the GIS Downstream Model defining the action area for the aquatic phase CRLF. The No effect conclusion for potato, row crops and melon is supported by no LOC exceedence.

Indirect Effects on Aquatic Phase CRLF (Surrogate Fish):

The risk conclusions for MITC indirect effect of prey reduction based on the surrogate fish for aquatic vertebrates for the aquatic phase indirect effects are shown in Table 1.1 There was no RQ exceedence for three modeled crops, potato, row crops and melon, resulting in a "No Effect" conclusion. . The listed species LOC exceedence for aquatic vertebrates supports a "may affect" conclusion for six modeled crops, strawberry, tomato, lettuce, turf, nursery and onion. The downstream high concentrations overlapping the species habitat are estimated from the GIS Downstream Model defining the action area for the aquatic phase CRLF. Refinements result in a "likely to adversely affect" conclusion based on the individual effects estimates for four modeled crops, strawberry, tomato, lettuce and turf which exceed the listed species LOC.

Risk quotients for nursery and onion fall between the listed species effect/no effect threshold and the non-listed species acute risk threshold. Consequently, further analysis was conducted to determine if the estimated levels of risk would be likely to adversely affect individual frogs. To accomplish this analysis the following topics were considered:

- The Severity and magnitude of the predicted effects on individuals of the affected taxa making up a potential food source for the frog
- The importance of those food items in the diet of the frog, and
- The pattern of pesticide use and the likelihood that effects on food items will occur over multiple days

Severity and Magnitude:

Predicted risks are associated with lethal effects on rainbow trout as a surrogate for aquatic vertebrates. Lethal responses have the potential to remove individual prey items from the resource base available to the frog, assuming that frogs are most likely to actively feed on living prey. Using the available RQ and the dose response relationship for the tested organisms, available probit interpolation tools suggest that exposures associated with the RQ would result in a 5.9 percent reduction in survival in the most sensitive tested species. If it is assumed that this laboratory effect is representative of all species within the taxanomic group, the percent effect may be extrapolated to other species comprising food resources for the species. Because metam sodium data base is limited in the breadth of species tested, this assumption may or may not be highly conservative.

Importance of Food items to the Frog:

While there are some qualitative discussions of the variety of dietary items in the frog's diet, data on the quantitative distribution of species or taxa in the frog's diet are unavailable. Lacking these data, it can be conservatively assumed that any given taxa could account for the majority or even the entirety of a frog's diet in any given day or progression of several days.

Pattern of Pesticide Use:

Pre plant fumigation normally occurs1 to 2 week prior to planting. Metam sodium is highly unstable in the environment, degrading rapidly to form MITC. Henry's Law constant (1.79 x 10^{-4} atm-m^3/mol) of MITC suggests that rapid volatilization of MITC from water and a soil surface is expected to be an important process of dissipation. Terrestrial field dissipation study also indicates that metam sodium and MITC residues were not detected in soils after 14 days. The physico-chemical and environmental fate data suggesting that the compound is highly transient. Therefore the effect associated with the use of the pesticide would involve small windows of use and only for limited periods of time after application. It is highly unlikely that individual frogs would occur in areas with long term exposure at levels where prey items will be continually suppressed.

Conclusion:

The above analysis suggests that risks associated with metam sodium use for nursery and onions for the indirect effect of prey reduction for aquatic vertebrates, fish, is confined to low levels of mortality, even when conservatively assuming that all observed effect levels will occur in all potentially exposure prey species and the taxanomic group is conservatively assumed to be the only utilized group at any given time. Combining these low expected effects with the transient and time-limited nature of expected exposures results in a conclusion that predicted effects are not likely to adversely affect individual frogs.

Indirect Effect on Aquatic Phase CRLF (Invertebrates, Non-vascular Plants):

The risk conclusions for MITC indirect effect of prey based on the surrogate *daphnia* for aquatic invertebrates for the aquatic phase indirect effects are shown in Table 1.1 There was no RQ exceedence for three modeled crops, potato, row crops and melon, resulting in a "No Effect" conclusion. . The listed species LOC exceedence for aquatic invertebrates supports a "may

affect" conclusion for six modeled crops, strawberry, tomato, lettuce, turf, nursery and onion. The downstream high concentrations overlapping the species habitat are estimated from the GIS Downstream Model defining the action area for the aquatic phase CRLF. Refinements result in a "likely to adversely affect" conclusion based on the individual effects estimates for four modeled crops, strawberry, tomato, lettuce and turf which exceed the listed species LOC.
Risk quotients for nursery and onion fall between the listed species effect/no effect threshold and the non-listed species acute risk threshold. Consequently, further analysis was conducted to determine if the estimated levels of risk would be likely to adversely affect individual frogs. To accomplish this analysis the following topics were considered:

- The Severity and magnitude of the predicted effects on individuals of the affected taxa making up a potential food source for the frog
- The importance of those food items in the diet of the frog, and
- The pattern of pesticide use and the likelihood that effects on food items will occur over multiple days

Severity and Magnitude:

Predicted risks are associated with lethal effects on rainbow trout as a surrogate for aquatic vertebrates. Lethal responses have the potential to remove individual prey items from the resource base available to the frog, assuming that frogs are most likely to actively feed on living prey. Using the available RQ and the dose response relationship for the tested organisms, available probit interpolation tools suggest that exposures associated with the RQ would result in a 4.5 percent reduction in survival in the most sensitive tested species. If it is assumed that this laboratory effect is representative of all species within the taxanomic group, the percent effect may be extrapolated to other species comprising food resources for the species. Because metam sodium data base is limited in the breadth of species tested, this assumption may or may not be highly conservative.

Importance of Food items to the Frog:

While there are some qualitative discussions of the variety of dietary items in the frog's diet, data on the quantitative distribution of species or taxa in the frog's diet are unavailable. Lacking these data, it can be conservatively assumed that any given taxa could account for the majority or even the entirety of a frog's diet in any given day or progression of several days.

Pattern of Pesticide Use:

Pre plant fumigation normally occurs 1 to 2 week prior to planting. Metam sodium is highly unstable in the environment, degrading rapidly to form MITC. Henry's Law constant (1.79×10^{-4} atm-m^3/mol) of MITC suggests that rapid volatilization of MITC from water and a soil surface is expected to be an important process of dissipation. Terrestrial field dissipation study also indicates that metam sodium and MITC residues were not detected in soils after 14 days. The physico-chemical and environmental fate data suggesting that the compound is highly transient. Therefore the effect associated with the use of the pesticide would involve small windows of use and only for limited periods of time after application. It is highly unlikely that individual frogs would occur in areas with long term exposure at levels where prey items will be continually suppressed.

Conclusion:

The above analysis suggests that risks associated with metam sodium use for nursery and onions for the indirect effect of prey reduction for *daphnia* is confined to low levels of mortality, even when conservatively assuming that all observed effect levels will occur in all potentially exposure prey species and the taxanomic group is conservatively assumed to be the only utilized group at any given time. Combining these low expected effects with the transient and time-limited nature of expected exposures results in a conclusion that predicted effects are not likely to adversely affect individual frogs.

The aquatic phase CRLF diet also includes aquatic non-vascular plants. The "No Effect" conclusion is supported by no LOC exceedence for non-vascular aquatic plants.

Indirect Effects on Aquatic Phase CRLF (habitat cover, primary productivity):

The risk conclusions for MITC exposure on indirect effects on habitat, cover and/or primary productivity (aquatic plant community) for the aquatic phase CRLF are shown in the Table. The "No Effect" conclusion is supported by no LOC exceedence for vascular and non-vascular aquatic plants.

Indirect Effects on Aquatic Phase CRLF (riparian vegetation):

The risk conclusions for MITC exposure on indirect effects on riparian vegetation for the aquatic phase CRLF are shown in Table 1.1. The conclusion of "may affect, likely to adversely affect" is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted studies or accepted open literature studies for crops were available for this assessment.

Terrestrial Phase Exposure:

Direct and Indirect Effects on Terrestrial Phase CRLF (vertebrates, invertebrates, and riparian vegetation):

The RQ for terrestrial direct survival effects from MITC inhalation exposure based on the surrogate mammal (rat) was below the LOC. The"No Effect" determination was based on no LOC exceedence.

The terrestrial phase CRLF diet includes small terrestrial mammals and terrestrial invertebrates. Indirect prey reduction effects are estimated for surrogates for each category represented in the diet.

The RQ for terrestrial indirect prey reduction effects from MITC inhalation exposure based on the surrogate mammal (rat) was below the LOC. The"No Effect" determination was based on the RQ not exceeding the LOC.

"May affect, likely to adversely affect" conclusion for the terrestrial phase CRLF for indirect effects of terrestrial invertebrate reduced prey is based on the uncertainty due to limited data and is the most conservative determination. No registrant submitted guideline studies or accepted open literature studies were available for this assessment.

"May affect, likely to adversely affect" conclusion for terrestrial phase CRLF for indirect effects on habitat (riparian vegetation) was based on uncertainty due to limited data and is the most conservative determination. No registrant submitted guideline studies or accepted open literature studies were available for this assessment.

1.1.2 Direct Survival Effects and Indirect Prey Reduction Effects for Metam Sodium Shank Injection Application Method:

Aquatic Phase Exposure:

The risk conclusions for the shank injection application method for direct and indirect effects of MITC exposure for the aquatic and terrestrial phase CRLF are shown in Table 1.1. RQs include estimates from the modeled crops of strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon for both direct and indirect effects. Aquatic phase direct survival effect RQs for the nine modeled crops for the surrogate fish do not exceed the LOC set by the Agency. The "No Effect" conclusion is based on no LOC exceedence.

The risk conclusions for MITC exposure on prey reduction of aquatic vertebrates, fish, for the aquatic phase indirect effects are shown in Table 1.1. The "No Effect" conclusion is based no LOC exceedence.

The risk conclusions for MITC exposure on prey reduction of aquatic invertebrates for the aquatic phase indirect effects are shown in Table 1.1. The "No Effect" conclusion is based no LOC exceedence.

The aquatic phase CRLF diet also includes aquatic non-vascular plants. The “No Effect” conclusion is supported by no LOC exceedence for non-vascular aquatic plants.

The risk conclusions for MITC exposure on indirect effects on habitat, cover and/or primary productivity (aquatic plant community) for the aquatic phase CRLF are shown in Table 1.1. The “No Effect” conclusion is supported by no LOC exceedence for vascular and non-vascular aquatic plants.

Terrestrial Phase Exposure:

The RQs for terrestrial direct survival effects from MITC inhalation exposure based on the surrogate mammal (rat) were below the LOC. The”No Effect” determination was based on no LOC exceedence.

In addition to the terrestrial phase direct survival effects determination, the indirect effects of prey reduction were determined. Prey items include small terrestrial mammals and terrestrial invertebrates. The”No Effect” determination was based on no LOC exceedence.

The RQ for terrestrial indirect prey reduction effects from MITC inhalation exposure based on the surrogate mammal (rat) was below the LOC. The”No Effect” determination was based on no LOC exceedence.

The risk conclusions for MITC exposure on indirect effects on prey reduction of terrestrial invertebrates for the terrestrial phase CRLF are shown in Table 1.1. The conclusion of “May affect, likely to adversely affect” is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted studies or accepted open literature studies for the bee were available for this assessment.

The risk conclusions for MITC exposure on indirect effects on riparian vegetation for the terrestrial phase CRLF are shown in Table 1.1. The conclusion of “May affect, likely to adversely affect” is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted studies or accepted open literature studies for crops were available for this assessment.

1.2 Indirect Effects of Metam Sodium Application on Critical Habitat:

1.2.1 Indirect Effects of Metam Sodium Sprinkler Irrigation Application Method on Critical Habitat:

The risk conclusions for the sprinkler irrigation application method for Critical Habitat Impact effects of MITC exposure for the aquatic and terrestrial phase CRLF are shown in Table 1.2. RQs were estimated for nine crops, strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon.

Aquatic Phase Exposure:

RQs for aquatic phase CRLF PCEs were based on aquatic breeding habitat and non-breeding habitat, including aquatic and riparian vegetation for alteration of channel morphology. The RQs for aquatic plants do not exceed the LOC set by the Agency for any of the nine modeled crops. The "No habitat modification" conclusion is based on no LOC exceedence.

The risk conclusions for MITC exposure on riparian vegetation for the aquatic phase CRLF PCEs are shown in Table 1.2. The conclusion of "habitat modification" for riparian vegetation in alterations of channel morphology is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for crops were available for this assessment.

RQs for aquatic phase CRLF PCEs were based on aquatic breeding habitat and non-breeding habitat, including aquatic and riparian vegetation for alteration in water chemistry. The RQs for aquatic plants do not exceed the LOC set by the Agency for any of the nine modeled crops. The "No habitat modification" conclusion is based on no LOC exceedence.

The conclusion of "habitat modification" for riparian vegetation for alteration in water chemistry is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for crops were available for this assessment.

RQs for aquatic phase CRLF PCEs were based on aquatic breeding habitat and non-breeding habitat, including aquatic and riparian vegetation for alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and food sources. The RQs for aquatic plants do not exceed the LOC set by the Agency for any of the nine modeled crops. The "No habitat modification" conclusion is based on no LOC exceedence.

The conclusion of "habitat modification" for riparian vegetation for alteration of other chemical characteristics is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for crops were available for this assessment.

RQs for aquatic phase CRLF PCEs were based on aquatic breeding habitat and non-breeding habitat, including aquatic and riparian vegetation for reduction and/or modification of aquatic-based food sources (algae). The RQs for non-vascular aquatic plants do not exceed the LOC set by the Agency. The "No Effect" conclusion is based on no LOC exceedence.

Terrestrial Phase Exposure:

The risk conclusions for MITC exposure on elimination and/or disturbance of upland habitat for the terrestrial phase CRLF PCEs are shown in Table 1.2. The conclusion of "May affect, likely to adversely affect" for elimination and/or disturbance of upland habitat is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for crops were available for this assessment.

The risk conclusions for MITC exposure on elimination and/or disturbance of dispersal habitat for the terrestrial phase CRLF PCEs are shown in Table 1.2. The conclusion of "May affect, likely to adversely affect" is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted studies or accepted open literature studies for crops were available for this assessment.

The risk conclusions for MITC exposure on alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source for terrestrial phase CRLF PCEs are shown in Table 1.2. Effect determinations for aquatic vertebrates, aquatic invertebrates, aquatic plants, terrestrial vertebrates, terrestrial invertebrates and terrestrial plants are discussed.

The RQ for mammals does not exceed the LOC set by the Agency. The "No habitat modification" conclusion is based on no LOC exceedence.

The terrestrial invertebrate conclusion of "habitat modification" is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for terrestrial invertebrates were available for this assessment.

The conclusion of "habitat modification" is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted studies or accepted open literature studies for crops were available for this assessment.

The risk conclusions for MITC exposure for reduction and/or modification of food sources for terrestrial phase juveniles and adults are shown in Table 1.2. Effect determinations for terrestrial vertebrates, terrestrial invertebrates and terrestrial plants are discussed.

Terrestrial phase indirect prey reduction effect RQs for aquatic invertebrates exceed the listed species LOC for four modeled crops, strawberry, tomato, lettuce and turf.

The RQ for mammals does not exceed the LOC set by the Agency. The "No habitat modification" conclusion is based on the LOC.

The conclusion of "habitat modification" for prey reduction of terrestrial invertebrates is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for terrestrial invertebrates were available for this assessment.

The conclusion of "habitat modification" for modification of habitat is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for crops were available for this assessment.

1.3 Direct and Indirect Effects of Metam Sodium Shank Injection Application Method on Critical Habitat:

Aquatic Phase Exposure:

The risk conclusions for the shank injection application method for Critical Habitat Impact effects of MITC exposure for the aquatic and terrestrial phase CRLF are shown in Table 1.2. RQs are estimated from nine modeled crops, strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon. RQs for aquatic phase CRLF PCEs were based on aquatic breeding habitat and non-breeding habitat, including aquatic and riparian vegetation for alteration of channel morphology. The RQs for aquatic plants do not exceed the LOC set by the Agency for any of the nine modeled crops. The "No habitat modification" conclusion is based on no LOC exceedence.

The risk conclusions for MITC exposure on riparian vegetation for the aquatic phase CRLF PCEs are shown in Table 1.2. The conclusion of "habitat modification" for riparian vegetation in alterations of channel morphology is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for crops were available for this assessment.

RQs for aquatic phase CRLF PCEs are based on aquatic breeding habitat and non-breeding habitat, including aquatic and riparian vegetation for alteration in water chemistry. The RQs for aquatic plants do not exceed the LOC set by the Agency for any of the nine modeled crops. The "No habitat modification" conclusion is based on no LOC exceedence.

The conclusion of "habitat modification" for riparian vegetation for alteration in water chemistry is based on the uncertainty due to limited data as the most conservative determination. No guideline submitted studies or accepted open literature studies for crops were available for this assessment.

RQs for aquatic phase CRLF PCEs are based on aquatic breeding habitat and non-breeding habitat, including aquatic and riparian vegetation for alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and food sources. The RQs for aquatic invertebrates, aquatic vertebrates and aquatic plants do not exceed the LOC for any of the nine modeled crops. The "No habitat modification" conclusion is based on no LOC exceedence.

The conclusion of "habitat modification" for riparian vegetation for alteration other chemical characteristics is based on the uncertainty due to limited data as the most conservative determination. No guideline submitted studies or accepted open literature studies for crops were available for this assessment.

RQs for aquatic phase CRLF PCEs as aquatic breeding habitat and non-breeding habitat, including aquatic and riparian vegetation for reduction and/or modification of aquatic-based food sources (algae). The RQs for non-vascular aquatic plants do not exceed the LOC for any of the nine modeled crops. The "No habitat modification" conclusion is based on no LOC exceedence.

Terrestrial Phase Exposure:

The risk conclusions for MITC exposure on elimination and/or disturbance of upland habitat for the terrestrial phase CRLF PCEs are shown in Table 1.2. The conclusion of "habitat modification" for elimination and/or disturbance of upland habitat is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for crops were available for this assessment.

The risk conclusions for MITC exposure on elimination and/or disturbance of dispersal habitat for the terrestrial phase CRLF PCEs are shown in Table 1.2. The conclusion of "habitat modification" is based on the uncertainty due to limited data as the most conservative determination. No registrant guideline submitted studies or accepted open literature studies for crops were available for this assessment.

The risk conclusions for MITC exposure on alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source for terrestrial phase CRLF PCEs are shown in Table 1.2. Effect determinations for terrestrial vertebrates, terrestrial invertebrates and terrestrial plants are discussed.

The RQ for mammals does not exceed the LOC set by the Agency. The "No habitat modification" conclusion is based on no LOC exceednce.

The conclusion of "habitat modification" is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for terrestrial invertebrates were available for this assessment.

The conclusion of "habitat modification" is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for crops were available for this assessment.

The risk conclusions for MITC exposure for reduction and/or modification of food sources for terrestrial phase juveniles and adults are shown in Table 1.2. Effect determinations for terrestrial vertebrates, terrestrial invertebrates and terrestrial plants are discussed.

The RQ for mammals does not exceed the LOC set by the Agency. The "No habitat modification" conclusion is based on no LOC exceedence.

The conclusion of "habitat modification" for prey reduction of terrestrial invertebrates is based on the uncertainty due to limited data as the most conservative determination. No guideline submitted studies or accepted open literature studies for terrestrial invertebrates were available for this assessment.

The conclusion of habitat modification is based on the uncertainty due to limited data as the most conservative determination. No guideline submitted studies or accepted open literature studies for crops were available for this assessment.

When evaluating the significance of this risk assessment's direct/indirect and adverse habitat modification effects determinations, it is important to note that pesticide exposures and predicted risks to the species and its resources (i.e., food and habitat) are not expected to be uniform across the action area. In fact, given the assumptions of drift and downstream transport (i.e., attenuation with distance), pesticide exposure and associated risks to the species and its resources are expected to decrease with increasing distance away from the treated field or site of application. Evaluation of the implication of this non-uniform distribution of risk to the species would require information and assessment techniques that are not currently available. Examples of such information and methodology required for this type of analysis would include the following:

- Enhanced information on the density and distribution of CRLF life stages within specific recovery units and/or designated critical habitat within the action area. This information would allow for quantitative extrapolation of the present risk assessment's predictions of individual effects to the proportion of the population extant within geographical areas where those effects are predicted. Furthermore, such population information would allow for a more comprehensive evaluation of the significance of potential resource impairment to individuals of the species.
- Quantitative information on prey base requirements for individual aquatic- and terrestrial-phase frogs. While existing information provides a preliminary picture of the types of food sources utilized by the frog, it does not establish minimal requirements to sustain healthy individuals at varying life stages. Such information could be used to establish biologically relevant thresholds of effects on the prey base, and ultimately establish geographical limits to those effects. This information could be used together with the density data discussed above to characterize the likelihood of adverse effects to individuals.
- Information on population responses of prey base organisms to the pesticide. Currently, methodologies are limited to predicting exposures and likely levels of direct mortality, growth or reproductive impairment immediately following exposure to the pesticide. The degree to which repeated exposure events and the inherent demographic characteristics of the prey population play into the extent to which prey resources may recover is not predictable. An enhanced understanding

of long-term prey responses to pesticide exposure would allow for a more refined determination of the magnitude and duration of resource impairment, and together with the information described above, a more complete prediction of effects to individual frogs and potential adverse modification to critical habitat.

2.0 Problem Formulation

Problem formulation provides a strategic framework for the risk assessment. By identifying the important components of the problem, it focuses the assessment on the most relevant life history stages, habitat components, chemical properties, exposure routes, and endpoints. The structure of this risk assessment is based on guidance contained in U.S. EPA's *Guidance for Ecological Risk Assessment* (U.S. EPA 1998), the Services' *Endangered Species Consultation Handbook* (USFWS/NMFS 1998) and is consistent with procedures and methodology outlined in the Overview Document (U.S. EPA 2004) and reviewed by the U.S. Fish and Wildlife Service and National Marine Fisheries Service (USFWS/NMFS 2004).

2.1 Purpose

The purpose of this endangered species assessment is to evaluate potential direct and indirect effects on individuals of the federally threatened California red-legged frog *(Rana aurora draytonii*) (CRLF) arising from FIFRA regulatory actions regarding use of the fumigant metam-sodium on agricultural crops/soils, deciduous fruit trees, golf courses, manure, outdoor buildings/structures, uncultivated areas/soils, rights-of ways/fencerows/hedgerows, ornamental trees, ornamental plants, ornamental lawns, forest plantings, forest trees, and household/domestic dwellings outdoor premises. In addition, this assessment evaluates whether these actions can be expected to result in the destruction or adverse modification of the species' critical habitat. Key biological information for the CRLF is included in Section 2.5, and designated critical habitat information for the species is provided in Section 2.6 of this assessment. This ecological risk assessment has been prepared as part of the *Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 02-1580-JSW(JL)) settlement entered in the Federal District Court for the Northern District of California on October 20, 2006.

The CRLF is endemic to California and Baja California (Mexico) and historically inhabited 46 counties in California including the Central Valley and both coastal and interior mountain ranges (USFWS 1996). Its range has been reduced by about 70%, and the species currently resides in 22 counties in California (USFWS 1996).

In this endangered species assessment, direct and indirect effects to the CRLF and potential adverse modification to its critical habitat are evaluated in accordance with the methods (both baseline level and species-specific refinements, when appropriate) described in the Agency's Overview Document (U.S. EPA 2004). Additional California-specific aquatic exposure models were used. Use of such information is consistent with the guidance provided in the Overview Document (U.S. EPA 2004), which specifies that "the assessment process may, on a case-by-case basis, incorporate additional methods, models, and lines of evidence that EPA finds technically appropriate for risk management objectives" (Section V, page 31 of U.S. EPA 2004).

In accordance with the Overview Document, provisions of the ESA, and the Services' *Endangered Species Consultation Handbook,* the assessment of effects associated with registrations of metam-sodium are based on an action area. The action area is considered to be the area directly or indirectly affected by the federal action, as indicated by the exceedance of Agency Levels of Concern (LOCs) used to evaluate direct or indirect effects. It is acknowledged that the action area for a national-level FIFRA regulatory decision associated with a use of metam-sodium may potentially involve numerous areas throughout the United States and its Territories. However, for the purposes of this assessment, attention will be focused on relevant sections of the action area including those geographic areas associated with locations of the CRLF and its designated critical habitat within the state of California.

As part of the "effects determination," one of the following three conclusions will be reached regarding the potential for registration of metam-sodium at the use sites described in this document to affect CRLF individuals and/or result in the destruction or adverse modification of designated CRLF critical habitat:

- "No effect";
- "May affect, but not likely to adversely affect"; or
- "May affect and likely to adversely affect".

Critical habitat identifies specific areas that have the physical and biological features, (known as primary constituent elements or PCEs) essential to the conservation of the listed species. The PCEs for CRLFs are aquatic and upland areas where suitable breeding and non-breeding aquatic habitat is located, interspersed with upland foraging and dispersal habitat (Section 2.6).

If the results of initial baseline-level assessment methods show no direct or indirect effects (no LOC exceedences) upon individual CRLFs or upon the PCEs of the species' designated critical habitat, a "no effect" determination could be made for the FIFRA regulatory action regarding metam-sodium and MITC as it relates to this species and its designated critical habitat. The "no effect" determination depends on the availability of a complete database and other information indicating a potential for a "may effect'. If, however, direct or indirect effects to individual CRLFs are anticipated and/or effects may impact the PCEs of the CRLF's designated critical habitat, a preliminary "may affect" determination is made for the FIFRA regulatory action regarding metam-sodium.

If a determination is made that use of metam-sodium within the action area(s) associated with the CRLF "may affect" this species and/or its designated critical habitat, additional information is considered to refine the potential for exposure and for effects to the CRLF and other taxonomic groups upon which these species depend (e.g.., aquatic and terrestrial vertebrates and invertebrates, aquatic plants, riparian vegetation, etc.). Additional information, including spatial analysis (to determine the geographical proximity of CRLF habitat and metam sodium use sites) and further evaluation of the potential impact of metam-sodium on the PCEs is also used to determine whether destruction or adverse modification to designated critical habitat may occur.

Based on the refined information, the Agency uses the best available information to distinguish those actions that "may affect, but are not likely to adversely affect" from those actions that "may affect and are likely to adversely affect" the CRLF and/or the PCEs of its designated critical habitat. This information is presented as part of the Risk Characterization in Section 5 of this document.

The Agency believes that the analysis of direct and indirect effects to listed species provides the basis for an analysis of potential effects on the designated critical habitat. Because metam-sodium is expected to directly impact living organisms within the action area (defined in Section 2.7), critical habitat analysis for metam-sodium is limited in a practical sense to those PCEs of critical habitat that are biological or that can be reasonably linked to biologically mediated processes (i.e., the biological resource requirements for the listed species associated with the critical habitat or important physical aspects of the habitat that may be reasonably influenced through biological processes). Activities that may destroy or adversely modify critical habitat are those that alter the PCEs and appreciably diminish the value of the habitat. Evaluation of actions related to use of metam-sodium that may alter the PCEs of the CRLF's critical habitat form the basis of the critical habitat impact analysis. Actions that may affect the CRLF's designated critical habitat have been identified by the Services and are discussed further in Section 2.6.

2.2 Scope

The end result of the EPA pesticide registration process (the FIFRA regulatory action) is an approved product label. The label is a legal document that stipulates how and where a given pesticide may be used. Product labels (also known as end-use labels) describe the formulation type (e.g., liquid or granular), acceptable methods of application, approved use sites, and any restrictions on how applications may be conducted. Thus, the use or potential use of metam-sodium in accordance with the approved product labels for California is "the action" being assessed.

Metam-sodium is a widely used fumigant registered for use on agricultural and non agricultural sites in California. It is highly unstable in the environment, degrades rapidly to form methyl isothiocyanate (MITC), which acts as preplant soil sterilant to control nematodes, soil-borne diseases, insects and weeds.

Although current registrations of metam sodium allow for use nationwide, this ecological risk assessment and effects determination addresses currently registered uses of metam sodium in portions of the action area that are reasonably assumed to be biologically relevant to the CRLF and its designated critical habitat. Further discussion of the action area for the CRLF and its critical habitat is provided in Section 2.7.

Metam sodium degrades rapidly to MITC upon application to the soil. The risk assessment is based on exposure of surrogate fish and mammal for direct effects, prey organisms for indirect dietary effects, as well as aquatic and terrestrial plants for indirect habitat effects through exposure to off-gassed MITC and aquatic MITC residues in the aquatic environment.

2.2.1 Product Formulations Containing Multiple Active Ingredients

As summarized in Appendix A, there are no product LD50 values, with associated 95% Confidence Intervals (CIs) available.

As discussed in U.S. EPA (2000), a quantitative component-based evaluation of mixture toxicity requires data of appropriate quality for each component of a mixture. In this mixture evaluation, an LD50 with associated 95% CI is needed for the formulated product. The same quality of data is also required for each component of the mixture. Given that the formulated products for metam sodium do not have LD50 data available, it is not possible to undertake a quantitative or qualitative analysis for potential interactive effects. However, because the active ingredients are not expected to have similar mechanisms of action, metabolites, or toxicokinetic behavior, it is reasonable to conclude that an assumption of dose-addition would be inappropriate. Consequently, an assessment based on the toxicity of metam sodium is the only reasonable approach that employs the available data to address the potential acute risks of the formulated products in Appendix A.

Table 2.1 Products Containing Multiple Active Ingredients

			PRODUCT		ADJUSTED FOR ACTIVE INGREDIENT	
PRODUCT/TRADE NAME	EPA Reg.No.	% Metam Sodium	LC 50 (mg/kg)	CI (mg/kg)	LC50 (mg/kg)	CI (mg/kg)
Busan 1016	1448-93	18				
Roo-pru super tri pak	1015-72	32.7	No Data	No Data	No Data	No Data
Rout	64898-4	32.7	No Data	No Data	No Data	No Data

2.3 Previous Assessments

Metam sodium is currently being assessed under the Agency's reregistration program. An August, 2004 revised Environmental Fate and Ecological Risk Assessment for the Existing Uses of Metam-sodium nationwide is the most recent risk assessment. The following brief summary is largely from that assessment:

The major concern with metam-sodium is the exposure of terrestrial and aquatic organisms to the degradate MITC. Based on an inhalation analysis using mammal inhalation data and both monitoring and modeling data for air residues of MITC, there does not appear to be an acute risk concern for wild mammals. However, since the refined analyses were performed with the air monitoring data derived from out-side of the treated fields at certain heights (≈2.0 meter) the acute risk to mammals may have been underestimated. Acute aquatic LOCs are exceeded for both aquatic invertebrates and fish in all modeled scenarios except potatoes.

2.4 Stressor Source and Distribution

Metam sodium (sodium-N-methyl dithiocarbamate) and its primary degradation product methyl isothiocyanate (MITC) are the potential stressors that would result from application of metam sodium to soil to control weeds, nematodes and various soil-borne pathogens. Following application of formulated metam sodium products to soils, rapid hydrolysis and biodegradation are expected to result in the formation of its major degradation product MITC. The high vapor pressure and low affinity for sorption on soil of MITC suggest that volatilization is the most important environmental route of dissipation. Additional transport mechanisms include runoff from pre-plant fumigated fields, and secondary drift of volatilized MITC and potential redeposition through precipitation in adjacent areas. Thus, the major concern is the exposure of non-target terrestrial and aquatic organisms to MITC. The environmental fate data and the residual contents of metam sodium in soils suggest that there will be no risk of exposure in ground water or surface water from metam sodium, so this exposure will result in a “no effect’ determination.

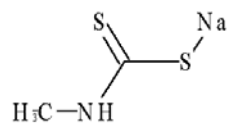
2.4.1 Environmental Fate Assessment

The following fate and transport description for metam sodium is consistent with the information contained in the revised RED document (U.S. EPA, 2004). Aerobic soil metabolism, photodegradation in water, and hydrolysis studies suggest that metam sodium is very unstable and degrades rapidly to MITC and other minor degradates. However, for MITC, the major metabolite of metam sodium, degradation in soil and water appears to be dependent on hydrolysis and microbially-mediated degradation and persist longer than metam sodium in the environment. The dissipation of MITC in aquatic and terrestrial environments appears to be predominantly dependent on volatilization and to a lesser extent on leaching and degradation. Photolytic degradation is the major dissipation route of MITC in atmosphere.

2.4.1.1 Physicochemical Properties

A summary of physical and chemical properties of technical grade active ingredient (TGAI) of metam sodium (metam sodium dihydrate; crystalline) are listed in Table 2.2. Metam sodium is stable in its dry, crystalline and concentrated aqueous solution and has a distinct pungent horse-radish like odor. Metam sodium is non-volatile and readily soluble (722 g/L @ 20^0C) in water and degrades very rapidly to MITC in soil. MITC has high vapor pressure (19 mm Hg at 20^0C) and the Henry’s Law Constant of 1.79×10^{-4} atm-m^3/mol, which suggests that it will be volatilized from metam sodium applied fields

Table 2.2. Physico-chemical and environmental fate properties of Metam Sodium and Methyl Isothiocyanate (MITC)

Parameters	Values & Units	Sources
Chemical Name: Sodium N-methyldithiocarbamate, Methyldithiocarbamic acid sodium salt **Common Name: Metam Sodium, Metam, Metham, Metham Sodium**		
Chemical Abstract Number (CAS)	137-42-8	Tomlin, 1997 (ed.)
Molecular Formula	$C_2H_4NNaS_2$	Tomlin, 1997 (ed.)
Molecular Weight	129.2 g $Mole^{-1}$	MRID 459194-01
Structure		Tomlin, 1997 (ed.)
Vapor Pressure 25^{o}C	Non volatile	Tomlin, 1997 (ed.)
Water Solubility @ pH 7.0 and 20^{o}C	722g L^{-1}	Tomlin, 1997 (ed.)
Chemical Name: Methyl isothiocyanate **Common Name: Methyl isothiocyanate, MITC, MIT, Methyl Mustard Oil**		
Chemical Abstract Number (CAS)	556-61-6	Tomlin, 1997 (ed.)
Molecular Formula	C_2H_3NS	Tomlin, 1997 (ed.)
Molecular Weight	73.12g $Mole^{-1}$	Tomlin, 1997 (ed.)
Structure	$S{=}C{=}N\text{-}CH_3$	Tomlin, 1997 (ed.)
Vapor Pressure 25^{o}C	19 mm Hg	Tomlin, 1997 (ed.)
Water Solubility @ pH 7.0 and 25^{o}C	7.6 g L^{-1}	Tomlin, 1997 (ed.)
Henry's Law Constant	1.79×10^{-4} (atm-m^3/mol)	CDPR, 2002

2.4.1.2 Environmental Fate in soil and water

The aerobic soil metabolism study suggests that metam sodium degrades in soil with a half-life of 23 minutes and generates 83% of its principal gaseous degradate MITC. A similar degradation pattern and rate were observed in the photodegradation in water ($t_{1/2}$ = 28 minutes). MITC was also the major degradate formed in the hydrolysis studies. The hydrolysis half-lives were 2 days at pH 5 and 7, and 4.5 days at pH 9. The major degradate formed at pH 5 and 7 was MITC (18% to 60%). At pH 9, two major degradates formed, with 20 % of MITC and 16% of

MCDT. The other major degradates identified in the hydrolysis study were methylamine, 1,3-dimithylthiourea (DMTU) and 1,3 dimethylurea (DMU). Methylcarbamo (dithioperoxo) thioate (MCDT) was identified in the pH 9 test solutions. The formation of methylamine was favored under acidic conditions compared to neutral or alkaline conditions. All degradates identified in the photodegradation study were also identified in the hydrolysis study except syn- and anti-N-methylthioformamide. Supplemental data from field dissipation studies (MRID 415144-02 and 417986-01) also indicated that metam sodium degrades rapidly to MITC and DMU in the terrestrial environment and both of the degradates were detected only at soil depth of 0-6 inches except one time MITC at 6-9 inches depth. No MITC (<0.02 ppm) and DMU (<0.02 ppm) were detected at 7-14 days and 32-91 days respectively in post treatment soil sampling in both sites. Methylamine was the main degradate of MITC identified in all pHs in the hydrolysis study.

Table 2.3. Environmental fate properties of Metam Sodium and Methyl isothiocyanate (MITC)

Parameters	Values & Units	Sources
Metam Sodium		
Hydrolysis Half-Life (pH 5)	2.0 Days	MRID 416311-01
Hydrolysis Half-Life (pH 7)	2.0 Days	MRID 416311-01
Hydrolysis Half-Life (pH 9)	4.5 Days	MRID 416311-01
Aerobic Soil Metabolism ($t_{½}$)	23 Minutes	MRID 401985-02
Photodegradation in water($t_{½}$)	28 Minutes	MRID 415177-01
Photodegradation in soil($t_{½}$)	63 Minutes	MRID 429787-01
Octanol/Water partition coefficient (log K_{ow})	0.46	EPISUITE*
Soil Water Partition Coefficient (K_{oc})	4.04 L Kg^{-1}	EPISUITE*
Methyl isothiocyanate (MITC)		
Hydrolysis Half-Life (pH 5)	3.5 day	MRID 00158162
Hydrolysis Half-Life (pH 7)	20.4 day	MRID 00158162
Hydrolysis Half-Life (pH 9)	4.6 day	MRID 00158162
Aerobic Soil Metabolism ($t_{½}$)	6.01 Days (mean value)	Gerstl et at., 1977
Anaerobic aquatic metabolism($t_{½}$)	21 day	MRID 435965-01
Photodegradation in water($t_{½}$)	51.6 Day	CDPR, 2002
Photodegradation in Air($t_{½}$)	1.21 to 1.60 Days	Geddes, et al., 1995

Table 2.3. Environmental fate properties of Metam Sodium and Methyl isothiocyanate (MITC)

Parameters	Values & Units	Sources
Octanol/Water partition coefficient (log K_{ow})	0.98	Product Chemistry
Soil Water Partition Coefficient (K_d)	0.26 L Kg^{-1} (Mean K_d)	Gerstl et at., 1977

* = The EPI (Estimation Program Interface) SuiteTM is a Windows® based suite of physical/chemical property and environmental fate estimation models developed by the EPA's Office of Pollution Prevention Toxics and Syracuse Research Corporation SRC. http://www.epa.gov/opptintr/exposure/docs/updates_episuite_v3.11.htm

2.4.1.3 Environmental Transport Assessment

Potential transport mechanisms include pesticide surface water runoff, spray drift, and secondary drift of volatilized or soil-bound residues leading to deposition onto nearby or more distant ecosystems. The magnitude of pesticide transport via secondary drift depends on the pesticide's ability to be mobilized into air and its eventual removal through wet and dry deposition of gases/particles and photochemical reactions in the atmosphere. A number of studies have documented atmospheric transport and redeposition of pesticides from the Central Valley to the Sierra Nevada mountains (Fellers et al., 2004, Sparling et al., 2001, LeNoir et al., 1999, and McConnell et al., 1998). Prevailing winds blow across the Central Valley eastward to the Sierra Nevada mountains, transporting airborne industrial and agricultural pollutants into Sierra Nevada ecosystems (Fellers et al., 2004, LeNoir et al., 1999, and McConnell et al., 1998). Therefore, physicochemical properties of the pesticide that describe its potential to enter the air from water or soil (e.g., Henry's Law constant and vapor pressure), pesticide use, modeled estimated concentrations in water and air, and available air monitoring data from the Central Valley and the Sierra Nevadas are considered in evaluating the potential for atmospheric transport of metam-sodium to habitat for the CRLF.

Volatilization of MITC is likely the primary mechanism for transport as indicated in the environmental fate studies. Once MITC volatilizes into the atmosphere, it dissipates rapidly due to direct photolysis (photolysis in air half-live, 29 to 39 hours). In a laboratory experiment, several MITC degradates were identified that include methyl isocyanate (MIC), methyl isocyanide, sulfur dioxide, hydrogen sulfide, carbonyl sulfur, N-methylthioformamide, and methylamine resulting from direct photolysis. In addition, its high solubility (7.2 g L^{-1}) in water and low adsorption in soil (K_d of 0.26 L Kg^{-1}) suggest that leaching to groundwater may be a potential transport pathway under flooded and saturated conditions. However, under most field moisture conditions, the potential for groundwater contamination of MITC is unlikely due to unsaturated soil conditions and its volatilization and degradation characteristics in soil (aerobic soil half-lives of 3.3 to 20.2 days). MITC can also potentially move to surface water through runoff under a possible worst-case scenario, that is, if an intense rainfall and/or continuous irrigation occurs right after metam sodium application. However, the Henry's Law Constant of MITC suggests that it will volatilize rapidly from surface water.

2.4.2 Mechanism of Action

Metam sodium is a dithiocarbamate that converts readily to the isothiocyanate MITC (methyl isothiocyanate) upon application to soil. The rate of decomposition depends on the type of soil, soil moisture content and temperature. MITC is the chemical responsible for much of the toxicity to both target and non-target organisms. For example, MITC is highly reactive with the nucleophilic centers such as thiol groups in vital enzymes of nematodes, and thus appears to be the mechanism of toxic action (Cremlyn, 1991).

2.4.3 Use Characterization

Analysis of labeled use information is the critical first step in evaluating the federal action. The current label for metam-sodium represents the FIFRA regulatory action; therefore, labeled use and application rates specified on the label form the basis of this assessment. The assessment of use information is critical to the development of the action area and selection of appropriate modeling scenarios and inputs.

The Label Use Information System (LUIS) report, received from the OPP's Biolgical and Economic Analysis Division dated April 12, 2007 list the following use groups for metam sodium: terrestrial food, terrestrial feed, terrestrial non-food, aquatic non-food Industrial, agricultural soils, nonagricultural soils, greenhouse non-food, and outdoor residential. The U.S. Geological Survey (USGS) pesticide use map (Figure 2.1) shows regional scale patterns in use intensity within the United States. Metam sodium is a widely used fumigant on agricultural and non-agricultural sites to control nematodes, soil-borne diseases, insects and weeds. Metam sodium is used on a wide variety of crops, with major usage on potatoes, peanuts, and carrots. The USGS pesticide maps are based on state-level estimates of pesticide use rates for individual crops, which have been compiled by the National Center for Food and Agricultural Policy (NCFAP) for 21995-1998, and on a 1997 Census of Agriculture for county crop acreage. There are approximately 35 different products containing metam sodium in concentrations ranging from 18-42% active ingredient.

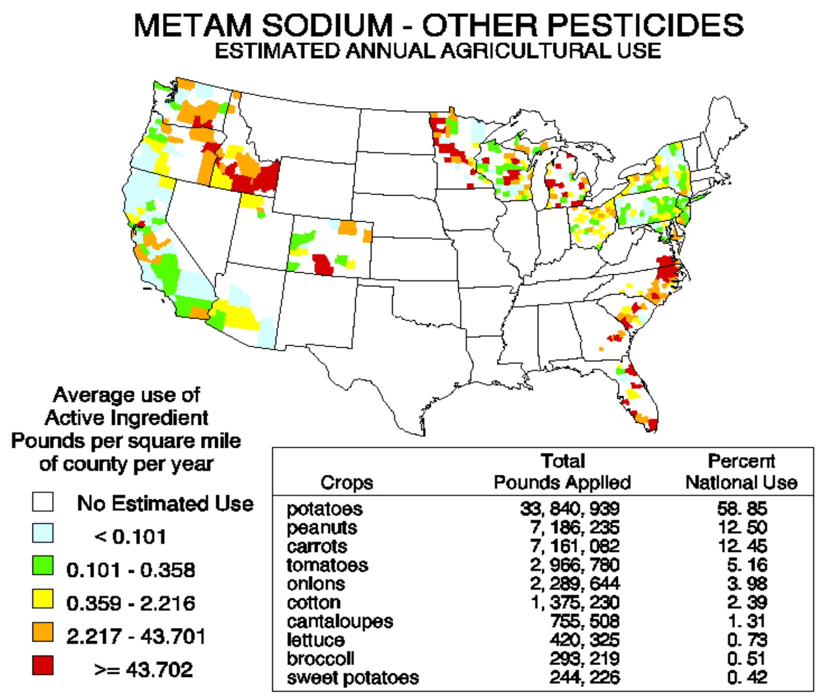


Figure 2.1. Estimated uses of metam sodium by crop(Source: U.S. Geological Survey, http://ca.water.usgs.gov/pnsp/pesticide_use_maps_1997

2.4.3.1 Metam Sodium Management Practices

Application methods of metam sodium include soil injection and chemigation followed by water sealing or tarping, surface compaction with rotary tiller, disc, power mulcher, and drenching. The maximum application rate for food crops (with rate in lbs ai/A) is 320 lbs ai/A, with one application per crop cycle (BEAD Label Use Information System Report, 4/12/07). Table 2.4 shows summery of recommended fumigation application and management practices. Post application methods like water sealing, surface compacting or tarping reduces the MITC diffusion to atmosphere from the metam sodium applied sites. Shank injection and chemigation are the two most frequent options when applying metam sodium. For the production of some crops, the entire field is treated and is termed "flat fume", "broadcast", or "broadacre" (Figure 2.2). For the production of other crops, fumigation occurs when planting beds are formed. A bed press forms a raised bed and the fumigant is injected into the bed as it is formed. The entire bed, or only the portion of the bed, is fumigated. This is termed "strip" treatments (Figure 2.3). The production of some ornamentals and strawberries use a combination of techniques. First, the entire field is fumigated and tarped. The tarps are then removed, raised beds are formed, and these beds are then tarped. There are a range of tarps used to reduce emission from the fumigated field. Low density polyethylene (LDPE) and high density polyethylene (HDPE) are most commonly used for tarping methods. Recently, high barrier impermeable film (e.g., virtually impermeable film or VIP) was introduced to reduce emission from the fumigated field.

Table 2.4. Summery of Recommended Fumigation Techniques*

Application Equipment	Soil Incorporation Method	Field Treatment	Flat Fume vs. Raised Bed	Tarping / Sealing Method	
				Water Seal	Tarp
spray blade, shank	Roller, rotary harrow, bed press	Entire field, strip (may be entire bed or only part of the raised bed)	Flat fume, raised bed	None, standard, intermittent	Untarped LDPE HDPE High barrier
Shank	Roller, rotary harrow, bed press	Entire field, strip (entire bed)	Flat fume, raised bed	N/A	Untarped LDPE HDPE High barrier
Drip line, sprinkler	None (drip tape(s) under tarp or surface application)	Entire field, strip (entire bed)	Flat fume, raised bed	None, standard, intermittent	Untarped LDPE HDPE High barrier

*Combinations of formulation, application methods and equipment, soil incorporation methods, field treatments, and tarping / sealing methods vary by fumigant, crop, and geographic region. Note that not all potential combinations are used (e.g., water seals are not used with tarps).

Figure 2.2. Shank injection and tarping during broadcast/flat fumigation

Figure 2.3. Typical drip irrigation system and beds for fumigation

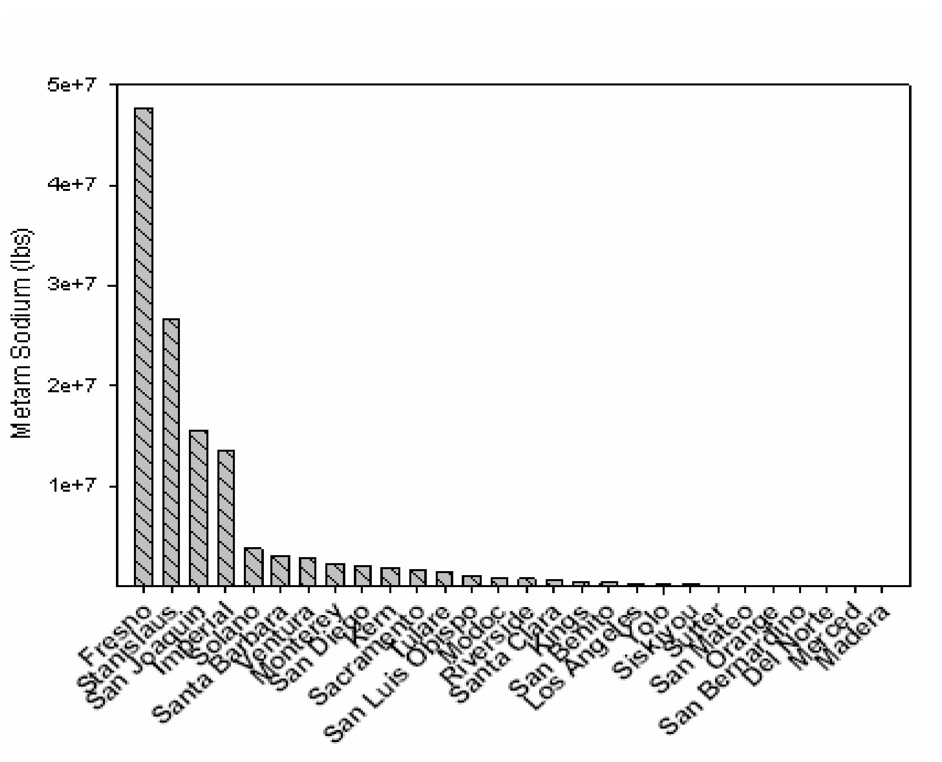


Fig. 2.4 Metam sodium Use in California (2202-2005) by County

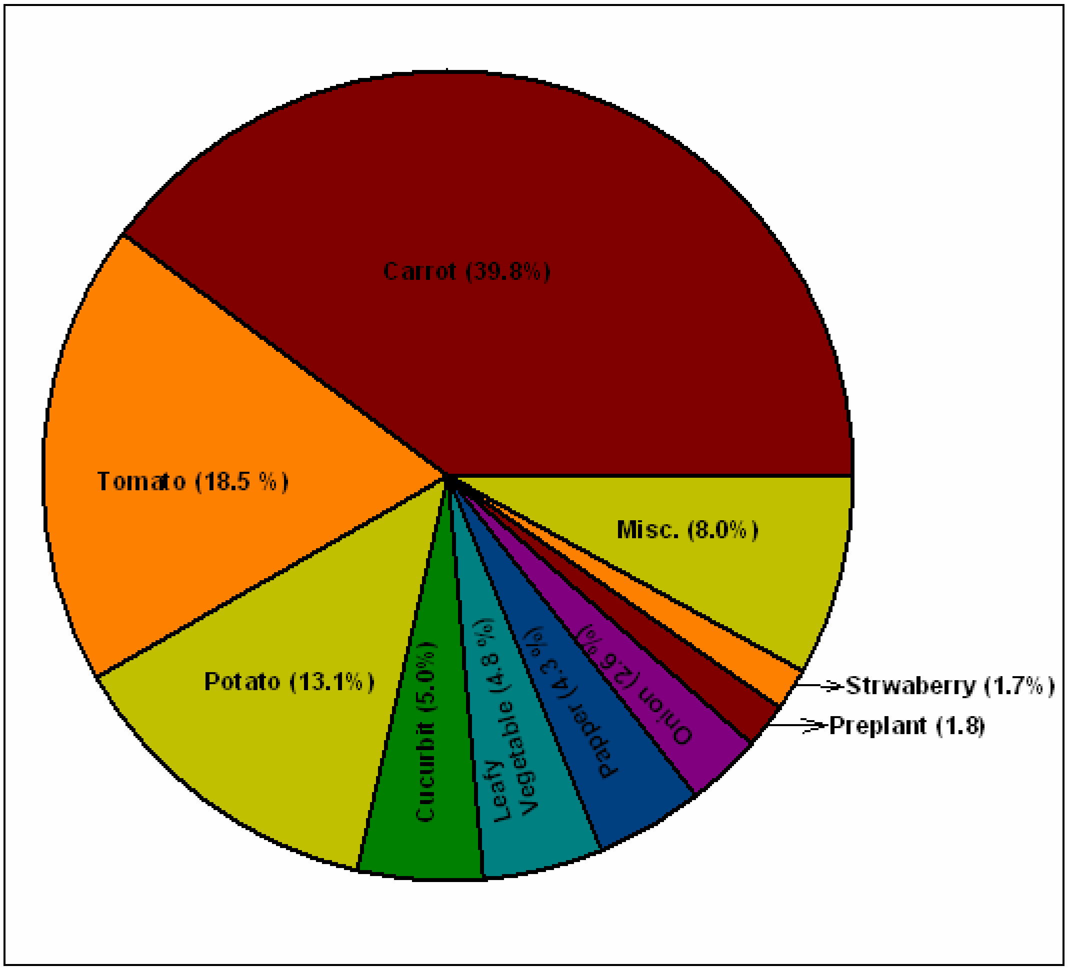


Figure 2.5. Distribution of metam sodium for various usages during 2002 2005.

BEAD provides an analysis of both national- and county-level usage information (BEAD Label Use Information System Report, 4/12/07) using state-level usage data obtained from USDA-NASS, Doane (www.doane.com; the full dataset is not provided due to its proprietary nature), and the California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database. CDPR PUR is considered a more comprehensive source of usage data than USDA-NASS or EPA proprietary databases, and thus the usage data reported for metam-sodium by county in this California-specific assessment were generated using CDPR PUR data. California State law requires that every pesticide application be reported to the state and made available to the public. The amount of metam sodium used in California has steadily increased in recent years, from an average of 5.5 million pounds in 1990 and 1991, to nearly 15 million pounds in recent years. Usage data are averaged together over the years 2002 to 2005 to calculate average annual usage statistics by county and crop for metam-sodium, including pounds of active ingredient applied and base acres treated. Figure 2.4 shows the average annual usage in various counties. Highest usage (>1 million lbs of metam sodium) was reported in Fresno, Stanislaus, San Joaquin, and Imperial counties. Metam sodium usages' data from California suggest that carrots appear to have the most pounds applied overall with an average of estimated 5,549,185 pounds during 2002 to 2004). Figure 2.5shows that carrot, potato, tomato, cucurbit and leafy vegetable are accounted for 80% of the total usage of metam sodium.

2.5 Assessed Species

The CRLF was federally listed as a threatened species by USFWS effective June 24, 1996 (USFWS 1996). It is one of two subspecies of the red-legged frog and is the largest native frog in the western United States (USFWS 2002). A brief summary of information regarding CRLF distribution, reproduction, diet, and habitat requirements is provided in Sections 2.5.1 through 2.5.4, respectively. Further information on the status, distribution, and life history of and specific threats to the CRLF is provided in Attachment I.

Final critical habitat for the CRLF was designated by USFWS on April 13, 2006 (USFWS 2006; 71 FR 19244-19346). Further information on designated critical habitat for the CRLF is provided in Section 2.6.

2.5.1 Distribution

The CRLF is endemic to California and Baja California (Mexico) and historically inhabited 46 counties in California including the Central Valley and both coastal and interior mountain ranges (USFWS 1996). Its range has been reduced by about 70%, and the species currently resides in 22 counties in California (USFWS 1996). The species has an elevational range of near sea level to 1,500 meters (5,200 feet) (Jennings and Hayes 1994); however, nearly all of the known CRLF populations have been documented below 1,050 meters (3,500 feet) (USFWS 2002).

Populations currently exist along the northern California coast, northern Transverse Ranges (USFWS 2002), foothills of the Sierra Nevada (5-6 populations), and in southern California south of Santa Barbara (two populations) (Fellers 2005a). Relatively larger numbers of CRLFs are located between Marin and Santa Barbara Counties (Jennings and Hayes 1994). A total of 243 streams or drainages are believed to be currently occupied by the species, with the greatest numbers in Monterey, San Luis Obispo, and Santa Barbara counties (USFWS 1996). Occupied drainages or watersheds include all bodies of water that support CRLFs (i.e., streams, creeks, tributaries, associated natural and artificial ponds, and adjacent drainages), and habitats through which CRLFs can move (i.e., riparian vegetation, uplands) (USFWS 2002).

The distribution of CRLFs within California is addressed in this assessment using four categories of location including recovery units, core areas, designated critical habitat, and known occurrences of the CRLF reported in the California Natural Diversity Database (CNDDB) that are not included within core areas and/or designated critical habitat (see Figure 2.6. Recovery units, core areas, and other known occurrences of the CRLF from the CNDDB are described in further detail in this section, and designated critical habitat is addressed in Section 2.6. Recovery units are large areas defined at the watershed level that have similar conservation needs and management strategies. The recovery unit is primarily an administrative designation, and land area within the recovery unit boundary is not exclusively CRLF habitat. Core areas are smaller areas within the recovery units that comprise portions of the species' historic and current range and have been determined by USFWS to be important in the preservation of the species. Designated critical habitat is generally contained within the core areas, although a number of critical habitat units are outside the boundaries of core areas, but within the boundaries of the recovery units. Additional information on CRLF occurrences from the CNDDB is used to cover the current range of the species not included in core areas and/or designated critical habitat, but within the recovery units.

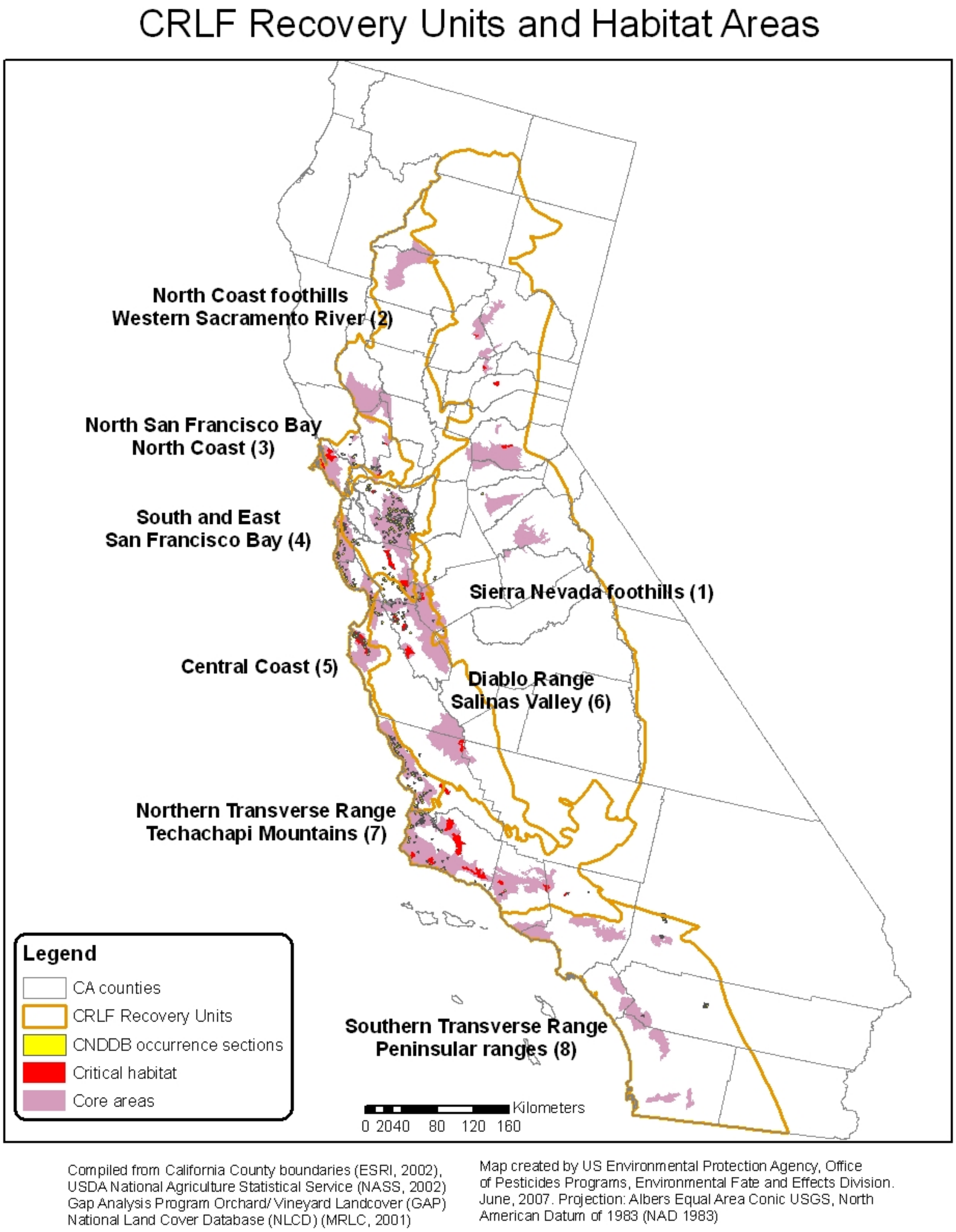
2.5.1.1 Recovery Units

Eight recovery units have been established by USFWS for the CRLF. These areas are considered essential to the recovery of the species, and the status of the CRLF "may be considered within the smaller scale of the recovery units, as opposed to the statewide range" (USFWS 2002). Recovery units reflect areas with similar conservation needs and population statuses, and therefore, similar recovery goals. The eight units described for the CRLF are delineated by watershed boundaries defined by US Geological Survey hydrologic units and are limited to the elevational maximum for the species of 1,500 m above sea level. The eight recovery units for the CRLF are listed in Table 2.5 and shown in Figure 2.6.

2.5.1.2 Core Areas

USFWS has designated 35 core areas across the eight recovery units to focus their recovery efforts for the CRLF (see Figure 2.6). Table 2.5 summarizes the geographical relationship among recovery units, core areas, and designated critical habitat. The core areas, which are distributed throughout portions of the historic and current range of the species, represent areas that allow for long-term viability of existing populations and reestablishment of populations within historic range. These areas were selected because they: 1) contain existing viable populations; or 2) they contribute to the connectivity of other habitat areas (USFWS 2002). Core area protection and enhancement are vital for maintenance and expansion of the CRLF's distribution and population throughout its range.

For purposes of this assessment, designated critical habitat, currently occupied (post-1985) core areas, and additional known occurrences of the CRLF from the CNDDB are considered. Each type of locational information is evaluated within the broader context of recovery units. For example, if no labeled uses of metam-sodium occur (or if labeled uses occur at predicted exposures less than the Agency's LOCs) within an entire recovery unit, a "no effect" determination would be made for all designated critical habitat, currently occupied core areas, and other known CNDDB occurrences within that recovery unit. Historically occupied sections of the core areas are not evaluated as part of this assessment because the USFWS Recovery Plan (USFWS 2002) indicates that CRLFs are extirpated from these areas. A summary of currently and historically occupied core areas is provided in Table 2.5 (currently occupied core areas are bolded). While core areas are considered essential for recovery of the CRLF, core areas are not federally-designated critical habitat, although designated critical habitat is generally contained within these core recovery areas. It should be noted, however, that several critical habitat units are located outside of the core areas, but within the recovery units. The focus of this assessment is currently occupied core areas, designated critical habitat, and other known CNDDB CRLF occurrences within the recovery units. Federally-designated critical habitat for the CRLF is further explained in Section 2.6.



* Core areas that were historically occupied by the California red-legged frog are not included in the map

Figure 2.6. Recovery Unit, Core Area, Critical Habitat, and Occurrence Designations for CRLF

Core Areas

1. Feather River
2. Yuba River- S. Fork Feather River
3. Traverse Creek/ Middle Fork/ American R. Rubicon
4. Cosumnes River
5. South Fork Calaveras River*
6. Tuolumne River*
7. Piney Creek*
8. Cottonwood Creek
9. Putah Creek – Cache Creek*
10. Lake Berryessa Tributaries
11. Upper Sonoma Creek
12. Petaluma Creek – Sonoma Creek
13. Pt. Reyes Peninsula
14. Belvedere Lagoon
15. Jameson Canyon – Lower Napa River
16. East San Francisco Bay
17. Santa Clara Valley
18. South San Francisco Bay
19. Watsonville Slough-Elkhorn Slough
20. Carmel River – Santa Lucia
21. Gablan Range
22. Estero Bay
23. Arroyo Grange River
24. Santa Maria River – Santa Ynez River
25. Sisquoc River
26. Ventura River – Santa Clara River
27. Santa Monica Bay – Venura Coastal Streams
28. Estrella River
29. San Gabriel Mountain*
30. Forks of the Mojave*
31. Santa Ana Mountain*
32. Santa Rosa Plateau
33. San Luis Ray*
34. Sweetwater*
35. Laguna Mountain*

Table 2.5. California Red-legged Frog Recovery Units with Overlapping Core Areas and Designated Critical Habitat

Recovery Unit [1] (Figure 2.a)	Core Areas [2,7] (Figure 2.a)	Critical Habitat Units [3]	Currently Occupied (post-1985) [4]	Historically Occupied [4]
Sierra Nevada Foothills and Central Valley (1) (eastern boundary is the 1,500m elevation line)	**Feather River (1)**	BUT-1A-B	✓	
	Yuba River-S. Fork Feather River (2)	YUB-1		
	--	NEV-1	✓[6]	
	Traverse Creek/Middle Fork American River/Rubicon (3)	--	✓	
	Consumnes River (4)	ELD-1	✓	
	S. Fork Calaveras River (5)	--		✓
	Tuolumne River (6)	--		✓
	Piney Creek (7)	--		✓
	East San Francisco Bay (partial)(16)	--	✓	
North Coast Range Foothills and Western Sacramento River Valley (2)	**Cottonwood Creek (8)**	--	✓	
	Putah Creek-Cache Creek (9)	--		✓
North Coast and North San Francisco Bay (3)	Putah Creek-Cache Creek (partial) (9)	--		✓
	Lake Berryessa Tributaries (10)	NAP-1	✓	
	Upper Sonoma Creek (11)	--	✓	
	Petaluma Creek-Sonoma Creek (12)	--	✓	
	Pt. Reyes Peninsula (13)	MRN-1, MRN-2	✓	
	Belvedere Lagoon (14)	--	✓	
	Jameson Canyon-Lower Napa River (15)	SOL-1	✓	
South and East San Francisco Bay (4)	--	CCS-1A	✓[6]	
	East San Francisco Bay (partial) (16)	ALA-1A, ALA-1B, STC-1B	✓	
	--	STC-1A	✓[6]	
	South San Francisco Bay (partial) (18)	SNM-1A	✓	
Central Coast (5)	**South San Francisco Bay (partial) (18)**	SNM-1A, SNM-2C, SCZ-1	✓	
	Watsonville Slough- Elkhorn Slough (partial) (19)	SCZ-2 [5], MNT-1 [5]	✓	
	Carmel River-Santa Lucia (20)	MNT-2	✓	
	Estero Bay (22)	--	✓	
	Arroyo Grande Creek (23)	SLO-8	✓	
	Santa Maria River-Santa Ynez River (24)	--	✓	
Diablo Range and Salinas Valley (6)	**East San Francisco Bay (partial) (16)**	MER-1A-B	✓	

Table 2.5. California Red-legged Frog Recovery Units with Overlapping Core Areas and Designated Critical Habitat

Recovery Unit [1] (Figure 2.a)	Core Areas [2,7] (Figure 2.a)	Critical Habitat Units [3]	Currently Occupied (post-1985) [4]	Historically Occupied [4]
	--	SNB-1, SBB-2	✓[6]	
	Santa Clara Valley (17)	--	✓	
	Watsonville Slough- Elkhorn Slough (partial)(19)	--	✓	
	Carmel River-Santa Lucia (partial)(20)	--	✓	
	Gablan Range (21)	SNB-3	✓	
	Estrella River (28)	SLO-1	✓	
Northern Transverse Ranges and Tehachapi Mountains (7)	--	SLO-8	✓[6]	
	Santa Maria River-Santa Ynez River (24)	STB-4, STB-5, STB-7	✓	
	Sisquoc River (25)	STB-1, STB-3	✓	
	Ventura River-Santa Clara River (26)	VEN-1, VEN-2, VEN-3	✓	
	--	LOS-1	✓[6]	
Southern Transverse and Peninsular Ranges (8)	**Santa Monica Bay-Ventura Coastal Streams (27)**	--	✓	
	San Gabriel Mountain (29)	--		✓
	Forks of the Mojave (30)	--		✓
	Santa Ana Mountain (31)	--		✓
	Santa Rosa Plateau (32)	--	✓	
	San Luis Rey (33)	--		✓
	Sweetwater (34)	--		✓
	Laguna Mountain (35)	--		✓

[1] Recovery units designated by the USFWS (USFWS 2002, pg 49)
[2] Core areas designated by the USFWS (USFWS 2002, pg 51)
[3] Critical habitat units designated by the USFWS on April 13, 2006 (USFWS 2006, 71 FR 19244-19346)
[4] Currently occupied (post-1985) core areas and core areas historically occupied only (i.e., not currently occupied) designated by the USFWS (USFWS 2002, pg 54)
[5] Critical habitat unit where identified threats specifically included pesticides or agricultural runoff (USFWS
[6] Critical habitat units that are outside of core areas, but within recovery units
[7] Currently occupied core areas that are included in this effects determination are bolded.

2.5.1.3 Other Known Occurrences from the CNDBB

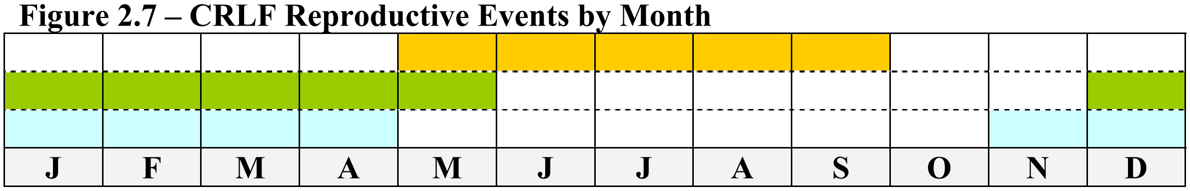
The CNDDB provides location and natural history information on species found in California. The CNDDB serves as a repository for historical and current species location sightings. Information regarding known occurrences of CRLFs outside of the currently occupied core areas and designated critical habitat is considered in defining the current range of the CRLF. See: http://www.dfg.ca.gov/bdb/html/cnddb_info.html for additional information on the CNDDB.

2.5.2 Reproduction

CRLFs breed primarily in ponds; however, they may also breed in quiescent streams, marshes, and lagoons (Fellers 2005a). According to the Recovery Plan (USFWS 2002), CRLFs breed from November through late April. Peaks in spawning activity vary geographically; Fellers (2005b) reports peak spawning as early as January in parts of coastal central California. Eggs are fertilized as they are being laid. Egg masses are typically attached to emergent vegetation, such as bulrushes (*Scirpus* spp.) and cattails (*Typha* spp.) or roots and twigs, and float on or near the surface of the water (Hayes and Miyamoto 1984). Egg masses contain approximately 2000 to 6000 eggs ranging in size between 2 and 2.8 mm (Jennings and Hayes 1994). Embryos hatch 10 to 14 days after fertilization (Fellers 2005a) depending on water temperature. Egg predation is reported to be infrequent and most mortality is associated with the larval stage (particularly through predation by fish); however, predation on eggs by newts has also been reported (Rathburn 1998). Tadpoles require 11 to 28 weeks to metamorphose into juveniles (terrestrial-phase), typically between May and September (Jennings and Hayes 1994, USFWS 2002); tadpoles have been observed to over-winter (delay metamorphosis until the following year) (Fellers 2005b, USFWS 2002). Males reach sexual maturity at 2 years, and females reach sexual maturity at 3 years of age; adults have been reported to live 8 to 10 years (USFWS 2002). Figure 2.7 depicts CRLF annual reproductive timing.

Based on the application cycle for metam sodium which ranges from October to May, there will applications overlapping the breeding period and tadpole stage of development. Both periods would be effected by exposures in the aquatic habitat.

Figure 2.7 – CRLF Reproductive Events by Month



Light Blue = **Breeding/Egg Masses**
Green = **Tadpoles (except those that over-winter)**
Orange = **Young Juveniles**
Adults and juveniles can be present all year

2.5.3 Diet

Although the diet of CRLF aquatic-phase larvae (tadpoles) has not been studied specifically, it is assumed that their diet is similar to that of other frog species, with the aquatic phase feeding exclusively in water and consuming diatoms, algae, and detritus (USFWS 2002). Tadpoles filter and entrap suspended algae (Seale and Beckvar, 1980) via mouthparts designed for effective grazing of periphyton (Wassersug, 1984, Kupferberg *et al.*; 1994; Kupferberg, 1997; Altig and McDiarmid, 1999).

Juvenile and adult CRLFs forage in aquatic and terrestrial habitats, and their diet differs greatly from that of larvae. The main food source for juvenile aquatic- and terrestrial-phase CRLFs is thought to be aquatic and terrestrial invertebrates found along the shoreline and on the water surface. Hayes and Tennant (1985) report, based on a study examining the gut content of 35 juvenile and adult CRLFs, that the species feeds on as many as 42 different invertebrate taxa, including Arachnida, Amphipoda, Isopoda, Insecta, and Mollusca. The most commonly observed prey species were larval alderflies (*Sialis* cf. *californica*), pillbugs (*Armadilliadrium vulgare*), and water striders (*Gerris* sp). The preferred prey species, however, was the sowbug (Hayes and Tennant, 1985). This study suggests that CRLFs forage primarily above water, although the authors note other data reporting that adults also feed under water, are cannibalistic, and consume fish. For larger CRLFs, over 50% of the prey mass may consists of vertebrates such as mice, frogs, and fish, although aquatic and terrestrial invertebrates were the most numerous food items (Hayes and Tennant 1985). For adults, feeding activity takes place primarily at night; for juveniles feeding occurs during the day and at night (Hayes and Tennant 1985).

2.5.4 Habitat

CRLFs require aquatic habitat for breeding, but also use other habitat types including riparian and upland areas throughout their life cycle. CRLF use of their environment varies; they may complete their entire life cycle in a particular habitat or they may utilize multiple habitat type es. Overall, populations are most likely to exist where multiple breeding areas are embedded within varying habitats used for dispersal (USFWS 2002). Generally, CRLFs utilize habitat with perennial or near-perennial water (Jennings et al. 1997). Dense vegetation close to water, shading, and water of moderate depth are habitat features that appear especially important for CRLF (Hayes and Jennings 1988). Breeding sites include streams, deep pools, backwaters within streams and creeks, ponds, marshes, sag ponds (land depressions between fault zones that have filled with water), dune ponds, and lagoons. Breeding adults have been found near deep (0.7 m) still or slow moving water surrounded by dense vegetation (USFWS 2002); however, the largest number of tadpoles have been found in shallower pools (0.26 – 0.5 m) (Reis, 1999). Data indicate that CRLFs do not frequently inhabit vernal pools, as conditions in these habitats generally are not suitable (Hayes and Jennings 1988).

CRLFs also frequently breed in artificial impoundments such as stock ponds, although additional research is needed to identify habitat requirements within artificial ponds (USFWS 2002). Adult CRLFs use dense, shrubby, or emergent vegetation closely associated with deep-water pools bordered with cattails and dense stands of overhanging vegetation (http://www.fws.gov/endangered/features/rl_frog/rlfrog.html#where).

In general, dispersal and habitat use depends on climatic conditions, habitat suitability, and life stage. Adults rely on riparian vegetation for resting, feeding, and dispersal. The foraging quality of the riparian habitat depends on moisture, composition of the plant community, and presence of pools and backwater aquatic areas for breeding. CRLFs can be found living within streams at distances up to 3 km (2 miles) from their breeding site and have been found up to 30 m (100 feet) from water in dense riparian vegetation for up to 77 days (USFWS 2002).

During dry periods, the CRLF is rarely found far from water, although it will sometimes disperse from its breeding habitat to forage and seek other suitable habitat under downed trees or logs, industrial debris, and agricultural features (UWFWS 2002). According to Jennings and Hayes (1994), CRLFs also use small mammal burrows and moist leaf litter as habitat. In addition, CRLFs may also use large cracks in the bottom of dried ponds as refugia; these cracks may provide moisture for individuals avoiding predation and solar exposure (Alvarez 2000).

2.6 Designated Critical Habitat

In a final rule published on April 13, 2006, 34 separate units of critical habitat were designated for the CRLF by USFWS (USFWS 2006; FR 51 19244-19346). A summary of the 34 critical habitat units relative to USFWS-designated recovery units and core areas (previously discussed in Section 2.5.1) is provided in Table 2.5.

'Critical habitat' is defined in the ESA as the geographic area occupied by the species at the time of the listing where the physical and biological features necessary for the conservation of the species exist, and there is a need for special management to protect the listed species. It may also include areas outside the occupied area at the time of listing if such areas are 'essential to the conservation of the species.' All designated critical habitat for the CRLF was occupied at the time of listing. Critical habitat receives protection under Section 7 of the ESA through prohibition against destruction or adverse modification with regard to actions carried out, funded, or authorized by a federal Agency. Section 7 requires consultation on federal actions that are likely to result in the destruction or adverse modification of critical habitat.

To be included in a critical habitat designation, the habitat must be 'essential to the conservation of the species.' Critical habitat designations identify, to the extent known using the best scientific and commercial data available, habitat areas that provide essential life cycle needs of the species or areas that contain certain primary constituent elements (PCEs) (as defined in 50 CFR 414.12(b)). PCEs include, but are not limited to, space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, rearing (or development) of offspring; and habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species. The designated critical habitat areas for the CRLF are considered to have the following PCEs that justify critical habitat designation:

- Breeding aquatic habitat;
- Non-breeding aquatic habitat;
- Upland habitat; and
- Dispersal habitat.

Please note that a more complete description of these habitat types is provided in Appendix I. Occupied habitat may be included in the critical habitat only if essential features within the habitat may require special management or protection. Therefore, USFWS does not include areas where existing management is sufficient to conserve the species. Critical habitat is designated outside the geographic area presently occupied by the species only when a designation limited to its present range would be inadequate to ensure the conservation of the species. For the CRLF, all designated critical habitat units contain all four of the PCEs, and were occupied by the CRLF at the time of FR listing notice in April 2006. The FR notice designating critical habitat for the CRLF includes a special rule exempting routine ranching activities associated with livestock ranching from incidental take prohibitions. The purpose of this exemption is to promote the conservation of rangelands, which could be beneficial to the CRLF, and to reduce the rate of conversion to other land uses that are incompatible with CRLF conservation. Please see Appendix I for a full explanation on this special rule.

USFWS has established adverse modification standards for designated critical habitat (USFWS 2006). Activities that may destroy or adversely modify critical habitat are those that alter the PCEs and jeopardize the continued existence of the species. Evaluation of actions related to use of metam sodium that may alter the PCEs of the CRLF's critical habitat form the basis of the critical habitat impact analysis. According to USFWS (2006), activities that may affect critical habitat and therefore result in adverse effects to the CRLF include, but are not limited to the following:

(1) Significant alteration of water chemistry or temperature to levels beyond the tolerances of the CRLF that result in direct or cumulative adverse effects to individuals and their life-cycles.
(2) Significant increase in sediment deposition within the stream channel or pond or disturbance of upland foraging and dispersal habitat that could result in elimination or reduction of habitat necessary for the growth and reproduction of the CRLF by increasing the sediment deposition to levels that would adversely affect their ability to complete their life cycles.
(3) Significant alteration of channel/pond morphology or geometry that may lead to changes to the hydrologic functioning of the stream or pond and alter the timing, duration, water flows, and levels that would degrade or eliminate the CRLF and/or its habitat. Such an effect could also lead to increased sedimentation and degradation in water quality to levels that are beyond the CRLF's tolerances.
(4) Elimination of upland foraging and/or aestivating habitat or dispersal habitat.
(5) Introduction, spread, or augmentation of non-native aquatic species in stream segments or ponds used by the CRLF.

(6) Alteration or elimination of the CRLF's food sources or prey base (also evaluated as indirect effects to the CRLF).

As previously noted in Section 2.1, the Agency believes that the analysis of direct and indirect effects to listed species provides the basis for an analysis of potential effects on the designated critical habitat. Because metam-sodium is expected to directly impact living organisms within the action area, critical habitat analysis for metam-sodium is limited in a practical sense to those PCEs of critical habitat that are biological or that can be reasonably linked to biologically mediated processes.

2.7 Action Area

For listed species assessment purposes, the action area is considered to be the area affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). It is recognized that the overall action area for the national registration of metam-sodium is likely to encompass considerable portions of the United States based on the large array of both agricultural and non-agricultural uses. However, the scope of this assessment limits consideration of the overall action area to those portions that may be applicable to the protection of the CRLF and its designated critical habitat within the state of California. Deriving the geographical extent of this portion of the action area is the product of consideration of the types of effects that metam-sodium may be expected to have on the environment, the exposure levels to metam-sodium that are associated with those effects, and the best available information concerning the use of metam-sodium and its fate and transport within the state of California.

The definition of action area requires a stepwise approach that begins with an understanding of the federal action. The federal action is defined by the currently labeled uses for metam-sodium. An analysis of labeled uses and review of available product labels was completed. This analysis indicates that, for metam-sodium, the following uses are considered as part of the federal action evaluated in this assessment:

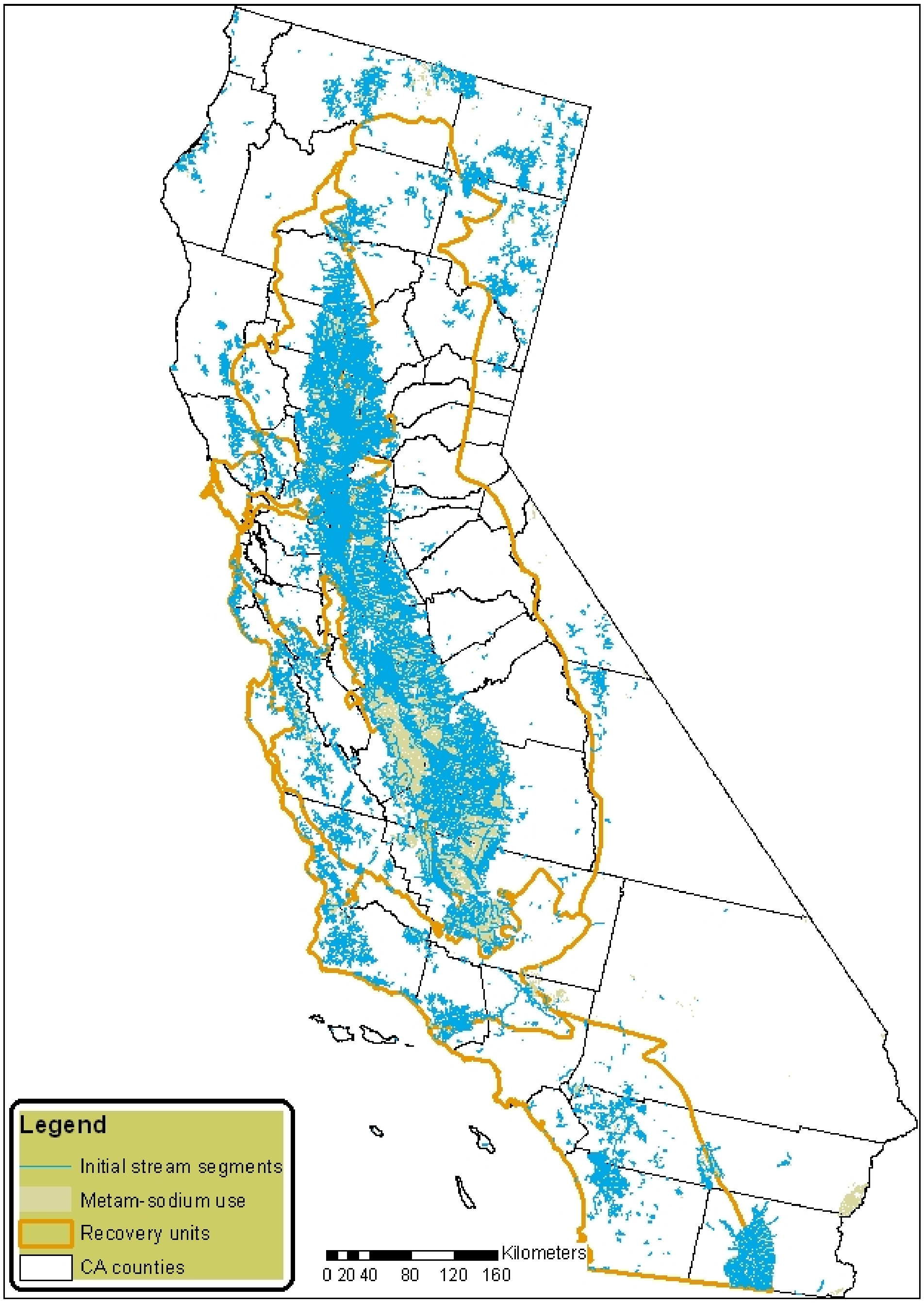
- All agricultural crops
- Commercial storages/warehouse premises
- Commercial facilities (non-food/nonfeed)
- Compost/compost piles
- Food processing plant premises
- Forest trees
- Golf course turf
- Mulch
- Non-ag rights of way, fencerows, hedgerows
- Non-ag uncultivated areas/soils
- Ornamental and/or shade trees
- Ornamental herbaceous plants
- Ornamental lawns and turf
- Ornamental non-flowering plants

- Ornamental woody shrubs and vines
- Potting soil/topsoil
- Recreational area lawns
- Recreational areas
- commercial/industrial water cooling systems
- sewage systems

The risk assessment will focus quantitatively on the agricultural and non-agricultural uses of metam sodium, which has the highest application rates and is expected to present the greatest risk to nontarget organisms. The analysis also indicates that the following uses of metam-sodium has several antimicrobial uses in addition to the agricultural uses. These are: treatment of wood poles, treatment of sewage/organic sludge and animal wastes, cane/beet sugar mills, and hides/skins (leather manufacture). In 2004, the Antimicrobial Division (AD) performed an ecological risk assessment for antimicrobial uses of metam sodium. No appreciable risk to non-target and endangered/threatened plant or animal species is expected from the above antimicrobial uses of metam-sodium (US EPA, 2004d). Since metam sodium also use as spot treatment for tree replantation and placed at deeper depth, exposure of MITC is not likely to exceed estimated exposures for annual crops. Tobacco is not grown in California and excluded in this assessment.

After determination of which uses will be assessed, an evaluation of the potential "footprint" of the use pattern should be determined. This "footprint" represents the initial area of concern and is typically based on available land cover data. Local land cover data available for the state of California were analyzed to refine the understanding of potential metam-sodium use. Maps representing uses for forestry, pasture, and orchard and vineyards are shown in Appendix C, but are not included in the initial area of concern. The action area indicates uses with the highest application rates, which is expected to present the greatest risk to nontarget organisms. The initial area of concern is defined as all land cover types that represent the labeled uses described above. A map representing all the land cover types that make up the initial area of concern is presented in Figure 2.8.

Metam-sodium - Initial Area of Concern



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. July 12, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

Figure 2.8 – CRLF Initial Area of Concern

Once the initial area of concern is defined, the next step is to compare the extent of that area with the results of the baseline level risk assessment. The baseline level risk assessment will define which taxa, if any, are predicted to be exposed at concentrations above the Agency's LOC. The baseline level assessment includes an evaluation of the environmental fate properties of metam-sodium to determine which routes of transport are likely to have an impact on the CRLF.

LOC exceedances are used to describe how far effects may be seen from the initial area of concern. Factors considered include: spray drift, downstream run-off, atmospheric transport, etc. This information is incorporated into GIS and a map of the action area is created.

Subsequent to defining the action area, an evaluation of usage information was conducted to determine area where use of metam-sodium may impact the CRLF. This analysis is used to characterize where predicted exposures are most likely to occur but does not preclude use in other portions of the action area. A more detailed review of the county-level use information was also completed.

The species data along with the potential use (Figure 2.9) demonstrates the area of concern for the overlapping boundaries. No LOCs were exceeded for either aquatic or terrestrial phase CRLF for the shank injection application method, so no further analysis was conducted (section 5.1. and 5.2).

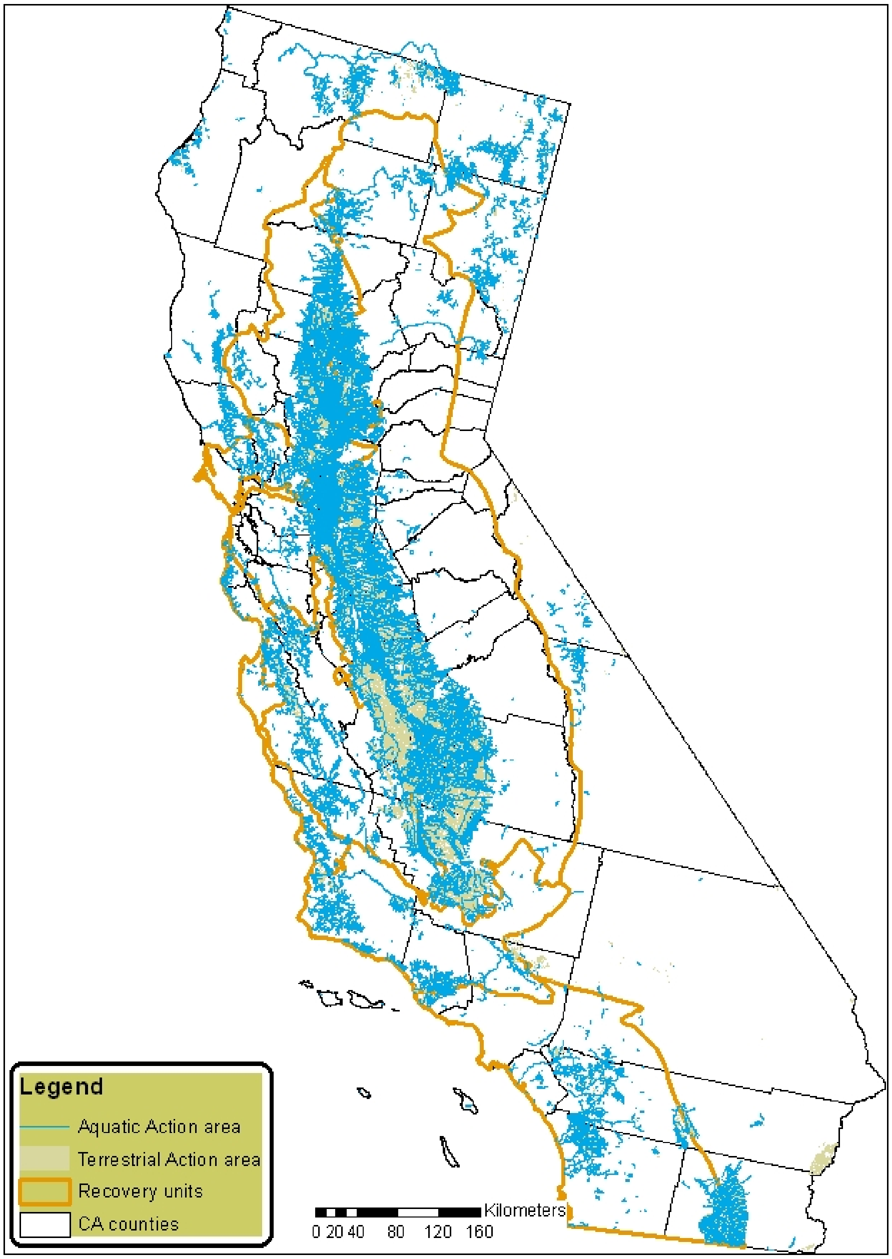
Only the sprinkler irrigation application method resulted in LOC exceedences for the aquatic or terrestrial phase CRLF (section 5.1 and 5.2). For the aquatic phase CRLF, LOCs were exceeded for direct effects for the surrogate fish and for indirect effects of diet for aquatic invertebrates. No LOCs were exceeded for aquatic plants. For the terrestrial phase CRLF, LOCs were not exceeded for the direct effects assessment for the surrogate mammal. The LOC for the indirect effect of fish as a food source did exceed the LOC for the sprinkler irrigation application method for the terrestrial phase CRLF. No data was available to calculate RQs to compare to LOCs for any indirect effects for habitat for the terrestrial phase CRLF.

Based on LOC exceedences, further refinements will be provided for aquatic exposure. Overlapping areas from the aquatic Downstream Model indicate widespread stream exposure from the use of metam sodium in each recovery unit.

Review of the environmental fate data of as well as physico-chemical properties of MITC indicate aquatic exposure is likely to be the dominant route of exposure. The review also indicates inhalation is likely to be the dominant route of exposure for the terrestrial exposure. Given the physico-chemical profile for MITC and observed detections of MITC in both air and rainfall samples, the potential for long range transport outside of the defined action area cannot be precluded; however, these exposure concentrations are not expected to approach those predicted by modeling using the agricultural scenarios.

The exceedences are then used to describe how far outside the initial area of concern effects may be seen. Several models are available to determine how far outside the initial area of concern effects may be seen including AgDRIFT, used to define how far from the initial area of concern an effect to non-target terrestrial plants may be expected. Other processes considered in expanding the initial area of concern can include downstream distance where concentrations are expected to be above the LOC, long-range transport, and secondary exposure through biological vectors. The process of expanding the initial area of concern is repeated for all taxa where exceedences of the LOC occur, and the greatest expansion of the initial area of concern is considered the action area (Fig 2.9).

Metam-sodium - Action Area

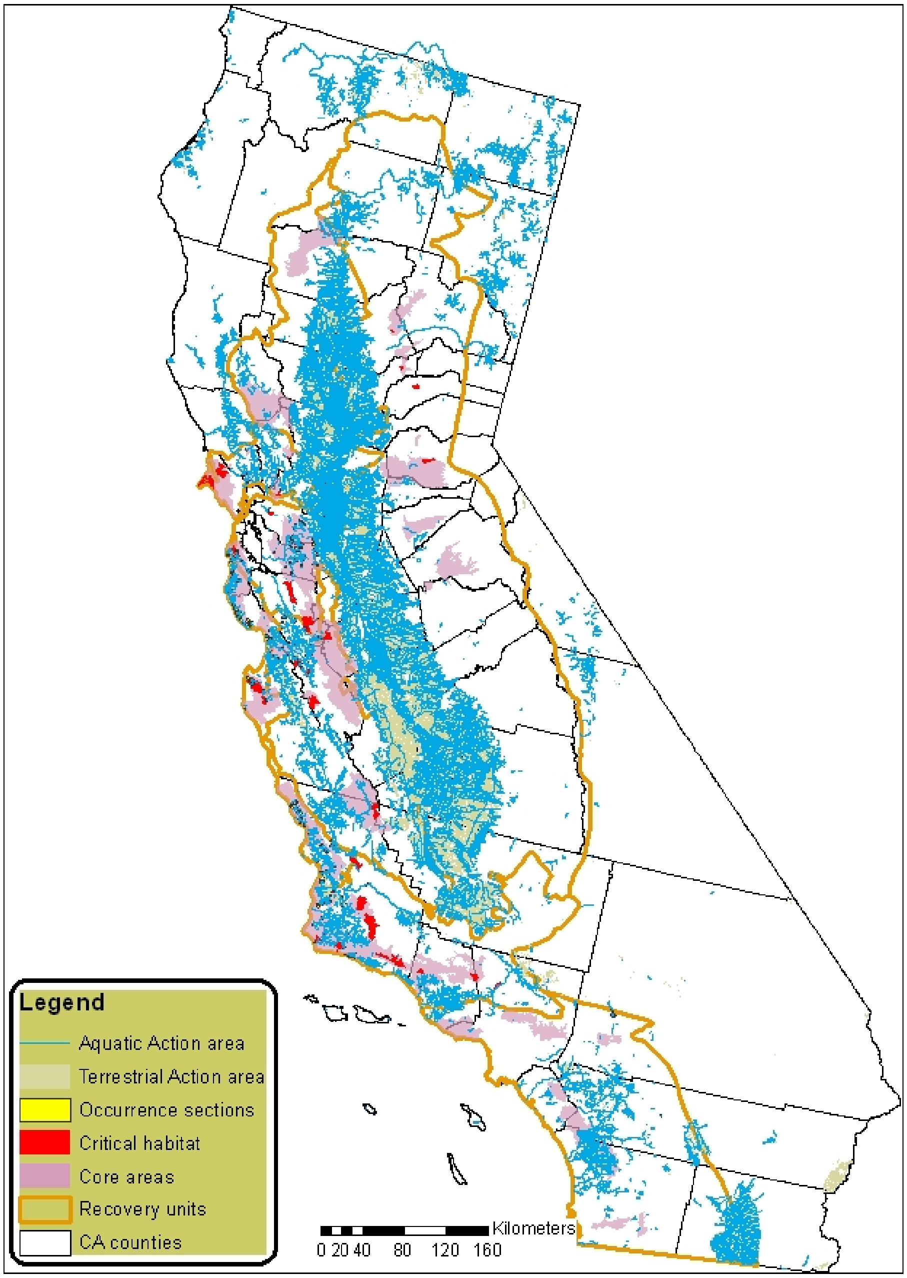


Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. July 12, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

Fig. 2.9 Action Area Based on Aquatic Exposure

Metam-sodium - Action Area & CRLF Habitat



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. July 12, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

Fig 2.10 represents the intersection of the action area and the CRLF habitat. This area is to be used in section 5.1 for the refinement analysis.

2.8 Assessment Endpoints and Measures of Ecological Effect

Assessment endpoints are defined as "explicit expressions of the actual environmental value that is to be protected."(U.S. EPA, 1992). Selection of the assessment endpoints is based on valued entities (e.g., CRLF, organisms important in the life cycle of the CRLF, and the PCEs of its designated critical habitat), the ecosystems potentially at risk (e.g,. waterbodies, riparian vegetation, and upland and dispersal habitats), the migration pathways of metam-sodium (e.g., runoff, spray drift, etc.), and the routes by which ecological receptors are exposed to metam-sodium-related contamination (e.g., direct contact, etc).

2.8.1. Assessment Endpoints for the CRLF

Assessment endpoints for the CRLF include direct toxic effects on the survival, reproduction, and growth of the CRLF, as well as indirect effects, such as reduction of the prey base and/or modification of its habitat. In addition, potential destruction and/or adverse modification of critical habitat is assessed by evaluating potential effects to PCEs, which are components of the habitat areas that provide essential life cycle needs of the CRLF. Each assessment endpoint requires one or more "measures of ecological effect," defined as changes in the attributes of an assessment endpoint or changes in a surrogate entity or attribute in response to exposure to a pesticide. Specific measures of ecological effect are generally evaluated based on acute and chronic toxicity information from registrant-submitted guideline tests that are performed on a limited number of organisms. Additional ecological effects data from the open literature are also considered.

A complete discussion of all the toxicity data available for this risk assessment, including resulting measures of ecological effect selected for each taxonomic group of concern, is included in Section 4 of this document. A summary of the assessment endpoints and measures of ecological effect selected to characterize potential assessed direct and indirect CRLF risks associated with exposure to MITC is provided in Table 2.6.

Table 2.6 Summary of Assessment Endpoints and Measures of Ecological Effects for Direct and Indirect Effects of MITC on the California Red-legged Frog

Assessment Endpoint	Measures of Ecological Effects
Determination of Effects for Aquatic Phase CRLF Using Sprinkler irrigation and Shank Injection Application Method (eggs, larvae, tadpoles, juveniles, and adults)	
1. Survival, growth, and reproduction of CRLF individuals via direct effects on aquatic phases	1a. Most sensitive fish or amphibian acute LC_{50} (Guideline: rainbow trout LC50 of 51.2 µg/L for MITC). 1b. Most sensitive fish or amphibian chronic NOAEC (No guideline data available for MITC) 1c. Most sensitive fish or amphibian early-life stage data (No guideline data available for MITC).
2. Survival, growth, and reproduction of CRLF individuals via effects to food supply (*i.e.*, freshwater invertebrates, non-vascular plants)	2a. Most sensitive fish, aquatic invertebrate, and aquatic plant EC_{50} or LC_{50} (Guideline: rainbow trout LC50 = 51.2 µg/L, acute daphnia LC50 = 55 µg/L, Scenedesmus subspicatus (algae) EC50 =254 µg/L and Duckweed NOAEC = 90 µg/L).

Table 2.6 Summary of Assessment Endpoints and Measures of Ecological Effects for Direct and Indirect Effects of MITC on the California Red-legged Frog

Assessment Endpoint	Measures of Ecological Effects
	2b. Most sensitive aquatic invertebrate and fish chronic NOAEC (No early lifestage fish data available for MITC Supplemental study for chronic daphnia, LC50 = 25 μg/L)
3. Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat, cover, and/or primary productivity (*i.e.*, aquatic plant community)	3a. Vascular plant acute EC_{50} (duckweed EC50 = 590 μg/L) 3b. Non-vascular plant acute EC_{50} (freshwater algae EC50 = 254 μg/L, supplemental data)
4. Survival, growth, and reproduction of CRLF individuals via effects to riparian vegetation, required to maintain acceptable water quality and habitat in ponds and streams comprising the species' current range.	No guideline data is available for MITC. No open literature is available for terrestrial plants. Based on the uncertainty due to limited data, MITC is considered have an adverse effect on riparian vegetation.
Terrestrial Phase *(Juveniles and adults)*	
5. Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles	5a. Most sensitive bird or terrestrial-phase amphibian acute LC_{50} or LD_{50} (Inhalation rat as surrogate for terrestrial phase CRLF for MITC: LC50 = 0.54 mg/kg 5b. Most sensitive bird or terrestrial-phase amphibian chronic NOAEC (No guideline data for inhalation for MITC)
6. Survival, growth, and reproduction of CRLF individuals via effects on prey (*i.e.,*terrestrial invertebrates, small terrestrial vertebrates, including mammals and terrestrial phase amphibians)	6a. Most sensitive terrestrial invertebrate and vertebrate acute EC_{50} or LC_{50} (Surrogate rat inhalation LC50.= 0.54 mg/kg 6b. Most sensitive terrestrial invertebrate and vertebrate chronic NOAEC (Guideline acute daphnia NOAEC = 25 μg/L for MITC. No guideline chronic vertebrate inhalation study submitted for MITC.)
Terretrial Phase (Juvenile and adults)	
7. Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat (*i.e.*, riparian vegetation)	No guideline data is available for MITC. Based on the uncertainty due to limited data, MITC is considered have an adverse effect on riparian vegetation.

2.8.2. Assessment Endpoints for Designated Critical Habitat

As previously discussed, designated critical habitat is assessed to evaluate actions related to the use of metam-sodium that may alter the PCEs of the CRLF's critical habitat. PCEs for the CRLF were previously described in Section 2.6. Actions that may destroy or adversely modify critical habitat are those that alter the PCEs and jeopardize the continued existence of the CRLF. Therefore, these actions are identified as assessment endpoints. It should be noted that evaluation of PCEs as assessment endpoints is limited to those of a biological nature (i.e., the biological resource requirements for the listed species associated with the critical habitat) and those for which metam-sodium effects data are available.

Assessment endpoints and measures of ecological effect selected to characterize potential modification to designated critical habitat associated with exposure to metam-sodium are provided in Table 2.8. Adverse modification to the critical habitat of the CRLF includes the following, as specified by USFWS (2006) and previously discussed in Section 2.6:

1. Alteration of water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs.
2. Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs.
3. Significant increase in sediment deposition within the stream channel or pond or disturbance of upland foraging and dispersal habitat.
4. Significant alteration of channel/pond morphology or geometry.
5. Elimination of upland foraging and/or aestivating habitat, as well as dispersal habitat.
6. Introduction, spread, or augmentation of non-native aquatic species in stream segments or ponds used by the CRLF.
7. Alteration or elimination of the CRLF's food sources or prey base.

Measures of such possible effects by labeled use of metam-sodium on critical habitat of the CRLF are described in Table 2.7. Some components of these PCEs are associated with physical abiotic features (e.g., presence and/or depth of a water body, or distance between two sites), which are not expected to be measurably altered by use of pesticides. Assessment endpoints used for the analysis of designated critical habitat are based on the adverse modification standard established by USFWS (2006).

Table 2.7. Summary of Assessment Endpoints and Measures of Ecological Effect for Primary Constituent Elements of Designated Critical Habitat

Assessment Endpoint	Measures of Ecological Effect
Aquatic Phase PCEs (Aquatic Breeding Habitat and Aquatic Non-Breeding Habitat)	
Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond: aquatic habitat (including riparian vegetation) provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs.	Most sensitive aquatic plant EC50 is the duckweed guideline data, No guideline data is available for terrestrial plants for MITC. Based on the uncertainty due to limited data, MITC is considered have an adverse effect on riparian vegetation.
Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source.[1]	Most sensitive aquatic plant EC50 is the algae *Scenedesmus subspicatus* EC50 = 254 µg/L guideline data, No terrestrial plant guideline data is available for MITC. Based on the uncertainty due to limited data, MITC is considered have an adverse effect on riparian vegetation
Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.	a. Most sensitive EC_{50} or LC_{50} values for fish or aquatic-phase amphibians and aquatic invertebrates (rainbow trout LC_{50}.= 51.2 µg/L . No amphibian guideline data submitted

Table 2.7. Summary of Assessment Endpoints and Measures of Ecological Effect for Primary Constituent Elements of Designated Critical Habitat

Assessment Endpoint	Measures of Ecological Effect
	for MITC.. acute Daphnia LC_{50} = 55 µg/L for MITC). b. Most sensitive NOAEC values for fish or aquatic-phase amphibians and aquatic invertebrates (Guideline: Supplemental chronic daphnia LC50 = 25 µg/L, but no early lifestage fish studies are available.)
Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.,* algae)	a. Most sensitive aquatic plant EC_{50} (Algae EC50 = 254 µg/L and Duckweed NOAEC = 90 µg/L b guideline)
Terrestrial Phase PCEs *(Upland Habitat and Dispersal Habitat)*	
Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs: Upland areas within 200 ft of the edge of the riparian vegetation or dripline surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that provides the CRLF shelter, forage, and predator avoidance	No terrestrial plant guideline data is available for MITC. Based on the uncertainty due to limited data MITC is considered to have an adverse effect on riparian and upland habitat vegetation. .
Elimination and/or disturbance of dispersal habitat: Upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal	
Reduction and/or modification of food sources for terrestrial phase juveniles and adults	The most sensitive estimated food source values for terrestrial phase CRLF include vertebrates (rat inhalation LC50 – 0.54 mg/kg mammals), freshwater fish Rainbow trout LC50 = 51.2 µg/L), and aquatic invertebrates (LC50-55 µg/L). No guideline studies submitted for terrestrial invertebrates.
Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.	

[1] Physico-chemical water quality parameters such as salinity, pH, and hardness are not evaluated because these processes are not biologically mediated and, therefore, are not relevant to the endpoints included in this assessment.

2.9 Conceptual Model

2.9.1 Risk Hypotheses

Risk hypotheses are specific assumptions about potential adverse effects (i.e., changes in assessment endpoints) and may be based on theory and logic, empirical data, mathematical models, or probability models (U.S. EPA, 1998). For this assessment, the risk is stressor-linked, where the stressor is the release of metam-sodium to the environment. The following risk hypotheses are presumed for this endangered species assessment:

- Labeled uses of metam-sodium within the action area may directly affect the CRLF by causing mortality or by adversely affecting growth or fecundity;
- Labeled uses of metam-sodium within the action area may indirectly affect the CRLF by reducing or changing the composition of food supply;

- Labeled uses of metam-sodium within the action area may indirectly affect the CRLF and/or adversely modify designated critical habitat by reducing or changing the composition of the aquatic plant community in the ponds and streams comprising the species' current range and designated critical habitat, thus affecting primary productivity and/or cover;
- Labeled uses of metam-sodium within the action area may indirectly affect the CRLF and/or adversely modify designated critical habitat by reducing or changing the composition of the terrestrial plant community (i.e., riparian habitat) required to maintain acceptable water quality and habitat in the ponds and streams comprising the species' current range and designated critical habitat;
- Labeled uses of metam-sodium within the action area may adversely modify the designated critical habitat of the CRLF by reducing or changing breeding and non-breeding aquatic habitat (via modification of water quality parameters, habitat morphology, and/or sedimentation);
- Labeled uses of metam-sodium within the action area may adversely modify the designated critical habitat of the CRLF by reducing the food supply required for normal growth and viability of juvenile and adult CRLFs;
- Labeled uses of metam-sodium within the action area may adversely modify the designated critical habitat of the CRLF by reducing or changing upland habitat within 200 ft of the edge of the riparian vegetation necessary for shelter, foraging, and predator avoidance.
- Labeled uses of metam-sodium within the action area may adversely modify the designated critical habitat of the CRLF by reducing or changing dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal.
- Labeled uses of metam-sodium within the action area may adversely modify the designated critical habitat of the CRLF by altering chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs.

2.9.2 Diagram

The conceptual model is a graphic representation of the structure of the risk assessment. It specifies the stressor (metam-sodium), release mechanisms, biological receptor types, and effects endpoints of potential concern. The conceptual models for aquatic and terrestrial phases of the CRLF are shown in Figures 2.11 and 2.12, and the conceptual models for the aquatic and terrestrial PCE components of critical habitat are shown in Figures 2.13 and 2.14. Exposure routes shown in dashed lines are not quantitatively considered because the resulting exposures are expected to be so low as not to cause adverse effects to the CRLF.

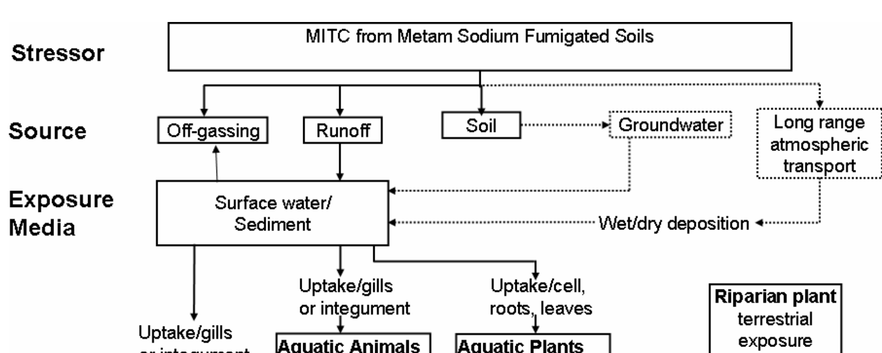


Figure 2.11 Conceptual Model for metam sodium and MITC Effects on Aquatic Phase of the Red –Legged frog

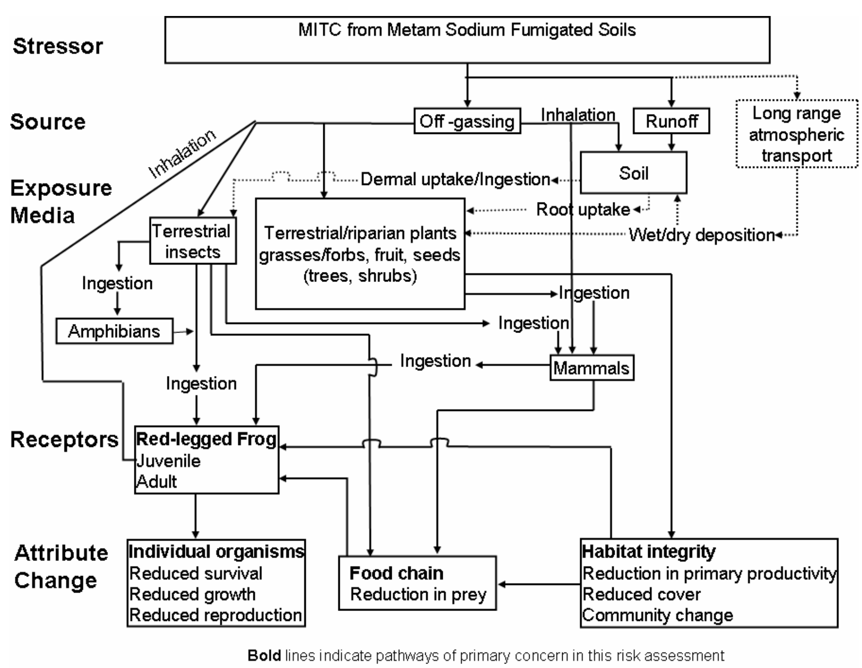


Figure 2.12. Conceptual model for metam Sodium and MITC effects on terrestrial phase of the red-legged frog

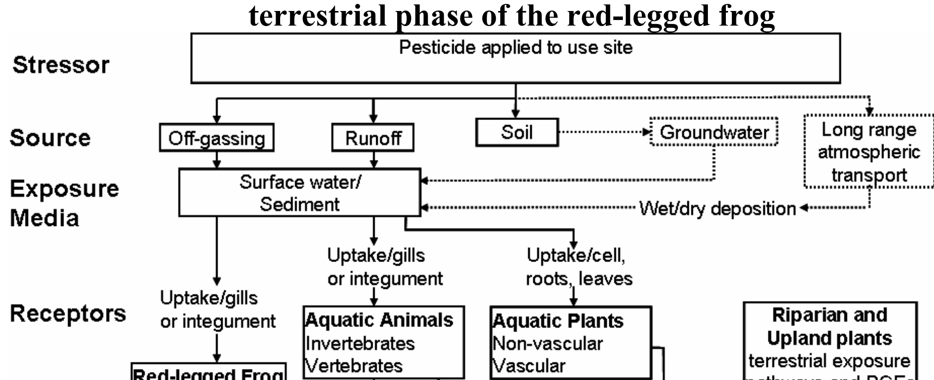


Figure 2.13. Conceptual model for metam sodium and MITC effects on aquatic component of red –legged frog critical habitat

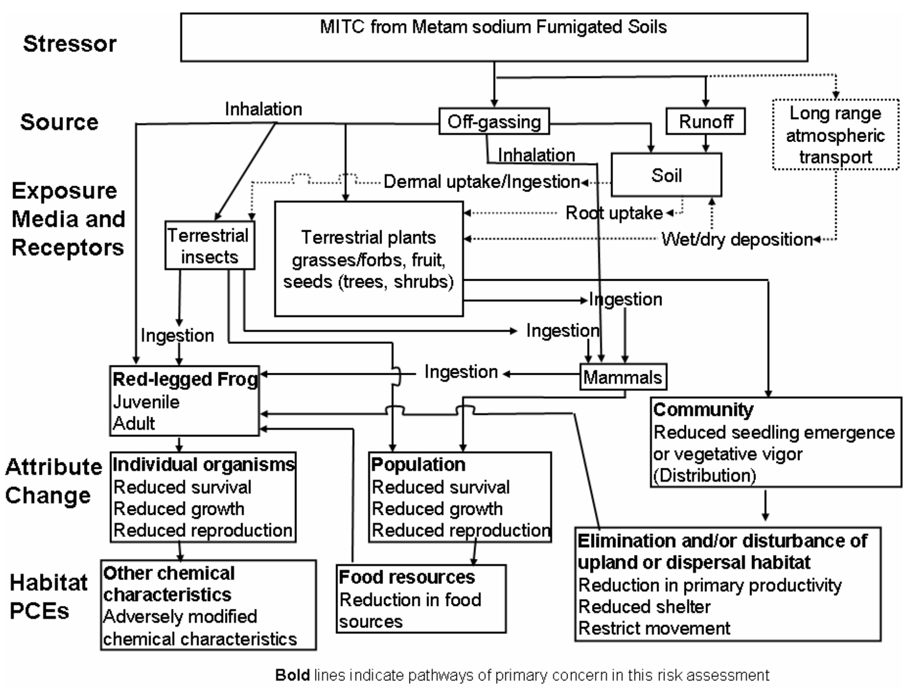


Figure 2.14. Conceptual model for metam sodium and MITC effects on terrestrial component of the red –legged frogcritical habitat

2.9.3 Analysis Plan

In order to address the risk hypothesis, the potential for adverse effects on the CRLF, its prey and its habitat is estimated. Metam sodium is a widely used fumigant on agricultural and non-agricultural sites to control nematodes, soil-borne diseases, insects and weeds.
Since metam sodium degrades rapidly to MITC (section 2) and practically no metam sodium is found in air or water, it is not included for further assessment. In the following sections, the use, environmental fate, and ecological effects of MITC are characterized and integrated to assess the risks. This was accomplished using a risk quotient (RQ), the ratio of exposure concentration to effects concentration. Although risk is often defined as the likelihood and magnitude of adverse ecological effects, the risk quotient-based approach does not provide a quantitative estimate of likelihood and/or magnitude of an adverse effect. However, as outlined in the Overview Document (USEPA 2004), the likelihood of effects to individual organisms from particular uses of metam sodium is estimated using the probit dose-response slope and either the level of concern (discussed below) or actual calculated risk quotient value. If the registrant studies do not provide sufficient data to calculate the RQs, studies from the open literature will be reviewed to determine if acceptable studies are available to be used quantitatively or qualitatively.

To determine the risk of MITC exposure for the aquatic phase of the CRLF, PRZM/EXAMS will be used to provide peak concentrations for the RQ calculations. These concentrations will be used in determining RQs to compare to the endangered species level of concern for the direct effects of survival, growth and reproduction for the fish surrogate and indirect effects of diet and habitat for aquatic plants.

Although birds are used as surrogates for terrestrial risk assessment because they provide a more conservative estimate of risk, no bird acute or inhalation studies have been submitted for MITC. To determine the risk of MITC inhalation exposure for the terrestrial phase of the CRLF, the estimated air concentrations from the ISCST3 model and air monitoring data will be used for the RQ calculations based on the rat surrogate. These concentrations are used to determine RQs for the direct effects of survival. Based on the physio-chemical properties of the chemiccal (section 2) ingestion is not an exposure pathway, and an assessment to determine the indirect effects for the terrestrial phase CRLF for the diet is not required No registrant crop studies have been submitted to determine RQs for terrestrial habitat to determine a risk conclusion for and indirect effects on the CRLF and on critical habitat.

The RQs will be used to determine LOC exceedences for direct and indirect effects for the CRLF. A "preliminary determination of a "May Affect" is based on the listed species LOC exceedence. For "May Affect" conclusion, further refinements are based on the individual effects estimation based on the probit slope model and spatial characteristics from mapping the overlapping areas of metam sodium stream exposure and the core areas for the CRLF through a downstream model from GIS.

2.10 Preliminary Identification of Data Gaps

The adequacy of the submitted data was evaluated relative to the Agency guidelines. The following identified data gaps for ecological fate and direct effect endpoints of survival, growth and reproduction, and indirect effect endpoints of diet and habitat results in a degree of uncertainity in evaluating the ecological risk of MITC.

No data are available to assess the acute or chronic risk of MITC to birds, including no inhalation data.

No data are available to assess freshwater diatoms.

No data is available to assess the chronic risk of MITC to freshwater fish.

No data are available to assess the risk of terrestrial invertebrates.

No data are available to assess the risk of MITC to terrestrial plants.

3.0 Exposure Assessment

3.1 Label Application Rates and Intervals

Metam sodium is applied as a preplant fumigation by shank injecting or chemigation via sprinkler or drip irrigation into the soil. Application rates and fumigation application methods for the selected crops are largely determined based on major uses of metam sodium for agricultural and non-agricultural practices in California (Figure 2.5). Additional scenarios were selected for exposure assessment if particular niche locations were found to be vulnerable to RLF habitats. Application rates, timing, and techniques were compiled from actively registered labels and crop scenarios. Rates used in modeling are the maximum allowed rate for that specific crop or crop group. Metam sodium labels permit a single application, thus intervals are not included in Table 2.3. There are some labels with higher rates than 320 lbs/A which are not included in this assessment because those rates are recommended for small treatment area (< 100 ft^2) using handheld sprinkler containers. Lower rates may also exist, and/or growers may choose to apply lower concentrations than permitted by the label.

3.2 Aquatic Exposure Assessment

Estimated environmental concentrations (EEC) of MITC in surface waters were calculated using PRZM (Pesticide Root Zone Model) v.3.12 for subsurface application and v.3.12.2 for surface application by sprinkler irrigation, which simulates runoff and erosion from the agricultural field, and EXAMS v.2.98 (Exposure Analysis Modeling System), which simulates environmental fate and transport in surface water. A graphical user interface developed by EPA (http://www.epa.gov/oppefed1/models/water/) was employed to enter the input values for each model run. A pond scenario was used to determine EEC for the RLF risk assessment.

Tier II PRZM/EXAMS simulations are run for multiple (usually 30) years and the reported EECs are the concentrations that are expected once every ten years based on the thirty years of daily values generated by the simulation. As such, it provides high-end values of the pesticide concentrations that might be found in ecologically sensitive environments following pesticide application. PRZM/EXAMS simulates a 10 hectare (ha) field immediately adjacent to a 1 ha pond, 2 meters deep with no outlet. Exposure estimates generated using the standard ecological pond are intended to represent a wide variety of vulnerable water bodies that occur at the top of watersheds including prairie pot holes, playa lakes, wetlands, vernal pools, man-made and natural ponds, and intermittent and first-order streams. As a group, there are factors that make these water bodies more or less vulnerable than the standard surrogate pond. Static water bodies that have larger ratios of drainage area to water body volume would be expected to have higher peak EECs than the standard pond. These water bodies will be either shallower or have large drainage areas (or both). Shallow water bodies tend to have limited additional storage capacity, and thus, tend to overflow and carry pesticide in the discharge whereas the standard pond has no discharge. As watershed size increases beyond 10 hectares, at some point, it becomes unlikely that the entire watershed is planted to a single crop, which is all treated with the pesticide. Headwater streams can also have peak concentrations higher than the standard pond, but they tend to persist for only short periods of time and are then carried downstream.

The location of the field is specific to the crop being simulated using site specific information on the soils, weather, cropping, and management factors associated with the scenario. The crop and location of specific scenarios in California is intended to represent a high-end vulnerable site on which the crop is normally grown. Based on historical rainfall patterns, the pond receives multiple runoff events during the years simulated.

3.2.1 Modeling Approach

Henry's Law constant (1.79 x 10^{-4} atm-m^3/mol) of MITC suggest that rapid volatilization of MITC from water and soil surfaces is expected to be an important process. Since Tier I model GENEEC is not capable in accounting the loss of the vapor phase of MITC from the fumigated field, Tier II PRZM/EXAMS was used in estimating MITC as well as metam sodium concentrations in surface water. Additional chemical specific physical parameters vapor phase diffusion coefficient (DAIR) and enthalpy of vaporization (ENPY) of MITC were activated during the PRZM/EXAMS simulation. Intended application methods via sprinkler, shank or drip irrigation are to fumigate subsurface uniformly. Therefore, subsurface chemical application method (CAM 8-chemical incorporated entirely into depth specified by PRZM user) was used in mimicking subsurface fumigation of metam sodium to simulate its uniform distribution for certain depths through vapor diffusion under the tarp and other sealing methods.

The maximum application rates and relevant environmental fate parameters for MITC were used in the screening model PRZM/EXAMS in estimating concentrations in surface water. Tables 3.1 and 3.2 present the input parameters used in the Tier II PRZM/EXAMS modeling. The application rate of MITC was calculated using the following approach. From the equation shown below, one mole or 129.2 mass unit of metam sodium degrades to produce one mole or 73.1 mass units of MITC. Thus, the mass conversion ratio or molecular weight (MW) ratio of MITC to metam sodium is 0.57. The aerobic soil metabolism study suggests that the maximum conversion rate of metam sodium to MITC was 83.0%. Therefore, for example, the maximum application rate of MITC would be (0.83)(0.57)(320) = 151.4 lbs/Acre at 320 lbs/Acre application rate of metam sodium.

Stoichiometry of MITC formation from Metam Sodium

$$\underset{\substack{\text{Metam Sodium}\\ \text{MW} = 129.2\ \text{g Mole}^{-1}}}{\mathbf{C_2H_4NNaS_2}} \longrightarrow \underset{\substack{\text{MITC}\\ \text{MW} = 73.1\ \text{g Mole}^{-1}}}{\mathbf{C_2H_3NS}} + \textbf{other products}$$

3.2.2 Model Inputs

A summary of model inputs of physicochemical and environmental fate properties used in this assessment are provided in Table 3.1 and 3.2.

Table 3.1. PRZM/EXAMS Input Parameters for Metam sodium

Parameters	Values & Units	Sources
Molecular Weight	129.2 g $Mole^{-1}$	
Vapor Pressure 20°C	Non-volatile	
Water Solubility @ pH 7.0 and 25°C	722 g L^{-1}	
Hydrolysis Half-Life (pH 7)	2 Days	MRID# 41631101
Aerobic Soil Metabolism $t_{½}$,	0.06 x 3 Days*	MRID# 40198502
Aerobic Aquatic metabolism: for entire sediment/water system	0.18 x 2 Days**	EFED Guideline
Aqueous Photolysis	0.02 Days	MRID# 41517701
Soil Water Partition Coefficient (K_{oc})	4.038 L Kg^{-1} ***	EPISUITE
Pesticide is Wetted-In	No	Product Label

* = Due to one reported half-life, input half-life was multiplied by 3 according to Guidance for selecting input parameters in modeling for environmental fate and transport of pesticides. Version II. December 4, 2001.
**= In the absence of an aerobic aquatic metabolism half-life, the reported half-lives of aerobic soil metabolism were multiplied by 2 according to Guidance for selecting input parameters in modeling for environmental fate and transport of pesticides. Version II. February 28, 2002.
*** = The EPI (Estimation Program Interface) SuiteTM is a Windows® based suite of physical/chemical property and environmental fate estimation models developed by the EPA's Office of Pollution Prevention Toxics and Syracuse Research Corporation SRC. http://www.epa.gov/opptintr/exposure/docs/updates_episuite_v3.11.htm
‡ www.pestdata.ncsu.edu/cropprofiles/cropprofiles.cfm

Table 3.2. PRZM/EXAMS Input Parameters for MITC, a Metam sodium Metabolite

Parameters	Values & Units	Sources
Molecular Weight	73.12g $Mole^{-1}$	Product Chemistry
Vapor Pressure @ 25°C	19 mm Hg	CDPR, 2002
Water Solubility @ pH 7.0 and 25°C	7600 mg L^{-1}	Product Chemistry
Vapor Phase Diffusion Coefficient (DAIR)	8227 cm^2 day^{-1}	Fuller et al., 1966
Enthalpy of Vaporization	8.91 kcal $mole^{-1}$	Chickos and Acree, 2003
Hydrolysis Half-Life (pH 7)	20.4	MRID 001581-62
Aerobic Soil Metabolism $t_{½}$,	9.61 Days (5.4 - 20.2 days) (3.3-9.9 days)	(Calculated 90th Percentile) MRID 460847-01 Gerstl et al, 1977

Table 3.2. PRZM/EXAMS Input Parameters for MITC, a Metam sodium Metabolite

Parameters	Values & Units	Sources
Aerobic Aquatic metabolism: for entire sediment/water system	19.2[†]	EFED Guideline
Anaerobic aquatic metabolism	Stable	MRID 439084-26
Aqueous Photolysis	51.6 Day	CDPR, 2002
Soil Water Partition Coefficient	0.26 L Kg^{-1} (Mean K_d)	Gerstl et al., 1977
Application Method	MITC generates from ground application of metam sodium	MRID# 40198502

[†] = In the absence of an aerobic aquatic half-life, the reported half-life of aerobic soil metabolism is multiplied by 2 according to Guidance for selecting input parameters in modeling for environmental fate and transport of pesticides. Version II. December 4, 2001.

3.2.2.1 PRZM scenarios

Table 3.3 summarizes the crop-specific management practices for all of the assessed uses of metam sodium that were used in PRZM/EXAMS modeling, including application rates, application method, sealing method and the first application date for each crop. Since metam sodium also use as spot treatment for tree replantation and placed at deeper depths, exposure of MITC is not likely to exceed estimated exposures for annual crops. Therefore, no fruit and nut tree scenarios were evaluated for this assessment. PRZM scenarios used to model aquatic exposures resulting from applications of specific uses are identified in Table 3.3**.** In cases where a scenario did not exist for a specific use, it was necessary to assign a surrogate scenario. Those surrogates were assigned to be most representative of the use being considered. Justifications for assignments of surrogates are defined below. In all cases, scenarios were run for sprinkler irrigation and shank injection with non-irrigated scenarios to estimate aquatic exposure. Since shank injection and drip irrigation are subsurface application methods, exposures from drip irrigation were not performed. However, the aquatic exposures from shank injection are more conservative than the drip irrigation method.

Table 3.3. PRZM/EXAMS Input data for Crop management .

Crops	App. Rate (lb/A)	App. Methods	Depth of Incorporation (cm)	Surface Sealing	App. Date
Leafy Vegetable[1]	320.0	Sprinkler irrigation Shank injection	25	No tarp	February 15
Melon[2]	320.0	Sprinkler irrigation Shank injection	25	No tarp	May 15

Table 3.3. PRZM/EXAMS Input data for Crop management .

Crops	App. Rate (lb/A)	App. Methods	Depth of Incorporation (cm)	Surface Sealing	App. Date
Nursery[3]	320.0	Sprinkler irrigation Shank injection	76	No tarp	February 15
Onion[4]	320.0	Sprinkler irrigation Shank injection	25	No tarp	December 15
Potato[5]	320.0	Sprinkler irrigation Shank injection	25	No tarp	February 15
Row Crops[6]	320.0	Sprinkler irrigation Shank injection	25	No tarp	December 15
Strawberry	320.0	Sprinkler irrigation Shank injection	25	No tarp	December 15
Tomato	320.0	Sprinkler irrigation Shank injection	25	No tarp	February 15
Turf	320.0	Sprinkler irrigation Shank injection	25	No tarp	December 15

[1] CA lettuce to represent lettuce and leafy vegetables
[2] CA melon to represent Cucurbits (Melons, cantaloupes, cucumber, honeydews, watermelons)
[3] CA Nursery to represent Outdoor ornamentals
[4] CA Potato to represent Tuber crops (White and sweet potatoes)
[5] CA Onion to represent Root Crops (onion)

3.2.3 Results

For each PRZM/EXAMS scenario, a sprinkler irrigation and a shank injection application into soil with no tarp scenario was evaluated following the maximum application rate of 320 lbs/A of metam sodium (Table 3.4). Acute risk assessments are performed using peak EEC values for a single application. Since, metam-sodium is a preplant fumigant and its breakdown product MITC is a phytotoxic compound, presence of these compounds are not desirable in the treated fields during the planting and crop emergence. MITC is also volatile and very reactive in the environment. Terrestrial field dissipation study indicates that metam sodium and MITC residues were not detected in soils after 14 days. Therefore, measurable residues of metam-sodium and MITC are not reported to remain in the treated field before planting and crop emergence and thus the potential for chronic exposure is considered unlikely. PRZM/EXAMS estimated 21- and 90-day's chronic values for aquatic assessment are not used.

Table 3.4. Estimated Environmental Concentrations (EECs) fo Metam sodium and MITC in surface water for selected crop scenarios of California

Crops (California)	Application Methods	
	Sprinkler Irrigation	Shank Injection
	Acute: Peak EEC µg/L	Acute: Peak EEC µg/L
	Metam Sodium	
For All modeled crops	0.00	0.00
	MITC	
Strawberry	59.43	0.60
Potato	0.06	0.00
Onion	4.11	0.28
Row Crops (carrot and pepper)	0.12	0.01
Tomato	35.35	0.00
Lettuce	56.58	0.00
Melon	0.02	0.00
Nursery	23.16	0.11
Turf	28.12	0.00

3.2.4 Existing Monitoring Data

A critical step in the process of characterizing EECs is comparing the modeled estimates with available surface water monitoring data. Surface water monitoring data from the United States Geological Survey (USGS) NAWQA (http://water.usgs.gov.nawqa) and the California Department of Pesticide regulation (CDPR) programs were accessed and downloaded. At present time, metam sodium or MITC is not included in the USGS-NAWQA and CDPR Pesticide monitoring survey. Based on non-targeted survey data, no MITC has been detected in 14864 ground water samples collected from 45 states over several years for Pesticides in Ground Water Data Base (PGWDB).

However, several water monitoring studies were conducted following the derailment of a railroad car north of Dunsmuir, California on July 4, 1991, when approximately 19,000 to 27,000 Kg of metam sodium spilled into the Sacramento River. MITC concentrations in water samples collected following the spill, reach a maximum of 5500 µg/L three days after the spill at the northern most inlet of Shasta Lake, and decreased to 8 µg/L six days later. None of the degradates of metam sodium in water samples analyzed were detected 1 week after the spill (del Rosareo et al., 1994 and Segawa et at., 1991).

3.3 Terrestrial Animal Exposure Assessment

To determine terrestrial exposure of MITC from metam sodium application, a deterministic approach was used in estimating exposures around the treated fields. This deterministic approach is based on monitoring data of MITC and the use of the EPA's Industrial Source Complex:

Short-Term Model (ISCST3) air dispersion model developed by USEPA (U.S.EPA, 1995). ISCST3 is a steady-state Gaussian plume model, which can be used to assess pollutant concentrations from a wide variety of sources. The ISCST3 model is a publicaly vetted tool that is currently used by the Agency's Office of Air for regulatory decision making. A number of support documents for this tool can be found at the Agency's website *Technology Transfer Network Support Center for Regulatory Air Models* (http://www.epa.gov/scram001/tt22.htm#isc.) The ISCST3 has been used successfully to simulate fumigant levels in air following the fumigation of warehouses and agricultural fields located in California (Barry et al. 1997). ISCST3 provides useful results because it allows estimation of air concentrations based on changing factors such as application rates, field sizes, downwind distances, wind and weather conditions, and other factors. Using this model for the soil fumigants allows Agency to predict off-site movement given fixed meteorological and other conditions.

The modeling approaches used by the Agency were based on 24 hours exposure intervals (i.e., 24 hours time-weighted average of monitored air concentration of MITC). Field sizes include 1-, 5-, 10-, 20-, and 40 acre squares to represent a cross section of the fields that might be fumigated for agriculture use. ISCST3 was used in estimating air concentration using field emission ratio (ratio of the flux rate to the application rate), various sized fields, methods of metam sodium placement, and different meteorological conditions. The basic approaches to estimate air concentrations using ISCST3 model are outlined in the Health Effects Division's Draft Standard Operating Procedures (SOPs) for Estimating Bystander Risk from Inhalation Exposure to Soil Fumigant (USEPA,2004b). ISCST3 estimated downwind air concentrations using hourly meteorological conditions that include the wind speed and atmospheric stability.

In this assessment, one set of computations was completed using ISCST3 model at varying acreage and atmospheric conditions. The lower the wind speed and more stable the atmospheric environment, the higher the air concentrations were observed near the treated areas. The outputs were then scaled to appropriate emission ratios and application rates assuming stable weather condition, Table 3.5 reflects a wide variety of application methods as well as the estimated concentrations of MITC in air at the edge of a 40 acres field size under stable weather condition. A maximum concentration of 0. 008 mg/L (8404 μg/m^3) was estimated using 320 lbs/A application rate, 40 acres field size and 0.23 emission ratio under selected California Department of Pesticide Regulation's (CDPR) application Permit Conditions. Permit conditions and detailed input assumptions and model results were described in the *HED's Draft Chapter on Non-Occupational Risks Associated with MITC (USEPA, 2004c).*

The specific inputs for the ISCST3 model calculations drove the associated uncertainties in the results. For example, the key input factors for pre-plant agricultural uses were field size, flux/emission rates, atmospheric stability, and windspeed. Wind direction is another factor which also should be considered. The field sizes used by the Agency in this assessment were 1 to 40 acres which is well within the range of what could be treated on a daily basis.

There are uncertainties associated with point estimates of flux/emission rates for specific application techniques which is another varying factor. The flux rates which were used have been calculated by the Agency and they compare reasonably well with those calculated by the study investigators. The reality is that there is a large distribution of flux rates which is a phenomena inherent in the nature of these types of data.

Table 3.5. ISCTS3 estimated air concentrations of MITC at various distances from the edge of 40 acres fumigated fields (meter) under several application methods

Application Methods	Surface sealing	Application Rate (lbs/Acre)	Concentration MITC in Air ($\mu g/m^3$)[1]			
			0 M[2]	25 M	100 M	500 M
Sprinkler Irrigation Broadcast	No	320	8404	4834	3035	1334
Shank Injection Broadcast	No	320	6304	3650	2292	1008
Shank Injection Broadcast	Water	320	2744	1578	992	436
Drip Irrigation Raised Bed	Tarping	320	1204	690	434	190
Drip Irrigation Raised Bed	No	320	427	247	155	68

[1] mg/L = $\mu g/m^3$/1,000,000
[2] Distances (meter) from the edge of the field

The values used for this assessment yield conservative air concentration estimates because considering a constant flux rate does not allow for diurnal/nocturnal changes that may occur, which when coupled with the appropriate wind speed and stability category, can result in lower concentrations. The meteorological inputs also will provide a conservative estimate of exposure because the wind direction is considered to be perpendicular (pointed downwind) to the treated field for the entire 24 hours represented in the calculation. This is not a normal situation in the atmosphere for most locations. There is normally a prevailing wind with directional changes over the course of a typical day, especially when diurnal and nocturnal differences are noted. Overall, the Agency believes that the approach used to evaluate potential exposures from a known area source can be considered conservative. It is believed, however, that the range of selected input values and outputs represent what could reasonably occur in agriculture given proper field and climatological conditions.

3.4 Atmospheric Monitoring Data

Several air monitoring studies have been conducted in California to determine the concentrations of MITC in air adjacent to the metam sodium applied sites associated with specific application methods. Wofford et al., (1994) conducted a study in August 1993 in Kern County, California to measure the concentrations of MITC in air associated with a sprinkler application of metam sodium. Sixty percent of air samples had detectable MITC residues. The highest MITC concentration occurred primarily during the application and immediately following the watering-in referred as soil sealing periods. Concentration during application ranged from 78.3 to 2450 $\mu g/m^3$ at 5 meters from the field edge and 11.7 to 1320 $\mu g/m^3$ at 150 meters from the field edge.

Hydrogen sulfide gas (H_2S) was also detected at 3-76 μg/m^3 during application and 3-8 μg/m^3 22 hours post application. These concentrations gradually decreased to non detect over the course of the study (72 hours). No carbon disulfide (CS_2) was detected above the detection limit of 4 μg/m^3. A separate air monitoring study was conducted in Kern County, California to measure the MITC and MIC residue in air associated with soil injected application of metam sodium (ARB, 1997). Measurable MITC residues were detected in all samples ranging from 0.21 to 84 μg/m^3 (0.24 to 250 μg/m^3). MIC concentrations were ranging from 0.09 to 2.5 μg/m^3 (0.2-5.8 μg/m^3). These studies suggest that the metam sodium application methods affect the volatility rates of MITC and consequently dictate the ambient residue of MITC in the air samples.

Several studies were performed to determine the concentrations of MITC in the ambient air samples. These air sampling studies are not necessarily coincided with application of metam sodium in the area. However, these studies were carried out in high use areas of California. MITC concentration measured in the ambient air were considerably lower than the concentrations monitored in the application site. Seiber et al. (1999) reported the MITC concentrations in ambient air samples from indoor (residential) and outdoor near Kern County, California. This study was conducted during the summer of 1997 and the winter of 1998. Approximately 75 percent of the samples in summer of 1997 and 67 percent of air samples in winter 1998 had detectable concentrations of MITC. The reported MITC concentrations in the air samples collected during the summer of 1997 ranged from " not detected" to 6.02 μg/m^3 for indoor air samples and "not detected" to 10.41 μg/m^3 for the outdoor air samples. The MITC concentration for winter 1998 air samples for both indoor and outdoor were very similar and had MITC concentrations less than 1.36 μg/m^3. It was concluded that the proximity to the treated fields, timing of the metam sodium application, and prevailing wind directions seemed to be contributing factors with respect to detectable MITC residue in the ambient air samples. Another air monitoring study was conducted at five locations in Lompoc, California. The concentrations of MITC and other pesticides in ambient air samples were monitored from August 31 through September 13, 1998 within the Lompoc City limits adjacent to the agricultural fields. The concentrations of MITC ranged from "not detected" to 0.34 μg/m^3 (1.0 μg/m^3).

4. 0 Effects Assessment

Effects characterization describes the potential effects a pesticide can produce in an aquatic or terrestrial organism. This characterization is typically based on studies that describe acute and chronic effects toxicity information for various aquatic and terrestrial animals and plants. Acute studies will be used for this characterization due to the physio-chemical properties of metam sodium and MITC which indicate no residue detected in the soil at 14 days. However, data for metam sodium and the degradate MITC, while relatively extensive for mammals, are very limited otherwise. Toxicity testing reported in this section does not represent all species of birds, mammals, or aquatic organisms. For mammals, acute studies are usually limited to Norway rat or the house mouse. The risk assessment assumes that avian toxicity would be protective for the terrestrial phase CRLF, therefore the avian toxicity test results would be used to represent that life cycle of the CRLF. Due to the lack of inhalation data on avian toxicity tests, mammal data is utilized in this assessment. The fish toxicity data is used to represent the aquatic phase amphibians under the assumption that fish and amphibian toxicities are similar. Inhalation is considered to be the only relevant route of exposure due to the rapid degradation of metam sodium to MITC.

Both terrestrial and aquatic exposure is expected to be largely, if not entirely, to MITC. Metam sodium converts rapidly to MITC upon application in the field, as discussed earlier. The effects assessment summary focuses on MITC as does the risk assessment. The most sensitive acute toxicity references values associated with MITC exposure to aquatic organisms are summarized in the following sections.

4.1 Evaluation of Amphibian Ecotoxicity Studies

There were no registrant submitted studies for amphibians for metam sodium or MITC.

A study (Birch and Prahlad, 1986, ECOTOX Ref. #12119) examines the developmental toxicity of MITC in the South African clawed frog (*Xenopus laevis*). Data from this study was not used due to the limitations of the study based on no report of measured concentrations for a volatile chemical in a static toxicity test, no control mortality data, and water quality issues from number of animals per chamber.

No control versus solvent control mortality was reported for the tadpole study. No control mortality was reported. The loading (number of tadpoles per chamber) would impact water quality . There was no report of tadpoles being fed. No results for the mortality were provided in data for the tadpole study, therefore no dose-response effect was verified.. No measured concentrations were reported either initial or termination concentrations for the volatile pesticide MITC. No data was available for statistical review. Embryos were less sensitive to MITC than tadpoles for mortality. Only embryo data for survival and damage were reported for the control and for concentrations below 1 μg/L No data was available for statistical review. No measured concentrations were reported for this volatile chemical.

4.2 Evaluation of Aquatic Ecotoxicity Studies

4.2.1 Registrant Studies

The most sensitive study from the submitted guideline studies are presented in Tables 4.1 through 4.5.

Two freshwater fish toxicity studies using the TGAI are required to establish the toxicity of MITC to the surrogate fish. It has been determined that data on MITC satisfy the data requirement for metam-sodium. The preferred test species are rainbow trout (a coldwater fish) and bluegill sunfish (a warmwater fish). Results of these tests are tabulated below. The toxicity category descriptions for freshwater and estuarine/marine fish and aquatic invertebrates, are defined below in parts per million (ppm).

> If the LC_{50} is *less than 0.1 ppm a.i.*, then the test substance is *very highly toxic*.
> If the LC_{50} is *0.1-to-1.0 ppm a.i.*, then the test substance is *highly toxic*.
> If the LC_{50} is *greater than 1 and up through 10 ppm a.i.*, then the test substance is *moderately toxic*.
> If the LC_{50} is *greater than 10 and up through 100 ppm a.i.*, then the test substance is *slightly toxic*.
> If the LC_{50} is *greater than 100 ppm a.i.*, then the test substance is *practically nontoxic*.

4.2.1.1 Freshwater Fish, Acute

Table 4.1. Freshwater Fish Acute Toxicity-MITC

Species/ Flow-through or Static	% ai	LC_{50} (mg/L)	Toxicity Category	MRID/Accession (ACC) No. Author/Year	Study Classification
Rainbow Trout/(Oncorhynchus sp.)/static renewal	99.6	0.0512	very highly toxic	45919420/Zok/2002	Suppl.
Bluegill Sunfish *(Lepomis macrochirus)*/flow-through	94.9	0.142	highly toxic	44523412 (=42058001)/Schupner & Stachura/1991	Core

MITC is considered very highly toxic to freshwater fish (e.g., rainbow trout LC_{50} = 51.2 µg/L).

4.2.1.2 Freshwater Invertebrates, Acute

A freshwater aquatic invertebrate toxicity test using the TGAI is required to establish the toxicity of MITC to aquatic invertebrates. The preferred test organism is *Daphnia magna*, but early instar amphipods, stoneflies, mayflies, or midges may also be used. Results of this test are tabulated below.

Studies have been conducted on MITC, the principal degradate of metam-sodium and the focus of the present risk assessment. They are summarized in the following table.

Table 4.2: Freshwater Invertebrate Acute Toxicity – MITC

Species/ Flow-through or Static	% ai	LC_{50} (ppm)	Toxicity Category	MRID/Accession (ACC) No. Author/Year	Study Classification
Daphnid *(Daphnia magna)*/flow-through	95	0.055	very highly toxic	41819302/Schupner/ 1991	Acceptable

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

With a lowest EC_{50} of 0.055 ppm, MITC is categorized very highly toxic to freshwater aquatic invertebrates on an acute basis.

4.2.1.3 Freshwater Invertebrates, Life Cycle

Based on the physio-chemical properties of MITC which indicates non-detectable levels in the soil at 14 days, no chronic exposure is expected. The guideline study submitted is for 21 days.

4.2.1.4 Aquatic Freshwater Plants

Table 4.4 Aquatic Plant Toxicity (Tier II) - MITC

Species	% A. I.	EC_{50}/NOAEC (ppm) (nominal or measured)	MRID No. Author/year	Classification
Vascular Plants				
Duckweed (*Lemna gibba)*	99.6	0.59/0.09 # fronds and growth (meas.)	45919421/Junker/2002	Acceptable
Nonvascular Plants				
Algae *Scenedesmus subspicatus*	95.7	0.254 cell density (nominal)	44588903/van Dijk/1990	Supplemental

Toxicity values for aquatic plants are presented in Table 4.4. Aquatic plant testing with MITC indicates that the most sensitive non-vascular species tested is the algae *Scenedesmus subspicatus*. The EC_{50}, based on cell density, is 0.254 ppm. The available test on a vascular test species, duckweed, indicates an MITC EC_{50} of 0.59 ppm, based on number of fronds and growth.

4.2.2 Open Literature Studies

A study (Haendel, M, et. al. 2004; ECOTOX Ref. #80675) examines the developmental toxicity of both metam sodium and MITC in the zebrafish (*Danio rerio*). This study is not used in this assessment due to the limitations of the study. The study is classified as invalid based on no reported measured concentrations for initial or termination concentrations for a static toxicity test. It reports "severely twisted" notochords in the developing fish.

4.3 Evaluation of Terrestrial Ecotoxicity Studies

Terrestrial ecotoxicity studies include guideline studies for acute and chronic bird exposures, terrestrial invertebrates and terrestrial plant studies for emergence and vegetative vigor. In addition, acute oral mammal and multiple generation reproductive studies are reviewed. Due to the chemical fate properties for MITC, studies for mammal inhalation will also be included. Based on chemical fate properties for MITC,

4.3.1 Acute Avian Oral Toxicity

No guideline studies were submitted for acute oral toxicity for MITC

4.3.1.1 Avian Dietary Toxicty

No registrant submitted or open literature data is available to assess MITC exposure for dietary effects of MITC on birds.

4.3.1.2 Birds, Chronic

Based on the physio-chemical properties of MITC which indicates non-detectable levels in the soil at 14 days, no chronic exposure is expected.

No registrant submitted or open literature data is available to assess MITC exposure for birds for chronic endpoints.

4.4. Mammalian AcuteToxicity Data

Due to the absence of surrogate bird inhalation studies, a terrestrial mammal was used to identify the risk of inhalation to the CRLF.

Table 4.5 Acute Toxicity of Methyl Isothiocyanate (PC Code 068103)

Guideline No.	Study Type	MRID #(S).	Results	Toxicity Category
81-1	Acute Oral-Rat	162331	LD_{50} = 82 mg/kg ♂ 55 mg/kg ♀	II

81-3	Acute Inhalation-Rat	16232742365605	LC_{50} = 0.54 mg/L	II

Mammalian toxicity data indicate that MITC has an acute oral LD_{50} of 55 mg/kg in female rats and an acute inhalation LC_{50} of 0.54 mg/L. The MITC NOAEL based on a 28-day subchronic rat inhalation study, classified as non-guideline, is 5.4 mg/kg/day. Based on the above results of an acute oral toxicity study in rats, MITC is considered to be highly toxic to mammals. The most sensitive endpoint, acute inhalation, is used for the inhalation analyses.

4. 5 Terrestrial Plant Toxicity

Although seedling emergence and vegetative vigor testing of a Typical End-Use product (TEP) is currently recommended for all pesticides having outdoor uses, no data from registrant submitted studies or open literature is available to assess the indirect effects for riparian vegetation for the CRLF.

4.6 Terrestrial Invertebrate Toxicity

No registrant submitted or open literature data is available to assess MITC exposure for terrestrial invertebrates to determine indirect effects of prey reduction.

5.0 Risk Characterization

Risk characterization is the integration of the exposure and effects characterizations to determine the potential ecological risk from various MITC use scenarios within the action area and likelihood of direct or indirect effects on the California Red legged Frog. The risk characterization provides estimation and description of the likelihood of adverse effects, describes risk assessment assumptions, limtations and uncertainties, and integrates the available information into an overall conclusion regarding the effects determination (*i.e.*, "no effect", "likely to adversely affect" or "may affect, but not likely to adversely affect") for the CRLF.

5.1 Risk Estimation

Risk is determined for direct effects to the aquatic phase CRLF from MITC exposure by using the surrogate fish, with indirect dietary effects using aquatic invertebrates and aquatic non-vascular plants.. Risk for the terrestrial phase CRLF using a mammal, the rat, provides a risk estimation for the direct effects of MITC inhalation exposure, with indirect dietary effects based on fish, aquatic invertebrates, small mammals and terrestrial invertebrates. Risk is determined for indirect effects of exposure to MITC for aquatic habitats using aquatic vascular and non-vascular plants and for terrestrial habitat using crops. .

5.1.1 Direct Effects

5.1.1.1 Direct Aquatic Effects

Risk to fish is used as a measure of ecological effect for direct effects to aquatic phases of the CRLF. Two application methods, shank injection and sprinkler irrigation, are modeled to provide EECs to determine the Risk quotients (RQs). The method for calculating risk quotients is described in Appendix C. Risk quotients are presented in Table 5.1. The risk quotients are calculated using the toxicity data from Tables 4.1 through 4.5 and EECs from PRZM/EXAMS summarized in Table 3.5. For assessing acute risks, the 24-hour peak concentration is used. Chronic toxicity data for fish are not available to calculated chronic risk quotients, however no chronic exposure is expected based on physio-chemical characteristics of MITC, and the assumption that the CRLF will not be at the application site, which would have the highest concentration.

Table 5.1 provides acute RQ values for MITC exposure to the freshwater fish species rainbow trout relative to strawberry, tomato, onion, potato, carrots/pepper, turf, leafy vegetables, melon and nursery use patterns of MITC (pre-plant fumigations of the soil), based on PRZM/EXAMS exposure modeling for shank injection and sprinkler irrigation applications. Only peak values are presented due to the volatility of MITC. The EEC values for the shank injection application were zero for leafy vegetables, melons, tomatoes and nursery applications, so are not shown in the table.

Table 5.1 Aquatic Phase CRLF LOCs: Direct Effects for the Surrogate Fish						
CA Crop App. Rate (lbs ai/A); # Apps.	**Organism**	**EC_{50} (µg/L)**	**NOAEC (µg/L)**	**EEC Peak (µg/L)**	**Acute RQ (EEC_{50}/LC_{50}**	**Exceed Listed Species LOC**
Strawberry Shank Injection	Freshwater	51.2	NA	0.6	0.01	No
Strawberry Irrigation	Freshwater	51.2	NA	59.4	**1.16***	**Yes**
Tomatoe Sprinkler irrigation	Freshwater	51.2	NA	35.3	**0.689***	**Yes**
Onion Shank Injection 320 (1)	Freshwater	51.2	NA	0.28	0.00	No
Onion Sprinkler irrigation 320 (1)	Freshwater	51.2	NA	4.1	**0.08***	**Yes**
Potato Shank Injection 320 (1)	Freshwater	51.2	NA	0.	0.0	No
Potato Sprinkler irrigation 320 (1)	Freshwater	51.2	NA	0.06	0.001	No
Row crops (Carrot/ Pepper) Shank Injection	Freshwater	51.2	NA	0.01	0.00	No
Row crops (Carrot/ Pepper) Sprinkler irrigation	Freshwater	51.2	NA	0.1	0.002	No
Lettuce Sprinkler irrigation	Freshwater	51.2		56.6	**1.10***	**Yes**
Melon Sprinkler irrigation	Freshwater	51.2		0.2	0.004	No
Nursery Sprinkler irrigation	Freshwater	51.2		23.2	**0.45***	**Yes**
Turf Sprinkler irrigation	Freshwater	51.2		28.1	**0.549***	**Yes**

None of the nine modeled sites (strawberry, tomato, onion, potato, turf, leafy vegetables, Row crops, melon and nursery) exceed LOCs for fish for the shank injection application method.

Six of the nine modeled sites (strawberry, tomato, onion, lettuce, nursery and turf) exceed endangered species LOCs (0.05) for fish for the sprinkler irrigation application method.

Four of the nine modeled sites (strawberry, tomato, turf, and leafy vegetables) exceed Acute LOC (0.5) for fish for the sprinkler irrigation application method.

Metam sodium use has been linked to six reported adverse ecological incidents in aquatic systems from the EIIS system, which included mortality. Amphibians are not among the reported mortalities; however, this does not necessarily mean that they have not occurred.

Table 5.2 Adverse Aquatic Incidents: Metam sodium

EIIS Incident No. (Date)	Location	Species Affected	Magnitude of Effect	Incident Summary	Certainty Index
I006515-001 (01 June 1991)	Sacremento River, CA	Fish	1000	A railroad tank car spill in which thousands of fish (as well as most insects and some plants) were killed in a 42-mile stretch of the Sacramento River in California in 1991. While not representative of agricultural applications, this incident shows clearly that metam-sodium has the ability to kill large numbers of aquatic organisms if the chemical gets into water in large quantities.	(3) Probable
I005525-016 (July 17 1991)	Sacremento River,CA	Trout, suckers, squawfish and sculpin and other fish	1000	This incident report is a summary report only, but cites the death of over 1000 fish, including trout, suckers, squawfish, and sculpin in Siskiyou and Shasta counties in California in 1991. It very likely refers to the same railroad tank car spill cited above. It provides the additional information of fish species involved.	
I012648-001 (Nov 1 1994)	St Johns, FL	Fish	Unknown	This incident report involved a phone call in which a Florida fish farm representative claimed that the use of metam-sodium nearby resulted in several fish kills from 1994 - 2001.	(2) Possible
I008259-001 (December 23 1998)	Hastings, FL	Bass	2700	This incident report under 6(a)(2) (from a registrant) cites a claim from a Florida fish farm owner that 2700 hybrid bass were killed after metam-sodium was applied within 300 feet of the fish tanks. The owner suspected that drift occurred (i.e., of MITC, the toxic degradate of metam-sodium that off-gasses) and that his aeration system picked it up and re-dissolved it into the fish tanks. Also cited in the report is a pump malfunction that apparently interrupted water and oxygen circulation.	(2) Possible

Table 5.2 Adverse Aquatic Incidents: Metam sodium

EIIS Incident No. (Date)	Location	Species Affected	Magnitude of Effect	Incident Summary	Certainty Index
I008275-003 (Nov 30 1998)	NR	Fish	NR	This incident report under 6(a)(2) (from a registrant) cites a reported pond contamination and a fish kill following metam-sodium application. There was no report of application method or if there was a misapplication. Very few details were provided, although it states that USFWS was notified when the incident occurred.	(2) Possible
I011162-001 (Jan 6 2001)	Hastings, FL	Bass	>400	This incident report under 6(a)(2) (from a registrant) cites a claim from a Florida fish farm owner that approximately 400 striped bass were killed after metam-sodium was applied within about 600 feet of the fish tank. Although reportedly most of the tanks receive air from a common source, mortality was reported in only one of 94 tanks	(1) Not probable

The incidents reported in this assessment include agriculture applications based on the conceptual model. The incidents I012648-001 and I 008259-001 report applications to adjacent areas with drift impacting fish. The distances reported vary from 300 feet to ¼ mile. These reports were assigned an uncertainity index of possible (2 out of 4). Both of these reports fail to provide sufficient information to exclude other causes for the fish mortality and therefore are not used in the assessment.

I005525-016, the tank car spill incident was not considered in this assessment as it does not reflect an agricultural labeled use or method of application.

Incident I008275-003 was not included in this assessment due to the lack of information provided in the report. The county or state was not identified, and the number of dead fish and the application method or if this was a misapplication was not reported.

Incident I011162-001 was not used in this assessment due to the certainity index assigned, of 1 = not probable.

5.1.1.2 Direct Terrestrial Effects

Due to the inhalation exposure risk described in the conceptual model, a mammal, the rat, is used as a surrogate for the terrestrial phase CRLF. The risk to terrestrial animals will be discussed under the risk description section 5. based on the ISCST3 model. The LOC was not exceeded for the inhalation mammal study based on that model. No avian data is available to determine the for this risk assessment for MITC.

5.1.1.3 Indirect Effects of Prey Reduction and Habitat Modification

5.1.1.4 Evaluation of Potential Indirect Effects via Reduction in Food Items (Freshwater and terrestrial invertebrates, fish, amphibians, mammals)

5.1.1.4.1 Indirect Dietary Effects for the Aquatic Phase CRLF

Risk to invertebrates and fish is used as a measure of ecological effect for indirect dietary effects to aquatic phases of the CRLF. Two application methods, shank injection and sprinkler irrigation, are modeled to provide EECs to determine the Risk quotients (RQs).

Table 5.3 provides acute RQ values for MITC exposure to freshwater invertebrates relative to strawberry, tomato, onion, potato, carrots/pepper, turf, leafy vegetables, melon and nursery use patterns of MITC (pre-plant fumigations of the soil), based on PRZM/EXAMS exposure modeling. The EEC values were zero for leafy vegetables, melons, tomatoes and nursery applications for the shank injection application method , so are not shown in the table.

Table 5.3 Indirect Prey of MITC: Aquatic Invertebrates

CA Crop App. Rate (lbs ai/A of metam-sodium); # Apps.	Organism	EC_{50} (µg/L)	EEC Peak (µg/L)	Acute RQ (EEC/ LC_{50})	Exceed Listed Species LOC (0.05)	Exceed Acute LOC (0.5)
Strawberry Shank Injection	Freshwater	55	0.60	0.01	No	No
Strawberry Sprinkler Irrigation	Freshwater	55	59.4	**1.08***	**Yes**	**Yes**
Tomato Sprinkler irrigation 320 (1)	Freshwater	55	35.3	**0.64***	**Yes**	**Yes**
Onion Shank Injection 320 (1)	Freshwater	55	0.28	0.00	No	No
Onion Sprinkler Irrigation 320 (1)	Freshwater	55	4.1	**0.07***	**Yes**	No
Potato Shank Injection 320 (1)	Freshwater	55	0.00	0.00	No	No
Potato Sprinkler Irrigation 320 (1)	Freshwater	55	0.06	0.001	No	No
Carrot/ Pepper Shank Injection	Freshwater	55	0.01	0.000	No	No

Table 5.3 Indirect Prey of MITC: Aquatic Invertebrates

CA Crop App. Rate (lbs ai/A of metam-sodium); # Apps.	Organism	EC_{50} (µg/L)	EEC Peak (µg/L)	Acute RQ (EEC/ LC_{50})	Exceed Listed Species LOC (0.05)	Exceed Acute LOC (0.5)
Carrot/ Pepper Sprinkler Irrigation	Freshwater	55	0.1	0.002	No	No
Lettuce Sprinkler Irrigation	Freshwater	55	56.6	**1.03***	**Yes**	**Yes**
Melon Sprinkler Irrigation	Freshwater	55	0.2	0.004	No	No
Nursery Sprinkler Irrigation	Freshwater	55	23.2	**0.42***	**Yes**	No
Turf Sprinkler Irrigation	Freshwater	55	28.1	**0.51***	**Yes**	**Yes**

None of the nine modeled sites (strawberry, tomato, onion, potato, row crops of carrot/pepper, turf, leafy vegetables, melon and nursery) based on the shank injection application method exceed LOC for fish.

Six of the nine modeled sites (strawberry, tomato, onion, turf, leafy vegetables and nursery) exceed endangered species LOCs (0.05) for fish for the sprinkler irrigation application method.

Four of the nine modeled sites (strawberry, tomato, turf, and leafy vegetables) exceed both listed species and acute LOCs (0.5) for fish for the sprinkler irrigation application method.

Two of the nine modeled sites (onion and nursery) fall between the listed species and acute LOC.

Table 5.1 provides acute RQ values for MITC exposure to freshwater fish species relative to strawberry, tomato, onion, potato, row crops (carrots/pepper), turf, leafy vegetables, melon and nursery use patterns of MITC (pre-plant fumigations of the soil), based on PRZM/EXAMS exposure modeling. RQs for six of the nine modeled sites (strawberry, tomato, onion, turf, leafy vegetables and nursery) exceed Endangered Species LOCs (0.05) for fish using the sprinkler irrigation application method.

RQs for four of the nine modeled sites (strawberry, tomato, turf, and leafy vegetables) exceed both listed species and acute LOCs (0.5) for fish for the sprinkler irrigation application method.

RQs for two of the nine modeled sites (onion and nursery) fall between the listed species and acute LOC for the sprinkler irrigation application method.

RQs for three of the nine modeled sites (potato, row crops and melon) do not exceed LOCs for fish for the sprinkler irrigation application method as an indirect prey reduction effect (Table

5.1).

None of the nine modeled sites (strawberry, tomato, onion, potato, row crops of carrot/pepper, turf, leafy vegetables, melon and) exceed LOCs for fish as an indirect prey reduction effect using the shank injection method.

5.1.2. Indirect Dietary Effects on the Terrestrial Phase CRLF

No guideline studies have been submitted for terrestrial insects for MITC.

Table 5.13 provides a determination for the inhalation effect through RQ values for MITC exposure to mammals as representative of the terrestrial phase for the CRLF as modeled by the ICST23. The LOC is not exceeded for the terrestrial phase CRLF for the inhalation study as an indirect dietary effect.

Section 5.1.1 discusses direct effects to aquatic and terrestrial vertebrates, used as surrogates for the CRLF. Where direct effects occur to these vertebrates, numbers of prey items for the CRLF could also decline, posing a potential indirect effect to the CRLF.

5.1.2.1 Evaluation of Potential Indirect Effects via Reduction in Aquatic Habitat and/or Primary Productivity (freshwater aquatic plants)

Aquatic plants serve several important functions. They are primary producers, and provide the autochthonous energy base for the aquatic system, especially the non-vascular plants. Typically, vascular plants provide structure to the system rather than energy, providing attachment sites for many aquatic invertebrates, and refugia for juvenile organisms, such as fish and frogs. Emergent plants help reduce sediment loading, and provide some stability to nearshore areas and lower streambanks.. For the CLRF, vascular aquatic plants provide an attachment site for egg masses.

Exposure to nontarget aquatic plants may occur through runoff or offgassing from adjacent treated sites. An aquatic plant risk assessment for acute risk is usually made for aquatic vascular plants from the surrogate duckweed *Lemna gibba*. Nonvascular acute aquatic plant risk assessments are performed using either algae or a diatom, whichever is the most sensitive species. An aquatic plant risk assessment for acute endangered species is usually made for aquatic vascular plants from the surrogate duckweed *Lemna gibba*. There are no nonvascular plant species on the endangered species list. Runoff and drift exposure is computed from PRZM and EXAMS. The RQ is determined by dividing the pesticide's peak concentration in water by the plant EC_{50} or NOAEC value.

Acute Risk Quotients for aquatic vascular plants are based upon the duckweed *Lemna gibba* EC50 (0.59 ppm). Table 5.4 provides acute and values for MITC exposure to aquatic vascular plants relative to strawberry, tomato, onion, potato, carrots/pepper, leafy vegetables, melon, nursery and turf use patterns of MITC (pre-plant fumigations of the soil), based on PRZM/EXAMS exposure modeling. The EEC values were zero for leafy vegetables, melons, tomato and nursery applications, so are not shown in the table.

None of the nine modeled sites (strawberry, tomato, onion, potato, row crops of carrot/pepper, turf, leafy vegetables, melon and nursery) exceed endangered species or acute LOC for vascular plants based on these EECS.

Table 5.4 Aquatic Phase CRLF LOCs for Vascular Plant Indirect Effects

Site / Rate of Application (No. of Applications)	Species	EC50 (□g/L)	EEC (□g/L)	Plant RQ (EEC/EC50)	Exceed Listed Species LOC (0.05)	Exceed Acute LOC (0.5)
Strawberry Shank Injection	Duckweed	590	0.60	0.001	No	No
Strawberry Sprinkler irrigation	Duckweed	590	59.4	0.101	No	No
Tomato Sprinkler irrigation	Duckweed	590	35.3	0.06	No	No
Onion Shank Injection	Duckweed	590	0.28	0.000	No	No
Onion Sprinkler irrigation	Duckweed	590	4.1	0.007	No	No
Potato Shank Injection	Duckweed	590	0	0.000	No	No
Potato Sprinkler irrigation	Duckweed	590	0.06	0.000	No	No
Row crops (Carrot/Pepper) Shank Injection	Duckweed	590	0.01	0.000	No	No
Row crops (Carrot/Pepper) Sprinkler irrigation	Duckweed	590	0.1	0.000	No	No
Lettuce Sprinkler irrigation	Duckweed	590	56.6	0.09	No	No
Melon Sprinkler irrigation	Duckweed	590	0.60	0.00	No	No
Nursery Sprinkler irrigation	Duckweed	590	23.2	0.039	No	No
Turf Sprinkler irrigation	Duckweed	590	28.1	0.048	No	No

Table 5.5 provides acute RQ values for MITC exposure to aquatic nonvascular plants relative to strawberry, tomato, onion, potato, carrots/pepper, turf, leafy vegetables, melon and nursery use

patterns of MITC (pre-plant fumigations of the soil), based on PRZM/EXAMS exposure modeling. The EEC values were zero for leafy vegetables, melons, tomato and nursery applications, so are not shown in the table.

Risk Quotients for aquatic nonvascular plants are based upon the algae *Scenedesmus subspicatus* EC50 (0.254 mg/L).

Table 5.5 Aquatic Phase CRLF LOCs for Non-Vascular Plant Indirect Effects

Site / Rate of Application (No. of Applications)	Species	EC50 (µg/L)	EEC (µg/L)	Plant RQ (EEC/EC50)	Exceed Listed Species LOC (0.05)	Exceed Acute LOC (0.5)
Strawberry Shank Injection	Algae	254	0.60	0.002	No	No
Strawberry Sprinkler irrigation	Algae	254	59.4	0.234	No	No
Tomato Sprinkler irrigation	Algae	254	35.3	0.139	No	No
Onion Shank injection	Algae	254	0.28	0.001	No	No
Onion Sprinkler irrigation	Algae	254	4.1	0.016	No	No
Potato Shank Injection	Algae	254	0.	0.00	No	No
Potato Sprinkler irrigation	Algae	254	0.06	0.000	No	No
Carrot/Pepper Shank Injection	Algae	254	0.01	0.000	No	No
Carrot/Pepper irrigation	Algae	254	0.1	0.000	No	No
Lettuce Sprinkler irrigation	Algae	254	56.6	0.223	No	No
Melon Sprinkler irrigation	Algae	254	0.2	0.001	No	No
Nursery sprinkler irrigation	Algae	254	23.2	0.091	No	No
Turf Sprinkler irrigation	Algae	254	28.1	0.111	No	No

None of the nine modeled sites (strawberry, tomato, onion, potato, row crops of carrot/pepper, turf, leafy vegetables, melon and nursery) exceed endangered species or acute LOC for vascular plants based on these EECS for either the sprinkler irrigation or shank injection application methods.

5.1.2.2 Evaluation of Potential Indirect Effects via Reduction in Terrestrial Plant Community (Riparian Habitat)

Air monitoring data from application sites as well as ambient monitoring data show the presence of MITC in the air samples. Ambient air sampling does not necessarily coincide with application of metam sodium in the area. MITC concentration measured in the ambient air were considerably lower than the concentrations monitored and modeled for the application sites (Section 3.4). No registrant studies for terrestrial crops have been submitted. Due to the outdoor use for metam sodium and the MITC residues in air, terrestrial plant data are needed to quantitatively address effects.

Table 5.6 shows five terrestrial incidents reports involving metam-sodium included in the agency's Ecological Incident Information System (EIIS) database. They have certainty indices ranging from 1 (unlikely) to 4 (highly probable).

Table 5.6 Adverse Terrestrial Incidents: Metam sodium

EIIS Incident No. (Date)	Location	Species Affected	Magnitude of Effect	Incident Summary	Certainty Index
I011510-001 (12 November 1999)	Bullard, TX	Pine	30 acres	This incident report under 6(a)(2) (from a registrant) cites an incident in which 30 acres of pine seedlings in Texas were alleged to be damaged by drift (presumably of MITC) from a metam-sodium application in which no water seal was used.	(3) Probable
I011838-056 (22 May 2001)	Robersonville River,NC	Peanuts	80 acres	This incident report under 6(a)2 cites an incident in which 80 acres of peanuts were damaged in North Carolina. Metam sodium was one of five products applied	(2) Possible
I012457-005 (22 May 2001)	Robersonville River,NC	Peanuts	120 acres	This incident report under 6(a)(2) (from a registrant) cites an incident in which 120 acres of peanuts were damaged in North Carolina. Metam-sodium was apparently one of two pesticides applied.	(2) Possible
I014405-002 (23 May 1996)	Grant County, Washington	Potato	NR	This incident reported in the Washington State Department of Health 1997 Annual Misapplication of metam sodium damaged potatoe crop. Report. Complaint was withdrawn.	(2) Possible
I0161-7-001 (23	Broad Brook,CT	Spruce and Cherry trees	Several	A complaint was received by the State of Connecticut Department of	(2) Possible

September 2004)				Environmental Protection citing damage to spruce trees as well as a cherry tree.	

Incident I 016107-001 reported application on according to label instructions with a certainity index of 2 (possible). This demonstrates the possible adverse effect of metam sodium on crops. No distance covered by metam sodium was reported, the amount of metam sodium was not reported and no other pesticide use was reported.

Incidents I011510-001 and I014405-002 were not used in this assessment due to misapplication of metam sodium.

Both I011838-056 and I012457-005 reported use of multiple pesticides. No percentages of the mixture were reported.

5.1.3 Summary of Effects of MITC Based on LOC Exceedence

There were no LOC exceedences based on the shank injection application method for exposure to MITC. Table 5.7 summarizes the LOC exceedences for RQs using the sprinkler irrigation application for exposure to MITC.

Table 5.7 MITC Risk Quotients for Aquatic Phase Using the Sprinkler irrigation Application Method

Assessment Endpoint	Organism or Life Stage	Concentration Estimate	RQ	Listed Species LOC Exceedence	Acute LOC Exceedence
Aquatic Phase (Eggs, larvae, tadpoles, juvenile, and adults)[a]					
Direct Effects					
Acute Toxicity to Frog	Juveniles, adults	Strawberry (highest) Potato (lowest)	1.16* 0.001	Yes No	Yes No
Indirect Effects and Critical Habitat Effects					
Acute Toxicity to Prey	Fish	Strawberry (highest) Potato (lowest)	1.16* 0.001	Yes No	Yes No
	Invertebrate	Strawberry (highest) Potato (lowest)	1.08* 0.001	Yes No	Yes No
Acute Toxicity to Aquatic Plants (Habitat, Food Source)	Duckweed	Strawberry (highest) Potato and Carrots/ peppers (lowest)	0.66 0.001	No No	No No
	Green algae	Strawberry (highest) Potato (lowest)	0.475 0	No No	No No
Acute Toxicity to Terrestrial Plants (Wetland)	Monocot	No registrant data is available to calculate the RQ..	NA	NAo	NA
	Dicot	No registrant data is available to calculate the RQ.	NA	NA	NA
Acute Toxicity to Terrestrial Plants	Monocot	No registrant data is available to calculate the RQ.	NA	NA	NA

(Upland)	Dicot	No registrant data is available to calculate the RQ.	NA	NA	NA

Table 5.8 summarizes the LOC exceedences for the terrestrial phase CRLF using the rat surrogate to assess direct effects of survival. Indirect effects of diet are assessed using the rat surrogate, terrestrial and aquatic invertebrates and fish. Terrestrial plants are used to assess indirect effect on habitat . Based on the conceptual model, inhalation is the major exposure route for direct and indirect effects. Direct effects for survival of the CRLF based on inhalation exposure to MITC are shown in section 5.2

Table 5.8 MITC Risk Quotients for Terrestrial Phase Using the Sprinkler irrigation Application Method

Assessment Endpoint	Organism or Life Stage	Concentration Estimate	RQ	Listed Species LOC Exceedence	Acute LOC Exceeden
Terrestrial Phase (Juveniles and adults)					
Indirect Effects and Critical Habitat Effects					
AcuteToxicity to Prey	Terrestrial Invertebrate	No registrant data is available to calculate the RQ.	NA	NA	NA
Acute Toxicity to Terrestrial Plants (Wetland)	Monocot	No registrant data is available to calculate the RQ.	NA	NA	NA
	Dicot	No registrant data is available to calculate the RQ.	NA	NA	NA
Acute Toxicity to Terrestrial Plants (Upland)	Monocot	No registrant data is available to calculate the RQ.	NA	NA	NA
	Dicot	No registrant data is available to calculate the RQ.	NA	NA	NA

The preliminary risk conclusions for the sprinkler irrigation application method are shown in Table 5.9.

Table 5.9 Preliminary Effects Determination Summary for Direct and Indirect Effects of MITC on the California Red-legged Frog

Assessment Endpoint	Effects Determination		Basis
Aquatic-Phase Effects (Eggs, Larvae, Tadpoles, Adults)			
Application Methods	Sprinkler irrigation	Shank Injection	
Survival of CRLF individuals via direct effects on aquatic phases (Surrogate Fish)	May affect	No Effect	Risk conclusion supported by LOC exceedence with probability and exposure – habitat overlap from downstream model

Table 5.9 Preliminary Effects Determination Summary for Direct and Indirect Effects of MITC on the California Red-legged Frog

Reproductive and Growth effects	No Effect	No Effect	for the surrogate fish. No chronic exposure is anticipated based on one application at the maximum application rate due to the physio-chemical properties.
Survival, growth, and reproduction of CRLF individuals via effects to food supply (*i.e.,* freshwater invertebrates, non-vascular plants)	Aquatic invertebrates: May affect Aquatic non-vascular plants: No Effect	Aquatic invertebrates: No Effect Aquatic non-vascular plants: No Effect	Risk conclusion supported by LOC exceedence and downstream model results for aquatic invertebrates.
Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat, cover, and/or primary productivity (*i.e.,* aquatic plant community)	No Effect	No Effect	Risk conclusion supported by no LOC exceedence for aquatic plants
Survival, growth, and reproduction of CRLF individuals via effects to riparian vegetation, required to maintain acceptable water quality and habitat in ponds and streams comprising the species' current range	Aquatic Plants: No Effect Terrestrial Plants: May affect	Aquatic Plants: No Effect Terrestrial Plants: May affect	Risk conclusion supported by no LOC exceedence for aquatic plants No terrestrial plant studies have been submitted. No open literature is available to calculate RQs. Risk determination of may affect is due the uncertainty from the limited data.
Terrestrial Phase Effects Using Both Shank Injection andSprinkler Irrigation Application Methods (Juveniles and adults)			
Application method	Sprinkler irrigation	Shank Injection	
Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles	No Effect	No Effect	MITC inhalation RQs do not exceed LOCs for direct effects using mammals as a surrogate. Risk conclusions supported by RQ
Survival, growth, and reproduction of CRLF individuals via effects on prey (*i.e.,* small terrestrial vertebrates, including mammals and terrestrial phase amphibians)	No Effect	No Effect	MITC inhalation RQs do not exceed LOCs for terrestrial vertebrates. Risk conclusions supported by RQ.
Survival, growth, and reproduction of CRLF individuals via effects on prey (*i.e.,* terrestrial invertebrates)	Terrestrial invertebrates: May affect	Terrestrial invertebrates: May affect	No terrestrial invertebrate studies have been submitted. No open literature is available to calculate RQs. Risk determination of may affect is due the uncertainty from the limited data.
Survival, growth, and reproduction of CRLF individuals via effects on prey (*i.e., aquatic* vertebrates and amphibians)	Aquatic vertebrates: May affect	No Effect	MITC RQs do exceed LOCs for aquatic vertebrates (surrogate fish) for shank injection but do exceed for sprinkler irrigation. Risk conclusions supported by RQ.
Survival, growth, and reproduction of CRLF individuals via effects on	Aquatic invertebrates:	No Effect	MITC RQs do not exceed LOCs for aquatic invertebrates. Risk conclusions supported

Table 5.9 Preliminary Effects Determination Summary for Direct and Indirect Effects of MITC on the California Red-legged Frog

prey (*i.e.,* aquatic invertebrates)	May affect		by RQ for sprinkler irrigation method.
Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat (*i.e.,* riparian vegetation)	Terrestrial plants: May affect	Terrestrial plants: May affect	No terrestrial plant studies have been submitted. No open literature is available to provide data for RQs. Risk determination of may affect is due the uncertainty from the limited data.

Table 5.10 Effects Determination Summary for the Critical Habitat Impact Analysis

Assessment Endpoint	Effects Determination		Basis
Aquatic Phase PCEs Using Sprinkler Irrigation and Shank Injection Application Methods (Aquatic breeding Habitat and Aquatic Non-breeding Habitat)			
Application Method	Sprinkler Irrigation	Shank Injection	
Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond: aquatic habitat (including riparian vegetation) provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs.	Aquatic Plants: No Effect Terrestrial plants: May affect	Aquatic Plants: No Effect Terrestrial plants: May affect	Aquatic plant RQs for both application methods do not exceed LOCs. Risk determination is based on RQ for aquatic habitat. No registrant terrestrial plant studies have been submitted for MITC. No open literature is available for determining RQs for terrestrial plants. Based on the uncertainty due to limited data for MITC, there is a "may affect, likely to adversely affect" determination for the terrestrial habitat.. Risk conclusion is based on uncertainty due to limited data .
Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source[1].	No Effect	No Effect	No aquatic plant RQs exceeded LOCs. Risk conclusion based on RQ data.
Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.	No Effect	No Effect	No aquatic plant RQs exceeded LOCs. Risk conclusion is based on RQ data.
Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.,* algae)	No Effect	No Effect	No aquatic plant RQs exceeded LOCs. Risk conclusion is based on RQ data..
Terrestrial Phase PCEs (Upland Habitat and Dispersal Habitat)			
Application Methods	Sprinkler Irrigation	Shank Injection	
Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs: Upland areas within 200 ft of the edge	May Affect	May Affect	No terrestrial plant studies have been submitted. No open literature is available to calculate RQs. Risk determination of may affect, likely to

Table 5.10 Effects Determination Summary for the Critical Habitat Impact Analysis

of the riparian vegetation or dripline surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that provides the CRLF shelter, forage, and predator avoidance			adversely affect, is due the uncertainty from the limited data .
Elimination and/or disturbance of dispersal habitat: Upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal	May Affec	May Affect,	No terrestrial plant studies have been submitted. No open literature is available to calculate RQs. Risk determination of may affect, likely to adversely affect, is due the uncertainty from the limited data ..
Terrestrial Phase PCEs Base (Upland Habitat and Dispersal Habitat)			
Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.	Aquatic Invertebrates: May affect Aquatic Plants: No Effect Terrestrial Vertebrate: No Effect Terrestrial; invertebrates May affect Terrestrial plants: May affect	Aquatic invertebrates: No Effect Aquatic plants: No Effect Terrestrial Vertebrate: No Effect Terrestria nvertebrates: May affect Terrestrial plants: May affect	Risk conclusion supported by LOC exceedence for aquatic invertebrates Risk conclusion supported by LOC exceedence for aquatic plants The MITC RQ small mammals do not exceed the LOC. Risk conclusions for aquatic invertebrate and the terrestrial mammal prey are based on the RQs. No terrestrial invertebrate studies have been submitted. No open literature is available to calculate RQs. Risk determination of may affect, likely to adversely affect, is due the uncertainty from the limited data No terrestrial plants studies have been submitted. No open literature is available to calculate RQs. Risk determination of may affect, likely to adversely affect, is due the uncertainty from the limited data
Terrestrial Phase PCEs (Upland Habitat and Dispersal Habitat)			
Application Methods	Sprinkler irrigation	Shank Injection	
Reduction and/or modification of food sources for terrestrial phase juveniles and adults	Aquatic vertebrates: May affect	Aquatic vertebrates:: No Effect	The MITC RQ for fish and and for aquatic invertebrates exceeds the LOC for irrigation applications method, but not for the shank injection method. .Risk

Table 5.10 Effects Determination Summary for the Critical Habitat Impact Analysis

	Aquatic invertebrates: May Affect	Aquatic Invertebrates: No Effect	conclusion supported by RQ.
	Aquatic Plants: No Effect	Aquatic Plants: No Effect	The RQs for aquatic plants do not excedd the LOC. The risk conclusion is based on the RQ.
	Terrestrial mammals: No Effect	Terrestrial mammals: No Effect	The MITC RQ for small mammals does not exceed the LOC. The risk conclusion for small mammals is based on the RQ.
	Terrestrial invertebrates: May Affect	Terrestrial invetebrates: May Affect	No terrestrial invertebrate studies have been submitted. No open literature is available to calculate RQs. Risk determination of may affect, is due the uncertainty from the limited data
[1] Physico-chemical water quality parameters such as salinity, pH, and hardness are not evaluated because these processes are not biologically mediated and, therefore, are not relevant to the endpoints included in this assessment.			

RQs for the surrogate fish for the direct effects of MITC for the aquatic phase CRLF using the sprinkler irrigation application method exceed the listed species LOC resulting in a preliminary " May affect"for six modeled crops (strawberry, tomato, lettuce, turf, nursery and onion).

RQs for the surrogate mammal for the direct effects of MITC for the terrestrial phase CRLF are below the LOC. The "no effect' risk conclusion is based on no LOC exceedence for the direct terrestrial phase CRLF.

The risk conclusions for the indirect effects of diet are shown in Table 5.9. The LOC exceedence for aquatic invertebrates supports a "May effect for six modeled crops (strawberry, tomato, lettuce, turf, nursery and onion). The "no effect" risk conclusion for indirect effects of diet for the aquatic phase CRLF is supported by no exceedence for the LOC for aquatic plants. The "no effect" risk conclusion for indirect effects of diet of small mammals for the terrestrial phase CRLF is supported by no exceedence for the LOC for mammals. The "may affect" risk conclusion for indirect effects of diet of fish for the terrestrial phase CRLF is supported by the LOC exceedence for fish for six modeled crops (strawberry, tomato, lettuce, turf, nursery and onion). The "may affect" risk conclusion for indirect effects of diet on terrestrial invetebrates for the terrestrial phase for the CRLF is supported by the uncertainty due to limited data.

The "no effect" risk conclusion for indirect effects of habitat for the aquatic phase CRLF is supported by no exceedence for the LOC for vascular and non-vascular plants for nine modeled crops (strawberry, tomato, lettuce, turf, nursery,onion, potato, row crops and melon).. The "may affect" risk conclusion for indirect effects of riparian and upland dispersal habitat for the aquatic phase and for the critical habitat for the CRLF is supported by the uncertainty due to limited data.

The risk conclusions for the shank injection application method for all nine modeled crops (strawberry, tomato, lettuce, turf, nursery, potato, row crops, melon and onion). are shown in Table 5.9. All direct effect RQ values for MITC for the shank injection are below the Agency's LOC for aquatic and terrestrial phases. The "no effect' risk conclusion is based on the RQ exceedence for the surrogate fish direct aquatic phase and the surrogate mammal for the terrestrial phase CRLF.

The "no effect" risk conclusion for indirect effects of diet for the aquatic phase CRLF is supported by no exceedence for the LOC for aquatic invertebrates and non-vascular plants.

The "no effect" risk conclusion for indirect effects of diet of fish and small mammals for the terrestrial phase CRLF is supported by no exceedence for the LOC for fish and mammals. The "may affect" risk conclusion for indirect effects of diet as terrestrial invertebrates for the terrestrial phase for the CRLF is supported by the uncertainty due to limited data.

The "no effect" risk conclusion for indirect effects of habitat for the aquatic phase CRLF is supported by no exceedence for the LOC for vascular and non-vascular plants.

The may affect, likely to adversely affect" risk conclusion for indirect effects of riparian and upland dispersal habitat for the aquatic phase and for the critical habitat for the CRLF is supported by the uncertainty due to limited data.

5.1.4 Refinements for the Preliminary "May Affect" Risk Conclusions

"May affect" determinations are further refined using additional information based on the life history of the CRLF (habitat range, feeding preferences, etc). Using the best available information, the Agency distinguishes actions that "may affect, but are not likely to adversely affect" from those actions that are "likely to adversely affect" the CRLF.

Several criteria are used to make determinations to differentiate those actions that are"not likely to adversely affect" from those actions that are "likely to adversely affect" the CRLF. Significance of effect is based on effects that are meaningfully measured, detected or evaluated at the level of a single individual. The results from the probit slope model are used to determine the probability of individual exposure as discussed in section 5.1.4 (Table 5.11).

Use of Probit Slope Response Relationship to Provide Information on the Endangered Species Levels of Concern

Generally, available toxicity data provides an LC_{50} or an EC_{50}, (the concentration at which 50% of the test population exhibits the designated endpoint, usually mortality). Because the Endangered Species Act (ESA) requires determination of potential effects at an individual level, this information must be extrapolated from existing data. The Agency uses the probit dose response relationship as a tool for providing additional information on the potential for acute direct effects to individual listed species and aquatic animals that may indirectly affect the listed species of concern (U.S. EPA, 2004). As part of the risk characterization, an interpretation of the acute LOC for listed species (or specific RQ) is discussed. This interpretation is presented in terms of the chance of an individual event (*i.e.*, mortality or immobilization) should exposure at the LOC (or for a specific RQ) actually occur for a species with sensitivity to metam sodium/MITC consistent with the acute toxicity endpoint selected for RQ calculation. To accomplish this interpretation, the Agency uses the slope of the dose response relationship (where available) from the toxicity study used to establish the acute toxicity measures of effect for each taxonomic group that is relevant to this assessment. The individual effects probability associated with the LOC (or specific RQ) is based on the mean estimate of the slope and an assumption of a probit dose response relationship. In addition to a single effects probability estimate based on the mean, upper and lower estimates of the effects probability are also provided to account for variance in the slope, if available. The upper and lower bounds of the effects probability are based on available information on the 95% confidence interval of the slope. A statement regarding the confidence in the estimated event probabilities is also included. Studies with good probit fit characteristics (*i.e.*, statistically appropriate for the data set) are associated with a high degree of confidence. Conversely, a low degree of confidence is associated with data from studies that do not statistically support a probit dose response relationship. In addition, confidence in the data set may be reduced by high variance in the slope (i.e., large 95% confidence intervals), despite good probit fit characteristics. In the event that dose response information is not available to estimate a slope, a default slope assumption of 4.5 with lower and upper slope bounds of 2 to 9 (Urban and Cook, 1986) is used.

Individual effect probabilities are calculated using an Excel spreadsheet tool IECV1.1 (Individual Effect Chance Model Version 1.1) developed by the U.S. EPA, OPP, Environmental Fate and Effects Division (June 22, 2004). The model allows for such calculations by entering the mean slope estimate (and the 95% confidence bounds of that estimate) as the slope parameter for the spreadsheet. The acute aquatic or terrestrial endangered species animal LOC (or specific RQ) is entered as the level to be evaluated. Probability of individual effects for the various assessment endpoints is provided below in 5.11.

Table 5.11 Individual Effects Probability

Assessment Endpoint	Surrogate Species	Modeled Crop	LC_{50}/ LD_{50} and Slope	Chance of Individual Effect at LOC Threshold (0.05)	Chance of Individual Effect at RQ Threshold
Acute Toxicity to Frog	Rainbow trout	Strawberry	2 mg/L (lower bound of the slope)	1 in 216	1 in 1.81

Table 5.11 Individual Effects Probability

Assessment Endpoint	Surrogate Species	Modeled Crop	LC_{50}/ LD_{50} and Slope	Chance of Individual Effect at LOC Threshold (0.05)	Chance of Individual Effect at RQ Threshold
			4.5 mg/L (default slope)	1 in 4.18 x 10^{8}	1 in 1.63
			9 (upper bound of slope)	1 in 1.75 x 10^{31}	1 in 1.39
		Tomato	2 mg/L (lower bound of the slope)		1 in 2.68
			4.5 mg/L (default slope)		1 n 4.29
			9 (upper bound of slope)		1 in 13.8
		Lettuce	2 mg/L (lower bound of the slope)		1 in 1.88
			4.5 mg/L (default slope)		1 in 1.74
			9 (upper bound of slope)		1 in 1.55
		Turf	2 mg/L (lower bound of the slope)		1 in 3.32
			4.5 mg/L (default slope)		1 in 8.29
			9 (upper bound of slope)		1 in 105
		Nursery	2 mg/L (lower		1 in 4.10

Table 5.11 Individual Effects Probability

Assessment Endpoint	Surrogate Species	Modeled Crop	LC_{50}/ LD_{50} and Slope	Chance of Individual Effect at LOC Threshold (0.05)	Chance of Individual Effect at RQ Threshold
			bound of the slope)		
			4.5 mg/L (default slope)		1 in 16.9
			9 (upper bound of slope)		1 in 1 in 1,110
		Onion	2 mg/L (lower bound of the slope)		1 in 95.7
			4.5 mg/L (default slope)		1 in 9.88 x 10^{6}
			9 (upper bound of slope)		1 in 7.58 x 10^{24}
Acute Toxicity to Prey	Water flea	Strawberry	2 mg/L (lower bound of the slope)	1 in 2.16	1 in 1.90
			4.5 mg/L (default slope)	1 in 418,000,000	1 in 1.79
			9 (upper bound of slope)	1 in 1.75 x 10^{31}	1 in 1.62
		Tomato	2 mg/L (lower bound of the slope)		1 in 2.86
			4.5 mg/L (default slope)		1 in 5.22
			9 (upper bound of slope)		1 in 24.7
		Lettuce	2 mg/L (lower bound of the slope)		1 in 1.96

Table 5.11 Individual Effects Probability

Assessment Endpoint	Surrogate Species	Modeled Crop	LC_{50}/ LD_{50} and Slope	Chance of Individual Effect at LOC Threshold (0.05)	Chance of Individual Effect at RQ Threshold
			4.5 mg/L (default slope)		1 in 1.91
			9 (upper bound of slope)		1 in 1.83
		Turf	2 mg/L (lower bound of the slope)		1 in 3.58
			4.5 mg/L (default slope)		1 in 10.6
			9 (upper bound of slope)		1 in 236
		Nursery	2 mg/L (lower bound of the slope)		1 in 4.43
			4.5 mg/L (default slope)		1 in 22.2
			9 (upper bound of slope)		1 in 2,870
		Onion	2 mg/L (lower bound of the slope)		1 in 70.8
			4.5 mg/L (default slope)		1 in 2,510,000
			9 (upper bound of slope)		1 in 3.64×10^{22}
	Rainbow trout	Strawberry	2 mg/L (lower bound of the slope)	1 in 216	1 in 1.81

Table 5.11 Individual Effects Probability

Assessment Endpoint	Surrogate Species	Modeled Crop	LC_{50}/ LD_{50} and Slope	Chance of Individual Effect at LOC Threshold (0.05)	Chance of Individual Effect at RQ Threshold
			4.5 mg/L (default slope)	1 in 4.18 x 10^{8}	1 in 1.63
			9 (upper bound of slope)	1 in 1.75 x 10^{31}	1 in 1.39
		Tomato	2 mg/L (lower bound of the slope)		1 in 2.68
			4.5 mg/L (default slope)		1 n 4.29
			9 (upper bound of slope)		1 in 13.8
		Lettuce	2 mg/L (lower bound of the slope)		1 in 1.88
			4.5 mg/L (default slope)		1 in 1.74
			9 (upper bound of slope)		1 in 1.55
		Turf	2 mg/L (lower bound of the slope)		1 in 3.32
			4.5 mg/L (default slope)		1 in 8.29
			9 (upper bound of slope)		1 in 105
		Nursery	2 mg/L (lower bound of the slope)		1 in 4.43

Table 5.11 Individual Effects Probability

Assessment Endpoint	Surrogate Species	Modeled Crop	LC_{50}/ LD_{50} and Slope	Chance of Individual Effect at LOC Threshold (0.05)	Chance of Individual Effect at RQ Threshold
			4.5 mg/L (default slope)		1 in 22.2
			9 (upper bound of slope)		1 in 2,870
		Onion	2 mg/L (lower bound of the slope)		1 in 70.8
			4.5 mg/L (default slope)		1 in 2,510,000
			9 (upper bound of slope)		1 in 3.64 x 10^{22}

Direct Effects

Individual Probabilities at the Listed Species LOC Threshold for Modeled Crops

Table 5.11 shows the results of determining the individual effects for direct aquatic and terrestrial phases of the CRLF. Calculations for the effects on an individual were based on the LC_{50} for the surrogate species fish, so the results are the same for both the shank injection and sprinkler irrigation methods (Urban and Cook, 1986). For the probit slope analysis to determine the direct effects of MITC an assumption of a probit dose response relationship with a mean estimated default slope of 4.5. The corresponding estimated chance of individual mortality associated with the listed species LOC of 0.05 for the acute toxic endpoint for the rainbow trout as a surrogate for the aquatic phase of the CRLFis ~1 in 418,000,000 It is recognized that extrapolation of very low probability events is associated with considerable uncertainty in the resulting estimates. To explore possible bounds to such estimates, the upper and lower values for the mean slope estimate, 2 and 9, were used to calculate upper and lower estimates of the effects probability associated with the listed species LOC. These estimated individual values are ~1 in 216 for a slope = 2 to ~1 in 1.75 x 10^{31} for the slope = 9.

The terrestrial phase LD50 of the CRLF is based on an assumption of a probit dose response relationship with a mean estimated default slope of 4.5. The corresponding estimated chance of individual mortality associated with the listed species LOC of 0.1. the acute toxic endpoint for rat as a surrogate for the terrestrial phase of the CRLF is 1in 294,000. It is recognized that extrapolation of very low probability events is associated with considerable uncertainty in the resulting estimates. To explore possible bounds to such estimates, the upper and lower values for the default mean slope estimates (2 and 9) were used to calculate upper and lower estimates of the effects probability associated with the listed species LOC. These estimated individual mortality values are 1 in 4.4 for a slope = 2 to 1 in 8.86×10^{18} for the slope = 9.

Individual Probabilities at the RQ Threshold for Modeled Crops

A similar analysis to that above was provided for each of the modeled crops with an RQ that exceeded the LOC.

Table 5.11 shows the results of determining the individual effects for direct aquatic and terrestrial phases of the CRLF for strawberry. For the probit slope analysis to determine the direct effects of MITC an assumption of a probit dose response relationship with a mean estimated default slope of 4.5. The corresponding estimated chance of individual mortality associated with the listed species RQ of 1.16 for the acute toxic endpoint for the rainbow trout as a surrogate for the aquatic phase of the CRLF.is ~1 in 1.63. It is recognized that extrapolation of very low probability events is associated with considerable uncertainty in the resulting estimates. To explore possible bounds to such estimates, the upper and lower values for the mean slope estimate, 2 and 9, were used to calculate upper and lower estimates of the effects probability associated with RQ. These estimated individual values are ~1 in 1.81 for a slope = 2 to ~1 in 1.39^1 for the slope = 9.

Table 5.11 shows the results of determining the individual effects for direct aquatic and terrestrial phases of the CRLF for tomato. For the probit slope analysis to determine the direct effects of MITC an assumption of a probit dose response relationship with a mean estimated default slope of 4.5. The corresponding estimated chance of individual mortality associated with the listed species RQ of 0.689 for the acute toxic endpoint for the rainbow trout as a surrogate for the aquatic phase of the CRLF is ~1 in 4.29. It is recognized that extrapolation of very low probability events is associated with considerable uncertainty in the resulting estimates. To explore possible bounds to such estimates, the upper and lower values for the mean slope estimate, 2 and 9, were used to calculate upper and lower estimates of the effects probability associated with the RQ. These estimated individual values are ~1 in 2.68 for a slope = 2 to ~1 in 13.8 for the slope = 9.

Table 5.11 shows the results of determining the individual effects for direct aquatic and terrestrial phases of the CRLF for lettuce For the probit slope analysis to determine the direct effects of MITC an assumption of a probit dose response relationship with a mean estimated default slope of 4.5. The corresponding estimated chance of individual mortality associated with the listed species RQ of 1.1 for the acute toxic endpoint for the rainbow trout as a surrogate for the aquatic phase of the CRLF is ~1 in 1.74. It is recognized that extrapolation of very low probability events is associated with considerable uncertainty in the resulting estimates. To explore possible bounds to such estimates, the upper and lower values for the mean slope estimate, 2 and 9, were used to calculate upper and lower estimates of the effects probability associated with the RQ. These estimated individual values are ~1 in 1.88 for a slope = 2 to ~1 in 1.55 for the slope = 9.

Table 5.11 shows the results of determining the individual effects for direct aquatic and terrestrial phases of the CRLF for turf For the probit slope analysis to determine the direct effects of MITC an assumption of a probit dose response relationship with a mean estimated default slope of 4.5. The corresponding estimated chance of individual mortality associated with the listed species RQ of 0.0.549 for the acute toxic endpoint for the rainbow trout as a surrogate for the aquatic phase of the CRLF is ~1 in 8.29. It is recognized that extrapolation of very low probability events is associated with considerable uncertainty in the resulting estimates. To explore possible bounds to such estimates, the upper and lower values for the mean slope estimate, 2 and 9, were used to calculate upper and lower estimates of the effects probability associated with the RQ. These estimated individual values are ~1 in 3.32 for a slope = 2 to ~1 in 105 for the slope = 9.

Table 5.11 shows the results of determining the individual effects for direct aquatic and terrestrial phases of the CRLF for nursery For the probit slope analysis to determine the direct effects of MITC an assumption of a probit dose response relationship with a mean estimated default slope of 4.5. The corresponding estimated chance of individual mortality associated with the listed species RQ of 0.0.45 for the acute toxic endpoint for the rainbow trout as a surrogate for the aquatic phase of the CRLF is ~1 in 16.9. It is recognized that extrapolation of very low probability events is associated with considerable uncertainty in the resulting estimates. To explore possible bounds to such estimates, the upper and lower values for the mean slope estimate, 2 and 9, were used to calculate upper and lower estimates of the effects probability associated with the RQ. These estimated individual values are ~1 in 4.10 for a slope = 2 to ~1 in 1,110 for the slope = 9.

Table 5.11 shows the results of determining the individual effects for direct aquatic and terrestrial phases of the CRLF for onion For the probit slope analysis to determine the direct effects of MITC an assumption of a probit dose response relationship with a mean estimated default slope of 4.5. The corresponding estimated chance of individual mortality associated with the listed species RQ of 0.08 for the acute toxic endpoint for the rainbow trout as a surrogate for the aquatic phase of the CRLF.is ~1 in 2,510,000. It is recognized that extrapolation of very low probability events is associated with considerable uncertainty in the resulting estimates. To explore possible bounds to such estimates, the upper and lower values for the mean slope estimate, 2 and 9, were used to calculate upper and lower estimates of the effects probability associated with the RQ. These estimated individual values are ~1 in 70.8 for a slope = 2 to ~1 in 3.64×10^{22} for the slope = 9.

Indirect Effects

Table 5.11 shows the results of determining the individual effects for indirect effects on prey for the CRLF. The indirect effects on prey are based on fish, aquatic and terrestrial invertebrates, and terrestrial mammals. Data is available only to assess the effect on prey for fish, aquatic invertebrates and mammals. The results for individual effects for fish are discussed and for small mammals.

Table 5.11 shows the results of determining the individual effects for the indirect aquatic and terrestrial phases of the CRLF for strawberry. For the probit slope analysis to determine the indirect effects of MITC an assumption of a probit dose response relationship with a mean estimated default slope of 4.5. The corresponding estimated chance of individual effects associated with the RQ of 1.08 for the acute toxic endpoint for *daphnia* .is ~1 in 1.79. It is recognized that extrapolation of very low probability events is associated with considerable uncertainty in the resulting estimates. To explore possible bounds to such estimates, the upper and lower values for the mean slope estimate, 2 and 9, were used to calculate upper and lower estimates of the effects probability associated with the RQ. These estimated individual values are ~1 in 1.90 for a slope = 2 to of ~1 in 1.62[4] for the slope = 9.

Table 5.11 shows the results of determining the individual effects for the indirect aquatic and terrestrial phases of the CRLF for tomato. For the probit slope analysis to determine the indirect effects of MITC an assumption of a probit dose response relationship with a mean estimated default slope of 4.5. The corresponding estimated chance of individual effects associated with the RQ of 0.64 for the acute toxic endpoint for *daphnia* .is ~1 in 5.22. It is recognized that extrapolation of very low probability events is associated with considerable uncertainty in the resulting estimates. To explore possible bounds to such estimates, the upper and lower values for the mean slope estimate, 2 and 9, were used to calculate upper and lower estimates of the effects probability associated with the RQ. These estimated individual values are ~1 in 2.86 for a slope = 2 to of ~1 in 24.7 for the slope = 9.

Table 5.11 shows the results of determining the individual effects for the indirect aquatic and terrestrial phases of the CRLF for lettuce. For the probit slope analysis to determine the indirect effects of MITC an assumption of a probit dose response relationship with a mean estimated default slope of 4.5. The corresponding estimated chance of individual effects associated with the RQ of 1.03 for the acute toxic endpoint for *daphnia* .is ~1 in 1.91. It is recognized that extrapolation of very low probability events is associated with considerable uncertainty in the resulting estimates. To explore possible bounds to such estimates, the upper and lower values for the mean slope estimate, 2 and 9, were used to calculate upper and lower estimates of the effects probability associated with the RQ. These estimated individual values are ~1 in 1.96 for a slope = 2 to of ~1 in 1.83 for the slope = 9.

Table 5.11 shows the results of determining the individual effects for the indirect aquatic and terrestrial phases of the CRLF for turf. For the probit slope analysis to determine the indirect effects of MITC an assumption of a probit dose response relationship with a mean estimated default slope of 4.5. The corresponding estimated chance of individual effects associated with the RQ of 051 for the acute toxic endpoint for *daphnia* .is ~1 in 10.6. It is recognized that extrapolation of very low probability events is associated with considerable uncertainty in the resulting estimates. To explore possible bounds to such estimates, the upper and lower values for the mean slope estimate, 2 and 9, were used to calculate upper and lower estimates of the effects probability associated with the RQ. These estimated individual values are ~1 in 3.58 for a slope = 2 to of ~1 in 236 for the slope = 9.

Table 5.11 shows the results of determining the individual effects for the indirect aquatic and terrestrial phases of the CRLF for nursery For the probit slope analysis to determine the indirect effects of MITC an assumption of a probit dose response relationship with a mean estimated default slope of 4.5. The corresponding estimated chance of individual effects associated with the RQ of 0.0.42 for the acute toxic endpoint for *daphnia* ~1 in 22.2. It is recognized that extrapolation of very low probability events is associated with considerable uncertainty in the resulting estimates. To explore possible bounds to such estimates, the upper and lower values for the mean slope estimate, 2 and 9, were used to calculate upper and lower estimates of the effects probability associated with the RQ. These estimated individual values are ~1 in 4.43 for a slope = 2 to ~1 in 287 for the slope = 9.

Table 5.11 shows the results of determining the individual effects for the indirect aquatic and terrestrial phases of the CRLF for onion For the probit slope analysis to determine the indirect effects of MITC an assumption of a probit dose response relationship with a mean estimated default slope of 4.5. The corresponding estimated chance of individual effects associated with the RQ of 0.07 for the acute toxic endpoint for *daphnia* .is ~1 in 9.88×10^{6}. It is recognized that extrapolation of very low probability events is associated with considerable uncertainty in the resulting estimates. To explore possible bounds to such estimates, the upper and lower values for the mean slope estimate, 2 and 9, were used to calculate upper and lower estimates of the effects probability associated with the RQ. These estimated individual values are ~1 in 95.7 for a slope = 2 to of ~1 in 7.58×10^{24} for the slope = 9.

5.1.5 GIS Down Stream Model

Another refinement for the LOC exceedence is likelihood of the effect occurring. Discountable effects are those that are extremely unlikely to occur. Additional information may be provided through downstream modeling for the likelihood of exposure.

The GIS DownStream Model uses the highest aquatic effects LOC exceedence to determine the effect of runoff.

Table 5.12 DownStream Model

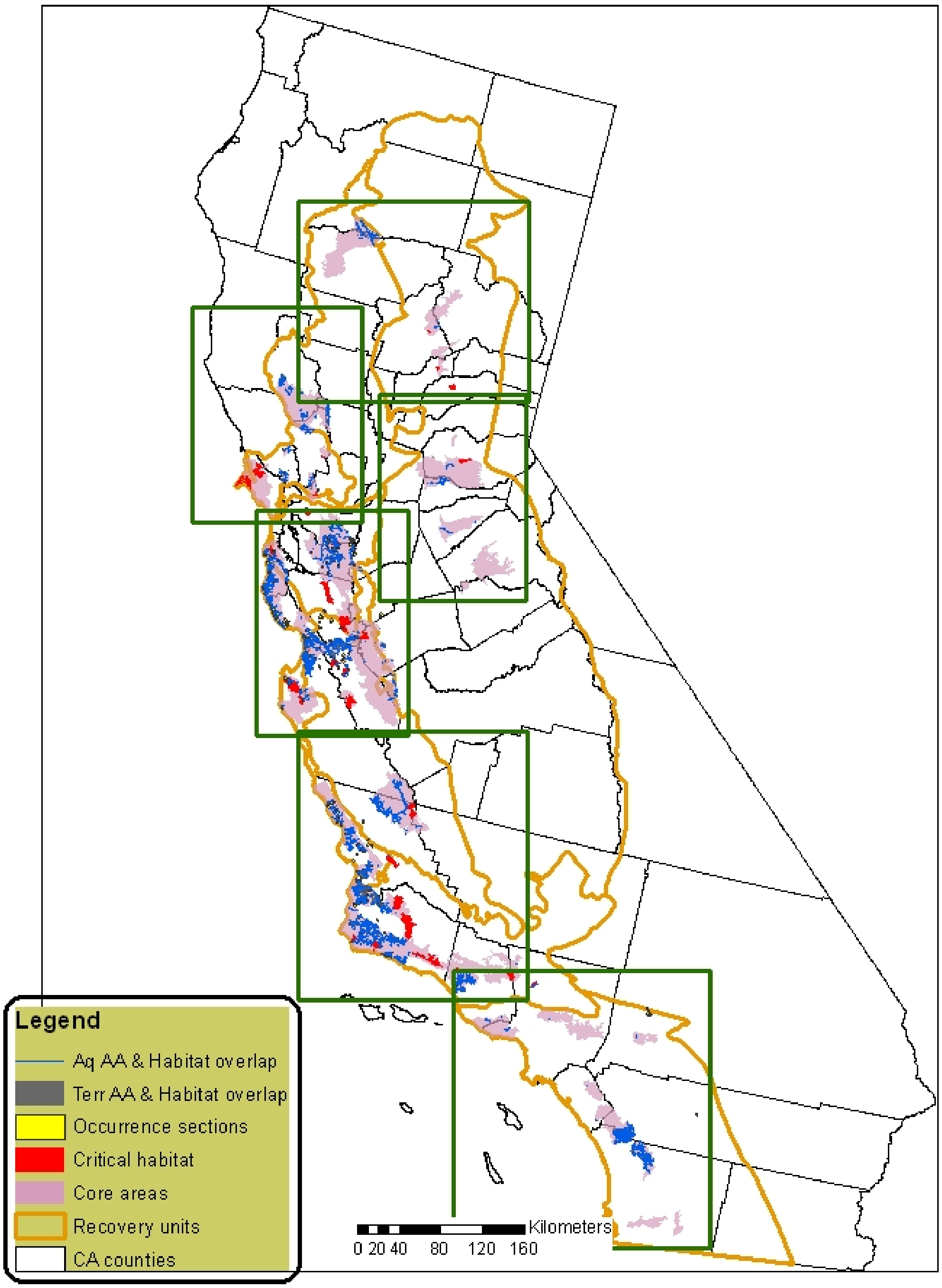
Measure	Total
Total California stream kilometers	332,962
Total stream kilometers in initial area of concern	65,444
Total stream kilometers added downstream	4,785
Total stream kilometers in final action area	70,229

Effects are anticipated to occur only for those occupied core habitat areas, CNDDB occurrence sections, and designated critical habitat for the California red-legged frog that are located in areas of overlapping concern, defined as agricultural lands. Potential indirect effects on the prey of primary productivity in waters receiving runoff from fields treated with metam sodium.

Using ARGIS9, the NLCD classified data, and CLRF habitat information supplied by the U.S. FWS, the agency has identified the habitat areas where effects are anticipated to occur and designated critical habitat areas where adverse modifications are anticipated to occur. Table 5.12 shows that 65,444 stream kilometers are in the intial area of concern with an additional 4,785 km added downstream, resulting in 70,229 stream km, about 21% of total stream km in California. Specific core areas, and designated critical habitat units which could be adversely affected by use of MITC are listed, as well as counties in which the units occur. In some cases, core areas and/or critical habitat units may be located in more than one county or recovery unit, and will be listed in both.

The geographical overlap for aquatic exposure and species habitat is shown for the state in Fig 5.1.

Metam-sodium - Action Area & Habitat Overlap (statewide)



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. July 12, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

The exposure-habitat overlap areas are shown for individual counties in Appendix D.

5.2 Risk Description

The agency uses quantative modeling to determine risk, but other information may also be used to support the risk characterization. Examples of other information include exposure data based on use characteristics, incident reports and data from open literature articles that is used qualitatively.

A major concern with metam sodium is the transformation to MITC which is highly volatile and can off-gas from treated fields and potentially expose a range of nontarget terrestrial organisms in its path. MITC also has the potential to reach surface water bodies. Given the broad spectrum use of metam sodium, it is assumed that most living organisms in the treated fields (including any beneficial insects and/or burrowing mammals) would be at high risk of mortality.

The risk to terrestrial phase CRLF and to terrestrial animal prey items of the CRLF is expected to largely depend on inhalation exposure to off-gassed MITC from treated sites. Inhalation toxicity data are only available for mammals.

Using the inhalation toxicity data for mammals and monitoring data for MITC, an RQ for inhalation is calculated. The Agency has not established level of concern (LOC) thresholds expressly for the interpretation of RQs calculated for inhalation exposure risks. For this risk assessment the estimate provided is compared to the existing endangered species mammal LOC = .1. Available monitoring data for MITC from California (et al., 1994) indicate that the highest MITC concentrations occur primarily during pesticide application and immediately following watering-in referred to as soil sealing periods. Concentration during application ranged from 78.3 to 2450 µg/L (0.002342 to 0.007327 mg/L) at 5 meters from the field edge and 11.7 to 1320 µg/L (0.000035 to 0.003948 mg/L) at 150 meters from the field edge. A comparison of these air concentrations with available mammalian acute inhalation effects data (MRID 42365605) from Table 5.13 .

Table 5.13: Comparison of Measured Air Concentrations with Acute Mammalian Inhalation Toxicity Endpoint

Air concentration (mg/L)	Acute Mammal LC50	Ratio Exposure/Effects (RQ)
5 meters off field		
0.002342	0.54	0.004
0.007327	0.54	0.014
150 meters off field		
0.000035	0.54	0.00006
0.003948	0.54	0.007

If the existing LOC values for acute mammalian wildlife risk were used to evaluate such RQs, the above analysis based on monitoring data (highest risk quotient of 0.014) and modeling (risk quotient of 0.02) would suggest that the acute endangered species LOC (0.1) would not be exceeded. Based on the ISCST3 model using the inhalation mammal data, there was a "no effect: for the surrogate mammal compared to the LOC CRLF. There was no ECOTOX or incident data to support another determination.

Monitoring data for a limited number of application sites is not necessarily predictive of all site conditions where the pesticide may be used. Also, most monitoring data is for samples collected at least 0.5 m above the ground, often higher. This height is above the level for many ground-dwelling mammals and ground-feeding birds as well as the terrestrial phase CRLF. It is reasonable to assume a gradient of concentrations at the treatment site, with higher concentrations of MITC occurring closer to the ground. This would be especially applicable to those times that a tarp is not used (and animals would be more likely to be on the soil surface of the treated field). Thus, modeling has been used to attempt to estimate residues closer to the field and ground.

The ISCST3 model provides more flexibility based on distance compared to the monitoring data (i.e., results are more easily extrapolated) and generally allows the Agency to consider a much broader set of circumstances in its assessments. Nevertheless, since the agency is relying on off-site monitoring data, the model calculation does not specifically produce on-field, ground surface level air residues. Because of uncertainties associated with both monitoring and modeling, the Agency has calculated risk estimates based on both.

The ISCST3 model-estimated MITC concentrations were used in calculating the concentrations on the edge of the field from a field application of metam sodium. The highest air concentration of 0.0084 mg/L was estimated immediately adjacent to the field, using sprinkler irrigation and a standard seal. With an acute mammal LC50 of 0.54 mg/L, the risk quotient for this modeled concentration is 0.02 (0.0084/0.54).

The above assessment is limited to acute effects and exposure windows. Wild mammals may have home ranges in the treatment area and may be exposed continuously and/or repeatedly as the result of metam sodium use on multiple fields over multiple days in any geographic area. Although the rat 28-day inhalation NOAEL for MITC at 20 µg/L is higher than the acute 4 h inhalation endpoint, the agency investigated the potential for a concern for chronic exposure and effects. Wofford et al., 1994 reported that air samples were below a detection limit of 2 µg/L (0.000006 mg/L) by 72 hours after application, suggesting that long term air concentrations would be well below the chronic inhalation NOAEL for mammals, based on the treatment of a single field.

The above analysis is based on mammalian toxicity data for the inhalation route. Birds are considered to be surrogates for amphibians, including the CRLF. A similar analysis could be performed for birds, if the necessary data were available. However, no inhalation toxicity data for MITC are available for birds. If acute toxicity by the oral route were available for both mammals and birds, an evaluation of the relative sensitivity via the oral route might be extrapolated to the inhalation route to estimate an acute inhalation endpoint for birds. However, no acute oral toxicity data for MITC are available for birds. Therefore, the agency is limited to an assumption of equivalent sensitivity between birds and mammals for MITC exposure through inhalation. Such an extrapolation may not be protective, given higher respiration rates for birds versus mammals, and physiological differences in the avian lung that would tend to favor higher diffusion rates across the lung membrane when compared to mammals. Therefore, inhalation analyses that suggest a potential for adverse effects in mammals would also suggest potential risks to birds via the inhalation route, but analyses not indicating risk to wild mammals would not necessarily be true for birds also. Because of generally lower metabolism of amphibians relative to birds, they may be less sensitive than birds to inhaled toxicants, but they are less mobile than adult birds and thus may thus be at similar or greater risk overall.

Based on the limited information for MITC on the treated fields, it is expected that indirect effects for habitat for the CRLF from off-site exposure may also be a risk from off-gassed MITC. Terrestrial plant guideline toxicity data are needed to evaluate this risk. The adverse incident report for terrestrial plants was not used in this assessment due to insufficient information provided in the report. . The LOCs for aquatic plants are not exceeded based on available data for the sprinkler irrigation and shank injection application methods. There are two incident reports resulting in aquatic exposure from metam sodium applications with claims of fish mortality. Neither incident is used in this assessment based on the volatility of MITC and the distances reported in the incidents and due to the possibility of other contaminants in the fish tanks.

The EECs to determine the acute risk to aquatic organisms from MITC were estimated using PRZM/EXAMS models with selected scenarios (strawberry, onion, tomatoes, potatoes, carrots/peppers, turf, leafy vegetables, melon and nursery), involving shank applied metam sodium to represent the numerous crops for which metam sodium is registered for use. Although the same application rate of 320 lbs of metam sodium per acre was used for all nine crop scenarios, the MITC exposure estimated resulted in different risk potentials. Based on this exposure assessment, no modeled scenario resulted in an LOC exceedance for acute endangered species LOCs for direct or indirect aquatic or terrestrial effects.

The acute study provides information for mortality as an endpoint, but does not provide information for non-lethal direct endpoints such as growth or reproduction.

5.3 Risk Conclusion Summary

The purpose of this assessment is to evaluate potential direct and indirect effects on the California red-legged frog *(Rana aurora draytonii*) (CRLF) arising from FIFRA regulatory actions regarding use of metam sodium on agricultural and non-agricultural sites. In addition, this assessment evaluates whether these actions can be expected to result in the destruction or adverse modification of the species' designated critical habitat. This assessment was completed in accordance with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) *Endangered Species Consultation Handbook* (USFWS/NMFS, 1998 and procedures outlined in the Agency's Overview Document (U.S. EPA, 2004).

The CRLF was listed as a threatened species by USFWS in 1996. The species is endemic to California and Baja California (Mexico) and inhabits both coastal and interior mountain ranges. A total of 243 streams or drainages are believed to be currently occupied by the species, with the greatest numbers in Monterey, San Luis Obispo, and Santa Barbara counties (USFWS 1996) in California.

Metam sodium (sodium-N-methyl dithiocarbamate) degrades rapidly in soil to generate methyl isothiocyanate (MITC), a volatile biocide active product to control weeds, nematodes and various soil-borne pathogens. The high vapor pressure and low affinity for sorption on soil of MITC suggest that volatilization is the most important environmental route of dissipation. Once MITC volatilizes into the atmosphere, it degrades rapidly due to direct photolysis. MITC is also highly soluble in water and has low adsorption in soil, it can potentially leach into ground water and transport to surface water through runoff under a flooded condition. It is registered for use on all crops and on many non-crop areas. Metam sodium is typically applied once per growing season through soil injection or irrigation to fumigate the upper six to twelve inches of soil a number of weeks prior to planting annual crops. For perennial trees, metam sodium is applied only once per life cycle of tree.

Environmental fate and transport models were used to estimate high-end exposure values expected to occur in the CRLF action area as a result of agricultural and non-agricultural metam sodium use in accordance with label directions. Since CRLF exist within aquatic and terrestrial habitats, exposures to the CRLF, its prey and its habitats are assessed separately for the two habitats. Two application methods are assessed to determine the effects of MITC on the CRLF in the aquatic environment. The methods are subsurface fumigation via shank injection, or drip irrigation and surface application using sprinkler irrigation. The effects of MITC on CRLF due to surface and subsurface fumigations will be evaluated.

Since metam sodium degrades rapidly to MITC upon application to the soil, the risk assessment is based on organism exposure to off-gassed MITC and aquatic MITC residues in surface water. Comparison of available toxicity information for MITC indicates greater aquatic toxicity than the metam sodium parent for freshwater invertebrates, and aquatic plants. Pesticide Root Zone Model/Exposure Analysis Modeling System (PRZM/EXAMS) modeled concentrations of MITC provide the estimates of exposure in a static water body, which are intended to represent metam sodium and MITC concentrations transported with runoff water to potential CRLF aquatic habitat. Industrial Source Complex: Short-Term Model (ISCST3) estimated downwind air concentrations of MITC from metam sodium application which are used for terrestrial organisms.

Due to the environmental fate properties of MITC, the focus for terrestrial exposure is inhalation. Due to the absence of amphibian toxicity data, birds are used as a surrogate for the terrestrial phase CRLF. Although birds are more protective of the CRLF, no acceptable bird inhalation toxicity data is available, therefore mammals are used as a surrogate for CRLF to estimate the inhalation risks to the terrestrial phase CRLF and as surrogates for small mammals in their diet. Indirect risks to terrestrial-phase CRLF for their potential habitats can not be estimated due to lack of terrestrial plant data as studies prepared under OPPTS test guidelines or open literature for MITC. Since MITC is a volatile chemical, the dietary exposure of terrestrial-phase CRLF is considered to be sufficiently low to be of no risk.

The CRLF direct toxic effects include survival, growth and reproduction assessment endpoints. Freshwater fish are generally used as an amphibian surrogate for direct effects in the aquatic habitat, so toxicity information for freshwater fish will be used in this assessment. Only acute freshwater fish data is available. Due to unacceptable open literature studies, no growth or reproductive effects will be determined for this assessment.

Birds are usually used as an amphibian surrogate for direct effects in the terrestrial habitat due to the higher level of protection provided. However, no MITC bird data is available, including no inhalation studies. This assessment will use inhalation mammal studies to assess terrestrial phase CRLF direct effects of MITC exposure.

This assessment will also determine indirect effects of prey and habitat modification from MITC exposure in both aquatic and terrestrial habitats. Aquatic phase CRLF prey items are dependent on fish, aquatic invertebrates and non-vascular aquatic plants. Toxicity information for acute studies from aquatic invertebrates and plants will be discussed. Terrestrial phase CRLF indirect effects for prey are assessed by considering effects to terrestrial insects and small mammals.

Indirect effects for the CLRF are determined by assessing modification of critical habitat as an indirect effect for the CRLF. Primary constituent elements (PCEs) are used to describe modifications to critical habitat. PCEs include, but are not limited to, space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements, cover or shelter, sites for breeding, reproduction, rearing/development of offspring; and habitats that are protected from disturbance or are representative of the historic geographical and ecological distribution of a species. The designated critical habitat areas for the CRLF are considered to have the following PCEs that justify critical habitat designation:

Breeding aquatic habitat;
Non-breeding aquatic habitat;
Upland habitat; and
Dispersal habitat.

Aquatic phase CRLF critical habitat is dependent on aquatic plants. Vascular and non-vascular plant registrant studies have been submitted and are used to determine modification of CRLF critical habitat.

Terrestrial phase CRLF indirect effects for modification of critical habitat are characterized by available data for monocots and dicots. No terrestrial plant guideline studies are available.

Risk quotients (RQs), quantitative estimates of potential high risk, are derived from available registrant submitted studies or acceptable open literature studies used quantitatively. Acute and chronic RQs are compared to the Agency's levels of concern (LOCs) for Federally-listed threatened species and non-listed species to identify if metam sodium use within the action area has direct or indirect effects on the CRLF.

For those effects with a "may affect" determination", further refinements are estimated using the probit slope model for individual effects and GIS modeling for overlapping areas. Aquatic habitat overlapping areas are determined from the GIS downstream model. Terrestrial habitat overlapping areas are determined from GIS use data.

Table 5.14 describes the risk conclusions for direct and indirect effects for the aquatic and terrestrial phase CRLF. Two application methods are described for each assessment endpoint.

Table 5.14 Effects Determination Summary for Direct and Indirect Effects of MITC on the California Red-legged Frog

Assessment Endpoint	Effects Determination		Basis
Aquatic-Phase Effects (Eggs, Larvae, Tadpoles, Adults)			
	Application Methods		
	Sprinkler Irrigation	Shank Injection	
Direct Effects of MITC on the Aquatic Phase CRLF			
Survival of CRLF individuals via direct effects on aquatic phases (Surrogate Fish)	Aquatic vertebrates (fish) May affect, LAA: Six modeled crops (strawberry, tomato, lettuce, turf, nursery and onion) No Effect; Three modeled crops (potato, row crops and melon)	Aquatic vertebrates (fish) No Effect: Modeled crops (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon	*Sprinkler Application*: For the sprinkler irrigation application method the risk conclusion is supported by listed species LOC exceedence for "May affect". LAA based on individual effects results and exposure overlap from the downstream model for the surrogate fish for six modeled crops. RQs of three modeled crops (potato, row crops and melon) do not exceed listed species LOC. *Shank Injection Application:* For the shank injection application method, the risk conclusion is based on no LOC exceedence for any of the nine modeled crops.
Reproduction (Embryos)	No Effect	No Effect	No Effect conclusion supported by MITC physio-chemical characteristics, volatilization and fate transport for chronic exposure. Due to absence of prey and vegetation to provide shelter and predator protection, CRLF not anticipated to be at application site, which has highest concentration.
Growth	No Effect	No Effect	No Effect conclusion supported by MITC physio-chemical characteristics,

Table 5.14 Effects Determination Summary for Direct and Indirect Effects of MITC on the California Red-legged Frog			
Assessment Endpoint	Effects Determination		Basis
			volatilization and fate transport for chronic exposure. Due to absence of prey and vegetation to provide shelter and predator protection, CRLF not anticipated to be at application site, which has highest concentration. .
Reduction of Prey as Indirect Effects of MITC on the Aquatic Phase CRLF			
Survival, growth, and reproduction of CRLF individuals via effects on prey (*i.e., aquatic* vertebrates and amphibians)	Aquatic vertebrates (fish): May affect: Modeled crops: strawberry, tomato, lettuce, turf, nursery and onion LAA Effect: strawberry, tomato, lettuce, turf NLAA: nursery and onion No Effects: potato, row crops and melon	Aquatic vertebrates (fish) No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon	*Sprinkler Application:* Risk conclusion supported by listed species LOC exceedence for fish and aquatic invertebrates for "May affect". LAA based on individual effects results and downstream model exposure results for the surrogate fish for four modeled crops. LOCs for nursery and onion fall between listed species and acute LOCs. NLAA for nursery supported by RQ resulting in 5.9% effect. lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. NLAA for onion supported by RQ resulting in a low probability of 1 in 9.88 x 10^6, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. No effect for potato, row crops and melon based on no LOC exceedence. *Shank Injection Application:* For the shank injection application method, the risk conclusion is based on no LOC exceedence for the fish for all nine of the modeled crops
Survival, growth, and reproduction of CRLF individuals via effects to food supply (*i.e.,* freshwater invertebrates, non-vascular plants)	Aquatic invertebrates: May Effect: Modeled crops: (strawberry,	Aquatic invertebrates: No Effect Modeled crops (strawberry,	*Sprinkler Irrigation Application:* Risk conclusion supported by listed species LOC exceedence for aquatic invertebrates for "May affect". LAA based on individual effects

Table 5.14 Effects Determination Summary for Direct and Indirect Effects of MITC on the California Red-legged Frog			
Assessment Endpoint	Effects Determination		Basis
	tomato, lettuce, turf, nursery and onion) LAA for strawberry, tomato, lettuce and turf. NLAA for nursery and onion. No effect for potato, row crops and melon	tomato, lettuce, turf, nursery, onion, potato, row crops and melon	results and downstream model exposure results for the aquatic invertebrates for four modeled crops. LOCs for nursery and onion fall between listed species and acute LOCs. NLAA for nursery supported by RQ resulting in 4.5% effect, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. NLAA for onion supported by RQ resulting in a low probability of 1 in 2,510,000, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. No Effect for potato, row crops and melon based on no LOC exceedence.
	Aquatic non-vascular plants: No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon	Aquatic non-vascular plants: No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon	For the sprinkler irrigation application method, the risk conclusion is based on no LOC exceedence for aquatic plants. *Shank Injection Application*: For the shank injection application method, the risk conclusion is based on no LOC exceedence for aquatic invertebrates and aquatic plants.
Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat, cover, and/or primary productivity (*i.e.,* aquatic plant community)	Aquatic plants No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion,	Aquatic plants No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion,	Risk conclusion supported by no LOC exceedence for aquatic plants for both application methods for all nine modeled crops.

<table>
<tr><td colspan="4">Table 5.14 Effects Determination Summary for Direct and Indirect Effects of MITC on the California Red-legged Frog</td></tr>
<tr><td>Assessment Endpoint</td><td colspan="2">Effects Determination</td><td>Basis</td></tr>
<tr><td></td><td>potato, row crops and melon)</td><td>potato, row crops and melon)</td><td></td></tr>
<tr><td colspan="4">Habitat as Indirect Effect of MITC on the Aquatic Phase CRLF</td></tr>
<tr><td>Survival, growth, and reproduction of CRLF individuals via effects to riparian vegetation, required to maintain acceptable water quality and habitat in ponds and streams comprising the species' current range</td><td>Aquatic Plants

No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon

Terrestrial Plants:

May Effect, LAA</td><td>Aquatic Plants

No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon

Terrestrial Plants:

May affect, LAA</td><td>Risk conclusion supported by no LOC exceedence for aquatic plants for both application methods for all nine modeled crops.

No terrestrial plant guideline studies have been submitted. No open literature is available to calculate RQs. Risk determination of may affect is due to the uncertainty from the limited data as the most conservative determination for both application methods.
.</td></tr>
<tr><td colspan="4">Terrestrial Phase Effects Using Both Shank Injection and Sprinkler Irrigation Application Methods (Juveniles and adults)</td></tr>
<tr><td rowspan="2"></td><td colspan="2">Application Methods</td><td rowspan="2"></td></tr>
<tr><td>Sprinkler Irrigation</td><td>Shank Injection</td></tr>
<tr><td colspan="4">Direct Effects of MITC on Terrestrial Phase CRLF</td></tr>
<tr><td>Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles</td><td>Terrestrial vertebrates (mammals)

No Effect</td><td>Terrestrial vertebrates (mammals)

No Effect</td><td>MITC inhalation RQs do not exceed LOCs for direct effects using mammals as a surrogate. Risk conclusions supported by RQs for mammal inhalation for both application methods</td></tr>
<tr><td colspan="4">Reduction of Prey as Indirect Effects of MITC on the terrestrial Phase CRLF</td></tr>
<tr><td>Survival, growth, and reproduction of CRLF individuals via effects on prey (i.e., small terrestrial vertebrates, including mammals and terrestrial phase amphibians)</td><td>Terrestrial vertebrates (mammals)

No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion,</td><td>Terrestrial vertebrates (mammals)

No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion,</td><td>MITC inhalation RQs do not exceed LOCs for terrestrial vertebrates. Risk conclusions supported by RQ for terrestrial vertebrates (mammals) for both application methods.</td></tr>
</table>

Table 5.14 Effects Determination Summary for Direct and Indirect Effects of MITC on the California Red-legged Frog			
Assessment Endpoint	Effects Determination		Basis
	potato, row crops and melon	potato, row crops and melon	
Survival, growth, and reproduction of CRLF individuals via effects on prey (*i.e.,* terrestrial invertebrates)	Terrestrial invertebrates: May affect, LAA	Terrestrial invertebrates: May affect, LAA	No terrestrial invertebrate guideline studies have been submitted. No open literature is available to calculate RQs. Risk determination of may affect is due to the uncertainty from limited data as the most conservative determination for both application methods. .
Habitat as Indirect Effect of MITC on the Terrestrial Phase CRLF			
Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat (*i.e.,* riparian vegetation)	Terrestrial plants: May affect, LAA	Terrestrial plants: May affect, LAA	No terrestrial plant guideline studies have been submitted. No open literature is available to provide data for RQs. Risk determination of May affect, Likely to Adversely Affect is due to the uncertainty from limited data as the most conservative determination.

Table 5.15 Effects Determination Summary for the Critical Habitat Impact Analysis

Assessment Endpoint	Effects Determination		Basis
Aquatic Phase Primary Constituent Elements (PCEs) Using Sprinkler Irrigation and Shank Injection Application Methods (Aquatic breeding Habitat and Aquatic Non-breeding Habitat)			
	Application Methods		
	Sprinkler Irrigation	Shank Injection	
Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond: aquatic habitat (including riparian vegetation) provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs.	Aquatic Plants: No Habitat Modification Terrestrial plants: Habitat Modification	Aquatic Plants: No Habitat Modification Terrestrial plants: Habitat Modification	Aquatic plant RQs for both application methods do not exceed LOCs for any of the nine modeled crops. Risk determination is based on no LOC exceedence. No registrant terrestrial plant guideline studies have been submitted for MITC. No open literature is available for determining RQs for terrestrial plants. Habitat modification risk conclusion is based on the uncertainty due to limited data for MITC for both application methods.

Table 5.15 Effects Determination Summary for the Critical Habitat Impact Analysis

Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source[1].	Aquatic vertebrates (fish): Habitat Modification: Modeled crops: (strawberry, tomato, lettuce, turf) No Habitat modification: nursery and onion No habitat modification: potato, row crops and melon	Aquatic vertebrates (fish): No Habitat Modification: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon)	*Sprinkler Application:* Risk conclusion supported by listed species LOC exceedence for fish. Habitat modification based on individual effects results and downstream model exposure results for the surrogate fish for four modeled crops. LOCs for nursery and onion fall between listed species and acute LOCs. No habitat modification for nursery supported by RQ resulting in 5.9% effect, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. No habitat modification for onion supported by RQ resulting in a low probability of 1 in 9.88 x 10^6, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. No habitat modification for potato, row crops and melon based on no LOC exceedence. *Shank Injection Application:* For the shank injection application method, the risk conclusion is based on no LOC exceedence for the fish for all nine of the modeled crops

Table 5.15 Effects Determination Summary for the Critical Habitat Impact Analysis

	Aquatic invertebrates: Habitat Modification Modeled crops: (strawberry, tomato, lettuce and turf.) No Habitat Modification for nursery and onion. No Habitat Modification for potato, row crops and melon	Aquatic invertebrates: No Habitat Modification Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon	*Sprinkler Irrigation Application:* Risk conclusion supported by listed species LOC exceedence for aquatic invertebrates. Habitat modification based on individual effects results and downstream model exposure results for the aquatic invertebrates for four modeled crops. LOCs for nursery and onion fall between listed species and acute LOCs. No habitat modification for nursery supported by RQ resulting in 4.5% effect, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. No habitat modification for onion supported by RQ resulting in a low probability of 1 in 2,510,000, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. No habitat modification for potato, row crops and melon based on no LOC exceedence. *Shank Injection Application*: For the shank injection application method, the risk conclusion is based on no LOC exceedence for aquatic invertebrates and plants.

Table 5.15 Effects Determination Summary for the Critical Habitat Impact Analysis

	Aquatic non-vascular plants: No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon)	Aquatic non-vascular plants: No Effect: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon)	*Sprinkler Application* For the sprinkler irrigation application method, the risk conclusion is based on no LOC exceedence for aquatic plants. *Shank Injection Application*: For the shank injection application method, the risk conclusion is based on no LOC exceedence for aquatic plants for both application methods.
Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source. Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.*, algae)	Aquatic vertebrates (fish): Habitat Modification: Modeled crops: (strawberry, tomato, lettuce, turf) No Habitat Modification: nursery and onion No Habitat Modification: potato, row crops and melon	Aquatic vertebrates (fish) No Habitat Modification : Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon)	*Sprinkler Application:* Risk conclusion supported by listed species LOC exceedence for fish. Habitat modification based on individual effects results and downstream model exposure results for the surrogate fish for four modeled crops. LOCs for nursery and onion fall between listed species and acute LOCs. No habitat modification for nursery supported by RQ resulting in 5.9% effect, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. No habitat modification for onion supported by RQ resulting in a low probability of 1 in 1 in 9.88×10^6, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. No habitat modification for potato, row crops and melon based on no LOC exceedence. *Shank Injection Application:* For the shank injection application method, the risk conclusion is based on no LOC exceedence for the fish for all nine of the modeled crops

Table 5.15 Effects Determination Summary for the Critical Habitat Impact Analysis

	Aquatic invertebrates: Habitat Modification: Modeled crops: (strawberry, tomato, lettuce and turf.) No Habitat Modification for nursery and onion. No Habitat Modification for potato, row crops and melon	Aquatic invertebrates: No Habitat Modification Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon	*Sprinkler Irrigation Application:* Risk conclusion supported by listed species LOC exceedence for aquatic invertebrates. Habitat modification based on individual effects results and downstream model exposure results for the aquatic invertebrates for four modeled crops. LOCs for nursery and onion fall between listed species and acute LOCs. No habitat modification for nursery supported by RQ resulting in 4.5% effect, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. No habitat modification for onion supported by RQ resulting in a low probability of 1 in 2,510,000, lack of food item matrix data for CRLF diet and duration based on physio-chemical and fate transport properties of MITC. No habitat modification for potato, row crops and melon based on no LOC exceedence. *Shank Injection Application*: For the shank injection application method, the risk conclusion is based on no LOC exceedence for aquatic invertebrates and plants.

Table 5.15 Effects Determination Summary for the Critical Habitat Impact Analysis

	Aquatic non-vascular plants: No Habitat Modification: Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon)	Aquatic non-vascular plants: No Habitat Modification Modeled crops: (strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon)	*Sprinkler Irrigation Application* For the sprinkler irrigation application method, the risk conclusion is based on no LOC exceedence for aquatic plants. *Shank Injection Application*: For the shank injection application method, the risk conclusion is based on no LOC exceedence for aquatic plants for both application methods.
Terrestrial Phase Primary Constituent Elements (PCEs) (Upland Habitat and Dispersal Habitat)			
	Application Methods		
	Sprinkler Irrigation	Shank Injection	
Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs: Upland areas within 200 ft of the edge of the riparian vegetation or dripline surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that provides the CRLF shelter, forage, and predator avoidance	Terrestrial plants: Habitat Modification	Terrestrial plants Habitat Modification	No terrestrial plant guideline studies have been submitted. No open literature is available to calculate RQs. Risk determination of habitat modification is due to the uncertainty from limited data as the most conservative determination. .
Elimination and/or disturbance of dispersal habitat: Upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal	Terrestrial plants: Habitat Modification	Terrestrial plants: Habitat Modification	No terrestrial plant guideline studies have been submitted. No open literature is available to calculate RQs. Risk determination of habitat modification is due to the uncertainty from limited data as the most conservative determination.
Terrestrial Phase PCEs Base (Upland Habitat and Dispersal Habitat)			
Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source. Reduction and/or modification of food sources for terrestrial phase juveniles and adults.	Terrestrial Vertebrate: No Habitat Modification Terrestrial invertebrates:	Terrestrial Vertebrate: No Habitat Modification Terrestrial invertebrates:	The MITC RQ for small mammals does not exceed the LOC. Risk conclusions for aquatic invertebrate and the terrestrial mammal prey are based on the RQs for both application methods. No terrestrial invertebrate guideline studies have been submitted. No

Table 5.15 Effects Determination Summary for the Critical Habitat Impact Analysis

	Habitat Modification Terrestrial plants: Habitat Modification	Habitat Modification Terrestrial plants: Habitat Modification	open literature is available to calculate RQs. Risk determination of habitat modification is due to the uncertainty from limited data as the most conservative determination for both application methods. No terrestrial plant guideline studies have been submitted. No open literature is available to calculate RQs. Risk determination of habitat modification, is due the uncertainty from the limited data for both application methods.
[1] Physico-chemical water quality parameters such as salinity, pH, and hardness are not evaluated because these processes are not biologically mediated and, therefore, are not relevant to the endpoints included in this assessment.			

5.3.1 Direct Survival Effects and Indirect Effects on Prey for Metam Sodium Exposure:

Table 5.14 summarizes both direct effects of survival and indirect effects on prey based on estimated environmental concentrations from MITC exposure for the CRLF. Both aquatic and terrestrial phase CRLF effects are represented by two currently registered application methods for metam sodium, sprinkler irrigation and shank injection.

Direct Survival and Indirect Effects of Prey for Metam Sodium Sprinkler Irrigation Application Method:

There are no anticipated chronic effects of reproduction or growth based on the short- term exposure period anticipated from the physio-chemical properties of MITC for both application methods and for aquatic and terrestrial phase CRLF. No detected MITC residues in soil after 14 days. Due to the volatility and photodegradation properties of MITC the concentration is anticipated to decrease over time. Although the study is limited by information that is not reported, it indicates no notochord damage from a sample of 60 developing embryos for *Xenopus* after 10 days at MITC concentrations ranging from 1-50 µg/L. Severe notochord damage was reported for concentration ranging from 100-500 µg/L. (Birch and Prahlad, 1986). The peak modeled concentration EEC for shank injection was 0.6 µg/L and for sprinkler irrigation was 59.4. µg/L.

Aquatic Phase Effects:

Direct Effects on the Aquatic Phase CRLF (Surrogate Fish):

The risk conclusions for survival of the aquatic phase CRLF for the nine modeled crops described below are described in Table 1.1. Aquatic phase direct survival effect RQs for the surrogate fish do not exceed the listed species LOC set by the Agency for three of the modeled crops, potato, row crops and melon. The "may affect" conclusion is based on the LOC exceedence for six of the nine modeled crops (strawberry, tomato, lettuce, turf, nursery and onion). The downstream high concentrations overlapping the species habitat are estimated from the GIS Downstream Model defining the action area for the aquatic phase CRLF. The No effect conclusion for potato, row crops and melon is supported by no LOC exceedence.

Indirect Effects on Aquatic Phase CRLF (Surrogate Fish):

The risk conclusions for MITC indirect effect of prey reduction based on the surrogate fish for aquatic vertebrates for the aquatic phase indirect effects are shown in Table 1.1 There was no RQ exceedence for three modeled crops, potato, row crops and melon, resulting in a "No Effect" conclusion. . The listed species LOC exceedence for aquatic vertebrates supports a "may affect" conclusion for six modeled crops, strawberry, tomato, lettuce, turf, nursery and onion. The downstream high concentrations overlapping the species habitat are estimated from the GIS Downstream Model defining the action area for the aquatic phase CRLF. Refinements result in a "likely to adversely affect" conclusion based on the individual effects estimates for four modeled crops, strawberry, tomato, lettuce and turf which exceed the listed species LOC.

Risk quotients for nursery and onion fall between the listed species effect/no effect threshold and the non-listed species acute risk threshold. Consequently, further analysis was conducted to determine if the estimated levels of risk would be likely to adversely affect individual frogs. To accomplish this analysis the following topics were considered:

- The Severity and magnitude of the predicted effects on individuals of the affected taxa making up a potential food source for the frog
- The importance of those food items in the diet of the frog, and
- The pattern of pesticide use and the likelihood that effects on food items will occur over multiple days

Severity and Magnitude:

Predicted risks are associated with lethal effects on rainbow trout as a surrogate for aquatic vertebrates. Lethal responses have the potential to remove individual prey items from the resource base available to the frog, assuming that frogs are most likely to actively feed on living prey. Using the available RQ and the dose response relationship for the tested organisms, available probit interpolation tools suggest that exposures associated with the RQ would result in a 5.9 percent reduction in survival in the most sensitive tested species. If it is assumed that this laboratory effect is representative of all species within the taxonomic group, the percent effect may be extrapolated to other species comprising food resources for the species. Because metam sodium data base is limited in the breadth of species tested, this assumption may or may not be highly conservative.

Importance of Food items to the Frog:

While there are some qualitative discussions of the variety of dietary items in the frog's diet, data on the quantitative distribution of species or taxa in the frog's diet are unavailable. Lacking these data, it can be conservatively assumed that any given taxa could account for the majority or even the entirety of a frog's diet in any given day or progression of several days.

Pattern of Pesticide Use:

Pre plant fumigation normally occurs1 to 2 week prior to planting. Metam sodium is highly unstable in the environment, degrading rapidly to form MITC. Henry's Law constant (1.79×10^{-4} atm-m^3/mol) of MITC suggests that rapid volatilization of MITC from water and a soil surface is expected to be an important process of dissipation. Terrestrial field dissipation study also indicates that metam sodium and MITC residues were not detected in soils after 14 days. The physico-chemical and environmental fate data suggesting that the compound is highly transient. Therefore the effect associated with the use of the pesticide would involve small windows of use and only for limited periods of time after application. It is highly unlikely that individual frogs would occur in areas with long term exposure at levels where prey items will be continually suppressed.

Conclusion:

The above analysis suggests that risks associated with metam sodium use for nursery and onions for the indirect effect of prey reduction for aquatic vertebrates, fish, is confined to low levels of mortality, even when conservatively assuming that all observed effect levels will occur in all potentially exposure prey species and the taxanomic group is conservatively assumed to be the only utilized group at any given time. Combining these low expected effects with the transient and time-limited nature of expected exposures results in a conclusion that predicted effects are not likely to adversely affect individual frogs.

Indirect Effect on Aquatic Phase CRLF (Invertebrates, Non-vascular Plants):

The risk conclusions for MITC indirect effect of prey based on the surrogate *daphnia* for aquatic invertebrates for the aquatic phase indirect effects are shown in Table 1.1 There was no RQ exceedence for three modeled crops, potato, row crops and melon, resulting in a "No Effect" conclusion. . The listed species LOC exceedence for aquatic invertebrates supports a "may affect" conclusion for six modeled crops, strawberry, tomato, lettuce, turf, nursery and onion. The downstream high concentrations overlapping the species habitat are estimated from the GIS Downstream Model defining the action area for the aquatic phase CRLF. Refinements result in a "likely to adversely affect" conclusion based on the individual effects estimates for four modeled crops, strawberry, tomato, lettuce and turf which exceed the listed species LOC.
Risk quotients for nursery and onion fall between the listed species effect/no effect threshold and the non-listed species acute risk threshold. Consequently, further analysis was conducted to determine if the estimated levels of risk would be likely to adversely affect individual frogs. To accomplish this analysis the following topics were considered:

- The Severity and magnitude of the predicted effects on individuals of the affected taxa making up a potential food source for the frog
- The importance of those food items in the diet of the frog, and

- The pattern of pesticide use and the likelihood that effects on food items will occur over multiple days

Severity and Magnitude:

Predicted risks are associated with lethal effects on rainbow trout as a surrogate for aquatic vertebrates. Lethal responses have the potential to remove individual prey items from the resource base available to the frog, assuming that frogs are most likely to actively feed on living prey. Using the available RQ and the dose response relationship for the tested organisms, available probit interpolation tools suggest that exposures associated with the RQ would result in a 4.5 percent reduction in survival in the most sensitive tested species. If it is assumed that this laboratory effect is representative of all species within the taxanomic group, the percent effect may be extrapolated to other species comprising food resources for the species. Because metam sodium data base is limited in the breadth of species tested, this assumption may or may not be highly conservative.

Importance of Food items to the Frog:

While there are some qualitative discussions of the variety of dietary items in the frog's diet, data on the quantitative distribution of species or taxa in the frog's diet are unavailable. Lacking these data, it can be conservatively assumed that any given taxa could account for the majority or even the entirety of a frog's diet in any given day or progression of several days.

Pattern of Pesticide Use:

Pre plant fumigation normally occurs 1 to 2 week prior to planting. Metam sodium is highly unstable in the environment, degrading rapidly to form MITC. Henry's Law constant (1.79×10^{-4} atm-m^3/mol) of MITC suggests that rapid volatilization of MITC from water and a soil surface is expected to be an important process of dissipation. Terrestrial field dissipation study also indicates that metam sodium and MITC residues were not detected in soils after 14 days. The physico-chemical and environmental fate data suggesting that the compound is highly transient. Therefore the effect associated with the use of the pesticide would involve small windows of use and only for limited periods of time after application. It is highly unlikely that individual frogs would occur in areas with long term exposure at levels where prey items will be continually suppressed.

Conclusion:

The above analysis suggests that risks associated with metam sodium use for nursery and onions for the indirect effect of prey reduction for *daphnia* is confined to low levels of mortality, even when conservatively assuming that all observed effect levels will occur in all potentially exposure prey species and the taxanomic group is conservatively assumed to be the only utilized group at any given time. Combining these low expected effects with the transient and time-limited nature of expected exposures results in a conclusion that predicted effects are not likely to adversely affect individual frogs.

The aquatic phase CRLF diet also includes aquatic non-vascular plants. The "No Effect" conclusion is supported by no LOC exceedence for non-vascular aquatic plants.

Indirect Effects on Aquatic Phase CRLF (habitat cover, primary productivity):

The risk conclusions for MITC exposure on indirect effects on habitat, cover and/or primary productivity (aquatic plant community) for the aquatic phase CRLF are shown in the Table. The "No Effect" conclusion is supported by no LOC exceedence for vascular and non-vascular aquatic plants.

Indirect Effects on Aquatic Phase CRLF (riparian vegetation):

The risk conclusions for MITC exposure on indirect effects on riparian vegetation for the aquatic phase CRLF are shown in Table 1.1. The conclusion of "may affect, likely to adversely affect" is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted studies or accepted open literature studies for crops were available for this assessment.

Terrestrial Phase Exposure:

Direct and Indirect Effects on Terrestrial Phase CRLF (vertebrates, invertebrates, and riparian vegetation):

The RQ for terrestrial direct survival effects from MITC inhalation exposure based on the surrogate mammal (rat) was below the LOC. The"No Effect" determination was based on no LOC exceedence.

The terrestrial phase CRLF diet includes small terrestrial mammals and terrestrial invertebrates. Indirect prey reduction effects are estimated for surrogates for each category represented in the diet.

The RQ for terrestrial indirect prey reduction effects from MITC inhalation exposure based on the surrogate mammal (rat) was below the LOC. The"No Effect" determination was based on the RQ not exceeding the LOC.

"May affect, likely to adversely affect" conclusion for the terrestrial phase CRLF for indirect effects of terrestrial invertebrate reduced prey is based on the uncertainty due to limited data and is the most conservative determination. No registrant submitted guideline studies or accepted open literature studies were available for this assessment.

"May affect, likely to adversely affect" conclusion for terrestrial phase CRLF for indirect effects on habitat (riparian vegetation) was based on uncertainty due to limited data and is the most conservative determination. No registrant submitted guideline studies or accepted open literature studies were available for this assessment.

5.3.2 Direct Survival Effects and Indirect Prey Reduction Effects for Metam Sodium Shank Injection Application Method:

Aquatic Phase Exposure:

The risk conclusions for the shank injection application method for direct and indirect effects of MITC exposure for the aquatic and terrestrial phase CRLF are shown in Table 5.14. RQs include estimates from the modeled crops of strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon for both direct and indirect effects. Aquatic phase direct survival effect RQs for the nine modeled crops for the surrogate fish do not exceed the LOC set by the Agency. The "No Effect" conclusion is based on no LOC exceedence.

The risk conclusions for MITC exposure on prey reduction of aquatic vertebrates, fish, for the aquatic phase indirect effects are shown in Table 5.14. The "No Effect" conclusion is based no LOC exceedence.

The risk conclusions for MITC exposure on prey reduction of aquatic invertebrates for the aquatic phase indirect effects are shown in Table 5.14. The "No Effect" conclusion is based no LOC exceedence.

The aquatic phase CRLF diet also includes aquatic non-vascular plants. The "No Effect" conclusion is supported by no LOC exceedence for non-vascular aquatic plants.

The risk conclusions for MITC exposure on indirect effects on habitat, cover and/or primary productivity (aquatic plant community) for the aquatic phase CRLF are shown in Table 5.14. The "No Effect" conclusion is supported by no LOC exceedence for vascular and non-vascular aquatic plants.

Terrestrial Phase Exposure:

The RQs for terrestrial direct survival effects from MITC inhalation exposure based on the surrogate mammal (rat) were below the LOC. The"No Effect" determination was based on no LOC exceedence.

In addition to the terrestrial phase direct survival effects determination, the indirect effects of prey reduction were determined. Prey items include small terrestrial mammals and terrestrial invertebrates. The"No Effect" determination was based on no LOC exceedence.

The RQ for terrestrial indirect prey reduction effects from MITC inhalation exposure based on the surrogate mammal (rat) was below the LOC. The"No Effect" determination was based on no LOC exceedence.

The risk conclusions for MITC exposure on indirect effects on prey reduction of terrestrial invertebrates for the terrestrial phase CRLF are shown in Table 5.14. The conclusion of "May affect, likely to adversely affect" is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted studies or accepted open literature studies for the bee were available for this assessment.

The risk conclusions for MITC exposure on indirect effects on riparian vegetation for the terrestrial phase CRLF are shown in Table 5.14. The conclusion of “May affect, likely to adversely affect” is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted studies or accepted open literature studies for crops were available for this assessment.

5.4 Indirect Effects of Metam Sodium Application on Critical Habitat:

5.4.1 Indirect Effects of Metam Sodium Sprinkler Irrigation Application Method on Critical Habitat:

The risk conclusions for the sprinkler irrigation application method for Critical Habitat Impact effects of MITC exposure for the aquatic and terrestrial phase CRLF are shown in Table 1.2. RQs were estimated for nine crops, strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon.

Aquatic Phase Exposure:

RQs for aquatic phase CRLF PCEs were based on aquatic breeding habitat and non-breeding habitat, including aquatic and riparian vegetation for alteration of channel morphology. The RQs for aquatic plants do not exceed the LOC set by the Agency for any of the nine modeled crops. The “No habitat modification” conclusion is based on no LOC exceedence.

The risk conclusions for MITC exposure on riparian vegetation for the aquatic phase CRLF PCEs are shown in Table 1.2. The conclusion of “habitat modification” for riparian vegetation in alterations of channel morphology is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for crops were available for this assessment.

RQs for aquatic phase CRLF PCEs were based on aquatic breeding habitat and non-breeding habitat, including aquatic and riparian vegetation for alteration in water chemistry. The RQs for aquatic plants do not exceed the LOC set by the Agency for any of the nine modeled crops. The “No habitat modification” conclusion is based on no LOC exceedence.

The conclusion of “habitat modification” for riparian vegetation for alteration in water chemistry is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for crops were available for this assessment.

RQs for aquatic phase CRLF PCEs were based on aquatic breeding habitat and non-breeding habitat, including aquatic and riparian vegetation for alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and food sources. The RQs for aquatic plants do not exceed the LOC set by the Agency for any of the nine modeled crops. The "No habitat modification" conclusion is based on no LOC exceedence.

The conclusion of "habitat modification" for riparian vegetation for alteration of other chemical characteristics is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for crops were available for this assessment.

RQs for aquatic phase CRLF PCEs were based on aquatic breeding habitat and non-breeding habitat, including aquatic and riparian vegetation for reduction and/or modification of aquatic-based food sources (algae). The RQs for non-vascular aquatic plants do not exceed the LOC set by the Agency. The "No Effect" conclusion is based on no LOC exceedence.

Terrestrial Phase Exposure:

The risk conclusions for MITC exposure on elimination and/or disturbance of upland habitat for the terrestrial phase CRLF PCEs are shown in Table 1.2. The conclusion of "May affect, likely to adversely affect" for elimination and/or disturbance of upland habitat is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for crops were available for this assessment.

The risk conclusions for MITC exposure on elimination and/or disturbance of dispersal habitat for the terrestrial phase CRLF PCEs are shown in Table 1.2. The conclusion of "May affect, likely to adversely affect" is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted studies or accepted open literature studies for crops were available for this assessment.

The risk conclusions for MITC exposure on alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source for terrestrial phase CRLF PCEs are shown in Table 1.2. Effect determinations for aquatic vertebrates, aquatic invertebrates, aquatic plants, terrestrial vertebrates, terrestrial invertebrates and terrestrial plants are discussed.

The RQ for mammals does not exceed the LOC set by the Agency. The "No habitat modification" conclusion is based on no LOC exceedence.

The terrestrial invertebrate conclusion of "habitat modification" is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for terrestrial invertebrates were available for this assessment.

The conclusion of "habitat modification" is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted studies or accepted open literature studies for crops were available for this assessment.

The risk conclusions for MITC exposure for reduction and/or modification of food sources for terrestrial phase juveniles and adults are shown in Table 1.2. Effect determinations for terrestrial vertebrates, terrestrial invertebrates and terrestrial plants are discussed.

Terrestrial phase indirect prey reduction effect RQs for aquatic invertebrates exceed the listed species LOC for four modeled crops, strawberry, tomato, lettuce and turf.

The RQ for mammals does not exceed the LOC set by the Agency. The "No habitat modification" conclusion is based on the LOC.

The conclusion of "habitat modification" for prey reduction of terrestrial invertebrates is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for terrestrial invertebrates were available for this assessment.

The conclusion of "habitat modification" for modification of habitat is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for crops were available for this assessment.

5.4.2 Direct and Indirect Effects of Metam Sodium Shank Injection Application Method on Critical Habitat:

Aquatic Phase Exposure:

The risk conclusions for the shank injection application method for Critical Habitat Impact effects of MITC exposure for the aquatic and terrestrial phase CRLF are shown in Table 5.15. RQs are estimated from nine modeled crops, strawberry, tomato, lettuce, turf, nursery, onion, potato, row crops and melon. RQs for aquatic phase CRLF PCEs were based on aquatic breeding habitat and non-breeding habitat, including aquatic and riparian vegetation for alteration of channel morphology. The RQs for aquatic plants do not exceed the LOC set by the Agency for any of the nine modeled crops. The "No habitat modification" conclusion is based on no LOC exceedence.

The risk conclusions for MITC exposure on riparian vegetation for the aquatic phase CRLF PCEs are shown in Table 1.2. The conclusion of "habitat modification" for riparian vegetation in alterations of channel morphology is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for crops were available for this assessment.

RQs for aquatic phase CRLF PCEs are based on aquatic breeding habitat and non-breeding habitat, including aquatic and riparian vegetation for alteration in water chemistry. The RQs for aquatic plants do not exceed the LOC set by the Agency for any of the nine modeled crops. The "No habitat modification" conclusion is based on no LOC exceedence.

The conclusion of "habitat modification" for riparian vegetation for alteration in water chemistry is based on the uncertainty due to limited data as the most conservative determination. No guideline submitted studies or accepted open literature studies for crops were available for this assessment.

RQs for aquatic phase CRLF PCEs are based on aquatic breeding habitat and non-breeding habitat, including aquatic and riparian vegetation for alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and food sources. The RQs for aquatic invertebrates, aquatic vertebrates and aquatic plants do not exceed the LOC for any of the nine modeled crops. The "No habitat modification" conclusion is based on no LOC exceedence.

The conclusion of "habitat modification" for riparian vegetation for alteration other chemical characteristics is based on the uncertainty due to limited data as the most conservative determination. No guideline submitted studies or accepted open literature studies for crops were available for this assessment.

RQs for aquatic phase CRLF PCEs as aquatic breeding habitat and non-breeding habitat, including aquatic and riparian vegetation for reduction and/or modification of aquatic-based food sources (algae). The RQs for non-vascular aquatic plants do not exceed the LOC for any of the nine modeled crops. The "No habitat modification" conclusion is based on no LOC exceedence.

Terrestrial Phase Exposure:

The risk conclusions for MITC exposure on elimination and/or disturbance of upland habitat for the terrestrial phase CRLF PCEs are shown in Table 5.15. The conclusion of "habitat modification" for elimination and/or disturbance of upland habitat is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for crops were available for this assessment.

The risk conclusions for MITC exposure on elimination and/or disturbance of dispersal habitat for the terrestrial phase CRLF PCEs are shown in Table 5.15. The conclusion of "habitat modification" is based on the uncertainty due to limited data as the most conservative determination. No registrant guideline submitted studies or accepted open literature studies for crops were available for this assessment.

The risk conclusions for MITC exposure on alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source for terrestrial phase CRLF PCEs are shown in Table 5.15. Effect determinations for terrestrial vertebrates, terrestrial invertebrates and terrestrial plants are discussed.

The RQ for mammals does not exceed the LOC set by the Agency. The "No habitat modification" conclusion is based on no LOC exceednce.

The conclusion of "habitat modification" is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for terrestrial invertebrates were available for this assessment.

The conclusion of "habitat modification" is based on the uncertainty due to limited data as the most conservative determination. No registrant submitted guideline studies or accepted open literature studies for crops were available for this assessment.

The risk conclusions for MITC exposure for reduction and/or modification of food sources for terrestrial phase juveniles and adults are shown in Table 1.2. Effect determinations for terrestrial vertebrates, terrestrial invertebrates and terrestrial plants are discussed.

The RQ for mammals does not exceed the LOC set by the Agency. The "No habitat modification" conclusion is based on no LOC exceedence.

The conclusion of "habitat modification" for prey reduction of terrestrial invertebrates is based on the uncertainty due to limited data as the most conservative determination. No guideline submitted studies or accepted open literature studies for terrestrial invertebrates were available for this assessment.

The conclusion of habitat modification is based on the uncertainty due to limited data as the most conservative determination. No guideline submitted studies or accepted open literature studies for crops were available for this assessment.

When evaluating the significance of this risk assessment's direct/indirect and adverse habitat modification effects determinations, it is important to note that pesticide exposures and predicted risks to the species and its resources (i.e., food and habitat) are not expected to be uniform across the action area. In fact, given the assumptions of drift and downstream transport (i.e., attenuation with distance), pesticide exposure and associated risks to the species and its resources are expected to decrease with increasing distance away from the treated field or site of application. Evaluation of the implication of this non-uniform distribution of risk to the species would require information and assessment techniques that are not currently available. Examples of such information and methodology required for this type of analysis would include the following:

- Enhanced information on the density and distribution of CRLF life stages within specific recovery units and/or designated critical habitat within the action area. This information would allow for quantitative extrapolation of the present risk assessment's predictions of individual effects to the proportion of the population extant within geographical areas where those effects are predicted. Furthermore, such population information would allow for a more comprehensive evaluation of the significance of potential resource impairment to individuals of the species.
- Quantitative information on prey base requirements for individual aquatic- and terrestrial-phase frogs. While existing information provides a preliminary picture of the types of food sources utilized by the frog, it does not establish minimal requirements to sustain healthy individuals at varying life stages. Such information could be used to establish biologically relevant thresholds of effects on the prey base, and ultimately establish geographical limits to those effects. This information could be used together with the density data discussed above to characterize the likelihood of adverse effects to individuals.

- Information on population responses of prey base organisms to the pesticide. Currently, methodologies are limited to predicting exposures and likely levels of direct mortality, growth or reproductive impairment immediately following exposure to the pesticide. The degree to which repeated exposure events and the inherent demographic characteristics of the prey population play into the extent to which prey resources may recover is not predictable. An enhanced understanding of long-term prey responses to pesticide exposure would allow for a more refined determination of the magnitude and duration of resource impairment, and together with the information described above, a more complete prediction of effects to individual frogs and potential adverse modification to critical habitat.

6.0 Uncertainties

6.1 Exposure Assessment Uncertainties

The environmental fate data base for the parent compound provided mostly supplemental information. However, key environmental fate studies such as aerobic soil metabolism and photolysis in air have several deficiencies and problems. Therefore, data related to these key environmental fate processes were also obtained from open literature to complete the environmental fate and exposure assessment.

6.2 Maximum Use Scenario

The screening-level risk assessment focuses on characterizing potential ecological risks resulting from a maximum use scenario, which is determined from labeled statements of maximum application rate and number of applications with the shortest time interval between applications. The frequency at which actual uses approach this maximum use scenario may be dependant on insecticide resistance, timing of applications, cultural practices, and market forces.

6.3 Usage Uncertainties

County-level usage data were obtained from California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database. Four years of data (2002 – 2005) were included in this analysis because statistical methodology for identifying outliers, in terms of area treated and pounds applied, was provided by CDPR for these years only. No methodology for removing outliers was provided by CDPR for 2001 and earlier pesticide data; therefore, this information was not included in the analysis because it may misrepresent actual usage patterns. CDPR PUR documentation indicates that errors in the data may include the following: a misplaced decimal; incorrect measures, area treated, or units; and reports of diluted pesticide concentrations. In addition, it is possible that the data may contain reports for pesticide uses that have been cancelled. The CPDR PUR data does not include home owner applied pesticides; therefore, residential uses are not likely to be reported. As with all pesticide use data, there may be instances of misuse and misreporting. The Agency made use of the most current, verifiable information; in cases where there were discrepancies, the most conservative information was used.

6.4 Modeling Inputs

The standard ecological water body scenario (EXAMS pond) used to calculate potential aquatic exposure to pesticides is intended to represent conservative estimates, and to avoid underestimations of the actual exposure. The standard scenario consists of application to a 10-hectare field bordering a 1-hectare, 2-meter deep (20,000 m3) pond with no outlet. Exposure estimates generated using the EXAMS pond are intended to represent a wide variety of vulnerable water bodies that occur at the top of watersheds including prairie pot holes, playa lakes, wetlands, vernal pools, man-made and natural ponds, and intermittent and lower order streams. As a group, there are factors that make these water bodies more or less vulnerable than the EXAMS pond. Static water bodies that have larger ratios of pesticide-treated drainage area to water body volume would be expected to have higher peak EECs than the EXAMS pond. These water bodies will be either smaller in size or have larger drainage areas. Smaller water bodies have limited storage capacity and thus may overflow and carry pesticide in the discharge, whereas the EXAMS pond has no discharge. As watershed size increases beyond 10-hectares, it becomes increasingly unlikely that the entire watershed is planted with a single crop that is all treated simultaneously with the pesticide. Headwater streams can also have peak concentrations higher than the EXAMS pond, but they likely persist for only short periods of time and are then carried and dissipated downstream.

The Agency acknowledges that there are some unique aquatic habitats that are not accurately captured by this modeling scenario and modeling results may, therefore, under- or over-estimate exposure, depending on a number of variables. For example, aquatic-phase CRLFs may inhabit water bodies of different size and depth and/or are located adjacent to larger or smaller drainage areas than the EXAMS pond. The Agency does not currently have sufficient information regarding the hydrology of these aquatic habitats to develop a specific alternate scenario for the CRLF. CRLFs prefer habitat with perennial (present year-round) or near-perennial water and do not frequently inhabit vernal (temporary) pools because conditions in these habitats are generally not suitable (Hayes and Jennings 1988). Therefore, the EXAMS pond is assumed to be representative of exposure to aquatic-phase CRLFs. In addition, the Services agree that the existing EXAMS pond represents the best currently available approach for estimating aquatic exposure to pesticides (USFWS/NMFS 2004).

6.5 Aquatic Exposure Estimates

In general, the linked PRZM/EXAMS model produces estimated aquatic concentrations that are expected to be exceeded once within a ten-year period. The Pesticide Root Zone Model is a process or "simulation" model that calculates what happens to a pesticide in a farmer's field on a day-to-day basis. It considers factors such as rainfall and plant transpiration of water, as well as how and when the pesticide is applied. It has two major components: hydrology and chemical transport. Water movement is simulated by the use of generalized soil parameters, including field capacity, wilting point, and saturation water content. The chemical transport component can simulate pesticide application on the soil or on the plant foliage. Dissolved, adsorbed, and vapor-phase concentrations in the soil are estimated by simultaneously considering the processes of pesticide uptake by plants, surface runoff, erosion, decay, volatilization, foliar wash-off, advection, dispersion, and retardation.

Uncertainties associated with each of these individual components add to the overall uncertainty of the modeled concentrations. Additionally, model inputs from the environmental fate degradation studies are chosen to represent the upper confidence bound on the mean values that are not expected to be exceeded in the environment approximately 90 percent of the time. Mobility input values are chosen to be representative of conditions in the environment. The natural variation in soils adds to the uncertainty of modeled values. Factors such as application date, crop emergence date, and canopy cover can also affect estimated concentrations, adding to the uncertainty of modeled values. Factors within the ambient environment such as soil temperatures, sunlight intensity, antecedent soil moisture, and surface water temperatures can cause actual aquatic concentrations to differ for the modeled values.

Unlike spray drift, tools are currently not available to evaluate the effectiveness of a vegetative setback on runoff and loadings. The effectiveness of vegetative setbacks is highly dependent on the condition of the vegetative strip. For example, a well-established, healthy vegetative setback can be a very effective means of reducing runoff and erosion from agricultural fields. Alternatively, a setback of poor vegetative quality or a setback that is channelized can be ineffective at reducing loadings. Until such time as a quantitative method to estimate the effect of vegetative setbacks on various conditions on pesticide loadings becomes available, the aquatic exposure predictions are likely to overestimate exposure where healthy vegetative setbacks exist and underestimate exposure where poorly developed, channelized, or bare setbacks exist.

6.6 Action Area

An example of an important simplifying assumption that may require future refinement is the assumption of uniform runoff characteristics throughout a landscape. It is well documented that runoff characteristics are highly non-uniform and anisotropic, and become increasingly so as the area under consideration becomes larger. The assumption made for estimating the aquatic Action Area (based on predicted in-stream dilution) was that the entire landscape exhibited runoff properties identical to those commonly found in agricultural lands in this region. However, considering the vastly different runoff characteristics of: a) undeveloped (especially forested) areas, which exhibit the least amount of surface runoff but the greatest amount of groundwater recharge; b) suburban/residential areas, which are dominated by the relationship between impermeable surfaces (roads, lots) and grassed/other areas (lawns) plus local drainage management; c) urban areas, that are dominated by managed storm drainage and impermeable surfaces; and d) agricultural areas dominated by Hortonian and focused runoff (especially with row crops), a refined assessment should incorporate these differences for modeled stream flow generation. As the zone around the immediate (application) target area expands, there will be greater variability in the landscape; in the context of a risk assessment, the runoff potential that is assumed for the expanding area will be a crucial variable (since dilution at the outflow point is determined by the size of the expanding area). Thus, it important to know at least some approximate estimate of types of land use within that region. Runoff from forested areas ranges from 45 – 2,700% less than from agricultural areas; in most studies, runoff was 2.5 to 7 times higher in agricultural areas (e.g., Okisaka et al., 1997; Karvonen et al., 1999; McDonald et al., 2002; Phuong and van Dam 2002). Differences in runoff potential between urban/suburban areas and agricultural areas are generally less than between agricultural and forested areas. In terms of likely runoff potential (other variables – such as topography and rainfall – being equal), the relationship is generally as follows (going from lowest to highest runoff potential): Three-tiered forest < agroforestry < suburban < row-crop agriculture < urban.

There are, however, other uncertainties that should serve to counteract the effects of the aforementioned issue. For example, the dilution model considers that 100% of the agricultural area has the chemical applied, which is almost certainly a gross over-estimation. Thus, there will be assumed chemical contributions from agricultural areas that will actually be contributing only runoff water (dilutant); so some contributions to total contaminant load will really serve to lessen rather than increase aquatic concentrations. In light of these (and other) confounding factors, Agency believes that this model gives us the best available estimates under current circumstances.

6.7 Effects Assessment Uncertainties

Due to the physio-chemical properties of metam sodium, the degradate MITC was used to model ecological risk. Although there are substantial uncertainties concerning the ecological effects of MITC, in part due to the extremely limited data available for risk assessment, a risk conclusion is based on the best available information. Life stage fish data is not available to assess reproduction or growth direct effects. No data is available to assess the direct effect of MITC on birds. .No data is available to assess the indirect effects of prey reduction for terrestrial invertebrates. No data is available for terrestrial plants to assess modification of habitat.

6.7.1 Use of Surrogate Species Data

Currently, there are no FIFRA guideline toxicity tests for amphibians. Therefore, in accordance with Agency policy, data for the most sensitive freshwater fish are used as a surrogate for aquatic-phase amphibians such as the California red-legged frog. The study available from the open literature information on MITC toxicity to aquatic-phase amphibians (*Xenopus laevis,* African clawed frog) was not used due to limitations based on good laboratory practices of the study for information not reported. The African clawed frog appears to be less sensitive than some of the native species. Therefore, the endpoint based on freshwater fish ecotoxicity data is assumed to be protective and extrapolation of the risk conclusions from the most sensitive tested species to the California red-legged frog is more likely to overestimate the potential risks than to underestimate the potential risk. At the time of the assessment, it was not known where California red-legged frog may fall in a species sensitivity distribution.

The uncertainties associated with the risk to terrestrial organisms from MITC use are mainly focused on the extent and effect of terrestrial animal exposure via inhalation. There is uncertainty with the mammal acute inhalation toxicity, as indicated above. Avian inhalation toxicity data are not available at all, as also noted. In addition, the lack of avian acute oral data prevents an extrapolated estimation of inhalation toxicity based on mammal data.

6.7.2 Location of Wildlife Species

For this baseline terrestrial risk assessment, a generic bird or mammal was assumed to occupy either the treated field or adjacent areas receiving a treatment rate on the field. Actual habitat requirements of any particular terrestrial species were not considered, and it was assumed that species occupy, exclusively and permanently, the modeled treatment area. Spray drift model predictions suggest that this assumption leads to an overestimation of exposure to species that do not occupy the treated field exclusively and permanently.

6.7.3 Sublethal Effects

For an acute risk assessment, the screening risk assessment relies on the acute mortality endpoint as well as a suite of sublethal responses to the pesticide, as determined by the testing of species response to chronic exposure conditions and subsequent chronic risk assessment. Consideration of additional sublethal data in the assessment is exercised on a case-by-case basis and only after careful consideration of the nature of the sublethal effect measured and the extent and quality of available data to support establishing a plausible relationship between the measure of effect (sublethal endpoint) and the assessment endpoints.

No guideline growth or reproductive studies were submitted for the surrogate fish for the aquatic phase of the CRLF. A developmental study from ECOTOX on the South African Clawed Frog (Birch and Prahlad, 1986 ECOTX Ref #12119) was not used in this assessment due to the limitations of the study.

For the terrestrial phase of the CRLF, there was no LOC exceedence for the guideline acute mammal inhalation as a surrogate for the terrestrial phase CRLF. No guideline mammal inhalation studies and no bird inhalation studies were submitted. The surrogate mammal sublethal dermal and eye irritation studies submitted showed no effect. No sublethal effects from ECOTOX literature or adverse incidents were reported for the terrestrial phase CRLF.

6.7.4 Age Class and Sensitivity of Effects Thresholds

It is generally recognized that test organism age may have a significant impact on the observed sensitivity to a toxicant. The acute toxicity data for fish are collected on juvenile fish between 0.1 and 5 grams. Aquatic invertebrate acute testing is performed on recommended immature age classes (e.g., first instar for daphnids, second instar for amphipods, stoneflies, mayflies, and third instar for midges).

Testing of juveniles may overestimate toxicity at older age classes for pesticide active ingredients that act directly without metabolic transformation because younger age classes may not have the enzymatic systems associated with detoxifying xenobiotics. In so far as the available toxicity data may provide ranges of sensitivity information with respect to age class, this assessment uses the most sensitive life-stage information as measures of effect for surrogate aquatic animals, and is therefore, considered as protective of the California Red Legged Frog.

6.8 Acute LOC Assumptions

The risk characterization section of this assessment includes an evaluation of the potential for individual effects. The individual effects probability associated with the acute RQ is based on the assumption that the dose-response curve fits a probit model. It uses the mean estimate of the slope and the LC_{50} to estimate the probability of individual effects.

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DataBases and Models

The California Department of Pesticide Regulation's Pesticide Use Reporting database provides a census of pesticide applications in the state. See http://www.cdpr.ca.gov/docs/pur/purmain.htm.

Pesticides in Groundwater DataBase (PGWDB)

http://www.epa.gov/oppefed1/models/water

http://www.epa.gov/scram001/tt22htm#isc

Doane (www.doane.com; the full dataset is not provided due to its proprietary nature)

United States Depart of Agriculture (USDA), National Agricultural Statistics Service (NASS) Chemical Use Reports provide summary pesticide usage statistics for select agricultural use sites by chemical, crop and state. See http://www.usda.gov/nass/pubs/estindx1.htm#agchem.

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Appendices

Appendix A: Pesticide Products Formulated with Metam Sodium and Other Pesticide Active Ingredients

PRODUCT FORMULATIONS CONTAINING MULTIPLE ACTIVE INGREDIENTS

The Agency does not routinely include, in its risk assessments, an evaluation of mixtures of active ingredients, either those mixtures of multiple active ingredients in product formulations or those in the applicator's tank. In the case of the product formulations of active ingredients (that is, a registered product containing more than one active ingredient), each active ingredient is subject to an individual risk assessment for regulatory decision regarding the active ingredient on a particular use site. If effects data are available for a formulated product containing more than one active ingredient, they may be used qualitatively or quantitatively[1] [2].

There are no product LD50 values, with associated 95% Confidence Intervals (CIs) available for metam sodium.

As discussed in USEPA (2000) a quantitative component-based evaluation of mixture toxicity requires data of appropriate quality for each component of a mixture. In this mixture evaluation an LD50 with associated 95% CI is needed for the formulated product. The same quality of data is also required for each component of the mixture. Given that the formulated products for metam sodium do not have LD50 data available it is not possible to undertake a quantitative or qualitative analysis for potential interactive effects. However, because the active ingredients are not expected to have similar mechanisms of action, metabolites, or toxicokinetic behavior, it is reasonable to conclude that an assumption of dose-addition would be inappropriate. Consequently, an assessment based on the toxicity of metam sodium is the only reasonable approach that employs the available data to address the potential acute risks of the formulated products.

			PRODUCT		**ADJUSTED FOR ACTIVE INGREDIENT**	
PRODUCT/TRADE NAME	**EPA Reg.No.**	**% Metam Sodium**	**LC_{50} (mg/kg)**	**CI (mg/kg)**	**LC_{50} (mg/kg)**	**CI (mg/kg)**
Busan 1016	1448-93	18				
Roo-pru super tri pak	1015-72	32.7	No Data	No Data	No Data	No Data
Rout	64898-4	32.7	No Data	No Data	No Data	No Data

[1] From registrant submitted data to support registration. Compiled by Office of Pesticide Programs Health Effects Division.

[1] Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs, Environmental Protection Agency (January 2004) (Overview Document).

[2] Memorandum to Office of Prevention, Pesticides and Toxic Substance, US EPA conveying an evaluation by the U.S. Fish and Wildlife Service and National Marine Fisheries Service of an approach to assessing the ecological risks of pesticide products (January 2004).

Appendix B: ECOTOX Open Literature

A study (Birch and Prahlad, 1986, ECOTOX Ref. #12119) examines the developmental toxicity of MITC in the South African clawed frog (*Xenopus laevis*). Data from this study was not used due to the limitations of the study. No control versus solvent control mortality was reported for the tadpole study. No control mortality was reported. The loading (number of tadpoles per chamber) would impact water quality . There was no report of tadpoles being fed. No results for the mortality were provided in data for the tadpole study, therefore no dose-response effect was verified.. No measured concentrations were reported either initial or termination concentrations for the volatile pesticide MITC. No data was available for statistical review. Embryos were less sensitive to MITC than tadpoles for mortality. The LOAEL for embryo mortality is reported to be 0.01 µg/L at 10 days for MITC. Embryos demonstrated a 50% mortality effect at 0.05 µg/L at 10 days for MITC. The study reports "severely twisted" notochords in the developing embryos in concentrations above 50.0 µg/L. The MITC concentration at which malformations are reported is above the EFED peak aquatic EEC of 0.6 µg/L for strawberries. Only embryo data for survival and damage were reported for the control and for concentrations below 1 µg/L. No data was available for statistical review. No measured concentrations were reported for this volatile chemical. Based on no report of measured concentrations,no control mortality data, no report of feeding tadpoles, and loading issues impacting water quality this study is classified as invalid.

A study (Haendel, M, et. al. 2004; ECOTOX Ref. #80675) examines the developmental toxicity of both metam sodium and MITC in the zebrafish (*Danio rerio*). The data from this study was not used in this assessment. This study is classified as invalid based on no reported measured concentrations for initial or termination concentrations for a static toxicity test on a vaolatile chemical . It reports "severely twisted" notochords in the developing fish. The LOAEL for both notochord defects and decreased hatching rate is reported to be 26 µg/L for metam sodium (where 25% of the fish had malformations) and 29 µg/L for MITC. A 48 hour post fertilization (hpf) LC50 is reported to be 248 µg/L and 137 µg/L for MITC. The LOEL for notochord defects and hatching effects reported for MITC is lower the EFED peak aquatic EEC of 59.4 µg/L for strawberries using the irrogation application method. The LC50, 137 µg/L, effects reported for MITC is higher the EFED peak aquatic EEC of 59.4 µg/L for strawberries using the sprinkler irrigation application method

Appendix C: Assumptions Associated with RQ Caclulations

A deterministic approach is used to evaluate the likelihood of adverse ecological effects to non-target species. In this approach, risk quotients (RQs) are calculated by dividing exposure estimates (EECs) by ecotoxicity values for non-target species, both acute and chronic.

RQ = EXPOSURE/TOXICITY

RQs are then compared to OPP's levels of concern (LOCs). These LOCs are criteria used by OPP to indicate potential risk to non-target organisms and the need to consider regulatory action. The criteria indicate that a pesticide used as directed has the potential to cause adverse effects on non-target organisms. LOCs currently address the following risk presumption categories: (1) acute endangered species - the potential for acute risk to endangered species is high, regulatory action may be warranted, and (4) chronic risk - the potential for chronic risk is high, regulatory action may be warranted. Currently, EFED does not perform assessments for chronic risk to plants, acute or chronic risks to non-target insects, or chronic risk from granular/bait formulations to mammalian or avian species.

The ecotoxicity test values (i.e., measurement endpoints) used in the acute and chronic risk quotients are derived from the results of required studies. Examples of ecotoxicity values derived from the results of short-term laboratory studies that assess Direct acute effects are: (1) LC_{50} (fish) representing the aquatic phase for the CRLF and (2) LD_{50} (birds and mammals) representing the terrestrial phase for the CRLF and indirect effects (3) EC_{50} (aquatic plants and aquatic invertebrates) and (4) EC_{25} (terrestrial plants). An example of a toxicity test effect level derived from the results of long-term laboratory study that assesses chronic effects is: NOAEC (birds, fish and aquatic invertebrates). Risk presumptions, along with the corresponding RQs and LOCs are tabulated below: All LOCs for this risk assessment are calculated using the endangered species LOC.

Table 6.1 Risk presumptions for terrestrial animals based on risk quotients (RQ) and levels of concern (LOC).

Risk Presumption	RQ	LOC
	Birds	
Acute Endangered Species	**EEC/LC_{50} or LD_{50}/ft^2 or LD_{50}/day**	**0.1**
Chronic Risk	**EEC/NOAEC**	**1**
	Wild Mammals	
Acute Endangered Species	**EEC/LC_{50} or LD_{50}/ft^2 or LD_{50}/day**	**0.1**
Chronic Risk	**EEC/NOAEC**	**1**

[1] abbreviation for Estimated Environmental Concentration (ppm) on avian/mammalian food items
[2] mg/ft^2
[3] mg of toxicant consumed/day
LD_{50} * wt. of bird

LD_{50} * wt. of bird

Table 6.2. Risk presumptions for aquatic animals based on risk quotients (RQ) and levels of concern (LOC).

Risk Presumption	RQ	LOC
Acute Endangered Species	**EEC/LC_{50} or EC_{50}**	**0.05**
Chronic Risk	**EEC/NOAEC**	**1**

[1] **EEC = (mg/L or µg/L) in water**

Table 6.3. Risk presumptions for plants based on risk quotients (RQ) and levels of concern (LOC).

Risk Presumption	RQ	LOC
	Terrestrial and Semi-Aquatic Plants	
Acute Endangered Species	EEC/EC_{05} or NOAEC	1
	Aquatic Plants	
Acute Endangered Species	EEC/EC_{05} or NOAEC	1

[1] EEC = lbs ai/A
[2] EEC = (µg/L /mg/L) in water

Appendix D: Spatial Summary for Terrestrial and Aquatic Uses
Metam-sodium

Table 1 Use list from labels

Use List
The following use list is derived from label use information. It is used as a basis for terrestrial and aquatic pesticide use area determination.

Table 1 Use list from labels

Category	**Use**
Agriculture & Greenhouse/Nursery *(includes agriculture, pasture and orchard/ vineyard landcover classes in maps and tables)*	alfalfa, almonds, apples, apricots, asparagus, avocados, bahiagrass, bare ground, barley, beans, beans-dry, beans (succulent), beets, blackberries, blueberries (ground only), bok choy, boysenberries, broccoli, brussels sprouts, cabbage, caneberries, cantaloupes, carrots, cauliflower, celery, cherries, cherry, chicory, chinese cabbage, chinese okra (hechima), chinese radish/daikon, christmas tree plantings, citrus, collards, corn, corn (field) (grain) (pop) (silage) (stubble) (sweet) cotton, cucumbers, dates, eggplant, endive (escarole), figs, forage crops, garlic, ginseng, grapefruit, grapes, hops, kale, kentucky bluegrass, kumquat, lemons, lettuce, lettuce-head, lettuce-leaf, mint (spearmint, peppermint), mushrooms, mustard, mustard greens, nectarine, N-greenhouse flower, N-greenhouse plants in containers, nursery stock, oats, onions (bulb), onions (shallots), oranges, orchards, parsley, pastureland, peaches, peanuts, pears, peas (english) (garden) (southern) (succulent) (pigeon) (chick) (garbanzo) (dwarf) (green) (field) (edible pod), pecans, peppers (chili) (sweet), pistachio, plums, pomegranates, potatoes, potting soil/topsoil, prunes, pumpkin, radishes, rangeland, raspberries, rice, rutabagas, rye, safflower, sorghum (forage) (grain), spinach, squash, stone fruits, strawberries, sugar beets, sweet potatoes, tangelo, tangerines, tomatoes, turf (sod farms only), turnips, vegetable crops, vegetables, walnuts, watermelon, wheat, ornamental and/or shade trees, ornamental herbaceous plants, ornamental non-flowering plants, ornamental woody shrubs and vines
Forestry**	wood protection treatment to forest products, forest plantings (reforestation programs) (trees farms--tree plantations), forest trees
Non-agriculture *(not mapped)*	food processing water systems, sewage systems, non-ag rights of way, fencerows, hedgerows, manure, ornamental lawns and turf, golf course turf

*****Forestry use is not included in the initial area of concern nor the action area in the following maps and calculations, as this use could not be assessed quantitatively. Further discussion on forestry use is included in the main document.***

Terrestrial Use Determination

Sources and Methods

Base mapping layers for the terrestrial analysis component were obtained from the National Land-cover Dataset (NLCD 2001) for the majority of land use types and the California GAP data (6/98) for the orchards and vineyard uses. The NLCD is a recently released national land use dataset and the GAP is from the Biogeography Lab from UCLA-Santa Barbara. These raster files were converted to vector and used in the analysis. Table 2 shows the land-cover sources used.

Table 2 Land cover data sources.

Land Cover Data Sources			
Layer name	**Base source**	**Description**	**non-NASS**
Cultivated Crops	NLCD	Grid code 82: Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.	No
Developed, High Intensity	NLCD	Grid code 24: Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 to100 percent of the total cover.	Yes
Developed, Low Intensity	NLCD	Grid code 22: Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49 percent of total cover. These areas most commonly include single-family housing units.	Yes
Developed, Medium Intensity	NLCD	Grid code 23: Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79 percent of the total cover. These areas most commonly include single-family housing units.	Yes
Developed, Open Space	NLCD	Grid code 21: Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.	Yes
Forest	NLCD	Grid codes 41,42,43: Deciduous, evergreen and mixed. Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover.	Yes
Open Water	NLCD	Grid code 11: All areas of open water, generally with less than 25% cover of vegetation or soil.	Yes
Orchards and vineyards	CA GAP	Grid codes 11210, 11211 and 11212. This is the only CA GAP reference.	No
Pasture/Hay	NLCD	Grid codes 81: Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation	No

Land Cover Data Sources			
Layer name	**Base source**	**Description**	**non-NASS**
		accounts for greater than 20 percent of total vegetation.	
Wetlands	NLCD	Grid codes 90, 95: Woody wetlands and emergent herbaceous.	Yes

U.S. Department of Agriculture's National Agriculture Statistics Service (NASS) census dataset, 2002 was used to determine whether a crop was grown in a particular county. This census dataset provides survey information over five years on agricultural practices and is used mainly for cultivated or agriculture crops. Chemical labeled uses were matched to NASS uses; an agriculture use match would result in a mapped area for one or more counties. For uses that are not agricultural, the use is assumed to occur in every county where that particular land-cover occurs within California (*i.e.* a 'forestry' labeled use is assumed to potentially occur in all California counties where NLCD indicates there is forest land-cover).

The 'Initial Area of Concern' represents the use type and its occurrence in the NASS or NLCD datasets. These are the areas where the pesticide has potential to be applied. The 'Action Area' represents the 'Initial Area of Concern' plus a buffer distance. There may not always be a buffer distance in which case the 'Action Area' is the same as the 'Initial Area of Concern'. The overlap of the 'Action Area' with CRLF habitat areas is named 'Overlapping Area' and is the target of spatial analysis. The ratio of Overlapping Area to CRLF habitat area is reported for each of eight Recovery Units (RU1 to RU8).

There are three types of CRLF habitat areas considered in this assessment: Critical Habitat (CH); Core Areas; and California Natural Diversity Database (CNDDB) occurrence sections (EPA Region 9). Critical habitat areas were obtained from the U.S. Fish and Wildlife Service's (USFWS) final designation of critical habitat for the CRLF (USFWS 2006). Core areas were obtained from USFWS's Recovery Plan for the CRLF (USFWS 2002). The occurrence sections represent an EPA-derived subset of occurrences noted in the CNDDB. They are generalized by the Meridian Range and Township Section (MTRS) one square mile units so that individual habitat areas are obfuscated. As such, only occurrence section counts are provided and not the area potentially affected.

Table 3 Terrestrial spatial summary results for agriculture uses. No buffer applied.

Measure	RU1	RU2	RU3	RU4	RU5	RU6	RU7	RU8	Total
Initial Area of Concern (no buffer)									43,378 sq km
Action Area – Initial area of concern + buffer									43,378 sq km
Established species range area (sq km)	3654	3654	3654	3654	3654	3654	3654	3654	3654

Overlapping area (sq km)	8	8	8	8	8	8	8	8	8
Percent area affected	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*
# CNDDB Occurrence Sections (959 total)	2	2	2	2	2	2	2	2	2

Aquatic Action Area Delineation

The aquatic analysis uses a downstream dilution model to determine the downstream extent of exposure in streams and rivers. The downstream component, combined with the initial area of concern, define the aquatic action area. The downstream extent includes the area where the EEC could potentially be above levels that would exceed the most sensitive LOC. The model calculates two values, the dilution factor (DF) and the threshold Percent Cropped Area (PCA). The dilution factor (DF) is the maximum RQ/LOC, and the threshold PCA is the inverse value represented as a percent.

The dilution model uses the NHDPlus data set (http://www.horizon-systems.com/nhdplus/) as the framework for the downstream analysis. The NHDPlus includes several pieces of information that can be used to analyze downstream effects. For each stream reach in the hydrography network, the data provide a tally of the total area in each NLCD land cover class for the upstream cumulative area contributing to the given stream reach. Using the cumulative land cover data provided by the NHDPlus, an aggregated use class is created based on the classes listed in Table 2. A cumulative PCA is calculated for each stream reach based on the aggregate use class (divided by the total upstream contribution area).

The dilution model traverses downstream from each stream segment within the initial area of concern. At each downstream node, the threshold PCA is compared to the aggregate cumulative PCA. If the cumulative PCA exceeds the threshold then the stream segment is included in the downstream extent. The model continues traversing downstream until the cumulative PCA no longer exceeds the threshold. The additional stream length by the downstream analysis is presented in Table 4.

Table 4 Aquatic spatial quantitative results for metam-sodium.

Measure	**Total**
Total California stream kilometers	332,962
Total stream kilometers in initial area of concern	65,444
Total stream kilometers added downstream	4,785
Total stream kilometers in final action area	70,229

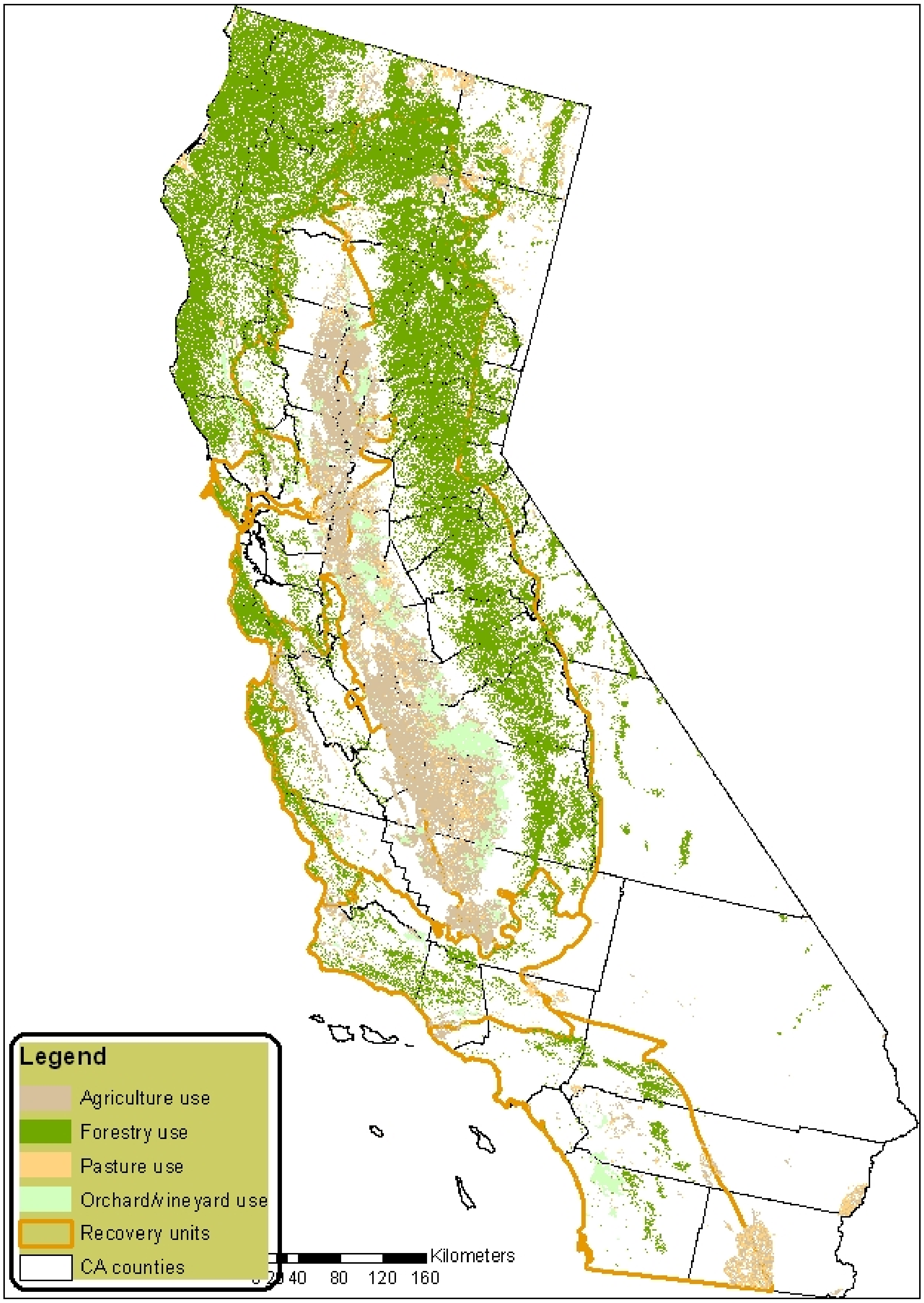
A Note on Limitations and Constraints of Tabular and Geospatial Sources

The geographic data sets used in this analysis are limited with respect to their accuracy and timeliness. The NASS Census of Agriculture (NASS 2002) contains adjusted survey data collected prior to 2002. Small use sites, and minor uses (e.g., specialty crops) tend to be underrepresented in this dataset. The National Land Cover Dataset (NLCD 2001) represents the best comprehensive collection of national land use and land cover information for the United States representing a range of years from 1994 – 1998. Because the NLCD does not explicitly include a class to represent orchard and vineyard landcover, California Gap Analysis Project data (CaGAP 1998) were overlaid with the NCLD and used to identify these areas.

Hydrographic data are from the NHDPlus dataset (http://www.horizon-systems.com/nhdplus/). NHDPlus contains the most current and accurate nationwide representation of hydrologic data. In some isolated instances, there are, however, errors in the data including missing or disconnected stream segments and incorrect assignment of flow direction. Spatial data describing the recovery zones and core areas are from the US Fish and Wildlife Service. The data depicting survey sections in which the species has been found in past surveys is from the California Natural Diversity Database (http://www.dfg.ca.gov/bdb/html/cnddb.html).

The relatively coarse spatial scale of these datasets precludes use of the data for highly localized studies, therefore, tabular information presented here is limited to the scale of individual Recovery Units. Additionally, some labeled uses are not possible to map precisely due to the lack of appropriate spatial data in NLCD on the location of these areas. To account for these uncertainties, the spatial analysis presented here is conservative, and may overestimate the areal extent of actual pesticide use in California.

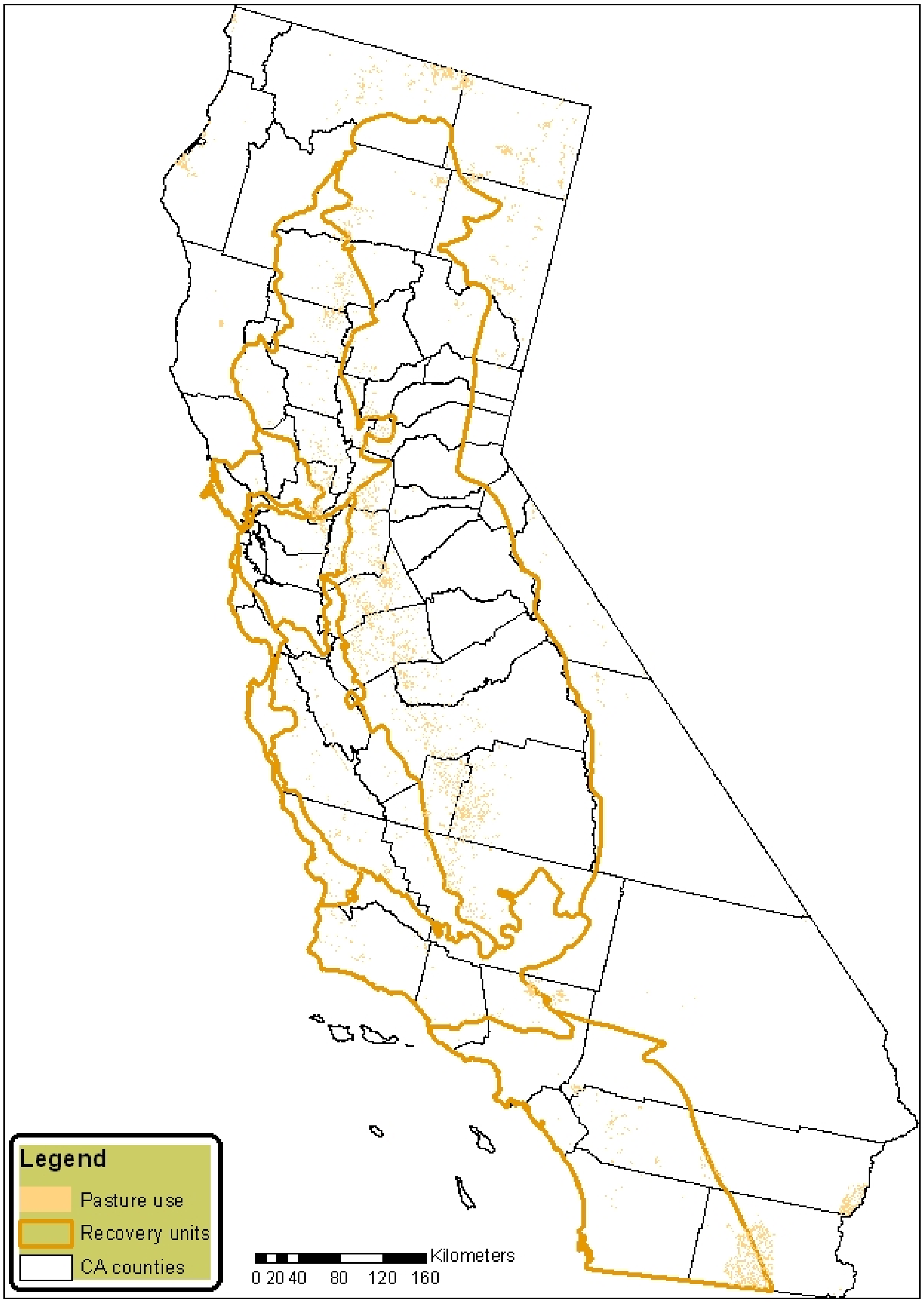
Metam-sodium Use



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. July 12, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

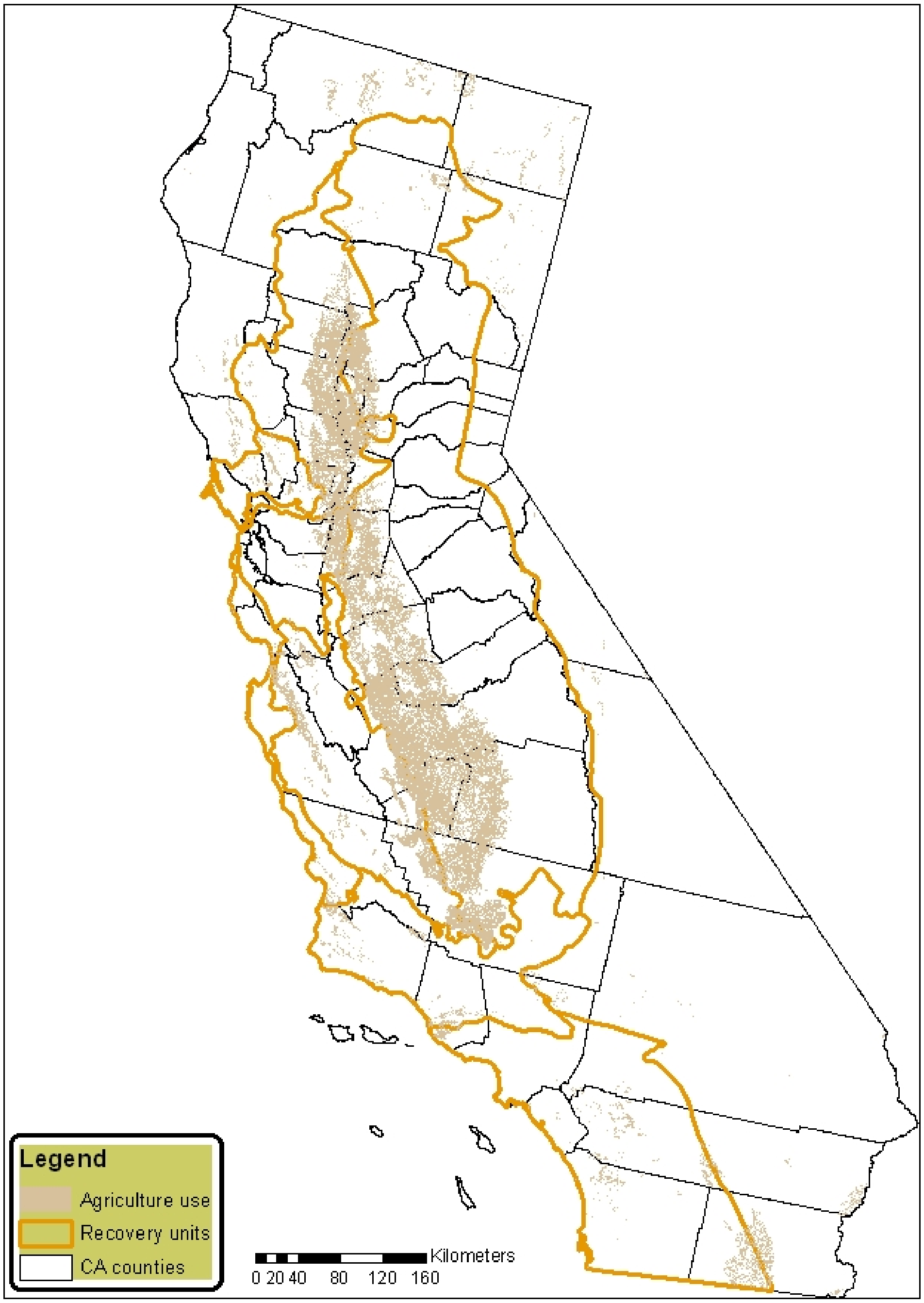
Metam-sodium - Pasture Use



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. July 12, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

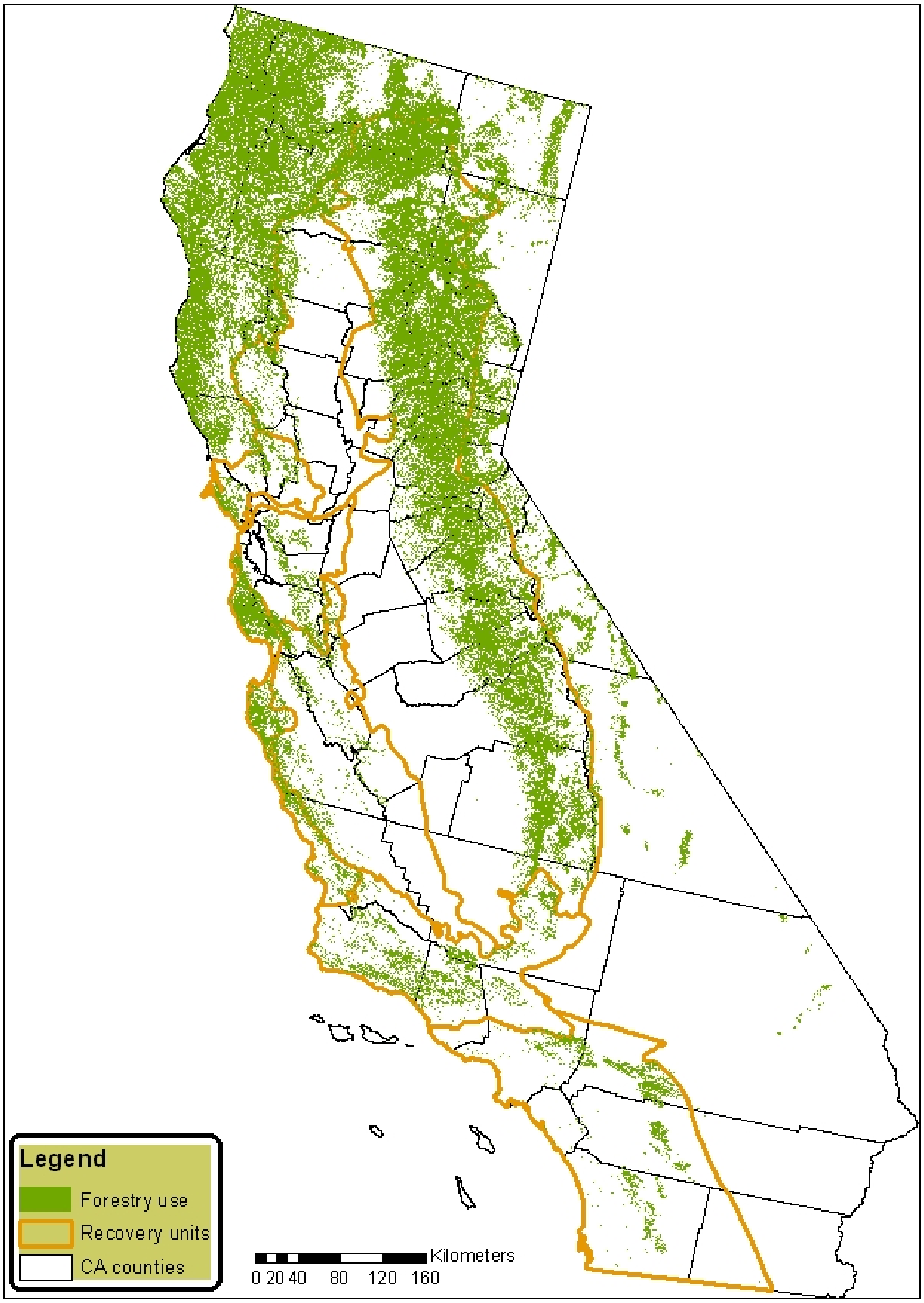
Metam-sodium - Agriculture Use



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. July 12, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

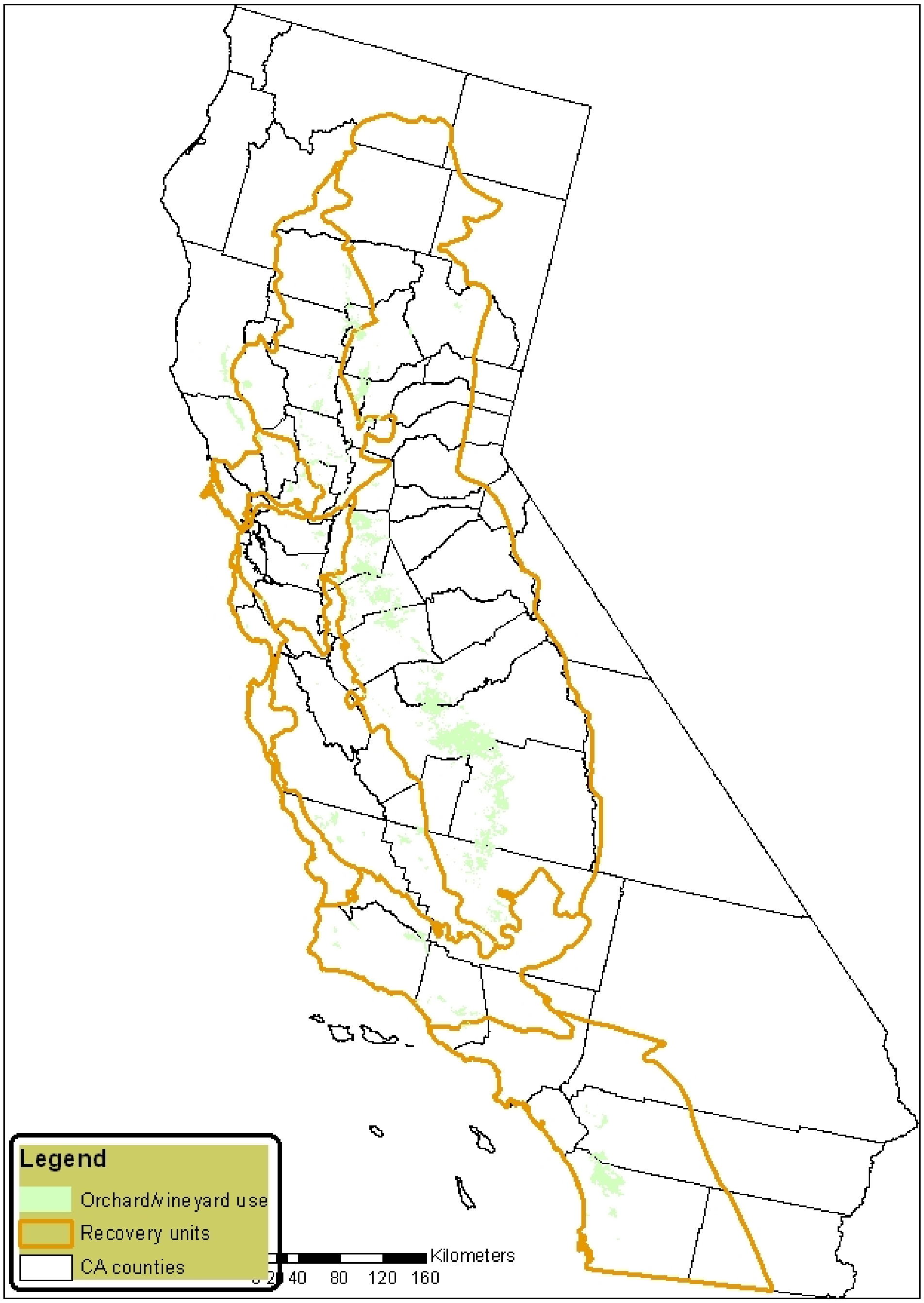
Metam-sodium - Forestry Use



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. July 12, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

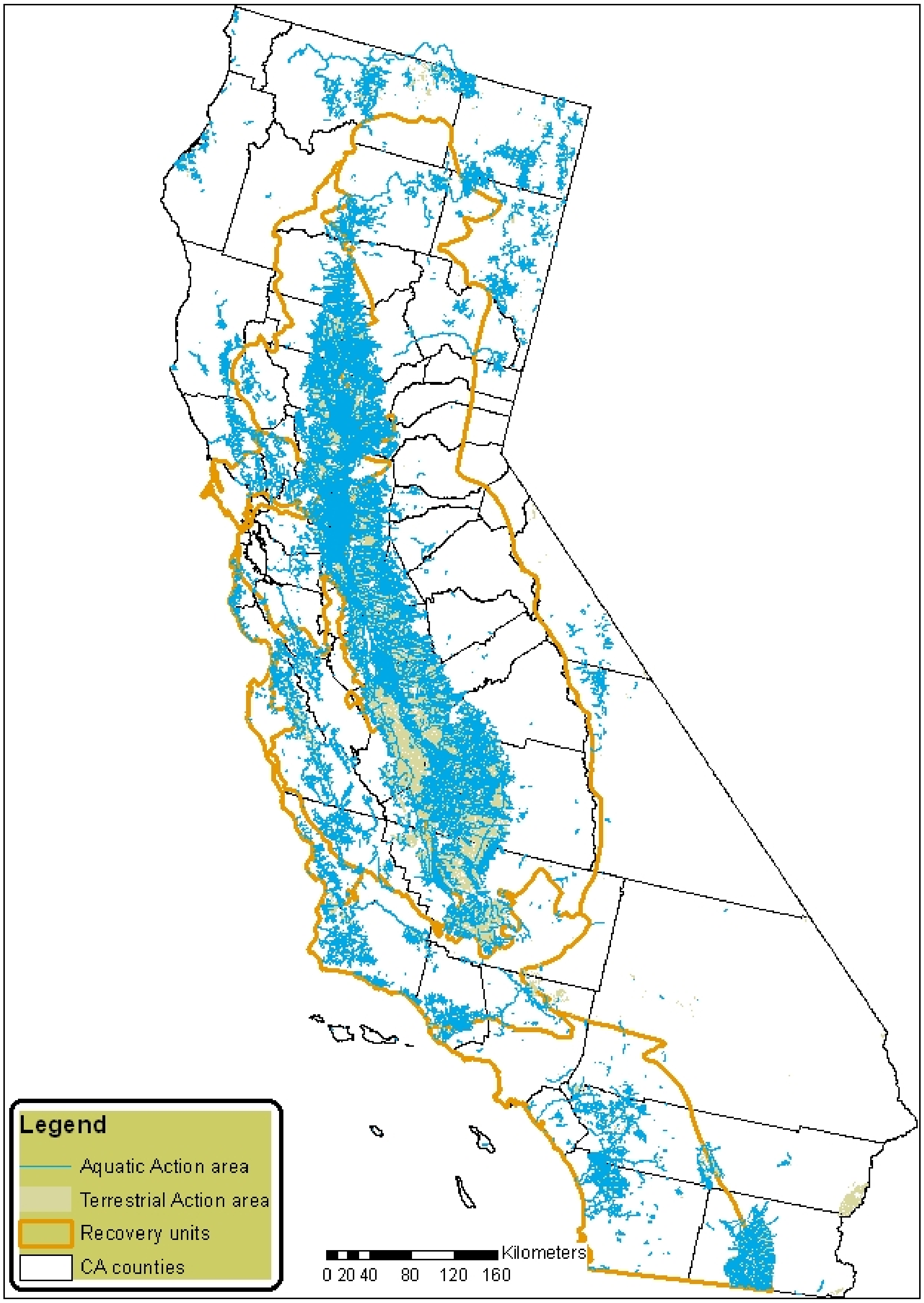
Metam-sodium - Orchard/vineyard Use



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. July 12, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

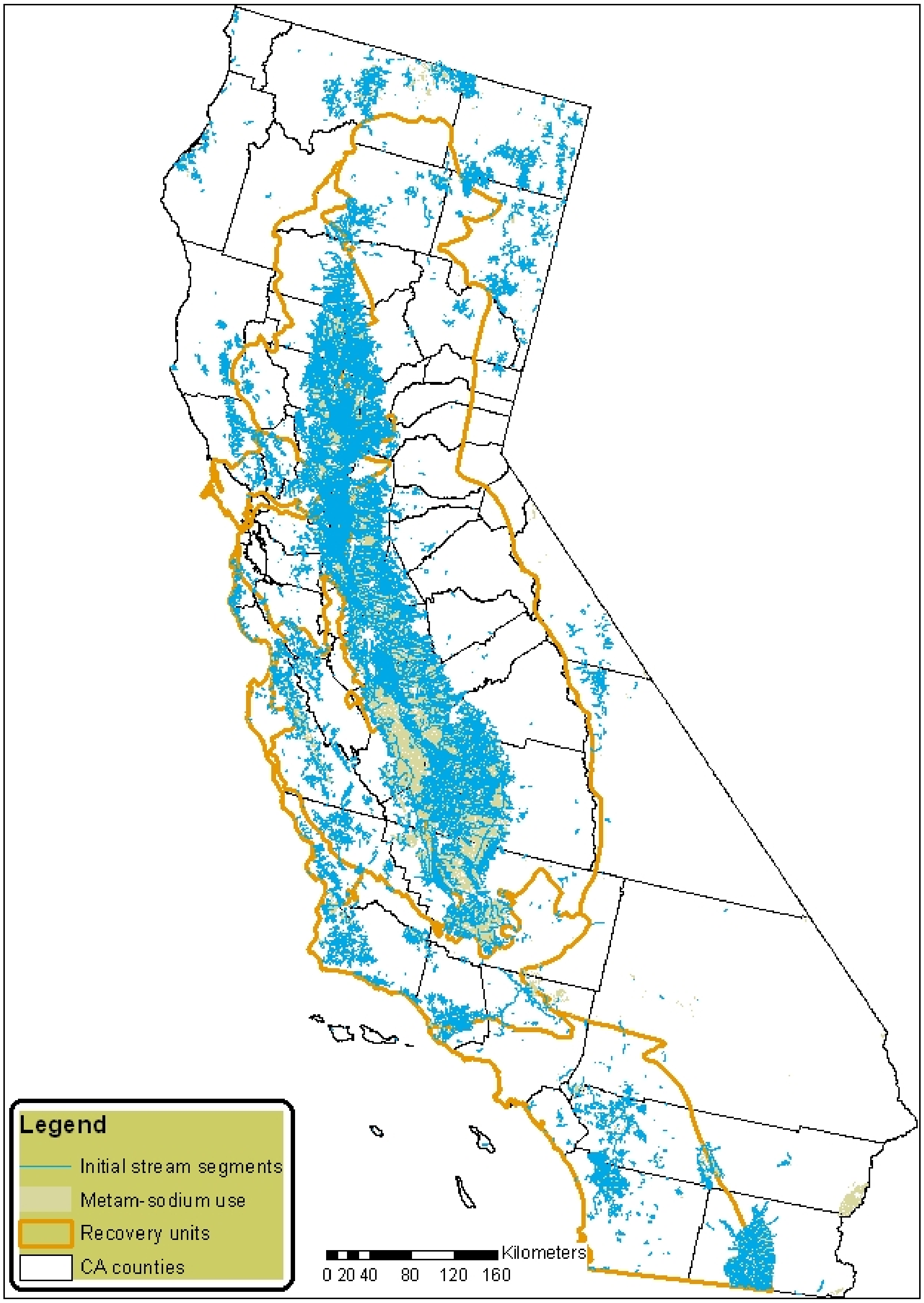
Metam-sodium - Action Area



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. July 12, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

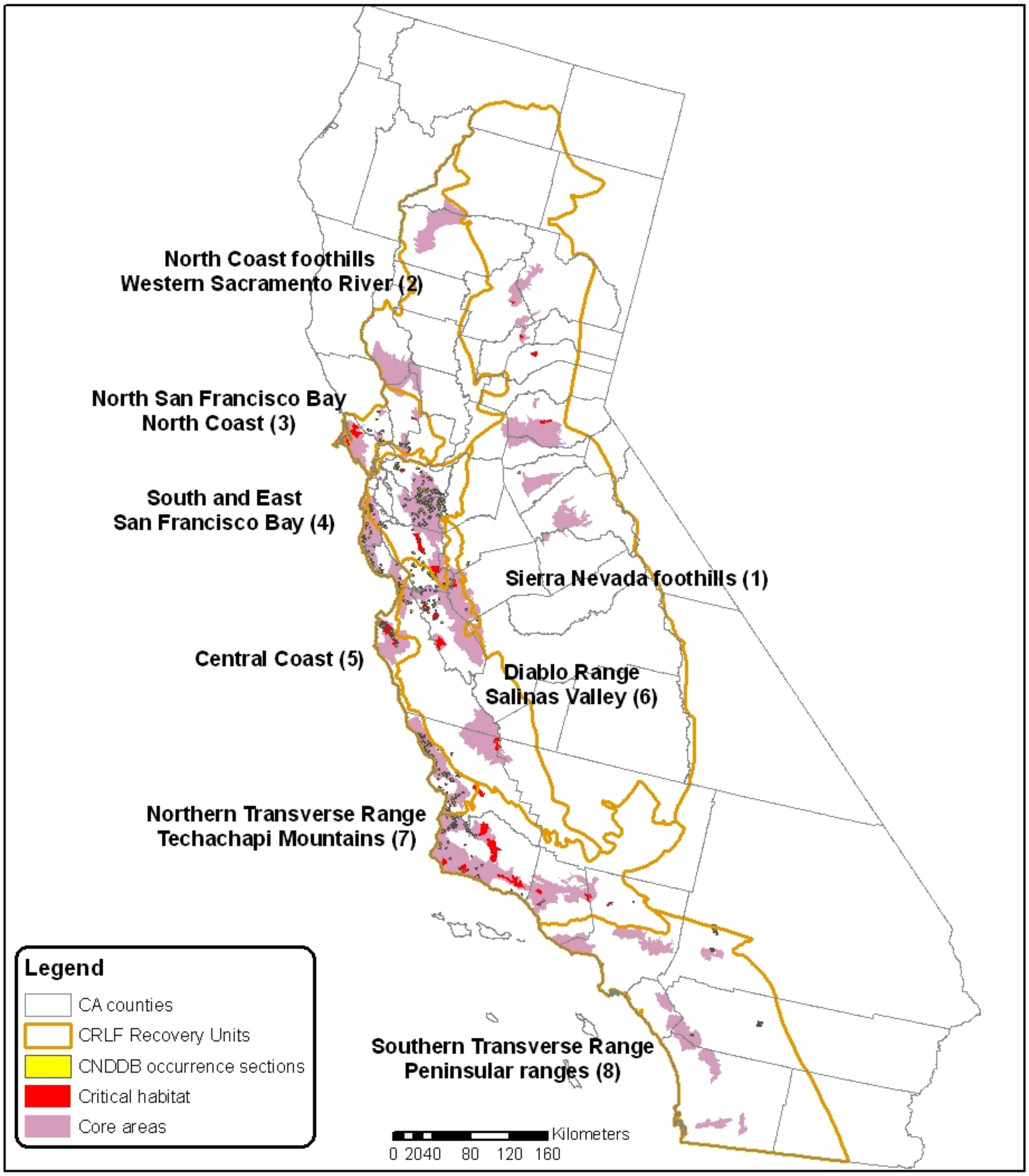
Metam-sodium - Initial Area of Concern



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. July 12, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

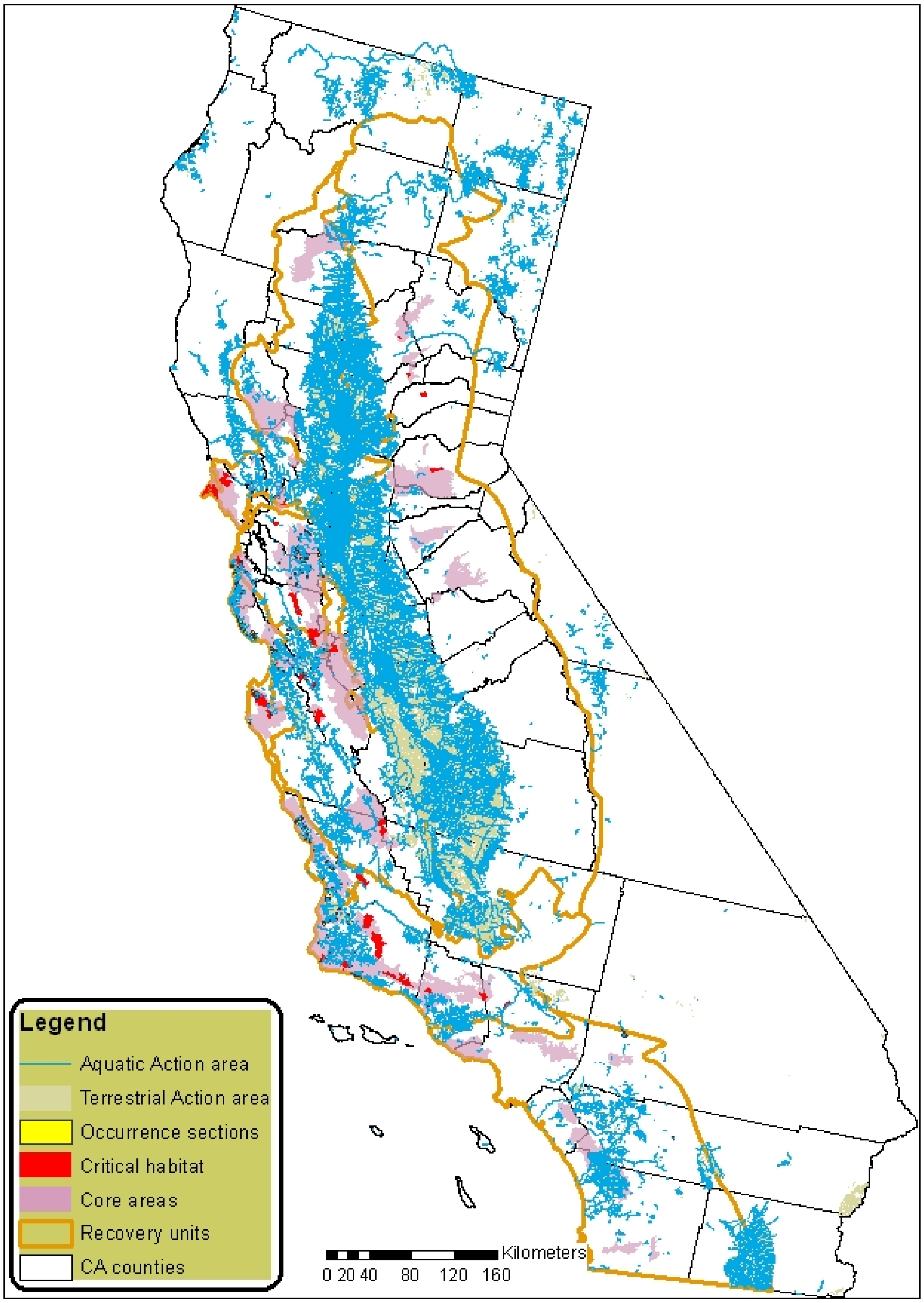
CRLF Recovery Units and Habitat Areas



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. June, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

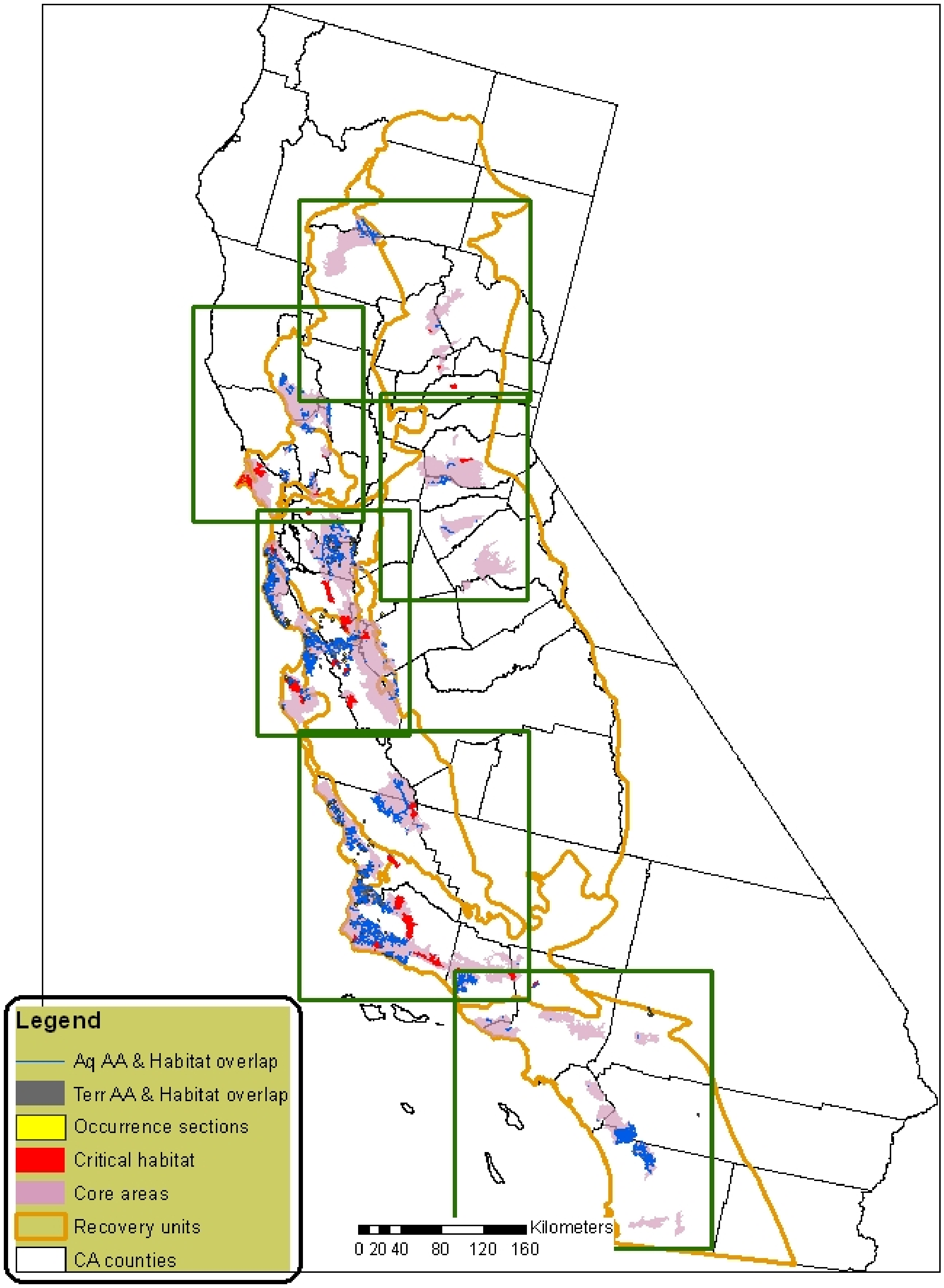
Metam-sodium - Action Area & CRLF Habitat



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. July 12, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

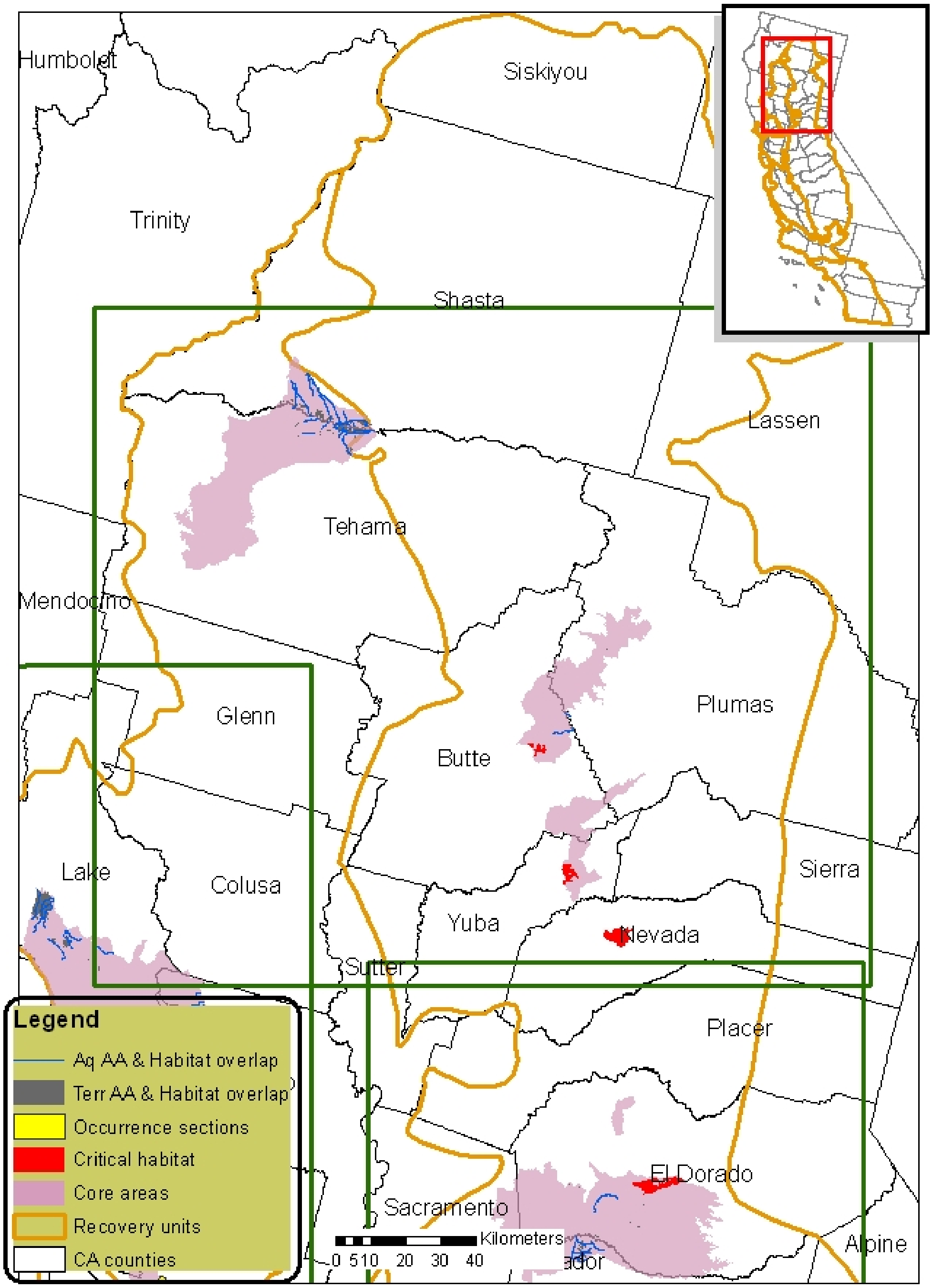
Metam-sodium - Action Area & Habitat Overlap (statewide)



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. July 12, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

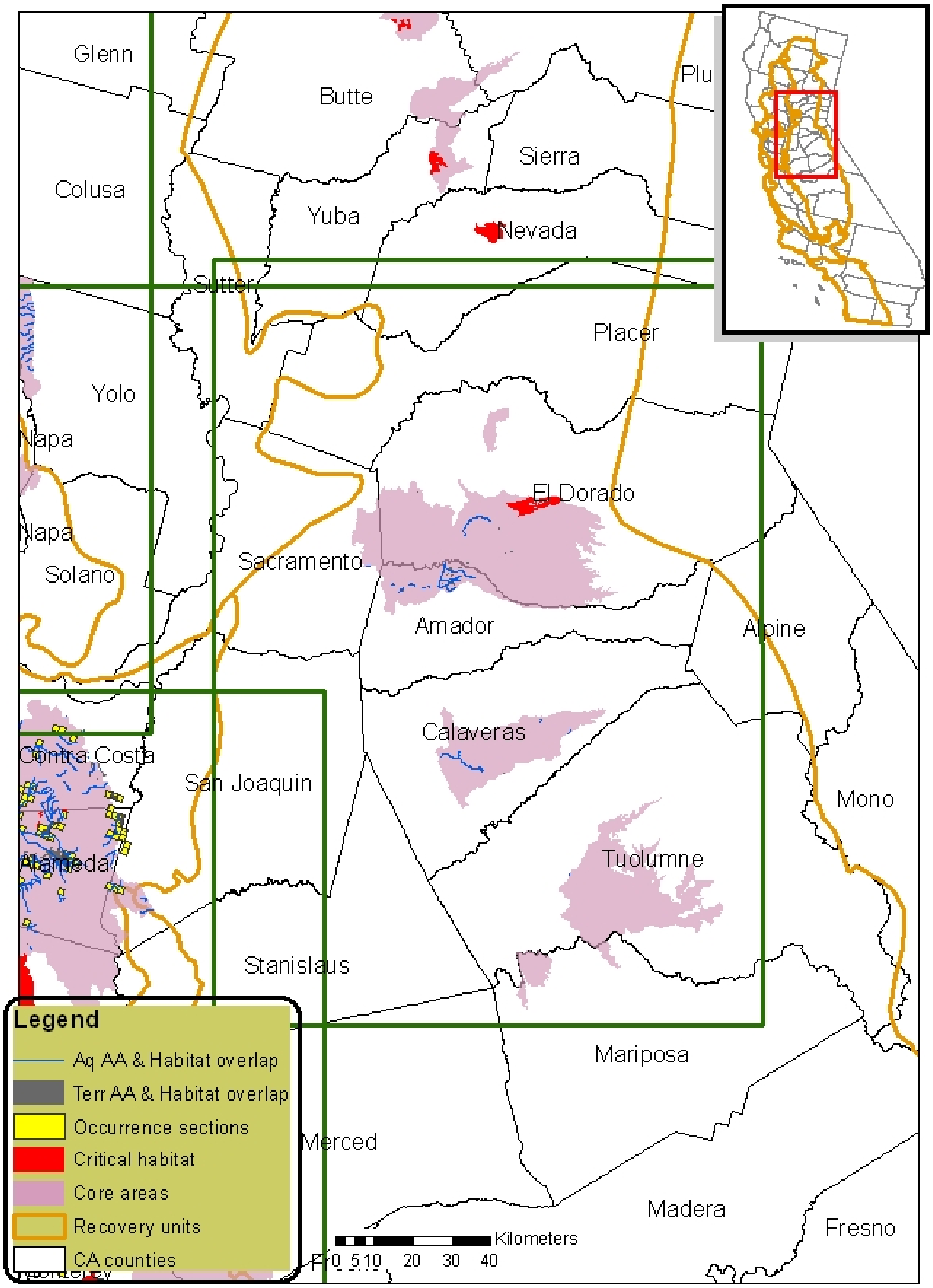
Metam-sodium - Action Area & Habitat Overlap 1



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. July 12, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

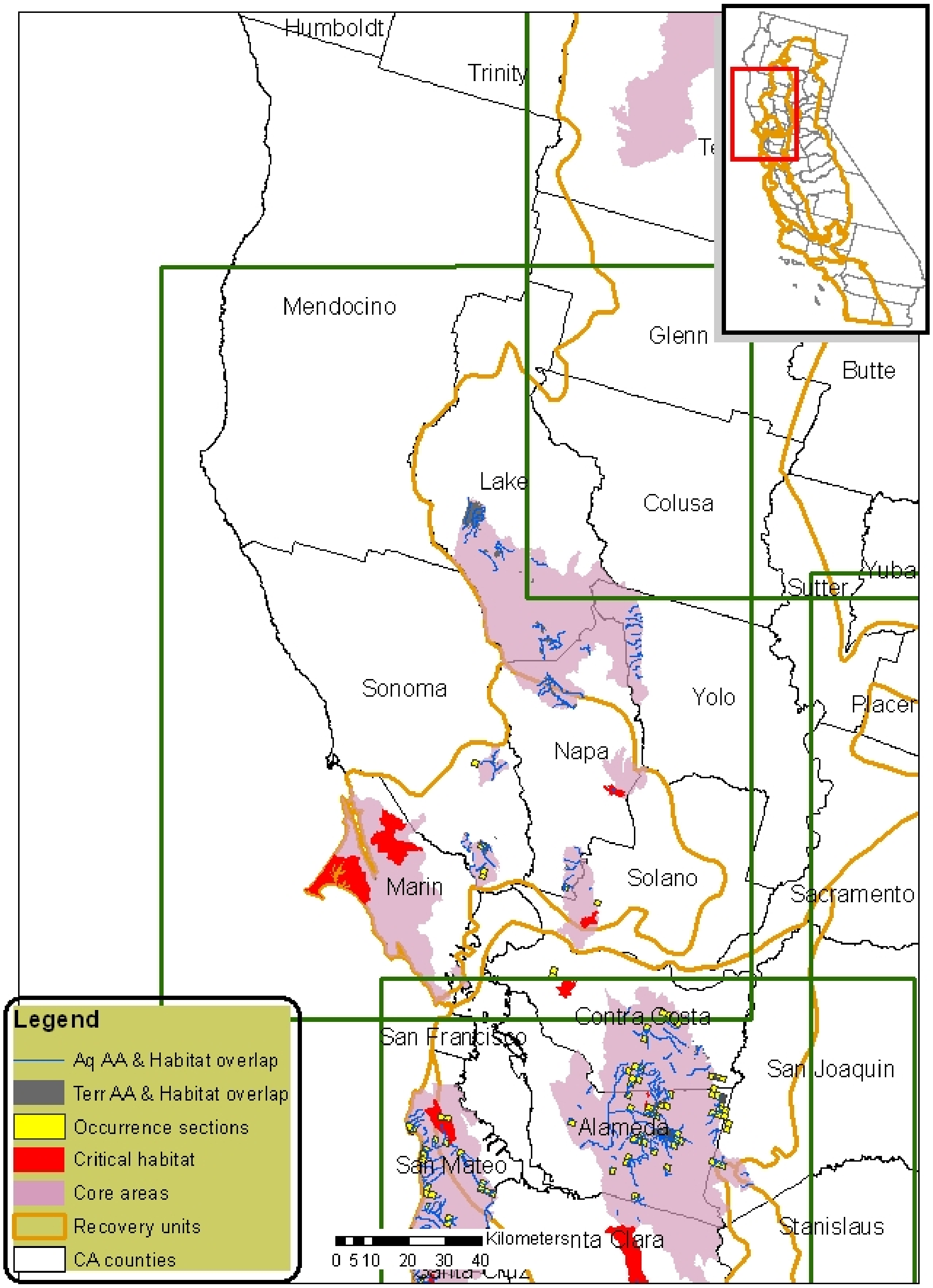
Metam-sodium - Action Area & Habitat Overlap 2



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. July 12, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

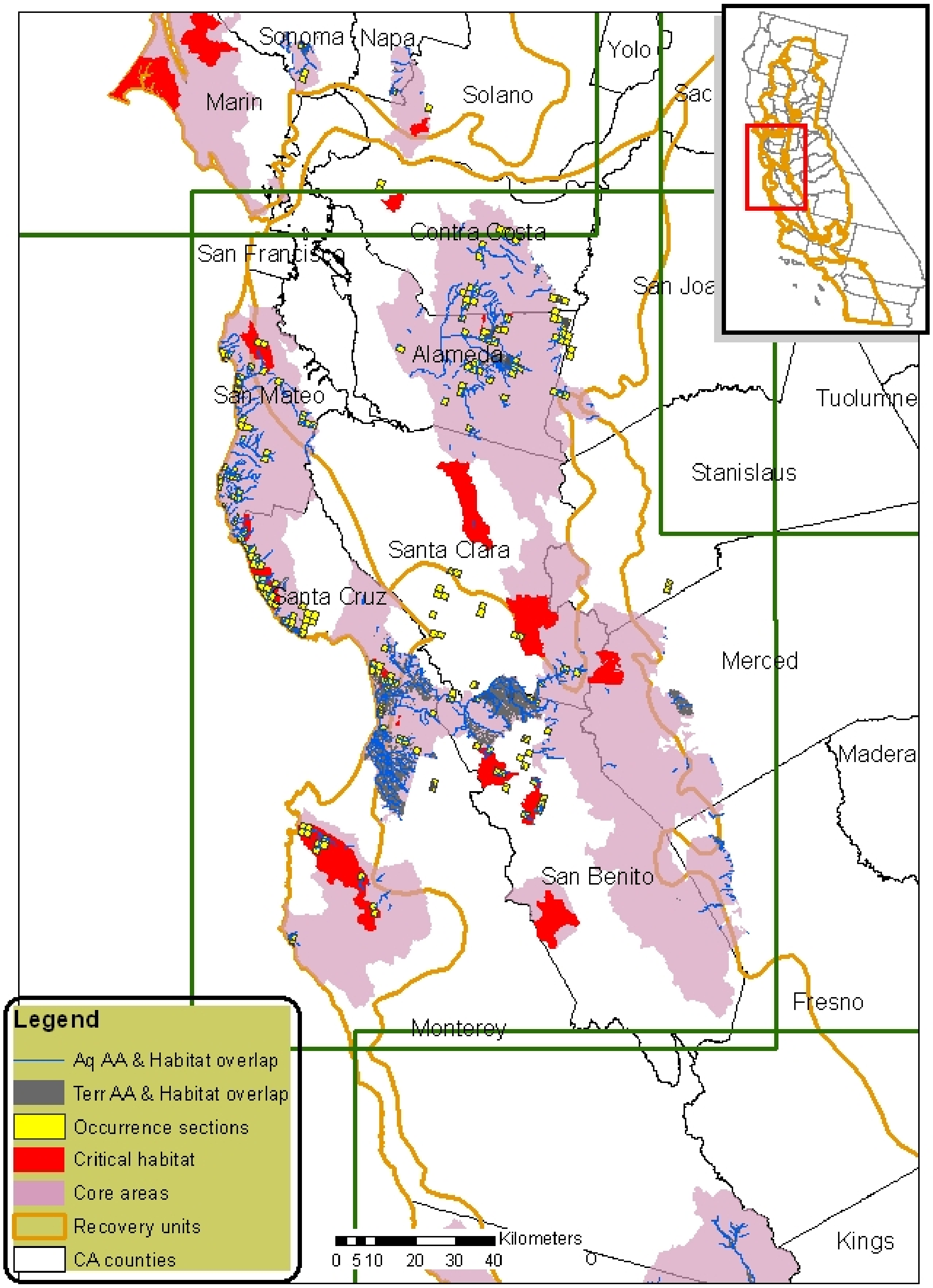
Metam-sodium - Action Area & Habitat Overlap 3



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. July 12, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

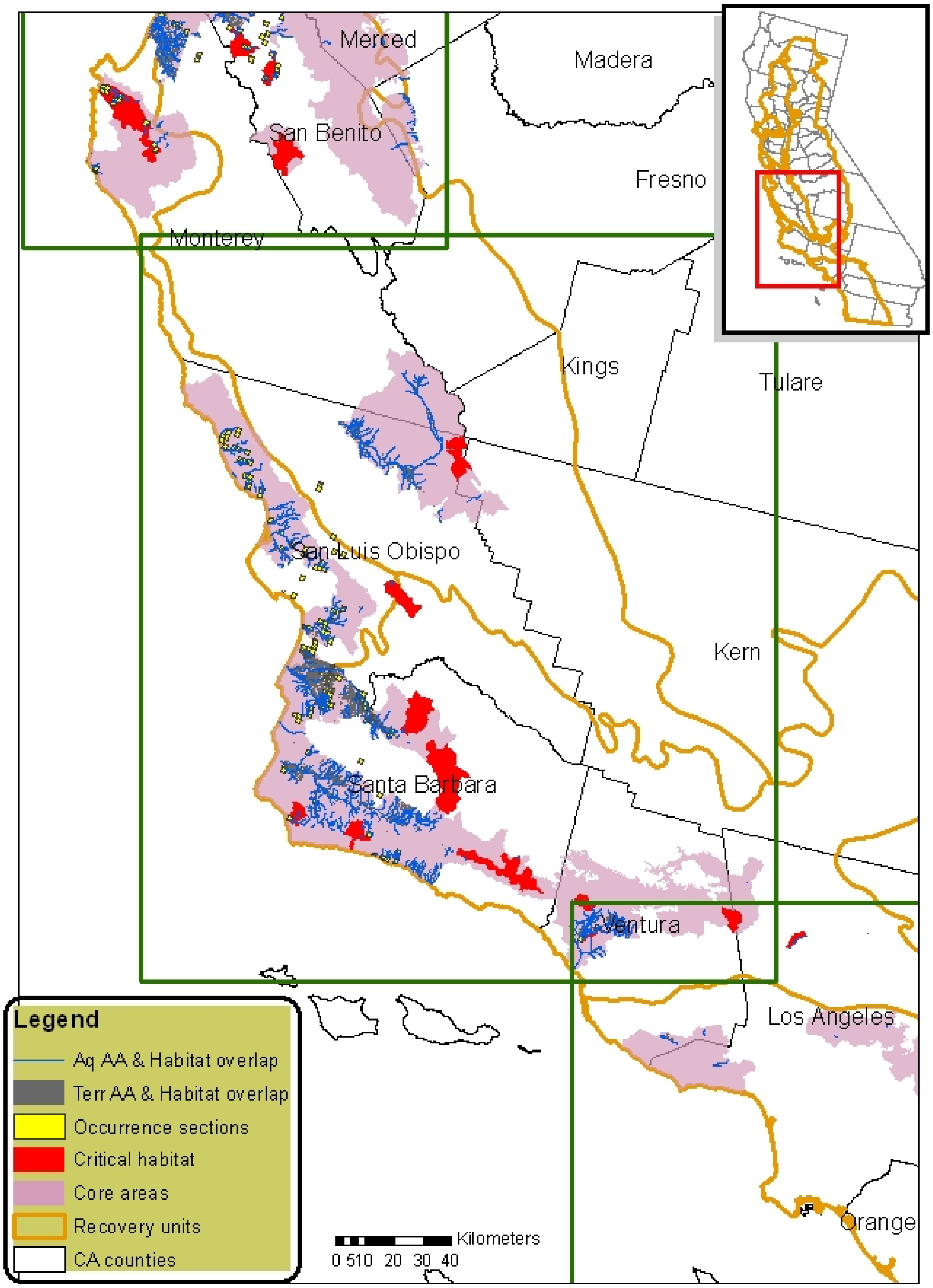
Metam-sodium - Action Area & Habitat Overlap 4



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. July 12, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

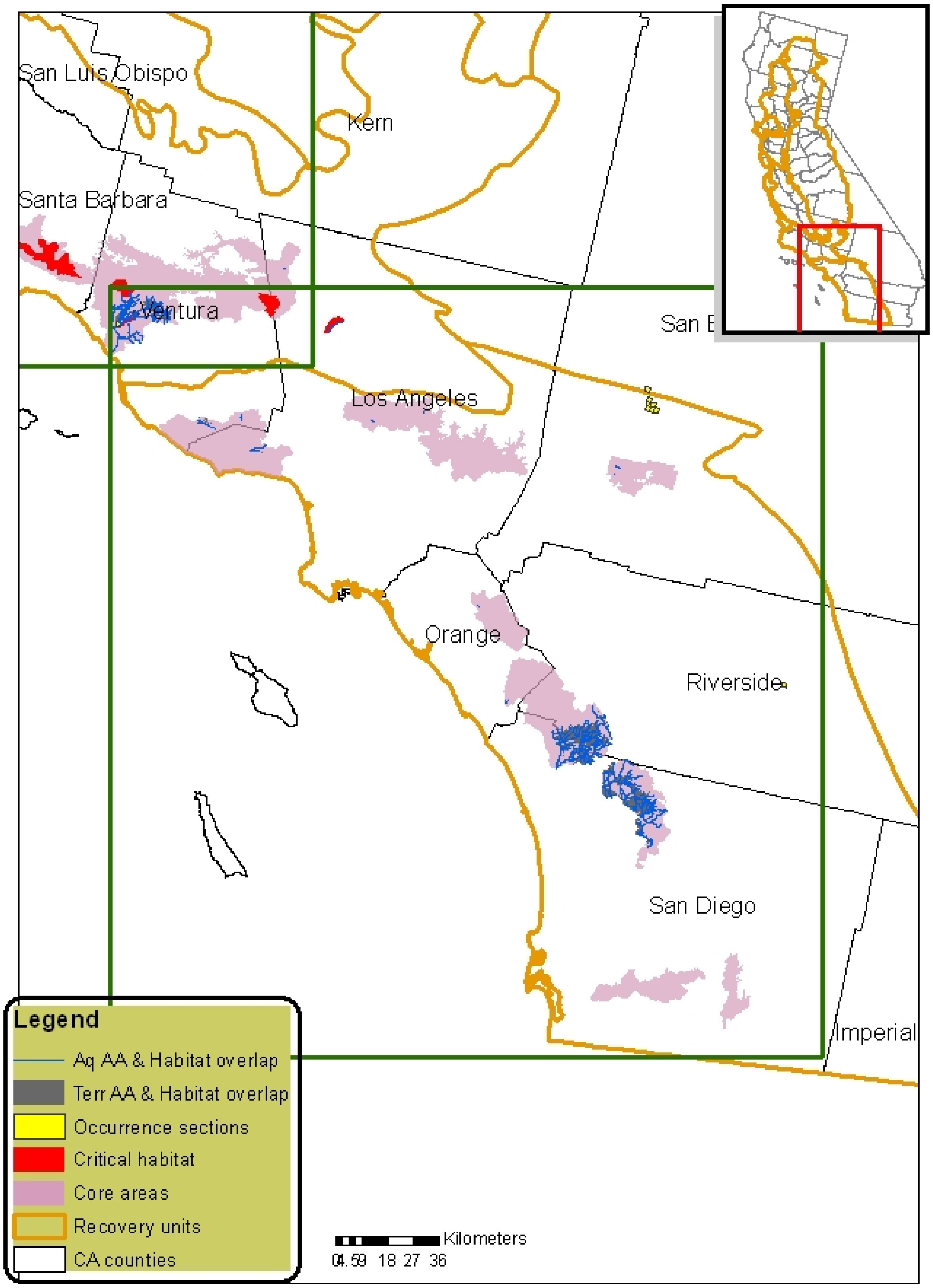
Metam-sodium - Action Area & Habitat Overlap 5



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. July 12, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

Metam-sodium - Action Area & Habitat Overlap 6



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by US Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. July 12, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

Appendix E: Bibliography of Ecotox Open Literature not used quantitatively or qualitatively

METHYL ISOCYANATE (MITC)

Papers that Were Accepted for ECOTOX

Explanation of OPP Acceptability Criteria and Rejection Codes for ECOTOX Data

Studies located and coded into ECOTOX must meet acceptability criteria, as established in the *Interim Guidance of the Evaluation Criteria for Ecological Toxicity Data in the Open Literature, Phase I and II*, Office of Pesticide Programs, U.S. Environmental Protection Agency, July 16, 2004. Studies that do not meet these criteria are designated in the bibliography as "Accepted for ECOTOX but not OPP." The intent of the acceptability criteria is to ensure data quality and verifiability. The criteria parallel criteria used in evaluating registrant-submitted studies. Specific criteria are listed below, along with the corresponding rejection code.

- The paper does not report toxicology information for a chemical of concern to OPP; (Rejection Code: NO COC)
- The article is not published in English language; (Rejection Code: NO FOREIGN)
- The study is not presented as a full article. Abstracts will not be considered; (Rejection Code: NO ABSTRACT)
- The paper is not publicly available document; (Rejection Code: NO NOT PUBLIC (typically not used, as any paper acquired from the ECOTOX holding or through the literature search is considered public)
- The paper is not the primary source of the data; (Rejection Code: NO REVIEW)
- The paper does not report that treatment(s) were compared to an acceptable control; (Rejection Code: NO CONTROL)
- The paper does not report an explicit duration of exposure; (Rejection Code: NO DURATION)
- The paper does not report a concurrent environmental chemical concentration/dose or application rate; (Rejection Code: NO CONC)
- The paper does not report the location of the study (e.g., laboratory vs. field); (Rejection Code: NO LOCATION)
- The paper does not report a biological effect on live, whole organisms; (Rejection Code: NO IN-VITRO)
- The paper does not report the species that was tested; and this species can be verified in a reliable source; (Rejection Code: NO SPECIES)

- The paper does not report effects associated with exposure to a single chemical. (Rejection Code: NO MIXTURE)

Additionally, efficacy studies on target species are excluded and coded as NO TARGET.

Data that originated from the OPP Pesticide Ecotoxicity Database is coded as NO EFED. These data are already available to the chemical team.

Acceptable for ECOTOX and OPP

Akagi, K., Sano, M., Ogawa, K., Hirose, M., Goshima, H., and Shirai, T. (2003). Involvement of Toxicity as an Early Event in Urinary Bladder Carcinogenesis Induced by Phenethyl Isothiocyanate, Benzyl Isothiocyanate, and Analogues in F344 Rats. *Toxicol.Pathol.* 31: 388-396.

EcoReference No.: 88454
Chemical of Concern: MITC; Habitat: T; Effect Codes: PHY,BCM,CEL,BEH,GRO; Rejection Code: LITE EVAL CODED(MITC).

Birch, W. X. and Prahlad, K. V. (1986). Effects of Nabam on Developing Xenopus laevis Embryos: Minimum Concentration, Biological Stability, and Degradative Products. *Arch.Environ.Contam.Toxicol.* 15: 637-645.

EcoReference No.: 12119
Chemical of Concern: Nabam,MITC,ETU; Habitat: A; Effect Codes: GRO,BEH,MOR,CEL; Rejection Code: LITE EVAL CODED(MITC),OK(Nabam,ETU).

Branham, B. E., Hardebeck, G. A., Meyer, J. W., and Reicher, Z. J. (2004). Turfgrass Renovation Using Dazomet to Control the Poa annua L. Soil Seed Bank. *Hortscience* 39: 1763-1767.

EcoReference No.: 79903
Chemical of Concern: DZM,MITC; Habitat: T; Effect Codes: POP; Rejection Code: LITE EVAL CODED(DZM).

Goldman, J. M., Stoker, T. E., Cooper, R. L., McElroy, W. K., and Hein, J. F. (1994). Blockade of Ovulation in the Rat by the Fungicide Sodium N-Methyldithiocarbamate: Relationship Between Effects on the Luteinizing Hormone Surge and Alterations in Hypothalamic Catecholamines. *Neurotoxicol.Teratol.* 16: 257-268.

EcoReference No.: 49625
Chemical of Concern: NaDC,MTAS,MITC; Habitat: T; Effect Codes: REP,BCM; Rejection Code: LITE EVAL CODED(MTAS,MITC),OK(NaDC).

Haendel, M. A., Tilton, F., Bailey, G. S., and Tanguay, R. L. (2004). Developmental Toxicity of the Dithiocarbamate Pesticide Sodium Metam in Zebrafish. *Toxicol.Sci.* 81: 390-400.

EcoReference No.: 80675
Chemical of Concern: MTAS,MITC; Habitat: A; Effect Codes: GRO,CEL,MOR; Rejection Code: LITE EVAL CODED(MTAS,MITC).

Keil, D. E., Padgett, E. L., Barnes, D. B., and Pruett, S. B. (1996). Role of Decomposition Products in Sodium Methyldithiocarbamate-Induced Immunotoxicity. *J.Toxicol.Environ.Health* 47: 479-492.

EcoReference No.: 50882

Chemical of Concern: MTAS,MITC; Habitat: T; Effect Codes: CEL,GRO; Rejection Code: LITE EVAL CODED(MTAS,MITC).

Luoma, D. L. and Thies, W. G. (1995). Effects of Live Free Tree Fumigation on Nontarget Vegetation. *Can.J.For.Res.* 24: 2384-2389.

EcoReference No.: 77614
Chemical of Concern: CLP,MITC; Habitat: T; Effect Codes: PHY; Rejection Code: LITE EVAL CODED(CLP),OK(ALL CHEMS).

Moorhouse, K. G. and Casida, J. E. (1992). Pesticides as Activators of Mouse Liver Microsomal Glutathione S-Transferase. *Pestic.Biochem.Physiol.* 44: 83-90.

EcoReference No.: 79085
Chemical of Concern: ACL,Captan,TMT,ATZ,ACR,EPTC,MITC; Habitat: T; Effect Codes: BCM; Rejection Code: LITE EVAL CODED(MITC,Captan),NO IN VITRO(ACL,ACR,ATZ,TMT),OK(EPTC).

Pruett, S. B., Zheng, Q., Schwab, C., and Fan, R. (2005). Sodium Methyldithiocarbamate Inhibits MAP Kinase Activation Through Toll-Like Receptor 4, Alters Cytokine Production by Mouse Peritoneal Macrophages, and Suppresses Innate Immunity. *Toxicol.Sci.* 87: 75-85.

EcoReference No.: 80613
Chemical of Concern: MITC,MTAS; Habitat: T; Effect Codes: MOR,CEL,BCM; Rejection Code: LITE EVAL CODED(MITC,MTAS).

Qureshi, S. A., Mohiuddin, S., Parveen, R., and Kemal, R. (1982). Larvicidal Activity of Aryl Substituted Isothiocyanates Against the Yellow-Fever Mosquito, Aedes aegypti (L.). *Pak.J.Zool.* 14: 91-95.

EcoReference No.: 88491
Chemical of Concern: MITC; Habitat: A; Effect Codes: MOR; Rejection Code: LITE EVAL CODED(MITC).

Schmidt, R. J. and Chung, L. Y. (1993). Perturbation of Glutathione Status and Generation of Oxidative Stress in Mouse Skin Following Application of Contact Allergenic Sesquiterpene Lactones and Isothiocyanates. *Xenobiotica* 23: 889-897 .

EcoReference No.: 82832
Chemical of Concern: ASCN,MITC; Habitat: T; Effect Codes: BCM,PHY; Rejection Code: LITE EVAL CODED(ASCN,MITC).

Staub, R. E., Sparks, S. E., Quistad, G. B., and Casida, J. E. (1995). S-Methylation as a Bioactivation Mechanism for Mono- and Dithiocarbamate Pesticides as Aldehyde Dehydrogenase Inhibitors. *Chem.Res.Toxicol.* 8: 1063-1069.

EcoReference No.: 40195
Chemical of Concern: DZM,MITC; Habitat: T; Effect Codes: BCM,MOR; Rejection Code: NO COC(MLT),LITE EVAL CODED(DZM),OK(MITC).

Thies, W. G. and Patton, R. F. (1971). Evaluation of Cylindrocladium Root Rot Control by Fumigation. *For.Sci.* 17: 323-331.

EcoReference No.: 79901
Chemical of Concern: MTAS,MITC,MB,DZM; Habitat: T; Effect Codes: GRO,MOR,POP; Rejection Code: LITE EVAL CODED(MITC,DZM),OK(MB),OK TARGET(MTAS).

Tilton, F., La Du, J. K., Vue, M., Alzarban, N., and Tanguay, R. L. (2006). Dithiocarbamates Have a Common Toxic Effect on Zebrafish Body Axis Formation. *Toxicol.Appl.Pharmacol.* 216: 55-68.

EcoReference No.: 88674
Chemical of Concern: MTAS,FBM,THM,MITC,DZM,MZB; Habitat: A; Effect Codes: MOR,GRO; Rejection Code: LITE EVAL CODED(MTAS,MITC),OK(ALL CHEMS) .

Torres, H., Martin, C., and Henfling, J. (1985). Chemical Control of Pink Rot of Potato (Phytophthora erythroseptica Pethyb.). *Am.Potato J.* 62: 355-361.

EcoReference No.: 79892
Chemical of Concern: DZM,NaN3,MLX,MITC,DPDP,PNB,MB; Habitat: T; Effect Codes: POP; Rejection Code: LITE EVAL CODED(DZM),OK(ALL CHEMS).

Williams, T. D. and Beane, J. (1980). Some Effects of Differently-Acting Nematicides on the Cereal Cyst-nematode (Heterodera avenae) and on the Appearance of 'Scorch' in Spring Wheat on Light Loamy Sand. *Ann.Appl.Biol.* 95: 225-234.

EcoReference No.: 79887
Chemical of Concern: DZM,ADC,FML,MITC; Habitat: T; Effect Codes: POP,GRO,PHY; Rejection Code: LITE EVAL CODED(DZM),OK(ALL CHEMS).

Acceptable for ECOTOX but not OPP

Birch, W. X. and Prahlad, K. V. (1986). Effects of Minute Doses of Ethylenebisdithiocarbamate Disodium Salt (Nabam) and its Degradative Products on Connective Tissue Envelopes of the Notochord in Xenopus: An Ultrastructural Study. *Cytobios* 48: 175-184.

EcoReference No.: 88565
Chemical of Concern: Nabam,MITC,ETU; Habitat: A; Effect Codes: GRO; Rejection Code: NO MIXTURE(MITC,ETU),OK(Nabam).

Borek, V., Elberson, L. R., McCaffrey, J. P., and Morra, M. J. (1997). Toxicity of Rapeseed Meal and Methyl Isothiocyanate to Larvae of the Black Vine Weevil (Coleoptera: Curculionidae). *J.Econ.Entomol.* 90: 109-112.

EcoReference No.: 64065
Chemical of Concern: MITC; Habitat: T; Rejection Code: TARGET MITC.

Branham, B. E., Hardebeck, G. A., Meyer, J. W., and Reicher, Z. J. (2004). Turfgrass Renovation Using Dazomet to Control the Poa annua L. Soil Seed Bank. *Hortscience* 39: 1763-1767.

EcoReference No.: 79903
Chemical of Concern: DZM,MITC; Habitat: T; Effect Codes: POP; Rejection Code: LITE EVAL CODED(DZM),TARGET MITC.

Highley, T. L. and Eslyn, W. E. (1989). Evaluation of Fumigants for Control of Decay in Non-pressure-treated Southern Pine Timbers. I. Unwrapped Timbers. *Holzforschung* 43: 225-230.

EcoReference No.: 79885
Chemical of Concern: DZM,MITC,BSN,CLP,NaBS; Habitat: T; Effect Codes: POP; Rejection Code: NO ENDPOINT(ALL CHEMS).

Lam, W.-W., Kim, J.-H., Sparks, S. E., Quistad, G. B., and Casida, J. E. (1993). Metabolism in Rats and Mice of the Soil Fumigants Metham, Methyl Isothiocyanate, and Dazomet. *J.Agric.Food Chem.* 41: 1497-1502.

EcoReference No.: 88582
Chemical of Concern: MITC,DZM,MTAS; Habitat: T; Effect Codes: BCM; Rejection Code: NO CONTROL(MTAS,MITC,DZM).

Luoma, D. L. and Thies, W. G. (1995). Effects of Live Free Tree Fumigation on Nontarget Vegetation. *Can.J.For.Res.* 24: 2384-2389.

EcoReference No.: 77614
Chemical of Concern: CLP,MITC; Habitat: T; Effect Codes: PHY; Rejection Code: LITE EVAL CODED(CLP),OK(ALL CHEMS),TARGET MITC.

Maas, J. L. (1990). Toxicity Research with Thiourea. *Laboratory for Ecotoxicology, Institute for Inland Water Management and Waste Water Treatment, Report No.AOCE* 4 p. (DUT).

EcoReference No.: 5374
Chemical of Concern: MITC; Habitat: A; Rejection Code: NO FOREIGN(ALL CHEMS).

Matthiessen, J. N., Desmarchelier, J. M., Vu, L. T., and Shackleton, M. A. (1996). Comparative Efficacy of Fumigants Against Hatchling Whitefringed Beetle (Coleoptera: Curculionidae) Larvae and Their Sorption by Soil. *J.Econ.Entomol.* 89: 1372-1378.

EcoReference No.: 88496
Chemical of Concern: MITC; Habitat: T; Effect Codes: MOR; Rejection Code: OK TARGET(MITC),NO COC(MTAS).

Purcell, D. L. (1966). Sandalwood (Eremophila mitchellii) Control in Gidyea Country. *Qld.J.Agric.Anim.Sci.* 23: 387-395.

EcoReference No.: 56976
Chemical of Concern: MITC; Habitat: T; Rejection Code: TARGET MITC.

Reynolds, L. B., Olthof, T. H. A., and Potter, J. W. (1992). Effect of Fumigant Nematicides on Yield and Quality of Paste Tomatoes Grown in Southwestern Ontario. *J.Nematol.* 24: 656-661.

EcoReference No.: 77622
Chemical of Concern: CLP,DPDP,MITC; Habitat: T; Effect Codes: POP; Rejection Code: OK(DPDP),NO MIXTURE(CLP,MITC).

Scanland, J. C. and Fossett, G. W. (1984). Herbicidal Control of Woody Weeds in Central Queensland: 3. False Sandalwood (Eremophila Mitchellii). *Trop Grassl* 18: 78-83.

EcoReference No.: 31962
Chemical of Concern: MITC; Habitat: T; Rejection Code: TARGET MITC.

Schultz, T., Gabrielson, R. L., and Olson, S. (1986). Control of Xanthomonas campestris pv. campestris in Crucifer Seed with Slurry Treatments of Calcium Hypochlorite. *Plant Dis.* 70: 1027-1030.

EcoReference No.: 80748
Chemical of Concern: TCMTB,STRP,ASCN,Cu,MITC,Zn; Habitat: T; Effect Codes: POP,REP,GRO; Rejection Code: NO ENDPOINT(ALL CHEMS).

Shionogi and Company, Ltd. (1990). Summary of Toxicity Data on Methyl Isothiocyanate (MITC). *J.Pestic.Sci.* 15: 297-304.

EcoReference No.: 88569

Chemical of Concern: MITC; Habitat: T; Effect Codes: MOR,CEL,GRO,REP,BEH,PHY; Rejection Code: NO CONTROL(MITC).

Staub, R. E., Sparks, S. E., Quistad, G. B., and Casida, J. E. (1995). S-Methylation as a Bioactivation Mechanism for Mono- and Dithiocarbamate Pesticides as Aldehyde Dehydrogenase Inhibitors. *Chem.Res.Toxicol.* 8: 1063-1069.

EcoReference No.: 40195
Chemical of Concern: MTAS,DZM,MITC; Habitat: T; Effect Codes: BCM,MOR,ACC; Rejection Code: LITE EVAL CODED(DZM),NO ENDPOINT(MITC,MTAS).

Stoner, K. A., Ferrandino, F. J., Gent, M. P. N., Elmer, W. H., and Lamondia, J. A. (1996). Effects of Straw Mulch, Spent Mushroom Compost, and Fumigation on the Density of Colorado Potato Beetles (Coleoptera: Chrysomelidae) in Potatoes. *J.Econ.Entomol.* 89: 1267-1280.

EcoReference No.: 88495
Chemical of Concern: MITC; Habitat: T; Effect Codes: POP; Rejection Code: OK TARGET(MITC),NO COC(MTAS).

Teasdale, J. R. and Taylorson, R. B. (1986). Weed Seed Response to Methyl Isothiocyanate and Metham. *Weed Sci.* 34: 520-524.

EcoReference No.: 31323
Chemical of Concern: MTAS,MITC; Habitat: T; Effect Codes: REP,POP; Rejection Code: OK TARGET(MITC,MTAS).

Thies, W. G. and Nelson, E. E. (1987). Survival of Douglas-Fir Injected with the Fumigants Chloropicrin Methylisothiocyanate or Vorlex. *Northwest.Sci.* 61: 60-64.

EcoReference No.: 77690
Chemical of Concern: CLP,MITC; Habitat: T; Effect Codes: MOR,PHY; Rejection Code: NO ENDPOINT(CLP),TARGET MITC.

Torres, H., Martin, C., and Henfling, J. (1985). Chemical Control of Pink Rot of Potato (Phytophthora erythroseptica Pethyb.). *Am.Potato J.* 62: 355-361.

EcoReference No.: 79892
Chemical of Concern: NaN3,MLX,MITC,DPDP,PNB,MB,DZM; Habitat: T; Effect Codes: POP; Rejection Code: LITE EVAL CODED(DZM),OK(MLX,DPDP,PNB,MB),OK TARGET(NaN3),NO MIXTURE(MITC).

Warton, Ben, Matthiessen, John N., and Shackleton, Mark A. (2003). Cross-Enhancement: Enhanced Biodegradation of Isothiocyanates in Soils Previously Treated with Metham Sodium. *Soil Biol.Biochem.* 35: 1123-1127.

EcoReference No.: 88490
Chemical of Concern: ASCN,MITC; Habitat: T; Effect Codes: MOR; Rejection Code: OK(ASCN),NO COC(MTAS),NO ENDPOINT(MITC).

Whitehead, A. G. (1975). Chemical Control of Potato Cyst-nematode. *ARC Res.Rev.* 1: 17-23.

EcoReference No.: 79948
Chemical of Concern: DZM,MITC,TBA,BMY,DPDP,ADC,FMP,DML; Habitat: T; Effect Codes: POP,MOR; Rejection Code: NO ENDPOINT(ALL CHEMS).

Whitehead, A. G., Fraser, J. E., and French, E. M. (1979). Control of Potato Cyst-Nematode, Globodera

pallida, on Tomatoes Grown Under Glass, by Applying Steam or Chemical Nematicides to the Soil. *Ann.Appl.Biol.* 92: 275-278.

EcoReference No.: 79893
Chemical of Concern: DZM,MB,CLP,MITC,OML; Habitat: T; Effect Codes: POP,MOR; Rejection Code: NO MIXTURE(CLP,DZM,OML,MITC),OK(MB).

Williams, T. D. and Beane, J. (1980). Some Effects of Differently-Acting Nematicides on the Cereal Cyst-Nematode (Heterodera avenae) and on the Appearance of 'Scorch' in Spring Wheat on Light Loamy Sand. *Ann.Appl.Biol.* 95: 225-234.

EcoReference No.: 79887
Chemical of Concern: DZM,ADC,FML,MITC; Habitat: T; Effect Codes: POP,GRO,PHY; Rejection Code: LITE EVAL CODED(ADC,DZM),OK(FML),TARGET(MITC).

Papers from the metam sodium bibliography were only reviewed if they related to the degradate MITC, which was the focus of this risk assessment.

METAM SODIUM
Papers that Were Excluded from ECOTOX

Dithiocarbamate Pesticides, Ethylenethiourea, and Propylenethiourea: a General Introduction. *Environmental health criteria , 78 (1988) 140 p.*
Rejection Code: REVIEW.

Drug-Induced Convulsions. Report From Boston Collaborative Drug Surveillance Program. *Lancet. 1972, sep 30; 2(7779):677-9. [Lancet.]: Lancet.*
Rejection Code: HUMAN HEALTH.

Maximum Concentrations at the Workplace and Biological Tolerance Values for Working Materials 1987. *Vch verlagsgesellschaft mbh, postfach 1260/1280, 6940 weinheim, federal republic of germany, 1987.*
Rejection Code: HUMAN HEALTH.

Maximum Concentrations at the Workplace and Biological Tolerance Values for Working Materials 1988. *Vch publishers, suite 909, 220e. 23rd street, new york, ny 10010-4606, usa; vch verlagsgesellschaft mbh, postfach 1260/1280, 6940 weinheim, federal republic of germany, 1988. 107p. Bibl. Ref.*
Rejection Code: HUMAN HEALTH.

1995). Metam Sodium and Methyl Isothiocyanate. *Food and Chemical Toxicology* 33: 338 (ABS).
Rejection Code: HUMAN HEALTH, ABSTRACT.

1995). Metam Sodium and Methyl Isothiocyanate. *Food and Chemical Toxicology* 33: 338 (abs).
Rejection Code: HUMAN HEALTH.

1990). Pesticide Health and Safety Policy in the Uk a Flawed and Limited Approach Au - Watterson a. *J public health policy* 11: 491-503.
Rejection Code: HUMAN HEALTH.

Abrams, K., Hogan, D. J., and Maibach, H. I. (1991). Pesticide-Related Dermatoses in Agricultural Workers. *Occup med - state of the art rev* 6: 463-492.
Rejection Code: HUMAN HEALTH.

Adamek, P., Bergstrom, B., Borjesson, T., and Stollman, U. (1992). Determination of Volatile Compounds for the Detection of Moulds. *Samson, r. A., Et al. (Ed.). Developments in food science, vol. 31. Modern methods in food mycology* Second international workshop on standardization of methods for mycological examination of foods, baarn, netherlands, august 20-24, 1990. Xvi+388p. Elsevier science publishers b.v.: Amsterdam, netherlands; new york, new york, usa. Isbn 0-444-88939-6.; 0: 327-336.
Rejection Code: HUMAN HEALTH.

Aizenman, C. D. and Linden, D. J. (Regulation of the Rebound Depolarization and Spontaneous Firing Patterns of Deep Nuclear Neurons in Slices of Rat Cerebellum. *J neurophysiol. 1999, oct; 82(4):1697-709. [Journal of neurophysiology.]: J Neurophysiol*.
Rejection Code: IN VITRO.

Ajwa, Husein A. and Trout, Thomas (2004). Drip application of alternative fumigants to methyl bromide for strawberry production. *HortScience* 39: 1707-1715.
Rejection Code: METHODS.

Akhani, H. and Ku(dieresis)rschner, H. (2004). An Annotated and Updated Checklist of the Iranian Bryoflora. *Cryptogamie, Bryologie, 25 (4) pp. 315-347, 2004*.
Rejection Code: NO TOXICANT.

Aki, T., Yoshida, K., and Fujimiya, T. (Phosphoinositide 3-Kinase Accelerates Calpain-Dependent Proteolysis of Fodrin During Hypoxic Cell Death. *J biochem (tokyo). 2002, dec; 132(6):921-6. [Journal of biochemistry.]: J Biochem (Tokyo).*
Rejection Code: HUMAN HEALTH.

Akishina, T. M. (The Retention Times for Residual Amounts of Carbathion in Soil. *Faktory vneshn. Sredy i ikg zanchen.; 1: 136, 1969*.
Rejection Code: NO SPECIES.

Akutagawa, T., Kitahata, L. M., Saito, H., Collins, J. G., and Katz, J. D. (Magnesium Enhances Local Anesthetic Nerve Block of Frog Sciatic Nerve. *Anesth analg. 1984, feb; 63(2):111-6. [Anesthesia and analgesia.]: Anesth Analg*.
Rejection Code: IN VITRO.

Alberts, W. M. and Do Pico Ga (1996). Reactive Airways Dysfunction Syndrome. *Chest* 109: 1618-1626.
Rejection Code: HUMAN HEALTH.

Alexandrov, A., Keffel, S., Goepel, M., and Michel, M. C. (Differential Regulation of 46 and 54 Kda Jun N-Terminal Kinases and P38 Mitogen-Activated Protein Kinase by Human Alpha(1a)-Adrenoceptors Expressed in Rat-1 Cells. *Biochem biophys res commun. 1999, aug 2; 261(2):372-6. [Biochemical and biophysical research communications.]: Biochem Biophys Res Commun*.
Rejection Code: NO TOX DATA.

Alexeeff, G. V., Shusterman, D. J., Howd, R. A., and Jackson, R. J. (Dose-Response Assessment of Airborne Methyl Isothiocyanate (Mitc) Following a Metam Sodium Spill. *Risk anal. 1994, apr; 14(2):191-8. [Risk analysis : an official publication of the society for risk analysis]: Risk Anal*.
Rejection Code: HUMAN HEALTH.

Alphey, T. J. W. (1981). Subsurface Application of Liquid Fumigants to Arable Soils for the Control of Plant-Parasitic Nematodes. *Hortic.Res.* 21: 169-180.

Ames, R. G. and Shusterman, D. J. (1992). Odor and Irritant Effects From Pesticide Exposure. *203rd acs (american chemical society) national meeting, san francisco, california, usa, april 5-10, 1992. Abstr pap am chem soc* 203: Agro35.
Rejection Code: ABSTRACT.

Andersen, G. G&Oslash, Qvigstad, E., Schiander, I., Aass, H., Osnes, J. B., and Skomedal, T. (Alpha(1)-Ar-Induced Positive Inotropic Response in Heart Is Dependent on Myosin Light Chain Phosphorylation. *Am j physiol heart circ physiol. 2002, oct; 283(4):h1471-80. [American journal of physiology. Heart and circulatory physiology.]: Am J Physiol Heart Circ Physiol*.
Rejection Code: NO TOX DATA.

Andersen, K. J., Leighty, E. G., and Takahashi, M. T. (1972). Evaluation of Herbicides for Possible Mutagenic Properties. *J AGRIC FOOD CHEM* 20: 649-656.
Rejection Code: BACTERIA.

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