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

OFFICE OF
PREVENTION, PESTICIDES, AND
TOXIC SUBSTANCES

MEMORANDUM

SUBJECT: EFED Science Chapter for Phorate RED

TO: Jack Housenger, Chief
Special Review Branch
Special Review and Reregistration Division (7508W)

THRU: Kathy Monk, Acting Chief
Science Analysis and Coordination Staff
Environmental Fate and Effects Division (7505C)

FROM: Pauline Wagner 7/18/96
Science Analysis and Coordination Staff
Environmental Fate and Effects Division (7505C)

Attached to this memorandum is the EFED Reregistration Eligibility Decision (RED) Science Chapter for Phorate. The EFED Science Chapter contains the environmental assessment which is divided into three sections: the ecological toxicity data, the environmental fate and transport and the exposure and risk characterization. Also attached to this memorandum is a summary of the risk characterization and recommendations for your consideration.

Please note, for this RED chapter, there are no separate science chapters.

The members of the Phorate Team are:

Fate Scientist	John Jordan, EFGWB
Ground Water Scientist	James Wolf, EFGWB
Surface Water Modeler	Henry Nelson, EFGWB
Biologist	Denny McLane, EEB
Coordinator	Pauline Wagner, SACS

Any questions regarding this document should be directed to Pauline Wagner.

cc: D. Keehner
H. Jacoby (memo only)
A. Maciorowski (memo only)
E. Leovey (memo only)
L. Rossi (memo only)

Environmental Risk Characterization

Overview of the Chemical

Phorate is a soil incorporated systemic and contact organophosphate insecticide, acaricide, and nematocide registered for use on terrestrial food, ornamental, and feed crops. Phorate is a cholinesterase inhibitor and is highly toxic to mammals, birds, bees and aquatic species. Because of its high toxicity, it is marketed only as a granular product. Formulations can be either singular at concentrations of 0.2, 0.4, 6.5, 10, 15, and 20% G or include ethoprop and fonofos. Phorate is classified as a restricted use pesticide (RUP) for most of its uses.

Phorate is one of four organophosphate insecticides assessed in the corn cluster document. In comparison to the other three, phorate posed the greatest risk to terrestrial wildlife. Of the four chemicals, phorate is reported be the most toxic to avian species. Field incident reports support the risk to avian species for phorate since the terrestrial incident reports all involved adverse effects to a variety of birds. Phorate has been shown to be the most toxic to marine/estuarine fish, as well.

Overview of Findings

<u>Environmental Fate and Transport</u>

Data Gaps

All previous environmental fate data requirements for phorate re-registration are satisfied. Ground and surface water study requirements are currently reserved. Soil photolysis was waived on 9/29/92 because the granules are covered with soil at application. Based on laboratory results that showed moderate volatility and a low Henry's Law Constant, field volatility studies were also waived. Spray drift was waived because phorate is formulated only in granules for soil incorporation.

However, the environmental fate of the phorate degradates, which are expected to exhibit toxicity similar to the parent, have not been well characterized. Specifically, data gaps include:

- Field monitoring for degradates
- Half-lives ($t_{1/2}$) for degradates

Summary

Phorate itself is not persistent in the environment. It has been shown to degrade in soil by chemical and microbial action and to dissipate in the field with a $t_{1/2}$ of 2 - 15 days. It is moderately mobile in soil, and has been shown to migrate to a maximum depth of 6 inches in loamy sand and sandy loam soils. Additionally, phorate is subject to rapid hydrolysis with a $t_{1/2}$ of 3 days. Due to the limited migration and the rapid hydrolysis, phorate is not expected to pose a significant risk to ground water. While phorate contamination of surface water by surface runoff may be an acute problem, the rapid hydrolysis will tend to lessen the concentration in a relatively short period of time. Parent adsorption to permeable soils low in organic matter is low to moderate with Kds = 1.5 - 3.5. The anaerobic soil metabolism $t_{1/2}$ is 32 days. The aerobic aquatic metabolism in sediment $t_{1/2}$ of 2 - 6 weeks may indicate that phorate, if it reaches the sediment, will be more persistent in sediment than in the water column. However, phorate itself is not expected to persist long enough to reach the sediment, so no risk from the parent is anticipated to occur.

In contrast to phorate, the phorate degradates, phorate sulfoxide and phorate sulfone, are both more persistent and more mobile in the environment. The aerobic soil metabolism half-lives ($t_{1/2}$) for the sulfoxide and sulfone degradates are 65 and 137 days, respectively. The potential of these degradates to migrate in soil was demonstrated in a Georgia field dissipation study where they were found at depths of 12 - 18 inches. The potential for groundwater contamination by the degradates exists, although as of now neither of the degradates has been detected in the wells that have been sampled. It should be noted that, in general, the degradates have not been the focus of monitoring efforts. By analogy to the carbamate insecticide, aldicarb, which also has sulfoxide and sulfone degradates that have been detected in well samples, there are concerns that phorate degradates may contaminate ground water. The degradates, with a tendency to partition preferentially into water, may be available for runoff to surface water for a longer time period than phorate. As reported in the HED chapter, the sulfoxide degradate is slightly more toxic than the parent. Currently, there are no data for the other degradates, but the degradates containing the organophosphate moiety are expected to act similarily to the parent. Although there are no drinking water standards for phorate sulfoxide, there may be some risk associated with high runoff situations when drinking water intakes are downstream of runoff areas.

General Conclusions for Ecological Effects

Data Gaps

The guideline requirements have been fulfilled for all studies except for the following:

chronic mysid testing cycle test -- the available studies did not fulfill guideline requirements but are considered scientifically sound and adequate for registered use sites.

Early life-stage study showed that phorate is toxic at extremely low concentrations, 190 ug/L, to sheephead minnow. Therefore, estuarine fish life-cycle test was not required.

Summary

Acute Risk

Phorate applications equal or exceed the acute Level of Concern (LOC) for all species, for all crops, and for all applications rates.

The greatest exceedences were calculated for small mammals (body weight/kg) in broadcast applications for corn and hops with a RQ = 1486, banded or in-furrow for potatoes with a RQ = 1164, banded or in-furrow for radishes with a RQ = 1489. For mammals whose body weight approximates 1000 g, the RQs range from 22 for broadcast use for corn and hops and side-dress radishes to 0.5 for banded or in-furrow use in wheat.

Avian RQ values ranged from 624 for songbirds in broadcast use in corn and hops to 0.5 for upland gamebirds for soil in-furrow use in wheat. Songbirds were the avian species most at risk: the RQ value ranged from two to three orders of magnitude greater than the level of concern for all uses and all application methods.

For aquatic species all the uses resulted in exceedence of the acute levels of concern with the exception of mollusks (Quahog clam) when phorate is used on wheat. The calculation of RQ values assumed applications were at plant and banded (LUIS). The use of phorate on field grown lilies and daffodils resulted in the highest RQ values overall. These values exceeded the levels of concern for both freshwater and estuarine species. Phorate uses on wheat and potatoes have the lowest RQ values for freshwater fish and invertebrates, calculated at approximately 1 and 2, respectively, but still clearly exceed the level of concern.

Incident reports which describe fatalities to birds and mammals add to the weight of evidence that environmental concentrations are exceeding concern concentrations. For example, bird fatalities in winter wheat crops point to a particular situation where, because of the geographical area and severity of the weather, phorate may reside in the soils for several months. In these cases, it appears that the spring thaw and accompanying rain create conditions where the phorate and its toxic degradates are available to avian species in lethal quantities. In such special circumstances the calculated acute RQ values may under estimate the actual risk.

Chronic Risk

Although methods are not currently available to determine chronic RQs for terrestrial mammalian wildlife, there is ample evidence that phorate is highly toxic to laboratory test species such as the rat and dog. Using these species as surrogates for terrestrial mammalian wildlife, the table below provides an indication of expected toxicity:

SPECIES	STUDY TYPE	EFFECT	NOEL
Rat	90-day	cholinesterase inhibition	0.033mg/kg
Dog	105-day	cholinesterase inhibition	0.01mg/kg

Data from HED RED chapter

In addition to the laboratory studies, several incident reports have involved terrestrial wildlife--specifically, reports from Wisconsin have cited dead skunk and opossum. Field studies conducted with phorate on corn showed that, under normal use conditions, phorate can be lethal to raccoon and short-tailed shrew.

Chronic risk quotients for reproductive effects have not been developed for avian species, but a mallard reproductive study with a reported NOEL = 5ppm strongly suggests that such a risk may exist.

Phorate equals or exceeds the chronic Level of Concern (LOC) for freshwater fish and amphibians for all crops except potatoes and wheat, assuming at plant and banded applications. It exceeds the chronic Level of Concern (LOC) for freshwater invertebrates for all crops and for all application rates, although use on potatoes and wheat with RQs of 1.2 and 1.9, respectively are the lowest. Phorate exceeds the chronic Level of Concern (LOC) for estuarine/marine organisms for all crops and for all application rates.

Recommendations

Surface Water Monitoring Request

EFED has concerns over actual and potential aquatic risks of phorate and/or its sulfoxide and/or sulfone degradates to humans fish, and aquatic invertebrates. Also, it is unclear how representative existing monitoring data are of phorate use areas or peak concentrations (because of the use of set sampling intervals instead of sampling in response to increased flow after runoff events). In addition, the available monitoring data do not include the sulfoxide or sulfone degradates. Consequently, EFED recommends that surface water monitoring studies on watersheds where phorate is known to be heavily used be required as a condition for reregistration. The extent and nature of the studies should be approved by the Agency. Such data will enable HED and EFED to more accurately assess aquatic risks to humans, fish, and aquatic invertebrates and the effectiveness of any agreed upon mitigation steps.

Labelling

Surface Water Label Advisory Request

If a decision is made to require labelling precautions to minimize runoff, EFGWB recommends the following wording:

Under some conditions, phorate may also have a high potential for runoff into surface water (primarily via dissolution in runoff water), for several days post-application. These include poorly draining or wet soils with readily visible slopes toward adjacent surface waters, frequently flooded areas, areas over-laying extremely shallow ground water, areas with in-field canals or ditches that drain to surface water, areas not separated from adjacent surface waters with vegetated filter strips, areas over-laying tile drainage systems that drain to surface water, and areas where an intense or sustained rainfall is forecasted to occur within 48 hours.

No additional labelling changes from the present label are requested.

Risk Mitigation Options

The potential for risk reduction is minimal. Due to the small quantity of phorate required to cause adverse effects, it is difficult to develop risk reduction without determining the functional relationship between the laboratory data and effects in the field. The following are the risk reduction techniques, in quotes, discussed in the Corn Cluster Document and additional comments specific to the phorate RED.

"LIMITATIONS ON USE"

"Application Rates"

"In considering limitations on use, the first option is always reducing the application rate. Due to the extreme toxicity and relatively low application rates of these chemicals, reduction in the application rates is unlikely to reduce risks appreciably. The average percentage reduction that would be required to get below the level of concern for aquatic risk is 99.9% and for terrestrial 93%. Clearly, for chemicals which are this toxic, the label application rates should be the lowest possible. The point is: even the lowest possible rates represent exceptionally high risk".

For the crops considered in this RED, it is not likely that risk can be reduced appreciably by lowering the application rate. For mammals, the lowest risk quotients are from 12.9 to 25.9 times the level of concern. Therefore, the application rate of 0.24 oz/1000 ft of row would have to be reduced to 0.0093 oz./1000 ft of row. The aquatic situation is similar. The lowest risk quotient for estuarine invertebrates is 12.1. Hence, the application rate would have to be reduced to 0.0099 oz./1000 ft of row. It is not likely that these rates would be efficacious.

"Number of Applications/Application Intervals"

"Because these chemicals are applied only once for the corn at-plant use, reductions in the number of applications and changes in the application intervals are not possible for this particular use."

Both terrestrial and aquatic risk quotients exceed acute level of concern for all crops after only one application.

Crops with two applications are corn, peanuts, potatoes, sorghum, and sugarbeets. The interval between applications ranges between 25 and 60 days. Due to rate of dissipation, increase in the interval beyond 25 days would not be expected to change the concentration estimate significantly.

"Other Use Limitations/Prescription Use"

"Other methods for limiting use fall under the general category of prescription use. Examples include limiting the total number of acres treated; limiting the total use (lbs/year); and, when considering the overall use of these chemicals, limiting the crops on which they may be used. However, the levels of concern for these chemicals will still be exceeded in the areas where they continue to be used, therefore, all available mitigation measures should be implemented to reduce risks if use of these chemicals is permitted in these areas."

This would also apply to the crops covered by this RED.

"Use of Alternative Chemicals and Pest Management Practices"

"Any use of these organophosphate chemicals presents environmental risks to aquatic and terrestrial wildlife resources and habitat, therefore, every effort should be made to promote their replacement with safer alternative chemicals and other pest management practices.

As discussed in detail in the Corn Cluster Document, crop rotation when corn is rotated with a non-host crop like soybeans is an effective method of controlling the rootworm. However, this practice would only apply to corn at plant, and not be expected to work with other crops.

"REDUCTIONS IN AVAILABILITY OF CHEMICALS TO WILDLIFE"

"Soil Incorporation: Depth/Efficiency".

"The principal mitigation option identified for reducing exposure to both terrestrial and aquatic organisms is soil incorporation. Although risk for the in-furrow applications are still very high, the risk for broadcast and banded applications is even greater. Banded and broadcast applications result in higher exposure because these methods offer little opportunity to decrease surface exposure or to reduce surface water runoff of unincorporated residues."

"In general, the greater the degree of soil incorporation the less probability of terrestrial exposure and runoff to surface water. In addition to explicit depth-of-incorporation requirements, equipment efficiency and turn row exposure must be addressed. Examples of mitigation measures for turn rows include placing turn rows so that they are most distant from sensitive habitat and completing the planting of fields by planting over turn rows. The more efficient the application equipment is at directing the applications (in this case achieving the desired incorporation, electronic cutoffs, etc.) the better. In addition, educational programs should emphasize the risks associated with using worn and miscalibrated equipment; spillage; and excessive applications in turn rows. Education, research, and subsidies should support the use of the most advanced application technologies and equipment available."

Because of possible phytotoxicity, in-furrow applications do not appear to be an alternative for most crops. Also, due to the high toxicity, even if in-furrow was an option it would not adequately mitigate the risk. The same is true for educational programs. The risk quotients were calculated assuming proper application techniques, such as, proper calibration and cutoffs for turn rows.

"Surface Water Mitigation Measures"

"Other mitigation measures directed specifically at surface water include buffer zones; vegetated filter strips; detention practices and limitations based on climate and rainfall conditions."

"If broadcast applications were to continue, buffer zones to limit spray drift into surrounding aquatic habitat are appropriate. The effectiveness of vegetated filter strips in reducing surface water runoff of these chemicals is questionable, given their mobility characteristics. If a registrant were to suggest this as a possible mitigation measure, they would need to provide data showing why it might be expected to work."

"Detention practices involve impoundment of water and subsequent release after chemical degradation processes have occurred. This mitigation measure would not be out of the question based on the persistence of the chemicals, however, given the extent and nature of the corn use, detention is not practical."

"Limitation of applications based on climate and rainfall conditions is a viable option to decrease surface water risks, if it is possible to limit applications to time periods when runoff is not likely to occur. This would again involve some type of prescription use which would only permit applications under the most favorable conditions (i.e. when runoff events are not likely). This mitigation option was rated favorably but was considered questionable due to problems with implementation."

All use sites covered by the RED would be handicapped by these implementation problems.

"Terrestrial Mitigation Measures"

> "Other mitigation measures directed specifically at terrestrial concerns include timing of application; formulation changes; and ranking of habitat. Limitations based on timing of application were not considered to be applicable to this use. The window of opportunity for pre-plant applications is too small to allow for adjustments due to other factors such as migration, nesting, etc."
>
> "Formulation changes which address wildlife avoidance for carriers and repellents are considered possible avenues for mitigation but ones for which extensive research is still required."
>
> "Restrictions based on ranking of habitat could be addressed but were not, because their complexity makes characterization and implementation difficult without clear risk management guidance."
>
> "Exposure of terrestrial organisms as the result of puddling of water on fields has emerged as a potential route of exposure. Of specific concern are incident reports that phorate has caused wildlife kills in the winter following growing season applications. This particular problem should be discussed in depth with the registrant to determine the specific causes and possible mitigation options."

EFED does not believe that contaminated water is the only route of exposure expected to be of concern for phorate. As shown in the RED all the terrestrial risk quotients considered ingestion of contaminated food not water. Also, field studies found mortality where drinking water contamination did not appear to be any more significant than food. When it only takes 3 granules of the 20% product and 4 of the 15% product to equal the dose which will kill 50% of the test birds (red winged blackbird), either water or food contamination is highly likely.

OTHER TYPES OF MITIGATION

> "Other areas of mitigation activity including research, compensatory mitigation, and monitoring were considered. Research topics considered useful follow from the discussion above where there is uncertainty or where advances in methods and technology might be beneficial. These areas include application methods and equipment; filter strips; terrestrial organism

routes of exposure; formulation changes; and effects of soil type on pests, runoff, and leaching."

"In all cases where the use of extremely toxic chemicals may continue in some form, EFED is suggesting funding of incident data collection, analysis, and systems for both ecological incidents and ground water detections."

Compensatory mitigation is a possibility but is not addressed directly in this document due to its complexity and dependence on other decisions yet to be made. Monitoring was not specifically addressed for the same reasons."

The field and incident data and the high amount of toxicant available show there is an overwhelming likelihood of risk. Also the toxicity to both aquatic and terrestrial species make it difficult to mitigate one hazard without creating another. For example, if dams are built to prevent runoff the ponds formed may attract waterfowl and shorebirds to the contaminated water. Incidents with a variety of birds, songbirds and upland gamebirds as well as waterfowl, indicate that different habitat situations have been shown to be hazardous. Therefore, the common denominator is the overwhelming toxicity of phorate. As previously shown, 3 granules of the 15 percent product carry a quantity of toxicant equal to the avian LD50 dose. If we assume it would take an order of magnitude difference in exposure then the amount of phorate in each granule should be reduced to one tenth if the number of granules available stays the same (667 exposed granules per square foot based on the 15 percent product). Therefore, the chances of reducing risk and maintaining efficacy is minimal for all crops.

Overall recommendation

All of the above measures may mitigate and/or control some risk and will, therefore, lower the RQ values in some of the current uses of phorate. However, none of these control techniques are expected to lower RQ values to values below the concern level. As a result, EFED considers the potential for reducing the actual risks associated with phorate to levels below the concern levels to be problematic. EFED recommends that some consideration be given to the cancellation of the uses of phorate in all but the most extreme circumstances. EFED also recommends that studies and/or research be initiated to identify equally effective non-organophosphate pesticides that would serve as viable substitutes for all phorate uses without the associated potential for ground and surface water contamination and high risk to all exposed wildlife.

C. ENVIRONMENTAL ASSESSMENT

1. Ecological Toxicity Data

Toxicity Summary

The acute toxicity data are available for both terrestrial and aquatic organisms. Both birds and mammals have single dose LD_{50} and dietary LC_{50} study results. The LD_{50} ranged from 1-12.8 mg/kg (mg toxicant/kg bodyweight). The dietary LC_{50} results range from 248 to 441 ppm (parts toxicant per million parts of food). Therefore, on a single dose basis phorate is in the very highly toxic range (or less than 10 mg/kg) and for the dietary exposure it is in highly toxic category (or greater than 50 and less than 500 ppm). Phorate's mammalian toxicity is also in the very highly toxic range based on either the LD_{50} (1.4 mg/kg) or the LC_{50} (28 ppm). Field studies and incidents have shown under normal use conditions phorate can be fatal to birds and mammals. Phorate is in the highest toxicity category for bees (LD_{50} > 1 ug/bee to LD50 = 0.32 μg/bee). It is very highly toxic (highest toxicity category, LC_{50} < 100 ppb) to freshwater organisms (LC50 = 0.6-50 ppb, toxicant/water), and very highly toxic to estuarine/marine organisms (LC50 or EC50 = 0.33-900 ppb). Chronic toxicity studies established the following NOEC values: 5 ppm for mallard ducks; 0.01-0.05 mg/kg for small mammals; 0.21 ppb for freshwater invertebrates; 2.6 ppb for freshwater fish; 0.007 ppb for estuarine/marine invertebrates and 0.0722 ppb for estuarine and marine fish.

a. Toxicity to Terrestrial Animals

(1) Birds, Acute and Subacute

An acute oral toxicity study using the technical grade of the active ingredient is required to establish the toxicity of a pesticide to birds and reptiles. The preferred test species is either mallard duck or bobwhite quail. Results of this test are tabulated below.

Table 1: Avian Acute Oral Toxicity

Surrogate Species	%A.I.	LD50 mg/kg (95% confidence limits)	Toxicity Category[1]	MRID No. Author/ Year	Study Classification [2]
Mallard Duck	96.8	0.62 (0.37-1.03)	very highly toxic	160000 Hudson 1984	Supplemental
Ring necked Pheasant	98.8	7.12 (4.94-10.3)	very highly toxic	160000 Hudson 1984	Supplemental
Starlings	Tech.	7.5	very highly toxic	20560 Schafer 1972	Supplemental
Redwing Blackbird	Tech.	1.0	very highly toxic	20560 Schafer 1972	Supplemental
Grackle	Tech.	1.3	very highly toxic	20560 Schafer 1972	Supplemental
Mallard Duck	88.0	2.55 (2.02-3.21)	very highly toxic	160000 Hudson 1979	Supplemental
Chukar	98.8	12.8 (3.2-51.2)	highly toxic	160000 Hudson 1984	Supplemental

[1] "Very highly toxic" (<10 mg/kg) is the highest rate for toxicity in the scheme proposed by Brooks (1973). Notice that toxicity description such as "highly toxic" (10 > 50 mg/kg) (may be misleading because very small application rates would reduce exposure and likewise the concern).

[2] Study classification is divided into three categories: "Core" which indicates that the study fulfills guideline requirements, "Supplemental" which indicates that the study is scientifically sound but does not fulfill guideline requirements, and "Invalid" which indicates the study is neither scientifically sound nor does it fulfill guideline requirements. "Invalid" studies are not included in any of the tables or discussion in this RED.

The guideline requirement (71-1) is fulfilled. Although no one study is fully acceptable, the consistency of the results indicates no further testing is warranted. Hudson gave the following description of the signs of intoxication:

> Ataxia, diarrhea, beak-sharpening reflex, polydipsia, lacrimation, loss of righting reflex, immobility, irregular heart and respiratory rates, tremors, wing-beat convusions or opisthotonos. Levels as low as 0.09 mg/kg poroduced signs in mallards. This was an extremely fast-acting compound

on all species tested. Signs occurred in pheasants as soon as 3 minutes after treatment. Mortalities usually occurred between 10 minutes and 4 hours after treatment. Remission took up to 2 days.

Two dietary studies using the technical grade of the active ingredient are required to establish the toxicity of a pesticide to birds. The preferred test species are mallard duck (a waterfowl) and bobwhite quail (an upland gamebird). Results of these tests are tabulated below.

Table 2: Avian Dietary Toxicity

Surrogate Species	**% A.I.**	**LC_{50} ppm (95% Confidence Limits)**	**Toxicity Category[1]**	**MRID No. Author/ Year**	**Study Classification**
Northern Bobwhite	90.0	373 (326-431)	highly toxic	00022923 Hill 1975	Core
Ring-necked Pheasant	90.0	441 (381-510)	highly toxic	00022923 Hill 1975	Core
Mallard	90.0	248 (198-306)	highly toxic	00022923 Hill 1975	Core

[1] "Highly toxic" (50-500 mg/kg) is the second highest rate for toxicity in the scheme proposed by Brooks (1973).

These results indicate that phorate is "highly toxic" to avian species on an dietary basis. The guideline requirement (71-2) is fulfilled. (MRID No.: 00022923)

(2) Birds, Chronic

Avian reproduction studies using the technical grade of the active ingredient are required when any **one** of the following conditions are met: (1) birds and reptiles may be subject to repeated or continuous exposure to the pesticide, especially preceding or during the breeding season; (2) the pesticide is stable in the environment to the extent that potentially toxic amounts may persist in animal feed; (3) the pesticide is stored or accumulated in plant or animal tissues; and/or (4) information derived from mammalian reproduction studies indicates reproduction in terrestrial vertebrates may be adversely affected by the anticipated use of the product. The preferred test species are mallard duck and bobwhite quail. Avian reproduction studies are required for phorate because present product labeling allows several applications of the end-use product per growing season. Results of these tests are tabulated below.

Table 3: Avian Reproduction

Surrogate Species[1]	% A.I.	NOEL (ppm)	Affected Endpoint	MRID No. Author/ Year	Study Classification
Northern Bobwhite Quail	92.1	>60	None	158333 Beavers/ 1986	Supplemental
Mallard Duck	92.1	5	Eggs laid, Viable embryos, Normal hatchlings	0158334 Beavers/ 1986	Core

The acceptable mallard study shows the ability of adult mallards to lay eggs, to produce viable embryos and to produce hatchlings is significantly inhibited when they are fed 60 ppm of the technical phorate, 92.1% a.i., for 19 weeks. The guidelines requirements are only partially fulfilled by the quail study due to poor egg production in the controls. However, it is not likely the quail is more sensitive than the mallard. Therefore, another study was not requested.(MRID No. 158334).

The guideline requirement (71-4) is fulfilled (MRID #0158333).

(3) Mammals, Acute and Chronic

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

Table 4: Mammalian Toxicity

Surrogate Species	% A.I.	Type Test	Endpoint[1] Results	MRID No.
Rat Male	>92% Analytical	Oral LD_{50}	3.7 mg/kg	05014313
Rat Female	>92% Analytical	Oral LD_{50}	1.4 mg/kg	05014313
Albino Norway Rat	85%	Dietary LC_{50}	28 ppm	43961101
Male Rat	92% Tech.	Dermal LD50	9.3 mg/kg	00126343
Female Rat	92% Tech.	Dermal LD50	3.9 mg/kg	00126343
Male Rat	92% Tech.	Inhalation LC50	0.06 mg/L	00126343
Female Rat	92% Tech.	Inhalation LC50	0.011 mg/L	00126343
Chronic Toxicity				
Rat	92% Tech.	90 Day feeding	0.66 ppm- NOEL 2-ppm LOEL	00092873
Dog	92.1% Tech.	105 Day feeding	0.01 mg/kg/day NOEL 0.05 mg/kg/day LOEL	00092873
Rat	Phorate sulfoxide 93% Tech.	90 Day Feeding Study	0.32 ppm NOEL- 0.80 ppm LEL	00092912

[1] Acute toxicity data indicates that phorate is "very highly toxic" (<10 mg/kg). This is the highest rating for toxicity in Brook's (1973) scheme of toxicity ratings.

The acute oral LD_{50} results indicate that phorate is very highly toxic to small mammals. The discussion of the toxicity results in the human health section of the RED made the following comments concerning the acute toxicity studies evaluated:

> Technical phorate is highly toxic on an acute oral, dermal, or inhalation basis. The oral LD50 values for phorate with rats were 3.7 and 1.4 mg/kg in males and females, respectively (Toxicity Category 1). All of the animals that died in this study showed typical clinical signs of cholinergic toxicity such as salivation, lacrimation, exophthalmos, muscle fasciculation and excessive urination and defecation
>
> The dermal LD50 values for phorate with rats were 9.3 and 3.9 mg/kg in males and females, respectively (Toxicity Category 1). The cholinergic signs noted for the acute oral study were also observed in the acute dermal study In addition, a dermal LD50 of 415.6 mg/kg in guinea pigs with typical cholinergic signs noted at higher doses was also reported
>
> The acute inhalation LC50s for rats were 0.06 and 0.011 mg/L for males and females, respectively (Toxicity Category 1), based on a one-hour exposure to analytical grade phorate aerosol. Typical cholineric signs were observed in intoxicated animals.

Based on the above studies the dermal and inhalation routes of exposure are as hazardous as the oral route of exposure.

The 90 day feeding studies with phorate and phorate sulfoxide show cholinesterase differences from the control at very low concentrations, the NOELs are 0.66 ppm and 0.32 ppm, respectively. The Agency has not adopted descriptive toxicity categories for the results of mammalian chronic studies. The human health section of the RED provided insight into the above study and the 105-day feeding study:

> In a 90-day dietary feeding study (1956) with rats, plasma, RBC and brain cholinesterase inhibition (ChEI) measurements were made on Day 6. At 0.3 mg/kg/day males exhibited decreases in plasma, RBC, and brain ChE while females at this dose had decreases in plasma and RBC ChE.
>
> In a 105-day dietary feeding study (1956) with dogs, ChEI was determined at Week 1. Plasma ChE was decreased by approximately 50% at 0.05 mg/kg/day. The NOEL for ChEI was 0.1 mg/kg/day. This 1955 study was classified as supplementary due to non adherence to current guidelines (MRID #92873).

These feeding studies and the dietary LC50 of 28 ppm indicate that the dietary route of exposure can cause intoxication and death at very low concentrations.

Another important observation made in the human health chapter is that "Phorate can be metabolized to more potent anticholinesterase compounds through oxidative desulfuration and/or sulfide oxidation." These processes would produce phorate oxygen analog, phorate sulfoxide, phorate oxygen analog sulfoxide, phorate sulfone, and phorate oxygen analog sulfone.

(4) Insects

A honey bee acute contact study using the technical grade of the active ingredient is not required for granular formulations. However, studies have been submitted. The following table tabulates the available bee studies.

Table 5: Nontarget Insect Acute Toxicity

Surrogate Species	% A.I.	LD_{50} (µg/bee)	Toxicity[1] Category	Author/ Year	Study Class.
Honey Bee	Tech.	0.32	Highly toxic (highest cat.)	Steveson/ 1978	Core
Honey Bee	Tech.	10.07	Moderately toxic (middle cat.)	Atkins/ 1975	Core

[1] The toxicity categories are those reported in Reducing Pesticide Hazards to Honey Bees: Mortality Prediction Techniques and Integrated Management Strategies. The group with the most toxic pesticides is called "highly toxic" and is defined as those pesticides with an LD50 between 0.001 and 1.99 ug/bee (MRID No.: 44038201).

The results indicate that phorate is in the highest toxicity category for bees on an acute contact basis. These studies fulfill guideline requirement (141-1). MRID 05001991; 00036935

(5) Terrestrial Field Testing

Simulated Field Studies

Small pen studies are simulated field studies with cages (pens) of birds and /or mammals placed in a treated crop. Pen studies were conducted on the effect of phorate on **bobwhite quail** (MRID Nos: 00074623; 0074624; 00074625; 00074626). Because this type of study did not address all of the species and stresses associated with a particular use site the amount of useful information is limited.

The following findings from these bobwhite quail studies are of interest to the risk assessment.

1. Thimet 20G was applied to both irrigated and non-irrigated corn. Mortality occurred on all treated plots (MRID No. 00074623).

2. Although the quail is not as sensitive to phorate as the mallard duck, red winged blackbird, or common grackle, four pen studies with quail showed mortality.(MRID Nos: 00074623; 0074624; 00074625; 00074626)

3. Both whorl and soil application resulted in adverse effects. (MRID Nos: 00074623; 0074624; 00074625; 00074626)

Another simulated field study with phorate was a littoral mesocosm field study that was conducted in the Prairie Pothole Region of South Dakota. Three mesocosms were treated in both the upland and wetland portions of the mesocosm with phorate at the following rates: 1, 2, and 4.3 lbs a.i./A. Mallard ducklings were the surrogate species. The ducklings died at all three treatment levels. In the second year of the study 15 of 24 ducklings required restocking on days 2-3 post-treatment due to high mortality. (MRID No. 43819501)

Field Studies

Field studies can help document field kills or observe adverse effects to nontarget organisms due to pesticide use. Field studies also can help reduce the uncertainty in extrapolating from laboratory data to the field. Laboratory toxicity data and EECs fail to show the effects of the many variables that can greatly influence impacts under field conditions. Those variables have been identified as potential influences on the effects of the toxicant to nontarget organisms under field conditions; however, the degree to which these factors influence field effects remains poorly defined. Because of these uncertainties, verification of the presence or absence of effects under actual use conditions can provide useful insight into the risk associated with a pesticide.

Several limitations to field testing also should be considered when evaluating risks associated with pesticide use. Field studies generally sample only a small segment of the field conditions that can occur from actual use. While field studies can provide a significant increase in the understanding of risk to nontarget species over the laboratory experiments, generally it is not practical to collect data on all species, or even a high percentage of species potentially at risk. Also, there are practical limits to sampling the various application methods under all crop/use patterns, locations/regions, and weather conditions, particularly for pesticides with large and varied uses. Therefore, even with field studies, extrapolation to other field conditions can lead to erroneous conclusions for reasons similar to those involved in extrapolating from the laboratory to the field. Natural variability among endpoints within and between species can complicate interpretation of field study data, making it difficult to sort out effects. However, when field studies are done with adequate sample size and appropriate scale to provide reasonable sensitivity, they can provide useful information in evaluating the hazards to nontarget organisms associated with pesticide use.

A field study was conducted using phorate on corn with at-plant, at-cultivation, and aerial applications. The usefulness of the study was limited because the researchers did not sufficiently search the treated areas. Even so, the study showed that phorate granules kill birds and mammals. Among the killed and poisoned species found were a peacock, raccoon, indigo bunting, goldfinch, short-tailed shrews, and starlings. Residue analysis indicated that phorate and its degradates were sufficient to cause death to birds and mammals for two to three weeks after application. (MRID No.; 40165901)

Field studies confirmed the expected risk by demonstrating that phorate can kill birds and mammals both large and small. Smaller animals usually eat a higher percent of food relative to their bodyweight than larger animals. Therefore, the raccoon found in this study is significant. If a raccoon can receive a lethal dose, animals the size of raccoons are at risk in addition to small mammals such as rodents. Also, this brings up the possibility of secondary poisoning. Secondary poisoning occurs when an animal is poisoned after feeding on a poisoned animal.

Terrestrial Incidents (see Appendix 1 for Table of Incidents)

The following is the list of incidents EFED believes occurred under typical use scenarios.

On January 5, 1991, what appeared to be eight bobwhite quail were found dead adjacent to a phorate-treated field near Waynesboro, GA. Apparently, the wheat field had been planted in late November. This is probably when the field was treated. The formulation was not Thimet, but another formulation of phorate. Apparently during application, the equipment used had a tendency to clog because the soil was wet, and upon reaching the turn row, the applicator would lift the planter and whatever was clogged in the drill would spill out onto the ground. Phorate was determined to be the cause of death (B000150-016. USEPA, 1991).

Two songbirds, including a robin, were found dead in a tilled corn field in Isle of Wight County, VA on April 5, 1991. The field had been treated with carbofuran (Furadan 15G) on April 4 and 5, 1991. This was under a field monitoring study being conducted at the time of observation. Based on residue analysis, it was determined that phorate probably caused the deaths, with residues of 7.9 ppm detected. How and where the birds had been exposed to phorate remains unknown (I000504-028. Southeastern Cooperative Wildlife Disease Study, 1991).

On March 26, 1989, Thimet 20G killed birds on a winter wheat field in Pierre, SD, that was treated on September 20, 1988 at the application rate of 1.2 oz/1000 foot row with a 10-inch row spacing. If label instructions were followed, then granules would have been applied in-furrow at planting. During late winter to early spring, a pond had formed in the wheat field from the thaw of the snow cover and from rain on March 16 and 17, 1989. On March 29, 1989, 70 Canada geese and other waterfowl were found dead around this temporary pond. A few days later, 12 Canada geese, ducks and a sharp-tailed grouse were found dead in a second small pond about one-third mile from the first pond. On March 19, eagles had been observed at one of these ponds feeding on dead geese. Seven bald eagles and possibly one golden eagle are believed to have been fatally poisoned by phorate in this manner. Phorate residues were measured in wheat at 2.2 ppm and at 0.025 ppm in the pond water samples (FWS, 1989a). Additional information from FWS (letter dated Dec. 22, 1989) indicates seven bald eagles, 81 Canada geese, one snow goose, 13 waterfowl, and one sharp-tailed grouse were found dead at both ponds (B000150-015. 89B01. South Dakota Department of Agriculture, 1989).

Ten Canada geese, 55 mallards, one barn owl, one skunk, and two opossums were killed by phorate from April through June 1989 in Spring Green, WI. The conditions under which the incidents occurred were not reported (B000150-013. FWS, 1989).

On January 16,1987, a red-tailed hawk was reported dead in Solano County, CA from a weakened, stressed condition in a mud field nine miles from Dixon. The cause of death was from exposure to phorate through an unknown set of circumstances (B000150-009. Littrell, 1987).

On February 16, 1987, in Jefferson County, ID, a bald eagle was found dead with a concentration of phorate in its stomach of 631 ppm. The mode of death is undetermined. American Cyanamid proposed that the eagle died after eating from a predator-control carcass poisoned with phorate because the stomach contents contained high amounts of fat and wavy white hair (B000150-011. American Cyanamid, 1990).

On November 4, 1986, 50 to 60 mallards and pintails were found dead in a field that had been planted in barley the previous summer in Tulelake, AC (FWS,1989). Patuxent Wildlife Research Center analysis of crop contents for 7 birds (5 mallards and 2 pintails) identified phorate in every crop. No evidence of misuse was found. (B000150-010. USEPA, 1991).

In October 1982, an incident occurred from the use of phorate on wheat fields in Lyman County, SD. Species (and number of each) found dead were: mallards (38), gadwalls (four), wigeons (nine), pintails (six), green-winged teal (seven), red-tailed hawk (one), and golden eagle(one). Details were not reported (B000150-008. FWS, 1989).

On October 18 and 20, 1982, about 350 waterfowl (133 mallards, 51 pintails, 42 wigeons, 36 gadwall, 12 green-winged teal, three Canada geese, six marsh harriers, two red-tailed hawks, and four great horned owls were found dead in two ponds in Potter County, SD (FWS, 1989). Exposure apparently was from two wetland areas: an adjacent field treated with Thimet 15G in a band in the grass around a winter wheat field; and a second pond, also located in the middle of a winter wheat field, that had been entirely treated. Both ponds also had been exposed by a spill of Thimet 15G and Thimet 20G. A bag of Thimet 15G had been found floating in the pond, and the second pond had two bags in the vicinity. Heavy precipitation had been reported. Runoff was implicated for the second pond.(B000150-007. South Dakota Department of Agriculture 1982).

On December 5, 1982, in Potter County, SD, a bald eagle was found near the previous bird kill area. Various duck parts containing residues of 26 ppm phorate were found in the eagle's gastrointestinal tract. The eagle probably died from eating the remains of the duck carcass that had not been removed (B000150-018. American Cyanamid, 1990).

On February 19, 1981 in Fresno County, CA, an incident involving phorate killed 2,000 blackbirds, two pheasants and several pigeons. Thimet 15 G was applied by air to a wheat field at the recommended rate nine days after reseeding. Standing water was observed in several irrigation ditches as a result of a rain storm about one week before application. American Cyanamid suspects that the birds contacted contaminated irrigation ditch water. Phorate residues were detected in the blackbirds at 24 ppm

(B000150-005. California Fish and Game Department, 1981).

On February 21, 1981 in Merced, CA, phorate, while being applied by aerial application to an alfalfa field, was inadvertently applied to an adjacent property. Due to a faulty dump mechanism, a large amount was also dumped into the waterway around the field . One hundred waterfowl and 100 other birds of various species died. Phorate residues were 54 ppm in teal and 31 ppm in coots. Phorate also was detected in water and vegetation within the property boundary. Although this is a case of misapplication the low lethal doses should be noted (B000150-006. California Department of Food and Agriculture, 1981).

On Nov. 4, 1978, in Calipatria, CA, Thimet 10G was applied, contrary to label instructions, to an alfalfa field during irrigation. Two days after application, 195 bird carcasses were removed, including ring-billed gulls, cattle egrets, and curlews. Phorate was detected in all of the gulls. Phorate residues ranged from 0.05 ppm to 56 ppm. Regurgitated gizzard contents found at the exposure site contained nearly 100% crickets and 92.7 ppm phorate. Brain cholinesterase activity was inhibited by 76% to 96%. Cattle egrets had consumed coleoptera, orthoptera and arachnids. Phorate residues in the egrets were 150 ppm (B000150-004. FWS, 1989; and USEPA, 1991).

In June 1972, it was reported that 25 ducks and blackneck stilts died in the tail water area of a sugar beet field in Fresno, CA. Two days earlier, the field was treated with phorate. Residues were 90 ppm (B000150-014. Bischoff, 1973).

In conclusion the field studies and the incidents indicate that the use of phorate will result in adverse effects. Phorate and its metabolites can express their toxicity several months after application as shown in the above incidents. The Agency believes that during the winter the topsoil and subsoil are frozen, and there is slow degradation until spring thaws when phorate and metabolites begin to move. Storage stability data cited in the human health assessment chapter indicating that phorate and the metabolites are stable for 1 to 3 years if stored under frozen conditions lend support to the above scenario. No downward movement of phorate or metabolites will occur until the subsoil thaws, but spring rains wash phorate and metabolites into surface water ponds, lakes and streams. The waterfowl deaths appear to be connected with this flooding of treated fields. The flooded fields will attract the birds. The water could poison the birds in many different ways. For example, it could be through the skin, drinking, preening, or through eating contaminated flora or fauna growing in the puddle but, as with many incidents, the exact route of exposure could be single or multiple. Also, of equal significance, incidents show phorate can kill songbirds, upland gamebirds, and mammals, as well as waterfowl. Field studies both simulated and actual with corn show that phorate presents a risk under more conventional application and exposure scenarios.

b. Toxicity to Aquatic Animals

(1) Freshwater Fish and Amphibians, Acute

Two freshwater fish toxicity studies using the technical grade of the active ingredient are required to establish the toxicity of a pesticide to fish. The preferred test species are rainbow trout (a cold-water fish) and bluegill sunfish (a warmwater fish). Results of these tests are tabulated below.

Table 6: Freshwater Fish Acute Toxicity

Surrogate Species	% A.I.	LC_{50} (ppb)	Toxicity Category[1]	MRID No. Author/Year	Study Class.
Rainbow trout *(Oncorhynchus mykiss)*	100	13	Very highly toxic	40094602/ Johnson & Finley/ 1980	Core
Bluegill sunfish *(Lepomis macrochirus)*	100	1	Very highly toxic	40098001/ Mayer & Ellersieck/ 1986	Core

[1] "Very highly toxic" (<100 ppb) is the highest category of toxicity in Brook's scheme of rating toxicity.

The results indicate that phorate is "very highly toxic" to freshwater fish on an acute basis. The guideline requirement (72-1) is fulfilled. (MRID No.: 40094602; 40098001)

(2) Freshwater Fish and Amphibians, Chronic

A freshwater fish early life-stage test using the technical grade of the active ingredient is required if the product is applied directly to water or is expected to be transported to water from the intended use site, and when any one of the following conditions exist: (1) the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent regardless of toxicity; (2) any acute LC_{50} or EC_{50} is less than 1 mg/L; (3) the EEC in water is equal to or greater than 0.01 of any acute EC_{50} or LC_{50} value; or (4) the actual or estimated environmental concentration in water resulting from use is less than 0.01 of any acute EC_{50} or LC_{50} value and any one of the following conditions exist: studies of other organisms indicate the reproductive physiology of fish may be affected, physicochemical properties indicate cumulative effects, or the pesticide is persistent in water (e.g. half-life greater than 4 days). The preferred test species is rainbow trout. A fish early life stage test is required for phorate because LC_{50} is < 1 mg/kg and monitoring data indicate that phorate (6.8 and 32.2 ppb) was present in a pond where fish died. Results of this test are tabulated below.

Table 7: Freshwater Fish Early Life-Stage Toxicity

Surrogate Species	% A.I.	NOEC/LOEC (ppb)	MATC (ppb)	Endpoints Affected	MRID No. Author/Year	Study Class.
Rainbow trout *(Oncorhynchus mykiss)*	92.1%	1.9/4.2	2.6 µg/L	Total length	158335/ Surprenant/ 1986	Core

The guideline requirement (72-4a) is fulfilled (MRID #158335). The NOEC, MATC, and LOEC are very low and indicate minimal concentrations are needed to effect growth.

A freshwater fish life-cycle test (72-5) using the technical grade of the active ingredient is required when an end-use product is intended to be applied directly to water or is expected to be transported to water from the intended use site, and when either of the following conditions exist: (1) the EEC is equal to or greater than one-tenth of the NOEL in the fish early life-stage or invertebrate life-cycle test; or (2) studies of other organisms indicate the reproductive physiology of fish may be affected. The preferred test species is the fathead minnow.

The rainbow trout early life stage NOEC was used to estimate an NOEC for the bluegill sunfish. The resultant risk quotients exceed the chronic effects LOC. Although the full life cycle study is expected to provide a lower NOEC, all LOCs are exceeded with the short term study. Therefore the full life cycle study is not required.

(3) Freshwater Invertebrates, Acute

A freshwater aquatic invertebrate toxicity test using the technical grade of the active ingredient is required to assess the toxicity of a pesticide to invertebrates. The preferred test species is *Daphnia magna*. Results of this test are tabulated below:

Table 8: Freshwater Invertebrate Acute Toxicity

Surrogate Species	% A.I.	LC_{50}/ EC_{50} ppb (confidence limits)	Toxicity Category[1]	MRID No. Author/Year	Study Classification
G.fasciatus	Tech	0.68 (0.36-1.0) 0.60 (0.3-0.8)	Very highly toxic	05017538 Sanders/1972	Supplemental
G.fasciatus	Tech	9(5.1-13)	Very highly toxic	0097842 Sanders/1969	Supplemental
G.fasciatus	Tech	4(2-7)	Very highly toxic	0003503 Johnson/1980	Supplemental
Pteronarcys	100	4(2-6)	Very highly toxic	0003503 Johnson/1980	Supplemental
Orconectes nais	Tech	50 (30-75)	Very highly toxic	05017538 Sanders/1972	Supplemental
		Formulation Testing[2]			
Daphnia magna	20% (Thimet 20G)	37(30-44)	Very highly toxic	0161825 Nicholson/ 1986	Core
Midge larvae *(Paratanytarsus parthenogenica)*	20% (Thimet 20G)	41(38-45)	Very highly toxic	0161826 Nicholson/ 1986	Core
Mayfly nymphs *(Hexagenia sp.)*	20% (Thimet 20G)	65 (47-74)	Very highly toxic	0161827 Hoberg 1986	Core

[1] "Very highly toxic" (<100 ppb) is the highest toxicity rating in Brook's (1973) scheme of rating toxicity.

[2] The LC50 values are expressed as concentration of formulated product.

The results indicate that both the technical grade and 20% product of phorate are "very highly toxic" to aquatic invertebrates on an acute basis. The guideline requirement (72-2) is fulfilled. Although, no study is fully acceptable the consistence of the results indicates no further testing is warranted.

(4) Freshwater Invertebrate, Chronic

A freshwater aquatic invertebrate life-cycle test is required if the product is applied directly to water or expected to be transported to water from the intended use site, and when any **one** of the following conditions exist: (1) the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent regardless of toxicity; (2) any acute LC_{50} or EC_{50} is less than 1 mg/L; or (3) the EEC in water is equal to or greater than 0.01 of any acute EC_{50} or LC_{50} value; or (4) the actual or estimated environmental concentration in water resulting from use is less than 0.01 of any acute EC_{50} or LC_{50} value and any of the following conditions exist: studies of other organisms indicate the reproductive physiology of invertebrates may be affected, physicochemical properties indicate cumulative effects, or the pesticide is persistent in water (e.g. half-life greater than 4 days). The preferred test species is *Daphnia magna*. An aquatic invertebrate life-cycle test is required for phorate because 1) the lowest LC_{50} value is 0.68 μg/L and 2) and monitoring data indicate that phorate (6.8 to 32.3 μg/L) was present in a pond where fish were kill. Results of this test are tabulated below.

Table 9: Freshwater Aquatic Invertebrate Life-Cycle Toxicity

Surrogate Species	% A.I.	NOEC/ LOEC (ppb)	MATC (ppb)	Endpoints Affected	MRID No. Author/Year	Study Classification
Daphnid *(Daphnia magna)*	100	0.21/0.41	0.29	Number of offspring per female and growth of parental daphnids	42227102 Yurk, J.J./1991	Core

The NOEC,MATC, and LOEC are very low and indicate minimal concentrations are needed to effect reproduction and growth. The guideline requirement (72-4) is fulfilled (MRID # 42227102).

(5) Estuarine and Marine Animals, Acute

Acute toxicity testing with estuarine/marine organisms (fish, shrimp and oyster) using the technical grade of the active ingredient is required when an end-use product is intended for direct application to the marine/estuarine environment or the active ingredient is expected to reach this environment because of its use in coastal counties. The preferred test species are sheepshead minnow, mysid and eastern oyster. Estuarine/marine acute toxicity testing is required for phorate because the active ingredient is expected to be transported to estuarine waters. Results of these tests are tabulated below.

Table 10: Estuarine/Marine Acute Toxicity

Surrogate Species	% A.I.	LC_{50}/EC_{50} (confidence limits) ppb	Toxicity Category[1]	MRID No. Author/ Year	Study Class.
Eastern oyster embryo-larvae *(Crassostrea virginica)*	89.5	900 (400-1900)	Highly toxic	40228401 U.S.EPA/ 1981	Core
Mysid *(Americamysis bahia)*	89.0	1.9(1.0-3.2)	Very highly toxic	40228401 U.S.EPA/ 1981	Core
Mysid *(Americamysis bahia)*	90.0	0.33(0.27-0.43)	Very highly toxic	40228401/ U.S. EPA/ 1981	Supple-mental
Penaeid shrimp	89.5	0.27(0.18-0.32)	Very highly toxic	40228401 U.S.EPA/ 1981	Supple-mental
Pink shrimp	89.5	0.11(0.08-0.160)	Very highly toxic	40228401 U.S.EPA/ 1981	Supple-mental
Spot	89.5	5.0(4.2-5.6)	Very highly toxic	40228401 U.S.EPA/ 1981	Core
Spot	89.5	3.9(3.1-5.6)	Very highly toxic	40228401 U.S.EPA/ 1981	Supple-mental
Sheepshead minnow	89.5	1.3(0.97-1.7)	Very highly toxic	40228401 U.S.EPA/ 1981	Supple-mental
Longnose Killifish	90	0.36	Very highly toxic	40228401/ U.S.EPA/ 1981	Supple-mental
Sheepshead minnow	89.5	4.0(3.5-4.5)	Very highly toxic	40228401 U.S.EPA/ 1981	Core
Formulation Testing					
Quahog clam	Thimet 20G (20% a.i.)	17(4.4-71)	Very highly toxic	40004201/Suprenant/ 1986	Core
Sheepshead minnow *(Cyprinodon variegatus)*	Thimet 20G (20% a.i.)	8.2(5.5-10)	Very highly toxic	40001801/ Suprenant/1986	Core
Mysid *(Americamysis bahia)*	Thimet 20G (20% a.i.)	0.3(0.26-0.35)	Very highly toxic	41803804 Sousa/ 1990	Core

[1] "Very highly toxic" (<100 ppb) and "highly toxic" (100 to >1000 ppb) are highest and second highest toxicity categories, respectively, provided for in Brook's (1973) scheme of toxicity rating.

The results indicate that technical grade and 25% product of phorate are "very highly toxic" to estuarine/marine fish and invertebrates on an acute basis. The guideline requirement (72-3a) is fulfilled (MRID # 40228401 and 41803804).

(6) Estuarine and Marine Animals, Chronic

Estuarine/marine fish early life-stage and aquatic invertebrate life-cycle toxicity tests are required if the product is applied directly to the estuarine/marine environment or is expected to be transported to this environment from the intended use site, and when any **one** of the following conditions exist: (1) the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent regardless of toxicity; (2) any acute LC_{50} or EC_{50} is less than 1 mg/L; (3) the EEC in water is equal to or greater than 0.01 of any acute EC_{50} or LC_{50} value; or (4) the actual or estimated environmental concentration in water resulting from use is less than 0.01 of any acute EC_{50} or LC_{50} value and any of the following conditions exist: studies of other organisms indicate the reproductive physiology of fish and/or invertebrates may be affected, physicochemical properties indicate cumulative effects, or the pesticide is persistent in water (e.g. half-life greater than 4 days). The preferred test species are sheepshead minnow and mysid shrimp. Estuarine/marine fish early life-stage and aquatic invertebrate life-cycle toxicity tests are required for phorate because (1) the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent regardless of toxicity; (2) acute LC_{50} and EC_{50} are less than 1 mg/L; (3) the EEC in water is equal to or greater than 0.01 of any acute EC_{50} and LC_{50} values; or (4) the actual and estimated environmental concentration in water resulting from use is less than 0.01 of any acute EC_{50} or LC_{50} value and studies of other organisms indicate the reproductive physiology of invertebrates may be affected, or the pesticide is persistent in water (e.g. half-life greater than 4 days). Results of this test are tabulated below:

Table 11: Estuarine/Marine Chronic Toxicity

Surrogate Species	% A.I.	NOEC/LOEC (pptr)	MATC (pptr)	Endpoints Affected	MRID No. Author/Year	Study Classification
Mysid (*Americamysis bahia*)	99	5.3/9.8	7.5	total length and dry weight	43730501 Overman & Wisk/1995	Supplemental
Mysid (*Americamysis bahia*)	99	9/21	13.74	Survivability	40228401/ USEPA/1981	Supplemental
Sheepshead Minnow (*Cyprinodon variegatus*)	99	96/190	72.2	weight and length	418038-06/ Sousa/1991	Core

The guideline requirement (72-4a) is fulfilled (MRID #41803806) and (72-4b) is not fulfilled (MRID #43730501). However, no further chronic mysid testing is required. The additional testing is not expected to result in a significantly different NOEC.

An estuarine/marine fish life-cycle test using the technical grade of the active ingredient is required when an end-use product is intended to be applied directly to water or is expected to transport to water from the intended use site, and when any of the following conditions exist: (1) the EEC is equal to or greater than one-tenth of the NOEC in the fish early life-stage or invertebrate life-cycle test or; (2) studies of other organisms indicate the reproductive physiology of fish may be affected.

This test will not be required. The MATC is very low. The early-life stage test produced a MATC in the parts per trillion. More importantly, the estimated environmental concentration will greatly exceed the early-life stage MATC.

The guideline requirement (72-4a) is fulfilled (MRID # 41803806).

(7) Aquatic Field Testing and Incidents

An aquatic pond study conducted in Iowa used Thimet 20G insecticide. The study only produced comparable data for 3 of 5 ponds. Three ponds have similar chemical and physical characteristics. One pond was a reference pond, the other two were watersheds treated with Thimet 20G. Significant rainfall events did not occur until 10-14 days after treatment. Reductions to invertebrate populations, fish growth and bluegill fecundity were apparent in ponds adjacent to the treated field. Most of the population reductions noted in the study were as a result of exposure to the metabolites of phorate, phorate sulfone and sulfoxide Both metabolites were found when the pond water was analyzed. Despite several factors that compromised comparisons between treated and untreated areas, the study provided valuable data concerning phorate behavior in the environment. The authors of the study suggest that phorate may significantly decrease diversity in natural ecosystems (MRID No.: 42227101).

A mesocosm study in South Dakota investigated the effects of phorate to wetlands macroinvertebrates. Each wetland had a reference and 3 treated mesocosm with application rates of 1.2, 2.4, and 4.8 kg/ha (1,.2, and 4.3 lbs/A), respectively. For 1 month all rates resulted in mortality to all amphipods and chironomids (Dieter et al., 1995; MRID No.: 43957801)

The EPA has received several reports of field incidents involving phorate products through the Pesticide Incident Monitoring System (PIMS). Three fish kills were reported in Illinois involving phorate combined with propachlor, atrazine, EPTC, or esters of 2,4-D. As phorate is considered more toxic than the other chemicals the Agency believes that phorate was primarily responsible for the mortalities.

In May 1970, fish kills were reported involving three ponds following the use of phorate, propachlor, EPTC, atrazine, or the isooctyl ester of 2,4-D on corn fields. Phorate residues were measured in the three ponds. Two ponds were measured two weeks post-application and reported residues of 8.3 and 32.3 ppb. The third pond was measured 37 days post-application and revealed concentrations as high as 12.1 ppb. The effects for the three ponds varied from 30 to 50 dead bluegill and bass for one pond and about 2,000 to 3,000 bluegill, bass, greengills, silver minnows, catfish, and crappies, a watersnake, and fox squirrels for the second pond, approximately three to four days post-application. In the third pond phorate, atrazine, and propachlor probably caused the death of bass and bluegill 7 to 14 days post-application (B000150-001,002,003).

These data would indicate that phorate runs off in amounts sufficient to cause effects to aquatic fauna.

c. Toxicity to Plants

(1) Terrestrial

Currently, terrestrial plant testing is not required for granular insecticides.

(2) Aquatic

Currently, aquatic plant testing is not required for granular insecticides, however, Tier I toxicity data on the technical/TEP material was submitted and are listed below:

Table 12: Nontarget Aquatic Plant Toxicity Findings

Species	% A.I.	EC_{50} (ppb)
Navicula pelliculosa (Freshwater diatom)	^N/R[1]	N/R
Lemna gibba	N/R	N/R
Selenastrum capricornutum	N/R	N/R
Skeletonema costatum	90	1,300 (1,000-1,400)
Anabaena flos-aquae	N/R	N/R

[1] N/R indicates that the these tests were not reported.

2. Environmental Fate

a. Environmental Fate Assessment

Phorate itself is not persistent in the environment. It has been shown to degrade in soil by chemical and microbial action and to dissipate in the field with a $t_{1/2}$ of 2 - 15 days. It is moderately mobile in soil, and has been shown to migrate to a maximum depth of 6 inches in loamy sand and sandy loam soils. Additionally, phorate is subject to rapid hydrolysis with a $t_{1/2}$ of 3 days. Due to the limited migration and the rapid hydrolysis, phorate is not expected to pose a significant risk to ground water. While phorate contamination of surface water by surface runoff may be an acute problem, the rapid hydrolysis will tend to lessen the concentration in a relatively short period of time. Parent adsorption to permeable soils low in organic matter is low to moderate with Kds = 1.5 - 3.5. The anaerobic soil metabolism $t_{1/2}$ is 32 days. The aerobic aquatic metabolism in sediment $t_{1/2}$ of 2 - 6 weeks may indicate that phorate, if it reaches the sediment, will be more persistent in sediment than in the water column. However, phorate itself is not expected to persist long enough to reach the sediment, so no risk from the parent is anticipated to occur.

In contrast to phorate, the phorate degradates, phorate sulfoxide and phorate sulfone, are both more persistent and more mobile in the environment. The aerobic soil metabolism half-lives ($t_{1/2}$) for the sulfoxide and sulfone degradates are 65 and 137 days, respectively. The potential of these degradates to migrate in soil was demonstrated in a Georgia field dissipation study where they were found at depths of 12 - 18 inches. The potential for groundwater contamination by the degradates exists, although as of now neither of the degradates has been detected in the wells that have been sampled. It should be noted that, in general, the degradates have not been the focus of monitoring efforts. By analogy to the carbamate insecticide, aldicarb, which also has sulfoxide and sulfone degradates that have been detected in well samples, there are concerns that phorate degradates may contaminate ground water. The degradates, with a tendency to partition preferentially into water, may be available for runoff to surface water for a longer time period than phorate. As reported in the HED chapter, the sulfoxide degradate is slightly more toxic than the parent. Currently, there are no data for the other degradates, but the degradates containing the organophosphate moiety are expected to act similarily to the parent. Although there are no drinking water standards for phorate sulfoxide, there may be some risk associated with high runoff situations when drinking water intakes are downstream of runoff areas.

According to the Pesticides in Ground-Water Data Base, twelve samples have been analyzed for phorate sulfone and sulfoxide. There were no detections, but samples may have either been taken where no phorate had been applied or on non-vulnerable soils. The lack of degradate detection in 12 ground-water samples does not exclude the possibility of degradates in other areas. Monitoring data from the 12 samples do not provide valid evidence addressing the leaching potential of phorate sulfoxide or sulfone.

There is a greater possibility for ground-water contamination over a wide area from phorate degradates than for surface water contamination by parent and degradates. The probability of surface water contamination is dependent upon storm events shortly after application. In permeable soils low in OM, phorate degradate movement depends on the hydraulic gradient but, generally, degradates move to lower depths with soil water.

In the northern wheat growing states, fall applications of phorate appear especially hazardous for fish and wildlife. During the winter the topsoil and subsoil are frozen, and degradation is slow until spring thaws when phorate and degradates begin to move. Spring rains wash phorate and degradates into surface water ponds, lakes and streams, because there is no downward movement of phorate or degradates until the subsoil thaws.

b. Environmental Fate and Transport

(1) Degradation

Phorate degrades by hydrolysis at pH 5, 7, and 9 with half-lives of approximately 3 days (MRID 41348507) and by direct photolysis in water (pH7) with a half-life of one day(MRID 41348508). The aerobic (MRID 42459401; 41131112; 40077301) and anaerobic (MRID 41936002; 41936002; 40077302) soil metabolism half-lives in sandy loam soils were 3 and 32 days, respectively. The major degradates are the sulfoxide (t-1/2= 65 days aerobic soil) and sulfone (t-1/2= 137 days) which are more persistent than parent phorate.

(2) Mobility

Although phorate is moderately mobile in soil, rapid hydrolysis and aerobic soil metabolism of 3 days reduces the potential of parent phorate to reach ground water. However, the degradates sulfoxide and sulfone are more mobile and persistent, and also more likely to reach ground water. Laboratory Kd values for parent in loamy sand and sandy loam soils with 1% O.C. are 1.5 and 3.5, respectively, which indicate potential mobility in permeable soils; the Kd range is from 1.5 to 20 in a variety of soils. No major degradate Kds are available.

Sulfone degradate was mobile in aged soil columns of loamy sand and sandy loam soils and was uniformily distributed in the column. Sulfoxide was found in the leachate at 12% and 3 %, respectively, in loamy sand and sandy loam soils. Parent did not move below 6 inches in the column. Parent appears to be moderately mobile in most mineral soils, but the degradates are more mobile than parent. The order of mobility in soil is sulfoxide > sulfone > phorate.(MRID 42208201)

(3) Accumulation

The maximum accululation in edible fish was 326X. After 14 days depuration, approximately 90% of the residues were eliminated.(MRID 42701101)

(4) Field Dissipation

In general, phorate is not a persistent chemical; it degrades by chemical and microbial action and dissipates in the field with t-1/2 of 2 - 15 days. In a Georgia field dissipation study on sandy loam soil (MRID 42547701) parent did not move below 6 inches in soil, but the sulfoxide and sulfone leached to 18 inches. In an Illinois study on silt loam soil (MRID 70586500) a comparable half-life of 9 - 15 days was observed. No leaching of either the parent of degradates below 6 inches was observed. (MRID 70586500)

(5) Laboratory Volatility

Maximum volatility rates of 7.5 - 13.3 ug/cm^2/hr were observed at 3 days with corresponding maximum air concentrations of 530 - 1400 ug/m^3 from soil moistures of 50 and 75% FMC and flow rates of 100 and 300 mu/min. Phorate was 68 -71% of the applied material in the foam plug extracts at 14 days post treatment. Phorate sulfoxide was <5% in the foam plug extracts and phorate sulfone was present at <0.3%. In the soil extracts plus flask rinsates phorate was measured at 14.2 - 27.5% of the applied and the degradates, phorate sulfoxide and phorate sulfone, were measured at 3.1 - 6.4 and 0.7 - 4.5% respectively. (MRID 42930301)

(6) Spray Drift

Application of phorate is by soil incorporation of granules only.

c. Water Resources

(1) Ground Water

The environmental fate data suggest that phorate parent may leach to ground water under certain vulnerable conditions. When compared to several other pesticides (for example, atrazine and aldicarb), the predicted leaching potential of the parent appears relatively low. The degradates phorate sulfoxide and phorate sulfone are more persistent and mobile in soil than the parent (as is the case with aldicarb). Persistence data are available for phorate sulfoxide and phorate sulfone; the persistence of parent phorate is much less. Specific measurements of mobility (K_{ads}) are lacking for the degradates, but the degradates are more mobile than the parent. Thus, the degradates of phorate may have a greater leaching potential than the parent, especially when soils are coarse textured and organic carbon contents are low.

The available information is inadequate to assess exposure to phorate and phorate degradates on a national level. Only a limited amount of monitoring for phorate and even less for degradates has occurred. Therefore, several insecticides in addition to phorate are discussed here, because they are organophosphates (OPs) or have similar fate properties. This will provide additional insight concerning the potential of phorate to contaminate ground water.

Detections of phorate residues in ground water: A number of insecticides, including phorate, have been included as analytes in ground-water monitoring studies conducted by federal, state or local agencies and chemical companies. Many of these studies are summarized in the Pesticides in Ground Water Database (PGWDB) (Hoheisel et al., 1992). The PGWDB reports that parent phorate has not been detected in 3,341 ground-water samples summarized (Table 1), which is generally consistent with the results of the laboratory and field dissipation studies. There were no detections of the degradates phorate sulfone and sulfoxide in 12 samples and phoratoxon sulfone and phoratoxon sulfide in 9 samples collected in California (USEPA, 1992). However, the small number of degradate samples reported do not represent a significant body of data. Fate data indicate that the degradates would likely be detected in hydrogeologically vulnerable conditions if more extensive sampling were conducted.

No heath advisory, MCL, DWEL, or cancer group has been established for phorate or its degradates. However, since OPP has set the reference dose (RfD) as 0.0005 mg/kg/day, an estimated Drinking Water Equivalent Level (DWEL) can be calculated to be 17.5 μg/L (17.5 ppb). From this the lifetime Health Advisory (HAL) can be **estimated** as 3.5 μg/L (3.5 ppb). For some pesticides with toxic degradates -- aldicarb, for example -- the parent compound and the degradates have been included by the Office of Water in a proposed MCL for total residues. This is not the case for phorate. If in the future, a phorate HAL is established to include the toxic degradates, the likelihood of exceeding this level in ground water may increase.

A few limitations were noted in these ground-water monitoring studies and are briefly indicated. First, the degradates, with greater leaching potentials, were not considered in most of the studies. Second, the monitoring studies were designed for agricultural chemicals other than phorate. Therefore, phorate may not have been used where the studies were conducted. Other limitations include the analytical methods and detection limits that vary between studies and may not be adequate in all studies. Good Laboratory Practices (GLP) and quality control also may not have been used. A final consideration is that most of the monitoring studies did not include detailed hydrogeological investigations. Therefore, conclusions from these studies may be incorrect or impossible to confirm.

Distribution and concentrations of similar insecticides in ground water: The PGWDB (Hoheisel et al., 1992) summarizes the results of studies which included chlorpyrifos, fonofos, and terbufos, three widely used OP insecticides. Limitations for these studies are similar to those previously stated. Residues have been detected in ground water for these three insecticides (Table 1). Health advisory (HA) levels were exceeded for chlorpyrifos (apparently from the termiticide use) and terbufos. Eight of the 11 wells with terbufos detections (73%) exceeded the HA of 0.90 μg/L.

Table 1. Summary of number of wells sampled and with detections for phorate and a number of other insecticides and degradates. (Hoheisel et al., 1992).

Chemical / Degradates	Number of Wells		Percent with Detections
	Sampled	With Detections	
Chlorpyrifos	5398	32	0.59
TMP	237	0	0
Fonofos	4446	18	0.41
Phorate	3341	0	0
phorate sulfoxide	12	0	0
phorate sulfone	12	0	0
phoratoxon sulfide	9	0	0
Terbufos	4224	11	0.26
terbufos sulfone	13	0	0

Carbaryl	23753	106	0.41
Aldicarb	43786	3002	6.9
aldicarb sulfoxide	37652	5070	13.5
aldicarb sulfone	37593	4991	13.3

For comparison of leaching potential (not toxicity), two other widely used carbamate insecticides: carbaryl and aldicarb, were also considered. Carbaryl and aldicarb residues were detected in ground water (Table 1). Aldicarb residues exceeded the MCL of 10 μg/L in 2010 wells (4.6%). Aldicarb degradates: aldicarb sulfone and sulfoxide were also detected. It should be noted that the many of the wells with detections were in Florida and Long Island, New York, and were associated with studies conducted in areas vulnerable to ground-water contamination and with known aldicarb use (Wells and Waldman, 1991). Fenamiphos residues, from another OP with sulfone and sulfoxide degradates, have also recently been detected in ground water in Florida.

In spite of these limitations, some observations can be made. The concentrations at which the parent compounds of these OP insecticides (fonofos, chlorpyrifos, terbufos)have been detected in ground water are generally quite low, generally well below any established HA levels, and the frequency of detection is also low. An exception appears to be the termiticide use(not a registered phorate use) of chlorpyrifos which has resulted in higher concentrations. The degradates of phorate and the three OPs were often not included as analytes in the studies, although they tend to have greater leaching potentials. Therefore, the existing monitoring data provides little information confirming or disproving the leaching potential of phorate degradates and the resultant ground-water contamination. Because aldicarb and phorate insecticides both have sulfone and sulfoxide degradates, and aldicarb sulfone and sulfoxide degradates have been detected in ground water more frequently than parent aldicarb, we can assume that the phorate degradates may also have some potential to contaminate ground water. It is however also true that phorate residues appear to be generally less persistent than aldicarb residues. Maximum application rates for phorate and aldicarb are generally similar for corresponding uses. Phorate, chlorpyrifos, fonofos, and terbufos have similar maximum application rates for corn.

Comparative leaching assessment-modeling: The leaching potential of four OPs (chlorpyrifos, fonofos, phorate, and terbufos) insecticides used on corn and two other non-corn insecticides was evaluated by EFED using the Pesticide Root Zone Models (PRZM): PRZM-1 (Carsel et al., 1984) and PRZM-2 (Mullins et al., 1992), in the corn insecticide cluster analysis. At least one of the non-corn insecticides (aldicarb) is known to leach under some environmental conditions simulated in these modeling scenarios.

Model inputs included environmental fate data, properties of several different soil series, and more than 30 years of meteorological data from each of three corn-growing regions.

Modeling results indicated that while all of the chemicals have the potential to leach into ground water under certain conditions, the leaching potentials of the four corn **parent** insecticides are low. Of the four, fonofos **parent** had the greatest simulated leaching potential, followed by terbufos, phorate, and chlorpyrifos parent compounds. The simulated leaching potentials of the OPs were considerably less than aldicarb, the comparison insecticide which is known to leach. Although PRZM-2 can consider degradates, they were not included in the cluster assessment because of incomplete environmental fate data for several of the degradates.

It is important to recognize the limitations and restrictions in the computer models before evaluating the results (for more detail see the corn cluster report). Computer models currently available are not capable of predicting quantitatively the concentration (or amount) of a pesticide transported to ground water. Therefore these models should only be used to qualitatively compare the relative leaching potentials or amounts of pesticides leached below a specified depth.

(2) Surface Water

Substantial fractions of applied phorate could be available for runoff for several days to weeks post-application (aerobic soil metabolism half-life of < 3 days; terrestrial field dissipation half-lives of 2 days, 9-15 days and 12 days). The relatively low soil/water partitioning of phorate (K_{oc}s of 450, 512, 705, and 505; K_ds of 1.5, 7.5, 20, and 3.2) indicate that most granule released phorate runoff will be via dissolution in runoff water as opposed to adsorption to eroding soil. Although the concentration may be a little greater in the eroding soil than in runoff water, the mass of runoff water is generally much greater than the mass of eroding soil. Granules containing phorate may also be carried to surface water by runoff.

The susceptibility of phorate to hydrolysis (half-lives of 2.6, 3.2, and 3.9 days at pHs 5, 7, and 9, respectively), direct photolysis (irradiated half-life of 1 day compared to dark control half-life of 2.7 days), and aerobic metabolism indicate that phorate will probably not be very persistent in the water column, even in waters with long hydrological residence times. However, a lower susceptibility to anaerobic metabolism (anaerobic soil metabolism half-life of 32 days) than to aerobic metabolism and half-lives in the sediment of aerobic aquatic metabolism studies of 2-4 weeks and 6 weeks indicate that phorate will be more persistent in sediment than in the water column. Consequently, some of the phorate dissipated in the water column may be replenished by desorption from the sediment.

Although K_d values > 1 indicate that phorate concentrations adsorbed to suspended and bottom sediment will probably be somewhat greater than concentrations dissolved in sediment pore water and in the water column, its relatively low soil/water partitioning indicates it will readily partition into water. Reported BCFs for the bluegill sunfish of 326X, 816X, and 483X for edible tissue, non-edible tissue, and the whole fish, respectively indicate that the bioaccumulation potential of phorate is not sufficient to be of concern.

The major degradates of phorate in terrestrial field dissipation studies were the sulfoxide and sulfone degradates. The extent of vertical movement of those degradates in terrestrial field dissipation studies suggest they may be somewhat more persistent and mobile than phorate. Consequently their tendency to partition into water may be somewhat greater than phorate, and in poorly draining soils (that would inhibit vertical transport), significant fractions may be available for runoff somewhat longer than phorate.

Surface Water Monitoring and Modeling

Approximately 11,700 samples were recently listed for phorate in the STORET database. Approximately 10% of the samples had detections above detection limits which varied below 1 ug/L. Detected concentrations ranged from 0.001 to 1 ug/L.

The State of Illinois (Moyer and Cross 1990) sampled 30 surface water sites for pesticides at various times from October 1985 through October 1988. Although substantial use in Illinois was a criteria for pesticides being included in the analyses, total phorate was not detected in any of the samples above a detection limit of 0.05 ug/L.

The USGS (Coupe etal 1995) sampled 8 widely dispersed locations in the Mississippi Basin from April 1991 through September 1992. Samples were collected once per week, twice per week, or once every two weeks depending upon the time of year. The samples were filtered before analysis. Phorate (dissolved) was not detected above a detection limit of 0.011 ug/L in any of the 360 samples for which an analysis for phorate was performed.

The USGS (Kimbrough and Litke 1995) collected samples from each of two Colorado watersheds (one agricultural and one urban) at least monthly from April 1993 through March 1994. Samples were collected more frequently in late spring and early summer. A total of 25 samples were collected from each watershed. Phorate was detected above a method reporting limit of 0.02 ug/L in 2 of the samples collected from the agricultural watershed at concentrations of 0.08 ug/L to 0.60 ug/L. Phorate was not detected in any of the samples collected from the urban watershed.

The South Florida Water Management District (Miles and Pfeuffer 1994) collected samples every two to three months from 27 surface water sites within the SFWMD from November 1988 through November 1993. Approximately 810 samples (30 sampling intervals X 27 sites sampled/interval) were collected from the 27 sites from November 1988 through November 1993. Phorate was not detected in any of the samples above detection limits ranging from 0.016 to 0.13 ug/L.

Refined surface water modeling was performed by Ron Parker for phorate use on cotton, corn, peanuts, sugarcane, soybeans, sugar beets, sorgum, potatoes, wheat, and beans. In each case, a reasonable high runoff 10 ha site draining to an adjacent 1 ha 2 meter deep pond was simulated over 36 years using PRZM 2.3 and EXAMS II. One in 10 year maximum peak, 96-hour average, 21-day average, 60-day average and 90-day average concentrations are listed for the various sites in the attached table. Details concerning the geographical and soil characteristics of the sites are discussed in the modeling report. Ranges of one in 10 year EECs were peak: 1.3 to 16 ug/L, 96-hour average: 0.8 to 10 ug/L, 21-day average: 0.3 to 4.1 ug/L, 60-day average: 0.1 to 1.9 ug/L, 90-day average: 0.1 to 1.3 ug/L.

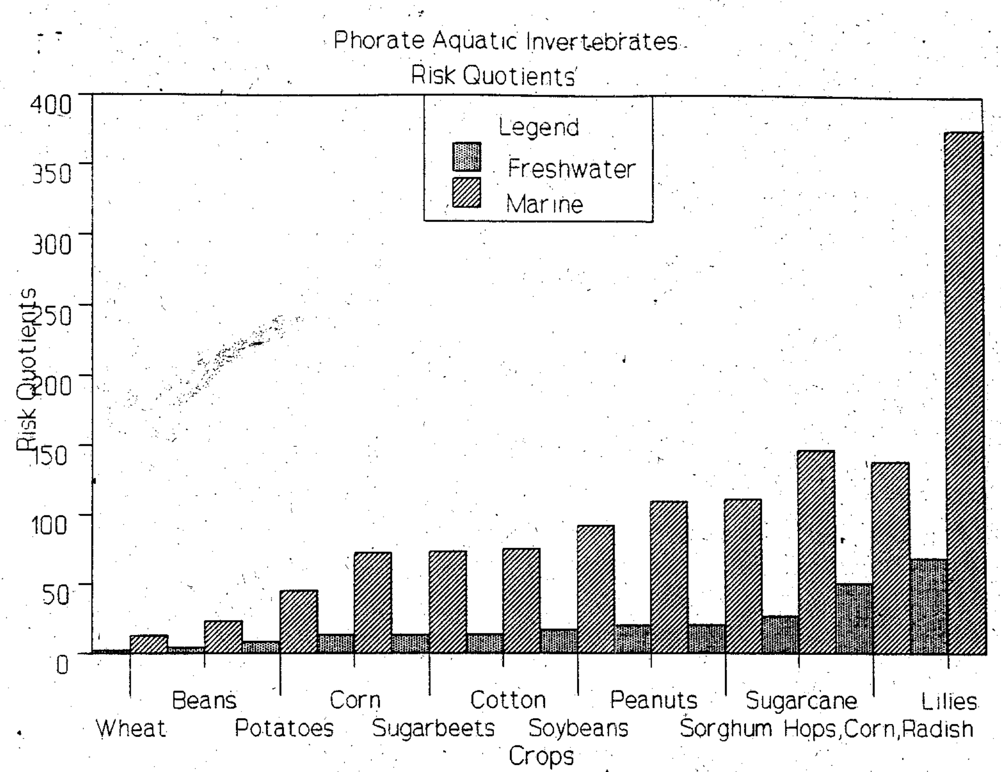
The one in 10 year sub-ppb to several ppb computer estimated EECs for stagnant edge of the field ponds may be reasonable upper bound estimates of actual concentrations in farm ponds and can serve as screening levels for other types of surface water in which the concentrations are probably generally substantially lower (such as the detected concentrations of several ppt to several hundred ppt in flowing water).

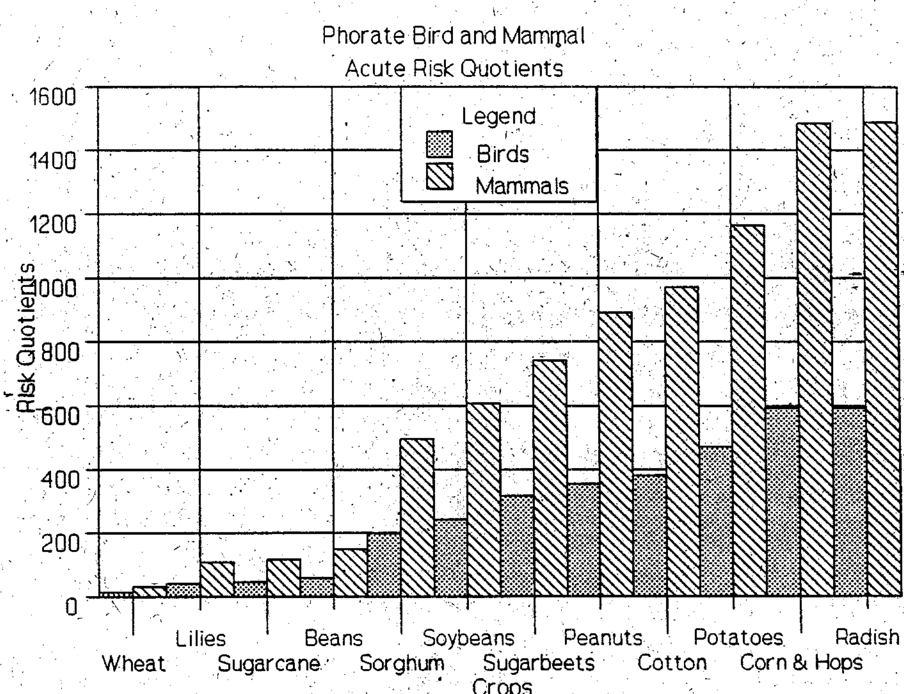
3. Exposure and Risk Characterization

Summary

Phorate risk quotients exceed EFED's level of concern to wild fauna (terrestrial and aquatic) for all crops (beans, corn, cotton, hops, radish, peanuts, field grown lilies and daffodils, potatoes, sorghum, soybeans, sugarbeets, sugarcane, and wheat). More importantly, field studies and incidents have shown that the risk quotient index predictions of adverse effects were correct. The available data are not sufficient to scientifically discriminate the risk between use sites.

The following are two charts showing aquatic invertebrate (both daphnids and shrimp) and birds and mammals risk quotients for each crop.


Phorate Aquatic Invertebrates
Risk Quotients
Legend
Freshwater
Marine
Risk Quotients
400
350
300
250
200
150
100
50
0
Beans
Corn
Cotton
Peanuts
Sugarcane
Lilies
Wheat
Potatoes
Sugarbeets
Soybeans
Sorghum
Hops,Corn,Radish
Crops


Phorate Bird and Mammal
Acute Risk Quotients
Legend
Birds
Mammals
Risk Quotients
1600
1400
1200
1000
800
600
400
200
0
Lilies
Beans
Soybeans
Peanuts
Potatoes
Radish
Wheat
Sugarcane
Sorghum
Sugarbeets
Cotton
Corn & Hops
Crops

When considering risk quotients in the above graphs it is important to note that they all exceed the LOC of 0.5 by a wide margin. Secondly, use site comparisons should be considered as qualitative and not quantitative because the functional relationship between the laboratory data and the effects in the field have not been established. It is likely that many different variables will affect the ability of a toxicant to express toxicity in the field. Therefore, it is not likely that the risk is directly related to the application rate alone. However, in general, more risk is expected the higher the risk quotient.

a. Ecological Exposure and Risk Characterization

Risk Quotients (RQs) and the Levels of Concern (LOCs):

Risk characterization integrates the results of the exposure and toxicity data to evaluate the likelihood of adverse ecological effects. The means of integrating the results of exposure and toxicity data is called the quotient method. For this method, risk quotients are calculated by dividing exposure estimates by toxicity values, both acute and chronic. Notice that this method of characterizing risk does not determine the probability of the occurrence of an adverse event.

$$\text{RISK QUOTIENT} = \frac{\text{EXPOSURE}}{\text{TOXICITY}}$$

Risk quotients are then compared to OPP established levels of concern. These LOCs are criteria used by OPP to indicate potential risk to nontarget organisms and the need to consider regulatory action. More specifically, the criteria indicate that a pesticide, when used as directed, has the potential to cause adverse effects on nontarget organisms. LOCs currently address the following risk presumption categories:

o **acute high risk** - potential for acute risk is high; regulatory action may be warranted in addition to restricted use classification
o **acute restricted use** - the potential for acute risk is high, but this may be mitigated through restricted use classification
o **acute endangered species** - the potential for acute risk to endangered species is high; regulatory action may be warranted
o **chronic risk** - the potential for chronic risk is high; regulatory action may be warranted

Currently, EFED has no procedures for assessing chronic risk to plants, acute or chronic risks to nontarget insects, or chronic risk from granular/bait formulations to mammalian or avian species.

The toxicity test values (i.e., measurement endpoints) used in the acute and chronic risk quotients are derived from the results of required studies. Examples of toxicity values derived from the results of short-term laboratory studies which assess acute effects are:

- LC_{50} (fish and amphibians; birds)
- LD_{50} (birds and mammals)
- EC_{50} (aquatic plants and invertebrates)
- EC_{25} (terrestrial plants)
- EC_{05} or NOEC (endangered plants)

Examples of toxicity test effect levels derived from the results of long-term laboratory studies which assess chronic effects are:

- LOEC (birds, fish, and aquatic invertebrates)
- NOEC (birds, fish and aquatic invertebrates)
- MATC (fish and aquatic invertebrates)

Generally, for birds, reptiles and mammals, the NOEC value is used as the toxicity test value in assessing chronic effects. Other values may be used when justified. Generally, the MATC (defined as the geometric mean of the NOEC and LOEC) is used as the toxicity test value in assessing chronic effects to fish and amphibians and aquatic invertebrates. However, if the measurement end point is production or survivability then the NOEC is used.

Risk presumptions, along with the corresponding risk quotients and levels of concern, are tabulated below.

RISK PRESUMPTION	RISK QUOTIENT	LEVEL OF CONCERN
Birds and Reptiles		
Acute High Risk	EEC^1/LC_{50} or $LD_{50}/sqft^2$ or LD_{50}/day^3	0.5
Acute Restricted Use	EEC/LC_{50} or $LD_{50}/sqft$ or LD_{50}/day (or $LD_{50} < 50$ mg/kg)	0.2
Acute Endangered Species	EEC/LC_{50} or LD50/sqft LD_{50}/day	0.1
Chronic Risk	EEC/NOEC	1
Wild Mammals		
Acute High Risk	EEC/LC_{50} or LD50/sqft or LD_{50}/day	0.5
Acute Restricted Use	EEC/LC_{50} or $LD_{50}/sqft$ or LD_{50}/day (or $LD_{50} < 50$ mg/kg)	0.2
Acute Endangered Species	EEC/LC_{50} or LD50/sqft or LD_{50}/day	0.1
Chronic Risk	EEC/NOEC	1

1. abbreviation for Estimated Environmental Concentration; designated ppm in avian/mammalian food items

2. $\frac{mg/ft^2}{LD_{50} * \text{wt. of bird}}$ 3. $\frac{\text{mg of toxicant consumed/day}}{LD_{50} * \text{wt. of bird}}$

Aquatic Animals

RISK PRESUMPTION	RISK QUOTIENT	LEVEL OF CONCERN
Acute High Risk	EEC^1/LC_{50} or EC_{50}	0.5
Acute Restricted Use	EEC/LC_{50} or EC_{50}	0.1
Acute Endangered Species	EEC/LC_{50} or EC_{50}	0.05
Chronic Risk	EEC/MATC or NOEC	1

1 abbreviation for Estimated Environmental Concentration; designated ppb/ppm in water

Plants

RISK PRESUMPTION	RISK QUOTIENT	LEVEL OF CONCERN
Terrestrial and Semi-Aquatic Plants		
Acute High Risk	EEC^1/EC_{25}	1
Acute Endangered Species	EEC/EC_{05} or NOEC	1

Aquatic Plants		
Acute High Risk	EEC^2/EC_{50}	1
Acute Endangered Species	EEC/EC_{05} or NOEC	1

[1] abbreviation for Estimated Environmental Concentration; designated lb ai/A

[2] abbreviation for Estimated Environmental Concentration; designated ppb/ppm in water

(1) Risk to Nontarget Terrestrial Animals

(a) Limitations and Uncertainities

A variety of uncertainties and limitations are associated with estimating toxicity values and terrestrial exposure. When integrated with other information, toxicity data are useful in evaluating the effects of pesticides on nontarget species and for providing insight into a pesticide's potential to affect nontarget organisms. However, there are limitations to this utility. Laboratory tests are standardized to allow comparisons of results. These idealized test methods do not show the effects of natural biological variables that can greatly influence toxicity under field conditions, such as exposure duration, sex, age, nutritional status, diet, size, activity periods, seasonal variation in temperature and breeding conditions, and other physiological and behavioral variables. To establish the functional relationship between laboratory toxicity data and toxicological hazard in the field environment requires a greater understanding of ecological interactions.

In addition to the uncertainties associated with extrapolating laboratory data to the field, laboratory results themselves must be interpreted cautiously. Results from individual tests represent only a point estimate of the toxicity of a compound. Replicated tests should be conducted (Stephan, 1977) to determine if a test can produce the same results under the same conditions, i.e. the precision of the estimated median lethal dose or concentration (Stephan, 1977). Replicate tests have shown as much as a several-fold difference in results with the same species and chemical under similar conditions (Hill et al., 1975) in the laboratory.

Further uncertainty is introduced when extrapolating from one species to another. The large majority of laboratory data for birds are collected for the northern bobwhite quail and mallard duck, but the sensitivity of these species relative to other species is usually unknown. Hill (1993) reported that the median multiplication factor comparing the high to low LD_{50} values across seven species for 10 pesticides within a single laboratory was 15X.

Because of these uncertainties maximum application rates and near maximum estimated environmental concentrations are used to insure minimum risk when the risk quotients indicate minimum risk.

(b) Birds and Reptiles

Liquid insecticides contaminate wildlife food sources. Hence the estimated environmental concentration can be compared to the dietary LC50 value. Granular formulations requires a different approach. Birds and reptiles may be exposed to granular pesticides by ingesting granules when foraging for food or grit. They also may be exposed by other routes, such as by walking on exposed granules or drinking water contaminated by granules. The number of lethal doses ($LD_{50}s$) that are available within one square foot immediately after application ($LD_{50}s/ft^2$) is used as the risk quotient for granular/bait products. Risk quotients are calculated for three separate weight class of birds: 1000 g (e.g. waterfowl), 180 g (e.g. upland gamebird) and 50 g (e.g. songbird). The following paragraphs from the Draft Corn Insecticide Cluster Analysis, April 25, 1996 relate the rational for the $LD50/ft^2$ approach:

The size range of pesticide granules overlaps that of grit and many seeds (U.S. EPA, 1980). Consequently, particularly birds, feeding in fields treated with granular pesticides can consume granules that are mistaken for grit or seed. They also may consume granules by ingesting prey organisms that have consumed granules, or by ingesting prey (e.g., earthworms) to which granules may adhere.

Consumption of granules depends on their availability, bird behavior, characteristics of grit/granules preferred by birds, and grit/granule retention in the gizzard (Best and Fischer, 1992). Exposure of nontarget organisms, particularly birds, to pesticide granules is assumed to be related to the application rate and number of granules present on or near the soil surface. The quantity of pesticide near the ground surface after application, in a unit area -- typically, one square foot is used to estimate terrestrial exposure to pesticide granules. Support for this approach can be found in the literature. DeWitt (1966), after conducting a quail field study, concluded, "Losses of birds may be expected if the quantity of toxicant per square foot equals or exceeds the quantity causing deaths of quail in short term feeding tests." Additional support is provided by Tucker, who has reported that "field kills have happened in many instances when the amount of toxicant per acre exceeded 50,000 mallard $LD_{50}s$ (assuming 1 kg mallard body weight).

All application methods for granular formulations will result in the presence of some granules at or near the soil surface, where they are accessible to foraging wildlife. Both band and in-furrow application of granular pesticides using conventional commercial application equipment result in exposed granules on the soil surface. In a laboratory soil study using a variety of incorporation techniques and several models of planters operated at different speeds, Hummel (1983) found granule incorporation ranged from 69% to 96% for band application, and generally 99% for in-furrow application. Erbach and Tollefson (1983) found that an average of 15.% of the granules remained visible when no incorporation other than a press wheel was used.

The percentage of visible granules presented above probably underestimates the actual number of granules remaining, because granule counts were within rows and did not include row ends. Also, the fluorescent techniques used to observe granules were not 100% efficient, and thus did not allow the identification of all granules (Tollefson 1979). In addition, the number of granules found in turn areas at row ends (where application equipment is raised from the soil) would be considerably higher than along row areas where granules are incorporated.

Based on the foregoing studies, the following percentages of granules exposed with different application techniques were chosen for use in the risk assessment (Table 12.1):

TABLE 12.1: Percentage of pesticide granules remaining exposed after application (all crops)

APPLICATION METHODS	% UNINCORPORATED
Preplant broadcast	15
In-furrow, drill, shank	1
T-band or band (applied over emerged plants, incorporated, or in front of the press wheel)	15
Post-plant/at-cultivation (band)	15

The acute risk quotients for broadcast applications with no incorporation of granular products (Table 13) and with banded and in-furrow incorporation (Table 14) are tabulated below.

Table 13: Avian Risk Quotients for Granular Products (Broadcast , No Incorporation)

Site/Method Lbs (ai/A)	%(decimal) of Unincorporated Pesticide	Body Weight (g)	LD_{50} (mg/kg)	Acute RQ[1] (LD_{50}/ft^2)
Corn and Hops				
3	1.0	50	1.0	624.0
3	1.0	180	7.0	24.8
3	1.0	1000	0.62	50.3
Corn, Sorghum and Wheat				
1	1.0	50	1.0	208.0
1	1.0	180	7.0	8.3
1	1.0	1000	0.62	16.8
Sugarbeets				
1.6	1.0	50	1.0	332.8
1.6	1.0	180	7.0	13.2
1.6	1.0	1000	0.62	26.8

[1] The equation for the RQ is:

$$\frac{\text{App. Rate (lbs a.i./A)} * (453{,}590 \text{ mg/lb}/43{,}560 \text{ ft}^2/\text{A})}{LD_{50} \text{ mg/kg} * \text{Weight of Animal (g)} * 1000 \text{ g/kg}}$$

The results indicate that for broadcast applications of granular products with no incorporation, avian acute high risk, restricted use, and endangered species levels of concern are all exceeded.

The acute risk quotients for banded or in-furrow applications of granular products are tabulated below.

Table 14: Avian Acute Risk Quotients for Granular Products (Banded or In-furrow)

Site/Method		Bird Type & Body Weight (grams)	% (dec.) of Phorate Unincorp.	Exposed mg/ft[2]	LD_{50} (mg/kg)	Acute RQ[1] (LD_{50}/Ft^2)
Band Width	Oz.a.i./1000 ft of row					
Beans (soil band)						
0.17	1.875	Songbird (50)	0.01	3.13	1.0	62.6
0.17	1.875	Upland Gamebird (180)	0.01	3.13	7.0	2.5
0.17	1.875	Waterfowl (1000)	0.01	3.13	0.62	5.0
Corn (Banded over the Row at planting) Sorghum (soil band)						
0.6	1.2	Songbird (50)	0.15	8.50	1.0	170.0
0.6	1.2	Upland Gamebird (180)	0.15	8.50	7.0	6.7
0.6	1.2	Waterfowl (1000)	0.15	8.50	0.62	13.7
Cotton (soil sidedress treatment incorporated)						
0.5	2.4	Songbird (50)	0.15	20.41	1.0	408.2
0.5	2.4	Upland Gamebird (180)	0.15	20.41	7.0	16.2
0.5	2.4	Waterfowl (1000)	0.15	20.41	0.62	32.9
Filed Grown Lilies and Daffodils[2]						
1	4.7	Songbird (50)	0.01	1.33	1.0	26.6
1	4.7	Upland Gamebird (180)	0.01	1.33	7.0	1.1
1	4.7	Waterfowl (1000)	0.01	1.33	0.62	2.1

Table 14: Avian Acute Risk Quotients for Granular Products (Banded or In-furrow)

Site/Method: Band Width	Site/Method: Oz.a.i./1000 ft of row	Bird Type & Body Weight (grams)	% (dec.) of Phorate Unincorp.	Exposed mg/ft[2]	LD_{50} (mg/kg)	Acute RQ[1] (LD_{50}/Ft^2)
Peanuts (Soil band, at pegging)						
0.5	2.2	Songbird (50)	0.15	18.71	1.0	374.2
0.5	2.2	Upland Gamebird (180)	0.105	13.10	7.0	10.4
0.5	2.2	Waterfowl (1000)	0.15	18.71	0.62	30.2
Potato, White/Irish (Soil band)						
0.6	3.5	Songbird (50)	0.15	24.81	1.0	496.2
0.6	3.5	Upland Gamebird (180)	0.15	24.81	7.0	19.7
0.6	3.5	Waterfowl (1000)	0.15	24.81	0.62	40.0
Radish (soil sidedress)						
0.17	1.25	Songbird (50)	0.15	31.27	1.0	625.4
0.17	1.25	Upland Gamebird (180)	0.15	31.27	7.0	24.8
0.17	1.25	Waterfowl (1000)	0.15	31.27	0.62	50.4
Soybeans (Soil band)						
0.6	1.8	Songbird (50)	0.15	12.76	1.0	255.2
0.6	1.8	Upland Gamebird (180)	0.15	12.76	7.0	10.1
0.6	1.8	Waterfowl (1000)	0.15	12.76	0.62	20.6
Sugar beets[3]						

Table 14: Avian Acute Risk Quotients for Granular Products (Banded or In-furrow)

Site/Method		Bird Type & Body Weight (grams)	% (dec.) of Phorate Unincorp.	Exposed mg/ft[2]	LD_{50} (mg/kg)	Acute RQ[1] (LD_{50}/Ft^2)
Band Width	Oz.a.i./1000 ft of row					
0.8	0.9	Songbird (50)	0.15	4.78	1.0	95.6
0.8	0.9	Upland Gamebird (180)	0.15	4.78	7.0	3.8
0.8	0.9	Waterfowl (1000)	0.15	4.78	0.62	7.7
Sugarcane						
1	8.6	Songbird (50)	0.01	2.44	1.0	48.8
1	8.6	Upland Gamebird (180)	0.01	2.44	7.0	1.9
1	8.6	Waterfowl (1000)	0.01	2.44	0.62	3.9
Wheat (Soil in-furrow)						
0.1	0.24	Songbird (50)	0.01	0.68	1.0	13.6
0.1	0.24	Upland Gamebird (180)	0.01	0.68	7.0	0.5
0.1	0.24	Waterfowl (1000)	0.01	0.68	0.62	1.1

[1] The equation for the RQ is:

$$\frac{\text{oz. a.i. per 1000 ft.} * 28349\ \text{mg/oz} * \%\ \text{Unincorporated} / \text{bandwidth (ft)} * 1000\ \text{ft}}{\text{LD50(mg/kg)} * \text{Weight of the Animal (g)} * 1000\ \text{(g/kg)}}$$

[2] The equation used to calculate the number of ounces per 1000 foot of row from 8 pounds per acre rate is shown below:

$$\text{Oz. a.i./1000 ft of row} * (43.56\ \text{feet/row spacing}) = \text{Lbs/A}$$

[3] This is a post-emergence application. This scenario assumes every row was two plants wide, the post-treatment was foliar, and the band extended from the outside of one plant to the outside edge of the other plant or a 14 inch band was used. Based on the label, this use was not soil incorporated.

The results indicate that for banded and in-furrow applications of granular products, avian acute high risk, restricted use, and endangered species levels of concern are all exceeded. The risk quotient appear to separate into two groups those 95 and above and those 62 and below. However, this does not relate to the method of application. Also it should be noted that phorate can be phytotoxic. The labeling carries the following warnings:

1. Beans - Do not place Phorate 20G granules in direct contact with seed at planting time.

2. Field corn, Sorghum, Soybeans, Sugarbeets - Do not place Phorate 20G granules in direct contact with seed.

3. Do not apply in-furrow or allow to come in direct contact with the seed.

4. Do not allow granules to contact the seed piece.

5. Do not use on Diakon radish varieties.

The phytotoxicity and label warnings would appear to rule out in-furrow as a risk reduction measure for most crops. Sugarcane and wheat appear to be the only two in-furrow crops at the present time. As shown in the table above sugarcane and wheat risk quotients are 48.8 and 13.6, respectively. Wheat is the lowest of all the banded and in-furrow applications. Therefore the lowest risk quotient is 27.2 times the level of concern.

The number of granules per square foot and number of granules a bird needs to ingest exceed the lowest LD_{50} dose are reported below for the 20 G product when used on corn.

Table 15: Estimated Number of Granules per Square Foot and Number of Granules per LD_{50} Index for Corn at Plant (Corn Cluster document)

Pesticide	Formulation[1]	Granule Wt.[1]	Range of Granule Wt.[1]	App. Rate[2]	Band Width[2]	Percent Unincorporated[5]	Amount of Active Ingredient Exposed[3]	No. of Exposed Granules[4]	No. of Granules/ LD_{50}[6,7]
	(%AI/100)	(mg)	(mg)	(oz/1000 ft of row)	(ft)	(decimal)	(mg/ft²)	(/ft²)	(granules)
Chlorpyrifos	0.15	0.064	0.062-0.078	2.4	0.6	0.15	17.01	1,771.88	28.9
	0.15	0.064	0.062-0.078	2.4	0.1	0.01	6.80	708.33	28.9
Fonofos[8]	0.20	0.197	0.184-0.560	4.8	0.6	0.15	34.02	863.45	13.4
	0.10	0.197	0.184-0.560	4.8	0.6	0.15	34.02	1,726.90	26.7
Phorate	**0.20**	**0.085**	**0.067-0.143**	**1.2**	**0.6**	**0.15**	**8.50**	**500.00**	**3.1**
	0.15	**0.085**	**0.067-0.143**	**1.2**	**0.6**	**0.15**	**8.50**	**666.67**	**4.1**
Terbufos	0.20	0.85	0.056-0.080	1.2	0.6	0.15	8.50	50.00	4.6
	0.20	0.85	0.056-0.080	1.2	0.1	0.01	3.40	20.00	4.6
	0.15	0.066	0.056-0.080	1.2	0.6	0.15	8.50	858.59	79.7
	0.15	0.066	0.056-0.080	1.2	0.1	0.01	3.40	343.43	79.7

[1] Granule weights were obtained from Hill and Camardese, 1984, except the for terbufos 20% product which was provides by the company.

[2] Rates are from BEAD,(D.Brassard's June 25th memorandum entitled: "Transmittal of Corn Cluster Use Information for EFED Risk Assessment").

[3] Amount of pesticide exposed (mg/ft²) was calculated with the following formula:

[(oz a.i./1000 ft of row)*(28349 mg/oz conversion factor)]/[1000 ft of row * bandwidth (ft)] * [0.15 % unincorporated]

[4] Number of exposed granules per square foot was determined by the following formula:

(mg of a.i./ft² exposed / percent a.i. of the product) / dividing the that by the weight of the granule.

[5] Based on the rationale from the "Comparative Analysis of Acute Avian Risk from Granular Pesticides (1992) which indicates that 85% of the granules are incorporated.

[6] Number of granules per LD_{50} was calculated with the following formula:

$[(LD_{50} * \text{bird weight})] / [(\%a.i./100) * \text{granule weight}]$

[7] The species with the lowest LD_{50} was used in this calculation. They were: house sparrow, red-winged blackbird, and bobwhite quail for chlorpyrifos, fonofos, phorate, and terbufos, respectively. Unlike the other chemicals, for terbufos the only available LD_{50} was for bobwhite quail. The smaller weight of passerine species increases the risk ratio. Therefore, to adjust for this, the weight of the red-winged blackbird was used with the bobwhite quail LD_{50} value to estimate an LD_{50} for red-winged blackbird.

[8] The weight of the 10% product was not available for fonofos. Hence the weight for the 20% product was used in these calculations.

Phorate granules are more hazardous than similar granular pesticides for the following reasons:

1. Only 3 or 4 granules are necessary to equal the lethal dose. These calculations are supported by Balcomb et al. (1984). He gave red-winged blackbirds 1, 5, and 10 granules of of Thimet 15G at 5 granules 60% of the birds died and at 10 granules 80% of the birds died.

2. The number of granules per square foot is relatively high (500 to 667 granules per sq. ft.) considering the few granules needed to be fatal.

Birds are more likely to ingest an amount equal to an LD_{50} because to ingest 3 or 4 granules does not have to be intentional (i.e., when a bird is collecting grit). Birds feeding on ground insects or grubs brought to the soil surface by the planting and application process may ingest 3 or 4 granules inadvertently stuck to an insect or grub.

Field studies further confirm the expected risk by demonstrating that phorate can kill birds and mammals. For example, phorate has poisoned animals as large as a raccoon, indicating that phorate poses a risk to large, as well as, small animals. This also suggests a high risk of secondary poisoning, the poisoning of animals from feeding on other poisoned animals.

Simulated field studies, as discussed in the ecological toxicity data section, confirm the toxicity and exposure estimates. They also suggest that contaminated water may be a route of exposure. All four bobwhite quail pen studies show mortality, even though quail are not the most sensitive species based on the LD_{50} studies. Mallard duck, red-winged blackbird, and common grackle are all more sensitive. Both whorl and soil application resulted in adverse effects. There is additional exposure to birds in the turn row areas, increasing the overall risk to birds. At the rate of 6 oz per 1000 row feet, 71 granules per square foot were found in the row, while over twice that many were found in the turn rows (150 granules per square foot).

Bird kill incidents show that phorate is indiscriminate in its ability to cause adverse effects. Songbirds, waterfowl, shorebirds, upland game, and mammals are all associated with these incidents. Large birds such as geese, ducks, and eagles as well as small birds such as robins and curlews have shown effects. It appears that the amount of pesticide available after application is more than sufficient to cause mortality, regardless of the size of the animal. In addition, risk is not limited to any particular feeding habit or ecological niche, and multiple routes of exposure (i.e., ingestion, dermal, and inhalation) are suspected. Although the environmental fate data would indicate parent phorate is relatively short-lived, several incidents indicate sufficient phorate and/or its degradates were available after several months to cause bird kills. In addition, incidents have occurred with carnivores, such as eagles, owls, hawks, opossums, and skunks.

In addition to the risk to terrestrial wildlife, phorate can be expected to kill aquatic invertebrates, Dieter et al. (1995) indicated that amphipods and chironomids were affected for 1 month at applications rates as low as 1 pound per acre. These are an important food source for waterfowl. Dieter et al. (1995) explains the effect on waterfowl as follows:

> In the Prairie Pothole Region [South Dakota], insecticides are applied sporadically, and acute toxic effects on aquatic macroinvertebrates may be followed by subsequent adverse effects of feeding ducks at critical life stages. Pesticide induced reduction of macroinvertebrate abundance has resulted in abandonment of nests, reduced survival of young, and caused emigration of ducks (Grue et al. 1986). Hunter et al. (1984) reported decreased growth rates of American black ducks and mallard ducklings in response to a decrease in wetland macroinvertebrates after application of carbaryl. In North Dakota, fewer duck broods used wetlands treated with carbaryl than controls (McEwen, et al. 1964), and carbaryl is less toxic than phorate to aquatic macroinvertebrates. (Smith, 1987). The amounts of phorate adsorbed by aquatic macroinvertebrates is unknown, but major food items of ducklings are obtained from within the water column or from wetland sediments and would probably contain high concentrations of phorate or its metabolites.

Based on this, it is likely that both acute toxic poisoning will occur and waterfowl food resources will be reduced from applications of phorate in wetland areas. Reduced food can result in abandonment of nests, reduced survival of young, and cause emigration of ducks.

Also, similar organophosphates have shown bioaccumulation which may make amphibians poisonous to birds. Hall and Kolbe (1980) demonstrated this by feeding tadpoles raised in parathion contaminated water to mallard ducklings. The tadpoles proved to be fatal to the ducklings. Bioaccumulation factors (BCF) for parathion and phorate are similar. Phorate BCF for whole fish is 483X, which is very similar to parathion BCF which for whole body is 430X. Therefore, there is the potential of secondary poisoning for birds which feed on phorate tolerant species.

Dermal exposure may play an important role in poisoning. Human incidents suggest dermal and inhalation poisoning is likely. These incidents usually do not involve oral exposure. The victims are usually handling the product, i.e. loaders and applicators. Toxicity data show dermal and oral toxicity are similar. If mammals are a surrogate for birds (oral LD50=0.62 mg/kg) the mammal dermal LD50 is nearly the same as the oral LD50, 3.9 and 1.4 mg/kg, respectively. It highly likely that where phorate contacts the skin it will be absorbed. For many birds the skin shows under the wing where the wing meets the body. Under the wing tests with parathion revealed dermal toxicity results that were very similar the oral toxicity results (Schafer et al. 1973). An example of typical bird behavior where dermal exposure is likely would be birds dusting themselves. However, Hudson et al. (1984) performed a 24 hour percutaneous LD50 with 1 year old mallard hens and the 88% technical product. This dermal foot treatment indicated that through this route of exposure LD50 was only 203 mg/kg which is in the moderately toxic range. Therefore, dermal exposure may or may not contribute to the total avian exposure picture. The exposed skin under the wing may be more likely to absorp the chemical that the feet. The two tissues are very different and dermal exposure can be discounted at this time.

Although risk quotients for chronic/reproductive effects have not been developed the following list of items indicate there is a potential for adverse effects.

1. Many routes of exposure are expected. Ingestion of granules is not the only method of poisoning. For the pesticide to adequately protect corn from pests such as grubs and nematodes, the pesticide must saturate the area between granules. Because the pesticide is expected to migrate out of the granule to cover the area between the granules, bird food items and water are expected to be contaminated. Also prey animals are expected to retain sufficient phorate and/or degradates to turn themselves into a poisonous bait.

Bird preening after dusting themselves is another route of exposure. Human incidents suggest dermal poisoning is likely. Toxicity data supports this approach. If mammals are a surrogate for birds (oral LD50=0.62 mg/kg) the mammal dermal LD50 is nearly the same as the oral LD50, 3.9 and 1.4 mg/kg, respectively. Therefore, it is highly likely that where phorate contacts the skin it will be absorbed. For many birds the skin shows under the wing were the wing meets the body.

2. Reproductive effects (eggs laid, viable embryos, and normal hatchlings) are seen at very low dietary levels of <60 ppm. Parental toxicity occurred at 20 ppm in the form of weight loss.

3. Data on preharvest intervals indicate that 30 days is required for residues in sprayed corn plants to reach a level below the tolerance level (0.1 ppm for phorate).

4. Studies have shown that highly toxic organophosates can initiate negative effects on avian reproduction after very short exposures (eight to 10 days) (Bennett and Ganio, 1991). Bennett and Ganio (1991) state:

Several pesticides have been shown to reduce egg production within days after initiation of dietary exposure (Bennett and Bennett 1990, Bennett et al. 1991). Effects on eggshell quality (Bennett and Bennett 1990, Haegele and Tucker 1974) and incubation and brood rearing behavior (Bennett et al. 1991, Brewer et al. 1988, Busby et al. 1990) have resulted from short-term pesticide exposures.

5. Degradation of the pesticides over a few days would have minimum impact on reducing the risk of reproductive effects. For example, if 3 or 4 granules carry enough phorate to cause mortality to 50% of the test population at day zero it is likely than even with a 3 day half-life nonfatal effects would be expected a 8 to 10 day period.

6. The phorate sulfoxide metabolite is more toxic, A 90 day rat feeding study shows that phorate sulfoxide has a lower NOEL than phorate, 0.66 ppm for phorate and 0.32 ppm for phorate sulfoxide. In both studies cholinesterase inhibition was the endpoint. Therefore, the mode of action is similar. Other phorate degradates that retain the organophosphate structure, phorate sulfone, phorate oxygen analog, phorate oxygen analog sulfoxide, and phorate oxygen analog sulfone metabolites are expected to also exhibit cholinesterase inhibition and therefore be as toxic as phorate.

8. Residue analysis indicated that phorate and its degradates were sufficient to cause of death to birds and mammals for two to three weeks after application.

(b) Mammals

EFED believes mammals may be exposed to granular pesticides ingesting granules when foraging for food, grooming, by walking on exposed granules or drinking contaminated water. The number of lethal doses (LD_{50}s) that are available within one square foot immediately after application ($LD_{50}s/ft^2$)is used as the risk quotient for granular/bait products. Risk quotients are calculated for three separate weight classes of mammals: 1000 g, 35 g and 15 g.

The acute risk quotients for broadcast applications of granular products are tabulated below.

Table 16: Mammalian Risk Quotients for Granular Products (Broadcast, unincorporated) Based on a Rat LD_{50} of 1.4 mg/kg

Site/Method Lbs(ai)/A Unincorporated	%(decimal) of Pesticide Left on the Surface	Body Weight (g)	LD_{50} (mg/kg)	Acute RQ[1] (LD_{50}/ft^2)
Corn and Hops				
3	1.0	15	1.4	1,485.71
3	1.0	35	1.4	636.73
3	1.0	1000	1.4	22.29
Corn, Sorghum and Wheat				
1	1.0	15	1.4	495.24
1	1.0	35	1.4	212.24
1	1.0	1000	1.4	7.43
Sugarbeets				
1.5	1.0	15	1.4	742.86
1.5	1.0	35	1.4	318.37
1.5	1.0	1000	1.4	1.11

[1] The equation for the RQ is:

$$\frac{\text{App. Rate (lbs a.i./A)} * (453{,}590\ \text{mg/lb}/43{,}560\ \text{ft}^2\text{/A})}{LD_{50}\ \text{mg/kg} * \text{Weight of Animal (g)} * 1000\ \text{g/kg}}$$

The results indicate that for broadcast, unincorporated granular products, acute high risk and restricted use LOCs are all exceeded. Also endangered species LOC has been exceeded for all weight classes. As with the avian analysis, the band width and application rates were selected to produce the highest EEC for each crop.

The acute risk quotients for banded or in-furrow applications of granular products are tabulated below.

Table 17: Mammalian Acute Risk Quotients for Granular Products (Banded or In-furrow) Based on a rat LD_{50} of 1.4 mg/kg

Band Width (feet)	oz. a.i./1000 ft of row	Body Weight (kg)	% (decimal) of Unincorporated Pesticide	Exposed mg/ft[2]	Rat LD_{50} (mg/kg)	Acute[1] RQ[2] (LD_{50}/ft[2])
Beans (Banded incorporated)						
0.17	1.875	15	0.01	3.13	1.4	149.0
0.17	1.875	35	0.01	3.13	1.4	63.9
0.17	1.875	1000	0.01	3.13	1.4	2.2
Corn and Sorghum						
0.6	1.2	15	0.15	8.50	1.4	404.8
0.6	1.2	35	0.15	8.50	1.4	173.5
0.6	1.2	1000	0.15	8.50	1.4	6.1
Cotton (Soil sidedress treatment, incorporated)						
0.5	2.4	15	0.15	20.41	1.4	971.9
0.5	2.4	35	0.15	20.41	1.4	416.5
0.5	2.4	1000	0.15	20.41	1.4	14.6
Field Grown Lilies and Daffodils						
1	4.7	15	0.01	1.33	1.4	63.3
1	4.7	35	0.01	1.33	1.4	27.1
1	4.7	1000	0.01	1.33	1.4	1.0
Peanuts (Soil band, at pegging)						
0.5	2.2	15	0.15	18.71	1.4	891.0
0.5	2.2	35	0.15	18.71	1.4	381.8
0.5	2.2	1000	0.15	18.71	1.4	13.4
Potato White/Irish (Soil band)						

Table 17: Mammalian Acute Risk Quotients for Granular Products (Banded or In-furrow) Based on a rat LD_{50} of 1.4 mg/kg

Band Width (feet)	oz. a.i./1000 ft of row	Body Weight (kg)	% (decimal) of Unincorporated Pesticide	Exposed mg/ft²	Rat LD_{50} (mg/kg)	Acute[1] RQ[2] (LD_{50}/ft²)
0.6	3.45	15	0.15	24.45	1.4	1,164.3
0.6	3.45	35	0.15	24.45	1.4	499.0
0.6	3.45	1000	0.15	24.45	1.4	17.5
			Radish (Soil sidedress)			
0.17	1.25	15	0.15	31.27	1.4	1,489.0
0.17	1.25	35	0.15	31.27	1.4	638.2
0.17	1.25	1000	0.15	31.27	1.4	22.3
			Soybeans (Soil band)			
0.6	1.8	15	0.15	12.76	1.4	607.6
0.6	1.8	35	0.15	12.76	1.4	260.4
0.6	1.8	1000	0.15	12.76	1.4	9.1
			Sugar beets			
0.8	0.9	15	0.15	4.78	1.4	227.6
0.8	0.9	35	0.15	4.78	1.4	97.6
0.8	0.9	1000	0.15	4.78	1.4	3.4
			Sugarcane			
1	8.6	15	0.01	2.44	1.4	116.2
1	8.6	35	0.01	2.44	1.4	49.8
1	8.6	1000	0.01	2.44	1.4	1.7
			Wheat (Soil in-furrow)			
0.1	0.24	15	0.01	0.68	1.4	32.4
0.1	0.24	35	0.01	0.68	1.4	13.9

Table 17: Mammalian Acute Risk Quotients for Granular Products (Banded or In-furrow) Based on a rat LD_{50} of 1.4 mg/kg

Band Width (feet)	oz. a.i./1000 ft of row	Body Weight (kg)	% (decimal) of Unincorporated Pesticide	Exposed mg/ft[2]	Rat LD_{50} (mg/kg)	Acute[1] RQ[2] (LD_{50}/ft^2)
0.1	0.24	1000	0.01	0.68	1.4	0.5

[1] The equation for the RQ is:

$$\frac{\text{oz. a.i. per 1000 ft.} * 28349\ \text{mg/oz} * \%\ \text{Unincorporated/bandwidth (ft)} * 1000\ \text{ft}}{LD_{50}(\text{mg/kg}) * \text{Weight of the Animal (g)} * 1000\ \text{g/kg}}$$

[2] This is a post-emergence application. This scenario assumes every row was two plants wide, the post-treatment was foliar, and the band extended from the outside of one plant to the outside edge of the other plant or a 14 inch band was used. Based on the label this use was not soil incorporated.

The results indicate that for banded/in-furrow granular products, acute high risk, endangered species and restricted use LOCs are all exceeded. Also the HED chapter of the RED reports human poisoning. This indicates two important items: (1) humans are larger than most the wild mammals hence, there is a potential for large mammals to be poisoned and (2) the route of exposure is most likely not oral. The dermal LD50 is very similar to the oral LD50, 3.9 and 1.4 mg/kg, respectively. Also inhalation is more likely if the animal is sniffing the ground is search of prey. The inhalation LC50 is extremely low (0.01 mg/L for female rats). In addition to risk quotients exceeding the level of concern, field studies and incidents show that mammal mortalities can be expected where phorate is used according to the label.

In addition to the mammalian acute effects, chronic effects are expected for the following reasons:

1. The NOECs are lower than shown in the bird studies. A 15 week rat feeding study resulted in an NOEL of 6 ppm.

2. Mammals are more sensitive to phorate than birds on a dietary basis. The lowest mammal LC_{50} is 28 ppm and the lowest avian LC50 is 248 ppm.

(b) Insects

Currently, EFED has no procedure for assessing risk to nontarget insects. Results of acceptable studies are used for recommending appropriate label precautions. EFED assumes that for granular formulations the hazard is minimal to bees.

(2) Risk to Nontarget Aquatic Animals

EFED uses a computer model to calculate refined EECs. The Pesticide Root Zone Model (PRZM2.3) simulates pesticides in field runoff. The Exposure Analysis Modeling System (EXAM II) simulates pesticide fate and transport in an aquatic environment (one hectare body of water, two meters deep). EECs derived using these methods are tabulated below. The EEC in each category is expected to be equaled or exceed once every ten years, that is, it represents a 1 in 10 year return frequency.

Table 18: Estimated Environmental Concentrations (EECs) For Aquatic Exposure

Site	Application Method	Application Rate (lbs a.i./A)	No. of App.	Interval	Initial (PEAK) EEC (ppb)	21-day EEC (ppb)	60-day EEC (ppb)
All Crops							
Beans	Banded	2	1	0	2.57	0.48	0.19
Corn, Hops, Radish, Peanuts[1]	Broadcast, Sidedress	3	1	0	15.18	3.795	1.53
Corn	Banded	1.3	2	25	7.94	1.55	0.74
Cotton	Sidedress	1.6	1	0	8.26	2.07	0.83
Field Grown Lilies and Daffodils[1/]	Sidedress	8	1	0	41.3	10.35	4.15
Peanuts	Banded, Sidedress	1.5+3	2	49	12.07	2.62	1.08
Potatoes	Banded	3.5	1	0	4.95	0.95	0.21
Potatoes	Sidedress	2.3	2	30	1.33	0.25	0.14
Sorghum	Banded, Foliar	1.3	2	30	12.23	2.64	1.17
Soybeans	Banded	2	1	0	10.12	2.53	1.02
Sugarbeets	Foliar	1.5	2	60	8.06	1.51	0.68
Sugarcane	Banded	3.9	1	0	16.8	4.11	1.91
Wheat	Broadcast	1	1	0	1.4	0.39	0.16

1 These EECs were extrapolated from the Tier II EECs for 3 lbs/A rate for corn, radishes, hops, and peanuts and lilies with application rate of 8 lbs a.i./A. In order to make this estimate, we assumed that cotton EECs scenario was similar to the lilies and soybeans scenario was similar to the 3 lb/A crops. The follow method of estimation was used:

$$\text{Est. EEC for the crop X} = \frac{\text{Tier II EEC for Crop Y} * \text{App. Rate for Crop X}}{\text{App. Rate for Crop Y}}$$

(a) Freshwater Fish and Amphibians

Freshwater fish and amphibian acute and chronic risk quotients are tabulated below.

Table 19: Freshwater Fish and Amphibians Risk Quotients Based On the Bluegill Sunfish LC_{50} of 1 ppb and the Bluegill Sunfish Estimated NOEC[1] of 0.2 ppb

Site/ Application Rate (lb ai/A)	LC_{50} (ppb)	NOEC/ (ppb)	EEC Initial (ppb)	EEC 60-Day (ppb)[2]	Acute RQ (EEC/LC_{50})	Chronic RQ (EEC/ NOEC)[4]
All Crops						
Beans/2	1	0.2	2.57	0.19	2.6	1.0
Corn,Hops,Radish Peanuts/3[3]	1	0.2	15.18	1.53	15.2	7.7
Corn/1.3+1.3	1	0.2	7.94	0.74	7.9	3.7
Cotton/ 1.6	1	0.2	8.26	0.83	8.3	4.2
Field Grown Lilies and Daffodils[3]	1	0.2	41.3	4.15	41.3	20.8
Peanuts/1.5+3	1	0.2	12.07	1.08	12.1	5.4
Potatoes/ 3.5	1	0.2	4.95	0.21	5.0	1.1
Potatoes/2.3	1	0.2	1.33	0.14	1.3	0.7
Sorghum/ 1.3+1.3	1	0.2	12.33	1.17	12.3	5.9
Soybeans/ /2	1	0.2	10.12	1.02	10.1	5.1
Sugarbeets/ /1.5+1.5	1	0.2	8.06	0.68	8.1	3.4
Sugarcane/3.9	1	0.2	16.08	1.91	16.1	9.6
Wheat/ 1	1	0.2	1.44	0.16	1.4	0.8

1 Estimated NOEC for bluegill was derived using the following calculations:

$$\text{Estimated Bluegill NOEC} = \frac{1\ LD_{50}\ \mu g/L * 2.6\ \text{ppb Rainbow Trout NOEC}}{13\ \text{Rainbow Trout}\ LD_{50}\ \mu g/L} = 0.2\ \text{ppb}$$

2 The study used to determine the chronic effects does not determine the length of time needed to cause an effect. Therefore, the 56-day EEC may under estimated the potential for adverse effects.

3 These EECs were extrapolated from the Tier II EECs for 3 lbs/A rate for corn, radishes, hops, and peanuts and lilies with application rate

of 8 lbs a.i./A. In order to make this estimate, we assumed that cotton EECs scenario was similar to the lilies and soybeans scenario was similar to the 3 lb/A crops. The follow method of estimation was used:

$$\text{Est. EEC for the crop X} = \frac{\text{Tier II EEC for Crop Y * App. Rate for Crop X}}{\text{App. Rate for Crop Y}}$$

4 All these scenarios were at plant and banded applications.

The results indicate that acute high risk, restricted use, and endangered species levels of concern are exceeded for freshwater fish and amphibians for all crops and EECs. Pond studies and incidents confirm the risk predicted by the risk quotients. Field studies and incidents confirm these predictions. The pond field study reported that phorate, phorate sulfone, and phorate sulfoxide were in a pond 18, 13, and 20 days after application, respectively. The incident residue analysis showed concentrations of phorate of 8.3 ppb, 32.3 ppb, and 12.7 ppb after 14 days, 15 days, and 37 days, respectively. More importantly, the field study, regardless of it deficiencies, showed effects on fish growth and fish reproduction parameters. Incidents, on the other hand, show fish mortality.

The chronic risk level of concernfor freshwater fish and amphibians is exceeded for all crops except potatoes when applied at 2.3 lbs a.i./A and wheat at 1 lbs a.i./A.

(b) Freshwater Invertebrates

The acute and chronic risk quotients are tabulated below.

Table 20: Freshwater Invertebrates Risk Quotients Based On a *Gammarus fasciatus* EC_{50} of 0.68 ppb and a *Daphnia magna* NOEC of 0.21 ppb

Site/ Rate (lb ai/A)	EC_{50} (ppb)	NOEC/ (ppb)	EEC Initial (ppb)	EEC 21-Day (ppb)[1]	Acute RQ (EEC/EC_{50})	Chronic RQ (EEC/ NOEC)[4]
All Crops						
Beans 2	0.6	0.21	2.57	0.48	4.28	2.3
Corn/Hops/ Radish Peanuts/3[2]	0.6	0.21	15.18	3.8	25.30	18.1
Corn/ 1.3+1.3	0.6	0.21	7.94	1.55	13.23	7.4
Cotton/1.6	0.6	0.21	8.26	2.07	13.77	9.9
Field Grown Lilies and Daffodils/8[2]	0.6	0.21	41.3	10.35	68.83	49.3
Peanuts/1.5+3	0.6	0.21	12.07	2.62	20.12	12.5
Potatoes/ 3.5	0.6	0.21	4.95	0.93	8.25	4.4
Potatoes/2.3+2.3	0.6	0.21	1.33	0.25	2.22	1.2
Sorghum/ 1.3+1.3	0.6	0.21	12.23	2.64	20.38	12.6
Soybeans/ 2	0.6	0.21	10.12	2.53	16.87	12.0
Sugarbeets/1.5+1.5	0.6	0.21	8.06	1.51	13.43	7.2
Sugarcane/ 3.9	0.6	0.21	16.08	4.11	26.80	19.6
Wheat/ 1	0.6	0.21	1.44	0.39	2.40	1.9

1 The study used to determine the chronic effects does not determine the length of time needed to cause an effect. Therefore, the 21-day EEC may under estimated the potential for adverse effects.

2 These EECs were extrapolated from the Tier II EECs for 3 lbs/A rate for corn, radishes, hops, and peanuts and lilies with application rate of 8 lbs a.i./A. In order to make this estimate, we assumed that cotton EECs scenario was similar to the lilies and soybeans scenario was similar to the 3 lb/A crops. The follow method of estimation was used:

$$\text{Est. EEC for the crop X} = \frac{\text{Tier II EEC for Crop Y} * \text{App. Rate for Crop X}}{\text{App. Rate for Crop Y}}$$

3 All these scenarios were at plant and banded applications.

The results indicate that acute high risk, restricted use, and endangered species levels of concern are exceeded for freshwater invertebrates. The chronic risk quotients also exceed the levels of concern. Field studies and incidents confirm these predictions. The pond field study reported that phorate, phorate sulfone, and phorate sulfoxide were detected in a pond 18, 13, and 20 days after application, respectively. Of the incident residue analysis showed concentrations of phorate of 8.3 ppb, 32.3 ppb, and 12.7 ppb after 14 days, 15 days, and 37 days, respectively. More importantly, the field study, regardless of it deficiencies, showed effects on phytoplankton populations and certain populations of invertebrates.

However, and more importantly, the potential of phorate to cause adverse effects has been demonstrated in a field study and incidents. This supports the prediction of adverse effects from the risk quotients. Therefore, adverse acute and reproductive effects to nontarget aquatic organisms are expected to occur from the use of phorate.

(c) Estuarine and Marine Animals

The estuarine and marine acute and chronic risk quotients are tabulated below.

Table 21: Estuarine/Marine Organisms Risk Quotients

Site/ Application Rate (lb ai/A)	Surrogate Species	EC_{50} (ppb)	NOEC/ (ppb)	EEC Initial (ppb)	EEC 21-Day (ppm)[1]	Acute RQ (EEC/ EC_{50})	Chronic RQ (EEC/ NOEC)
			All Crops				
Beans/Banded/2	Quahog Clam	3.4	N/A	2.57	N/A	0.8	—
	Pink Shrimp	0.11	N/A	2.57	N/A	23.4	—
	Mysid	N/A	0.0053	N/A	0.48	—	91
	Longnose killifish	0.36	N/A	2.57	N/A	7.1	—
	Sheepshead minnow	N/A	0.096	N/A	0.48	—	5
Corn/Hops/ Peanuts/Radishes/ 3[3]	Quahog Clam	3.4	N/A	15.18	N/A	4.5	—
	Pink Shrimp	0.11	N/A	15.18	N/A	138.0	—
	Mysid	N/A	0.0053	N/A	3.8	—	717
	Longnose killifish	0.36	N/A	15.8	N/A	43.9	—
	Sheepshead minnow	N/A	0.096	N/A	3.8	—	40
Corn, (sweet&field) /1.3+1.3	Quahog Clam	3.4	N/A	7.94	N/A	2.3	—
	Pink Shrimp	0.11	N/A	7.94	N/A	72.2	—
	Mysid	N/A	0.0053	N/A	1.55	—	292
	Longnose killifish	0.36	N/A	7.94	N/A	22.1	—
	Sheepshead minnow	N/A	0.096	N/A	1.55	—	16
Cotton/ 1.6	Quahog Clam	3.4	N/A	8.26	N/A	2.4	—
	Pink Shrimp	0.11	N/A	8.26	N/A	75.1	—
	Mysid	N/A	0.0053	N/A	2.07	—	391
	Longnose killifish	0.36	N/A	8.26	N/A	22.9	—
	Sheepshead minnow	N/A	0.096	N/A	2.07	—	22
Field Grown Lilies and Daffodils[3]	Quahog Clam	3.4	N/A	41.3	N/A	12.1	—
	Pink Shrimp	0.11	N/A	41.3	N/A	375.5	—
	Mysid	N/A	0.0053	N/A	10.35	—	1,953
	Longnose killifish	0.36	N/A	41.3	N/A	114.7	—

Table 21: Estuarine/Marine Organisms Risk Quotients

Site/ Application Rate (lb ai/A)	Surrogate Species	EC_{50} (ppb)	NOEC/ (ppb)	EEC Initial (ppb)	EEC 21-Day (ppm)[1]	Acute RQ (EEC/ EC_{50})	Chronic RQ (EEC/ NOEC)
	All Crops						
	Sheepshead minnow	N/A	0.096	N/A	10.35	—	108
Peanuts/ 1.5+3.0	Quahog Clam	3.4	N/A	12.07	N/A	3.6	—
	Pink Shrimp	0.11	N/A	12.07	N/A	109.7	—
	Mysid	N/A	0.0053	N/A	2.62	—	494
	Longnose killifish	0.36	N/A	12.07	N/A	33.5	—
	Sheepshead minnow	N/A	0.096	N/A	2.62	—	27
Potatoes/ 3.5	Quahog Clam	3.4	N/A	4.95	N/A	1.5	—
	Pink Shrimp	0.11	N/A	4.95	N/A	45.0	—
	Mysid	N/A	0.0053	N/A	0.93	—	175
	Longnose killifish	0.36	N/A	4.95	N/A	13.8	—
	Sheepshead minnow	N/A	0.096	N/A	0.93	—	10
Potatoes/ 2.3+2.3	Quahog Clam	3.4	N/A	1.33	N/A	0.4	—
	Pink Shrimp	0.11	N/A	1.33	N/A	12.1	—
	Mysid	N/A	0.0053	N/A	0.25	—	47
	Longnose killifish	0.36	N/A	1.33	N/A	3.7	—
	Sheepshead minnow	N/A	0.096	N/A	0.25	—	3
Sorghum/ 1.3+1.3	Quahog Clam	3.4	N/A	12.23	N/A	3.6	—
	Pink Shrimp	0.11	N/A	12.23	N/A	111.2	—
	Mysid	N/A	0.0053	N/A	2.64	—	498
	Longnose killifish	0.36	N/A	12.23	N/A	34.0	—
	Sheepshead minnow	N/A	0.096	N/A	2.64	—	28
Soybeans/ 2	Quahog Clam	3.4	N/A	10.12	N/A	3.0	—
	Pink Shrimp	0.11	N/A	10.12	N/A	92.0	—
	Mysid	N/A	0.0053	N/A	2.53	—	477

Table 21: Estuarine/Marine Organisms Risk Quotients

Site/ Application Rate (lb ai/A)	Surrogate Species	EC_{50} (ppb)	NOEC/ (ppb)	EEC Initial (ppb)	EEC 21-Day (ppm)[1]	Acute RQ (EEC/ EC_{50})	Chronic RQ (EEC/ NOEC)
			All Crops				
	Longnose killifish	0.36	N/A	10.12	N/A	28.1	—
	Sheepshead minnow	N/A	0.096	N/A	2.53	—	26
Sugarbeets/ 1.5+1.5	Quahog Clam	3.4	N/A	8.06	N/A	2.4	—
	Pink Shrimp	0.11	N/A	8.06	N/A	73.3	—
	Mysid	N/A	0.0053	N/A	1.51	—	285
	Longnose killifish	0.36	N/A	8.06	N/A	22.4	—
	Sheepshead minnow	N/A	0.096	N/A	1.51	—	16
Sugarcane/ 3.9	Quahog Clam	3.4	N/A	16.08	N/A	4.7	—
	Pink Shrimp	0.11	N/A	16.08	N/A	146.2	—
	Mysid	N/A	0.0053	N/A	4.11	—	775
	Longnose killifish	0.36	N/A	16.08	N/A	44.7	—
	Sheepshead minnow	N/A	0.096	N/A	4.11	—	43
Wheat/ 1	Quahog Clam	3.4	N/A	1.4	N/A	0.4	—
	Pink Shrimp	0.11	N/A	1.4	N/A	12.7	—
	Mysid	N/A	0.0053	N/A	0.39	—	74
	Longnose killifish	0.36	N/A	1.4	N/A	3.9	—
	Sheepshead minnow	N/A	0.096	N/A	0.39	—	4

[1] The study used to determine the chronic effects does not determine the length of time needed to cause an effect. Therefore, the 21-day EEC may under estimated the potential for adverse effects.

[2] All these scenarios were at plant and banded applications.

[3] These EECs were extrapolated from the Tier II EECs for 3 lbs/A rate for corn, radishes, hops, and peanuts and lilies with application rate of 8 lbs a.i./A. In order to make this estimate, we assumed that cotton EECs scenario was similar to the lilies and soybeans scenario was similar to the 3 lb/A crops. The follow method of estimation was used:

$$\text{Est. EEC for the crop X} = \frac{\text{Tier II EEC for Crop Y * App. Rate for Crop X}}{\text{App. Rate for Crop Y}}$$

The results indicate that acute high risk, restricted use, and endangered species levels of concern are exceeded for estuarine fish and amphibians for all crops except the acute high risk level of concern to estuarine/marine clams from applications to potatoes and wheat. The chronic risk level of concern is exceeded for estuarine fish and amphibians for all crops.

The risk to estuarine and marine organisms may be higher than that to freshwater organisms. The toxicity values for estuarine and marine organisms are lower. The lowest LC_{50} for freshwater fish and invertebrate are 1 ppb and 0.6, respectively. On the other hand, the marine/estuarine fish and invertebrate LC_{50} are 0.36 ppb and 0.3 ppb, respectively. Therefore, the adverse effects seen in the field study and incidents would be expected in marine/estuarine wetlands.

(3) Exposure and Risk to Nontarget Plants

Plant testing is not required for granular pesticieds or insecticides. Therefore, a plant risk assessment was not done.

(4) Endangered Species

All terrestrial and aquatic endangered species LOCs are exceeded for phorate.

The Endangered Species Protection Program is expected to become final in the future. Limitations in the use of phorate will be required to protect endangered and threatened species, but these limitations have not been defined and may be formulation specific. EPA anticipates that a consultation with the Fish and Wildlife Service will be conducted in accordance with the species-based priority approach described in the Program. After completion of consultation, registrants will be informed if any required label modifications are necessary. Such modifications would most likely consist of the generic label statement referring pesticide users to use limitations contained in county Bulletins.

Date:
Case No:
Chemical No:

PHASE IV
DATA REQUIREMENTS FOR
ECOLOGICAL EFFECTS BRANCH

Data Requirements	Composition[a]	Use Pattern[b]	Does EPA Have Data To Satisfy This Requirement? (Yes, No)	Bibliographic Citation	Must Additional Data Be Submitted under FIFRA3(c)(2)(B)?
6 Basic Studies in Bold					
71-1(a) Acute Avian Oral, Quail/Duck	(TGAI)	A,B	No[c]	00160000, 00020560,	No
71-1(b) Acute Avian Oral, Quail/Duck	(TEP)	A,B	N/A	N/A	No
71-2(a) Acute Avian Diet, Quail	(TGAI)	A,B	Yes	0022923	No
71-2(b) Acute Avian Diet, Duck	(TGAI)	A,B	Yes	0022923	
71-3 Wild Mammal Toxicity	(TGAI)	A,B	No	43961101, 05014313	No[d]
71-4(a) Avian Reproduction Quail	(TGAI)	A,B	No	0158333	No
71-4(b) Avian Reproduction Duck	(TGAI)	A,B	Yes	0158334	No
71-5(a) Simulated Terrestrial Field Study	(TEP)	A,B	No[e]	74623, 74624, 74625, 74626, 92832, 92834, 52237	No
71-5(b) Actual Terrestrial Field Study	(TEP)	A,B	No[f]	40165901	No[g]
72-1(a) Acute Fish Toxicity Bluegill	(TGAI)	A,B	Yes	40098001, 40094602	No
72-1(b) Acute Fish Toxicity Bluegill	(TEP)	A,B	Yes	0161823	No
72-1(c) Acute Fish Toxicity Rainbow Trout	(TGAI)	A,B	Yes	40094602	No
72-1(d) Acute Fish Toxicity Rainbow Trout	(TEP)	A,B	Yes	090490, 161822	No
72-2(a) Acute Aquatic Invertebrate Toxicity	(TGAI)	A,B	No	05017538, 0097842, 40094602	No
72-2(b) Acute Aquatic Invertebrate Toxicity	(TEP)	A,B	Yes	0161825, 0161826, 0161827	No
72-3(a) Acute Estu/Mari Tox Fish	(TGAI)	A,B	Yes	40228401, 40001801	No
72-3(b) Acute Estu/Mari Tox Mollusk	(TGAI)	A,B	Yes	40228401	No
72-3(c) Acute Estu.Mari Tox Shrimp	(TGAI)	A,B	Yes	40228401	No

Data Requirements	Composition[a]	Use Pattern[b]	Does EPA Have Data To Satisfy This Requirement? (Yes, No)	Bibliographic Citation	Must Additional Data Be Submitted under FIFRA3(c)(2)(B)?
72-3(d) Acute Estu/Mari Tox Fish	(TEP)	A,B	Yes	40001801	No
72-3(e) Acute Estu/Mari Tox Mollusk	(TEP)	A,B	Yes	40004201	No
72-3(f) Acute Estu/Mari Tox Shrimp	(TEP)	A,B	Yes	41803804, 40001802	No
72-4(a) Early Life-Stage Fish	(TGAI)	A,B	Yes	00158335, 40228401, 43730501,	No
72-4(b) Live-Cycle Aquatic Invertebrate	(TGAI)	A,B	Yes	00158335, 42227102, 40228401, 43730501	No
72-5 Life-Cycle Fish		A,B		—	No[h]
72-6 Aquatic Org. Accumulation	(TGAI)	A,B	No	—	No[i]
72-7(a) Simulated Aquatic Field Study	(TEP)	A,B	No	42227101 43957801	No[7]
72-7(b) Actual Aquatic Field Study	(TEP)	A,B	No	—	No
122-1(a) Seed Germ./Seedling Emerg.	(TEP)	A,B	No	—	No
122-1(b) Vegetative Vigor	(TEP)	A,B	No	—	No
122-2 Aquatic Plant Growth	(TEP)	A,B	Yes	40228401	No
123-1(a) Seed Germ./Seedling Emerg.	(TEP)	A,B	No	—	No
123-1(b) Vegetative Vigor	(TEP)	A,B	No	—	No
123-2 Aquatic Plant Growth	(TEP)	A,B	No	—	No
124-1 Terrestrial Field Study	(TEP)	A,B			No
124-2 Aquatic Field Study	(TEP)	A,B			No
141-1 Honey Bee Acute Contact	(TGAI)	A,B	Yes[j]	05001991, 00036935	No
141-2 Honey Bee Residue on Foliage		A,B	No[11]	—	No
141-5 Field Test for Pollinators		A,B	No[11]	—	No

[a]Composition: TGAI = Technical grade of the active ingredient; PAIRA = Pure active ingredient, radiolabeled; TEP = Typical end-use product

[b]Use Patterns: A = Terrestrial/Food; B = Terrestrial/Feed; C = Terrestrial Non-Food; D = Aquatic Food; E = Aquatic Non-Food (Outdoor); F = Aquatic Non-Food (Industrial); G = Aquatic Non-Food (Residential); H = Greenhouse Food; I = Greenhouse Non-Food; J = Forestry; K = Residential Outdoor; L = Indoor Food; M = Indoor Non-Food; N = Indoor Medical; O = Indoor Residential

[c] Although these studies do not fulfill the guideline requirements, because of similarity of results further testing is not expected to add significantly to the database.

[d] The rat acute oral study submitted for human health database (MRID No. 05014313) and the rat LC_{50} (1981);MRID No. 43961101) were substituted for 71-3 wild mammal toxicity test.

[e] These studies are not required because they are usually not sufficient to rebut the presumed risk.

[f] This field study did not fulfill the guideline requirement because, among other things, the search area insufficient.

[g] Additional testing is not required. L.Fisher's Memorandum of October 1992 indicated that the Agency would make risk assessments based on the laboratory data.

[h] The MATC from the fish early life-stage study shows that phorate is toxic at extremely low concentrations, <190.0 parts per trillion for sheepshead minnow. Therefore, the further testing was not required.

[i] The bioaccumulation study required by the EFGWB (MRID No. 42701101) was used in lieu of the EEB study 72-6.

[j] These studies are not required for granular formulated products.

APPENDIX 1: Summary of Incident Reports for Phorate

PHORATE				
Year	State Incident Number	Number of Organisms Affected	Species Affected	Use Pattern
TERRESTRIAL				
1994	BC, Canada I001476-001	5 (3 dead, 2 debilitated)	Bald Eagles	Potatoes?
1991	GA B000150-016	8	bobwhite	wheat
1989	SD B000150-015	7 81 1 13 1	Bald Eagles Canada geese Snow Goose Waterfowl sharp-tailed grouse	wheat
1989	WI B000150-013	10 55 1 1 2	Canada geese mallards barn owl skunk opossum	Not Reported
1987	ID B000150-011	1	Bald Eagle	Not Reported
1987	CA B000150-009	1	red-tailed hawk	Not Reported
1986	CA B000150-010	50-75	mallards and pintails	barley

PHORATE				
1982	SD B000150- 008	38 4 9 6 7 1 1	mallards gadwalls wigeons pintails green-winged teal red-tailed hawk golden eagle	winter wheat
1982	SD B000150- 007	133 51 42 36 12 3 6 2 4	mallards pintails wigeons gadwall green-winged teal Canada geese marsh harriers red-tailed hawks great-horned owls	winter wheat /possible spill
1982	SD B000150- 018	1	bald eagle	secondary poisoning[1]
1981	CA B000150- 005	2,000 2 several	blackbirds pheasant pigeons	wheat
1981	CA B000150- 006	100 100	waterfowl other species	alfalfa/ misuse[2]
1978	CA B000150- 004	195	ring billed gulls, cattle egrets, and curlews	alfalfa
1972	CA B000150- 014	25	ducks and blackneck stilts	sugar beet

[1] The bald eagle was feeding on a duck which had been exposed to phorate. Actual use pattern under which duck was exposed to phorate undetermined.

[2] This incident involved registered use of phorate on alfalfa as well as accidental misuse of the pesticide. Actual bird mortality attributed to registered use and misuse is undetermined.

PHORATE				
Incidents reported as a Result of Field Monitoring Studies				
1991	VA B000150-017/ I000504-028	2	robins	Undetermined[3]
AQUATIC				
1970	IL B000150-001	30-50	bluegill sunfish	[4]corn
1970	IL B000150-002	2000-3000	bluegill, greengill, silver minnows, one catfish, small and large bass, and crappies.	corn
1970	IL B000150-003	Not reported	bass and bluegill	corn

[3] These two birds were found on a corn field as a result of a field monitoring for Furadan 15G on a cornfield. An adjacent field must have been treated with phorate. Use site of phorate is undetermined.

[4] Note* all three of these incidents were implicated with multiple pesticides.