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OFFICE OF
PREVENTION, PESTICIDES AND
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MEMORANDUM

SUBJECT: Azinphos Methyl—EFED Response to Stakeholder Comments on the Ecological Risk Assessment for "Group 3" Uses

FROM: Colleen Flaherty, Biologist (ERB 3)
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THRU: Daniel Rieder, Branch Chief (ERB 3)
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TO: Diane Isbell, Risk Manager (RRB 2)
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Attached please find the Office of Pesticide Program's (OPP's) response to stakeholder comments on the ecological risk assessment for the use of azinphos methyl on apples, blueberries (low- and high bush), Brussels sprouts, cherries (sweet and tart), grapes, nursery stock, parsley, pears, pistachios, and walnuts (*i.e.* "Group 3 uses").

Cherry Marketing Institute (EPA-HQ-OPP-2005-0061-0071)

1. Comment (Page 3): "Using tree-row-volume technology and spraying in the evening and at night when the winds are calm is a critical practice that most growers have used to minimize drift."

EFED Response: Tree-row-volume technology and spraying at night may indeed reduce spray drift. However, azinphos methyl is extremely toxic to aquatic animals, and aquatic exposures of azinphos methyl are predominantly runoff driven in the eastern United States. Thus, aquatic risks would remain even if these spray drift mitigation techniques were employed universally by cherry growers.

2. Comment (Page 3): "CMI believes that the Agency has over-estimated the ecological risk when AZM is used on cherries. Over the years, there have not been any adverse incidents resulting from the use of AZM reported in our industry."

EFED Response: This statement assumes that there is a rigorous ecological incident monitoring program in place. This is not the case. Based on laboratory toxicity data, projected environmental exposures for azinphos methyl use on cherries, and field studies in fruit orchards (including one in Michigan), the risks to aquatic and terrestrial animals remain.

Mark Whalon (EPA-HQ-OPP-2005-0061-0081)

1. Comment (Page 4): "AZM did not produce detectable residues (below LOD) in processed cherries in a 2-year independent study conducted in Michigan (1998-9)… these data did not find their way into any of USEPA's ecological or benefit analysis on AZM."

EFED Response: EFED does currently consider the residues on fruit at harvest for use in the ecological risk assessment, although it is an important part of the human health risk assessment. Ecological risks accrue between application and harvest, so post-harvest data are not relevant for our assessments.

2. Comment (Page 5-11): Acute & Chronic Toxicity Assessment: Inference to Ecological Sustainability; beneficial insect indices.

EFED Response: EFED agrees that chronic (*e.g.* reproductive, growth) effects can have profound ecological consequences, such as alteration of the trophic cascade, reduction in biodiversity, *etc*. Chronic azinphos methyl toxicity studies were available for a number of aquatic and terrestrial animals, and these studies have been reviewed and incorporated into the ecological risk assessment.

Dr. Whalon's comments focus on the ecology of beneficial insects in agricultural settings. The EPA assessment took into consideration *all* aquatic and terrestrial animals (including beneficial insects) and plants in the United States. The aquatic ecosystems potentially at risk include water bodies adjacent to or downstream from the treated field. These water bodies include impounded bodies such as ponds, lakes, and reservoirs; and flowing waterways, such as streams and rivers; and marine ecosystems, including estuaries. The terrestrial ecosystems potentially at risk include the treated area and areas immediately adjacent to the treated area that might receive drift or runoff. These terrestrial ecosystems include other cultivated fields, fencerows, hedgerows, meadows, fallow fields, grasslands, woodlands, riparian habitats, other uncultivated areas.

EPA's ecological risk assessment concluded that all of the remaining azinphos methyl uses pose chronic (and acute) risks to all aquatic and terrestrial animals (including beneficial insects). These risk presumptions are supported by various field studies and adverse ecological incidents, including numerous beneficial insect kills.

Bayer CropScience (EPA-HQ-OPP-2005-0061-0092)

1. Comment (Page 4): "The modeled water concentrations that were used in the aquatic risk assessment (Page 39, Table 3.12) were much higher than the actual concentrations observed in monitoring."

EFED Response: Comparisons between modeling and monitoring need to consider (among other things) 1) differences in hydrologic setting between the modeled scenario and the monitoring data; 2) use patterns in the monitoring data; 3) the return frequency in the modeling versus the study duration for the monitoring; 4) sampling frequency in the monitoring.

The hydrologic setting for the aquatic modeling represents a pond that is located high in the watershed and is more vulnerable than most sites where the specific crop is grown. The watershed is assumed to be dominated by the production of a single crop. It is a surrogate for other small vulnerable water bodies near the tops of watersheds such as playa lakes, prairie pot holes, vernal pools, and first-order streams. In contrast, most monitoring data are collected on larger creeks, rivers, and reservoirs where dilution by untreated water and dissipation processes have had some opportunity to reduce the concentration from that of water bodies close to the application site. For example, in the Pilot Reservoir Monitoring Study, the smallest watershed was Lake LeRoy in New York, with an area of 3.3 square miles.

In order to evaluate monitoring data, it is important to know the use intensity and application timing in the basin upstream of the sampling station. However, this information is usually not available. None of the studies listed in Bayer's comment (Pilot Reservoir Monitoring Study, NAWQA, STORET, NAWQA phase pilot monitoring program, and the Washington State Surface Water Monitoring Program) were targeted to azinphos methyl usage or to crops on which azinphos methyl may be applied. In some cases, the usage or potential usage can be evaluated *post hoc*, as was done for the final EFED ecological risk assessment supporting the RED.

Monitoring data are collected from several sites, but only a few years in time. Simulation modeling represents longer periods of time at each site. Currently, 30 years is usually simulated, and the 1-in-10 year concentration is used for screening risk assessment. The 1-in-10 year concentration will be greater than more frequent return periods. For example, for the Pennsylvania apple scenario, the 1-in-10 year return value with a 25-ft buffer was 15.0 µg L^{-1}, while the 1-in-2 year value is 9.7 µg L^{-1}.

Tier-2 simulation modeling estimates the concentration in the surrogate water body every day for 30 years, which results in over 10,000 daily concentration estimates. In contrast, monitoring data usually only have a few measurements at each location due the relatively large expense required to collect and analyze each sample. Studies with a high frequency of monitoring typically have 12 to 20 samples taken in a year, resulting in several hundred samples analyzed from all sites in the course of the study. Unless the monitoring study is correlated with pesticide application schedules, it is unlikely that the highest concentrations that occur during the study period will be captured. Consequently, using monitoring data alone to assess acute aquatic risks will usually underestimate the actual risks. Monitoring data tend to be more useful in establishing chronic exposure estimates for risk assessment purposes, provided that the sampling schedule adequately captures the pesticide's presence at the sampling site.

Based on the combination of all of these factors, in general, monitoring data underestimate the exposure of pesticides in the environment especially for pesticides where the short-term or one-time exposure elicits an effect of concern. Tier-2 modeling is used by EPA as a screening tool and may overestimate actual exposures. Real-life exposures generally lie between the estimates from these two methods.

2. Comment (Page 6): "The label specifies medium or coarser spray, applications when wind velocity favors on-site product deposition, use during dormant season prohibited…"

EFED Response: EFED's current model for spray drift from air blast is a regression model and is unable to account for spray quality (*e.g.* medium or coarser spray). (Note that the labels specify spray quality only for aerial and ground boom applications). Wind speed effects also cannot be directly accounted for as the original calculations on which the model is based could not separate wind speed effects from the background variability. Contrary to the comment, EFED did not simulate a dormant application. EFED simulated a sparse orchard to account for air blast spraying over the top of the orchard. The current labels indicate that this practice is, in fact, restricted on the label ("To minimize spray loss over the top in orchard applications, spray must be directed into the canopy.") and a new simulation has been prepared that uses the 'normal' rather than the sparse orchard. Additional modeling has been done using the standard orchard ("Orchard" in AgDrift), rather than the sparse orchard, and the risks to aquatic animals remain.

3. Comment (page 6): "Increasing drift value by a factor of three was not necessary, since the value generated by AgDrift was already conservative."

EFED Response: As noted above, the spray blast model in AgDrift is a regression model, and as such, predicts the mean estimate across the trials that were used in the regression calculation. Consequently, about half of the time, the spray drift deposition will be higher; the other half of the time, it will be lower. Multiplying the pond deposition accounts for this background variability and assures that the screening estimate will be conservative.

4. Comment (Page 6): "Aerial application is prohibited on the label"

EFED Response: There is an SLN label for aerial application to apples in Idaho. The estimate with aerial application only applies to that label. The Oregon apples scenario was used as a surrogate for apples grown in Idaho. Ground spray application was also modeled for apples.

5. Comment (Page 6): "The models do not take into account the dilution that can be attributed to the runoff water and sediment reaching the water body. Also, the models do not take into account the mass of pesticide removed from the pond by overflow."

EFED Response: The volume of the pond is several times the volume of runoff from a 10 hectare field even in the largest runoff events. For example, a large runoff event may generate 5 cm (about 2 inches) of runoff per hectare, which is equivalent to 5 million liters. There are 20 million liters in the pond, so the dilution in the pond is larger than that for dilution in the runoff. The EXAMS model is a steady-state model, and it cannot estimate storm-by-storm runoff. Setting a single steady-state flow tends to underestimate potential exposure substantially, partly because the release from the pond is too great, and partly because real ponds also evaporate, which concentrates the pesticide between storm events. Consequently, the pond scenario is set so there is no flow out of the water body. This is equivalent to assuming that evaporation and runoff are equal, which is a reasonable assumption for many small static water bodies.

6. Comment (Page 10-11): "For aquatic species, detailed field studies have been conducted by a number of researchers… Based on the results of these studies, Bayer CropScience believes that the No Observed Adverse Effects Concentration (NOEAC) for azinphos-methyl to aquatic organisms is near 1 ppb (µg a.i./L)."

EFED Response: The studies that Bayer CropScience refers to suggest that a *single* exposure of azinphos methyl at a very low level (*i.e.* 4 µg a.i./L) can elicit *population-level* effects in aquatic ecosystems (Sierszen and Lozano, 1997). At this level, taxon richness (diversity) was significantly reduced, and recovery of zooplankton populations and communities took one month. Most of the remaining azinphos methyl uses allow more than one application per season, and we would expect that the magnitude of the population declines and the time to recover would increase with increasing applications.

In addition, chronic toxicity studies indicate that significant reproductive effects can occur at levels well below 1 µg a.i./L. In a 21-day *Daphnia magna* chronic toxicity study, significant effects on survivorship, length, and fecundity (mean number of young per adult per reproductive day) were observed at a LOAEC of 0.40 µg a.i./L. For these reasons, a NOAEC of 1 µg a.i./L for aquatic organisms (as suggested in the comment) would not be adequately protective for azinphos methyl.

7. Comment (Page 11): "…significant reduction in both aquatic and terrestrial incidences reported in association to labeled uses…"

EFED Response: Cancellation of the use of azinphos methyl on both sugar cane and cotton, in particular, undoubtedly reduced the ecological risks associated with this chemical. However, the risks associated with the remaining uses of azinphos methyl are still very high. Our assessment concluded that there are acute and chronic risks to all potentially exposed aquatic and terrestrial animals for all of the remaining labeled uses.

Further, the trend of decreasing adverse ecological incidents in the EIIS database is not unique to azinphos methyl. Reports of adverse ecological incidents have dropped dramatically since 1995. We suspect that this decline is more of a result of reduced reporting rather than to a drastic decrease in pesticide risk to fish and wildlife.

8. Comments
(Page 14): "…While model predictions indicate dietary exposure via residues in excess of mortality thresholds, no terrestrial incidence has appeared in the EIIS Pesticide Report since 1999. BCS feels this is indicative of the probability of effects likely elicited in the field with current use patterns."

(Page 14): "The reference to terrestrial incidents should be qualified with the fact that none have been reported since 1999. BCS believes this is related to current label uses and the reduced probability of effects."

(Page 18): "Former field incidences are not in line with current trends associated with current uses. No terrestrial incidence has appeared in the EIIS Pesticide Report since 1999."

(Page 18): "While LOCs are exceeded for these uses, terrestrial incidence reports have not occurred since 1999."

(Page 23): "The assumption that mitigation measures would not reduce risk potential is unsubstantiated. While the Agency's LOCs have been exceeded for terrestrial for many uses patterns the predicted effects have not been realized under true field exposure condition in recent years (i.e. no terrestrial incidence reports since 1999)."

(Page 23): "No terrestrial incidence has been reported since 1999. BCS believes this to be a direct correlation to use mitigation and effective best management practices employed since that time."

EFED Response: These statements assume that there is a rigorous ecological incident monitoring program in place. Wildlife incidents from exposure to an environmental stressor may go unnoticed by humans because dead wildlife can be easily overlooked, even by experienced and highly motivated observers. Reasons for underreporting of wildlife incidents include:

- Wildlife carcass detection is difficult in areas with sparse vegetative cover and nearly impossible where there is dense vegetative growth.
- Birds may fly from the poisoning site, and intoxicated animals often seek cover before dying.
- Scavengers may remove carcasses before they can be observed by humans. Balcomb *et al.* (1984) reported that the removal rate of songbird carcasses by scavengers ranged from 62 to 92 percent in the first 24 hours following placement.
- The density of live birds in agricultural settings is typically low. Thus, even if all the birds in a field were killed and remained on the field, the probability of detecting carcasses, particularly when not systematically searching, is very low. Even when highly-trained individuals conduct systematic searches for placed carcasses in agricultural environments, recovery rates rarely exceed 50 percent (Madrigal *et al.*, 1996).
- If wildlife kills are observed, they are not always reported to the Agency. Those unfamiliar with the potential ecological effects of pesticides may fail to associate the dead wildlife with a pesticide application, especially if the two events are separated by several days or the kill magnitude is low. If the observer makes the connection, he must still be motivated enough to report the incident to the Agency.

Further, the trend of decreasing adverse ecological incidents in the EIIS database is not unique to azinphos methyl. Reports of adverse ecological incidents have dropped dramatically since 1995. We suspect that this decline is more of a result of reduced reporting rather than to a drastic decrease in pesticide risk to fish and wildlife.

9. Comment (Page 15): "EFED presents no argument supporting the expected commensurate toxicity associated with azinphos-methyl degradates. It is unreasonable to assume degradates would magnify potential risk to aquatic organisms without factual substance. This statement by EFED is later contradicted on page 20 of the EFED risk assessment as follows: "Furthermore, none of the degradates that are produced by metabolic pathways, which are the primary routes of degradation for azinphos-methyl, are present at any time at concentrations greater than 10% of the nominal starting concentration of the parent, so they would not be expected to contribute substantially to total toxicity of azinphos-methyl in the environment."

EFED Response: The risks from the parent alone exceed the risk thresholds. There are some environmental degradates, particularly the azinphos methyl oxon, that are potentially toxic. Oxons of other organodithiophosphates are more toxic than the parent. OPP often makes a default assumption that degradates are of equal toxicity to the parent when data has not been provide to the contrary. However, azinphos methyl degradates have not been found in the significant quantities in the environment, and they were not considered quantitatively in the risk assessment. To the extent they are present they increase the risk above what has been estimated for parent, which is already above the Agency's levels of concern for non-target species.

10. Comment (Page 16): "No aerial use is included on the pending label in Idaho."

EFED Response: There is still an active 24(c) in Idaho for aerial application on apples. The SLN number is ID000006.

11. Comment (Page 16): "The pending use label does not include grapes."

EFED Response: At the time the assessment was written, there was an active 24(c) for azinphos methyl use on California grapes.

12. Comment (Page 16): "The pending Group 3 label for azinphos-methyl states that a medium to coarse spray nozzle should be used (according to ASAE 572 definition for standard nozzles) for ground boom and aerial applications. AgDrift inputs should have been made using a medium to coarse droplet size."

EFED Response: EFED agrees that the assessment of aerial application for Idaho should have used a medium spray. However, the risk conclusions would not change if medium spray was used for this use.

13. Comment (Page 17): "The Guthion Solupack label (264-733) is pending for the current uses included in this assessment. Therefore, broadcast spray for Brussels sprouts should not be included. Incorporation or in furrow spraying should have been assessed thus reducing spray drift potential."

EFED Response: The current label allows broadcast spray on Brussels sprouts and that practice was the one used for the risk assessment. If Bayer has submitted alternative use language for Brussels sprouts, it can be evaluated as part of the continuing re-evaluation process for azinphos methyl.

14. Comment (Page 17): "The pending Group 3 label for azinphos-methyl does not include aerial application to apples."

EFED Response: There is still an active 24(c) in Idaho for aerial application on apples. The SLN number is ID000006.

15. Comment (Page 17): "The vast majority of these 130 reported adverse aquatic incidences come from the late 1980's and early 1990's on uses no longer labeled and are therefore not relevant to current label uses."

EFED Response: Cancellation of the use of azinphos methyl on both sugar cane and cotton, in particular, undoubtedly reduced the ecological risks associated with this chemical. However, the risks associated with the remaining uses of azinphos methyl are still very high. Our assessment concluded that there are acute and chronic risks to all potentially exposed aquatic and terrestrial animals for all of the remaining labeled uses.

16. Comment (Page 22): "EFED concludes that risk quotients suggest expected mortality and/or sub-lethal effects, incident data and surface water monitoring data since 2001 (since significant mitigating practices have been implemented) suggest a low probability of such effects."

EFED Response: As discussed above, because monitoring data generally underestimate acute risk, it cannot be used to rule out risk above the level of concern. Further, the slope of the dose-response curve for azinphos methyl is very steep, and small exceedance of effects thresholds can elicit profound ecological effects.

17. Comment (Page 24): "The studies performed were level 1 field studies which are designed to provide only qualitative information about effects. They were not designed to quantify the magnitude of effects occurring."

EFED Response: These field studies were used in a qualitative manner and only to provide additional lines of evidence in the ecological risk assessment.

U.S. Apple Association (EPA-HQ-OPP-2005-0061-0087.2)

1. Comment (Page 2): "…spray drift model assumes that wind is always blowing in the direction of its hypothetical farm pond at the highest allowable wind velocity, the vegetation cover is sparse and the drift value is multiplied by three. The water model calculates loading of the pesticide in the pond assuming that all orchards are composed of soils with high runoff potential. Additionally, the water model counts pesticide runoff carried by water into the pond, counting only the pesticide deposition and not the water….This model compounds the pesticide loading scenario by restricting natural out flow of the pond. Also, it does not count the run off reduction from the 25 foot buffer which is required on the azinphos methyl label, and it does not include the run off reduction from a vegetative buffer between the pond and the hypothetical farm field. This assumption contradicts the real scenario in apple production. These assumptions reflect the most conservative scenario for azinphos methyl use, not a realistic scenario."

EFED Response: The U.S. apple association is correct that EFED modeling assumes that the wind is always blowing directly at the pond. Currently, available spray drift models do not have the capability to account for wind direction, so assuming that the wind always blows towards the pond allows the assessment of spray drift in the absence of such a capability. Sparse orchards can be used to represent dormant applications (which are prohibited on the label) as well as applications to immature orchards and to address the drift from applications that go over the top of the canopy. For these simulations, it was this last case (over the top of the canopy) which was the justification for using the sparse orchard. However, there is language on the label which indicates that practice is prohibited, so it was incorrect to use a sparse orchard on that basis. Additional modeling has been performed with a generic orchard rather than the sparse orchard to correct this error. Predicted exposures are somewhat lower; however, risks still exceed the Agency's level of concern.

The modeling considered spray drift buffers, but not run-off buffers. A high runoff potential soil is used in the scenario so that the simulation will account for the most sensitive areas where there are apple orchards, in general. Vegetative buffers are not expected to meaningfully reduce azinphos methyl movement to water unless they are specifically constructed and maintained for that purpose. Otherwise, water tends to flow along the buffer to a low point and cross the buffer as concentrated flow with little or no mitigation effect. EFED does believe that the use of constructed and maintained Vegetated Filter Strips (USDA NRCS 2000) can reduce the potential for runoff. However, tools are not currently available to quantify the expected reduction in runoff when this mitigation practice is used.

An explanation for dilution effects in pond is provided in the response to comment #1 from Bayer CropScience.

2. Comment (Page 2): "EPA's modeling scenario utilizes data that are inconsistent with monitoring data measuring real azinphos methyl concentrations in water bodies across the United States. In its Pennsylvania air blast modeling scenario EPA generates a concentration of 15.1 parts per billion (ppb) and 9.9 ppb for its Oregon air blast scenario. However, STORET and U.S. Geological Survey (USGS) monitoring data indicate azinphos methyl concentrations are mostly 1 ppb or less, with two peak values of less than 4 ppb between 1990 and 2005. After 2001, the highest concentrations from actual monitoring data were 0.75 ppb in Oregon and less than 0.05 ppb in Pennsylvania."

EFED Response: Explanation for differences in modeling and monitoring are discussed in the response to comment #1 from Bayer CropScience.

3. Comment (Page 2): "…EPA's ecological risk assessment fails to provide the full context when discussing azinphos methyl detections in Washington state. While stating on pages 39-40 that azinphos methyl was detected in a high percentage of samples collected by USGS in 1999 and 2000, the agency does not mention that more than 95 percent of the detections were below 0.1 ppb. The assessment also omits USGS data that would reflect significant usage changes resulting from azinphos methyl label changes in 2002 and 2003. USGS data indicate that between 2001 and 2004 in Washington state there were 408 azinphos methyl samples with a maximum value of 0.18 ppb with only 7 samples with concentrations above 0.05 ppb."

EFED Response: EFED agrees that azinphos methyl was detected in a large number of samples at relatively low concentrations. EPA did not re-evaluate all available monitoring data for this assessment; however, monitoring data evaluated for one site, Granger Drain, indicated a similar trend, with a high percentage of azinphos methyl detections at low concentrations during the application season (May 20-August 31). The maximum concentration, 0.18 µg/L, was reported in 2003. Samples were collected at most on a weekly basis. There was no discernable trend in concentrations at that site to correlate with a decline in azinphos methyl usage referred to in the comment. In approximately weekly sampling from 1999 to 2004 (except 2000), detection frequency ranged from 76% in 2003 to 100% in 2001 and 2002. Only two samples were collected during the application season in 2000. There were also no apparent trends in concentration during the application season as well. Monitoring in the NAWQA program for the most part reflects larger streams and rivers that reflect a wide variety of land uses in the basin. Smaller water bodies will have higher aquatic exposures of azinphos methyl.

4. Comment (Page 2): "The weight of the evidence from available monitoring data indicates that azinphos methyl concentrations are significantly lower than the hypothetical values used in the ecological risk model to calculate ecological impacts from azinphos methyl. Additionally, the monitoring data indicate that these values have continued to decline as EPA has imposed greater restrictions on azinphos methyl use. These factors are strong indicators that EPA's model overestimates the ecological risk, since real measurements of azinphos methyl are significantly lower than the hypothetical values used in the model."

EFED Response: A cursory analysis of the monitoring data from Washington did not support the claim that concentrations in surface waters have declined in all areas, although that may be the case in areas where agriculture is dominated by crops on which azinphos methyl can no longer be used (*e.g.* sugar cane). EFED believes that the monitoring data do not reflect the full potential for toxic exposures to azinphos methyl as discussed above (in the response to comment #1 from Bayer CropScience). Available monitoring data are collected at most on a weekly basis and would be expected to result in lower concentrations than are estimated by the 1-day modeling time-step. EFED's Tier-2 simulation modeling is conservative by design and estimates risk for locations that are most vulnerable to ecological risk. The concentrations to which aquatic organisms are actually exposed probably fall somewhere between the monitored and modeled results. Since there continues to be some monitoring measurements above the level of concern, based on these results alone, we would expect there to be some adverse environmental impacts as a result of azinphos methyl use.

5. Comment (Page 2): "…the absence of recent adverse ecological incidences indicates that previous label modifications have been effective in reducing the ecological impact of azinphos methyl use. The dearth of such incidents also suggests that EPA's theoretical risk model overstates the real risk from azinphos methyl use. As an example, most previous incidents were caused by uses on cotton or sugarcane which are no longer labeled for use. Additionally, there have been no reported incidents since 2001."

EFED Response: Cancellation of the use of azinphos methyl on both sugar cane and cotton, in particular, undoubtedly reduced the ecological risks associated with this chemical. However, the risks associated with the remaining uses of azinphos methyl are still very high. Our assessment concluded that there are acute and chronic risks to all aquatic and terrestrial animals for all of the remaining labeled uses.

Further, the trend of decreasing adverse ecological incidents in the EIIS database is not unique to azinphos methyl. Reports of adverse ecological incidents have dropped dramatically since 1995. We suspect that this decline is more of a result of reduced reporting rather than to a drastic decrease in pesticide risk to fish and wildlife. In recent years, state budget shortfalls have caused many states have cut funding for programs responsible for investigating and reporting fish and wildlife mortality incidents.

Citations

Balcomb R, Stevens R, Bowen II C. 1984. Toxicity of 16 granular insecticides to wild-caught songbirds. *Bull. Environ. Contam. Toxicol*. 33:302-307.

Madrigal JL, Pixton GC, Collings BJ, Booth GM, Smith HD. 1996. A comparison of two methods of estimating bird mortalities from field-applied pesticides. *Env. Tox. Chem*. 15:878-885.

USDA NRCS. 2000. *Conservation Buffers for Reducing Pesticide Losses.* Natural Resource Conservation Service. Fort Worth, TX. 21 pp.