26/OPP#34134 (36PP)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

NOV 1 1994

Mr. John S. Thornton
Manager Registrations
Miles, Inc.
Box 4913 Hawthorn Road
Kansas City, MO 64120-0013

Dear Mr. Thornton:

Subject: Risk Mitigation Procedures - Fenamiphos

The Environmental Fate and Effects Division /EPA has provided recommendations on the development of risk reduction procedures that can be applied to pesticides. The enclosed paper "Preliminary Recommendations on Developing Risk Reduction Strategies and Monitoring Programs" provides the background information and the rationale for the development of risk mitigation procedures.

Appendix II is a format to be used by all registrants for submitting "mitigation procedures." However, to expedite the RED process for Fenamiphos, strict adherence to this format will not be required. You will be expected to use the established procedure for submitting mitigating procedures, if needed, for other pesticides.

Questions regarding this letter should be addressed to Irwin Hornstein at (703) 308-8042.

Sincerely,

/S/

Lawrence J. Schnaubelt, Section Head
Reregistration Branch, Section II
Special Review and
Reregistration Division

Enclosure:

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CONCURRENCES

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## Preliminary Recommendations on Developing Risk Reduction Strategies and Monitoring Programs

### Acknowledgements

In this paper the Environmental Fate and Effects Division of the Office of Pesticides, U.S. EPA, provides preliminary recommendations on development of risk reduction strategies and monitoring programs for pesticides which exceed an established level of concern. These recommendations encompass methods for risk mitigation which have been suggested in the context of pesticide use, as well as in other arenas. Addressing the questions surrounding mitigation of the ecological risks of pesticides requires utilizing the work of many people who have devoted years to studying pesticides and their effects on the environment. We have relied heavily on many sources of existing information including regulations and guidance from EPA's Office of Water; the Avian and Aquatic Dialogue Groups; the Avian Granular Analysis; as well as proposals previously submitted by registrants for specific chemicals.

Registrants have the obligation under FIFRA of showing that their pesticide does not cause unreasonable adverse effects. In situations where the pesticide exceeds an established Level of Concern (LOC), EPA encourages registrants to undertake measures to reduce the ecological risks. This document provides registrants preliminary recommendations on the development of risk reduction strategies. EPA will certainly consider risk reduction actions taken by the registrant as EPA continues to weigh the risks and benefits of pesticides. However, these risk reduction actions will not be in lieu of EPA carrying out its responsibility to take appropriate regulatory action.

Risk reduction or risk mitigation measures are actions to reduce or eliminate environmentally unacceptable concentrations of pesticides in aquatic and terrestrial habitats where they impact nontarget species. EPA believes that environmental exposure and adverse effects of pesticides to non-target species can be reduced for many chemicals that exceed Levels of Concern. Registrants are encouraged to propose risk mitigation measures; provide data to support proposed risk mitigation measures; and provide data to further characterize exposure, hazard, and risk following implementation of mitigation.

This overview of preliminary recommendations to develop risk reduction strategies and associated monitoring programs is divided into nine sections: 1.0 Introduction; 2.0 Primary Risk Mitigation; 3.0 Educational Programs; 4.0 Risk Mitigation for Surface Water Concerns; 5.0 Risk Mitigation for Terrestrial Concerns; 6.0 Application Methods; 7.0 Monitoring Programs; 8.0 Other Related Research, Monitoring and Mitigation; and 9.0 Format for Submitting Risk Mitigation/Monitoring Proposals to the Agency.

## 1.0 Introduction

Recent emphasis on risk-based approaches for environmental regulations (Thomas 1987; U.S. EPA 1989c, Science Advisory Board 1990a,b,c,d) is leading to increased integration of societal values, science, and risk mitigation practices in environmental decision-making. The integrated decision-making process involves three interactive phases: 1) risk assessment; 2) risk management; and 3) risk reduction.

Risk assessment is the scientific phase of the overall process and consists of hazard identification and characterization; exposure assessment; and ultimately integration of hazard and exposure to characterize risk.

Risk management is a policy based activity that defines assessment questions and endpoints to protect human health and ecosystems. Of necessity, risk management incorporates societal norms by considering socioeconomic values and legal statutes in establishing assessment goals. Risk management, therefore, considers broad based objectives for further scientific risk assessment and for risk reduction activities.

Risk Reduction involves implementation of remedial or mitigation measures to reduce or eliminate unacceptable source contamination and adverse environmental impact.

In this three phase decision making process risk assessment identifies the hazard and resources at risk; defines measurement questions and endpoints to determine the condition of the resources at risk; links cause and effect through stress-response studies; and determines environmental exposure. To achieve this end the risk assessment process may involve experimentation, modeling, monitoring, or a combination of techniques.

If risk managers deem the scientific and societal risk to be unacceptable, source reduction through mitigation activities is one management option to minimize the exposure and effects to resources at risk. If the risk cannot be reduced to an acceptable level, EPA can take regulatory action under FIFRA to require additional actions for lowering the risk; restrict use of the pesticide; or cancel the pesticide registration.

As a scientific process, risk assessment is a function of ecotoxicological hazard and environmental exposure. Ecotoxicological hazard is the intrinsic quality of a chemical to cause direct or indirect effects under a particular set of circumstances. Hazard data may include acute effects, chronic effects, and observed field effects for terrestrial and aquatic vertebrates, invertebrates, beneficial insects, and plants. Environmental exposure consists of two components: 1) the concentration of residue in the environment and available to nontarget organisms; and 2) the numbers and kind of nontarget biota that may come into contact with these chemical residues. The latter information may be incomplete or unavailable. Ecological risk is characterized by comparing the toxicological hazard to the environmental exposure to determine the ecological risk(s).

For pesticide registration and reregistration, ecological risk assessments generally consist of the following activities.

1) Establish the endpoints of concern for the pesticide and its use(s).

2) Review the eco-toxicity data submitted to support the registration or reregistration and evaluate the overall toxicity to non-target, non-human organisms and their habitat based upon the data submitted and evaluated.

3) Calculate risk quotients based upon the eco-toxicity data; and the pesticide use data, fate and transport data, and estimates of exposure.

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

4) Compare the risk quotients to established regulatory Levels of Concern. Several ecological levels of concern are used in OPP regulatory decision-making. The LOC's consist of a quotient comparison of a measured hazard with the estimated environmental concentration (EEC).

5) If LOC's are exceeded, a refined risk assessment may then be conducted. Exposure estimates are refined and the extent of risk is further examined with

respect to the extent of use, incident reports, species exposed, and quality of treated habitat. Interim risk reduction measures may be pursued at this time.

6) If LOC's are still exceeded, a comparative analysis of alternative pesticides may be done. This includes a weight of evidence analysis reflecting the refined exposure assessment and including a characterization of the duration, extent, and frequency of the risk. The information is summarized in an ecological risk conclusion and communicated to the risk management Divisions.

In the recent past, the Agency allowed registrants the option of rebutting the presumption of risk when LOCs for a particular pesticide were exceeded. This was accomplished by conducting terrestrial and aquatic field studies or simulated field studies. The Agency's recent policy decisions place less reliance on rebutting the presumption of risk with field studies, and, instead, promote risk reduction when LOC exceedances are identified through the risk assessment process. If risk mitigation measures have been identified and implemented, post-registration or post-reregistration monitoring may be necessary to ensure the efficacy of the mitigation measures.

The Agency believes that environmental exposure and adverse effects of pesticides to non-target species can be reduced for many chemicals that exceed Levels of Concern. Accordingly, when LOCs are exceeded registrants should:

- Propose risk mitigation measures;

- Provide data to support proposed risk mitigation measures; and

- Provide data to further characterize exposure, hazard, and risk following implementation of mitigation.

Mitigation measures should reflect the best possible non-point control practices, technologies, processes, or other alternatives which will result in the greatest achievable reduction in the availability of pesticides to nontarget organisms. Chemical specific, site-specific, regional and national conditions associated with pesticide use will influence ecological hazard, environmental exposure, the characterization of risk, and possible mitigation measures. As a result, the recommendations provided in this document are not all-inclusive, nor do they preclude the use of other innovative, technically sound mitigation measures. The recommendations provided here will serve as a starting point for The Agency's development of more comprehensive guidance for pesticide risk reduction and monitoring.

When preparing risk mitigation proposals, registrants should list site specific conditions that would either enhance or detract from the effectiveness of the proposed mitigation measures. In the proposal stage, relevance of a mitigation measure to exposure reduction may be shown by relating the characteristics of the specific chemical to the properties of the mitigation measure, under specified use conditions. For example, if variations in soil type change the effectiveness of a measure, these variations should be addressed in the proposal. It is likely that different mitigation measures would then be proposed for areas with different soil types.

All risk mitigation proposals should be approached as a system of interactions. For example, decreasing avian risk only to increase worker risk, or vice versa, might be acceptable under certain circumstances, but is never optimal. Similarly, increasing groundwater risk in order to reduce surface water risks is not an optimal solution. The existence of these types of interactions is one of the many reasons the Agency emphasizes source reduction as the best mitigation option.

Risk reduction proposals must be shown to be capable of accomplishing the desired objective--reduction of exposure and hazard, and ultimately prevention of unacceptable risk. The criteria for judging the effectiveness of a mitigation measure in actual use conditions will be performance based. Evaluation of risk reduction will be a continuing process and may require exposure and effects monitoring to verify the efficacy of a particular mitigation action. It should be emphasized that the Agency's acceptance of specific risk mitigation or exposure reduction proposals does not imply that risk from a particular pesticide or pesticide use-pattern has been reduced to an acceptable level. EPA will continue to assess the risks and benefits of pesticide and to take the appropriate regulatory action.

## 2.0 Primary Risk Mitigation Measures

There is general agreement that the best approach to reducing levels of concern for highly toxic chemicals is <u>source control</u>, that is, putting less of the chemicals into the environment. Measures to reduce the movement of pesticides to surface and groundwater (field and delivery control), or make pesticides less available to aquatic and terrestrial habitats where they affect non-target habitat are considered secondary to source reduction. In the long run, source reduction not only reduces risk to non-target organisms and groundwater, it also benefits the agricultural user by reducing pesticide costs. For example, the initial cost of a cutoff device can be recouped through savings on the amount of chemical used. Optimizing application rates will decrease user costs by providing for use of the minimum amount of pesticide that is efficacious and will discourage the development of resistance and possibly more costly remedies in the future.

The mitigation measures listed in this section are generally applicable to both aquatic and terrestrial exposure. Methods that are targeted at specific groups of organisms are included in the respective sections on surface water (4.0), or terrestrial concerns (5.0).

The primary methods of source control are:

(1) reduction in the application rate; and
(2) reduction in the number of applications.

Reduced application has been and will remain the starting point for risk mitigation proposals. Each mitigation proposal submitted must explicitly address the possibility of reduced rates for each use. Where reductions are possible new rates should be proposed.

An example of an innovative approach to reducing application rates occurred in the avian granular analysis. At least one registrant committed to developing efficacy data to support a wider range of use rates. This effort to "optimize" use rates to enable users to fine tune their applications represents the kind of commitment to long-term source reduction that the Agency wishes to promote. Other registrants provided revised instructions that included a range of applications for control. Under this general category there were recommendations for "split" applications. In split applications, the second "part" of the application is recommended only in instances of very heavy infestations.

Reduction in the number of applications allowable has also been used as a risk reduction strategy. Data showing that reduced numbers of applications will result in less exposure and/or hazard will be required.

Depending on the specific pesticide characteristics and the type of toxicity of concern, an additional mitigation measure in this category might be:

(3) increasing the application interval.

However, in some cases increasing the application interval may result in the exposure of more animals for a longer period of time. Therefore, specific evidence, based on a detailed analysis of the fate of the chemical and its use pattern, must be developed to show that this is unlikely to occur.

Other mitigation measures that come under the general category of source reduction and which may be useful in cases where it is not possible to reduce application rates for specific crop/pests are: limiting crops; limiting the total number of acres treated; imposing production caps; and State Management Plans (see Prescription Use, p. 7). Mitigation measures in each of these categories may reduce overall usage even if specific application rates are unchanged. In each case the effectiveness of a specific measure must be demonstrated. In general, to support these types of proposals, data on acreage treated and evidence that a likely result of the mitigation measure is a reduction in number of acres treated is necessary. Such data may include information on maximum versus typical use rates and estimates of acreage affected by the proposed label changes.

In limited circumstances, where other mitigation measures are not sufficient to reduce risk, and there are high benefits from retaining a pesticide in a particular, well defined use, then:

(4) prescription use may be considered.

In the case of prescription use, application would be allowed only under narrowly defined circumstances. Due to the relative high costs of operation and implementation, prescription use is only recommended when benefits are expected to be large. Where prescription use has been attempted, a recognized mechanism for the approval of the specified uses is established. This mechanism usually involves a state agency. These types of specific limitations have often been used in California, for example.

Another example of a plan for prescription use involved application of Guthion to sugarcane in Louisiana. The opportunities for aquatic risk mitigation were limited, while the benefits, as judged by the State, were high. Therefore, the proposed risk mitigation strategy was to limit total Guthion application in a given watershed, over a pre-specified time interval, by issuing permits for use. Mechanisms for issuing permits, as well as tracking recommended and actual applications had to be developed. The resources required to implement this plan were substantial.

State Management Plans to address the risks posed by chemicals which may contaminate groundwater in specific geographic areas are another example of prescription use.

Finally, in cases where unacceptable risk cannot be effectively mitigated:

(5) elimination of specific uses, formulations, application methods, etc. may be the only available risk reduction option.

If registrants do not agree to undertake risk mitigation measures that are adequate to reduce the ecological risk, EPA will consider regulatory action under FIFRA.

## 3.0 Educational Programs

A mitigation measure recommended in all cases and one which must be included in every mitigation proposal is an educational program.

Educational programs, at a minimum, should inform users and the public of:

(a) the ecological risks of the use of the particular pesticide;

(b) the relevant factors that affect the ability of the user to mitigate these risks under very specific use scenarios; and

(c) other pest control measures which may be appropriate. These measures might include cultural practices such as crop rotation, cover cropping, and alternative tillage practices; pest monitoring techniques such as scouting, trapping, and population modeling; and biological mitigation techniques such as resistant plant varieties, appropriate planting dates, and the augmentation or maintenance of beneficial species. The aim should be to reach economically acceptable, rather than total, pest control.



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Educational programs directed at formulators and users are being employed by some registrants as a result of the avian granular risk reduction effort; in connection with limiting aquatic exposure in the use of synthetic pyrethroids; as a part of reducing the use of Guthion on sugarcane in Louisiana; and in connection with the proper mixing and application of pesticides.

Promotion of specific farming practices may be useful in educational programs. Farming practices that are well documented elsewhere are not discussed in detail here. However, examples of potentially useful practices include soil conservation and related runoff control practices; as well as, integrated pest management as applied to specific chemicals, crops, and site conditions. These methods have the advantage of often reducing other adverse environmental impacts of agriculture such as erosion and nutrient loading to surface water. Furthermore, some of these methods can be implemented fairly inexpensively and without reducing the efficacy of the pesticide.

It is important that the suggested practices be considered in the context of the specific pesticide's properties and the overall minimization of adverse impacts. For example a relevant farming practice might be to require that certain tillage practices which reduce erosion be used when certain types of pesticides are applied. This might be an effective mitigation measure for pesticides which bind tightly to the soil but not very effective for an extremely water soluble chemical. Also, changing the application timing of herbicides from pre-emergent to post-emergent can reduce transport since growing plant transpiration reduces soil moisture thus increasing infiltration and reducing runoff. A drawback to some of these methods is that they may tend to increase ground-water contamination in the process. These types of tradeoffs need to be considered on a case-by-case basis with minimizing risk to watersheds and the relevant ecosystem as a whole being the ultimate objective.

The Agency's experience indicates that the most useful education programs incorporate pest management strategies that focus on diagnosing pest infestation levels to determine whether pesticide applications are needed. If pesticides are needed, only the amount of pesticide necessary should be applied. Educational material is most useful if widely distributed and incorporated into training programs for certified applicators. Educational materials appear to have much greater utility when linked to "on farm" demonstrations.

## 4.0. Risk Mitigation for Surface Water Concerns

EPA recommends surface water risk mitigation measures in cases where source control does not adequately mitigate risk. Mitigation measures are required for pesticide uses which may result in risk to natural or man made bodies of water such as lakes; public reservoirs; rivers; permanent streams; marshes; ponds; estuaries; or any area where surface water is present or any intertidal area below the mean high water mark.

The physical characteristics to be considered in developing site specific proposals should include proximity of use site to surface water; runoff potential; wind erosion and prevailing wind direction; general erodibility of soils; adsorptive capacity of soils; and soil permeability.

The measures listed here apply principally to reduction of exposure that is associated with runoff. Spray drift and differences in exposure resulting from different application methods are included in Section 6.0.

The discussion of each measure includes factors which argue for or against its use in different situations. Although only illustrative, the examples present several of the kinds of factors that need to be listed in detail for each mitigation proposal submitted.

## 4.1 Vegetative Buffer Zones

Vegetative buffers are defined as strips of vegetation separating a water body from a pesticide use that could act as a non-point pollution source. Vegetated buffers are variable in width and can range in function from a vegetated filter strip to a constructed wetland or riparian area.

### 4.1.1 Vegetative Filter Strips

The term vegetative filter strip has been used in many contexts and there is no consensus on what constitutes a buffer, what activities are acceptable in a buffer zone, or appropriate buffer widths. The purpose of vegetated filter strips is to remove pesticides, sediment, and other pollutants from runoff by filtration, deposition, infiltration, absorption, adsorption, decomposition, and volatilization, thereby reducing the amount of the pesticide entering surface waters. Vegetated filter strips can improve water quality by removing nutrients, sediment, suspended solids, and pesticides. They appear to be most effective in sediment removal (with rates generally greater than 70 percent); other suspended solids; and pesticides which adsorb to sediments and other suspended solids. Results are more variable for nutrient removal. Testing done on toxicant removal has found that removal rates are lower for soluble pesticides (Schueler, 1987; Dillaha et al., 1988, 1989; Magette et al., 1989; Young et al., 1980; Dickey and Vanderholm, 1981; Schwer and Clausen, 1989; and Overman and Schanze, 1985).

Vegetated filter strips are designed to be used under conditions in which runoff passes over the vegetation in a uniform sheet flow. Such flow is critical to the success of the filter strip. If runoff concentrates or is channelized, the vegetated filter strip is easily inundated and will not perform an effective removal function. There is evidence that, unless properly maintained, filter strips work for a period of time but then become funnels that move chemicals directly to water bodies.

Vegetated filter strips need the following elements to work properly: (1) a device such as a level spreader that ensures that runoff reaches the vegetated filter strip as a sheet flow; (2) a dense vegetative cover of erosion resistant plant species; (3) a gentle slope of no more than

5%; and (4) a length at least as long as the adjacent contributing area. If these requirements are met, vegetative filter strips have been shown to remove a large percentage of particulate pollutants. If existing site conditions include concentrated flows, then this measure will not work. Contact time between runoff and the vegetation is a critical variable influencing their effectiveness. Pollutant-removal effectiveness increases as the ratio of vegetative filter strip area to runoff-contributing area increases. Again, however, the effectiveness of vegetative filter strips at removing soluble pollutants is not well documented (Schueler, 1987). Finally, it should be noted that if a storm caused runoff is in excess of the design runoff, the filter may be flooded and cause a large load of pesticides to be released into surface water.

Effectiveness varies with topography, vegetative cover, implementation, and use with other management practices. These factors need to be considered on a pesticide and site specific basis. In-addition, different characteristics such as size and type of vegetation will affect removal efficiency. Regional differences will also impact the effectiveness of vegetative filter strips. Regional differences that require consideration include: climate; amount and duration of rainfall; seasonal differences in precipitation patterns; and the type of vegetation suitable for local climatic conditions. Soil type and land use practices also vary and will affect surface water runoff and thus vegetative filter strip performance.

Key elements to be considered in the design of vegetated filter strips are:

Type and quantity of pesticide. The primary factor to be considered is that removal rates are much lower for soluble pesticides.

Slope. Vegetative filter strips function best on slopes of less than 5 percent; slopes greater than 15 percent render them ineffective because surface runoff flow will not be sheet-like and uniform. The effectiveness of vegetative filter strips is strongly site-dependent. They are ineffective on hilly plots or in terrain that allows concentrated flows.

Native/Non-invasive Plants. The best species for vegetative filter strips are those which will produce dense growths of grasses and legumes resistant to overland water flow. Native or at least non-invasive plants should be used in order to avoid adverse impacts to adjacent natural areas.

Length. The length of the vegetative filter strip is an important variable influencing its effectiveness because contact time between runoff and vegetation in the strip increases with increasing strip length. Some sources recommend a minimum length of about 50 feet (Dillaha et al., 1989a; Nieswand et al., 1989; Schueler, 1987). USDA has prepared design criteria for vegetative filter strips that take into consideration the nature and source area for the runoff and the slope of the terrain. Another suggested design criterion found in the literature, is for the vegetative filter strip length to be at least that of the runoff-contribution area. The optimal length of the buffer strip is a question that may usefully be considered under Section 8.0 in terms of research areas and under Section 7.0 in terms of specific questions to be addressed in monitoring studies.

Detention Time. In the design process for a vegetative filter strip, some consideration should be given to increasing the detention time of runoff as it passes over the strip. An example of an improved method might be to design the vegetative filter strip to include small rills that run parallel to the leading edge of the vegetated filter strip. These would serve to trap water as runoff passes through the vegetative filter strip. Another possibility is to plant crops upslope of the vegetated filter strip in rows running parallel to the leading edge of the strip. (Young, 1980).

Monitoring Performance. The design, placement, and maintenance of vegetative filter strips are all critical to their effectiveness, and concentrated flows should be prevented. Although intentional planting and naturalization of the vegetation will enhance the effectiveness of a larger filter strip, the strip should be inspected periodically to determine whether concentrated flows are bypassing or overwhelming the strip, particularly around the perimeter. The filter strip should be regularly inspected to determine whether sediment is accumulating within the strip in quantities that would reduce its effectiveness (Magette et al., 1989). Specific instructions on how to remove and dispose of contaminated sediments should be included in the mitigation proposal.

Maintenance. Dillaha and others (1989b) showed that many vegetative filter strips installed in Virginia performed poorly because of poor design and maintenance. Maintenance measures which will make performance more efficient are: addition of a stone trench to spread water effectively across the surface of the filter; keeping the strip carefully shaped to ensure sheet flow; inspecting for damage following major storm events; and removal of any accumulation of sediment.

Although a vegetated buffer strip is likely to be the best physical solution to control pesticide laden surface runoff, research has been undertaken into other options which could be effective under unique circumstances on a case-by-case basis. These would include constructed wetlands, detention ponds, etc. Evaluation of historical aerial photos can be used to identify where natural landscape detention or riparian zones once existed. These can be used in landscape management decisions. A brief description of these follows.

### 4.1.2 Constructed Wetlands

Constructed wetlands are, typically, engineered complexes of saturated substrates, emergent and submergent vegetation, animal life, and water that simulate wetlands (Hammer et al., 1989 also 1992). According to Hammer et al., (1989) constructed wetlands typically have four principal components that may assist in pollutant removal:

(1) substrates with various rates of hydraulic conductivity;
(2) plants adapted to water-saturated anaerobic substrates;
(3) a water column (water flowing through or above the substrate); and
(4) aerobic and anaerobic microbial populations.

Constructed wetlands have been considered for use in agricultural settings where some sort of engineered system is suitable for non-point source pollution reduction. Studies have been conducted to evaluate the effectiveness of artificial wetlands that were designed and constructed specifically to remove pollutants from surface water runoff (Touvila et al. 1987; Martin and Smoot. Undated; Rushton and Dye 1990; Oberts and Osgood 1991).

In the case of pesticide removal the constructed wetlands offer few, if any, additional ecological benefits due to the quantity and type of pollutants that are received in runoff. Constructed wetlands that receive water containing large amounts of pesticides must be fenced, covered, and otherwise barricaded to prevent wildlife use.

In general, constructed wetland systems designed for treatment of non-point source pollution in surface water runoff have been found to be effective at removing suspended solids and pollutants that attach to solids and soil particles (Touvila et al. 1987; Martin and Smoot. Undated; Rushton and Dye 1990; Oberts and Osgood 1991). Like the vegetative filter strips, constructed wetland systems have not been found to be as effective at removing dissolved pollutants and those pollutants that dissolve under conditions found in the wetland.

With proper planning and maintenance, vegetated buffer zones (filter strips and constructed wetlands) can be a beneficial aspect of a network of non-point source pollution control measures. When coupled with farming practices that reduce pesticide inputs and minimize soil erosion, constructed wetlands and filter strips may be particularly effective. Whether constructed wetlands and vegetative filter strips are used individually or in combination will depend on several factors, including the quantity and quality of the inflow from runoff, the characteristics of the existing hydrology, and the physical limitations of the area surrounding the surface water to be protected.

### 4.2 Detention ponds/other water holding areas

Structural practices to control pesticides in runoff rely on retaining runoff water for a long enough period for natural degradation to take place before the water is released to the environment.

#### 4.2.1 Detention Practices

Detention methods temporarily impound runoff to allow pesticides to degrade before release of the water into surface water. Detention methods are most useful for chemicals which have a short hydrolysis/photolysis half life and therefore degrade in a relatively short period of time. Disadvantages of these measures are that removal rates for soluble pollutants are quite low and there is potential for negative impacts such as downstream warming, reduced baseflow, and trophic shifts. In addition detention areas must be fenced, covered, and otherwise barricaded to prevent wildlife use. Consideration must also be given to ensure these measures do not adversely affect groundwater.

### 4.2.2 Other Water Holding Areas

Detention and other water holding methods have been used in pollution prevention on irrigated lands. Holding areas are used to collect and store irrigation tailwater for reuse in the farm irrigation distribution system. An example of this mitigation practice is provided by a California rice pesticide demonstration project (Sutton et al., 1992). Rice agriculture in the Sacramento Valley occurs on poorly drained clay soils. The predominant irrigation method is continuous flood from sowing to harvest. Water flows from one field to another, and excess water enters a drain at the end of the field, where it may be recycled, reused in a downstream field, or discharged to the river. The conventional method resulted in release of pesticide laden irrigation water directly into surface waters.

Since 1983, in the demonstration project, pesticide levels in public waters have been reduced over 90% through education, stringent regulatory programs, and changes in water management practices. The primary means of reducing residual pesticide levels has been holding irrigation tailwater on the rice field or on set-aside lands to allow natural degradation to occur. Monitoring the demonstration sites includes testing irrigation water entering and leaving the field every two days during the irrigation season. Watershed and ambient monitoring is also part of the project.

In conjunction with irrigation, factors affecting the movement of pesticides are the pathways taken by applied water and precipitation; the physical, chemical, and biological characteristics of the irrigated land; the type of irrigation system used; crop type; the degree of erosion and sediment control; pesticide management; and the management of the irrigation system. Return flow, runoff, and leachate from irrigated lands may transport both particulate bound pesticides and soluble pesticides. Since irrigation is a consumptive use of water, any pollutants in the source waters that are not consumed by the crop can be concentrated in the soil, concentrated in the leachate, or concentrated in the runoff or return flow from the system. Special risk mitigation measures, for example, backflow preventers, tailwater prevention, and control of deep percolation have been recommended when chemigation is used.

## 4.3 Other surface water mitigation measures

Other risk reduction measures have been used by various state agencies, as demonstrated by submissions of incident data to the Office of Pesticide Programs. For example, in one state it was realized after applying an aquatic herbicide in a band across ponds, fish kills were significantly fewer than with non-banded applications. Since it is common practice to evaluate incidents and make necessary label changes at the state level, the collection of incident data can be a valuable source of ideas for mitigation proposals as well as efficacy information.

## 5.0 Risk Mitigation for Terrestrial Concerns

EPA recommends terrestrial risk mitigation measures in cases where source control does not adequately mitigate risk. The measures listed here apply principally to mitigation of exposure resulting from pesticide residues. Differences in exposure resulting from different application methods are also addressed. Spray drift is discussed separately in Section 6.0, which also contains more information on application methods.

Assessing pesticide risks to terrestrial non-target animals can be complex because of the variability associated with ingestion or absorption of a pesticide or its residues in different non-target species. Uncertainty can be reduced by identifying potential exposure of the species at risk, and the timing and geography of exposure in order to better characterize the potential impact. Mitigation strategies can then be tailored to the properties of the pesticide, the pesticide uses, and populations and systems specifically at risk. Risk mitigation proposals should address these factors.

The Agency is moving toward use of this more specific information to prioritize pesticide use based on such factors as environmental fate; acreage treated; quality of the crop and the surrounding use areas as habitat; wildlife utilization; and the species exposed. However, until additional research and information synthesis are completed, the Environmental Fate and Effects Division will principally use acres treated to prioritize concerns. Additional considerations will be used on a case-by-case basis if there are specific resources or critical ecological habitats at risk. Examples of how more specific priorities could be set, and have been in some cases, are included in this Section under "ranking habitat" (Section 5.4).

### 5.1 Formulation

An area of ecological risk mitigation that has been investigated more extensively than some others, particularly as the result of terrestrial risk concerns, is changes in pesticide formulations. A well developed example is the analysis of avian risks, and possible risk mitigation for granular pesticides. Registrants have proposed research to study the use of repellents; modified release rates; alternative carriers; avian granular choice; faster decomposition and fertilizer/pesticide compounds. As a result of this type of research, registrants may be able to modify formulations so they are less likely to be ingested by birds.

Alterations are possible in formulation strength, which may provide exposure reduction by requiring an organism to consume inordinately high numbers of granules in order to reach or exceed an LOC.

Some manufacturers have prepared encapsulated forms of active ingredients. These may provide the desired efficacy while lowering risk to exposed species. A similar approach has been the investigation of "time release" formulations, which may reduce the total concentration in the environment at any one time. These, however, do not solve the toxic granule problem.

Bait and pellet type formulations provide a potential direct exposure to the chemicals. However, when placed in bait "boxes" and "concealments" exposure to non-target wildlife may be mitigated.

## 5.2 Application Methods

Methods and timing of applications vary with the specific product, crop, and reason for treatment. Some application/incorporation methods are better suited to reduce terrestrial exposure than others. For example the incorporation efficiency of granules was estimated in the "Comparative Analysis of Acute Avian Risk from Granular Pesticides" to range from 0% for side-dress, banded (unincorporated), broadcast, aerial broadcast, and unincorporated application methods to 99% for banded (covered with specified amount of soil), in-furrow, drill, and shanked-in methods.

Soil Incorporation. Most of the avian granular risk mitigation proposals included strict instructions on the incorporation requirements such as: requiring soil incorporation at least 2 inches deep for band treatments applied to all agricultural row crops; and, for carbofuran, California required tilling in of the granular formulation.

Equipment. Application equipment has been addressed as another possible area for development of mitigation measures. For example, in the avian granular analysis it was noted that granules are left on the soil surface when (1) machinery is being loaded, (2) planter shoes are lifted out of the furrows to permit turning, (3) planter shoes rise out of the soils of irregularly contoured fields, and (4) machinery is worn or is not operating correctly.

In response to such equipment related concerns, mitigation proposals in the avian granular analysis included research on the development of new farm equipment as well as subsidies to growers in the purchase of new equipment; and requirements for the use of positive displacement equipment (PDE) for some applications. A proposal that addressed both incorporation and equipment concerns, provided specifications for subsurface placement equipment. Application technologies such as electrostatic application methods should also be considered where the concern is to improve on target deposition of the pesticide.

For post-emergence applications, specialized equipment to direct the application to the specified area of the plant, for example, whorl treatment or just below the surface knifed in side dressing, may offer some mitigation opportunities.

Checking equipment for worn and faulty parts and the use of shut-off devices on planters can help limit chemical loss during the raising and lowering of equipment in turn rows. The way in which a field is planted, for example, having turns distant from likely habitat areas, planting over the turn rows to complete planting of the field, may be a useful area for mitigation. This type of educational information should be included in the mitigation proposals.

Research on the use of these methods should include providing data that allows revision of the EEC calculations. This will allow the Agency to evaluate the mitigation achieved with these methods.

## 5.3 Other Methods

Other avian risk mitigation proposals resulting from the avian granular analysis were: elimination of broadcast applications for some uses; a reduction in band widths; split applications, requiring second applications only in instances of heavy infestations; suggestions for watering-in (the usefulness of this practice has been questioned and remains an area for research); and limitations on the timing of applications to the crop growth period.

Pesticide free borders for agricultural fields has been another area of discussion. Habitat diversity adjacent to agricultural fields has been enhanced to increase use by terrestrial organisms. Such borders can have intrinsic economic value. For example, in parts of Iowa revenues from hunting are beginning to compete with agriculture. However, questions remain about the net benefits of attracting wildlife to field areas where pesticides are applied. This is another area where research would be useful.

Mitigation measures may not always be effective. As a result, it is necessary for untested mitigation measures to be evaluated under actual use conditions. An instructive example involved a switch from application of a chemical by chemigation during daylight to application only at night because it was believed that avian deaths were resulting from birds drinking contaminated water from puddles. As a result of biological monitoring it was recognized that bird deaths were continuing even after the change in timing of the applications. Further investigation led to the discovery that the chemical was being deposited on leaf litter; weeds with ripe seed heads; and both raisined and plump grapes which were on the soil surface. Apparently the chemical was being splashed from emitter puddles formed at night. This partially failed attempt at mitigation illustrates the value of knowing routes of exposure when preparing mitigation plans, as well as the necessity for biological effects monitoring of the measures when they are implemented.

## 5.4 Ranking Habitat

Mitigation which accounts for ranking of habitats may take the form of restricted use by specific geographic area; types of geographic area; time of year; or other method of habitat prioritization. These types of restrictions were included in proposals from the avian granular analysis. They included products not being labeled for sites that pose risk to waterfowl through exposure to puddles on waterlogged fields (i.e., wheat, barley and rice); limitation of use of pesticide/pest combinations to specific states; limitations of the number of lbs./year;

and several examples of mitigation by regions of the country. Other examples of these types of restrictions include geographic restrictions on atrazine in many mid-western states, and phenoxy herbicide restrictions in southern rice states.

Likely pesticide use patterns for regulatory attention include pesticides which are used on large numbers of acres or where there is field evidence of non-target organism kills. While total acreage may be important for some decisions, ecological risk is not necessarily proportional to the number of acres treated. For example, pesticide application to a relatively small site in an ecologically sensitive area will potentially have greater risk than the same pesticide used on a larger area of less ecological value.

An assessment of habitat would require, at a minimum, a matrix which includes crop and crop area; species potentially impacted; and species use of the crop. Factors that the Agency has considered in estimating the magnitude of risk to, for example, avian species in site-specific decisions include: the location, climate, and topographic features of specific crop growing areas; the abundance and richness of bird species in these areas; the reproductive potential and resilience of local bird populations; the timing of pesticide applications in relation to bird breeding and migration cycles; the likelihood of secondary poisonings; and the proximity, extent and quality of available habitat.

### 5.5 If Terrestrial Risk Reduction Is Not Possible

Mitigation strategies are not always effective and efficacy of potential mitigation methods must be considered when evaluating chemicals and developing risk reduction proposals. In mitigation plans, simply stating that mitigation may not be efficacious or many not be possible is preferred to proposing something of minimal or no value. When there are limited means for preventing exposure, reduced numbers of acres allowed, geographic or timing constraints, or prescription use may be the only alternatives.

## 6.0 Application Methods

Application methods may significantly affect exposure. As a result there may be important risk mitigation opportunities available through refining and altering application methods and equipment. For chemicals which exceed a Level of Concern, application methods and instructions should be carefully examined to identify areas where exposure can potentially be decreased. For example, as discussed in the terrestrial section (5.0), proposals to reduce avian exposure to granular pesticides focused on improved soil incorporation methods; improvements in application equipment; and decreased surface areas for applications. The goal of each risk reduction measure should be to specifically target application methods based upon detailed knowledge of potential routes of exposure to non-target organisms combined with knowledge of the mode of action of the chemical in relationship to the target pests.

## 6.1 Aerial Application

The problems associated with aerial application of pesticides and the associated risks of spray drift are well documented. The traditional approaches to mitigate these risk include restrictions due to climatic conditions at the time of application; restrictions on application equipment; and requirements for buffer zones between the spray areas and non-spray areas.

There has been a great deal of research and discussion in this area. Currently a pesticide industry group, the Spray Drift Task Force, is attempting to satisfy the spray drift data requirements by creating a large generic data set to predict spray drift based on droplet size distribution and environmental parameters. One product of this effort should be a spray drift model capable of predicting spray drift quantities for most pesticides under various application practices and environmental conditions. This should aid in evaluating spray drift mitigation strategies.

The task force results show that droplet size is one of the most important parameters affecting on-target application. Droplet size is determined by the inherent physical and chemical properties of the tank mix, nozzle size, nozzle orientation, flight speed, release height, relative humidity, and general environmental conditions. Also important is the plane's configuration in terms of the distribution of nozzles and the percentage of wing span used to hold nozzles. Cross-wind speed has also been shown to be an important factor. In proposing a risk reduction plan all relevant factors should be considered together because modifying only one factor may not produce the desired results.

The Agency recommends meaningful buffer zones, commensurate with the toxicity of the chemical, be required. Monitoring programs may then be used to establish that smaller buffer zones are sufficient. Specialized monitoring programs may be required for chemicals that are difficult to detect. For example, biological monitoring may be used to detect changes in highly sensitive invertebrates in surface waters.

## 6.2 Other Broadcast Applications

Another possible mitigation method is restriction of spray application to ground applications. Most ground applications reduce spray drift when compared to aerial applications. However, air blast application is associated with many of the same drift problems as application by aircraft. If air blast is an application method for a chemical, drift must be controlled by considering many of the same factors discussed above for aerial application.

Like aerial application, other broadcast methods suffer from not being specifically targeted. Application equipment which more precisely targets spray should be developed and promoted. An example would be a canopy constraint for mist blower applications which would contain the mist over the plants/area being targeted, like a canopy fit over citrus trees. Newer air-blast sprayers have electronic sensors which will shut off specific spray nozzles to account for differences in tree height and will turn the sprayer off completely when driving between trees.

### 6.3 Chemigation

Application of a pesticide during irrigation is sometimes used where water is limited and/or crop management practices allow this as an alternative to other forms of applications. A principle concern with this use is direct or indirect exposure of wildlife to the irrigation water which contains concentrated pesticide. Indirect exposure results when concentrated pesticide in the chemigation water comes into contact with wildlife food sources. Standard irrigation systems (overhead, whirly-bird, etc.) probably offer the greatest potential for this type of exposure. These can possibly be mitigated by making applications at a time of day when field use by wildlife is limited. But, as noted previously in Section 5.3, measures must still be taken to ensure that indirect exposure does not occur, and these measures must be monitored to ensure they are efficacious. Other possible mitigation includes use of drip irrigation lines at the soil surface. Exposure may be further mitigated if the drip lines are covered to make them more difficult for wildlife to reach.

## 7.0 Monitoring Programs

For the Agency to consider a risk mitigation proposal to be adequate, evaluation of the effectiveness of each proposed mitigation measure must be included. The evaluation of the effectiveness of many measures, at least initially, will require some form of monitoring. Monitoring may be conducted in a variety of ways but should always be designed to provide pertinent information to resolve risk concerns identified in the risk assessment for a particular chemical. Formal monitoring guidance is currently being developed.

Because the range of mitigation measures and environmental conditions is complex, monitoring plans will generally be developed on a case-by-case basis. Basic monitoring plans should focus on discrete technical objectives that are well-defined and amenable to regulatory use, for example, the type of buffer strip required to prevent movement of a specified chemical to surface water. Larger scale monitoring programs should be directed towards watershed or ecosystem management goals.

Effective monitoring proposals will be based on an understanding of the ecotoxicological hazard and environmental fate of the chemical involved; an understanding of the environment affected by the use; and an understanding of the resources at risk. Different pesticides and different uses will clearly involve different crops and different topographical, geological, and ecological characteristics.

Despite these differences, monitoring programs usually share common assessment questions and basic methodological approaches. It is envisioned that the regulatory guidance for pesticide mitigation monitoring, which is currently being developed, will be adapted from existing ecotoxicological regulatory guidance developed for other EPA program areas. Registrants are advised to examine existing regulatory guidance developed in response to the

Clean Water Act (CWA) and the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) as amended by the Superfund Amendment and Reauthorization Act. A list of pertinent titles is contained in Appendix I.

Chemical analyses, toxicity tests, and ecological reconnaissance have been the traditional monitoring approaches for determining ecological impact. More recently, biomarkers have become prominent in superfund work (U.S. EPA 1989a), and may see increased use in the future. Each monitoring methodology provides a specific type of information, and no single approach is superior. Rather, each provides data important to the overall assessment question. Chemical analyses identify exposure by providing relative concentrations occurring in the environmental compartment or compartments at risk. However, complex chemical mixtures and difficult environmental matrices (e.g., soil, sediment) often confound precise identification and quantification of chemical constituents and their environmental interactions. Accordingly, attempts to estimate the environmental toxicity of a material solely by chemical measurements often prove difficult.

The toxicity based monitoring approach directly measures the toxicity of a contaminated environmental sample and therefore serves as an integrated measure of actual toxicity in the field. Toxicity tests link the occurrence of chemical contamination to biological effects. However, toxicity tests are usually performed with laboratory animals in laboratory settings and therefore only indicate the potential for toxic effects to free living populations of non-target organisms. Biomarkers are biochemical or physiological responses of organisms that indicate chemical exposure or sublethal stress. Biomarkers represent a powerful bridge between laboratory toxicity tests and field surveys because they can be used in both modes of investigation. Demonstration and quantification of natural population and community responses to chemicals requires field surveys in the area of the site to verify structural or functional changes caused by contaminants.

The general advantages and limitations of chemical analyses, toxicity tests, field surveys, and biomarkers in ecological monitoring and assessment are detailed in various U.S. EPA regulatory documents. Although existing regulatory guidance was developed for specific regulatory actions under the Clean Water Act, the Comprehensive Environmental Response Compensation and Liability Act and the Superfund Amendment and Reauthorization Act, the general concepts and methodologies can be adapted for use with pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).

By combining methodological approaches, data can be used in a weight-of-the-evidence analysis to characterize exposure and effects which cannot be determined from a single methodological approach. It is anticipated that the pesticide specific mitigation and monitoring guidance to be developed by OPP will focus on pragmatic regulatory approaches like those developed by other U.S. EPA program offices and will combine various methodologies.

### 7.1 Surface Water Monitoring

Monitoring objectives should be narrowly and clearly defined for each proposal. The proposals should address a specific problem at an appropriate level of detail. The primary parameter(s); locations of concern; the degree of causality or other relationship; and the anticipated effect to be observed should be specified. The general monitoring objective is to assess the success of a measure or group of measures in reducing pesticide loads in surface waters and in reducing their associated environmental risks. The specific objective should be clearly stated in each proposal.

#### 7.1.1 Parameters and Other Data Requirements

Data requirements are a direct function of the monitoring objectives. Thus, data needs cannot be established until specific objectives are defined. Furthermore, the type of data analysis to be used should be specified before data collection protocols are developed.

The types of data generally needed for non-point source monitoring programs include chemical, physical, and biological water quality data; precipitation data; topographic and morphologic data; soils data; land use data; and land treatment data. The specific parameters should be determined based on site-specific variables and the monitoring objectives.

#### 7.1.2 Sampling

The number and frequency of samples required to meet the monitoring objectives need to be established as soon as the objective is defined. Necessary sampling frequency is generally determined by:

- o Monitoring goals
- o The minimum amount of change in the measured parameter that will be considered statistically significant
- o The amount of variability in the system and the desired accuracy of the estimate of change
- o The expected variability in the parameter
- o The statistical power desired (probability of detecting a change when there actually is one)
- o Statistical methods to be used in the analysis of the data
- o Response time of the system
- o Half-life and response time of the pesticide

Sampling frequency would increase with increasing system and parameter variability; and decreasing system response time. The time period during which sampling is conducted may be relatively short, if pesticide runoff events are relatively brief. Thus, it may be necessary to sample frequently during a few major storm events and infrequently during baseflow conditions.

Consideration needs to be given to how best to collect a representative sample. This includes consideration of how to sample across depths and widths of water bodies and whether and how samples should be composited in space and time. Compositing may increase statistical power by physically averaging out dimensional variability, but may also result in loss of information that is necessary to define the system.

Samples should be collected with automated sampling devices. This will ensure that adequate samples are collected to provide the relevant data relating to runoff events.

In one particularly well conceived study (Richards and Baker, 1993) auto samplers were used to collect event related samples. The sampling pattern was three samples per day between April 15 and August 15, during which time most pesticide runoff occurs. All samples from runoff events during this period were analyzed, whereas two samples per week were analyzed during low flow periods. At least two samples per month were collected and analyzed at other times of the year.

Biological samples may require different sampling approaches. These are well documented in the literature cited in Appendix I.

### 7.1.3 General Types of Monitoring Programs

Process Monitoring. Delivery reduction methods such as detention basins, filter strips, constructed wetlands, and similar practices for trapping or treatment prior to release or discharge to receiving waters, lend themselves to monitoring at the level of the individual measure. These can initially be evaluated by process or inflow-outflow monitoring. In general no inputs other than the inflow are present and the only factor affecting outflow is the mitigation measure. The experimental approach is to take samples of inflow and outflow at appropriate time intervals to measure differences in the pesticide load between the two points.

Watershed/Ambient Monitoring. The impact of source reduction measures often cannot be monitored using a process design because there are often no discrete inflow and outflow points. In addition, most monitoring studies in the past, and especially agricultural research programs, have focused on edge-of-field concentrations, leaving the effects throughout the watershed largely unstudied. This has resulted in information gaps concerning the ultimate effects on the system as a whole.

Ambient monitoring involves sampling and evaluation of receiving waters, not necessarily associated with specific perturbations. Studies and assessment programs are moving in the direction of incorporating watershed and/or ambient monitoring components, as well as modelling, so that expected outcomes may be extended to more situations. (See "Assessing Physical Impacts of Water Quality Projects" USDA May 1992. An excellent example is the "Sycamore Creek Watershed Hydrologic Unit Area, Michigan".)

The effectiveness of source reduction measures and the system impact of other measures is generally evaluated using approaches such as paired watershed studies and "up-stream down-stream" designs. These might also take the form of comparisons with "normal" or minimally disturbed water as defined by biocriteria.

## 7.2 Terrestrial Monitoring

Monitoring studies for terrestrial concerns should focus on both residue evaluation to determine if exposure of the species of concern has been reduced and on biological components to determine if any reduction in residues observed translates into reduced biological effects.

Targeted monitoring normally focuses on a specific compound and a specific use whereas long-term monitoring or research focuses more broadly on risks to ecosystems. Targeted monitoring studies for effects of specific chemicals have been used in Virginia for carbofuran. This type of monitoring requires a substantial amount of cooperation and coordination in order to ensure that the monitoring is done when the chemical is actually being used. For example, growers were required to notify a Virginia State Agency when the chemical was being applied.

### 7.2.1 Residue Monitoring

A residue monitoring component should be a part of any proposed terrestrial monitoring study.

### 7.2.2 Biological Monitoring

Larger scale monitoring programs are designed to provide notification of changes in wildlife population components. They attempt to identify areas of concern rather than provide specific answers (unlike research studies). Examples of monitoring programs include background population monitoring, constant effort banding, integrated population monitoring, and targeted monitoring. An important aspect of these programs is to pick a scale, for example, a field or region, that is appropriate and feasible.

It is also necessary to develop reliable biological markers of exposure such as brain ChE activity for organophosphate and carbamate pesticides and pesticide residue in tissue or gut contents for various other pesticides. Development of new markers, and refinements in use of available markers, is an important focus of research. One issue is the stability of markers after death (carcasses found during field trials can be several days old). Possibly, this concern could be addressed by using telemetric methods to detect death so that carcasses can be recovered more promptly. Consideration should also be given to more refined behavioral indicators of exposure related stress.

In defining the criteria for evaluation, the resolution of field data should be kept in mind. For example, considering avian species, a raptor species with a large home range compared to redwing blackbirds with closely packed, well-delineated territories will require different criteria for evaluation.

### 7.3 Monitoring Implementation

In those cases where mitigation measures are optional, implementation monitoring should be used to determine to what extent growers are actually using the measure. Implementation tracking is a necessary component of larger field scale monitoring since one cannot evaluate the effectiveness of a measure on this scale unless it is known how widely the mitigation measure is being used.

## 8.0 Other Related Research, Monitoring, and Mitigation

There may be cases in which registrants will need to address more long term efforts; or participate with other registrants in joint efforts to solve generic problems or fund larger scale monitoring efforts. Areas for research which have been identified and used to date include long term and/or complex research projects and some joint educational efforts. A major joint effort which has been undertaken is the Spray Drift Task Force. Many companies who register chemicals that are applied aerial have joined together in an effort to collect the data necessary to develop a general model. This model is to be used to describe the drift characteristics of any specific pesticide based on its chemical properties. Similarly, the pyrethroid working group has sponsored an educational program which addresses the aquatic risk of these chemicals.

### 8.1 Long Term Research

Some smaller, more short term research areas were noted in other section of this paper. These focus on answering specific technical questions such as the necessary properties of a buffer strip to prevent movement of a specific chemical to surface water. Exposure mitigation research needs fall into several general areas--exposure, formulation, and application methods. Specific questions in the area of exposure include determination of the routes of exposure; determination of the residues present and available through these routes; and quantification of mitigation effectiveness in reducing these residues. For example, in the case of avian risk, as a result of the avian granular analysis five companies have jointly funded research on various aspects of avian preference.

Several research questions concerning organism behavior overlap the areas of exposure and product formulation. Is ingestion random or selective? Is preference/avoidance species specific? Can pesticides be designed or formulated to repel non-target species or to pass through their digestive systems without toxic effect?

Other formulation questions have focused on release rates of active ingredients from various substrates; and the deterrent effects of insecticide/fertilizer mixes. In the case of birds, it has been suggested the granular size and the smell of pesticide/fertilizer mixes may be less attractive to birds, thereby decreasing exposure.

Questions regarding application methods include whether exposure reduction is accomplished from watering in and from establishment of enhanced habitat in pesticide free border areas of agricultural fields.

Under long term research the Agency is interested in moving toward, for example, analyses of the effects of pesticide use on specific watersheds, habitats or ecosystems. In conjunction with this, improved data on pesticide use patterns for integration with wildlife exposure data would be useful. This additional information on pesticide usage will be needed if population level risks are to be assessed adequately.

Modelling may be a useful research area to pursue in conjunction with monitoring. Models may be developed to predict effects of risk reduction measures under specific use conditions; to locate areas with the greatest potential problems; and to extend results beyond the small scale upon which monitoring is usually done.

### 8.2 Ecological Incident Monitoring and Reporting

The Ecological Effects Branch of the Environmental Fate and Effects Division, collects and analyzes fish, wildlife, and plant incident data associated with the national use of pesticides. Incidents may be used as indicators of pesticide effects. These data are one of the major factors to be considered in evaluating the risks to nontarget organisms. Incident monitoring programs should be included as part of the monitoring proposals. In addition, registrant assistance with incident analysis could include, for example, making laboratory facilities available for carcass analysis, or other contractor support.

One of the major benefits from collecting nationwide incident data is to identify trends. When incidents are found for certain chemicals for certain use patterns, then label changes which incorporate risk reduction measures may be identified. This is being done by several states already. For example, one state realized after applying an aquatic herbicide in a band across ponds, that fish kills were significantly fewer than with non-banded applications. Since it is common practice to analyze incidents and make necessary label changes at the state level, the collection of incident data is an additional valuable source for mitigation ideas.

### 8.3 Compensatory Mitigation

In limited situations funding for compensatory programs has been used as a method to offset impacts to wildlife. This compensatory mitigation is not intended to compensate for those risks that can effectively be addressed through the risk mitigation measures reviewed previously in this paper. Similarly, compensatory mitigation is not a substitute for cancellation of a pesticide where Levels of Concern warrant such action. Rather, the use of compensatory mitigation is limited to those situations where the compensation activity balances the risks to non-target species.

An example of the use of compensatory mitigation occurred during EPA's special review of dicofol (EPA's Notice of Intent to Cancel dicofol registrations at 51 Fed. Reg. 19508; May 29, 1986). The Office of Endangered Species (OES) issued a biological opinion that dicofol contaminated with greater than 0.1% of DDT and related impurities (DDTr) jeopardized the continued existence of the peregrine falcon. However, technical registrants needed time to build new manufacturing plants to produce dicofol with 0.1% or less of DDTr. OES revised its opinion, concluding that jeopardy could be avoided if the level of DDTr in technical dicofol were reduced to 0.1% or less by December 31, 1988, except in California. For California, OES listed two alternatives: 1) ban use and sale of all dicofol in California immediately, or 2) compensate for the negative effects of the use of dicofol during the time period until all dicofol products with greater than 0.1% DDTr are prohibited from the channels of trade, by funding a portion of the nest manipulation work of the Santa Cruz Predatory Bird Research Group--a group whose work was vital to the continued existence of the peregrine falcon.

The dicofol producers agreed to provide funds for the nest manipulation program. EPA agreed with OES that expeditious phase out of dicofol products would be adequate to prevent jeopardy to the falcon in California "in view of other efforts being made to support recovery of the species." EPA concluded the special review by prohibiting the sale and distribution of dicofol products contaminated with greater than 0.1% DDTr after December 31, 1988, and banning use of existing stocks for a specified time period after that date.

## 9.0 Format for Submitting Risk Mitigation and Monitoring Proposals

The required format for mitigation proposals is contained in Appendix II. All proposals should be submitted in this form.

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## Appendix II. Format for Submitting Risk Mitigation and Monitoring Proposals

Each mitigation proposal should contain the following sections:

### I. Identification

Active Ingredient/Formulated Product:
*[Give common name/chemical case #'s/ and formulated product name and #'s]*

Crops/Pests Covered by This Proposal:

Level of Concern Addressed:

### II. Mitigation Proposal

A. Source Reduction Measures:

(1) Application Rate:
*[current and proposed]*

(2) Number of Applications:
*[current and proposed]*

(3) Application Interval:
*[current and proposed]*

Rationale:

(4) Prescription Use:

Rationale:

(5) Canceled Uses:
*[crops/pests; geographic locations; etc.]*

B. Other Mitigation Measures:

a. First Measure

(1) Mitigation Measure:
*[describe measure]*

Rationale:

*[Description of the properties of the chemical (formulation) that support the use of the measure. Relate the properties of the chemical to the properties of the measure. Clearly cite the source of all chemical parameters. Note when a parameter is available from an EPA reviewed core study and what those numbers are even if, for some reason, you chose to cite other studies. Highlight chemical parameters numbers from EPA reviewed core studies and note also if there are other submitted studies that apply to the same guideline.]*

(2) Geographic Restrictions:

*[list geographic areas for which the measure is recommended]*

Rationale:

(3) Site Characteristic Restrictions:

*[list specific site characteristics for which the measure is recommended and those for which it will not work]*

Rationale:

(4) Other Factors Which Impact the Effectiveness of the Measure

i. Factors Which Enhance Effectiveness of Measure:

ii. Factors Which Impede Effectiveness of Measure:

iii. Expected Overall Effectiveness:

*[For example, potential for positively impacting one area but negatively impacting another, e.g., if a detention pond might improve surface water but might also adversely affect groundwater; or decrease exposure for one form of wildlife but increase exposure for another. This section should explain why the net effect is expected to be beneficial.]*

b. Second Measure etc.

## III. Research Proposals

*[This section should cite existing or proposed research which will demonstrate that each mitigation measure proposed will have the expected results. Registrants are encouraged to propose joint efforts to address generic issues, to study watershed and ecosystem effects, as well as to address other long term research needs.]*

## IV. Monitoring Program

## V. Proposals for Other Options

*[Incident monitoring or monitoring support; compensatory mitigation]*

## VI. Educational Program

*[The educational program should include the details outlined in Section 3.0. In addition, a detailed explanation of all aspects of the mitigation program is required. For example, while a label may simply specify use of a 100 ft. vegetated filter strip, the educational program should include a detailed discussion of the characteristics required to make a vegetated filter strip work properly; the site specific problems which make them ineffective; maintenance requirements; etc.]*