The Investigation and Surveillance of Agrichemical Spraydrift Incidents

Guidelines for
Public Health Units
Revised edition

Ministry of Health. 2007. *The Investigation and Surveillance of Agrichemical Spraydrift Incidents: Guidelines for Public Health Units: Revised edition*. Wellington: Ministry of Health.

Published in October 2007 by the
Ministry of Health
PO Box 5013, Wellington, New Zealand

ISBN 978-0-478-31220-1 (print)
ISBN 978-0-478-31221-8 (online)
HP 4476

This document is available on the Ministry of Health's website:
http://www.moh.govt.nz

Preface

The New Zealand economy is heavily reliant on income from the export of agricultural products. To ensure that export produce meets the stringent quality and phytosanitary standards demanded by important overseas markets, farmers and growers are reliant on a wide range of agrichemical products.

Although agrichemical use in New Zealand remains high, there have been initiatives in the agricultural and horticultural industries to reduce the amount of agrichemicals sprayed.

These guidelines (in conjunction with the surveillance software package *DriftNet*) are designed to provide a systematic framework for the investigation and surveillance of agrichemical spraydrift incidents. The guidelines have a focus on human health risk and health impact assessment, rather than on plant damage or effects on property or animal health. Impacts on vegetation or the wider environment are matters for other agencies, such as local government or the regional councils.

When dealing with farmers/growers, contractors and the community, it is important for investigating authorities to remain impartial and to show consideration to all parties. The issue of spraydrift and its possible effects can be highly contentious, and it is important to ensure that all those involved have equal opportunity to be heard and to have their concerns documented and considered.

A speedy resolution of issues and fair and appropriate feedback to all parties are important.

These guidelines are intended to assist public health units in addressing public concerns and giving sensible advice. Apart from drawing together background information, they suggest a protocol that lays out a response related to the likely level of risk to health, as well as considering how risks may be evaluated and communicated.

The guidelines are also available on the Ministry of Health's website at http://www.moh.govt.nz.

The Environmental Health Team, Ministry of Health would like your comments on the implementation of the guidelines. They should be addressed to: Environmental Health Team, Ministry of Health, PO Box 5013, Wellington. If you would like to make specific suggestions for amendment to the guidelines, please use the format overleaf. Suggestions and comments will be considered when the guidelines are being reprinted.

Suggested amendments to *The Investigation and Surveillance of Agrichemical Spraydrift Incidents: Guidelines for public health units*

Name .....

Organisation .....

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Section and page	Amendment requested (include rationale)

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Acknowledgements

The Ministry of Health gratefully acknowledges the contributions of Dagmar Schmidt (Northland Health), Dr Julia Peters (Auckland Healthcare), Wade Lawson (Waikato Health), Sally Gaw (ESR: Christchurch Centre), John Maber and Associates Ltd, Chris Sies (Canterbury District Health Board) and Neil Whitelegg (Agriquality NZ Ltd). These guidelines were derived from work undertaken for the Ministry of Health by Juliette Begg and Dr Michael Bates of the Epidemiology Group, ESR: Kenepuru Science Centre, and by Dr Craig Stevenson of the ESR: Mt Eden Science Centre.

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Background

In 1989 the Ministry for the Environment published a report entitled *Pesticides: Issues and options for New Zealand* (Ministry for the Environment 1989). This report covered a wide range of issues relating to pesticide use, control, policy, government interventions and options for the future. It was critical of the level of research and monitoring for food and environmental contamination by pesticides, and also of the ongoing high level of use of pesticides in New Zealand.

In addition to the actual health risk from agrichemical spraydrift, there is the associated perception of risk. The actual and perceived risks are often at variance. In 1990 the Department of Health (now the Ministry of Health) commissioned a research project with several objectives, including the investigation of whether people were concerned about contact with chemicals and pollutants, and whether they perceived that their families had suffered any illness as a result of that contact. The resulting report, *The Public Perception of Risk from Chemical*s (Department of Health 1990), showed that, when asked to identify the important health issues facing them today, 7 percent of respondents raised chemical sprays as a concern, while chemicals added to food or water were an important issue for 4 percent of respondents. However, when asked about their level of concern about a list of specific health issues, 44 percent were either very or somewhat concerned about coming into contact with poisonous substances. A total of 6 percent of the adult New Zealanders surveyed believed that some illness that they personally had suffered was attributable to contact with chemicals, sprays, additives or pollution, and 14 percent attributed the illness of a family member to such contact. Since this survey was carried out, the level of public concern is unlikely to have reduced, and may have risen, given that agrichemical use continues at a high rate.

In 1993 the Office of the Parliamentary Commissioner for the Environment published a report on the *Management of Agrichemical Spray Drift* (PCE 1993). This report provided several recommendations, including recommendations with regard to public health monitoring that the:

1. Public Health Commission (now the Ministry of Health) ensure that the public health service has the ability to test clinically for agrichemical exposure to people
2. Minister of Health direct the Public Health Commission to establish an Adverse Incidents Register to record any adverse effects on health, including public health, arising from agrichemical use.

Areas in which further research was recommended included ‘the relationship between pesticide use or exposure and effects on human health, short and long term ... and ... establishment of a clinical technique to detect the presence of agrichemicals in humans within a few hours of exposure’.

Subsequently, the Public Health Commission, in its advice to the Minister of Health, proposed that a protocol be produced for investigating spraydrift incidents to assess their effects on public health. This proposal led to the commissioning of these guidelines by the Ministry of Health.

There have been several reports documenting specific agrichemical spraydrift concerns or incidents (Bay of Plenty Area Health Board 1990; Department of Health 1977, 1986; Jarman 1996; Wanganui Area Health Board 1987). The conclusions and recommendations of these reports addressed several issues. These included recommendations for legislative change regarding toxic sprays, establishment of education and training schemes for agrichemical users and the general population of the effects of sprays and precautions to be taken, restrictions on spraying times near sensitive areas such as schools, encouragement of discussion between farmers/growers and other residents, notification to neighbours of the intention to spray, discussion with the community regarding the safe and acceptable use of pesticides, provision of information to the public regarding the environmental and health effects of pesticides, and provision of information to the public regarding key agencies in each region, including contact details.

Those reports relating to human exposure to agrichemical spraydrift demonstrated the difficulties in estimating the level of exposure experienced. Consequently, it can be difficult to draw specific conclusions about the relationship of any illness suffered to the agrichemical exposure. These guidelines could make a significant contribution to the assessment of any human health risk or health impact through uniform advice on the procedures for investigating spraydrift complaints, appropriate environmental and biological sample collection, and the provision of a facility for the comprehensive documentation of spraydrift incidents and any related human exposures or illnesses.

After a period of use, the accumulated data may be used in an epidemiological analysis to determine if any association exists between adverse human health effects and involuntary exposure to off-target agrichemical spraydrift.

Purpose of the guidelines

The guidelines provide guidance to public health units that investigate complaints of adverse health impacts from agrichemical spraydrift incidents. These guidelines should be used whenever a complaint of off-target agrichemical spraydrift is made or referred to the public health unit. In most cases, the complainant will be a member of the public. **All** complaints of specific agrichemical spraydrift incidents should be recorded, irrespective of whether anybody has been exposed and irrespective of the likelihood that an investigation will eventually be carried out.

Properly applied, the guidelines will assist with determining:

- the health impact of an agrichemical spraydrift incident
- appropriate advice on managing the consequences of the incident, including risk communication.

The guidelines will provide guidance to public health staff on the systematic recording of data on agrichemical spraydrift complaints and incidents, and associated exposures and illnesses, in order to:

- facilitate investigations of alleged incidents

- provide data to local authorities for policy and plan development, monitoring and evaluation, and enforcement of the Resource Management Act 1991
- provide evidence for enforcement action under other legislation (eg, Hazardous Substances and New Organisms Act 1996 (HSNO Act), Health Act 1956 and Health and Safety in Employment Act 1992)
- facilitate epidemiological research.

The guidelines will also assist with the assessment of the risk to public health from agrichemical spraydrift incidents and the accurate identification of illness that may be associated with agrichemical spraydrift incidents. Finally, they will assist with the management of the risk to public health, including through taking action under the HSNO Act where a risk to public health has been created, or under the Health Act 1956 if there is sufficient evidence to show that unintended exposure to an agrichemical spray was either unnecessarily offensive or likely to be injurious to health.

Exclusions

Complaints relating to solid pest control products (such as 1080 carrot baits or cyanide paste) and domestic pest control products (such as fly sprays, snail baits and mosquito coils) are **not** within the scope of these guidelines.

These guidelines are **not** intended to be applicable to situations where reproductive outcomes (such as birth defects) or chronic illnesses (such as cancer) are alleged to be associated with exposures to agrichemicals. Nor are they to be used when there is concern about health effects related to perceived chronic exposure to pesticides but no specific incidents are involved.

Risk analysis

A public health risk-analysis model is outlined in *A Guide to Health Impact Assessment* and forms the basis for these guidelines (Ministry of Health 1998). There are three sequential steps in the process of decision-making regarding risk:

1. risk assessment
2. risk communication
3. risk management.

Risk assessment asks: ‘What are the hazards?’ ‘What are the risks?’ and ‘Who will be affected, how, and to what extent?’ It includes hazard identification, dose-response assessments, exposure assessment, and risk characterisation.

As the first step in the risk assessment process, hazards have to be identified. If the assessment of the hazard suggests that the likelihood of significant risk is small, or control is straightforward and safe, it may not be necessary to proceed to the quantification of risk. It is generally accepted that the risk from exposure to agrichemicals in the non-occupational environment is likely to be low.

The next steps in risk assessment are the consideration of dose-response and the assessment of exposure to agrichemical spraydrift. Dose-response models are developed from occupational data or animal toxicology and extrapolated to low levels of exposure. Both aspects are approximate only and the dose-response models are subject to considerable debate about the validity of their assumptions. Because of the low levels of exposure from agrichemical spraydrift, these guidelines refer to 'health effects' in general rather than dose-response relationships. The information from these three steps is used in the final step of risk assessment: risk characterisation.

The acceptability of risk is a decision either for individuals or for society as a whole. Without societal judgements about acceptable risk, no decisions can be reached on proposals that carry both benefits and risks. On the other hand, individuals expect to suffer no more than negligible harm unless they are taking voluntary risks in the pursuit of some activity in which they see benefits. Various scientific and regulatory bodies have set levels of what they consider to be acceptable risks, but there is no certainty that these levels will be understood or accepted by individuals.

During any communication of risk, there must be adequate consultation on the risks, and public concerns must be taken into account. Risk management seeks to address the questions: 'How can risks be avoided or reduced?', 'What are the options?', 'Are contingency and emergency plans adequate?', 'How can differing perceptions of risk be mediated?' and 'Can future health risks be predicted?'

Further information

Much of the information in the guidelines has been drawn from the publications listed in the References.

Users may find it useful to copy parts of the text from the Graded Response Protocol (Chapter 3) and other material into the Report Sheets (Appendix 6).

A software package, *DriftNet*, has been developed to record the data collected during the investigation of agrichemical spraydrift incident and assist with the national surveillance of spraydrift incidents. Copies of *DriftNet* have been provided to public health units for their use.

Chapter 1: Risk Assessment Part 1 – Hazard Identification

Main points

- An agrichemical is any chemical used in an agricultural context, including pesticides, fertilisers and spray additives.
- Application of an agrichemical using a spray technique will inevitably involve some off-target drift but the extent of spraydrift is determined by meteorological factors, topographical factors and those factors that are operator controlled.
- The risk associated with spraydrift involves a combination of the extent, concentration and nature of the spraydrift, the toxicity or other hazardous properties, and the personal characteristics of the people exposed.

Agrichemicals

Agrichemicals is a term that describes any chemical used in an agricultural context. This includes pesticides as listed under the Hazardous Substances (Pesticides) Transfer Notice 2004 (including subsequent amendments) and agricultural compounds as defined under the Agricultural Compounds and Veterinary Medicines Act 1997 (ACVM Act), as well as fertilisers and spray additives, such as marker dyes and wetting agents. Given the large number of chemicals used in agriculture, a comprehensive description of their properties and hazards is not possible within the scope of these guidelines. The following sources of information will provide this detail on specific chemicals or classes of chemicals.

Trade name and active ingredient lists

It is advisable that each public health unit obtain a trade name and active ingredients list for New Zealand registered pesticide products.

The Environmental Risk Management Authority New Zealand (ERMA New Zealand) maintains a database containing a list of pesticides that have been transferred to the HSNO Act (http://www.ermanz.govt.nz/hs/pesticides/pestlist.xls). Alternatively, the Agricultural Compounds and Veterinary Medicines Group of the New Zealand Food Safety Authority can be contacted.

However, it must be noted that many agrichemicals in common use fall outside the HSNO Act. A significant number of people use on their own property agrichemicals that are outdated and do not have current registration. It is important to avoid misidentification when lists of currently registered pesticides are used; mistakes arise when a name is assumed to have been spelt wrongly but the product is, in fact, not currently registered.

Manufacturer safety data sheets

Manufacturers and licensed distributors can usually provide safety data sheets (SDSs) (formerly known as material safety data sheets or MSDSs) for their products. The

name and contact details of the manufacturer or chemical distributor can be found on the product label. Often there will be a freephone number or another contact number listed.

MSDSs vary considerably in the quantity and quality of information provided. Therefore, it may be appropriate for the investigating officer to obtain additional information on the active ingredient(s) in the product.

Local information services

Resources available regionally may provide useful and detailed technical and toxicological information on agrichemical compounds. Some public health units have access to electronic databases such as TOXINZ, Medline, TOMES, Commonwealth Agricultural Bureaux Abstracts (CAB Abstracts), AGRICOLA, BIOSIS (Biological Abstracts) and Science Citation Index (Sci Search), and to libraries that hold or have access to agrichemical and general toxicology references. Useful pesticide toxicology and general toxicology references include the following.

- Hayes WJ, Lawes ER (eds). 1991. *Handbook of Pesticide Toxicology*. San Diego: Academic Press.
- Tomlin C (ed). 2006. *The Pesticide Manual.* 14th ed. Thornton Heath, United Kingdom: British Crop Protection Council and Royal Society of Chemistry.
- WHO. 1986. *Environmental Health Criteria 63. Organophosphorous Insecticides: A general introduction*. Geneva: World Health Organization.
- WHO. 1993. *Environmental Health Criteria 155. Biomarkers and Risk Assessment: Concepts and principles*. Geneva: World Health Organization.
- WHO. 1994. *Safe Use of Pesticides: 20th report of the WHO Expert Committee on Insecticides*. Geneva: World Health Organization.

A list of locally available resources can be compiled and updated as necessary.

National Poisons Centre

The National Poisons Centre (the Poisons Centre) runs a 24-hour service providing information on chemicals, drugs, poisonous plants, poisonous insects and marine animals. The urgent telephone number is 0800 POISON (0800 764 766) (24 hours); during working hours the non-urgent number is 03 479 7248. The permanent information specialist staff have expertise in toxicology, medical toxicology, chemistry and pharmacy. The Poisons Centre maintains an extensive database, which incorporates comprehensive technical and toxicological information on agrichemical products, including all New Zealand–registered pesticides. In addition to the database resource, the Poisons Centre maintains a comprehensive toxicology library and has access to a range of other databases and information sources, both nationally and internationally.

TOXINZ is an Internet database containing information regarding hazardous substances and the management of poisoned patients. The database contains some 88,000 listed

chemical products, pharmaceuticals, plants and hazardous creatures. It is available online at http://www.toxinz.com.

Spraydrift and drift hazard

In any situation where application of an agrichemical incorporates a spray technique, some off-target drift is inevitable. The extent of spraydrift is determined by meteorological factors, topographical factors and those factors that are operator controlled.

The risk associated with spraydrift involves a combination of three main factors: the extent, concentration and nature (eg, droplet size) of the spraydrift, the toxicity or other hazardous properties of the agrichemical or any adjuvants present, and the personal characteristics of the people exposed. Although all three factors can be controlled to an extent, most agrichemical products are by nature hazardous (although the degree varies greatly, depending on the chemical), and humans, animals and non-target plants cannot be entirely removed from the surrounding environment. Therefore, the main focus of drift hazard minimisation is on reducing the extent of the spraydrift.

A report prepared on behalf of the National Air Quality Working Group identified six main issues relating to the use of agrichemicals and the problem of spraydrift (Hughes 1996). These issues are:

1. land use planning
2. actual and perceived environmental and human health effects
3. knowledge and training
4. technology for agrichemical application and the prevention of drift
5. regulation and enforcement
6. measurability of risk and impact on humans and the environment.

The data generated by application of these guidelines may make a useful contribution to each of these issues, in particular, the issues relating to human health.

A 1996 survey of New Zealand public health units, undertaken as part of the development of the first edition of these guidelines, found that the number of complaints of spraydrift varied considerably from region to region, generally reflecting the nature and patterns of land use in each region. All but three regions reported receiving only a few (one to five) complaints of spraydrift over the 12 months immediately prior to the time of the survey. One region reported receiving between 6 and 10 complaints, and two regions received more than 15 complaints.

It was expected that the spraydrift complaints would increase with the introduction of the surveillance software package *DriftNet* in 1998. *DriftNet* collects information on spraydrift complaints and incidents reported to public health units. However, annual reporting data suggest that the system is underutilised (McDowell 2004; McDowell and Gallagher 2005; McDowell et al 2006; Tisch and Slaney 2007). For instance, there were only five spraydrift complaints reported in 2005 (McDowell et al 2006) and seven in 2006 (Tisch and Slaney 2007). The number of complaints reported through *DriftNet* since its implementation in 1998 averages 12 per year for the whole country. The Environmental Science and Research Ltd (ESR) report (Tisch and Slaney 2007) concluded that there is a need for the public health units and the regional councils to co-ordinate their efforts in relation to incident reporting. Illustrating the inconsistency in reporting, one of the data sets containing over 60 complaints, some of which indicated human health concerns, came from a regional council whose public health unit had reported no health spraydrift complaints in *DriftNet* for the years in question.

Regulation 27(1) of the Hazardous Substances (Classes 6, 8, and 9 Controls) Regulations 2001 provides that 'A person must not use a class 6.1 substance in a manner that would result in a concentration of the substance in an environmental medium that exceeds the tolerable exposure limit (TEL) set for the medium.' However, it should be noted that at this time no TEL has been set for a number of substances, such as hydrogen cyanamide.

- Complaints that are health-related should be reported to the local public health unit and should be entered in *DriftNet.*
- Medical practitioners/hospitals that have attended to people injured by spraydrift exposures must report the incident, as required under section 143 of the HSNO Act.
- An incident report should be completed on any health-related spraydrift incident, emailed to ERMA New Zealand (hsincidents@ermanz.govt.nz) with 'Incident Report' in the subject line, and copied to your locality manager. Incidents of public health significance should also be copied to the Environmental Health Team at the Ministry of Health.

Factors contributing to spraydrift and drift hazard

Environmental factors contributing to spraydrift

Environmental factors that may contribute to agrichemical off-target spraydrift are wind velocity, wind direction, turbulence, atmospheric stability, relative humidity, precipitation, air pressure, presence of inversion conditions, and air temperature.

In general, light winds (2–10 km/h) are most desirable for spraying operations. These conditions improve the coverage of the target crop or weed. They also enable the operator to predict the direction and distance the spray is likely to drift and to make allowances for this. In still conditions, the movement of spray mist and vapour is less predictable due to turbulence. As wind speed increases above about 10 km/h, there is a corresponding increase in the potential for off-target spraydrift. Spraying should not be carried out in high winds (over 15 km/h). The experience and expertise of the operator may contribute to reducing drift.

Air temperature and humidity can affect the evaporation rate of the spray. As air temperature rises and/or relative humidity drops, the evaporation rate of droplets increases. This higher evaporation rate can increase droplet and aerosol drift during agrichemical application operations due to a decrease in droplet size, as turbulence and wind carry fine droplets and aerosols further than larger droplets. Vapour drift is more likely on hot days when there is low humidity as evaporation from droplets, as well as evaporation of volatile chemicals from deposits on the ground and vegetation, is increased. Generally, temperatures below 25°C and relative humidity greater than 50 percent provide desirable spraying conditions.

Pesticides should not be applied immediately before, during or after a rainstorm. Rain can wash the agrichemical off the target on to adjacent land and into waterways. In addition, rain dilutes the spray, reducing the concentration at the target, thus also reducing its effectiveness.

Physicochemical characteristics of the chemical

Whenever possible, the least volatile chemical should be used. Evaporation of the active ingredient during or after deposition can result in off-target vapour drift. This can be a problem, particularly when temperatures are high and humidity is low. The addition of spraydrift reduction agents, such as Sprayfast, in the sprayed chemical will reduce drift.

Equipment characteristics

Equipment type, nozzle type, droplet size, spray pressure, and distance from applicator to target are all important factors with regard to agrichemical spraydrift. Among the most important variables are the number and size of droplets formed during atomisation. It is desirable to use the largest possible droplet size that enables good coverage. Small droplets or mists are more likely to drift as they are more easily carried by wind or air turbulence. High pressure spraying will also contribute to drift. The larger the distance between the point of spray release and the target, the greater the potential for off-target drift to occur.

Sensitive areas

The hazard from off-target spraydrift is dependent, to a large extent, on the nature of the adjacent land use. There may be considerable spraydrift, but no drift hazard, if there is nothing at risk downwind from the spraying operation – that is, there is no sensitive area. Agrichemical users should be aware of any sensitive areas within the vicinity of their spraying operation and make allowances for these areas in terms of taking preventive measures.

Sensitive areas include:

- school buildings, including childhood education centres
- residential buildings
- amenity areas
- public water supply catchments
- water bodies
- sensitive crops or farming systems (eg, organic farms)
- wetlands
- public roads.

Appropriate timing of spraying may reduce the potential impact on sensitive areas from any drift that does occur. For example, spraying out of the season for sensitive crops that are grown nearby (that is, when the land is dormant) and spraying when nearby schools or institutions are unoccupied are ways of reducing exposures for sensitive environments and individuals.

Chapter 2: Risk Assessment Part 2 – Health Effects, Exposure Assessment

Main points

- Spraydrift occurs via deposition drift and aerosol/vapour drift.
- The principal source of human exposure is deposition drift leading to exposure by dermal contact and ingestion.
- Field measurements indicate that inhalation of aerosol or vapour spraydrift is a minor route of human exposure.
- The health significance of any estimated exposure requires comparison with a suitable toxicologically based criterion for the pesticide(s) in question.

Assessment of exposures from spraydrift

This section is to assist in the assessment of where significant human exposures to pesticides as a result of a spraydrift incident may have occurred, and where they are unlikely. It is intended to help guide decisions on whether to undertake further investigations of particular complaints and incidents but should certainly not be the sole determinant of such decisions.

a) Estimates of exposure

Estimates of the range of exposures likely to arise in a variety of situations are based on several New Zealand studies of spraydrift, as a means of assessing the likely order of magnitude of exposures in situations that may be the subject of complaints. There are wide ranges of uncertainty in all of the estimates. These arise partly from the inherent variability in natural processes affecting spraydrift, partly from the lack of a complete understanding of all of these processes and partly from the difficulty of accurately measuring key factors (such as wind speed and direction in complex environments, and droplet size distribution from sprayers). Estimates should be based on as much data as possible and interpreted with some allowance for error.

The health significance of the exposures can be assessed by comparison with toxicologically based benchmarks, such as acceptable daily intakes (ADIs) for the levels of pesticide residues in food. Such comparisons may be useful in that they may show that exposures are unlikely to be of any health significance. It needs to be borne in mind, however, that ADIs are based on an assumption of lifetime daily exposure and incorporate safety factors generally of at least 100. Spraydrift incidents usually result in potential for exposures of a few days or less. Therefore, if an estimated exposure exceeds an ADI by several times (even by an order of magnitude), for example, it is unlikely to be toxicologically important.

The approach set out here may be used at varying stages of responding to an incident or complaint:

- at the initial stage, when information about the distance of the affected location from the spray application site is known; inspection of the tables in this chapter may indicate that significant exposures are unlikely under any reasonable assumptions
- when information about distances, spraying methods, pesticides used and their toxicity, application rates, wind directions, shelter belts and so on is available, to decide whether further investigation, possibly including sampling, is appropriate
- in the identification of the most likely major routes of exposure, and in the development of advice on how to minimise these
- in the interpretation of results of analyses.

It is strongly recommended that the whole of this chapter be read carefully before decisions or calculations based on it are made.

b) Modelling of spray events

A wide range of factors interact to determine the fate of an agrichemical spray event in the environment and the actual outcome tends to be site specific. A lot is known or can be predicted before the spray event about some of these factors (eg, spray nozzle type, canopy type, spray release direction and agrichemical toxicity) but less is known about others (eg, catch efficiency of shelter belts). Still other factors such as wind speed and wind direction are time dependent and therefore must be measured at or close to the time of the application event.

Mathematical models can be used as tools to predict the dispersion and deposition from a given spray event in terms of on-site on-target (on the target crop), on-site off-target (run-off or bypass) and off-site off-target (spray that deposits outside the target area). These models, when put into the context of the confines of the property to be sprayed, can assist managers with day-to-day decisions on agrichemical application and help with the question, 'Is it safe to spray?', from a hazard analysis point of view. They can also be used to test different scenarios in the analysis or prediction of outcomes of a spraydrift event.

One benefit of the use of such tools is that it highlights the need for adequate description and documentation of a spray application event so that the likely cause of any adverse outcomes in terms of spraydrift can be more easily identified.

One tool, Cumulative Agrichemical Residue Tracking (known as CART), links a series of databases, models and their outputs for site-specific spraydrift predictions (Zabkiewicz and Praat 2004). Components include climate data geographical information systems (GIS), soil types, operational inputs (eg, nozzle types and related information), an agrichemical database, and models to predict deposition, retention and dissipation. Health risks may be assessed as cumulative depositions from a series of spray events over time. Another tool, Spray Plan Manager (http://www.sprayplan.co.nz), describes seasonal spraying plans and also improves documentation of spray events.

Modes of spraydrift and human exposures

Spraydrift occurs via two modes:

1. **deposition drift** – this is drift of droplets off-target, which will eventually deposit on the ground or other surfaces
2. **aerosol/vapour drift** – this is drift from fully evaporated droplets or pesticide vapour released from either spray droplets or spray deposits on leaves, soil or other surfaces (sometimes referred to as 'volatilised' spray).

The principal source of human exposure is deposition drift leading to exposure by dermal contact and ingestion. This form of exposure can occur through:

- direct dermal deposition
- indirect dermal exposure (deposition on other surfaces with which skin then comes in contact)
- deposition on crops
- water supply contamination.

Field measurements indicate that inhalation of aerosol or vapour spraydrift is a minor route of human exposure. Also, aerosols do not deposit readily on surfaces and are not easily washed out by rain, so they do not contribute significantly to deposition exposures.

Basis for exposure estimates

In the following tables, exposures estimated from New Zealand studies of spraydrift have, as far as practicable, been brought to a comparable basis of:

- an active ingredient application rate of 1 kg/ha
- a sprayed area such that substantial increases in the sprayed area are not likely to cause major increases in exposure
- where estimates are for direct dermal exposure and inhalation of aerosol/vapour, the person remaining at the point of exposure throughout the spraying operation.

Adjustment of the exposure estimates to the circumstances of a particular spraydrift incident is discussed later.

Important factors for which the data have not been standardised include wind speed and droplet distribution spectra for the spray nozzles.

Wind speed has a direct effect on deposition rates, with a doubled wind speed doubling the distance at which any particular deposition rate will occur. However, corrections for wind speed will be complicated for most situations except simple open fields. Where there are shelter belts, there is first the question of where wind speed should be measured, because the speed will vary markedly with height and position relative to the shelter belt. This variation means that a falling droplet will experience different wind speeds as it travels from its point of emission to its ultimate deposition point.

These complexities are probably why wind speed effects are not evident in the shelter belt trials (except within one trial where wind speed changed between runs of the trial). The wind speeds for the shelter belt trials were in the range of 0–7 m/sec, but it was often not clear where these measurements were made.

Information on the effect of droplet size distribution is available only for the trials of helicopter spraying in an open field. These trials showed a marked effect: nozzles that produced about 6 percent of the spray volume in droplets below 100 µm gave deposition rates out to 150 m, about three times higher than nozzles that produced about 2 percent of their droplets smaller than 100 µm.

Aerosol concentrations for the former type of nozzles were about five times higher than those for the latter type.

The estimates of exposures do not cover spraying equipment other than airblast sprayers and helicopter spraying. Other types of equipment, such as boom sprays or hand-held equipment, would be expected to produce substantially lower levels of aerosol drift, but there is insufficient information on which to base estimates of exposure.

The data for deposition rates and aerosol/vapour drift doses cover a wide range for any distance interval, with a factor of about 50 between highest and lowest estimates being usual.

Deposition drift exposure estimates

Tables 1 to 4 set out exposure estimates for various scenarios. For assessment of deposition drift exposures, the deposition rate (mg/m^2) of pesticide active ingredient found in the various trials is the basic information from which exposures are calculated. The estimates for 200–300 m in open fields are for helicopter spraying only, and the deposition rates in the tables may be overestimates because of uncertainty about the detection limits of the methodology.

Direct dermal exposure

Tables 1 and 2 set out estimations of dermal exposure for a 70 kg adult exposed throughout typical spraying operations at varying distances from various types of spraying operation, based on New Zealand field trials. Two scenarios are presented:

1. whole upper body, considering a person wearing no shirt, and taking the area of exposed skin as shown in the tables; this is probably an overestimate of the effective exposed area, because vertical surfaces will not collect as much droplet deposition as the essentially horizontal surfaces used for collection in the trials
2. arms only, considering a person wearing a short-sleeved shirt, and considering half of the hand/arm skin area, corresponding to the upper surfaces only.

If the conservative assumption of 100 percent absorption of pesticide deposited on skin is made, these exposures may be compared with recommended acceptable daily intakes (ADIs), which for many pesticides are in the range of 0.0002–0.02 mg/kg body weight of the exposed person per day for lifetime intakes. Note, however, the comments in the Introduction about the very conservative nature of comparisons of short-term exposures with ADIs.

Indirect dermal exposure

Indirect exposure may occur through droplet deposition on surfaces such as leaves, lawns, clothing, veranda floors, railings and outdoor furniture. When skin comes into contact with these surfaces, some exposure will occur.

The best approach to assessing whether there is likely to be a health risk in any particular situation appears to be through consideration of re-entry or resting criteria for agricultural workers to work in sprayed orchards. Such criteria have not been established for all pesticides likely to be encountered, but one of the more toxic organophosphate insecticides, azinphosmethyl (or gusathion) (ADI 0.005 mg/kg/day), has a re-entry criterion in California of 30 mg/m^2 (3 $\mu g/cm^2$) on leaves. This criterion is based on studies involving chronic and extensive contact with sprayed leaves. Many other pesticides are less toxic than azinphosmethyl, so that use of this criterion is likely to provide a good margin of safety in most cases. Alternatively, multiplication of the 30 mg/m^2 criterion by the ratio of ADI for the pesticide in question to the ADI for azinphosmethyl would give an indication of a level that is likely to be acceptable.

Table 1: Dermal exposure estimates from aerosol/vapour drift

Airblast or helicopter spraying inside shelter belts						
Distance from shelter (m)	**Deposition rate mg/m^2**		**Dose mg**		**Dose mg/kg body weight**	
	Maximum	**Minimum**	**Maximum**	**Minimum**	**Maximum**	**Minimum**
Exposure of whole upper body (no shirt)						
Exposed skin area (m^2): 0.66						
Adult with body weight (kg): 70						
0 (inside)	50	1	33	0.7	0.5	0.01
10–20	2.5	0.015	1.7	0.01	0.02	0.0001
21–50	0.75	0.015	0.5	0.01	0.007	0.0001
51–100	0.25	0.005	0.2	0.003	0.003	0.00004
101–150	0.05	0.002	0.03	0.001	0.0004	0.00001
Exposure of arms only, upper surfaces						
Exposed skin area (m^2): 0.16						
0 (inside)	50	1	8	0.2	0.11	0.003
10–20	2.5	0.015	0.4	0.002	0.006	0.00003
21–50	0.75	0.015	0.12	0.002	0.002	0.00003
51–100	0.25	0.005	0.04	0.0008	0.0006	0.00001
101–150	0.05	0.002	0.008	0.0003	0.0001	0.000004

Notes:

Doses normalised to 1 kg/ha active ingredient application rate in sprayed area.

These exposure estimates should be adjusted to each particular spraydrift incident. See 'Adjustment of exposure assessments to the circumstances of particular incidents'.

Estimated exposures should be compared with toxicologically based criteria, guidelines or standards for the pesticide(s) in question. See 'Comparison of estimated exposures to health criteria'.

Source: Adapted from Agricultural Engineering Institute (1987); Holland and Maber (1991, 1992); Maber (1978); May et al (1994); NZ Forest Research Institute (1993); Richardson et al (1993).

Table 2: Dermal exposure estimates from aerosol/vapour drift

Airblast or helicopter spraying inside shelter belts						
Distance from spray swath edge (m)	**Deposition rate mg/m^2**		**Dose mg**		**Dose mg/kg body weight**	
	Maximum	**Minimum**	**Maximum**	**Minimum**	**Maximum**	**Minimum**
Exposure of whole upper body (no shirt)						
Exposed skin area (m^2): 0.66						
Adult with body weight (kg): 70						
In sprayed area	100	0	66		0.9	
10–20	10	4	7	2.6	0.1	0.037
21–50	10	0.5	7	0.33	0.1	0.005
51–100	2.5	0.2	1.7	0.13	0.02	0.002
101–200	1.5	0.2	1	0.13	0.01	0.002
201–300	0.6	0.1	0.4	0.07	0.006	0.001
Exposure of arms only, upper surfaces						
Exposed skin area (m^2): 0.16						
In sprayed area	100	0	16		0.2	
10–20	10	4	1.6	0.63	0.02	0.009
21–50	10	0.5	1.6	0.08	0.02	0.001
51–100	2.5	0.2	0.4	0.03	0.006	0.0004
101–200	1.5	0.2	0.2	0.03	0.003	0.0004
201–300	0.6	0.1	0.10	0.016	0.0014	0.0002

Notes:

Doses normalised to 1 kg/ha active ingredient application rate in sprayed area.

Here:

- the deposition rates for 100–300 m are for helicopter spraying only
- the deposition rates for 200–300 m may be overestimates, because of uncertainty about the detection limits of the methodology
- the release height for the helicopter spraying was 10 m, and the wind speed was 5 m/s
- airblast sprayer distances adjusted to 5 m/s wind speed.

These exposure estimates should be adjusted to each particular spraydrift incident. See ‘Adjustment of exposure assessments to the circumstances of particular incidents’.

Estimated exposures should be compared with toxicologically based criteria, guidelines or standards for the pesticide(s) in question. See ‘Comparison of estimated exposures to health criteria’.

Sources: Adapted from Agricultural Engineering Institute (1987); Holland and Maber (1991, 1992); Maber (1978); May et al (1994); NZ Forest Research Institute (1993); Richardson et al (1993).

Contact with contaminated surfaces in non-occupational settings is likely to be less than would occur for agricultural workers handling or brushing against contaminated surfaces continually throughout the working day. One possible exception might be an infant crawling on a contaminated floor or lawn, where the potential for exposure may be very high (see 'Worked example' later in this chapter).

Pesticide deposition levels on leaves and in glass beakers used in spraydrift trials are closely similar. Accordingly, the deposition levels in Tables 1 to 3 give a good indication of pesticide levels that could be expected on foliage and on other surfaces with which people may come into contact. It is suggested that conditions and distances for which the maximum deposition rates in Tables 1 and 2 are below 30 mg/m^2 are unlikely to give rise to health problems. The possible exception is crawling infants. However, for surfaces contaminated to 30 mg/m^2, dermal absorption of all the pesticide from 0.1 m^2 (33 x 33 cm) would correspond to a dose of 0.04 mg/kg (above the ADI for most organophosphate pesticides), and it may be prudent to work to levels one-tenth or less of this re-entry level, even though the ADI is very conservative if applied to short-term exposures.

Indirect dermal exposure has the greatest potential for relatively high exposures, because of the possibility of dermal contact with quite large areas that have received deposition, and because this source of exposure can potentially persist for some days, at least in some cases. This is illustrated in the 'Worked example' later in this chapter.

Because of this relatively high potential for exposure, where some level of contamination is likely, it would be prudent to wash down surfaces with which people are likely to come into contact, and infants' access to potentially contaminated areas such as lawns should be restricted. These are the most effective actions that people potentially affected can take to reduce exposure to spraydrift. However, as wiping surfaces is also likely to be the best way of assessing the level of deposition from an incident, it may be appropriate to advise people affected to take tissue wipe samples before washing down, as described in Appendix 2 ('Environmental and Biological Sampling') if there is a possibility that the level of deposition may have been significant.

Intake via deposition on crops

Table 3 estimates intakes that may arise from spraydrift deposition on crops. These estimates assume the crop is a vegetable such as silverbeet, the outer leaves of which are eaten, and which may not be readily washed. The deposition area is taken as a circle of radius 20 cm, and it is assumed that a person may eat one-third of the vegetable occupying this area in a day.

For many crops, the intake is limited because the outer leaves are discarded and/or the vegetable is washed before eating. Cooking may further reduce the intake. These exposures may be compared with ADIs that for many pesticides are in the range of 0.0002–0.02 mg/kg/day for lifetime intakes.

Table 3: Exposure estimates via deposition on crops

Airblast or helicopter spraying inside shelter belts						
Distance from shelter (m)	**Deposition rate mg/m^2**		**Dose mg**		**Dose mg/kg body weight**	
	Maximum	**Minimum**	**Maximum**	**Minimum**	**Maximum**	**Minimum**
Adult with body weight (kg): 70						
Target plants	50	0	2		0.03	
0 (inside)	50	1	2	0.04	0.03	0.0006
10–20	2.5	0.015	0.1	0.0006	0.001	0.000009
20–50	0.75	0.015	0.03	0.0006	0.0004	0.000009
50–100	0.25	0.005	0.01	0.0002	0.0001	0.000003
100–150	0.05	0.002	0.002	0.00008	0.00003	0.000001
Helicopter or airblast spraying in open field						
Distance from spray swath edge (m)	**Deposition rate mg/m^2**		**Dose mg**		**Dose mg/kg body weight**	
	Maximum	**Minimum**	**Maximum**	**Minimum**	**Maximum**	**Minimum**
Target plants	100		4		0.06	
10–20	10	4	0.4	0.2	0.006	0.003
21–50	10	0.5	0.4	0.02	0.006	0.0003
50–100	2.5	0.2	0.1	0.008	0.001	0.0001
100–200	1.5	0.2	0.06	0.008	0.0009	0.0001
200–300	0.6	0.1	0.03	0.004	0.0004	0.00006

Notes:

Doses normalised to 1 kg/ha active ingredient application rate in sprayed area.

The deposition rates for 100–300 m are for helicopter spraying only.

The deposition rates for 200–300 m may be overestimates, because of uncertainty about the detection limits of the methodology.

The release height for the helicopter spraying was 10 m, and the wind speed was 5 m/s.

These exposure estimates should be adjusted to each particular spraydrift incident. See 'Adjustment of exposure assessments to the circumstances of particular incidents'.

Estimated exposures should be compared with toxicologically based criteria, guidelines or standards for the pesticide(s) in question. See 'Comparison of estimated exposures to health criteria'.

Sources: adapted from Agricultural Engineering Institute (1987); Holland and Maber (1991, 1992); Maber (1978); May et al (1994); NZ Forest Research Institute (1993); Richardson et al (1993).

Water supply contamination

Table 4 estimates the concentrations of pesticide in a rainwater supply collected from a roof subject to spraydrift deposition. The roof area used is 100 m^2, and the concentrations are estimated for all of the pesticide being washed off in rainfall, and after mixing into a tank of one metre radius containing varying depths of water.

The zero distance deposition rates are for the roof that is sprayed directly, for example by aerial spraying.

Much or all of a volatile pesticide will evaporate if there is even a short period of sun between the time when spray is deposited on a roof and rainfall.

Table 4: Exposure estimates for contamination of a roof water supply

Airblast or helicopter spraying inside shelter belts						
Distance from shelter (m)	**Deposition rate mg/m^2**		**Concentration in tank, 1 m radius, 0.3 m depth, mg/l**		**Concentration in tank, 1 m radius, 2 m depth, mg/l**	
	Maximum	**Minimum**	**Maximum**	**Minimum**	**Maximum**	**Minimum**
0 (inside)	50	1	5	0.1	0.8	0.02
10–20	2.5	0.015	0.3	0.002	0.04	0.0002
20–50	0.75	0.015	0.08	0.002	0.01	0.0002
50–100	0.25	0.005	0.03	0.0005	0.004	0.00008
100–150	0.05	0.002	0.005	0.0002	0.0008	0.00003
Helicopter or airblast spraying in open field						
Distance from spray swath edge (m)	**Deposition rate mg/m^2**		**Concentration in tank, 1 m radius, 0.3 m depth, mg/l**		**Concentration in tank, 1 m radius, 2 m depth, mg/l**	
	Maximum	**Minimum**	**Maximum**	**Minimum**	**Maximum**	**Minimum**
0	100		11		1.6	
10–20	10	4	1	0.4	0.2	0.06
20–50	10	0.5	1	0.05	0.2	0.008
50–100	2.5	0.2	0.3	0.02	0.04	0.003
100–200	1.5	0.2	0.2	0.02	0.02	0.003
200–300	0.6	0.1	0.06	0.01	0.01	0.002

Notes:

Doses normalised to 1 kg/ha active ingredient application rate in the sprayed area.

Open field deposition rates for 100–300 m are for helicopter spraying only.

Open field deposition rates for 200–300 m may be over-estimates, because of uncertainty about the detection limits of the methodology.

The release height for the open field helicopter spraying was 10 m, and the wind speed was 5 m/s.

Airblast sprayer distances adjusted to 5 m/s wind speed.

Sources: Adapted from Agricultural Engineering Institute (1987); Holland and Maber (1991, 1992); Maber (1978); May et al (1994); NZ Forest Research Institute (1993); Richardson et al (1993).

The concentrations in Table 4 may be compared with the maximum acceptable values (MAVs) for pesticides set out in *Drinking-Water Standards for New Zealand* (Ministry of Health 2005). Excluding the organochlorine pesticides aldrin, dieldrin, chlordane, heptachlor and heptachlor epoxide, which were banned under the HSNO (Stockholm Convention) Amendment Act 2003, the MAVs are in the range 0.0007–1.4 mg/l. Although the list does not cover all pesticides that may be involved in spraydrift

incidents, the MAV range 0.0007–1.4 mg/l is likely to cover all pesticides. For pesticides for which there is no MAV, a reasonable estimate of the MAV can be obtained by multiplying the TDI for the pesticide concerned by the MAV for another pesticide (for which both MAV and TDI are available) and dividing by the TDI for that other pesticide. (Note that TDIs and ADIs are used synonymously in this document.)

Alternatively, the amounts of pesticide consumed in two litres of water per day may be compared with the TDI for the pesticide concerned.

Note that MAVs are even more conservative than TDIs for short-term exposures, because they are established on the basis of lifetime exposure, and also assume that intakes from water will be only a minor proportion of the total pesticide intake. The intake of pesticide from consuming two litres per day of water at the MAV is typically about one-fifth of the TDI, in most cases, for the same pesticide. The assumption about the proportion of pesticide intake via the water exposure route may or may not be valid for any particular exposure incident.

Aerosol/vapour drift exposure

Table 5 sets out estimates of aerosol/vapour drift exposure for an adult exposed throughout typical spraying operations at varying distances from various types of spraying operation, based on the New Zealand trials. Because aerosol/vapour drift does not deposit readily on surfaces, the route of exposure is essentially via inhalation.

Table 5: Inhalation exposure estimates from aerosol/vapour drift

Airblast sprayers and helicopters, inside shelter belts and open fields				
Distance from shelter or edge of spray swath (m)	**Dose mg**		**Dose mg/kg body weight**	
	Maximum	**Minimum**	**Maximum**	**Minimum**
Adult with body weight (kg): 70				
0 (inside)	0.3	0.001	0.004	0.00001
10–100	0.01	0.0003	0.0001	0.000004
100–200	0.005	0.0002	0.00007	0.000003

Notes:

Doses normalised to 1 kg/ha active ingredient application rate in the sprayed area.

These exposure estimates should be adjusted for each particular spraydrift incident. See ‘Adjustment of exposure assessments to the circumstances of particular incidents’.

Estimated exposures should be compared with toxicologically based criteria, guidelines or standards for the pesticide(s) in question. See ‘Comparison of estimated exposures to health criteria’.

Sources: Adapted from Agricultural Engineering Institute (1987); Holland and Maber (1991, 1992); Maber (1978); May et al (1994); NZ Forest Research Institute (1993); Richardson et al (1993).

There is no clear difference in the estimated doses from the various spraying methods, and the ranges of doses cover all of the New Zealand trials for both airblast sprayers and helicopter spraying, both within shelter belts and in open fields.

These figures illustrate that aerosol/vapour drift is a very minor route of exposure compared with droplet deposition drift. The doses are about an order of magnitude less than for the situation of lowest exposure to droplet deposition above (airblast sprayers and helicopter spraying inside shelter belts, arms only exposed).

Adjustment of exposure assessments to the circumstances of particular incidents

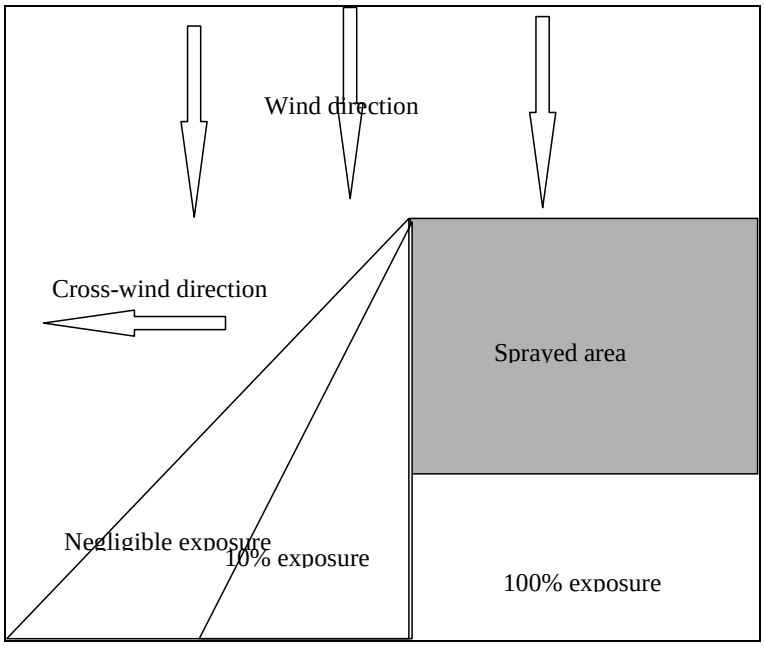
It is suggested that, where information is available for a particular spraydrift incident, the following adjustments be made.

- **Active ingredient application rate (kg/ha)**: Multiply the dose ranges in the tables by the actual active ingredient application rate in kg/ha. The ranges of doses given here are all based on an active ingredient application rate of 1 kg/ha.
- **Wind speed for helicopter or airblast sprayer in open fields**: Multiply the distances in the tables by the actual wind speed (in m/sec) and divide by five (m/sec). This means, for example, that if the wind speed had been 10 m/sec, the deposition rate range and doses for 50–100 m in the tables would be expected to occur at distances in the range 100–200 m. However, this would only be reliable if the wind speed and direction had been steady, and such corrections are likely to be unreliable at wind speeds below about 2 m/s.

Exposures and cross-wind distances

If a site was not directly downwind of the area where spray was being applied, it would have received less exposure, down to zero if the cross-wind distance were great enough. For winds that are moderately steady in direction, sites that are half as far cross-wind from the cross-wind edge of the sprayed area as they are from the upwind edge of the sprayed area would be expected to receive about 10 percent of the exposure given in the tables. Sites that are the same distance cross-wind from the edge as they are downwind would receive negligible exposure. This rule is most likely to break down at short distances (less than 50 m) and in light winds or calm conditions. Figure 1 illustrates the lines corresponding to 100 percent, 10 percent and negligible exposures.

Figure 1: Exposures cross-wind from sprayed area



Comparison of estimated exposures to health criteria

The health significance of any estimated exposure requires assessment by comparison with a suitable toxicologically based criterion, guideline or standard, which should be for the particular pesticide(s) in question. Generally, comparison with ADIs for food intakes is suggested here, but the very conservative nature of this comparison should be noted. Estimated exposures several times the ADI are still unlikely to have significant health effects (see the start of this section).

The Pesticide Manual (Tomlin 2006) gives ADIs established by the Joint Meeting on Pesticide Residues of the World Health Organization (WHO) and Food and Agriculture Organization (FAO) for a high proportion of pesticides. Other toxicity information is also provided, which can be useful where an ADI has not been established.

For drinking-water, the estimated exposure can be compared with the MAV from *Drinking-Water Standards for New Zealand* (Ministry of Health 2005). However, it should be noted that for short-term exposures, the MAV values may be even more conservative than TDIs, because the MAVs also assume that only a minor proportion (about one-fifth, in most cases) of total pesticide intake occurs through water consumption.

Estimation of wind speeds

Table 6, based on the Beaufort scale, should assist the estimation of wind speeds from discussions with complainants, spray applicators or land owners/managers.

Table 6: Estimating wind speeds for spraying

Beaufort scale (force)	Description	Wind effects on land	Approximate airspeed at boom height	Spraying notes

0	Calm	Smoke rises vertically	< 2 km/h	Avoid fine sprays
1	Light air	Direction shown by smoke drift	2–3 km/h	Avoid fine sprays on warm sunny days
2	Light breeze*	Leaves rustle, wind felt on face	3–6 km/h	Ideal spraying
3	Gentle breeze*	Leaves and twigs in constant motion	6–10 km/h	Good spraying
4	Moderate breeze	Small branches move, dust rises	10–15 km/h	Avoid fine sprays
5	Fresh breeze	Small trees sway	> 15 km/h	Extreme caution with any sprays
6	Strong breeze	Large branches sway	Unsuitable for any spraying	
7	Moderate gale	Whole trees in motion	Unsuitable for any spraying	

* At this wind speed the wind direction is likely to be stable. Make sure that the wind direction is away from any sensitive area.

Remember: Any time spraying is carried out, there will be spraydrift. You have the responsibility to eliminate any risk from that drift. One way is to make sure any wind takes the spray away from a sensitive area. Check your local boating store for wind meters.

Worked example

Situation

An orchard inside a shelter belt has been sprayed with an airblast sprayer, using diazinon at a rate of 0.5 kg/ha of active ingredient. There is concern about whether significant exposures have occurred at a house 75 m downwind from the shelter belt. The house has a roof water supply. Throughout the spraying, a man was working in the garden, which stretches 20 m from the house towards the shelter belt. He was not wearing a shirt.

Direct dermal exposure

The man was about 50–60 m downwind of the shelter belt during the spraying. From Table 1, the estimated deposition rate range for 50–100 m is (a) 0.005 to (b) 0.25 mg/m^2, and the corresponding dose range for the 70 kg man is (d) 0.00004 to (e) 0.003 mg/kg body weight for an application rate of 1 kg/ha active ingredient.

The actual application rate was (*c*) 0.5 kg/ha, so the calculated deposition rate range is:

c x a	to	c x b
= 0.5 x 0.005	to	0.5 x 0.25 mg/m^2

= 0.0025 to 0.125 mg/m^2

and the calculated dose range is:

c x d	to	c x e
= 0.5x 0.00004	to	0.5 x 0.003 mg/kg body weight
= 0.00002	to	0.0015 mg/kg body weight

The TDI for diazinon is 0.002 mg/kg/day. This is the intake that should be without effect over a lifetime of exposure. Even if the man absorbs 100 percent of the diazinon deposited on his skin, his exposure would have been below the TDI.

Indirect dermal exposure

The re-entry criterion for azinphos-methyl is 30 mg/m^2 on leaves. It is not straightforward to derive an equivalent value for diazinon, but if the rates of degradation are assumed to be similar, a comparison based on toxicity could be used as an approximation. Two toxicity measures could be used: (a) the LD_{50} or (b) the TDI. Re-entry criteria usually relate to short-term toxicity hazards, which suggests the use of LD_{50} may be more appropriate, but in this instance the long-term toxicity is considered more relevant so the TDI has been used. Based on the TDI for azinphos-methyl (0.005 mg/kg body weight/day) and the TDI for diazinon (0.002 mg/kg body weight /day), the estimate of the re-entry criterion for diazinon is:

30 x 0.002/0.005 = 12 mg/m^2

Because the deposition rate in the garden (0.0025–0.125 mg/m^2) is far lower than the estimated re-entry criterion for diazinon (12 mg/m^2), exposure risks to people working in the garden are very small.[1]

An estimate of indirect dermal exposure may be obtained by assuming that a person might contact and absorb all of the diazinon deposited on, for example, a surface area of 1 m^2. Because the deposition rate is 0.0025–0.125 mg/m^2, this corresponds to a dose of 0.00004–0.002 mg/kg for a 70 kg adult.

There is a lawn at the side of the house also exposed to the spray, and the baby of the house often crawls on the lawn with bare legs and arms. The baby might crawl over much of the lawn (say, 3.3 m x 3.3 m) and potentially be exposed to the pesticide deposited on the 10 m^2 of the lawn. The dose to the baby's skin might therefore potentially be:

= 0.0025 mg/m^2 x 10 m^2	to	0.125 mg/m^2 x 10 m^2
= 0.025	to	1.3 mg

If the baby weighs 10 kg, the dose is 0.0025–0.13 mg/kg body weight, or possibly up to 60 times the TDI. As noted previously, the TDIs usually contain a safety factor of at least 100 generally and are developed for lifetime exposures. The assumption that the child is exposed to and absorbs all the pesticide deposited on the 10 m^2 area is unlikely; however, it would still be prudent to discourage the baby from crawling on the lawn.

[1] The LD_{50}s in mice are: azinphos-methyl, 11 mg/kg body weight and diazinon, 80 mg/kg body weight. If these figures are used to derive a 're-entry criterion' for diazinon, the result is 218 mg/m^2, a value much higher than that derived from the TDI.

Intake via deposition on crops

From Table 3, assuming that a 70 kg adult eats one-third of a vegetable occupying a circle of 20 cm radius in the garden, without washing or discarding the outer leaves, the dose range would be 0.000003–0.0001 for an application rate of 1 kg/ha, or 0.0000015–0.00005 mg/kg for the present case of applying 0.5 kg/ha active ingredient. Even though it is assumed that the vegetables collect all the deposited pesticide, these exposures are well below the ADI.

Water supply contamination

The house roof water supply is contained in a tank that is 0.75 m in radius (r), and the roof area is 150 m^2. The spraying took place on a cool, dull afternoon (so that loss of the pesticide from the roof by evaporation may have been small), and 5mm of rain fell overnight; the following morning, the depth of water in the tank was 0.8 m (d). The volume of water in the tank is:

$\pi r^2 d$
= 3.14 x (0.75 x 0.75) x 0.8 m^3
= 1.41 m^3 or 1400 litres

The range of estimated spray deposition on the roof is 0.005 (e) to 0.25 (f) mg/m^2 from Table 4 for a 1 kg/ha application rate, which for a roof area of 150 m^2 (g) and 0.5 kg/ha (h) application rate is a total weight of active ingredient of:

g x e x h		g x f x h
= 150 x 0.005 x 0.5	to	150 x 0.25 x 0.5 m
= 0.38	to	19 mg

When this weight of pesticide is mixed in the rainwater tank water volume of 1400 litres, the resulting estimated concentration range is:

0.38/1400	to	19/1400 mg/l
= 0.00027	to	0.014 mg/l

The MAV for diazinon is 0.01 mg/l, so that the concentration in the supply might be of some concern. However, it should be noted that the MAVs for water supplies are set on the basis of lifetime consumption, and accordingly are very conservative for short-term exposures.

If a person consumes two litres of water per day, their intake from this source would be in this range:

	= 2 x 0.00027	to	2 x 0.014
	= 0.0005	to	0.03 mg/day/2 l of water consumed
or	= 0.0005/70	to	0.03/70
	= 0.000007	to	0.0004 mg/kg/day for a 70 kg person.

This intake is at least four times lower than the TDI. A 10 kg infant, approximately 18 months of age, would consume an estimated one litre of water per day (Beck et al 2001; Ministry of Health 1997; US EPA 1992), giving an estimated intake of 0.00027–0.014 mg/day or 0.000027–0.0014 mg/kg/day, also below the TDI.

Aerosol/vapour drift exposure

From Table 5 above, the doses for a 70 kg person are estimated to be in the range 0.000004–0.0001 mg/kg body weight for a 1 kg/ha active ingredient application rate, corresponding to 0.000002–0.00005 mg/kg body weight for this example. These exposures are very small.

Concluding remarks

Table 7 summarises the exposure estimates and estimates total exposures.

The total exposures for the adult and infant may exceed the TDI of 0.002 mg/kg body weight. As noted above, the TDIs are based on a lifetime exposure and usually include a safety factor of at least 100, so it is unlikely that these exposures are of toxicological significance. However, it would be prudent to take precautions to reduce exposures, such as flushing and replacing the tank water, discouraging the infant from crawling on the lawn, and thoroughly washing fruit and vegetables before use.

Table 7: Overall summary of worked example

	Duration	**Dose mg/kg body weight/day**
Exposure route for adult		
Direct dermal exposure	Once only	0.00002–0.0015
Indirect dermal exposure (contact with 1 m^2 of surface deposit)	Possibly days	0.00004–0.002
Intake via deposition on crops	Possibly days	0.0000015–0.00005
Water supply contamination	Possibly weeks	0.000007–0.0004
Inhalation of aerosol/vapour	Once only	0.000002–0.00005
Total dose, all routes	First day only	0.00007–0.004
Exposure route for infant		
Indirect dermal exposure	Possibly days	0.0025–0.13
Water supply contamination	Possibly weeks	0.000027–0.0014
Intake via deposition on crops	Possibly days	0.0000015–0.0001
Total dose, all routes	First day only	0.0025–0.13

Chapter 3: Risk Communication and Management

Summary of the graded response protocol

Step 1: Receipt and processing of the complaint(s)

Step 2: Decision to investigate further

Step 3: The investigation

Step 4: Decision on action required

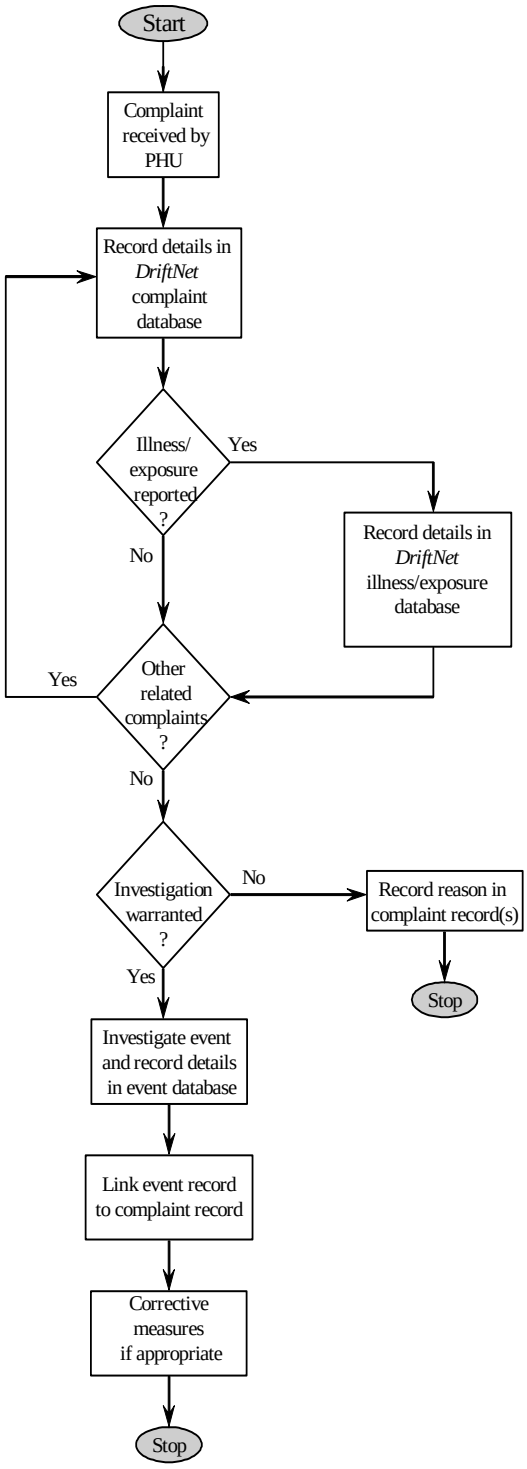
Figure 2 summarises the general processes for dealing with complaints of spraydrift incidents, as a flowchart. The steps in the flowchart are outlined in the remainder of this chapter.

Almost always, the first indication that there has been a spraydrift incident will come in the form of a 'complaint'. A complaint may be defined as advice to the public health unit, from any person, that an agrichemical spraydrift incident has occurred. Such complaints may come from, for example, members of the public, doctors, local government agencies, or farmers.

Whenever a complaint of an agrichemical spraydrift incident is received at a public health unit, the information received is recorded. At the same time, information on individuals who have been exposed, and possibly made ill as a result of that exposure, is also recorded. Several separate complaints may be received as a result of a single spraydrift incident, and the information for each complaint (and associated exposures and illnesses) is separately recorded.

Once one or more related complaints have been received, a decision whether to investigate further (and/or whether to involve other authorities) must be made. At the end of the investigation process it will be necessary to decide whether further action (such as a prosecution, referral to other authorities or a requirement for particular precautionary measures to be put in place) is appropriate.

Figure 2: Overview of the process from receipt of a complaint to investigation and outcome



Risk communication

Community perception of risk is not based on technical risk assessment alone. Public recognition of risk, in contrast to risk assessment based on probabilities prepared by experts, includes intuitive risk perception. The characteristics of such perception appear to be related to concepts of fairness, familiarity, future and present 'catastrophe potential', and people's outrage at involuntary exposures to hazards not of their making.

Agrichemical spraydrift hazards in the home environment, where people expect to be safe, are hazards that will be judged by the public from more than a perception of scientific risk assessment. Comparisons with common risks, such as road traffic crashes, will generally not convince a person who feels that they (or their child) are at risk. Involuntary exposures that may cause a dreadful disease at some unknown time in the future, in a way that is still not understood, and for which there may be little hope of a cure, are particularly alarming.

Effective risk communication is more likely to be achieved if:

- a careful and sensitive explanation is given to assist and improve the level of understanding of the risk
- the feelings of dread towards agrichemical spraydrift are recognised and efforts made to assist a person to come to terms with those feelings before decisions are made
- there are both an appropriate urgency and an appropriate level of response to hazards that may affect a large number of people (especially children) (Warner 1983).

Bear in mind that in general:

- younger adults and better educated individuals tend to have better technical, scientific and medical knowledge about hazards
- the most concern about risks tends to be expressed by women, particularly women with young children, and by older people
- people tend to simplify complex and uncertain information into 'rules of thumb' (in the case of agricultural chemicals, these may relate to the perception of occupational risk)
- people attempt to impose patterns on patternless events
- people overestimate the frequency of rare events and underestimate the frequency of common events
- individuals taking voluntary risks tend to be overconfident and believe they are not subject to the same risk as other individuals
- individuals forced to take involuntary risks overestimate the risk, and are unwilling to agree to 'acceptable risk' criteria set out by national and international agencies
- people tend to use past life experiences to relate to new situations, affecting their perception of the new situation (Health and Welfare Canada 1990).

Risk communication needs to be a two-way process as described in some detail in *A Guide to Health Impact Assessment* (Ministry of Health 1998). It needs to be done in such a way that people are informed and guided in the actions they take, while knowing that the experts are taking account of, and acting on, their concerns.

Risk management

Priorities for managing risk should be based on the risk assessment but should also consider public perception of risk. The range of risk reduction alternatives must be evaluated, including the social, economic and cultural implications of options.

This risk management could be achieved along two lines:

- control of actions and events that can translate a spraydrift hazard into a spraydrift risk
- the removal or near-permanent containment of the spraydrift hazard.

Spraydrift exposures in non-occupational settings may vary greatly. A protocol for the investigation and management of such exposures should aim to provide a response that is graded according to the likely harm. Exposures are likely to be of several orders of magnitude less than the current permissible workplace exposures.

Background to the graded response protocol

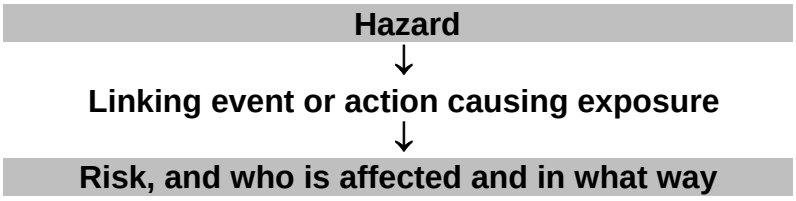
These guidelines have been written for use by staff of public health units in New Zealand. The guidelines provide a framework to be used by health protection officers and medical officers of health in the investigation and surveillance of agrichemical spraydrift incidents and provide advice on how to go about investigating agrichemical spraydrift incidents. This advice is based on a Graded Response Protocol, including advice on dealing with complaints about agrichemical spraydrift, the investigative process, and decision-making at key points in the process (that is, after receipt of a complaint and after an investigation).

The guidelines offer advice on co-ordination with other agencies, such as regional councils, local authorities, ERMA New Zealand and the Department of Labour, and are designed to be compatible with investigations carried out by these agencies.

These guidelines should be used whenever a complaint of off-target agrichemical spraydrift is made or referred to the public health unit. In most cases, the complainant will be a member of the public. However, a complaint or a report of an agrichemical spraydrift incident, exposure or illness may also come from a variety of other sources (eg, a health professional, a journalist or reporter, an employee of the regional or district council, or a commercial farmer or grower).

A complaint or a series of complaints of agrichemical spraydrift is likely to have been precipitated by a spraying event that has resulted in off-target drift. This may be due to one factor or a combination of factors, which might relate to, for example, the method of application, changes in weather conditions at the time of spraying, or operator error. Each complaint may correspond to one or more people who have been exposed and/or are alleged to have illness relating to the exposure.

Not every agrichemical spraydrift incident creates a health hazard. The risk of developing health effects depends on exposure to spraydrift. A graded response is based on the following three elements:



In more detail, these elements are the:

- nature and scale of the spraydrift and the corresponding potential to be a risk to human health
- mechanisms that may open pathways of exposure to create risk
- nature of the risk in terms of probability, likely consequences, people affected, and the degree of risk each may face. The existing state of health of each person will influence likely consequences for each individual.

All complaints of specific agrichemical spraydrift incidents should at least be recorded in *DriftNet*. A complaint may be the result of exposure to off-target drift of fertiliser, spray or vapour from an orchard sprayer, vapour from the fumigation of a commercial or residential property, or any similar activity. Contamination of a drinking water supply or food crop through off-target spraydrift may also be documented and investigated using these guidelines and the software.

Whenever a complaint is received by the public health unit, the person taking the call or dealing with the complainant should always record details in the complaint database of *DriftNet* and record the details of any exposure(s) or illness(es) in the exposure/illness database. Once such data (which may be from more than one complaint) have been received, they can be evaluated and a decision made on whether an investigation is warranted (refer Appendix N of NZS 8409:2004). The next section includes guidance on factors to be considered in making a decision whether to investigate.

Should an investigation be carried out, data on the event/incident that precipitated the complaint(s) will be obtained and entered into the *DriftNet* event/incident database. At the end of the investigation process, it will be necessary to decide whether further action (such as a prosecution, referral to other authorities, or a requirement for particular precautionary measures to be put in place) is appropriate.

How to use the graded response protocol and report sheets

The report sheets (Appendix 6) record information and decisions corresponding to the graded response protocol. The information recorded should be entered on to *DriftNet*. **It is important that the report sheets are not altered as the layout and information collected are in the appropriate format necessary for entry onto *DriftNet*.**

DriftNet is a Microsoft® Access-based computer software program for detailed recording of event/incident, complaint and exposure/illness data. Along with these guidelines, public health units have been supplied with a copy of *DriftNet* and its user manual. *DriftNet* facilitates the collection of standardised data sets. It is discussed in detail later in this chapter.

The principle is to grade the response to the level of hazard.

In practice, while Step 1 will always be completed, Steps 2, 3 and 4 will be completed only if appropriate.

Step 1: Receipt and processing of the complaint

In each public health unit , the initial contact point for spraydrift complaints should be designated (and appropriately trained) in advance. The designation of the initial contact point may rotate among several people to ensure that there is always somebody available.

The designated contact person(s) should have a good telephone manner, be familiar with Windows®-based software, be able to reliably record data received over the telephone, and have good judgement and initiative. They need reasonable (but not necessarily constant) access to the computer on which *DriftNet* is installed in the public health unit. They need not necessarily be a health protection officer, but they should have ready access to health protection officers and the medical officer of health.

Telephone operators in public health units should be trained to recognise callers who are calling to complain about a spraydrift incident, and should at any time know who the appropriate contact person is.

A complaint about an agrichemical spraydrift incident received by a public health unit may have been precipitated by any of several events. These include observation of off-target spraydrift, plant damage, illnesses in people or animals (which may be reported by a doctor or a vet treating the case), or human exposure to an agrichemical. Irrespective of the reason for the complaint, details of each complaint should be recorded in a separate *DriftNet* complaint record. Several complaints associated with the same incident may be received. Each should be recorded in a separate record.

The data collected generally relate to the impressions of the complainant about the incident. These data are usually subjective and further investigation may be needed to demonstrate their accuracy. Nonetheless, data should be recorded in the form in which they are received. Data collected from the complainant are about what was observed and where, whether anyone was exposed or made ill, and any other damage that occurred.

Collecting complaint data

Complaints to the public health unit will usually be made by telephone and the suggested procedures below are based on that assumption. On occasion, however, complaints may be received by other means, such as letter, fax or email, in which case appropriate (but generally minor) modifications may need to be made to the suggested procedures.

When a spraydrift complainant makes telephone (or direct) contact with the designated contact person within the public health unit, the following procedure would generally be appropriate:

1. Thank the caller for calling.
2. Explain that there is a special procedure for recording data on spraydrift incident complaints and, therefore, you would like to ask a systematic series of questions, although the person calling will have the opportunity to add any additional information that they think is relevant, but that has not been requested.
3. Using either the *DriftNet* screens (and entering the data directly) or the paper forms, ask the appropriate questions in sequential order and record the information received.
4. Initially record information on a complaint form or screen. However, for every individual person whom the complainant advises was directly exposed (and possibly ill as a result), record data on an exposure/illness record or form.
5. At the end of the specified questions, give the caller an opportunity to supply any additional information that they think relevant, thank them for calling and advise that someone from the public health unit will get back to them shortly.
6. Supply a copy of either a printout of the *DriftNet* screens or a photocopy of the paper forms to the appropriate health protection officer.
7. If data were initially entered onto paper forms, transfer the information to *DriftNet* screens (taking care to avoid mistakes in transferring the data).
8. Within a day or two of the complaint having been received, check with the appropriate health protection officer as to what, if any, further action (eg, an investigation) is taking place. Record the information in *DriftNet*.
9. If there is a field investigation involving a visit to the site where drift is alleged to have occurred, then additional information may need to be added to the complaint record. This may be done either by the designated contact point or the officer carrying out the investigation, but responsibility for entering such data should be clearly designated.

Complaint data are recorded under four main subheadings (pages in *DriftNet*): location, details, management and investigation.

Location

This page records fundamental information, including contact details for the complainant, the geographic location of the site affected, and where the drift appeared to come from.

Details to be recorded include:

- the name of the person in the public health unit recording the information
- name, address and telephone number of the complainant
- date and time of the complaint to the public health unit
- type of complainant (eg, member of the public, government agency, farmer, doctor, other health professional, journalist or reporter, other)
- the address of the area affected by spraydrift
- affected location type (eg, private residence, public area, school, workplace, childcare centre)
- the address of the property from which drift is presumed to have come
- the name of the owner of that property.

Details

This page records information about the extent and circumstances of the incident, as perceived by the complainant. Recorded data include:

- how the spraydrift was first detected (eg, by sight, smell, physical contact)
- a brief text description of the incident
- date and time of the spraydrift incident
- the observed application vehicle and application device (if known by complainant)
- what (if anything) the complainant believed the agrichemical to be
- whether prior notice of agrichemical application was given and, if so, how and when the notification took place
- how far the operator was from the affected area
- in what direction the operator was relative to the affected area
- wind strength at the time
- wind direction at the time (note that for drift to have occurred this should be similar to the direction of the operator relative to the affected area)
- temperature at the time
- if applied by air, the aircraft registration number (if noted)

- whether the property on which the spraying operation was taking place was uphill or downhill from, or level with, the exposure site
- type of water supply to the house (eg, roof collection, town supply, well or bore, spring, other)
- whether food crops were exposed to spraydrift
- whether non-food crops were exposed to spraydrift.

It must be emphasised that the source of the contaminant is not necessarily the most obvious one. For example, volatile herbicides may drift for as much as 25 km and still be detected by the nose. This means that alternative sources have to be investigated along with an obvious source, such as roadside spraying.

Management

This page records the names of any individuals exposed (and possibly made ill), and the decision on whether to take any further action. Further action may include a field investigation and/or referral to another agency. Recorded data include:

- whether further action, such as a field investigation, was considered to be warranted
- the event/incident record number, which will be displayed on this page (although it cannot be changed from this record) when a field investigation takes place and is linked (through the event/incident record) to the complaint record
- when no further action is considered to be warranted, the reason for that decision
- the name of any other agency to whom the complaint was referred
- the name(s) of any person(s) believed to have been exposed (for each name recorded, an exposure/illness record will automatically be opened).

Investigation

This page records information on the investigation of **the site where the spraydrift occurred** (not the investigation of the actual event that led to the drift occurring – that is the subject of the event/incident record). This page will only be needed if a field investigation is considered to be warranted (as recorded on the management page). Data recorded on the investigation page are:

- name(s) of the investigating officer(s)
- the date of the investigation
- whether plant damage consistent with herbicide damage was noted
- whether samples (eg, foliage, water or soil) were taken for analysis
- the results of any analyses
- conclusions of the investigation
- whether further action was required.

The public health unit should also check, at this point, whether the regional council or unitary authority has a regional plan that makes the application of agrichemicals a permitted activity subject to conditions and, if so, what those conditions are and whether the alleged operator has a resource consent to undertake the activity, subject to conditions. Conditions of consents and rule in regional plans may include those relating to effects on human health.

Collecting exposure/illness information

For each individual person alleged by the complainant to have been exposed, whether or not they experienced symptoms or illness as a result, details (including any biomarker results) should be recorded in a separate exposure/illness record. Each corresponding exposure/illness record will automatically be linked to the relevant complaint record by a complaint number. This will, at the same time, automatically link the exposure/illness record to any event/incident record already linked to the complaint record.

No exposure/illness record can stand on its own. It must come from and be linked to a complaint record. This ensures that additional data on the precipitating incident are available. Aggregation of exposures/illnesses under a complaint record also captures the inter-related nature of cases of exposure and illness. This information is important. For example, five separate illnesses that are linked to five separate complaints associated with the same incident could have a quite different interpretation to five illnesses that are related to a single complaint. Linkage of individual exposure and illness records to a complaint record also enables identification of individuals similarly exposed who did not experience the illness. This could be important in the interpretation of whether there is a cause and effect relationship.

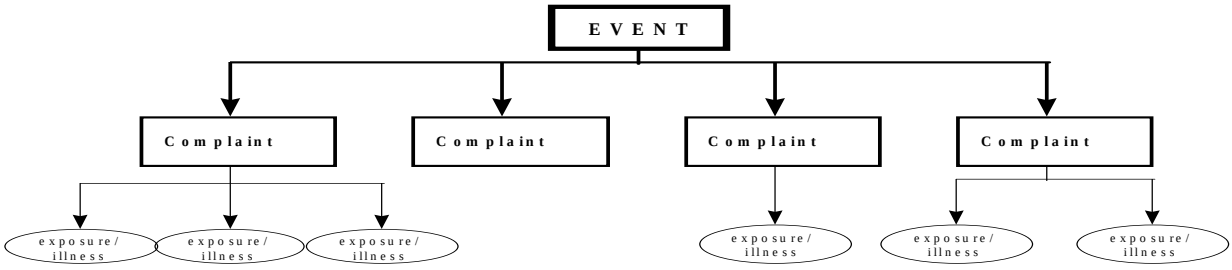
Linkage of exposure/illness records through complaint records to event/incident records is represented diagrammatically in Figure 3. Figure 3 shows the relationship of the records within *DriftNet* that relate to a single hypothetical spraydrift incident/event involving three complaints and a total of six people exposed.

Within the exposure/illness record in *DriftNet*, data are recorded under four main subheadings (pages): personal, symptoms, risk factors and diagnosis.

Initial data for creation of the exposure/illness record will be obtained from the original complainant. However, it may be necessary to interview the exposed/ill person (or a caregiver) to complete the form, particularly if illness is alleged to be associated with the exposure. In some cases it will be necessary to approach the person's medical practitioner to obtain medical details. Note that poisoning associated with 'chemical contamination of the environment' is a notifiable disease under section B of the Second Schedule to the Health Act 1956 and that hazardous substances injuries are notifiable to the medical officers of health by all medical practitioners under section 143 of the HSNO Act.

Although most exposure/illness records will be initiated from the complainant interview, subsequent investigation may reveal others who claim to have been exposed or made ill. Separate exposure/illness records will need to be created for these people. This can only be done by entering their names onto the management page of the complaint record (ie, by editing that record).

Figure 3: Illustration of the record structure associated with an event



The data fields on each page of the exposure/illness record are described below.

Personal

This page records personal data for the individual affected and it links this record to the complaint record (and any associated event/incident record).

- The name of the person recording the details will appear as a default from the corresponding name on the location page of the complaint record (this can be overwritten).
- The name of the person exposed or ill will automatically be inserted from the complaint record (management page). The address of the complainant from the complaint record will be inserted as a default for the address of the person affected (this can be overwritten).

Other information to be collected includes:

- date of birth of the exposed/ill person
- sex of the exposed/ill person
- ethnicity (Census categories) of the exposed/ill person
- current main occupation of the exposed/ill person
- where the exposed/ill person was at the time of the exposure (eg, inside the house, in the garage, in the garden)
- the activity that the exposed/ill person was engaged in at the time of the exposure (eg, mowing the lawn, driving, playing at school)
- how the exposure was experienced (eg, smell, felt on skin or clothing, visible mist or cloud)
- whether the person experienced symptoms or illness that they associated with the exposure (this item opens the subsequent pages in this record).

Symptoms

This page records any symptoms of illness that the person associated with the exposure. Data will only be able to be entered onto this page if it is specifically indicated on the personal page that symptoms or illness were associated with the exposure. Symptoms are recorded systematically using a series of check boxes (refer report sheets in Appendix 6 for details). A box should only be checked if symptoms were experienced.

Risk and protective factors

As with the symptoms page, this page should only be opened if symptoms/illness were experienced. This page extends the questions about symptoms, but also covers risk factors and protective factors that may have either been responsible for the symptoms/ illness experienced or affected susceptibility to the spraydrift exposure.

Other data recorded on this page are:

- the date when symptoms were first noticed
- the time when symptoms were first noticed
- the most severe symptom
- whether tissue or fluid samples were taken for analysis
- the results of such analyses
- whether the subject normally suffers from any of the following conditions: asthma, skin allergies, hayfever, migraine, eczema and/or other chronic diseases
- any medicines taken during the week prior to the exposure
- whether the subject is pregnant
- whether the subject is breastfeeding
- the usual health status of the subject (eg, excellent, good, fair, poor)
- whether the subject had any illnesses in the week prior to the exposure
- the average number of cigarettes smoked per day (smoking is related to a possible route of exposure)
- number of alcoholic drinks consumed in the 12 hours prior to the exposure (alcohol may affect metabolism).

Diagnosis

This page will also not be needed if symptoms or illness are not experienced. It mainly records information that will be available if a doctor was consulted. It also includes the final conclusions of the investigating officer in relation to the possibility of a cause and effect relationship between exposure and illness.

Data recorded include:

- whether a medical practitioner or any other health professional was consulted
- name and address of doctor (or other health professional)
- diagnosis
- whether the illness is acute or chronic
- whether the illness is systemic or local
- overall severity of the symptoms (acute/chronic/intermittent, systemic/local)
- whether the symptoms have resolved and, if so, when (date and time)
- whether the symptoms were consistent with an effect of the agrichemical(s)
- overall conclusions of the investigating officer in regard to the association between illness and the exposure.

Step 2: Decision to investigate further

Within each public health unit, levels of authority for decision-making and responsibility for taking action for dealing with spraydrift incidents, with clear lines of accountability, should be designated in advance. Some officers might specialise in dealing with such incidents, so that experience and responsibility are not spread too thinly.

Once one or more spraydrift complaints have been received and data recorded, it is necessary for a decision to be made as to whether to proceed with a field investigation of the incident. This is necessarily a local decision and must take into account local circumstances. These guidelines suggest factors that should be considered by public health staff in making this decision.

Once data related to one or more complaints (and associated exposures/illnesses) have been recorded in *DriftNet*, the designated contact person who recorded the information should supply to the appropriate health protection officer (or medical officer of health) either a printout of the relevant *DriftNet* screens or the paper forms onto which the data were first recorded.

The officer responsible for dealing with a complaint should have available established procedures for ensuring the appropriate response and, as appropriate, should consult or convene the response team. The first task is to decide on the appropriate action.

The three main possible actions are:

1. take no further action
2. refer to another agency (possibly in conjunction with a public health unit investigation)
3. begin an investigation (with or without referral to another agency).

Factors that should be considered include:

- whether people were reported as actually exposed, or whether non-target drift was simply observed
- the number of people exposed
- whether exposed people reported symptoms or illness associated with the exposure
- whether there was possible contamination of food or water supply
- the nature of the non-target area affected (eg, a school or childcare centre would be of particular concern)
- the number of separate complaints about the same incident
- the level of local concern, or potential for such concern to occur
- availability of investigative resources
- the time interval between the incident and the complaint.

No further action

Considerations that might influence such a decision are:

- a lack of human exposure
- only one complaint received (depending on the nature and seriousness of the complaint)
- complaint likely to be frivolous
- no potential for food or water contamination
- low level of public concern
- long time interval between the incident and the complaint
- lack of available investigative resources
- symptoms not associated with those expected from the alleged contaminant.

When a decision is made that no further investigation is necessary, then the reason should be documented and the decision endorsed by the senior health protection officer or the medical officer of health.

Referral to another agency

Chapter 4 provides information on the roles of other agencies in spraydrift incidents. An up-to-date list of appropriate contact people in those agencies should be maintained by the public health unit. Similarly, those agencies should be aware of whom in the public health unit to contact, should they first become aware of a spraydrift health-related incident.

Any incident that involves herbicide-related plant damage should be referred to the regional council, even if the public health unit decides to carry out its own investigation.

Incidents that involve dangerous operation of an aircraft during aerial spraying should be referred to the Civil Aviation Authority.

Local agreement should have been reached with other agencies, including the Department of Labour, the regional council and territorial authorities, in regard to criteria for referral of complaints to those agencies. In addition, there would be advantages in establishing with those agencies agreed written protocols for procedures to be adopted for joint investigations, including establishment of the lead agency in any such joint action.

If a complaint is to be referred to another agency (whether or not the public health unit is intending also to investigate), the consent of the complainant should first be sought.

A summary sheet of the information provided by the complainant (or a copy of the complaint record) should be forwarded to the appropriate agency or agencies. Generally, information passed on to other agencies should not include illness information from the exposure/illness records. The only information that should be provided is that recorded on the first page (personal page) of those records. Illness information is usually relevant only to the public health service investigation.

Refer the information by fax to the appropriate agencies. Follow up with a phone call to check that it has reached the appropriate person(s). As far as possible, co-ordinate the investigation with the other agencies that will also be carrying out investigations.

Further investigation

Considerations influencing a decision to carry out a further investigation include:

- illness associated with exposure reported
- more than one person exposed
- exposure occurred in a sensitive area (eg, a school)
- more than one separate complaint received
- food or water contaminated
- appreciable public concern
- investigative resources available.

Step 3: The investigation

A public health investigation of an agrichemical spraydrift incident may include some or all of the following.

1. A field visit is made with staff from other agencies to:
    - inspect the property onto which the agrichemical was being intentionally applied
    - inspect the non-target site(s) onto which spraydrift occurred, as identified by the complainant(s)

- interview people identified as exposed (either with or without associated illness)
- interview the spraydrift operator and review any records of the agrichemical spraying.

2. Biological and environmental samples are collected for laboratory analysis of residues.
3. Information requests are made to medical practitioners (with patient consent) about people who consulted their doctors.
4. Where an incident is claimed to have caused illness in a number of people, a cross-sectional epidemiological study may be considered, if resources are available. In such a case, it would be advisable first to seek professional epidemiological advice.

When carrying out investigations, it is important to remain impartial and to show consideration to all parties. Speedy resolution of issues and fair and appropriate feedback to all parties are important.

Appointment of an investigation team leader

It is important that a leader be appointed for each incident investigation, although this may always be the same person if one person is given responsibility for investigating all such incidents. The responsibilities of the investigation team leader would include:

- co-ordinating the investigation team
- seeing the investigation through to completion
- informing and liaising with other investigating agencies
- collecting the appropriate information, including technical and toxicological information on the agrichemicals implicated
- collecting environmental samples and referring them for analysis
- ensuring that data from the investigation are recorded on *DriftNet*
- maintaining a complete physical file of documents from the investigation
- informing the complainant(s) of the outcome of the investigation and action (if any) taken, and why
- ensuring follow-up action is taken (if appropriate).

Time is of the essence

It is important that investigations of spraydrift incidents be carried out as fast as possible. With each passing day, information (particularly physical evidence) may be lost. Equally, plant damage by herbicides, which may provide crucial corroborative evidence, may not become apparent for several weeks. For this reason, a return visit (possibly by the regional council) to the affected site may be necessary some time in the future. The initial investigation will establish whether the drift material was in fact a herbicide.

Visiting the site of the spray application

Ideally, field investigations should be conducted jointly by representatives of all involved agencies, including the public health unit. However, this joint approach will often not be practicable, and the lack of one is not a reason to delay the investigation.

The owner or manager of the property where the intended application of the agrichemical took place should be contacted by phone to arrange a visit, including a face-to-face interview (although there may be circumstances in which an unannounced visit is appropriate). A request should also be made to interview (if possible, during the same visit) the operator who applied the chemical, if that person is not the same person as the owner/manager.

This visit should be arranged to take place at the earliest possible opportunity. It should be at or near the site of the actual application.

The purpose for the site visit and the interview should be made clear in advance: to obtain information on the agrichemical being used, the site and method of application, weather conditions at the time of spray application, and other information that might be relevant to assessing the complaint(s). It must be reiterated that the source of the contaminant is not necessarily the most obvious possibility. For example, volatile herbicides may drift for as much as 25 km and still be smelled. This means that alternative sources have to be investigated along with an obvious source, such as roadside spraying.

The names of the officer(s) who will be making the site visit(s), and the agencies that these individuals represent should be advised in advance.

The name of the complainant should not at any time be divulged, unless the complainant has given their permission to do so.

If, during the investigation, information should indicate that an ongoing operation is causing or is likely to cause danger to humans due to contamination of crops, stock, agricultural lands or the environment, the medical officer of health may, under sections 29, 60 and 32–35 of the Health Act 1956, intercede to stop the operation. Warranted HSNO enforcement officers may also serve an HSNO compliance order under section 104 to cease an operation that is having or is likely to have an adverse effect on the health and safety of the people.

Visiting the location affected by spraydrift

The off-target location(s) where spraydrift is alleged to have occurred should be visited as soon as possible, preferably close to the time of the visit to the site where the intentional application took place.

The site investigation should take place in the presence of the complainant. This will provide an opportunity to complete any gaps in the *DriftNet* complaint record. A paper report of that record should be taken and additional data written on it. Those data should be transferred to the electronic record as soon as possible after returning to the public health unit office.

If appropriate, environmental samples may be collected under section 103(2) of the HSNO Act to confirm whether contamination has occurred. Collection of samples is specialised, especially where plant material is concerned. If there is to be a prosecution, then the full details of the technique by which the sample was collected must be recorded (see Appendix 2 for further information on environmental sampling). Environmental samples may include:

- water samples, particularly if drinking water is possibly contaminated
- soil samples
- swabs of physical surfaces
- samples of food crops or foliage
- other possibly contaminated items.

During the visit it is a good idea to draw an A4 approximate scale map of the location where the drift took place. This map should include:

- an indicator for north
- where the drift occurred
- the target area for the spray
- any roads, property boundaries and buildings
- an arrow indicating the path of the spraydrift
- wind direction at the time of the incident
- any natural or artificial shelter belts (including hedges and large trees) between the target and the drift areas
- the sampling locations and sample numbers of any environmental samples
- the location of the exposed people at the time the spraydrift occurred
- an indication of the relevant topography
- any other relevant feature(s).

Taking photographs, as permitted under section 103(2) of the HSNO Act, will often be appropriate as well.

In a case where plant damage due to herbicide drift is evident, the regional council should be advised.

Interviewing exposed/ill cases

During the initial complaint report, information on each person believed to have been exposed is recorded on an exposure/illness record. Often, particularly when symptoms or illness have occurred, the complainant will not know all the information that is sought. In such cases it would be appropriate to interview the exposed/ill people themselves as part of the field investigation.

Interviews with exposed/ill people should be arranged by phone and conducted within 48 hours of the exposure, and preferably within 24 hours, if it is intended to take biological samples.

When conducting the interview, the investigating officer should refer to a hard copy of the *DriftNet* exposure/illness record and confirm all details supplied by the complainant, as well as filling in the gaps. Interviewees should be assured that all information collected will be kept confidential to those conducting the investigation and involved in any subsequent prosecution.

Interviews with anyone under the age of 16 years should take place only in the presence of a caregiver.

If a person with symptoms or illness associated with their exposure has consulted with a doctor, request from the patient (or, as appropriate, a caregiver) written permission to contact their doctor to discuss the diagnosis.

A urine sample may be collected at the time of the interview. This may be referred for analysis for the implicated agrichemical or its metabolites.

Non-invasive urine collection is preferable to blood sample collection. However, if a blood test is justified, advise the exposed/ill person that they should arrange this test as soon as possible with their medical practitioner.

More information on collecting biological samples is provided in Appendix 2.

Collecting event/incident information

Data on the incident that are collected during the field investigation will be recorded in an event/incident record on *DriftNet*. Once an event/incident record has been created, it can be linked to each of the corresponding complaint records, and the event/incident record number will then appear automatically in those records.

Most data on the agrichemical event/incident will be obtained during an interview with the owner/manager of the property where the agrichemical was intended to be applied and with the agrichemical operator (if that was a different person). Sections 2.6, 4.5, 5.3.5, 6.6 and 7.5 of the New Zealand Standard *Management of Agrichemical* NZS 8409:2004 describe the record-keeping required of spraydrift operators. This includes name of operator, equipment and method of use, type and amount of agrichemical stored and used, location and nature of sensitive areas, notification requirements met, area of application site, date and time of application, weather conditions, equipment calibration, disposal and any abnormal situation or incident including emergency

preparedness and management. For aerial application, any emergency release of load, and the location of such a release, should be noted. This information will be useful for investigators in the event of a spraydrift incident, as well as making operators more aware of what they are doing and possibly preventing a complaint in the first instance.

It must be remembered that a highly visible source is not necessarily the most likely source of the contamination. High-volume airblast spraying, for example, is highly visible. There are now also 'tower' sprayers that are only moderately visible, and controlled droplet application (CDA) that is almost invisible. All of this equipment may be used on the same crops. While the public may identify the source with the visible application, this source may not be the true source of the contaminant.

During the interviews and property inspections, information should be recorded on paper event/incident forms. Back at the office, the data from the forms should be used to create a *DriftNet* event/incident record. Any notes made at the time should be retained on file in case a prosecution is taken.

Within the event/incident record in *DriftNet*, data are recorded under four main subheadings (pages): location, details, chemicals and management.

Location

This page records basic information to do with the property where the spraying took place and who carried it out, as well as the name(s) of the investigating officer(s). Recorded data are:

- the incident number (automatically assigned when a new record is created)
- the name of the local public health unit (automatically assigned)
- name(s) of investigating officer(s)
- the date of the investigation
- the address of the property where the spray application took place
- the territorial authority that contains this property
- the name, address and telephone/fax numbers of the owner (or manager) of the property
- the name and address of the spray operator
- whether the operator is an approved handler.

Details

This page records information on the actual spray application and the meteorological conditions at the time. Recorded data are:

- date of spray application
- time of event/incident
- intended target of the spray
- the method of application (spray equipment used, method of carriage, nozzle type)
- the application rate of the diluted spray (in litres per hectare or kilograms per hectare)

- weather conditions at the time of application (wind speed, wind direction, air temperature, relative humidity); consultation with MetService may be necessary to obtain this
- whether the spray log was kept up to date and whether weather conditions (for the incident) were recorded
- when spray equipment was last calibrated
- the width of the buffer zone (minimal distance maintained between spraying and neighbours)
- whether there was a shelter belt downwind of the application site
- the distance of the spray area from the nearest neighbour and their compass direction from the site of application
- whether neighbouring residents were notified in advance of the spray application
- other circumstances that may have contributed to the incident.

Chemicals

This page records information on the chemicals involved in the incident. Recorded details are:

- trade name of each separate product included in the spray mix
- the type of formulation for each trade name product
- agrichemical classification of each trade name product
- dilution rate for each trade name product
- the list of active ingredients and their percentages in the formulation for each trade name product.

Management

This page records conclusions of the investigation and any follow-up actions. These include:

- conclusions from the investigation
- actions initiated
- recommendations
- related complaints. The associated complaint records are linked from a field on this page by selecting from complaint records that are currently unlinked to any event/ incident record.

Evaluation of information collected

During an incident investigation, including the interviews with the complainant(s) and the spray operator, information will be collected in order to answer key questions.

- Did off-target spraydrift actually occur?
- Did the owner/manager of the property take all reasonable precautions to minimise off-target spraydrift?

- Did the spray operator take all reasonable precautions to minimise off-target spraydrift?
- What else could have been done?
- Is there evidence that the law has been broken? (Refer Chapter 4, 'Roles and Responsibilities', for a summary of applicable legislation.)

These questions can only be answered after fully taking into account the information relating to the particular incident. As circumstances will vary widely, only general guidance can be given here. However, it is suggested that at least the following be given particular consideration:

- the degree of consistency of the information received from the complainant with the details obtained from the investigation, including details from the interviews of the property owner/manager and the spray operator; inconsistent items (eg, whether spraying actually took place on the time and day specified by the complainant, or differences over the wind strength and direction) should, if possible, be checked using a third source of information (eg, MetService)
- whether the agrichemical was being used according to label instructions (eg, target crop, application rate)
- the appropriateness of the application method
- whether the wind strength at the time was appropriate to the particular application
- whether there was physical evidence of non-target drift
- whether the buffer distance was adequate
- the qualifications and experience of the operator
- the adequacy of the maintenance of spray equipment
- whether the spray log was kept up to date
- the consistency of any symptoms/illness with what is known about the agrichemical and whether the exposure could have been sufficient to cause such symptoms; whether symptoms/illness could have other causes, such as medications or infection
- other factors as appropriate.

Step 4: Decision on action required

Once information has been collected and evaluated and questions answered, then the appropriate follow-up action needs to be considered. It would be appropriate for such consideration to take into account any related history of complaints and/or incidents. Possible follow-up actions include one or more of the following.

Take no further action

This may be the case if a complaint were found to be frivolous/malicious or if no corroborative evidence could be found to substantiate a complaint from a single individual.

Caution the farmer/operator

This would be appropriate if there was no prior history of such problems and the incident could have been avoided with a little more care (eg, in regard to wind speed and direction).

Require the farmer/operator to take appropriate measures to prevent similar occurrences

This might be appropriate if, for example, poorly maintained spray equipment contributed to the incident, buffer distances were too short, or prior notice to neighbours would have helped to avoid problems.

Refer to another agency for possible action

This is likely to be appropriate if bylaws, or legislation administered by other agencies, had apparently been violated, or if plant damage was involved. (Refer Chapter 4, 'Roles and Responsibilities', for a summary of applicable legislation, roles and relevant agencies.)

Initiate a prosecution

This would be appropriate, for example, if there was a prior history of similar problems, or if there was evidence that the incident had been caused by gross negligence (eg, spraying in high winds), or there had been a significant public health problem. A summary of the legislation relevant to agrichemical use and off-target spraydrift is provided in Chapter 4.

Information may be provided to complainants, or other interested parties, on how to minimise exposure and document an incident in the event that they or their property are exposed to off-target spraydrift. This could be in the form of an information sheet (or pamphlet) using the same key messages as in Appendix 3.

The *DriftNet* surveillance system

DriftNet has been developed to link multiple complaints, exposures and illness to a single precipitating spraydrift incident. *DriftNet* is a Microsoft® Access-based computer software program for detailed recording of event/incident, complaint and exposure/illness data.

To avoid potential problems, *DriftNet* should be installed on only **one** designated computer in each public health unit. *DriftNet* and its data should be backed up regularly, so that, in the event that computer hardware problems occur (as they inevitably will), the program may easily be installed on another computer.

DriftNet contains three separate but linked databases. These are referred to as the event/incident database, the complaint database and the exposure/illness database. The purposes and relationships of these three databases are outlined below, and illustrated in Figure 4.

Whenever a complaint of an agrichemical spraydrift incident is received at a public health unit, a complaint record is opened on *DriftNet* and appropriate data are entered.

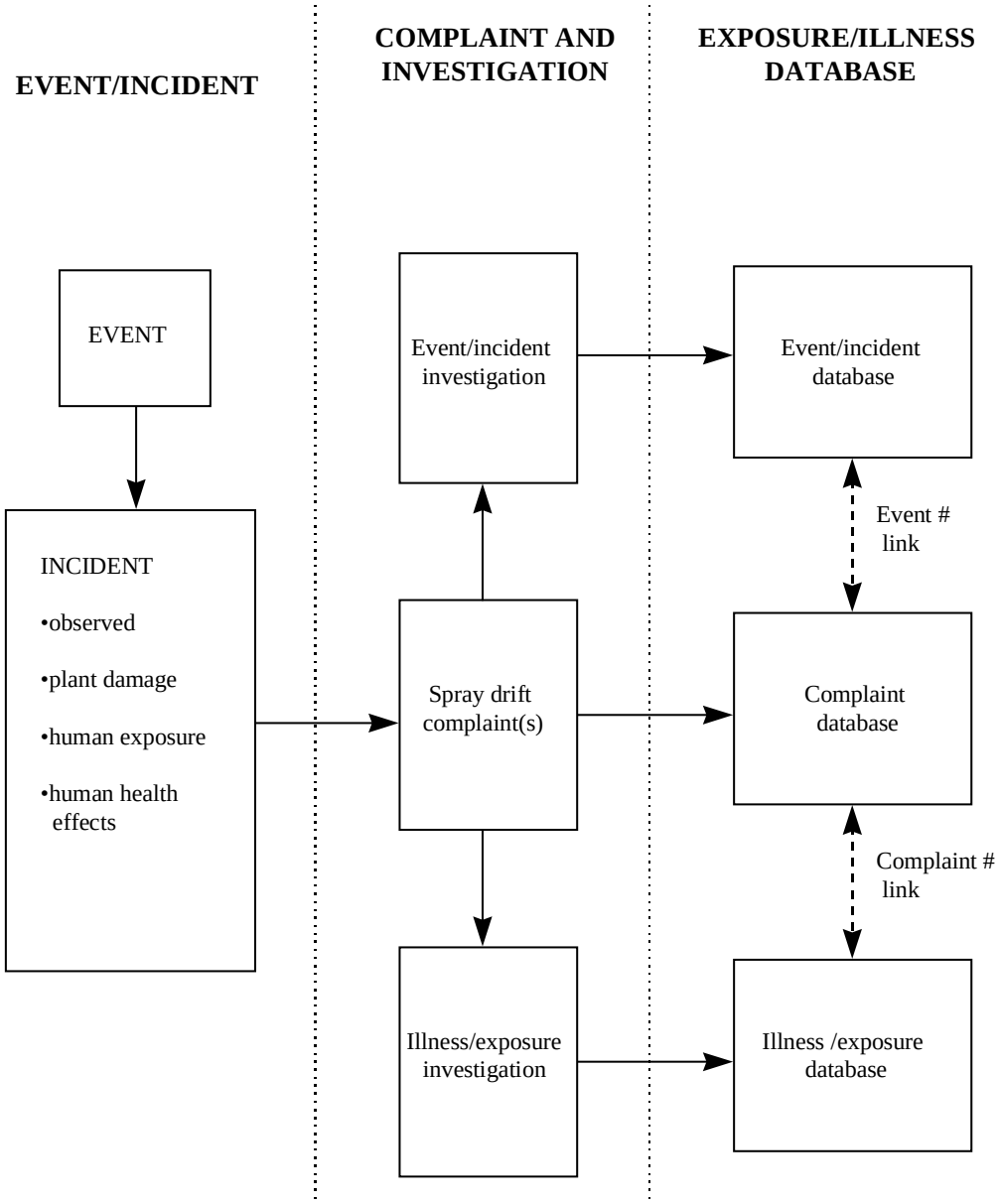
For each individual reported by the complainant to have been exposed to the agrichemical as a result of the incident, a separate exposure/illness record is automatically created when their name is entered into the appropriate field on *DriftNet*. Exposure/illness records can only be **created** through a complaint record, and this linkage remains permanently. However, an exposure/illness record can be entered directly for the purposes of **editing** the record.

It may be that a particular agrichemical spraydrift incident leads to several complaints. For each separate complaint received by the public health unit, a separate complaint record must be created.

It may be that it is not convenient for data to be directly entered onto the computer when someone contacts the public health unit with a complaint. In that case, the appropriate information (for both complaints and exposures/illnesses) should be entered onto the record sheets (Appendix 6). These forms contain the same data fields and are structured similarly to the *DriftNet* screens. If there is initial recording of information on the paper forms, then the information should be transferred to *DriftNet* as soon as possible.

If, following a complaint, an investigation is carried out, then data collected during that investigation should be entered into an event/incident record. This record can be linked to the records of associated complaints. Unlinking of such records can only be done through the event/incident record. Linking a complaint record to an event/incident record also automatically links all associated exposure/illness records to the appropriate event/incident record.

Figure 4: Data flow and database structure



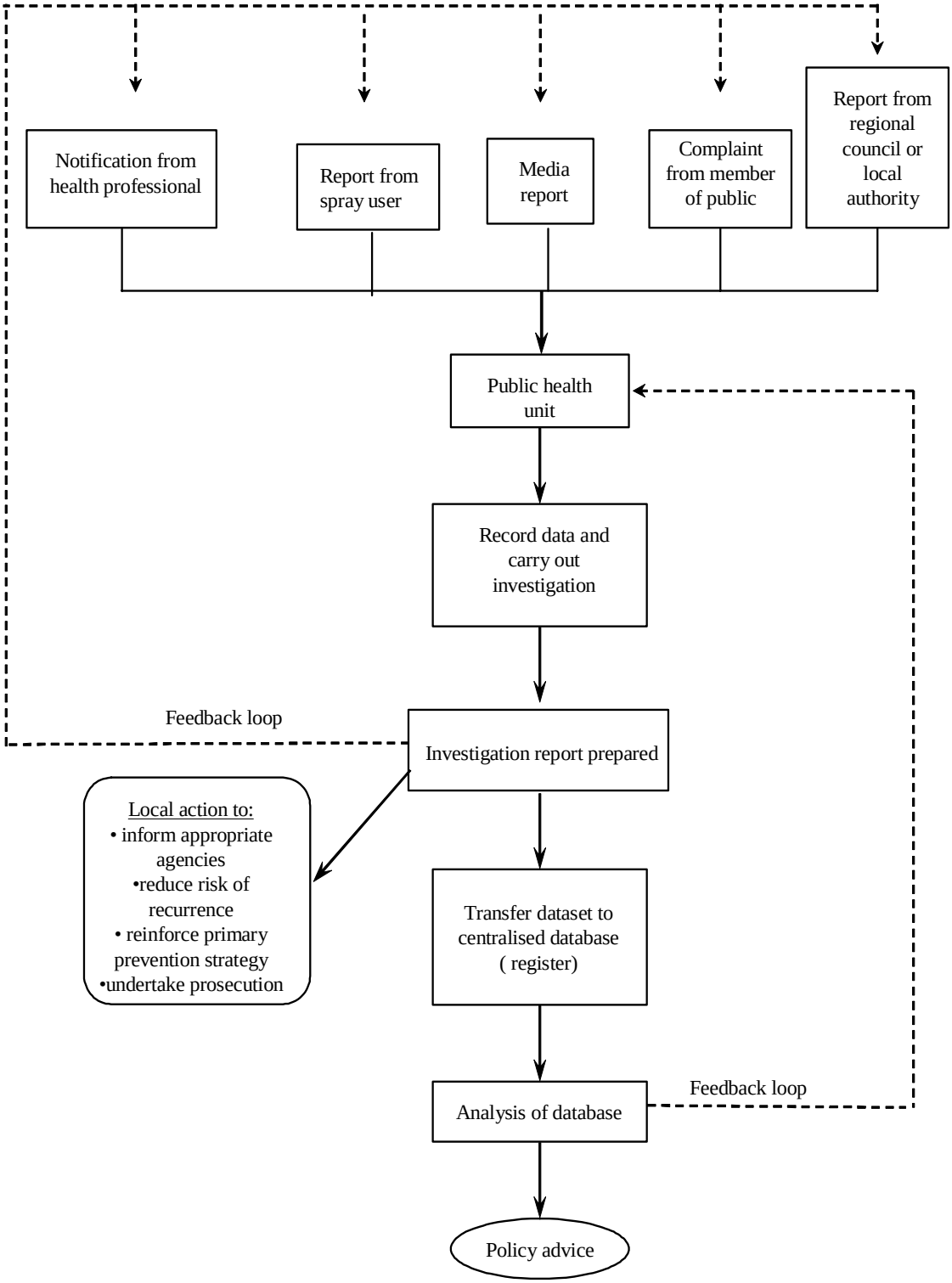
A unique number is automatically assigned to each record created by the *DriftNet* software. Each number indicates whether it is a complaint, exposure/illness or event/incident record, the year, the public health unit recording the information, and the sequential number of the record for that year (within the particular public health unit).

A variety of standard reports can be generated from *DriftNet*.

Data collected in *DriftNet* should be downloaded to floppy disk at the end of each month and sent to ESR: Kenepuru Science Centre, PO Box 50-348, Porirua (nil returns are also required). There, data from all public health units will be compiled into a national database for use by policy makers. Summary reports will periodically be sent back to public health units. The operation of the national surveillance system is illustrated in Figure 5.

DriftNet data may also be made available to bona fide researchers for epidemiological studies. Data may also be provided to local and national agencies, such as regional councils and local authorities, to assist with investigations.

Figure 5: Flow of data in the operation of the national surveillance system



Chapter 4: Roles and Responsibilities

Agencies with roles and responsibilities in investigating agrichemical spraydrift incidents include:

- regional councils
- territorial authorities (district and city councils)
- Civil Aviation Authority
- industry federations and associations
- Department of Labour
- Accident Compensation Corporation (ACC).

Roles and responsibilities must be considered in three contexts:

1. the regulatory agency with statutory authority to bring about remedial action
2. the person or organisation taking remedial action
3. agencies with statutory functions to ensure that the facts are established and the best advice is made available.

> The investigation of agrichemical spraydrift incidents needs to be undertaken in a collaborative way to avoid duplicated effort and wasted resources and to ensure the most effective statutory response.

An understanding of the roles and responsibilities of other national and local government agencies is important to facilitate efficient and effective local management of agrichemical spraydrift complaints and incidents.

The Ministry for the Environment has developed guidelines for regional councils and local authorities investigating environmental impacts from agrichemical spraydrift, which complement these guidelines.

Good communication links between key agencies are important. These should be established or reinforced, and regularly maintained to allow for efficient and effective dissemination of information and resolution of issues.

Role of the public health unit

The public health unit may often be the first to be made aware of a concern about an agrichemical spraydrift incident. Preliminary investigations (as set out in the Graded Response Protocol in Chapter 3) should establish the responsible people and any need to pass information on to others. Particular roles for the public health unit include:

- providing specialist advice in epidemiology and toxicology where risk assessment is complex
- obtaining copies of any sections of district or regional plans that relate to spraydrift
- preparing statements or advice about the risks to individuals or groups

- providing scientific advice on whether sampling is likely to be useful
- providing advice on how to effectively communicate statements to the public and media about risk
- providing advice to other agencies with statutory authority to effect remedies
- making submissions on resource consent applications to spray agrichemicals.

Health Act 1956

Section 74 of the Health Act 1956 requires medical practitioners to notify the medical officer of health of cases of listed notifiable diseases. Section B of the Second Schedule of the Act includes 'poisoning arising from chemical contamination of the environment' as a notifiable disease. Section 74 of the Health Act should be interpreted broadly. The Act requires reporting by medical practitioners, to medical officers of health, of any poisoning arising from chemical contamination of the environment. This reporting of notifiable diseases is critical so that the medical officer of health can analyse the reported incidents and decide whether any public health action is required.

Poisoning, chemical and contamination are not defined in the Act, so the ordinary meaning of these words must apply.

- 'Poisoning' is defined in the *Oxford English Dictionary* as 'any substance that can impair function, cause structural damage, or otherwise injure the body'. Poisoning does not need to be fatal, or to require admission to hospital.
- A 'chemical' is defined as 'any substance used in or resulting from a reaction involving changes to atoms or molecules'.
- 'Contamination' is defined as the act or process of contaminating, or the state of being contaminated. To 'contaminate' is to 'make impure especially by touching or mixing; pollute'.

An incident is considered to be notifiable provided it meets the definition for 'poisoning', 'chemical' and 'contamination' as described above.

Hazardous Substances and New Organisms Act 1996

The purpose of the Hazardous Substances and New Organisms Act 1996 is to protect the environment and the health and safety of people and communities by preventing and managing the adverse effects of hazardous substances and new organisms. The HSNO Act allowed for the establishment of the Environmental Risk Management Authority (ERMA). In exercising all functions, powers and duties under this Act, ERMA must take into account public health.

ERMA is responsible for investigating whether new hazardous substances, including pesticides, should be permitted for use in New Zealand. The HSNO Act empowers ERMA to make regulations that set acceptable daily exposure values (ADEs) for hazardous substances such as pesticides. These ADEs will specify the maximum permitted levels for a substance in any place where an unprotected person might be (eg, a public road next to a field where pesticide spraying is occurring). They take into account all exposure routes, including inhalation.

Tolerable exposure limit (TEL) is a concentration of a substance in an environmental medium set under regulation 27(1) of the Hazardous Substances (Classes 6, 8, and 9 Controls) Regulations 2001. Environmental medium means air, water and soil; or a surface that a hazardous substance may be deposited onto.

Section 13, on general duty, requires that no action or omission by any person will cause a hazardous substance to adversely affect any other person or the environment. This duty is not of itself enforceable; however, a compliance order may be served on any person under section 108, by an enforcement officer, to cease or prohibit that person from doing anything that relates to hazardous substances if, in the opinion of that officer, there is a risk to the health and safety of people or the environment.

In December 2005 an amendment to the HSNO Act was made that requires all medical practitioners, in addition to hospitals, to report injuries caused by hazardous substances to the medical officer of health as required under section 143 of the HSNO Act. This notification requirement includes agrichemical spraydrift health-related incidents.

Under section 144 of the HSNO Act, every person in charge of a hazardous substance resulting in serious harm to any person or serious environmental damage, as defined under the HSNO Act, shall report the incident to an enforcement officer.

Role of the health protection officer

The skills of the health protection officer are necessary for the following tasks.

1. Initial response and preliminary assessment
    - Receive, record and interpret queries and concerns.
    - Identify the cause of concern or complaint, location and associated parties.
    - Provide initial response and support to concerned people.

2. Inspection, hazard evaluation and risk assessment
    - Identify person(s)/groups at risk.
    - Identify compounding risks (eg, occupational exposure to agrichemicals).
    - Identify sources and types of agrichemicals implicated, hazards, open pathways of exposure.
    - Collect samples if appropriate.
    - Interpret laboratory results if appropriate.
    - Seek advice from the medical officer of health and others if necessary (eg, epidemiologists, toxicologists).
    - Assess the likely health risk from the information collected.

3. Information and risk communication
    - Explain how the risk should be managed, in consultation with other relevant agencies.

- Consult with property owners and occupiers.
- Refer information to the regulatory agency with statutory authority to bring about remedial action.

4. Management plans
    - Assist other agencies to determine appropriate action including, if necessary, the design of appropriate abatement and exposure control strategies.
    - Subject to the approval of the regulatory agency, advise property owners and occupiers on the implementation of the management plan.
    - Monitor the implementation of the public health aspects of the plan.
    - Maintain communication and co-operation with the other agencies and parties (recognising privacy).
    - Evaluate the effectiveness of the management plan.

5. Enforcement
    - Encourage enforcement by the appropriate regulatory agency.

The public health unit may also consider health promotion initiatives aimed at increasing awareness of the safe use of agrichemicals and the hazards associated with these chemicals.

News media

Unless other arrangements have been made, media liaison should be carried out by the medical officer of health or an experienced health protection officer in consultation with other agencies as appropriate.

The role of regional councils

The Resource Management Act 1991 (RMA) requires each regional council to develop a regional policy statement for the purpose of managing, in a sustainable manner, the natural and physical resources of that region. The RMA also allows for the development of regional plans, which may include a plan for the management of air quality. Functions of a regional council include the control of discharges to land, air and water for the purpose of preventing or mitigating adverse environmental effects, including those that may arise through the use of hazardous substances.

Regional plans that are currently being developed by regional councils specify which discharges to air are likely to result in minor effects on the environment, including human health (permitted activities), and which may cause adverse effects and therefore need a resource consent (discretionary/controlled or non-complying). The plans often contain rules about application of agrichemicals.

Conditions will be applied to both the permitted activities and the resource consents. These conditions can specify the way in which the spray must be applied and the adverse effects that are not allowed to occur. These adverse effects include effects on

health and the wider environment. When investigating complaints, it is appropriate to check the status of the regional council's plan and its requirements, and whether the alleged offender has a resource consent.

Controls on aerial discharges, from premises other than industrial or trade premises, are governed by rules in current or proposed regional plans. A discharge would only be permitted if it were allowed in the regional plan, had a resource consent or was an existing lawful activity under the RMA.

Many regional councils operate a permanent 24-hour telephone helpline for environmental emergencies. Within regional councils the air quality division of the environment section should be the first point of contact when referral of agrichemical spraydrift complaints from the public health unit is necessary. In some regions, however, the investigation and management of agrichemical spraydrift are contracted out to the respective district or city councils.

Resource Management Act 1991 and regulations

Discharge of contaminants into air from any industrial or trade premises is prohibited unless expressly allowed by a rule in a current or relevant proposed regional plan, a resource consent, or regulations. Otherwise controls on aerial discharges, from premises other than industrial or trade premises, are governed by rules in current or proposed regional plans. Discharge is prohibited if a rule in a current or proposed regional plan is contravened, unless the discharge is allowed by a resource consent or as an existing lawful activity under the RMA.

A resource consent is not required for aerial discharges when the source of the discharge is a natural discharge from production land. However, discharges from land due to human interference are covered by section 15(2) of the RMA, which states that no one may discharge any contaminant into the air or onto land from any place or source unless this is allowed by a resource consent or a rule in the regional plan (or proposed regional plan), or is a lawful activity.

Under section 43 of the RMA, central government can issue national standards for air quality. Such standards exist for some hazardous substances (Resource Management (National Environmental Standards Relating to Certain Air Pollutants, Dioxins and Other Toxics) 2004), but do not specifically contain guidance on spraydrift as an air pollutant.

Under section 60 of the RMA, each regional council is required to develop a regional policy statement to provide an overall framework for the management of the natural and physical resources of that region. Regional councils may also develop regional plans for resources such as air quality (sections 30 and 65).

Functions of regional councils include the control of the use of land for the purpose of the prevention or mitigation of any adverse effects, including the use of hazardous substances (section 30). Section 2 of the RMA defines a hazardous substance as any substance defined as a hazardous substance under section 2 of the HSNO Act.

Regional councils may be able to use the general duty (section 17) on any person to avoid, remedy or mitigate any adverse effect on the environment arising from an activity. This includes environmental harm resulting from off-target agrichemical spraydrift. This duty is not of itself enforceable (section 17(2)).

However, there are circumstances when enforcement or abatement proceedings may be taken. Enforcement orders (Planning Tribunal) or abatement notices (enforcement officer) may be issued requiring a person to cease, or prohibiting a person from commencing, anything that is currently or is likely to be:

- noxious
- dangerous
- offensive
- objectionable.

Similar action may require a person to do certain things to avoid, remedy or mitigate adverse environmental effects.

The role of territorial authorities (city and district councils)

Under section 31 of the RMA, the functions of territorial authorities include the control of any actual or potential effects of land use and land development, including prevention or mitigation of any adverse effects of use of hazardous substances. This allows for territorial authorities to make provision in their district plans for management of the hazards from agrichemical spraydrift. District plans need to be consistent and compatible with regional plans, but may be more restrictive.

Although territorial authorities have the primary responsibility for land use management, they may serve a role complementary to that of the regional council on hazardous substance management. Many district councils have developed district plans that may include rules to minimise the environmental effects of off-target agrichemical spraydrift. There is considerable variability in the extent to which these plans allow for mitigation, prevention or remedy of agrichemical spraydrift incidents.

In some areas, land use incompatibilities have developed. These contribute significantly to the problem of spraydrift. Territorial authorities are responsible for the control of subdivision of land within their district. In rural districts, the way in which the residential or rural-residential subdivisions are created is identified as crucial to the mitigation or prevention of agrichemical spraydrift. Therefore, through the careful management of land use, territorial authorities have a significant role in the avoidance of spraydrift incidents. Their involvement can be seen as complementary to that of the regional council which, through provision in the regional air quality plan, may restrict or control aerial discharges in relation to agrichemical spraying.

Within most territorial authorities, the environmental health officers are responsible for environmental issues such as spraydrift.

Health Act 1956

Under section 23 of the Health Act 1956, territorial authorities have responsibilities to improve, promote and protect the public health within the district. This includes making regular inspections for the purpose of ascertaining if any nuisances or conditions are offensive or likely to be injurious to health, and to secure abatement of those nuisances or conditions. Territorial authorities are required to appoint environmental health officers and other officers as necessary to carry out these functions. Territorial authorities may make bylaws for the purpose of protecting the public health.

Section 60 of the Health Act makes it an offence to cause pollution of a water supply that constitutes a health risk. It is similarly an offence to pollute any water course that passes through an urban area, whether or not the water course is part of the local water supply.

Section 29 of the Health Act specifies the circumstances in which an activity can be regarded as a nuisance, generally when it is 'offensive or likely to be injurious to health'. District Court action to abate nuisances is authorised by sections 32 to 35 of the Act, if a nuisance is not abated voluntarily. Section 34 enables certain territorial authority officers to act immediately without resorting to the courts. Works undertaken by a territorial authority to abate a nuisance may result in costs being recovered from the owner or occupier. It should be noted that any person can lay an information regarding a nuisance. However, a nuisance has to exist before any action can be taken and, accordingly, it is not an effective means of preventive action.

The role of other agencies

Civil Aviation Authority

Any person concerned about the dangerous operation of an aircraft should write to the Director of the Civil Aviation Authority (CAA) in Wellington (see Appendix 5 for contact details). The letter should include the date, time and location of the incident, the aircraft registration number and any other relevant details. Photographs supporting the written information on the incident may be included. It should be noted that Civil Aviation Rule part 137 allows a pilot carrying out an agricultural operation over a non-populous area to fly at any height necessary for the operation, provided there is no hazard to people or property on the ground.

Civil Aviation Act 1990 regulations and rules

Under the Civil Aviation Rule part 61, Pilot Licences and Ratings, pilots applying agrichemicals by aircraft must hold a current pilot's licence with an appropriate grade of agricultural rating (Grade 1 or 2) and, if applying agricultural chemicals in terms of the CAA definition, must also hold a pilot's chemical rating.

The chief pilot of a commercial aerial agrichemical organisation must have a Grade 1 agricultural rating. A Grade 2 agricultural rating applies to a person engaged in private aerial agrichemical application, but alone is not sufficient for commercial operation.

To apply agrichemicals by air, under part 137, subpart D, of the Civil Aviation Rules, a person or organisation must have an Agricultural Aircraft Operator Certificate.

To obtain a chemical rating, the candidate must complete the National Certificate in Aerial Application of Agrichemicals.

Under part 137, subpart A, of the Civil Aviation Rules, an agrichemical must be dispensed for its intended use and in accordance with label safety instructions and use limitations.

Part 137, subpart E (137.205), describes the operating requirements of commercial aerial agrichemical operations over populated areas.

Industry federations and associations

Industry federations and associations establish industry standards and represent industry interests to local and central government. The level of regional activity of the different federations and associations will depend to a large extent on local farmer, grower and contractor activities.

Relevant industry federations and associations include the Aviation Industry Association of New Zealand, Federated Farmers of New Zealand, Horticulture New Zealand, Pest Management Association of New Zealand, New Zealand Contractors Federation and New Zealand Forest Owners Association. Titles of these organisations are generally explanatory of their sectors of interest. Addresses and contact numbers may be found in Appendix 5.

Department of Labour

The Department of Labour is responsible for the administration and enforcement of provisions under the Health and Safety in Employment Act 1992 (HSE). Under general duties of the HSE, employers, contractors, sub-contractors and employees must ensure that no action or inaction harms any person. In addition, the HSE requires all people with control of places of work (such as the owner, lessee or sublessee) to take all practicable steps to ensure people in the vicinity of the place of work are not harmed by any hazard that is in or that arises in that place of work. Therefore, there are implications under the HSE legislation for agrichemical users when application of an agrichemical product resulting in off-target drift can be proven to have harmed any person.

The Department of Labour may conduct investigations to ascertain whether the HSE has been complied with. Department of Labour staff have considerable experience and expertise in investigation of hazards or incidents arising from incorrect or negligent use of chemicals in the workplace. Under provisions in the HSE legislation, the Department of Labour may be required to investigate a spraydrift incident. This may be at the request of the public health unit or a member of the public.

It is advisable that the public health unit establish a procedure for the transfer of information to the Department of Labour.

It should be noted that the Department of Labour is an enforcement agency under section 97 of the HSNO Act to ensure that the provisions of the HSNO Act are enforced in any place of work.

Health and Safety in Employment Act 1992

The HSE is administered by the Department of Labour through 18 branch offices in the main centres. While the great majority of spraydrift complaints will fall outside the provisions of the HSE, there may be occasions where deliberate or gross contamination occurs from spraying operations. In these cases the Department of Labour may be able to use the general provisions of the HSE to seek redress. All employers (and others) have a duty to effectively manage hazards due to work activities. Where poisonous sprays are used, due consideration must be given to controlling these hazards to prevent harm. Section 16 of the HSE requires people in control of a place of work to take all practicable steps to ensure that people in that place, or in the near vicinity, are not harmed by the hazard. It may be worth contacting the Department of Labour in cases where there has been a clear mismanagement of the hazard control process.

Section 12 of the HSE requires employers to ensure employees have information about any hazards to which an employee may be exposed, or that the employee may create while carrying out the work, and the steps to be taken to minimise the likelihood that the hazards will cause harm or be a source of harm to other people.

Sections 15 and 16 of the HSE require employers, or other persons in charge of a workplace, to ensure that no action or inaction by an employee causes harm to any other person. Under sections 17 and 19 of the HSE, self-employed people and employees must ensure both their own safety while at work and the safety of other people.

New Zealand Food Safety Authority

The Agricultural Compounds and Veterinary Medicines Act 1997 is administered by the New Zealand Food Safety Authority. The ACVM Act considers a hazardous substance only once it has been approved by ERMA New Zealand – that is, approval is required under both Acts. It is primarily concerned with trade issues, animal welfare, and biosecurity.

National Poisons Centre

The National Poisons Centre call record database for the period 1 July 2004 to 30 June 2005 received 1980 enquiries concerning registered pesticides or other agrichemical products (L Schieffelbein, Poisons Centre, personal communication, September 2005). It is unknown how many of these enquiries relate to spraydrift complaints. However, Poisons Centre staff acknowledge that requests for information on agrichemical products, precipitated by agrichemical spraydrift incidents, are frequent. The Poisons Centre is currently an important point of contact for members of the public and is able to provide referral advice to appropriate regional agencies.

The Poisons Centre has a list of all public health units throughout New Zealand. However, public health units may wish to provide the Poisons Centre with the names of the officer or officers responsible for dealing with spraydrift complaints.

Accident Compensation Corporation

A claim under the Injury Prevention, Rehabilitation and Compensation Act 2001 may be made in respect of an accident or injury due to chemical poisoning as a result of agrichemical exposure. Such a claim is subject to the provisions of the Injury Prevention, Rehabilitation, and Compensation Act 2001, which applies to personal injury that is caused by an accident, including chemical absorption through the skin, and personal injury that is caused by a gradual process or disease arising through employment.

Injury Prevention, Rehabilitation, and Compensation Act 2001

Section 8 of the Injury Prevention, Rehabilitation, and Compensation Act 2001 applies to personal injury through a gradual process or disease occurring in relation to employment. This application may include a gradual process or disease as a result of chemical exposure during employment.

Under section 20 of the Injury Prevention, Rehabilitation, and Compensation Act 2001, cover shall extend to personal injury that is caused by an accident not necessarily in relation to employment, and to personal injury that is caused by a gradual process or disease arising in relation to employment (as defined in section 7). Under section 6, Interpretation, the definition of an accident includes chemical absorption through the skin within a defined period of time not exceeding one month.

Conclusions

A number of agencies and organisations are involved directly or indirectly with the investigation of agrichemical spraydrift incidents under a variety of statutes. Public health units are encouraged to consider setting up a local 'investigation team' with other agencies, to identify local roles and responsibilities and establish local processes.

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Appendix 1: Biological Markers of Agrichemical Exposure

This is a literature review on biological markers (biomarkers) of agrichemical exposure for the purpose of evaluating the usefulness of biomarkers as a tool in the qualitative and/or quantitative assessment of human health risk and health impact from non-occupational agrichemical spraydrift exposure. Practical considerations for the application of biomarkers to field studies will also be discussed.

Biomarkers are gaining increasing popularity in occupational and environmental health and have the potential to contribute to the risk assessment process in terms of hazard identification, exposure assessment, dose-response assessment, and risk and/or impact characterisation. Various guidelines have been published by government and industry groups for the purpose of facilitating exposure studies and monitoring of occupational exposure to pesticides. Guidelines by the World Health Organization (WHO), the National Agricultural Chemicals Association (NACA) and the International Group of National Associations of Manufacturers of Agrochemicals (GIFAO) are examples of these.

A biomarker technology research project was launched by Praat (undated). It aimed, first, to identify biomarkers with known degradation rates that are compatible with a range of biological surfaces and non-hazardous to people and the environment. Its second aim was to develop an integrated computer-based tool as a hazard mitigation tool for agrichemical applications.

Markers for many of the pesticides in current use have yet to be developed and validated, and information on population variability is generally lacking for existing markers. The majority of methodologies that have been developed are for occupational monitoring of workers engaged in pesticide manufacturing, mixing, loading and application. Non-occupational exposure has been the focus of few studies.

Before applying occupational biological monitoring (biomonitoring) methodologies to non-occupational settings, it is necessary to carefully evaluate their appropriateness for this application.

This review provides a summary of information on validated and potential biomarkers, with comment on their applicability to non-occupational exposure. Also discussed are practical considerations, such as the logistics of sample collection, the availability of analytical methodologies and the availability of laboratory resources. It would be impractical to comprehensively review all New Zealand-registered pesticide active ingredients. Therefore, classes of pesticides are considered. Only biomarkers directly relevant to humans are considered. Biomarkers of environmental impact are not the subject of this review.

Types of biomarker

Five different classes of biomarker have been defined based on the sequence of events leading to disease (Brewster et al 1992). These are external exposure markers, internal dose markers, biologically effective dose (BED) markers, biological response markers and susceptibility markers. However, broadly speaking, biomarkers can be described in terms of three classes: biomarkers of exposure, biomarkers of effect and biomarkers of susceptibility.

Biomarkers of exposure include markers of external exposure and internal dose, and markers of biologically effective dose. Biomarkers of effect are markers of the biological response of an organism to a xenobiotic. Biomarkers of susceptibility reflect an organism's inherent sensitivity to a challenge from an exogenous substance or organism.

In terms of exposure assessment, and health risk and impact assessment, in the context of current biomonitoring and investigation of agrichemical exposure, the main focus is biomarkers of exposure.

Figure A-1 (modified from Brewster et al 1992) provides an overview of the sequence of events leading from the release of a chemical into the environment to a disease, and the corresponding phases for environmental and biological monitoring.

Biomarkers of exposure

A biomarker of exposure is defined by WHO (1993) as an exogenous substance or its metabolite or the product of an interaction between a xenobiotic agent and some target molecule or cell that is measured in a compartment within an organism.

Biomarkers of exposure can be distinguished as measures of either external dose or internal dose.

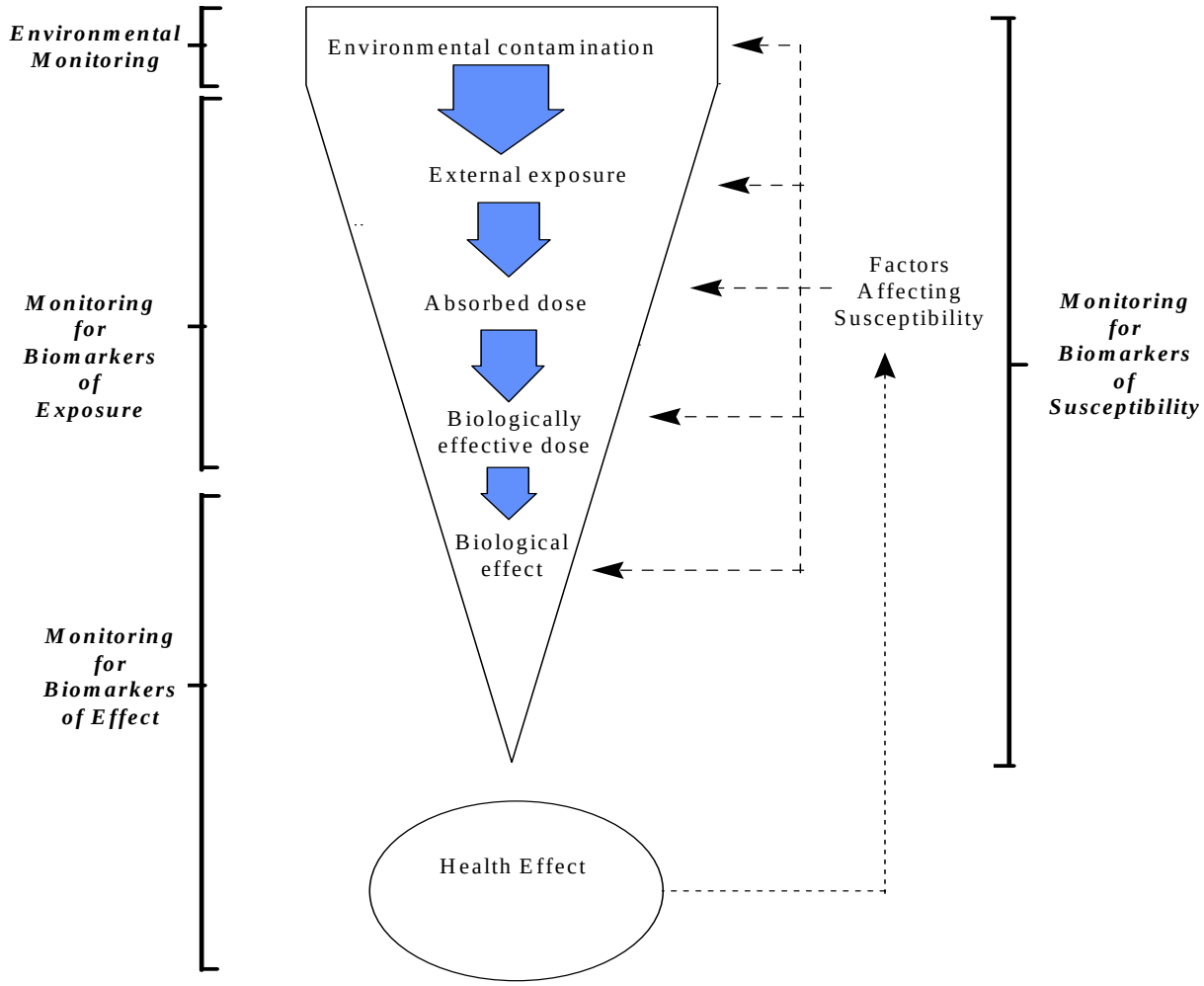
The external dose is the amount of an environmental chemical in contact with a person. This is measured by sampling the external environment – for example, by measuring residues on skin surfaces, in clothing samples, in drinking water, on physical surfaces, on or in vegetation, or in air samples. Sample collection and analysis are relatively straightforward, but external dose is not a good measure of potential health impact or health risk.

In a contaminated environment, the capacity of a contaminant to elicit a toxic effect depends on several factors. These include the concentrations of the agent in environmental media (air, water, soil, biota), the duration and frequency of human contact with these media, the ability of the agent and/or a toxic biotransformation product to be absorbed and to reach the target organ or tissue, and the concentration and duration at the target site. With the exception of agents that primarily cause local irritant effects, it is the internal dose, not the environmental concentration, that has the potential to impact most heavily on the health of the exposed individual.

The internal dose is the amount of the substance absorbed by the organism. This can be estimated from measurements of the amount of an agent or a metabolite in biological fluids, tissues, cells or in excreta, or from measurements of the interaction products of the toxin and a biological substrate, such as DNA or protein adducts (WHO 1993). Biologically effective dose markers can be considered those internal dose markers that measure an interaction between the toxin and the intracellular, cellular or tissue components that directly or indirectly results in the toxic manifestation.

In many cases, biomarkers of exposure are among the most convenient to determine because the contaminant or its metabolites can be quantified from nonlethally obtained samples of exhaled air, urine, faeces, blood or breast milk as well as tissues obtained through biopsy or necropsy. The non-lethally obtained samples are the more desirable sources because they can be used for multiple determinations over time, thus making the biomarker more useful by providing more information on the effects of the toxicant with time and by reducing variability (WHO 2001).

Figure A-1: Sequence of events and corresponding phases for environmental and biological monitoring



Source: Brewster et al 1992.

When internal, rather than external, measures of exposure are employed, consideration of variables that might influence absorption (eg, lipophilicity of the compound, type of clothing worn, skin integrity, and type and rate of physical activity) is no longer necessary. Thus, when evaluating human exposure and potential impact on human health, internal biomarkers are usually more informative.

Biologically effective dose markers, if available, provide a measure of the dose that has chemically interacted with critical subcellular targets, such as a nucleic acid or a cellular protein. The product of such an interaction is termed an adduct. The presence of a biologically effective dose marker does not necessarily mean that a toxic effect has occurred, although it may serve as a predictor of, or a surrogate for, a toxic effect.

Markers of exposure, total internal dose and biologically effective dose are very closely related. When considered in series, the magnitude of one directly influences the magnitude of the next. The total absorbed dose is proportionate to, but only a very small fraction of, the amount of an agent in the environment. In turn, the biologically effective dose is only a small fraction of the total absorbed dose.

For the purposes of human biomonitoring, as well as classical analyses of biological samples, modern immunochemical techniques (immunoassay) have been developed for assessment of exposure to a small number of environmental pollutants, including some pesticides. Immunoassay techniques offer the advantages of rapidity, sensitivity, specificity, cost-effectiveness, simplicity, and supplementation of more sophisticated analytical methods (Knopp 1995). A summary list of over 40 commercially available immunochemical test kits is included in a review on immunological methods in human biomonitoring (Knopp 1995). The majority of these test kits were developed for detecting pollutants in air, water, soil and other environmental matrices, and would require modification and validation before they could be used for measuring human biomarkers. Immunoassay techniques are also being developed for measurement of genotoxic dose such as levels of carcinogen-DNA adducts and carcinogen-protein adducts (Vanderlaan et al 1991).

Biomarkers of effect

A biomarker of effect is a measurable biochemical, physiological, behavioural or other alteration within an organism that, depending on its magnitude, may represent health impairment or disease (WHO 1993). Biomarkers of effect tend not to be specific to particular chemical exposures. They are measurements of physiological change in an organism that may be caused by a number of agents. For example, measurements of liver enzymes in plasma can provide evidence of injury caused by a hepatotoxic compound, as can a biopsy of liver tissue. Both are equally valid biomarkers of effect, although taken alone neither is sufficient to implicate a particular chemical cause, as hepatic damage has a variety of possible aetiologies.

The prospective epidemiological study is the gold standard for validation effect biomarkers (WHO 2001). This type of study provides estimates of the individual's risk of disease with and without a particular marker. However, it is acknowledged that these studies are time consuming and costly.

Biomarkers of susceptibility

A biomarker of susceptibility is defined as an indicator of an inherent or acquired ability of an organism to respond to the challenge of exposure to a specific xenobiotic substance (WHO 1993). Biomarkers of susceptibility are those factors in a person's genetic, behavioural or physiological predisposition, or the physical environment within which they live, that alter their susceptibility to the effects of a xenobiotic.

For instance, low-level exposure to a cytochrome P4501A1 or 1A2 inducer may elevate enzyme activity in humans; such elevations have been linked to greater risk of a number of cancers due to increased bioactivation of procarcinogen (Frame et al 1998).

Uses of biomarkers

Biomarkers have roles in investigating cause-effect and dose-response relationships in health risk and health impact assessments, in clinical diagnosis and treatment evaluation, and in occupational health monitoring and surveillance programmes.

Biomarkers can provide quantitative information about the magnitude of an exposure and the extent of the corresponding health impact (that is, the dose-response relationship). They may also be used qualitatively, to confirm that an exposure has or has not taken place. Biomarkers can be particularly useful when the relationship between cause and effect is uncertain. This uncertainty often exists when ill health coincides with possible exposure to off-target agrichemical spraydrift. In addition, surveillance programmes that include biomarker data may provide information on effects of low-level chronic exposure or delayed effects from acute exposures. Such information could aid in diagnosis and also identify where more stringent regulatory controls and industry codes are necessary to reduce the potential for both occupational and non-occupational injury.

Currently, a major limitation of biomonitoring for agrichemical exposure is the large number of compounds currently in use and under development. Worldwide, there have been more than 1000 pesticide active ingredients incorporated in about 10,000 commercially available preparations (Plestina 1984). However, biological monitoring data are available only for fewer than 50 active ingredients (Coye et al 1986).

Biomarkers have been developed primarily for occupational hazard management. If it is assumed that there is a threshold level for a biologically effective dose above which a toxic effect occurs, it follows that there will be a corresponding threshold level for internal dose. In turn, this can be related to exposure and the concentration of the agent in the environment. For any given chemical, the focus of much study is determining what environmental concentration limits need to be applied to prevent the biologically effective dose threshold from being exceeded. The existence of a specific toxicological threshold level for a chemical, often quantified from dose-response studies as the lowest observable adverse effect level (LOAEL) or no observable adverse effect level (NOAEL), is the basis for recommending maximum occupational exposure levels, known in New Zealand as workplace exposure standards (Kreiger and Ross 1993). The majority of these have their origin in the threshold limit values compiled by the American Conference of Government Industrial Hygienists. Workplace exposure standards incorporate time-weighted averages, short-term exposure limits and

biological exposure indices (OSH 2002). Biological exposure indices are biomarkers of exposure used to quantify worker exposure to a range of industrial and agricultural compounds.

Selection of biomarkers

Ideally, when selecting an appropriate biomarker, consideration should be given to the route of exposure, the time since exposure, the types of agents involved, and the physiological, pathological and genetic characteristics of the exposed person. Biomarker selection should also take into account the toxicokinetic profile of the compound being measured. Factors, including uptake, distribution, biotransformation and elimination, will affect results dependent primarily on the time between exposure and sampling and the physiological characteristics of the exposed person. However, with the rapid response often required in an agrichemical incident, information on all of these factors may not be available.

For spraydrift exposure incidents, where there is likely to be more than one route of absorption, biomarkers of internal dose are likely to be of greatest value as these integrate exposure from all routes.

General considerations

There are a number of practical implications to consider when deciding to do sampling and analyses for biomarkers in the context of an agrichemical spraydrift investigation. These include:

- usefulness of results: what they could provide in terms of exposure, health risk and health impact assessment
- availability of appropriate biomarkers for the implicated agrichemical or its metabolites, or for biochemical indicators of exposure; and the applicability of these biomarkers to low-level non-occupational exposure
- availability of defined, validated, precise and accurate analyses, incorporating suitable quality assurance measures
- access to facilities with appropriate skills and instrumentation for sample analysis
- timing of sample collection relative to exposure
- sample collection logistics: suitable matrix, time and personnel availability for sample collection, non- or least-invasive sample collection technique, special conditions required for collection handling, storage and transportation
- suitability of the subject for sample collection: practical, ethical, social and cultural considerations – whether the biomarker measurement will potentially offer some benefits
- costs (collection, transport, storage and analysis of samples).

Because of the points listed above and the large number of different agrichemical active ingredients used in New Zealand, it is not possible to construct a definitive list of biomarkers suitable for routine measurement. As each incident arises, a decision must be made by the investigating officer about the value of biomarker measurements in the investigation.

Application of biomarkers to non-occupational pesticide exposure

The majority of biomarkers used in the investigation and biomonitoring of agrichemical exposure are those of exposure. That is, they involve measurement of levels of parent compounds, metabolites, or biochemical parameters in biological matrices. This section deals with different classes of pesticides, discussing in practical terms where and how biomarkers might play a role in risk and impact assessment following human non-occupational agrichemical exposure.

Insecticides

Organophosphorus compounds

Organophosphorus insecticides comprise two classes: phosphate esters (eg, mevinphos) and phosphorothioate esters (eg, diazinon, malathion, chlorpyrifos). The primary distinction is that phosphate esters are direct-acting, whereas phosphorothioate esters are comparatively weakly active until they are converted by ultraviolet light or, *in vivo*, by metabolic processes to the corresponding phosphate ester (Gallo and Lawryk 1991).

a) Blood cholinesterase activity

In cases of poisoning or over-exposure to a chemical agent, diagnosis or exposure can be confirmed by analysis of the chemical, or one or more of its metabolites, in a biological sample. For some types of chemicals, measuring the change of a biochemical parameter, such as a change in the activity level of an enzyme, may provide a useful surrogate for these more 'direct' analyses. Organophosphorus compounds fall into this category.

Cholinesterases are enzymes that hydrolyse certain esters. The most important acute toxicological effect of organophosphorus compounds is inhibition of the enzyme acetylcholinesterase in the central and peripheral nervous systems. Under normal conditions, acetylcholinesterase almost instantly hydrolyses the neurotransmitter acetylcholine released from cholinergic fibres, limiting its effect to a brief unit response. Inhibition of acetylcholinesterase results in accumulation of acetylcholine at nerve junctions, leading to signs and symptoms of excess cholinergic activity (headache, nausea, vomiting, dizziness, salivation, muscular fasciculations, pin-point pupils, lachrymation, abdominal cramps, confusion, convulsions).

In blood, acetylcholinesterase is present on the cell membranes of erythrocytes, and another enzyme, pseudocholinesterase, is present in plasma. The physiological function(s) of these enzymes is not known. For occupational screening purposes, to estimate worker exposure to organophosphorus insecticides, both erythrocyte acetylcholinesterase activity and pseudocholinesterase activity can be measured. Pseudocholinesterase activity provides a sensitive measure of organophosphorus insecticide exposure, although inhibition of erythrocyte acetylcholinesterase is probably a better reflection of inhibition of acetylcholinesterase at nerve synapses, and thus of toxicity. In a study comparing pseudocholinesterase and whole blood cholinesterase activity, Sanz et al (1991) suggested that their results supported the use of whole blood cholinesterase activity as a more accurate and appropriate index of toxicity from the organophosphorus insecticide ethylparathion than pseudocholinesterase activity. This is likely to be true for other organophosphorus compounds also. In a recent review of cholinesterase inhibition interpretation, Lotti (1995) supports the use of erythrocyte enzyme levels as a measure of toxicity.

Under certain circumstances, measurement of pseudocholinesterase activity can confirm exposure to organophosphorus compounds. However, the large intra- and inter-individual variation of normal human erythrocyte and serum pseudocholinesterase activity complicates the diagnosis in cases where decreased cholinesterase levels remain within the normal range (Gallo and Lawryk 1991). For erythrocyte acetylcholinesterase activity, intra-individual variation is approximately 10 percent and inter-individual variation is approximately 10–40 percent (Gallo and Lawryk 1991). Unless exposure to an organophosphorus insecticide is heavy, or a pre-exposure baseline level is available, a subsequent post-exposure test will usually not be diagnostic of exposure or poisoning. Comparison of the pre-exposure baseline enzyme activity to post-exposure enzyme activity provides the basis for the monitoring of occupational organophosphorus pesticide exposure. This is usually expressed as percentage inhibition. Without a baseline comparison, only when poisoning is moderate to severe is a measurement of enzyme activity likely to provide confirmation of diagnosis.

Several assays for determining cholinesterase activity have been developed for occupational and clinical monitoring purposes, including a spectrophotometric field kit developed by WHO (1994).

Other factors that have been shown to affect an individual's erythrocyte acetylcholinesterase level include sex, race, age, time of the day, serum albumin concentration, and various physiological and pathological states. Exercise may also influence results. Although these factors are taken into account when comparing an individual result with the normal range for the population, they may cause interpretation difficulties when comparing results from a series of tests for an individual.

Relatively rare genetic differences in acetylcholinesterase activity may also provide a source of error. Three different phenotypes for acetylcholinesterase activity are known (Gallo and Lawryk 1991). Individuals homozygous for the gene for the abnormal enzyme may show markedly lower acetylcholinesterase activity than the lower end of the normal range; those heterozygous for the abnormal enzyme also show lower overall acetylcholinesterase activity but not nearly as great as for the homozygous genotype. The presence of the abnormal enzyme does not correspond to an increased susceptibility to anticholinesterase pesticides, such as organophosphorus insecticides. The relevance of the different phenotypes for acetylcholinesterase activity is in the interpretation of a lower than normal result when a baseline level is not available. Under some circumstances it may be necessary to determine whether low activity of acetylcholinesterase is due to inhibition by an exogenous substance, or whether it has a genetic basis.

The organophosphorus insecticide exposure profile can influence the relationship between acetylcholinesterase inhibition and the development of clinical signs. The potential for the development of illness is dependent on the frequency of exposure, as well as overall dose. Workers exposed to small amounts of an organophosphorus insecticide daily over several weeks may develop 87 percent inhibition of plasma enzyme activity and 90 percent inhibition of red cell enzyme activity before symptoms develop. On the other hand, after a single substantial exposure, mild symptoms can develop while blood cholinesterase levels are within the normal range. In such cases, the occurrence of symptoms is suggestive but not diagnostic of poisoning (Gallo and Lawryk 1991). Also relevant to low dose exposure, some absorption of an organophosphorus compound can occur without a measurable reduction in blood acetylcholinesterase activity.

In summary, due to the factors discussed above, there is real difficulty in determining the level of cholinesterase activity that may be interpreted with confidence as due to inhibition rather than normal variation. This is true for routine occupational monitoring, where intra-individual factors provide the major source of variation, and even more so for non-occupational exposure. For non-occupational exposure, a pre-exposure baseline will almost invariably be unavailable. The enzyme activity for an individual would then need to be compared with population norms. Only changes in plasma enzyme activity of about 30 percent or greater and changes in red cell enzyme activity of about 20 percent or greater could then be recognised as probably not due to normal variation (Gallo and Lawryk 1991).

It is reasonable to conclude that following an incident, such as contact with off-target organophosphorus insecticide drift, where the exposure is relatively minor, the magnitude of enzyme activity depression is rarely likely to be great enough to provide evidence of the exposure.

b) Urinary tests for the parent compound and/or metabolites

Organophosphorus chemicals may undergo hydrolysis *in vivo* to yield phosphoric acids that are subsequently excreted. Gas chromatography and combined gas chromatography/mass spectrometry can be used to determine concentrations of appropriate metabolites in urine samples. Compared with blood esterase determination, these techniques have the advantages of being non-invasive, sensitive and readily standardised. However, the rapid clearance of organophosphate compounds and their metabolites from the blood makes such techniques useful only for a short period following an acute exposure (Wilson and Henderson 1992). Furthermore, measurements of urinary metabolites are difficult to interpret in the absence of comparative cholinesterase activity data. Further complicating factors include variability in the time course of metabolite excretion, with serial testing being more desirable than testing of a single sample, and considerable variation in toxicities of different compounds with similarities in urinary metabolite profiles (eg, parathion-methyl and fenitrothion) (WHO 1986).

Use of an immunoassay technique for detection of *p*-nitrophenol, a major urinary metabolite of parathion, has been studied in relation to occupational exposure (Rogers and Van Emon 1994). This method has potential applicability to non-occupational exposures with detection limits in urine (1 percent dilution) of 0.1 ppm *p*-nitrophenol, which is below the levels observed in residents near to application sites. A radioimmunoassay (RIA) technique has been used for determination of parathion in blood plasma (Knopp 1995).

Using a gas chromatographic technique, Maroni et al (1990) measured acephate in human urine. The results showed a good correlation between estimated exposures and urine acephate levels in workers.

Urinalysis for biomarkers of organophosphorus insecticide exposure is largely still experimental. Although these analyses are more sensitive than cholinesterase determinations, the lack of dose-response data means that they could be useful only as qualitative markers of exposure.

c) Local effects as a qualitative biomarker of exposure

Phosphate esters are direct inhibitors of acetylcholinesterase. Direct inhibitors are capable of producing local effects at the site of contact, typically the eyes, skin and respiratory tract. These symptoms may include lachrymation, miosis, diaphoresis, and bronchial hypersecretion. Indirect inhibitors (phosphorothioate esters) require systemic absorption and metabolic activation before they can elicit a toxic pharmacological response. This qualitative approach is not likely in itself to be diagnostic of exposure. However, it could provide evidence of exposure and prompt more thorough biological testing.

Carbamate insecticides

a) Cholinesterase activity

Like organophosphorus insecticides, carbamate insecticides inhibit cholinesterase enzymes. For carbamates, erythrocyte acetylcholinesterase activity monitoring pre- and

post-exposure provides a good measure of the effect of exposure. Erythrocyte acetylcholinesterase provides a more sensitive measure of carbamate cholinesterase inhibition than plasma-cholinesterase. Symptoms of cholinergic excess appear in a carbamate-exposed individual when blood acetylcholinesterase activity is approximately 70 percent of the individual's baseline. However, the effect of carbamate-induced cholinesterase inhibition is relatively short-lived compared with the effect of over-exposure to organophosphorus compounds, as the carbamylated enzyme rapidly converts back to the non-carbamylated form. Carbamate-induced acetylcholinesterase inhibition is, therefore, regarded as reversible, unlike cholinesterase inhibition by organophosphorus compounds, which is irreversible without specific treatment.

This short-lived inhibition of acetylcholinesterase, together with the difficulties of acetylcholinesterase activity interpretation for non-occupational exposure (as described in the above section on organophosphorus compounds) means that for carbamate pesticides the potential usefulness of acetylcholinesterase activity determination is limited. Whole blood stored without dilution is subject to further *in vitro* acetylcholinesterase inhibition, giving larger drops in activity than would otherwise occur (Brewster et al 1992). If cholinesterase determinations are used to test for carbamate exposure, testing of erythrocyte activity or whole blood activity is recommended. Only where blood sampling and analysis can be carried out within a few hours of the exposure and where the exposure is relatively large is acetylcholinesterase activity measurement likely to have any value.

b) Urinary metabolites

Urinary levels of carbamate metabolites can be used as a measure of exposure and absorption. However, urinary metabolite concentrations corresponding to biological effect levels have not been established.

Carbaryl-exposed subjects are reported to have an elevated urinary α-napthol level. Carbofuran exposure is associated with urinary excretion of 3-ketocarbofuran and 3-hydroxycarbofuran. Workers exposed to pirimicarb had higher than normal urinary levels of metabolites I (2-dimethylamino 4-hydroxy-5,6-dimethylpyrimidine) and V (2-methylamino-4-hydroxy-5,6-dimethylpyrimidine) (He 1993). Enzyme-linked immunosorbent assay (ELISA) techniques have been developed for detection of carbaryl and metabolites in urine (Knopp 1995).

Currently, data on levels of urinary metabolites are not useful for biological monitoring purposes, as the relationship between urinary level and biological effect is not known.

Organochlorines

This class is important because of historical more than current use. Organochlorine insecticides were widely used in New Zealand until the 1970s, when they were largely phased out due to concerns over toxicity and persistence in the environment. Examples of organochlorines include aldrin, dieldrin, DDT, chlordane, lindane and the herbicide 2,4,5-T. Of particular concern was the presence in 2,4,5-T, at very low levels, of a very toxic contaminant 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD or dioxin). Organochlorines deposit in fatty tissue in the body and residues are persistent. Levels of organochlorines detected in tissues increase with the age of the individual, reflecting a longer period of accumulation (Nauman et al 1994). Organochlorines are still an important class in terms of biological monitoring, due to the problems of persistence in the environment and bioaccumulation. However, as they are no longer used in New Zealand they will not be considered further here.

Synthetic pyrethroids

This class has been little studied. In general, metabolites are eliminated quickly, within two to four days, via urine, faeces and expired air. Present data indicate that the determination of urinary pyrethroids and their metabolites can be used only as a qualitative indicator of exposure (He 1993). In a review of pesticide biomarkers, Brewster et al (1992) include permethrin and fenvalerate as pyrethroids for which methodologies have been developed for the detection of urinary metabolites. Woollen (1993) discusses urinalysis of cypermethrin metabolites, *cis*- and *trans*-cyclopropane acids, phenoxybenzoic acid (3PBA) and hydroxyphenoxybenzoic acid (40H3PBA). These analyses remain in the realm of research.

Herbicides

Chlorophenoxy herbicides

It has been found that over 90 percent of an absorbed dose of 2,4-D is excreted within five days. Urinary excretion is probably pH-dependent. Urinary excretion of 2,4-D has been used for assessment of occupational exposure and absorption (He 1993). A study comparing 2,4-D deposition on skin patches and urinary excretion showed urinary excretion to be a more valid dose measure (Brewster et al 1992).

A review by Knopp (1995) of immunoassay methods in human biomonitoring, lists 2,4-D as a compound for which polyclonal RIA techniques and ELISA techniques can be used for determination of the parent compound in blood serum and urine.

The pharmacokinetics of 2,4-D have been well studied. It is likely that analysis of urine for 2,4-D could provide useful qualitative exposure assessment data, provided urine samples are collected within 24 to 48 hours of an exposure.

Dipyridilium compounds

Cases of suicidal and accidental ingestion of paraquat and diquat have contributed data to plasma and urine levels in relation to mortality. However, more sensitive assays designed to measure field exposures have yielded mixed results (Brewster et al 1992). Immunoassay methods utilising RIA and ELISA techniques have been used to detect paraquat in blood serum and plasma, and in urine (Knopp 1995).

These immunoassay techniques have potential applicability to low-level exposure to paraquat, but these analyses are not readily available in New Zealand nor are they validated for non-occupational exposure assessment.

Triazines and triazoles

Atrazine, a widely used herbicide, has been measured in the urine of occupationally exposed workers. Urinary analysis of atrazine is potentially useful as a qualitative marker for confirmation of exposure (Catenacci et al 1990). It is not useful quantitatively, as atrazine itself in urine is only a very small proportion of the absorbed dose. More recently, immunoassay using ELISA has been used to detect atrazine mercapturate, the major metabolite of atrazine, in urine samples of exposed workers (Knopp 1995). This technique has the greatest potential value in investigating non-occupational exposure to atrazine.

The majority of picloram, ingested or dermally absorbed by humans, is eliminated unchanged in the urine within 24 hours (Brewster et al 1992). Analysis of picloram in urine is a possible means of estimating the internal dose. However, rapid excretion would require collection of urine samples within a few hours of an exposure.

The usefulness of these analyses in non-occupational exposure assessment has not been evaluated.

Miscellaneous herbicides

Two urinary metabolites of alachlor – an amide herbicide, diethyl aniline (DEA), and hydroxyethyl-ethyl aniline (HEEA) – have been measured in animal studies (Nauman et al 1994; Woollen 1993). In initial human studies, only DEA was found in urine. More recently, results from high performance liquid chromatography (HPLC) determination of DEA-yielding metabolites were compared with values (alachlor equivalents) obtained by using the ELISA technique. This ELISA technique was more than 50 times more sensitive than the HPLC method, although a mechanism of cross reactivity was postulated to explain this difference. Further work would be required to establish the usefulness of this technique for non-occupational screening purposes (Nauman et al 1994).

Fluazifop, a metabolite of the herbicide fluazifop-butyl, has been measured in human urine. Results demonstrated extremely close agreement between field and laboratory exposure studies (Woollen 1993). However, this methodology has not been validated for low-level non-occupational exposure assessment.

Fungicides

Dithiocarbamates

Ethylenethiourea (ETU) is an impurity and degradation product of the ethylenebisdithiocarbamate (EBDC) fungicides maneb and mancozeb. Measurement of ETU in urine has been shown to reflect occupational exposure to EBDCs (Brewster et al 1992).

Pastorelli et al (1995) suggest that determination of ETU adducts to haemoglobin using gas chromatography-mass spectrometry may have some future applicability to risk assessment for low-level acute and chronic exposure to EBDC fungicides. This method more accurately reflects the body load of the chemical following either an acute or a chronic exposure, as the covalent adduct will last the lifetime of the haemoglobin molecule (approximately 120 days). The accuracy of this method is not so dependent on sampling time, and the results represent chronic as well as acute exposures. However, the methodology for this application requires further validation.

Dicarboximides

Using gas chromatography, van Welie et al (1991) measured two metabolites (tetrahydrothalimide and thiazolidine-2-thione-4-carboxylic acid) of captan fungicide in human urine. More recently, Krieger and Thongsinthusak (1993) analysed human urinary tetrahydrothalimide and thiazolidine-2-thione-4-carboxylic acid using gas-liquid chromatography and high performance liquid chromatography. These are promising parameters for the biological monitoring of captan exposure. However, the methodology is still at the developmental stage.

Miscellaneous

Inorganic and organic metal compounds

Levels of tin, mercury, arsenic, copper and other metals in biological fluids can provide a measure of exposure and absorption for a range of metallic and organometallic pesticide compounds. The quantity of biological and toxicological data on these metals is large. These analyses are likely to be readily available and easily applicable to non-occupational exposures, although it may be more difficult to locate methodologies for the analysis of individual parent compounds. However, these elements are also present in the diet, and the results of testing would be non-specific and probably not useful unless exposure was massive.

Discussion

Biomarkers of exposure – in particular, markers of internal dose – are currently the most useful biomarker types for the purpose of pesticide exposure assessment. Internal dose markers are more useful than external dose markers for health risk and health impact assessment, as they integrate absorption from all exposure routes (lung, skin, gut).

With the exception of cholinesterase determinations for organophosphorus insecticide exposure, none of the biomarkers discussed in this review is used routinely, and many of the methodologies are still experimental. The majority of recent reviews and studies address the issue in terms of occupational exposure and risk assessment. Many of the techniques described have potential for application to non-occupational pesticide exposure, but would need to be studied in this context before confident recommendations could be given on methodologies for sample collection, analysis and the interpretation of results. Although not readily available in New Zealand, immunoassay techniques offer significant advantages over the more traditional chemical analysis techniques, in that they are generally more sensitive, rapid, specific, cost-effective and simple.

When conducting a field investigation of an agrichemical spraydrift incident, it is necessary to consider a series of practical factors. These factors include:

- the potential usefulness of the results
- the availability of a biomarker for the implicated agrichemical
- the availability of validated analytical methodology
- suitable laboratory resources
- appropriately skilled personnel
- timing of sample collection
- personal factors relating to the subject from whom samples would be taken
- costs.

These factors are critical to the practice of pesticide biomarker measurement and interpretation.

In the context of exposure assessment, accumulated occupational monitoring data may provide a background with which subsequent results could be compared. For such a comparison to be useful in the non-occupational setting, however, further work would be required to validate potential markers, to establish methodologies for analysis and, particularly, to provide guidance on interpretation of results. It is possible that findings from human volunteer studies could, in future, provide a basis for the interpretation of biomarker data for non-occupational pesticide exposure.

For the purposes of exposure and health impact assessment, biomarker data for a relatively small range of agrichemicals can be considered only as complementary to environmental measurement data. Currently, the majority of potential biomarkers, in the context of low-level non-occupational exposure, are of qualitative value only. The lack of human pharmacokinetic and toxicological data for most pesticides is a barrier to more useful quantitative, dose-response interpretations. The results of analyses for markers of exposure could serve qualitatively to confirm that systemic absorption has or has not occurred. Such results may be of questionable value for spraydrift incident investigations, especially in terms of cost versus benefits. However, in deciding whether to investigate biomarkers, there is a need to consider other factors, such as the level of public concern, the uncertainty with respect to cause and effect for an illness that corresponds with an incident, the magnitude of the exposure, and the time elapsed since it occurred. Definitive guidance on use of possible biomarkers is beyond the

scope of this review as there are too many incident-specific variables to consider in deciding when and which biomarkers might be useful.

In a recent study, Lessenger et al (1995) examined cases of alleged pesticide exposure and concluded that laboratory testing generally was not useful in the diagnosis of mild to moderate pesticide illness. There were two exceptions: such testing could be useful in formal occupational monitoring programmes and when an occasional test result is grossly outside the normal limits. The authors stated that the most informative tests were cholinesterase levels but concluded that the most important diagnostic predictor of exposure was actual documented pesticide exposure.

Acetylcholinesterase determinations (following heavy exposures or when baseline levels are known) and urinalysis for some parent compounds or metabolites (eg, 2,4-D) are possibly the most potentially useful of all biomarkers described above. Other biomarkers remain primarily the domain of researchers.

The current limitations notwithstanding, biomarker data are an increasingly important component of the assessment of exposure, health risk and health impact. As new biomarkers are identified and as experience with their use accumulates, it is possible that biomarker data will become more useful in the assessment of non-occupational, as well as occupational, exposure. However, currently biomarkers are of little investigative value for agrichemical spraydrift incidents, with the exception of unusual cases of high exposure, which might cause gross deviation of a result from the normal population range. The decision as to whether to carry out such testing will have to be made on a case by case basis.

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Appendix 2: Environmental and Biological Sampling

Availability of analyses

Currently, in New Zealand, there is routine monitoring for occupational exposure to organophosphorus insecticides. Blood is tested for both plasma cholinesterase and erythrocyte cholinesterase activity. These analyses are available routinely.

To ensure drinking-water quality is consistent with the requirements of the *Drinking-Water Standards for New Zealand* (Ministry of Health 2005), testing is carried out to determine the levels of a number of organic chemical contaminants, including some pesticides, in potable water. Consequently, there are established methodologies for the determination of certain pesticide contaminants in water samples. These methodologies may be applied to biological matrices, such as blood, urine and serum, once interference from other components in the matrix is overcome. In many cases, this process is likely to be relatively straightforward.

Listed below are currently registered organic pesticides for which testing of potable water is carried out by Agriquality Ltd, Gracefield, Lower Hutt (N Whittleberg, personal communication, September 2007).

Acid herbicides

mecoprop, MCPA, dichlorprop, 2,4-D, triclopyr, 2,4-DB, fenoprop, picloram, 2,4,5-T, bentazone

Semivolatile organic contaminants

(i)	Organochlorine pesticides:	procymidone, gamma-HCH, hexachlorobenzene, aldrin, heptachlor, heptachlor epoxide, alpha-chlordane, gamma-chlordane, p,p'-DDD, p,p'-DDE, p,p'-DDT, dieldrin, methoxychlor, *cis*-permethrin, *trans*-permethrin, alpha-BHC, beta-BHC, delta-BHC, endosulfan I, endosulfan II, endosulfan sulphate, endrin, endrin aldehyde, endrin ketone, toxaphene
(ii)	Organophosphorus pesticides:	diazinon, pirimiphos methyl, chlorpyrifos, azinphos methyl
(iii)	Organonitrogen herbicides:	trifluralin, simazine, atrazine, terbuthylazine, alachlor, metolachlor, pendimethalin, propanil, molinate, propazine, hexazinone, metalaxyl, cyanazine, oxadiazon, metribuzin, bromacil, oryzalin
(iv)	Carbamate insecticides:	carbofuran

The cost of analyses varies considerably. Assays for detection of some herbicides can cost several hundred dollars. If multiple tests are required, the cost per sample will often be reduced. There will be additional costs depending on the nature and complexity of any extraction procedures that are required to isolate the contaminant from the matrix.

It is suggested that each public health unit compiles a list of laboratories available to it both locally and nationally. If possible, request a summary list of analyses offered by each laboratory, including cost per sample. Laboratories may have specific requirements with regard to sample collection methods and storage.

Environmental sample collection and analysis

Environmental samples may be collected if there is reasonable evidence that agrichemical spraydrift has occurred, the identity of the agrichemical(s) is known, and the results of analyses could potentially contribute to health risk assessment. Environmental samples may include water tank samples, swabs of physical surfaces (such as roofs and window panes), plant material, soil samples and clothing samples.

There are a number of general points to consider before undertaking environmental sampling, as discussed below. Practical points about sample collection, storage and handling are also discussed. However, collection, storage and transport procedures may vary depending on the laboratory that carries out the analyses.

General considerations

Usefulness of results

The results must be able to contribute to the process of exposure, health risk and health impact assessment, or possibly provide evidence for a prosecution.

Availability of analyses

There must be defined, validated, precise and accurate analyses, incorporating suitable quality assurance measures available through national or regional laboratory services.

Access to laboratory facilities

There must be rapid access to laboratory facilities with appropriate skills and instrumentation for the required sample analysis.

Timing of sample collection

Samples must be collected at a time sufficiently close to the spraydrift incident that analysis is likely to provide useful results. The sooner the samples are collected, the better. Some pesticides are quite persistent, but others can break down rapidly (eg, glyphosate, the active ingredient in Roundup®).

Sample collection logistics

Suitable methods and equipment must be available for sample collection. Plastic press-seal bags are suitable for soil, vegetation and surface swab samples. Suitable sealable containers are suitable for water samples.

Advice on collecting samples

1. Always seek permission from the landholder before taking samples.
2. There is no particular 'correct' number of samples to take; rather, enough samples should be taken so that environmental data is representative of the area believed to be affected by spraydrift. The total area affected by spraydrift, the number of residences, and wind speed and direction are variables to consider when deciding on sampling sites and the number of samples that need to be taken.
3. Always wear disposable plastic gloves. Use a new pair for each sample.
4. Store each sample separately in its own sealed container to avoid cross contamination.
5. Store samples out of direct light to avoid photodegradation.
6. If the compound is volatile, use the smallest containers possible to avoid loss of volatile compounds to the air space in the container. Remove as much air as possible from plastic bags before sealing.
7. Vegetation samples can be placed in press-seal plastic bags. Do not take samples from just a single plant. Take samples from the outer, more exposed part of the plant.
8. Take soil samples from exposed areas. These samples should be scrapings from the surface only. Place each sample in a suitable container, such as a clean press-seal bag.
9. Freezing of vegetation and soil samples is recommended as biological breakdown of analytes continues fairly rapidly in some cases when samples are only kept cool.
10. Water samples must be collected in specially prepared sample bottles to avoid contamination. Tank water can be sampled after allowing the tap to run to flush the pipe.
11. Surface samples can be collected by wiping the surface with a clean tissue and placing the tissue in a clean press-seal bag. An unused tissue should be submitted in a separate plastic bag for comparison.
12. Keep other samples cool: do not freeze unless otherwise recommended (see point 9).
13. Many organic chemicals are susceptible to breakdown from UV light, so storage of samples in the dark is recommended.

14. For each sample, complete an environmental sample form (see later this section). The information recorded on this form includes the sample identification number, type of sample, quantity (weight or volume) of sample taken, the time and date the sample was collected, and the name of the person who collected the sample. This form must be signed and placed in the corresponding investigation file. This file number should be entered onto the event/incident or complaint database within the location page.
15. Make arrangements for transport of the sample to the appropriate laboratory as soon as possible.
16. Notify the laboratory when the samples have been dispatched. The laboratory will need to know:
    - the number and type of samples (that is, water, soil, foliage, etc)
    - the identity of the chemical(s) to be tested for
    - the identity of the sampler and contact details
    - the method of dispatch to the laboratory and expected time of arrival.

Advice on environmental sampling is based on the protocol on sample collection provided by the Tasmanian Department of Primary Industries and Energy.

Biological sample collection and analysis

This section is a summary of the practical aspects of the more comprehensive literature review of biological markers of agrichemical exposure (see Appendix 1).

Biomarkers of exposure – in particular, markers of internal dose – are currently the most useful biomarker types for the purpose of pesticide exposure assessment. Internal dose markers are more useful than external dose markers for health risk and health impact assessment, as they integrate absorption from all exposure routes (lung, skin, gut).

When selecting an appropriate biomarker, consideration should be given to the route of exposure, the time since exposure, the types of agents involved, and the physiological, pathological and genetic characteristics of the exposed person.

Biomarker selection should also take into account the toxicokinetic profile of the compound being measured. Factors, including uptake, distribution, biotransformation and elimination, will affect results dependent primarily on the time between exposure and sampling and the physiological characteristics of the exposed person. However, with the rapid response often required for an agrichemical incident, information on all of these factors may not be available. Therefore, routine sample collection is desirable in certain situations.

General considerations

There are a number of general considerations that must be addressed when deciding to do biological sampling. These include the following.

Usefulness of results

The results must be able to contribute to the process of exposure, health risk and health impact assessment. Currently, the majority of potential biomarkers, in the context of low-level non-occupational exposure, are of qualitative value only. That is, they may be able to discriminate between 'exposed' and 'not exposed' (provided information on background levels in the population is available), but may provide little information on the degree of exposure or its health implications (if any). The lack of human pharmacokinetic and toxicological data for most pesticides is a barrier to more useful quantitative, dose-response interpretations.

The results of analyses for markers of exposure could serve qualitatively to confirm that systemic absorption has or has not occurred. Such results may be of questionable value for spraydrift incident investigations, especially in terms of cost versus benefits. However, in deciding whether to investigate biomarkers, other factors should taken into account as well. These factors include the level of public concern, the uncertainty with respect to cause and effect of an illness that corresponds with an incident, the magnitude of the exposure and the time elapsed since the exposure occurred. Implications under the Health and Safety in Employment Act 1992, Injury Prevention Rehabilitation and Compensation Act 2001 and other legislation also need to be considered (see Chapter 4 for a summary of the relevant legislation).

Availability of appropriate biomarkers

There must be an appropriate biomarker for the implicated agrichemical or its metabolites, or for biochemical indicators of exposure. In addition, the biomarker must be applicable to low-level non-occupational exposure.

Availability of analyses

There must be defined, validated, precise and accurate analyses, incorporating suitable quality assurance measures available through national or regional laboratory services. Currently, in New Zealand, there is routine monitoring for occupational exposure to organophosphorus insecticides. Blood is tested for both plasma cholinesterase and erythrocyte cholinesterase activity. These analyses are available routinely.

There are disadvantages to be noted, however. The natural level of plasma and erythrocyte cholinesterase activity varies considerably, and such measurements will be of limited value unless a baseline measure is available. Pre-exposure baseline levels will very rarely be available. It is possible to take a post-exposure baseline four months or longer after an exposure, provided there has been no re-exposure to a cholinesterase inhibiting compound within that time. The major disadvantage of using such post-exposure cholinesterase baseline activity is the time delay in obtaining the results. Although these results may contribute little to the immediate investigation and

immediate exposure assessment, therefore, they may offer some benefits in terms of long-term surveillance of illness related to organophosphorus pesticide drift.

Access to laboratory facilities

There must be rapid access to laboratory facilities with appropriate skills and instrumentation for the required sample analysis. If prosecution is being considered, a gazetted analyst may be the most appropriate person to conduct the analysis.

Timing of sample collection

Samples must be collected at a time sufficiently close to exposure that sample analysis is likely to provide useful results. The most suitable timing for sample collection will depend on the pharmacokinetic profile of the agrichemical or one or more of its metabolites. Generally, samples should be collected within 48 hours (but preferably within 24 hours) of the exposure.

Sample collection logistics

A suitable biological matrix (typically urine or blood) is required. The least invasive sampling procedure (eg, urine collection) is recommended. Blood samples may be collected only by a nurse, doctor or other suitably trained health care worker. Any special conditions required for the collection, handling, storage and transportation of samples can be requested from the laboratory where the analyses will be conducted.

Suitability of the subject for sample collection

Practical, ethical, social and cultural considerations must be taken into account in each case where sample collection for biomarker analysis is being considered. The biomarker measurement must potentially offer some benefits to the person from whom the sample is being taken.

Costs

The costs of sample collection, transportation, storage and analysis may be a limiting factor. These costs could be considerable, particularly for a pesticide for which there are no routinely available analyses.

Advice on collecting samples

For practical reasons, because it is the least invasive in terms of sample collection, urine is the preferred biological matrix for biological marker testing. Blood samples may be collected on site if a suitably trained person is available. Timing is crucial for cholinesterase testing, so blood samples should be collected as soon as possible to provide a meaningful analysis.

When developing a working protocol for biological sample collection and analysis, it is important to consult with the laboratory that will be carrying out the work. Special requirements for collection, storage and transportation will need to be clear in any protocol. These special precautions will depend on the physico-chemical properties of the analyte(s) in the sample.

1. Urine collection and storage
    a) It may be necessary to take measures to prevent loss of volatile compounds to air spaces in containers.
    b) To avoid photodegradation of light sensitive compounds, ambered or opaque bottles are preferred.
    c) Adsorption to collection vessel walls should be considered. Polypropylene or polyethylene vessels are normally used, although glass containers may be used if the analyte(s) bind to these materials.
    d) The 24-hour stability of analyte(s) in urine must be known for temperatures likely to be found in the field.
    e) Preservatives may be added to urine samples, but samples may be frozen without the addition of a preservative. The effect of freezing on the container must be considered. If a preservative is used, ensure this will not interfere with the analysis.
2. Blood collection and storage
    a) Special procedures may be necessary if the compound or metabolites are volatile. To avoid loss of volatile compounds to air spaces, samples may be collected in heparinised syringes that can be sealed.
    b) Possible interaction between anticoagulants and analyte(s) should be considered.
    c) Adsorption of analyte(s) to glass collection tubes, rubber collection tube stoppers, and plastic syringe components must be considered.
    d) Blood samples should be collected using universal precautions by an experienced phlebotomist or medical practitioner.
3. The minimum data requirements for sample labels are the date and time the sample was taken, sample identification number, and type of sample. Labels should be clear (eg, printed or typed), impervious to water (eg, overlaid with water-impervious tape) and able to withstand freezing for extended periods.
4. All containers must have leak-proof caps.
5. For each sample, complete a biological sample form (see later in this section). The information recorded on this form includes the sample identification number, the name, address and age of the person from whom the sample was taken, type of sample, quantity of sample taken, the time and date the sample was collected, and the name of the person who collected the sample. This form must be signed and placed in the corresponding investigation file.
6. Make arrangements for transport of the sample to the appropriate laboratory as soon as possible.

7. Notify the laboratory when the samples have been dispatched. The laboratory will need to know:
   - the number and type of samples (that is, urine or blood)
   - the identity of the chemical(s) to be tested for
   - the identity of the sampler and contact details
   - the method of dispatch to the laboratory and expected time of arrival.

Advice on biological sampling is based on the appendix to Woollen (1993).

General comment on the usefulness of biomarkers for spraydrift investigations

Because of the general considerations noted above, and the large number of different agrichemical active ingredients used in New Zealand, it is not possible to construct a definitive list of biomarkers suitable for routine measurement.

Currently, biomarkers are of little investigative value for agrichemical spraydrift incidents, with the exception of unusual cases of high exposure, which might cause gross deviation of a result from the normal population range. Acetylcholinesterase determinations (following heavy exposures or when baseline levels are known) and urinalysis for some parent compounds or metabolites (eg, 2,4-D) are possibly the most potentially useful. Other biomarkers remain primarily the domain of researchers.

As each incident arises, a decision must be made by the investigating officer about the overall value of biomarker measurements in the investigation. However, it is expected that these measurements would be of value in no more than a small minority of cases.

Communicating results

If samples are submitted for analysis, the results of the analyses should be communicated in writing to the individual to whom they relate, or to that person's parent or legal guardian.

Forms for biological or environmental samples

If sample submission forms are not available from the laboratory that will be carrying out the analysis, the following forms may be used. A copy of all sample submission forms should be kept in the corresponding file.

References to Appendix 2

ESR. October 1995. *Limits of Detection for Organics in Drinking Water (Based on WHO Guidelines and NZDWS)*. Wellington: ESR: Environmental, Environmental Organics Laboratory.

Ministry of Health. 2005. *Drinking-Water Standards for New Zealand*. Wellington: Ministry of Health.

Woollen BH. 1993. Biological monitoring for pesticide absorption. *Annals of Occupational Hygiene* 37(5): 525–40.

Biological sample form

Leave blank those sections that do not apply. If you are unsure of the information for any section, annotate this form as such.

Sample identification number:.....
(Exposure/illness record number/B1 or B2 etc for each consecutive sample)

Date collected: ..... (dd/mm/yy)
Time collected:.....

Collected by: .....

Public health unit or other workplace: .....

Name of person from whom sample was taken: .....

Date of birth of person from whom sample was taken: .....(dd/mm/yy)

Address of person from whom the sample was taken:
.....
.....
.....
.....

Name of agrichemical(s) and/or metabolite(s) the sample is to be analysed for (use a separate line for each if more than one):
.....
.....
.....

Sample type

Urine ☐
Blood ☐
Other ☐ Specify:.....

Quantity collected: .....(ml)

Special collection/storage requirements (if any): .....
.....
.....
.....

Type of sample collection container:.....

Environmental sample form, page 2

Was the sample frozen before transport to the laboratory?

Yes ☐

No ☐

Name and address of the analytical laboratory the sample was or is to be sent to:

.....

.....

.....

.....

Name of contact person at the analytical laboratory:.....

Contact telephone number: .....

Form completed by:.....

Date:.....

Time: .....

Appendix 3: Advice on Agrichemical Spraydrift Incident

Adapted from the Agrichemical Spraydrift health education resource Code No 10108.

AGRICHEMICAL Spraydrift

Reducing risks and taking action!

What is agrichemical spraydrift?

Agrichemicals are chemicals used in agriculture for various reasons. Agrichemical spray may be used to control insects or other pests, weeds, diseases, or to fertilise crops. When the spray drifts away from the target area it is known as spraydrift.

The amount of agrichemical spraydrift depends on weather conditions, the landscape (hills, shelter-belts etc), and the way the operator carries out the spraying. Operators should be following the guidelines in their Code of Practice.

Risks from spraydrift will depend on such things as the extent of the drift, the chemical used and its effect, and the strength of the spray.

If you have concerns about your health after there has been spraying in your area, contact your doctor or health professional.

What should I do if significant spraydrift occurs around my home?

Operators are encouraged to inform neighbours before they spray. This gives you a chance to:

- stop any outdoor activity, eg, children – and pets – playing outside
- close windows
- bring in the washing from the line
- store some water in clean containers, adding ½ teaspoon household bleach per 10 litre bucket of water to keep stored water clean
- disconnect the pipes to any water tank collecting rain water from a roof
- cover fish ponds.

These actions help prevent contact with spraydrift.

If spraydrift does occur:

- shower and change your clothing if you have been exposed
- wash exposed fruit or vegetables
- if possible, do not re-connect pipes to any water tank collecting rain water from a roof until after the roof has been washed down by rainfall.

Appendix 4: The Agrichemical Industry

NZS 8409:2004 Management of Agrichemicals

The New Zealand Standard *Management of Agrichemicals* (the Standard) was adopted by the New Zealand Standards Association (*NZS 8409:2004 Management of Agrichemicals*). In terms of managing the hazard of off-target drift, section 5 of the Standard offers advice on notification of spraying, low-drift additives, application equipment and technique, drift hazard and record keeping. The most important aspects in relation to spraydrift hazard are described below.

Notification

With regard to notification, the Standard states that it is the user's responsibility to ensure that risks to people, crops, livestock and the environment are minimised. The Standard further advises that, in terms of public safety, prior notification and suitable placarding should be used when agrichemicals are applied to properties adjacent to dwellings, schools or playing fields.

Application

The Standard recommends that low-drift additives be used where applicable, but that these should not be relied on to eliminate drift. Application equipment and technique should be selected after due consideration of public safety and drift hazard. In order to minimise drift, the largest droplet size that enables good coverage should be used. Users should be competent in equipment operation and application technique, including equipment and equipment settings, weather conditions and product selection.

Drift hazard

The Standard states that it is the responsibility of the person applying the chemical to minimise the spraydrift hazard. The user must assess the risk and note who or what might be at risk.

Appendix G of the Standard outlines methods of minimising drift hazard. The following methods are described.

Preventing spraydrift

There are several measures that can be taken to prevent or at least minimise the amount of off-target agrichemical spraydrift. These include selection of less volatile agrichemicals, use of drift control adjuvants, appropriate selection, calibration and adjustment of equipment, and selection of favourable weather conditions, especially wind speed and direction.

Buffer zones

This is the distance downwind from the target being sprayed, beyond which the drift hazard is considered acceptable. Buffer zones should be used where possible.

Record-keeping

Agrichemical users are advised in section 5.3.5 of the Standard that the information recorded should include the name of the operator, the equipment and method of use, the type and amount of agrichemical used, the location and nature of sensitive areas, confirmation that notification requirements have been met, the area of the application site, the date and time of application, weather conditions, equipment calibration details, and any abnormal situation or event. For aerial applications, any emergency release of load and the location of this release should be noted.

GROWSAFE programme

The New Zealand Agrichemical Education Trust (NZAET) has established the GROWSAFE training programme for users of agrichemicals. The training programme is based on NZS 8409:2004. There is a range of courses now available and they are linked to the New Zealand Qualifications Authority's National Qualifications Framework. The courses are conducted by accredited GROWSAFE trainers. There are two main GROWSAFE courses: the introductory course (completed in about 10 hours) and the applied course (completed in about 22 hours). More information is available by contacting the NZAET (see Appendix 5 for contact details or visit http://www.growsafe.co.nz).

New Zealand Agrichemical Manual

Agri Media Ltd publishes the *New Zealand Agrichemical Manual*. The manual is aimed at farmers, growers and orchardists. It includes information on safety equipment, advice on the use of agrichemicals in built-up areas, and information related to agrichemical use generally. Further material is available from the various industry federations and authorities.

Certification required under HSNO Act

Person in charge

A 'person in charge' must take responsibility for ensuring that the Hazardous Substances and New Organisms Act 1996 is complied with at each place where a hazardous substance is located. The 'person in charge' can be the owner, lessee, sublessee, occupier, or person in possession of the place or any part of that place; or any other person who, at the relevant time, is in effective control or possession of the place.

Approved handler

Any quantity of a Class 6.1A, 6.1B or 6.1C will require an approved handler certificate, although there are some exceptions. Other classifications (eg, flammable materials) may also require an approved handler certificate, depending on the quantity and classification. Contact a test certifier or an HSNO advisor if you are not sure whether an approved handler certificate is required.

Controlled substance licence

Controlled substance licenses are required for anyone in possession of a controlled substance, mostly vertebrate toxic agents.

Application methods and equipment

This section considers the spray platform (air or ground); carriage (pedestrian or vehicle); and application equipment and nozzle type.

Platform

The platform refers mainly to whether the application of the agrichemical is an aerial or ground operation. A further category is 'other', which may include application of agrichemicals from a boat, such as for the control of water weeds.

Carriage

The method of carriage relates to whether the spraying equipment is aircraft mounted, vehicle towed/mounted, or pedestrian (ie, carried by a person, for example in a knapsack). 'Pedestrian' also includes hand-gun sprayers for which the tank reservoir is mounted on a vehicle or a trailer.

Spraying equipment

The main types of agrichemical application equipment are described below.

Micronair applicators

Micronair applicators are distinguished from other types of spraying equipment by the type of nozzle. Micronair applicators have rotary nozzles and tend to work at lower flow rates (lower application rates) and produce finer droplets than other common nozzle types, although this depends on calibration. These are sometimes used for aerial applications but are now being used on boom and orchard sprayers.

Hand-gun sprayers

Directional hand-guns may be fed from a large vehicle-mounted tank or a smaller hand-held tank. The method of carriage is pedestrian. Hand-gun sprayers are used when high volumes of water are needed. Hand-guns usually, but not always, have high-pressure nozzles.

Hand pump knapsacks

Hand pump knapsacks are worn on the back. They are pumped by hand to build up the pressure necessary to produce the spray.

Motorised knapsacks

Motorised knapsacks are worn on the back. These are hand-operated knapsacks with a motorised pump.

Motorised mist blowers

Motorised mist blowers have a small motor, a centrifugal fan, a flexible discharge hose, and a small tank reservoir. The fan produces a high velocity airstream; some of the air is used to pressurise the tank. Motorised mist blowers are more likely to contribute to drift than either hand pump or motorised knapsacks and are carried on foot.

Boom applicators

Boom applicators are aircraft- or vehicle-mounted booms fed from a tank reservoir. Aircraft-mounted booms should not extend more than 80 percent of the wing span or, for a helicopter, of the rotor diameter.

Wickwipers (wipers or wiping equipment)

Wickwipers are unlikely to be involved in a spraydrift incident due to the mechanism of application. The chemical is applied by wiping the spray material directly onto the plant surface.

Control droplet application equipment

This category includes all types of sprayers, for example, boom sprayers, airblast orchard sprayers, and knapsacks. The difference between CDA equipment and conventional equipment is that CDA equipment produces a narrower range of droplet sizes. This is an ultra-low-volume (ULV) method of spraying.

Airblast orchard sprayers

Airblast orchard sprayers release droplets that are forced into the trees by a strong fan. Generally these sprayers operate under a tree canopy and force the spray droplets up into the canopy.

Nozzle types

Nozzle types affect droplet size and distribution. The usual categories for nozzles are based on the energy/method of creating the droplet. The main categories are hydraulic, air, shear and rotary. By selecting appropriate nozzles, it is possible to virtually eliminate spraydrift.

Appendix 5: National Organisations Contact List

Agriculture Industry Training Organisation
PO Box 10 383
WELLINGTON
Tel (04) 801 9616
Fax (04) 801 9262

Association for Animal Health and Crop Protection (AGCARM Inc)
PO Box 5069
WELLINGTON
Tel (04) 499 4225
Fax (04) 499 4223

Aviation Industry Association of New Zealand
Agriculture House
12 Johnson Street
WELLINGTON
Tel (04) 472 2707

Civil Aviation Authority
PO Box 31 441
LOWER HUTT
Tel (04) 560 9400
Fax (04) 569 2024

ERMA New Zealand
PO Box 131
WELLINGTON
Tel (04) 916 2426
Fax (04) 916 0433

Federated Farmers of New Zealand
154 Featherston Street
WELLINGTON
Tel (04) 473 7269

Horticulture New Zealand
Huddart Parker Building, Post Office Square
WELLINGTON
Tel (04) 472 3795
Fax (04) 471 2681

Ministry for the Environment
PO Box 10 362
WELLINGTON
Tel (04) 917 7400
Fax (04) 471 0195;917 7523

Ministry of Health
133 Molesworth Street
PO Box 5013
WELLINGTON
Tel (04) 816 2000
Fax (04) 816 2340

National Poisons Centre
University of Otago Medical School
PO Box 913
DUNEDIN
Urgent Tel 0800 POISON (0800 764766) (24 hours)
Non-urgent Tel (03) 479 7248 (8.30 am – 5.00 pm)
Fax (03) 477 0509

New Zealand Agrichemical Education Trust (NZAET)
Huddart Parker Building, Post Office Square
WELLINGTON
Tel (04) 472 9997
Fax (04) 472 9997

New Zealand Chemical Industry Council
12 Johnston Street
WELLINGTON
Tel (04) 499 4311
Fax (04) 472 7100

New Zealand Contractors Federation (Inc)
21 Fitzherbert Street
Thorndon
WELLINGTON
Tel (04) 496 3270

New Zealand Food Safety Authority
PO Box 2835
WELLINGTON
Tel (04) 463 2500
Fax (04) 463 2501

New Zealand Forest Owners Association
85 The Terrace
WELLINGTON
Tel (04) 473 4769
Fax (04) 499 8893

Parliamentary Commissioner for the Environment
PO Box 10 241
WELLINGTON
Tel (04) 471 1669
Fax (04) 495 8350

Pest Management Association of New Zealand
PO Box 31 067
LOWER HUTT
Tel 0800 4PMANZ
Fax (04) 528 1378

Standards New Zealand
Standards Council
Private Bag 2439
WELLINGTON 6020
Tel (04) 498 5990
Fax (04) 498 5994

Appendix 6: Report Sheets

How you can copy the report sheets and adapt them for your own use

The text of this document can be downloaded from the Ministry of Health website, http://www.moh.govt.nz. Save the Word document onto your hard drive so that the report sheets may be easily reproduced and adapted if necessary to suit individual cases.

Users may also find it useful to copy parts of the text from the graded response protocol (Chapter 3) and other material into the report sheets. Please note that the layout of the report sheets has been developed to enable information collected to be entered into *DriftNet* so it is **important that the questions and options for responses** in the report sheets **are not changed**.

Complaint form

Complaint (Part 1 of 4)

Complaint number:		File number:	
Local public health unit:		Recorded by:	

Complainant details

First name:	
Surname:	
Address:	
Local authority:	
Phone:	
Date reported:	/ /
Time reported:	

Complainant type: (tick one)		
	Doctor or other health professional	
	Farmer	
	Government agency	
	Member of the public	
	Reporter, other	

Incident location

Address of affected area:	

Type of location: (tick one)		
	Private residence	
	Public area	
	School	
	Workplace	
	Childcare centre	
	Other	

Address from which spraydrift presumably came:	
Name of property owner:	

Complaint details (Part 2 of 4)

How was the drift first detected?

Visible mist or cloud:		Symptoms:	
Felt on skin or eyes:		Plant damage:	
Smell:		Spray residue on surfaces:	

Incident description

Date of incident:	/ /
Time of incident:	

Food crops contaminated:	Yes		No		Unsure	
Other plants contaminated:	Yes		No		Unsure	
Evidence of plant damage:	Yes		No		Unsure	

→ Date plant damaged first noticed: / /

Applicator distance: metres *How far away was the applicator from you?*

Applicator direction:

E		N		NE		NW		*What was the direction of the applicator from you?* (tick one)
S		SE		SW		W		

Wind strength:

Nil		Light breeze	Tick one
Moderate wind		Strong wind	

Wind direction:

E		N		NE		NW		Tick one
S		SE		SW		W		

Temperature °Celsius

Topography:

Uphill		Downhill	*Position of the spray vehicle in relation to the complainant.*
Level		Other	

Water supply:

Town supply		Roof collection		Other	
Well or bore		Spring		Tick all that apply	

Method of application: (tick one)

Helicopter	
Fixed wing aircraft	
Vehicle mounted or towed	
Hand held	
Other	

Complaint details (Part 2 of 4) continued ...

If applied by air:

Aircraft registration number:

Direction aircraft was flying in (tick one):

E		N		NE		NW	
S		SE		SW		W	

Agrichemical (if known):

Was prior notice of the application given?

(Tick one) Yes ☐ → Date notified / /

No ☐

Not sure ☐

How notified:

Complaint management (Part 3 of 4)

Management and conclusions

Action taken (tick one):

Field investigation warranted	
No further action	

Event number:

Referred to another agency (list):

Related exposures/illnesses:

Event/incident number	Name of case

Complaint investigation (Part 4 of 4)

Investigation

Date of incident: / /

Investigating officers:

First name	Surname

Is plant damage consistent with herbicide damage?

Yes	
No	
Too early to say	

Samples taken for analysis:

Foliage		Soil	
Water		Other	

Results of analyses:

Other relevant details:

Conclusion of investigation:

Further action required:

Exposure/illness form

Exposure/illness personal (Part 1 of 4)

Exposure/illness number:	
Local public health unit:	
Complaint number:	

Investigating officers

First name	Surname

Case details

First name:	
Surname:	
Address:	
Phone number:	
Date of birth:	/ /
Sex	

Ethnicity: (tick one)	
European	
NZ Māori	
Pacific groups	
Other	

Main occupation:	

Exposure definition

Where (when exposed):	
Activity engaged in:	

What was experienced?	Visible mist or cloud:		Felt on skin or eyes:		Smell:	

Where symptoms of illness experienced from the exposure? ☐

Exposure/illness symptoms (Part 2 of 4)

General

Feeling unwell:	
Tired:	
Fever:	

Central nervous system

Headache:	
Dizziness:	
Blackout or fits:	
Double vision:	
Unsteady walking:	
Other:	

Peripheral nervous system

Numb/tingling extremities:	
Other:	

Eyes

Burning eyes:	
Watering eyes:	
Blurred vision:	
Other:	

Psychological function

Anxiety:	
Insomnia:	
Confusion:	
Depression:	
Tearfulness:	
Other:	

Cardiovascular

Palpitations:	
Rapid pulse:	
Slow pulse:	
Other:	

Skin

Sweating:	
Flushing:	
Rash:	

Describe rash:

Respiratory

Cough:	
Wheeze:	
Out of breath:	
'Burning' lungs:	
Blocked nose:	
Other:	

Gastrointestinal

Salivation:	
Swollen lips:	
Nausea:	
Vomiting:	
Diarrhoea:	
Stomach pains (cramps):	
Other:	

Musculoskeletal

Muscle weakness:	
Aching muscles:	
Twitching muscles:	
Other:	

Other body systems affected

Renal:	
Hepatic:	
Reproductive:	
Immune:	
Endocrine:	
Other:	

Risk/protective factors: exposure/illness medical history (Part 3 of 4)

Outcome (complete if symptoms experienced from this exposure)

Date symptoms were first noticed:	
Time symptoms were first noticed:	
Most severe symptom:	

Samples collected for analysis:

Blood:		Clothing:		Other physical surface:	
Urine:		Skin swab:			

Results of analyses:

Medicines taken in week prior to exposure

Medicine

Individual risk/protective factors

Do you suffer from ...

Skin allergies:		Migraine:		Asthma:	
Hayfever:		Eczema:			

If you suffer from any chronic diseases – list these:

Are you currently pregnant?	
Are you currently breastfeeding?	

Usual health status: (tick one)

Excellent	
Good	
Fair	
Poor	

If alcohol consumed in the 12 hours prior to exposure, number of drinks:	
If you are a smoker, average number of cigarettes smoked per day:	

Exposure/illness diagnosis (Part 4 of 4)

GP/health professional consulted:

First name:	
Surname:	
Address:	
Have the details been confirmed with the GP?	
GP's diagnosis:	

Management and conclusions

Are these symptoms:	Acute:		Intermittent:		Local:		
	Chronic:		Systemic:				
Overall severity							
Have these symptoms resolved?							
If so, date symptoms resolved?							
and time symptoms resolved?							
Are symptoms/illness consistent with the known effects of the agrichemical?	Yes						
	No						
	Unsure						
Conclusions of the investigation officer:							

Event/incident form

Event/incident location (Part 1 of 4)

Incident number:	
Public health unit:	
File number:	

Investigating officers

First name	Surname	Investigation date

Incident location

Address:	
Local authority:	

Person in charge of the property

First name:	
Surname:	
Address:	

Status: (tick one)	
Owner	
Manager	
Tenant	

Phone:		Fax:	

Operator name and address

First name:	
Surname:	
Address:	

Is the operator registered or licensed or not: (tick those that apply)	
Licensed to use controlled pesticides:	
Registered pest control technician:	
Registered to apply ground chemicals:	
Not licensed or registered:	

Event/incident details (Part 2 of 4)

Date of event:	/ /
Time of event:	

Intended target: (tick one)

Pasture	
Scrub control	
Market garden	
Pip/stone fruit	
Kiwifruit	
Citrus	
Cereal	
Forestry	
Fumigation	
Local authority, regional council weedspraying	
Residential	
Other	

Method of carriage of equipment: (tick one)

Helicopter	
Fixed wing aircraft	
Vehicle towed or mounted	
Pedestrian	

Spray equipment: (tick one)

Micronair applicator	
Hand gun	
Hand pump knapsack	
Motorised knapsack	
Boom applicator	
Wickwipers (wipers or wiping equipment)	
Control droplet applicator (CDA)	
Airblast orchard sprayer	
Other	

Nozzle type: (tick one)

Hydraulic	
Air	
Shear	
Rotary	
Other	

Formulation type: (tick one)

Liquid	
Dust	
Granules	
Other	

Application rate: _____ l/ha or kg/ha

Event/incident details (Part 2 of 4) continued ...

Weather conditions at the time of the incident

Wind speed: _____ km/hr

Wind direction (tick one):

E		N		NE		NW	
S		SE		SW		W	

Air temperature: _____ °Celsius

Relative humidity: _____

Raining: ☐

Risk/protective factors

Is a spray log up to date? (tick one)
- Yes ☐
- No ☐
- Not sure ☐

Weather conditions recorded ☐

Date of last equipment calibration: / /

Width of buffer zone: _____ metres

Shelter belt downwind from the site of application:
- Yes ☐
- No ☐

Neighbouring residents notified: (tick one)
- Yes ☐
- No ☐
- Unknown ☐

Nearest neighbour: _____ metres *Shortest distance between the application and the site of the nearest complaint*

Compass direction: (tick one)

E		N		NE		NW	
S		SE		SW		W	

Compass direction to nearest neighbour from the event site

Other circumstances relating to the incident: _____

Event/incident chemicals (Part 3 of 4)

What chemical(s) were applied? (Use a new section for each product.)

			Active ingredients:	Concentration:
Trade name:				%
Dilution rate:		(times diluted)		%
				%

Formulation type: (tick one)		Agrichemical classification: (tick one)	
Emulsifiable concentrate		Animal/bird repellent	
Aqueous concentrate		Fungicide/insecticide	
Wettable powder		Fungicide/vertebrate	
Microencapsulate		Fungicide	
Dust		Herbicide	
Granules		Insecticide	
		Molluscicide	
		Multiple product type	
		Other	
		Plant growth regulator	
		Vertebrate poison	

			Active ingredients:	Concentration:
Trade name:				%
Dilution rate:		(times diluted)		%
				%

Formulation type: (tick one)		Agrichemical classification: (tick one)	
Emulsifiable concentrate		Animal/bird repellent	
Aqueous concentrate		Fungicide/insecticide	
Wettable powder		Fungicide/vertebrate	
Microencapsulate		Fungicide	
Dust		Herbicide	
Granules		Insecticide	
		Molluscicide	
		Multiple product type	
		Other	
		Plant growth regulator	
		Vertebrate poison	

			Active ingredients:	Concentration:
Trade name:				%
Dilution rate:		(times diluted)		%
				%

Formulation type: (tick one)		Agrichemical classification: (tick one)	
Emulsifiable concentrate		Animal/bird repellent	
Aqueous concentrate		Fungicide/insecticide	
Wettable powder		Fungicide/vertebrate	
Microencapsulate		Fungicide	
Dust		Herbicide	
Granules		Insecticide	
		Molluscicide	
		Multiple product type	
		Other	
		Plant growth regulator	
		Vertebrate toxic agent	

Event/incident management (Part 4 of 4)

Management and conclusions

Conclusions from the investigation:	
Action initiated:	
Recommended further action:	

Related complaints:	**Number**	**Name**	**Date**

Glossary of Terms and Abbreviations

µg	microgram or one millionth of a gram (sometimes written mcg)
µm	micrometre or one millionth of a metre (also known as micron)
ACC	Accident Compensation Corporation
ACVM Act	Agricultural Compounds and Veterinary Medicines Act 1997
ADE	acceptable daily exposure
ADI	acceptable daily intake for pesticide residues in food, determined by toxicological data estimating safe consumption levels over a lifetime of daily exposure and incorporating a safety factor of at least 10; used interchangeably with TDI in this document
Agrichemical	any chemical used in an agricultural context. This category encompasses pesticides listed in the Hazardous Substances (Pesticides) Transfer Notice 2004, including subsequent amendments or agricultural compounds as defined under the Agricultural Compounds and Veterinary Medicines Act 1997, as well as fertilisers, plant growth regulators and spray additives, such as marker dyes and wetting agents
Biomarker	a measurement, typically a chemical, biochemical or other biological parameter, that reflects an interaction between a living organism and an environmental agent, which could be biological, chemical or physical
CAA	Civil Aviation Authority
CDA	controlled droplet application
Complaint	an advice to the public health service by any person that an agrichemical spraydrift incident may have occurred
Determinand	A constituent or property of the water which is determined, or estimated, in a sample, for example, chemical determinand – chloride; physical determinand – pH.
EBDC	ethylene-bis-di-thiocarbamate fungicides, including maneb and mancozeb
ELISA	enzyme-linked immunosorbent assay
ERMA	Environmental Risk Management Authority
ERMA New Zealand	Environmental Risk Management Authority New Zealand
ESR	Environmental Science and Research Ltd
ETU	ethylenethiourea, an impurity and degradation product of EBDC fungicides
Event	the intended application of the agricultural chemical that precipitated the incident
Exposure	human exposure to an agrichemical by ingestion, skin absorption or inhalation
Hazard	a source or situation of potential harm
HSE	Health and Safety in Employment Act 1992
HSNO Act	Hazardous Substances and New Organisms Act 1996

Incident	the circumstances leading to one or more complaints or notifications of spraydrift
Lipophilicity	fat solubility, attraction to fatty tissues
m/s	metres per second
MAV	maximum acceptable value – the concentration of a determinand below which the presence of the determinand does not result in any significant risk to a consumer over a lifetime of consumption. For carcinogenic chemicals, the MAVs set in the *Drinking-Water Standards for New Zealand* (Ministry of Health 2005) generally represent a risk of one additional incidence of cancer per 100,000 people ingesting the water at the concentration of the MAV for 70 years
Micron (µm)	one millionth of a metre (also known as a micrometre)
MSDSs	material safety data sheets
NZAET	New Zealand Agrichemical Education Trust
PHC	Public Health Commission, disestablished in 1996
Poisons Centre	National Poisons Centre
RIA	radioimmunoassay
Risk	the probability of harmful consequences arising from a hazard together with a measure of the scale or severity of the harmful consequence. In qualitative terms, the risk may be said to have a probability that is 'high' or 'low' or another chosen term. In quantitative terms, the probability can range from zero (no possible harm) to one (certainty that harm will occur). The scale and severity of the harm may be characterised by the number of people affected and the sort of harm (eg, death or serious injury)
Risk assessment	the systematic acquisition and evaluation of information that enables the probability, scale and severity of the risk to be described
Risk management	all actions of a management nature that are designed to minimise risk to levels acceptable to the person(s) exposed to the risk
RMA	Resource Management Act 1991
SDSs	safety data sheets
Spraydrift	any unintended off-target migration of an agrichemical
TDI	tolerable daily intake – an estimate of the intake of a substance over a lifetime considered to be without appreciable health risk; used interchangeably with ADI in this document
TEL	tolerable exposure limit
WHO	World Health Organization