Technical Information relating to the Agricultural Aviation Industry

This information supports the Guidance Note entitled “Agricultural and Rural Aviation” which is an outcome from the SFF funded project 11/076 called Environmental Best Practice in Agricultural and Associated Rural Aviation”.

The Guidance Note is available on the Quality Planning (QP) website and can be found here.The QP website is owned by the Ministry for the Environment (MfE) and is a partnership between MfE, Local Government NZ, the Resource Management Law Association, the New Zealand Planning Institute and the NZ Surveyors Institute.

Guidance Notes are designed for council practitioners and consultants, environmental managers and others involved in resource management practice under the RMA. This Technical Information provides more detailed information primarily for pilots and operators to help them achieve best practice in agricultural aviation. NZAAA and NZHA maintain this Technical Information and will updateas necessary.

This Technical information provides:

- Specific technical explanation and details to enable better understanding of the technical nature of the industry and the interface with the regulatory environment
- Support for the risk based approach used in the Guidance Note
- Details of pilot management options referred to in the Guidance Note

The Technical Information generally follows the format in the Guidance Note, including risk management, and substance specific sections, fertiliser, agrichemicals and VTA’s.

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CONTENTS

1. INDUSTRY OVERVIEW

The agricultural aviation industry's main role is the application of agrichemicals, fertilisers and baits from the air, from both fixed wing aircraft and helicopters. Because helicopters can be used in many different roles, some that are used in agricultural work will carry out other non-agricultural work, eg fire fighting and lifting. Each year about 60,000 hours of flying time (helicopters and fixed wing) can be attributed to agricultural work, with a trend towards more helicopter hours and less fixed wing. Actual figures for the various types of application vary according to the season but agricultural work in NZ in 2005 – 2010 is summarised in Table 1.1.

Some operators elect to provide only one service, e.g. fertiliser application, whereas others will carry out agrichemical and VTA applications as well. There are no restrictions on what part of the country an operator can work with many operators working in a number of regions throughout NZ. Typically, especially with fixed wing aircraft, an operator will work from a base with an established client list. To work in agricultural aviation, an operator must hold a CAR Part 137 Certificateissued by CAA. The certificate is held by the organisation or operator who may have a number of aircraft operating under that certificate. In addition to the CAR Part 137 Certificate, other Civil Aviation Rules (CAR) apply, including CAR Part 91- General Operating and Flight Rules

Table 1.1 Agricultural aviation work in New Zealand (all figures rounded)

Year	A/C	Bait (tonne)	Fertiliser including lime ('000 t)	Spray ('000 litres)
2010	FW	475	439	4900
	Heli	1000	39	60,300
2009	FW	600	380	6700
	Heli	1850	26	54,500
2008	FW	1700	482	6600
	Heli	1800	35	55,500
2007	FW	500	567	2000
	Heli	1450	27	40 000
2006	FW	70	577	2500
	Heli	1250	28	41000
2005	FW	300	704	5500
	Heli	2300	28	51500

Note:

- Total bait application (tonnes) trending down because of lower application rates per ha.
- Helicopters now fly more hours on agricultural work than aeroplanes (FW).
- For helicopter spraying 70 – 80% of the total is agrichemical and about 15% is for fine particle suspension.

2. RISK MANAGEMENT

Risk is formally defined as the effect of uncertainty on objectives[1]. The GN uses a risk assessment/management approachto deliver the required outcomes in terms of discharges to air, land and water and impacts on amenity values for agrichemicals, fertilisers and VTA's. These notes summarise how a risk management process works.

Hazard x Exposure = Risk

The level of risk depends on the degree of hazard and the amount or extent to which there is exposure to that hazard. Some simple examples:

- Hazard: a patch of oil on the hangar floor
  Exposure: you don't go into the hangar
  Risk: Zero because exposure to that hazard is zero.

- Hazard: A sealed container of insecticide in the agrichemical store.
  Exposure: The container is taken from the store and remains sealed
  Risk: There is no risk because there is no exposure.

- Hazard: A sealed container of insecticide in the store.
  Exposure: The container is taken from the store and opened and mixed by someone not wearing gloves
  Risk: There is risk of contamination and spillages.

- Hazard: An insecticide is applied by aircraft on the target property
  Exposure: A person is working on an adjacent property, without protective equipment
  Risk: That person may be at risk in the event of off-target drift.

2.1 Simple risk matrix

A simple risk matrix such as set out below brings together the likelihood of an adverse effect with the potential impact of that adverse effect. The risk factor in S5 of theGuidance Note is based on a slightly more complex risk matrix than that given here but the principles are the same. A still more detailed matrix has been developed – the AIRCARE™ Risk Matrix whichmay be needed, depending on the situation.

2.2 Is a Risk Management Matrix needed?

Situation A

- Nothing is new or unusual
- The job is well understood as are the risks
- There are established procedures and standards in place
- There is a typically high level of control
- In emergency or urgency situations

→

Reference to a RiskMatrix not needed

- Identify hazards – eliminate/avoid/ protect
- Standard procedures
- Professional judgement
- Good airmanship
- Mindfulness

[1] ISO 31000:2009

Situation B

Risk matrix needed

- There is change. (change internal to the organisation or external)
- Something is new or unusual
- Something is not well understood
- Procedures are incomplete
- There is uncertainty
- Risk trade-offs are being made
- There is limited control

→

Combine Risk Matrix outcome with:

- Professional judgement
- Good practice
- Group input (discuss / challenge / debate)

Situation C

Risk Matrix useful in deciding on course of action

- There is technical complexity
- There is a very high level of risk
- A procedure is being designed
- There is a very high level of uncertainty

→

Use of Risk Matrix indicates you should seek expert advice and specialist assistance

In the Guidance note, Table 5.2.5 sets out what is involved in risk assessment requirements (risk factors) and management controls for aerial application of fertiliser, agrichemical and VTA, using the headings:

Risk assessment requirements	Information needed	Information able to be used for task verification	Pilot Management

This general framework for risk management for aerial applications in the Guidance Noteprovides the basis on how to apply this to manage the discharge of fertilizers (Table 6.1), agrichemicals (Table 7.1 and VTA (Table 8.1) as well as the management of aircraft noise. It includespilot management options, - the measures pilots can take to minimise risks and potential adverse effects from aerial application discharges and noise abatement.

2.3 Legislative controls and risk management

HSNO

The Hazardous Substances and New Organisms legislation (HSNO Act 1996) includes a number of Regulations, which set out the detailed requirements and provide tables showing threshold values for volumes or weights of substances beyond which controls apply. A hazardous substance is any substance with one or more of the following intrinsic properties – explosiveness, flammability, capacity to oxidise, corrosiveness, toxicity, ecotoxicity. The hazard classifications are divided into physical and biological classes. (Appendix 1 and 2).*Physical* hazard classes are Flammability (Classes 2, 3, 4) and Capacity to oxidise (Class 5). *Biological* hazard classes are Toxicity (Class 6) , Corrosiveness (Class 8), Ecotoxicity (Class 9). The HSNO legislation includes a number of regulations, which set out the detailed requirements and provide tables showing threshold values for volumes or weights of hazardous substances beyond which the controls apply. HSNO Controls are rules put in place to prevent or manage the adverse effects of hazardous substances. A summary of the controls that may be required for a hazardous substance are listed in Table 2.1 below.

Table 2.1 HSNO controls

HSNO Control	Explanation
Approved handler (AH)	Depending on the degree of hazard users may need to show that they are competent to handle and use the substance, by being an approved handler as described by the HSNO Personnel Qualifications Regulations.
Disposal	Disposing of unwanted substances poses a risk to the environment. The HSNO Disposal Regulations require that the substance must either be treated so that it is no longer hazardous or discharged within set environmental concentration limits.
Documentation (information about the substance)	The HSNO Identification Regulations set out the information that must be available for any hazardous substance. The information ranges from a description of the substance and the types of hazard it has, to steps that can be taken to prevent harm.
Emergency Management	HSNO Emergency Management Regulations have three levels of emergency management depending on the amount of substance and the hazard classifications of each substance.
Emergency Response Plans	If the quantity stored triggers Emergency Response Level 3 then an Emergency Response Plan must be developed, setting out what actions need to be taken in an emergency, who is responsible for actions needed, and what information and equipment these people will need.
Equipment to use	The HSNO Personnel Qualification Regulations describe the qualifications relating to being an approved handler. An approved handler must know about the operating equipment used to apply the hazardous substance. This includes personal protective equipment.
Location Test Certificate	If the substance has a hazard classification of 2, 3, 4 or 5 and the amount stored is greater than the quantity given in the HSNO (Controls 1-5) Regulations then the site will need a Location Test Certificate (LTC) which can be obtained through a Test Certifier who is able to issue LTC's. A site visit will be necessary.
Priority identifier	A priority identifier is part of the HSNO Identification Regulations. For any hazardous substance there must be some words or pictures (pictograms) on the label that tells what the main hazard is with that substance. This is a priority identifier and the information must be able to be located within 2 seconds.
Record keeping (Documentation after use)	A record of an application must be kept if specified in the HSNO Classes (6, 8 and 9) Control Regulations. This will depend on the hazard classification of the substance, if it is applied in a place where the public may be present, or if it may move off the application site through the air or water. This is not the same as tracking (see below).
Secondary identifier	The secondary identifier is information that must be available to any person handling the substance within ten seconds, and primarily consists of an indication of the degree of hazard and other risks associated with the substance, together with information on how to prevent and manage those risks. Normally it is in the form of hazard, warning or precautionary statements, and/or risk phrases.
Signage in the workplace	Where the amount of hazardous substance held exceeds set trigger levels then there must be signage that says what the substance is, what the hazard is and what action is needed in an emergency.
Secondary	Secondary containment is needed when the amounts stored exceed certain thresholds. A concrete or other impervious bunding around the edge of the storage area a common method

HSNO Control	**Explanation**
containment	used to provide secondary containment.

HSNO Control	Explanation
Tracking	The more highly hazardous substances are required to be tracked. Under the HSNO Tracking Regulations the location and movement of tracked substances must be **recorded through every stage of its lifecycle** (transport, storage, use, and disposal). Tracked substances require an approved handler.

For substances with physical hazard classification(s) there are provisions for controls on storage (location test certificates) and competency of persons in possession of the substance (Approved Handler).

Each hazard class also has degrees of hazard eg: Toxic Substances are Class 6 with sub classes, eg 6.1 (risk to humans) and degrees of hazard, eg; Class 6.1 A (highly toxic). Refer to Appendix 1 and 2 for details of the hazard classifications.

A range of information sheets are available to advise on Hazardous Substances and New Organisms (HSNO) requirements for managing fuels and agrichemicals. Where threshold quantities for storage of agrichemicals and other hazardous products are exceeded, an emergency response plan is necessary. A summary of the quantities of hazardous substances that trigger key requirements (threshold quantities) from the regulations and transfer notices is available here.

The hazard classifications for any given substance can be obtained from the Safety Data Sheet (SDS) or for on farm use or storage, a Product Safety Card (PSC) for that substance. A PSC summarises all the relevant information on any given hazardous substance. The difference between a SDS and a PSC is evident when the two are compared for the same substance. See SDS for the common herbicide Glyphosate, and a PSC for the same substance
.

The Agricultural Compound and Veterinary Medicine Act (ACVM)

As part of the registration process conditions may be imposed to manage or reduce the risks specified in the ACVM Act with the product label specifying any prohibition, obligation or requirement on users as a condition of the registration. Such information may include such things as withholding periods for a substance. If the product is used outside of the conditions on the label, the user is liable and responsible for all actions taken, and any consequences, provided certain conditions are met. Following label directions will help ensure safe and responsible use of the product, including not exceeding any Maximum Residue Limit (MRL) set.

NOTE: Under the HSNO Act, there are also labelling requirements include priority and secondary identifiers relating to the hazard of the substance.

The ACVM Act is administered by Ministry for Primary Industries (MPI)
http://www.foodsafety.govt.nz/industry/acvm/

The Health and Safety in Employment Act 1992 (HSE)

The HSE Act promotes the prevention of *harm*to all people at work and other people in or around a place of work. The starting point for the HSE Act is the identification of hazards. The hazards then need to be assessed so that *significant hazards* can be identified and procedures (controls) developed to manage those hazards.

The HSE Act is designed to ensure the safety of people and places and responsibilities of the person in charge, the landowners or manager, employees, contractors and visitors in terms of managing potential hazards. The RMA also is intended to ensure the safety and wellbeing of people. The use of machinery and the products applied in agricultural aviation present potential hazards so an aerial operator has to have adequate safety systems in place. There should be no requirement for safety matters to be duplicated in regional or district plans.

3. FERTILISER APPLICATION

3.1 Fertiliser application methods

Where application rates are typically greater than 100 kg/ha application costs dictate that the application of superphosphate (P), and of other products such as lime, is usually carried out by fixed wing aircraft. In these cases no spreading device is used – the fertiliser is simply released from the aircraft hopper. Where no spreader device is used on a fixed wing aircraft, and in calm conditions, fertiliser particle size does not influence the distribution pattern. The pattern will tend to be narrow and sharply peaked with an effective width of about 10 to 12 metres and the same pattern will occur almost irrespective of fertiliser type. (Fig 3.1)

Fertiliser applied by air is normally in the form of solid particles. The fertiliser is loaded directly into the hopper of a fixed wing aircraft or into a hopper or bucket that is slung beneath a helicopter. For the fixed wing the fertiliser is discharged through an opening in the hopper bottom which also is used to control the discharge rate. Superphosphate (P) is most often applied this way at rates of up to 300kg per ha (or more for application of agricultural lime). Various types of spreaders can also be fitted to the hopper outlet to increase the spreading width and are also used for high analysis nitrogen (N) fertilisers where the application rate is no greater than about 150 kg per ha.By contrast the hopper slung beneath the helicopter has a spinning disc which distributes the fertiliser to get a wider and more even spread.

Fertiliser is also applied as a suspension (slurry) or as a liquid. A suspension is a liquid product containing fine solid particles which are dependent on agitation or stirring to keep them in suspension. Such products require specialist mixing and loading systems and possibly special nozzles. The normal operational concentration for the suspension is 30% water and 70% fine ground lime (or other solid fertiliser). Liquid fertilisers can be handled using the conventional spray application equipment

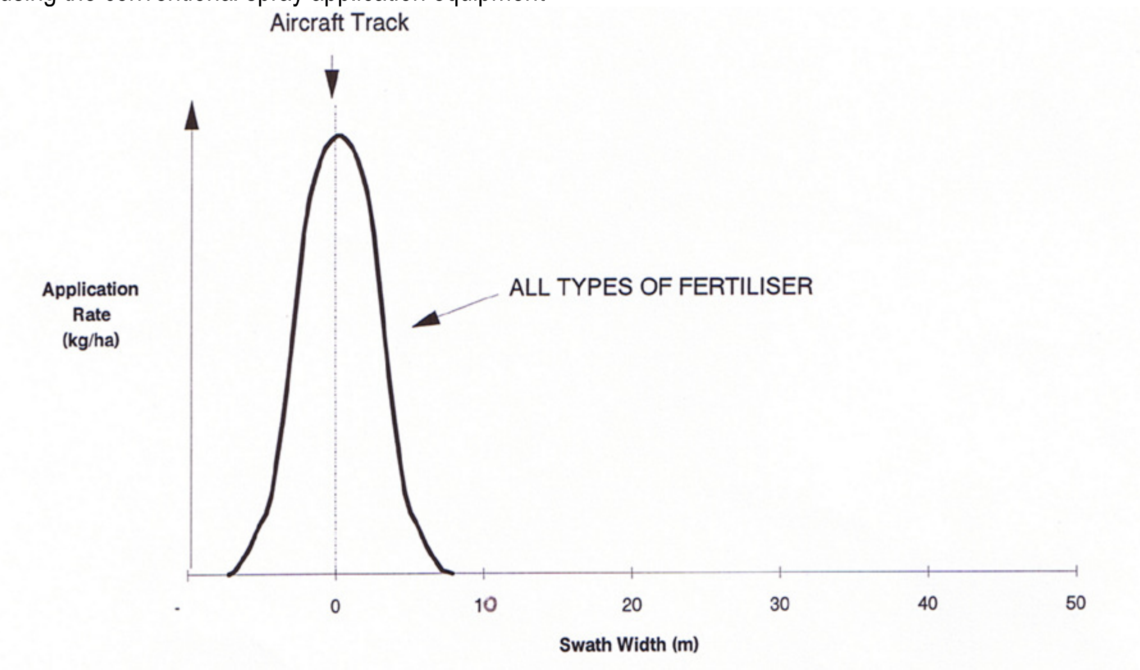


Fig 3.1 Single pass spread pattern, no spreader and no cross wind

High analysis fertilisers typically have large particle sizes and little or no fine particles (< 0.5 mm diameter). For reasons of cost and productivity, these products are applied using a spreading device, so that the distance between successive passes or tracks flown by the aircraft is greater, and evenness of the spread pattern is optimised.

N and other high analysis fertilisers tend to be more uniform and consistent in terms of particle size, and more expensive. These fertilisers will be applied using either a mechanical (eg spinning disc) spreader (helicopter) or aerodynamic (eg ram air) spreader if a fixed wing. In either case, the spreader imparts energy into the fertiliser particles to propel them transversely (sideways) in relation to the travel direction. The larger the fertiliser particle the more energy can be imparted and the greater the distance the particle can be moved. Conversely the smaller the particle size the less energy can be imparted and the greater the influence of any wind in terms of potential off target loss of fertiliser. (Fig 3.2)

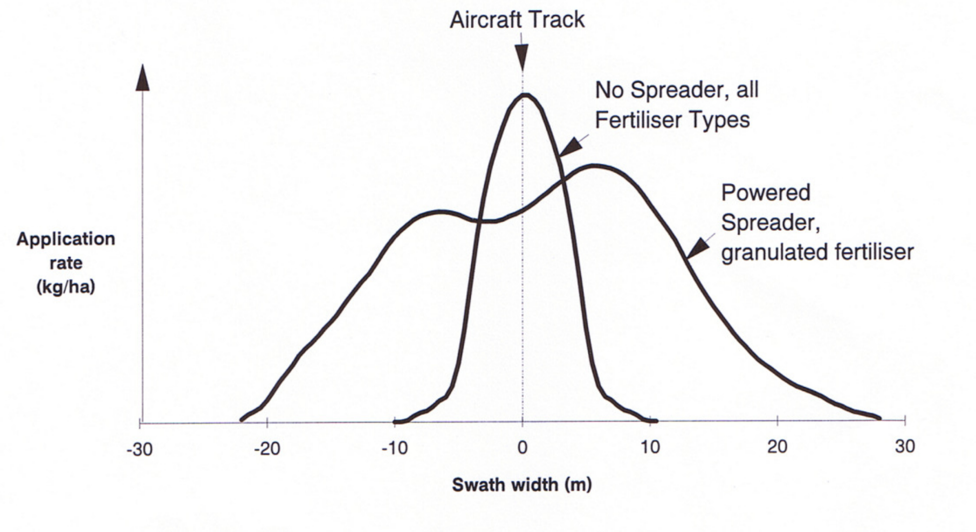


Fig 3.2Single pass spread pattern, helicopter bucket (spinning disc) spreader and no cross wind

3.2. Track spacing

Track spacing is the distance between successive passes of the aircraft. The application rate achieved and the variation in application rate across the swath, expressed by CV%, is obtained when the single pass spread pattern is overlapped at the track spacing selected. Modern GPS systems allow the pilot to both select and accurately maintain a nominated track spacing, and, following completion of the task, to record and display where the aircraft flew while carrying out the task. Most GPS systems are also able to record and display whether the aircraft was discharging any fertiliser at any specified point.

Although an aircraft may be in the correct position, there are a number of environmental factors affecting where the fertiliser lands. Wind clearly has an effect, and is discussed in section 3.4.The aircraft air disturbance as it travels at speeds up to 200km per hr (fixed wing) also has an effect on distribution. The physical characteristics of the material being spread also have a major bearing on ballistic behaviour of particles and hence the final spread pattern.

Recording where the aircraft went is an important part of task verification, but the critical information is where the fertiliser went. Despite the obvious effect of wind influencing lateral movement the correlation between where the fertiliser being applied went and where the aircraft flew is largely a function of the ballistic properties of the fertiliser. The main factor determining ballistic properties is fertiliser particle size. Particle shape surface roughness) and density also have some influence.

3.3 Application verification

Verification of the fertiliser application task carried out may be required. Information required may include:

- Location of the application site
- Date of application

- Fertiliser applied (eg, N, P K S) including trace elements and other additives
- Application rate (kg/ha)

The standard of evidence to verify any given application depends on any associated risks (eg environmental, health and safety), and includes:

- Verbal, with documentation where appropriate (eg diary note)
- Written daily flight logs
- GPS records

Where the application has been carried out within a (specified distance) from an identified sensitive area, then verifiable or auditable information of the application may be requested. The Information shall include tracks flown and weather conditions (wind speed and direction) at the application site.

3.4 The effect of wind on swath patterns for different fertilisers

The spread or swath pattern from either a fixed wing aircraft or a helicopter, with or without a spreading device will be dominated by:

- Fertiliser particle size
- Crosswind speeds
- Application height

Where there is a crosswind, small particles will be moved downwind more than large particles. If the fertiliser contains a range of particle sizes, the spread pattern will become skewed. Where all the particles are large the shape of the spread pattern will not change much but the whole swath will move downwind.

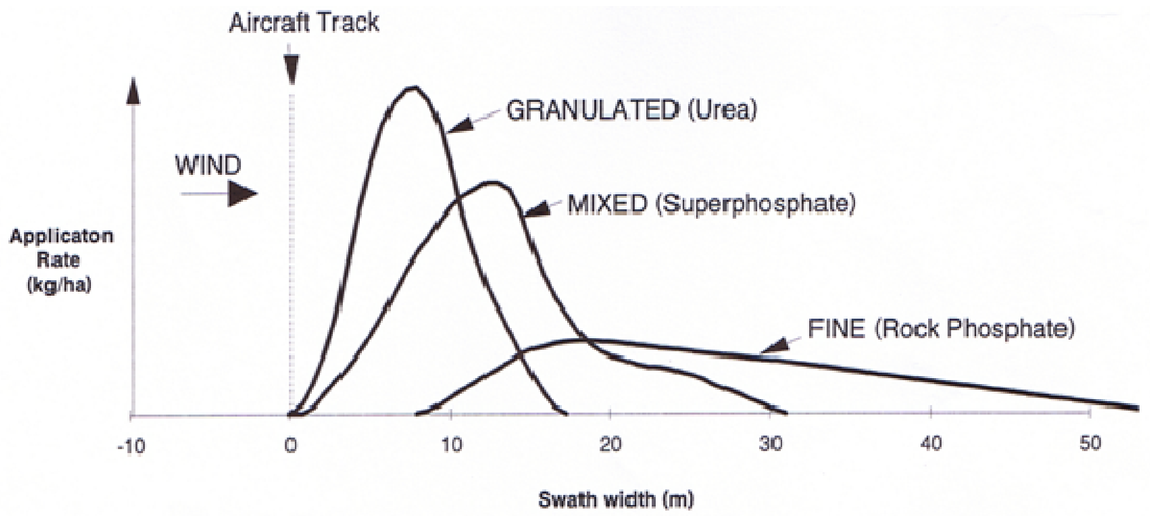


Fig 3.4 (Crosswind effects on swath spread patterns)

Not all fertilisershave the samephysical properties. The particle size of fertilisers varies from very fine (less than 0.5mm particle diameter)) to coarser or granulated products (3 to 4 mm particles). The particle size directly affects the ballistic property of the substance and how it falls when discharged. The coarser the particle size means that the product trajectory will be more predictable than products with a smaller particle size which present a greater likelihood of drift and dust. (Fig 3 4) Within a fertiliser mix there is likely to be a range of particle sizes therefore the range of sizes needs to be factored into the application. There is also variation with product quality over time – the same mix can be quite different in different batches. High analysis fertilisers (granulated) are more consistent within a batch and over time.

For situations where no fertiliser is permitted to be applied in a specified area, the track of the aircraft will not be a reliable or predictable indicator of where the fertiliser went when particle size is less than 0.5mm. Also, where the flight path is directly towards a sensitive area the flow of fertiliser must be stopped in time so that no fertiliser reaches the sensitive area, and particles less than 0.5mm have no ballistic properties so cannot be controlled or directed by the pilot to achieve that.

5.0 Fertiliser application best practice standards

There are a number of publications which assist with setting out best practice for fertiliser application.
These include:

- Safety Guideline: Farm Airstrips and associated fertiliser cartage, storage and application
http://www.caa.govt.nz/HSE-CAA/HSE_Info.htm#Ag

- Code of Practice for Nutrient Management (COPNM)
http://www.fertiliser.org.nz/Site/code_of_practice/default.aspx

- Fertmark Code of Practice
- http://www.fertqual.co.nz/files/downloads/fertmarkcodeofpractice.pdf

- The Aerial Spreadmark Code of Practice
  - Aerial Spreadmark Code Part A http://www.fertqual.co.nz/download.php?view.5
  - Aerial Spreadmark Part B http://www.fertqual.co.nz/download.php?view.6

  Part A deals with Spreadmark protocols and procedures.
  Part B is the Aerial Spreadmark Code of Practice which includes risk management.

Aerial Spreadmark is the performance standard for placement of fertiliser that applies to any aerial application of fertiliser and sets out the requirements for aerial operators. This is one of the Codes of Practice that forms part of the AIRCARE™ Accreditation programme and which operators are audited against.

Product standards
Fertmark is a fertiliser quality assurance scheme that came about in 1992 after the government withdrew from fertiliser auditing. Fertmark is managed by the Fertiliser Quality Council and was originally formed to ensure farmers could be confident in purchasing quality fertiliser and having it accurately spread.

The Fertmark brand means that fertiliser has been independently audited to ensure that the declared chemical composition for major nutrient elements (N, P, K, S, Mg, Ca, Na, Cl) and micronutrient elements (B, Co, Cu, Fe, Mn, Mo, Zn and Se) are according to claims on the label.

The manufacturer of Fertmark registered product must declare that the product:

- does not contain microorganisms at pathogenic levels or any other plant or animal pest that is likely to promote pest or disease transmission;
- that when used as recommended it will not result in residues in food products that violate New Zealand or overseas limits;
- that when used as recommended it will not result in animal health or animal welfare issues

The Fertmark auditing currently only addresses chemical properties of the product. It does not extend to physical properties such as particle size or size range for fertilisers. Achieving accurate placement and even application of fertilizer consistently requires good spreading equipment design and accurate calibration in conjunction with appropriate fertilizer physical properties as described in Section 3.1 to 3.4 incl. of these notes.

Guidance note management options

There are a range of management options that pilots can use and also options that can be included in plan provisions to address the potential adverse effects from fertiliser discharges.

Indirect options, pilot

Minimising potential for drift – technical options pg A 85
http://www.fertqual.co.nz/files/downloads/aerialapp02.pdf

- Target site ID (GPS)
- Use of fertiliser with good ballistic properties (particle size)

Indirect options,planning

- Classify as *sensitive areas:*
  - Residential buildings
  - Educational facilities
  - Public places and amenity areas where people congregate
  - Domestic and community water supplies
  - Water bodies and associated riparian vegetation
  - Crops which are sensitive to agrichemicals or faming systems (eg organic farms, greenhouses)
  - Wetlands, indigenous vegetation habitat areas and reserves
  - Public roads

Possible conditions re application over or near sensitive areas.

- All reasonable measures must be taken to avoid discharges to surface water bodies – risk assessment to establish reasonable measures
- Controls by hazard classification (eg 9.3 and 9.4)

Direct management options, pilot

- Appropriate rate, concentration gradient, soil profile
- Management measures for loading sites, mixing sites and storage

Direct management options, planning

Management measures for loading sites, mixing sites and storage

- Requirement to meet label recommendations
- Methods of disposal
- Fate processes

Table 6.1 in the Guidance Note sets out a risk management approach to manage the discharge of fertiliser from aerial application. For each potential adverse effect, the table identifies the risk factor, exposure pathway and management options for both the pilot and councils through plan provisions and conditions. The extent to which a risk factor applies and management options need to be considered varies according to the nature of the receiving environment and the potential adverse effect.

4. AGRICHEMICAL APPLICATION

4.1 Spray Drift hazard

Every spray application of agrichemicals will result in some degree of spray drift as it is not possible to have zero drift due to the range of variables. However, the most important issue from a risk management perspective is what risk does the spray drift pose and how can these risks be managed (ie avoided or minimised). Drift hazard is defined in NZS 8409:2004 as the hazard associated with drift and consequent trespass which may result in an adverse effect to human health animal health or the environment. Appendix G in NZS8409:2004 includes a potential draft hazard scale from NZS8409:2004. This table highlights the range of variables that need to be considered such as wind speed and direction, height and application and sensitive areas. It also identifies ways to address these hazards which requires knowledge of all the variables that are relevant to the agrichemical application at the time. Plan provisions relating to the discharge of agrichemicals need to ensure that they recognise these options so that they are assessed at the time of application.

Table 4.1 sets out factors contributing to off target drift and the extent to which they may be high or low hazard.

- Column A lists the factors which separately or collectively affect drift hazard.
- Column B identifies the situations where the drift hazard would be high.
- Column C identifies when the drift hazard would be low.
- Column D shows that some factors require further qualification, e.g. buffer zones only apply downwind of an application.

Table 4.1: Potential drift hazard scale

	A	B	C	D
	Factor	**High hazard**	**Low hazard**	**Comment**
1	Wind speed	Zero/very low (less than 1 m/s or 1.9kn) or greater than 6 m/s	Steady (1 – 3 m/s) (2 – 6kn)	Measure or estimate using smoke
2	Wind direction	Unpredictable	Predictable, and away from sensitive areas	Use smoke to indicate
3	Humidity	Low (delta T > 8 °C)	High (delta < 4 °C)	Measure, using whirling psychrometer
4	Atmospheric stability	Inversion layer present	No inversion layer	Use cold smoke to indicate
5	Maximum height of release of agrichemical	> 1.5 m above the target	< 0.5 m above the target	Application technique
6	Particle (droplet) size	< 50 microns diameter	> 250 microns diameter	Spray quality
7	Volatility of agrichemical	High (vapour pressure > 10 mPa)	Low (vapour pressure < 0.1 mPa)	Check product label, SDS, or PSC
8	Sensitive area	Close (< 100 m) away	None, or more than 1 km distant	Identify on property spray plan
9	Buffer zone	None	Yes (> 100 m)	Guideline only
10	Shelter belts	No shelter	Live shelter, > 3 m high and 1 m thick	Not for herbicides
11	Toxicity	Class 6.1A, B, C,	Class 6.1D, E	Check label

10 m/sec = 36 km/h or 22 mph or 19.5 kn

The following sections explore some of the factors contributing to spray drift hazard.All spray applications have a driftable component and every spray application will also result in spray drift. Spray drift is the movement of airborne spray droplets away from the target. Physical droplet drift is normally due to wind movement. However some weather conditions can prevent the gravitational settling of small droplets and facilitate movement away from the spray site even during relatively calm conditions. The important point is how much drift occurred, and more importantly, where did it go, ie which direction from the spray application site.

The volume and distance of spray drift is influenced by many factors, but the main ones are droplet size, spray release height and wind speed. Given that in all spray applications some spray drift will always occur the important point then is to minimize spray drift hazard – what is at risk from any spray drift and the location of that risk in relation to the target area. Wind direction at the application site is therefore important in relation to drift hazard.The important concept is:

Risk (of spray drift) = *hazard* (associated with the application task) X *exposure* to those hazards

Minimising either or both the hazard or the exposure will minimize the risk.

4.1.1 Droplet Spectra

Droplet size is very important if agrichemicals are to be applied accurately and efficiently with the minimum off target drift. The volume mean diameter (VMD), measured in microns, is used to describe the droplet spectrum from a nozzle (one micron is 1/1000 of a millimeter- a full stop on this page is about 500 micron diameter). A sample of droplets is divided into two equal parts by volume, so that half the volume contains droplets smaller than the VMD and the other half of the volume contains droplets larger than the VMD. The size of the droplet determines the sedimentation velocity (vertical fall rate) and with what efficiency it will be intercepted by the target. Larger droplets are less prone to drift than smaller droplets.

The VMD has been the accepted method to compare different nozzles with respect to droplet size. However spray quality is a more complete description and is defined in ASAE S-572 Spray Classification by Droplet Size. This standard defines droplet spectrum categories for the classification of spray tips, relative to specified reference fan tips discharging spray into static air or so that no stream of air enhances atomization. The purpose of classification is to provide the tip user with droplet size information, primarily to indicate off-site spray drift potential, and secondarily, for application efficiency when selecting nozzles. Droplet size directly affects coverage, settling velocity, evaporation, movement by air currents and deposition on various targets. Consequently, the droplet size spectrum influences the spray distribution pattern, efficacy of pest control and potential drift hazards.

Knowledge of the agrichemical mode of action, the target plant surface and droplet spectra is essential to make decisions on which equipment to use to optimise application (target deposition) while minimizing spray drift. Tables4.1.1 and 4.1.2 refer[2].

Table 4.1.1 Droplet range for application/pest control[1].		
Application	**Spray quality[2]**	**Approximate VMD Range[3] (in microns)**
Fungicide		
foliar protective or curative	Medium (M)	226-325
Insecticide		
foliar contact or stomach poison	Medium (M)	226-325

[2]Adapted from Virginia Copoperative Extension, VirginiaTech
http://pubs.ext.vt.edu/442/442-031/442-031.html

foliar systemic	Coarse (C)	326-400
soil-applied systemic	Coarse (C) Very Coarse (VC) Extremely Coarse (XC)	326-400 401-500 > 500
Herbicide		
foliar/post-emergent contact	Medium (M)	226-325
Application	**Spray quality[2]**	**Approximate VMD Range[3] (in microns)**
foliar/post-emergent systemic	Coarse (C)	326-400
soil-applied/pre-emergent systemic	Coarse (C) Very Coarse (VC) Extremely Coarse (XC)	326-400 401-500 > 500

[1]Always read the label. Agrichemical product labels may specify what droplet size to use, which will direct nozzle selection and, in turn, affect spraying equipment configuration and calibration.
[2]ASABE (American Society of Agricultural & Biological Engineers) Standard 572.
[3]Reported VMD ranges vary widely, based upon the type of laser analyzer used. VMD = Volume Median Diameter: a value where 50% of the total VOLUME or mass of liquid sprayed is made up of droplets LARGER than and 50% SMALLER than this value.

Table 4.1.2 Spray quality classification chart

Category[1]	Symbol	Colour Code	Approximate VMD Range[2] (in microns)
Very Fine	VF	Red	< 145
Fine	F	Orange	145-225
Medium	M	Yellow	226-325
Coarse	C	Blue	326-400
Very Coarse	VC	Green	401-500
Extremely Coarse	XC	White	> 500

[1]ASABE (American Society of Agricultural & Biological Engineers) Standard 572.
[2]Reported VMD ranges vary widely, based upon the type of laser analyzer used. VMD = Volume Median Diameter: a value where 50% of the total VOLUME or mass of liquid sprayed is made

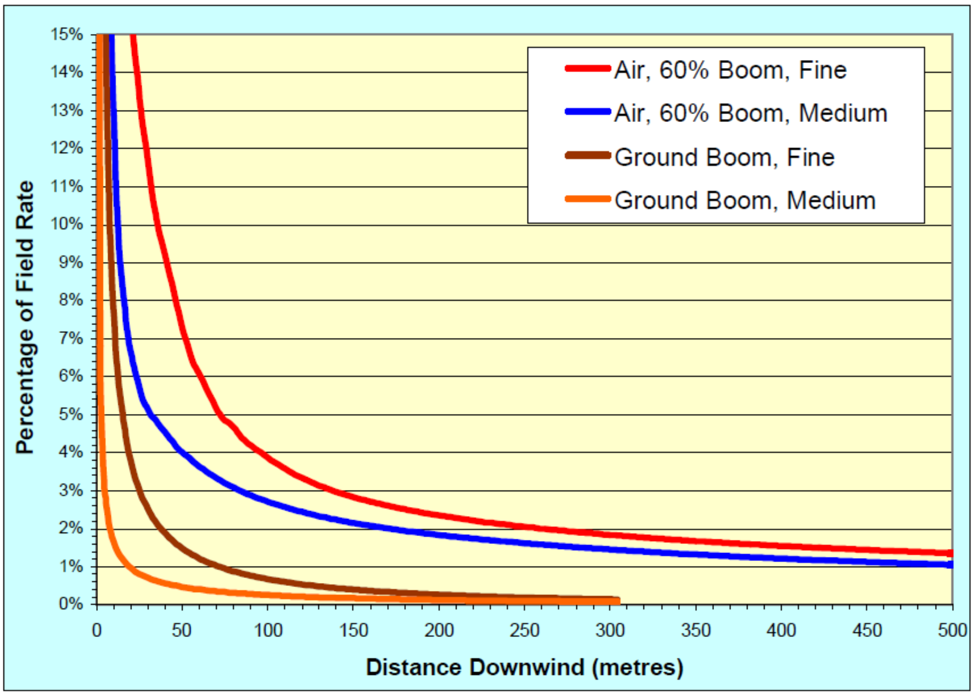
up of droplets LARGER than and 50% SMALLER than this value.

4.2 Spray Drift Risk Assessment Tool

Aerial application scenarios are now being used to address the most common agricultural and forestry spray practices. They are intended to help understand how to assess spray drift risk.The method relies on modeling software called AGDISP developed by the US Government. AGDISP is a 'true model' based on first principles that allows the use of different parameters to examine spray release height, wind speed, temperature, humidity and many others parameters including relevant features of different aircraft.

Summaries of the input parameters are included with each scenario. Each scenario displays downwind deposition data for ASAE droplet size categories each modeled for three different wind speeds eg the spray drift risk assessment scenario – see Table 4.3 below. This Chart has been extracted from AgDisp to illustrate the way in which airborne spray concentrations decrease downwind from the release point. All else being equal the airborne concentrations downwind from the spray release point will be higher for aerial because of the greater spray release height.

Table 4.3Typical model data for downwind spray deposition



On this graph, zero on the horizontal axis represents the downwind edge of the application area. The wind is blowing from left to right. The vertical axis is scaled in percent of the intended field application rate. For example, the top curve (red) shows that approximately 4% of the intended field rate is deposited at a distance 100 metres downwind from the downwind end of the application area.

4.3 Effect of Droplet Size on Drift

The larger the droplet, the faster it will fall to the ground. The falling droplets do not accelerate but fall at constant velocity (if the droplet remains the same size, ie no evaporation). Therefore the distance a drop will drift varies directly with release height and wind velocity. Droplets smaller than 200 microns are generally considered to be more prone to drift than larger droplets, which leads to the common “rule of thumb” that a spray quality no finer than coarsewill virtually eliminate spray drift in most situations.

4.4 Meteorological effects
Smaller droplets are more prone to drift. Weather conditions have a significant impact on drift because wind speed, direction, temperature, humidity and atmospheric stability affect the transport and deposition of droplets and particles. For these reasons it is advisable to have a weather station on site to monitor meteorological conditions, especially if the drift hazard is high.

4.5 Wind speed and direction
The wind speed and direction are very important factors to consider when applying agrichemicals. Wind speed and direction not only determines the direction of the spray, but also influences the degree to which droplets are caught by the canopy or spray target. The higher the wind speed the greater the risk of drift but the direction of drift is more predictable. Aerial application of agrichemicals should be avoided if the wind direction is towards sensitive non-target areas. There is no absolute cut off wind speed when it is too windy to fly as this will depend on the locality, the type of vegetation being sprayed and theagrichemical used. However spraying would normally cease when the wind reaches between 10 and 15 km/h. A rough guide of an 8 km/h wind is when blades of grass or leaves on trees tend to show a definite direction of lean. Spraying with a positive wind (under 8 km/h) is safer than spraying under very low wind conditions. This is because under still conditions very small spray particles may move unpredictably in any direction. Other meteorological factors to consider are temperature and relative humidity.

4.6 Temperature and Relative Humidity and inversions
Temperature and humidity play a major role in the rate of evaporation of water based spray droplets. Aerial spraying should cease once the air temperature reaches 20^{0}C or humidity drops to 50 percent. In New Zealand the humidity rarely reaches this low level. Aircraft performance drops under high temperature and low humidity conditions. The higher the temperature and the lower the relative humidity, the faster droplets will evaporate and reduce in size which in turn increases their potential to drift. Aerial spraying should only be carried out when the atmosphere is stable, i.e. the air temperature decrease is less than the adiabatic lapse rate. This inhibits upward air movement, so the atmosphere is stable. One of the greatest causes of spray drift is when an inversion layer exists above the target. Inversion layers are formed when the ground surface loses heat by radiation at night, followed by a hot sunny day. The air temperature closer to the ground surface is then cooler than the air above it. Small spray droplets released above an inversion layer will be carried by turbulence in any unpredictable direction.

The shearing of moving air at the target plant surface causes air turbulence. Therefore, the rougher the target surface the greater the turbulence. Droplets are affected by this type of turbulence according to their size. In low wind conditions larger droplets should be used, so that they settle fast onto the target. The main influence on small dropletdispersal is turbulence. Therefore some advantage can be gained by applying smaller droplets in stronger wind conditions that will increase the capture of droplets more efficiently in the plant canopy.

4.7 Operational factors
Four important factors to consider when planning and executing a spray application are:

- Avoid spraying in an inversion (typical of early morning conditions when there is a clear sky and little wind).
- Regardless of other factorswhen wind speeds exceed 10 km/h the risks may be unacceptable
- Wind speeds less than 3 km/h should be treated with caution because of possible variability in wind direction.
- Spray only with a wind blowing away from sensitive areas, and use smoke or other means to observe wind direction at the application site.

Humidity and temperature both affect spray drift by influencing evaporation rates, but humidity is more important than temperature in this respect. There is a significant increase in drift when relative humidity falls below 80% and or temperature rises above 20'C. Where low humidity and or high temperature conditions are common, sensitive areas should be sprayed when meteorological conditions are most favourable using techniques that minimise drift.

4.7.1 Air currents produced by the aircraft.

Fixed Wing
The wing of an aircraft produces a vortex which rolls upwards and outwards behind each wing tip. Any spray droplets caught in these vortices may also be moved outwards and up – depending on the circumstances as much as 5 times the height of the aircraft and are therefore more likely to move off target because they are airborne longer. See Fig 4.1a and 4.1b.

Figure 4.1 a) No vortex – Fixed wing

Figure 4.1 b) Vortex – Fixed wing

Figure 4.2 a) No vortex – Helicopter

Figure 4.2 b) Vortex – Helicopter

Rotary Wing

Air currents near the ends of the rotors are outward and upwards producing a trailing vortex somewhat similar and potentially more pronounced than that of the fixed wing aircraft. At low forward speeds of less than 25 km/h, a turbulent wake is also produced along with a pronounced downwash in the central portion of the boom. Increasing speed to 50 km/h and greater, considerably reduces the strength of these vortices and downwash, resulting in a less overall turbulent airflow pattern. See Fig 4.2a and 4.2b.

To maximize deposition on target and minimize losses means minimizing the effects of these air movements by using a range of techniques including boom placement on the aircraft, nozzle selection and orientation and flying technique. For both FW and helicopters, greater all-up-weight and higher speeds will produce stronger vortices.

4.8Spray Pattern Testing Track spacing and swath width

Evenness of application on the specified target for both liquids and solids can only be determined by testing a single pass of the aircraft to establish the swath pattern. Such testing is done under controlled conditions using collectors appropriate for the task.

The swath width is the total width of one pass of the applicator. The distance between successive passes of the aircraft is the track spacing, sometimes called the bout width, which will always be less than the swath width. The required track spacing (bout width) is determined according to the evenness of application required. CV% (=standard deviation divided by the mean x100) depends on the shape of the swath pattern. The higher the CV% value the poorer the overall distribution ie the more uneven it is. (For systemic herbicides a 30% CV is usually the maximum acceptable.) Almost all agricultural aircraft are fitted with GPS which allows the pilot to adopt and accurately maintain any track spacing nominated.

5. VERTEBRATE TOXIC AGENTS (VTA)

Under new legislation vertebrate toxic agents (VTA) are both hazardous substances (HSNO Act) and vertebrate toxic agents (ACVM Act). The Health and Safety in Employment Act also applies. VTA includes pellets containing sodium fluoroacetate (1080), soluble concentrate containing sodium fluoroacetate (when mixed with food bait), and pellets containing pindone. This GN deals with the most common aerial application system – 1080 applied as cereal bait.

5.1 VTA application methods

Cereal baits are available at different concentrations of 1080. Normally a prefeed bait application is made in which case the baits have no colouring. Any bait containing 1080 will be coloured green.

Preferably, baits should each be about 12-gram - this will ensure that single (eg 12-gram) baits will contain a lethal amount of 1080 for a large possum (> 3 kilograms). Twelve-gram baits may also be more important at lower sowing rates to ensure all possums have access to enough toxic bait to receive a lethal dose. Bait fragmentation resulting in small pieces of bait is a hazard because the resultant fragments become available to animals other than the target pest. Fragmentation may be due to poor bait cohesion when manufactured or a poorly designed/operated spinning disc mechanism on the spreader. Depending on the design a spinning disc spreader may achieve a swath width of 150m or more using 12 kg baits. Because the baits are relatively large, their trajectories are in unaffected by local wind speeds that are low enough to allow the aircraft to continue to operate. That means the actual placement of bait on the ground can be accurately predicted and tracked by following the flight path of the aircraft.

Bait application rates are low (5 kg per ha is common but down to 1 kg per ha or less). Baits are usually applied using a hopper slung beneath a helicopter, similar to the method used for fertiliser application. If you have 10gm baits that means 100 baits per ha or 1 bait every 100m^{2}. To check on swath width – ie the width achieved when baits are applied, 10m x 100m grids are laid out across the flight path and the number of baits counted in each grid can be used to calculate effective application rate.

5.2 The application task

While not all of the specifc tasks items will be the responsibility of the aerial operator, it is good practice to check that those items not the responsibility of the aerial operator have been met by the contractor or delegated person.

Contract item	Detail
a. All licenses, permits and consents obtained	• MoH permit sighted • Pilots and ground crew licences and ratings current
b. Boundaries of operational/treatment are defined	• Exclusions zones, water supply catchments and intakes, any other sensitive areas • Buffer zones mapped and specified
c. Notifications	• Public and other affected parties notified within the required time • Appropriate information provided
d. Signage	• In the right areas • Signs have the required information • Sign removal after the operation
e. Loading equipment and practice	• Holder of controlled substance licence available at the loading site • Appropriate equipment available, including PPE
f. Application equipment calibrated	• Bait quality check • Provision for monitoring bait output at the specified application rate • GPS equipment fitted • Pilot current and competent in GPS • Capability to achieve ± 2 m of required track • Secondary tracking available
g. Aircraft operation	• Flight paths plotted

6. NOISE ABATEMENT

The Code of Practice for Aircraft Noise Abatement provides guidance on the safe and responsible operation of aircraft so that their noise nuisance is minimized. The Code forms part of the AIRCARE Accreditation programme. See also Noise management in mixed-use urban environments and Managing noise through enforcement

Appendix 1:Hazardous Substances Physical Hazard Classification Chart

Property	**Flammability**									**Capacity to Oxidise**		
Class	**Class 2**		**Class 3**		**Class 4**					**Class 5**		
Subclass	2.1.1 Gases	2.1.2 Aerosol	3.1 Liquids	3.2 Liquid Desensitised Explosive	4.1.1 Readily Combustible	4.1.2 Self Reactive	4.1.3 Solid Desensitised Explosive	4.2 Spontaneous Combustible	4.3 Dangerous when Wet	5.1.1 Liquids/Solids	5.1.2 Gases	5.2 Organic Peroxides
Hazard Classification	2.1.1A AH	2.1.2A AH	3.1A AH TR	3.2.A	4.1.1A	4.1.2A AH TR	4.1.3A	4.2A AH TR	4.3A AH TR	5.1.1A AH TR	5.1.2A AH	5.2A AH TR
Hazard Classification	2.1.1B		3.1B AH	3.2B	4.1.1B	4.1.2B AH TR	4.1.3B	4.2B AH	4.3B AH	5.1.1B AH		5.2B AH TR
Hazard Classification			3.1C	3.2C		4.1.2C AH	4.1.3C	4.2C	4.3C	5.1.1C AH		5.2C AH
Hazard Classification			3.1D			4.1.2D AH						5.2D AH
Hazard Classification						4.1.2E AH						5.2E AH
Hazard Classification						4.1.2F						5.2F AH
Hazard Classification						4.1.2G						5.2G

Notes: AH = Approved handler required. Volumes may apply.

TR = Tracking required.

Class 1 (Explosives) are not included as there are no agrichemicals in this class.

Appendix 2 Hazardous Substances Biological Hazard Classification

Property	Toxicity (Human Risk)								Corrosiveness			Ecotoxicity			
Class	Class 6								Class 8			Class 9			
Subclass	6.1 Acutely Toxic	6.3 Skin Irritation	6.4 Eye Irritation	6.5 Sensitation	6.6 Mutagen	6.7 Carcinogen	6.8 Reproductive Development	6.9 Target Organ	8.1 Metallic Corrosive	8.2 Skin Corrosive	8.3 Eye Corrosive	9.1 Aquatic	9.2 Soil	9.3 Terrestrial Vertebrate	9.4 Terrestrial Invertebrate
Hazard Classification	6.1A TR AH	6.3A	6.4A	6.5A	6.6A	6.7A AH	6.8A	6.9A	8.1A	8.2A AH	8.3A	9.1A AH*	9.2A AH*	9.3A AH*	9.4A AH*
Hazard Classification	6.1B TR AH	6.3B		6.5B	6.6B	6.7B	6.8B	6.9B		8.2B		9.1B	9.2B	9.3B	9.4B
Hazard Classification	6.1C TR AH						6.8C			8.2C		9.1C	9.2C	9.3C	9.4C
Hazard Classification	6.1D											9.1D	9.2D		
Hazard Classification	6.1E														

Notes: AH = Approved handler required. Volumes may apply * indicates that AH is required unless exempted

TR = Tracking required.Class 7 (Radioactive substances) are not included as they are not applicable to agrichemicals.

Appendix 3 Diagram showing possible relationship of the various terms and definitions used