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SID 5 Research Project Final Report

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Project identification

1. Defra Project code: PS2011
2. Project title: Aquatic buffer zones in the UK - the potential to extend the existing LERAP scheme for boom sprayers.
3. Contractor organisation(s): The Arable Group (Silsoe Spray Applications Unit)
4. Total Defra project costs (agreed fixed price): £ 9,965
5. Project: start date .... 11 December 2006
   end date .... 22 January 2007

6. It is Defra's intention to publish this form.
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Executive Summary

7. The executive summary must not exceed 2 sides in total of A4 and should be understandable to the intelligent non-scientist. It should cover the main objectives, methods and findings of the research, together with any other significant events and options for new work.

Summary

1**. Extending the existing LERAP scheme**

A no-spray (buffer) zone is a key risk mitigation tool for certain products to ensure aquatic ecosystems are protected. A no spray buffer zone of 5 m is currently used for field crops in the UK, i.e. applications made by boom sprayers. The opportunity for farmers to reduce a 5 m no spray buffer zone can be achieved via the LERAP scheme post approval. The LERAP scheme seeks to maintain the same high level of protection whilst increasing the practicality of using buffer zones. Data relating to the current Local Environmental Risk Assessment for Pesticides scheme has been reviewed to determine the potential to extend the widths of buffer zones within a revised scheme. Results from the review concluded the following.

(i) It is possible to extend the existing scheme and that three additional buffer zone distances of 10, 20 and 50 m could be added in an extended scheme.

(ii) In an extended scheme it is necessary to have a definition of a standardised water body and a drift deposition curve upon which the assessments of buffer zone distance will be based. It is proposed that:

(a) no changes are made to the existing definition of a standardised water body on which buffer zone calculations are based;

(b) the current drift deposition curve based on data from German trials be reviewed to take account of the likely boom heights to be used in practice: given that there is no data from field trials conducted with boom heights greater than 500 mm and measuring ground deposits at downwind distances of 5.0 to 50.0 m, it is proposed that a drift deposition curve corresponding to the operation of boom sprayers with boom heights of circa 700 mm be generated based on the limited data available, the form of relationships established in trials with boom heights of 500 mm and the results from wind tunnel and computer modelling studies: in the longer term, experiments should be conducted to establish the form of the drift deposition curve for application conditions typical of current UK practice particularly with regard to boom heights and forward speeds.

(iii) The widths of buffer zones in the existing scheme can be reduced based on applications using less than the full dose, features of the water body and the drift reducing characteristics of the application system. It is proposed that the extended scheme would allow changes to the dimensions of larger buffer zones based on the applied dose rate and drift reducing characteristics of the application system. Changes to the widths of buffer zones initially 10 to 50 m wide would be made in 5.0 m increments.

2. Using wider buffer zones with the mandatory use of drift reducing application systems.

It is concluded that the use of wider buffer zones and the mandatory use of drift reducing application systems is feasible although there are likely to be implications for efficacy with the treatment of small targets such as grass weeds at an early stage of growth. If implementing such a system it is recommended that two levels of drift reducing capability in relation to a reference system are used (giving 25 to 50% and greater than 25% reductions) with buffer zone distances of 5, 10 and 20 m.

3. The introduction of an additional Star rating category achieving a 90% drift reduction in relation to the defined reference system and the implications this may have for the approaches to using extended buffer zones.

The approach of using an additional Star rating category giving a 90% drift reduction has been adopted in some European countries and would give options for substantially reducing the widths of buffer zones. The results of this review however suggest that without a comprehensive restructuring of the ways in which drift reductions against a reference are assessed, it is unlikely that an adequate resolution of drift reducing capability will enable 90% drift reductions to be assessed with sufficient confidence to include them in a revised system.

4. Proposals for further work

Further work is needed to:

(a) derive a drift deposition curve that can be used in the short term (if needed) based on existing experimental data (field and wind tunnel) and the results from modelling exercises that will relate to the use of boom sprayers with boom heights of greater than 500 mm and travelling at speeds greater than 10 km/h;

(b) provide sufficient data from field trials (in the longer term) to support the establishment of a drift deposition curve at the 90^{th} percentile relating to the use of boom heights above 500 mm and spraying speeds of more than 10 km/h;

(c) review the protocols for assessing the drift reducing capabilities of application equipment particularly using drift reducing nozzles on conventional boom designs and that may involve spray trajectories other than vertically downwards when stationary, to consider approaches to managing the variability in such measurements, the linkage between wind tunnel and field measurements and the use of nozzles at the end of the boom that modify trajectories to give an improved definition at the edge of the treated area.

8. As a guide this report should be no longer than 20 sides of A4. This report is to provide Defra with details of the outputs of the research project for internal purposes; to meet the terms of the contract; and to allow Defra to publish details of the outputs to meet Environmental Information Regulation or Freedom of Information obligations. This short report to Defra does not preclude contractors from also seeking to publish a full, formal scientific report/paper in an appropriate scientific or other journal/publication. Indeed, Defra actively encourages such publications as part of the contract terms. The report to Defra should include:
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   - the extent to which the objectives set out in the contract have been met;
   - details of methods used and the results obtained, including statistical analysis (if appropriate);
   - a discussion of the results and their reliability;
   - the main implications of the findings;
   - possible future work; and
   - any action resulting from the research (e.g. IP, Knowledge Transfer).

AQUATIC BUFFER ZONES IN THE UK – THE POTENTIAL TO EXTEND THE EXISTING LERAP SCHEME FOR BOOM SPRAYERS

1. Project objectives

1. To examine the potential for extending the existing Local Environmental Risk Assessment (LERAP) scheme to accommodate wider buffer zones and an increased range of application situations and, if appropriate, propose ways in which this could be achieved.

2. To examine and report the potential for using wider buffer zone specifications as part of the product approval process with the use of drift reducing nozzles being specified as part of the statutory conditions of use and with a smaller width of buffer zone also being specified.

3. To evaluate the option of using a new category for drift reducing nozzles that could, for example, achieve drift reduction of greater than 90% when compared with the reference standard system.

2. Extending the existing LERAP system

The concept of using an unsprayed “buffer zone” adjacent to surface water to minimise the potential for contamination by pesticides during applications with boom sprayers treating arable crops can provide protection by:

(a) minimising the risk of direct over-spray of the water body; and
(b) using spray sedimentation and impaction within the buffer zone to reduce the potential deposition on to the water surface.

The current Local Environmental Risk Assessment for Pesticides (LERAP) scheme is based on the use of a 5.0 m wide buffer zone adjacent to surface waters and measured from the edge of the sprayed area to the top of the bank surrounding the surface water. The width of this buffer zone can be reduced based on the results of an assessment that takes account of:

- the dose rate of chemical being applied;
- the characteristics of the surface water (size of the water surface and whether or not it is a dry ditch);
- the drift reducing potential of the application system in comparison with a reference system based on the use of conventional FF110/1.2/3.0 nozzles on a standard boom arrangement.

The relatively small size of buffer zone within the existing LERAP scheme provides protection based on a combination of (a) and (b) above with the component due to (a) being of substantial importance. Increasing the width of the buffer zone would enable the approval and use of products that would not otherwise be possible because the expected level of surface water contamination would give predicted concentrations above the acceptable concentrations for these products. This study therefore examines the options of working with larger buffer zone distances, the methods that might be used for adjusting the width of these larger zones and the requirements associated with implementing such a scheme.

The reduction in pesticide deposition on to horizontal surfaces at ground level with increasing distance from a treated area is well established and documented (e.g. Ganzelmeier *et al.*, 1995; van de Zande *et al*., 2002) and is the basis for buffer zone protection measures that have been implemented in a number of countries. These have been reviewed as part of this project and are summarised in Appendix 1.

The mechanisms that lead to drift from boom sprayers operating over arable crops have been defined by a number of authors (e.g. Miller, 1993) and have been modelled mathematically (e.g. Miller and Hadfield, 1989; Ghosh and Hunt, 1994). Small droplets (typically <150 µm in diameter) are detrained from the spray structure generated by most nozzle designs used on boom sprayers by cross flows of air generated by a combination of the natural wind and the forward motion of the sprayer. These detrained droplets are then transported away from the treated area by the action of the wind. The larger airborne droplets have significant fall speeds (e.g. 100 µm diameter water droplets have a terminal velocity of 0.28 m/s) and hence deposit on to horizontal surfaces at shorter downwind distances while smaller diameter droplets are subject to atmospheric dispersion with less sedimentation. The rate of decrease of ground deposits with increasing distance from the edge of the treated area is therefore generally greater than that of airborne concentrations at a given height or range of heights.

Calculations as part of the pesticide approvals process relating to aquatic buffer zones are based on comparing predicted environmental concentrations (PEC) in a typical water body with acceptable concentrations defined from toxicity tests. This requires a standard form of water body (see Figure 1) and a defined relationship for the horizontal sedimenting drift profiles with increasing distance from the treated area. Existing assessments are based on the drift data reported by Rautmann *et al.*, 2001 which were obtained using similar approaches to those reported by Ganzelmeier *et al*., 1995. (see Figure 2).

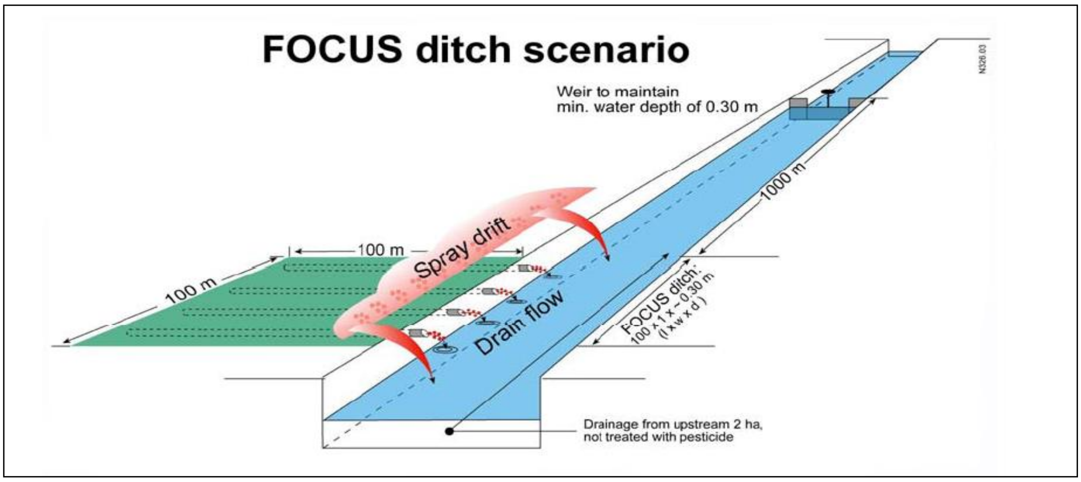

Figure 1. Standardised water body configuration for calculating concentrations due to surface contamination from drift and from drain flow.

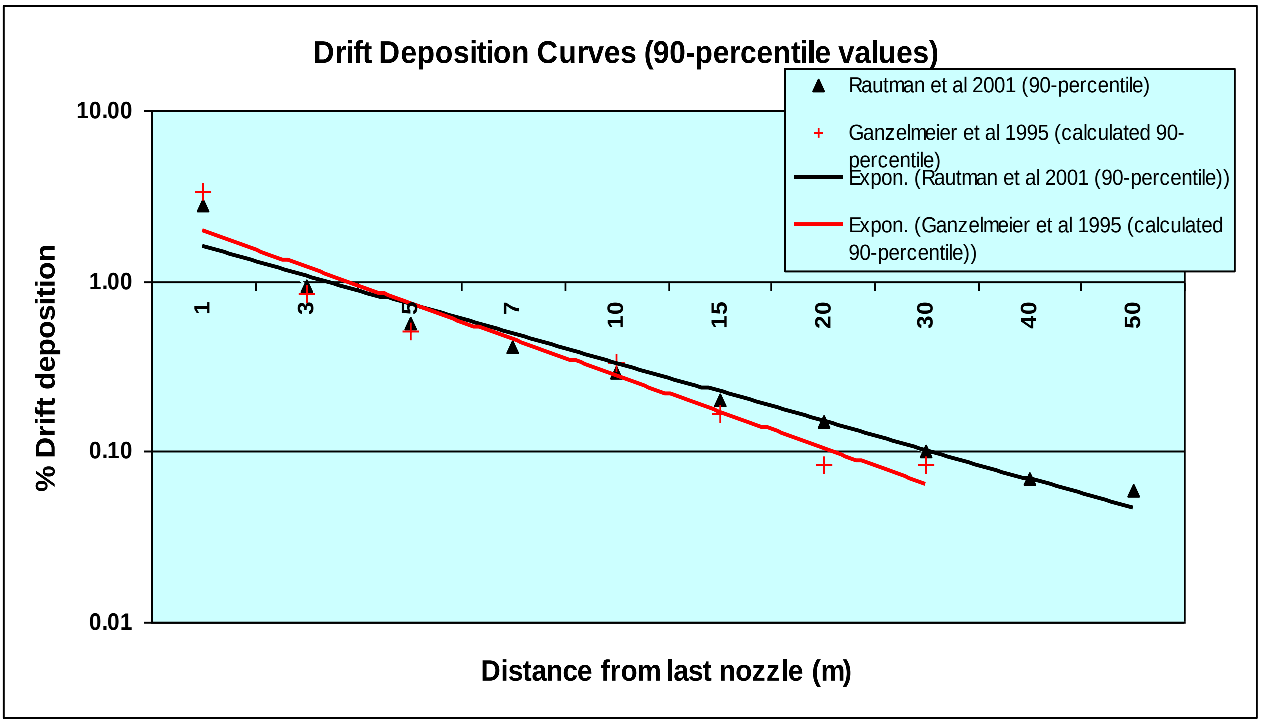

Figure 2 Drift deposition with distance from the treated area relationships used in the current approvals calculations (relationships are based on 90th percentiles measured downwind of a treated area and described by an exponential function)

These are reported as 90th percentile values. The Ganzelmeier data were originally reported as 95th percentiles but have been recalculated to 90th percentiles to bring these data in line with the Rautman data.

Any revision of a scheme for using buffer zones to protect surface water from spray drift contamination must therefore consider:

(i) the specification of the water body to be protected;
(ii) a standardised relationship for the horizontal sedimenting drift profile with increasing distance from the treated area;
(iii) methods of adjusting the width of the buffer zone based on a number of defined factors.

2.1 Specification of the standardised water body

The specification for a standard water body based on a ditch (Figure 1) with water 1.0 m wide and 0.3 m deep and considered over a 100 m length of the ditch is used as a basis for calculating concentrations arising from drain water flows as well as airborne drift contamination. No changes are proposed to this specification.

2.2 Drift deposition curves

While the relationships defined from experimental measurements by Ganzelmeier *et al*., (1995) and Rautmann *et al*., (2001) have been used as the basis for determining the widths of buffer zones needed to protect surface water, there is now evidence to suggest that these relationships are not representative of typical spray application conditions currently used in the UK. The field measurements reported by Ganzelmeier *et al.*, (1995) and extended by Rautmann *et al.,* (2001) were based on using relatively small booms (12 m wide or less) travelling at less than 8.0 km/h and applying volumes of greater than 250 L/ha. The need to operate with high work rates so as to achieve timely applications, minimise application costs and make the most effective use of scarce labour resources has meant that in the UK applications are now commonly made with booms that are 24 m wide or greater, travelling at speeds of around 12 km/h and applying volumes of 150 L/ha or less. These trends will have implications for the magnitudes of drift. Figure 3(a) plots drift deposition profiles measured in different conditions and reported by different authors.

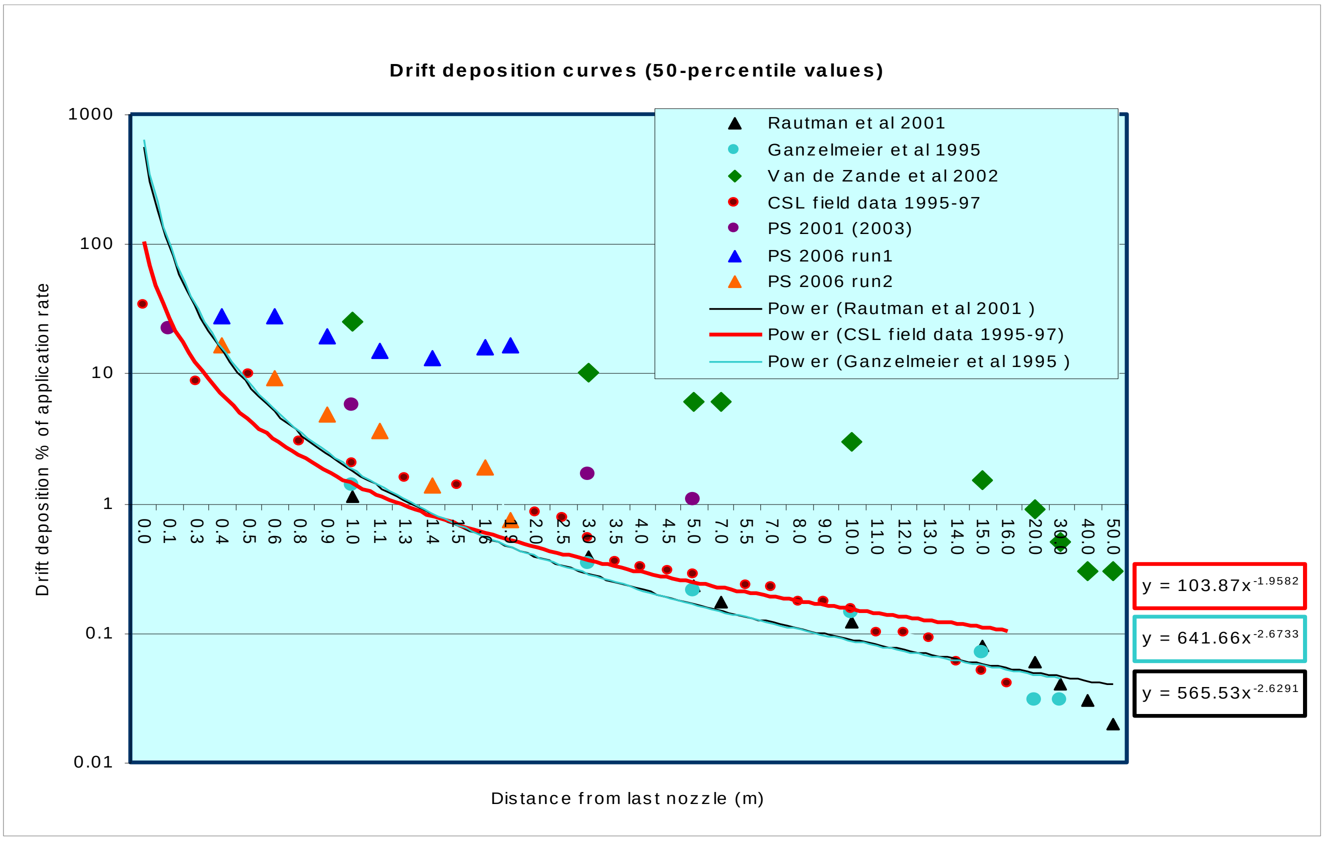

Figure 3(a). Drift deposition at various distances downwind of a treated area – comparison of results from a number of sources.

Data from CSL (1995-97 field trials, Glass – private communication with data), Ganzelmeier *et al.*, (1995) and Rautmann *et al.*, (2001) were obtained by measuring drift deposition downwind of relatively small boom sprayers (12 m boom width or less) operating over short cut grass with a boom height of 500 mm and travelling at forward speeds of 6.0 to 8.0 km/h. The data from CSL were obtained using a 6.0 m boom sprayer operating to make a number of passes along a single defined track and using FF110/0.8/3.0 and FF110/1.2/3.0 nozzles applying 120 and 180 L/ha respectively. Results from the two nozzle sizes gave similar values. The data plotted on Figure 3(a) are mean values for the two nozzle sizes and have been adjusted to give drift deposition profiles from a treated area for direct comparison with the data from Ganzelmeier *et al*., and Rautmann *et al*. Results from both Ganzelmeier *et al*., and Rautmann *et al*., are based on operations following good agricultural practice in Germany typically applying more than 300 L/ha through a range of nozzle designs and with nozzle sizes of FF110/1.6/3.0 or larger. These results show relationships of the expected form with relatively good agreement between the different datasets. The smaller nozzle sizes used in the CSL experiments would create finer sprays than those used in the German work and this would be expected to give higher values of drift deposition. It is noticeable that the results from the measurements by CSL showed a more rapid reduction in drift deposition with increasing distance from the sprayed area and this may have been due to differences in the terrain over which the measurements were made and/or the performance of the nozzles used.

Experiments conducted as part of research work for The Pesticides Safety Directorate (PS 2001 and PS 2006 – Anon, 2007(a)) both used a boom height 700 mm above the target and speeds in the range 10 to 12 km/h. Levels of drift deposit that were higher than those made over short grass with a boom height of 500 mm were recorded but only at relatively small distances downwind of the sprayed area. The results reported by van de Zande *et al*., (2002) were for boom sprayers operating in potato or cereal crops with a boom height of 500 m above the top of the crop applying 300 L/ha as a medium quality spray. Values are substantially higher than other reported data. It should be noted that the results in Figure 3(a) have not been plotted from the original data from van de Zande but from relationships reported in published papers. The power law function does not then provide a good description of the drift deposition profile particularly close to the treated area.

The paper by de Schampheleire *et al.*, (2007) gives power law equations for the drift deposition based on both the German and Dutch data and uses values from these relationships in comparative risk assessments. These equations are plotted in Figure 3 (b) and show relationships of the same form as Figure 3(a) as expected.

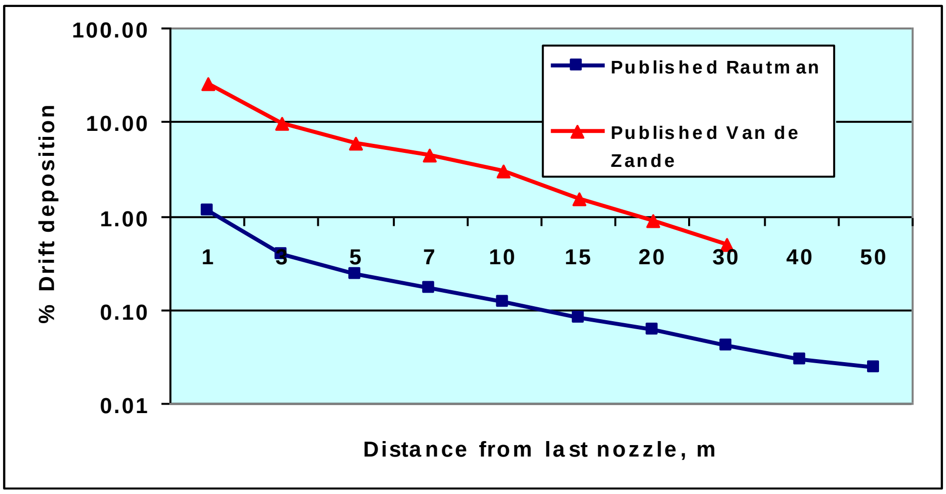

Figure 3(b). Drift deposition predicted from equations used by de Schampheleire *et al.*, 2007

Experiments, conducted by the team of which van de Zande is a part, examined the effect of boom height on spray drift deposition when treating an arable crop (potatoes, sugar beet and yellow mustard) with a 24 m trailed boom sprayer. Results from these experiments extracted from the data in a paper reporting the work are summarised in Figure 4 below.

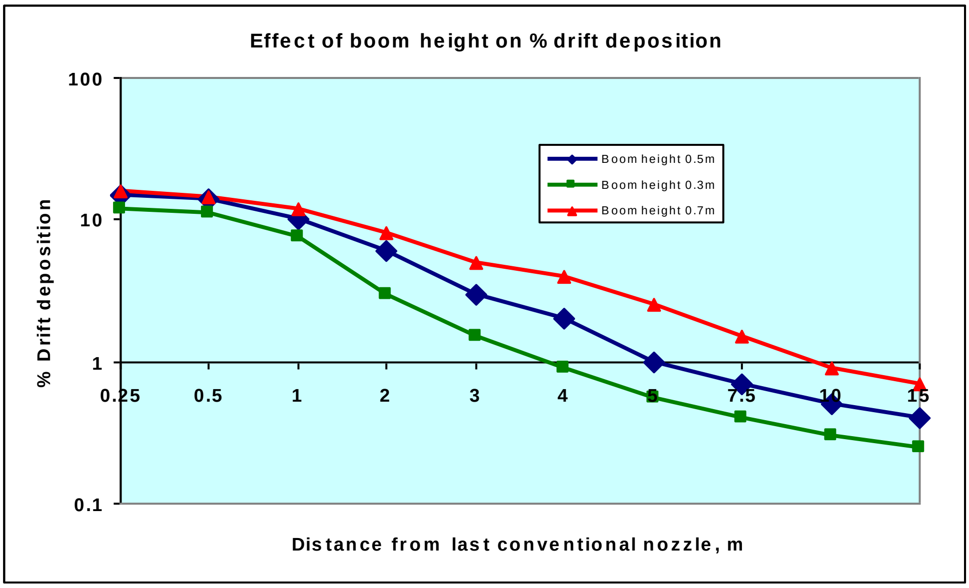

Figure 4. The effect of boom height on spray deposition in field experiments (from Jong *et al.*, 2000).

Measurements of drift deposition from the treated area have often used the last nozzle position on the boom as the reference from which measurements have been made. This does not then account for the proportion of the end nozzle output that is directed away from the main part of the boom assuming a conventional nozzle is used at the boom end or the displacement of the sprayed swath by the action of the cross wind (Taylor, 2002). The use of a “boom end nozzle” design would give a sharper cut off to deposits within the treated area and is used as part of control measures to prevent surface water contamination in the Netherlands. The use of “boom end” nozzles is particularly relevant when small buffer zone distances are to be used and is therefore less relevant when using larger zones in an extended scheme. However, it is recommended that protocols used to support the existing LERAP scheme be modified to accommodate the use of “boom end” nozzles.

The possible effects of nozzle type and boom height on drift has been examined in a series of wind tunnel tests in which the total airborne spray volumes at different downwind distances was measured on an array of passive sampling lines. All measurements were made in a wind speed of 2.0 m/s using a protocol based on that used to collect data to support claims for LERAP Low Drift star ratings and the results are summarised in Figures 4 and 5. These show that:

- drift volumes were critically dependant upon boom height with a change in height from 500 to 700 mm giving increases of drift of 409 and 171% at the 2.0 and 5.0 m sampling distances respectively;
- higher values of drift were measured with the extended range/variable pressure nozzle design and this is consistent with the wider spray angle and smaller droplet size produced by this nozzle design;
- larger differences due to boom height and nozzle type when measured at 2.0 m compared with results at 5.0 m downwind of the nozzle.

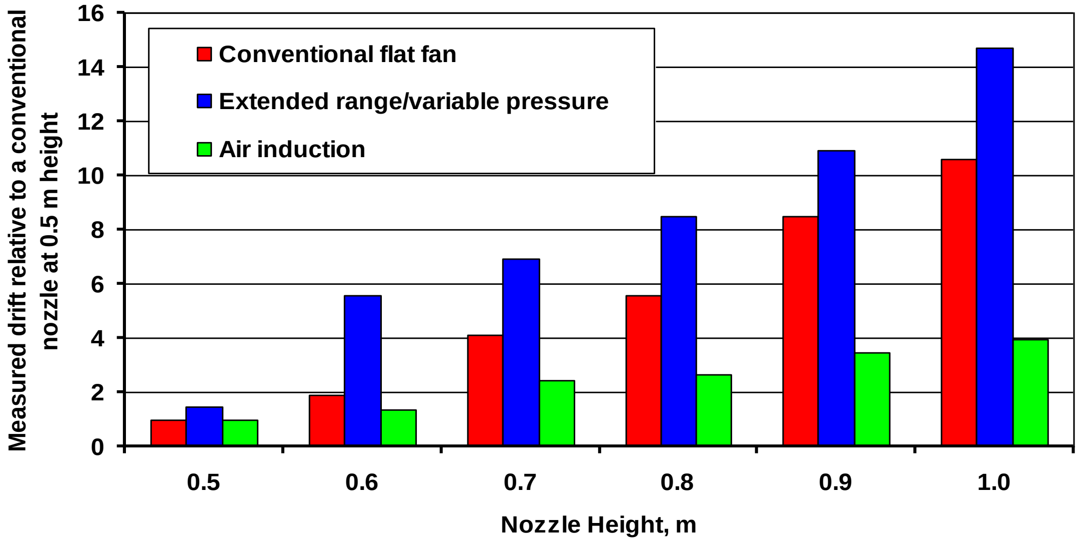

Figure 4. Measurements of the relative total airborne spray in wind tunnel conditions 2.0 m downwind from a static nozzle for different nozzle designs operating at different heights above the ground

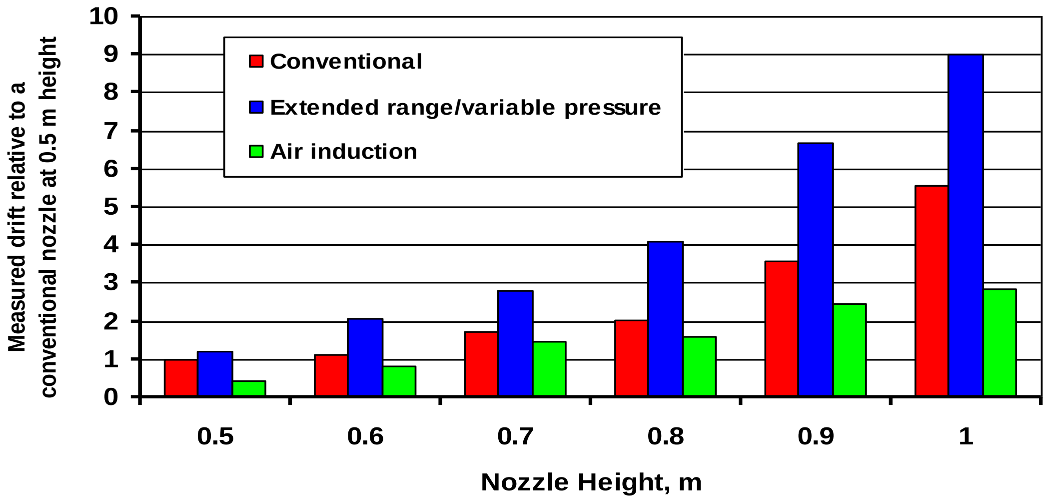

Figure 5 Measurements of the relative total airborne spray in wind tunnel conditions 5.0 m downwind from a static nozzle for different nozzle designs operating at different heights above the ground

The results reported in Figures 4 and 5 give total airborne spray volumes and therefore do not directly map to the drift deposit data shown in Figure 3(a). It is also possible that measurements made in wind tunnels will not directly scale to field conditions although results obtained in a LINK-funded project investigating the effects of boom height on drift strongly support the trends shown in Figures 4 and 5.

Results reported by Byass and Lake (1977) also indicated that boom height was a major factor influencing spray drift although the measurements of spray deposition in this study were made with a static boom. Experiments with a moving boom assessed drift effects using sensitive plant species downwind but the application conditions used were not directly comparable with current UK practice. Results reported by Norby and Skuterud (1974) also showed a increase in drift with boom height with drift 1.0 m downwind increasing by a factor of 6.5 for an increase in boom height from 0.4 to 0.8 m.

It is concluded that boom height is a major factor influencing drift deposition and that current commercial practice may involve the use of boom heights of more than 500 mm. No published information is currently available relating to the heights of booms that are used in practice and it is accepted that such data would be difficult to obtain. Observations of sprayer operation and discussions with a number of operators support the suggestion that many applications are made with boom heights greater than 500 mm above the crop canopy. If this is a true reflection of current practice, then the drift deposition curves produced from experiments conducted over short cut grass and using a boom height of 500 mm are unlikely to be representative of the current commercial situation in the UK.

There is currently no dataset from field experiments that relates to boom heights of more than 500 mm that could be used as a basis for determining buffer zone widths in a revised scheme. The data from van de Zande et al., (2002) is higher than from other comparative studies and while some of the differences between this and other datasets can be explained by the presence of the crop and the use of extended range/variable pressure nozzles, the values still appear to be high. There is therefore an urgent need to obtain a drift deposition profile for distances up to 50 m from a sprayed area that could be used as a basis for determining buffer zone distances in a revised scheme. It is recognised that this will take time to obtain and that some measure may be needed in the interim. This could be based on:

1. a power law function fitted to the available data for a boom height of 700 mm and with a form similar to that for the CSL, Ganzelmeier and Rautmann data;

2. the existing curve on Figure 3(a) from the fitted CSL data but recognising that this may be too low and need to be revised at a later date.

It is also recognised that existing modelling approaches (e.g. Miller and Hadfield, 1989) and those being developed as part of current research funded by The Pesticides Safety Directorate in the BREAM project also provide some basis for establishing the form of drift deposition with distance from the treated area. This may be important particularly when considering distances greater than 20 m downwind when measurements in field conditions are difficult to make with the required accuracy and resolution.

2.3 Potential buffer zone distances that could be used in a revised scheme

In order to consider the sizes of buffer zone that may be appropriate in any extended scheme in the UK, a review of possible scenarios relating to products that could not currently be approved was undertaken in conjunction with staff from The Pesticides Safety Directorate (J. O'Leary-Quinn – personal correspondence with data) and the results are summarised in Appendix 2. Four cases were considered involving a range of application rates and toxicity profiles. Each of the cases combined would gain approval at the lower application rates based on the current assessment methods but would only be approved at the higher rates if a wider buffer zone were to be used. In all of the examples extending the buffer zone width to 10 m would enable the products to be approved. However, the current assessments are based on the Rautmann *et al*., (2001) data expressed as 90th percentiles. If the agreements relating to the effects of boom height on spray drift profiles are accepted, then the levels of drift deposition will be increased and the width of the buffer zone needed to give protection will be wider. An indication of the increase in buffer zone widths has been obtained by using the data from van de Zande *et al*., rather than Rautman *et al*., in the calculations and the results are summarised in Appendix 2. It should be noted that no other data has given drift deposition values as high as those reported by van de Zande *et al*.

An examination of the widths of buffer zones used in other European States as summarised in Appendix I suggests that zones up to 50 m wide are used in many circumstances. It is therefore proposed that three additional buffer zone categories be added to the current UK system having widths of 10, 20 and 50 m. In proposing buffer zone distances with set values it is expected that this will provide a basis for a scheme that is relatively simple to understand and implement at the farm level. A greater degree of complexity will arise when considering options for reducing the widths of buffers are considered (see 2.4 below) but it is anticipated that the concept of dealing with fixed buffer zone values will be preferable to an infinitely variable system.

The values of 10, 20 and 50 m for potential buffer zone widths have not been related to typical widths of boom sprayer currently used in the UK. There may be some merit in making such a linkage particularly given that the latest survey of farm spraying practices in the UK (Garthwaite, 2004) indicated that more than 50% of the arable area was sprayed with booms of between 21 and 24 m wide, and that 24 m has become an industry standard. However, it also needs to be recognised that:

(i) a range of boom sizes are used in practice (Garthwaite, 2004);

(ii) boom sizes are tending to increase;
(iii) compliance with international standards requires the output from the boom to be controlled in relatively short lengths and that modern sprayer control systems can achieve this level of control as part of a standard specification.

2.4 Options for reducing the widths of buffer zones in a revised scheme

The current LERAP scheme has the provision to reduce the width of a buffer zone depending on the applied dose, features of the surface water body and the drift reducing characteristics of the application system. Buffer zone distances are adjusted in increments of 1.0 m with a minimum buffer zone distance of 1.0 m. It is considered that the same approach can be used in an extended scheme with some adjustments to account for the larger scale of the buffer zones to be used.

2.4.1 Adjustments relating to the applied dose

The existing scheme provides for reductions in the width of the buffer zone for reduction in applied dose in steps of 25% of the maximum label rate. This approach is considered to be applicable to an extended scheme and desirable providing that steps towards implementation are not unduly complicated. For buffer zones in the range 10 to 50 m it is proposed that changes in buffer zone distance should be in increments of 5.0 m whereas for zone widths of up to 10 m, the increment for reducing the width of the zone should be 1.0 m in line with the existing system.

2.4.2 Adjustments relating to features of the water body

The existing scheme reduces the width of the buffer zone for surface water bodies that are wider than 3.0 m. For water bodies that are between 3.0 and 6.0 m wide, the size of the buffer zone can be reduced by 50% and when more than 6.0 m wide, then the minimum 1.0 m wide buffer zone must be applied. For a dry ditch at the time of application the minimum buffer zone distance is applied under the current system. Such adjustments are appropriate when considering buffer zones that are nominally 5.0 m wide but are less relevant when larger buffer zone distances need to be used. It is therefore recommended that the adjustments to buffer zone widths based on features of the water body are retained when using a distance of 5.0 m but that this factor is not included when larger zone widths have to be used.

2.4.3 Adjustments relating to the drift reducing characteristics of the application equipment

Three levels of drift reduction are defined within the existing system based on a reference FF110/1.2/3.0 nozzle mounted on a conventional boom arrangement in terms of LERAP Low Drift star ratings that are defined as follows:

- a one star rating giving drift levels greater than 50% and up to 75% of the reference system;
- a two star rating giving drift levels greater than 25% and up to 50% of the reference system; and
- a three star rating giving drift levels up to 25% of the reference system.

The reference system is based on a 12 m boom sprayer travelling at 8.0 km/h and with a boom height of 0.5 m above the crop canopy and drift assessments are based on ground deposits at distances up to 6.0 m beyond the end of the boom. Claims for LERAP Low Drift star ratings by commercial organisations can be based on field trials with full-scale measurements of drift deposition profiles or wind tunnel measurements with single nozzles that are then mounted on a conventional boom system. Such claims are technically assessed by an Accredited Laboratory and then are “recognised” by The Pesticides Safety Directorate. Details of equipment achieving LERAP Low Drift status are published on the PSD website.

This system has been widely used by the industry particularly for assessing the performance of nozzles but also with some claims relating to air assisted boom sprayers. The system has operated effectively and should be mapped on to an extended LERAP scheme. It is proposed that implementation would be as for the applied dose adjustments with buffer zone widths in the range 10 to 50 m resolved to the nearest 5.0 m and widths up to 10 m resolved to 1.0 m.

It is recognised that the adjustment of buffer zone widths in an extended scheme would, as in the existing scheme, accommodate combinations of effects due to the use of reduced doses as well as using drift reducing application systems.

It is considered that the current wind tunnel and field methods for assessing the drift reducing capabilities of application equipment used within the existing LERAP scheme could provide an initial basis for defining buffer zone widths in a scheme using wider zone widths. However, it should be noted that:

- The existing protocols for wind tunnel assessments of the drift reducing characteristics of nozzles make measurements over distances that are directly comparable with those used for the field buffer zone and no extrapolation to greater downwind distances is needed;
- The differences in sedimenting drift deposition profiles for nozzle-based systems having different drift characteristics tend to reduce with increasing distance from the treated area.

In considering using the drift reducing characteristics of the application system in an extended LERAP scheme, the opportunity should be taken to review test protocols and analysis methods that are used to support the definition of Low Drift status. While the current methods are generally effective, there are issues relating to:

(i) the variability and repeatability of measurements – see Section 4 of this report;
(ii) accommodating nozzles in which the main trajectory of spray from a static boom is not vertically downwards;
(iii) extending the results from wind tunnel tests conducted in relatively low wind speed conditions to operation on a boom sprayer at forward speeds of more than 10 km/h;
(iv) extrapolating sedimenting drift profiles to downwind distances that are greater than those used during the measurements
(iv) the use of “boom end” nozzles.

During the operation of the current system, improvements have been made to both measurement and analysis protocols. There is a need to confirm the details of the wind tunnel procedures used for a range of types of spraying system, the linkage between the results of such tests to the performance of systems under field conditions and the resolution that can be achieved in the drift profiles from different systems. Existing wind tunnel protocols involve a singe static nozzle aligned with an air flow that represents the effect of the forward motion of the sprayer and is equivalent to a relatively low driving speed (8.0 km/h). Studies are needed to examine whether protocols based on a moving nozzle or small boom of nozzles in an air flow could provide improved options for accounting for higher spraying speeds, different nozzle orientations and give an adequate resolution such that data could be extrapolated to greater downwind distances possibly using modelling approaches. Computer simulation models have the potential to extrapolate results from both wind tunnel and field tests to a wider range of conditions and distances and such extrapolation may be more straightforward if revised wind tunnel protocols were developed that directly related to the field condition. It would also be important to validate the results from modelling work using field trial data collected over the appropriate downwind distances.

It has been noted that drift reducing status in other European countries (e.g. Germany) has included a component relating to the uniformity of deposit when claiming such a status for application systems. This approach may be important if efficacy close to the buffer zone is to be maintained. Reducing the operating pressure with a number of nozzle designs in order to gain a low drift status will mean that a spray pattern is not fully developed and poor uniformity at the target level will result. Although the relationships between the uniformity of volume distribution (patternation) and efficacy may be limited, if there are areas in which there is little or no applied dose, then this will result in striping and a lack of control in some strips.

Some European member states assess the drift reducing capabilities of application systems based on measurements of droplet size distributions – see Section 4 below. A review of protocols for determining the drift reducing status of application systems should consider combining measurements of the physical characteristics of sprays with direct measures of drift in controlled wind tunnel conditions. Combining the results from such measurements is again likely to involve modelling approaches and the development of further such approaches as part of the BREAM project would be relevant to such a review.

3. Using wider buffer zones with the mandatory use of drift reducing application systems

A review of data relating to product efficacy when using drift reducing application systems conducted for The Pesticides Safety Directorate indicated that acceptable efficacy could be maintained when treating a wide range of arable crop targets with drift reducing application systems particularly based on the use of air induction nozzles mounted on conventional boom systems. The treatment of small targets such as grass weeds at early stages of growth and potentially the application of some pre-emergence treatments to cloddy seedbeds were the main exceptions where the use of a fine spray would be needed to give good product efficacy. The mandatory use of drift reducing application systems would therefore have implications for efficacy when treating such small targets.

The mandatory use of drift reducing application systems is a feasible option providing that the issue of treating small targets can be satisfactorily addressed. The available data suggests that this is more likely to be the case if the thresholds for drift reduction against a reference system were 50% rather than the 75% associated with a LERAP Low Drift three star system. Such a scheme could therefore be based on the two levels of drift reduction equivalent to the existing two and three star LERAP Low Drift ratings and with buffer zone widths of 5, 10 and 20 m.

4. The introduction of an additional star rating category achieving a 90% drift reduction in relation to the defined reference system and the implications this may have for buffer zone specification and use

It is recognised that the use of an application system giving a 90% drift reduction in relation to the defined reference system would enable buffer zone distances to be substantially reduced. The system in Germany does recognise this level of drift reduction based on wind tunnel measurements of a "DIX" parameter involving the measurement of vertical airborne profiles 2 m downwind of a static nozzle operating in a uniform 2.0 m/s airflow. Results from such measurements are interpreted in terms of the total quantity of spray liquid collected as a proportion of nozzle output and the height distribution of the airborne spray. While the measurement protocols are therefore similar to those used in the LERAP Low Drift status assessment for single nozzles, there are important differences relating to:

(a) making measurements of airborne spray profiles at a single and relatively short downwind distance from the nozzle;
(b) the interpretation of the results and the linkage to the field performance of boom sprayers.

In examining the potential to use existing LERAP Low Drift status protocols to determine whether or not an application system can achieve a 90% drift reduction when compared with a reference system based on either wind tunnel or field experimental there is concern relating to the accuracy and resolution with which such assessments can be made. It is very unlikely that data from field experiments could be resolved with sufficient accuracy to reliably determine the potential for application systems to achieve a 90% drift reduction in relation to a reference system. There is also considerable variation in the results from individual wind tunnel tests conducted to the LERAP protocols particularly since measurements are made for relatively short duration spraying periods (typically 10 s) and involve the interactions of the spray structure with the controlled air flow. This then generates vortex structures that in short timescales can lead to variability. The data presented in Appendix III summarises the results from an analysis of data from wind tunnel tests conducted with a well defined reference nozzle over a period when a large number of separate measurements were being made. These data show a standard deviation of some 15% about a mean value of a length scale parameter that would be the basis for assessing a drift reducing characteristic. Although the wind tunnel protocols have been further developed since this data was collected and the level of variability reduced, it is still considered technically difficult to determine a 90% drift reduction level with a high degree of confidence based on direct measures in either wind tunnel or field conditions.

It is noted that the assessment of drift reducing characteristics in some European states (e.g. The Netherlands) is based on the measurement of droplet size distributions and particularly the percentages of nozzle outputs that are contained in small droplets. Interpretation of such measurements is then based on the use of a computer model that predicts downwind drift profiles. Such an approach is likely to give less variability when assessing the performance of a well defined nozzle type since techniques for measuring droplet size distributions have made important progress and are continuing to be developed. As an example, Table 1 gives the typical variation associated with droplet size measurements for the reference nozzles in the current spray/nozzle classification scheme made with a light scattering instrument and based on a single line scan through the spray 350 mm below the nozzle. It can be seen that the level of variability is much less than that for the direct measures of drift in wind tunnel conditions presented in Appendix III.

Table 1. Droplet sizes (mean and standard deviation) for the reference nozzles in the current spray/nozzle classification scheme measured with a laser diffraction instrument.

Nozzle	**Droplet size, μm**	
	Mean	Standard Deviation
very fine/fine	123.7	0.59
fine/medium	176.1	0.42
medium/coarse	227.3	1.14
coarse/very coarse	314.2	0.26
Very coarse/extra coarse	358.2	1.20

However, drift risk is a function of variables other than the droplet size distribution, particularly droplet velocities, spray and droplet structures and a wide range of measurements are needed if these are to be well defined and input to a computer model. There are also issues relating to the reliability of existing models to accurately predict downwind drift deposit profiles although current research may influence the accuracy and resolution of such predictions in the future.

It is concluded that the use of an additional star rating category achieving a 90% drift reduction in relation to a defined reference system cannot be recommended without a major review of the methodologies used for assessing drift reduction levels.

5. Other factors influencing buffer zones as a means of controlling the drift contamination of surface water

Studies have shown that vegetation within a buffer zone can substantially increase the filtering of airborne spray and hence increase the effectiveness of the buffer in reducing the contamination of surface water by spray drift. There are no data that directly quantify the effects but measures of airborne spray through a buffer zone reported by Miller and Lane (1999) show reductions in the order of 75% in airborne spray passing through a tall vegetated boundary compared with a boundary having short vegetation (Figure 6). However before such effects could be included in an extended LERAP scheme, there is a need to establish how such vegetative structures can be generated and maintained throughout the period relevant to a typically spraying programme. This has implications for measures aimed at increasing biodiversity within field margins and again there is a need to show that appropriately structured vegetative boundaries can be maintained and continue to filter potential spray drift.

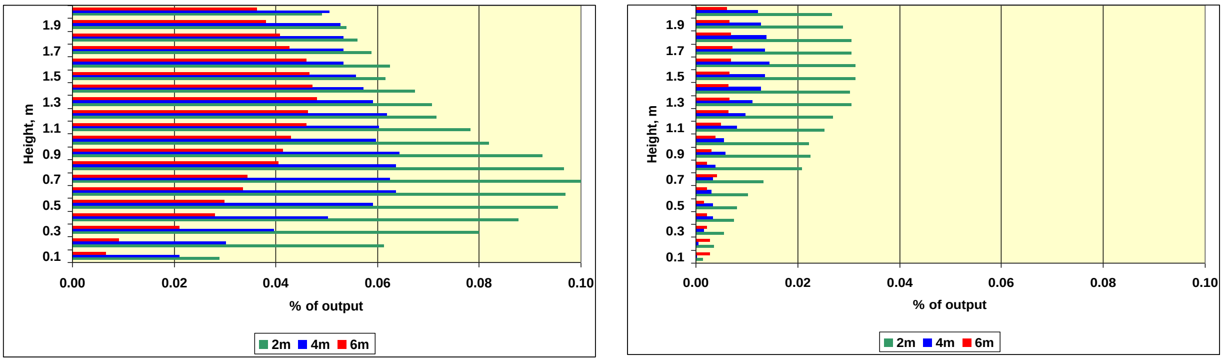

Figure 6. The potential of vegetation in a buffer zone to increase the filtering of airborne drift.

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Appendix I
Approaches to buffer zone specifications in different countries.

(see separate sheet)

Appendix II

Case studies

Case 1

Application rate **(g a.s./ha)**	**Acceptable concentration*** **(µg a.s./l)**	**PEC at 1 m**** **(µg a.s./l)**	**PEC at 5 m**** **(µg a.s./l)**	**Result of risk assessment*****	**Buffer zone at which acceptable concentration achieved (m) – based on Rautman et al., 2001**	**Buffer zone at which acceptable concentration achieved (m) – based on van de Zande, et al., 2002**
1000	32	9.23	-	Approval possible without buffer zone	<1 m	3.8 m
5000	32	46.17	9.5	Approval possible only with 5 m buffer zone	2 m	8.6 m
20000	32	184.7	38	No approval	7.5 m	>15 m
300	5.7	2.77	0.57	Approval possible without buffer zone	<1 m	5.5 m
1500	5.7	13.85	2.85	Approval only with 5 m buffer	3 m	13 m
3500	5.7	32.32	6.65	No approval	7.5 m	>15 m
10	0.1	0.092	0.019	Approval possible without buffer zone	1.3 m	7.5 m
20	0.1	0.185	0.038	Approval only with 5 m buffer	2.5 m	10.0 m
70	0.1	0.646	0.133	No approval	8.5 m	>15 m
5	0.05	0.047	0.01	Approval possible without buffer zone	1.2 m	7.5 m
10	0.05	0.07	0.019	Approval possible with 5 m buffer zone	2.5 m	10.0 m
30	0.05	0.257	0.057	Approval not possible	7.5 m	>15 m

* *Taking into account all available toxicity data and relevant directive triggers for acceptability (e.g. TERs).*

** *Based on Rautmann 2001 drift values into a 30 cm deep static water body.*

*** *Approval can be granted without a buffer zone since PEC at the default 1 m distance is below the "Acceptable concentration".*

**** *Approval can be granted for application rates which result in a PEC at the maximum permissible 5 m distance which is below the "Acceptable concentration".*

Appendix III

Data from tests conducted at Silsoe Research Institute in the period 19/05/99-01/07/99 with the reference standard flat fan (FF110/1.2/3.0) nozzle used in the LERAP scheme.

Test Nozzle	Single Nozzle Source Analysis	24 nozzle, 12 m boom, 0.5 m spacing			
		Length-scale		LERAP	
	Data Fit r^2	Mean	Std. error	PEC*	Star rating
Run 1	0.94	6.00	0.23	1.00	0
Run 2	0.98	6.50	0.82	1.11	0
Run 3	0.97	6.20	0.82	1.04	0
Run 4	1.00	6.38	0.39	1.08	0
Run 5	0.95	7.86	1.50	1.40	0
Run 6	0.97	6.67	0.88	1.14	0
Run 7	0.99	6.17	0.51	1.04	0
Run 8	0.97	6.41	0.88	1.09	0
Run 9	1.00	5.42	0.30	0.88	0
Run 10	0.98	4.75	0.48	0.75	1
Run 11	0.94	8.94	1.90	1.65	0
Run 12	0.99	5.71	0.50	0.94	0
Run 13	0.93	6.03	1.41	1.01	0
Run 14	0.98	5.06	0.58	0.81	0
Run 15	0.95	5.28	0.99	0.85	0
Run 16	0.99	5.62	0.35	0.92	0
Run 17	0.98	5.35	0.60	0.87	0
Run 18	0.99	5.23	0.49	0.84	0
Run 19	0.99	6.33	0.64	1.07	0
Run 20	0.99	5.8	0.39	0.96	0
Run 21	0.96	5.7	0.92	0.93	0
Run 22	0.98	7.8	0.90	1.40	0
Run 23	0.96	6.1	0.88	1.01	0
Run 24	0.95	6.1	1.15	1.03	0
(1) PEC: Permitted Environmental Concentrations (2) LERAP: Local Environmental Risk Assessment for Pesticides					
Mean	0.97	6.14	0.77		
Standard deviation		0.96	0.41		

References to published material

9. This section should be used to record links (hypertext links where possible) or references to other published material generated by, or relating to this project.

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