# 4 Risk Mitigation Measures to protect surface waters

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## 4.1 Introduction

Surface water bodies (e.g., rivers, streams, lakes, ponds) need to be protected from unacceptable impacts of crop protection products. Pesticide pollution sources for surface water can be differentiated into point source and diffuse pollution. Point source pollution originates from farmyard operations and spillages or accidents in the field. Point source pollution is not considered during the regulatory risk assessment for pesticides, as it is not a consequence of a proper use of the products and can be avoided by the operator using appropriate management practices (Good Agricultural Practices). Diffuse pollution can originate from correct pesticide applications to fields. Three major potential pollution pathways exist: spray drift, surface runoff, and (subsurface or artificial) drainage. Another indirect diffuse pollution source for surface water may be recharge from groundwater; however, this pathway is in principle separately addressed via the risk assessment for the groundwater compartment (leaching). Wet or dry deposition of pesticides following volatilization from treated surfaces is a further route of entry to surface waters, but mitigation measures to reduce exposure via this route were not discussed at the MAgPIE workshop.

To protect aquatic organisms against unacceptable threats, the EU regulatory risk assessment process for surface water considers all three major diffuse pollution pathways in its FOCUS (FOrum for the Coordination of pesticide fate models and their Use) scenarios (FOCUS 2001). Six scenarios consider entry via artificial drains and spray drift, while the remaining four consider entry via surface runoff and spray drift. In principle, each of these pollution pathways may lead to unacceptable predicted environmental concentrations (PECs) in the receiving water body. Consequently, suitable and accepted mitigation measures for each of the three pollution pathways may be needed in EU Member States in order to achieve successful risk mitigation to protect surface waters.

## 4.2 Surface runoff

Surface water can be contaminated by pesticides dissolved in the water phase of runoff or carried on sediment particles eroded by runoff. Thus, it is necessary to assess the risks for the regulatory authorization of pesticide uses, and for farmers to manage the risks in their fields in practice.

Fundamentally, runoff is caused by precipitation (or irrigation water) not being able to infiltrate through the soil fast enough, resulting in two types of runoff (see Figure 4.1). The first is due to a low permeability at the soil surface (infiltration restriction), due to its natural properties (heavy soil texture, capping), or soil compaction. The second is due to water flow restrictions below the soil surface – because the subsoil is less permeable than the topsoil. This may occur due to natural reasons, such as heavier textured subsoil, or due to soil cultivation practices, e.g., plough pans and sub-surface compaction. However, runoff occurs in these cases only when topsoil in lower slope positions saturates completely with water (saturation excess) due to water movement accumulating there below the soil surface. Another reason for this type of runoff can be the existence of a very shallow groundwater table. In principle, both types of runoff may occur in the same field, though often one will dominate.

Generally, runoff can be subdivided into two groups: one that tends to move uniformly down the whole or part of a field as diffuse sheet runoff, or one that tends to concentrate into discrete flow channels, either due to localized flow restrictions or channelling at the soil surface (e.g., along tramlines, cropping rows) or due to converging water flow in the larger landscape, following so-called talwegs (or waterways) downslope. Any concentrated runoff and erosion channels in-fields effectively extend the river and stream network into agricultural fields and are potentially the greatest cause of adverse diffuse pollution of surface water by pesticides. Through implementing appropriate Best Management Practices (BMPs) concentrated flow phenomena can be strongly reduced or completely avoided in practice (save for the most extreme precipitation events), thus reducing their potential impact to generally acceptable levels. For example, compaction management of tramlines and orienting tramlines across the slope reduces runoff and erosion from them dramatically (e.g., Deasy et al. 2010). Also, planting grassed waterways in talwegs reduces levels of pesticide in surface water, also acknowledging that pesticides should not be used in these saturated runoff source areas. Concentrated flow is one of the main reasons for cases of low effectiveness of vegetated buffer strips under field conditions (Blanco-Caqui et al. 2006). It can be actively managed through good agricultural practices that also address a range of other environmental issues, primarily soil loss (and hence loss of agricultural productivity), sedimentation of water courses, and nutrient or pesticide transport to surface water.

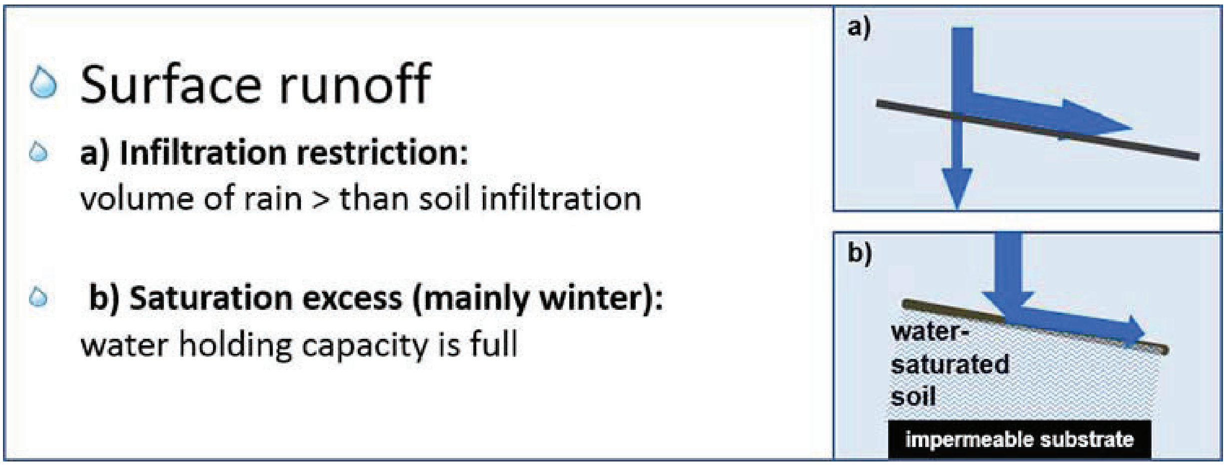


**Figure 4.1:** Runoff generation types (TOPPS-PROWADIS runoff diagnosis training, www.topps-life.org; modified)

To design a sound regulatory scheme to mitigate risks of runoff, it is important to have insight into how runoff and field erosion affect the amount of pesticide transfered to surface water and how successful buffers are at preventing this transfer. First of all, pesticide transfers from fields are known to increase exponentially as runoff and erosion levels increase. Yet, as the effectiveness of buffers for runoff mitigation is inversely related to the amount of runoff from fields, they generally get more efficient as runoff and erosion levels decrease. This means it is important to have an integrated approach to runoff and erosion management, which combines in-field measures reducing runoff at source (by maximizing water infiltration in agricultural fields), and vegetated edge-of-field strips, which buffer the remaining runoff from fields. In this way, in-field measures and edge-of-field buffering mitigation strategies act in a synergistic way to reduce runoff from agricultural fields. Consequently, farmers should focus on reducing field runoff (and erosion) at source, using a toolbox of known BMPs, and as a second step implement vegetated filter strips (and additional edge-of-field or off-field measures) to cope with the risk of any remaining runoff and erosion.

From a regulatory perspective, using representative field scenarios, it makes sense first to see how much pesticide transfer from field runoff and erosion needs to be mitigated (% of baseline runoff) to avoid unacceptable effects on aquatic organisms (Art. 4(3)e(ii) of Regulation (EC) No. 1107/2009) in edge-of-field surface water. Afterwards, it would be up to national regulators prescribing measures (or combinations thereof) from a toolbox of different in-field (e.g., no-till), edge-of-field (e.g., vegetated buffer strips), or off-field measures to achieve the targeted mitigation effectiveness. This could either be done via higher-tier modeling, or via a combinatory approach using default mitigation effectiveness values listed for the individual measures in official lists (i.e., national runoff mitigation toolboxes).

In summary, the regulatory perspective tends to work from the water body back to the field, while the farmers' perspective works from the field to the water body. A flexible runoff mitigation concept using a toolbox of acceptable in-field, edge-of-field, and off-field measures brings the two different perspectives together, meeting regulators' needs to ensure environmental protection and farmers' needs for practical ways to implement runoff mitigation measures in their fields while farming productively. Taking into account the variability of rainfall-soil-landscape scenarios and thus runoff generation conditions at catchment level, it is important to note that successful water protection depends on achieving the intended mitigation effectiveness on average across all treated fields in catchments, and less on achieving 100% of the mitigation effectiveness target for each individual field.

Another basic consideration is, if runoff mitigation is only to be implemented for fields directly bordering surface water, or if a certain distance (e.g., 100 m) between downslope field edge and next surface water body will be defined for application of surface runoff risk mitigation (or at least for concentrated runoff mitigation – see Chapter 4.2.4 on proposed new safety precaution phrases).

### 4.2.1 Surface runoff risk mitigation concept

The aim of the proposed mitigation concept is to achieve a specified runoff mitigation goal in the field and at the same time to allow farmers a certain degree of freedom to choose the appropriate mitigation measures that fit best to their cropping system and landscape conditions.

Good agricultural practice on fields is a prerequisite for effective runoff risk mitigation; the prevention of concentrated runoff from e.g., tramlines, rills, and gullies is a baseline activity and should be ensured by appropriate best management practices (such as tramline management schemes, grassed waterways, etc.) in any case as far as possible. Existing concentrated flow phenomena will also make many potential runoff mitigation measures less effective or ineffective (e.g., vegetated buffer strips, no-till), prejudicing the intended runoff mitigation effect of implemented measures. Tables A2.1 and A2.2 in Appendix 2 list a number of basic mitigation measures to reduce or prevent concentrated flow in agricultural fields. In the multi-stakeholder EU water protection project TOPPS-PROWADIS (www.topps-life.org), there is also a concentrated flow diagnosis, helping the user to select the appropriate measures to mitigate concentrated flow (Runoff BMP booklet). A more binding option would be to prescribe an effective management of concentrated flow via a safety precaution phrase (see proposal in Chapter 4.2.4 – either for all applied products or only for the ones that require runoff mitigation). For regulatory purposes it is important that a control of measures is possible; this would mean the farmer keeping a plan available for inspection with details of mitigation measures for all fields, together with a scientific reasoning from a competent organization for the effectiveness of the measures. Alternatively, mitigation failure could also be observed in the fields (e.g., erosion rills or deposited sediment below field) and documented.

The base case for diffuse runoff risk mitigation in the EU is the use of FOCUS modeling for different EU runoff scenarios in order to calculate surface water exposure concentrations. If a toxicity-exposure ratio (TER) of a representative (or worst-case) scenario is too low, a higher-tier risk assessment needs to be undertaken to demonstrate a safe use. A similar approach is taken by EU Member States that have national modeling approaches established for surface water risk mitigation (based on their specific models, parameterization, and scenarios). By defining only a runoff mitigation target (% mitigation needed based on the model and scenario used) in a first step, zonal rapporteur Member States would leave it up to national registration authorities how to achieve this target. At national level, regulators could define their nationally-approved mitigation toolbox, specifying the applicable measures and, if modeling is not used, the assigned default mitigation effectiveness values for their country.

The proposed basic set of runoff risk mitigation measures (toolbox) is listed in Table 5.1 (all pesticides) and Table A2.3 (differentiated according to hydrophobicity of pesticides, thus considering a predominant solution- or particle-based transport of substances) in Appendix 2. It should be noted that such a list (also at national level) needs to reflect the current state of knowledge. Therefore, the lists should be reviewed and updated regularly to remain flexible and open for new mitigation measures and approaches.

The following process is proposed for a harmonized EU regulatory runoff mitigation concept:

**Step 1: Identification of basic runoff risk mitigation need (in % of base case)**

The risk assessment outcome (EU FOCUS or national) identifies the necessary runoff reduction effectiveness (e.g., a required reduction of the PEC from 10 µg/L to 1 µg/L equals a mitigation need of 90%), which needs to be achieved in practice by implementing appropriate risk mitigation measures.

**Step 2: Define appropriate risk mitigation measures (with defined effectiveness) as toolbox**

The toolbox is a list of in-field, edge-of-field, and off-field runoff mitigation measures, which are accepted at national level for reducing runoff risks. Depending on national set-up, either the risk mitigation measures are integrated into higher-tier modeling (i.e., measures are considered via modified model parameters, such as reduction in curve number) or a basic mitigation effectiveness value is assigned to each measure. In Table 4.1, a basic list of runoff mitigation measures and their effectiveness values and integration into modeling is proposed as an EU-wide toolbox.

A basic runoff risk mitigation measure which is already used in several EU Member States (e.g., BE, BG, CZ, DE, ES, FI, IT) and in Switzerland, is the establishment of (permanently) vegetated filter strips between the treated field and surface water bodies. Mostly, filter strips of different widths are accepted (e.g., 5, 6, 10, 20 m) in the regulatory risk assessment, and implementation is easy to control in the field.

**Step 3: Provide methodology to calculate overall effectiveness for combinations of risk mitigation measures**

As the farmer shall have the flexibility to choose from the toolbox of mitigation measures according to their needs and be able to combine different measures for increased effectiveness, rules must be officially established to dictate (i) which measures may be combined, and (ii) how the overall effectiveness for combinations of measures is calculated.

The use of a simple runoff mitigation effectiveness value per measure (based on evidence from the literature, e.g., choosing a median or $x^{th}$ percentile value of reported results) has the advantage of being easy-to-use and light on regulatory workload; the drawback of this approach is the less accurate approach (ignoring the influence of local environmental conditions) and that a national acceptance for these more simplistic values needs to be ensured.

The effectiveness of vegetated filter strips of different widths, as well as that of several in-field mitigation measures (see Table 4.1), can be modeled e.g., using the PRZM-SWAN-VFSMOD models, meaning that a simulation of overall effectiveness of combinations of measures is also possible. The advantage of the integrated modeling approach is the complete scientific assessment of runoff conditions; the drawback is the higher modeling workload for all integrated measures and intended combinations thereof.

### 4.2.2 Toolbox of surface runoff risk mitigation measures

There is a multitude of potential and field-tested mitigation measures which can be sorted according to their nature; an overview is provided in Figure 4.2, which was developed by the TOPPS-PROWADIS project based on a multi-stakeholder process and literature review.

Runoff mitigation measures can be allocated to three different classes: (i) in-field mitigation measures, being implemented on the cropped field; (ii) edge-of-field mitigation measures, being implemented right at the downslope edge of the field; and (iii) off-field mitigation measures, being implemented downslope of the field, but not necessarily in direct contact with the field edge.

A survey of existing regulatory runoff mitigation measures (and related information) in EU Member States and associated countries was conducted in the framework of the MAgPIE workshop. The results are summarized in Table A2.4 in Appendix 2. Results of this survey demonstrate that some of these measures are already used for risk mitigation in one or more EU Member States: e.g., vegetated buffer strips (BE, BG, CZ, DE, ES, FI, IT; also CH), edge-of-field bunds (IT), water retention systems (DE), reduced tillage (BG, IT), band spraying (IT), and soil incorporation of product (IT).

| | | |
|---|---|---|
| Soil management | • Reduce tillage intensity<br>• Manage tramlines<br>• Prepare rough seedbed<br>• Establish in-field bunds | • Manage surface soil compaction<br>• Manage subsoil compaction<br>• Do contour tilling or disking<br>• Increase organic matter |
| Cropping practices | • Use Crop rotation<br>• Do strip cropping<br>• Enlarge headlands | • Use annual cover crops<br>• Use perennial cover crops<br>• Double sowing |
| Vegetative buffers | • Use in-field buffers<br>• Establish talweg buffers<br>• Use riparian buffers<br>• Use edge-of-field buffers | • Manage field access areas<br>• Establish hedges<br>• Establish or maintain woodlands |
| Retention structures | • Use edge-of-field bunds<br>• Establish vegetated ditches | • Establish artificial wetlands or ponds<br>• Build fascines |
| Adapted use of pesticides and fertilizer | • Adapt application timing<br>• Optimize seasonal timing | • Adapt product and rate selection |
| Optimized irrigation | • Adapt irrigation technique | • Optimize irrigation timing and rate |

**Figure 4.2:** Overview of available runoff mitigation measures (source: TOPPS-PROWADIS, Runoff BMP booklet, www.topps-life.org)

In order to propose a toolbox of runoff mitigation measures, a number of basic mitigation measures were identified during the initial workshop in Rome and in the following break-out group working phase that are considered to be universally accepted as effective in science and by agricultural stakeholders (see Table 4.1). The table lists proposals for basic mitigation effectiveness per measure, based on MAgPIE literature evaluations and expert judgment. These mitigation effectiveness values are designed to express the reduction in pesticide concentrations in surface water in the field that can be expected to arise from deploying the respective mitigation measure. As they are intended for use on the ground in selecting field measures, they deliberately simplify the mitigation effect into a single value. As an example, vegetated filter strips act to reduce pesticide transfer to water via surface runoff by (i) facilitating infiltration of runoff water and dissolved pesticide as it passes across the strip; and (ii) trapping erosive sediment and any associated pesticide. The mitigation effect of a vegetated filter strip will be different for pesticides primarily in the aqueous or sediment phases. For dissolved-phase pesticide, the reduction in pesticide load reaching surface water will be greater than the reduction in pesticide concentration within the surface water because the volume of runoff entering surface water is decreased as well. These detailed processes associated with vegetated filter strips are simplified in Table 4.1 into a single effectiveness value intended to guide selection and uptake of mitigation measures in the field. Considering the different mitigation effectiveness of measures for predominantly solution- or particle-based transport of substances with runoff water, differentiated effectiveness values are supplied in Table A2.3 in Appendix 2 for hydrophilic (Koc <1000 L $Kg^{-1}$) and hydrophobic pesticides. The values selected are intended to be representative and relatively precautionary, but not absolutely worst-case. It is recognized that field evidence on mitigation effectiveness continues to grow and that values may need to be refined further in due course within the framework of detailed evaluations at Member State and EU level.

Given that the focus of the basic mitigation effectiveness values in Table 4.1 is field selection and uptake of mitigation measures, there is also a need to incorporate the effect of different measures into the risk assessment for pesticides. The final column of Table 4.1 provides recommendations for how to achieve this integration of mitigation measures into regulatory exposure modeling, as an alternative to using basic mitigation effectiveness values.

Further measures, which were discussed but were not considered ready for integration into the basic toolbox of a regulatory concept are listed in Table A2.1 in Appendix 2. At present, these measures do not have sufficiently robust evidence in the available literature, field data, or knowledge, but each may have a role to play in runoff mitigation where a plan can be developed by a competent authority or organization. A comprehensive overview on all discussed measures and also measures to reduce concentrated runoff, the reasoning for their effectiveness, and the literature references are provided in Table A2.2 in Appendix 2.

A specific measure that is reported in the literature, but has not been included in Table 4.1 is vegetated filter strips with width <5m. Although the literature reports such structures to have some effect in reducing pesticide transfer to surface water in runoff, Reichenberger et al. (2007) note in their review that there is systematic bias in the studies present in the literature. Several studies consider vertisols that are prone to cracking and thus macropore flow that may accentuate infiltration of water under dry antecedent moisture conditions. Other studies on narrow buffers used simulated rainfall or run-on, but without pre-irrigation of buffers; the antecedent moisture content is not actually reported in these studies and so the relative vulnerability of the situation studied is unknown. For these reasons, vegetated filter strips <5m in width are excluded from Table 4.1 and research is required to demonstrate the effectiveness of these structures under a wider range of conditions. It should be noted that narrow buffers are likely to be more acceptable to farmers than wider buffers when applied within the field, and that use of in-field buffers to intercept runoff close to the point at which it is generated is a particularly effective approach in many situations. Ultimately, it remains up to the individual Member States to define the minimum width of vegetated buffer strips that they still consider to be of reliable effectiveness for runoff mitigation under their national conditions.

**Table 4.1:** Proposed toolbox of basic runoff mitigation measures. The basic mitigation effectiveness provides a generic and representative measure of reduction in pesticide concentrations in surface water that aims to simplify and promote selection and uptake of mitigation measures in the field. The proposed modeling approach provides a recommended method to incorporate the respective mitigation measure into regulatory exposure modelingrisk assessment. More detailed information on references is provided in Table A2.2 in Appendix 2).

| **Runoff Mitigation Measure** | **Strength of Scientific Evidence*** | **Basic Mitigation Effectiveness[1]** | **Proposed Modeling Tools or Parameter Modifications** |
|---|---|---|---|
| **Edge-of-field measures** | | | |
| 5 m vegetated filter strip | +++ | 40%[2] | VFSMOD[14] |

| | | | |
|---|---|---|---|
| 10 m vegetated filter strip | +++ | 65%[3] | VFSMOD |
| 20 m vegetated filter strip | +++ | 80%[3] | VFSMOD |
| Edge-of-field bunds | + | 40%[4] | Calculation of water retention, infiltration and environmental fate |
| **In-field measures** | | | |
| No-till / reduced tillage | ++ | 50%[5, 6, 7, 8] | Curve number reduction: -3 |
| In-field bunds (row crops) | + | 50%[4] | Curve number reduction: -3[15] |
| 5 m vegetated filter strips | ++ | 50%[9] | Modeling approaches would need to be adapted |
| Inter-row vegetated strips (in permanent crops) | ++ | 50%[2,4] | Proportionate consideration of curve numbers[16] |
| **Off-field measures** | | | |
| Artificial wetland and retention pond | +++ | 75%[10, 11] | Calculation of water retention, infiltration and environmental fate |
| Vegetated ditches | ++ | 50%[12, 13] | Calculation of water retention, infiltration and environmental fate |

* Symbols mean: +: few scientific publications existing; ++: many scientific publications existing; +++: abundant scientific publications existing; see also Table A2.2 in Appendix 2.

[1] Values give broad effectiveness (expressed in % of baseline concentration in surface water due to surface runoff) based on MAgPIE literature evaluations and expert judgement; values may need to be refined further to reflect more detailed evaluations of efficacy at Member State and EU level; these values are used to derive mitigation points for each measure from respective mitigation point scale (see Table 4.2).

[2] CCPF-Ministero della Salute 2009

[3] Conservative mean of values for high- and low-sorbing pesticides from: (Reichenberger et al. 2007).

[4] Proposal of Swiss regulatory authority for runoff mitigation effectiveness: 50%; according to reference 2: 20%.

[5] UBA 2004

[6] Miao et al. 2004

[7] Deasy et al. 2010

[8] Maetens et al. 2012

[9] Reichenberger et al. 2007. See Fig. 1, and reflecting the fact that buffer strips closer to runoff source have higher efficiency than edge-of-field or riparian buffer strips.

[10] Stehle et al. 2011

[11] Maillard et al. 2012

[12] Gregoire et al. 2009.

[13] Moore et al. 2008.

[14] The regulatory status of VFSMOD in the EU regulatory process is currently uncertain. The model is recommended for use here given its general validation status in the scientific literature and because it is able to reflect changes in buffer efficacy based on e.g. changes in antecedent moisture conditions. Additional work is recommended outside of the MAgPIE process to reach a conclusion on the regulatory acceptability of the model in the EU. A particular issue is evaluation of coupling of the basic VFSMOD code with the regression equation for pesticide transfer across vegetated filter strips reported by Sabbagh et al. (2009).

[15] Bunds are equivalent to terraces: Using the TR-55 curve number (CN) guideline, up to 4 lower CN are recommended; Use a fraction, if the bund only catches part of the runoff (bypassed)

[16] Proportionate calculation means: curve number CN= (% permanent crop area * CN(permanent crop)) + (% vegetated strip * CN(vegetated strip))

In order to achieve an adequate mitigation effectiveness of measures, appropriate environmental conditions and technical aspects of their implementation need to be defined in detail (at national level), as well as – if needed – appropriate activities for maintenance of measures. The technical advice sheets for risk mitigation measures in Appendix 1 provide a first basis for such specifications at an integrated European level.

The basic runoff mitigation effectiveness values provided in Table 4.1 are proposals for average effectiveness (e.g., usually 25$^{th}$ to <50$^{th}$ percentile), derived from available literature data and completed based on expert judgement. The reason for not using a “worst case” approach (e.g., 10$^{th}$ percentile) for measure effectiveness is (i) that an appropriate definition of acceptable implementation conditions (e.g., prohibiting establishment of vegetated filter strips in shallow groundwater areas) and maintenance prevents many cases of low effectiveness (as reported in the literature), and (ii) that the mitigation measures need to achieve their assumed effectiveness on average in an agricultural landscape, thereby making a certain amount of cases with lower effectiveness acceptable. The effectiveness of some measures depends on the sorptive properties of active substances (i.e., high or low Koc), which is reflected in differentiated effectiveness values provided as an alternative in Table A2.3 in Appendix 2.

Obviously, EU Member States should be free to include or discard measures in their national toolbox and to assign different effectiveness values to each measure (reflecting the degree of conservativeness for each measure). This does not prejudice the goal of a harmonized (zonal) runoff mitigation concept, as long as a certain minimum degree of overall runoff mitigation (e.g., 90%) is still possible in each EU Member State.

Control of the appropriate implementation of regulatory risk mitigation measures must be possible in the field. For some (perennial) risk mitigation measures this is straightforward (e.g. via field inspection), while for others an adequate mechanism for documentation (e.g., field-specific records, including photographs) by the farmer, as well as auditable criteria for "good implementation practice" need to be defined and published.

### 4.2.3 Calculating overall mitigation effectiveness for combinations of measures

All risk mitigation measures that can be integrated into regulatory modeling can also be simulated in combinations, providing a direct mitigation effectiveness output for combinations of measures.

For measures that have been assigned a basic mitigation effectiveness value (e.g., 50% runoff reduction), a methodology must be established to calculate the overall mitigation effectiveness for two or more measures applied to one field. In principle, two standard methods can be used to calculate the overall mitigation effectiveness of combinations of risk mitigation measures: a multiplicative or an additive approach. As a compromise between the relatively less conservative (additive, or linear) and the most conservative (multiplicative, or logarithmic) approach, a hybrid approach may be adopted, providing intermediate protectiveness (see Table 4.2 and Figure 5.3).

In order to provide a simple user interface for farmers and advisors, risk mitigation effectiveness for each measure could be translated into mitigation effectiveness points (e.g., 50% risk reduction equals 30 points, 90% risk reduction equals 100 points, for the multiplicative approach). The farmer just needs to know the number of mitigation points that is required for a product use and can then choose a combination of measures from an official list of measures (whitebook) that adds up to equal or more than the defined points requirement. The whitebook is to be established at national level and lists the acceptable runoff mitigation measures and the mitigation points per measure. As the point scale used reflects the combinatory approach (multiplicative, hybrid, additive), the farmer can always simply sum up the points without having to deal with complicated calculations. In principle, this points system could be applied to all surface water exposure pathways, i.e., also drainage and spray drift.

**Table 4.2:** Overview on potential combinatory point system scales for calculation of mitigation points.

| **Mitigation Effectiveness (%)** | **Calculated Mitigation Points** | | |
|---|---|---|---|
| | Logarithmic scale: Multiplicative effects (most conservative) | Double-exponential scale: Hybrid effects (medium conservative) | Linear scale: Additive effects (less conservative) |
| **40** | 22 | 21 | 20 |
| **45** | 26 | 25 | 25 |
| **50** | 30 | 30 | 30 |
| **55** | 35 | 34 | 35 |
| **60** | 40 | 39 | 40 |
| **65** | 46 | 44 | 45 |
| **70** | 52 | 50 | 50 |

| | | | |
|---|---|---|---|
| **75** | 60 | 56 | 55 |
| **80** | 70 | 64 | 60 |
| **85** | 82 | 73 | 65 |
| **90** | 100 | 86 | 70 |
| **95** | 130 | 106 | 75 |
| **99** | 200 | 130 | 79 |

As can be seen in Table 4.2 and Figure 4.3, there are no large differences in the scale system below a mitigation requirement of 70%; the conservativeness of the different methods shows only for higher mitigation needs. Yet, all of these approaches ignore the potential for synergistic effects of mitigation measures, reflecting their basic conservativeness: in reality, for example, the reduction of runoff water by 50% using no-till would further increase the runoff reduction effectiveness for vegetated filter strips, as they show higher effectiveness for lower runoff water volumes.

EU Member States might want to define an upper limit for possible mitigation to be achieved (e.g., 99%, as in Table 4.2), thereby creating a practical cut-off for products with high mitigation needs. Similarly, Member States may (i) limit the maximum width of vegetated filter strips that they are willing to accept in their regulatory risk mitigation systems or (ii) define a minimum width of vegetated filter strip (e.g., 5 m) that always needs to be established as a basic measure if runoff mitigation is needed.

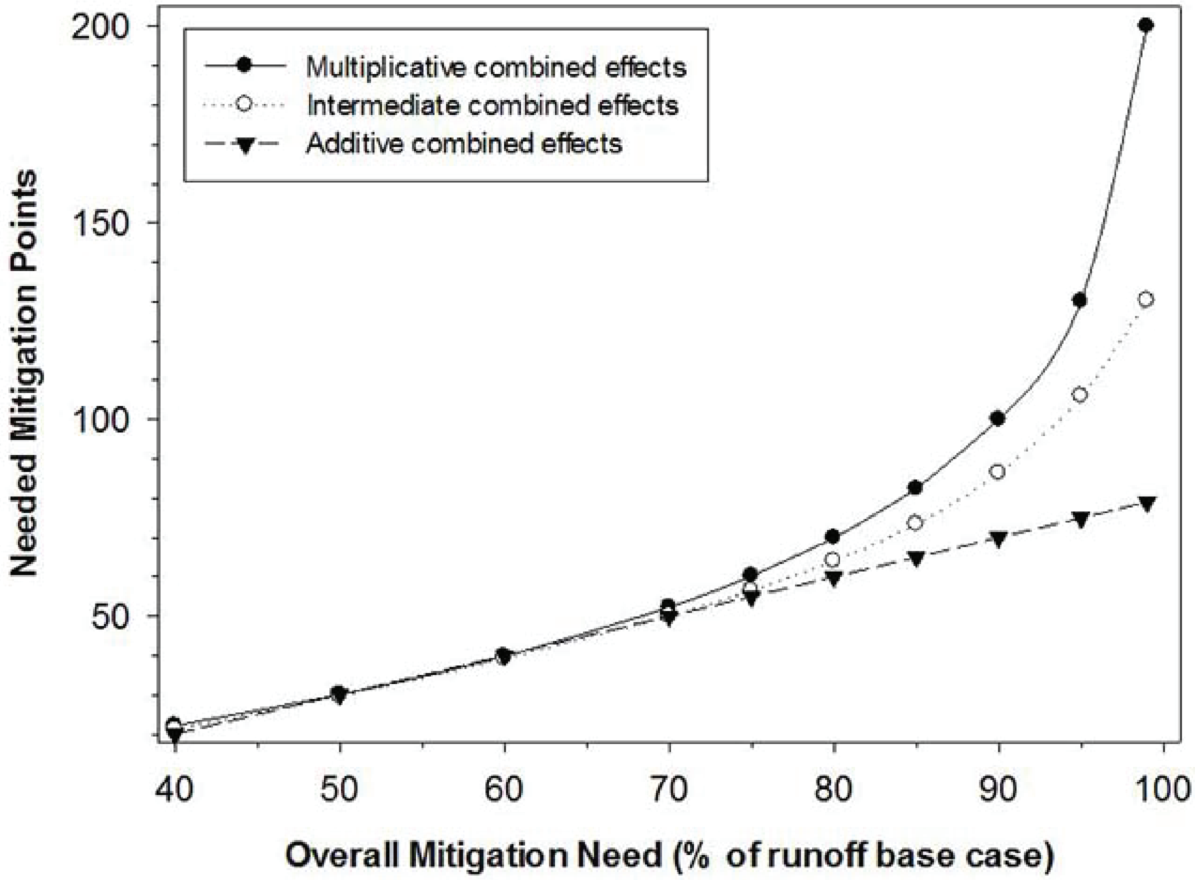


**Figure 4.3:** Visualization of mitigation points assigned to the overall mitigation need.

**Mitigation case example using field evidence-based effectiveness values for measures:**

**Step 1:** Determination of basic runoff mitigation need

Product A needs a reduction of the runoff-induced exposure by 90%. This would translate to
- 100 mitigation points (Table 4.2, logarithmic scale)
- 86 mitigation points (Table 4.2, double-exponential scale)
- 70 mitigation points (Table 4.2, linear scale)

**Step 2:** Toolbox of measures

The amount of mitigation points per measure is determined in this example by taking the individual mitigation effectiveness value (%) listed in

Table 4.1 and reading across the corresponding mitigation points in the different point scale systems (in practice, an official list of measures would only provide the mitigation points per measure). For example, a 10-m vegetated buffer strip is listed with an effectiveness of 65% (Table 4.1), which corresponds to 46 mitigation points in the logarithmic scale, 44 in the hybrid scale, and 45 in the additive scale in Table 4.2.

The farmer checks the available mitigation measures in the official table (e.g., the ones from Table 4.1), which would also list the mitigation points per measure, and can now choose different measures or combinations thereof. Presumably, the farmer will choose the measure(s) that are implemented with the least influence on their cropping system or the least investment regarding time and money (or land) for establishment and maintenance.

**Step 3:** Assessment of combinatory effects

The farmer adds up the points for the chosen measures and checks if this achieves the necessary amount of mitigation points needed for the application of the product. For this example, the following combinations of measures would qualify:

Logarithmic (multiplicative) scale (100 points needed): e.g.,
→ 20 m vegetated filter strip (70 points) & no-till (30 points): 100 pts
→ 10 m vegetated filter strip (46 points) & no-till (30 points) & vegetated ditch (30 points): 106 pts
→ 5 m vegetated filter strip (22 points) & no-till (30 points) & retention pond (60 points): 112 pts

Double-exponential (hybrid) scale (86 points needed), e.g.,
→ 20 m vegetated filter strip (64 points) & no-till (30 points): 94 pts
→ 5 m in-field vegetated filter strip (30 points) & no-till (30 points) & vegetated ditch (30 points): 90 pts
→ no-till (30 points) & retention pond (56 points): 86 pts

Linear (additive) scale (70 points needed), e.g.,
→ 10 m vegetated filter strip (45 points) & no till (30 points): 75 pts
→ 5 m vegetated filter strip (20 points) & retention pond (55 points): 75

pts
→ 5 m vegetated filter strip (20 points) & no-till (30 points) & vegetated ditch (30 points): 80 pts

**Mitigation case example using higher-tier modeling to assess overall mitigation effectiveness**

The modeling is done using the appropriate substance parameters, as well as the chosen runoff scenario parameters, based on the (national) risk assessment scheme. An indicative example of the approach that could be taken is provided below. The active substance has the following use conditions and properties:

***Use conditions:*** on maize, applied to soil at 1.0 kg a.s./ha; target date: between 1 April and 1 May.
***Physico-chemical properties*** of active ingredient:
- molecular weight 300 g/mol
- water solubility 100 mg/L
- vapour pressure 1 x $10^{-7}$ Pa
- soil sorption: Koc 100 L/kg, nf 0.9
- soil degradation half-life (at 20°C): 30 d
- water-sediment degradation half-life: 30 d
- degradation half-life on plant surfaces: 10 d

***Regulatory acceptable concentration*** (RAC) in surface water: 7 µg/L

**Step 1:** Calculation of the basic runoff risk for surface water

Standard FOCUS step 3 modeling is done based on the data above. The risk assessment fails at this step, as the PECmax is determined at 41.4 µg/L in the R4 stream scenario (Table 4.3); for comparison purposes, in order to achieve the RAC this would translate into an 83% mitigation requirement.

**Step 2:** Integration of toolbox measures into higher tier modeling

Step 4 modeling is carried out using SWAN to include VFSMOD simulations of the effect of a vegetated filter strip (VFS). This demonstrates that e.g., a

20-m VFS provides the necessary mitigation in all four FOCUS scenarios (PECmax of 5.15 µg/L in the R3 stream scenario), complying with the regulatory acceptable concentration (Table 4.3).

The effect of a minimum tillage mitigation is simulated by re-running standard FOCUS modeling, but with all runoff curve numbers reduced by 3. However, the use of minimum tillage alone does not meet the regulatory acceptable concentration (PECmax of 39.1 µg/L in the R4 stream scenario).

**Step 3:** Assessing the overall effectiveness for different combinations of mitigation measures

The final modeling step investigates potential combination of runoff risk mitigation measures, for example to allow a reduction in width of the VFS. For instance, a combination of minimum tillage with a 10-m VFS provides the necessary mitigation in all four FOCUS scenarios (PECmax of 6.28 µg/L in the R3 stream scenario).

The modeled regulatory surface water concentrations are summarised for all scenarios and mitigation options in Table 4.3.

**Table 4.3:** Modeled surface water concentrations using different modeling tiers for mitigation case example

| **Modeling Step** | **FOCUS Scenario** | | | | |
|---|---|---|---|---|---|
| | R1 pond | R1 stream | R2 stream | R3 stream | R4 stream |
| FOCUS Step 3 | 0.33 | 16.7 | 15.3 | 31.2 | **41.4 failed** |
| Step 4: 20-m VFS | 0.09 | 0.42 | 0.56 | **5.15 ok** | 0.42 |
| Step 4: minimum tillage* | 0.21 | 3.62 | 12.1 | 17.2 | **39.1 failed** |
| Step 4: min-till + 10-m VFS | 0.14 | 0.81 | 1.07 | **6.28 ok** | 0.08 |

*Note: effectiveness of the VFS is mainly determined by the volume of runoff water leaving the field. Although minimum-tillage has a relatively small effect on the concentration of the pesticide in runoff, it reduces the volume of runoff to a greater extent. Thus a smaller VFS is required to achieve the same net mitigation.

If a modeling approach is used, the product label would need to specify which measures or combinations of measures are required for an acceptable application of this product to a field.

In principle, modeling and field-evidence approaches can also be combined, e.g., by deriving single or overall mitigation effectiveness values from modeled measures or combinations thereof (% mitigation achieved) and then continuing the process as described for the field-evidence based approach for combinations with measures for which no integration into models was achieved.

### 4.2.4 Resulting label language

The current Safety Precaution phrases according to Regulation (EU) No. 547/2011 (see Chapter 3) do not yet allow to translate a flexible runoff mitigation concept into legal label language. Therefore, the following new SP-phrases are proposed, which are compatible with a flexible toolbox approach to mitigate diffuse runoff:

*SPe X1: To protect [aquatic organisms] only apply to fields [adjacent/within Y m to surface water] where approved mitigation measures(s) with [X% reduction of runoff potential/XY runoff mitigation points] are implemented. The official reference for approved mitigation measures is [detail official reference].*

The official document, detailing the list of accepted mitigation measures and advice for their implementation and maintenance, needs to be established at national level.

Alternatively, for modeling approaches with specified (combinations of) measures:

*SPe X2: To protect [aquatic organisms] only apply to fields [adjacent / within Y m to surface water] where the following [measure / measure combinations] to mitigate runoff are implemented: [detail the list of appropriate measures or combinations thereof].*

In practice, farmers will need to determine for each field the maximum runoff mitigation effectiveness needed for the complete group of pesticides (planned to be) used on that field with a given crop rotation. That said, many runoff mitigation measures are perennial (e.g., vegetated filter strips) and cannot or should not be established or dismantled each year.

The selection of mitigation measures by farmers and their implementation would need to be documented for each field, so that an effective control is possible. The official list of accepted mitigation measures will need to detail the correct establishment and maintenance procedures for each measure, together with auditable criteria for adequate measure implementation.

In addition, the new SP-phrases may be complemented by the following sentence for certain products or mitigation effectiveness levels:

*These product-specific runoff mitigation obligations may be superseded by implementing field-specific runoff mitigation measures on the field orfarmland, based on the participation in an officially approved national runoff risk diagnosis and management scheme ([detail names of officially accepted diagnosis systems]).*

This phrase would enable farmers to switch from product-specific runoff mitigation measures to (officially approved) field-specific runoff risk mitigation (e.g., Aquavallee® diagnosis by Arvalis Institut de Végétal in France, TOPPS-PROWADIS runoff diagnosis scheme), allowing them to achieve equivalent effectiveness but at lower cost. The logic behind this approach is that a field-specific approach would prevent runoff from fields (regardless of products used), using mitigation measures adapted to the specific pedo-climatic and landscape properties.

To tackle the issue of concentrated runoff in agricultural landscapes, the following phrase is proposed:

*SPe Y: To protect [aquatic organisms] only apply to fields [within Y m to surface water] where concentrated runoff is prevented by appropriate* *measures (see [detail official reference for concentrated flow mitigation measures]).*

This sentence could make the prevention of concentrated runoff more binding in comparison with relying on “good agricultural practice” only. As for diffuse runoff measures, the choice of mitigation measure(s) by farmers and their implementation would need to be documented for each field, so that an effective control is possible. The official list of accepted mitigation measures will need to detail the correct establishment and maintenance procedures for each measure, together with auditable criteria for adequate implementation of measures. Alternatively, a negative control in the field could be achieved via a diagnosis and documentation of traces of concentrated runoff in fields (erosion rills or gullies and deposited sediment at field edges).

## 4.3 Spray drift

Spray drift assessments are typical mandatory features of regulatory evaluations of plant protection products at the European level (Annex I assessments), zonal level, and on a country authorization basis. The purpose of this section is to provide a summary of:

- How spray drift is characterized
- What spray drift profiles are used to support regulatory risk assessments
- National options for mitigating spray drift
- Interpretation of labels under usage conditions

Particular emphasis is placed on two specific mitigation strategies: no spray zones and use of spray drift reduction technology. These techniques are also mentioned in Chapter 6, together with other mitigation options to be considered in an off-crop mitigation context. This chapter presents technical and regulatory context surrounding no spray zones and spray drift reduction technologies, which is considered warranted simply because there are sometimes significant differences between Member States when considering:

- Technical drift characterization and representation
- Permissible ranges of no-spray zones for different crops
- Acceptance of spray drift reduction technology as a label mitigation option
- Where accepted, the permissible options of spray drift reduction technology
- Examples where only voluntary implementation is permitted
- Examples of flexible implementation with adaptation of mitigation taking into account local conditions

A brief discussion on the implementation of spray drift reduction technology is proposed, recognizing that in a number of Member States there remain regulatory barriers for adoption or other constraints with users that may limit effective implementation. Possible options to address this are discussed. An illustration of expansion of options with spray drift reduction technology as a flexible strategy for implementation of spray drift mitigation is also provided based upon experiences in Southern Europe. Finally, proposals and recommendations for more practical, flexible, and meaningful spray drift mitigation (and spray drift reduction technology, in particular) are discussed with a view towards more effective harmonization of policy on spray drift mitigation between Member States.

### 4.3.1 How spray drift is characterized

Spray drift measurements may be performed under reference conditions in the field to assess the amount of applied spray volume blown away downwind of a treated area and deposited on the soil surface next to the treated field. This may be facilitated through the use of a fluorescent tracer to quantify spray deposition. A non-ionic surfactant may be added to mimic a spray solution of a plant protection product. Spray drift deposition is then assessed at a range of distances relative to the edge of the treated zone. Studies may be conducted with a range of different reference conditions (wind speed, nozzle height, temperature, humidity, etc.). Consequently, differences arise between assessments related to the choice of standard reference conditions for tests. This is illustrated in Table 4.4 (Huijsmans and van de Zande 2011).

**Table 4.4:** Summary of boom sprayer reference conditions (after Huijsmans and van de Zande 2011)

| | **NL** | **DE** | **UK** | **FR** | **PL** | **BE** | **SE** |
|---|---|---|---|---|---|---|---|
| Nozzle | XR11004 | FF 03, 04[a] | FF110/1.2/3.0 | FF11002 | FF03 | FF03 | F, M, C |
| Spray pressure (bar) | 3 | 2.0-5.0 | 3.0 | 2.5 | - | 3 | - |
| Spray volume (l/ha) | 300 | 150-300 | Speed dependent | - | - | - | - |
| Sprayer speed (km/h) | 6.5 | 6-8 | 6-12 (12, 16)[b] | 8.0 | - | - | 7.2 |
| Boom height (m) | 0.50 | 0.50 | 0.5 (0.7, 1.0) [b] | 0.70 | 0.5 | 0.5 | 0.25, 0.40, 0.60 |
| Sprayed surface | Potato, bare soil | Bare soil, short grass | Short grass, crop | - | - | - | Short grass |
| Crop height (m) | 0.5 / 0.10 | 0.10 | 0.05 – 2.0 | - | - | - | - |
| Sprayed width (m) | 24 | 20 | 48 | - | - | - | 96 |
| Temperature range (°C) | 5-25 | 10-25 | - | - | - | - | 10, 15, 20 |
| Wind speed range (m/s) | 1.5-5.0 | 1-5 | 2.5 (2.5, 3.5)[b] | - | - | - | 3,0, 4.5 |
| Wind speed height (m) | 2.0 | 2.0 | 3 | - | - | - | 2.0 |

[a] Basic drift curve contains data from measurements from other flat fan (FF) nozzle types and sizes

[b] Values in parenthesis are recently proposed (not yet adopted) for bystander/residents assessments

With respect to spray drift reduction technology, ISO identifies six classes of drift reducing technologies (ISO 22369-1, 2006) relating respectively to 25, 50, 75, 90, 95, and 99% of drift reduction. The underpinning characterization of drift reduction effectiveness varies and may include full-scale field trials (ISO 22866), wind tunnel tests (ISO 22856), and droplet size characterization (ISO/DIS 25358).

During discussions at the second workshop it was agreed that these differences should be acknowledged, but that harmonization of testing standards beyond ISO 22369 would be more effectively addressed independently via spray physics expert working groups. It was agreed that the workshop delegates should focus on general principles of mitigation – what is used, how it is used, and what opportunities can widen options and build upon regulatory and technical experience.

### 4.3.2 What spray drift profiles are used to support regulatory risk assessments

In general, the most common basis for representation of spray drift in risk assessments is drift tables presented by Rautmann et al. (2001). This, in turn drew upon the fundation of spray drift data tables established by Ganzelmeier et al. (1995) derived from trials over bare ground and were considered at the time to represent a worst case scenario. The original datset was collected from the late 1980s to the early 1990s, and included a total of 119 trials comprising 16 drift trials for field crops, 21 trials for grape vines, 61 trials for fruit crops, and 21 trials for hops. The 90$^{th}$ percentile values (or overall 90$^{th}$ percentile for multiple applications) derived from the data have remained the mainstay of EU risk assessments ever since (including incorporation into the FOCUS Surface Water modeling framework (FOCUS 2001). There are, however, notable differences in regulatory strategy and these are summarized in Figure 4.4 and detailed below.

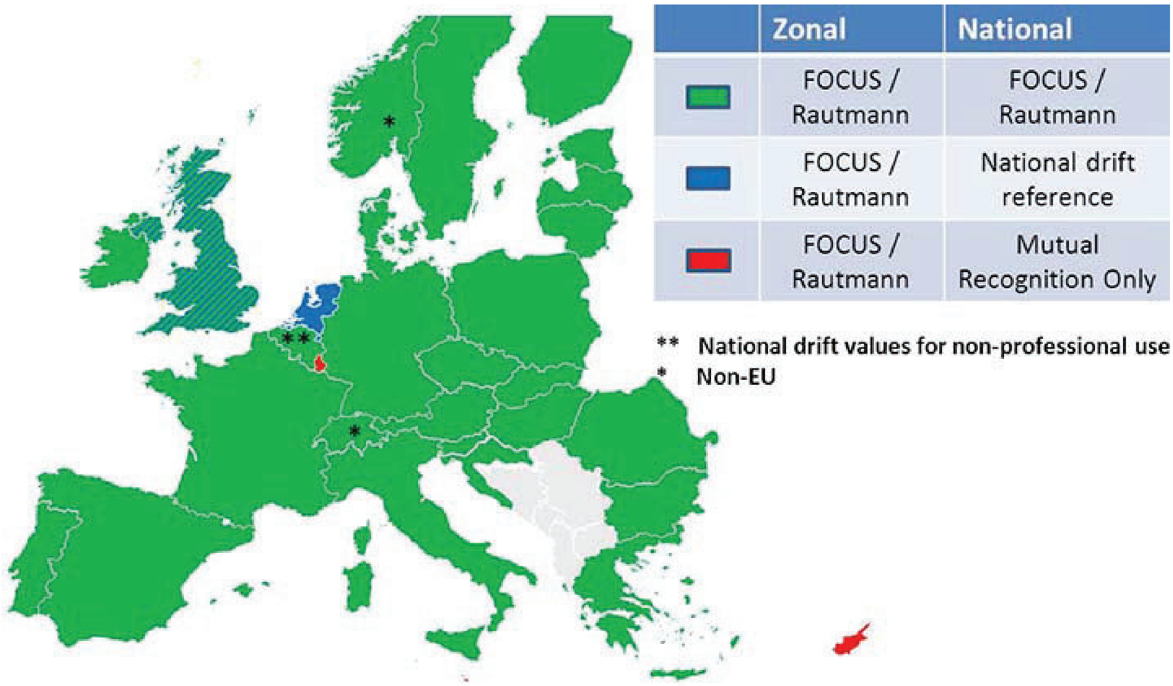


**Figure 4.4:** Summary of regulatory preferences for drift representation

Two Member States (the Netherlands and the UK) employ spray drift representations that differ from Rautmann et al. (2001) and these are discussed in brief below.

## ***Netherlands***

In the Dutch assessment procedure different spray drift curves are used for arable crops (boom sprayers), fruit crops, and nursery trees, all originating from field measurements carried out in the Netherlands based upon reference standards summarized (Huijsmans et al. 1997) in Table 4.4 for boom sprayers. In the Netherlands, the standard reference basis for assessment includes spray of a potato crop and in the near future also for bare soil or small crops (i.e., grass). For boom sprayers, the Netherlands specifies the position of the last nozzle relative to the last crop row. This originates from the experience in measuring spray drift in a crop situation where the nozzle position above the last crop row is fixed while the edge of the canopy varies. In other drift frameworks used in other countries, the edge of field is defined as half a nozzle spacing distance from the last nozzle (ISO 22866 2005). On this basis, and because of differences in reference nozzle standards and wind speed conditions during spray drift measurements, spray drift potential for the Netherlands is higher than represented in FOCUS.

Dutch spray drift profiles are implemented as a component of the Dutch government's policy (Multi-Year Crop Protection, Water Pollution Act, Plant Protection and Biocide Act, Sustainable Crop Protection I and II; LNV 2004, EZ 2013) that has set goals for the reduction of the emission of pesticides into the environment. A minimum set of agreed measures are mandatory to reduce spray drift deposition in practice based on drift-reducing application techniques and crop-free buffer zones based on the Water Pollution Act (I&M 2012). For example, in arable field crop spraying it is mandatory to use nozzles with at least 50% drift reduction on the outside 14 m of the field (VW and LNV 2001), a maximum boom height of 0.50 m and an end-nozzle on boom sprayers spraying alongside waterways (I&M 2012). For frequently sprayed crops like potatoes, flower bulbs, and onions, a crop-free buffer zone of 1.5 m measured between the center of the last crop row and the start of the ditch bank is obligatory. On the field edge it is also allowed to grow another non-sprayed crop or vegetation to serve as a buffer zone thereby introducing a no spray buffer zone. With higher level spray drift reducing techniques (drift reduction of 50% up to a drift reduction of 95%) the crop-free buffer zone is allowed to be smaller, up to 0.50 m (TC 2014) as long as authorization thresholds of pesticides are not exceeded for surface water (Ctgb 2014). For orchard spraying, specific combinations of spray techniques (Van de Zande et al. 2012) and crop-free buffer zones are mandatory as a first level leading to a minimal drift reduction of 90% at the water surface. Regulations are embedded in both the Pesticide Act and the Water Pollution Act. Based on the spray drift deposition level in surface water, the width of crop-free buffer zones can be set and impacts on the registration process of agrochemicals determined. A general reduction in spray drift to surface water next to the sprayed field can be achieved by improvements in spray application techniques. So in general in the Netherlands there are two levels of implementing SDRT and buffer zones:

1. Protection by general rules of mandatory drift reducing technologies and crop-free buffer zones

2. Wider buffer zones or more drift reducing technologies based on the toxicity of the agrochemical in the authorization procedure. From 2015 onward a minimum drift reduction of 75% is to be used on all fields sprayed with agrochemical irrespective of whether the field is alongside a water course.

***United Kingdom***

The current UK accepted approach for calculation of PECsw by spray drift is described in a previous Aquatic Guidance document (SANCO/3268/2001) drawing upon drift profiles proposed by Rautmann et al. (2001). This remains the primary basis for evaluation in most cases.

However, the UK authorities (CRD) have recently revised their policy to allow for greater flexibility to consider horizontal boom spray drift reduction technology. In this scheme, uses or products that do not give a satisfactory risk assessment without reliance upon SDRT can be assessed assuming the use of LERAP three star nozzles (HSE 2014), which provide at least 75% drift reduction. Where applicable, spray drift assessments based upon this SDRT framework may then be based upon the van de Zande spray drift dataset (van de Zande and Holterman 2005). The drift model contains the appropriate regression values from van de Zande data to calculate the initial surface water PEC due to spray drift (PECsw) for buffer zones from 5 m to 20 m in 5 m intervals. The basis for this policy revision is detailed in a CRD regulatory update (CRD 2014). It is for this reason that the UK is represented in Figure 4.4 as operating two parallel drift representation schemes.

### 4.3.3 National options for mitigating spray drift

Typically, where spray drift mitigation is required to support safe use, product labels make reference to no spray zones. In a number of Member States, the maximum width of these no spray zones is constrained by national policy. Certain Member States also permit the use of drift reducing nozzles as an independent or complementary means of mitigating spray drift. Examples of other schemes are summarized in the off-crop mitigation chapter. A summary is presented in the following discussion based upon status quo in mid-2014.

Specific national policies on the role of buffers and spray drift reducing nozzles in mitigating spray drift are summarized in the following tables. Examples for the Northern Zone have been summarized within the Northern Zone guidance document (Northern Zone Work Share Committee 2014) and are reproduced in Table 4.5. A similar assessment has been conducted for the Central Zone by Abu et al., (2013) with results reproduced in Table 4.6 and Table 4.7. Parallel tables including feedback from Member State regulators and companies for the Southern Zone are summarized in Table 4.8 to Table 4.11.

**Table 4.5:** Possible surface water mitigation measures in the countries of the Northern Zone (based upon Northern Zone Work Share Committee 2014)

<table>
<tr><th>Northern zone</th><th colspan="12">Width of No-Spray Buffer Zones (m) to Mitigate Drift Accepted by Northern Zone Member States</th><th>Drift Reducing Nozzles</th></tr>
<tr><th></th><th>2</th><th>3</th><th>5</th><th>10</th><th>15</th><th>20</th><th>25</th><th>30</th><th>35</th><th>40</th><th>45</th><th>50</th><th></th></tr>
<tr><td>Denmark</td><td>FVOB</td><td></td><td></td><td>FVOB</td><td></td><td>FVOB</td><td></td><td>VOB</td><td></td><td></td><td></td><td>O</td><td>NA</td></tr>
<tr><td>Estonia</td><td></td><td></td><td colspan="6">FVOB</td><td colspan="2">OB</td><td></td><td></td><td>NA</td></tr>
<tr><td>Finland</td><td></td><td colspan="5">FVOB</td><td></td><td>OB</td><td></td><td>O</td><td></td><td>O</td><td>Yes[A]</td></tr>
<tr><td>Latvia</td><td></td><td></td><td colspan="6">FVOB</td><td colspan="2">OB</td><td></td><td></td><td>NA</td></tr>
<tr><td>Lithuania</td><td></td><td></td><td colspan="4">FVOB</td><td colspan="4">OB</td><td></td><td></td><td>NA</td></tr>
<tr><td>Norway</td><td></td><td></td><td colspan="2">FVOB</td><td></td><td>FVOB</td><td></td><td>FVOB</td><td></td><td></td><td></td><td></td><td>NA</td></tr>
<tr><td>Sweden</td><td></td><td></td><td></td><td></td><td>FVB</td><td>O</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Yes[B,]</td></tr>
</table>

F = Field crops, V = Vegetables, O = Orchards, B = Bush & nurseries
NA: Not accepted
[A] 50%, 75%, 90%
[B] No spray buffer zone ("*Hjälpredan*"/"the Helper") is to be used as first option for off-field risk mitigation. If necessary, drift reducing equipment could be used in combination with no spray buffer zones to further reduce the exposure. Arable crops & vegetables: 50, 75, or 90%; Orchards: 25, 50, 75, 90, or 99%

**Table 4.6:** Summary of surface water mitigation measures currently applied by Member States in the Central Zone for arable crops (based on survey conducted by Abu et al. 2013)

| Member State | Maximum No Spray Buffer Zone | Drift Reducing Nozzles | Maximum No Spray + Drift Reduction Combination |
|---|---|---|---|
| Austria | 20 m | 50%, 75%, 90% | 20 m + 90% drift reduction |
| Belgium | 20 m | 50%, 75%, 90% | 20 m + 90% drift reduction |
| Czech Republic | 50 m | 50%, 75%, 90% | 90% drift reduction |
| Germany | 20 m | 50%, 75%, 90% | 20 m + 90% drift reduction |
| Hungary | 50 m | 50%, 75% | 50 m, No drift reduction |
| Netherlands | 3 m; No maximum set* | 50%, 75%, 90%, 95% | 95% drift reduction |
| Poland | No maximum set | 50, 75, 90, 95%[B] | 95% drift reduction |
| Ireland | Under review | Under review | Under review |
| Romania | No information | No Information | No Information |
| Slovakia | 20 m | 50%, 75%, 90% | Not specified |
| Slovenia | 20 m | 50%, 75%, 90% | Under review |
| United Kingdom | 20 m | LERAP[A] | LERAP[A] |

[A] Reduction in buffer width specified on the product label is possible at farm level under the Local Environmental Risk Assessment for Pesticides scheme when drift reducing equipment is used.

[B] Polish authorities are finalizing a legal act in which permissible spray drift reduction technology is defined rather than specifically referring to spray drift reducting nozzles

* In general, crop-free buffer zones are used

**Table 4.7:** Summary of surface water mitigation measures currently applied by Member States in the Central Zone for fruit crops (based on survey conducted by Abu et al. 2013)

| Member State | Maximum No Spray Buffer Zone | Drift Reducing Nozzles | Maximum No Spray + Drift Reduction Combination |
|---|---|---|---|
| Austria | 20 m | 50%, 75%, 90%, 95% | 95% drift reduction |
| Belgium | 30 m | 50%, 75%, 90%, 99% | 30 m + 90% drift reduction |
| Czech Republic | 50 m | 50%, 75%, 90% | 90% drift reduction |
| Germany | 20 m | 50%, 75%, 90% | 20 m + 90% drift reduction |
| Hungary | 50 m | 50%, 75% | 50 m, No drift reduction |
| Netherlands | 9 m; No Maximum Set*) | 50%, 75%, 90%, 95% | 95% drift reduction |
| Poland | No maximum set | 50, 75, 90, 95%[B] | 95% drift reduction |
| Ireland | Under Review | Under Review | Under Review |
| Romania | No Information | No Information | No Information |
| Slovakia | 50 m | 50%, 75%, 90% | Not specified |
| Slovenia | 20 m | 50%, 75%, 90% | Under review |
| United Kingdom | 20 m | LERAP[A] | LERAP[A] |

[A] Reduction in buffer width specified on the product label is possible at farm level under the Local Environmental Risk Assessment for Pesticides scheme when drift reducing equipment is used.

[B] Polish authorities are finalizing a legal act in which permissible spray drift reduction technology is defined rather than specifically referring to spray drift reducting nozzles

* In general, crop-free buffer zones are used

**Table 4.8:** Possible surface water mitigation measures in the countries of the Central zone (based on survey conducted by Abu et al. 2013)

| | Width of No-Spray Buffer Zones (m) to Mitigate Drift Accepted by Central Zone Member States | | | | | | | | | | | | | | | | | | | | | | | | | | | Drift Reducing Nozzles |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 100 | |
| Austria | FVOB | | FVOB | | FVOB | | | | | FVOB | | | | | FVOB | | | | | FVOB | | | | | | | | FV: 50, 75, 90%<br>OB: 50, 75, 90, 95% |
| Belgium | | FV | OB | | FVOB | | | | | FVOB | | | | | | | | | | FVOB | | OB | | | | | | FV: 50, 75, 90%<br>OB: 50, 75, 90, 99% |
| Czech Republic | | | | | FV | | | | | FVOB | | | | | | | | | | | FVOB | | | | | | | FVOB: 50, 75, 90% |
| Germany | | | | | FVOB | | | | | FVOB | | | | | FVOB | | | | | FVOB | | | | | | | | FVOB: 50, 75, 90% |
| Hungary | | | | | | | | | | | | | | | | | | | | | | | | | | FVOB[A] | | FVOB: 50, 75% |
| Ireland | | | | | | | | | | | | | | | | | | | | | | | | | | | | No information |
| Netherlands | | | | | FV | | | | OB | | | | | | | | | | | | | | | | | | | FV: 50, 75, 90, 95%<br>OB: 50, 75, 90, 95% |
| Poland | FV | | | | | | | | | | | | | | FVOB[B] | | | | | | | | | | | | | FVOB: 95% |
| Romania | | | | | | | | | | | | | | | | | | | | | | | | | | | | No information |
| Slovakia | | | | | | | | FV | | | | FV | | | FV | | | FV | | FV | | | | OB | | | | FVOB: 50, 75, 90% |
| Slovenia | | | | | | | | | | | | | | | | | | | | FV | | | | | | OB | | FVOB: 50, 75, 90% |
| United Kingdom[C,D] | | FV | | | FVOB | | FV[C] | | | FVOB[C] | | FV[C] | | | FVOB[C] | | | FV[C] | | FVOB | | OB | | OB | | OB | | LERAP[D] |

F = Field crops, V = Vegetables, O = Orchards, B = Bush & nurseries

[A] Only maximum buffers presented. Smaller buffers may be accepted.

[B] No maximum buffer width is defined

[C] FV buffer zones at 6, 12, or 18 m may also require use of 75% drift reducing equipment to control exposure.

[D] For FV buffer zones 1-5 m, and OB a reduction in buffer width specified on the product label is possible at farm level under the Local Environmental Risk Assessment for Pesticides (LERAP) scheme when drift reducing equipment or other measures are used. Drift reduction classes are 25%, 50%, 75%. For FV buffer zones 5-20 m with standard equipment no reduction is allowed under LERAP

**Table 4.9:** Summary of surface water mitigation measures currently applied by Member States in the Southern Zone for arable crops (based upon combination of Member State and company feedback)

| Member State | Maximum No Spray Buffer Zone | Drift Reducing Nozzles |
|---|---|---|
| Bulgaria | 100 m | SDRT proposals accepted[C] |
| Croatia | 20 m | No precedent for acceptance |
| Cyprus[A] | 20 m | SDRT proposals accepted[C] |
| France | 20 m | Used at discretion of farmers – cannot be introduced as label requirement |
| Greece | 20 m | SDRT proposals accepted[C] |
| Italy | 30 m | 50%, 75%, 90%, 95%, 99% |
| Malta[B] | 20 m | 50%, 75%, 90%, 95%, 99% |
| Portugal | 20 m | SDRT proposals accepted[C] |
| Spain | 50 m | 50%, 75%, 90%, 95% |

[A] Assumes mutual recognition with Greece

[B] Assumes mutual recognition with Italy

[C] No formal guidance available on nozzle effectiveness – subject to negotiation

**Table 4.10:** Summary of surface water mitigation measures currently applied by Member States in the Southern Zone for fruit crops (based upon combination of Member State and Company feedback)

| Member State | Maximum No Spray Buffer Zone | Drift Reducing Nozzles |
|---|---|---|
| Bulgaria | 100 m | SDRT proposals accepted[C] |
| Croatia | 20 m | No precedent for acceptance |
| Cyprus[A] | 40 m | SDRT proposals accepted[C] |
| France | 20 m | Used at discretion of farmers – cannot be introduced as label requirement |
| Greece | 40 m | SDRT proposals accepted[C] |

| | | |
|---|---|---|
| Italy | 30 m | 50%,75%,90%,95%, 99% |
| Malta[B] | 40 m | 50%,75%,90%,95%, 99% |
| Portugal | 20 m | SDRT proposals accepted[C] |
| Spain | 50 m | 50%, 75%, 90%, 95%, |

[A] Assumes mutual recognition with Greece

[B] Assumes mutual recognition with Italy

[C] No formal guidance available on nozzle effectiveness – subject to negotiation

**Table 4.11:** Possible surface water mitigation measures in the countries of the Southern zone (based upon combination of Member State and Company feedback)

| | Width of No-Spray Buffer Zones to Mitigate Drift (m) | | | | | | | | | | | | | | Drift Reducing Nozzles |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2** | **3** | **5** | **9** | **10** | **15** | **20** | **25** | **30** | **35** | **40** | **45** | **50** | **100** | |
| Bulgaria | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | FVOB | SDRT proposals accepted[C] |
| Croatia | ? | ? | ? | ? | ? | ? | FVOB | | | | | | | | No precedent for acceptance |
| Cyprus[A] | ? | ? | ? | ? | ? | ? | FV | ? | ? | ? | OB | | | | SDRT proposals accepted[C] |
| France | | | FVOB | | | | FVOB | | | | | | | | Used at discretion of farmers – cannot be introduced as label requirement |
| Greece | ? | ? | ? | ? | ? | ? | FV | ? | ? | ? | OB | | | | SDRT proposals accepted[C] |
| Italy | FVOB[D] | | | | | | | | | | | | | | 50%, 75%, 90%, 95%, 99% |
| Malta[B] | ? | ? | ? | ? | ? | ? | FV | ? | ? | ? | OB | | | | 50%, 75%, 90%, 95%, 99% |
| Portugal | ? | ? | ? | ? | ? | ? | FVOB | | | | | | | | SDRT proposals accepted[C] |
| Spain | | | FVOB | | FVOB | | | | | | | | | | 50, 75, 90, 95% |

F = Field crops, V = Vegetables, O = Orchards, B = Bush & nurseries

[A] Assumes mutual recognition with Greece

[B] Assumes mutual recognition with Italy

[C] No formal guidance available on nozzle effectiveness – subject to negotiation

[D] Exception for maize where maximum drift buffers are typically 5 m due to high density of water bodies in the primary maize production region (Po valley). For compounds requiring buffers for the purpose of run-off mitigation a label restriction is introduced to eliminate use in areas with greater than 2% slope.

? Acceptance of these intermediate widths is currently unknown

### 4.3.4 Interpretation of label under usage conditions

Requirements for spray drift mitigation based upon no spray zones or SDRT stipulated on the product label must be respected by the user. In selected Member States there is some further flexibility to reduce reliance upon no spray zones through compensatory actions. Examples where this is the case are discussed below.

***France***

The implementation of SDRT by farmers in France is purely voluntary. However, buffers may be reduced from 20 m to 5 m (or 50 m to 5 m) if the following conditions are met by farmers (JORF 2006):

- Planting of a permanent vegetated strip of 5 m width adjacent to the water body:
  - For high drift uses such as orchards and vineyards the strip must be planted with a hedge of at least equivalent height to the crop;
  - For other uses no height is specified and there is greater flexibility with vegetation.
- Implementation of other means of reducing risk to aquatic life, such as SDRT:
  - This must include approved methods published by the Ministry of Agriculture and Fisheries, which would have the effect of reducing risk to aquatic organisms by at least a factor of 3 relative to normal usage conditions (implicitly this means spray drift reduction must be at least 66.7%);
  - This includes a range of drift reducing nozzles published in the Ministry of Agriculture and Fisheries bulletin (Arrété du 12 Septembre 2006 relatif à la mise sur la marché et à l’utilisation des produits vises à l’article L.253-1 du code rural) (JORF 2006);

- Recording of products used (trade name, dates, and rates used).

***United Kingdom – LERAP***

Aquatic buffers for products applied by horizontal boom or broadcast air-assisted sprayers in the United Kingdom may be reduced through a legal obligation to carry out and record a Local Environmental Risk Assessment for Pesticides (LERAP; Gilbert 2000). For horizontal boom sprayers it is only possible to reduce buffer zones of 5 m; buffer zones of greater than 5 m cannot be reduced.

A flow chart summarizing the application of LERAPs in the United Kingdom to reduce buffer widths is provided in Figure 4.5.

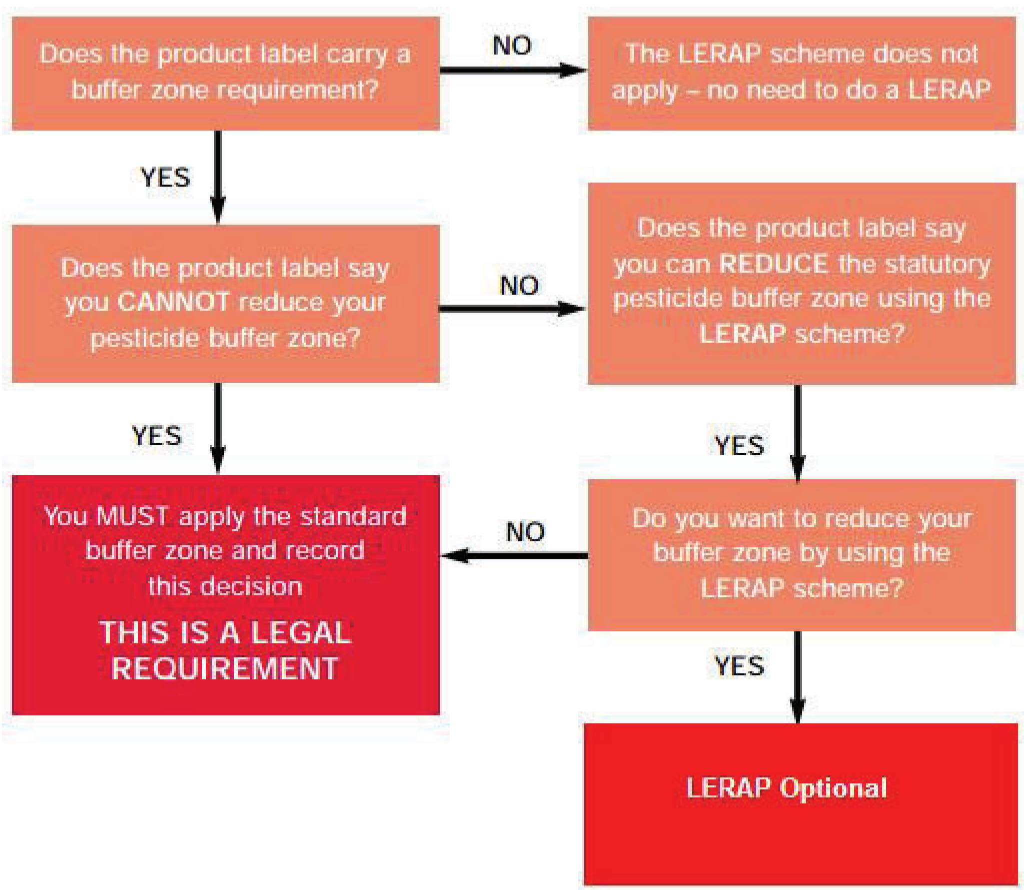


**Figure 4.5:** Summary of application of LERAP scheme in the United Kingdom

The LERAP procedure to reduce buffer zone widths in the United Kingdom is conducted by first characterizing the local environment and intended spray operation:

- Characterize water bodies adjacent to the spray area (width at narrowest point)
- Record dose rate proposed (e.g., full rate, ½ rate, ¼ rate)
- Decide whether a LERAP spray drift reduction nozzle is proposed to reduce spray drift
- LERAP spray drift reduction nozzle star rates represent 25% spray drift reduction (*), 50% spray drift reduction (**), and 75% spray drift reduction (***)

When considering applications using broadcast air-assisted sprayers there are further refinements. For example, it is possible to take into account living windbreaks fulfilling the following conditions to assist in reducing buffer widths:

- The windbreak is formed from broad-leaved trees or shrubs, not conifers (conifers may deflect spray down onto the watercourse behind them); It is managed to protect the crop from the effects of wind or to minimize spray drift
- It is at least 2 m higher than the crop to be sprayed
- It extends for the full length of the boundary between the treated crop and the watercourse
- It has no gaps over this length including those resulting from systematic stripping of lower branches
- Leaves are visible over its entire length

Those responsible for product application then work out the width of buffer zone for the intended spray operation. Using the information above users can, with the aid of tables provided in LERAP guidance, work out what unsprayed buffer zone reduction may be permitted. If the user intends to use a LERAP low-drift 3-star-rated sprayer (75% spray drift reduction), they may apply a 1 m buffer zone for all horizontal boom sprayer dose rates regardless of the width of watercourse or pond. For broadcast air-assisted sprayers the minimum buffer zones permitted on the basis of reduced doses alone is 7 m for all crops. When including other reduction aspects (e.g., SDRT, living windbreakers), the absolute minimum buffer zone is 5 m. If a ditch is dry at the time of application a 1 m or 5 m unsprayed buffer zone is applied for horizontal boom sprayers and broadcast air assisted sprayers, respectively.

Farmers are obliged to then record the LERAP decision, taking note of the following in sprayer records:

- date of assessment
- type of sprayer, nozzle, and spray pressure used (in particular any LERAP one, two, or three star rating drift reduction nozzle)
- the pesticide product applied
- the dose at which it was applied
- the width of the watercourse
- the result of the LERAP decision (i.e., the width of unsprayed buffer zone set)
- the name of the person who carried out the LERAP

As a result of recent changes in policy in the UK (CRD 2014), some products may be specified for use with spray drift reduction technology (LERAP 3 star low-drift status) and buffer zones of 6, 12, or 18 m (as necessary for each crop) as a condition of authorization for horizontal boom spraying. Authorizations issued under these arrangements also specify a second buffer zone of 30 m, beyond which use of spray drift reduction technology is not required. This is necessary to protect watercourses from higher rates of spray drift arising from use of standard spraying equipment and procedures. These distances cannot be reduced under the LERAP scheme.

***<u>Sweden – "Hjälpredan"</u>***

Hjälpredan (literally "the Helper") is to be used as a first option for off-field risk mitigation. If necessary, drift reducing equipment could be used in combination with no spray buffer zones to further reduce the exposure. Users first need to measure wind direction, wind speed, and temperature, and together with data on dose rate, spray boom height, and spray quality (fine, medium, coarse; nozzle type), they can calculate the proper safety distances needed taking into account "general" or "specific" areas of concern.

The objective for areas of "general" concern is protection of biodiversity outside the field and neighboring crops downwind of application, while a higher standard of protection exists for areas of "specific" concern downwind of application; these include water courses, areas with vulnerable biodiversity, sensitive crops, organically grown crops, bee-hives, home gardens, playgrounds, and other suburban areas.

The Helper gives the user several options in each spraying situation, which is also an important aspect. The user can reduce the dose rate or choose other spraying techniques, for example nozzles that may allow spraying closer to the field edges. If large safety distances (e.g., >50 m) are required due to particular weather conditions, the user can postpone spraying and come back later when the weather conditions are more suitable for spraying.

If the risk assessment indicates that (fixed) no-spray buffer zones wider than 15 or 20 m are necessary in order to maintain a low risk to non-target organisms, Hjälpredan is not sufficient. Additional risk management measures may then be needed to fulfill the requirement for authorization, such as spray drift-reducing equipment. However, it has to be established that the use of spray drift reducing nozzles does not impair the efficacy of the product.

According to a farmer survey, approximately 50% of all Swedish farmers spraying pesticides report that they use the Helper to determine when to apply safety distances such as buffer zones. KEMI (2012) now sets a demand in all new approvals and re-approvals that the Helper must be used to determine the size of buffer zones. This is a cross-compliance initiative which means that the farmers will need to maintain spray records based on the tool. It is expected that this will reinforce the use of the tool.

More information about the Hjälpredan can be found at:
http://sakertvaxtskydd.se/sv/Bibliotek/Mitigating-spray-drift-in-Sweden1/

While tools and options such as the Hjälpredan allow for a relatively high degree of customization of application to reflect the environmental and landscape conditions at the point of application, they require a high degree of compliance, awareness, and acceptance by farmers and applicators. The Hjälpredanis noted here simply as an example of a scheme in which a relatively high degree of responsibility is put in the hands of farmers and applicators to adjust application to reflect local conditions. In most Member States a more rigid framework of recommendations for applications is applied. While this has the disadvantage of constraining the ability to adapt application to local conditions, it has significant labeling advantages in terms of simplicity, ease of communication, and greater potential likelihood of compliance. The Hjälpredan is summarized here as an illustration of how Member States might choose to balance the need for flexibility to adapt an application framework and the need for label simplicity.

### 4.3.5 Overview of spray drift reductions measures

A compilation of the risk mitigation tools directly intended to manage spray drift that were identified via questionnaires was prepared to support preparation of an inventory of off-crop risk mitigation measures discussed in Chapter 6. These measures are summarized in Table 5.12. As in Chapter 6, the group discussed the following criteria for each tool:

- Efficacy of the tool to appropriately mitigate risks

- Regulatory and legal aspects relevant to the tool. This criterion considers, for example, the legal status of the risk mitigation tool in the countries where it is implemented. This criterion also considers the possibility to take the risk mitigation measure into account in the risk assessment process

- Implementation aspects, particularly with regards to the acceptability of the tool to farmers

Table 4.12 also lists the mitigation measures identified at Member State level for different groups of species of concern, and characterizes their level of practicality, effectiveness, and enforceability. Based on the expert judgement of the workshop participants, the risk mitigation measures identified were ranked, as explained in the introduction.

The risk mitigation tools identified as promising or well established are further detailed in dedicated Risk Mitigation Measure Technical Sheets (RMMTS) that are provided in Appendix 1.

It is noted that the measures summarized here are limited to those that would be primarily developed to manage spray drift. Other measures summarized in Chapter 6 may have a complementary benefit in reducing spray drift and associated impacts (e.g., vegetated buffer strips, multi-functional field margins), but are not discussed here for the sake of brevity. Readers are directed to Table 6.2 in Chapter 6 where additional spray drift reduction benefits from these measures are highlighted.

**Table 4.12:** Overview of the risk mitigation measures (RMM) suitable to reduce impact of spray drift. RMM are allocated into the following categories: Buffer Zones (BZ) aimed at reducing exposure of off-crop area via spray drift, Spray Drift Reduction Technologies (SDRT), which involve any technology associated with sprayers, nozzles, or spraying techniques that will reduce drift, and Good Agricultural Practices (GAP), which relate to product application (dose and application regime). Note that mitigation measures associated with field margin management may have a complementary spray drift reduction benefit but are discussed in Chapter 6. The corresponding Risk Mitigation Measure Technical Sheets (RMMTS)

are listed in the last column together with their location in the proceedings.

| Risk Mitigation Measure | Category | Description | Status[1] | Countries Where Implemented (as Based on the Questionnaires and Further Discussions) | Proposed New SPe Phrase in the Context of Regulation (EU) 547/2001 | RMM Taken Into Account in the Risk Assessment | RMMTS |
|---|---|---|---|---|---|---|---|
| No spray buffer zone | BZ | • No spray buffer zone in the field and/or at the field border to avoid direct spray of off-field area<br>• Usually product-specific<br>• Width typically comprised between 1 and 50 m<br>• Benefits on all off-field area and organisms through spray drift reduction | 4 | All MS | **Adapted from current SPe3:**<br><br>SPe3: To protect [aquatic organisms / non-target plants / non-target arthropods / insects] from spray drift respect an unsprayed buffer zone of (distance to be specified) to the edge of the field/surface water bodies]. The edge of the field is either the edge of the crop or, in the presence of a margin strip, the edge of a margin strip (see previous section). | Yes | Not necessary<br><br>The risk assessment already takes into account spray drift values for no spray buffer zones up to 100 m width |
| Wind direction – dependant no | BZ | • No spray zone in the field or at the field boarder to avoid direct spray of off-field area | 3 | SE | **Additional text to be associated to SPe3:** | Possible | Yes (RMMTS #1) |
| spray zone | | • Product specific, set as a function of wind speed and temperature based on a user guide (Helper)<br>• Benefits on all off-crop area and organisms through spray drift reduction | | | The buffer zone may be adjusted as a function of wind speed, wind direction and temperature conditions based on available recommendations. | | |
| Buffer zone of bare soil | BZ | • No spray zone at the field border to avoid direct spray of off-crop area<br>• Generic<br>• Width from 0.25 to 12 m if used with spray drift reduction technology<br>• Benefits on all off-crop area and organisms through spray drift reduction | 3 | NL, UK | **See SPe 3** | Yes | Yes (RMMTS # 2) |
| Drift reducing nozzles (incl. adjusted spray pressure, etc.) | SDRT | • Generic or product-specific<br>• Benefits on all off-crop area and organisms through spray drift | 3 | AT, BE, BG, CH, CZ, DE, ES, FR, HU, IT, NL, PL, SE, SL, UK | **Additional text to be added to a SPe3:**<br><br>The buffer zone may be reduced to (distance to be | Yes | Yes<br><br>(RMMTS # 11) |

| Risk Mitigation Measure | Category | Description | Status[1] | Countries Where Implemented (as Based on the Questionnaires and Further Discussions) | Proposed New SPe Phrase in the Context of Regulation (EU) 547/2001 | RMM Taken Into Account in the Risk Assessment | RMMTS |
|---|---|---|---|---|---|---|---|
| | | reduction | | | specified) if a combination of spray drift reduction technologies such as drift reducing nozzles, special equipment to reduce spray drift or directed spraying technique [is / are] used providing at least (% of drift reduction to be specified). | | |
| Special equipment/machinery (Wings-/Tunnel-/Band sprayer etc) | SDRT | • Generic or product-specific<br>• Benefits on all off-crop area and organisms through spray drift reduction | 4 | DE, NL | **As for drift reducing nozzles** | Possible | Yes (RMMTS # 12) |
| Directed spraying techniques (one-sided spraying, forward-speed, reflection shield, boom-height adjustment etc.) | SDRT | • Generic or product-specific<br>• Benefits on all off-crop area and organisms through spray drift reduction | 4 | CH, DE, IT, NL,SE | **As for drift reducing nozzles** | Possible | Yes (RMMTS #12) |
| Precision treatment (as sprayers' equipment) | SDRT | • Spray limited to the area of the crop identified as to be treated by the farmer – supported by GPS technology<br>• Used on some crops and depending on the growth stage<br>• Data on use and benefits are needed to propose detailed recommendations | 1 | - | n.a. | n.a. | Yes<br><br>(RMMTS # 13) |
| Dose of product (reduction or limitation) | GAP | • Label language limiting the application rate to a maximum<br>• Derived from the risk assessment<br>• Benefits related to the group of organisms having driven the risk assessment | 4 | BE, DE, ES, FR, NO, SE, UK | **New SPe proposing adapted Good Agricultural Practices (GAP) to reduce exposure of wildlife and/or transfers via runoff:**<br><br>To protect [birds / mammals / aquatic organisms / pollinators / non-target | Yes | Not necessary<br><br>The risk assessment already takes into account modified application regimes where |

| Risk Mitigation Measure | Category | Description | Status[1] | Countries Where Implemented (as Based on the Questionnaires and Further Discussions) | Proposed New SPe Phrase in the Context of Regulation (EU) 547/2001 | RMM Taken Into Account in the Risk Assessment | RMMTS |
|---|---|---|---|---|---|---|---|
| | | | | | arthropods / non-target plants/limit risks related to situations of runoff] respect an application rate of maximum (application rate to be specified) /do not apply this product more than (time period or frequency to be specified)/ do not apply during the bird breeding period / restrict applications to (dates or growth stages to be specified). | | necessary |
| Excluding types of application techniques (e.g., canon application) | GAP | • Label language excluding some application techniques to be used for a specific product<br>• Derived from the risk assessment<br>• Benefits related to the group of organisms having | 3 | - | n.a. | Yes | Not necessary<br><br>The risk assessment already takes into account modified |
| | | driven the risk assessment | | | | | application regimes where necessary |
| Forest aerial application - max. 50% area treated, no spray on the forest edges, standard buffer zones<br><br>Aerial applications | BZ | • Restriction of aerial applications with regards to the surface treated, implementation of in-crop buffer zones<br>• Case-by-case as related to restricted uses<br>• Benefits on all off-field area and organisms through spray drift reduction | 3 | DE, FR | n.a. | n.a. | Not necessary (see note)<br><br>Product and use specific and to be managed at the country level based on policy relative to aerial applications |
| Specific regulation orsuspension of pesticide | Regulatory | • Restriction of uses in the registration certificate/decision notification | 4 | IT, SI, UK | n.a. | n.a. | No |

[1] Status:

1. Not to be promoted

2. Under development
3. Needs consolidation and research
4. Promising tool implemented in some Member States
5. Well established tool implemented in most Member States.

### 4.3.6 Towards wider implementation and overcoming hurdles

There is a high level of awareness among farmers, risk assessors, and risk managers of both the benefits and constraints surrounding spray drift mitigation employing conventional no-spray buffer zones. Such buffers are easily and flexibly implemented and there is a substantial database of field research to characterize their effectiveness. This research has led to the development of formal spray drift mitigation representations that are readily incorporated into regulatory risk assessments.

Spray drift reduction nozzles (SDRN or DRN) provide an alternative or supplementary means of mitigating drift. SDRN are effective through reducing the production of droplets of diameter of ca.<100 µm, thereby reducing the impact of variables such as wind speed and release height. It is noteworthy that SDRN have a number of important benefits to growers, including:

- SDRN can be used with simple reductions in spray pressure and does not necessitate changes in any other application parameters such as water volume, application speed, use rate, or frequency of application, etc.
- SDRN can easily be substituted for standard hydraulic nozzles for a reasonable price, without any significant technical modification to the sprayer
- The reduction in spray drift also means that in-field buffers may be reduced, thereby helping the grower to maximize the area of production at their disposal

Nevertheless, SDRN remain an under-exploited means of managing spray drift losses in a number of Member States. There are a number of potential reasons for this:

- Grower and applicator constraints
    - Awareness of SDRN options
    - Misconceptions surrounding practicality of implementation
    - Concerns associated with loss of product efficacy
    - Uncertainties surrounding product label interpretation
- Regulatory uncertainties
    - SDRN mitigation efficacy in spray drift reduction
    - Variability in nozzle classification
    - Practicality and extent of grower or applicator implementation
    - Representation in risk assessments
    - Statement to be able to support the correct selection of drift reducing nozzles by farmers to achieve the drift reduction required by the risk assessment
    - Enforceability

Each of these constraints or uncertainties is considered here drawing upon recent initiatives such as the ECPA funded TOPPS-PROWADIS and SDRT info projects and other product stewardship activities.

#### 4.3.6.1 Perception regarding product efficacy

Growers have questioned product efficacy based on the idea that product delivery to target surfaces may be less consistent, but there is no evidence of loss of efficacy if the application equipment is properly calibrated through key parameters like pressure. Farmers are aware of other parameters, which are important for a successful treatment: growth stage of pests and their mobility on the plant, growth stage of crop where particularly important parameters include LAI (Leaf Area Index), and timing of application.

It is noted that the act of transferring nozzles should be accompanied by a recommendation that equipment should be maintained, cleaned, and calibrated at the same time in order to maximize performance and delivery of product spray. It is clear that use of SDRN requires an improvement in the technical background of farmers which is aligned with the principles of the Sustainable Use Directive (Directive [EC] No. 2009/128).

In case of downward placement like herbicide applications, the literature reports that the efficacy can be slightly reduced. It occurs because the application equipment typically used is already for low water volumes, so in these cases it is particularly important to assess the right rate per hectare to ensure that the final spray applied is not less than recommended by the label.

In the Netherlands, an intensive research program has investigated the efficacy of drift reducing technology in order to support its introduction. Results showed that drift reduction techniques up to 90% drift reduction showed no reduction in biological efficacy in orchard, flower bulb, vegetable, and arable crop spraying (Schepers & Meier 2007). Only two areas were identified as potentially having a small reduction in biological efficacy:

1. Application of herbicides in a low dose system on very small weeds (cotyledon stage) where biological efficacy was guaranteed up to 75% drift reducing nozzles. With an application at a 2-4 leaf stage the problem was already solved

2. Fungicide application in onions gave a reduced biological efficacy using 90% drift reducing nozzles, whereas there were no problems with DRN up to 75%

In general, experience has shown that issues that may be encountered with lesser efficacy may be resolved through slight adjustment of application practices. Examples of options in this case included:

1. Application with additives such as “stickers” may reduce loss of larger droplets (reduces run-off loss down stems)

2. Application with a 75% twin fan nozzle with simultaneous spraying to the front and back with reduced boom height providing an increased coverage with no negative drop size effects (a combination that has the same high drift reduction level)

3. Adaptation of timing of spraying to ensure application when weeds are a little larger in size

#### 4.3.6.2 Practicality of implementation

There are basically two kinds of pesticide sprayers on the market for 3D crops: hydraulic and pneumatic. Hydraulic sprayers already have nozzles so, to reduce drift keeping the same level of efficacy, it is necessary just to replace conventional nozzles with drift reducing nozzles.

Standard hydraulic nozzles can be easily substituted for spray drift reduction nozzles for a reasonable price, without any significant technical modification to the sprayer also considering that new sprayers usually adopt a multiple nozzle body, which has 3 to 5 spray positions for easy change of spray tips. These multiple nozzle bodies can be mounted after-market and on old or basic sprayers. Technologies for drift reduction are quickly improving across Europe and a further contribution from mechanical engineering is expected over the next years, as recommended in the Sustainable Use Directive.

Pneumatic atomizers generate droplets by tearing a spray film at high air speed. These are mainly used in south Europe especially in plantations (orchard, vine, etc.). With the technology available today, it is difficult to change the droplet spectra under practical conditions. Bigger drops will be generated if the airspeed is reduced. On the other hand the airspeed and air volume is important to transport the droplets to the target and to provide the necessary penetration of spray solution into the canopy.

#### 4.3.6.3 Addressing issues with characterizing spray drift reduction effectiveness

As noted earlier in this chapter, a common European classification of drift reducing nozzles would be helpful for harmonization as, for the time being, each Member State refers to local or national criteria to select them. It would be important to refer to the European standard provided by ISO 22369-1, which identifies six classes of drift reduction nozzles relating respectively to 25, 50, 75, 90, 95, and 99% drift reduction. The lack of detailed, agreed, technical standards for characterizing drift reduction effectiveness remains a technical and regulatory constraint to effective harmonization of mitigation standards. For boom sprayers the classification in drift reducing classes is defined in ISO 22369-2. Standard methodologies are still required for orchard sprayers, wind tunnel measurements, test bench measurements, and nozzle spray quality measurements combined with spray drift modeling.

A more fundamental hurdle in some Member States is related to the sometimes sparse availability of information on SDRT options. Until recently there was no European database where technologies and specifications used in each EU Member State were described. In recognition of this problem, ECPA funded an internet-based database (www.sdrt.info) as an inventory for SDR methodologies with the following objectives:

- To enable an EU Member State-by-Member State breakdown of status
- To improve awareness of such technologies and methodologies in those EU Member States that are not (yet) exploiting the benefits of spray drift reduction technology
- To promote a flexible and effective approach to SDRN classification and recognition in those countries currently without formal national SDRN schemes, drawing upon experiences and schemes already in existence elsewhere in Europe (classification transfer)
- To support sustainable use initiatives already underway (see Chapter 10)
- To help identify further needs for research or development

In this way, this extensive database is intended to provide a resource for:

- Growers and advisors: To understand options available to them in their jurisdiction
- Industry: To understand how spray drift reduction technology may be taken into account when compiling risk assessments
- Regulators: To consider technology transfer or ‘classification transfer’ from other Member States where well-established SDRN classification already exists

#### 4.3.6.4 Representations in risk assessments

Regulatory concerns may arise when considering practicality of representation in regulatory risk assessments. The representation of the ISO defaults (25, 50, 75, 90, 95, and 99% drift reduction) within formal regulatory risk assessments is very straightforward (simply reducing spray drift percentages versus defaults by appropriate factors). Drift reduction is included as an option within the SWAN software that is capable of post-processing Step 3 FOCUS SW input files (TOXSWA) to more readily represent a range of mitigation options.

### 4.3.7 Calculating overall mitigation effectiveness for combinations of measures

As noted in the preceding discussion regarding runoff, all risk mitigation measures that can be integrated into regulatory modeling can also be simulated in combinations, providing a direct mitigation effectiveness output for combinations of measures. A point system is discussed that may be applied to address mitigation needs for runoff in a flexible manner that is tailored to local conditions in the agricultural landscape and applicability or availability of risk mitigation measures.

The same basic structure may also be applied to drift mitigation. In many respects, such a system may be more readily adopted for spray drift given the greater simplicity of implementation and quantitative representation of effectiveness of measures. Drift mitigation achieved through the introduction of no-spray buffer zones or via spray drift reduction technology are already both expressed in quantitative forms that may be simply arithmetically compounded. The effectiveness of other factors or features may also be included in a similar manner so that an overall mitigation requirement may be achieved with flexibly through a variety of mechanisms in combination.

#### 4.3.7.1 Product label interpretation

Regulatory concerns may also arise associated with clarity of communication of mitigation needs on labels. Ideally, label language should be concise and transparent and provide options for adoption as measures in their own right or in conjunction with conventional no spray buffers. Correct use of SDRN may be most effective when accompanied by simple and clear implementation schemes readily adopted by growers as aids to customizing application to the agricultural landscape (relationship between field and non-target environments and other landscape features) and application conditions (temperature, wind speed, humidity, etc.). Examples that support these objectives include the UK LERAP and Swedish Hjälpreda schemes. It is noteworthy that as an aid to correct implementation at application, the latter of these schemes also includes an internet tool and tool for facilitating assessments in the field via mobile phone. A similar tool to assist with developing application assessments customized to local conditions and founded on good agricultural practice has been developed under the auspices of the TOPPS-PROWADIS project (TOPPS-PROWADIS Drift Evaluation Tool).

#### 4.3.7.2 Enforceability

When considering risk mitigation policy it is often stated that the enforceability of a measure needs to be considered to allow for practice verification to thereby increase regulatory and public confidence in such measures. It is noted that the enforceability status of SDRN is not significantly different from that of no-spray buffer zones; indeed, SDRN may actually be more readily enforced than no-spray buffer zones because of the dependency on specific equipment that may be verified after application. Formal classification of nozzles through accredited organizations encourages confidence in technical quality and indirectly supports enforceability through a framework of record keeping associated with nozzle selection.

The proper functioning of SDRN in a certain drift reduction class is only guaranteed when used with the correct spray pressure. Therefore, in the Netherlands it is proposed to make spray pressure recording mandatory from 2016 onward using the logging facilities of spray computers or specific pressure recording devices. Record keeping by applicators provides additional supporting evidence tied to subsidies. As no-spray buffer zones are difficult to control in the Netherlands, crop-free buffer zones are introduced as no farmer will spray a non-cropped strip next to the field and a no-crop distance is easy to measure.

### 4.3.8 Case study: Spray drift reduction in the UK and Italy

Farmer awareness of spray drift reduction technology continues to spread, thanks to farmer education and awareness campaigns (e.g., TOPPS-PROWADIS and other nationally-oriented campaigns). When accompanied by effective product stewardship campaigns, growers' awareness of the need to more effectively manage drift issues for a given product is significantly improved. An example of this is the successful information campaign, for implementation of low-drift nozzles and no-spray buffer zones developed in the UK (Say No To Drift) and in Italy (Miralbersaglio).

The UK information campaign was initiated in October 2011 and involved growers, farmer organizations, and regulatory authorities. The campaign resulted in an increased intention to use low-drift nozzles in the subsequent season from only 7% in 2011 to 91% of users in 2013 (source: 200 Pesticide Usage Survey Group interviews). The main reasons for the initial reluctance to use low-drift nozzles by farmers were a misconception regarding a loss of efficacy and the lack of familiarity with low-drift nozzles. This information campaign showed that technology transfer from companies to farmers can be helpful to significantly improve take-up of drift reducing nozzles and, thus, reduce spray drift more widely.

A similar information campaign was initiated in Italy in 2012 for apple and vine applications in two pilot areas: Emilia Romagna and Trentino Alto

Adige. This campaign consisted in technology transfer events from the south to the north of Italy and involved regional extension services for phytosanitary management, growers, experts in ecotoxicology, environmental fate of pesticides, and efficacy from the Pesticide Committee. The main objective of this campaign was to demonstrate to farmers that the use of low-drift nozzles is easy and delivers a real benefit to the environment. It is noted that in Italy the use of drift reducing nozzles and no-spray buffer zones will be linked to subsidies coming through CAP and to the Italian Action Plan as developed under the Sustainable Use Directive. In this context, the campaigns on technology transfer represent highly effective and well-targeted tools for farmers to meet future obligations. The results of this campaign will provide useful comparative indicators of willingness of farmers in Southern Europe to access and employ drift-reducing nozzles.

#### 4.3.9 Recommendations

Development of independent spray drift reduction technology classification schemes for each of the 28 Member States in the European Union is not only impractical but also inefficient and unjustified. It is recommended that Member States may draw upon extensive experience and sound scientific foundation associated with schemes in place in the countries where it is implemented, for recognition and transfer of classification to enable take up of SDRN throughout the European Union. There are precedents for such policies in Member States where there are not specific domestic classification schemes. This is noted in Belgium, for example, where there is acceptance of classification schemes in Germany, The Netherlands, and the United Kingdom. In practice the most stringent of these criteria is followed. Similar strategies for national recognition and acceptance of spray drift reduction nozzle classification would be effective and could be implemented rapidly and easily.

The regulatory role for such mitigation measures varies considerably across the European Union. In some Member States there is no formal role for spray drift reduction technology for a range of reasons explored earlier. In others, SDRN do not have a role in regulatory risk assessments, but adoption is encouraged in local environmental risk assessments conducted by farmers to gain greater flexibility with product use. Finally, a number of Member States allow for formal representation of SDRN in regulatory risk assessments including Austria, Belgium, Finland, Germany, The Netherlands, Poland, Sweden, and the United Kingdom. Harmonizing policies that encourage the adoption of SDRN by farmers would be beneficial. Additional regulatory benefits would include a higher degree of consistency within zonal evaluations where, currently, different policies lead to inefficient presentation of multiple versions of risk assessments customized to local preferences and policies on risk mitigation. Consideration of a harmonized basis for acceptance of basic SDRN efficacy thresholds (e.g., 50, 75, 90, and 95% effectiveness) is recommended to simplify the regulatory process. It is proposed that this would be expanded to allow for up to 99% spray drift reduction, anticipating future technological developments and increased practicality of implementation of current methods with this effectiveness. This recommendation needs to be considered in the context of guidance offered by the FOCUS Landscape and Mitigation Group (FOCUS 2007) nearly 10 years ago that ”a maximum cap of 95% reduction in exposure via spray drift is applied at Annex I. ” Expansion to include the potential to represent 99% spray drift reduction is now suggested as technically feasible.

Finally, as an aid to allowing for greater flexibility for farmers in managing drift in the local application environment, consideration should be given to schemes such as the Swedish Hjälpreda and the TOPPS-PROWADIS drift evaluation tool (http://www.topps-drift.org/). These schemes and tools allow for customizable application strategies to account for local environment and application conditions, and raise farmer awareness of drift issues and strategies for managing drift. Allowing landscape features, such as windbreaks or hedgerows and windbreak shields (nets) is another way to manage spray drift and is a feature of both the UK LERAP scheme and the Dutch spray drift guidance. As noted earlier, the experience gained elsewhere in Europe where options and policies have been tried and tested may present a way forward that can be adopted “as is” or customized to some extent to accommodate local agricultural norms.

The adoption of technological options for managing drift may be constrained by local regulatory policies. Removing barriers and allowing for a greater degree of consistency on policies for recognition and implementation of SDRN would be a significant step forward in improving not only the flexibility of risk mitigation strategies, but also the effectiveness of spray drift management, greater awareness of the issues by farmers of issues and greater attention to the correct setup of application technology. In many cases, other constraints such as cost or impact on efficacy, can be addressed through additional campaigns.

## 4.4 Drainage

The objective of land drainage is to remove excess water from the soil or land surface. Since the mid-eighteenth century, large-scale attempts have been made to improve subsurface water control through the installation of various underdrainage systems. Early stone drains were followed by baked clay horseshoe tiles and later still by round clay pipes. Many of these old systems, as well as more recent artificial drainage systems, are still effective and are responsible for draining many slowly permeable soils or those with shallow water tables that might not otherwise be cultivated. Artificial drainage is responsible for the transport of significant quantities of dissolved pesticide, particularly when rainfall and subsequent drainage occur shortly after pesticide application.

The design of a drainage scheme is influenced by many considerations, including climate, cropping practice, soils, and slope. Drain depth and spacing are used to control the depth of the water table and the rate of drainage, while the size, type, and gradient of pipe (e.g., slotted plastic pipe, clay tiles) determine how and when water is transported from the soil. Most clay subsoils have saturated hydraulic conductivities of 0.1 m day$^{-1}$ or less, so that effective drainage is mainly confined to the surface horizon. In clay soils, pipe drainage is usually ineffective unless the subsoil properties are modified to increase physically the number and size of cracks and fissures. This can be done by moling or by subsoiling the site. Mole drains are unlined channels that convey water readily through the soil to the pipe drainage system. They are formed by a mole plough consisting of a steel shaft with a circular steel foot or bullet at the base trailing a cylindrical expander behind. Mole drains are normally drawn at 45-60 cm depth, 2-3 m spacing, and at right angles to the primary drainage treatment. Subsoiling is another option in heavy soils and is carried out to break up soil layers, usually below the plough depth, to make the soil less dense and allow water and air entry. Permeable fill is commonly placed in the trench above a drainage pipe to form a permanent connector for moling or subsoiling treatments. The fill may consist of crushed gravel, hard crushed stone, or synthetic material, and serves to ensure that flows of water have easy access to the underlying drain pipe.

Artificial drainage is commonplace in most slowly permeable soils or in areas where shallow water tables limit agricultural production. An analysis by De la Cueva (2006) investigated the extent of drained land in different European countries. Overlay of artificially drained soil mapping units with land cover data suggested that the proportion of agricultural land that is drained ranges from 0.5% in Spain to 93% in Finland (Figure 4.6). Further analysis showed that the proportion of arable land that is drained is generally larger still and exceeds 50% in five countries: Finland (97%), Latvia (85%), Lithuania (65%), Netherlands (87%), and United Kingdom (66%) (De la Cueva 2006).

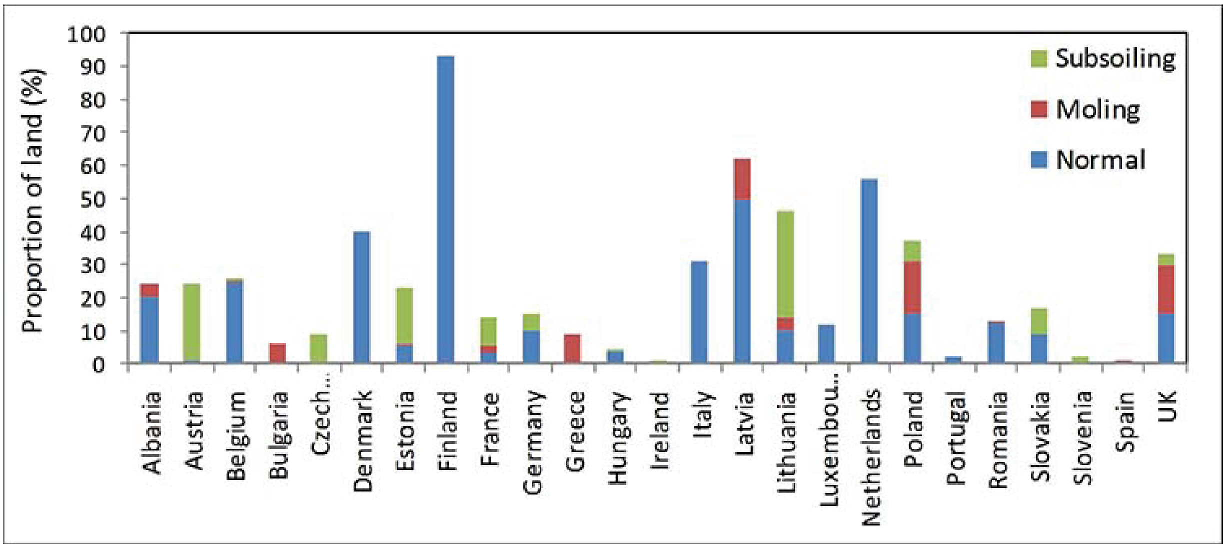


**Figure 4.6:** Estimated extent of drained land as a proportion of total agricultural land in different European countries. Data were derived by De la Cueva (2006) from analysis of drained soil units within the Soil Geographic Database for Europe and the CORINE Land Cover 2000 database.

While water and pesticide transported via subsurface drains will generally affect surface water quality, leaching through the soil layers that overlie the drains is the first step in transfer to drains. Thus, the processes governing the transport of pesticides via drainage are closely related to those controlling leaching of pesticides to groundwater. Many of the methods to assess, as well as to reduce, loadings to groundwater are in principle also applicable to assess and reduce drainage loadings. Nevertheless, there are some important differences that must be considered. Permeable sandy soils are generally considered as the most vulnerable situation for leaching to groundwater. Consequently corresponding scenarios and matrix flow models were selected for the majority of groundwater assessment schemes (e.g., FOCUS 2009). Transfer via drains in sandy soils with shallow groundwater is also relevant when considering risks to surface water from pesticides. However, subsurface drainage systems are also established in areas with slowly-permeable, fine-textured soils where transport via macropore flow plays a major and sometimes dominant role. The assessment scheme for drainage currently used in the European authorization procedure (FOCUS 2002) defines a number of soil and weather scenarios representing realistic worst case conditions for drainage situations. The scenarios are implemented into the MACRO model, chosen because it simulates both matrix and macropore flow. Specific national scenarios using the MACRO model have been established in the UK (Brown et al. 2004).

### 4.4.1 Drainage risk mitigation concept

There is a marked contrast between risk mitigation for runoff and that for drainage. Movement of water via runoff is generally deleterious for agricultural systems because it is associated with loss of soil via erosion, saturation of upper soil layers, and potential damage to crops. Subsequently, farmers are already implementing measures to control runoff and erosion as part of best management practices, and risk mitigation measures for pesticides fit well within this existing framework. In contrast, maintaining efficient drainage systems is fundamental to moving excess water out of topsoil layers and to maintaining normal agronomic practices. Thus, risk management for drainage cannot address the pathway of transport per se, and rather, needs to address the use of the plant protection product in situations that present an unacceptable risk.

Since the efficacy of a specific mitigation measure is very dependent on the interaction of substance properties, use pattern, and the properties of the relevant drainage scenario, the efficacy must be specifically evaluated for the individual case. For drainage as for leaching, this can be done most easily using the same simulation models and scenarios that are approved for the authorization process. However, the significantly faster nature of macropore flow compared with matrix flow increases the scope to use monitoring studies as an additional approach to evaluate the efficacy of mitigation measures implemented to reduce surface water exposure via drainage.

The following process is proposed for a harmonized EU regulatory drainage concept:

**Step 1: Identification of basic drainage risk mitigation approach**

The risk assessment outcome (EU FOCUS or national) identifies an unacceptable risk from transport via drains. It is then necessary to determine whether mitigation is feasible for specific areas at risk (e.g., specific soil types) or whether the same mitigation measure must be applied to all usage areas. This will depend primarily on the legal framework and existing practice within a specific Member State.

**Step 2a: Uniform mitigation measure**

Mitigation measures applied to all of the usage areas are focused on modifying the rate, timing, or nature (e.g., band spraying) of pesticide applications. In this case, standard risk assessment methods can be modified to incorporate the restriction on application and demonstrate acceptable risk. This approach is simple to communicate via the label, but carries a penalty in restricting use in areas where risk is shown to be acceptable as well as those where risk is considered not acceptable.

**Step 2b: Differentiated mitigation measure**

Mitigation measures applied only to areas considered to have unacceptable risk include restrictions based on soil type or vulnerability maps. It is necessary to identify the areas with unacceptable risk (e.g., using results of standard risk assessment modeling or higher-tier modeling). Next, the risk mitigation measure to be applied in areas with unacceptable risk needs to be demonstrated through refinement of inputs to the modeling; in practice, the mitigation will be some kind of restriction in application and may range from complete prohibition in use for the most vulnerable situations to restrictions on rate, time, or nature (e.g., band spraying) of applications in situations where this reduces risk to acceptable levels.

### 4.4.2 Toolbox of drainage mitigation measures

The toolbox of drainage risk mitigation measures has many parallels with those available for mitigating risk of leaching to groundwater. However, some measures applied in the groundwater situation are not applicable. For example, restriction to the number of times a compound can be applied within an arable rotation (e.g., only apply 1 year out of every 3) is not relevant for drainage because of the rapid transfer to surface water relative to rate of leaching to groundwater.

In order to propose a toolbox of drainage mitigation measures, a number of basic mitigation measures were identified during the initial workshop in Rome that are considered as effective by farmers and supported by data (see Table 4.13). The reader is referred to Chapter 5 on groundwater for a more detailed description of the approaches (e.g., restrictions based on soil type or vulnerability maps).

**Table 4.13:** Proposed toolbox of basic drainage mitigation measures (assessment of current use, technical and practical feasibility, and enforceability is included within Chapter 5 on groundwater)

| **Drainage Mitigation Measure** | **Scientific Data Basis*** | **Proposed Modeling Tool or Parameter Modifications** | **Comment** |
|---|---|---|---|
| Restriction | +++ | Modified application pattern | Can include restrictions based on crop growth |

| | | | |
|---|---|---|---|
| on application timing | | with standard risk assessment models | stage or dates |
| Restriction on application rate | +++ | Modified application pattern with standard risk assessment models | Can include maximum single rate or maximum rate per season |
| Band application | ++ | Simulate the effective application per unit area with standard risk assessment models | - |
| Restriction based on soil type | ++ | Purpose-designed modeling drawing on MACRO or other models and potentially incorporating GIS | Soil-based restriction is normally necessary rather than restriction based on presence or absence of drains, as the latter is not always known |
| Restriction based on vulnerability maps | + | Purpose-designed modeling drawing on MACRO or other models and likely to incorporate GIS | Vulnerability maps could draw on existing catchment management plans or Drinking Water Protection Areas defined under the Water Framework Directive |

* Symbols mean: + few scientific publications existing; ++ many scientific publications existing; +++ abundant scientific publications existing

One mitigation measure that can be applied to drainage but not leaching to groundwater is the use of retention structures including detention ponds, natural ponds, artificial wetlands and, potentially, stormwater tanks. The purpose of such structures is to intercept drainflow either before or very soon after entry into surface water; by slowing the movement of water, processes including filtration and sedimentation of suspended sediment and associated pesticide load, sorption of pesticide out of solution and degradation can reduce the total mass of pesticide transferred to the wider surface water network. Artificial wetlands and retention ponds are identified as a mitigation measure for pesticide transfer in surface runoff (Table 4.1). Recent research, particularly in France, has focused on using retention structures to mitigate pesticide transfer via drainage (e.g., Tournebize et al. 2013; Passeport et al. 2014). This research demonstrates that retention structures can be an effective mitigation measure, particularly in areas with silty soils (luvisols) and where (i) either the volume or rate of drainflow entering the retention structure is relatively small or the structure itself is large; or (ii) there is significant loss of water and pesticide during transfer through the structure due to infiltration. Design criteria published in France target a hydraulic retention time of 7 days and suggest that retention structures with an aerial extent of ca. 1% of the drained agricultural area and a depth of 0.8 m will be sufficient to retain 7-mm of drainflow (Tournebize et al. 2015).

Use of retention structures to mitigate pesticide transfer in drainflow from heavier clay soils can be more challenging than for surface runoff. This is because drains in such soils tend to run for extended periods whenever rainfall exceeds evapotranspiration and the volumes of drainflow per unit area of agriculture tend to be larger than for surface runoff (e.g., drainage occurs across the full drained area of land whereas surface runoff is episodic and may only be generated on part of a field). Hydraulic retention times (and thus efficacy) will decrease if the capacity of the retention structure is exceeded or if the structure is either partially or completely full of water at the time drainflow is initiated. Therefore, at the present time, retention structures for reducing pesticide transport in drainflow are considered an important possibility for national mitigation schemes. Further research into broad application to drainflow is required before the measure is suitable for inclusion into the harmonized mitigation scheme proposed by the MAgPIE workshop participants.

### 4.4.3 Resulting label language

The following safety precaution phrase according to Regulation (EU) No. 547/2011 is applicable for mitigating risk to surface waters from drainflow:

> *SPe 2: To protect groundwater/aquatic organisms do not apply to (soil type or situation to be specified) soils.*

As discussed in Chapter 5.4 on groundwater, an additional standard phrase is proposed to cover the risk mitigation measures that are connected to certain areas (e.g., vulnerability maps):

> *SPe X: To protect groundwater/aquatic organisms do not apply this or any other product containing (identify active substance or class*

*of substances, as appropriate) in vulnerable areas (areas of drinking water abstraction or other vulnerable conditions).*

A further new standard phrase is proposed to cover the remaining risk mitigation measures that are based on specific management options (e.g., band spraying)

*SPe XX: To protect groundwater/aquatic organisms the use of this or any other product containing (identify active substance or class of substances, as appropriate) is only allowed if specific management conditions (e.g., use of cover crops, band application, others [to be specified]) are fulfilled.*

### 4.4.4 Acknowledgements

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