ESTABLISHING THE REPRESENTATIVENESS OF FOCUS SURFACE WATER SCENARIOS FOR PESTICIDE RISK ASSESSMENT IN THE UK LANDSCAPE

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EXECUTIVE SUMMARY

Cambridge Environmental Assessments - ADAS were asked by Defra (Department of Environment, Food and Rural Affairs) to undertake a review of the FOCUS surface water modelling framework in order to establish relevance to aquatic landscapes within the United Kingdom. It is also appropriate to consider the suitability of the existing scenario framework as a basis for decision-making, develop guidance for interpretation within a UK regulatory context and provide recommendations for provision of supplementary information by notifiers, where relevant, to clarify aquatic risk potential.

Project methodology

This review is divided into five primary components as follows:

- Chapter 2: Overview of FOCUS Modelling framework and associated scenarios;

The regulatory context surrounding the FOCUS surface water framework within 91/414/EEC is summarised. The potential for employment as a basis for decision-making at the Member State level after Annex 1 is discussed. The FOCUS surface water process (Steps 1-3) is discussed and background provided on modelling systems and associated standard scenarios.

- Chapter 3: Spatial characterisation of agricultural areas in England and Wales that have pedoclimatic relevance to FOCUS scenarios;

In order to identify the scenarios of primary pedoclimatic relevance to England and Wales, national soils and climate databases are exploited in order to generate spatial distributions of soils and climate associated with each scenario.

- Chapter 4: Spatial and pedoclimatic characterisation of agricultural areas in England and Wales that are not represented by FOCUS scenarios;

In order to assess the spatial extent and pedoclimatic characteristics of regions not represented or protected by FOCUS scenarios, further assessments are carried out employing the SEISMIC spatial information system.

- Chapter 5: Comparison of default surface water body assumptions within FOCUS framework with evidence obtained from the UK aquatic landscapes project (PNO931);

Areas of England and Wales where there are similarities to the pedoclimatic regimes represented within the FOCUS scenarios are considered further. The distribution of aquatic landscapes within each pedoclimatic regime are considered and dominant systems identified. Characteristics of water bodies (including statistical distributions) within each dominant aquatic landscape are then compared with FOCUS defaults in order to provide indications of likely relevance of default water systems (ditch, stream and pond) simulated within FOCUS. Comments upon implications for decision-making and risk assessment are provided.

- Chapter 6: Comparative evaluation of exposure frameworks: current UK national scheme and FOCUS surface water

Evaluation of how the current UK surface water risk assessment compares with the new FOCUS surface water framework to assist with regulatory decision-making regarding status of FOCUS surface water as an alternative to the current national scheme.

- Chapter 7: Interpretation within a UK regulatory context

The results of the review exercise are then interpreted within a UK regulatory context. This takes the form of addressing three primary regulatory questions:

1) Which FOCUS scenarios should companies be requested to use when calculating PECs for UK risk assessments?
2) What supplementary information should companies be requested to supply to support relevant PEC calculations?
3) What other information could companies be asked to provide if risk assessments are uncertain?

Conclusions

A review of the FOCUS surface water modelling framework was undertaken in order to establish relevance to aquatic landscapes within the United Kingdom. The primary objective was to determine the suitability of the existing scenario framework as a basis for decision-making, develop guidance for interpretation within a UK regulatory context and provide recommendations for provision of supplementary information by notifiers, where relevant, to clarify aquatic risk potential.

Scenarios of primary pedoclimatic relevance

Of the ten scenarios developed within the FOCUS surface water modelling framework, four have been identified as having primary pedoclimatic relevance within England and Wales. These are:

Drainage: D2, D3, D4

Run-off: R1

As regulatory submissions are prepared for specific crop uses it is important to consider the proportions of the national crop that are directly represented by each scenario. More importantly for regulatory purposes, it is important to evaluate what proportion of the national crop would be characterised by pedoclimatic conditions that may be considered more challenging than the assemblage of relevant scenarios. This varies considerably between crops as can be seen in Table 1 (copy of Table 4.2.3-3).

A few crops are very well represented in terms of the extent of pedoclimatic challenge offered by the directly relevant FOCUS scenarios. These include winter cereals, OSR, field beans and potatoes. However, other crops are relatively poorly represented in terms of pedoclimatic challenge. These include managed grass (large areas of grass production extend into wetter parts of the UK than are represented by the directly relevant scenarios), spring cereals and sugar beet. The directly relevant FOCUS Surface Water scenarios encompass negligible areas associated with cultivation of small fruit and flowers and bulbs (characterised by very isolated areas of significant production). As a consequence, for certain crops it is anticipated that assessments would not rely on directly relevant scenarios alone and other information would need to be taken into account, either in the form of evaluations based on indirectly relevant scenarios or modified scenarios (discussed later).

Table 1 - Percentage area of individual crops grown in Great Britain that is covered by risk assessments using directly relevant FOCUS scenarios

Crop	Total crop area (ha)	Directly relevant scenarios	Percentage of total crop area 'covered' by these scenarios
Grass (managed)	5631045	D2, D3, D4	50
Winter Cereals	3285022	D2, D3, D4, R1	95
Spring Cereals	1525975	D3, D4	30
Winter OSR	380996	D2, D3, D4, R1	97
Spring OSR	153076	D3, D4, R1	82
Field Beans	122484	D2, D3, D4, R1	95
Sugar Beet	170066	D3	36
Potatoes	235926	D3, D4, R1	82
Legumes	134746	D3, D4, R1	73
Maize	94772	D3, D4, R1	55
Vegetables	119909	D3, D4, R1	77
Top Fruit	24407	D4, R1	72
Hops	4036	R1	70
Small Fruit	14755	None	0
Flowers & bulbs	7249	None	0

Relevance of FOCUS surface water body defaults to UK conditions

Dominant aquatic landscapes associated with each of the primary scenarios summarised above were characterised. Comparisons of FOCUS defaults with those provided by the UK aquatic landscapes project (Defra PNO931, 2003) suggest that there is broad similarity in key geometric parameters.

In general ditch systems within UK aquatic landscapes would be considered to be well protected by the geometry and flow rate assumptions within FOCUS surface water scenarios. Ditches typically encountered within related UK aquatic landscapes are deeper than the FOCUS defaults and subject to more rapid dilution through higher flow rates.

Stream systems simulated within FOCUS are deeper but narrower than similarly classified systems encountered in related UK aquatic landscapes. They are, nonetheless, similar in terms of volume over a given distance. The stream scenarios are, therefore, likely to be considered to provide protective assessments of drainage and run-off. However, because of difference in width and impact on areic deposition, such scenarios may slightly underestimate exposure *via* drift – provided that realistic worst-case assumptions regarding proximity to crop and applications are valid. In reality, as the worst-case assumptions embedded within FOCUS at Step 3 are considered likely to be highly conservative in many cases, the potential for increased risk due to differences in areic deposition potential are likely to be obscured.

Pond systems encountered with relevant UK aquatic landscapes are generally far shallower than those simulated within the FOCUS framework. As a consequence, such systems may be somewhat under-protected due to smaller dilution volumes for drainage, run-off and spray drift. It is estimated that, in general, realistic worst-case exposure estimates for typical ponds in UK aquatic landscapes would be underestimated by no more than a factor of two. However, as in the case of stream systems, the impact in reality may be obscured by other factors such as proximity to crop and application etc. In general these concerns would be limited to chronic risk

assessments as ditch and stream simulations represent clear worst case acute exposure profiles.

Scenarios of secondary pedoclimatic relevance

All FOCUS scenarios have soil characteristics that match with a range of soils in the UK, although climatic conditions in several cases are markedly different – these include D1, D5, D6, R2, R3 and R4. It is recognised that results of simulations carried out with certain of these scenarios could provide a useful benchmark for assessing the scale of relative risk in the UK, providing they have relevant recharge or rainfall/run-off characteristics.

The areas of land with soil characteristics correlated with scenarios D1, D5, D6 and R3&4 under each relevant UK crop are summarised in Table 2 (a reproduction of Table 7.1.1).

Scenario D1, which occurs mainly in England, has soil characteristics that correlate with small but significant areas of most types of relevant UK crops, except hops and, probably, small fruit. Importantly, D1 soil characteristics are assessed to be the next most vulnerable to pesticide losses *via* field drainage, after scenario D2 (see section 4.2.1). As a consequence, this scenario is significant in regulatory terms – particularly for those crops which are not represented in the most challenging drainage scenario (D2). The scenario recharge is relevant to significant areas of cropped land in Great Britain. The only scenario components that are unrepresentative of British agriculture are the mean daily spring and autumn temperature characteristics, which are colder than that of the correlated soil-recharge areas in Great Britain. However this feature means that risk assessments based on the D1 scenario are likely to be 'worse' than would be the case for the correlated soil-recharge areas. Risk assessments using this scenario would thus 'cover' all the correlated soil-recharge areas of Great Britain in addition to all those drained areas that have significantly less risk of soil losses *via* drainage.

Table 2 - Areas of land with soil characteristics correlated with scenarios D1, D5, D6 and R3&4 under relevant UK crops

Crop	Total crop area (ha)	D1 soil characteristics		D5 soil characteristics		D6 soil characteristics		R3&4 soil characteristics	
		Crop area	As a % of total crop	Crop area	As a % of total crop	Crop area	As a % of total crop	Crop area	As a % of total crop
Grass (managed)	5631045	132469	2	821797	15	73165	1	1033143	18
Winter Cereals	3285022	142059	4	461681	14	56994	2	358110	11
Spring Cereals	1525975	10428	1	136459	9	6081	0	66744	4
Winter OSR	380996	15991	5	56688	15	5269	1	32503	8
Spring OSR	153076	2120	3	13325	9	762	0.5	12704	8
Field Beans	122484	5797	5	14231	12	1976	2	15391	13
Sugar Beet	170066	10464	6	15983	9	8071	5	13374	8
Potatoes	235926	7864	3	21630	9	6157	3	11836	5
Legumes	134746	9157	7	12000	9	4531	3	19283	14
Maize	94772	4387	5	9675	10	1496	2	14815	16
Vegetables	119909	10579	9	4051	3	8722	7	9988	8
Top Fruit	24407	1391	6	1237	5	534	2	2623	11
Hops	4036	0	0	220	5	56	1	295	7
Small Fruit	14755	301	2	651	4	133	1	695	5
Flowers & bulbs	7249	389	5	287	4	776	11	729	10

Scenarios D5, D6, R3 & R4 all have soil characteristics that correlate with significant areas of British agriculture but have significantly warmer spring and autumn temperatures. D5 has a defined range of recharge that matches that of scenarios D2, D3 and D4, but, as indicated in Section 4.3.2, the rainfall run-off relationship for scenarios R3 and R4 are not representative of the UK. Seasonal run-off for the R3 scenario is less than that for R4 but is still significantly greater than for R1. It is thus suggested that R3 has a rainfall/run-off relationship that is most similar to the wetter parts of agricultural run-off land in the UK and represents a 'worst-case' for UK agricultural run-off. Based on this assessment, the only factor likely to make PEC's calculated using FOCUS scenarios D5 lower than those of equivalent areas in the UK is the scenario's warmer temperature regime. Similarly, the warmer temperature regime in scenario R3 would be likely to be less challenging than would characterise parallel soil conditions in the UK. However, it is noted that rainfall intensity in the R3 scenario is likely to be more challenging than would be experienced where parallel soil conditions occur in the UK.

A favourable aquatic risk assessment for these scenarios could thus indicate that aquatic ecosystems in significant areas of UK agriculture would be covered if it could be shown that the impact of lower UK temperatures was insignificant. It is important to consider the regulatory impact of widening the set of recommended scenarios to include these indirect scenarios. Areas of the UK that would be 'covered' by risk assessments including scenarios D1, D5 and R3, suitably modified to include relevant UK crops are provided in Table 3 (reproduction of Table 7.1.2).

Therefore, it is recommended that companies provide as a minimum, assessments carried out with the following scenarios:

- **Drainage: D1, D2, D3, D4, D5**
- **Run-off: R1, R3**

Table 3 Percentage areas of individual UK crops that are covered by risks assessments using FOCUS_SW scenarios of primary relevance and that would be covered by risk assessments using scenarios of primary relevance combined with suitably modified scenarios of secondary relevance

Crop	Total crop area (ha)	Scenarios of primary relevance	Percentage of total crop area 'covered' by these scenarios	Scenarios of secondary relevance	Percentage of total crop area 'covered' by combining the scenarios of primary and secondary relevance	Area (ha) not 'covered' by the combined scenarios
Grass (managed)	5631045	D2, D3, D4	50	D1, D5, R3	86.4	767915
Winter Cereals	3285022	D2, D3, D4, R1	95	D1, D5, R3	98.7	43052
Spring Cereals	1525975	D3, D4	30	D1, D5, R3	98.9	16357
Winter OSR	446340	D2, D3, D4, R1	97	D1, D5, R3	99.0	4574
Spring OSR	87732	D3, D4, R1	82	D1, D5, R3	96.6	3021
Field Beans	122484	D2, D3, D4, R1	95	D1, D5, R3	98.6	1768
Sugar Beet	170066	D3	36	D1, D5, R3	99.5	801
Potatoes	235926	D3, D4, R1	82	D1, D5, R3	98.4	3733
Legumes	134746	D3, D4, R1	73	D1, D5, R3	98.4	2095
Maize	94772	D3, D4, R1	55	D2, D5, R3	92.2	7432
Vegetables	119909	D3, D4, R1	77	D1, D5, R3	98.8	1444
Top Fruit	24407	D4, R1	72	D1, D5, R3	97.2	676
Hops	4036	R1	70	D5, R3	98.4	65
Small Fruit	14755	None	0	D5, R3	98.7	194
Flowers & bulbs	7249	None	0	D1, D5, R3	93.9	439

Potential modifications to better represent pedoclimatic conditions in the United Kingdom

Under certain circumstances it may be considered appropriate for notifiers to submit additional information to assist in clarifying exposure and risk potential within the recommended range of scenarios.

For most crops, favourable aquatic risk assessments based on the recommended combination of primary and secondary scenarios are likely to cover virtually all the relevant land in Great Britain. However, concerns may remain where significant areas of the crop are not covered by the recommended scenarios or where the risk assessments are marginal for some scenarios.

Areas of land not 'covered' by risk assessments using the combined primary and secondary relevant FOCUS SW scenarios are given in the final column of table 3. In order to give an idea of the spatial distribution of these areas, maps of England and Wales showing the distribution of such land under permanent (managed) grass, cereals, maize, sugar beet, potatoes and flowers and bulbs are given in Figures 7.2.1 to 7.2.7. In each case, the coloured grids in the Figures show the distribution of the 'worst-case' soil scenario for drainage (top map) and run-off (bottom map) in areas that are significantly wetter than the climate used to characterise the FOCUS worst-case drainage or run-off scenario.

For permanent grass (Figure 7.1) and cereals (Figure 7.2), the D2 and R3 soils represent the worst-case for soil conditions relevant to drainage and run-off in Great Britain. Both crops are widely distributed across the three countries, although grass has a bias to the west whereas cereals have a bias to the east (see Section 3.2.3). The areas not 'covered' by risk assessments carried out using the combined relevant scenarios reflect this distribution combined with the distribution of the worst-case soils. Thus drained areas not covered are concentrated in the south of England and particularly in the counties of Sussex, Somerset and Gloucestershire. Small areas of south Wales are also not covered. Run-off areas not covered are more extensive, particularly for permanent grass, and cover large parts of south west England and Wales.

For maize (Figure 7.3), sugar beet (Figure 7.4), potatoes (Figure 7.5) and bulbs and flowers (Figure 7.6), D1 and R3 soils represent the worst-case for soil conditions relevant to drainage and run-off in Great Britain.

All four crops have a much more localised distribution than permanent grass or cereals, as indicated in Section 3.2.3, and the areas not 'covered' by risk assessments carried out using the combined relevant scenarios are much more dependent on the location of the crops in relation to the relevant worst-case soils. Thus for maize and potatoes, the total hectarage of drained land not covered by risk assessments using combined relevant FOCUS scenarios is small, but such land is distributed across much of central and south western England and south Wales. Run-off areas not covered are focussed in south west England and south Wales. In contrast the location of sugar beet growing areas means that very little land, mostly in the western midlands and north east of England, is not covered by risk assessments carried out using the combined relevant scenarios.

Bulbs and flowers have an even more localised distribution than the other crops considered here, but the distribution of the small amount of land that would not be covered by risk assessments carried out using the combined relevant scenarios is broadly similar to that of maize and potatoes.

Finally, hops (Figure 7.7) are the most localised of all crops in Great Britain, being concentrated in the counties of Kent and Worcester and Herefordshire. For this crop D5 soils represent the worst-case for soil conditions relevant to drainage and, whereas such soils occupy only a small fraction of all soil types under the crop, most occur in hop growing areas that are wetter than the climate of the existing D5 scenario and thus would not be covered by risk assessments using a modified D5 scenario. R1 soils represent the worst-case for soil conditions relevant to run-off under hops and also are the most common soil type under the crop. However, because the existing R1 scenario climate is slightly wetter than that of D5, relatively small areas of R1 soils under hops are not covered by risk assessments using the R1 scenario.

It is thus recommended that, for registration in the UK, where there are concerns about the amount of cropped land not covered by the recommended scenarios, or the marginal nature of specific risk assessments, companies may also be asked to consider:

- **Submission of an aquatic risk assessment for the worst-case soil scenarios (as indicated in table 7.1.2) modified to represent the worst–case climatic conditions relevant to the spatial distribution of the worst-case soil scenario.**

Recommendations for further work to clarify exposure and risk potential

Under certain circumstances it may be considered appropriate to further clarify exposure and risk potential. This could include further modelling assessments to investigate fate and behaviour in a broader range of pedoclimatic regimes. Examples based upon drainage modelling conducted to reflect UK conditions are summarised for illustrative purposes. It is recognised that such assessments would be considered *ad hoc* and would need to reflect the regions of relevance to usage and issues of primary concern highlighted through initial FOCUS modelling. Further investigations could include consideration of the impact of changing default assumptions related to surface water characteristics (e.g. significance of upstream catchment, density of usage, depth and flow characteristics) to better reflect UK conditions.

1.0 Introduction

Under Directive 91/414 EEC, before Plant Protection Products may be authorised for use in EU Member States, they are required to undergo evaluation for inclusion of their active substances in Annex 1. A key element of this process is the assessment of risks to the terrestrial and aquatic environment. Risks to surface water (ponds, ditches and streams) are assessed using a modelling approach developed within the European Commission FOCUS framework (FOCUS, 2001)

Four risk evaluation steps are incorporated into the FOCUS scheme. Steps 1 and 2 in FOCUS are screening level steps incorporating conservative assumptions of surface water exposure potential. Step 3 employs 10 realistic worst-case standard scenarios representing combinations of crops, pedoclimatic regimes and routes of loss of pesticides to surface water (drift, run-off and drainage) across the EU covering both Northern and Southern European and climatic regions. Data on the physico-chemical properties of the active substance and environmental fate and behaviour data in soil, sediment and water, are used in combination with the standard scenarios and the FOCUS models (PRZM for run-off and MACRO for drainage) to estimate loadings of active substances and metabolites to surface water. The consequent distribution and fate of pesticides in surface water is then modelled by the FOCUS version of the TOXSWA model, resulting in the derivation of predicted environmental concentrations (PECs). These can be compared with appropriate ecotoxicity endpoints for the assessment of risk potential to aquatic organisms.

Registration at a Member State level (post Annex 1) could include the use of standard FOCUS scenarios and/or Member State/region specific scenarios. However, before the development of such scenarios is considered, it is clear that Member States will need to know the extent to which the use of the FOCUS scenarios in a given evaluation of aquatic risk offers protection to the aquatic environment within their jurisdiction. Whilst the ten scenarios have been characterised by FOCUS with respect to geographical relevance and prevalence, in order to assist in general interpretation of results, FOCUS has considered these factors in the context of Community Level authorisations. However, if FOCUS scenarios are to be used to inform regulatory risk assessment in the UK it is necessary to know in more detail the range of relevant environmental characteristics within UK agriculture and to what extent these characteristics are included in the existing scenarios.

One FOCUS scenario with drainage as the predominant route of pesticides entry to surface water is based on UK (Brimstone) pedoclimatic features. Whilst the proportion of UK agriculture that this scenario represents is significant, other FOCUS scenarios would need to be assessed for representativeness where either drainage or run-off is a dominant route of loss to surface water.

The research reported here was based upon five objectives:

Objective 1: To quantify the amount of relevant agricultural land in England, Wales and Scotland that is represented by the ten FOCUS surface water standard scenarios.

Objective 2: To identify the characteristics of all relevant agricultural land in England, Wales and Scotland that is not represented by any of the ten FOCUS surface water standard scenarios.

Objective 3: To identify how worse-case the correlated FOCUS scenarios identified in objective 1 are with respect to agriculture across England, Wales and Scotland.

Objective 4: To identify how relevant each of the correlated FOCUS scenario surface water bodies are to UK agriculture using existing data on relevant surface water body characteristics in England Wales and Scotland

Objective 5: To place the findings of the study into a regulatory context, with likely levels of confidence that can be placed in those FOCUS scenarios shown to be representative of UK agriculture.

The investigations have drawn upon the databases within the recently completed Defra funded aquatic ecosystems project (Defra project PN0931), which divides the UK into 13 landscape classes. These provide information on underlying geological structure and topography and can be related to soil type and hydrology (HOST classification (Boorman *et al.,* 1995) using information in the SEISMIC (Hallett et al., 1995) database. The aquatic ecosystems database also describes the prevalence and spatial distribution of water body types in the landscape. This facilitated comparison with the standardised water body descriptions in FOCUS.

2.0 FOCUS Surface Water Modelling Framework

2.1 Introduction

The FOCUS surface water (SW) scenarios (FOCUS, 2001) provide a standard assessment tool. The FOCUS SW modelling framework proceeds in a stepwise manner with relatively simple and conservative calculations being carried out at Steps 1 and 2. Step 1 is a worst case, scenario where a single load of pesticide is applied without specific additional characteristics. Step 2 calculations are closer to reality and consider sequential applications, while no specific additional characteristics of the scenario are defined. The Step 3 calculation performs an estimation of the PEC using realistic worst case drainage and run-off scenarios (designated 'D' and 'R' scenarios, respectively) and takes crop, climate and soil data into account for ten representative scenarios within the EU (see Figure 2.1.1 and Tables 2.1.1 and 2.1.2).

Among the aims of modelling exercises based on the FOCUS scenarios is the attempted identification of relevant "safe usage" scenarios for a given product prior to Annex 1 listing. It should be noted that these scenarios are not necessarily representative of the specific Member States in which the scenarios are located and in some cases further assessment may be required for individual Member States at the product registration/re-registration stage.

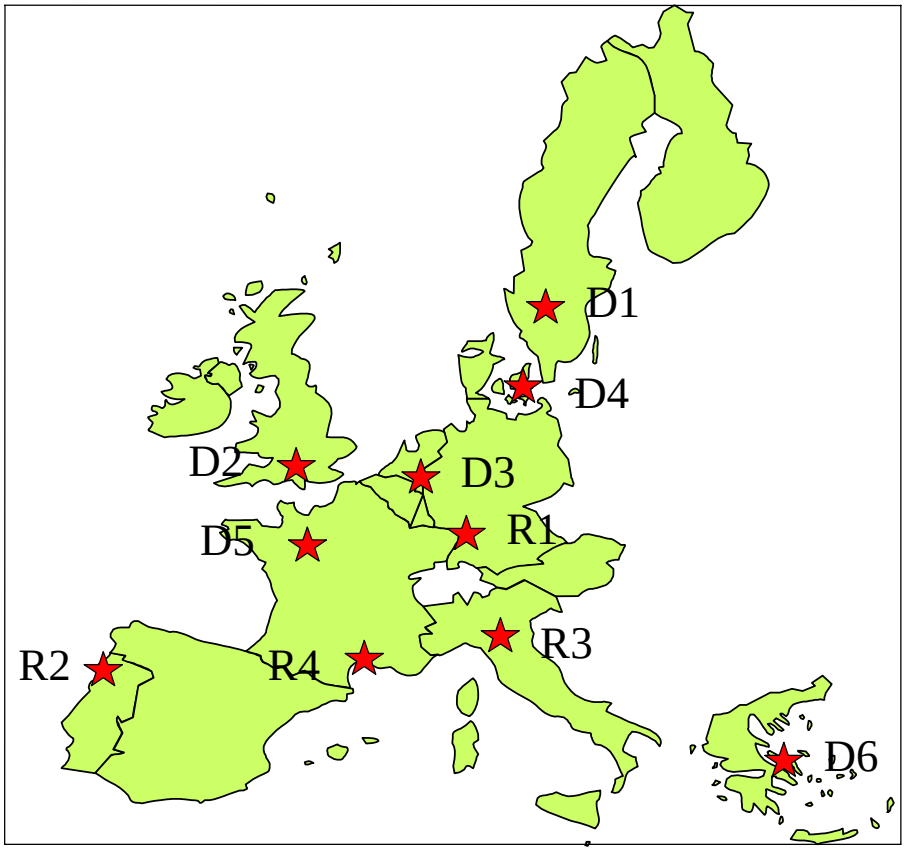


Figure 2.1.1 Location of FOCUS scenarios

Table 2.1.1 Characteristics of FOCUS scenario locations

Name	Mean annual Temp. (°C)	Annual Rainfall (mm)	Topsoil	Organic carbon (%)	Slope (%)	Water bodies	Weather station
D1	6.1	556	Silty clay	2.0	0 – 0.5	Ditch, stream	Lanna (S)
D2	9.7	642	Clay	3.3	0.5 – 2	Ditch, stream	Brimstone (UK)
D3	9.9	747	Sand	2.3	0 – 0.5	Ditch	Vreedepeel (NL)
D4	8.2	659	Loam	1.4	0.5 – 2	Pond, Stream	Skousbo (DK)
D5	11.8	651	Loam	2.1	2 – 4	Pond, stream	La Jailliere (F)
D6	16.7	683	Clay loam	1.2	0 – 0.5	Ditch	Thiva (EL)
R1	10.0	744	Silt loam	1.2	3	Pond, stream	Weiherbac h (D)
R2	14.8	1402	Sandy loam	4	20*	Stream	Porto (P)
R3	13.6	682	Clay loam	1	10*	Stream	Bologna (I)
R4	14.0	756	Sandy clay loam	0.6	5	Stream	Roujan (F)

Table 2.1.2 Agricultural profiles of FOCUS scenario locations

Scenario	Climate	Soil Type and Hydrological Management	Crops
D1	Cool with moderate precipitation.	Slowly permeable clay with field drains. Seasonally waterlogged by groundwater.	Grass, winter and spring cereals and spring oilseed rape.
D2	Temperate with moderate precipitation.	Impermeable clay with field drains. Seasonally waterlogged by water perched over impermeable massive clay substrate.	Grass, winter cereals, winter oilseed rape, field beans.
D3	Temperate with moderate precipitation.	Sands with small organic carbon content and field drains. Subsoil waterlogged by groundwater.	Grass, winter & spring cereals, winter and spring oilseed rape, potatoes, sugar beet, field beans, vegetables, legumes, maize, pome/stone fruit.
D4	Temperate with moderate precipitation.	Light loam, slowly permeable at depth and with field drains. Slight seasonal water logging by water perched over the slowly permeable substrate.	Grass, winter & spring cereals, winter and spring oilseed rape, potatoes, sugar beet, field beans, vegetables, legumes, maize, pome/stone fruit.
D5	Warm temperate with moderate precipitation.	Medium loam with field drains. Hard, impermeable rock at depth. Seasonally waterlogged by water perched over the impermeable substrate.	Grass, winter & spring cereals, winter and spring oilseed rape, legumes, maize, pome/stone fruit, sunflowers.
D6	Warm Mediterranean with moderate precipitation.	Heavy loam over clay with field drains. Seasonally waterlogged by groundwater.	Winter cereals, potatoes, field beans, vegetables, legumes, maize, vines, citrus, olives, cotton.
R1	Temperate with moderate precipitation.	Free draining light silt with small organic matter content.	Winter cereals, winter & spring oilseed rape, sugar beet, potatoes, field beans, vegetables, legumes, maize, vines, pome/stone fruit, sunflowers, hops.
R2	Warm temperate with very high precipitation.	Free draining light loam with relatively large organic matter content.	Grass, potatoes, field beans, vegetables, legumes, maize, vines, pome/stone fruit.
R3	Warm temperate with high precipitation.	Free draining calcareous heavy loam.	Grass, winter cereals, winter oilseed rape, sugar beet, potatoes, field beans, vegetables, legumes, maize, vines, pome/stone fruit, sunflower, soybean, tobacco.
R4	Warm Mediterranean with moderate precipitation.	Free draining calcareous medium loam over loose calcareous sandy substrate.	Winter & spring cereals, field beans, vegetables, legumes, maize, vines, pome/stone fruit, sunflower, soybean, citrus, olives.

2.2 Modelling Techniques

The models used to calculate PECs at Step 3 are PRZM, MACRO and TOXSWA. The models interact with each other: PRZM or MACRO produce an input file for the fate model TOXSWA. Input files for TOXSWA use the PRZM model for run-off scenarios and the MACRO model for drainage scenarios. An additional spray drift loading is defined, where relevant. The calculation of the spray drift is carried out in the Graphical User Interface developed for the surface water scenarios (SWASH: Surface WAter Scenarios Help).

Five modelling software tools have been adapted or developed by the FOCUS SW Working Group as follows:

- Step 1,2 calculator: Relatively simple, conservative calculations of exposure.
- MACRO: Sophisticated drainage modelling software (also in use in a different form under FOCUS groundwater recommendations)
- PRZM: Sophisticated run-off modelling software (also in use in a different form under FOCUS groundwater recommendations)
- TOXSWA: Sophisticated surface water fate model
- SWASH: Software designed to serve as basic input generator and as a means of linking input and output between soil models (MACRO and PRZM) and surface water model (TOXSWA)

2.3 Water Body Profiles

Three sets of water bodies are characterised within the FOCUS modelling framework, comprising standard;

- Ditches
- Streams
- Ponds

As summarised in Table 2.1.1, each scenario is associated with specific water body types based upon estimated or observed prevalence within associated landscapes. A summary of the fixed dimensions for each water-body type is described in Table 2.3.1 below. All three water bodies, pond, ditch and stream, have a rectangular internal cross-section (vertical side slope). Illustrations of the context and morphology of each water body type established within the FOCUS framework are provided in Figures 2.3.1 to 2.3.3. Further information on the sediment and suspended sediment characteristics of each system are provided in Table 2.3.2.

The drift loadings that are calculated using this Step 3 tool incorporate the following assumptions:

- Cumulative drift loadings are 90th percentile values based on Rautmann (2000) data
- Default distances have been established between treated crops and the top of the bank of the adjacent water body based on the type of crop. Specified distances range between 0.5m for cereals to 5.0m for aerial applications.
- Default distances have been established between the top of the bank and the edge of the water body based on the type of water body. Specified distances are 0.5m for ditches, 1m for streams and 3m for ponds.

Default distances for a winter wheat/stream combination are illustrated in Figure 2.3.4.

TOXSWA allows simulations to be conducted with dynamic hydrology. In other words, flow rate and depth respond to rainfall events and the entry of water into each system *via* drainage or run-off. The hydrological profiles of each scenario/water body combination are provided in Tables 2.3.3 to 2.3.7.

Table 2.3.1 Water body parameters

Type of water body	Width (m)	Total length (m)	Distance from top of bank to water (m)
Ditch	1	100	0.5
Pond	30	30	3.0
Stream	1	100	1.0

Table 2.3.2 Sediment and suspended solid characteristics of all FOCUS water bodies

Characteristic	Value
Concentration of suspended solids in water column ($mg.L^{-1}$)	15
Sediment layer depth (cm)	5
Organic carbon content (%)	5 (approx. 9% organic matter)
Dry bulk density ($kg.m^{-3}$)	800
Porosity (%)	60

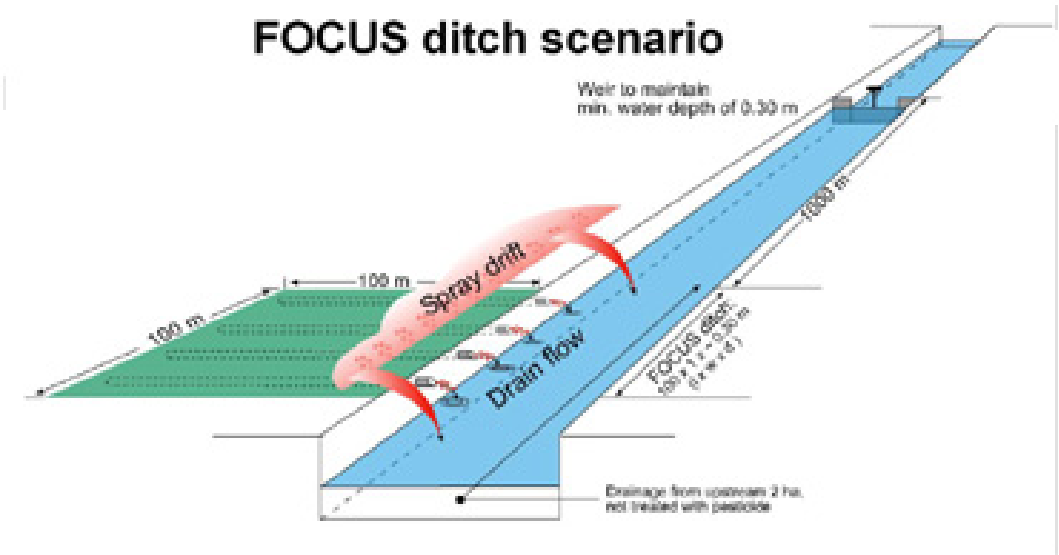


Figure 2.3.1 Schematic of FOCUS ditch scenario in FOCUS surface water framework

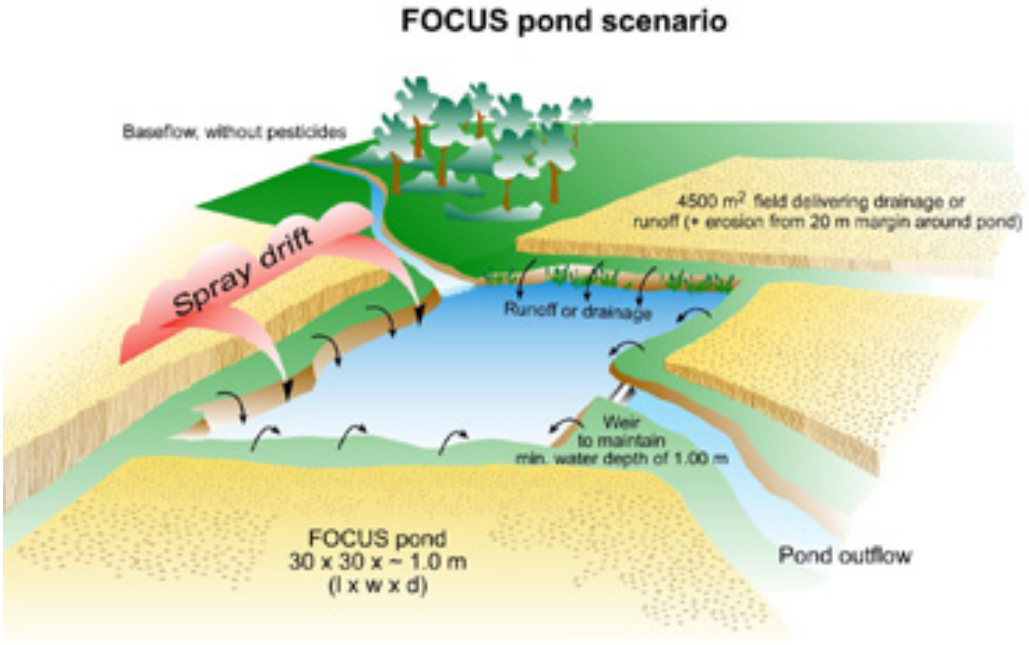


Figure 2.3.2 Schematic of FOCUS pond scenario in FOCUS surface water framework

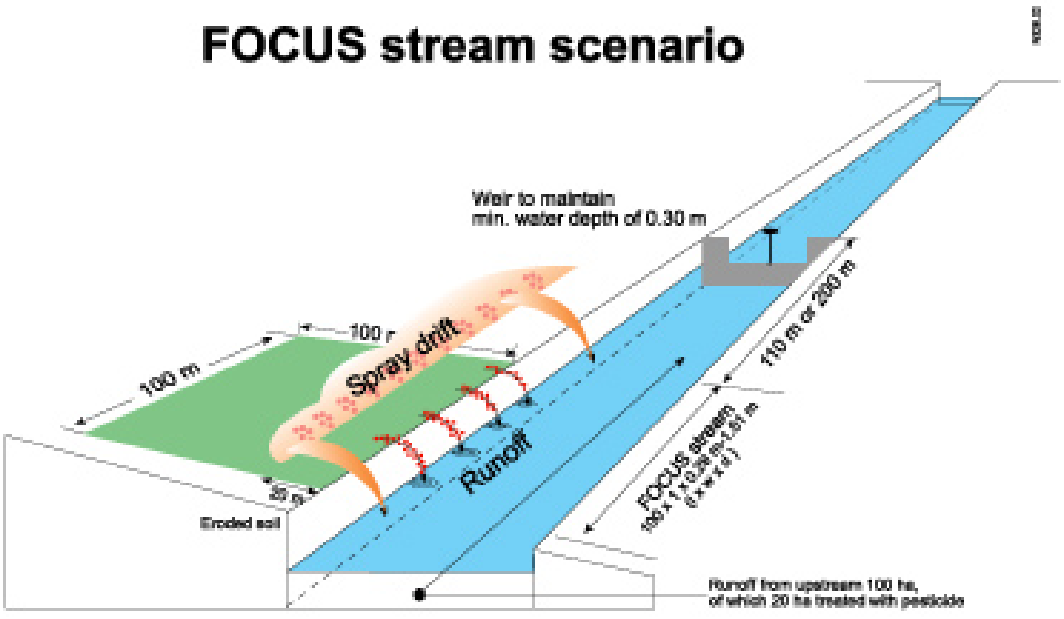


Figure 2.3.3 Schematic of FOCUS stream scenario in FOCUS surface water framework

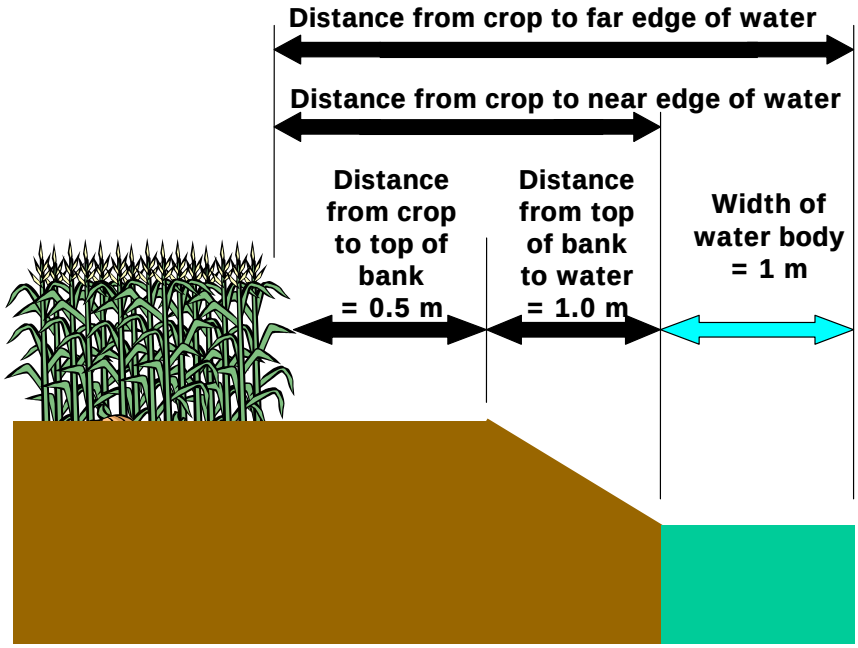


Figure 2.3.4 Schematic showing effective buffer distances for winter wheat/stream simulations

Hydrological Response Profiles - Ditches

Table 2.3.3 Main characteristics of the drainage scenario ditches. All values are for the example crop of winter wheat for the 16-month simulation period

Scenario	Upstream catchment (ha)	Length x width (m^2)	Min /max discharge (l/s)	Min /max water depth (m)	Min/max monthly residence time (d)
D1	2	100 x 1	0.008 – 3.88	0.30 – 0.32	0.4 – 45.5
D2	2 (20 for base flow)	100 x 1	0.001 – 11.5	0.30 – 0.35	0.65 – 250
D3	2	100 x 1	0.08 – 0.71	0.30 – 0.31	0.70 – 4.4
D6	2	100 x 1	0.04 – 12.8	0.30 – 0.36	0.24 – 8.1

Hydrological Response Profiles - Ponds

Table 2.3.4 Main characteristics of the drainage scenario ponds. All values refer to the example crop of winter wheat for the 16-month simulation period

Scenario	Length x width (m^2)	Min /max discharge (L/s)	Min/max water depth (m)	Min/max monthly residence time (d)
D4	30 x 30	0.025 – 0.40	1.00 – 1.01	87.7 – 283
D5	30 x 30	0.026 – 0.90	1.00 – 1.01	46.8 – 405

Table 2.3.5 Main characteristics of the run-off scenario ponds. All values refer to the non-irrigated crop of vines for the three 12-month simulation period, selected for each application season (spring: Mar-May, summer: Jun-Sep, autumn: Oct-Feb)

Scenario	Length x width (m)	Application season	Min /max discharge (L/s)	Min/max water depth (m)	Min/max monthly residence time (d)
R1	30 x 30	Spring	0.1 – 1.4	1.00 – 1.01	108 – 157
		Summer	0.1 – 1.6	1.00 – 1.01	85 – 157
		Autumn	0.1 – 1.6	1.00 – 1.01	85 – 157

Hydrological Response Profiles - Streams

Table 2.3.6 Main characteristics of the drainage scenario streams. All values refer to the example crop of winter wheat for the 16-month simulation period

Scenario	Length x width (m^2)	Min /max discharge (l/s)	Min /max water depth (m)	Min/max monthly residence time (d)
D1	100 * 1	0.38 – 131	0.31 – 0.82	0.017 – 0.93
D2	100 * 1	0.007 – 388	0.30 – 1.40	0.022 – 50.2
D4	100 * 1	1.23 – 85.2	0.31 – 0.68	0.017 – 0.29
D5	100 * 1	0.86 – 218	0.29 – 0.92	0.012 – 0.39

Table 2.3.7 Main characteristics of the run-off scenario streams. All values refer to the non-irrigated crop of vines for the three 12-month simulation period, selected for each application season (spring: Mar-May, summer: Jun-Sep, autumn: Oct-Feb)

Scenario	Length x width (m)	Application season	Min /max discharge (L/s)	Min/max water depth (m)	Min/max monthly residence time (d)
R1	100 x 1	Spring	2.22 – 399	0.41 – 1.32	0.06 – 0.21
		Summer	2.22 – 356	0.41 – 1.25	0.03 - 0.21
		Autumn	2.22 – 356	0.41 – 1.25	0.03 – 0.21
R2	100 x 1	Spring	3.24 – 350	0.31 – 1.17	0.01 – 0.10
		Summer	3.24 – 367	0.31 – 1.20	0.01 – 0.11
		Autumn	3.24 – 350	0.31 – 1.17	0.01 – 0.11
R3	100 x 1	Spring	0.88 – 330	0.29 - 1.13	0.02 - 0.38
		Summer	0.88 – 341	0.29 – 1.15	0.02 – 0.38
		Autumn	0.88 – 330	0.29 – 1.13	0.02 – 0.38
R4	100 x 1	Spring	2.23 – 491	0.41 – 1.46	0.01 – 0.21
		Summer	2.23 – 503	0.41 – 1.51	0.02 – 0.21
		Autumn	2.23 – 459	0.41 – 1.42	0.01 – 0.21

2.4 Establishing Pedoclimatic Significance in Europe

In order to establish pedoclimatic significance the FOCUS surface water work group developed a set of maps based upon general climatic and soil classifications. Climatic classifications are summarised in Table 2.4.1. The soil characteristics used to classify relative worst cases for drainage and run-off are given in Tables 2.4.2 and 2.4.3. Pedoclimatic classifications for each scenario are summarised in Table 2.4.4 and 2.4.5. Each of the resulting ten soil scenarios were then refined by overlaying soil data from the 1:1,000,000 scale Soil Geographic Database of Europe with the

relevant climatic zones for each scenario using a 0.5º longitude by 0.5º latitude grid dataset. The resulting maps (Figures 2.4.1 to 2.4.10) show the distribution of areas within Europe that are relevant to each of the ten scenarios. Together it was established that the 10 surface water scenarios have been demonstrated to be representative of 32.9% of all the agricultural land in the European Union. It was specifically noted by the FOCUS surface water work group that:

The maps do not mean that the scenarios are relevant to 100% of the areas highlighted. Rather they indicate that in any of the areas highlighted, some part of the agricultural landscape corresponds to the soil, climate and at least one of the cropping characteristics of the specified scenario.

As a consequence, it is likely that consideration at a different spatial scale (potentially employing higher quality datasets available within a specific Member State), and/or with refined climatic or soil/hydrological criteria will result in variations in the pedoclimatic significance of each scenario.

Table 2.4.1 Climatic classes for differentiating agricultural drainage and run-off scenarios

AVERAGE ANNUAL RECHARGE (drainage)		AVERAGE ANNUAL RAINFALL (Run-off)	
Range mm	**Assessment**	**Range mm**	**Assessment**
>300	Extreme worst case	>1000	Extreme worst case
200 – 300	Worst case	800 – 1000	Worst case
100 – 200	Intermediate case	600 – 800	Intermediate case
<100	Best case	< 600	Best case

Table 2.4.2 Relative worst-case soil characteristics for drainage

Soil Characteristics	**Assessment**
Coarsely structured 'cracking clay' soils with extreme by-pass flow on impermeable substrates	Extreme worst case
Clays and heavy loams with by-pass flow over shallow groundwater	Worst case
Sands with small organic matter content over shallow groundwater	Worst case
Light loams with small organic matter content and some by-pass flow on slowly permeable substrates	Intermediate case

Table 2.4.3 Relative worst-case soil characteristics for run-off

Soil Characteristics	**Assessment**
Soil hydrologic group D (heavy clay soils)	Extreme worst case
Soil hydrologic group C (silty or medium loamy soils with low organic matter content).	Worst case
Soil hydrologic group B (light loamy soils with small clay and moderate organic matter content)	Intermediate case

Table 2.4.4 Relative inherent worst-case characteristics for non-irrigated drainage scenarios

Scenario	Temperature	Recharge	Soil
D1	Extreme worst case	Intermediate case	Worst case
D2	Worst case	Worst case	Extreme worst case
D3	Worst case	Worst case	Worst case
D4	Worst case	Intermediate case	Intermediate case
D5	Intermediate case	Intermediate case	Worst case
D6	Best case	Worst case	Worst case

Table 2.4.5 Relative inherent worst-case characteristics for non-irrigated run-off scenarios

Scenario	Temperature	Rainfall	Soil	Slope
R1	Worst case	Intermediate case	Worst case	Intermediate case
R2	Intermediate case	Extreme worst case	Intermediate case	Extreme worst case
R3	Intermediate case	Worst case	Worst case	Worst case
R4	Best case	Intermediate case	Worst case	Worst case

Table 2.4.6 Extent of the ten surface water scenarios within the European Union

Scenario	Area (km^2)	Percentage of total agricultural land
D1	15,703	1.5
D2	8,459	0.8
D3	8,855	0.9
D4	44,204	4.2
D5	15,999	1.5
D6	36,531	3.5
R1	75,631	7.7
R2	6,779	0.7
R3	22,912	2.3
R4	95,716	9.7

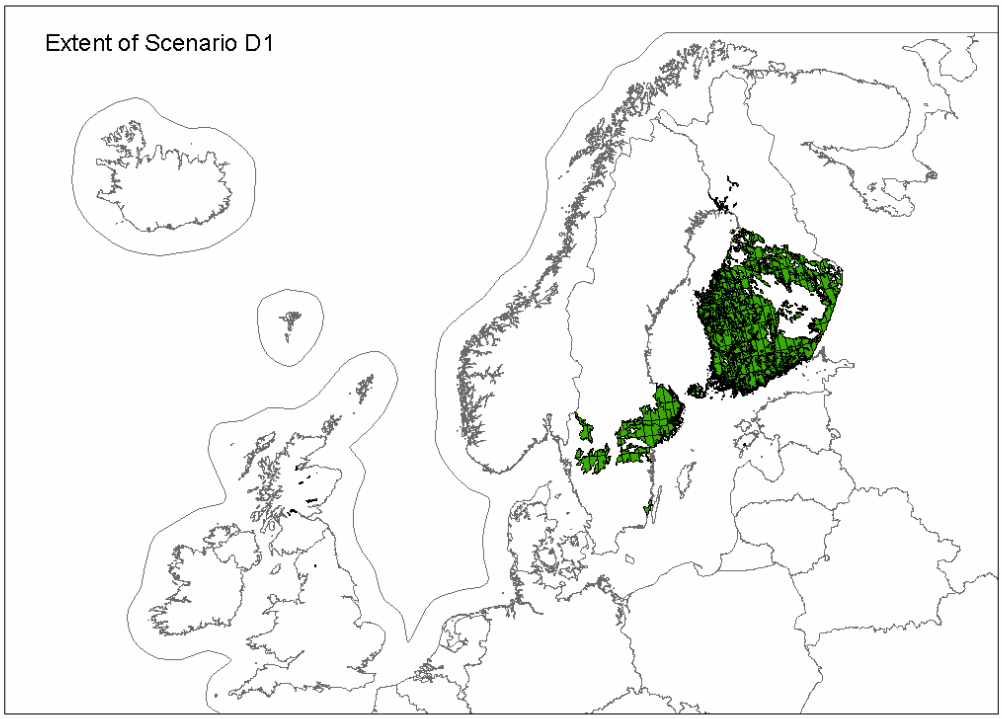


Figure 2.4.1 Extent of scenario D1 across Europe

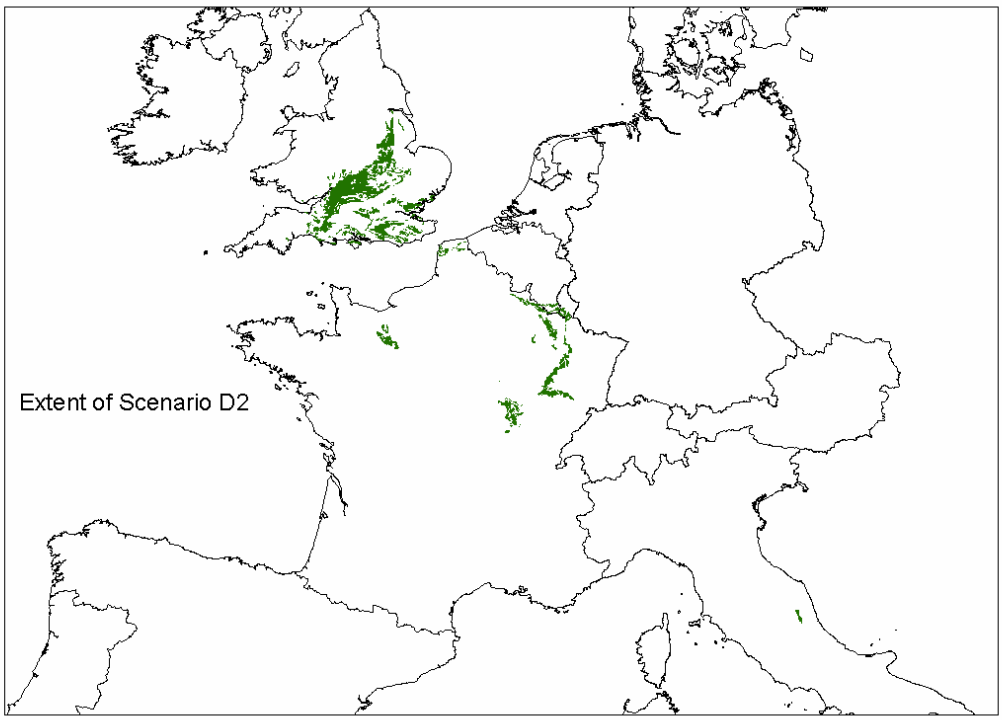


Figure 2.4.2 Extent of scenario D2 across Europe

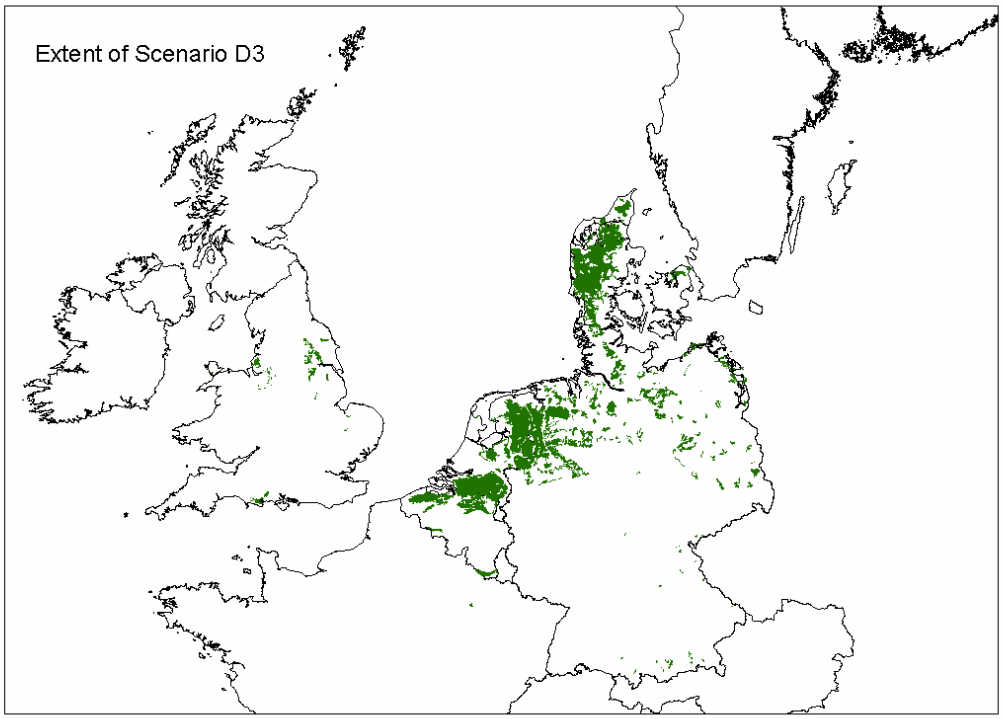


Figure 2.4.3 Extent of scenario D3 across Europe

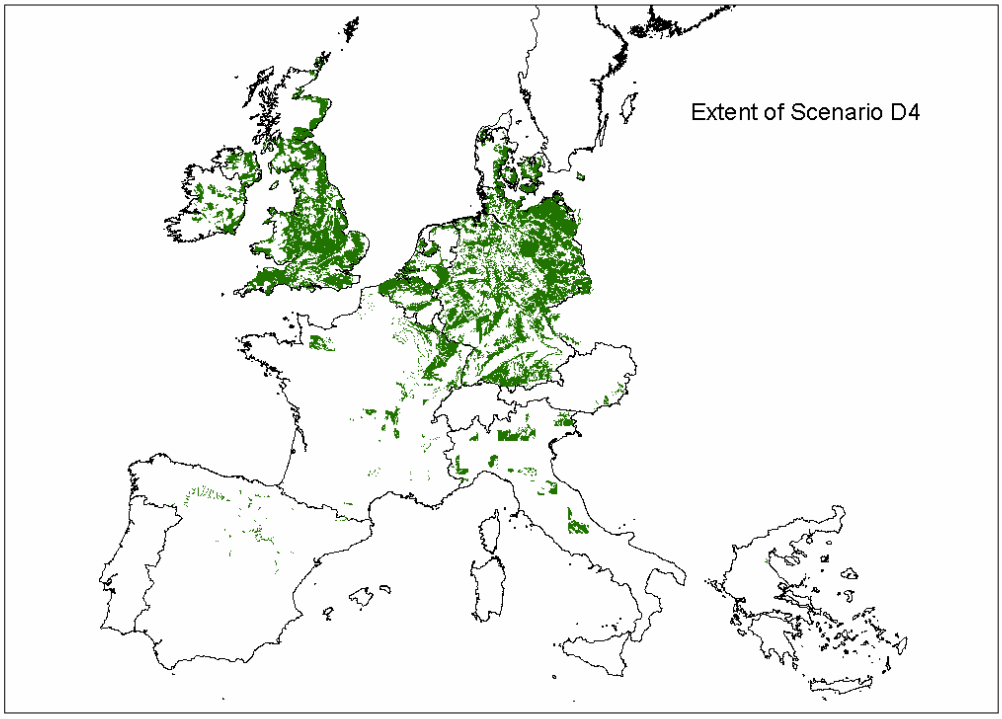


Figure 2.4.4 Extent of scenario D4 across Europe

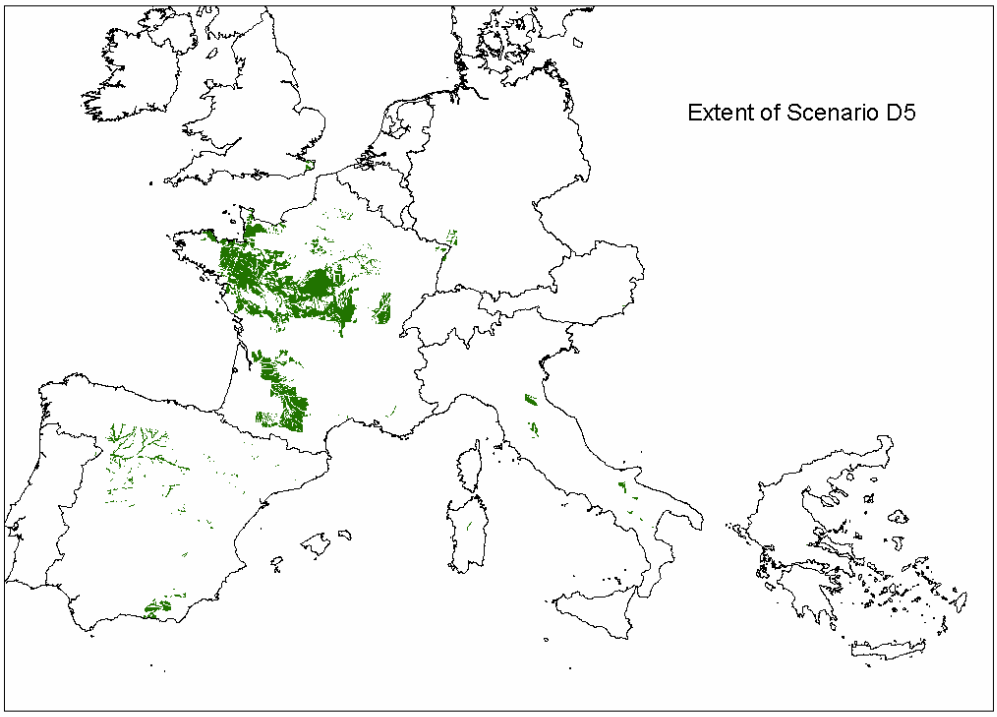


Figure 2.4.5 Extent of scenario D5 across Europe

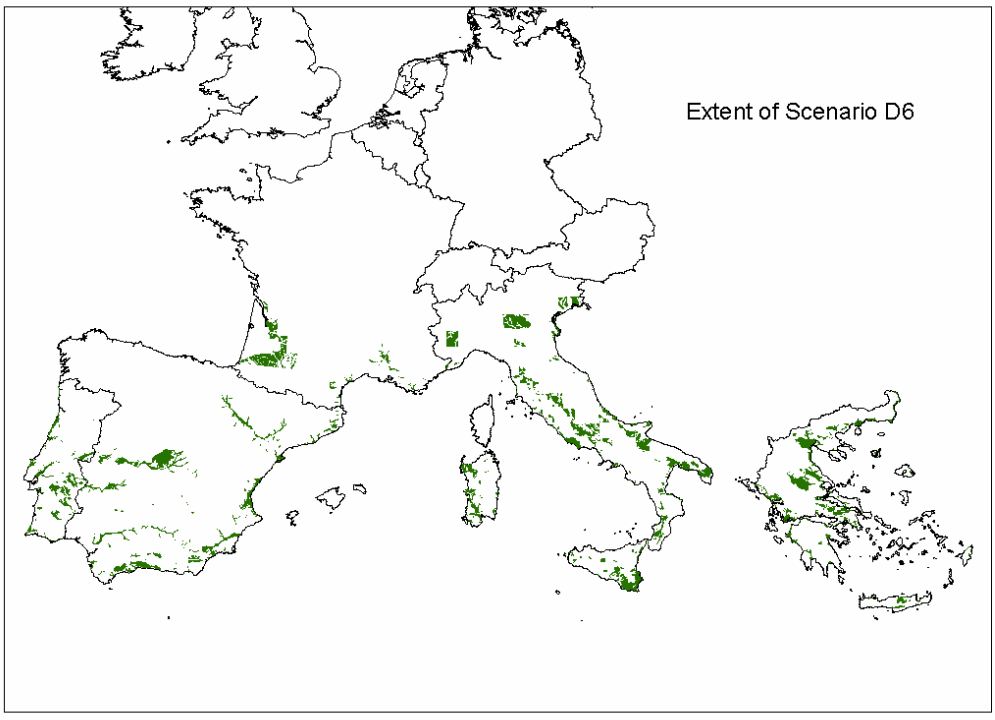


Figure 2.4.6 Extent of scenario D6 across Europe

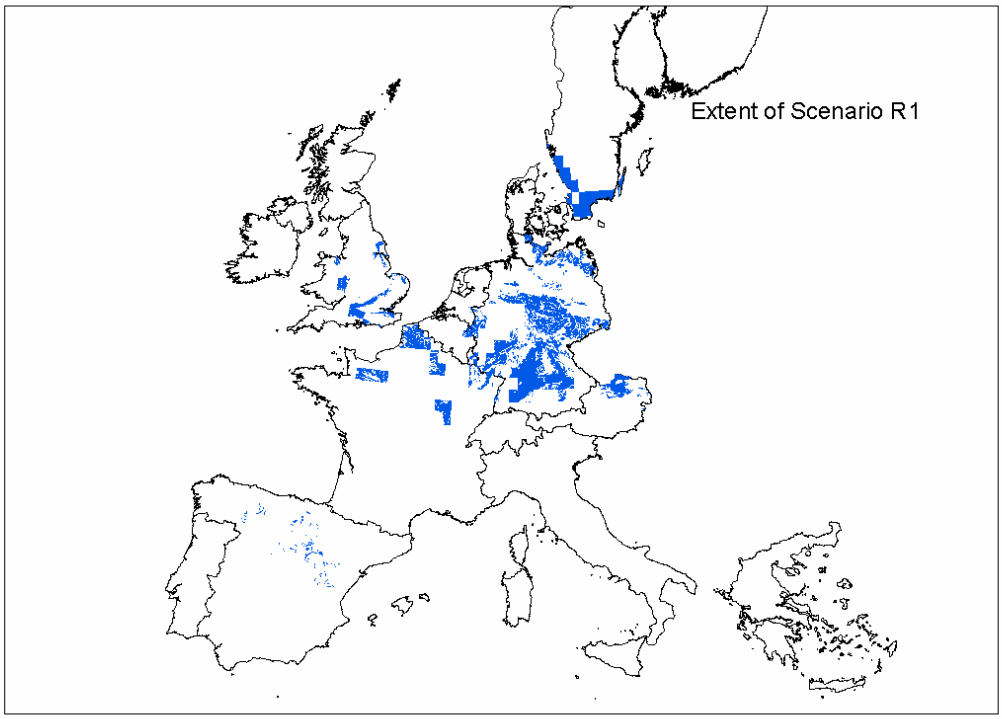


Figure 2.4.7 Extent of scenario R1 across Europe

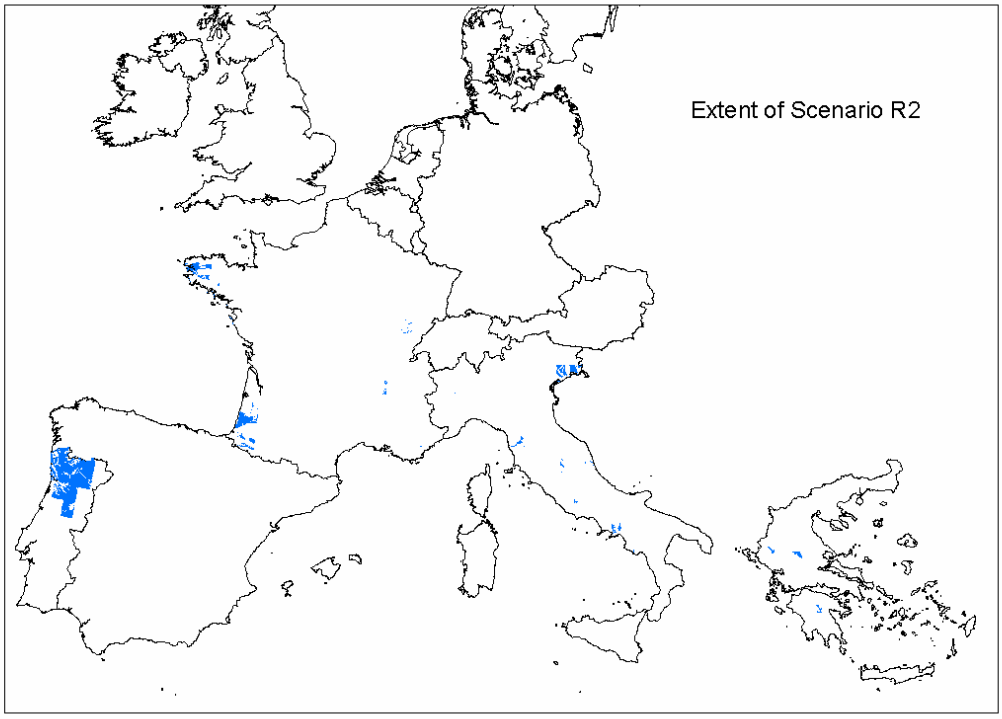


Figure 2.4.8 Extent of scenario R2 across Europe

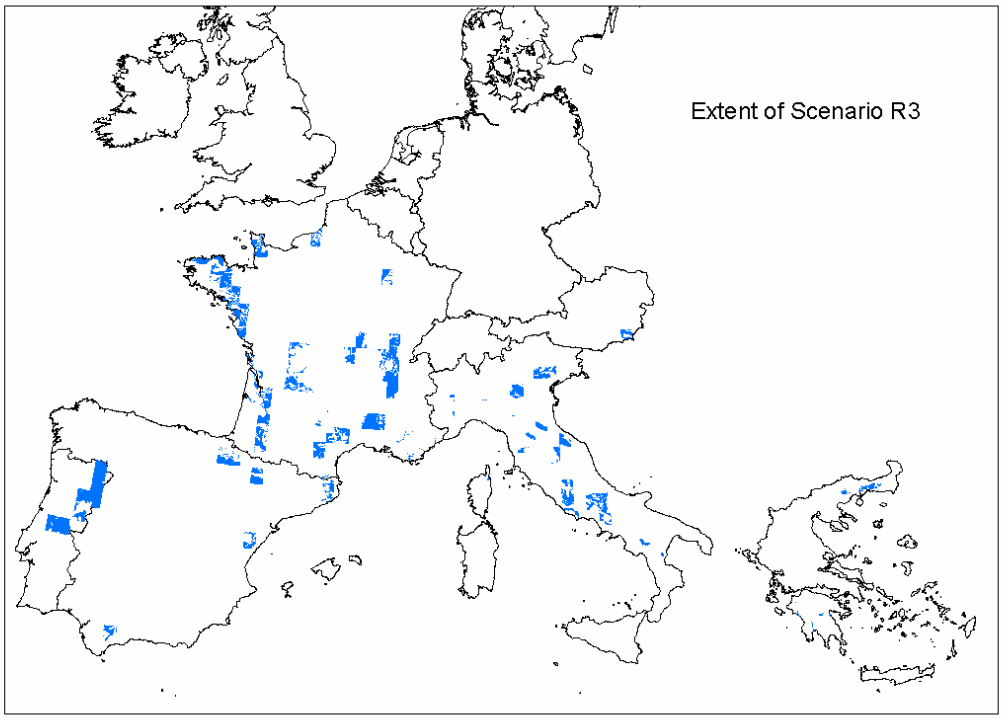


Figure 2.4.9 Extent of scenario R3 across Europe

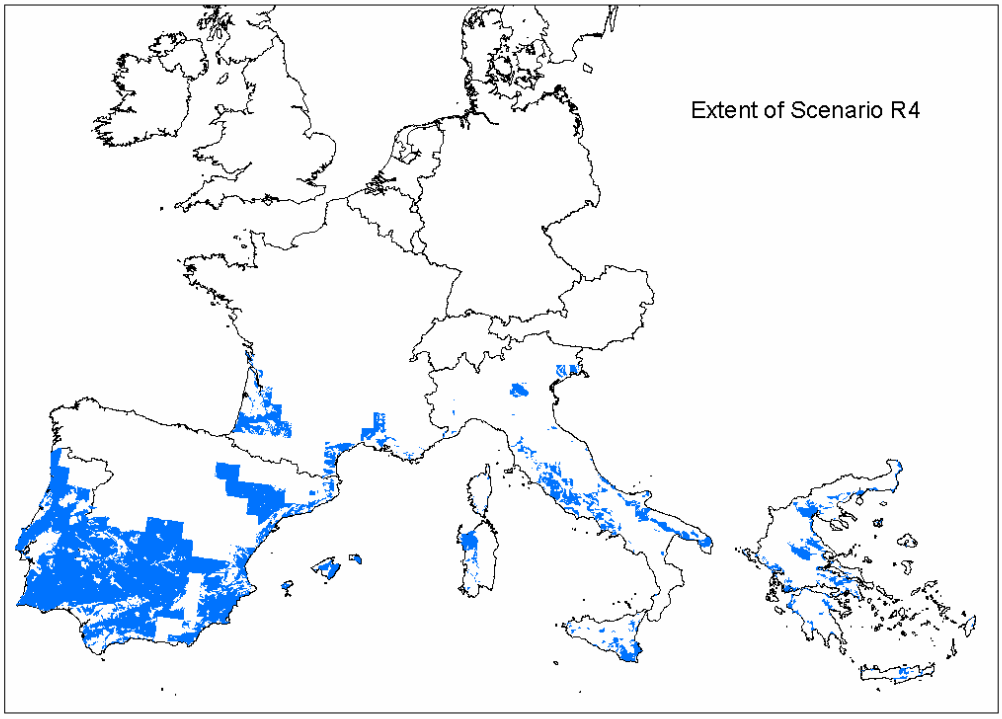


Figure 2.4.10 Extent of scenario R4 across Europe

Characterising the scale of protection in Europe

However, in the regulatory context it is important to know how representative the scenarios are in terms of a worst case for pesticide movement to surface waters. The following overall worst-case assessments were made:

Drainage

Scenario D2 combines an extreme worst-case soil with a worst-case recharge and represents a 98.8 percentile worst case for drainage within the worst case temperature range (see Table 2.4.4). The extreme worst case temperature range within Europe contains no extreme worst case soils, nor does it contain any agricultural land with significantly larger recharge values than D2. The only drained land considered more challenging than D2 was identified as 1.2% of areas within the worst-case temperature range that have significantly larger recharge. These areas represent 0.7% of all drained land (1.2% of worst case temperature drained agricultural land, which is 59% of all drained land). D2 thus represents a 99.3 percentile worst case for all drained agricultural land.

Run-off

Scenario R2 combines an extreme worst-case slope with an extreme worst-case rainfall and it represents a 98.1 percentile worst case for run-off within the intermediate case temperature range. There are no worse slopes under agriculture within all the run-off agricultural land in Europe. The only significantly worse areas of rainfall within all the agricultural run-off land occur in the intermediate temperature range where they represent 0.9 % of the agricultural run-off land. Worse-case run-off soils (hydrologic classes C & D) occur within the worst and extreme worst case temperature spatial ranges but areas with more than 1402 mm of rainfall occupy only 1.3% of the total agricultural run-off land. The only agricultural run-off land more challenging than R2 is thus this 1.3% of agricultural run-off land and the 0.9% of areas within the intermediate-case temperature range that have significantly larger rainfall plus the 1% of areas within the intermediate-case temperature range with class C or D soils (see Table 3.5.5; FOCUS, 2001). These areas represent 2.0% of all run-off land (1.3 % plus 1.9% of intermediate case temperature agricultural run-off land, which is 34.5% of all agricultural run-off land). R2 thus represents a 98 percentile worst case for all agricultural run-off land.

3.0 Agricultural Areas that are Represented by FOCUS Surface Water Scenarios.

The areas shown on the maps from the FOCUS report (see Figures 2-6 to 2-14) show those areas in Europe where the pedo-climatic characteristics are similar to those of each parameterised scenario. These maps show that scenarios D1, D2, D3, D4 and R1 all occur within the UK, although D1 is of very limited extent. However, the maps were derived using European-scale databases for soil and climate that are coarser than those available for the UK. There are two main limitations to the European scale data, compared to what is available at national level.

Firstly, the scale of the European soil data is 1:1,000,000 and the European climatic data has a grid resolution of 0.5^{o} longitude x 0.5^{o} latitude (approximately 50 km x 50 km), whereas the equivalent national soil data is at the 1:250,000 scale and the climatic data has a grid resolution of 5 km x 5 km. This means that the location of soil / climate combinations can be defined much more accurately when using the national data than when using the European level data.

Secondly, the soil texture data available for Europe is very broad, in that it groups all soil textures into 5 classes, coarse, medium, medium-fine, fine and very fine. The range of textures within these groups is illustrated in Figure 3-1. In contrast, the soil texture data available at national level is very precise with each soil type characterised by a set of analytical data which defines the mean measured values of clay-, silt- and sand-sized particles in each soil layer. At the national level, therefore it is possible to identify those soil types which correspond to the parameterised FOCUS soil scenarios much more precisely than using the European level data.

Using the national data therefore, it is possible to identify a much more precise distribution of the pedoclimatic characteristics corresponding to each of the FOCUS surface water scenarios.

3.1 National Data Sources

3.1.1 Soil

3.1.1.1 England & Wales

The soil data for England and Wales used in this study is that held in the National Soil Resources Institute Land Information System (LandIS, Proctor *et al*, 1999). Specific data used are:

1. Version 2 of the digital 1:250,000 scale National Soil Map of England and Wales, comprising digitally defined polygons showing the distribution of soil map units or *associations*, defined by an alpha-numeric code of the form '7.12b'. Each soil association has accompanying data that defines a set of named soil types or *series* that characterise the unit and the percentage area of the unit that each one occupies. These latter values have been estimated on a 'national average' basis using the point field observations made during creation of the map.
2. A 5 x 5 km grid resolution version of the vector 1:250,000 scale soil map, as derived for SEISMIC v. 2.0 (Hollis, *et al*, 2004). This comprises a set of geo-referenced 5 km x 5 km grid squares, each of which has a list of associated soil series and the percentage of the grid occupied by each one. Use of this data within the SEISMIC system allows integration of the soil data with other spatial grid data of similar resolution defining cropping statistics and climatic and aquatic landscape characteristics.
3. Soil property data defining the particle-size distribution (texture), organic carbon content, pH, bulk density and hydraulic characteristics of each soil series for each

significantly different soil layer down to a depth of 1.5 m or bedrock (whichever is shallower) and under each of four different land uses: arable; ley (short-term 'rotational') grass; permanent grass; other (all semi-natural vegetation). This is the dataset derived for and used in SEISMIC v. 2.0 (Hollis *et al*, 2004).

4. A digital vector dataset of polygons defining 'aquatic ecosystem landscapes', created by NSRI during the aquatic ecosystem project (PN0931, 2003). This dataset was derived by groupings polygons in the vector digital version 2.0 of the 1:250,000 national soils map (see 1 above) according to their dominant Hydrology Of Soil Types class and soil parent material characteristics, although polygons with soils that do not occur under agriculture were separated into a special class.

3.1.1.2 Scotland

The soil data for Scotland used in this study is based on that held by the Macaulay Land Use Research Institute. The specific data used are a derived 1 x 1 km grid resolution version of the vector 1:250,000 scale soil maps for Scotland. This comprises a set of geo-referenced 1 km x 1 km grid squares, each of which has an associated set of characteristics comprising: the single dominant soil series in the grid; the Hydology of Soil Types (HOST) class of the dominant soil series; the topsoil texture class of the dominant soil series.

3.1.2 Climate

3.1.2.1 England & Wales

The climate data for England and Wales used in this project is also derived from the NSRI Land Information System. It comprises long-term average data defining average annual rainfall (AAR) and average annual excess winter rainfall (XWR) at a 5 km x 5 km grid resolution across the two countries. The data were derived from meteorological office data supplied for a period from 1940 to 1970, using the methods described in Jones & Thomasson (1985). Excess winter rainfall is the total accumulated rainfall that occurs during the period when the potential soil moisture deficit is 0 and it is used in this project as a surrogate for recharge across England & Wales.

In addition, data relating to the average daily temperature during the 'spring' (March, April, May) and 'autumn' (September, October, November) periods is required to correspond with the climatic data used to define the FOCUS surface water scenarios. This dataset was created specifically for this project using the daily weather data for 109 individual stations held in Land IS and originally supplied for the period of 1961 to 1980 by the Meteorological Office for the purpose of creating the NSRI agroclimatic data file (Jones & Thomasson, 1985). Using the mean daily temperature data for each station, the mean daily spring & autumn temperature was calculated and a multiple regression equation derived for predicting this value from the altitude above O.D. and the national grid northing. This algorithm was then used to predict the mean daily spring & autumn temperature for each of the 5 km x 5 km climatic grids in LandIS.

3.1.2.2 Scotland

The climate data for Scotland used in this project is also derived from the UK-CIP Baseline Scenario mean climate statistics for 1971-2000. (Hulme *et al*., 2002). This data has been manipulated by ADAS Wolverhampton to produce a 1 km x 1 km grid of monthly mean daily values for a range of parameters, of which the ones used in this project are: mean daily rainfall and mean daily temperature. These values have been used to compute the required values for average annual rainfall, excess winter rainfall (based on rainfall during the months from mid-October to mid-March) and

average daily temperature during the 'spring' (March, April, May) and 'autumn' (September, October, November) periods.

3.1.3 Cropping data

The cropping data used in this project is based on the Defra agricultural census data and has been derived by Edinburgh Data Library using established interpolation routines to create a 2 km x 2 km grid dataset for England, Wales and Scotland. For England & Wales, cropping datasets incorporated into SEISMIC v. 2.0 have been used. Three datasets, for 1988, 1995 and 2000, are available in the system. In England, all crops except hops and vines have data for the year 2000 but for some very regionalised crops such as top or small fruit, the year 2000 data has been 'degraded' to a coarser level, whereas for field vegetables, no specific categories such as leafy vegetables or legumes are available. Data for vines is not supplied in the Defra agricultural census data and so has not been used for this project. For hops, the only data available is for 1988 and this has therefore been used.

For Scotland, data for 1997 is available from ADAS Wolverhampton and this has been manipulated to provide a dataset of crop statistics at 1 km x 1 km resolution.

The range of crops grown and data available is detailed in Table 3.1.3-1, which also lists those FOCUS scenarios that include representative data for the crop.

Table 3.1.3-1 Range of crops grown in England, Wales and Scotland in relation to the Defra agricultural census data available for the project

UK Crops	FOCUS Scenarios	England	Wales	Scotland
Grass (managed)	D1, D2, D3, D4, D5, R2, R3	2000	2000	1997
Winter Cereals	D1, D2, D3, D4, D5, D6, R1, R3, R4	2000	1995 [2]	1997
Spring Cereals	D1, D3, D4, D5, R4	2000	1995 [2]	1997
Winter OSR	D2, D3, D4, D5, R1, R3	2000	1995 [2]	1997
Spring OSR	D1, D3, D4, D5, R1	2000	1995 [2]	1997
Field Beans	D2, D3, D4, D6, R1, R2, R3, R4	2000	1995	1997
Sugar Beet	D3, D4, R1, R3	2000	1995	Not grown
Potatoes	D3, D4, R1, R3	2000	2000	1997
Legumes	D3, D4, D5, D6, R1, R2, R3, R4	2000	1988	1997
Maize	D3, D4, D5, D6, R1, R2, R3, R4	2000	1995	Not grown
Vegetables - Root	D3, D4, D6, R1, R2, R3, R4	1988 [1]	1988 [1]	1997
Vegetables - leafy	D3, D4, D6, R1, R2, R3, R4	1988 [1]	1988 [1]	1997
Vegetables - bulb	D3, D4, D6, R1, R2, R3, R4	1988 [1]	1988 [1]	1997
Vegetables - fruiting	D3, D4, D6, R1, R2, R3, R4	1988 [1]	1988 [1]	1997
Top Fruit	D3, D4, D5, R1, R2, R3, R4	2000	1988	1997
Hops	R1	1988	Not grown	Not grown
Small Fruit	None	2000	1988	1997
Flowers & bulbs	None	2000	1988	1997
Vines	D6, R1, R2, R3, R4	No data [3]	Not grown	Not grown

[1] Data relating to individual types of vegetable crops in England and Wales is only available for the year of 1988. In England data on total vegetables grown in the open is available for 2000 but no data is available for Wales.

[2] In Wales data on the different areas of winter and spring cereals is only available for 1995. Data for total cereals in Wales is available for 2000.

[3] Very small areas of vines are grown in England but this crop is not included in the Defra agricultural census returns.

3.2 Identification of representative scenarios

Each scenario identified and characterised in the FOCUS surface water scenarios report (FOCUS, 2001) has four components:

- A climatic range that is representative of the daily weather dataset used to drive the FOCUS pesticide fate models.
- A set of soil characteristics comprising its textural class, organic matter status, water regime and substrate permeability. These are used to identify the distribution of soils within Europe that have similar soil sorption and hydraulic characteristics to those used to drive the FOCUS pesticide fate models.
- A set of crops that are commonly grown on the scenario and, whose agronomic characteristics have been derived in order to drive the FOCUS pesticide fate models.

- A set of 'edge-of-field' water bodies that are commonly associated with the other scenario characteristics.

Ideally, to identify which of the FOCUS scenarios are relevant to UK agriculture, the distribution of each of the four scenario components within Great Britain should be mapped and quantified. In the following section, the first three of these components are dealt with. Relevance of the final component, the edge-of-field water bodies, is described in section 5.

3.2.1 Climatic relevance of the scenarios

The first step in this process is to identify which of the climatic ranges used to define scenarios are present and this has been done using the definitions taken directly from Table 3.2-6 of the FOCUS report (FOCUS, 2001) and the climatic data described in section 3.1.2 above. Maps have been produced to show the distribution of each scenario climatic range and these are shown in Figures 3.2-1 to 3.2-2 below, along with the climatic range definitions for each scenario.

The maps show that the climatic ranges that define scenario D1 are limited to only a small area of Scotland. This is because, where the cool temperature range (<6.6 ^{o}C) is present, the excess winter rainfall is normally greater than 200 mm. In contrast, the warm spring & autumn temperature range for scenarios D5, R2, R3 & R4 (>10 ^{o}C) does not occur in the Great Britain. Simply from climatic considerations therefore, only scenarios D1, D2, D3, D4 and R1 are relevant to British agriculture with scenario D1 having only very limited relevance.

Scenario	Temp. °C	XWR mm
D1	<6.6	100 - 200
D2	6.6 – 10	201 – 300
D3	6.6 – 10	201 – 300
D4	6.6 – 10	100 – 200
D5	10.1 – 12.5	100 – 200
D6	>12.5	201 – 300

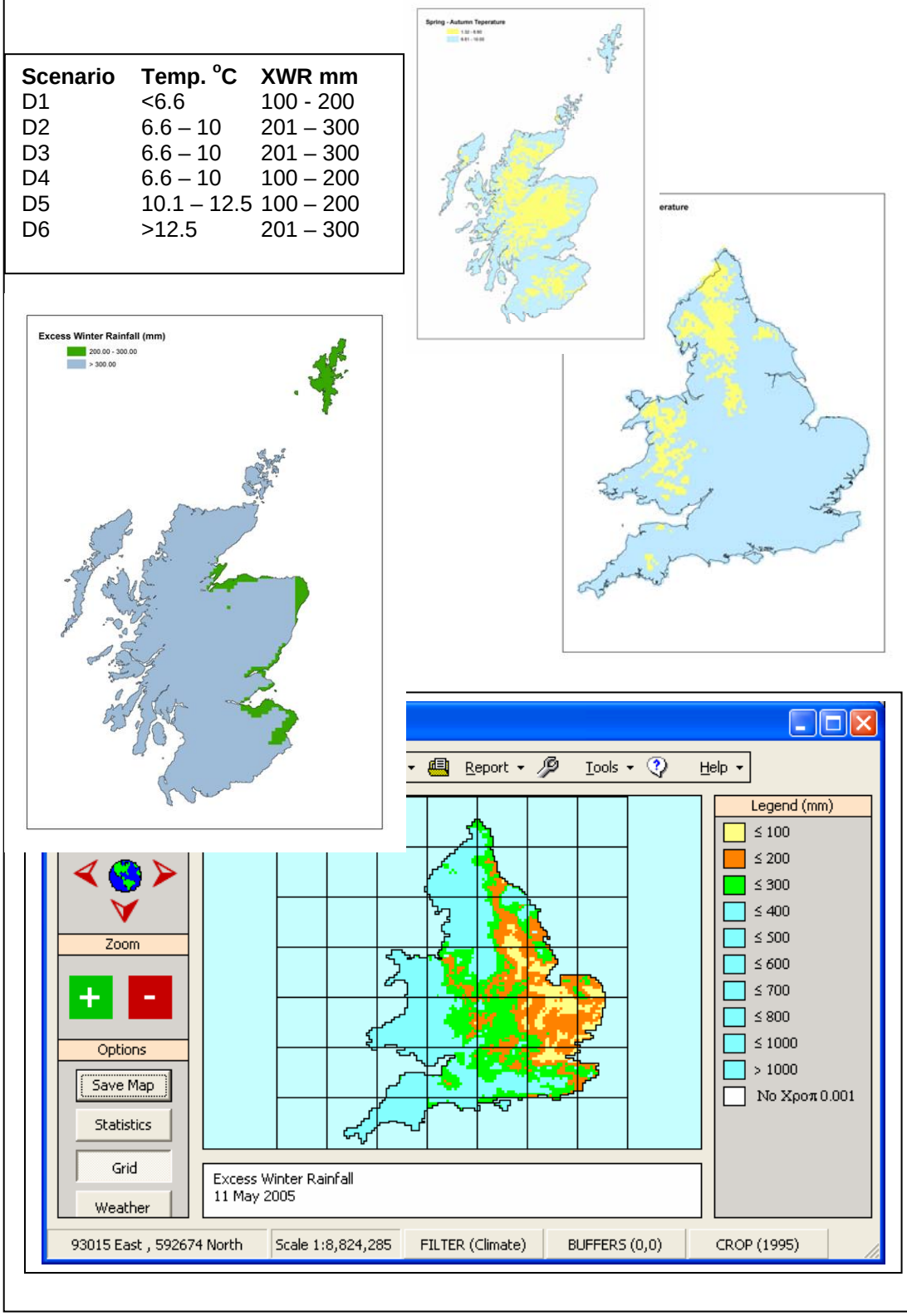


Figure 3.2.1.1 Distribution of climatic ranges associated with each drainage scenario.

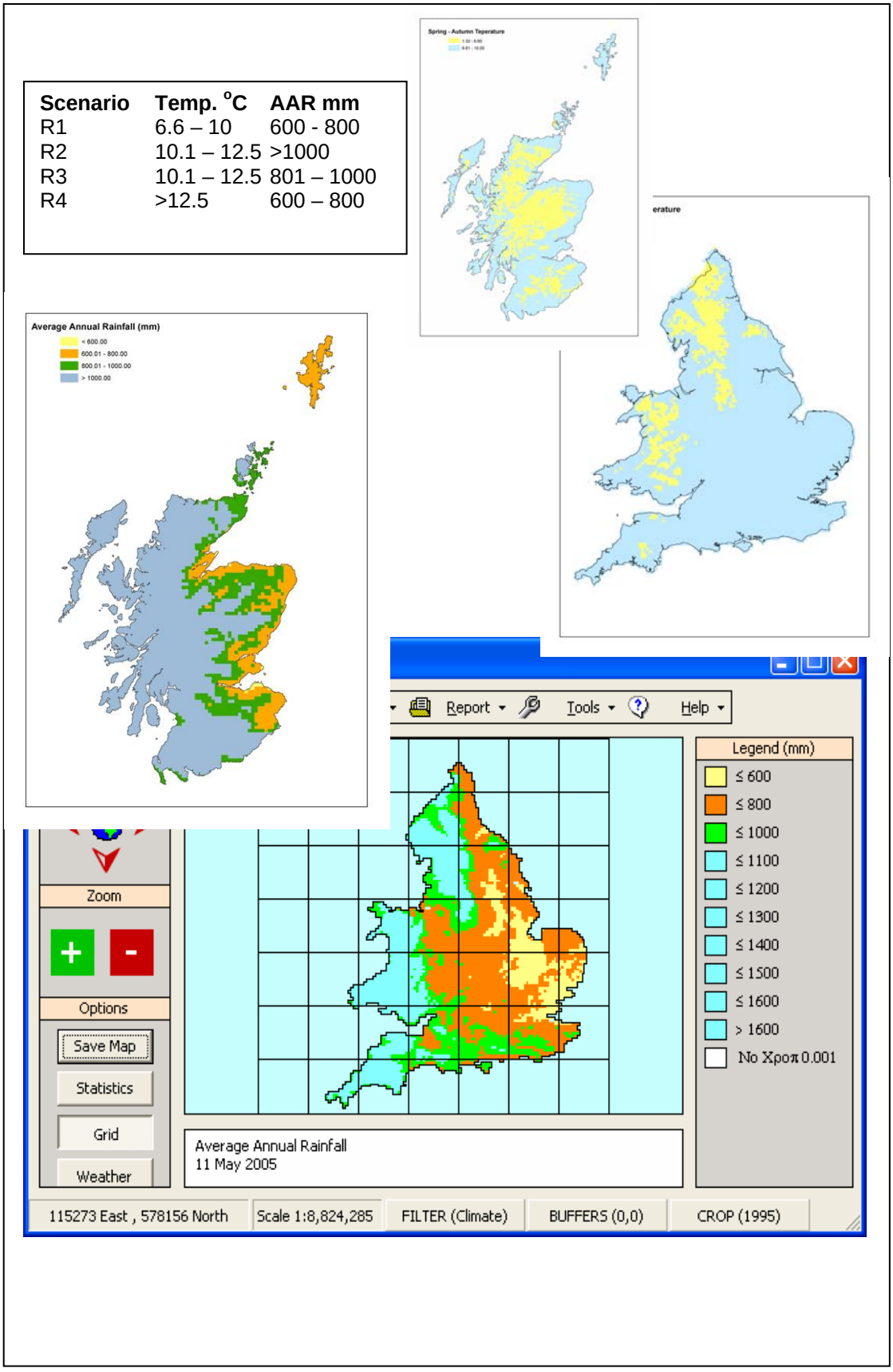


Figure 3.2.1.2 Distribution of climatic ranges associated with each run-off scenario.

3.2.2 Combined soil & climatic ('pedo-climatic) relevance of the scenarios

The next step in the identification process is to identify areas in Great Britain that have similar soil characteristics to those of the FOCUS surface water scenarios and to combine these areas with the relevant climatic ranges for each scenario. This identifies those areas that have similar pedo-climatic characteristics to those of the FOCUS scenarios.

To do this, the soil characteristics of each Focus Scenario described in section 3.3 of the FOCUS surface water scenarios report (FOCUS, 2001) were correlated with soil series in England, Wales and Scotland that have similar characteristics and this was done using the soil property data described in section 3.1.1,. The characteristics used to make the correlations are defined in Table 3.2-1. HOST classes were used to correlate both soil water regimes and substrate permeability.

Table 3.2-1. Soil characteristics used to correlate FOCUS scenarios with UK soil series

Scenario	Topsoil Texture	Topsoil organic matter status	HOST Class
D1	Clay content > 35%; Silty clay (Scotland)	Not humose or peaty	24 or 10
D2	Clay content > 35%; Clay (Scotland)	Not humose or peaty	25
D3	Sandy; Sand or loamy sand (Scotland)	Not humose or peaty	7 or 9
D4	Clay content ≤ 18%, sand content < 65%; Loam <18% clay (Scotland)	Not humose or peaty	18
D5	Clay content 18-35% sand content ≥ 15%; Loam >18% clay (Scotland)	Not humose or peaty	24
D6	Clay content 18-35% sand content ≥ 15%; Clay loam (Scotland)	Not humose or peaty	9
R1	Clay content < 35%, sand content < 15%; Silt loam (Scotland)	Not humose or peaty	1-6, 13, 16-23
R2	Clay content ≤ 18%, sand content < 65%; Sandy loam (Scotland)	Humose but not peaty	1-6, 13, 16-23
R3 & 4	Clay content 18-35% sand content ≥ 15%; Clay loam (Scotland)	Not humose or peaty	1-6, 13, 16-23

Having identified the groupings of soil series that are correlated with each FOCUS scenario, the distribution of each correlated group of soil series were mapped using the 1:250,000 scale digital soil database in Arc-Esri Geographical Information System software. These distributions were then intersected with each set of scenario climate ranges shown above to identify three types of areas:

- Those where the soil and climatic characteristics correspond to those of the FOCUS scenarios.
- Those where only the soil characteristics correspond to the FOCUS scenarios.

- Those where only the climatic characteristics correspond to the FOCUS scenarios.

The resulting maps are shown in Figures 3.2-1 to 3.2-9.

It is important to note that the mapped areas delineated in this way show the distribution of soil map units that contain one or more of the correlated soil series. *The mapped areas thus illustrate the geographic distribution of the correlated soils but do not indicate that correlated soils occupy all of the mapped area. They cannot be used to quantify the amount of correlated or missing soils*.

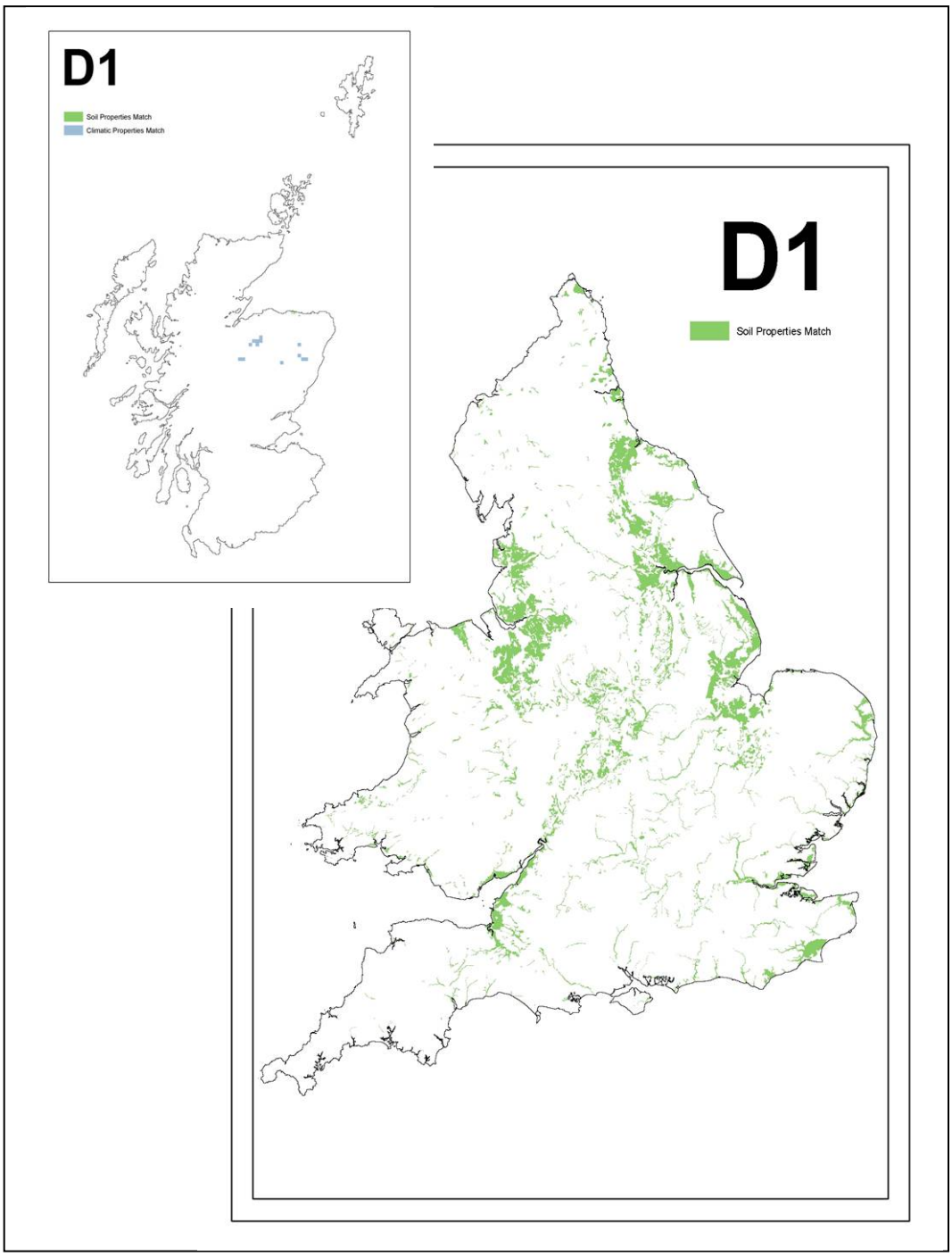


Figure 3.2.1 Distribution of correlated area of FOCUS scenario D1

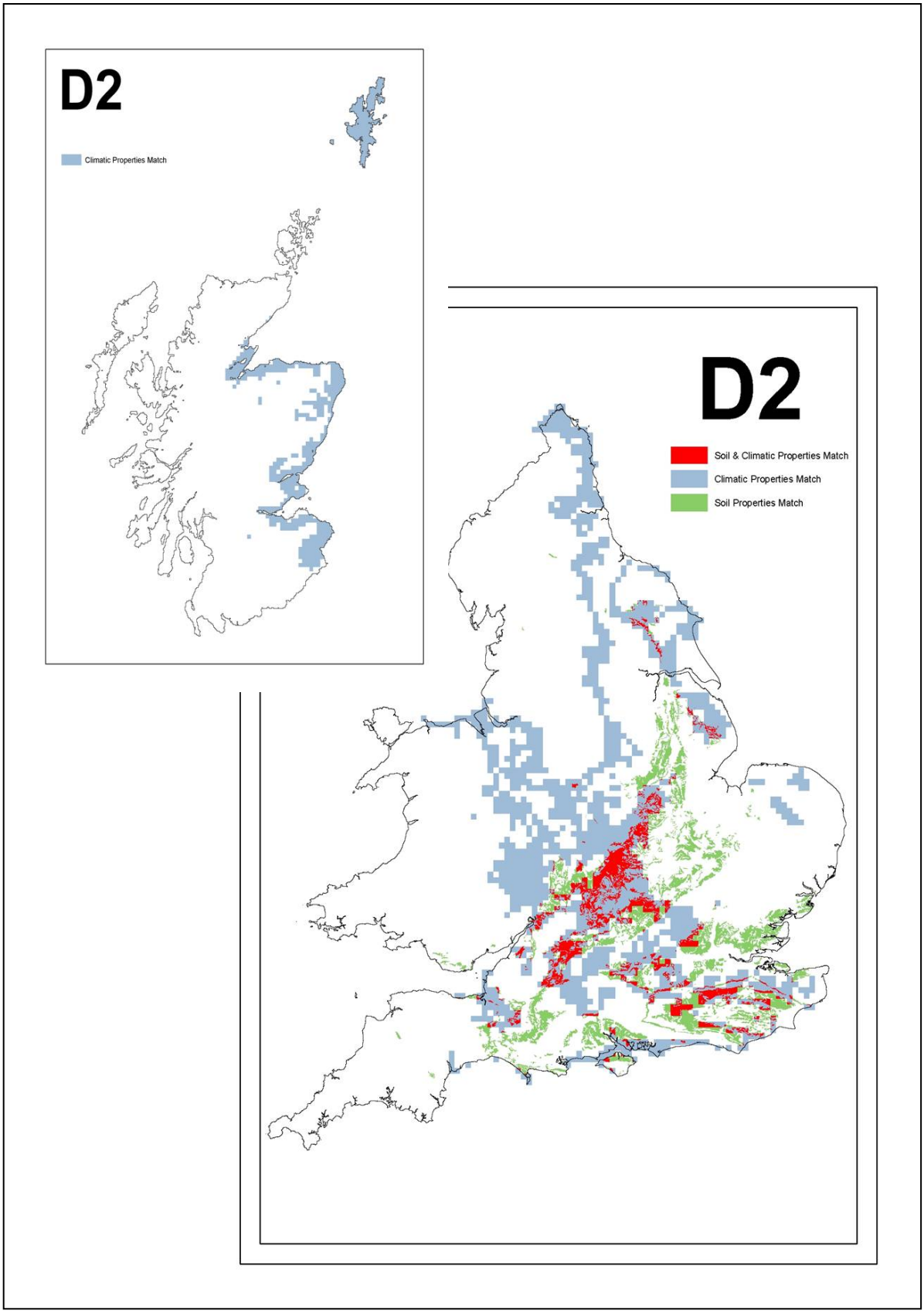


Figure 3.2.2 Distribution of correlated area of FOCUS scenario D2

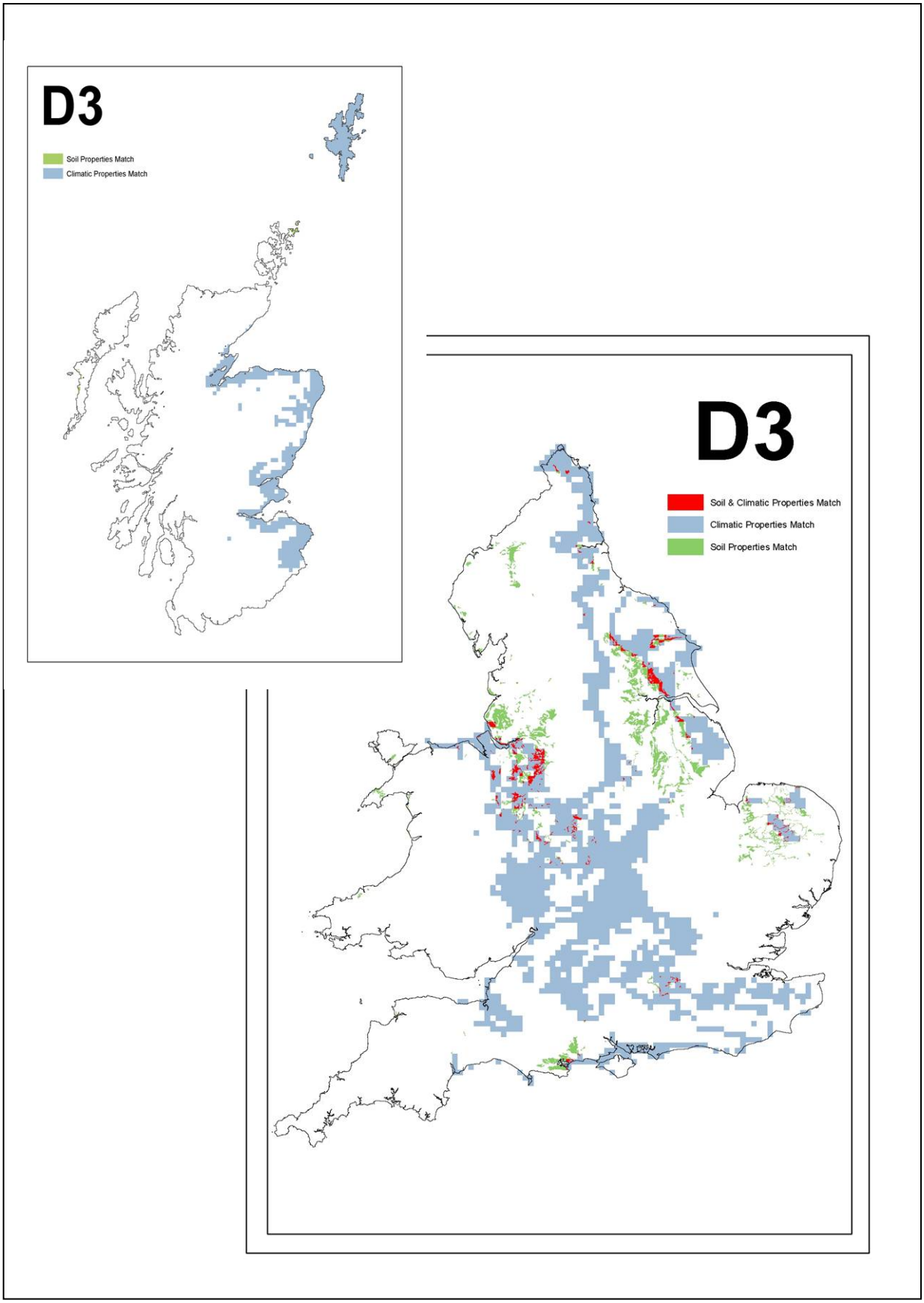


Figure 3.2.3 Distribution of correlated area of FOCUS scenario D3

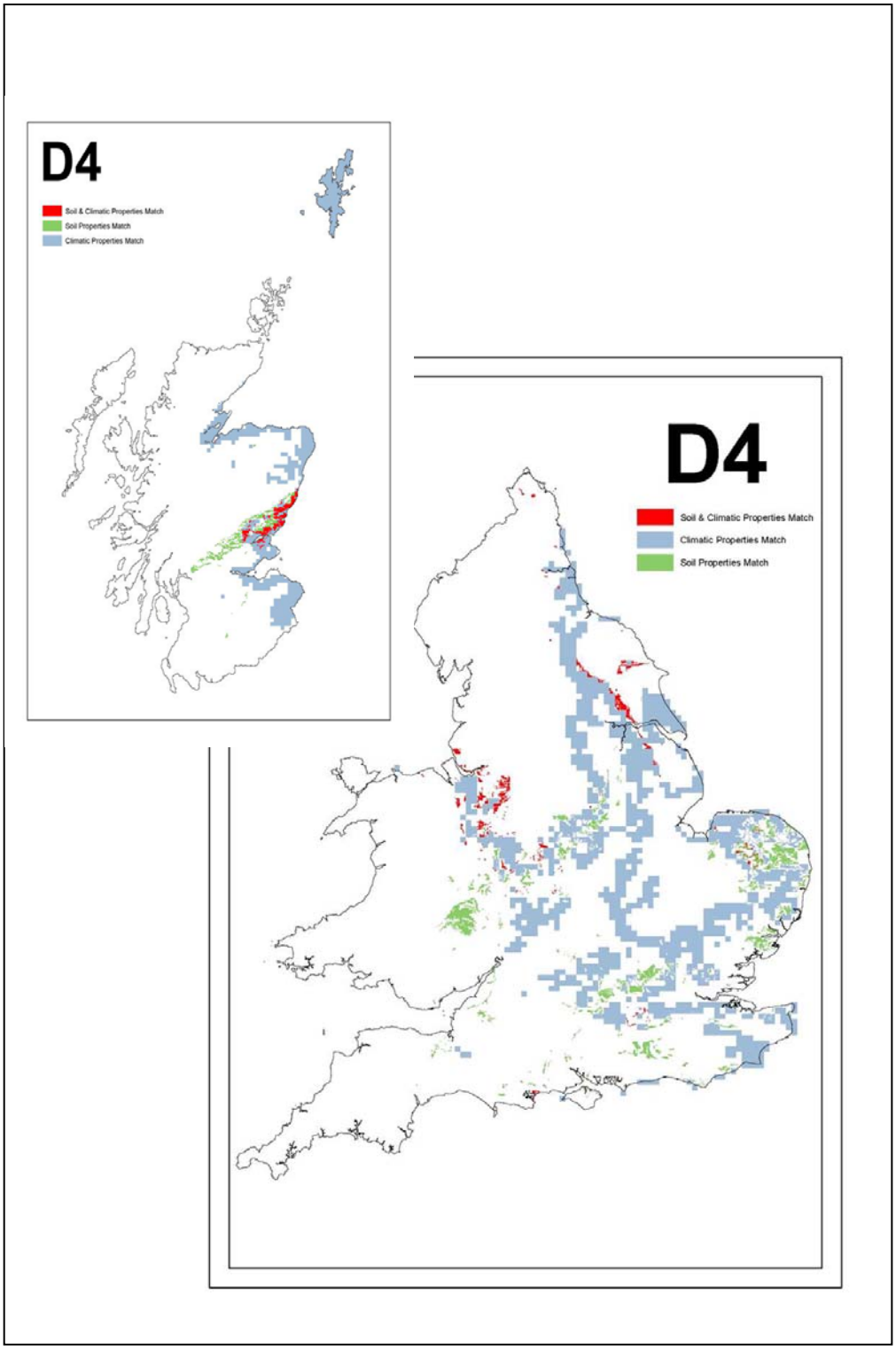


Figure 3.2.4 Distribution of correlated area of FOCUS scenario D4

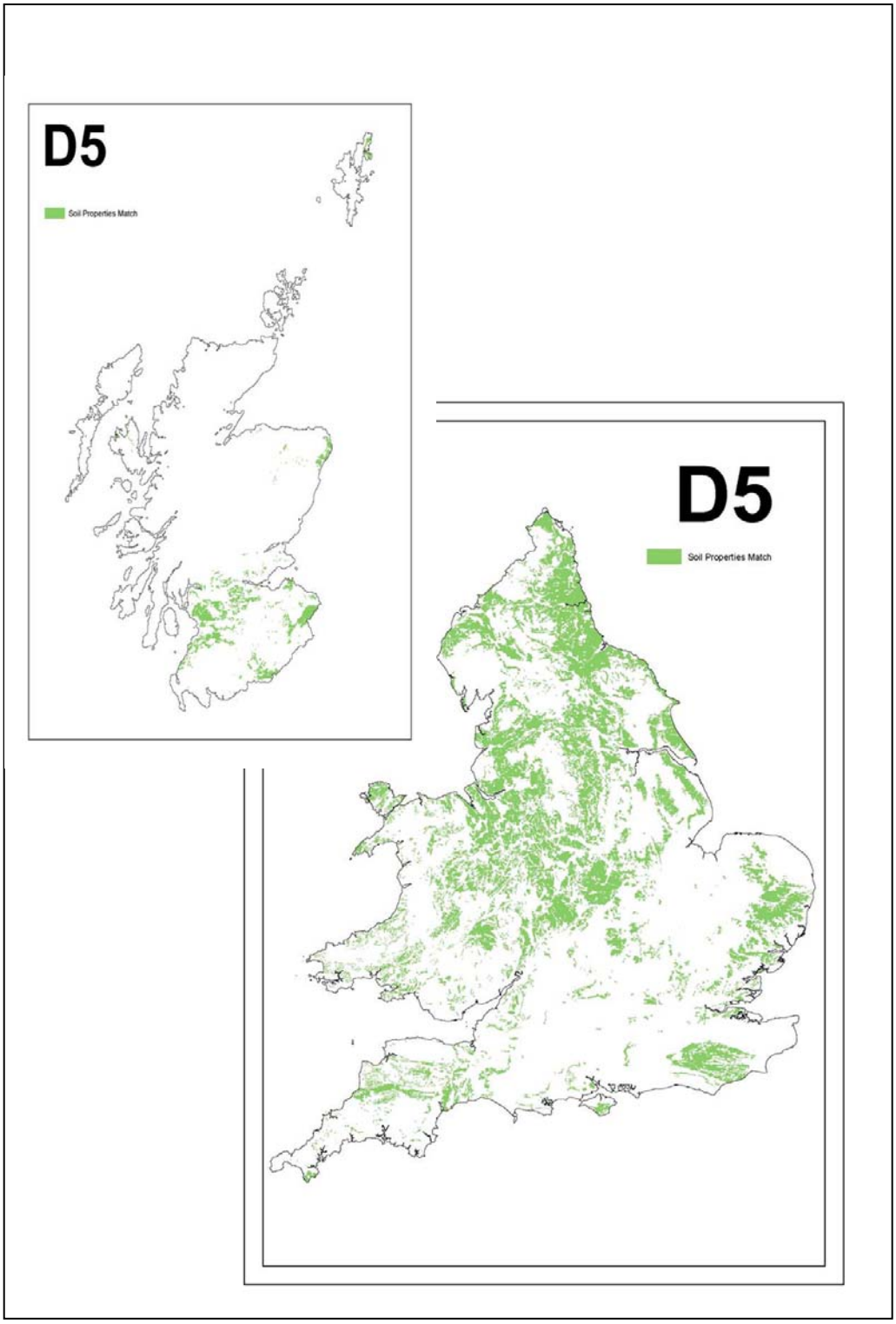


Figure 3.2.5 Distribution of correlated area of FOCUS scenario D5

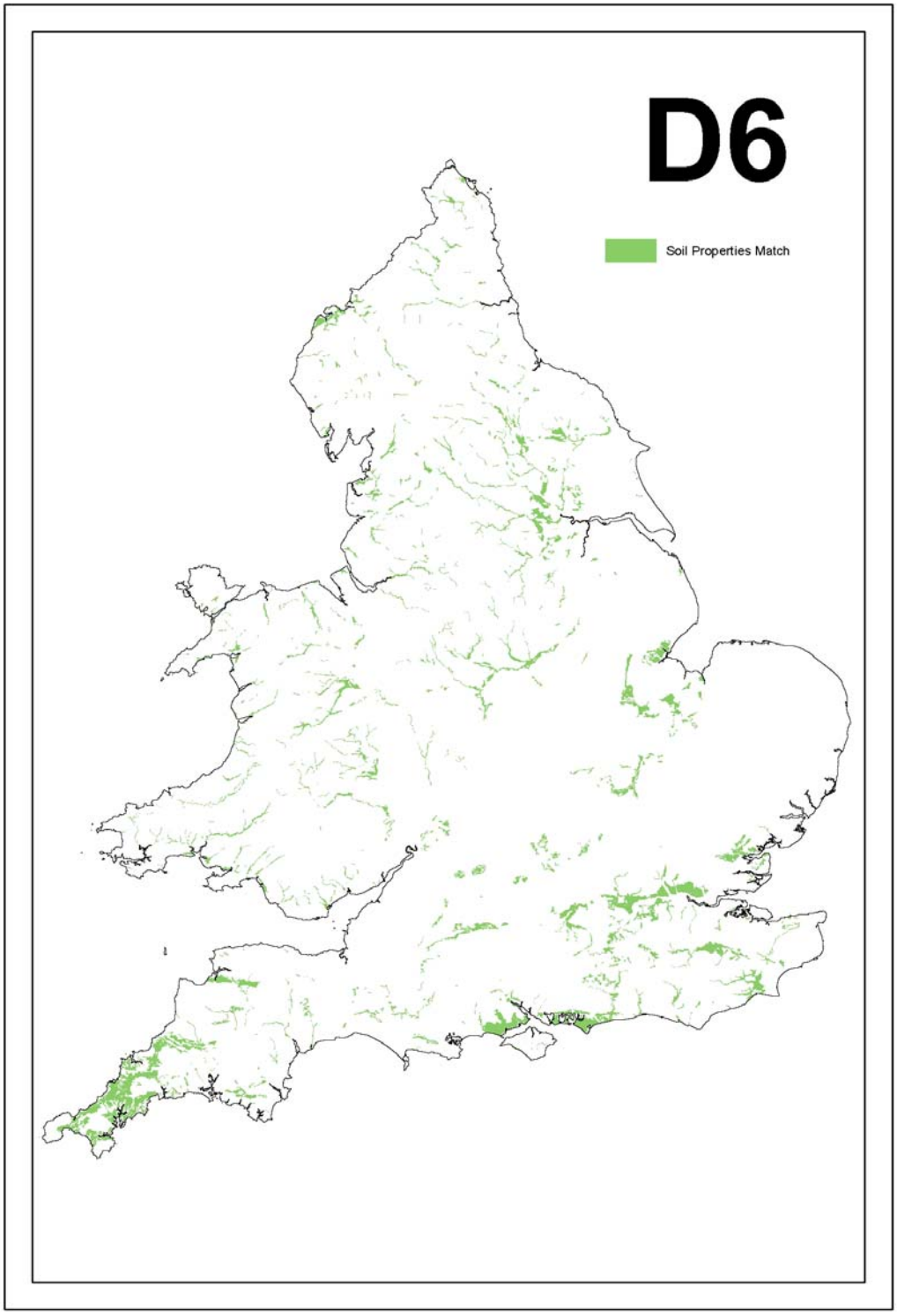


Figure 3.2.6 Distribution of correlated area of FOCUS scenario D6

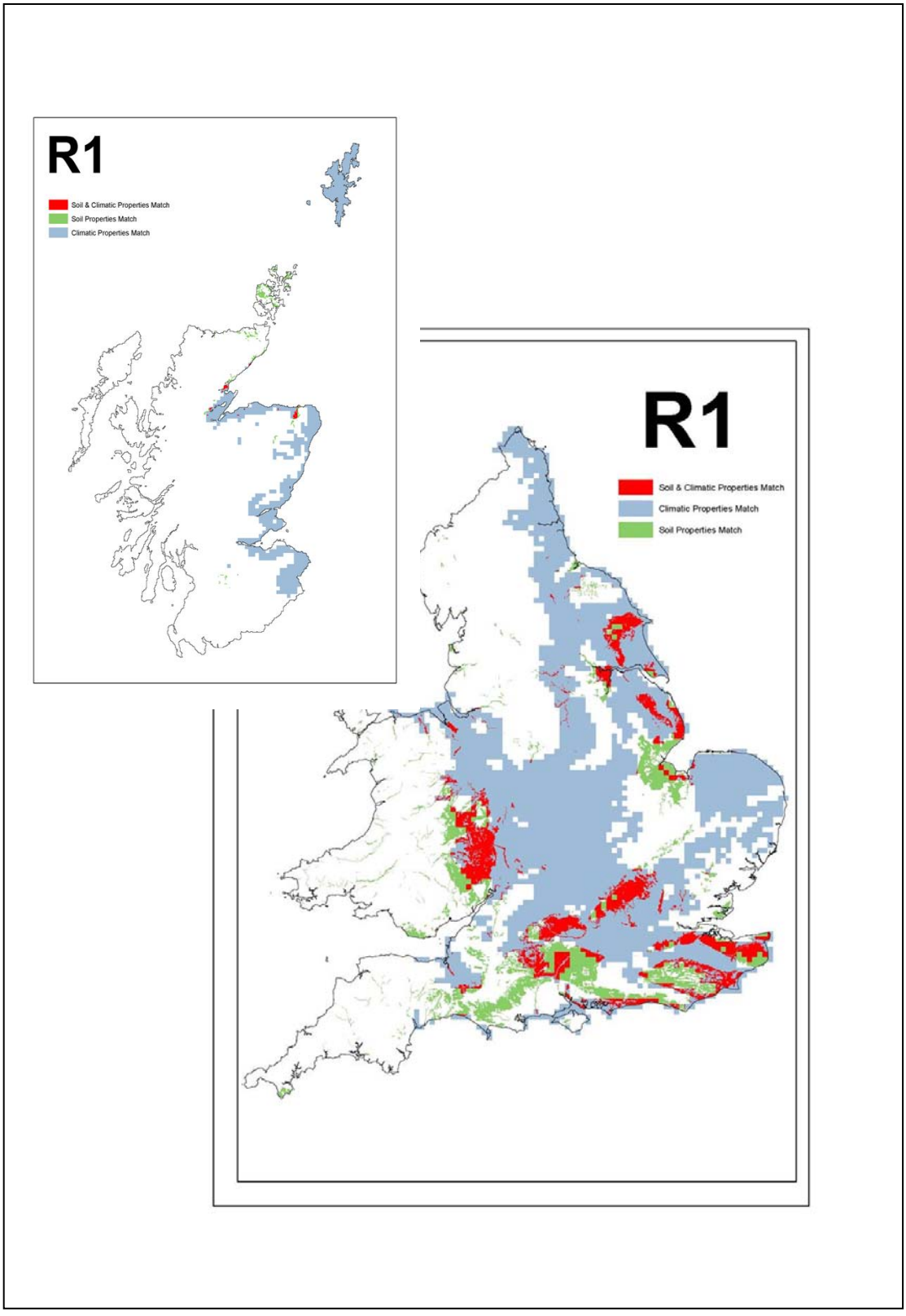


Figure 3.2.7 Distribution of correlated area of FOCUS scenario R1

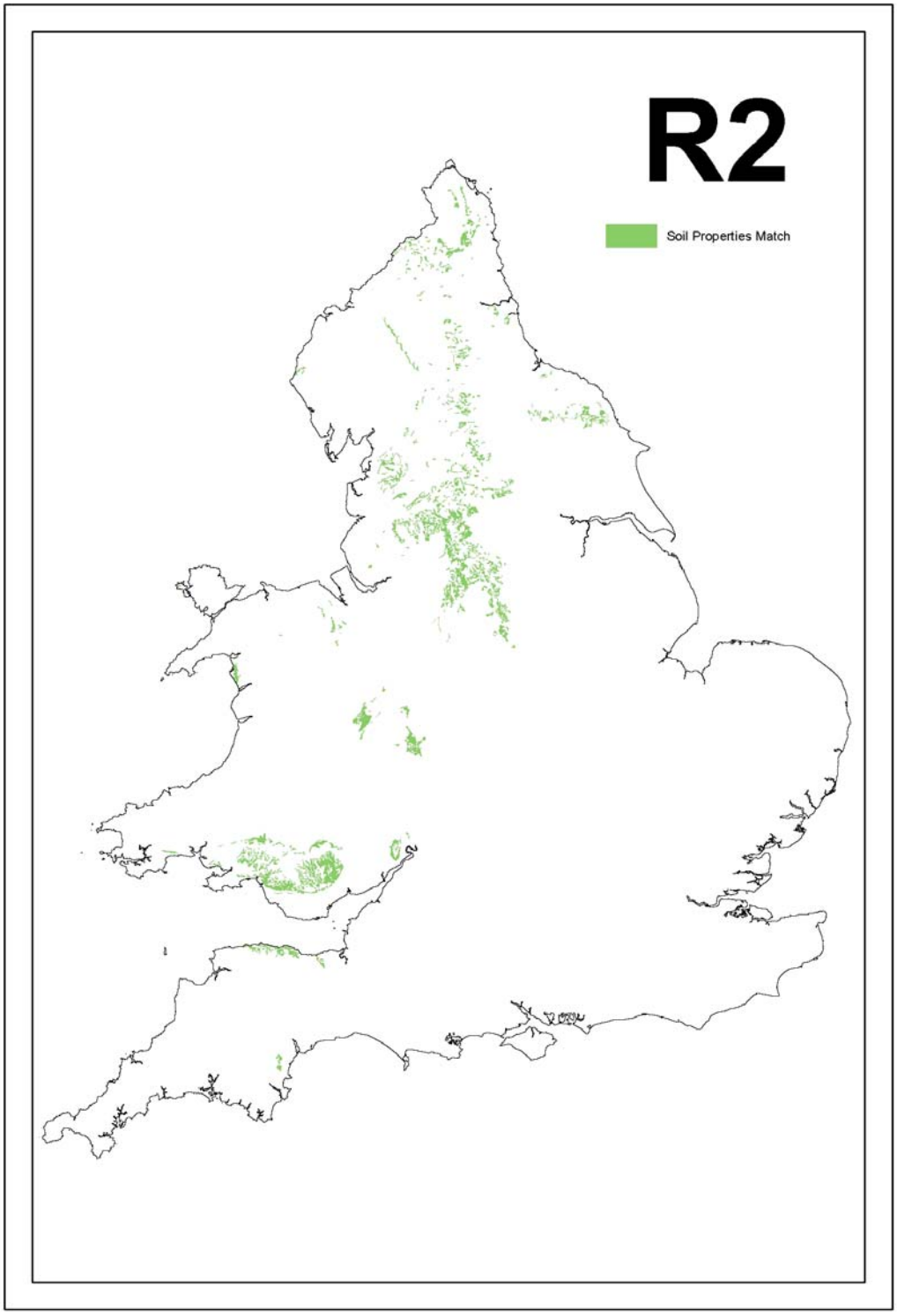


Figure 3.2.8 Distribution of correlated area of FOCUS scenario R2

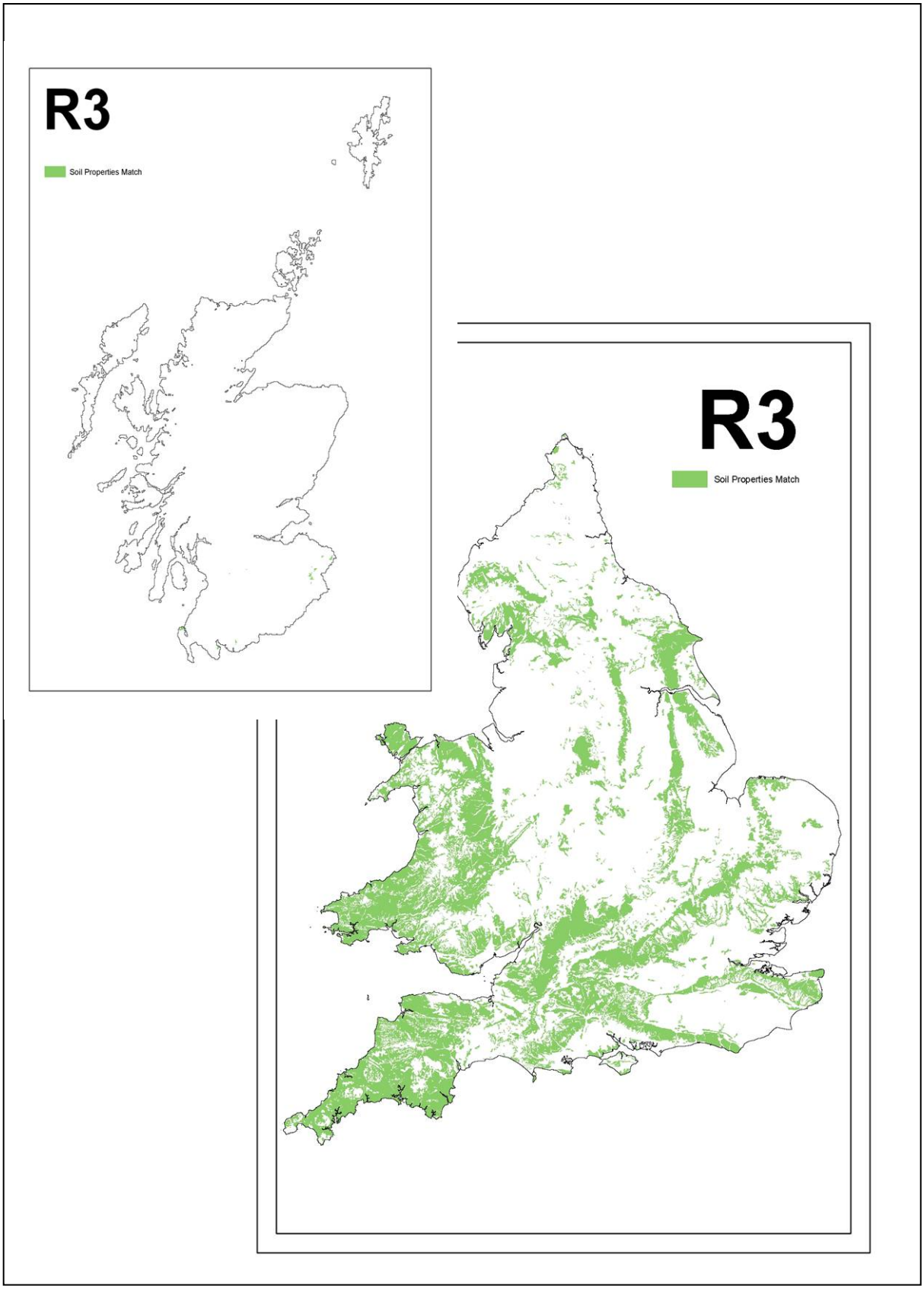


Figure 3.2.9 Distribution of correlated area of FOCUS scenario R3 (& R4)

These maps show that only scenarios D2, D3, D4 and R1 are directly relevant to pedo-climate conditions in Great Britain. Soil types corresponding to all 10 scenarios occur in Great Britain but the very restricted areas corresponding to the D1 climatic range do not include any soils correlated with that of the scenario, whereas the warm climates of scenarios D5, D6, R2, R3 and R4 do not occur within the UK.

Of those scenarios with a climate range that does not correspond to that of UK agriculture, **soil characteristics corresponding to those of scenarios D1, D5, R3 and R4 are extensive**.

3.2.3 Crops associated with each directly relevant pedo-climatic scenario

Using the cropping databases described in section 3.1.3, the range of crops that are grown under each of the identified directly relevant pedo-climatic scenarios was identified by intersecting the spatial cropping data with areas representing each identified set of pedo-climatic characteristics. For England & Wales this process was carried out using SEISMIC v. 2.0, whereas for Scotland it was carried out using the Arc-Esri Geographical Information System software. The results are quantified in Table 3.2.3-1

Table 3.2.3-1 Crops grown in Great Britain in relation to directly relevant FOCUS pedo-climatic scenarios.

Crop	Total crop area (ha)	D2 (ha)	As a % of crop area	D3 (ha)	As a % of crop area	D4 (ha)	As a % of crop area	R1 (ha)	As a % of crop area
Grass (managed)	5631045	187729	3.3	35594	0.6	52873	0.9	206952	3.7
Winter Cereals	3285022	156805	4.8	40132	1.2	103380	3.1	109201	3.3
Spring Cereals	1525975	12507	0.8	7813	0.5	155882	10.2	53193	3.5
Winter OSR	380996	19841	5.2	3560	0.9	1570	0.4	10031	2.6
Spring OSR	153076	4284	2.8	510	0.3	341	0.2	5178	3.4
Field Beans	122484	11474	9.4	1368	1.1	1286	1.1	5554	4.5
Sugar Beet	170066	0	0.0	7393	4.3	268	0.2	1039	0.6
Potatoes	235926	0	0.0	5034	2.1	32853	13.9	5522	2.3
Legumes	134746	0	0.0	2715	2.0	6750	5.0	5872	4.4
Maize	94772	8012	8.5	1156	1.2	2008	2.1	6156	6.5
Vegetables	119909	0	0.0	4208	3.5	3602	3.0	2267	1.9
Top Fruit	24407	0	0.0	19	0.1	3440	14.1	3389	13.9
Hops	4036	0	0.0	0	0.0	1902	47.1	1017	25.2
Small Fruit	14755	0	0.0	47	0.3	3137	21.3	663	4.5
Flowers & bulbs	7249	0	0.0	52	0.7	925	12.8	48	0.7

Note Data highlighted in red indicate pedo-climatic-crop scenario combinations that are unlikely to be relevant in Great Britain.

Data highlighted in magenta indicate pedo-climatic-crop combinations that are not included in the directly relevant FOCUS scenario

When assessing these results, the following considerations should be taken into account:

- The accuracy of the cropping statistics can be suspect, especially for crops that cover only small areas of any particular grid. It is proposed that, any crop covering less than about 1,000 ha of a scenario and representing less than about 1% the total area of that crop should be ignored. Such crop / scenario combinations are highlighted in red in Table 3.2.3-1
- Some crops, for example cereals, oilseed rape and grass are distributed throughout the agricultural areas of Great Britain, although with a bias towards eastern and southern or western and northern regions, depending on broad climatic limitations for the crop. Other crops however, such as maize, sugar beet, potatoes, legumes, vegetables, top fruit, hops, small fruit and flowers & bulbs are concentrated in specific areas related to soil/climatic suitability, historic development and economic factors. The directly relevant pedo-climatic FOCUS

scenarios are much more likely to encompass the non-localised crops than the 'localised' ones. The two types of crop distributions are illustrated in Figures 3.2.3-1 and 3.2.3-2 below.

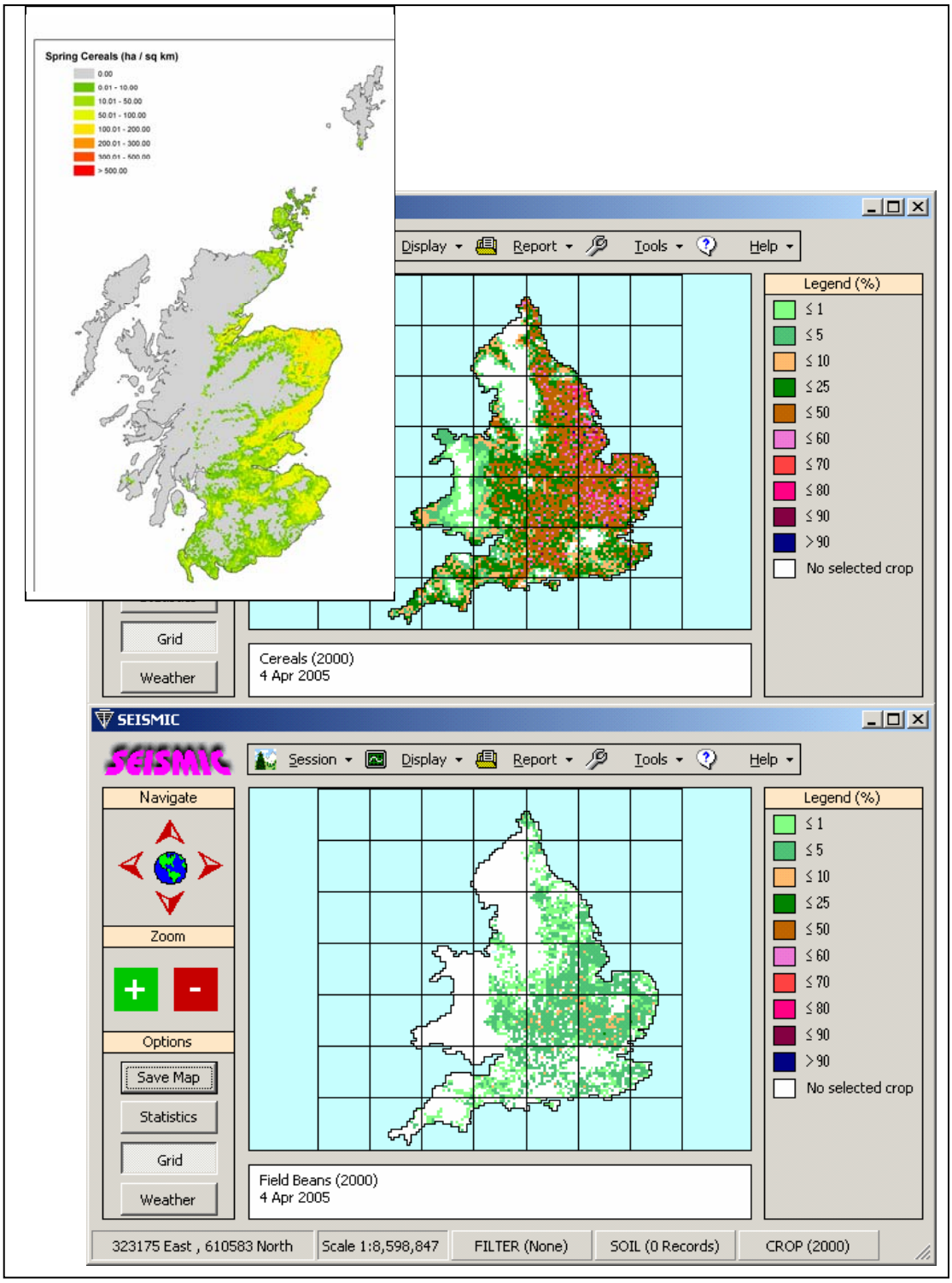


Figure 3.2.3.1 Examples of 'ubiquitous' crops in Great Britain

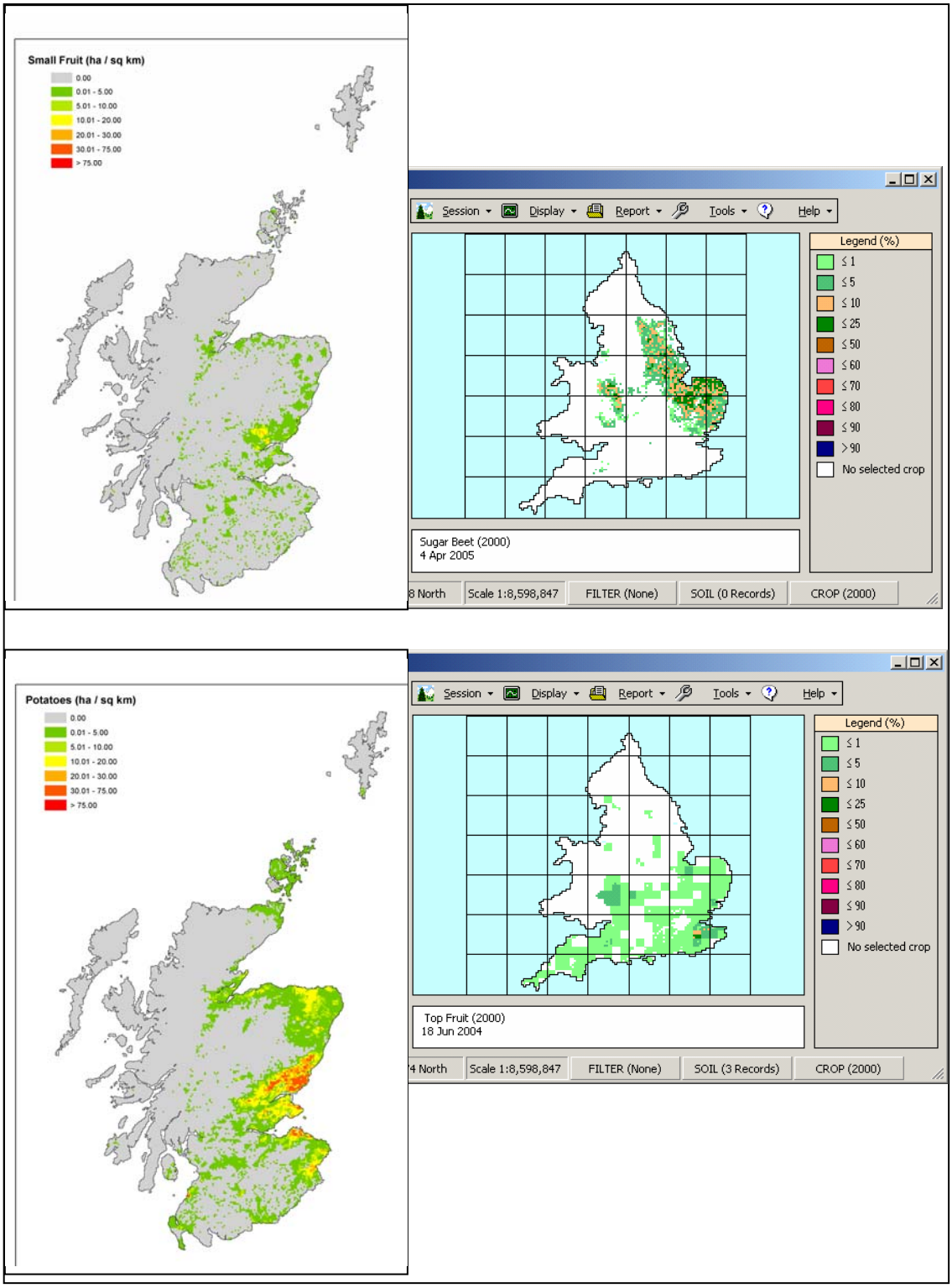


Figure 3.2.3.2 Examples of 'localised' crops in Great Britain

4. Agricultural areas not represented by FOCUS surface water scenarios.

When identifying the significance of agricultural areas of Great Britain that are not represented by the FOCUS surface water scenarios, it is important to be able to quantify both the amount of land that is directly correlated with a relevant scenario, the amount of land that has significantly less drainage or run-off risk (because of less challenging soil or climate characteristics) and the amount of land that has significantly greater drainage or run-off risk (because of more challenging soil or climate characteristics). Land that is directly correlated with a specific scenario or that has significantly less drainage or run-off risk can be said to be 'covered' by risk assessments for that specific scenario.

4.1 Identifying agricultural land subject to significant field drainage and to significant surface run-off.

The FOCUS surface water scenarios are designed to support the calculation of PEC's resulting from agriculturally applied pesticides. Edge-of-field surface water bodies receive inputs *via* spray drift and either surface run-off or field drainage. In order to assess and quantify the agricultural areas of Great Britain that are not represented by the FOCUS scenarios it is first necessary to separate the land into agricultural areas where field drainage is the dominant input (apart from spray drift) and areas where surface run-off is dominant.

Using SEISMIC, the Hydrology Of Soil Types (HOST) classification system (Boorman *et al*, 1995) was used to identify four groups of soil series:

1. All soil series where field drainage to edge-of-field surface water bodies occurs.
2. All soil series where surface run-off to edge-of-field water bodies is likely to occur.
3. All soil series where field drainage or surface run-off are insignificant (because they are free-draining soils on level ground).
4. All soil series that are not normally under a managed agricultural land use.

The HOST classes used to identify each group are listed in Table 4.1-1.

Table 4.1-1 HOST classes used to identify the four soil series groupings for identifying drainage and surface run-off land.

Soil Series Group	HOST Classes included
Soils subject to field drainage	9, 10, 11, 14, 18, 20, 21, 23, 24, 25
Soils subject to surface run-off	1, 2, 3, 4, 5, 6, 13, 16, 17, 18, 19, 20, 21, 22, 23
Soils with no drainage or run-off	7, 8
Non-agricultural soils	12, 15, 26, 27, 29

It should be noted that soils subject to field drainage and soils subject to run-off are NOT mutually exclusive, they overlap. Thus soils in HOST classes 18, 20, 21 and 23 are subject to both field drainage and run-off. Such soils are formed in slowly permeable or impermeable materials that impede the downward percolation of excess water and cause intermittent perched water tables. However, they are also formed on slopes that are steep enough to allow significant excess water to be removed *via* surface run-off or lateral through-flow and thus only suffer intermittent

waterlogging. Field drainage is installed to minimise the effect of this waterlogging. Soils in HOST classes 14, 24 and 25 are also formed in slowly permeable or impermeable materials, often on slightly sloping ground. However, such soils suffer prolonged seasonal wetness because the slopes are not steep enough to redistribute significant amounts of excess water *via* run-off or lateral through flow. Pesticide losses from soils in these HOST classes are thus principally *via* field drains and losses *via* surface run-off are minimal.

Areas subject to field drainage and surface run-off are shown in Figure 4.1-1.

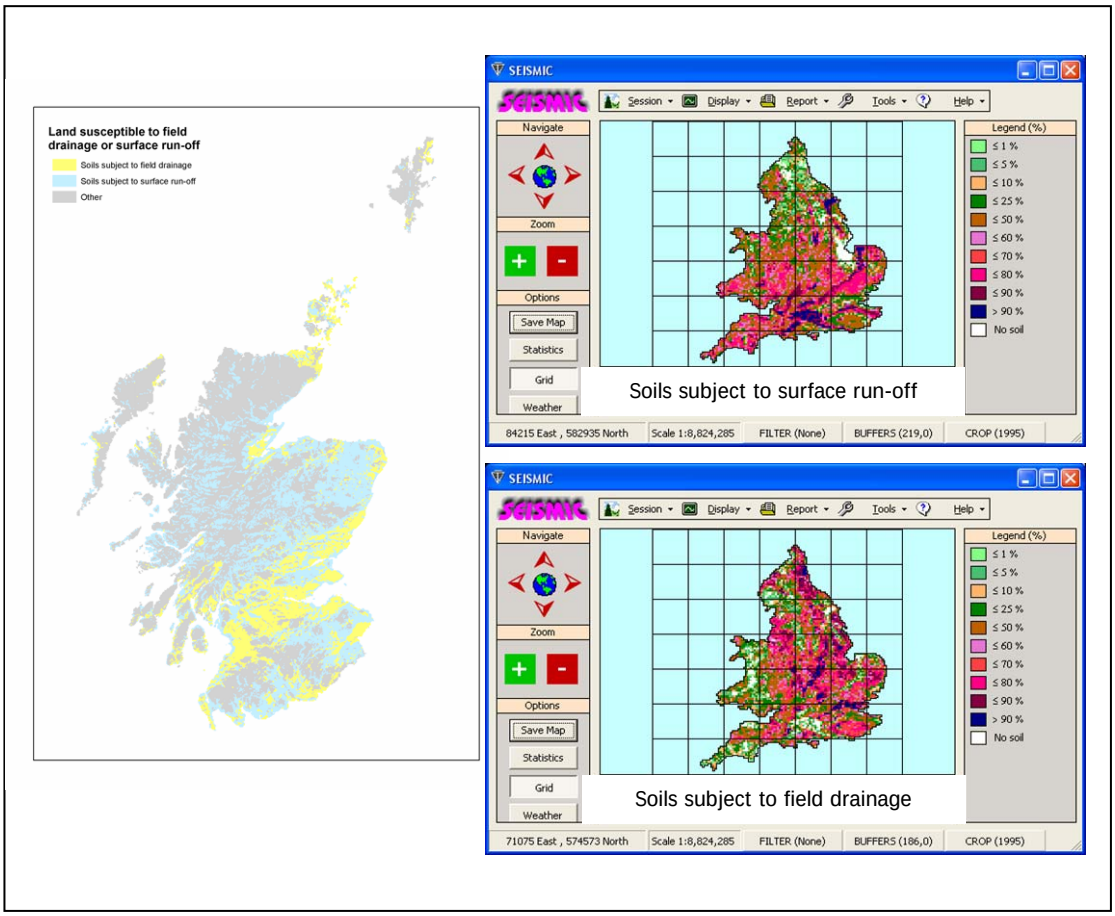


Figure 4.1.1 Land areas subject to pesticide losses *via* field drainage or surface run-off

The soil and crop databases described in section 3 were then used to map and quantify the amount of land under each crop grown in Great Britain that is subject to either field drainage or surface run-off. As with other mapping and quantification, SEISMIC v. 2.0 was used for England & Wales whereas the Arc-Esri Geographical Information System software was used for Scotland. The results are given in Table 4.1-2.

Table 4.1-2 Cropped land in Great Britain subject to field drainage or surface run-off.

Crop	Total crop area (ha)	Total drained area (ha)	As a % of total crop	Total run-off area (ha)	As a % of total crop
Grass (managed)	5631045	2293012	41	2765325	49
Winter Cereals	3285022	1744096	53	1578338	48
Spring Cereals	1525975	621120	41	896020	59
OSR	534072	280176	52	266949	50
Field Beans	122484	70306	57	60317	49
Sugar Beet	170066	83904	49	72490	43
Potatoes	235926	119008	50	53351	23
Legumes	134746	69069	51	58887	44
Maize	94772	48113	51	47870	51
Vegetables	119909	37686	31	44230	37
Top Fruit	24407	12080	49	11731	48
Hops	4036	2217	55	1935	48
Small Fruit	14755	7339	50	7352	50
Flowers & bulbs	7249	3619	50	2497	34

The data show that, for most crops, land subject to pesticide losses *via* field drainage and that subject to losses *via* surface run-off is fairly evenly divided. The exceptions are spring cereals, where significantly more land is subject to run-off losses than is subject to drainage losses and potatoes and flowers & bulbs, where the reverse is the case.

4.2 Quantifying areas of drained and run-off land not 'covered' by the FOCUS scenarios.

In Table 3.2.3-1, the amount of land under each crop in Great Britain that has the same pedo-climatic characteristics as each directly relevant FOCUS scenario is quantified. The data suggest that, apart from hops, over 70 % of land under each crop in Great Britain is not directly correlated with a FOCUS surface water pedo-climatic scenario. In order to identify how much of this land may be 'covered' by risk assessments based on the directly relevant FOCUS scenarios it is necessary to identify what proportion has a lesser risk of pesticide losses from field drains or surface run-off and what has a greater risk. To do this it is first necessary to separate the soil and climatic components that determine the risk of pesticides moving to surface water.

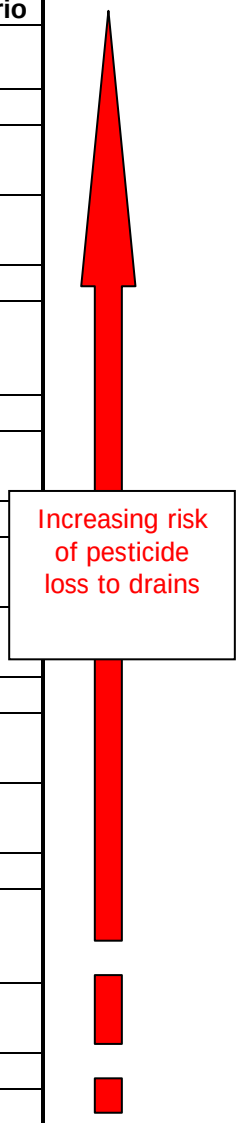
4.2.1 Soil characteristics

The principal soil characteristic that determines the risk of pesticide leaching to surface water bodies in drained land is its overall textural / structural relationship. This determines the extent of by-pass flow to drains, which is critical for pesticide losses in the first few drainage events following application.

Table 4.2.1-1 gives a ranking of soil characteristics in terms of pesticide loss risk and identifies which of these soil characteristics is represented by the FOCUS soil scenarios.

Table 4.2.1.1 Soil characteristics, pesticide drainage risk and FOCUS soil scenarios.

Wetness Class	Texture/structure	Parent material	Rank	FOCUS Scenario
Seasonally wet (classes 4 & 5)	Clay topsoil	Impermeable clay or hard rock	1	D2
	Clay topsoil	Slowly permeable	2	D1
	Medium loamy or silty topsoil	Impermeable clay or hard rock	3	
	Medium loamy or silty topsoil	Slowly permeable	4	D5
	Clay throughout	Permeable material	5	
	Coarsely structured medium loamy or silty throughout	Permeable material	6	D6
Classes 2 to 5	Sandy	Any	7	D3
Seasonally wet (classes 4 & 5)	Light loamy or silty topsoil	Impermeable clay or hard rock	8	
	Light loamy or silty topsoil	Slowly permeable	9	
	Well structure loamy or silty throughout	Permeable material	10	
Slight seasonal wetness (classes 2 & 3)	Clay topsoil	Impermeable clay or hard rock	11	
	Clay topsoil	Slowly permeable	12	
	Medium loamy or silty topsoil	Impermeable clay or hard rock	13	
	Medium loamy or silty topsoil	Slowly permeable	14	
	Clay throughout	Permeable material	15	
	Coarsely structured medium loamy or silty throughout	Permeable material	16	
	Light loamy or silty topsoil	Impermeable clay or hard rock	17	
	Light loamy or silty topsoil	Slowly permeable	18	D4
	Well structure loamy or silty throughout	Permeable material	19	

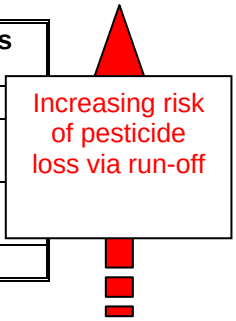


From this table it can be seen that the soil characteristics of scenarios D2 and D1 represent the highest risk of pesticide loss *via* drainage, whereas those of D5 also represent a high risk. **With respect to soil characteristics therefore there are no potential drainage scenarios that have a greater risk of pesticide loss *via* drains than D2 and only the D2 soil scenario is at greater risk than D1.**

The principal soil characteristics that determine pesticide losses *via* surface run-off relate to the soil hydrologic group that determines the run-off curve number used in the PRZM model (see Table 3.2-5 of the FOCUS report. FOCUS, 2001). There are four hydrologic groups and Table 4.2.1-2 describes their characteristics and identifies which are represented by the FOCUS soil scenarios.

Table 4.2.1.2 Soil characteristics, pesticide run-off risk and FOCUS soil scenarios.

Soil hydrologic group characteristics (according to Carsel *et al*, 1995)	**Rank**	**FOCUS scenarios**
Group D (Heavy clay soils)	1	
Group C (Silty or medium loamy soils with low organic matter content)	2	R1, R3 & R4
Group B (Light loamy soils with moderate clay and organic matter content)	3	R2
Group A (Sandy or very permeable soils)	4	



From this table it can be seen that no FOCUS soil scenarios are characterised by soil hydrologic group D, the group most at risk of pesticide loss *via* run-off. However, in Great Britain soils of hydrologic group D are always subject to field drainage because of their wetness and 'heavy' topsoil texture and they are also on more gently sloping land than many soils corresponding to those of the R1, R3 or R4 scenarios (see section 4.1). It is assumed that the principal risk to surface water in soil hydrologic group D is from drainage inputs because much of their surface run-off is intercepted by soil fissures and channelled through drains. Soils qualifying for hydrologic group D are therefore not included in the broad category of 'run-off soils' and, **in Great Britain, soils of hydrologic group C, directly correlated with the soils of FOCUS scenarios R1, R3 & R4, are the most vulnerable to run-off losses.**

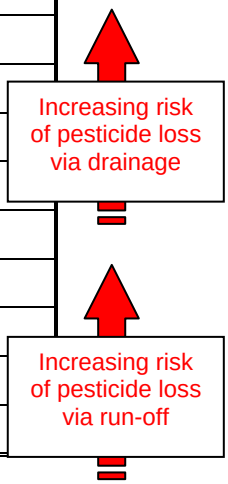
4.3.2 Climate characteristics

Each of the FOCUS surface water scenarios has a defined range of mean daily spring and autumn temperature and either annual average rainfall, for run-off scenarios, or average annual recharge (characterised here as Excess Winter rainfall), for drainage scenarios. These have been used in section 3 of this report to identify and map the scenarios that are relevant to UK agriculture. However, each parameterised scenario has a daily weather dataset associated with it and this drives the MACRO, PRZM and TOXSWA models that are used to calculate surface water PEC's. In Great Britain, rainfall is the main variable that differentiates the risk of pesticide losses *via* drainage or run-off. Temperature affects the rate of degradation, but only relative to the compound-specific rate measured at a standard temperature. In Great Britain the range of temperature in agricultural areas is relatively narrow, compared with Europe as a whole and most of British agriculture falls within only one of the mean daily spring and autumn ranges (6.6 – 10 ^{o}C) defined for the FOCUS scenarios (see Figures 3.2.1-1 & 3.2.1-2). With respect to temperature therefore, only the temperature range associated with scenario D1 represents a slightly greater risk for pesticide losses than does that of scenarios D2, D3, D4 and R1, whereas the temperature ranges for scenarios D5, D6, R2, R3 and R4, all represent a lesser risk. **For the current climatic assessment therefore differences in temperature have not been included**.

Rainfall and excess winter rain across agricultural areas of Great Britain are much more variable and in order to rank areas of the UK that are at greater or lesser risk of drainage from excess winter rainfall or rainfall induced run-off, ranges defined for the FOCUS scenarios have been used. These rankings are shown in Table 4.2.2-1.

Table 4.2.2.1 Climatic characteristics, risk of pesticide losses and FOCUS scenarios

Range of Excess Winter Rain (mm)	**Rank**	**FOCUS Scenario**
> 300	1	
201 – 300	2	D2, D3, D6
100 – 200	3	D1, D4, D5
<100	4	
Range of Average Annual Rainfall (mm)	**Rank**	**FOCUS Scenario**
>1000	1	R2
801 – 1000	2	R3
600 – 800	3	R1, R4
<600	4	



4.2.3 Combining the soil and climatic characteristics

By combining the relative rankings of risk related to soil and climatic characteristics, it is possible to identify and quantify the amount of land under each crop in Great Britain that is 'covered' by each of the directly relevant scenarios. This was done using the climate, soil and crop databases described in section 3.1 and, as with other quantification carried out for this project, intersection of the data were carried out using SEISMIC v. 2.0 for England & Wales and the Arc-Esri Geographical Information System software for Scotland. The results are given in Tables 4.2.3-1 & 4.2.3-2. These tables show, for each crop, each of the directly relevant FOCUS scenarios, the % of either drained or run-off land that will be 'covered' by risk assessments using that scenario and the percentage of land that is at greater risk, either because the soil properties give a greater leaching or run-off risk (irrespective of the climate) or because the soil properties are the same but the climate is wetter.

By combining the information from Tables 4.2.3-1 & 4.2.3-2, the total amount of land under each crop that is covered by risk assessments using the combined relevant scenarios can be calculated. This assessment is given in Table 4.2.3-3 and shows that, whereas risk assessments based on the directly relevant FOCUS scenarios for winter cereals, winter oilseed rape and field beans will cover at least 95 % of the land under each crop, other crops are less well covered. In particular, there are no relevant scenarios for either small fruit or flowers & bulbs, whilst two thirds of the land under both sugar beet and spring cereals and half the land under grass would not be covered by risk assessments using the relevant FOCUS scenarios.

Table 4.2.3-1 Crops grown in Great Britain and the percentage of drained land 'covered' by each directly relevant scenario

Crop	Total crop area (ha)	Area drained (ha)	Directly Relevant scenarios	% drained land 'covered' by scenario	% at risk from greater soil leaching	% at risk from wetter climate only
Grass (managed)	5631045	2293012	D2, D3, D4	99 42 4	0 57.4 95.4	1.0 0.4 0.2
Winter Cereals	3285022	1744096	D2, D3, D4	99.5 49 11	0 51.1 88.1	0.5 0.1 0.6
Spring Cereals	1525975	621120	D2, D3, D4	99.8 72 50	0 28.0 49.8	0.2 0.2 0.1
Winter OSR	380996	214713	D2, D3, D4	99.4 50 1.3	0 50.0 98.5	0.6 0.2 0.2
Spring OSR	153076	66512	D3, D4	65 0.9	34.5 99.0	0.1 0.1
Field Beans	122484	70306	D2, D3, D4	99.2 45 3	0 54.6 96.3	0.8 0.1 0.3
Sugar Beet	170066	83904	D3	56	43.7	0.1
Potatoes	235926	119008	D3, D4	68 55	31.2 44.8	0.4 0.2
Legumes	134746	69069	D3, D4	58 19	42.3 80.5	0.1 0.1
Maize	94772	48113	D3, D4	41 8	58.6 91.7	0.4 0.4
Vegetables	119909	37686	D3, D4	32 19	66.2 80.9	2.1 0.1
Top Fruit	24407	12080	D4	56	43.0	0.6
Hops	4036	2217	None	No scenario	No scenario	No scenario
Small Fruit	14755	7339	None	No scenario	No scenario	No scenario
Flowers & bulbs	7249	3619	None	No scenario	No scenario	No scenario

Table 4.2.3-2 Crops grown in Great Britain and the percentage of run-off land 'covered' by each directly relevant scenario

Crop	Total crop area (ha)	Area subject to run-off (ha)	Directly Relevant scenarios	% run-off land 'covered' by scenario	% at risk from greater soil run-off	% at risk from wetter climate only
Grass (managed)	5631045	2765325	None	No scenario	No scenario	No scenario
Winter Cereals	3285022	1578338	R1	91	0.8	8.2
Spring Cereals	1525975	896020	None	No scenario	No scenario	No scenario
Winter OSR	380996	170720	R1	95	None	5.4
Spring OSR	153076	87326	R1	94	None	5.6
Field Beans	122484	60317	R1	91	0.7	8.0
Sugar Beet	170066	72490	None	No scenario	No scenario	No scenario
Potatoes	235926	53351	R1	90	0.9	9.4
Legumes	134746	58887	R1	88	0.6	11.5
Maize	94772	47870	R1	71	4.4	24.7
Vegetables	119909	44230	R1	96	0.5	3.7
Top Fruit	24407	11731	R1	88	1.1	11.4
Hops	4036	1935	R1	93	0.0	7.4
Small Fruit	14755	7352	None	No scenario	No scenario	No scenario
Flowers & bulbs	7249	2497	None	No scenario	No scenario	No scenario

Table 4.2.3-3 Percentage area of individual crops grown in Great Britain that is covered by risk assessments using directly relevant FOCUS scenarios

Crop	**Total crop area (ha)**	**Directly relevant scenarios**	**Percentage of total crop area 'covered' by these scenarios**
Grass (managed)	5631045	D2, D3, D4	50
Winter Cereals	3285022	D2, D3, D4, R1	95
Spring Cereals	1525975	D3, D4	30
Winter OSR	380996	D2, D3, D4, R1	97
Spring OSR	153076	D3, D4, R1	82
Field Beans	122484	D2, D3, D4, R1	95
Sugar Beet	170066	D3	36
Potatoes	235926	D3, D4, R1	82
Legumes	134746	D3, D4, R1	73
Maize	94772	D3, D4, R1	55
Vegetables	119909	D3, D4, R1	77
Top Fruit	24407	D4, R1	72
Hops	4036	R1	70
Small Fruit	14755	None	0
Flowers & bulbs	7249	None	0

5.0 The Relevance of the FOCUS Surface Water Scenarios to the UK Landscape and its Water Bodies

5.1 Background

The UK's aquatic ecosystems project (PN0931, 2003) identified 13 distinct landscapes in England, Scotland and Wales. The classification was based predominantly upon soil parent material and soil hydrology. Twelve of the landscapes were defined as being agricultural, and captured differences in hydrogeology, soils, topography and cropping. The thirteenth landscape was classified as being non-agricultural, and comprised all areas that are unlikely to receive significant agricultural inputs of pesticide (Figure 5.1.1 and Table 5.1.1). Definitions of the water bodies present in the landscapes were developed and these included, rivers, lakes, ponds, streams and ditches (see Table 5.1.2). Lakes and rivers have not been included in this summary as they are not considered to be of primary concern.

Essentially, the project addressed two main areas, biological and physico-chemical aspects of aquatic ecosystems within the UK. In addition, it tried to put into context where these water bodies were located and what the land in the near vicinity was used for, it drew all the data together into an Access® database.

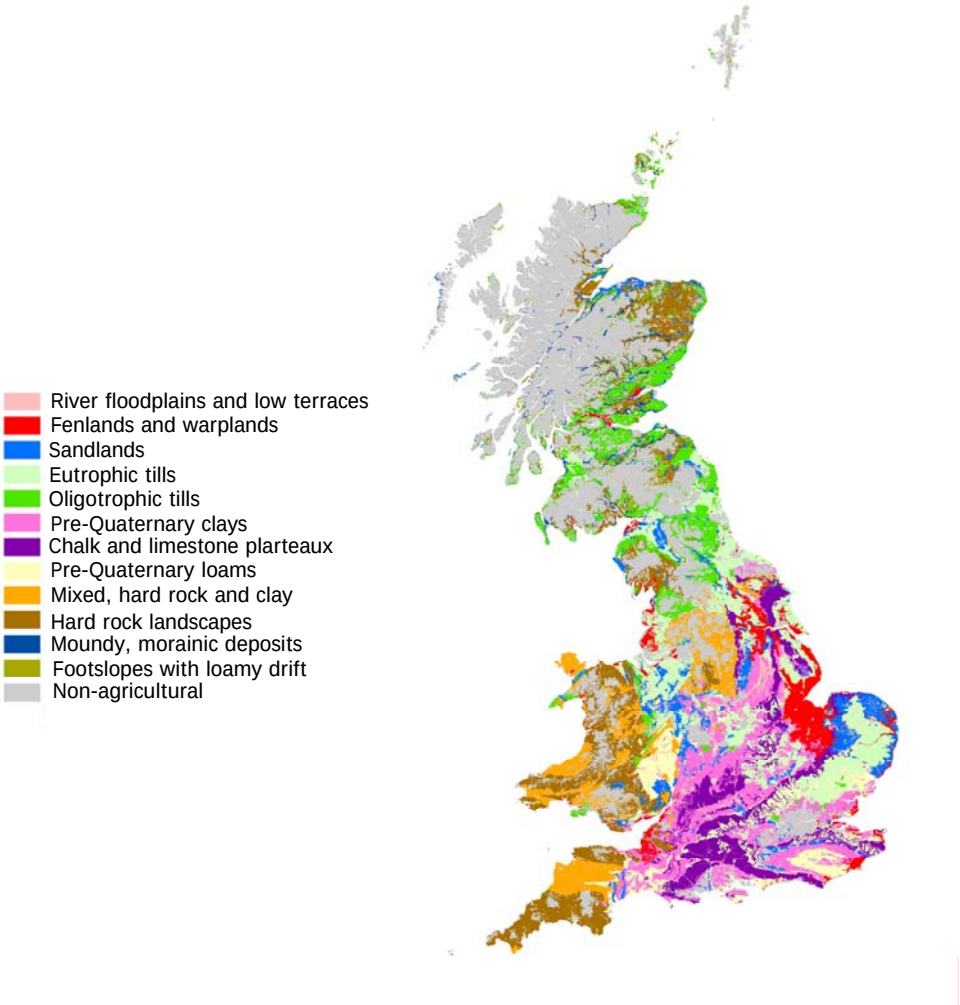


Figure 5.1.1 Distribution of landscape classes in England, Scotland and Wales

Table 5.1.1 Summary of the landscape classes derived for England, Scotland and Wales

No.	Landscape	*Description*	Total area (km^2)	Crops (minor crops in parentheses)
1	River floodplains and low terraces	Level to very gently sloping river floodplains and low terraces	7,781	Permanent grass, some cereals and oil-seed rape, probably more intensive on terraces
2	Warplands, fenlands and associated low terraces	Level, broad 'flats' with alluvial very fine sands, silts, clays and peats	9,017	Cereals (oil-seed rape, beans), sugar beet, potatoes, peas, vegetables, top fruit
3	Sandlands	Level to moderately sloping, rolling hills and broad terraces. Sands and light loams	10,871	Cereals (oil-seed rape, beans and peas), sugar beet, potatoes (peas in East Anglia)
4	Till landscapes	Level to gently sloping glacial till plains. Medium loams, clays and chalky clays, with high base status (eutrophic). Some lighter textured soils on outwash	22,151	Cereals, oil-seed rape and beans (peas in E. Yorks.), permanent and rotational grass (mainly in west)
5	Till landscapes	Level to gently sloping glacial till plains. Medium loams and clays with low base status (oligotrophic). Some lighter textured soils on outwash	15,449	Permanent and rotational grass with some cereals and oil-seed rape
6	Pre-quaternary clay landscapes	Level to gently sloping vales. Slowly permeable, clays (often calcareous) and heavy loams. High base status (Eutrophic)	19,706	Permanent grass, cereals (>10-15%), leys, oil-seed rape, maize (not in NE or Weald) and beans
7	Chalk and limestone plateaux and coombe valleys	Rolling 'Wolds' & plateaux with 'dry' valleys; shallow to moderately deep loams over chalk & limestone	14,197	Cereals (and oil-seed rape, beans), sugar beet, potatoes, peas
8	Pre-quaternary loam landscapes	Gently to moderately sloping ridges, vales and plateaux. Deep, free-draining & moderately permeable silts & loams	10,072	Permanent & rotational grass, cereals and oil-seed rape with some beans, grass, hops and fruit
9	Mixed, hard, fissured rock and clay landscapes	Gently to moderately sloping hills, ridges and vales. Moderately deep free draining loams mixed with heavy loams and clays in vales	12,259	Permanent grass, rotational grass and some cereals (<10-15%)
10	Hard rock landscapes	Gently to moderately sloping hills and valleys. Moderately deep free draining loams over hard rocks. Some slowly permeable heavy loams on lower slopes and valleys	23,342	Permanent grass, rotational grass and some cereals (<10-15%)
11	Moundy morainic and fluvioglacial deposits	Gently and moderately sloping mounds, some terraces. Free draining morains, gravels & sands on mounds, poorly draining gleys in hollows	2,270	Permanent and rotational grass, some cereals
12	Footslopes with loamy drift	Concave slopes or depressional sites often with springlines	1,081	Permanent and rotational grass
13	Non-agricultural	All areas not cultivated with arable (including orchards, soft fruit and horticultural) or maintained grassland	79,690	No crops
Total	-	-	227,886	-

Table 5.1.2 Definitions aquatic habitats used in the study

Waterbody	Definition
Ponds	Waterbodies between 25 m^2 and 2 ha in area which may be permanent or seasonal (Collinson *et al.* 1995). Includes both man-made and natural waterbodies.
Ditches	Man-made channels created primarily for agricultural purposes, and which usually: (i) have a linear planform; (ii) follow linear field boundaries, often turning at right angles; and (iii) show little relationship with natural landscape contours.
Streams	Small lotic waterbodies created mainly by natural processes. Marked as a single blue line on 1:25,000 Ordnance Survey (OS) maps and defined by the OS as being less than 8.25 m in width. Stream differ from ditches by: (i) usually having a sinuous planform; (ii) not following field boundaries, or if they do, pre-dating boundary creation; and (iii) showing a relationship with natural landscape contours e.g. running down valleys.

5.1.1 The Physico-Chemical Characteristics and the Morphology of the Aquatic Habitats

National datasets were obtained from Environment Agency and DEFRA monitoring programmes and from surveys of rivers, streams and ponds. There was little information available for ditches; ditches were poorly represented for all landscape classes except fens and river valleys. Table 5.1.1.1 gives the total number of data points available by landscape class.

Table 5.1.1.1 Number sites from which data on physico-chemical and morphological properties of water bodies were available in the 13 landscapes (parentheses indicate that the water body is rarely found in that landscape)

No.	Landscape	Rivers	Streams	Ponds	Ditches
1	River floodplains and low terraces	2457	153	28	259
2	Warplands, fenlands and associated low terraces	679	98	11	1259
3	Sandlands	415	77	17	(5)
4	Till landscapes	642	241	32	30
5	Till landscapes	232	85	6	10
6	Pre-quaternary clay landscapes	7738	348	55	11
7	Chalk and limestone plateaux and coombe valleys	307	96	(20)	(-)
8	Pre-quaternary loam landscapes	421	319	22	9
9	Mixed, hard, fissured rock and clay landscapes	508	109	16	(-)
10	Hard rock landscapes	818	204	(14)	(-)
13	Non-agricultural	1123	432	57	8

Note: Landscape classes 11 and 12 were not analysed because too few data were available.

5.1.2 Biological Characteristics

The available national biological datasets were analysed for five waterbody types (streams, rivers, ponds, lakes and ditches), and two biotic groups: (i) macroinvertebrates; and (ii) macrophytes, including submerged aquatic, floating-leaved and emergent plants.

For both invertebrates and plants, moderately comprehensive datasets were available for streams, ponds and, to a lesser extent, rivers. For lakes, data were available for macrophytes but not for invertebrates. Ditch data were particularly poorly represented and reliable descriptions of assemblages was possible for only 5 of the 13 landscape types.

5.1.3 Database

The Access® database (taken from Defra project PN0931) provides summary statistics for the morphological features of the defined water body types by landscape class. This includes data on channel width, water body area, depth, flow characteristics, bank angle, substrate depth and composition. Also included are bank-side features such as distance from the bank top to an arable crop, abundance of aquatic vegetation, bank scrub and tree density and adjacent land use. Up to 15 chemical parameters are represented in the database, including pH, conductivity, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), suspended solids and nutrients. Datasets were filtered to exclude monitoring sites potentially impacted from urban or industrial situations. Although the chemical determinands reported give an indication of the range of values for water quality indicators across the landscape classes (rivers, streams and ponds) it should be recognised that the dataset is limited. Caution should be used when attempting, for example, alignment of physico-chemical properties with the biological data described above.

5.1.4 Distribution of Water Bodies

The mean density of rivers, streams, ponds and ditches were calculated for landscape classes 1-10 (see PN0931). Waterbody length/density estimates were not made for non-agricultural areas (13), or for landscapes 11 and 12, which occupy a small proportion of the landscape and are relatively non-agricultural in use. The results of this analysis are summarised in Figure 5.1.4.1.

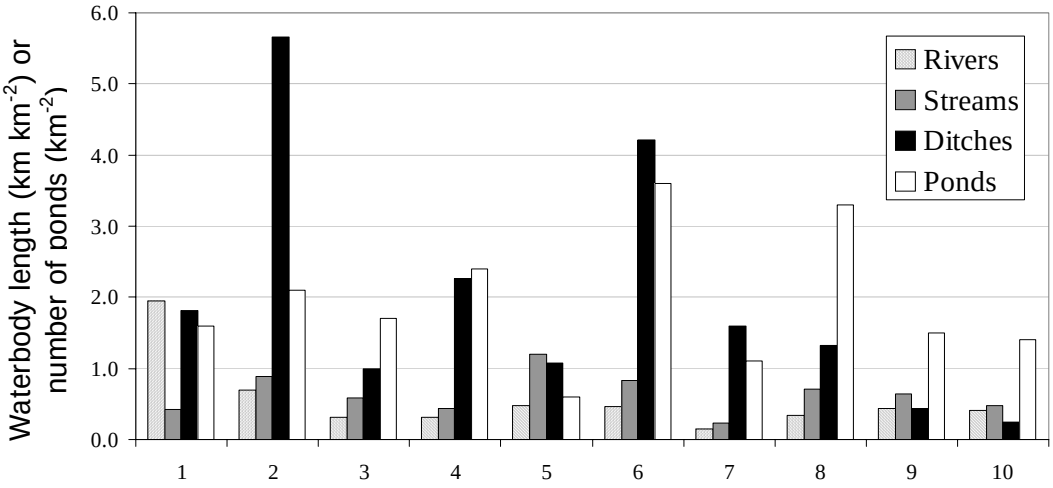


Figure 5.1.4.1 Density of waterbodies in agricultural landscape classes

Figure 5.1.4.1 demonstrates that all water bodies are found in all landscape classes. It indicates that rivers are most frequent in Landscape 2 and least frequent in Landscape 7. Ponds are most numerous in landscape 6 and 8 and least numerous in landscape 5. Ditches are most frequent in landscape 2 and 6 and least frequent in landscape 10. Lastly, streams are more abundant in landscape 5 and least abundant

in landscape 7.

5.2 Comparison of Landscapes in the UK that Represent the FOCUS Scenarios

5.2.1 Aquatic Landscapes Associated with FOCUS SW Scenario D2

Agricultural landscape class 6 dominates the soil/climate match (ca. 89%) and represents pre-quaternary clay landscapes with level to gently sloping vales (Table 5.2.1.1). The soils are clays (often calcareous) and heavy loams (typically slowly permeable) and the landscape class is characterised by all forms of water bodies (ditches, rivers, streams and ponds). All other scenarios individually represent <5% of the land that is represented by scenario D2 and are not considered further.

Table 5.2.1.1 Landscapes that represent FOCUS Scenario D2

Landscape	Rank	Proportion of area (%)	Water bodies
1	7	0.04	All
2	11	0.00	no streams or ponds
3	10	0.00	Rivers, ponds and streams
4	6	0.24	All
5	8	0.01	All
6[a]	1	89.08	All
7	3	2.59	Rivers + streams
8	4	1.91	All
9	5	0.33	no ditches
10	12	0.00	streams + rivers
13[b]	2	5.80	
14	9	0.00	
Grand Total		**100.00**	

[a]: Major relevance (>80%); [b]: Non-agricultural

FOCUS scenario D2 is characterised by field ditches and first order streams. The ditch morphological characteristics for landscape class 6 are given in Table 5.2.1.2. The characteristics that allow for a comparison to be made between the ditches present in the UK landscape and the assumptions made in FOCUS SW are water body depth, flow rate, and distance to crop. Figures 5.2.1.1 to 5.2.1.2 show that the assumptions made in FOCUS SW do, generally, represent the ditch scenarios in the UK landscape, e.g. distance to crop. However, there is a lack of information on these relatively small water systems to make firm/conclusive comparisons. An exception is found in Landscape 6 where FOCUS assumptions regarding flow rate are not typical. The flow rate of the ditch in FOCUS scenario D2 is between 5×10^{-6} to 0.0018 m/s, the mean flow rates associated to ditches in landscape 6 is ca. 0.2 m/s. Ditch width is reported in terms of width ranges and has therefore been reported in the form of a pie chart (Figure 5.2.1.3).

Table 5.2.1.2 Ditch properties for relevant scenarios

Landscape Class	Mean	Median	SD	Min	Max	Number of Samples	Std Error
Flow Rate (m/s): (FOCUS default = 5 x 10^{-6} to 0.0018 m/s)							
6	0.692	1	0.452	0	1	18	0.11
Water Depth (cm): (FOCUS default = 30 to 35 cm)							
6	0.432	0.233	0.463	0.023	2	29	0.09

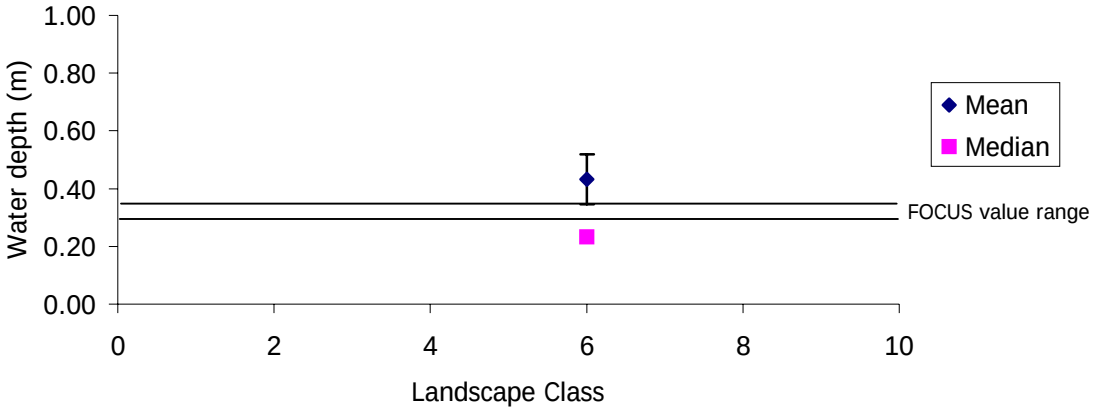


Figure 5.2.1.1 D2 Ditch Scenario (Water Depth)

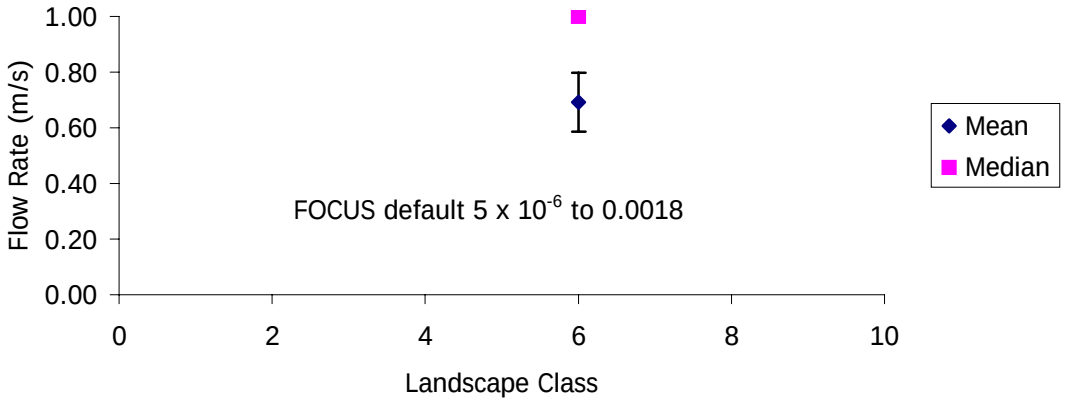


Figure 5.2.1.2 D2 Ditch Scenario Ditch (Flow Rate)

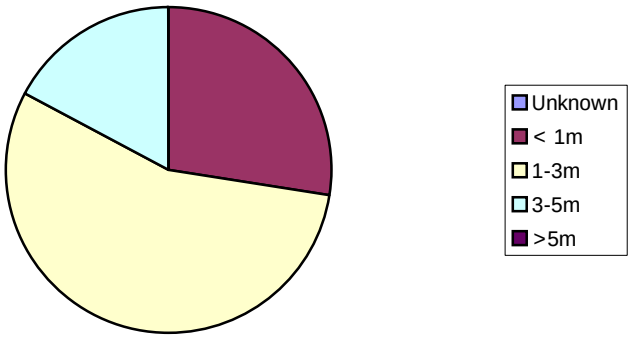


Figure 5.2.1.3 Ditch width data for Landscape Class 6

The stream morphological characteristics for landscape classes 6 are given in Table 5.2.1.3. The streams characteristics recorded in the aquatic landscape database that allow for a comparison to be made are water width and water depth (Figure 5.2.1.4 and 5.2.1.5, respectively). In addition, it was possible to calculate water volume assuming a 100 m running length of water (Figure 5.2.1.6). The stream water depth in landscape class 6 shallower (ca. 15 cm depth) than the FOCUS default (30 to 50 cm). The streams in landscape class 6 were wider (>2 m) than the FOCUS default value (1 m). However, when depth and width were considered together the average volume (assuming a 100 m segment) of the streams in landscape class 6 was similar to the FOCUS default.

Table 5.2.1.3 Stream characteristics for relevant Landscape Classes

Landscape Class	Mean	Median	SD	Min	Max	Number of Samples	Std Error
Water Depth (cm): (FOCUS default = 30 to 140 cm)							
6	0.13	0.1	0.17	0	2	302	0.01
Water Width (m): (FOCUS default = 1 m)							
6	2.25	2	1.55	0.1	13.5	813	0.05
Water Volume (m^3): (FOCUS default = 30 to 140 m^3)							
6	29.25	Estimated assuming 100 m segment					

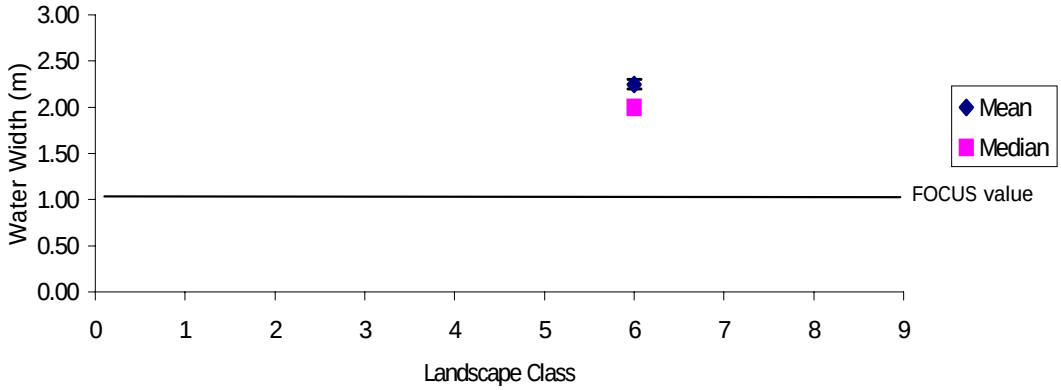


Figure 5.2.1.4 D2 Stream Sceanrio (Water Width)

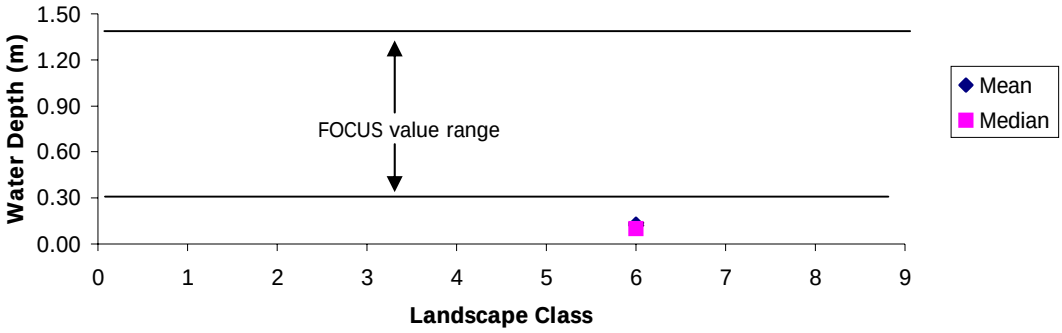


Figure 5.2.1.5 D2 Stream Sceanrio (Water Depth)

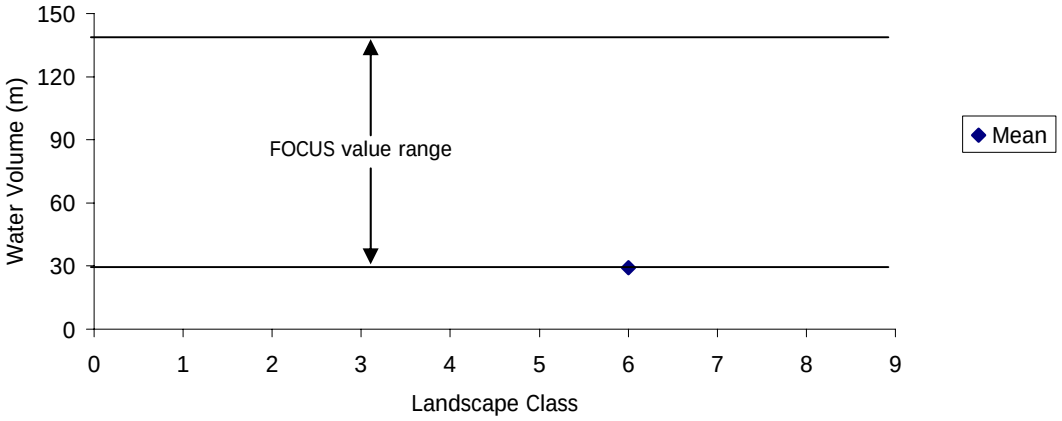


Figure 5.2.1.6 D2 Stream Sceanrio (Water Volume)

5.2.2 Aquatic Landscapes Associated with FOCUS SW Scenario D3

Four UK aquatic landscape classes, 1 to 4, dominate the soil climate match. Landscapes 1 to 4 have been classified as having major relevance (combined coverage >80% of area; Table 5.2.2.1). Non-agricultural uses represent 9.5 % of the total match. All of the relevant landscapes are characterised by ditches except landscape 3, which represents the Sandlands. The Sandlands are characterised by level to moderately sloping, rolling hills and broad terraces, the soil texture is predominantly sand and light loams.

Table 5.2.2.1 Relevant Landscape Classes for FOCUS Scenario D3

Landscape	Rank	Proportion of area (%)	Water bodies
1[a]	4	11.11	All
2[a]	2	25.87	no streams or ponds
3[a]	1	31.67	Rivers, ponds and streams
4[a]	3	20.27	All
5	7	0.33	All
6	6	1.27	All
7	9	0.00	Rivers + streams
8	11	0.00	All
9	10	0.00	no ditches
13[b]	5	9.48	
14	8	0.00	
Grand Total		**100.00**	

[a]: Major relevance (>80%); [b]: Non-agricultural

FOCUS scenario D3 is characterised by field ditches. The characteristics that allow for a comparison to be made between the ditches actually present in the UK landscape and the assumptions made in FOCUS are water body depth, flow rate and distance to crop (Table 5.2.2.2). Figures 5.2.2.1 to 5.2.2.3 demonstrate that the FOCUS SW ditch actually represent the ditches found in the UK aquatic landscape relatively well. The water depths of ditches in the UK aquatic landscapes are generally deeper than the FOCUS default (0.3 m). The distance to crop is comparable with the FOCUS defaults. The ditch flow rates reported generally exceed the D3 ditch scenario in FOCUS. The flow rate of the D3 ditch scenario in FOCUS SW is between 0.0003 and 0.0017 m/s. The mean flow rates for all relevant landscape classes exceed 0.035 m/s. The ditch width data is summarised in the form of pie charts (Figures 5.2.2.4 to 5.2.2.7).

Table 5.2.2.2 Ditch characteristics for relevant Landscape Classes

Landscape Class	Mean	Median	SD	Min	Max	Number of Samples	Std Error
Water Depth (cm): (FOCUS default = 30 to 31 cm)							
1	0.688	0.7	0.301	0	2	259	0.02
2	0.742	0.8	0.369	0	2	1259	0.01
3	0.18	0.2	0.11	0	0.3	5	0.05
4	0.271	0.193	0.257	0.03	0.8	30	0.05
Distance to crop (m): (FOCUS default = 1 to 3.5 m)							
1	0.3					1	
2	3	2.5	3.7	0	10	10	1.17
3							
4	1.45	0	2.98	0	10	18	0.70
Flow Rate (m/s): (FOCUS default = 0.0003 to 0.0017 m/s)							
1	0.458					1	
2	0.035	0.156	0.202	0	0.556	10	0.06
3							
4	0.083	0.049	0.12	0	0.333	18	0.03

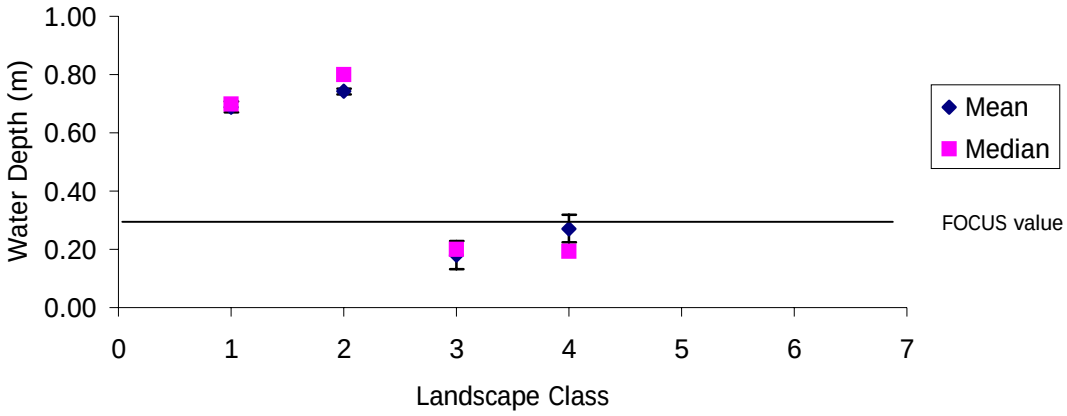


Figure 5.2.2.1 D3 Ditch Scenario (Water body Depth)

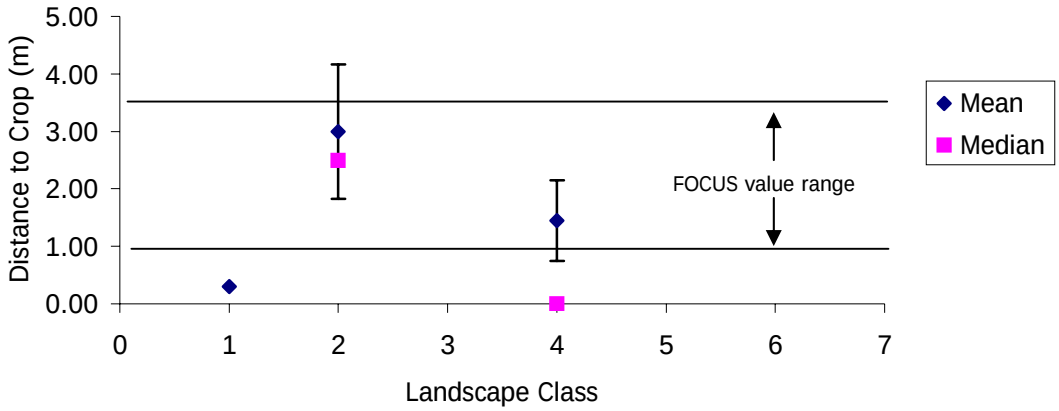


Figure 5.2.2.2 D3 Ditch Scenario (Distance to Crop (m))

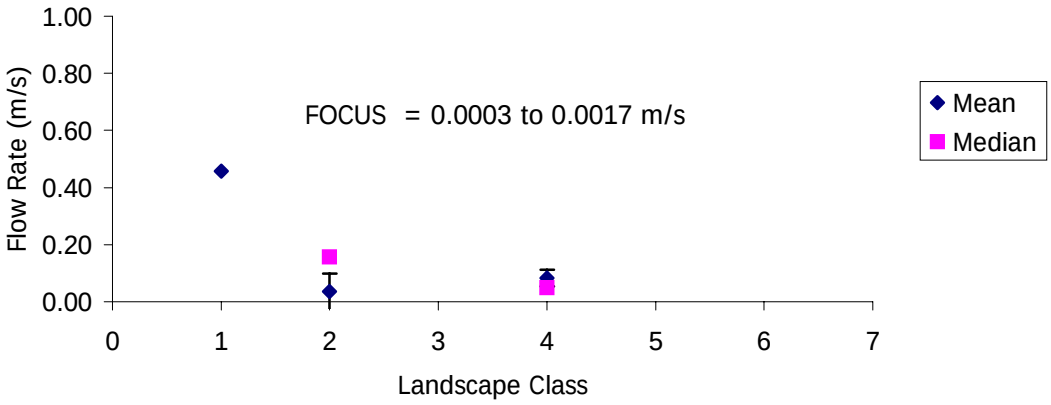


Figure 5.2.2.3 D3 Ditch Scenario (Flow Rate (m/s))

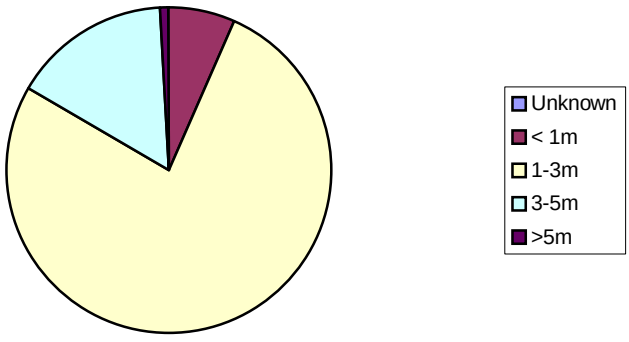


Figure 5.2.2.4 D3 Ditch Scenario Width data for Landscape Class 1

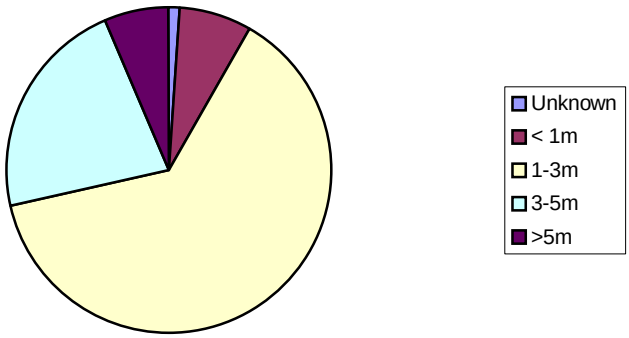


Figure 5.2.2.5 D3 Ditch Scenario Width data for Landscape Class 2

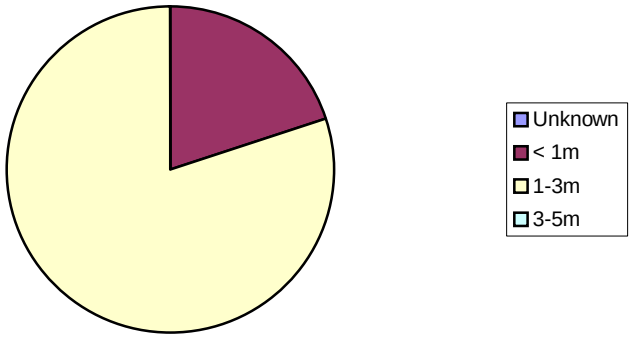


Figure 5.2.2.6 D3 Ditch Scenario Width data for Landscape Class 3

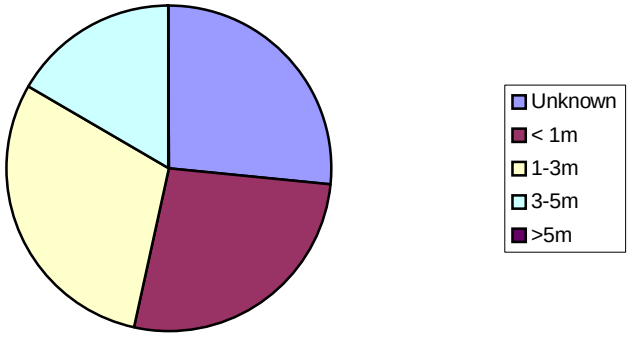


Figure 5.2.2.7 D3 Ditch Scenario Width data for Landscape Class 4

5.2.3 Aquatic Landscapes Associated with FOCUS SW Scenario D4

The Aquatic Landscape Classes that are associated with the FOCUS SW scenario D4 are; 3, 4, 6 and 8 (Table 5.2.3.1). Landscape Class 4 is dominant (ca. 38 %) and represents level to gently sloping glacial tilled plains. The dominant soils are medium loams, clays and chalky clays, with high base status. Landscape 3, which represent the Sandlands, are the next most relevant to FOCUS scenario D4 and are characterised by level to moderately sloping hills and broad terraces. The soils tend to consist of sands and light loams. Together, landscape classes 6 and 8 account for ca. 22 % of the total area of D4 represented in England and Wales. All 4 aquatic landscape classes (3,4,6 and 8) are characterised by the presence of streams and ponds.

Table 5.2.3.1 Relevant Landscape Classes for FOCUS Scenario D4

Landscape	Rank	Proportion of area (%)	Water bodies
1	8	0.00	All
2	9	0.00	no streams or ponds
3[a]	2	27.27	Rivers, ponds and streams
4[a]	1	37.79	All
5	6	4.32	All
6[a]	4	9.21	All
7	7	1.19	Rivers + streams
8[a]	3	12.25	All
9	11	0.00	no ditches
13[b]	5	7.98	
14	10	0.00	
Grand Total		**100.00**	

[a]: Major relevance (>80%); [b]: Non-agricultural

FOCUS scenario D4 is characterised by first order streams and ponds. The stream morphological characteristics for landscape classes 3, 4, 6 and 8 are given in Table 5.2.3.2. The characteristics that allow for a comparison to be made between the streams present in the UK aquatic landscape project and the assumptions made in FOCUS SW are water body depth and water body width (Figures 5.2.3.1 and 5.2.3.2, respectively). In addition, it was possible to calculate water body volume (assuming a 100 m segment of water), see Figure 5.2.3.3. In all cases the stream water depth was less (0.2 m) than the FOCUS minimum (0.30 m). However, the aquatic landscape project suggests that the streams in the UK landscape are wider (>2 m) than the FOCUS D4 stream (1 m). As a consequence, typical volume of UK streams in the UK is similar to that simulated in scenario D4.

Table 5.2.3.2 Stream Characteristics of relevant Landscape Classes

Landscape Class	Mean	Median	Sd	Min	Max	Number of samples	Std error
Water Depth (cm): (FOCUS default = 31 to 60 cm)							
3	0.16	0.1	0.2	0.01	1.5	74	0.02
4	0.22	0.1	1.05	0.01	15	80	0.12
6	0.13	0.1	0.17	0	2	302	0.01
8	0.13	0.05	0.15	0.01	1	275	0.01
Water Width (m): (FOCUS default = 1 m)							
3	2.82	2.3	1.93	0.3	12	212	0.13
4	2.34	2	1.69	0.15	15.5	558	0.07
6	2.25	2	1.55	0.1	13.5	813	0.05
8	2.09	1.6	1.5	0.1	7	559	0.06
Water Volume (m^3): (FOCUS default = 31 to 60 m)							
3	45.12	Estimated assuming a 100 m segment					
4	51.48						
6	29.25						
8	27.17						

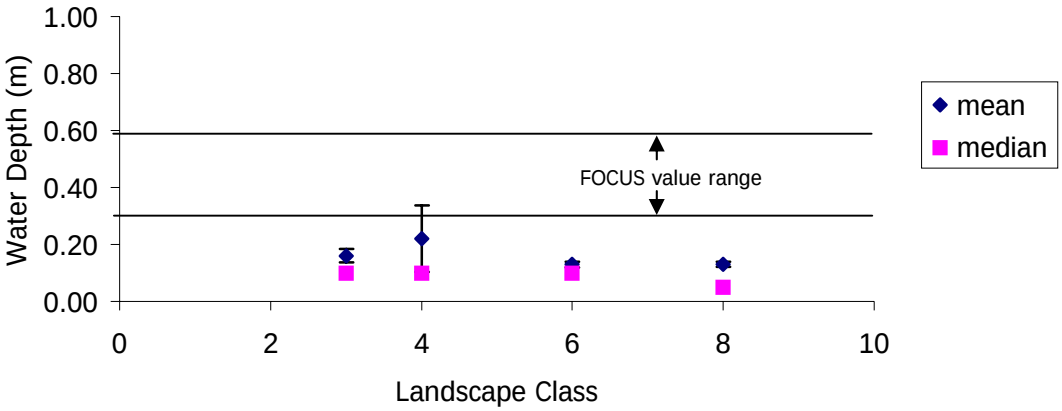


Figure 5.2.3.1 D4 Stream Scenario (Water Depth)

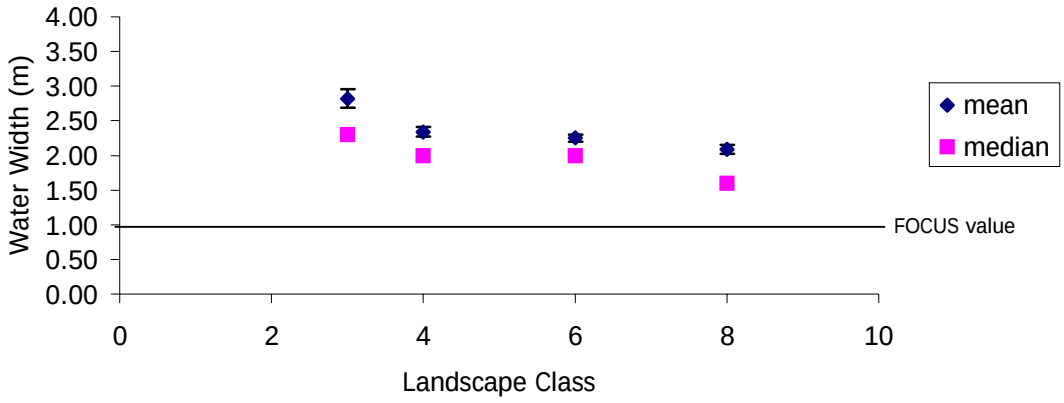


Figure 5.2.3.2 D4 Stream Scenario (Water Width)

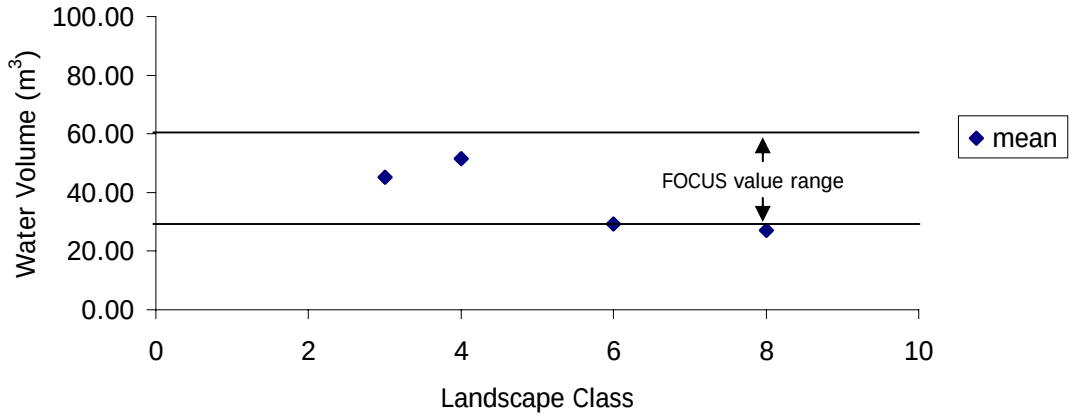


Figure 5.2.3.3 D4 Stream Scenario (Water Volume)

The pond morphological characteristics for landscapes 3, 4, 6 and 8 are given in Table 5.2.3.3. The pond characteristics recorded in the aquatic landscape database that allow for a comparison to be made are water depth and pond area (Figure 5.2.3.4 and 5.2.3.5, respectively). Using pond area and water depth it was possible to calculate pond water volume (Figure 5.2.3.6). The ponds in the UK landscape classes 3, 4, 6 and 8 were all shallower (<ca. 75 cm) than the FOCUS D4 pond value (1 m). Generally, the ponds in the UK tend to be larger (>900 m^2) in area than the FOCUS pond. The calculated volume of water in the ponds in the aquatic landscape project is smaller than the FOCUS pond scenario.

Table 5.2.3.3 Pond Characteristics of relevant Landscape Classes

Landscape class	Mean	Median	Sd	Min	Max	Number of samples	Std error
Pond Area (m^2): FOCUS default = 900 m^2)							
3	1156	742	916.66	175	3000	17	222.32
4	721.74	432.63	819.86	56	3750	32	144.93
6	1459.67	547	3116.21	24	20650	55	420.19
8	930.07	588	923.46	180	4000	22	196.88
Water Volume (m^3): (FOCUS default = 900 m^3)							
3	473.96	Estimated					
4	463.50143						
6	892.29627						
8	464.56997						
Water Depth (cm): (FOCUS default = 100 cm)							
3	41	28	33.64	5	144	17	8.16
4	64.22	43.8	49.08	0	180	32	8.68
6	61.13	36	58.61	2	250	55	7.90
8	49.95	32	49.53	0.4	190	22	10.56

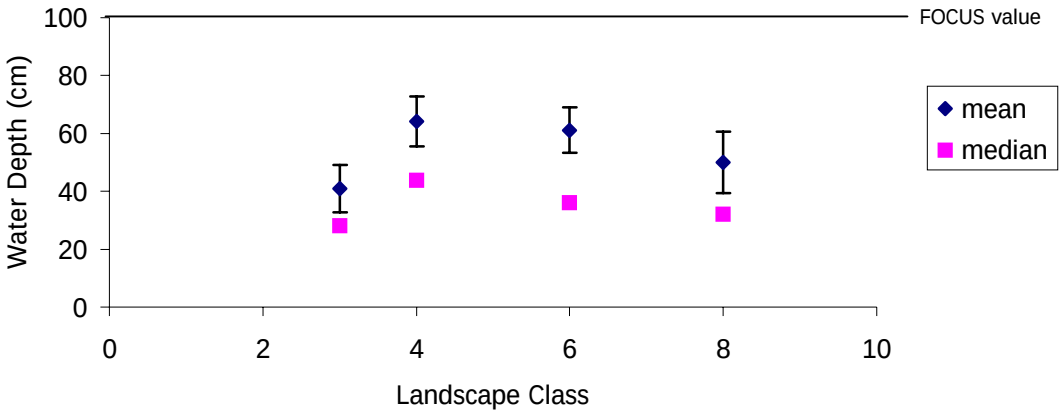


Figure 5.2.3.4 D4 Pond Scenario (Water Depth)

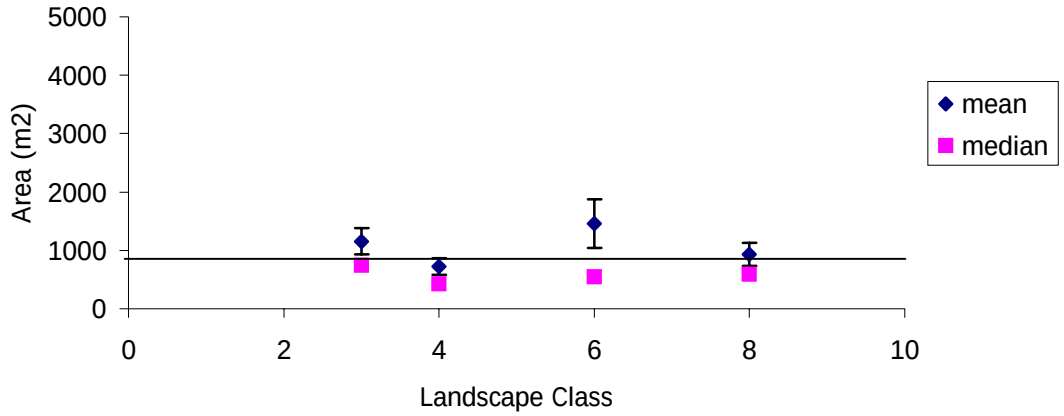


Figure 5.2.3.5 D4 Pond Scenario (Water Area)

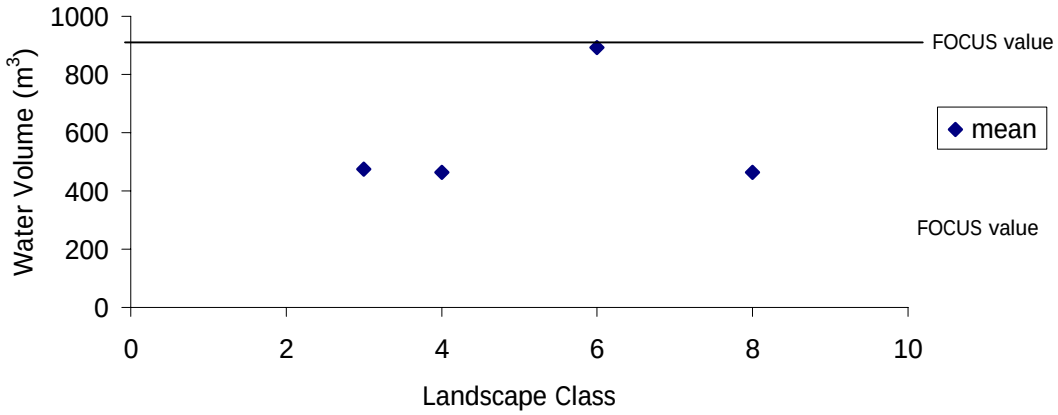


Figure 5.2.3.6 D4 Pond Scenario (Water Volume)

5.2.4 Aquatic Landscapes Associated with FOCUS SW Scenario R1

The Aquatic Landscape Classes that are associated with FOCUS SW scenario R1 are given in Table 5.2.4.1. The soil/climate match are dominated by 4 agricultural landscape classes; 1, 2, 7 and 8. The proportion of soil/climate match that landscape 1, 2, 7 and 8 represent are 6.2, 11.5, 31 and 36 %, respectively. Ponds and streams are present in landscapes 1, 2, 7 and 8. All other landscapes are considered less significant (representing <5% of scenario area).

Table 5.2.4.1 Relevant Landscape Classes for FOCUS Scenario R1

Landscape	Rank	Proportion of area (%)	Water bodies
1[a]	5	6.20	All
2[a]	3	11.53	no streams or ponds
3	7	2.32	Rivers, ponds and streams
4	11	0.14	All
5	9	0.68	All
6	8	2.16	All
7[a]	2	30.83	Rivers + streams
8[a]	1	35.87	All
9	6	3.08	no ditches
10	10	0.39	streams + rivers
13[b]	4	6.80	
14	12	0.00	
Grand Total		**100.00**	

FOCUS scenario R1 is characterised by first order streams and ponds. The stream morphological characteristics for landscape classes 1, 2, 7 and 8 are given in Table 5.2.4.2. The characteristics that allow for a comparison to be made between the streams present in the UK aquatic landscape project and the assumptions made in FOCUS SW are water body width and water body depth (Figures 5.2.4.1 and 5.2.4.2, respectively). In addition, as before, it was possible to calculate water body volume (assuming a 100 m segment of water), see Figure 5.2.4.3 In all cases the mean stream water depth was less (0.40 m) than the FOCUS minimum (0.41 m). However, the aquatic landscape project suggests that the streams in the UK landscape are wider (>2 m) than the FOCUS R1 stream (1 m). As a consequence, the volume of a typical UK Stream (as calculated from the Aquatic Ecosystem Document) is similar to that simulated in scenario R1.

Table 5.2.4.2 Stream Characteristics for relevant Landscape Classes

Landscape Class	Mean	Median	SD	Min	Max	Number of Samples	Std Error
Water Depth (cm): (FOCUS default = 41 to 132 cm)							
1	0.4	0.2	0.63	0.01	6	134	0.054
2	0.31	0.15	0.64	0.01	5	66	0.079
7	0.13	0.1	0.13	0.01	0.8	78	0.015
8	0.13	0.05	0.15	0.01	1	275	0.009
Water Width (m): (FOCUS default = 1 m)							
1	3.88	3.5	2.59	0.02	35	720	0.097
2	2.97	3	1.67	0.25	10	280	0.100
7	2.51	2.25	1.59	0	7.8	265	0.098
8	2.09	1.6	1.5	0.1	7	559	0.063
Water Volume (m^3): (FOCUS default = 41 to 132 m^3)							
1	155.2	Estimated assuming 100 m segment					
2	92.07						
7	32.63						
8	27.17						

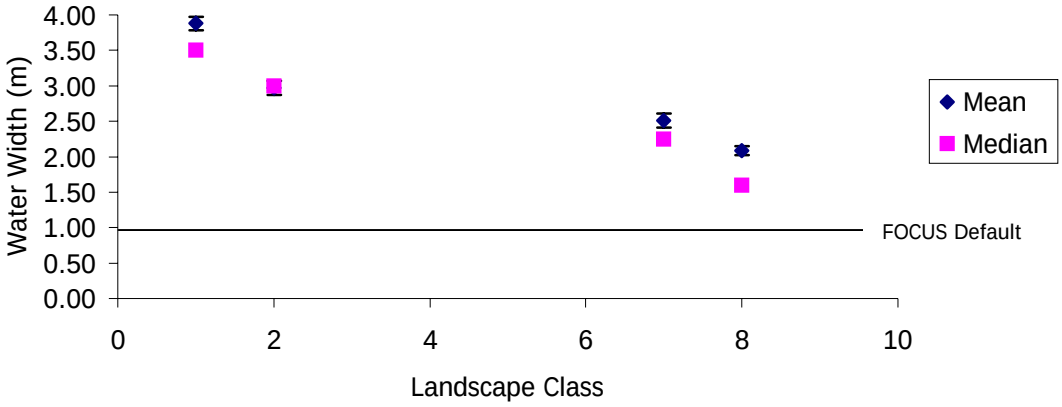


Figure 5.2.4.1 R1 Stream Scenario (Water Width)

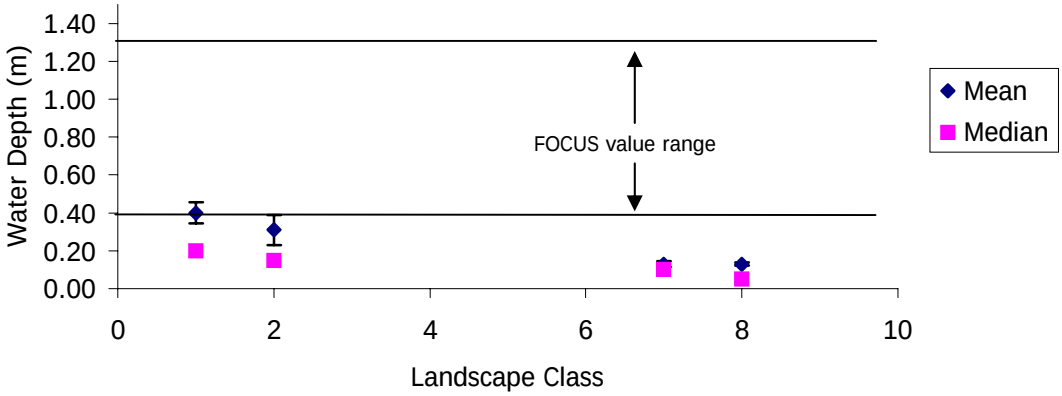


Figure 5.2.4.2 R1 Stream Scenario (Water Depth)

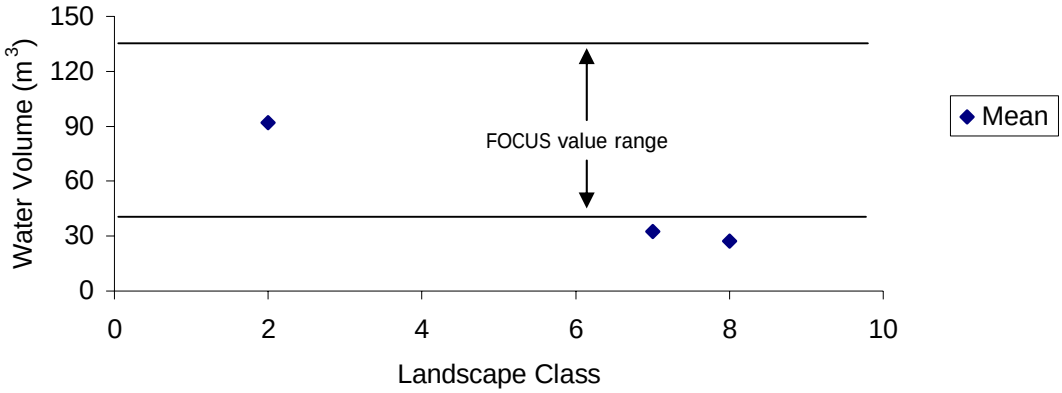


Figure 5.2.4.3 R1 Stream Scenario (Water Volume)

The pond morphological characteristics for landscapes 1, 2, 7 and 8 are given in Table 5.2.4.3. The pond characteristics recorded in the aquatic landscape database that allow for a comparison to be made are pond area and water (Figure 5.2.4.4 and 5.2.4.5, respectively). Using pond area and water depth it was possible to calculate pond water volume (Figure 5.2.4.6). The ponds in the UK Landscape Classes 1, 2, 7 and 8 were all shallower (<ca. 75 cm) than the FOCUS D4 pond value (1 m). Generally, the ponds in the UK tend to be larger (>900 m^2) in area than the FOCUS pond. The calculated volume of water in the ponds in the aquatic landscape project is smaller than the FOCUS pond scenario.

Table 5.2.4.3 Pond Characteristics for relevant Landscape Classes

Landscape Class	Mean	Median	SD	Min	Max	Number of Samples	Std Error
Pond Area (m2): (FOCUS default = 900 m^2)							
1	1204.71	527.5	1717.01	24	7650	28	324.48
2	983.85	700	1013.09	25	2842.5	11	305.46
7	1575.12	1303.68	1363.84	40	3931	20	304.96
8	930.07	588	923.46	180	4000	22	196.88
Water Volume (m^3): (FOCUS default = 900 m^3)							
1	798.84	Estimated					
2	546.82						
7	1205.44						
8	464.57						
Water Depth (cm): (FOCUS default = 900 m^3)							
1	66.31	53	59.36	5	247	28	11.22
2	55.58	40	41.03	9.4	150	11	12.37
7	76.53	54	62.1	10	180	20	13.89
8	49.95	32	49.53	0.4	190	22	10.56

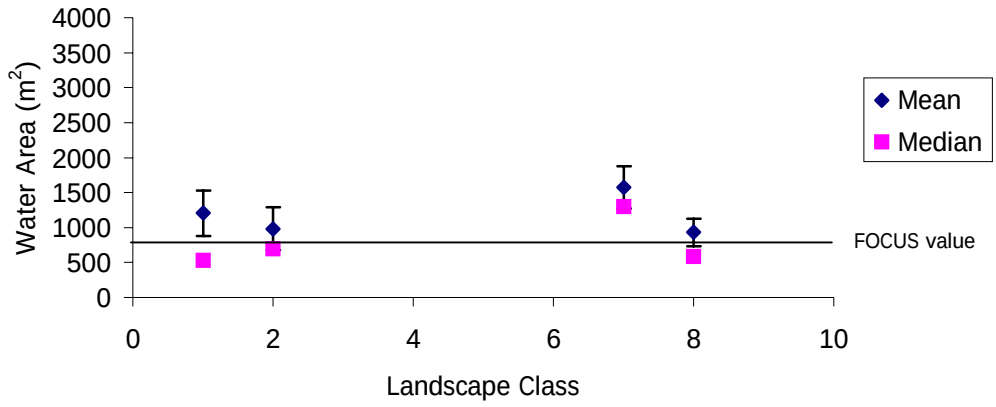


Figure 5.2.4.4 R1 Pond Scenario (Area)

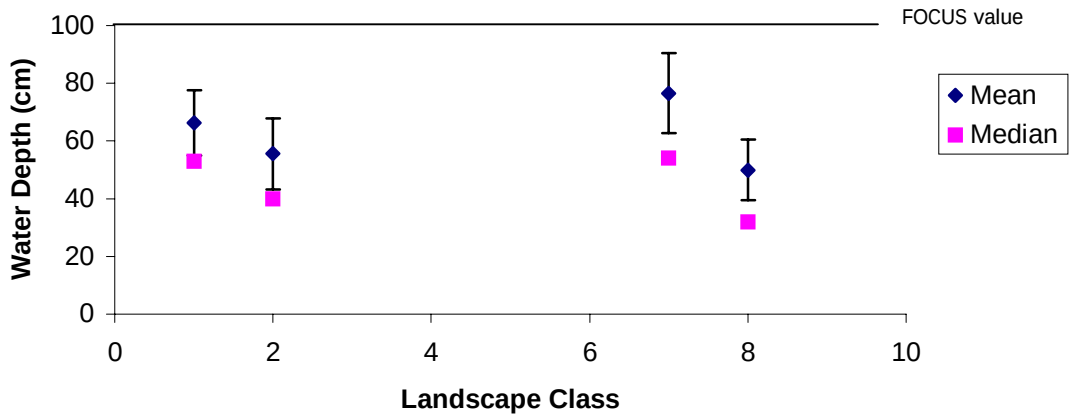


Figure 5.2.4.5 R1 Pond Scenario (Water Depth)

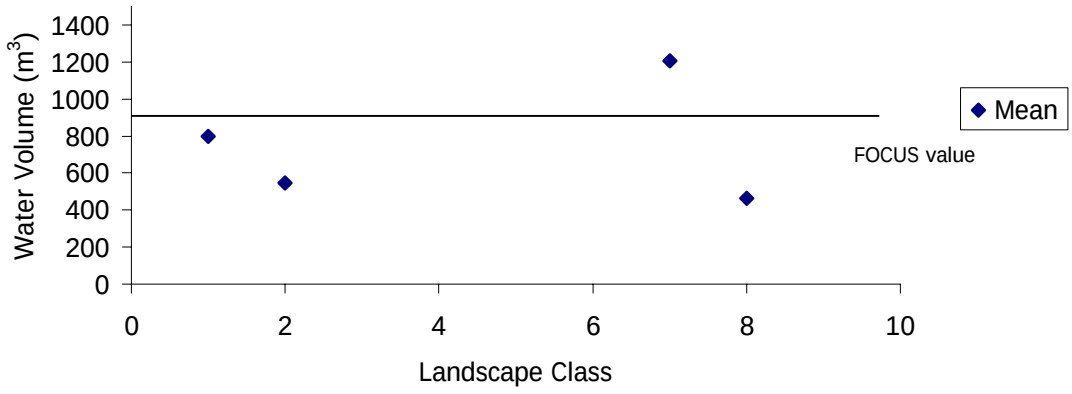


Figure 5.2.4.6 R1 Pond Scenario (Water Volume)

5.3 Drift Loadings

It has been demonstrated in the previous sections that the dimensions of the streams in FOCUS are generally deeper and narrower than typical streams in the UK. As such the loadings *via* drift may differ substantially in UK streams. In order to examine the impact of wider and shallower ditches on the calculated PEC_{SW} values from drift the regression curves, which were developed by FOCUS (2001) were used. These were based on fitting the various percentile drift results as a function of distance from the edge of the treated area. The drift equation developed by FOCUS is given in equation 1:

$$\overline{Drift} = \frac{A}{(z_2 - z_1) * (B+1)} * [z_2^{B+1} - z_1^{B+1}] \qquad \text{Equation 5.3.1}$$

$\overline{Drift}$ = mean percent drift loading across a receiving water body

A = constant regression factor for distance 0 to H, where H is a hinge point (Taken from the FOCUS drift calculator, FOCUS, 2001)

B = exponential regression factor for distance 0 to H, where H is a hinge point (Taken from the FOCUS drift calculator, FOCUS, 2001)

z_1 = distance from edge of treated field to closest edge of water body (m)

z_2 = distance from edge of treated field to farthest edge of water body (m)

Table 5.3.1 Drift regression terms

Scenario	Crop	A	B	Z_1	Z_2	Areic mean Drift %
Standard FOCUS Stream scenario	Winter Cereals	2.7593	-0.9778	1.5	2.5	1.430361
Stream (2m wide)	Winter Cereals	2.7593	-0.9778	1.5	3.5	1.190708
Standard FOCUS Stream scenario	Pome fruit, late application	60.3964	-1.2249	4	5	9.623657
Stream (2m wide)	Pome fruit, late application	60.3964	-1.2249	4	6	8.568016

To calculate the drift loading (Table 5.3.2) into surface water for use in TOXSWA, the mean drift loading is multiplied by the application rate as follows:

$$\text{Drift loading} = \text{App rate}/10 \times \overline{Drift}/\text{Area} \qquad \text{Equation 5.3.2}$$

Where Drift loading = drift loading into a receiving water body (units: mg/m^2)

App rate = application rate of chemical in treated field (g as/ha)

Table 5.3.2 Drift Loadings into water bodies

Scenario	Crop	Areic mean Drift %	App rate (g/ha)	Area (m^2)	Drift Loading (mg/m^2)
Standard FOCUS Stream scenario	Winter Cereals	1.430361	1000	100	143.0361
Stream (2m wide)	Winter Cereals	1.190708	1000	200	238.1416
Standard FOCUS Stream scenario	Pome fruit, late application	9.623657	1000	100	962.3657
Stream (2m wide)	Pome fruit, late application	8.568016	1000	200	1713.603

However, the depths of streams in the UK are typically shallower than those in FOCUS, e.g. Landscape 6 has a mean stream depth of 13 cm. The minimal FOCUS stream depth is 29 cm. The resulting volumes and generated PEC values (assuming drift only) for the different water bodies are given in Table 5.3.3. The generated PEC values

$$PEC\ (\mu g/m^3) = (\text{drift loading} * 1000)/(\text{Volume}/1000) \qquad \text{Equation 5.3.3}$$

Table 5.3.3 Generated PEC values based on drift

Scenario	Crop	Drift Loading (mg/m^2)	Depth (m)	Volume (m^3)	PEC (µg/L)
Standard FOCUS Stream scenario	Winter Cereals	143.0361	0.29	29	4.93
Stream (2m wide)	Winter Cereals	238.1416	0.13	26	9.16
Standard FOCUS Stream scenario	Pome fruit, late application	962.3657	0.29	29	33.19
Stream (2m wide)	Pome fruit, late application	1713.603	0.13	26	65.91

5.4 Conclusions

The Aquatic Landscape Project (Defra project PN0931, 2003) provides a wealth of statistical data on the characteristics and distribution of water bodies within the UK. However, the characteristics of the water bodies measured do not always allow for a detailed comparison with the water body characteristics in the FOCUS SW documentation. Where the characteristics measured in the Aquatic Landscapes Project match those of the FOCUS scenarios further assessments have been conducted. These similarities and differences have been summarised below for each type of water body and the implications/consequences (if any) are discussed:

Ditches

Little data were available on the characteristics of UK ditches (Table 5.1.1.1). Ditch data were predominantly available for two landscape classes; river flood plains and the fenlands. The characteristics measured in the aquatic landscape project that allow for a comparison to be drawn, with the FOCUS scenarios, are water body depth, ditch flow rate and distance to crop. There was a lack of detailed data on ditch

width, and these were summarised in the form of pie charts. Mean water depth in ditches is typically deeper in the UK scenarios and the residence time in UK ditches is far smaller than that in the FOCUS scenarios. The mean and median flow rates of water in UK ditches (as described in the Aquatic Landscapes Project) is far faster than that used in FOCUS to define water movement in a ditch. Where distance to crop data exists the assumptions in the FOCUS scenario are generally in agreement, with the exception of Landscape Class 1 (River Flood Plains and low terraces) where the distance from a ditch to a crop is typically less than 1m.

The consequences of these findings are that drainage and run-off assessments within FOCUS are considered protective of similarly classified systems within those aquatic landscapes of primary relevance to FOCUS scenarios in the UK. However, drift (depending on water width) could play a more dominant role, specifically where a chemical is applied to a crop grown on river floodplains and low terraces where the distance to a crop is <1m (FOCUS assumption). The data also indicates that the mean flow rate of water in these ditches is >0.4 m/s compared to the FOCUS values of 0.0003 to 0.0017 m/s, which is 2-orders of magnitude greater. Pesticide losses through advection could play a more significant role and reduce pesticide loadings *via* spray drift more rapidly than in FOCUS.

Streams

Large amounts of data were available in the Aquatic Landscapes database that defined the characteristics of streams in the UK (Table 5.1.1.1). Stream width and depth data for the UK was available, and it was possible to calculate the volume of typical streams in the UK (assuming a 100m length water body). Generally, it was demonstrated that streams are shallower in the UK than in FOCUS scenarios. The widths of streams in the UK are generally far greater than the width of a “FOCUS stream”, the resulting volumes are approximately equal. The consequences of these findings are that drainage and run-off assessments provided by FOCUS would be considered protective, however spray drift input may be greater than that simulated by FOCUS (due to the larger stream widths). Two examples were provided (one for winter cereals and one for an orchard crop) where different stream widths have been used to demonstrate the effect of stream width on pesticide loadings (Tables 5.3.1 and 5.3.2):

The examples demonstrate that stream widths in the UK could lead to increased loadings *via* spray drift, which could result in PEC values that are double that generated by FOCUS. However, it must be stressed that this is only one parameter and that other parameters such as flow rate were not available and it is likely that the flow rates are significantly higher than in FOCUS, as with ditches. In reality, as the worst-case assumptions embedded within FOCUS at Step 3 are considered likely to be highly conservative in many cases, the potential for increased risk due to differences in areic deposition potential are likely to be obscured.

Ponds

Large amounts of data were available in the aquatic landscapes database that defined the characteristics of the ponds in the UK (Table 5.1.1.1). Data were available on pond area and width, in addition pond volume was calculated. Pond areas in the UK (as reported in the aquatic landscape database) were similar to that in the FOCUS scenarios. However, the reported depths were significantly shallower in the UK. Therefore, the calculated pond volumes are generally lower in the UK. This could result in the FOCUS scenarios under predicting loadings *via* drainage, run-off and drift due to decreased dilution potential. However, there is no detail within the aquatic landscape project that details the proximity of the ponds to arable land where pesticide applications will take place.

Summary
In every case the scale of conservatism can be quantified, and although differences have been noted (e.g. ditch flow rate, stream width and pond depth) the estimates by FOCUS are likely to be close in many cases, and realistic worst-case estimates that do not take into account mitigating factors such as proximity to crop and application are likely to be within a factor of 2 or less. In reality, the impact of the differences observed between the statistical profiles UK aquatic landscapes and FOCUS defaults, are likely to obscured by a range of mitigating factors such as proximity to crop, margin vegetation, system hydrology and response to events upstream, density of usage upstream etc. Underestimates of exposure potential in ponds are likely to only be an issue for persistent products where chronic risks are significantly greater than acute risks due to mode of action. The worst-case acute exposure profiles are likely to be provided by ditch and stream scenarios.

6.0 Comparative Evaluation of Exposure Frameworks: Current UK National Scheme and FOCUS Surface Water

Registration at a Member State level (post Annex 1) may, in future, include the use of standard FOCUS scenarios and/or Member State/region specific scenarios. However, before the development of such scenarios is considered, it is clear that Member States will need to know the extent to which the use of the FOCUS scenarios offers sufficient protection to the aquatic environment within their jurisdiction. It is therefore appropriate to examine how the current UK surface water risk assessment compares with the new FOCUS surface water framework.

The research reported here was based upon three objectives:

Objective 1: Conduct surface water exposure modelling following the current UK guidance

Objective 2: To carry out surface water exposure simulations following the FOCUS framework

Objective 3: Compare the aquatic risk assessments conducted following the current UK assessment with the FOCUS framework

6.1 Test Chemicals Selected

Test chemicals were selected from the FOCUS documentation and used to derive predicted environmental concentrations following the current UK guidance and the FOCUS framework. Relevant environmental fate and ecotoxicology date were available to allow an exposure assessment using the current UK and the FOCUS surface water framework at Step 1, 2, 3 and 4. The physico-chemical and environmental fate properties of the test chemicals are listed in Table 6.1.1 and are based on chemicals 1 to 7 in the FOCUS surface water documentation (FOCUS, 2001). Crop wash-off factors and dissipation rates in sediment/water systems were calculated for each chemical (Appendix 1; Sections 1.1 and 1.2). Aquatic toxicity and application information for each test chemical are listed in Tables 6.1.2 and 6.1.3, respectively. Three herbicides, two insecticides and two fungicides were included in the assessment. Modifications were made to the crops and application regimes in order to be more representative of pesticides in the UK. The application rates ranged from 12.5 g/ha (three applications) to 3 kg/ha (as a single application). The test chemicals were applied to a range of crops, including potatoes, maize, winter wheat, winter oil seed rape, pome fruit and winter cereals. All six drainage and four run-off scenarios were well represented by the selected crops. All chemicals were spring applied (before the end of April) and chemicals 4, 5 and 7 had multiple applications. Simulations of application of the test chemicals was according to the guidance given in the FOCUS documentation.

Table 6.1.1 Physico-chemical and environmental fate properties of the test chemicals 1 to 7

	Test Chemicals						
Parameter	**1 (I)**	**2 (H)**	**3 (H)**	**4 (I)**	**5 (F)**	**6 (H)**	**7 (F)**
Molar Mass (g mol^{-1})	190.3	215.7	221.0	505.2	376.0	255.0	286.1
Vapour Pressure (Pa @ 20°C)	0.017	3.85×10^{-5}	$<1 \times 10^{-5}$	1.24×10^{-8} @25°C	6.4×10^{-9}	3.78×10^{-9}	1.3×10^{-4}
Water Solubility (mg/L @ 20°C	6000 @ 25°C	30	620 @ 25°C	0.0002 @ 25°C	1.15	91 @ pH 7	2.6 @ pH 7
Log K_{OW}	1.6	2.5	2.8	4.6	3.2	2.0	3.0
Soil half-life (days)	6	43	4	26	250	28	50
K_{OC} (g mL^{-1})	15	91	1	1024000	860	66	500
Freundlich exponent (1/n)	1.0	0.88	1.0	0.93	1.0	1.0	1.0
Surface water half-life (days)	6	26	1.5	0.7	6	24	2.5
Sediment half-life (days)	6	26	1.5	76	118	24	28

I: Insecticide; H: herbicide; F: fungicide

Table 6.1.2 Aquatic toxicity endpoints for test chemicals 1 to 7

Test species	**Test Chemical**						
	1 (I)	**2 (H)**	**3 (H)**	**4 (I)**	**5 (F)**	**6 (H)**	**7 (F)**
Fish acute LC50 (μg/L)	115	11000	18000	0.26	1900	14300	>18000
Aquatic invertebrate EC50 (μg/L)	410	87000	<100000	0.25	>5000	>100000	4000
Algae EC50 (μg/L)	1400	43	9800	>9100	14	49800	>1020
Lemna EC50 (μg/L)	-	20	12300	-	1400	12300	-
Fish chronic NOEC (μg/L)	-	250	200	0.032	300	200	50
Aquatic invertebrate chronic NOEC (μg/L)	110	40	100	0.0041	648	100	1950

- : Species not tested; I: Insecticide; H: herbicide; F: fungicide

Table 6.1.3 Application information for test chemicals 1 to 7

	Test Chemicals						
Parameter	**1 (I)**	**2 (H)**	**3 (H)**	**4 (I)**	**5 (F)**	**6 (H)**	**7 (F)**
Method of application	Pre-plant Soil inc	Pre-em ground	Post-em ground	Orchard air-blast	Pre-em ground	Post em ground spray	Pre-em ground
Crop	Potatoes	Maize	Winter Wheat	Apples	WOSR	Winter Cereals	Winter Cereals
Application rate (kg ha^{-1})	3.0	1.0	1.0	0.0125	0.075	0.4	0.5
Number of applications	1	1	1	3	2	1	3
Timing of application	Before Planting	First possible day after sowing	First possible app day after 1 March	First possible day after 15 April. Min. 14 day interval between remaining apps.	First possible day after 1 April. Min. 10 day interval between remaining apps.	First possible app day after 1 March	First possible app day after 1 April. Min 10 days between remaining apps

I: Insecticide; H: herbicide; F: fungicide; WOSR: Winter Oil Seed Rape

6.2 Current UK Drainage Assessment

The current UK surface water assessment considers exposure to surface waters from drainage and spray drift; it assumes that the assessment for drainage is expected to encompass the risk of run-off from most field-crops. Run-off may be considered for specific uses in the UK on a case by case basis (e.g. run-off in forestry where a drainage assessment is not triggered). The assessments are simple and are performed using a dilution assessment with a set of standard assumptions. The assessments are readily performed using a standard Excel spreadsheet (Appendix 1; Section 1.3).

The calculated PEC_{SW} values associated with drain flow for test chemicals 1-7 are given in Table 6.2.1. It should be noted that no degradation has been assumed because all applications are in early Spring (before the end of April) where drainflow is considered likely. The chemical with the largest loading *via* drainage was chemical 1 (highest application rate; applied pre-emergence); K_{OC} value of 15 mL/g). Chemical 4 has the lowest exposure *via* drainage to surface waters (lowest application rate; the highest crop interception rate and; a K_{OC} > 4,000). However, it should be noted that the UK drainage scenario may not necessarily be appropriate (too conservative) for uses on potatoes (chemical 1) and use on apples (chemical 4).

Table 6.2.1 Calculated PEC_{SW} values associated with drain flow values for chemicals 1 to 7

Parameter	Test Chemicals						
	1 (I)	**2 (H)**	**3 (H)**	**4 (I)**	**5 (F)**	**6 (H)**	**7 (F)**
Interception rate (%)	0	0	50	70	40	50	50
Field application rate (g/ha)	3,000	1,000	1,000	37.5 (3 x 12.5)	150 (2 x 75)	400	1,500 (3 x 500)
Koc (mL/g)	15	91	1	1,024,000	860	66	500
Percentage lost to drains (%)	1.9	0.7	1.9	0.008	0.5	1.9	0.5
Application rate to soil (g/ha)	3,000	1,000	500	11.25	90	200	750
Dilution volume (L)	130,000	130,000	130,000	130,000	130,000	130,000	130,000
PEC_{SW} (µg/L)	**438.46**	**53.85**	**73.08**	**0.01**	**3.46**	**29.23**	**28.85**

6.3 Current UK Drift Assessment

6.3.1 Current UK Estimation of PEC and TWA PEC values in surface water

For the purposes of this assessment initial maximum PECs were calculated for chemicals 1 to 7 in the standard 30 cm deep, static surface water body. The current UK risk assessment for spray drift loadings to surface water uses the spray drift percentage based on Rautmann (2000). PEC_{SW} values should be calculated for single and multiple (where relevant) applications for chemicals, because the spray drift values differ depending on the number of applications. Unlike the drainage assessment it considers each application as a separate loading and also allows for calculation of time-weighted averages. The initial PEC is calculated assuming drift loading into a 100 m length ditch that is 30 cm deep and 1 m wide. The highest calculated PEC_{SW} is then used in the subsequent risk assessment - see Appendix 1, Section 1.4 for details on calculating exposure *via* spray drift).

The assumptions and calculated initial loadings for chemicals 1 to 7 are given in Table 6.3.1.1. The calculated loading for chemical 4 using a 'no spray zone' of 5 m is given in Table 6.3.1.2.

Table 6.3.1.1 PEC surface water values for chemicals 1 to 7 following standard UK guidance (1 m 'no spray zone'; single and multiple applications)

Parameter	Test Chemicals						
	1 (I)	**2 (H)**	**3 (H)**	**4 (I)**	**5 (F)**	**6 (H)**	**7 (F)**
Application Rate (g/ha)	1 x 3,000	1 x 1,000	1 x 1,000	3 x 12.5	2 x 75	1 x 400	3 x 500
Crop	Potatoes	Maize	Winter Wheat	Apples	WOSR	Winter Cereals	Winter Cereals
Spray Drift (%)	0*	2.8	2.8	29.2[#] (24.0)	2.8 (2.4)	2.8	2.8 (2.0)
Minimum Application Interval (days)	-	-	-	14	10	-	10
Water Dissipation value (days)	5.85	21.69	1.48	0.43	5.82	21.57	2.44
Spray Drift max PEC (µg/L)	**0.00**	**9.33**	**9.33**	**1.22 (1.00)**	**0.70 (0.78)**	**3.73**	**4.67 (3.54)**

*: Chemical 1 is soil incorporated and therefore no spray drift occurs; [#]: a 3 m no spray zone is standard for pome fruit; numbers in parentheses refer to multiple applications; -: not relevant

Table 6.3.1.2 PEC surface water values for chemical 4 following standard UK guidance (5 m 'no spray zone'; multiple application/s)

Parameter	Test Chemicals
	4 (I)
Application Rate (g/ha)	3 x 12.5
Crop	Apples
No Spray zone (m)	5
Spray Drift (%)	19.88 (15.78)
Minimum Application Interval (days)	14
Water Dissipation value (days)	0.43
Spray Drift max PEC (µg/L)	**0.83 (0.66)**

numbers in parentheses refer to multiple applications

6.3.2 Current UK Estimation of PEC and TWA PEC values in Sediment

The current UK spray drift assessment also considers exposure to sediment. The framework is similar to that used to calculate surface water PECs (Appendix 1; Section 1.5). Calculated values for maximum formed in sediment (%) are given in Table 6.3.2.1 with other relevant variables for calculation of initial and TWA PEC (Time Weighted Average PEC) values in sediment.

Table 6.3.2.1 PEC sediment water values for chemicals 1 to 7 following standard UK guidance (1 m 'no spray zone'; single and multiple applications)

Parameter	Test Chemicals						
	1 (I)	**2 (H)**	**3 (H)**	**4 (I)**	**5 (F)**	**6 (H)**	**7 (F)**
Application Rate (g/ha)	1 x 3,000	1 x 1,000	1 x 1,000	3 x 12.5	2 x 75	1 x 400	3 x 500
Crop	Potatoes	Maize	Winter Wheat	Apples	WOSR	Winter Cereals	Winter Cereals
Spray Drift (%)	0*	2.8	2.8	29.2[#] (24.0)	2.8 (2.4)	2.8	2.8 (2.0)
Sediment degradation value (days)	6	26	1.5	76	118	24	28
Maximum % formed in sediment	0.0	10.82	0.13	99.93	53.42	8.09	40.00
max sediment PEC associated with spray drift (µg/L)	**0.0**	**4.66**	**0.06**	**5.61 (12.22)**	**1.73 (2.87)**	**1.39**	**8.62 (14.71)**

*: Chemical 1 is soil incorporated and therefore no spray drift occurs; [#]: a 3 m no spray zone is standard for pome fruit; numbers in parentheses refer to multiple applications

6.4 FOCUS Surface Water Assessment Steps 1, 2, 3 and 4

6.4.1 Predicted Environmental Concentrations at Steps 1 and 2

A comparison was made using Step 1 and 2 calculations and the current UK drainage and spray drift assessments. The UK spray drift assessment recommends 90th percentile spray drift values (Rautmann, 2000). Chemicals 1 to 7 are used on representative UK crops (arable and orchards). PEC surface water values for test chemicals 1 to 7 were calculated using the Step 1 and 2 FOCUS calculator. Drift rates are determined automatically within the drift calculator and are dependant on crop type and growth stage. Growth stage was set to "no interception" for all single application chemicals (1, 2, 3, and 6) and set to "minimal crop cover" for test chemicals 4, 5 and 7. The crop selected for test chemical 1 was "no drift (seed incorp or trtmt)". At Step 1, the total season application rate is applied as a single application. The results of the Step 1 and 2 FOCUS calculator and the current UK spray drift and drainage assessments are given in Figure 6.4.1.1 and Table 6.4.1.1.

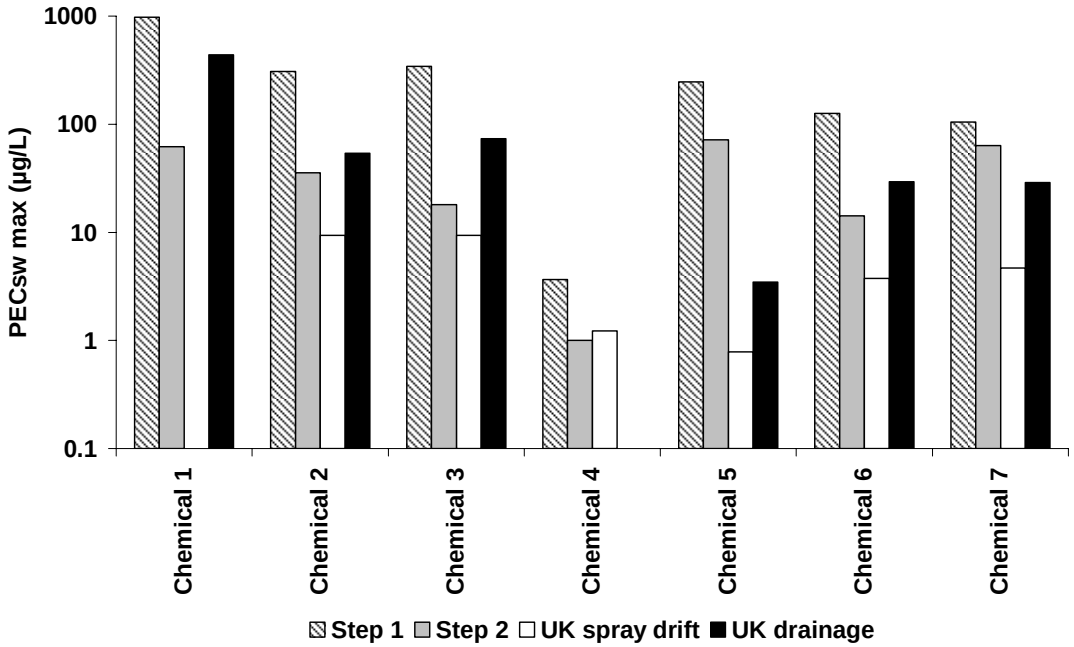


Figure 6.4.1.1 Initial PEC_{SW} concentrations for test chemicals 1 to 7 using the current UK approach and the FOCUS Step 1 and 2 approach

Table 6.4.1.1 Concentrations in Water Body at Steps 1 and 2 for test chemicals 1 to 7

Test chemical/crop	PEC value	Surface water concentrations (μg/L)			
		Step 1	Step 2	UK drainage assessment	UK spray drift assessment
Test chemical 1/ Potatoes[a]	PEC_{sw} max	980.39	61.76	438.46	0.00
Test chemical 2/ Maize	PEC_{sw} max	306.50	35.55	53.85	9.33
Test chemical 3/ Winter wheat	PEC_{sw} max	342.12	18.09	73.08	9.33
Test chemical 4/ Apples[b]	PEC_{sw} max	3.65	1.00	0.01	1.22
Test chemical 5/ Oil seed rape (winter)	PEC_{sw} max	246.71	71.91	3.46	0.78*
Test chemical 6/ Cereals (winter)	PEC_{sw} max	126.23	14.2	29.23	3.73
Test chemical 7/ Cereals (winter)	PEC_{sw} max	104.6	63.3	28.85	4.67

[a]: Pre-emergence application; [b]: 3 Applications per season (15 Apr – 30 Jun), assumed early season (air blast application); *: multiple application spray drift

Figure 6.4.1.1 demonstrates that the PEC values generated at FOCUS Step 1 are greater than those generated using the current UK methods for all test chemicals. The difference is significant for all chemicals indicating that the Step 1 calculator is more conservative than the current UK method because it includes the seasonal use rate and a significant run-off/drainage component. The results for Step 2 are generally of a similar magnitude to the current UK drainage assessment; exceptions include test chemicals 1, 3 and 5 where the calculated PEC surface water values at Step 2 are lower for chemicals 1 and 3, but higher for chemical 5 using the current UK drainage assessment. The refinements made at Step 2 include individual applications rather than a seasonal use rate, drift loadings resulting in an overall 90th percentile plus variable loadings *via* run-off and drainage losses depending on location and season of use. The PEC_{SW} values in surface water generated for test chemical 4 at Step 2 was 1 μg/L (N.B. it does not appear in Figure 6.4.1.1 because the y-axis is on a logarithmic scale).

6.5 Risk Assessments at Steps 1 and 2

TER values were calculated using maximum PEC values using the current UK drainage and spray drift assessment and the FOCUS Step 1 and 2 calculator (Appendix 1; Section 1.6). Both acute and chronic risk assessments were conducted using maximum PEC_{sw} values for all test chemicals. The calculated TER values using the exposure endpoints from Step 1 and 2 are given in Tables 6.5.1 and 6.5.2, respectively. The calculated TER values using the exposure endpoints from current UK drainage and spray drift assessments are given in Tables 6.5.3 and 6.5.4, respectively.

A comparison between the current UK method and the FOCUS Step 1 and 2 calculations for each test species is given in Appendix 1, Section 1.6. None of the test chemicals demonstrate acceptable TER values for all test species at FOCUS Step 1 and 2 and therefore Step 3 modelling is required. However, whilst test chemicals 3, 5, 6 and 7 pass the UK spray drift assessment, with default buffer distances, all fail the UK 1st tier drainage assessment.

Table 6.5.1 Calculated TERs from FOCUS Step 1 for chemicals 1-7

Chemical	Test species					
	Acute fish	**Acute aquatic invertebrate**	**Algae**	***Lemna***	**Chronic fish**	**Chronic aquatic invertebrate**
1	0.117	0.418	1.428	-	-	0.112
2	36	284	0.140	0.065	0.816	0.131
3	53	292	29	36	0.585	0.292
4	0.071	0.068	2493	-	0.009	0.001
5	7.701	20	0.057	5.675	1.216	2.627
6	113	792	395	97	1.584	0.792
7	172	38	9.751	-	0.478	19
Proportion of Passes	2:7	3:7	3:7	2:4	0:6	1:7

- : Species not tested

Table 6.5.2 Calculated TERs from FOCUS Step 2 for chemicals 1-7

Chemical	Test species					
	Acute fish	Acute aquatic invertebrate	Algae	*Lemna*	Chronic fish	Chronic aquatic invertebrate
Northern Europe						
1	1.862	6.639	23	-	-	1.781
2	309	2447	1.210	0.563	7.032	1.125
3	995	5528	542	680	11	5.528
4	0.260	0.250	9100	-	0.032	0.004
5	26	70	0.195	19	4.172	9.011
6	1007	7042	3507	866	14	7.042
7	284	63	16	-	0.790	31
Proportion of Passes	4:7	3:7	5:7	3:4	2:6	1:7

- : Species not tested

Table 6.5.3 Calculated TERs from current UK method (drainage assessment) for chemicals 1-7

Chemical	**Test species**					
	Acute fish	**Acute aquatic invertebrate**	**Algae**	***Lemna***	**Chronic fish**	**Chronic aquatic invertebrate**
1	0.262	0.935	3.193	-	-	0.251
2	204	1616	1	0	5	1
3	246	1368	134	168	3	1
4	26	25	910000	-	3.200	0.410
5	549	1445	4	405	87	187
6	489	3421	1704	421	7	3
7	624	139	35	-	2	68
Proportion of Passes	5:7	5:7	4:7	3:4	1:6	2:7

- : Species not tested

Table 6.5.4 Calculated TERs from current UK method (spray drift assessment) for chemicals 1-7

Chemical	Test species					
	Acute fish	**Acute aquatic invertebrate**	**Algae**	***Lemna***	**Chronic fish**	**Chronic aquatic invertebrate**
1	NA	NA	NA	NA	NA	NA
2	1179	9325	5	2	27	4
3	1929	10718	1050	1318	21	11
4	0.213	0.205	7459	-	0.026	0.003
5	2436	6410	18	1795	385	831
6	3834	26810	13351	3298	54	27
7	3854	857	218	-	11	418
Proportion of Passes	5:6	5:6	5:6	3:4	5:6	4:6

-: Species not tested; NA: Chemical 1 is soil incorporated

6.6 FOCUS Step 3 and Step 4 Exposure Assessments

Test chemicals 1 to 7 were used in FOCUS surface water assessments in order to make a comparison between the PEC_{SW} values derived under the FOCUS framework and the current UK spray drift and drainage assessments.

Step 3 and 4 calculations were carried out to assess the movement and fate of the test chemicals in surface waters and sediment. The scenarios with relevance to the GAPs are summarised and discussed in Appendix 1, Section 1.7.

6.6.1 FOCUS Step 3 and Step 4 Results

TOXSWA provides both acute and chronic exposure concentrations for the water layer as well as for the sediment. The maximum PEC_{SW} values are summarised and compared with the current UK drainage and spray drift assessment in Figures 6.6.1.1 to 6.6.1.7 for chemicals 1 to 7, respectively. A summary of the PEC_{SW} for all chemicals of primary UK relevance (FOCUS scenarios D2, D3, D4 and R1) and secondary and primary UK relevance (D1, D2, D3, D4, D5, R1 and R3) are given in Figures 6.6.1.8 and 6.6.1.9, respectively. In addition, the percent change in calculated PEC_{SW} values between the FOCUS Step 3 results and the current UK drainage and spray drift assessments for primary relevant and both primary and secondary relevant FOCUS scenarios are presented in Tables 6.6.1.1 and 6.6.1.2. The PEC_{SW} values calculated using FOCUS Step 3 (primary relevant scenarios) are generally lower than the PEC_{SW} values calculated using the current UK drainage assessment. Four out of seven test chemicals have at least one primary relevant UK FOCUS scenario where the PEC_{SW} values are higher as calculated by FOCUS Step 3 than the current UK drainage assessment. In total six out of the seven test chemicals have at least one scenario that has a higher PEC_{SW} value using FOCUS Step 3 (primary UK relevant scenarios) versus the current UK spray drift assessment. In addition, some Step 3 assessments result in higher maximum PEC_{SW} than calculated at Step 2 (R3 for chemical 1 and 2; D1, D3 and R3 for chemical 3; D1 and

D2 for chemical 6). The inclusion of the secondary UK relevant FOCUS scenarios makes the assessment more challenging for certain chemicals used on certain crops. For example, the FOCUS scenario R3 (of secondary relevance) is more challenging for mobile chemicals 1 and 2, which are used on potatoes and maize, respectively. The effect of including the FOCUS scenarios of secondary relevance to the UK on the exposure *via* spray drift was minimal.

The main exposure route for chemicals 1-3, 5-7 is drainage or run-off. The main exposure route for chemical 4 was *via* spray drift. The calculated PEC values for all chemicals using the FOCUS Step 3 results (of primary relevance to the UK) are within a factor of 2 of the current UK drainage assessment (all PEC <100% lower than the current UK drainage assessment). The current UK spray drift assessment is more conservative than the drift assessment within FOCUS and as a result the PEC_{SW} values calculated for chemical 4 are lower for FOCUS Step 3 than the current UK assessment (all PEC <98% for all chemicals for secondary and primary relevant FOCUS scenarios). Details on the calculated PEC values at Step 3 and 4 are given in Appendix 1, Section 1.8.

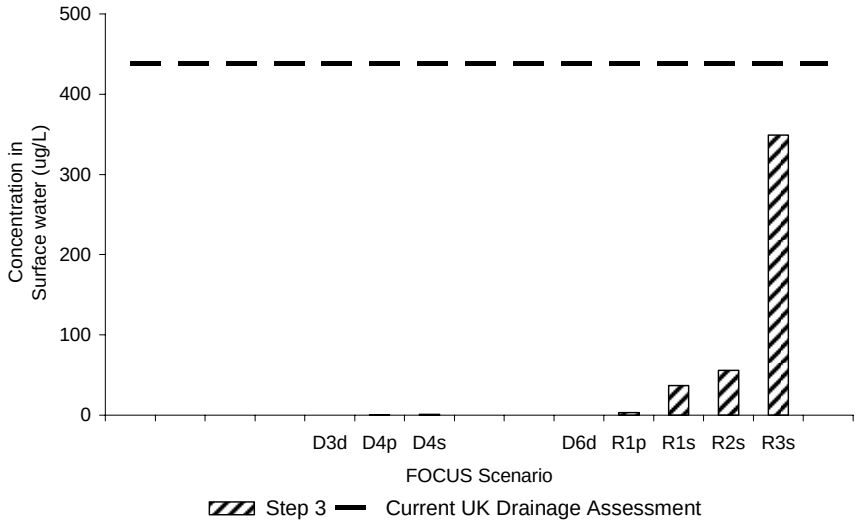


Figure 6.6.1.1 Exposure profile for modified FOCUS example chemical 1 as applied to potatoes

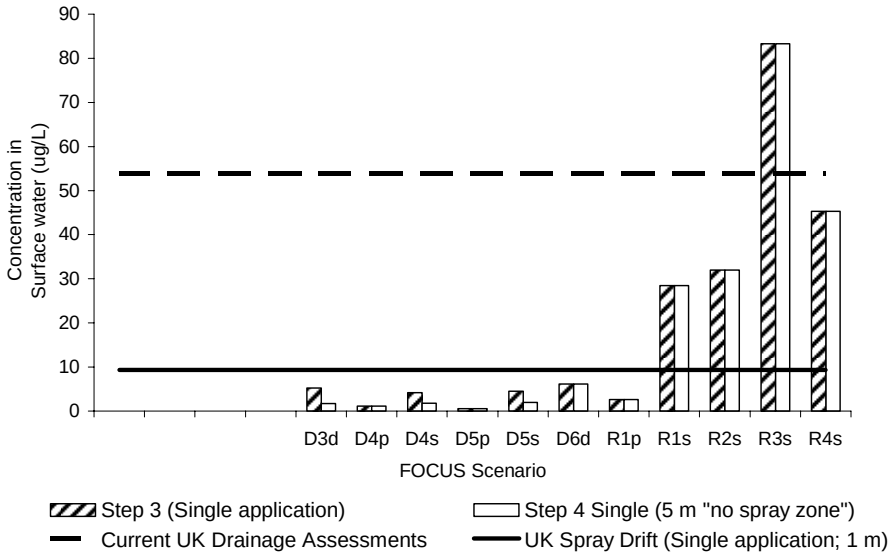


Figure 6.6.1.2 Exposure profile for modified FOCUS example chemical 2 as applied to maize

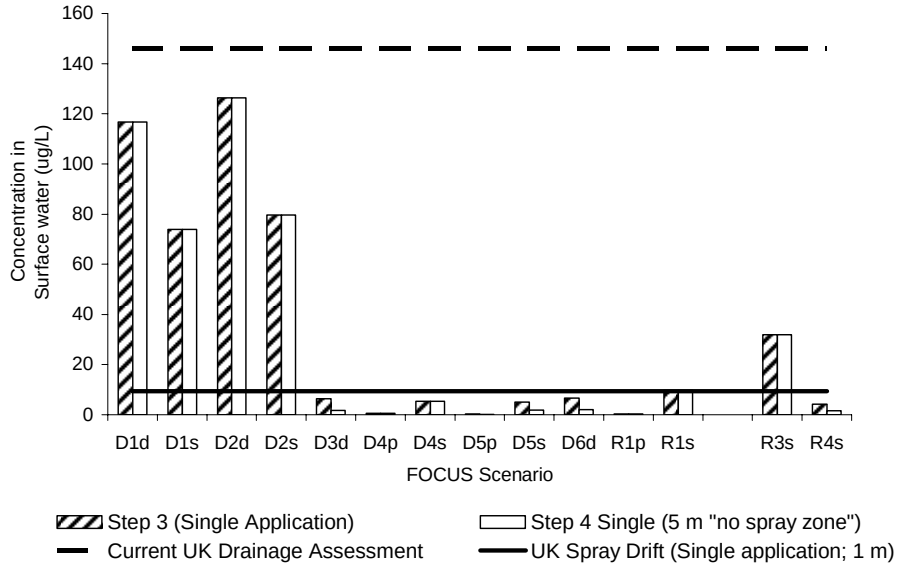


Figure 6.6.1.3 Exposure profile for modified FOCUS example chemical 3 as applied to winter cereals

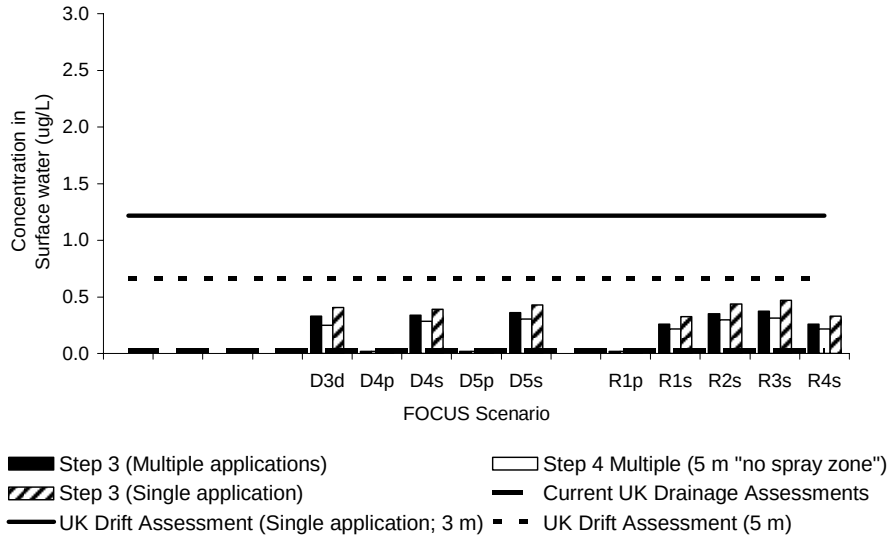


Figure 6.6.1.4 Exposure profile for modified FOCUS example chemical 4 as applied to pome fruit (early applications)

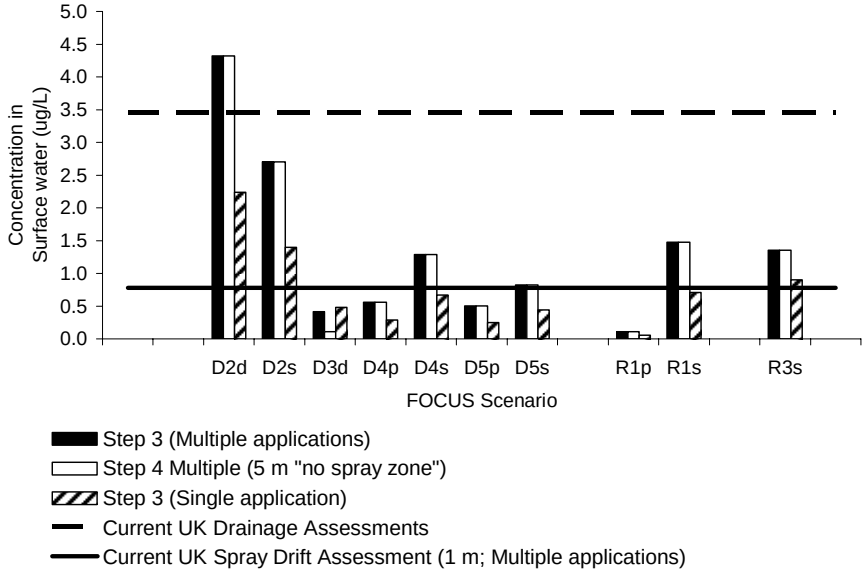


Figure 6.6.1.5 Exposure profile for modified FOCUS example chemical 5 as applied to winter oilseed rape

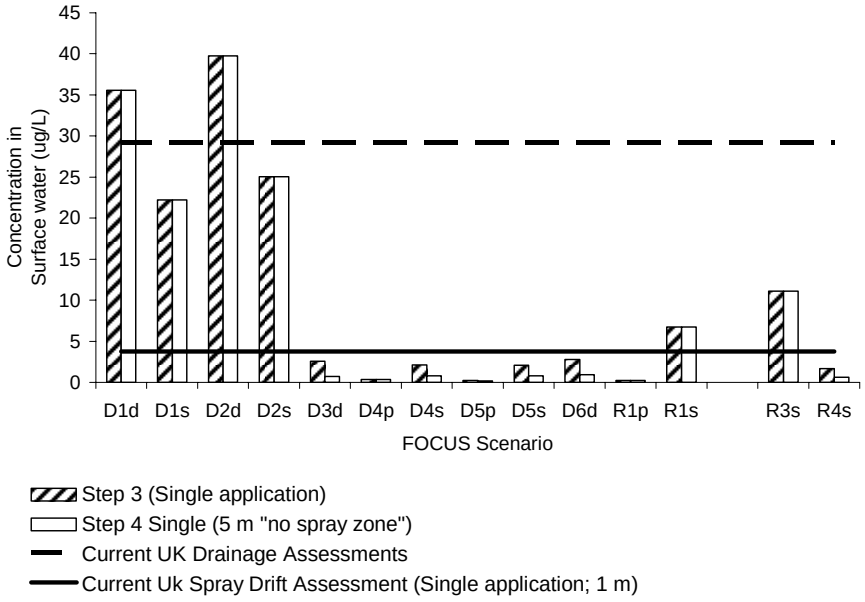


Figure 6.6.1.6 Exposure profile for modified FOCUS example chemical 6 as applied to winter cereals

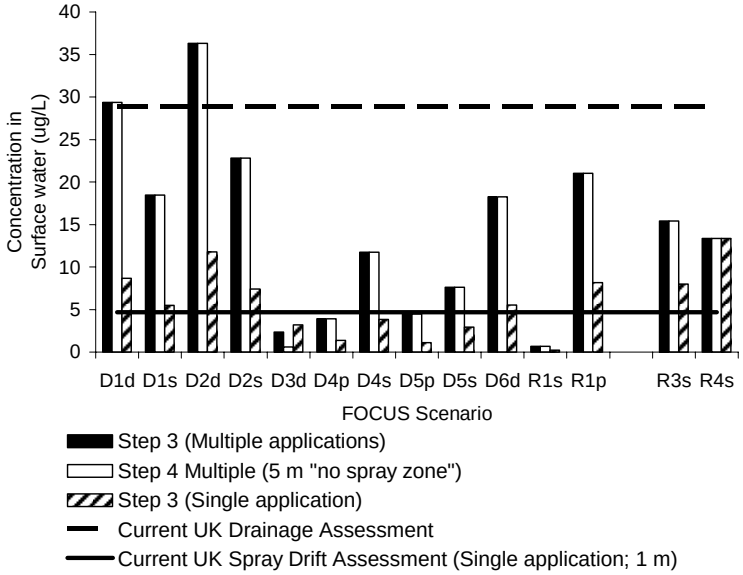


Figure 6.6.1.7 Exposure profile for modified FOCUS example chemical 7 as applied to winter cereals

Table 6.6.1.1 A comparison of maximum PEC_{SW} calculated using the FOCUS Step 3 (FOCUS scenarios of primary UK relevance; D2, D3, D4 and R1) and current UK drainage and spray drift schemes

Chemical	FOCUS Step 3 PEC as a % of the current UK drainage PEC	FOCUS Step 3 PEC as a % of the current UK spray drift (1 m)	FOCUS Scenario at Step 3	
			Minimum PEC	Maximum PEC
1	0 to 8	NA	D3d	R1s
2	2 to 53	13 to 305	D4p	R1s
3	0 to 87	3 to 1355	R1p	D2d
4#	73 to 1,357	2 to 33	D4p, R1p	D3d
5*	3 to 125	15 to 554	R1p	D2d
6	1 to 136	6 to 1,065	R1p	D2d
7*	2 to 126	15 to 777	R1p	D2d

*: results for multiple applications (worst-case); #: 3 m 'no spray' zone; NA: Not applicable (Chemical 1 is soil applied)

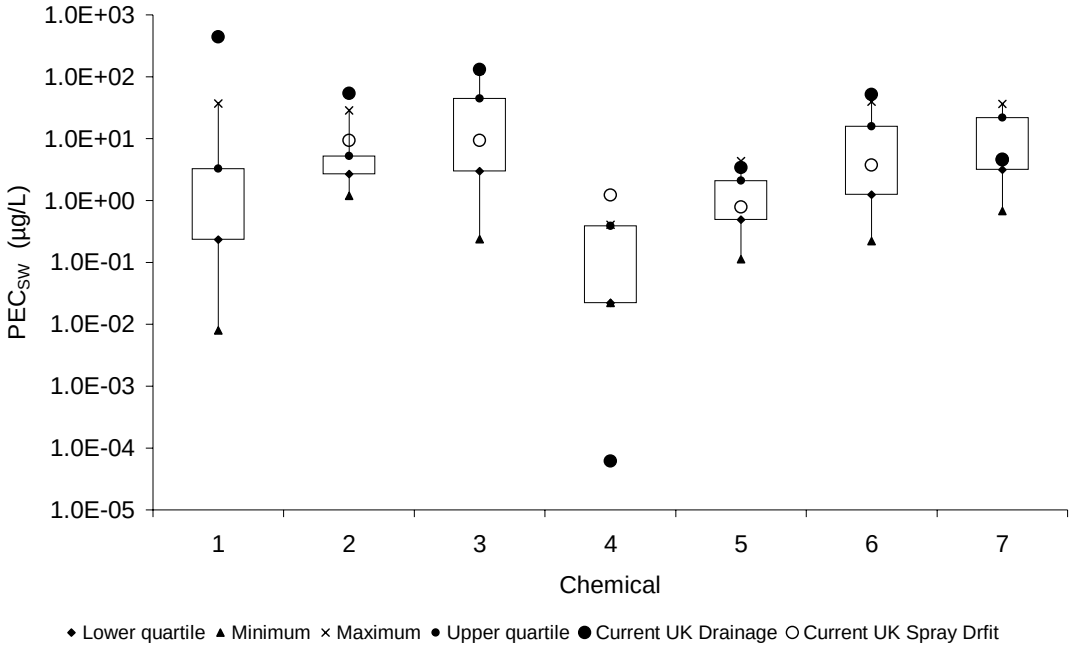


Figure 6.6.1.8 Summary of Initial PEC_{SW} values for Primary relevant FOCUS scenarios (D2, D3, D4 and R1) and a comparison with worst-case results for the current UK drainage and spray drift assessment. FOCUS Step 3 results for single applications are presented for chemicals 1-4 and 6; FOCUS Step 3 results for multiple applications are presented for chemicals 5 and 7.

Table 6.6.1.2 A comparison of maximum PEC_{SW} calculated using the FOCUS Step 3 (FOCUS scenarios of primary and secondary UK relevance; D1 – D5, R1, R3) and current UK drainage and spray drift schemes

Chemical	FOCUS Step 3 PEC as a % of the current UK drainage PEC	FOCUS Step 3 PEC as a % of the current UK spray drift (1 m)	FOCUS Scenario at Step 3	
			Minimum PEC	Maximum PEC
1	0 to 80	NA	D3d	R3s
2	1 to 155	6 to 893	D5p	R3s
3	0 to 87	2 to 1,355	D5p	D2d
4#	73 to 1563	2 to 39	D4p, D5p, R1p	R3s
5*	3 to 125	15 to 554	R1p	D2d
6	1 to 136	6 to 1,065	D5p	D2d
7*	2 to 126	15 to 777	R1p	D2d

*: results for multiple applications (worst-case); #: 3 m 'no spray' zone; NA: Not Applicable (Chemical 1 is soil applied)

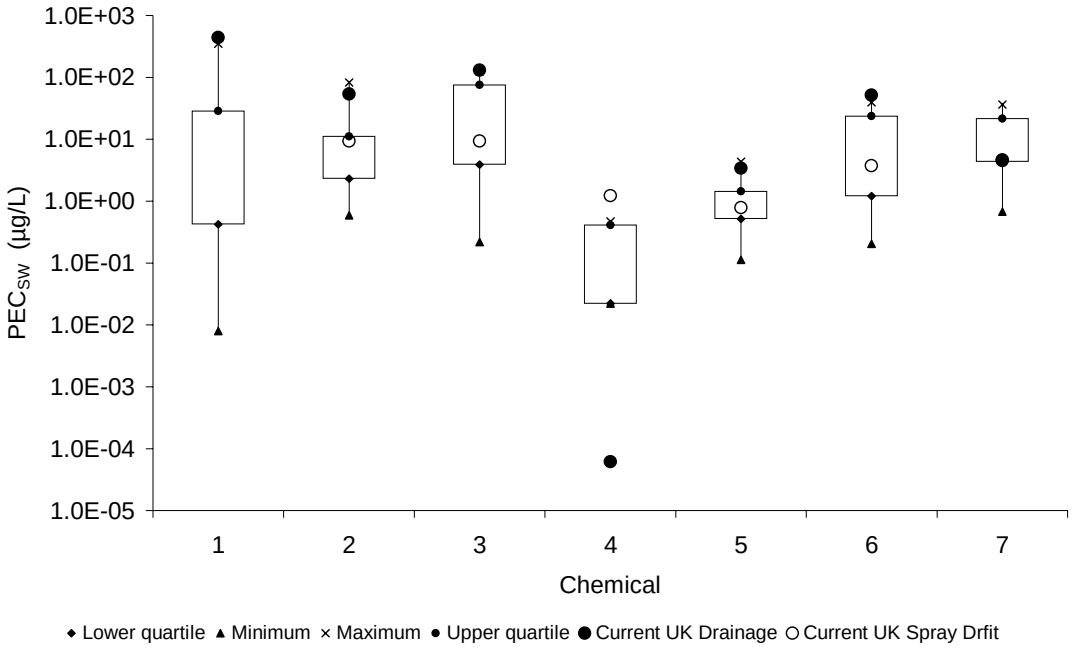


Figure 6.6.1.9 Summary of Initial PEC_{SW} values for Primary relevant FOCUS scenarios (D1, D2, D3, D4, D5, R1 and R3) and a comparison with worst-case results for the current UK drainage and spray drift assessment. FOCUS Step 3 results for single applications are presented for chemicals 1-4 and 6; FOCUS Step 3 results for multiple applications are presented for chemicals 5 and 7

6.7 Aquatic Risk Assessment for Chemicals 1 to 7 (FOCUS Step 3 and 4)

6.7.1 Risk Assessments at Step 3 and 4

Risk assessments have been carried out using the same methodology as in Appendix 1, Section 1.6. All risk assessments have been carried out using the maxPEC_{SW} values and the calculated TER values for chemicals 1 to 7 are given in Appendix 1, Section 1.9. The TER values are discussed with reference to specific aquatic species in Appendix 1, Section 1.9. A summary of the risk assessment is given in Table 6.7.1.1. The inclusion of only UK relevant scenarios makes little overall difference in terms of overall pass/fail ratios. None of the test chemicals pass all scenarios at Step 3 or Step 4. However, further refinement could be possible e.g. a 5 m buffer zone has been used for chemical 4 (where spray drift is the major contributing exposure route to surface waters), but larger buffer zones for orchard crops would be possible to use in the UK.

Table 6.7.1.1 Summary of the risk assessment for FOCUS Step 3 and 4 scenarios

Risk Assessment	Percent pass for each assessment								
	FOCUS Step 3 (Single application)			FOCUS Step 3 (Multiple applications)*			FOCUS Step 4 (Multiple applications)*		
	1^{ary} Relevant	1^{ary} + 2^{ary} Relevant	ALL	1^{ary} Relevant	1^{ary} + 2^{ary} Relevant	ALL	1^{ary} Relevant	1^{ary} + 2^{ary} Relevant	ALL
Acute[a]	88	87	85	86	86	84	88	89	87
Chronic[b]	68	62	60	67	60	58	68	62	60
Lemna	85	86	82	85	86	82	92	93	88

[a]: Average values for acute risk assessments to fish and aquatic invertebrates, and risks to algae
[b]: Average values for chronic risk assessments for fish and aquatic invertebrates
*: Multiple applications for chemicals 4, 5 and 7 only

6.8 Conclusions

The performance of the current UK risk assessment for exposure of pesticides to aquatic organisms in surface waters has been compared with the FOCUS framework (Steps 1 to 4). TERs were calculated using the risk assessment methodology established under 91/414/EEC.

The test chemicals used in this assessment were representative of a broad range of properties, including:

1. Variety of chemical classes (three herbicides, two insecticides and two fungicides)
2. Application rates from 12.5 g/ha to 3 kg/ha
3. Soil incorporated, ground spray and aerial blast applications
4. Various UK crop types including; potatoes, Winter Oilseed Rape, pome fruit, winter cereals
5. Single and multiple application rates
6. The use of 5 m 'no spray zones'
7. A broad range of environmental fate characteristics (e.g. range of DT_{50} in soil from 4 to 250 days)
8. A broad range of aquatic toxicity data

A summary of how the current UK assessment compares with the FOCUS scenarios is given in Table 6.8.1.

Table 6.8.1 Comparison between the risk assessments for the current UK and FOCUS SW scenarios assessments

Risk Assessment	Percent pass for each assessment						
	Current UK drainage	Current UK spray drift*	Step 1	Step 2 (NE)	Step $3^{m,\#}$	Step $3^{s,\#}$	Step $4^{\#}$
Acute[a]	66	83	38	38	84	87	87
Chronic[b]	23	75	7	7	58	62	60
Lemna	75	75	50	50	82	86	88

*: 1 m 'no spray zones for all crops, except apples that had a 3 m 'no spray zone'
[a]: Average values for acute risk assessments to fish and aquatic invertebrates, and risks to algae
[b]: Average values for chronic risk assessments for fish and aquatic invertebrates
[m] = multiple application; [s] = single application
[#]: All FOCUS scenarios

The Step 1 and 2 calculations, which consider spray drift and run-off/drainage losses, are more conservative than the current UK drainage and spray drift assessment.

The current UK spray drift assessment is comparable with the FOCUS Step 3 and Step 4 calculations; however, the current UK drainage assessment is more conservative than the FOCUS Step 3 and Step 4 calculations.

7.0 Conclusions and Regulatory Context

A review of the FOCUS surface water modelling framework was undertaken in order to establish relevance to aquatic landscapes within the United Kingdom. The primary objective was to determine the suitability of the existing scenario framework as a basis for decision-making, develop guidance for interpretation within a UK regulatory context and provide recommendations for provision of supplementary information by notifiers, where relevant, to clarify aquatic risk potential.

Among the aims of modelling exercises based on these scenarios is the attempted identification of relevant "safe usage" scenarios for a given product prior to Annex 1 listing. Since these scenarios are not necessarily representative of localised vulnerability conditions within each Member State it was recognised that in some cases further assessment may be required for individual Member States at the product registration/re-registration stage. Although the pedo-climatic relevance of the FOCUS surface water scenarios has been characterised earlier in this report, it is of importance to consider the broader regulatory ramifications of these findings and address three specific questions:

- Which FOCUS scenarios should companies be requested to use when calculating PECs for UK risk assessments?
- What supplementary information should companies be requested to supply to support relevant PEC calculations?
- What other information could companies be asked to provide if risk assessments are uncertain?

Each of these regulatory queries is addressed in detail within this chapter.

7.1 Which FOCUS scenarios should companies be requested to use when calculating PECs for UK risk assessments?

As described in Sections 3 and 4 of this report,

the scenarios that are of direct relevance to Great Britain are D2, D3, D4 and R1

,but not all of them are relevant for all crops and for small fruit and flowers & bulbs, there are no directly relevant scenarios. At a minimum therefore, for any specific crop, companies should be requested to calculate PEC's for all those FOCUS scenarios indicated in Table 4.2.3.3 in Section 4 as being directly relevant.

As shown in Figures 3.2.1 to 3.2.9, FOCUS scenarios D1, D5, D6, R2, R3 & R4 have soil characteristics that match with a range of soils in Great Britain, but their scenario climates are significantly different and for scenario R2, most of the soils are not under arable land use. It is recognised that results of simulations carried out with certain of these scenarios could provide a useful benchmark for assessing the scale of relative risk in the UK, providing they have relevant recharge or rainfall/run-off characteristics.

The areas of land with soil characteristics correlated with scenarios D1, D5, D6 and R3&4 under each relevant UK crop are summarised in Table 7.1.1. As with the data shown in figure 3.2.3-1, it is suggested that, because of the uncertainty of the cropping statistics used, any crop covering less than about 1000 ha of the scenario and representing less than about 1% of the total crop area should be discounted. Thus it is unlikely that scenario D6 soils are really associated with either small fruit or hops.

Scenario D1, which occurs mainly in England, has soil characteristics that correlate with small but significant areas of most types of relevant UK crops, except hops and, probably, small fruit. D1 soil characteristics are assessed to be the next most vulnerable to pesticide losses *via* field drainage, after scenario D2 (see Section 4.2.1). The scenario recharge is also relevant to significant areas of cropped land in Great Britain. The only scenario components that are unrepresentative of British agriculture are the mean daily spring and autumn temperature characteristics, which are colder than that of the correlated soil-recharge areas in Great Britain. However, this feature means that risk assessments based on the D1 scenario are likely to be 'worse' than would be the case for the correlated soil-recharge areas. Risk assessments using this scenario would thus 'cover' all the correlated soil-recharge areas of Great Britain in addition to all those drained areas that have significantly less risk of soil losses *via* drainage.

Table 7.1.1 Areas of land with soil characteristics correlated with scenarios D1, D5, D6 and R3&4 under relevant UK crops

Crop	Total crop area (ha)	D1 soil characteristics		D5 soil characteristics		D6 soil characteristics		R3&4 soil characteristics	
		Crop area	As a % of total crop	Crop area	As a % of total crop	Crop area	As a % of total crop	Crop area	As a % of total crop
Grass (managed)	5631045	132469	2	821797	15	73165	1	1033143	18
Winter Cereals	3285022	142059	4	461681	14	56994	2	358110	11
Spring Cereals	1525975	10428	1	136459	9	6081	0.4	66744	4
Winter OSR	380996	15991	5	56688	15	5269	1	32503	8
Spring OSR	153076	2120	3	13325	9	762	0.5	12704	8
Field Beans	122484	5797	5	14231	12	1976	2	15391	13
Sugar Beet	170066	10464	6	15983	9	8071	5	13374	8
Potatoes	235926	7864	3	21630	9	6157	3	11836	5
Legumes	134746	9157	7	12000	9	4531	3	19283	14
Maize	94772	4387	5	9675	10	1496	2	14815	16
Vegetables	119909	10579	9	4051	3	8722	7	9988	8
Top Fruit	24407	1391	6	1237	5	534	2	2623	11
Hops	4036	0	0	220	5	56	1	295	7
Small Fruit	14755	301	2	651	4	133	1	695	5
Flowers & bulbs	7249	389	5	287	4	776	11	729	10

Scenarios D5, D6, R3 & R4 all have soil characteristics that correlate with significant areas of British agriculture but have significantly warmer spring and autumn temperatures. D5 has a defined range of recharge that matches that of scenarios D2, D3 and D4, but, as indicated in Section 4.3.2, the rainfall run-off relationship for scenarios R3 and R4 are not representative of the UK. Seasonal run-off for the R3 scenario is less than that for R4 but is still significantly greater than for R1. It is thus suggested that R3 has a rainfall/run-off relationship that is most similar to the wetter parts of agricultural run-off land in the UK and represents a 'worst-case' for UK agricultural run-off. Based on this assessment, the only factor likely to make PEC's calculated using FOCUS scenarios D5 and R3 lower than those of equivalent areas in the UK is the scenarios warmer temperature regime. However, it is noted that rainfall intensity in the R3 scenario is likely to be more challenging than would be experienced where parallel soil conditions occur in the UK.

A favourable aquatic risk assessment for these scenarios could thus indicate that

aquatic ecosystems in significant areas of UK agriculture would be covered if it could be shown that the impact of lower UK temperatures was insignificant. Areas of the UK that would be 'covered' by risk assessments including scenarios of primary relevance and those of secondary relevance, which are extended to include relevant UK crops, are given in Table 7.1.2. Also included in the final column of the table is the area of land that would not be 'covered' by such risk assessments.

Table 7.1.2 Percentage areas of individual UK crops that are covered by risks assessments using FOCUS_SW scenarios of primary relevance and that would be covered by risk assessments using scenarios of primary relevance combined with suitably modified scenarios of secondary relevance

Crop	Total crop area (ha)	Scenarios of primary relevance	Percentage of total crop area 'covered' by these scenarios	Scenarios of secondary relevance	Percentage of total crop area 'covered' by combining the scenarios of primary and secondary relevance	Area (ha) not 'covered' by the combined scenarios
Grass (managed)	5631045	D2, D3, D4	50	D1, D5, R3	86.4	767915
Winter Cereals	3285022	D2, D3, D4, R1	95	D1, D5, R3	98.7	43052
Spring Cereals	1525975	D3, D4	30	D1, D5, R3	98.9	16357
Winter OSR	446340	D2, D3, D4, R1	97	D1, D5, R3	99.0	4574
Spring OSR	87732	D3, D4, R1	82	D1, D5, R3	96.6	3021
Field Beans	122484	D2, D3, D4, R1	95	D1, D5, R3	98.6	1768
Sugar Beet	170066	D3	36	D1, D5, R3	99.5	801
Potatoes	235926	D3, D4, R1	82	D1, D5, R3	98.4	3733
Legumes	134746	D3, D4, R1	73	D1, D5, R3	98.4	2095
Maize	94772	D3, D4, R1	55	D2, D5, R3	92.2	7432
Vegetables	119909	D3, D4, R1	77	D1, D5, R3	98.8	1444
Top Fruit	24407	D4, R1	72	D1, D5, R3	97.2	676
Hops	4036	R1	70	D5, R3	98.4	65
Small Fruit	14755	None	0	D5, R3	98.7	194
Flowers & bulbs	7249	None	0	D1, D5, R3	93.9	439

Therefore, it is recommended that companies provide as a minimum, assessments carried out with the following scenarios:

- **Drainage: D1, D2, D3, D4, D5**
- **Run-off: R1, R3**

7.2 What supplementary information should companies be requested to supply to support relevant PEC calculations?

Under certain circumstances it may be considered appropriate for notifiers to submit additional information to assist in clarifying exposure and risk potential within the recommended range of scenarios.

For most crops, favourable aquatic risk assessments based on the recommended combination of primary and secondary scenarios are likely to cover virtually all the relevant land in Great Britain. However, concerns may remain where significant areas of the crop are not covered by the recommended scenarios or where the risk assessments are marginal for some scenarios.

Areas of land not 'covered' by risk assessments using the combined primary and secondary relevant FOCUS SW scenarios are given in the final column of Table 7.1.2.

In order to give an idea of the spatial distribution of these areas, maps of England and Wales showing the distribution of such land under permanent (managed) grass, cereals, maize, sugar beet, potatoes and flowers and bulbs are given in Figures 7.2.1 to 7.2.7. In each case, the coloured grids in the Figures show the distribution of the 'worst-case' soil scenario for drainage (top map) and run-off (bottom map) in areas that are significantly wetter than the climate used to characterise the FOCUS worst-case drainage or run-off scenario.

For permanent grass (Figure 7.2.1) and cereals (Figure 7.2.2), the D2 and R3 soils represent the worst-case for soil conditions relevant to drainage and run-off in Great Britain. Both crops are widely distributed across the three countries, although grass has a bias to the west whereas cereals have a bias to the east (see Section 3.2.3). The areas not 'covered' by risk assessments carried out using the combined relevant scenarios reflect this distribution combined with the distribution of the worst-case soils. Thus drained areas not covered are concentrated in the south of England and particularly in the counties of Sussex, Somerset and Gloucestershire. Small areas of south Wales are also not covered. Run-off areas not covered are more extensive, particularly for permanent grass, and cover large parts of south west England and Wales.

For maize (Figure 7.2.3), sugar beet (Figure 7.2.4), potatoes (Figure 7.2.5) and bulbs and flowers (Figure 7.2.6), D1 and R3 soils represent the worst-case for soil conditions relevant to drainage and run-off in Great Britain.

All four crops have a much more localised distribution than permanent grass or cereals, as indicated in Section 3.2.3, and the areas not 'covered' by risk assessments carried out using the combined relevant scenarios are much more dependent on the location of the crops in relation to the relevant worst-case soils. Thus for maize and potatoes, the total hectarage of drained land not covered by risk assessments using combined relevant FOCUS scenarios is small, but such land is distributed across much of central and south western England and south Wales. Run-off areas not covered are focussed in south west England and south Wales. In contrast the location of sugar beet growing areas means that very little land, mostly in the western midlands and north east of England, is not covered by risk assessments carried out using the combined relevant scenarios.

Bulbs and flowers have an even more localised distribution than the other crops considered here, but the distribution of the small amount of land that would not be

covered by risk assessments carried out using the combined relevant scenarios is broadly similar to that of maize and potatoes.

Finally, hops (Figure 7.2.7) are the most localised of all crops in Great Britain, being concentrated in the counties of Kent and Worcester and Herefordshire. For this crop D5 soils represent the worst-case for soil conditions relevant to drainage and, whereas such soils occupy only a small fraction of all soil types under the crop, most occur in hop growing areas that are wetter than the climate of the existing D5 scenario and thus would not be covered by risk assessments using a modified D5 scenario. R1 soils represent the worst-case for soil conditions relevant to run-off under hops and also are the most common soil type under the crop. However, because the existing R1 scenario climate is slightly wetter than that of D5, relatively small areas of R1 soils under hops are not covered by risk assessments using the R1 scenario.

It is thus recommended that, for registration in the UK, where there are concerns about the amount of cropped land not covered by the recommended scenarios, or the marginal nature of specific risk assessments, companies may also be asked to consider:

- **Submission of an aquatic risk assessment for the worst-case soil scenarios (as indicated in table 7.1.2) modified to represent the worst-case climatic conditions relevant to the spatial distribution of the worst-case soil scenario.**

Figure 7.2.1 Distribution of areas in England & Wales under permanent grass that would not be 'covered' by risk assessments using the D2 (top map) and R3 (bottom map) scenarios

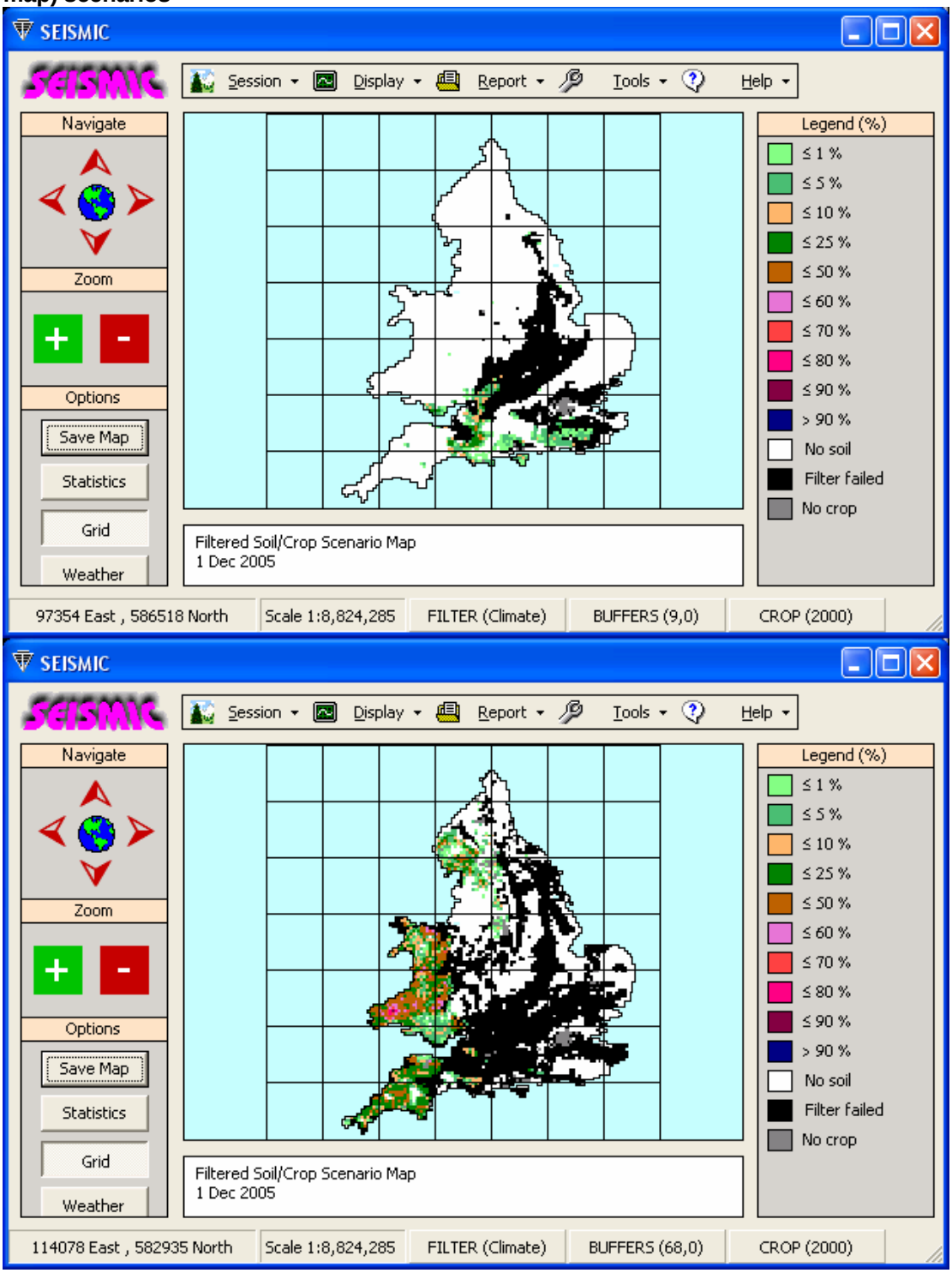


Figure 7.2.2 Distribution of areas in England & Wales under cereals that would not be 'covered' by risk assessments using the D2 (top map) and R3 (bottom map) scenarios

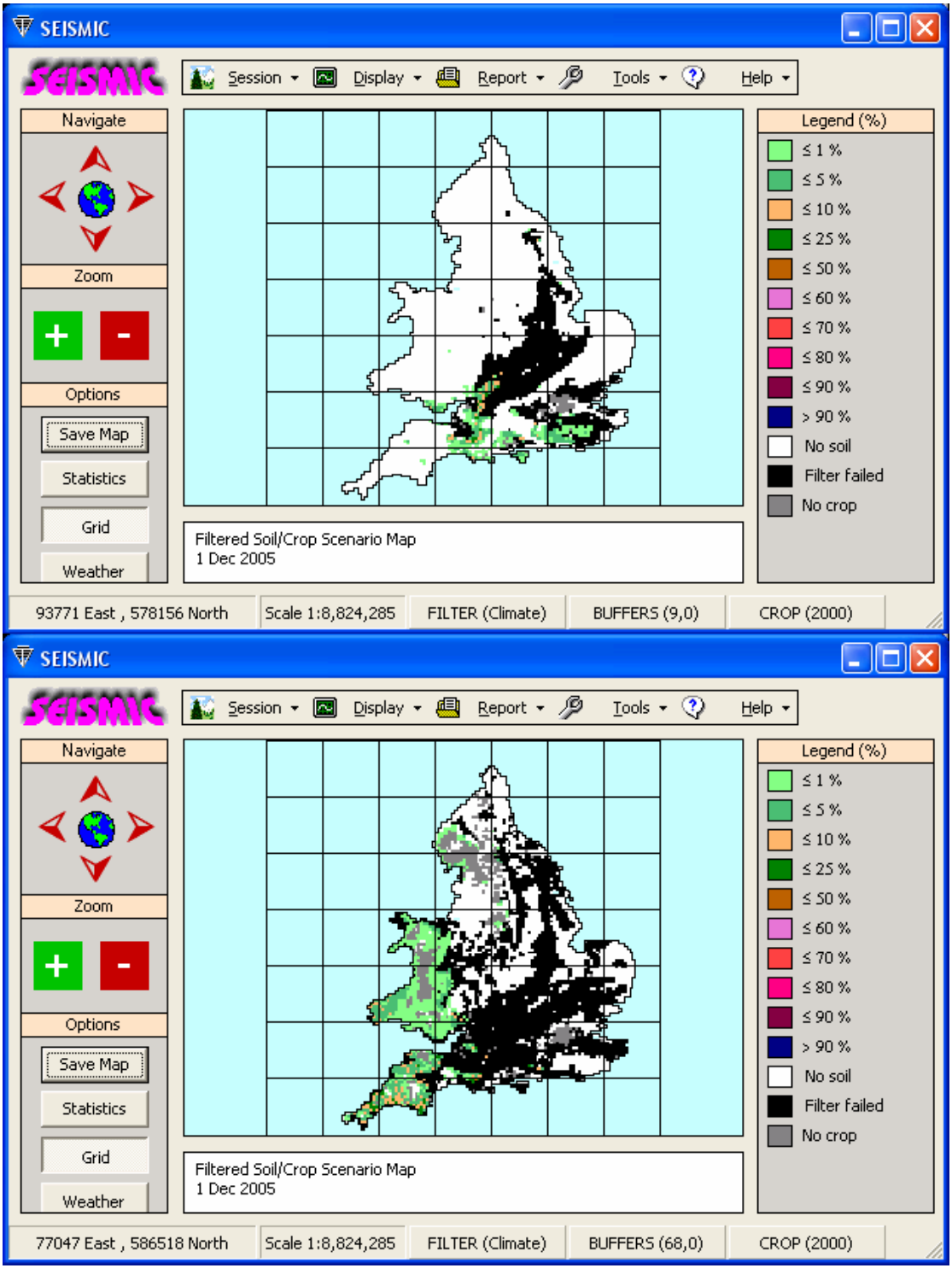


Figure 7.2.3 Distribution of areas in England & Wales under maize that would not be 'covered' by risk assessments using the D2 (top map) and R3 (bottom map) scenarios

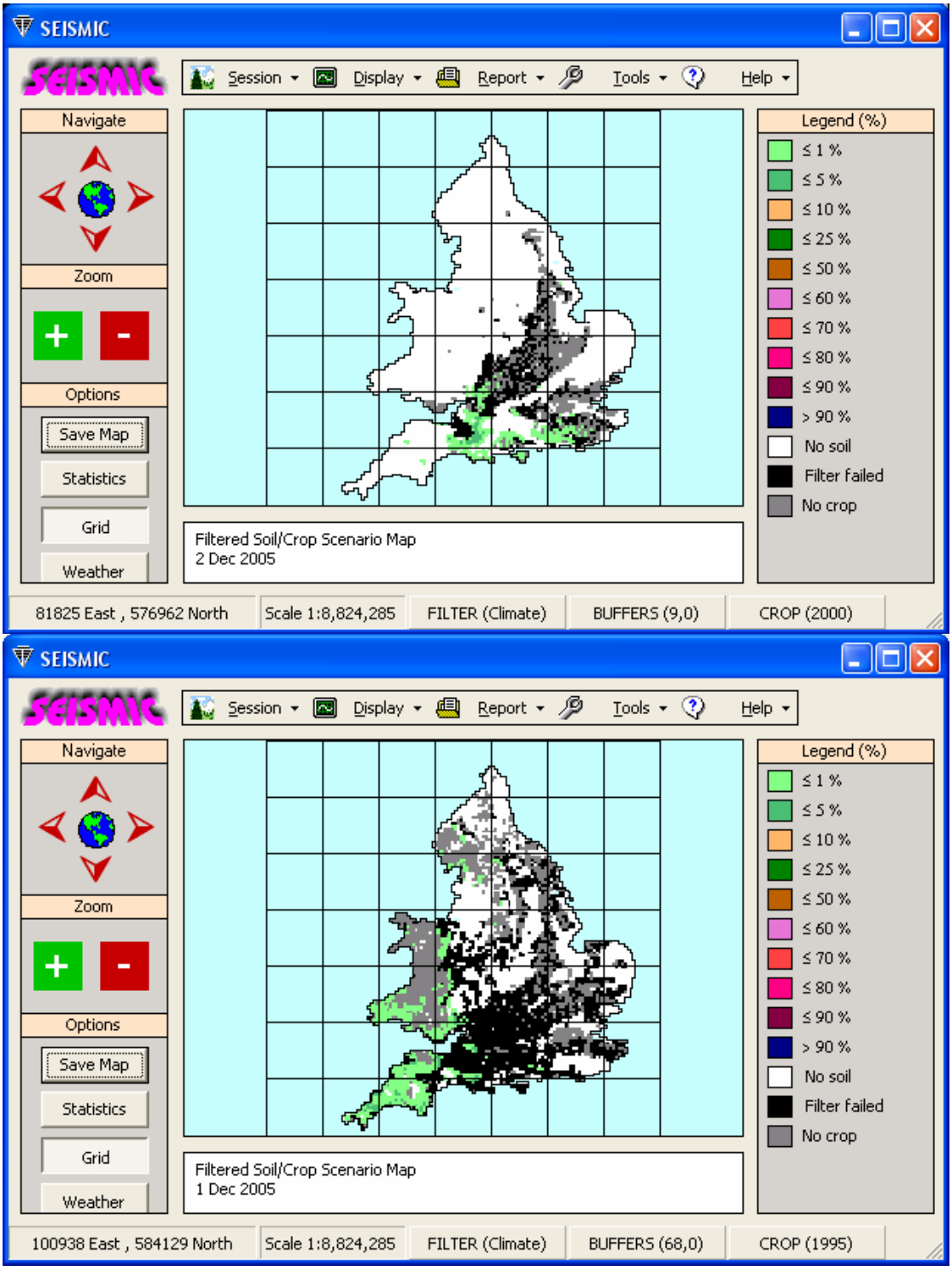


Figure 7.2.4 Distribution of areas in England & Wales under sugar beet that would not be 'covered' by risk assessments using the D1 (top map) and R3 (bottom map) scenarios

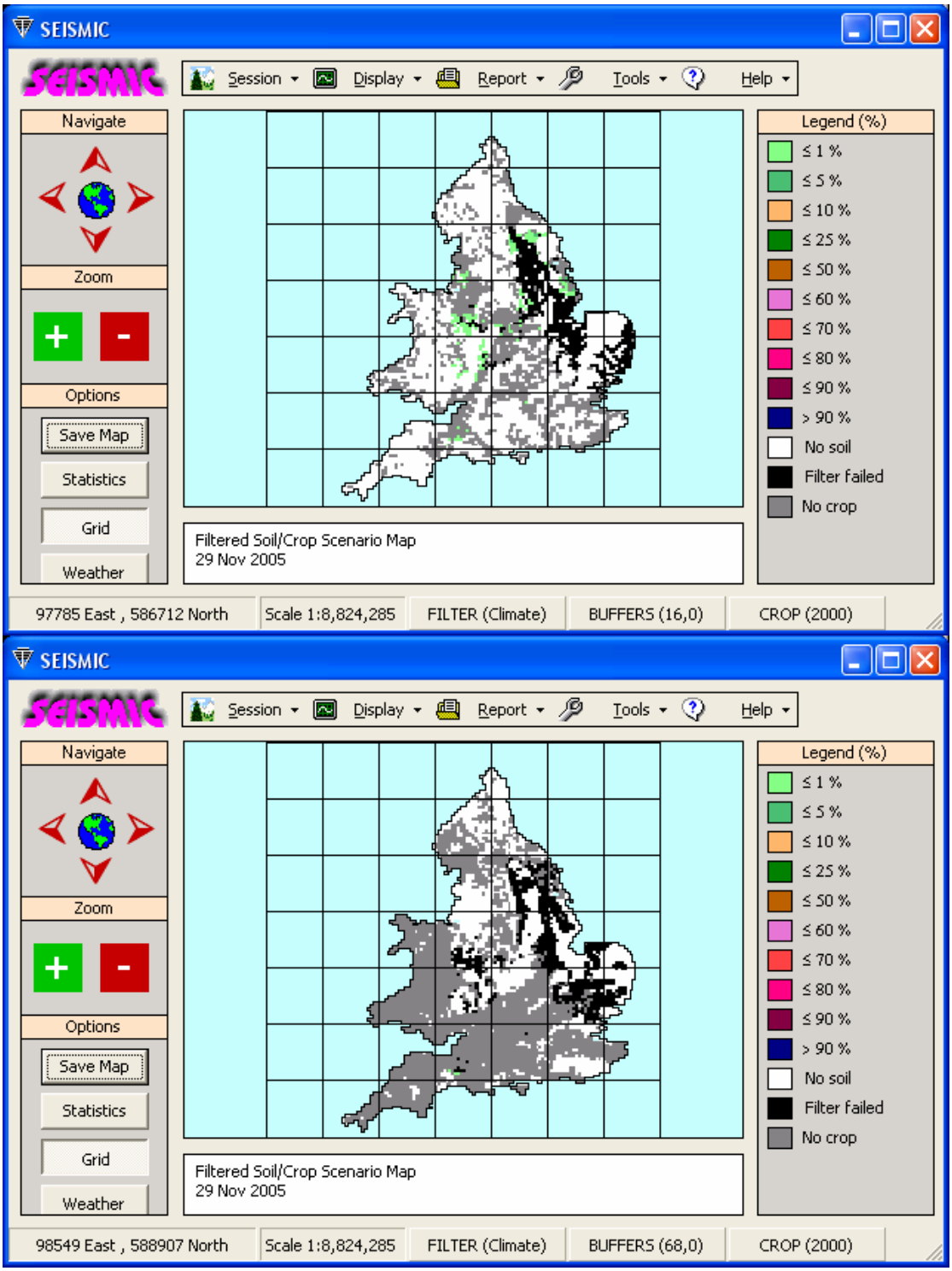


Figure 7.2.5 Distribution of areas in England & Wales under potatoes that would not be 'covered' by risk assessments using the D1 (top map) and R3 (bottom map) scenarios

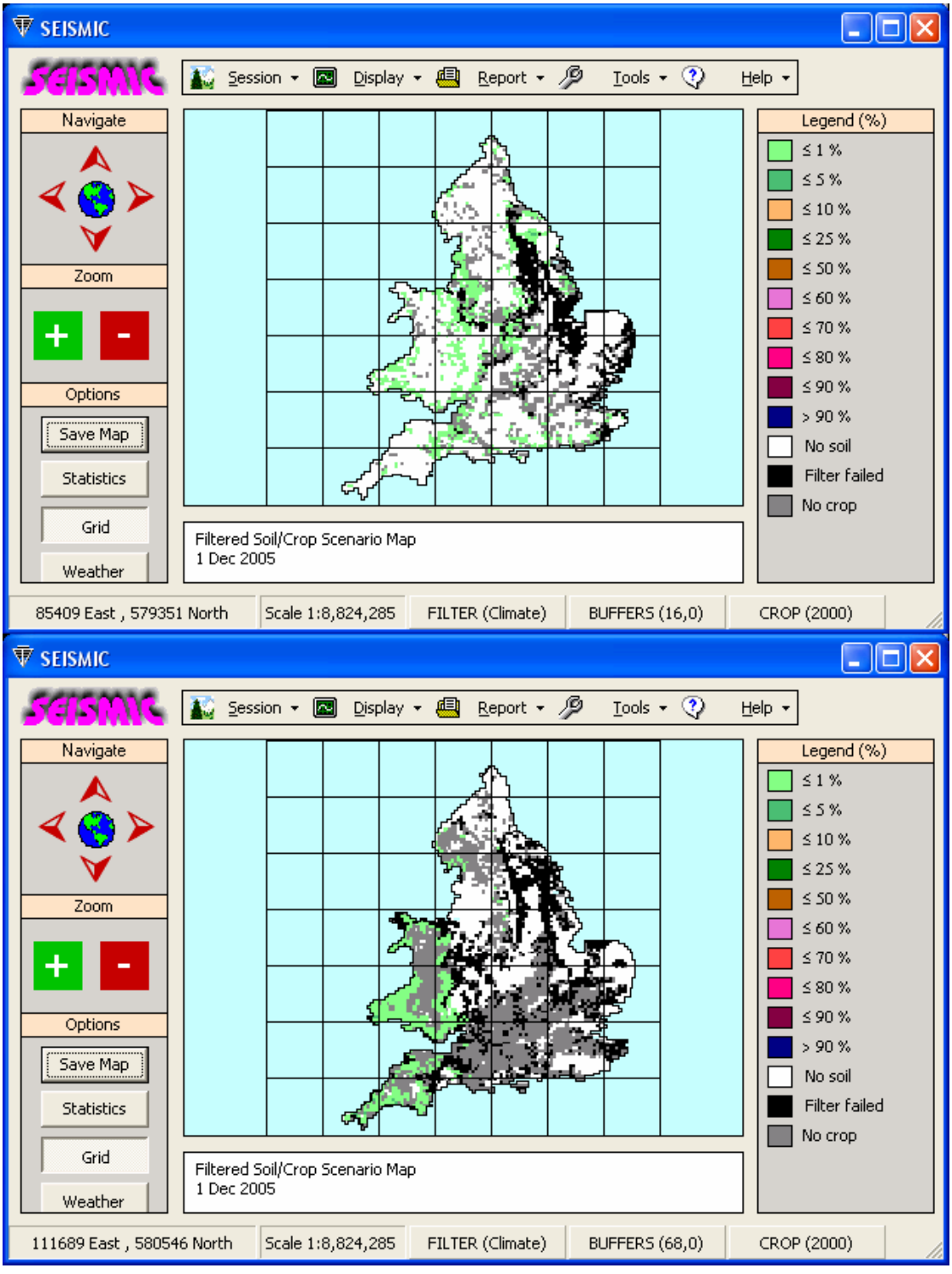


Figure 7.2.6 Distribution of areas in England & Wales under bulbs and flowers that would not be 'covered' by risk assessments using the D1 (top map) and R3 (bottom map) scenarios

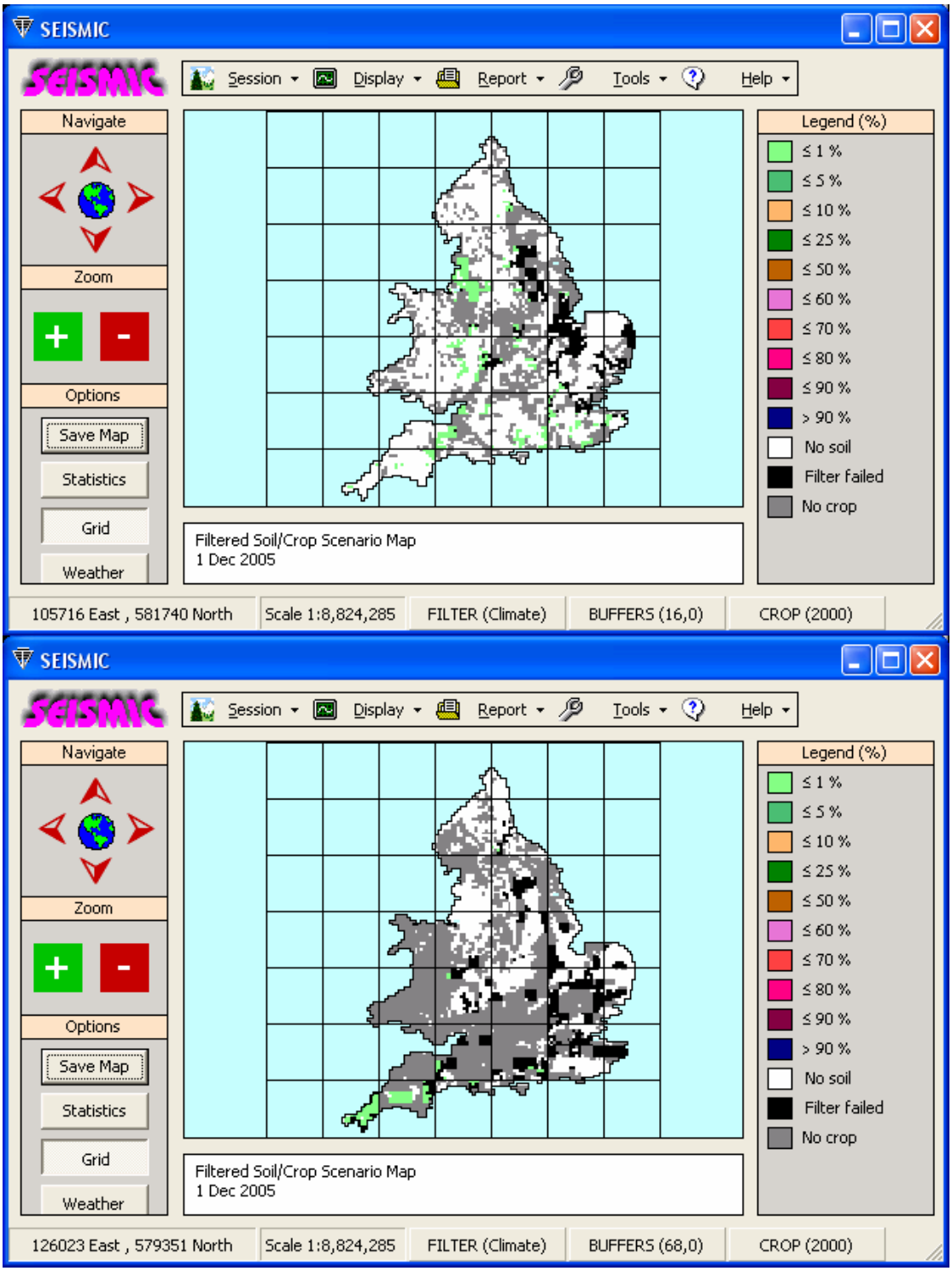
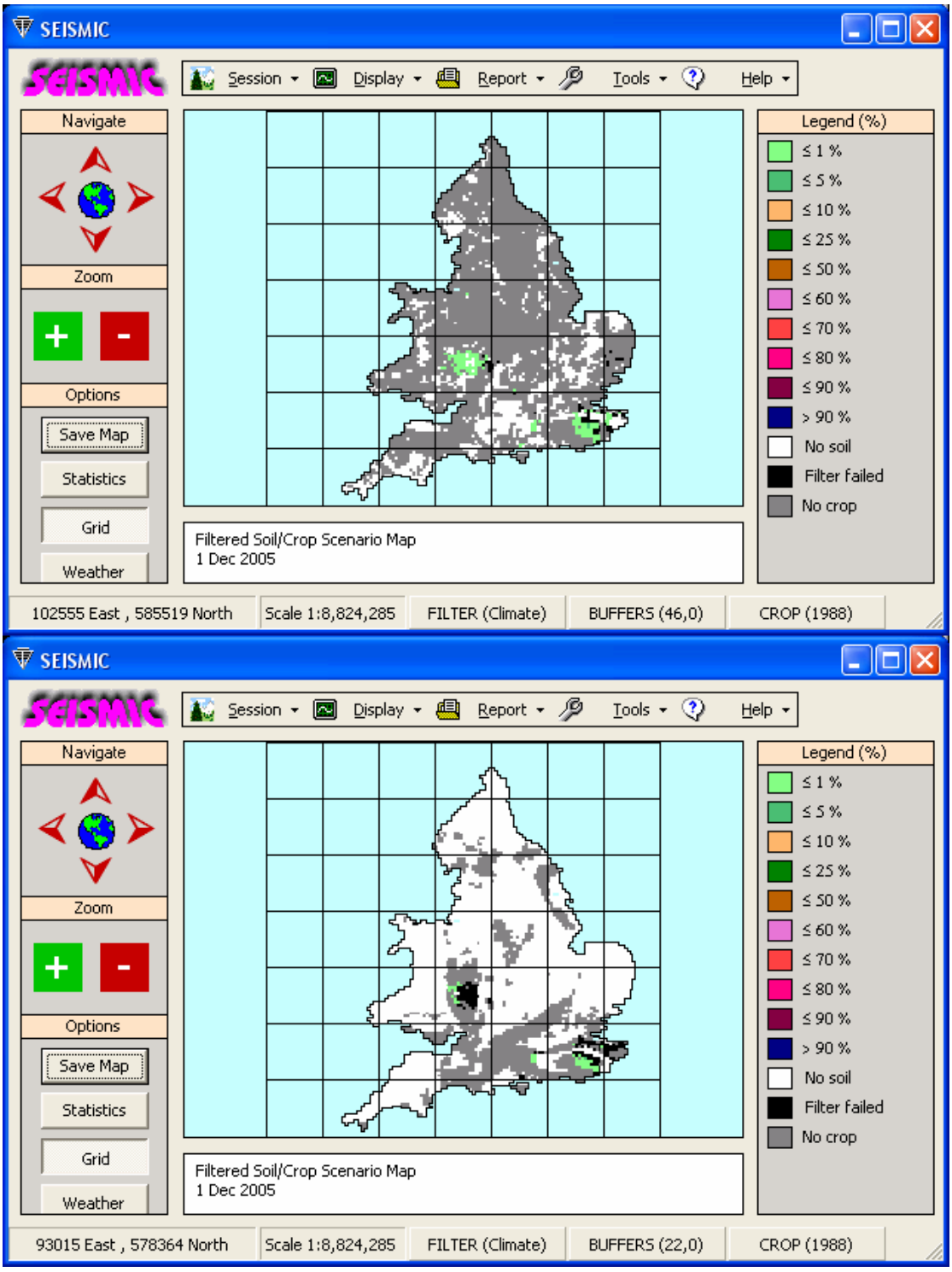


Figure 7.2.7 Distribution of areas in England & Wales under hops that would not be 'covered' by risk assessments using the D5 (top map) and R1 (bottom map) scenarios



7.3 What other information could companies be asked to provide if risk assessments are uncertain?

Following conduct of FOCUS Step 3 surface water modelling for England and Wales uncertainties may remain associated with three issues:

- D2 and D1 both fail but all other drainage scenarios give a favourable risk assessment.
- D1, D2 and D5 or a modified D5 fail.
- D3, D2 and D1 fail but D4 and a modified D5 give a favourable risk assessment

The focus of further assessments would then be to reduce uncertainty through characterising behaviour under a range of conditions that would otherwise have been protected by scenario D2. Further modelling could be conducted under alternative pedoclimatic regimes in a manner similar to that undertaken by Brown *et al.* (2004). A summary of this study is provided below:

Within this assessment field monitoring and scenario-based modelling were used to characterise exposure of small ditches in the UK to a herbicide (sulfosulfuron) following transport *via* field drains. A site in central England on a high pH, clay soil was treated with sulfosulfuron and concentrations were monitored in the single drain outfall and in the receiving ditch. MACRO was then used to simulate long-term fate of the herbicide for a broad range of environmental scenarios described below;

The target area (wheat-growing land in England and Wales; *ca*. 1.7×10^6 ha) was divided into environmental scenarios comprising discrete classes of soil type and climate. The soil series making up the drained wheat area were then divided into six broad classes (Table 7.2.1) based upon vulnerability for leaching of the acidic herbicide *via* drainflow. The division was made subjectively based on the relative mobility of sulfosulfuron (determined by soil pH) and the prevalence of rapid movement to drains *via* macropore flow (determined by clay content and structure). A representative soil series was selected as lying at the vulnerable end of each of the five remaining classes (Table 7.2.2). For each representative series, profile information was extracted from SEISMIC and used to parameterise MACRO.

Areas of wheat cultivation in England and Wales were divided into four approximately equal climatic classes designated 'dry' (<625 mm precipitation per annum), 'medium' (625-750 mm p.a.), 'wet' (750-850 mm p.a.) and ‘very wet’ (>850 mm p.a.). Four weather datasets were then selected from the SEISMIC database as representative of the four climatic classes. Average annual rainfall for the four datasets was 588, 713, 815 and 1115 mm (Table 7.2.2). The model was then run for the 20 scenarios resulting from the combination of five soil and four climate classes and assuming annual applications of the test compound in the spring of each of 30 years.

Resulting estimates for concentrations of sulfosulfuron in a receiving ditch were weighted according to the prevalence of each scenario to produce a probability distribution of daily exposure.

The example outlined above is a product-specific example, designed to assess drainage behaviour in the broad range of drainage soils in England and Wales. It should be noted that an assessment to provide further information on drainage behaviour of products should be customised to address environmental fate and behaviour of the product in question (e.g. pH relationship in the case of sulfosulfuron) and the range of drainage conditions already assessed *via* the FOCUS framework.

As a consequence, it is likely that a different range of soils may be assessed to address specific concerns than are described by Brown et al. (2004).

In addition, it should be recognised registrants can consider conducting further practical assessment (laboratory or field work) to challenge modelling assumptions – either in terms of modelling input or through direct evidence of behaviour in the field. Further investigations could include consideration of the impact of changing default assumptions related to surface water characteristics (e.g. significance of upstream catchment, density of usage, depth and flow characteristics) to better reflect UK conditions.

Table 7.3.1 Division of the wheat-growing land in England and Wales into soil vulnerability classes

Representative soil series	**Description of soil class**		**Proportion of wheat-growing land (%)**
Denchworth	Clayey soils with a strong inhibition to downwards movement of water which have a soft impermeable layer within 100 cm of the soil surface and a gleyed layer within 70 cm depth		7.0
Hanslope	Soils with clayey upper layers	Soils with either (a) significant inhibition of downwards movement of water which have a slowly permeable and a gleyed layer within 100 cm of the soil surface, or (b) prolonged seasonal saturation and a gleyed layer within 40 cm of the soil surface as a result of shallow groundwater	15.5
Brockhurst	Soils with clayey lower layers and lighter-textured upper layers		15.1
Clifton	Medium loamy and silty soils		9.2
Quorndon	Relatively permeable soils with a gleyed layer within 40 cm of the soil surface as a result of shallow groundwater		3.8
(None assigned)	Soils with humus or peaty layers		3.5

Table 7.3.2 Annual rainfall statistics (30 years) for the weather stations selected to represent the three climate scenarios (all values in mm)

Year	Cambridge (dry scenario)	Mylnefield (medium scenario)	Keele (wet scenario)	Rosemaund (very wet scenario)
30-year average	588	713	815	1115
Standard deviation	80	86	99	119
Minimum	447	526	614	858
Maximum	784	872	977	1361

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Appendix 1

1.1 Foliar wash-off coefficient determination

The FOCUS Surface Water Working Group have proposed consideration of foliar processes within their standard assessment framework (FOCUS, 2001). A default value for the foliar dissipation half-life (the overall rate of degradation and/or volatilisation from plant surfaces) of 10 days is recommended. This follows guidance in an EU document on bird and mammal risk assessment (SANCO/4145/2000, 2002). Wash-off from plant surfaces is modelled using a relationship based on foliar mass of pesticide, a foliar wash-off coefficient and rainfall amount. The amount of material lost from the plant surface during a simulated rainfall event is modelled by:

$$M = M_0 \times e^{\left(-F_{extrc} \times R\right)} \qquad \text{Equation 1.1.1}$$

where:

M = mass of pesticide on foliage after rainfall event
M_0 = mass of pesticide on foliage before rainfall event
F_{extrc} = foliar extraction coefficient
R = amount of rainfall

The foliar extraction coefficient is the FOCUS Surface Water foliar wash-off coefficient and a default value of 0.5 cm^{-1} (PRZM) and 0.05 mm^{-1} (MACRO) is recommended. However, this is based on a regression equation:

$$F_{extrc} = 0.016 \times Sol^{0.3832} \qquad \text{Equation 1.1.2}$$

where:

Sol = pesticide aqueous solubility (mg/L)

The default value corresponds to a water solubility of 8000 mg/L and is, therefore, appropriate for moderately to highly soluble pesticides. However, for the purposes of this comparison the foliar wash-off coefficients have been calculated for each pesticide (Table 1.1.1).

Table 1.1.1 Calculated foliar wash-off values

Parameter	Test Chemicals						
	1 (I)	2 (H)	3 (H)	4 (I)	5 (F)	6 (H)	7 (F)
Foliar Wash-off (PRZM; cm^{-1})	0.449	0.059	0.188	0.001	0.017	0.090	0.023
Foliar Wash-off (MACRO; mm^{-1})	0.045	0.006	0.019	0.000	0.002	0.009	0.002

1.2 Calculation of dissipation rates in water phase

Degradation rates in water and sediment were provided for each chemical. Separate degradation rates in water and sediment are required for FOCUS Step 2, 3 and 4 calculations. However, the current UK assessment uses an overall dissipation rate from the water phase, which encompasses degradation in water, partitioning to sediment and any volatilisation and decline rate from sediment, taken directly from the water/sediment study – this information was not available in the FOCUS surface water documentation (2001) and therefore had to be calculated. Dissipation rates in water for use in the current UK assessment were calculated using TOXSWA. TOXSWA ditch scenarios were modified to represent static water bodies. The ratio of sediment:water were set to mimic typical water/sediment studies from which dissipation rates are normally calculated. The scenarios and parameters that were modified in the relevant TOXSWA input files (*.txw files) are listed in Table 1.2.1 with parameter definitions in Table 1.2.2.

Table 1.2.1 Scenarios and parameters that were modified to mimic water/sediment studies in order to calculate water dissipation rates for chemicals 1 to 7

Test Chemical	Scenario modified	Parameters in *.txw		Parameters in Other files	
1, 2 and 4	D1 ditch	Wdh (m)	0.4	*.met	Temperature set to 20°C
		u (m/d)	0		
3, 6 and 7	D3 ditch	Crestbodyrc (m)	0.5		
		Wicrestrc (m)	0.4	*.m2t	Drainage and pesticide flux set to 0 for all days
5	D5 ditch	Qbasewc (m^3/d)	0.05		
		Qbaserc (m^3/day)			
		Arupwc (ha)	0.0		

Table 1.2.2 Definition of modified parameters in the *.txw file

Parameter	Units	Definition
Wdh	m	If op_valf=0, (constant flow of water in time and space) constant water depth (in pond or in watercourse)
u	m/day	Constant flow velocity (in pond or in watercourse)
Crestbodyrc	m	Height of weir crest above the channel bottom of the representative channel
Wicrestrc	m	Crest width of weir, located at the outflow of the representative channel
Qbasewc	m^3/day	Base flow, i.e. minimal inflow into watercourse, (occurring even when there is no drainage or run-off water entering)
Qbaserc	m^3/day	Base flow, i.e. minimal inflow into representative channel (occurring even when there is no drainage or run-off water entering)
Arupwc	ha	Size of the area located upstream of the watercourse, from which drainage or run-off water will flow across the upstream end of the watercourse.

The ratios of sediment to water was 1 to 4, which is typical of a sediment/water study used to calculated dissipation rates of test chemicals in water. The sediment depth

was 10 cm and the water depth was modified from 50 to 40 cm. The constant flow velocity and base flow characteristics were set to 0 and 0.05 m^3/day, respectively. The calculated residence time of the water in each water body was 800 days. The base flow could not be set to 0, therefore 0.05 m^3/day was used as surrogate zero. The area of the upstream catchment was set to zero and the height of the weir was increased from 0.4 to 0.5 to limit water flow out of the ditch. The weather files were modified so that a constant temperature of 20°C was maintained and inputs of water *via* rainfall were set to zero. The chemical loading was solely via spray drift loading and the drainage loadings in the *.mt2 files were set to zero.

Concentrations remaining in water were taken from the TOXSWA output files and single first order (SFO) kinetics were used to derive dissipation rates for chemicals 1 to 7. Dissipation rates were calculated using ExcelSolver. The equation used to model the dissipation rate was:

$$C_t = C_0 \times \exp(-k \times t) \qquad \text{Equation 1.2.1}$$

Where C_t is the concentration remaining at Time (t); C_0 is the concentration of chemical remaining at time 0; k is the rate constant; and t is the time interval

The DT_{50} value can be calculated as:

$$DT_{50} = \ln(2)/k \qquad \text{Equation 6.2.2}$$

Figures 1.2.1 to 1.2.7 show the dissipation of chemicals 1 to 7 in the water phase. Table 1.2.3 summarises the calculated dissipation rates for chemicals 1 to 7.

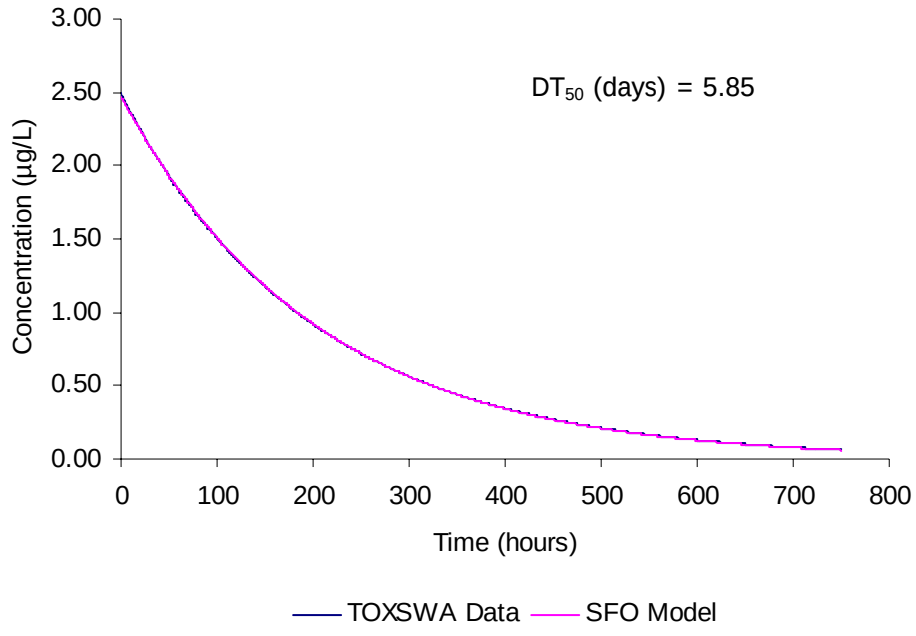


Figure 1.2.1 Dissipation rate of Chemical 1 in the water phase

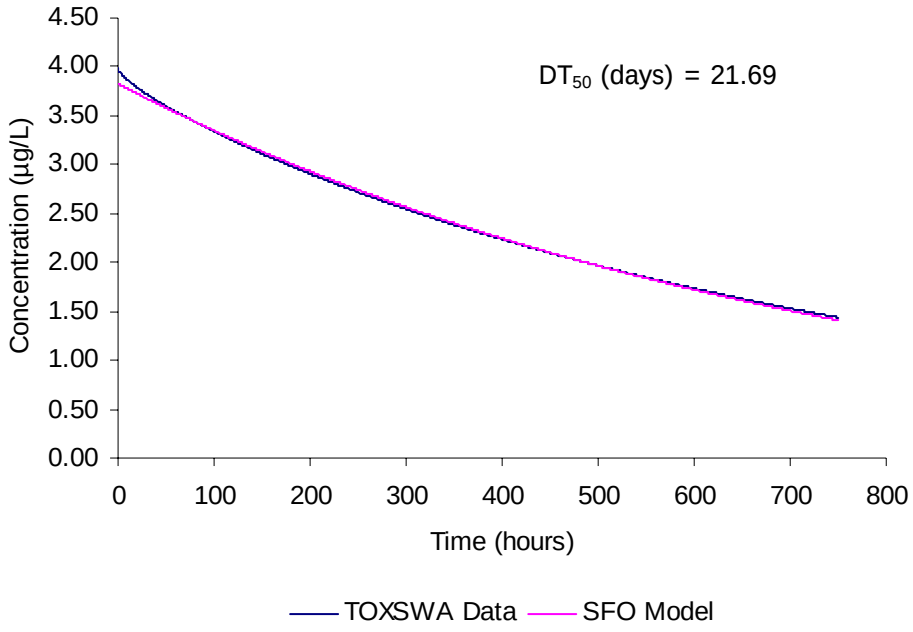


Figure 1.2.2 Dissipation rate of Chemical 2 in the water phase

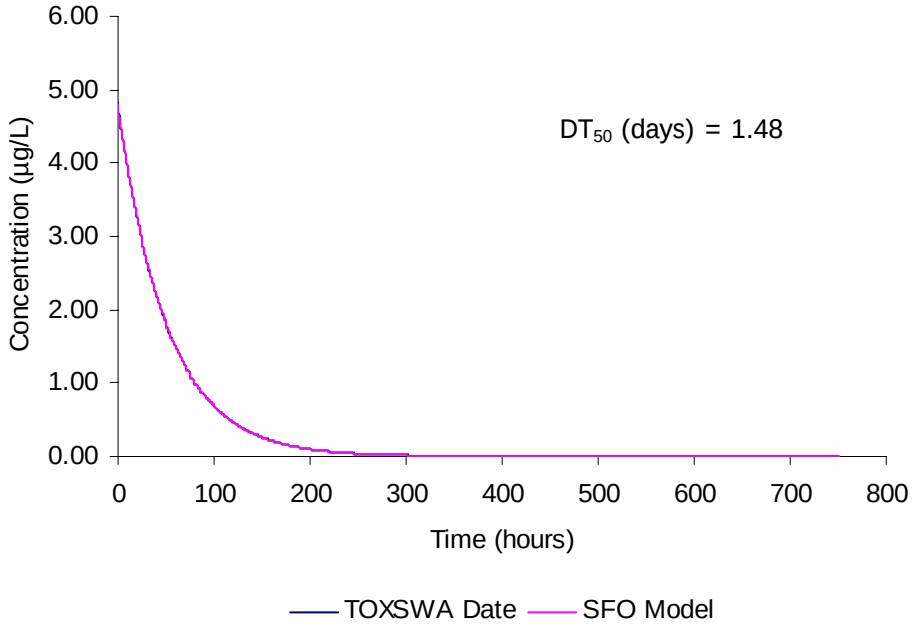


Figure 1.2.3 Dissipation rate of Chemical 3 in the water phase

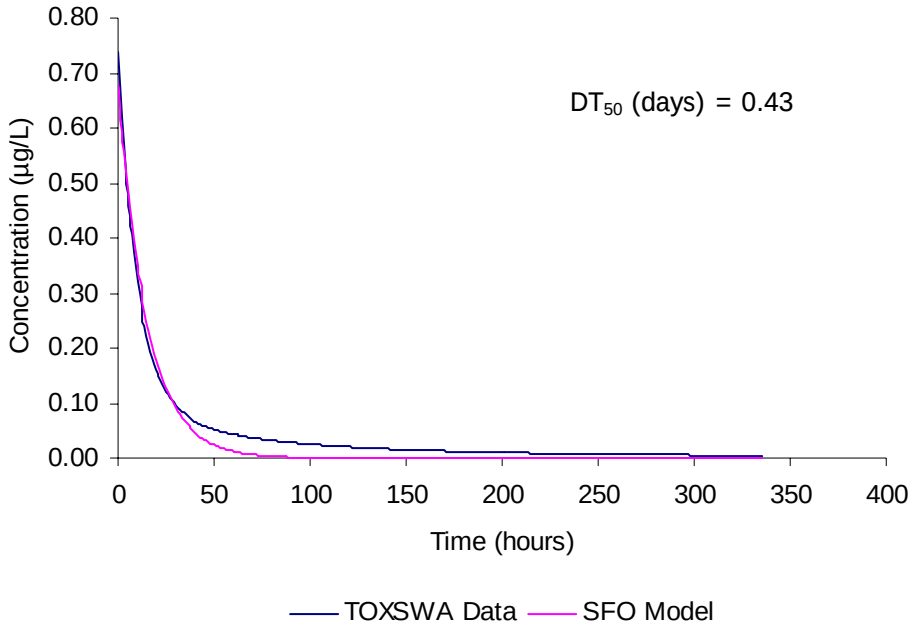


Figure 1.2.4 Dissipation rate of Chemical 4 in the water phase

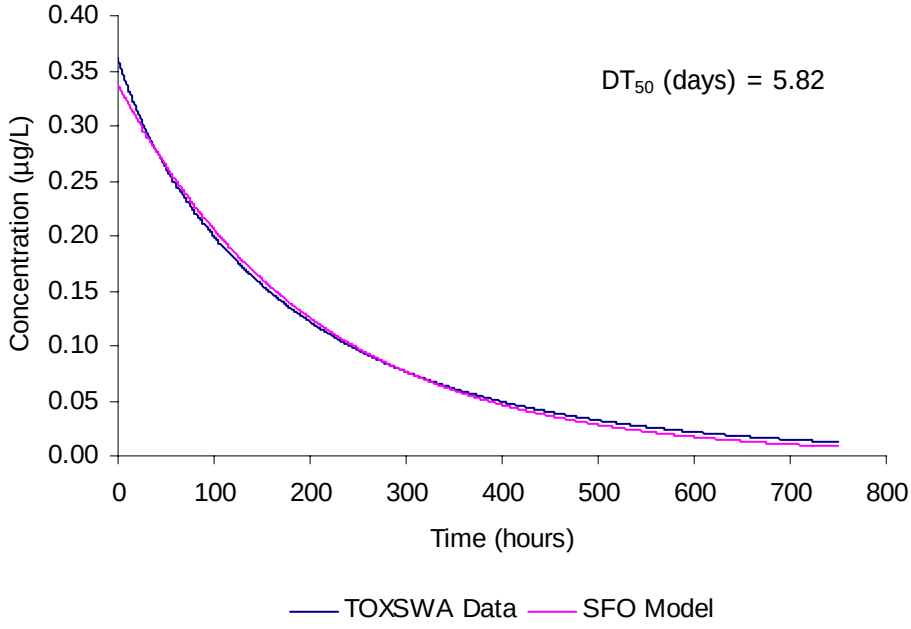


Figure 1.2.5 Dissipation rate of Chemical 5 in the water phase

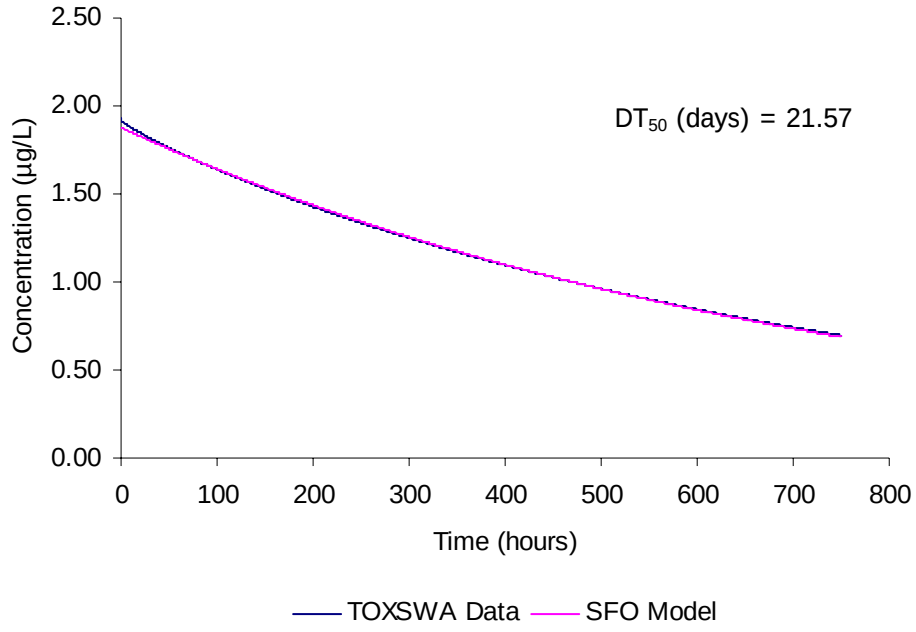


Figure 1.2.6 Dissipation rate of Chemical 6 in the water phase

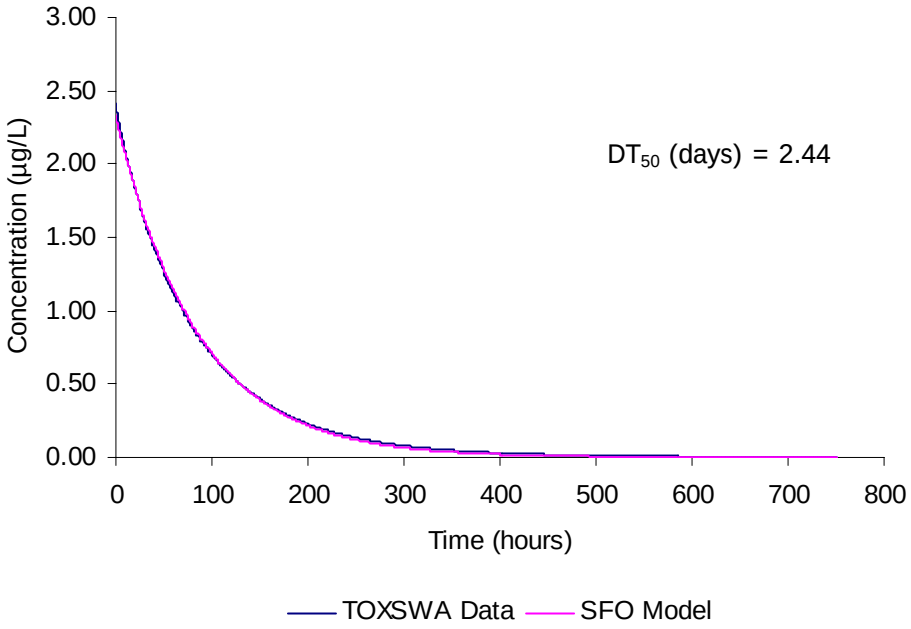


Figure 1.2.7 Dissipation rate of Chemical 7 in the water phase

Table 1.2.3 Calculated dissipation rates fro chemicals 1 to 7

Chemical	Water dissipation Rate (days)	Goodness of fit (r^2)
1	5.85	1.00
2	21.69	1.00
3	1.48	1.00
4	0.43	0.98
5	5.82	1.00
6	21.57	1.00
7	2.44	1.00

1.3 Current UK Drainage Assessment

The current UK drainage risk assessment to surface water bodies is driven by the adsorption coefficient and crop interception rate. The percentage of pesticide transported to drain water is based on the SSLRC mobility classification (Table 1.3.1; Hollis et al., 1991). The most susceptible to drainage are those pesticides that are weakly adsorbed (K_{OC} < 74 mL/g) and pesticides with a K_{OC} > 4,000 mL/g are classified as non mobile with little risk of movement to drain water. The crop interception rates are based on the BBCH crop development calendar. The FOCUS groundwater documentation provides information on likely crop interception rates at different growth stages for selected crops and is reproduced below (Table 1.3.2 and Table 1.3.3). The interception rates are, therefore, highly dependant on when a pesticide is applied.

Certain pesticides may be applied more than once during a season. The current UK drainage to surface water assessment sums multiple applications and assumes a single annual loading rate to soil. The application rate is then corrected using an interception rate and this value is then used to calculate the proportion of pesticide that is applied to the soil surface which is available for movement to surface water drains. The fraction lost to drains is then diluted in a standard ditch of a known volume and a Predicted Environmental Concentration in surface water (PEC_{SW}) is calculated. The calculation is given in Table 1.3.4.

Table 1.3.1 Mobility classification for use in UK surface water drainage assessments

SSLRC Mobility Classification	K_{oc} (ml/g)	% Pesticide transported per 10 mm drain water
Very mobile	< 15	1.90
Mobile	15 – 74	1.90
Moderately mobile	75 – 499	0.70
Slightly mobile	500 – 1000	0.50
	1000 – 4000	0.02
Non-mobile	> 4000	0.008

Table 1.3.2 Crop interception values that are dependant on growth stages (Taken from FOCUS, 2000)

Chemical	Crop	Bare emergence	Leaf development	Stem elongation	flowering	Senescence ripening
		BBCH[#]				
		00-09	10-19	20-39	40-89	90-99
1	Potatoes	0	15	50	80	50
2	Maize	0	25	50	75	90
3	Winter wheat	0	25	50 (tillering)	70 (elongated)	90
4*	Apples	NA (See Table 6.3.1.3)				
5	Winter Oil Seed Rape (WOSR)	0	40	80	80	90
6	Winter cereals	0	25	50 (tillering)	70 (elongated)	90
7	Winter cereals	0	25	50 (tillering)	70 (elongated)	90

#: The BBCH code is indicative; *: These growth stages are not relevant for apples

Table 1.3.3 Crop interception (%) by apples dependant on growth stage (Taken from FOCUS, 2000)

Chemical	Crop	Stage			
4	Apples	without leaves	flowering	foliage development	full foliage
		50	65	70	80

Table 1.3.4 Calculation of PEC_{SW} values associated with drain flow

Parameter	units	Description
Crop interception	%	Dependant on crop growth stage; guidance given in FOCUS groundwater document (FOCUS, 2000)
Field application rate	g/ha	Application rate of active substance to field
Percentage lost to drains	%	Based on the adsorption coefficient (See Table X)
Application rate to soil	g/ha	Field application rate x ((100 – crop interception rate) ÷ 100)
Dilution volume	L	130,000
Drain PEC	µg/L	((application rate to soil x % lost to drains ÷ 100) x 1,000,000) ÷ Dilution volume

The calculated PEC_{SW} values associated with drain flow for test chemicals 1-7 are given in Table 1.3.5. The chemical with the largest loading *via* drainage was chemical 1 (highest application rate; applied pre-emergence; K_{OC} value of 15 mL/g). Chemical 4 had the lowest exposure *via* drainage to surface waters (lowest application rate; the highest crop interception rate; a K_{OC} > 4,000).

Table 1.3.5 Calculated PEC_{SW} values associated with drain flow values for chemicals 1 to 7

Parameter	Test Chemicals						
	1 (I)	2 (H)	3 (H)	4 (I)	5 (F)	6 (H)	7 (F)
Interception rate (%)	0	0	50	70	40	50	50
Field application rate (g/ha)	3,000	1,000	1,000	37.5 (3 x 12.5)	150 (2 x 75)	400	1,500 (3 x 500)
Koc (mL/g)	15	91	1	1,024,000	860	66	500
Percentage lost to drains (%)	1.9	0.7	1.9	0.008	0.5	1.9	0.5
Application rate to soil (g/ha)	3,000	1,000	500	11.25	90	200	750
Dilution volume (L)	130,000	130,000	130,000	130,000	130,000	130,000	130,000
PEC_{SW} (µg/L)	**438.46**	**53.85**	**73.08**	**0.01**	**3.46**	**29.23**	**28.85**

1.4 Current UK Drift Assessment - Estimation of PEC and TWA PEC values in surface water

For the purposes of this assessment initial maximum PECs were calculated for chemicals 1 to 7 in the standard 30 cm deep, static surface water. The current UK risk assessment for spray drift loadings to surface water uses the spray drift percentage based on Rautmann (2000). The initial PEC is calculated assuming drift loading into a 100 m length ditch which is 30 cm deep and 1 m wide. The initial PEC is calculated as:

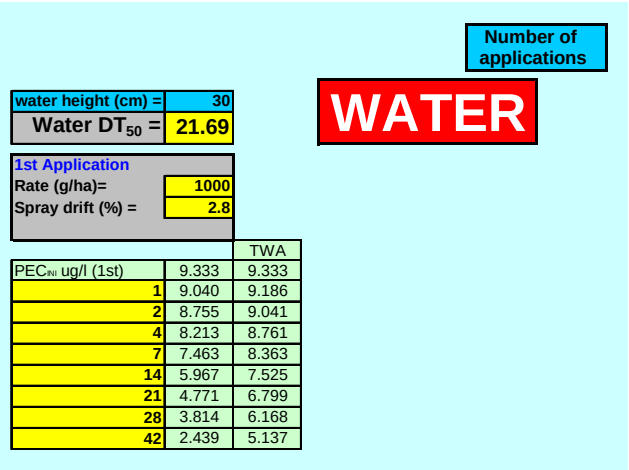
$$\text{Initial PEC surface water (µg/L)} = \frac{\lfloor \text{Rate (g/ha)} \times A \times \text{Spray drift (\%)} \rfloor}{\lfloor \text{Water height (m)} \times WL \times WW \times B \rfloor}$$

Where:

A = Conversion from g/ha to µg/m^2
WL = Water body Length (m)
WW = Water body width (m)
B = Conversion from m^3 to L

A standard spreadsheet is employed by PSD for calculating surface water PEC values resulting from spray drift; an example form is given in Figure 1.4.1 for chemical 2. In addition to the calculation of initial PEC values, the form provides PEC values for time points up to 42 days after application. If there are additional applications the calculator requires a minimum interval between applications. The calculator uses a water dissipation rate to calculate concentrations remaining over time. The water dissipation rate does not differentiate between degradation processes and mass transfer processes (e.g. partitioning into sediment).

The assumptions and calculated initial loadings for chemicals 1 to 7 are given in Table 1.4.1. The calculated loading for chemical 4 using a 'no spray zone' of 5 m is given in Table 1.4.2.



		TWA
PECINI ug/l (1st)	9.333	9.333
1	9.040	9.186
2	8.755	9.041
4	8.213	8.761
7	7.463	8.363
14	5.967	7.525
21	4.771	6.799
28	3.814	6.168
42	2.439	5.137

Figure 1.4.1 Example spreadsheet used to calculate PEC surface water values *via* spray drift from application of chemical 2 to maize

Table 1.4.1 PEC surface water values for chemicals 1 to 7 following standard UK guidance (1 m 'no spray zone'; single and multiple applications)

Parameter	**Test Chemicals**						
	1 (I)	**2 (H)**	**3 (H)**	**4 (I)**	**5 (F)**	**6 (H)**	**7 (F)**
Application Rate (g/ha)	1 x 3,000	1 x 1,000	1 x 1,000	3 x 12.5	2 x 75	1 x 400	3 x 500
Crop	Potatoes	Maize	Winter Wheat	Apples	WOSR	Winter Cereals	Winter Cereals
Spray Drift (%)	0*	2.8	2.8	29.2# (24.0)	2.8 (2.4)	2.8	2.8 (2.0)
Minimal Application Interval (days)	-	-	-	14	10	-	10
Water Dissipation value (days)	5.85	21.69	1.48	0.43	5.82	21.57	2.44
Spray Drift max PEC (µg/L)	**0.00**	**9.33**	**9.33**	**1.22 (1.00)**	**0.70 (0.78)**	**3.73**	**4.67 (3.54)**

*: Chemical 1 is soil incorporated and therefore no spray drift occurs; #: a 3 m no spray zone is standard for pome fruit; numbers in parentheses refer to multiple applications.

Table 1.4.2 PEC surface water values for chemical 4 following standard UK guidance (5 m 'no spray zone'; multiple application/s)

Parameter	Test Chemicals
	4 (I)
Application Rate (g/ha)	3 x 12.5
Crop	Apples
No Spray zone (m)	5
Spray Drift (%)	19.88 (15.78)
Minimal Application Interval (days)	14
Water Dissipation value (days)	0.43
Spray Drift max PEC (µg/L)	**0.83 (0.66)**

numbers in parentheses refer to multiple applications

1.5 Current UK Drift Assessment - Estimation of PEC and TWA PEC values in Sediment

The current UK spray drift assessment also considers exposure to sediment. The framework is similar to that used to calculate surface water PECs. Variables required for the calculation of PEC values in sediment are sediment height, sediment density, degradation rate in sediment, spray drift loading and percentage in sediment. Sediment height and density are set to default values of 5 cm and 1.3 g cm^{-3}, respectively. The maximum percentage of chemicals 1 to 7 formed in the sediment may be calculated following the guidance in FOCUS Surface water:

$$\text{Maximum formed in sediment (\%)} = 1 - \frac{W}{W + (S_{eff} \times OC \times K_{OC})} \times 100$$

Where:

W = Mass of water (30 g)
S_{eff} = Mass of sediment available for partition (0.8 g)
OC = Fraction of organic carbon in sediment (0.05)
K_{oc} = Pesticide organic carbon partition coefficient (mL/g)

Calculated values for maximum formed in sediment (%) are given in Table 1.5.1 with other relevant variables for calculation of initial and TWA PEC (Time Weighted Average PEC) values in sediment.

Table 1.5.1 PEC sediment water values for chemicals 1 to 7 following standard UK guidance (1 m 'no spray zone'; single and multiple applications)

Parameter	Test Chemicals						
	1 (I)	**2 (H)**	**3 (H)**	**4 (I)**	**5 (F)**	**6 (H)**	**7 (F)**
Application Rate (g/ha)	1 x 3,000	1 x 1,000	1 x 1,000	3 x 12.5	2 x 75	1 x 400	3 x 500
Crop	Potatoes	Maize	Winter Wheat	Apples	WOSR	Winter Cereals	Winter Cereals
Spray Drift (%)	0*	2.8	2.8	29.2[#] (24.0)	2.8 (2.4)	2.8	2.8 (2.0)
Sediment degradation value (days)	6	26	1.5	76	118	24	28
Maximum % formed in sediment	0.0	10.82	0.13	99.93	53.42	8.09	40.00
max sediment PEC associated with spray drift (µg/L)	**0.0**	**4.66**	**0.06**	**5.61 (12.22)**	**1.73 (2.87)**	**1.39**	**8.62 (14.71)**

*: Chemical 1 is soil incorporated and therefore no spray drift occurs; [#]: a 3 m no spray zone is standard for pome fruit; numbers in parentheses refer to multiple applications

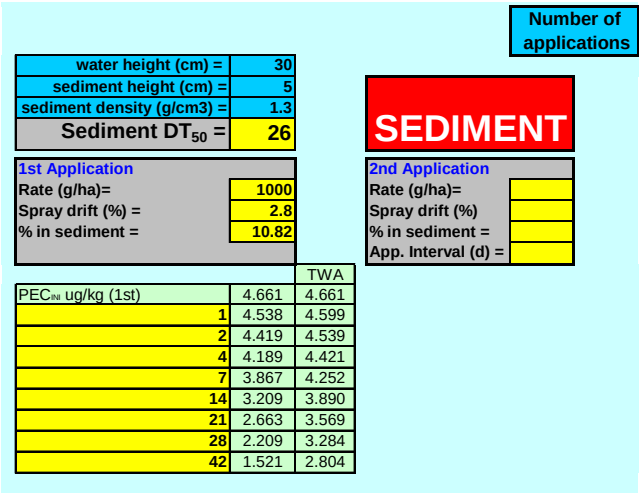
The max PEC sediment values are calculated assuming drift loading into a 100 m length ditch which is 30 cm deep and 1 m wide. The initial PEC sediment values are calculated as:

$$\text{The max PEC sediment} = \frac{[\text{max PEC}_{SW}] \times \text{Maxsed} \times \text{WH}}{\text{SD} \times \text{SH}}$$

Where,

max PEC_{SW} = max PEC in surface water (µg/L)
Maxsed = Maximum formed in sediment (%)
WH = Water height
SD = Sediment density (g m^{-1})
SH = Sediment height (m)

A standard form is available for calculating sediment PEC values resulting from spray drift; an example form for chemical 2 is given in Figure 1.5.1. As before for PEC_{SW} the calculation of max PEC values the form provides PEC values for time points up to 42 days after application. If there are additional applications then the calculator requires a minimum interval between applications to be specified. The calculator uses a sediment degradation value to calculate concentrations remaining over time.



water height (cm) =	30
sediment height (cm) =	5
sediment density (g/cm3) =	1.3
Sediment DT_{50} =	26

Number of applications

SEDIMENT

1st Application	
Rate (g/ha)=	1000
Spray drift (%) =	2.8
% in sediment =	10.82

2nd Application	
Rate (g/ha)=	
Spray drift (%)	
% in sediment =	
App. Interval (d) =	

		TWA
PEC_{INI} ug/kg (1st)	4.661	4.661
1	4.538	4.599
2	4.419	4.539
4	4.189	4.421
7	3.867	4.252
14	3.209	3.890
21	2.663	3.569
28	2.209	3.284
42	1.521	2.804

Figure 1.5.1 Example spreadsheet used to calculate PEC sediment values *via* spray drift from application of chemical 2 to maize

1.6 FOCUS Surface Water Assessment Steps 1, 2, 3 and 4

1.6.1 Risk Assessments at Steps 1 and 2

According to the criteria established under 91/414/EEC, safe uses are identified when the Toxicity Exposure Ratio (TER) value exceeds 10 (fish and aquatic invertebrate chronic, and *Algae* and *Lemna* endpoints) or 100 (fish and aquatic invertebrate acute endpoints). The toxicity exposure ratio is calculated as shown below;

$$\text{Toxicity Exposure Ratio (TER)} = \frac{\text{Effect Concentration}}{\text{Predicted Environmental Concentration}}$$

Following the recommendations laid down in the Aquatic Guidance Document (2002) the first stage of acute and chronic risk assessments is based on the initial/maximum PEC values. In general, the use of time weighted average (TWA) PEC values in the acute and chronic risk assessment is not appropriate without detailed justification based upon factors such as interpretation of mode of action.

1.6.2 Acute risk assessments for fish and aquatic invertebrates

Figure 1.6.2.1 and 1.6.2.2 show the TER calculated using the current UK spray drift and drainage assessment and the FOCUS Step 1 and 2 calculator for fish and aquatic invertebrates, respectively. The acute TER values for both fish and aquatic invertebrates are similar. The results of the current UK drainage and spray drift assessments demonstrate that two of the chemicals fail the risk assessment (chemicals 1 and 4), which are both insecticides. The TER values are lower for all chemicals using the FOCUS Step 1 exposure endpoints.

FOCUS Step 1 is more conservative than both the previous EU method and the current UK drainage/spray drift assessment. The FOCUS Step 2 TER values are of a similar magnitude as the current UK and previous EU methods.

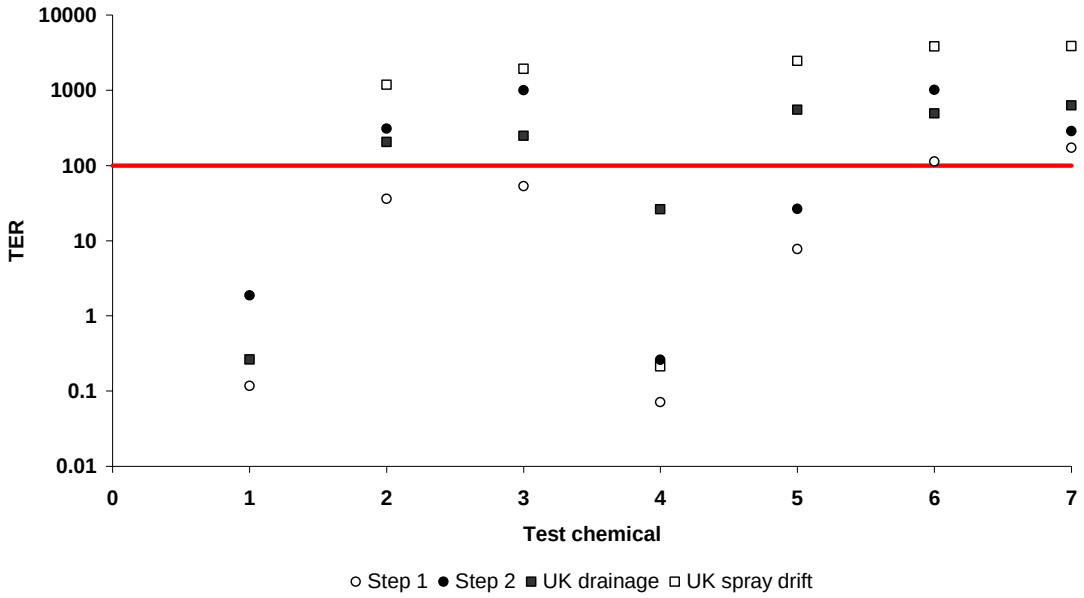


Figure 1.6.2.1 Acute assessment for fish for test chemicals 1 to 7

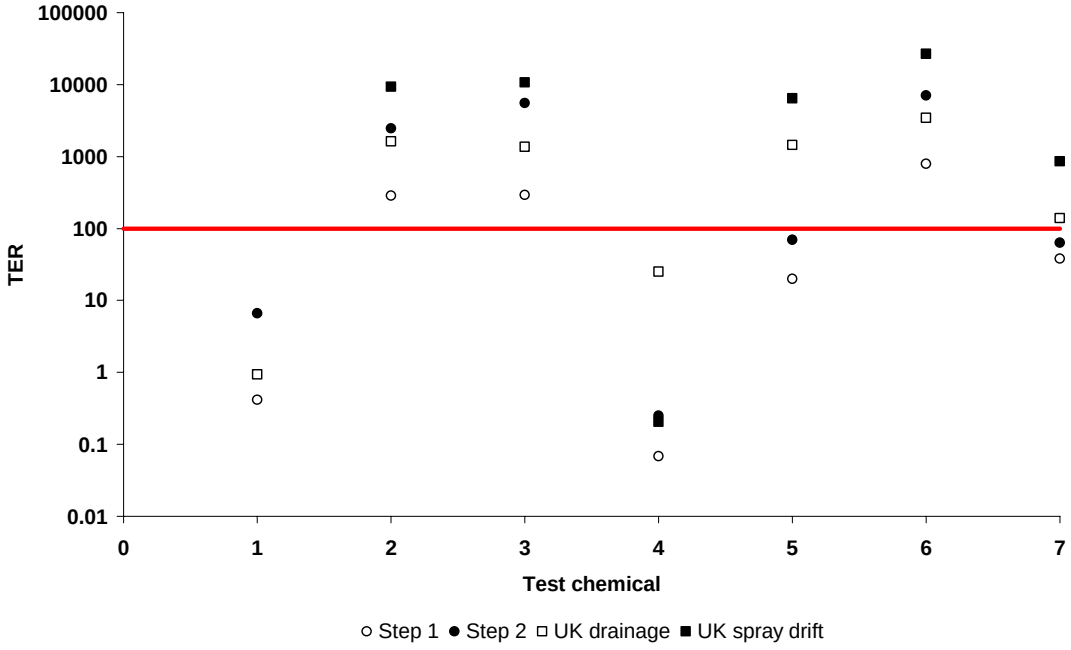


Figure 1.6.2.2 Acute assessment for aquatic invertebrates for test chemicals 1 to 7

1.6.3 Risk assessments for algae

Figure 1.6.3.1 shows the TERs calculated for algae using the current UK spray drift and drainage assessment and the FOCUS Step 1 and 2 calculator. The TER values are lower for all chemicals using the FOCUS Step 1 exposure endpoints.

FOCUS Step 1 is more conservative than the current UK drainage/spray drift assessment. The FOCUS Step 2 TER values are of a similar magnitude as the current UK drainage method.

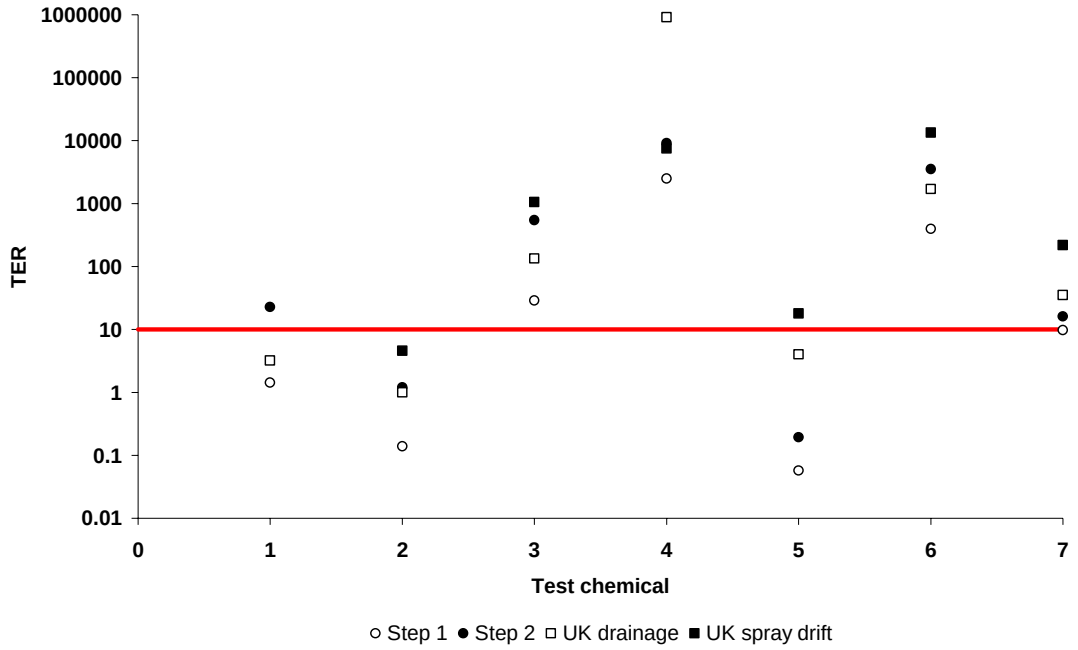


Figure 1.6.3.1 Acute assessment for algae for test chemicals 1 to 7

1.6.4 Chronic risk assessments for fish

Figure 1.6.4.1 shows the calculated TER values for chronic exposure to fish using the current UK spray drift and drainage assessment and the FOCUS Step 1 and 2 calculator. There was no chronic toxicity data for fish available for chemical 1. The TER values are lower for all chemicals using the FOCUS Step 1 exposure endpoints. However, the current UK drainage assessment does generally provide a more conservative risk assessment than the FOCUS Step 2 assessment.

FOCUS Step 1 is more conservative than the current UK drainage/spray drift assessment.

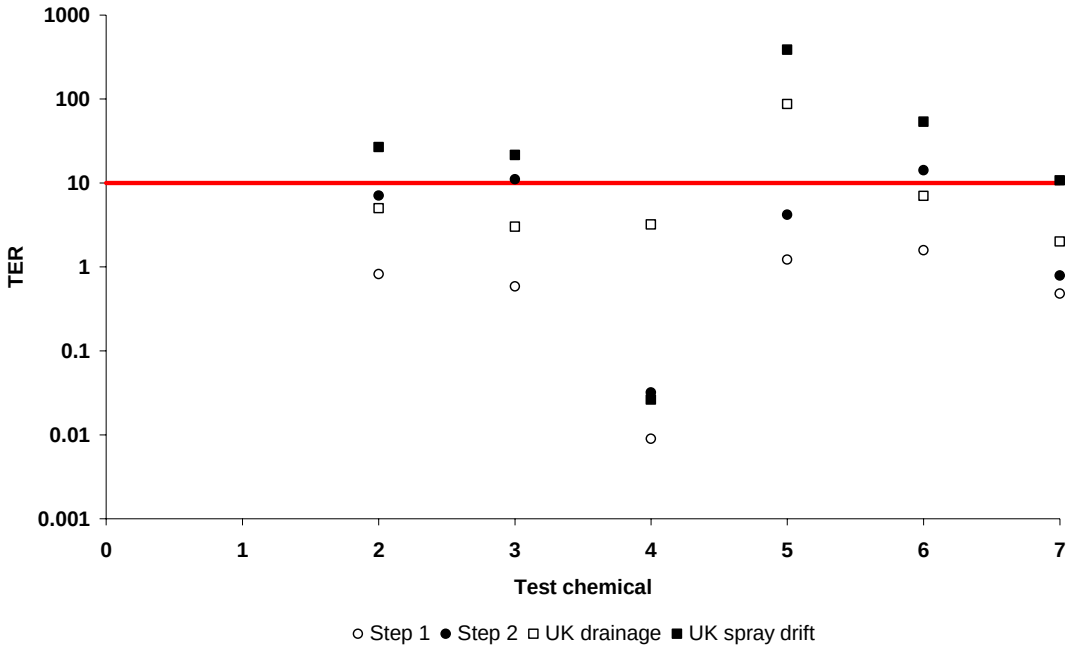


Figure 1.6.4.1 Chronic assessment for fish for test chemicals 1 to 7

1.6.5 Chronic risk assessment for aquatic invertebrates

Figure 1.6.5.1 shows the chronic risk assessments for aquatic invertebrates using the current UK spray drift and drainage assessment and the FOCUS Step 1 and 2 calculator. The results of the current UK drainage assessment demonstrate that five of the seven chemicals fail the risk assessment. The TER values are lower for all chemicals using the FOCUS Step 1 exposure endpoints and six out of seven fail the risk assessment.

FOCUS Step 1 is more conservative than the current UK drainage/spray drift assessment.

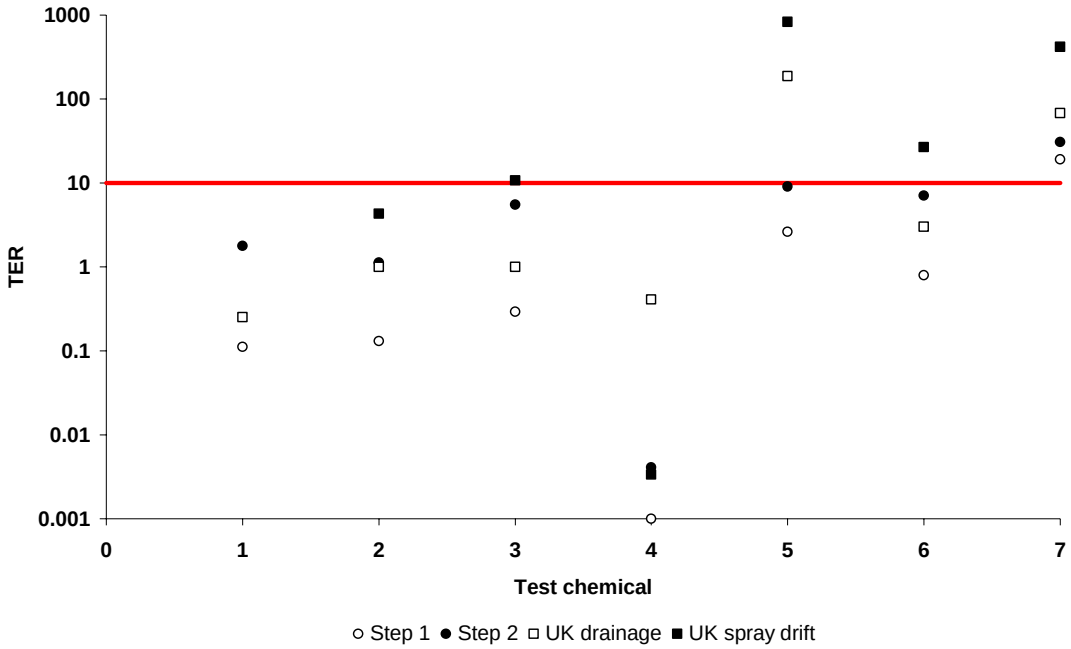


Figure 1.6.5.1 Chronic assessment for aquatic invertebrates for test chemicals 1 to 7

1.6.6 Risk assessment for *Lemna*

Figure 1.6.6.1 shows the risk assessments for *Lemna* using the current UK spray drift and drainage assessment and the FOCUS Step 1 and 2 calculator. Aquatic toxicity data for *Lemna* was only available for chemicals 2, 3, 5 and 6. The TER values are lower for all chemicals using the FOCUS Step 1 exposure endpoints and two out of four fail the risk assessment.

FOCUS Step 1 is more conservative than both the previous EU method and the current UK drainage/spray drift assessment.

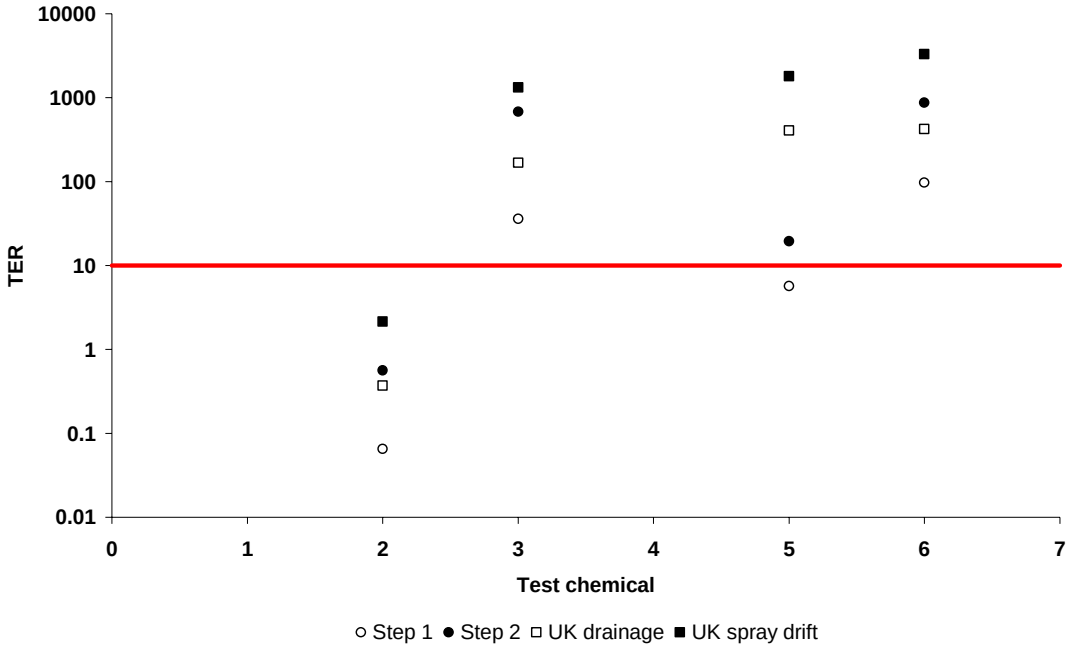


Figure 1.6.6.1 Risk assessment for *Lemna* for test chemicals 1 to 7

1.7 FOCUS Step 3 and Step 4 Exposure Assessment

The scenarios with relevance to the GAPs are summarised in Table 1.7.1 and each application scenario is discussed below.

Table 1.7.1 Scenarios used in Step 3 and Step 4 assessments

Chemical	Crop	Drainage Scenarios		Run-off Scenarios	
		Northern Europe	Southern Europe	Northern Europe	Southern Europe
1	Potatoes	D3, D4	D6	R1	R2, R3
2	Maize	D3, D4, D5	D6	R1	R2, R3, R4
3	Winter wheat	D1, D2, D3, D4, D5	D6	R1	R3, R4
4	Apples (Pome fruit, early)	D3, D4, D5	N.A.	R1	R2, R3, R4
5	WOSR	D2, D3, D4, D5	N.A.	R1	R3
6	Winter cereals	D1, D2, D3, D4, D5	D6	R1	R3, R4
7	Winter cereals	D1, D2, D3, D4, D5	D6	R1	R3, R4

N.A.: Not applicable; WOSR: Winter Oil Seed Rape

Application Scenarios:

It is important to base FOCUS assessments on realistic conditions of use, as far as is possible. The application scenarios are discussed below for each chemical and are based on the application information given in Table 1.7.1. The application windows selected were based on the smallest possible number of days that the FOCUS SW software would permit.

Chemical 1: Applications to potatoes:

Application Rate: 1 x 3,000 g a.s./ha (Annual total = 3,000 g a.s./ha)
Crop: Potatoes

A summary of the emergence and harvest dates for potatoes for all relevant FOCUS scenarios are given in Table 1.7.2. The application windows that were used as input into SWASH to generate application dates are given in Table 1.7.3. The generated application dates are given in Table 1.7.4. The chemical application method for chemical 1 was set to soil incorporation.

Table 1.7.2 Summary of emergence and harvest dates for potatoes

Scenario	Emergence date	Harvest date
D3	10th May	15th September
D4	22nd May	23rd September
D6	10th April/5th August	15th July/25th November
R1	5th May	8th September
R2	15th March	15th June
R3	10th April	1st September

Table 1.7.3 Summary of application windows for potatoes

Scenario	Possible days of application	
	First date	Last date
D3	15th March	14th April
D4	15th March	14th April
D6	15th March	14th April
R1	15th March	14th April
R2	15th March	14th April
R3	15th March	14th April

Table 1.7.4 Summary of application dates for potatoes

Scenario	Application Dates
D3	16th March 1992
D4	19th March 1985
D6	15th March 1986
R1	17th March1984
R2	22nd March 1977
R3	28th March 1980

Chemical 2: Applications to Maize:

Application Rate: 1 x 1,000 g a.s./ha (Annual total = 1,000 g a.s./ha)
Crop: Maize

A summary of the emergence and harvest dates for maize for all relevant FOCUS scenarios are given in Table 1.7.5. The application windows that were used as input into SWASH to generate application dates are given in Table 1.7.6. The generated application dates are given in Table 1.7.7. The chemical application method for chemical 2 was set to ground spray.

Table 1.7.5 Summary of emergence and harvest dates for maize

Scenario	Emergence date	Harvest date
D3	5th May	20th September
D4	10th May	12th September
D5	10th May	15th September
D6	20th April	15th September
R1	3rd May	25th September
R2	1st May	1st October
R3	1st May	1st October
R4	10th April	31st August

Table 1.7.6 Summary of application windows for maize

Scenario	Possible days of application	
	First date	Last date
D3	15th March	14th April
D4	15th March	14th April
D5	15th March	14th April
D6	15th March	14th April
R1	15th March	14th April
R2	15th March	14th April
R3	15th March	14th April
R4	15th March	14th April

Table 1.7.7 Summary of application dates for maize

Scenario	Application Dates
D3	16th March 1992
D4	19th March 1985
D5	8th April 1978
D6	15th March 1986
R1	17th March 1984
R2	22nd March 1977
R3	28th March 1980
R4	7th April 1984

Chemical 3: Applications to Winter wheat:

Application Rate: 1 x 1,000 g a.s./ha (Annual total = 1,000 g a.s./ha)
Crop: Winter wheat

A summary of the emergence and harvest dates for winter wheat for all relevant FOCUS scenarios are given in Table 1.7.8. The application windows that were used as input into SWASH to generate application dates are given in Table 1.7.9. The generated application dates are given in Table 1.7.10. The chemical application method for chemical 3 was set to ground spray.

Table 1.7.8 Summary of emergence and harvest dates for winter wheat

Scenario	Emergence date	Harvest date
D1	25th September	26th August
D2	25th October	7th August
D3	21st November	15th August
D4	22nd September	21st August
D5	10th November	15th July
D6	30th November	30th June
R1	12th November	31st July
R3	1st December	1st July
R4	10th November	15th July

Table 1.7.9 Summary of application windows for winter wheat

Scenario	Possible days of application	
	First date	Last date
D1	1st March	1st April
D2	1st March	1st April
D3	1st March	1st April
D4	1st March	1st April
D5	1st March	1st April
D6	1st March	1st April
R1	1st March	1st April
R3	1st March	1st April
R4	1st March	1st April

Table 1.7.10 Summary of application dates for winter wheat

Scenario	Application Dates
D1	7th March 1982
D2	12th March 1986
D3	29th February 1992
D4	1st March 1985
D5	7th March 1978
D6	5th March 1986
R1	17th March 1984
R3	1st March 1980
R4	5th March 1984

Chemical 4: Applications to Apples:

Application Rate: 3 x 12.5 g a.s./ha (Annual total = 37.5 g a.s./ha)
Crop: Pome Fruit (early application)

A summary of the emergence and harvest dates for pome fruit (early application) for all relevant FOCUS scenarios are given in Table 1.7.11. The application windows that were used as input into SWASH to generate application dates are given in Table 1.7.12. The generated application dates are given in Table 1.7.13. The chemical application method for chemical 4 was set to air blast.

Table 1.7.11 Summary of emergence and harvest dates for apples

Scenario	Emergence date	Harvest date
D3	15th April	30th October
D4	20th April	30th October
D5	1st April	10th October
R1	15th April	30th October
R2	15th March	30th September
R3	1st April	15th October
R4	15th March	15th October

Table 1.7.12 Summary of application windows for apples

Scenario	Possible days of application	
	First date	Last date
D3	16th April	13th June
D4	16th April	13th June
D5	16th April	13th June
R1	16th April	13th June
R2	16th April	13th June
R3	16th April	13th June
R4	16th April	13th June

Table 1.7.13 Summary of application dates for apples

Scenario	Application Dates
D3	20th April 1992 4th May 1992 18th May 1992
D4	18th April 1985 30th May 1985 13th June 1985
D5	22nd April 1978 11th May 1978 27th May 1978
R1	26th April 1984 10th May1984 31st May 1984
R2	22nd April 1977 7th May 1977 21st May 1977
R3	16th April 1980 18th May 1980 1st June 1980
R4	16th April 1984 4th May 1984 27th May 1984

Chemical 5: Applications to WOSR:

Application Rate: 2 x 75 g a.s./ha (Annual total = 150 g a.s./ha)
Crop: WOSR

A summary of the emergence and harvest dates for WOSR for all relevant FOCUS scenarios are given in Table 1.7.14. The application windows that were used as input into SWASH to generate application dates are given in Table 1.7.15. The generated application dates are given in Table 1.7.16. The chemical application method for chemical 5 was set to ground spray.

Table 1.7.14 Summary of emergence and harvest dates for WOSR

Scenario	Emergence date	Harvest date
D2	15th September	15th July
D3	2nd September	20th July
D4	3rd September	9th August
D5	20th September	5th July
R1	4th September	10th July
R3	5th October	5th June

Table 1.7.15 Summary of application windows for WOSR

Scenario	Possible days of application	
	First date	Last date
D2	1st October	10th November
D3	1st October	10th November
D4	1st October	10th November
D5	1st October	10th November
R1	1st October	10th November
R3	1st October	10th November

Table 1.7.16 Summary of application dates for WOSR

Scenario	Application Dates
D2	9th October 1986 3rd November 1986
D3	30th September 1992 10th October 1992
D4	1st October 1985 26th October 1985
D5	31st October 1978 10th November 1978
R1	6th October 1978 19th October 1978
R3	1st October 1980 27th October 1980

Chemical 6: Applications to winter cereals:

Application Rate: 1 x 400 g a.s./ha (Annual total = 400 g a.s./ha)
Crop: Winter cereals

A summary of the emergence and harvest dates for winter cereals for all relevant FOCUS scenarios are given in Table 1.7.17. The application windows that were used as input into SWASH to generate application dates are given in Table 1.7.18. The generated application dates are given in Table 1.7.19. The chemical application method for chemical 6 was set to ground spray.

Table 1.7.17 Summary of emergence and harvest dates for winter cereals

Scenario	Emergence date	Harvest date
D1	25th September	26th August
D2	25th October	7th August
D3	21st November	15th August
D4	22nd September	21st August
D5	10th November	15th July
D6	30th November	30th June
R1	12th November	31st July
R3	1st December	1st July
R4	10th November	15th July

Table 1.7.18 Summary of application windows for winter cereals

Scenario	Possible days of application	
	First date	Last date
D1	1st March	31st March
D2	1st March	31st March
D3	1st March	31st March
D4	1st March	31st March
D5	1st March	31st March
D6	1st March	31st March
R1	1st March	31st March
R3	1st March	31st March
R4	1st March	31st March

Table 1.7.19 Summary of application dates for winter cereals

Scenario	Application Dates
D1	7th March 1982
D2	12th March 1986
D3	29th February 1992
D4	1st March 1985
D5	7th March 1978
D6	5th March 1986
R1	17th March 1984
R3	1st March 1980
R4	5th March 1984

Chemical 7: Applications to winter cereals:

Application Rate: 1 x 400 g a.s./ha (Annual total = 400 g a.s./ha)
Crop: Winter cereals

A summary of the emergence and harvest dates for winter cereals for all relevant FOCUS scenarios are given in Table 1.7.20. The application windows that were used as input into SWASH to generate application dates are given in Table 1.7.21. The generated application dates are given in Table 1.7.22. The chemical application method for chemical 7 was set to ground spray.

Table 1.7.20 Summary of emergence and harvest dates for winter cereals

Scenario	Emergence date	Harvest date
D1	25th September	26th August
D2	25th October	7th August
D3	21st November	15th August
D4	22nd September	21st August
D5	10th November	15th July
D6	30th November	30th June
R1	12th November	31st July
R3	1st December	1st July
R4	10th November	15th July

Table 1.7.21 Summary of application windows for winter cereals

Scenario	Possible days of application	
	First date	Last date
D1	1st October	20th November
D2	1st October	20th November
D3	1st October	20th November
D4	1st October	20th November
D5	1st October	20th November
D6	1st October	20th November
R1	1st October	20th November
R3	1st October	20th November
R4	1st October	20th November

Table 1.7.22 Summary of application dates for winter cereals

Scenario	Application Dates
D1	3rd October 1982 23rd October 1982 5th November 1982
D2	9th October 1986 3rd November1986 15th November 1986
D3	30th September 1992 10th October 1992 20th October 1992
D4	1st October 1985 26th October 1985 17th November 1985
D5	31st October 1978 10th November 1978 20th November 1978
D6	6th October 1986 18th October 1986 31st October 1986
R1	6th October 1978 19th October 1978 14th November 1978
R3	1st October 1980 27th October 1980 15th November 1980
R4	1st October 1979 17th October 1979 3rd November 1979

The crop-specific parameters for calculating spray drift inputs at Step 3 are given in Table 1.7.23. The drift loading from a single application is larger than from multiple applications. For purposes of FOCUS surface water modelling it is important to carry out risk assessments for single and multiple applications of a chemical even where the GAP states multiple applications to ensure representation of the worst case. Therefore, FOCUS surface water scenarios for chemicals 4, 5 and 7 have been run using single applications as well as multiple.

Table 1.7.23 Crop specific parameters for calculating spray drift inputs at Step 3

Crop	Distance from edge of field to top of bank (m)	Water Body type	Distance from top of bank to edge of water body (m)	Total Distance from edge of field to water body (m)
Winter cereals	0.5	Ditch	0.5	1.0
		Stream	1.0	1.5
WOSR		Pond	3.0	3.5
Potatoes	0.8	Ditch	0.5	1.3
		Stream	1.0	1.8
Maize		Pond	3.0	3.8
Apples (Pome fruit, early)	3.0	Ditch	0.5	3.5
		Stream	1.0	4.0
		Pond	3.0	6.0

FOCUS Step 4

The current UK assessment permits the use of a 5 m no spray zone. At FOCUS Step 4 it is also possible to introduce risk management options, like buffer zones, specific nozzles, etc. FOCUS (2001) state that: *"It is conceivable that Step 4 approaches would be used both for Annex I listing and for national registration purposes. For example, for certain compounds it may be possible to identify a range of acceptable uses across the EU when appropriate mitigation measures (e.g., buffer zones) are applied".*

Therefore, FOCUS Step 4 calculations were carried out to further refine the assessment of the movement and fate of the test chemicals in surface waters and sediment. The application scenarios and ecotoxicological endpoints for Step 4 were the same as for Step 3. No-spray buffer zones were introduced. The buffer zones used in Step 3 are conservative and it is proposed that by introducing new buffer zones that a realistic mitigation strategy can be introduced, thereby reducing the environmental impact of the test chemicals. The proposed buffer zones to be used at Step 4 are given in Table 6.7.24. The areic mean deposition values (% of applied chemical reaching the SW as drift) were calculated using the drift calculator located in SWASH (stream values were multiplied by 1.2 to account for the upstream loading). Areic mean deposition values for Step 3 and Step 4 simulations for single and multiple applications are given in Table 6.7.25 and 6.7.26, respectively.

% Areic mean deposition: The adjective 'areic' is used to modify the name of a quantity (deposition - % in this case) to indicate the quotient (the number obtained by division) of that quantity (surface area – m^2 in this case). Therefore it means % deposition per square metre of surface.

Table 1.7.25 Areic mean deposition (%) for Step 3 and Step 4 calculations (single applications)

Chemical	Crop	Water Body type	Areic mean deposition (%)	Buffer zone width (m)	Areic mean deposition (%)
			FOCUS Step 3		FOCUS Step 4
1	Potatoes	Pond	0.2122	N.A.[#]	
		Ditch	1.5936		
		Stream	1.4894		
2	Maize	Pond	0.2122	5	0.1896
		Ditch	1.5936		0.5224
		Stream	1.4894		0.6269
3	Winter wheat	Pond	0.2191	5	0.1896
		Ditch	1.9274		0.5224
		Stream	1.7165		0.6269
4	Apples (Pome fruit, early)	Pond	4.7297	Not Simulated*	
		Ditch	23.5987		
		Stream	25.8991		
5	WOSR	Pond	0.2191	Not Simulated*	
		Ditch	1.9274		
		Stream	1.7165		
6	Winter cereals	Pond	0.2191	5	0.1896
		Ditch	1.9274		0.5224
		Stream	1.7165		0.6269
7	Winter cereals	Pond	0.2191	Not Simulated*	
		Ditch	1.9274		
		Stream	1.7165		

*Step 4 calculations based on multiple applications; [#]: Soil incorporated

Table 1.7.26 Areic mean deposition (%) for Step 3 and Step 4 calculations (multiple applications)

Chemical	Crop	Water Body type	Areic mean deposition (%)	Buffer zone width (m)	Areic mean deposition (%)
			FOCUS Step 3		FOCUS Step 4
4	Apples (Pome fruit, early)	Pond	3.8617	5	4.3332
		Ditch	19.0150		14.6315
		Stream	20.7073		17.5578
5	WOSR	Pond	0.1792	5	0.1541
		Ditch	1.6838		0.4369
		Stream	1.4844		0.5243
7	Winter cereals	Pond	0.1540	5	0.1328
		Ditch	1.0371		0.3719
		Stream	1.2445		0.4463

1.8 FOCUS Step 3 and Step 4 Results

TOXSWA provides both acute and chronic exposure concentrations for the water layer as well as for the sediment. The maximum PEC_{SW} and PEC_{sed} are summarised in Tables 1.8.1 to 1.8.7 for chemicals 1 to 7, respectively.

Chemical 1

It was demonstrated run-off was a more significant route of entry than drainage for Chemical 1. FOCUS surface water scenario R3 had the largest calculated PEC values; the maximum PEC value in surface water was 348.9 µg/L. Step 4 calculations were not necessary because chemical 1 was incorporated with the soil.

Table 1.8.1 Predicted environmental concentrations generated for chemical 1 using FOCUS SW

Scenario	Water body	Maximum PEC	
		Surface Water (µg/L)	Sediment (µg/kg)
Step 3: Single application			
D3	ditch	0.008	0.004
D4	pond	0.234	0.071
D4	stream	0.990	0.270
D6	ditch	0.151	0.020
R1	pond	3.249	0.757
R1	stream	37.151	2.815
R2	stream	55.969	3.709
R3	stream	348.866	19.381

Chemical 2

It was demonstrated that drift and drainage were the primary route of entry for Chemical 2. The calculated PEC values for the Step 4 run-off simulations were not affected by the introduction of 5 m 'no spray' zones indicating that a run-off event was driving the exposure to surface water bodies. The calculated maxPEC_{SW} values for the drainage scenarios were slightly reduced with the introduction of the 5 m 'no spray' zone, except for the pond scenarios and the D6 ditch scenarios.

Table 1.8.2 Predicted environmental concentrations generated for chemical 2 using FOCUS SW

Scenario	Water body	Maximum PEC	
		Surface Water (µg/L)	Sediment (µg/kg)
Step 3: Single application			
D3	ditch	5.260	1.187
D4	pond	1.185	2.316
D4	stream	4.198	1.316
D5	pond	0.589	1.066
D5	stream	4.478	0.601
D6	ditch	6.186	3.774
R1	pond	2.663	3.276
R1	stream	28.487	4.888
R2	stream	32.013	8.439
R3	stream	83.288	10.918
R4	stream	45.282	9.869
Step 4: Single application (5 m 'no spray zone')			
D3	ditch	1.734	0.446
D4	pond	1.185	2.316
D4	stream	1.844	1.316
D5	pond	0.589	1.043
D5	stream	1.983	0.545
D6	ditch	6.186	3.667
R1	pond	2.646	3.253
R1	stream	28.487	4.868
R2	stream	32.013	8.418
R3	stream	83.288	10.849
R4	stream	45.282	9.850

Chemical 3

It was demonstrated that drainage and drift were the primary routes of entry for Chemical 3. The introduction of a 5 m 'no spray' zone did reduce the calculated PEC values for 6 out of 14 scenarios. The greatest reduction was for the D3 and D6 ditch scenarios (70% reduction in $maxPEC_{SW}$). The largest $maxPEC_{SW}$ values for D1, D2 and R3 were not affected by the introduction of 5 m 'no spray' zones.

Table 1.8.3 Predicted environmental concentrations generated for chemical 3 using FOCUS SW

Scenario	Water body	Maximum PEC	
		Surface Water (µg/L)	Sediment (µg/kg)
Step 3: Single application			
D1	ditch	116.761	17.248
D1	stream	73.923	10.927
D2	ditch	126.430	10.830
D2	stream	79.702	6.910
D3	ditch	6.318	0.312
D4	pond	0.628	0.108
D4	stream	5.287	0.825
D5	pond	0.219	0.019
D5	stream	4.980	0.056
D6	ditch	6.653	0.382
R1	pond	0.238	0.025
R1	stream	9.734	0.511
R3	stream	31.954	1.750
R4	stream	4.175	0.120
Step 4: Single application (5 m 'no spray zone')			
D1	ditch	116.761	17.236
D1	stream	73.923	10.927
D2	ditch	126.430	10.746
D2	stream	79.702	6.854
D3	ditch	1.712	0.085
D4	pond	0.628	0.108
D4	stream	5.287	0.825
D5	pond	0.190	0.016
D5	stream	1.820	0.020
D6	ditch	2.036	0.140
R1	pond	0.235	0.024
R1	stream	9.734	0.510
R3	stream	31.954	1.746
R4	stream	1.526	0.044

Chemical 4

The calculated maxPEC$_{SW}$ values for a single application of chemical 4 to apples ranged from 0.018 (pond scenarios) to 0.373 µg/L (R3, stream). The effect of introducing a 5 m 'no spray' zone reduced the maxPEC$_{SW}$ value by 76 to 84% for streams and ditches and increased the maxPEC$_{SW}$ value by 11% for ponds. The increase in maxPEC$_{SW}$ values for ponds was because the inbuilt 'no spray' zone for ponds associated with apple production is greater than the 5 m 'no spray' zone used at Step 4 (Table 1.7.25). The use of a single application of chemical 4 at Step 3 resulted in an increase of 15 to 26% in the calculated maxPEC$_{SW}$ values.

Table 1.8.4 Predicted environmental concentrations generated for chemical 4 using FOCUS SW

Scenario	Water body	Maximum PEC	
		Surface Water (µg/L)	Sediment (µg/kg)
Step 3: Multiple applications			
D3	ditch	0.328	4.217
D4	pond	0.018	0.507
D4	stream	0.338	1.366
D5	pond	0.018	0.492
D5	stream	0.360	1.250
R1	pond	0.018	0.505
R1	stream	0.258	0.969
R2	stream	0.353	1.037
R3	stream	0.373	2.603
R4	stream	0.260	1.070
Step 4: Multiple applications (5 m 'no spray zone')			
D3	ditch	0.248	0.387
D4	pond	0.02	0.081
D4	stream	0.284	0.066
D5	pond	0.02	0.071
D5	stream	0.302	0.056
R1	pond	0.02	0.075
R1	stream	0.217	0.09
R2	stream	0.296	0.149
R3	stream	0.313	0.194
R4	stream	0.218	0.55
Step 3: Single application			
D3	ditch	0.407	3.476
D4	pond	0.022	0.481
D4	stream	0.389	0.493
D5	pond	0.022	0.423
D5	stream	0.428	0.631
R1	pond	0.022	0.427
R1	stream	0.326	1.152
R2	stream	0.438	0.811
R3	stream	0.469	2.428
R4	stream	0.328	1.301

1

Chemical 5

The calculated maxPEC_{SW} values for multiple applications of chemical 5 to WOSR ranged from 0.113 (R1 pond) to 4.323 µg/L (D2 ditch). The effect of introducing a 5 m 'no spray' zone reduced the maxPEC_{SW} value by 75% for the D3 ditch scenario, all other scenarios were not affected. The D3 scenario is characterised by having a light sandy textured soil. The calculated maxPEC_{SW} values for a single application of chemical 5 at FOCUS Step 3 resulted in decrease of *ca.* 50% for all scenarios except the D3 ditch scenario, which increased by 15%. This indicated that the exposure at Step 3 is driven by either run-off or drainage and that spray drift loadings were only significant for the D3 ditch scenario.

Table 1.8.5 Predicted environmental concentrations generated for chemical 5 using FOCUS SW

Scenario	Water body	Maximum PEC	
		Surface Water (µg/L)	Sediment (µg/kg)
Step 3: Multiple applications			
D2	ditch	4.323	14.826
D2	stream	2.702	8.902
D3	ditch	0.417	0.304
D4	pond	0.558	1.727
D4	stream	1.285	1.756
D5	pond	0.504	1.243
D5	stream	0.824	0.969
R1	pond	0.113	0.241
R1	stream	1.477	0.440
R3	stream	1.356	0.950
Step 4: Multiple applications (5 m 'no spray zone')			
D2	ditch	4.323	14.773
D2	stream	2.702	8.876
D3	ditch	0.110	0.081
D4	pond	0.558	1.725
D4	stream	1.285	1.752
D5	pond	0.504	1.242
D5	stream	0.824	0.964
R1	pond	0.113	0.240
R1	stream	1.477	0.438
R3	stream	1.356	0.939

Table 1.8.5a Predicted environmental concentrations generated for chemical 5 using FOCUS SW (Continued from Table 6.8.5)

Scenario	Water body	Maximum PEC	
		Surface Water (µg/L)	Sediment (µg/kg)
Step 3: Single application			
D2	ditch	2.240	7.789
D2	pond	1.399	4.688
D3	stream	0.479	0.253
D4	pond	0.290	0.898
D4	stream	0.667	0.914
D5	pond	0.250	0.615
D5	stream	0.444	0.482
R1	stream	0.054	0.116
R1	stream	0.706	0.207
R3	stream	0.902	0.374

Chemical 6

The calculated maxPEC_{SW} values for a single application of chemical 6 to winter cereals ranged from 0.221 (R1 pond) to 39.738 (D2 ditch) µg/L. The effect of introducing a 5 m 'no spray' zone reduced the maxPEC_{SW} value for 50% of the scenarios by 4 (R1 pond) to 72% (D3 ditch).

Table 1.8.6 Predicted environmental concentrations generated for chemical 6 using FOCUS SW

Scenario	Water body	Maximum PEC	
		Surface Water (µg/L)	Sediment (µg/kg)
Step 3: Single application			
D1	ditch	35.578	24.288
D1	stream	22.230	14.733
D2	ditch	39.738	17.098
D2	stream	25.025	9.952
D3	ditch	2.559	0.353
D4	pond	0.362	0.439
D4	stream	2.105	0.240
D5	pond	0.205	0.200
D5	stream	2.057	0.128
D6	ditch	2.789	0.636
R1	pond	0.221	0.162
R1	stream	6.753	0.840
R3	stream	11.092	1.462
R4	stream	1.671	0.109
Step 4: Single application (5 m 'no spray zone')			
D1	ditch	35.578	24.274
D1	stream	22.230	14.732
D2	ditch	39.738	16.964
D2	stream	25.025	9.870
D3	ditch	0.716	0.124
D4	pond	0.362	0.439
D4	stream	0.795	0.240
D5	pond	0.193	0.192
D5	stream	0.792	0.102
D6	ditch	0.942	0.368
R1	pond	0.212	0.154
R1	stream	6.753	0.835
R3	stream	11.092	1.447
R4	stream	0.611	0.040

Chemical 7

The calculated $maxPEC_{SW}$ values for multiple applications of chemical 7 to winter cereals ranged from 0.675 (R1 pond) to 36.303 µg/L (D2 ditch). The effect of introducing a 5 m 'no spray' zone reduced the $maxPEC_{SW}$ value by 75% for the D3 ditch scenario; all other scenarios were not affected. The D3 scenario is characterised by having a light sandy textured soil. The calculated $maxPEC_{SW}$ values for a single application of chemical 7 at FOCUS Step 3 resulted in decrease of 48 to 75% for all scenarios except the D3 ditch and R4 stream scenarios. The calculated $maxPEC_{SW}$ value for the R4 stream scenario is driven by a run-off event and is not determined by the spray drift loading. The exposure to surface waters for chemical 7 is driven by either run-off or drainage and spray drift loadings were only significant for the light sandy drained soils represented by D3 ditch scenario.

Table 1.8.7 Predicted environmental concentrations generated for chemical 7 using FOCUS SW

Scenario	Water body	Maximum PEC	
		Surface Water (µg/L)	Sediment (µg/kg)
Step 3: Multiple applications			
D1	ditch	29.347	81.564
D1	stream	18.479	53.425
D2	ditch	36.303	49.891
D2	stream	22.810	31.318
D3	ditch	2.320	1.275
D4	pond	3.920	7.657
D4	stream	11.757	11.267
D5	pond	4.474	6.133
D5	stream	7.633	6.603
D6	ditch	18.265	18.203
R1	pond	0.675	0.870
R1	stream	21.039	5.426
R3	stream	15.403	41.084
R4	stream	13.372	17.327
Step 3: Single application			
D1	ditch	8.695	25.540
D1	stream	5.490	16.992
D2	ditch	11.774	16.099
D2	stream	7.392	10.187
D3	ditch	3.179	1.165
D4	pond	1.356	2.646
D4	stream	3.845	3.897
D5	pond	1.099	1.512
D5	stream	2.956	1.636
D6	ditch	5.530	5.622
R1	pond	0.202	0.236
R1	stream	8.191	1.900
R3	stream	7.995	2.849
R4	stream	13.342	4.302

Table 1.8.7a Predicted environmental concentrations generated for chemical 7 using FOCUS SW

Scenario	Water body	Maximum PEC	
		Surface Water (µg/L)	Sediment (µg/kg)
Step 4: Multiple applications (5 m 'no spray zone')			
D1	ditch	29.347	81.564
D1	stream	18.479	53.425
D2	ditch	36.303	49.891
D2	stream	22.810	31.318
D3	ditch	0.614	0.339
D4	pond	3.919	7.649
D4	stream	11.757	11.242
D5	pond	4.474	6.129
D5	stream	7.633	6.585
D6	ditch	18.265	17.966
R1	pond	0.674	0.863
R1	stream	21.039	5.405
R3	stream	15.403	41.043
R4	stream	13.372	17.320

1.9 Aquatic Risk Assessment for Chemicals 1 to 7 (FOCUS Step 3 and 4)

1.9.1 Risk Assessments at Step 3 and 4

The calculated TER values for chemicals 1 to 7 are given in Tables 1.9.1.1 to 1.9.1.7. The TER values are discussed with reference to specific aquatic species in Section 1.9.2.

Table 1.9.1.1 Calculated TERs for chemical 1 using maxPECsw simulated by FOCUS SW

Scenario	Water body	Acute fish	Acute aquatic invertebrate	Algae	Chronic aquatic invertebrate
		LC_{50} 115 μg/L	**EC_{50} 410 μg/L**	**EC_{50} 1400 μg/L**	**NOEC 110 μg/L**
Step 3: Single application					
D3	ditch	14375	51250	175000	13750
D4	pond	491	1752	5983	470
D4	stream	116	414	1414	111
D6	ditch	762	2715	9272	728
R1	pond	35	126	431	34
R1	stream	3.10	11	38	2.96
R2	stream	2.05	7.33	25.01	1.97
R3	stream	0.33	1.18	4.01	0.32

Table 1.9.1.2 Calculated TERs for chemical 2 using maxPECsw simulated by FOCUS SW

Scenario	Water body	Acute fish	Acute aquatic invertebrate	Algae	*Lemna*	Chronic fish	Chronic aquatic invertebrate
		LC_{50} 11000 µg/L	EC_{50} 87000 µg/L	EC_{50} 43 µg/L	EC_{50} 20 µg/L	NOEC 250 µg/L	NOEC 40 µg/L
Step 3: Single application							
D3	Ditch	2091	16540	8.17	3.80	47.53	7.60
D4	Pond	9283	73418	36	17	210.97	34
D4	Stream	2620	20724	10	4.76	59.55	9.53
D5	Pond	18676	147708	73	34	424.45	68
D5	Stream	2456	19428	9.60	4.47	55.83	8.93
D6	Ditch	1778	14064	6.95	3.23	40.41	6.47
R1	Pond	4131	32670	16	7.51	93.88	15
R1	Stream	386	3054	1.51	0.70	8.78	1.40
R2	Stream	344	2718	1.34	0.62	7.81	1.25
R3	Stream	132	1045	0.52	0.24	3.00	0.48
R4	Stream	243	1921	0.95	0.44	5.52	0.88
Step 4: Single application (5 m 'no spray zone')							
D3	Ditch	6344	50173	25	12	144	23
D4	Pond	9283	73418	36	17	211	34
D4	Stream	5965	47180	23	11	136	22
D5	Pond	18676	147708	73	34	424	68
D5	Stream	5547	43873	22	10	126	20
D6	Ditch	1778	14064	6.95	3.23	40	6.47
R1	Pond	4157	32880	16	7.56	94	15
R1	Stream	386	3054	1.51	0.70	8.78	1.40
R2	Stream	344	2718	1.34	0.62	7.81	1.25
R3	Stream	132	1045	0.52	0.24	3.00	0.48
R4	Stream	243	1921	0.95	0.44	5.52	0.88

Table 1.9.1.3 Calculated TERs for chemical 3 using maxPECsw simulated by FOCUS SW

Scenario	Water body	Acute fish	Acute aquatic invertebrate	Algae	*Lemna*	Chronic fish	Chronic aquatic invertebrate
		LC_{50} 18000 µg/L	EC_{50} 100000 µg/L	EC_{50} 9800 µg/L	EC_{50} 12300 µg/L	NOEC 200 µg/L	NOEC 100 µg/L
Step 3: Single application							
D1	ditch	154	856	84	105	1.71	0.86
D1	stream	243	1353	133	166	2.71	1.35
D2	ditch	142	791	78	97	1.58	0.79
D2	stream	226	1255	123	154	2.51	1.25
D3	ditch	2849	15828	1551	1947	32	16
D4	pond	28662	159236	15605	19586	318	159
D4	stream	3405	18914	1854	2326	38	19
D5	pond	82192	456621	44749	56164	913	457
D5	stream	3614	20080	1968	2470	40	20
D6	ditch	2706	15031	1473	1849	30	15
R1	pond	75630	420168	41176	51681	840	420
R1	stream	1849	10273	1007	1264	21	10
R3	stream	563	3129	307	385	6.26	3.13
R4	stream	4311	23952	2347	2946	48	24
Step 4: Single application (5 m 'no spray zone')							
D1	ditch	154	856	84	105	1.71	0.86
D1	stream	243	1353	133	166	2.71	1.35
D2	ditch	142	791	78	97	1.58	0.79
D2	stream	226	1255	123	154	2.51	1.25
D3	ditch	10514	58411	5724	7185	117	58
D4	pond	28662	159236	15605	19586	318	159
D4	stream	3405	18914	1854	2326	38	19
D5	pond	94737	526316	51579	64737	1053	526
D5	stream	9890	54945	5385	6758	110	55
D6	ditch	8841	49116	4813	6041	98	49
R1	pond	76596	425532	41702	52340	851	426
R1	stream	1849	10273	1007	1264	21	10
R3	stream	563	3129	307	385	6.26	3.13
R4	stream	11796	65531	6422	8060	131	66

Table 1.9.1.4 Calculated TERs for chemical 4 using maxPECsw simulated by FOCUS SW

Scenario	Water body	Acute fish	Acute aquatic invertebrate	Algae	Chronic fish	Chronic aquatic invertebrate
		LC_{50} 0.26 μg/L	EC_{50} 0.25 μg/L	EC_{50} 9100 μg/L	NOEC 0.032 μg/L	NOEC 0.0041 μg/L
Step 3: Multiple applications						
D3	ditch	0.79	0.76	27744	0.10	0.01
D4	pond	14	14	505556	1.78	0.23
D4	stream	0.77	0.74	26923	0.09	0.01
D5	pond	14	14	505556	1.78	0.23
D5	stream	0.72	0.69	25278	0.09	0.01
R1	pond	14	14	505556	1.78	0.23
R1	stream	1.01	0.97	35271	0.12	0.02
R2	stream	0.74	0.71	25779	0.09	0.01
R3	stream	0.70	0.67	24397	0.09	0.01
R4	stream	1.00	0.96	35000	0.12	0.02
Step 4: Multiple applications (5 m 'no spray zone')						
D3	ditch	1.05	1.01	36694	0.13	0.02
D4	pond	13	13	455000	1.60	0.21
D4	stream	0.92	0.88	32042	0.11	0.01
D5	pond	13	13	455000	1.60	0.21
D5	stream	0.86	0.83	30132	0.11	0.01
R1	pond	13	13	455000	1.60	0.21
R1	stream	1.20	1.15	41935	0.15	0.02
R2	stream	0.88	0.84	30743	0.11	0.01
R3	stream	0.83	0.80	29073	0.10	0.01
R4	stream	1.19	1.15	41743	0.15	0.02
Step 3: Single application						
D3	ditch	0.64	0.61	22359	0.08	0.01
D4	pond	12	11	413636	1.45	0.19
D4	stream	0.67	0.64	23393	0.08	0.01
D5	pond	12	11	413636	1.45	0.19
D5	stream	0.61	0.58	21262	0.07	0.01
R1	pond	12	11	413636	1.45	0.19
R1	stream	0.80	0.77	27914	0.10	0.01
R2	stream	0.59	0.57	20776	0.07	0.01
R3	stream	0.55	0.53	19403	0.07	0.01
R4	stream	0.79	0.76	27744	0.10	0.01

Table 1.9.1.5 Calculated TERs for chemical 5 using maxPECsw simulated by FOCUS SW

Scenario	Water body	Acute fish	Acute aquatic invertebrate	Algae	*Lemna*	Chronic fish	Chronic aquatic invertebrate
		LC_{50} 1900 µg/L	EC_{50} 5000 µg/L	EC_{50} 14 µg/L	EC_{50} 1400 µg/L	NOEC 300 µg/L	NOEC 648 µg/L
Step 3: Multiple applications							
D2	ditch	440	1157	3.24	324	69	150
D2	stream	703	1850	5.18	518	111	240
D3	ditch	4556	11990	34	3357	719	1554
D4	pond	3405	8961	25	2509	538	1161
D4	stream	1479	3891	11	1089	233	504
D5	pond	3770	9921	28	2778	595	1286
D5	stream	2306	6068	17	1699	364	786
R1	pond	16814	44248	124	12389	2655	5735
R1	stream	1286	3385	9.48	948	203	439
R3	stream	1401	3687	10	1032	221	478
Step 4: Multiple applications (5 m 'no spray zone')							
D2	ditch	440	1157	3.24	324	69	150
D2	stream	703	1850	5.18	518	111	240
D3	ditch	17273	45455	127	12727	2727	5891
D4	pond	3405	8961	25	2509	538	1161
D4	stream	1479	3891	11	1089	233	504
D5	pond	3770	9921	28	2778	595	1286
D5	stream	2306	6068	17	1699	364	786
R1	pond	16814	44248	124	12389	2655	5735
R1	stream	1286	3385	9.48	948	203	439
R3	stream	1401	3687	10	1032	221	478
Step 3: Single application							
D2	ditch	848	2232	6.25	625	134	289
D2	stream	1358	3574	10	1001	214	463
D3	ditch	3967	10438	29	2923	626	1353
D4	pond	6552	17241	48	4828	1034	2234
D4	stream	2849	7496	21	2099	450	972
D5	pond	7600	20000	56	5600	1200	2592
D5	stream	4279	11261	32	3153	676	1459
R1	pond	35185	92593	259	25926	5556	12000
R1	stream	2691	7082	20	1983	425	918
R3	stream	2106	5543	16	1552	333	718

Table 1.9.1.6 Calculated TERs for chemical 6 using maxPECsw simulated by FOCUS SW

Scenario	Water body	Acute fish	Acute aquatic invertebrate	Algae	Lemna	Chronic fish	Chronic aquatic invertebrate
		LC_{50} 14300 µg/L	EC_{50} 100000 µg/L	EC_{50} 49800 µg/L	EC_{50} 12300 µg/L	NOEC 200 µg/L	NOEC 100 µg/L
Step 3: Single application							
D1	ditch	402	2811	1400	346	5.62	2.81
D1	stream	643	4498	2240	553	9.00	4.50
D2	ditch	360	2516	1253	310	5.03	2.52
D2	stream	571	3996	1990	492	7.99	4.00
D3	ditch	5588	39078	19461	4807	78	39
D4	pond	39503	276243	137569	33978	552	276
D4	stream	6793	47506	23658	5843	95	48
D5	pond	69756	487805	242927	60000	976	488
D5	stream	6952	48614	24210	5980	97	49
D6	ditch	5127	35855	17856	4410	72	36
R1	pond	64706	452489	225339	55656	905	452
R1	stream	2118	14808	7375	1821	30	15
R3	stream	1289	9016	4490	1109	18	9.02
R4	stream	8558	59844	29803	7361	120	60
D2*	pond	1008	7046	3509	867	14	7.05
Step 4: Single application (5 m 'no spray zone')							
D1	ditch	402	2811	1400	346	5.62	2.81
D1	stream	643	4498	2240	553	9.00	4.50
D2	ditch	360	2516	1253	310	5.03	2.52
D2	stream	571	3996	1990	492	7.99	4.00
D3	ditch	19972	139665	69553	17179	279	140
D4	pond	39503	276243	137569	33978	552	276
D4	stream	17987	125786	62642	15472	252	126
D5	pond	74093	518135	258031	63731	1036	518
D5	stream	18056	126263	62879	15530	253	126
D6	ditch	15180	106157	52866	13057	212	106
R1	pond	67453	471698	234906	58019	943	472
R1	stream	2118	14808	7375	1821	30	15
R3	stream	1289	9016	4490	1109	18	9.02
R4	stream	23404	163666	81506	20131	327	164

Table 1.9.1.7 Calculated TERs for chemical 7 using maxPECsw simulated by FOCUS SW

Scenario	Water body	Acute fish	Acute aquatic invertebrate	Algae	Chronic fish	Chronic aquatic invertebrate
		LC_{50} 18000 µg/L	EC_{50} 4000 µg/L	EC_{50} 1020 µg/L	NOEC 50 µg/L	NOEC 1950 µg/L
Step 3: Multiple applications						
D1	ditch	613	136	35	1.70	66
D1	stream	974	216	55	2.71	106
D2	ditch	496	110	28	1.38	54
D2	stream	789	175	45	2.19	85
D3	ditch	7759	1724	440	22	841
D4	pond	4592	1020	260	13	497
D4	stream	1531	340	87	4.25	166
D5	pond	4023	894	228	11	436
D5	stream	2358	524	134	6.55	255
D6	ditch	985	219	56	2.74	107
R1	pond	26667	5926	1511	74	2889
R1	stream	856	190	48	2.38	93
R3	stream	1169	260	66	3.25	127
R4	stream	1346	299	76	3.74	146
Step 4: Multiple applications (5 m 'no spray zone')						
D1	ditch	613	136	35	1.70	66
D1	stream	974	216	55	2.71	106
D2	ditch	496	110	28	1.38	54
D2	stream	789	175	45	2.19	85
D3	ditch	29316	6515	1661	81	3176
D4	pond	4593	1021	260	13	498
D4	stream	1531	340	87	4.25	166
D5	pond	4023	894	228	11	436
D5	stream	2358	524	134	6.55	255
D6	ditch	985	219	56	2.74	107
R1	pond	26706	5935	1513	74	2893
R1	stream	856	190	48	2.38	93
R3	stream	1169	260	66	3.25	127
R4	stream	1346	299	76	3.74	146
Step 3: Single application						
D1	ditch	2070	460	117	5.75	224
D1	stream	3279	729	186	9.11	355
D2	ditch	1529	340	87	4.25	166
D2	stream	2435	541	138	6.76	264
D3	ditch	5662	1258	321	16	613
D4	pond	13274	2950	752	37	1438
D4	stream	4681	1040	265	13	507
D5	pond	16379	3640	928	45	1774
D5	stream	6089	1353	345	17	660
D6	ditch	3255	723	184	9.04	353
R1	pond	89109	19802	5050	248	9653
R1	stream	2198	488	125	6.10	238
R3	stream	2251	500	128	6.25	244
R4	stream	1349	300	76	3.75	146

1.9.2 Graphical Representation of the FOCUS Step 3 Risk Assessments

The results summarised here are for Step 3 assessments for single applications for all chemicals. Figures in Sections 1.9.2.1 to 1.9.2.6 show the calculated TER values at Step 3 for test chemicals 1 to 7 (single application). The drainage scenarios are represented by the closed circles and the run-off scenarios are represented by the open circles. The scenarios that pass the risk assessment are above the line and the scenarios that fail are below.

1.9.2.1 Acute Fish Risk Assessments

Figure 1.9.2.1.1 summarises the results of the risk assessments at Step 3 for test chemicals 1 to 7. The results demonstrate that all scenarios for chemical 4 fail the Step 3 scenarios whilst test chemical 1 fails the four run-off scenarios; both are insecticides. All other test chemicals pass the scenarios with reasonable margins.

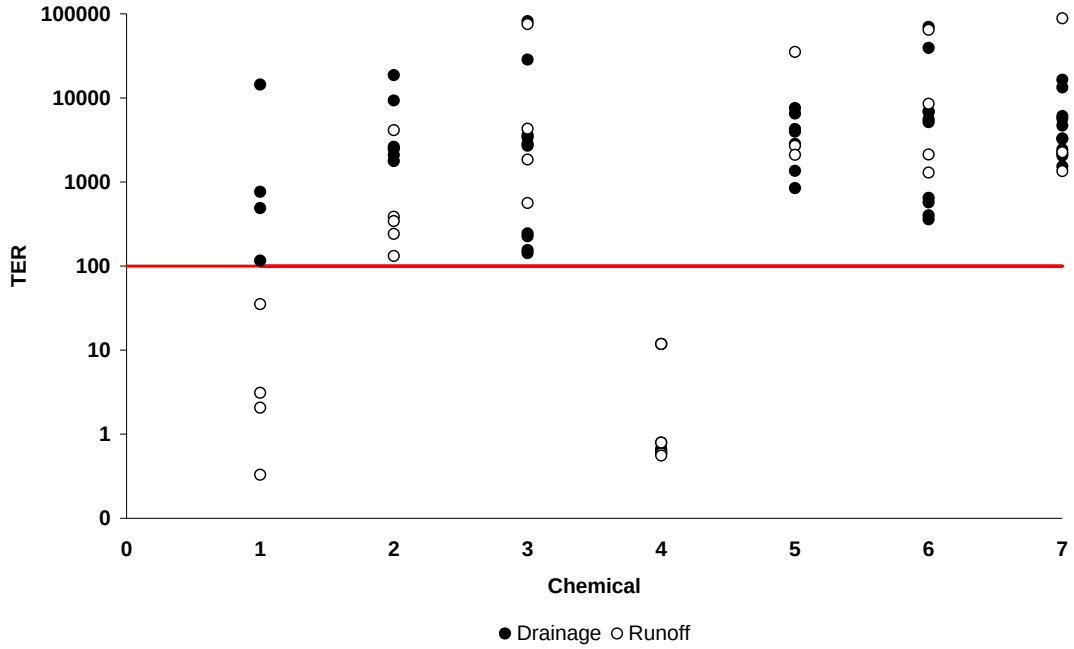


Figure 1.9.2.1.1 Distribution of acute TERs for fish calculated using PECs from FOCUS SW Step 3. Red line indicates TER trigger value.

The results of all FOCUS assessments and current UK drainage and spray drift assessments are summarised in Table 1.9.2.1.1 for acute risks to fish. It has been demonstrated that the current UK drainage and spray drift assessment is less protective than the FOCUS Step 1 and 2 calculator and equivalent to the FOCUS Step 3 and Step 4 assessments.

Table 1.9.2.1.1 Pass/fail rates for acute toxicity to fish for chemicals 1-7.

Chemical	UK drainage	UK Spray Drift (1 m)	Step 1	Step 2	Step 3^{m}	Step 3^{s}	Step 4
					Pass/Fail at each Step		
1	F	-	F	F	-	4/8	-
2	P	P	F	F	-	11/11	11/11
3	P	P	F	F	-	14/14	14/14
4	F	F*	F	F	0/10	0/10	0/10
5	P	P	F	F	10/10	10/10	10/10
6	P	P	P	P	-	15/15	14/14
7	P	P	P	P	14/14	14/14	14/14
Overall pass rate (%)	**71**	**83**	**29**	**29**	**71**	**83**	**86**

P = pass; F = fail; ^{m} = multiple application; ^{s} = single application; - = not applicable; * = 3 m 'no spray zone'

1.9.2.2 Acute Risk Assessments to Aquatic Invertebrates

Figure 1.9.2.2.1 summarises the results of the risk assessments at Step 3 for test chemicals 1 to 7. The results demonstrate that all scenarios for chemical 4 fail the Step 3 scenarios whilst test chemical 1 fails the four run-off scenarios; both are insecticides. All other test chemicals pass the scenarios with reasonable margins.

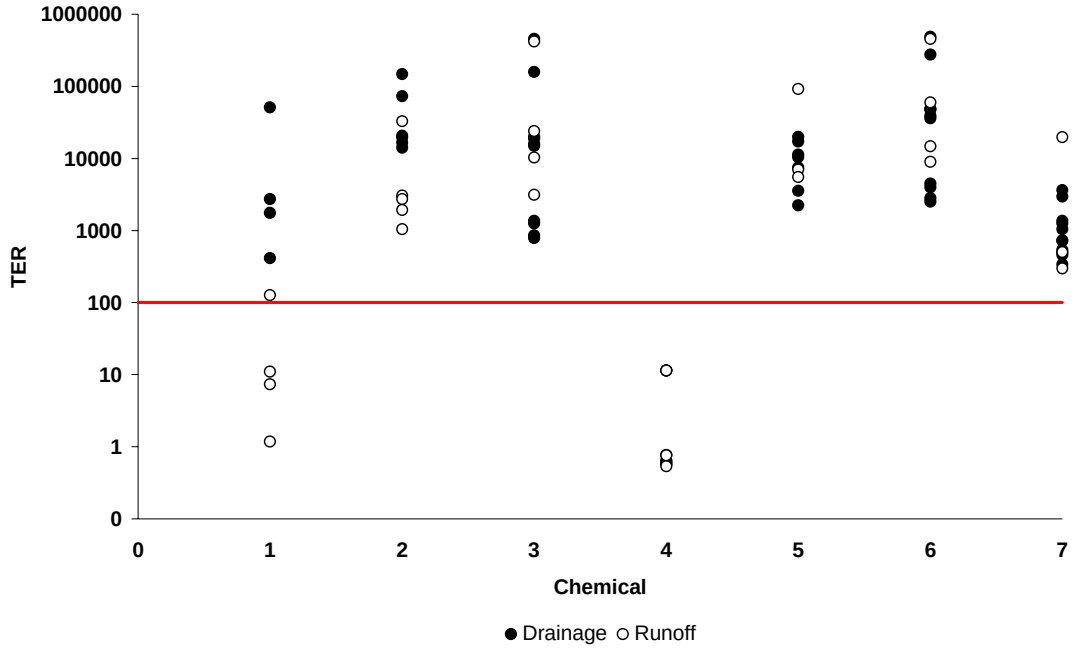


Figure 1.9.2.2.1 Distribution of acute TERs for aquatic invertebrates calculated using PECs from FOCUS SW Step 3. Red line indicates TER trigger value.

The results of all FOCUS assessments and current UK drainage and spray drift assessments are summarised in Table 1.9.2.2.1 for acute risks to aquatic invertebrates. It has been demonstrated that the current UK drainage and spray drift assessment is less protective than the FOCUS Step 1 and 2 calculator and similar to the FOCUS Step 3 and Step 4 assessments.

Table 1.9.2.2.1 Pass/fail rates for acute toxicity to aquatic invertebrates for chemicals 1-7.

Chemical	UK drainage	UK Spray Drift (1 m)	Step 1	Step 2	Step 3^{m}	Step 3^{s}	Step 4
					Pass/Fail at each Step		
1	F	-	F	F	-	5/8	-
2	P	P	P	P	-	11/11	11/11
3	P	P	P	P	-	14/14	14/14
4	F	F	F	F	0/10	0/10	0/10
5	P	P	F	F	10/10	10/10	10/10
6	P	P	P	P	-	15/15	14/14
7	P	P	F	F	14/14	14/14	14/14
Overall Pass rate	**71**	**83**	**43**	**43**	**71**	**84**	**86**

P = pass; F = fail; ^{m} = multiple application; ^{s} = single application; - = not applicable; * = 3 m 'no spray zone'

1.9.2.3 Acute Aquatic Risk Assessments to algae

Figure 1.9.2.3.1 summarises the results of the risk assessments at Step 3 for test chemicals 1 to 7. The results demonstrate that test chemicals 1, 2 and 5 fail some of the Step 3 scenarios, mostly run-off scenarios. All other test chemicals pass Step 3.

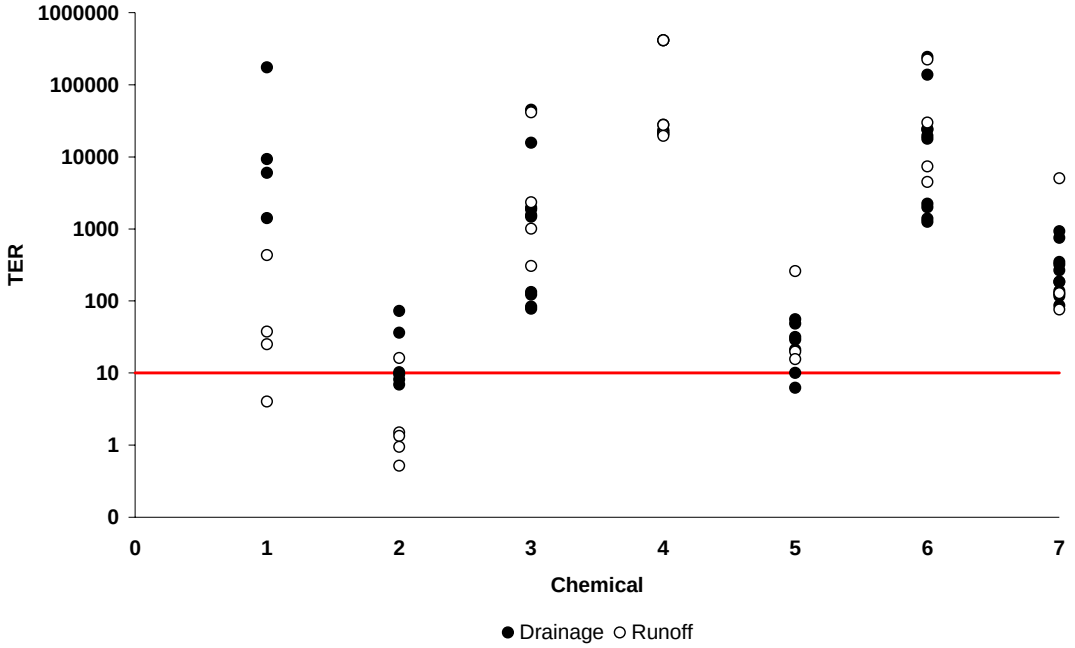


Figure 1.9.2.3.1 Distribution of acute TERs for algae calculated using PECs from FOCUS SW Step 3. Red line indicates TER trigger value.

The results of all FOCUS assessments and current UK drainage and spray drift assessments are summarised in Table 1.9.2.3.1 for risks to algae. It has been demonstrated that the current UK drainage and spray drift assessment is less protective than the FOCUS Step 1 and 2 calculator. The current UK spray drift assessment is similar to the FOCUS Step 3 and Step 4 assessments, but the UK drainage assessment results are generally lower than the calculated TER values at FOCUS Step 3 and 4.

Table 1.9.2.3.1 Pass/fail rates for acute toxicity to algae for chemicals 1-7.

Chemical	UK drainage	UK Spray Drift (1 m)	Step 1	Step 2	Step 3^{m}	Step 3^{s}	Step 4
					Pass/Fail at each Step		
1	F	-	F	F	-	7/8	-
2	F	F	F	F	-	4/11	6/11
3	P	P	P	P	-	14/14	14/14
4	P	P	P	P	10/10	10/10	10/10
5	F	P	F	F	7/10	9/10	7/10
6	P	P	P	P	-	15/15	14/14
7	P	P	F	F	14/14	14/14	14/14
Overall Pass rate	**57**	**83**	**43**	**43**	**97**	**87**	**89**

P = pass; F = fail; ^{m} = multiple application; ^{s} = single application; - = not applicable; * = 3 m 'no spray zone'

1.9.2.4 Aquatic Risk Assessments to *Lemna*

Figure 1.9.2.4.1 summaries the results of the risk assessments at Step 3 for test chemicals 1 to 7. No toxicity data were available for test chemicals 1, 4 and 7 so these chemicals were not included in the risk assessment. The results demonstrate that all the run-off scenarios and the majority of the drainage scenarios for test chemical 2 failed the risk assessment. All other test chemicals passed the risk assessment.

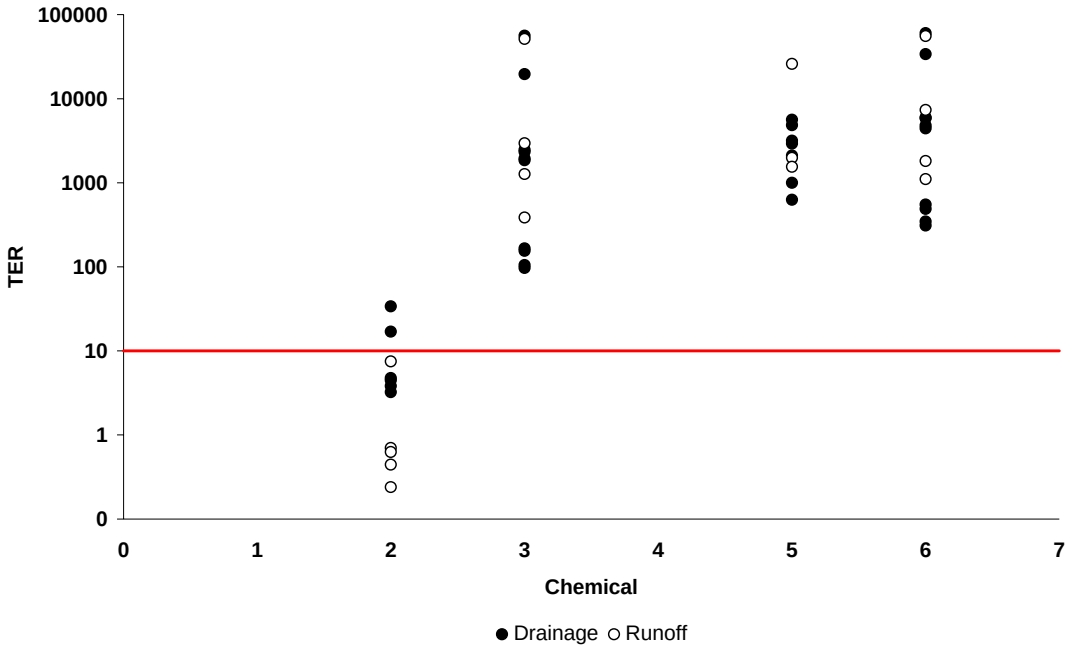


Figure 1.9.2.4.1 Distribution of acute TERs for *Lemna* calculated using PECs from FOCUS SW Step 3. Red line indicates TER trigger value.

The results of all FOCUS assessments and current UK drainage and spray drift assessments are summarised in Table 1.9.2.4.1 for risks to *Lemna*. It has been demonstrated that the current UK drainage and spray drift assessment is less protective than the FOCUS Step 1 and 2 calculator and is slightly more challenging to the FOCUS Step 3 and Step 4 assessments.

Table 1.9.2.4.1 Pass/fail rates for acute toxicity to *Lemna* for chemicals 1-7.

Chemical	UK drainage	UK Spray Drift (1 m)	Step 1	Step 2	Step 3^{m}	Step 3^{s}	Step 4
					Pass/Fail at each Step		
1	-	-	-	-	-	-	-
2	F	F	F	F	-	2/11	5/11
3	P	P	P	P	-	14/14	14/14
4	-	-	-	-	-	-	-
5	P	P	F	F	10/10	10/10	10/10
6	P	P	P	P	-	15/15	14/14
7	-	-	-	-	-	-	-
Overall Pass rate	**75**	**75**	**50**	**50**	**100**	**82**	**88**

P = pass; F = fail; ^{m} = multiple application; ^{s} = single application; - = not applicable; * = 3 m 'no spray zone'

1.9.2.5 Chronic Aquatic Risk Assessments to Fish

Figure 1.9.2.5.1 summarises the results of the risk assessments at Step 3 for test chemicals 1 to 7. The results demonstrate that test chemical 4 fails the risk assessment and that some of the scenarios for test chemicals 2, 3, 6 and 7 also fail the risk assessment. Test chemical 5 passes all scenarios by a reasonable margin.

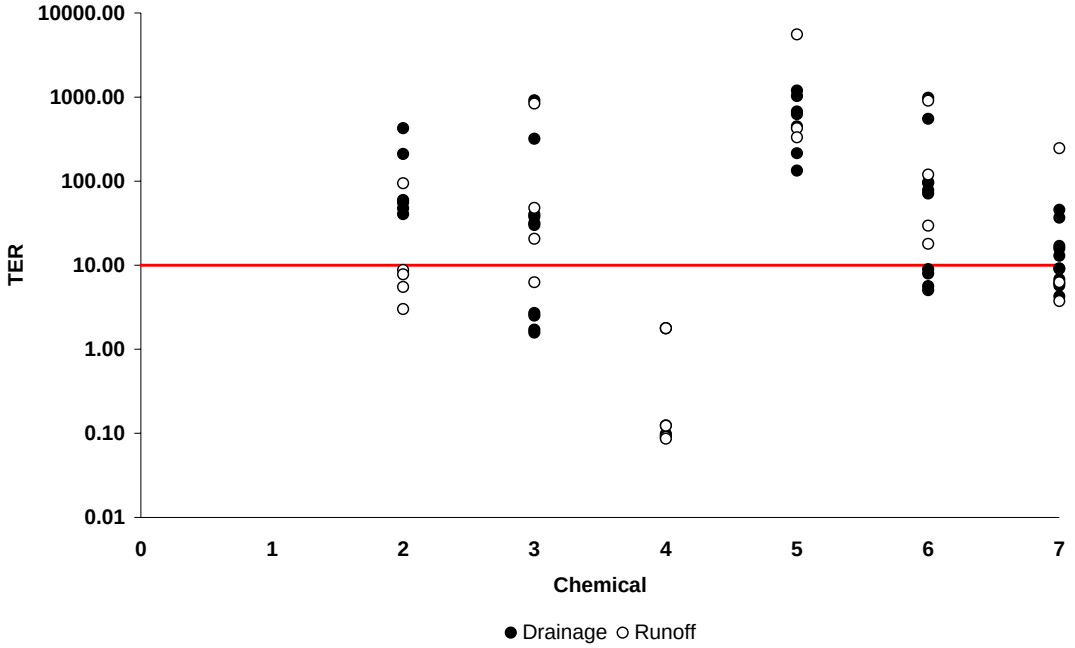


Figure 1.9.2.5.1 - Distribution of chronic TERs for fish calculated using PECs from FOCUS SW Step 3. Red line indicates TER trigger value.

The results of all FOCUS assessments and current UK drainage and spray drift assessments are summarised in Table 1.9.2.5.1 for chronic risks to fish. It has been demonstrated that the current UK drainage and spray drift assessment is less protective than the FOCUS Step 1 and 2 calculator. The current UK drift assessment is less protective than the FOCUS surface water scenarios, but the drainage assessment is far more conservative than the Step 3 and 4 assessments (for these chemicals).

Table 1.9.2.5.1 Pass/fail rates for chronic toxicity to fish for chemicals 1-7.

Chemical	UK drainage	UK Spray Drift (1 m)	Step 1	Step 2	Step 3^{m}	Step 3^{s}	Step 4
					Pass/Fail at each Step		
1	-	-	-	-	-	-	-
2	F	P	**F**	**F**	-	**7/11**	**7/11**
3	F	P	**F**	**F**	-	**9/14**	**9/14**
4	F	F	**F**	**F**	**0/10**	**0/10**	**0/10**
5	P	P	**F**	**F**	**10/10**	**10/10**	**10/10**
6	F	P	**F**	**F**	-	**11/15**	**10/14**
7	F	P	**F**	**F**	**4/14**	**6/14**	**4/14**
Overall Pass rate	**17**	**83**	**0**	**0**	**41**	**58**	**55**

P = pass; F = fail; ^{m} = multiple application; ^{s} = single application; - = not applicable; * = 3 m 'no spray zone'

1.9.2.6 Chronic Aquatic Risk Assessments to Aquatic Invertebrates

Figure 1.9.2.6.1 summarises the results of the risk assessments at Step 3 for test chemicals 1 to 7. The results demonstrate that test chemical 4 fails the risk assessment and that some of the scenarios for test chemicals 1, 2, 3 and 6 also fail the risk assessment. All other test chemicals (5 and 7) pass the scenarios by a reasonable margin.

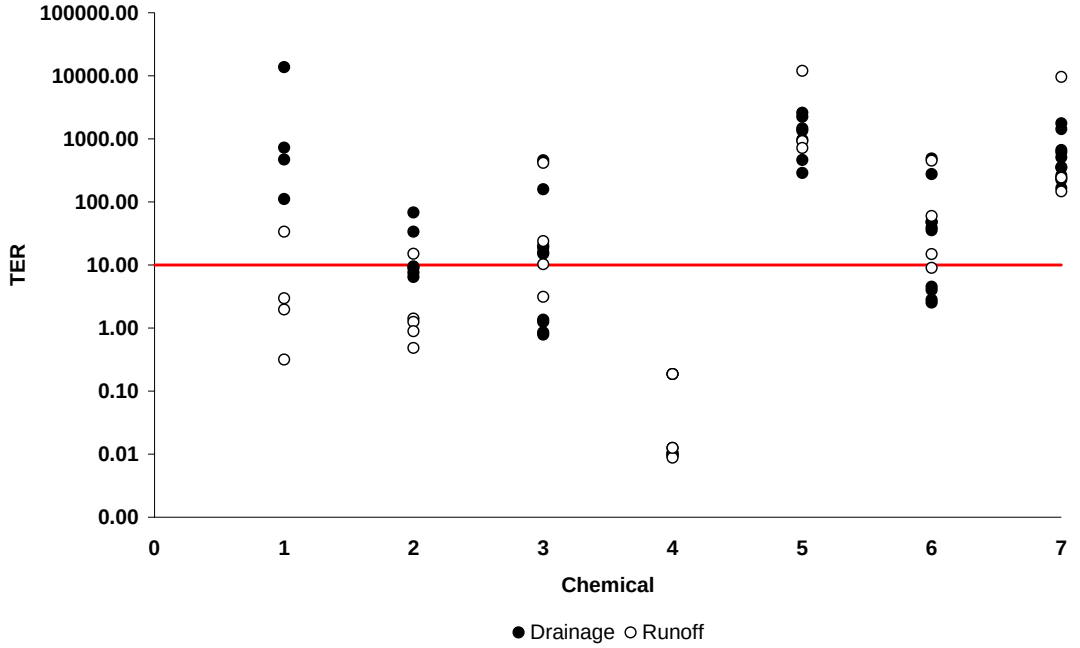


Figure 1.9.2.6.1 Distribution of chronic TERs for aquatic invertebrates calculated using PECs from FOCUS SW Step 3. Red line indicates TER trigger value.

The results of all FOCUS assessments and current UK drainage and spray drift assessments are summarised in Table 6.9.2.6.1 for chronic risks to aquatic invertebrates. It has been demonstrated that the current UK drainage and spray drift assessment is less protective than the FOCUS Step 1 and 2 calculator. The current UK drift assessment is similar to the FOCUS surface water scenarios, but the drainage assessment is far more conservative than the Step 3 and 4 assessments (for these chemicals).

Table 1.9.2.6.1 Pass/fail rates for chronic toxicity to aquatic invertebrates for chemicals 1-7.

Chemical	UK drainage	UK Spray Drift (1 m)	Step 1	Step 2	Step 3^{m}	Step 3^{s}	Step 4
					Pass/Fail at each Step		
1	F	-	**F**	**F**	**-**	**5/8**	**-**
2	F	F	**F**	**F**	**-**	**3/11**	**6/11**
3	F	P	**F**	**F**	**-**	**9/14**	**9/14**
4	F	F	**F**	**F**	**0/10**	**0/10**	**0/10**
5	P	P	**F**	**F**	**10/10**	**10/10**	**10/10**
6	F	P	**F**	**F**	**-**	**9/15**	**9/14**
7	P	P	**P**	**P**	**14/14**	**14/14**	**14/14**
Overall Pass rate	**29**	**67**	**14**	**14**	**71**	**61**	**66**

P = pass; F = fail; ^{m} = multiple application; ^{s} = single application; - = not applicable; * = 3 m 'no spray zone'