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COLLABORATIVE, IMPARTIAL RESEARCH

UKWIR DW14B207

Pesticide Risk Mapping and Catchment Interventions Phase 1

Cambridge Environmental Assessments

ADAS

CRD ERAR Meeting

9th June 2015

Greg Hughes, Hester Lyons, Tim Pepper, Susan Twining and Colleagues

Project Objectives

Produce risk maps for problem pesticides (primarily metaldehyde but also OSR & grassland herbicides) based on an agreed methodology, to identify areas of high risk with respect to raw drinking water quality

and supporting evidence, to enable decision makers to make informed assessments on appropriate interventions based on their impact, barriers to adoption and costs of implementation.

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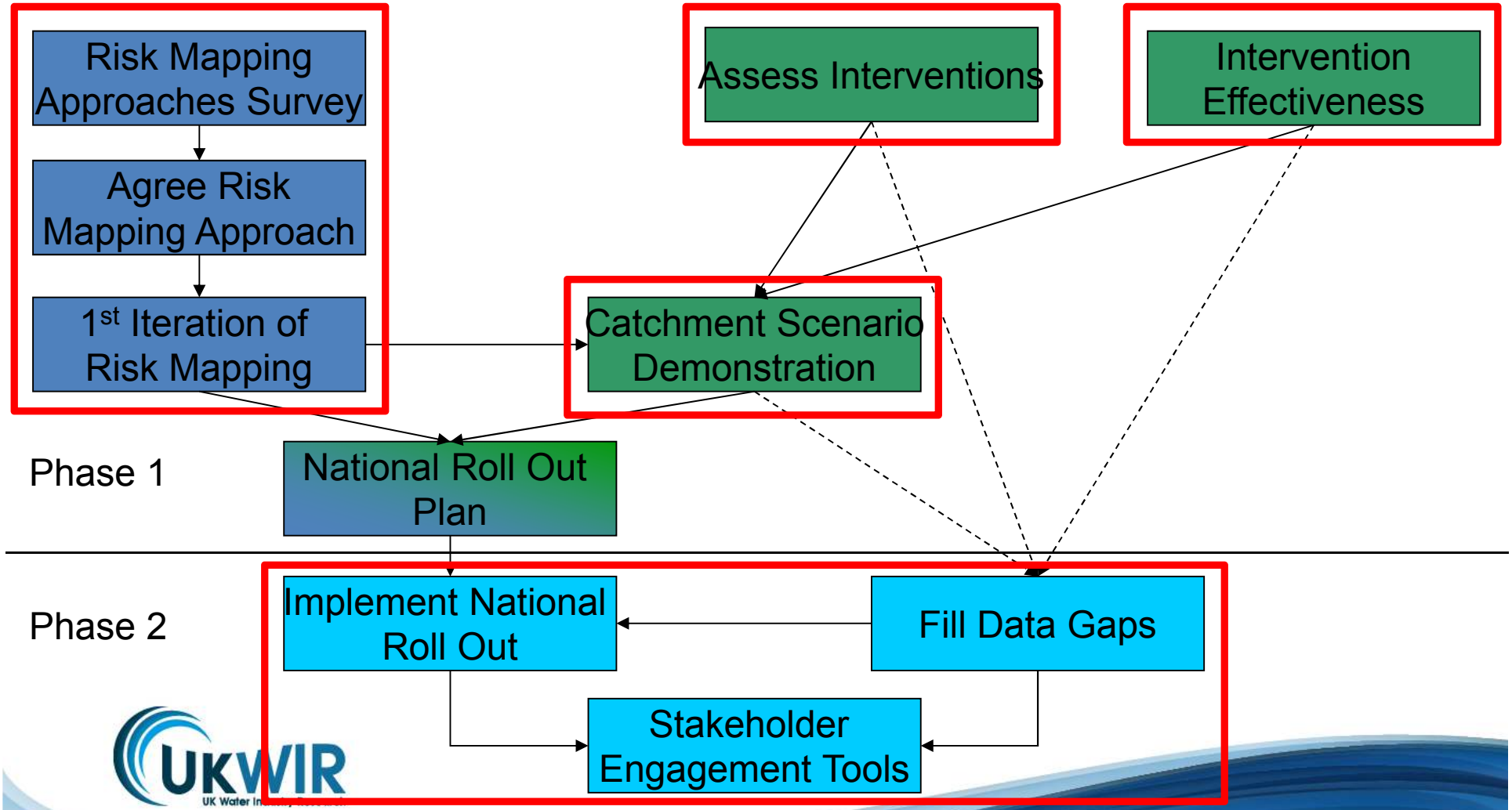
Project Outline



Risk Mapping Assessment

- Risk Mapping Review
  - Survey form sent to UKWIR members and a range of stakeholders
  - Literature Review
  - Grey Literature e.g. Defra Reports
- Dataset Review

- No one approach completely suited
- A number contained promising concepts, elements or approaches
- Approach outlined is a variant/hybrid of these promising approaches

	Ease of in-house implementation	Ease of understanding	Scalability	Need for additional software	Data costs and limitations	Precision of study	Overall assessment
MSG/Severn Trent Water Field-scale Hotspot Mapping	Med	High	Med	Med	Low	High	**High**
South West Water Field Scale Hot-spot Mapping	Med	High	Med	Med	Low	High	**High**
South East Water Field Scale Hot-spot Mapping	Med	High	Med	Med	Low	High	**High**
4-scope Field Scale Hot-spot Mapping	Med	High	High	Med	Med	High	**High?**
ADAS Predictive Pesticide Risk Assessment	Low	Med	High	Low	Low	Med	**Med**
CatchIS Pesticide Modelling	Med	Low	High	Low	Low	Med	**Med**
GFK I-Map	High	Med	High	Low	Low	Med	**Low**
Thames Water Monitoring Hot Spot Mapping	Med	High	Low	Med	Low	Low	**Med**
Thames Water Groundwater Modelling	Med	Med	Low	Med	Low	High	**Low?**
Targeted (sub-) Catchment Monitoring	High	High	Low	High	Low	Low/ High	**Low**
Catchment Characterisation	Med	Low	Low	Med	Low	High	**Med**
Chemicals Regulation Directorate Runoff Risk Index	Med	High	High	Med	Low/ Med	High	**High**
Chemicals Regulation Directorate Drainflow Risk Index	Med	High	High	Med	Low/ Med	Med	**High**
SNIFFER Diffuse Pollution Screening Tool	Low	Med	High	Low	Low	Med	**Med**
Landscape "regulatory" pesticide fate models	Low	Med	Med/ High	Low/ Med	Low/ Med	High	**Med/ High**
Intervention (Cost/)Effectiveness Catchment Modelling	Low	Med	Low	Low/ Med	Low	Low	**Med**
Groundwater Vulnerability Maps	High	High	High	High	Low/ Med	Med	**High**
MetaPEARL	Low	Med	High	Med	Low/ Med	Med	**Med**

† Not completely documented

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Risk Mapping Approach Pro's

- Representing all transport pathways– surface runoff, drainflow and leaching to GW
- Representing dual porosity and bypass flow
- Representation of different agricultural drainage systems (mole and tile drains)
- Representation of moisture and temperature gradients across the UK
- Utilising long term daily weather data as opposed to long term averages
- Accounting for pesticide properties (e.g. persistence and mobility) and formulation (pellet)
- Founded on a sound scientific basis rather than a piecemeal selection of factors

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Risk Mapping Approach Pro's

- Combining risk factors into a single, simulation model-derived, value rather than arbitrarily combining these by addition/multiplication
- Generating factor ratings that reflect the relative difference between settings [20,12,4,2,1] instead of using arbitrary scales of factor ratings [10,8,6,4,2]
- Accommodating a meaningful representation of interventions within the framework
- Accommodating the need for an assessment of catchment scale implications of field scale interventions that appropriately reflects the relative contribution of individual field parcels
- May be updated e.g. "live" in the field

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Risk Mapping Approach

Sources

- Diffuse agricultural only
  - Non-agric uses beyond the remit of this project
  - Agric “point” sources an operational issue

Pathways

- Runoff, drainflow, leaching
  - “Spray” drift an operational issue and not included

Receptors

- Surface water, ground water

Scales

- 1km grid and field

Good agricultural practice

Surface Water Risk Index as an Example

Surface water risk index comprised of surface runoff and drainflow risk components

Risk Factors

- Rainfall amount/intensity
- Soil Properties – organic matter, texture, structure, hydraulic response, condition, drainage status and properties
- Topography – slope
- Landcover/Landuse
- Connectivity
- Pesticide Usage

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Surface Water Risk Index

- Define normalised loss (%) of active applied *via* runoff and drainflow to surface water for set combinations of risk factors e.g. active ingredient, climate region, soil, drain status, slope, landcover so can “look them up”
- Losses modelled using regulatory PRZM and MACRO models using 30 year daily simulations
- Weighted by landscape factors e.g. connectivity, pesticide usage

$$RRI_{Field} = RunoffLoss_{active_ingredient,soil,drain_status,climate_region,slope,landcover} * RunoffConnectivity * PesticideUsage$$

$$DRI_{Field} = DrainLoss_{active_ingredient,soil,drain_status,climate_region,slope,landcover} * DrainConnectivity * PesticideUsage$$

Field Risk Index Calculation

Risk Factors					Normailsed Loss (Average Annual % Applied Lost)			
Landcover	Soil Class	Climate Class	Drain Status	Slope Class	Surface Runoff	Drainflow	Surface Water	Groundwater
Arable	E1	Low Warm	Undrained	<2%	0.14	0.00E+00	0.14	0.10
Grass	E2	Low Warm	Undrained	<2%	9.84E-04	0.00E+00	9.84E-04	0.06
Arable	K1	Low Warm	Drained	<2%	0.53	52.23	52.75	0.08
Grass	K1	Low Warm	Drained	<2%	0.03	33.64	33.67	0.04

Note: this may l
area weighted
depending on
requirements/u

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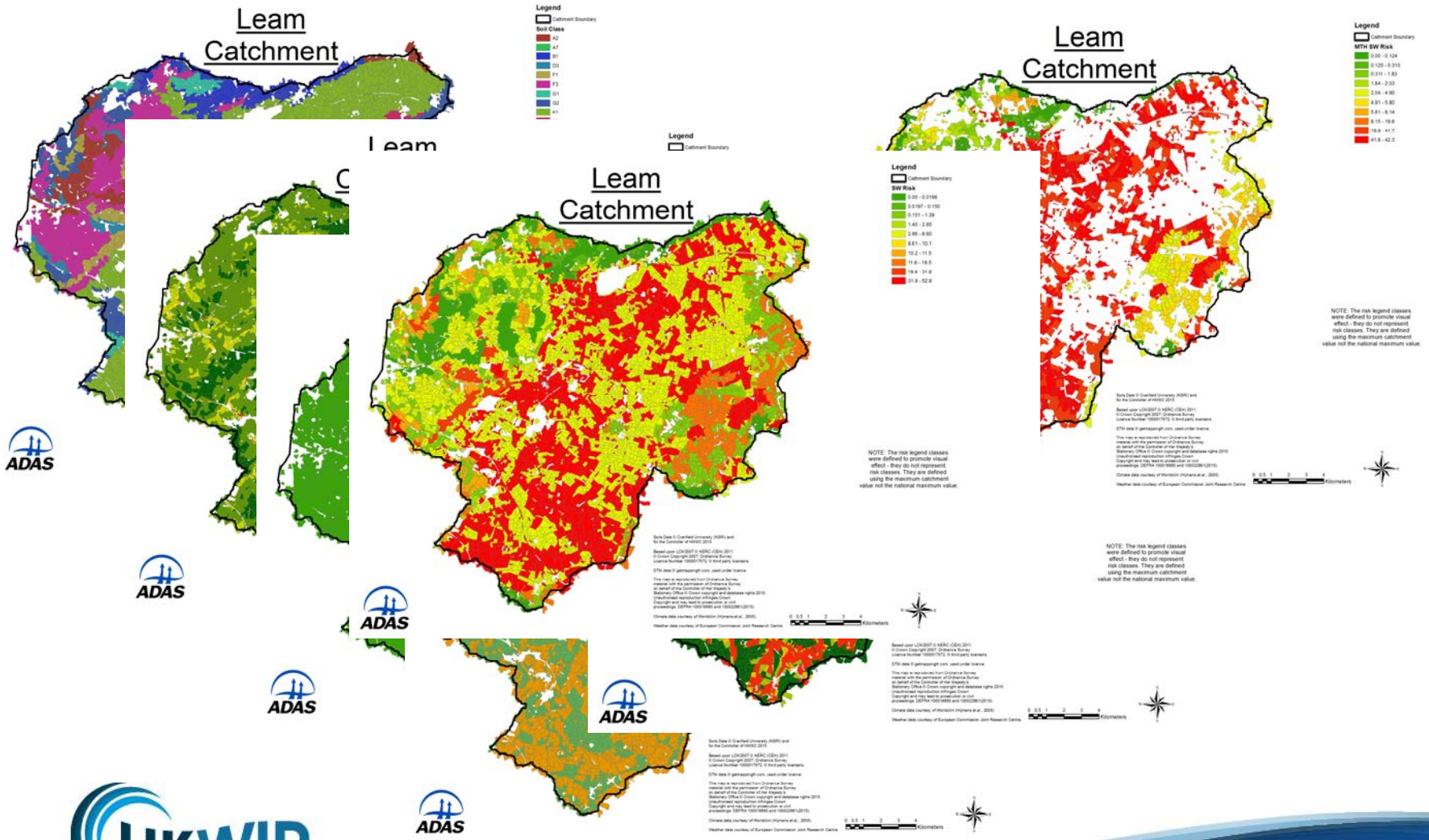
Field Risk Example



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UK Scale

- Intermediate product for whole UK required
- Same underlying risk factors and approach
- In a 1km grid cell there are a range of soils, landcovers, degrees of connectivity, extents of drainage, etc
- The risk index in each 1km grid cell needs to be the aggregate of all of these

$$RRIc = (GrassRRIc_{drained} + GrassRRIc_{undrained} + ArableRRIc_{drained} + ArableRRIc_{undrained})$$

$$RRIc_{drained} = \left(\sum_{1}^{n_soils} RLoss_{ai,soil,dstat,reg,slope,\{gr/ar\}} * PSoil * P\{gr/ar\} \right) * PDrained * PRunCon * PUsage$$

$$RRIc_{undrained} = \left(\sum_{1}^{n_soils} RLoss_{ai,soil,dstat,reg,slope,\{gr/ar\}} * PSoil * P\{gr/ar\} \right) * (1 - PDrained) * PRunCon * PUsage$$

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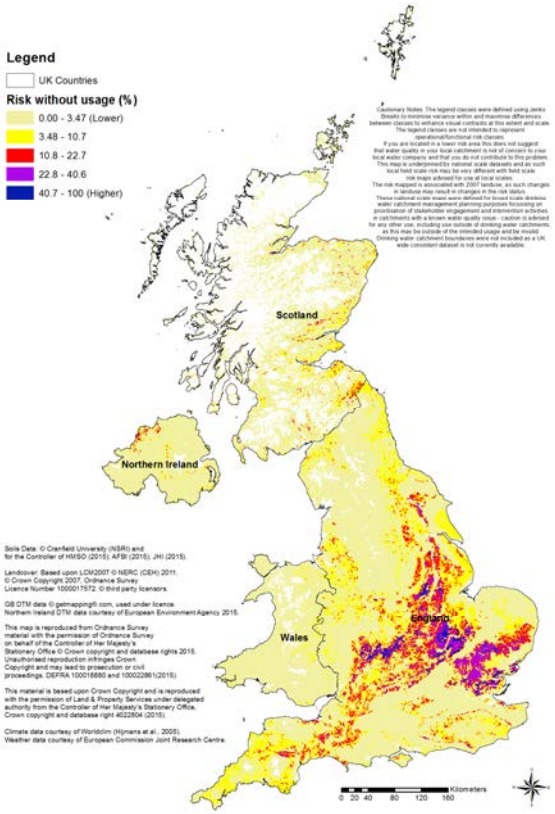
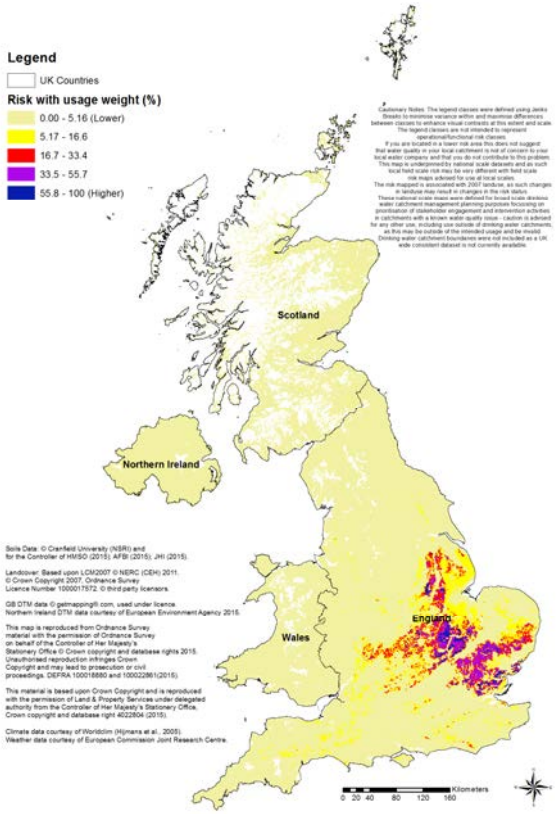
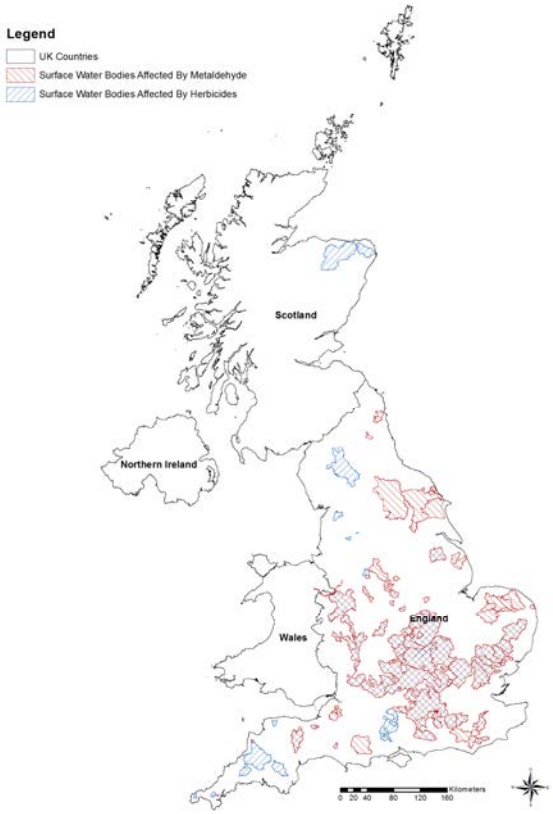
UK Risk Maps – Metaldehyde SW







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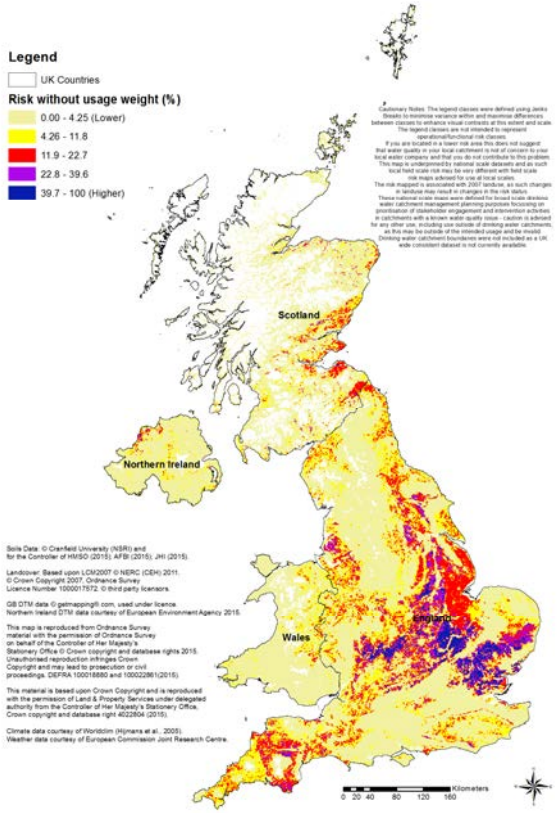
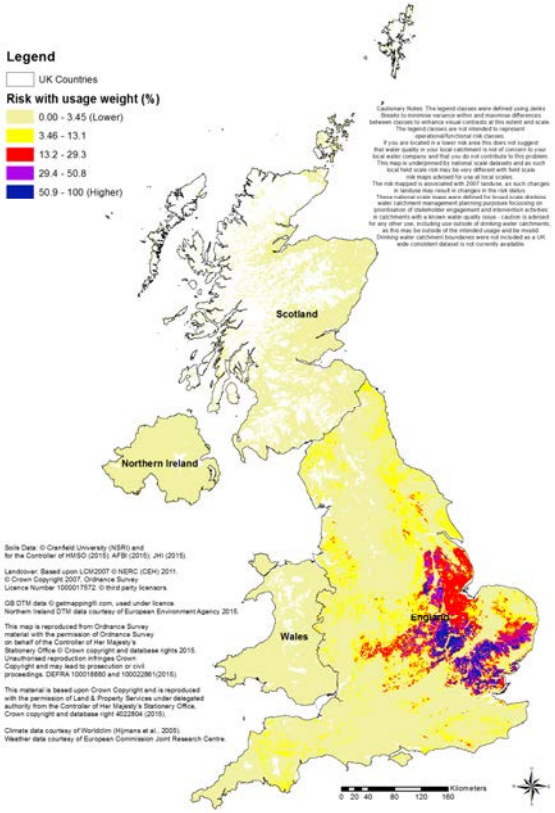
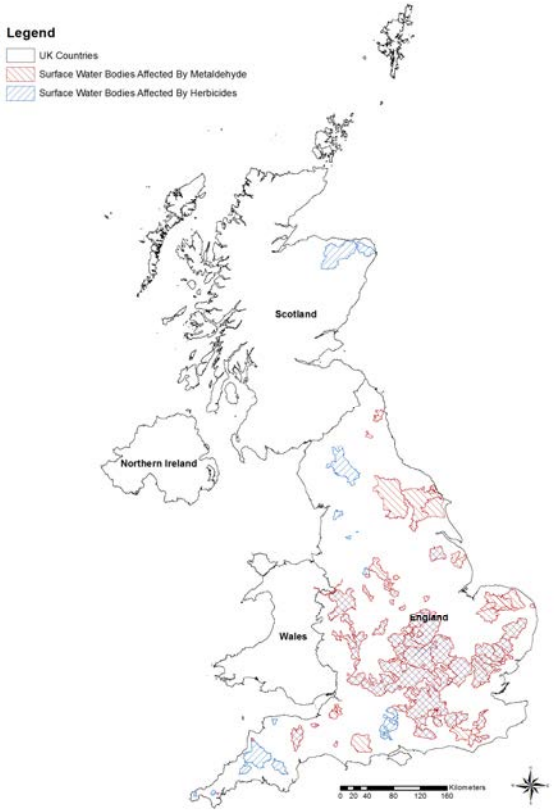
UK Risk Maps – Mobile Herbicides SW







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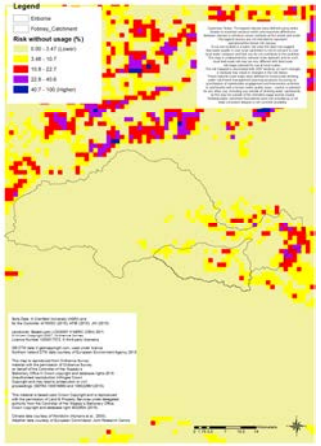
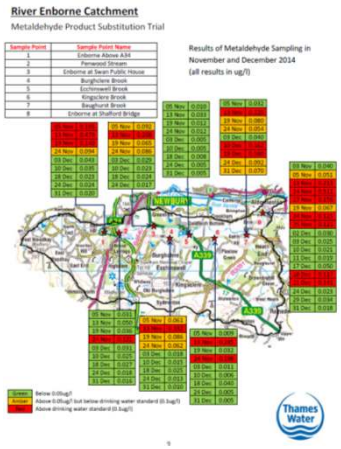
UK Maps

- Produced for all areas as consistent DrW catchments dataset for UK is not available
- **Read cautionary notes before use**
- Risk communication challenge
  - "lower" risk does not mean no risk
  - "lower" risk does not mean no contribution to catchment water quality problems – its all relative!





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Intervention Characterisation - Aims

- Identify farm practices that have a positive impact on reducing pesticides in water
- Assessment of farm practices with supporting evidence
- Identify costs of implementation for the farmer

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Identification of farm practices - methodology

- Long list of farm practices at a field level
  - Water company survey
  - Catchment sensitive farming
  - Literature
  - Guidance and advice

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Identification of farm practices – the long list

(Storage and handling)	Application Technology	Field operations	Modified movement
Biobeds/biofilters	Weedwipers	Buffer strips/No spray zone	Drain filters
Heliosecs	Low drift nozzles	Reduced application rate	Detention ponds
Machinery under cover	Training of operators	Changed application timing	Grassed waterways
Correct storage	Calibration/maintenance	Changed application method	Constructed wetlands
Washing and disposal		Product substitution	Polymers
Spill kit		Rotation/crop choice/reversion	Drain management
		IPM/cultivations/soils	Tramline disruption

Assessment of farm practices – drivers and adoption

- Driver for adoption:
  - Statutory
  - Best practice
  - Ideal practice

- Current level of adoption and potential for further adoption

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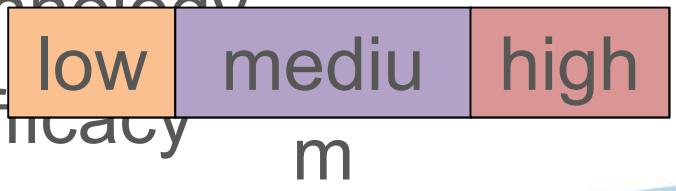
Assessment of farm practices - Barriers to adoption and efficacy

- Number of factors affect adoption of a farm practice:
  - Cost of implementation
  - Evidence of efficacy
  - Skill level
  - Practical issues
  - Benefits of adoption
  - Availability of tech
- Relative potential efficacy



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One page intervention/farm practices summarie

Product Substitution

Product (active ingredient) substitution (i) replacement of Metaldehyde (MTH) with Ferric Phosphate, and (ii) switch to glyphosate by using weedwiper in grassland.

Type of Measure	Current Adoption Level	Availability of Technology
Ideal Practice	Low	Current / In Development

Individual Barriers	*Rating*	*Overall Barriers to Adoption*
Costs of Implementation	Low	High — Key issue is confidence in alternative option and practical issues
Evidence for Efficacy	High	
Skill Levels	High	
Practical Issues	Moderate	

Detailed Costings

(i) Metaldehyde switch to ferric phosphate

- Chemical costings based on product prices from agrochemical distributor in Oct 2014.
- Costings calculated for a replacement of MTH at standard rate with Ferric Phosphate and based on single applications.

Replace MTH with Ferric Phosphate		
Product	£ / ha	Net effect of change on farm income £ / ha
MTH	11.9	
Ferric Phosphate	21.7	-9.8

(ii) Replacing spot treatment with grassland herbicides with glyphosate in weedwiper

- Costings also calculated for a move from various grassland herbicides containing CMPP to glyphosate in weedwiper.
- Assumed cost of a contract weedwiper hire is similar to contract boom sprayer so only difference is cost of chemical.

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Farm practice assessment – long list to a short list

- 35 farm practices on long list
- Efficacy, availability, potential adoption
- 4 groups of farm practices
  - Buffer strips
  - Reduced application – range of practices
  - Product substitution
  - Vegetated ditches
- Detailed costings

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Intervention Effectiveness - Aims

- Characterise intervention efficacies for selected mitigation techniques
- Should have quantifiable benefits that can be applied in the majority of UK situations

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Evidence Base

- Current Water Company trials
- Historic field/catchment scale data held by ADAS and other stakeholders (including Chemical Co's)
- Published reviews/literature
  - Regulatory modelling risk mitigation values e.g. FOCUS L&M

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Effectiveness of drainage mitigation measures at the farm and catchment s

Intervention	Pesticide load reduction effectiveness		Recommended as a mitigation measure
	Strongly sorbed	Weekly sorbed	
In-field			
Application timing	Variable	Variable	Yes
Application rate reduction	= % of rate reduction	= % of rate reduction	Yes
Fine tilth	Unknown	30%	No
Soil amendments	High	Low	No
Cultivations	Variable	Variable	No
Edge of field			
Drain efficiency	40%	20%	Yes
Drain filters	100%	75%	No
Detention ponds	Low	Low	No

Summary of relevant runoff mitigation measures and their effectiveness

Intervention	Pesticide Load Reduction Effectiveness		
	Strongly Sorbed	Weakly Sorbed	Mitigation measure?
Pesticide management practices			
Application timing	0-50%	0-50%	Yes
Application rate	0-50%	0-50%	Yes
Soil incorporation	25-50%	35-70%	No
In-field land management practices			
Contour Ploughing	0-75%	0-60%	No
Conservation tillage	40-75%	0-50%	No
Tramline disruption	?	?	No
Edge-of-field land management practices			
Vegetative filter strips	60-90%	50-80%	Yes
Constructed wetlands	90%	60%	Yes

Leaching losses (groundwater)

Few specific mitigation measures, although processes similar to water movement to drains

Reviews suggest mitigation could include:

- Restricting products to higher sorbtion/lower persistence characteristics
- Soil/Crop management regimes maximising pesticide retention/degradation (e.g. fine seedbeds, enhanced OM, cover crops)
- Modified crop rotations to increase timing between pesticide applications
- Promote OM status to restrict macropore flow

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Recommendations

Limited number of intervention options sufficiently well characterised to allow inclusion in risk mapping tool for these problem compounds

- **Drainflow** – Application rate and timing; Drain efficiency
- **Surface runoff** – Application rate and timing; Vegetated buffer strips; Constructed wetlands
- **Groundwater** – Application rate and timing

Use of the interventions with the risk

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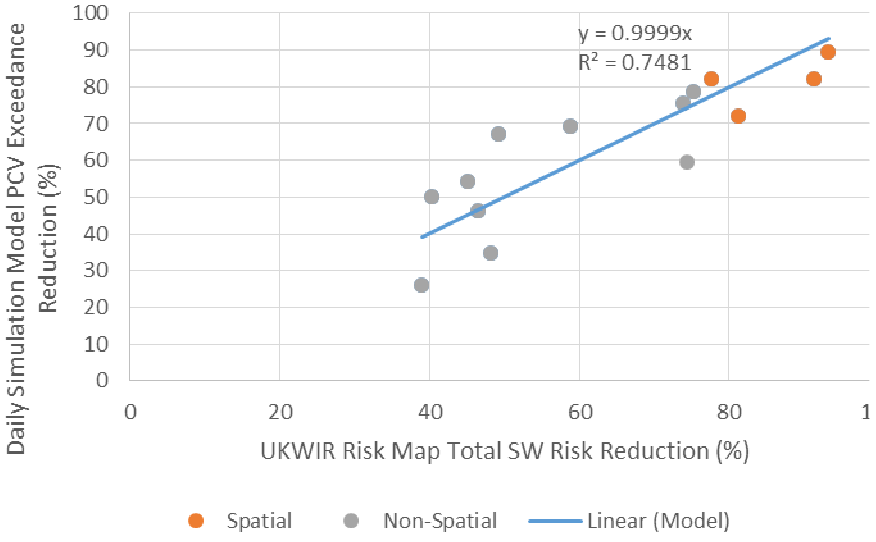
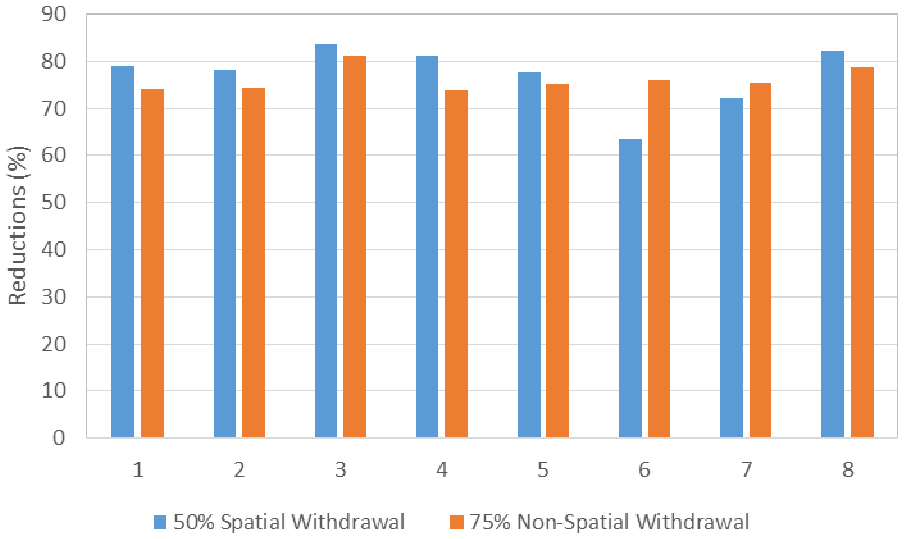
Catchment Modelling Results

- The relative changes in the number of simulated exceedances for each catchment were determined
- The reduction in the total catchment risk score was also determined





Phase 1 Reporting

- Revised draft reporting stage
- Should be available from UKWIR website by the summer 2015

Phase 2 Objectives

Phase 2 of the project focusses on the practical use of the developments from phase 1, for example:

- Expanding the field level mapping to all parts of the UK,
- Piloting it and developing tools to facilitate better use of, track benefits from and improve communication of the risk mapping and
- Address gaps in the evidence base, for example with intervention effectiveness

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Thank you

Project Steering Group
&
numerous ADAS Colleagues

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