Catchment Sensitive Farming

Evaluation Report - Phases 1 to 3 (2006 - 2014)

CSF Evidence Team
Environment Agency
August 2014

A clear solution for farmers

CATCHMENT SENSITIVE FARMING

Foreword

We all depend on fresh, clean water in our streams, rivers and aquifers for drinking, recreation and to enjoy diverse and abundant wildlife. Alongside this, we wish to see a sustainable and competitive farming sector. These are natural and understandable objectives in their own right, notwithstanding the legislative drivers, such as the EU Water Framework Directive (WFD). Around 70 per cent of land in England is used for agriculture, but it is one of many influences on water quality. To achieve our objectives, we need to tackle the range of sectors contributing to the problem in a cost-effective and proportionate way.

Water pollution from agriculture is more difficult to deal with than others sources. Firstly, it arises from numerous, often individually minor, sources across the landscape. Secondly, pollutant inputs vary greatly over time, often being greatest during periods of wet weather. Defra's Catchment Sensitive Farming (CSF) Project works with farmers to raise awareness of water pollution and encourage voluntary action. It is delivered jointly by Natural England and the Environment Agency, working closely with partners from the agricultural and water industries as well as voluntary organisations.

With fixed resources, it is very important to ensure that funds are spent on activities that deliver our desired outcomes. This requires that policy is based on reliable and robust evidence, with high quality evaluation vital. The knowledge we gain from evaluation is used to increase policy effectiveness and is essential for informing new policies to achieve the best results.

Evaluating CSF is challenging. It requires an approach that accounts for the complex nature of water pollution from agriculture and a clear understanding of the process by which voluntary advice translates into environmental outcomes. It also requires that account is taken of confounding factors, such as the time lags before environmental benefits arise, and the influence of external factors, such as the weather. Drawing on a range of evidence sources and applying advanced statistical analyses to environmental datasets, this report presents a detailed and robust evaluation of CSF. It provides evidence that CSF is delivering real improvements in water quality (particularly in terms of pesticides and sediment) and ecology, as well as providing a range of wider benefits. Importantly, it also provides an understanding of the reasons behind the project's success, which include the building of trusting relationships with farmers and a resulting high level of advice uptake.

We are grateful to all those who contributed to this report. Led by the CSF Evidence Team from the Environment Agency, it has involved input from across the wider CSF Project team; Environment Agency monitoring teams; and a range of independent consultants and researchers.

Executive summary

After eight years of Catchment Sensitive Farming (CSF) Project delivery, our evaluation demonstrates the project is achieving its primary objective of *encouraging action from farmers to help achieve Water Framework Directive (WFD) (primarily Protected Area) and SSSI objectives*.

Pesticide levels have declined significantly in monitored river catchments as a result of the voluntary uptake by farmers of best practice and grant funding for improved pesticide handling facilities and bio-beds.

Sediment pressures have also been reduced. A clear relationship is evident between modelled load reductions from farms receiving CSF advice and monitored concentrations, across representative river catchments. Intensive sediment flux monitoring in the Dorset Frome catchment, in combination with sediment fingerprinting, is demonstrating the beneficial impacts of CSF. For the first time we have also shown that ecological communities are responding positively to reductions in sediment pressure resulting from CSF, at a national scale.

Across a wider range of pollutants, including phosphorus and faecal indicator organisms, our modelling indicates CSF is making a significant contribution to meeting 'sector weighted or proportional targets' (based on the agricultural contribution of the pollutant) for Protected Areas, SSSIs and WFD good status, across CSF target areas.

CSF requires time in a catchment for effective farmer relationships to be established and for advice to be widely implemented. Our evidence indicates there is a lag of around three years before we start to see benefits in our surface water quality monitoring programmes.

An initial analysis of national groundwater monitoring data provides an early indication that CSF is likely to be contributing to improved groundwater quality.

Our evaluation also shows that CSF benefits go beyond water quality. At a national scale, significant ecosystem service benefits can be expected for fisheries, soil quality, air quality, hazard (floods and erosion), climate regulation and water supply. Although water quality improvements are the single largest ecosystem service benefit, they may account for a small minority of the total benefit.

Underpinning the successful delivery of environmental outcomes is effective farmer engagement and advice delivery. This is achieved through a combination of: direct delivery by project staff; work commissioned through contractors; and partnerships with other organisations, including industry bodies.

Awareness of the project in our catchments is high and expected to continue to rise. CSF Officers and Catchment Partnerships are integrating a range of related advice sources, taking a lead in providing farmers with a clear appreciation of catchment issues and priority actions to address water quality. They have established effective working relationships with the farmers in their catchments and farmers indicate they have trust in them. CSF is the single most important agricultural scheme or initiative for farmers within Priority Catchments in terms of helping or prompting them to make changes to reduce water pollution. 16,133 farm holdings have now received CSF advice, through an effective combination of one-to-ones, group events and clinics.

Widespread uptake of advice and a dedicated capital grant scheme have brought about significant improvements to soil and land management practices. 167,788 individual mitigation measures have been advised to farmers on 16,133 farm holdings and 62 per cent of measures recommended through one-to-one advice have been implemented. It is evident that CSF is both helping target and accelerate changes that might be expected through general trends towards improved farming practice, whilst also delivering significant additional change.

An important role of our evaluation is to help make the CSF Project more effective. Our modelling has developed to a point where we can target advice to geographic locations where it is likely to be most successful in influencing farmers to take action and where mitigation measures will make the greatest contribution to water quality improvements. We can also identify catchments where future CSF activity is unlikely to yield further significant improvements and project resources might be better deployed elsewhere.

Evaluation remains a core element of the CSF Project. We are continually refining our approach to provide an increasingly robust assessment of project benefits, whilst also helping increase the effectiveness of the project and contributing to the wider evidence base for mitigating water pollution from agriculture.

Contents

1. Introduction

Catchment Sensitive Farming (CSF) is an advice–led project that delivers targeted support enabling farmers to take action to reduce water pollution. Our evaluation is shaped by the primary objective of the project to:

> Encourage action from farmers to help achieve Water Framework Directive (primarily Protected Area) and SSSI[1] objectives

The project works with farmers to raise awareness of water pollution and encourage voluntary action to mitigate the problem. It also seeks to create partnerships and integrate with other initiatives that have similar objectives.

This report reviews the effectiveness of CSF after seven years of delivery.

CSF overview

Launched in December 2005, CSF supports farmers and land managers with targeted advice across 79 catchments. CSF is delivered in partnership by Natural England and the Environment Agency. The project contributes to Defra's priorities of: *improving the environment through managing our rural, urban and marine environments, reducing pollution and waste, and ensuring greater resilience to climate change and other environmental risks*.

The project has, to date, operated over 3 phases. Phase 1 ran to March 2008, phase 2 ran to March 2011 and phase 3 to March 2014. The selected catchments are those where improvements in water quality will help meet Protected Area and SSSI objectives. CSF catchments cover 6.1 million hectares of agricultural land, or approximately 46 per cent of England. Within larger catchments, the project focuses on specific sub-catchments or 'target areas' identified through a catchment appraisal process.

CSF is currently delivered through a network of CSF Officers (CSFOs) in 65 Priority Catchments; 9 Catchment Partnerships (where a local delivery partner, working collaboratively with CSF, takes the role of the CSFO); and 5 Catchment Projects (where the role of the CSFO is outsourced to a commercial contractor). Within 7 Priority Catchments specialist pesticide advice is also provided through a National Partnership that includes The Voluntary Initiative. Other National Partnerships, with industry organisations and The Rivers Trust, extend CSF advice beyond the 79 catchments.

The locations of the Priority Catchments, Catchment Partnerships and Catchment Projects; are shown in Figure1.

CSFOs (or their equivalents) provide, or co-ordinate the supply of, a range of advice, support and incentives including:

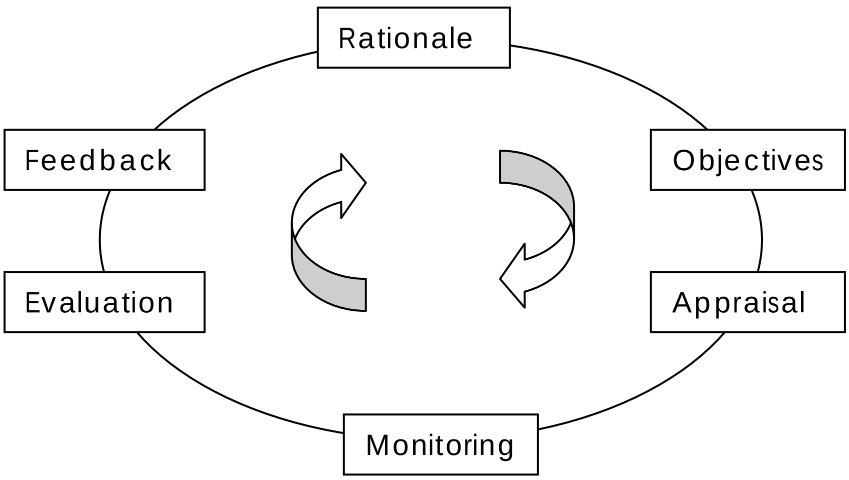
- farmer workshops, meetings, demonstrations and walks
- one to one advice either on-farm or through farmer 'clinics'
- capital grants towards the cost of mitigation measures to reduce water pollution
- workshops and seminars for farming advisers

[1] SSSI – Sites of Special Scientific Interest

Catchment Steering Groups bring together farmers and other key stakeholders to help shape advice delivery. They are important for ensuring strategies for targeting and delivering advice are appropriate for each catchment.

Evaluation design

Monitoring and evaluation are core elements of CSF. We have developed an extensive programme in order to assess the progress made towards meeting the project's objectives. Our evaluation helps shape decisions on the future of the project, including reinvestment and design, as well as informing wider policy development[2]. The role of monitoring and evaluation, as part of a process of continuous improvement, is formalised in the ROAMEF Cycle (HM Treasury, 2011).



There are substantial challenges to building a robust evaluation to assess the success of a voluntary initiative, not least in understanding the process through which voluntary advice translates through to environmental outcomes. We designed our evaluation, where possible, to take account of, or exclude, complicating factors, including the time lag before mitigation measures become effective and external influences, such as weather and point source impacts on water quality.

Our evaluation brings together and uses information on both the observed change (the *end effect*) and the mechanisms instigating change (the *process*). It is built up of a range of analysis approaches, some of which are bespoke to CSF:

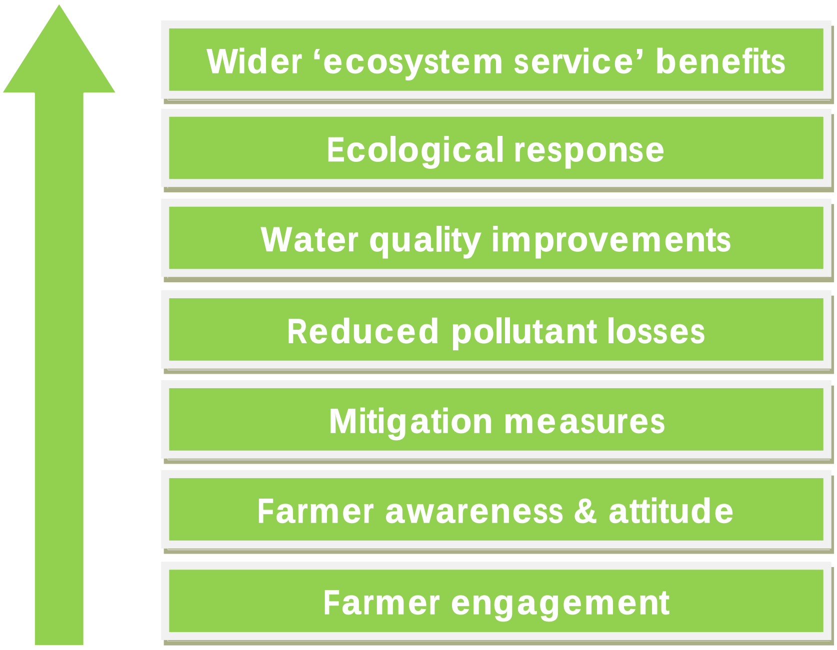
- a database of farmer engagement and advice delivery activity
- telephone surveys exploring farmer awareness and attitudes
- follow-ups with farmers to ascertain the extent of advice uptake
- modelling to assess reductions in pollutant losses and improvements in water quality
- water quality and ecological monitoring
- an ecosystem services assessment of wider project benefits and outcomes

Delivery of the evaluation is through a combination of: the CSF Evidence Team (including modelling assessments using peer-reviewed models); CSFOs (recording farmer engagement, advice delivery and advice uptake); the wider Environment Agency (water

[2] Economic evaluation is not currently within the scope of our assessment of the CSF Project

quality and ecological monitoring); independent consultants and academics (telephone surveys; analysis of monitoring data and assessment of wider project benefits).

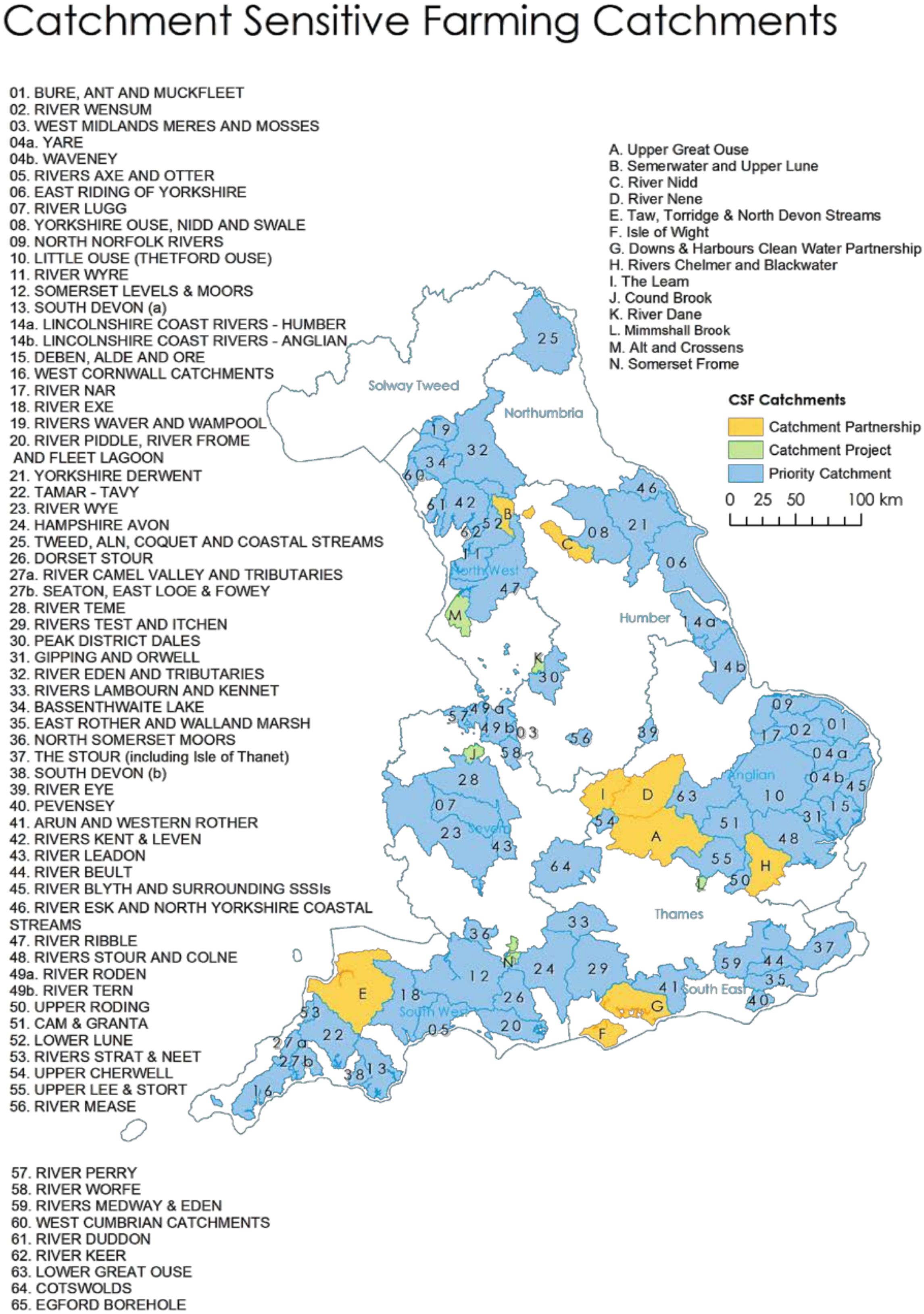
This report provides a summary of the main findings from our evaluation. Full details can be found in supporting technical reports which are referenced in each of the relevant sections. Appendix A provides a summary of the catchments that our evaluation uses monitored data from (including surface and groundwater, ecology and pesticide monitoring).



The seven levels of monitoring and evaluation

The various elements of the evaluation produce a weight of evidence that allows us to judge how successful CSF has been. Our evaluation has developed over time to reflect the increased duration of the CSF project. As a result, this report places significant emphasis on the longer-term, environmental, outcomes.

Figure 1. CSF catchments showing the locations of the Priority Catchments, Catchment Partnerships and Catchment Projects



2. Project outcomes

2.1 Modelled pollutant losses

We predict that CSF activity to the end of May 2013[3] will reduce agricultural losses of key pollutants by between 4 and 12 per cent, on average, across CSF target areas. This equates to reductions of in-river pollutant concentrations of between 3 and 7 per cent[4], averaged across CSF target areas.

CSF is most effective in terms of delivering sediment reductions. Predicted reductions vary greatly across catchments and can be up to 36 per cent, with an average agricultural load reduction of 12 per cent.

Reductions in agricultural dissolved phosphorus in-river concentrations are predicted to be up to 25 per cent. For both agricultural loads and in-river concentrations, the average reduction is predicted to be 7 per cent.

Our modelling shows CSF is making a significant contribution to meeting proportional targets (i.e. based on agriculture's contribution to the pollution issue) within priority Bathing Waters, Natura 2000 Protected Areas, SSSIs and WFD water bodies.

The challenges of water quality modelling and monitoring

The complexity of understanding the sources of different pollutants, how they are mobilised and the different pathways they follow through the environment makes the quantification of pollutant loads reaching a waterbody and the resulting riverine or lake concentrations difficult. By its very nature agricultural water pollution arises from numerous, often individually minor, sources across the landscape. Pollutants are often mobilised during high rainfall events and the amount of pollution delivered to watercourses varies greatly, from hour to hour, from season to season and from year to year. Furthermore, once mobilised, pollutants can travel along a range of pathways which can involve considerable delay, potentially undergoing significant change along the way (for example, through binding with sediment).

The assessment of chemical surface water quality change resulting from CSF mitigation measures presents a significant challenge[5]. We have established an Enhanced Water Quality Monitoring Programme (EWQMP) in eight of the 40 Phase 1 Priority Catchments (*see Section 2.2*). Using the monitoring data alongside a suite of models allows us to assess the likely impact of CSF across all of our catchments and take account of the varying response times of catchments to CSF measures.

Modelling pollutant losses

We use a model toolbox approach to assess the overall impact of the CSF project. The effectiveness of mitigation measures at the farm scale is modelled within the Catchment Change Matrix model (CCM). This links agricultural mitigation measures to individual

[3] The cut-off date for advice delivery data used in the modelling assessment
[4] Load and concentration figures based on the median for Phase 1 Priority Catchments
[5] Groundwater quality is considered in Section 2.5.

model farms that represent each of the 100,000 commercial farms in England. It combines measures to create a total farm-scale pollutant reduction and then aggregates these results to a variety of spatial scales. Previous CSF evaluations have solely focussed on Priority Catchments and target areas. Here, we also consider other scales that are more directly relevant to Protected Area, SSSI and WFD status (Environment Agency, 2014a)

The CCM only considers agricultural losses. To understand the true impact of the measures and how they can improve water quality, we integrate the CCM estimates into a variety of more detailed and complex modelling tools. The majority of the results featured are taken from the CSF statistical model suite, which are in turn heavily reliant on data from our EWQMP.

Our modelling tools allow us to:

- predict the cumulative effect of measures in terms of reducing agricultural pollutant loads
- predict changes in water quality, and how these vary both spatially and temporally
- estimate the significance of these changes in terms of status targets for rivers, lakes and bathing waters
- identify specific mitigation measures that are particularly effective in any given area
- inform where CSF should be targeted in the future (*see Section 4*)

We use three CSF scenarios within our model suite:

- Current - the effect of current CSF measures (i.e. those advised up to the end of May 2013, the cut-off for our modelling work) and implementation rates across the CSF catchments
- Optimised - a theoretical maximum reduction achievable by CSF, it involves applying the ten most effective measures per pollutant to each farm in our catchments and estimating their combined effect using current implementation rates
- Maximum - the greatest change to water quality achievable without catchment scale land use change, this applies all measures to all farms, and assumes a 95 per cent implementation rate

Pollutant reductions

We predict that current CSF activity reduces agricultural pollutant losses by between 4 and 12 per cent, on average[6]. However, there are large variations in predicted reductions across both CSF catchments and pollutants (Figure 2).

Table 1 shows our median estimate of pollutant reductions for the three scenarios. In terms of the current scenario, CSF is most effective at reducing sediment, with average reductions of 12 per cent. Phosphorus is the next most successfully reduced pollutant. Predicted reductions are greater for total phosphorus (particulate plus dissolved) than for the dissolved form alone because the particulate-bound fraction responds to measures targeting sediment.

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[6] Load and concentration figures quoted are based on the median of Phase 1 Priority Catchments

Figure 2. Boxplot showing variation in predicted load reductions based on current CSF scenario

(The dark band inside the box displays the median; the bottom and top of the box indicate the first and third quartiles; the vertical lines represent the maximum and minimum values.)

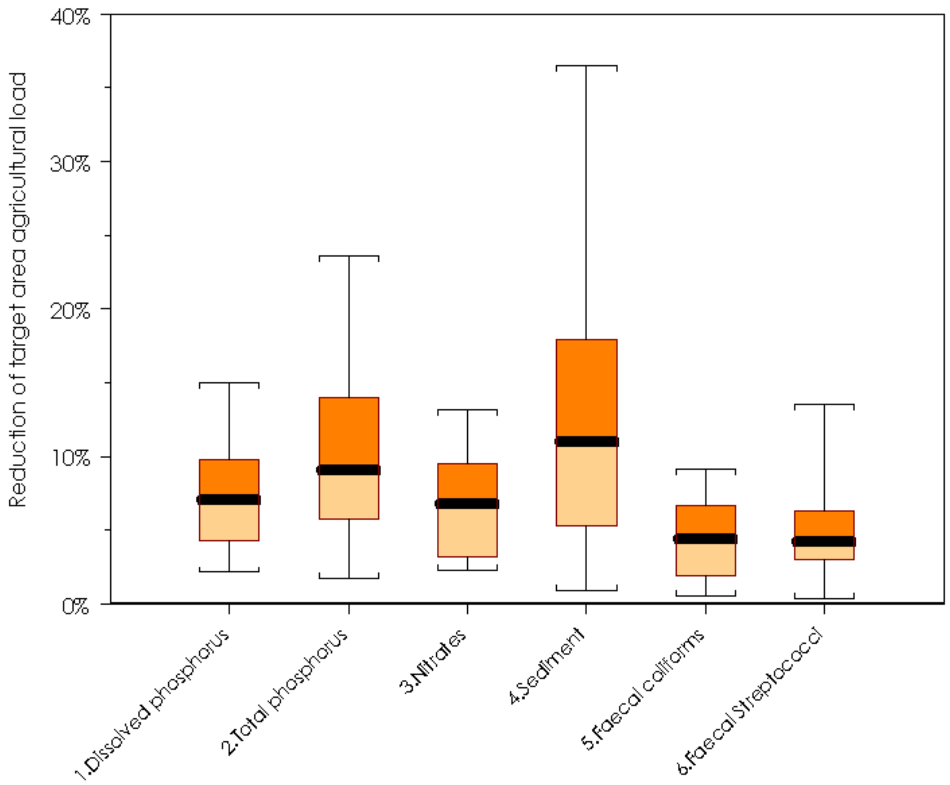

Table 1. Median reductions predicted for CSF scenarios (for CSF target areas within Phase 1 Priority Catchments)

Pollutant	*Agricultural load reduction (%)*			*In-river concentration reduction (%)*		
	Current	Optimised	Maximum	Current	Optimized	Maximum
Dissolved phosphorus	7	24	58	7	24	49
Total phosphorus	9	33	68	7	29	49
Nitrate	6	29	64	3	14	39
Sediment	12	47	82	5	21	34
Faecal coliforms	4	28	63	3	15	33
Faecal streptococci	4	27	67	3	16	37

Faecal Indicator Organisms (FIOs) show the least response to CSF, and we attribute this to three factors:

- FIOs are targeted in a limited number of bathing and shellfish water catchments which are not potentially the most responsive catchments to mitigation measures
- FIOs have only been targeted in catchments from Phase 2 onwards (with the exception of the South Devon Priority Catchment)

- the limited predicted effectiveness of FIO measures within the Mitigation Methods – User Guide (Newell Price *et al*., 2011)

Protected Area, SSSI and WFD status

Based on current activity we predict that CSF will deliver[7] the following status changes:

- one bathing water will meet sufficient status under the revised Bathing Water Directive (rBWD)(in total we modelled 38 bathing waters which are significantly influenced by agricultural sources and at risk of not meeting sufficient status)
- two SSSI rivers will meet their pragmatic targets; three will meet their near-natural targets and CSF activity is predicted to compensate for projected population growth and associated increased phosphorus levels over the next 25 years in nine SSSI rivers[8] (in total 141 SSSI river units were modelled)
- one WFD/SSSI lake will meet its total phosphorus standard out of the 241 lakes that required a reduction to meet GES [9]
- 33 WFD river water bodies currently at less than good status due to sediment[10] will improve to good status[11] (there are 512 water bodies that are failing to meet our indicative standards, that have a GES failure related to sediment and 50 per cent or more of the water body is within a CSF target area)
- 12 WFD river water bodies currently at less than good status due to phosphorus will improve to good status (there are 790 water bodies that are failing to meet current WFD P standards and 50 per cent or more of the water body is within a CSF target area)

A more meaningful assessment of CSF is in terms of its *contribution* to meeting targets, rather than the *number* of targets met. This is because CSF focuses solely on the agriculture sector and operates in conjunction with other policy mechanisms.

Sector-weighted, or proportional, targets are derived by dividing the ‘gap’ to target status by the relative source apportionment due to agriculture. Using this approach, CSF is making a significant contribution to delivery of Protected Area, SSSI and WFD status targets. For example, our modelling shows that current CSF activity contributes:

- 25 per cent or more of the proportional target in seven of 30 priority bathing waters and contributes on average an 11per cent reduction of the proportional target
- 22 per cent, on average, of the proportional (pragmatic)target for SSSI river catchments
- 23 per cent, on average, of the proportional target for the 512 WFD river water bodies within CSF target areas failing due to sediment
- 10 to15 per cent, on average, of the proportional target for river phosphorus (for both current and proposed WFD targets)

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[7]Our modelling assumes that all benefits from the measure happen immediately. Wider data from our evaluation suggests that there is a lag of several years between measures being implemented and becoming fully effective.

[8] SSSI river targets used in this assessment are provisional targets provided by Natural England in January 2014 - , they are currently being reviewed. Pragmatic targets are revised targets that are between current SSSI targets and near-natural Common Standards Monitoring targets.

[9] Based on current lake targets provided in January 2014

[10] Based on 2013 Reasons for Failure data

[11] As there are no directly relevant sediment targets at present, improvements in sediment status are based on comparisons between annual sediment loads and indicative sediment yield targets - refer to the modelling technical report for further details.

Figure 3 highlights those areas where current CSF activity is predicted to contribute 25 per cent or more of a proportional target. This clearly shows that in nearly all target areas CSF is making a significant contribution to one or more waters currently failing to meet their targets. In only three of the Priority Catchments are modelled reductions yet to exceed this 25 per cent contribution for at least one pollutant.

In relation to WFD and SSSI phosphorus targets for rivers we find that CSF measures provide the biggest reductions in tributaries and headwater streams rather than main rivers. This is a result of:

- the smaller catchment size and, therefore, greater coverage of mitigation measures
- the greater phosphorus contribution from agriculture in these types of water body - on average, the contribution from agriculture is 20-25 per cent higher (60 per cent compared to 35-40 per cent) in these smaller streams

As well as delivering improvements in status in some instances, CSF also contributes to meeting the WFD objective of preventing deterioration of status. It does this because CSF improvements provide a degree of 'protection' against the otherwise negative impacts of other environmental pressures.

The effect of measure coverage

Our modelling suggests there is a strong positive relationship between the area coverage of mitigation measures and the predicted reduction in pollutants. This relationship is particularly strong at larger scales (target area and catchment scales, which are on average approximately 300km²), but weakens when we assess the relationship in very small areas like WFD river catchments (which are on average approximately 30km²). While the relationship is still statistically significant, it is noticeable that larger predicted pollutant reductions can be achieved with lower catchment coverage and vice versa at the WFD river catchment scale.

This requires further investigation but has potential implications for the use of CSF and other agri-environment schemes as a mechanism for helping achieve Protected Area, SSSI and WFD status targets. For example, there may be areas where targeting a smaller number of farms with disproportionately high risk land use delivers the benefits required in a particular area. In general, however, our modelling strongly indicates that a catchment-wide approach is the surest way to make significant improvements to water quality.

Modelling the effectiveness of different measures

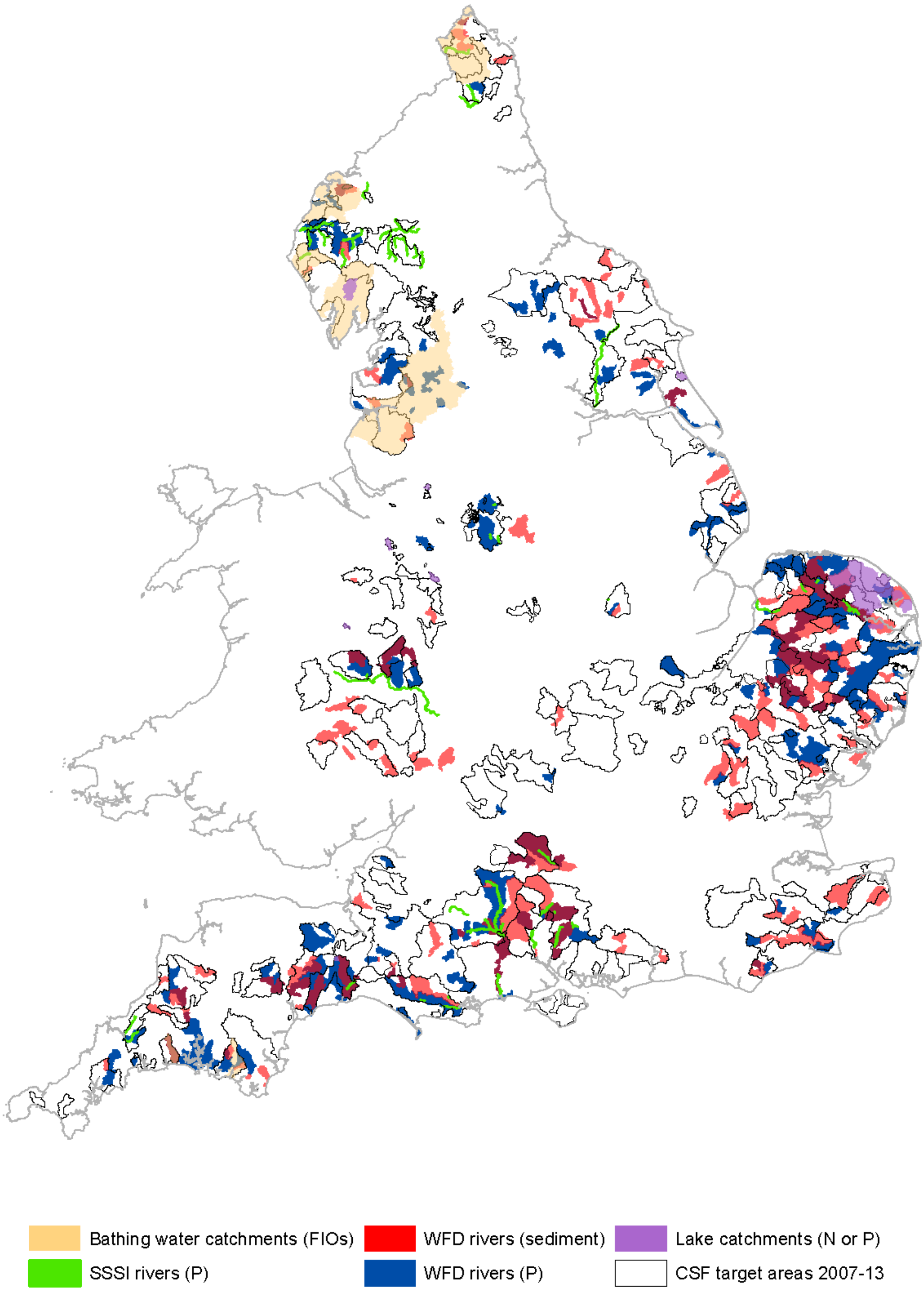
Our evaluation allows us to estimate the combined impact of the measures that CSF promotes, and also identify which ones are contributing most to our predictions. While the relative success of an individual measure is inherently linked to the modelling assumptions, our latest evaluation suggests that measures that are most effective in our assessment are those that:

- are widely recommended
- apply to larger proportions of a farm
- have high implementation rates within CSF

The best examples of these for the current CSF scenario are:

- soil management plans and reduced cultivation systems (sediment)
- integrating fertiliser and manure nutrient supplies and establishing cover crops (nutrients)
- reducing the length of the grazing season (FIOs)

Figure 3. Target Areas contributing to meeting proportional targets


Bathing water catchments (FIOs)
WFD rivers (sediment)
Lake catchments (N or P)
SSSI rivers (P)
WFD rivers (P)
CSF target areas 2007-13

Our modelling provides very strong indications that CSF can reduce FIO pollution most effectively by promoting measures that keep livestock as far from rivers as possible by:

- fencing off rivers from livestock access
- re-siting gateways away from high risk areas

Other highly effective measures are successfully promoted by CSF but only in small numbers. In these instances, we estimate a high reduction per measure but a low overall contribution to total pollutant reductions. Measures include:

- establishing artificial wetlands (FIOs and sediment)
- reducing overall stocking rates (nutrients and FIOs)
- growing biomass crops (all pollutants)

Case study

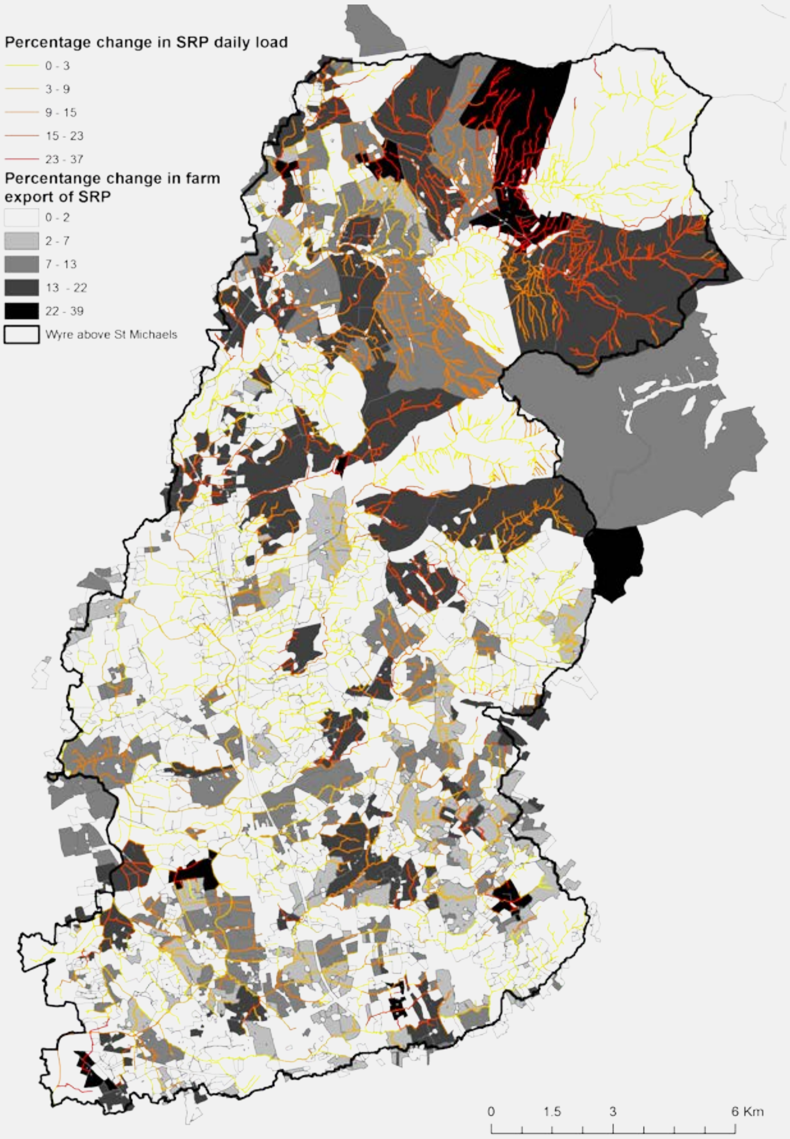
River Wyre modelled benefits

This case study demonstrates how models can be used to increase our understanding of the spatial and temporal variation in pollutant reductions delivered through CSF. The River Wyre catchment extends from the high moorland of the Forest of Bowland to the lower lying central area and flat plains of the Fylde Peninsular. The middle and lower reaches of the Wyre are generally managed for mixed agriculture. 10 per cent of the catchment is urban or suburban, with Blackpool & Fleetwood the most significant conurbations.

Fieldmouse - dissolved phosphorus

The Fieldmouse model (Hankin and Douglass, 2013) was used with the CCM-predicted baseline and current scenario results to examine the spatial variation in the impact of CSF measures on phosphorus load reductions. The outputs (Figure 4) show that large local reductions in load aren't necessarily

Figure 4. Change in Fieldmouse predicted dissolved phosphorus daily loads



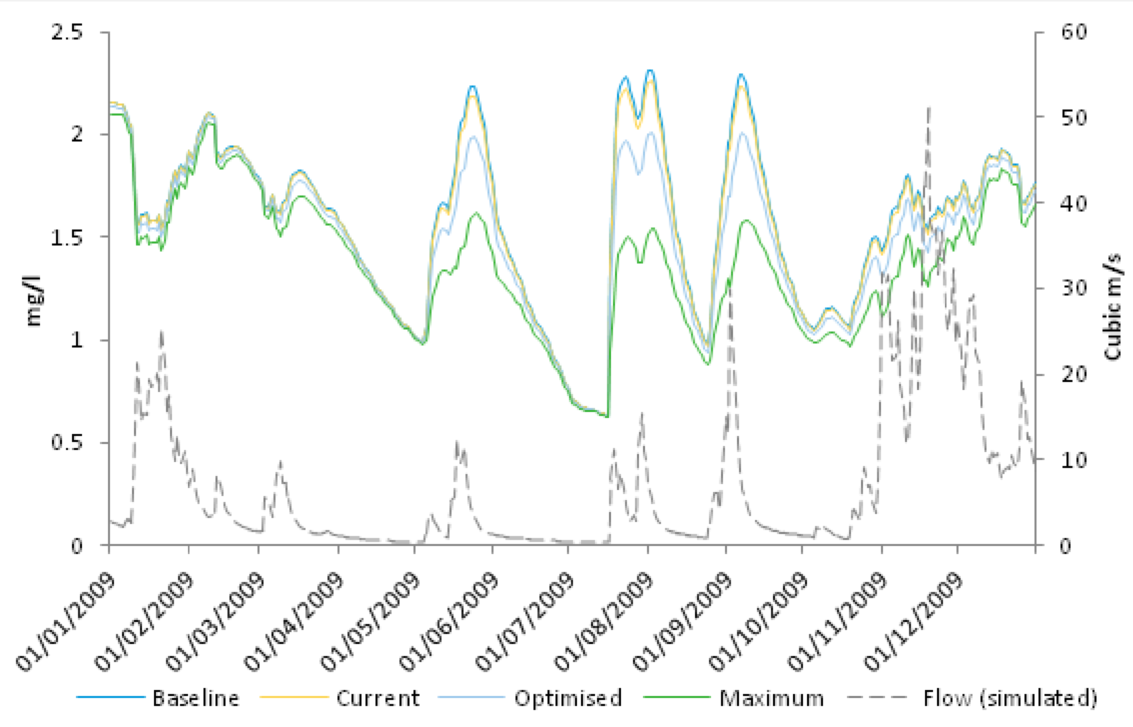
conveyed downstream where the channel flows through land less subject to load reductions. For example, the load reduction at the catchment outlet is 7 per cent, while some tributaries show reductions of up to 36 per cent.

This highlights the issue of the locality of measures to the receptor. Where measures can be applied locally to the receptor we would expect them to be more effective than those placed at a greater distance. This ‘dilution-of-benefit’ effect supports the conclusions of the CCM analysis where we have shown that high measure coverage is vital to secure improvements to large catchments, whilst smaller catchments are more sensitive to restricted measure coverage.

INCA-N - nitrate

The INCA-N[12] model provides insight into the temporal variation in measure effectiveness. The model predicts the largest nitrate reductions in the River Wyre will occur during summer high flow events (Figure 5) (the application period for fertiliser is assumed to be limited to the summer growing months).

Figure 5. INCA- N predicted nitrate concentrations at St-Michaels-on-the-Wyre



The use of models such as INCA-N, combined with an understanding of when environmental impacts occur, can help CSFOs provide effective advice to farmers. For example, measures such as planting a cover crop restrict the benefit to the period the measure is in place, which may or may not be when environmental impacts are most significant.

[12] http://www.reading.ac.uk/geographyandenvironmentalscience/research/INCA/

2.2 Water quality monitoring – nutrients, suspended solids and FIOs

A clear relationship is evident between CSF advice activity and monitored concentrations of suspended solids. Overall, mean suspended solids concentrations were approximately 0.7 per cent lower than they would have been without CSF for every 1 per cent reduction in predicted load.

No clear response to CSF activity is apparent when looking at other pollutants. This is due to the sensitivity of the data analysis and the limited predicted load reductions.

Data selection and analysis

Our assessment involved analysing trends in water quality monitoring data and relating these to the extent and timing of CSF activity (as reflected in predicted load reductions from the CCM). By accounting for point source inputs, rainfall, flow and changes to farming activity, the analysis isolates and quantifies the impact of CSF (WRc, 2014a).

The CSF EWQMP has been in place in eight representative Priority Catchments since 2007 (see Appendix A). Weekly 'spot' samples of suspended solids, nutrients and FIOs are collected across 79 sites. These have been supplemented with high frequency auto-sampler data taken during high-flow events (at a subset of sites) and routine Environment Agency data from 2000 to 2006.

The impact of CSF advice activity on pollutant losses was estimated using the CCM modelled load reductions. It was not possible to draw clear before-after comparisons because CSF advice is delivered incrementally over several years, so detailed records on the intensity and timing of CSF advice within each catchment were used to model changes in water quality as a function of increasing CSF activity.

The analysis focused on a subset of between 13 and 24 sites (depending upon the pollutant) that had:

- adequate monitoring data before and after the start of CSF activity
- limited influence from point source discharges
- measurable levels of pollution

For each pollutant at each site, mean concentration was modelled as a function of CSF activity with additional predictor variables to account for the effects of flow and season. The estimated percentage change in mean concentration was plotted against predicted percentage CCM change to test for an overall relationship between CSF and river water quality across the eight Priority Catchments. We repeated the analysis for each pollutant in turn.

We know that farmers gradually implement the mitigation measures recommended to them by CSFOs over several years, and a further delay is expected before some measures have a measurable impact on water quality. Exploratory analysis of the monitoring data suggested a three-year time lag between CSF activity and water quality responses, meaning that the analysis was effectively only able to directly measure the benefits of CSF advice delivered up to December 2010.

Monitored outcomes

As with our modelling analysis, suspended solids showed the clearest relationship with CSF activity. Mean concentration generally increased at sites where limited CSF activity had taken place but tended to remain stable or decrease at sites where the CCM predicted a greater reduction in sediment load (Figure 6). Overall, mean suspended solids concentrations were approximately 0.7 per cent lower than they would have been without CSF for every 1 per cent reduction in predicted load. This relationship was most evident across the full set of 24 sites in eight catchments, being less clear within individual catchments because, with the exception of the Wensum and Test, sites within a single catchment rarely had contrasting levels of CSF advice and hence CCM reductions.

The other pollutants analysed (nitrate, dissolved[13] and total phosphorus, *Escherichia coli* and faecal streptococci) showed no clear response to CSF. This does not necessarily indicate that the advice activity delivered to date has not been beneficial, but rather that any impact of CSF cannot be distinguished from other spatial differences and temporal changes in water quality. In particular, the following factors are likely to have limited the power of the analysis to detect improvements in these pollutants:

- the limited number of monitoring sites – FIOs are monitored in only 4 of the 8 catchments and a number of sites were excluded from the analysis where phosphorus concentrations were frequently below the limit of detection (0.002 mg l^{-1}) or heavily dominated by point source discharges
- limited load reductions – in contrast to suspended solids, CSF is predicted to have reduced loads of nitrate, phosphorus and FIOs by less than 15 per cent in most sub-catchments, so any water quality response will be smaller and harder to detect
- historic differences in farming activity – current trends in nitrate concentrations vary considerably among catchments and almost certainly reflect historic trends in fertilizer use and, in some cases the introduction of NVZ regulations, rather than changes resulting from CSF activity. Legacy stores of nitrogen and phosphorus also exist in soils, groundwaters and river bed sediments (Sharpley *et al*., 2013).

As shown in our modelling work, the time CSF is active within a catchment is critical to detecting positive results. Taking account of the time lag for measures to become effective, further water quality improvements can be expected from the CSF activity during Phase 3.

The EWQMP catchments in context

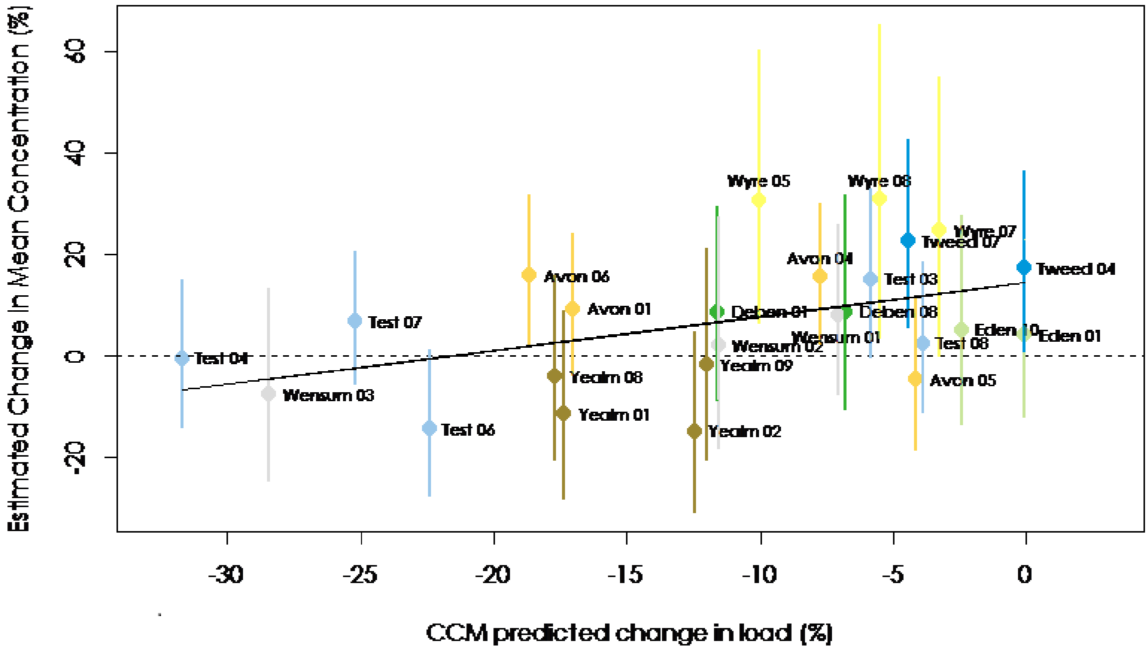
The eight monitored Priority Catchments are broadly representative of the wider CSF catchments, in terms of regional location, base flow index, rainfall and land usage. This suggests that the impacts of CSF on water quality observed in this study are likely to be mirrored across other unmonitored catchments.

It is also useful to look at how the eight catchments compare to the other catchments in terms of our modelling assessment.

Overall, the monitored catchments provide a good representation of the wider range of modelled target area reductions. For all pollutants, we have an almost equal split between catchments above and below the median reduction. The Hampshire Avon, River Yealm (South Devon b) and River Wensum have among the highest predicted reductions for most pollutants, while the River Eden and River Till (River Tweed, Aln, Coquet and Coastal Steams) are in the lower half of the target area reductions.

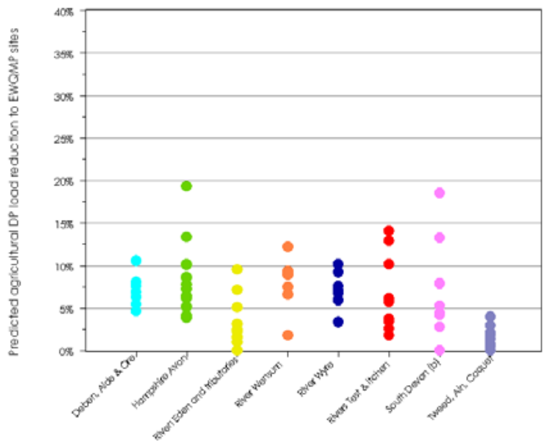
[13] Based on Environment Agency ortho-phosphate analysis

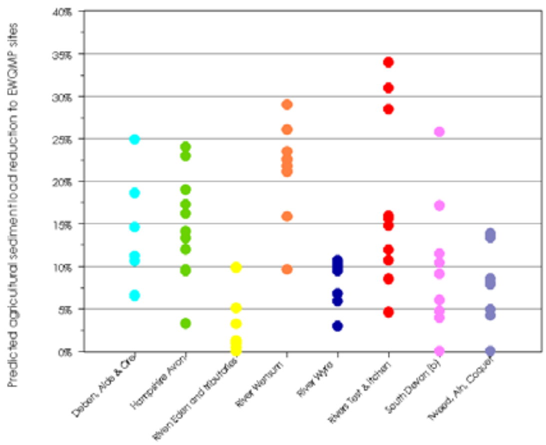
Figure 6. Estimated change in mean suspended solids concentration (±90% confidence interval) at 24 monitoring sites as a function of predicted reduction in sediment load



The target areas do not always map to the EWQMP sub-catchments, and when we estimate the percentage reductions upstream of each monitoring point we see that there is significant variation between pollutants and within catchments. The graphs below (Figure 7) plot the predicted dissolved phosphorus and sediment reductions for each monitoring point.

Figure 7. Predicted dissolved phosphorus reductions (a) and sediment (b) for the eight monitored Priority Catchments (each dot represents a EWQMP site)





The high level of variation helps explain the difficulty encountered in detecting changes in the monitoring data drawn from across the catchments. The generally greater predicted reductions for sediment (albeit with greater associated variability) also help explain why the monitoring results for this pollutant are most conclusive (the lower phosphorus predictions being generally as high, or higher, than those for nitrate and FIOs).

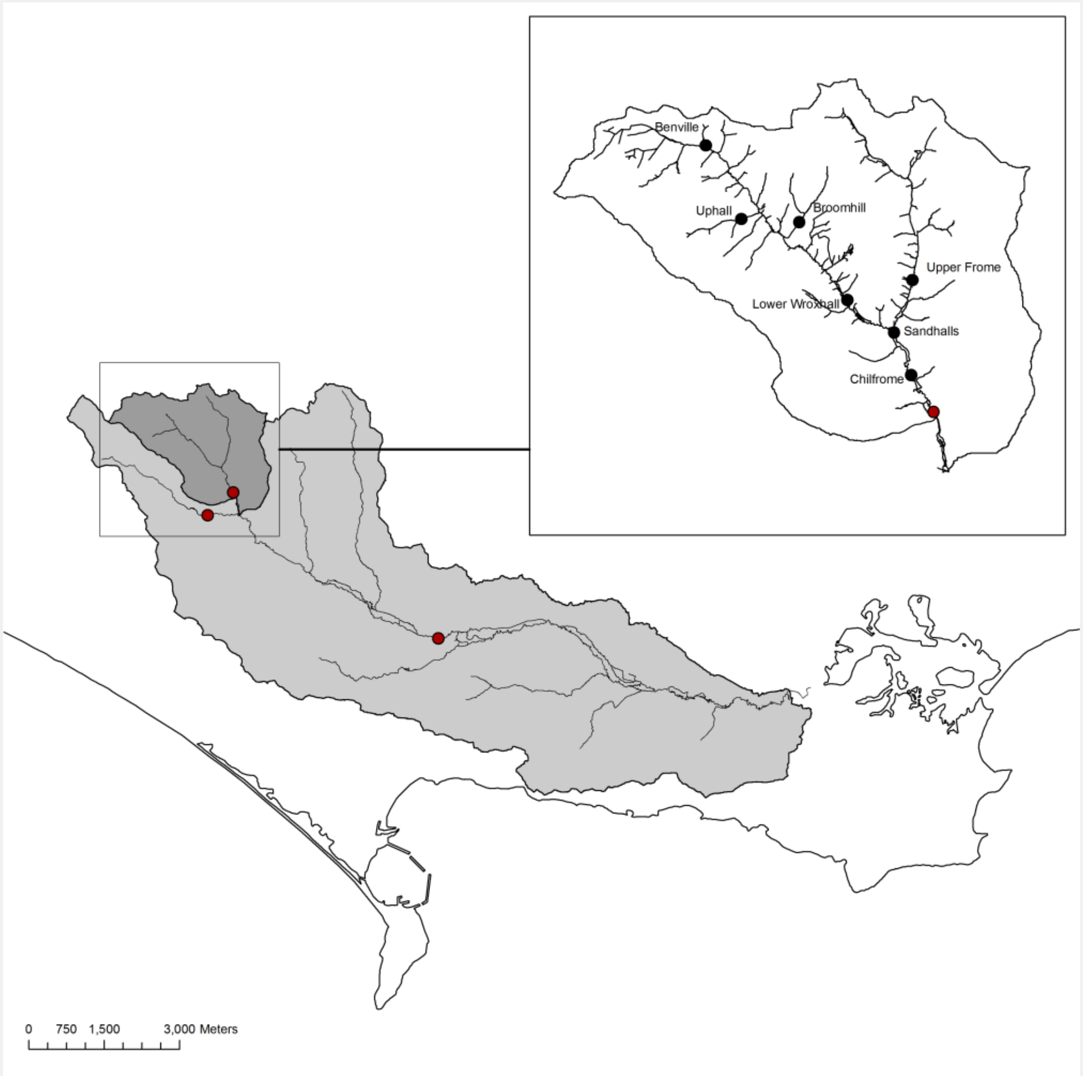
Case study

Sediment improvements on the River Frome

The River Frome (within the River Pidldle, River Frome and Fleet Lagoon Priority Catchment) has been targeted for advice delivery since the beginning of CSF. The main objective is to help improve the status of the River Frome SSSI and Poole Harbour Special Protection Area. Soil management in the upper catchment is a particular focus as this area makes a major contribution to the overall sediment loading.

The upper River Frome catchment has been subject to combined turbidity and bed sediment monitoring (Figure 8). Shifts in spatial sediment source apportionment and reductions in peak suspended sediment concentrations provide evidence of a positive response to CSF (Collins, 2014). This response is limited to the upper catchment, with wider catchment influences masking any effect further downstream.

Figure 8. River Frome turbidity and bed sediment monitoring locations



Advice delivery

CSF advice has been delivered to 47 per cent of the upper catchment area. The key mitigation measures are: adoption of soil management plans and minimum cultivation systems; avoiding over-winter tramlines and high risk crops on fields at risk of erosion; addressing soil compaction; improving farm tracks; cultivating across slopes; and establishing buffer strips.

Turbidity monitoring

Monitoring (quasi-continuous turbidity) established in 2002 under the NERC Lowland Catchment Research (LOCAR) programme has been extended at three sites in the upper catchment (shown as red dots in Figure 8). This provides long-term pre- and post- CSF data to assess the response of suspended sediment fluxes to CSF advice and mitigation.

At the scale of the Chilfrome (upper River Frome) and Maiden Newton (River Hooke tributary) sub-catchments (37.3 km^2 and 39.6 km^2, respectively) a reduction in the proportion of the water year experiencing the highest sediment concentrations is apparent between the pre- and post- CSF monitoring periods. However, only at Maiden Newton is this evident in terms of flow weighted mean concentration (FWMC), which decreased from an annual average of 20.7 mg L^{-1} pre-CSF to 11.2 mg L^{-1} during CSF Phase 3. FWMCs normalise sediment mass by flow per unit time, providing the most reliable comparison between pre- and post- CSF periods.

No improvement was apparent for the River Frome further downstream at Louds Mill (196.2 km^2). This is attributed to the increased significance of non-agricultural sediment sources, including, urban area and damaged road verges.

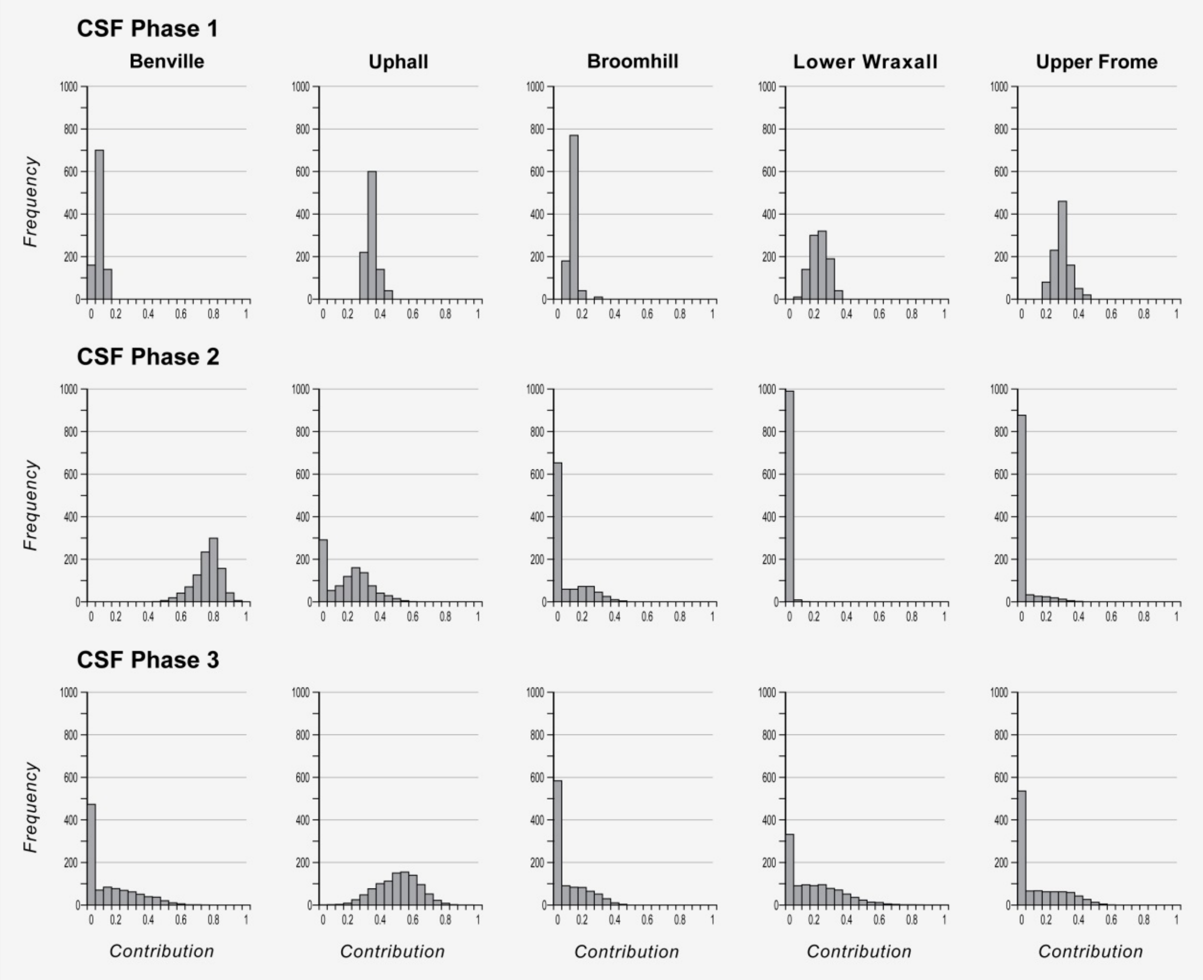
River bed sediment sampling

This part of the assessment focussed on repeat spatial sediment source apportionment, using channel bed sediment sampling, within the upper River Frome and Wraxall tributary (sites shown as black dots in Figure 8).

A statistically-significant decrease in the relative agriculturally-sourced sediment contributions from areas subject to CSF advice was apparent between CSF Phases 1 and 2 (as reflected at sampling points at Uphall, Broomhill and Lower Wraxall on the Wraxall Tributary and on the upper River Frome) with a corresponding increase in the relative contribution from the most upstream reaches of the Wraxall tributary (Benville sampling point). During Phase 3, the relative inputs from Uphall, Broomhill, Lower Wraxall and upper Frome increased again, with a resulting decrease in the relative contribution from Benville (Figure 9).

Overall, the results suggest a change in sediment source apportionment in response to improved management practices in the upper River Frome (above Chilfrome) and Wraxall tributary (below Benville) during Phase 2, although the repeat apportionment during Phase 3 indicates some issues of sediment mobilisation and delivery persist in these areas.

Figure 9. Agriculturally-sourced sediment contributions across CSF phases at each monitoring point (showing changes in the relative importance of different catchment sources over time)

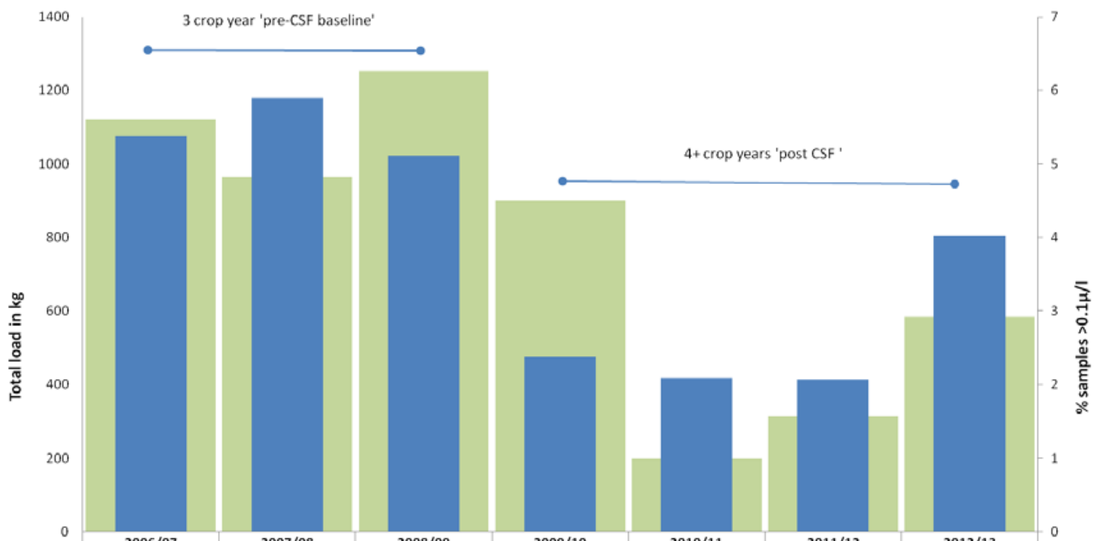


2.3 Water quality monitoring - pesticides

After seven full crop years we can be confident that CSF is delivering significant reductions in the overall pesticide levels in six monitored catchments, where we work with partners including The Voluntary Initiative. This success is despite significant challenges, especially from the increased area of oilseed rape and associated herbicide use (Environment Agency, 2014b).

Our two main indicators combine a multitude of data across six monitoring points[14] and show a broadly similar positive trend (Figure 10). If we take the first three years as a baseline, the mean of the latest four years is some 50 per cent lower for both the 'percentage of samples >0.1µg/l' and the 'total annual load' of the seven pesticides.

Figure 10. Trend in pesticide indicators from the six monitoring points, 2006-2013



	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13
Total load (kg)	1121.1	964.4	1253.3	899.6	198.8	313.4	584.5
% of all samples >0.1µg/l	5.38	5.90	5.11	2.38	2.09	2.06	4.03

Both our indicators are higher for the latest crop year (2012/13) compared to the previous one (2011/12). Despite this recent increase, results for the most recent crop year are still 47 per cent lower (annual load) and 26 per cent lower (samples >0.1µg/l) than in 2006/07. The increase in the latest crop year is due to high levels of oilseed rape herbicides observed in East Anglian catchments particularly, in the winter/spring of 2012/13.

Analysis of changes in the main factors (estimated usage of the indicator pesticides and river flow) allows us to broadly define the likely pesticide pollution pressure in our monitoring years without considering all the complex catchment-specific factors that may influence the data at different times of any particular year. At a macro-level we can be sure that pesticide levels in rivers will be higher in areas of high usage and vice versa

[14] See Appendix A for monitored catchments

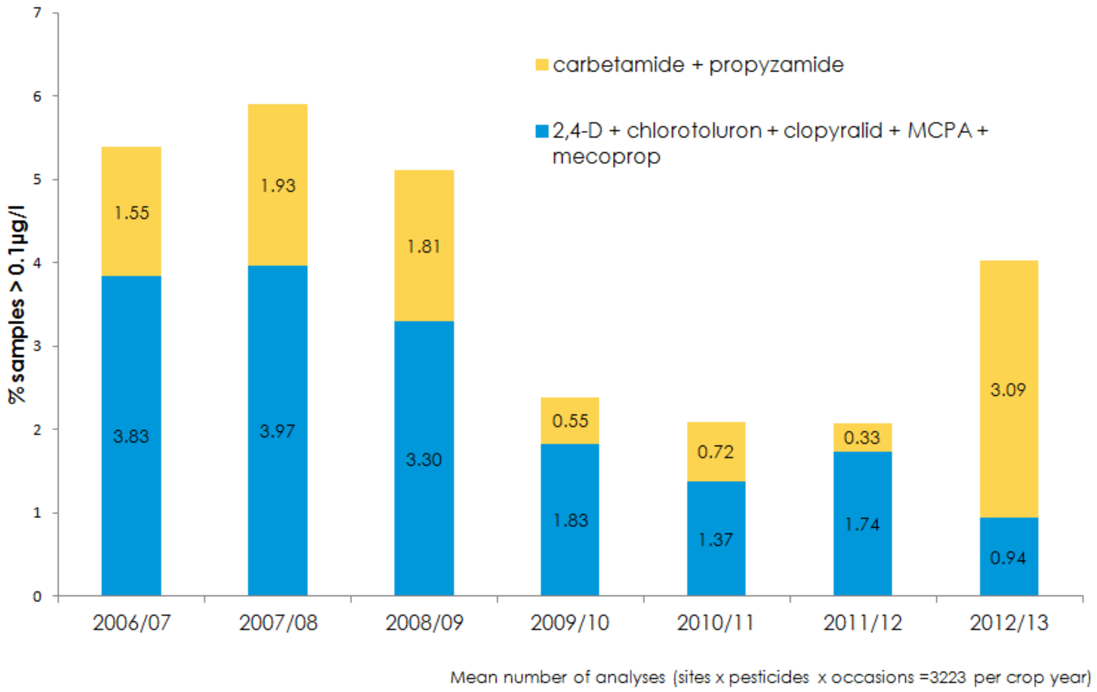
where a pesticide has been used less. We use river flow as a reliable integrated measure of the run-off from farms (with associated pesticides). By using the integrated indicators (shown above) and a consistent monitoring scheme over time, we can minimise the complicating effects upon the data, such as individual extreme weather events.

Pesticide usage

The improvements in monitored pesticide levels have been achieved against the backdrop of increased usage of most of the indicator pesticides and also more intensive cropping, in particular, of oilseed rape. Over the study period, national usage (by weight) of the seven indicator pesticides increased by 23 per cent from 2006/07 to 2011/12. The oilseed rape area has also increased significantly and in 2012/13 there was some 10 per cent more oilseed rape nationally than in 2006/07. Oilseed rape-related herbicide use, in particular, increased significantly in the same period with carbetamide use increasing by 62 per cent and propyzamide by 147 per cent by weight.

These two herbicides disproportionately influenced the annual indicators (Figure 11) in the latest crop year. Oilseed rape herbicides were used late in spring 2013 because of delayed establishment of the crop in the cold spring weather. This late usage resulted in high levels in rivers in March 2013 exacerbating the high winter 2012 levels. Looking forward, if the trend in increased usage of a small number of autumn and winter applied oilseed rape herbicides continues, this will be a further challenge for CSF to reduce pesticide levels overall in the test catchments.

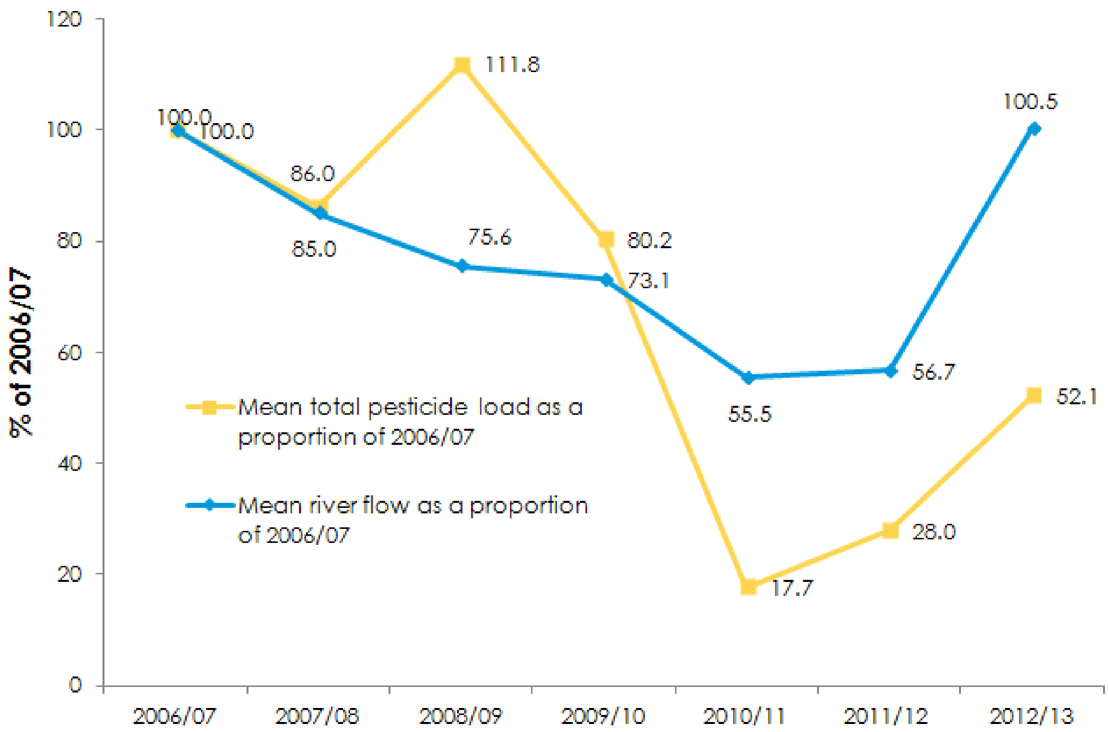
Figure 11. Per cent of all samples at all sites >0.1µg/l by crop year showing the relative effect of two oilseed rape herbicides (carbetamide and propyzamide)



River flow

Rainfall and annual run-off in each crop year vary and therefore our indicators fluctuate to some extent. However, the relationship between measured mean annual river flow and calculated mean total pesticide load (Figure 12) shows a divergence in the most recent monitoring years. This contra-indication shows that less pesticide is finding its way into rivers per unit flow of river. As a result, in 2012/13, the mean total pesticide load was some 50 per cent lower with an almost identical river flow to 2006/07.

Figure 12. Contra-indication of reduced pesticide load per unit of river flow across six monitoring points in the most recent monitoring years



Pesticide advice delivery

During the monitoring period CSF and partners have helped to reduce pesticide levels through a variety of actions in the catchments. The project has provided advice and information to agronomists and farmers on best practice use and integrated crop management. Agronomists advising farmers have been sent regular pesticide monitoring data and real time warnings of spraying risks associated with weather and soil conditions. This advice programme has continued on a similar basis since 2007. There has been a gradual increase in the number of agronomists and advisers engaged by the programme from 215 in 2007 to over 260 current recipients of the monthly bulletin and weekly text messaging services. A total of 191 agronomists and advisers attended the latest round of workshops, bringing the total workshop attendees for the whole programme to 625. In addition to advice, specific grants have been made available for farm infrastructure improvements aimed at reducing pesticide contamination of rivers. Through the Capital Grant Scheme, CSF part-funded 145 bio-beds, 71 bio-filters, 184 pesticide handling areas (alone and with associated bio-bed) and 139 roofs over pesticide handling areas. The total value of grant awarded on pesticide items is over £1M. Some 65 of the facilities are located in the six monitored catchments.

2.4 Ecological assessment

Our assessment of ecological data provides the first evidence that CSF is delivering improvements in ecological status due to reductions in water pollution from agriculture, at a national scale (WRc, 2014b).

There is strong evidence that macro-invertebrate status has improved since the introduction of CSF advice activity, the most significant relationship being between suspended solids and the macro-invertebrate sediment metric PSI. This is consistent with the water quality modelling and monitoring findings that sediment has shown the clearest response to CSF.

The macro-invertebrate metric ASPT (reflecting more general water pollution) showed a weaker but similar relationship with CSF when analysed alongside ammonia.

There is a tentative indication that diatom status improved after the introduction of CSF, particularly at more polluted sites.

This assessment used the Environment Agency's national datasets for macro-invertebrates, diatoms and physical habitat, across all CSF Priority Catchments with available data (62 in total, see Appendix A for locations). These datasets provide a high degree of statistical power to detect and measure responses of ecological communities to a range of natural processes and human activities. Our primary aim was to use the data to seek evidence of trends in ecological metrics and attempt to relate these to changes in water quality and the extent and timing of CSF advice activity.

We examined spatial patterns and temporal trends in the ecological status of macro-invertebrate and diatom communities using linear mixed-effects regression models. The analysis focused on three macro-invertebrate metrics:

- ASPT - Average Score Per Taxon expressed as observed/expected (O/E) ratio
- PSI - Proportion of Sediment-sensitive macro-Invertebrates (O/E ratio)
- P/R ratio - an indicator of autotrophic (P) or heterotrophic (R) dominance, based on functional feeding groups

and one diatom metric:

- TDI4 - Trophic Diatom Index v4 (O/E ratio)

Both ASPT and TDI4 are existing WFD classification metrics. PSI is a sediment-sensitive macro-invertebrate metric, which can act as a proxy to describe temporal and spatial impacts of sedimentation (Extence *et al*., 2013)[15].

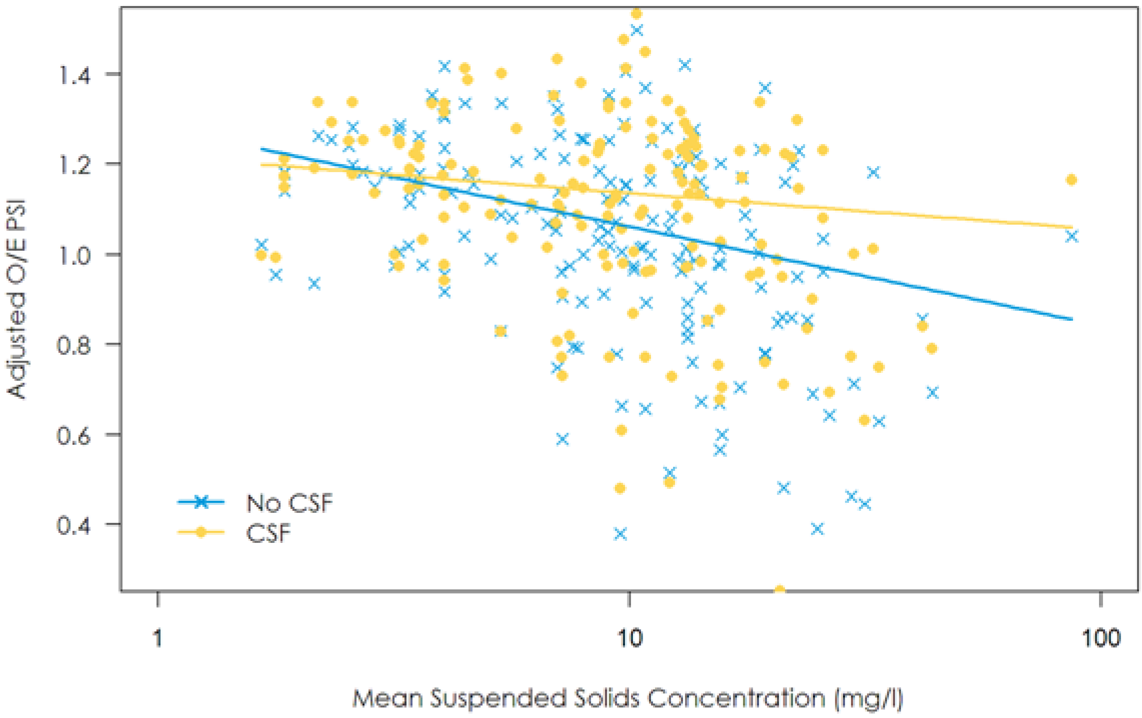
Ecological systems are complex and we incorporated additional environmental variables in the analysis that might interact with water quality or be important in driving ecological status. These included riparian tree cover; high and low flows preceding each biological sample; arable and urban land use; and channel re-sectioning.

To varying degrees all of the additional variables had an influence on macro-invertebrate status. After controlling for the influence of these variables, there was evidence that

[15] The metrics used do not necessarily reflect the ecological outcomes sought to achieve favourable conservation status for SSSIs / Natura 2000 Sites, though they undoubtedly represent progress towards them

ecological status improved following CSF advice activity[16], particularly at sites with high long-term mean pollutant concentrations. The strongest response was observed in the sediment (PSI) metric (see Figure 13), with smaller improvements evident for ASPT.

Figure 13. Interaction between PSI and suspended solids at sites with and without CSF activity.



Spatial patterns in the diatom metrics were influenced strongly by an interaction between alkalinity and mean phosphorus concentration. In low alkalinity rivers, ecological status declined with increasing phosphorus, but elevated dissolved phosphorus concentrations had little or no effect in high alkalinity rivers.

After controlling for these factors, there was some evidence that ecological status improved after the introduction of CSF, particularly at more polluted sites, but a lack of clear trends at individual sites and limited pre-CSF diatom data means that this result should be interpreted with caution.

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[16] CSF activity was summarised by presence/absence of engagement in the catchment area upstream of the monitoring point.

2.5 Groundwater assessment

CCM modelling has shown that for relevant CSF measures, nitrate losses can be reduced up to 20 per cent at a field scale. Alongside Nitrate Vulnerable Zones (NVZs) and other initiatives to reduce nitrate losses from agriculture, CSF should contribute to groundwater quality trend reversal in the long-term.

Our initial analysis provides some evidence that CSF activity may be contributing to improvements in groundwater quality. Further analysis is, however, needed to assess on-going trends and establish any relationship between the intensity of CSF activity and observed nitrate trend reversals.

To assess whether CSF is contributing to improving groundwater quality an analysis was developed that considered the aquifers most likely to show early changes in long-term trends (Amec, 2014a; 2014b). These were characterised by low matrix and high fracture permeability and included all solid geology formations comprising limestone, slate or igneous rock, as well as Quaternary gravels. Monitoring points on baseflow-dominated surface waters (e.g. in chalk catchments like the Hampshire Avon) were also used as 'surrogates' for groundwater quality monitoring points. It was considered that these geologies might reasonably be expected to produce indications of trend reversal within ten years.

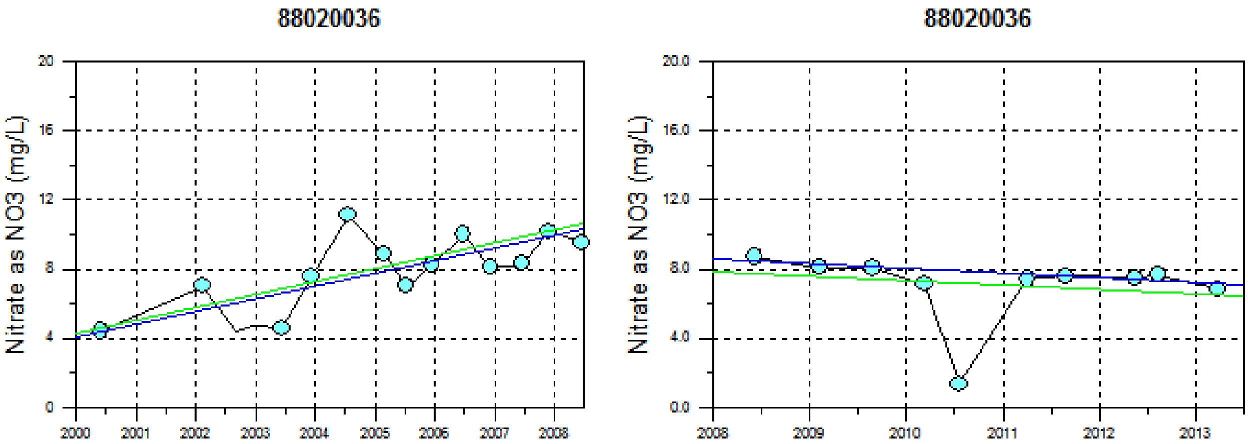
We identified Environment Agency groundwater monitoring points within the above geologies, using the following criteria:

- points that have shown signs of water quality trend reversal in previous WFD analyses points within de-designated Safeguard Zones

Nitrate was selected for the trend analyses due to the generally longer time-series, higher frequency and greater spatial coverage of monitoring data. Trend analyses, using the Aquachem model[17], were undertaken for monitoring points within Phase 1 Priority Catchments and compared for the periods after the rollout of CSF measures with those in the period preceding CSF. Figure 14 shows an example of an individual trend plot. The initial trend outcomes from individual points have been aggregated in terms of the number of increasing and decreasing trends, and 'no trend' outcomes for each of the pre-CSF and CSF periods.

[17] Aquachem - software for the analysis and reporting of groundwater quality data

Figure 14. Example groundwater trend plot showing a significant increasing to decreasing trend (using Aquachem).



Overall, the analysis shows a general improvement. A reduction is evident in the number of monitoring points with increasing nitrate trends once CSF has been implemented and an increase in the number of monitoring points showing a decreasing nitrate trend (Table 2).

Table 2. Summary groundwater nitrate trend outcomes aggregated in terms of the number of increasing and decreasing trends, and 'no trend' outcomes for the pre-CSF and CSF periods (using Aquachem)

Trend	*Pre – CSF period*	*CSF period*
Increasing	49	31
No Trend	54	44
Decreasing	41	69
Insufficient data	52	52
Total	196	196

CCM load reductions for nitrogen were then plotted within relevant surface waterbodies and, where trend analysis outcomes were available, these were overlaid to investigate any agreement between nitrate trend change and modelled CSF nitrogen reductions. This initial visual assessment showed no obvious relationship and further work is needed to understand to what extent, if at all, CSF is driving the observed changes in trends.

2.6 Wider CSF benefits

The measures promoted through CSF deliver benefits that go well beyond improving water quality. At a national scale, the most significant wider ecosystem service benefits are for fisheries, soil quality, air quality, hazard (floods and erosion), climate regulation and water supply.

A small number of individual mitigation measures contribute disproportionately, the top five measures together accounting for 42 per cent of the total impact of CSF.

There are clear win-win opportunities for CSF to promote measures that deliver multiple benefits, but also some trade-offs that need to be considered to limit pollution swapping or other unintended consequences.

It is increasingly recognised that the natural environment is vital to our health and prosperity, and that the goods and services provided by ecosystems within river catchments have a real economic value to society. Catchment management provides a way of dealing with these complex, multi-stakeholder issues.

The positive and negative impacts of a management intervention can be described using an ecosystem services approach that values the natural environment by looking at the range of goods it provides to people and how these might change. Where a scheme changes the ecosystem services provided, these impacts can be measured, thereby providing a comprehensive assessment of the benefits attributable to the management action.

Given the complex inter-relationships within ecosystems, the measures to improve one ecosystem service can also have positive (or sometimes negative) impacts on other services. These effects can be direct (e.g. improved biodiversity as a result of hedgerow creation) or indirect (e.g. improved recreational fishing as a result of improved water quality). This is sometimes referred to as 'stacking' or 'co-benefits' and the ability to stack benefits is clearly of policy interest where financial resources are limited.

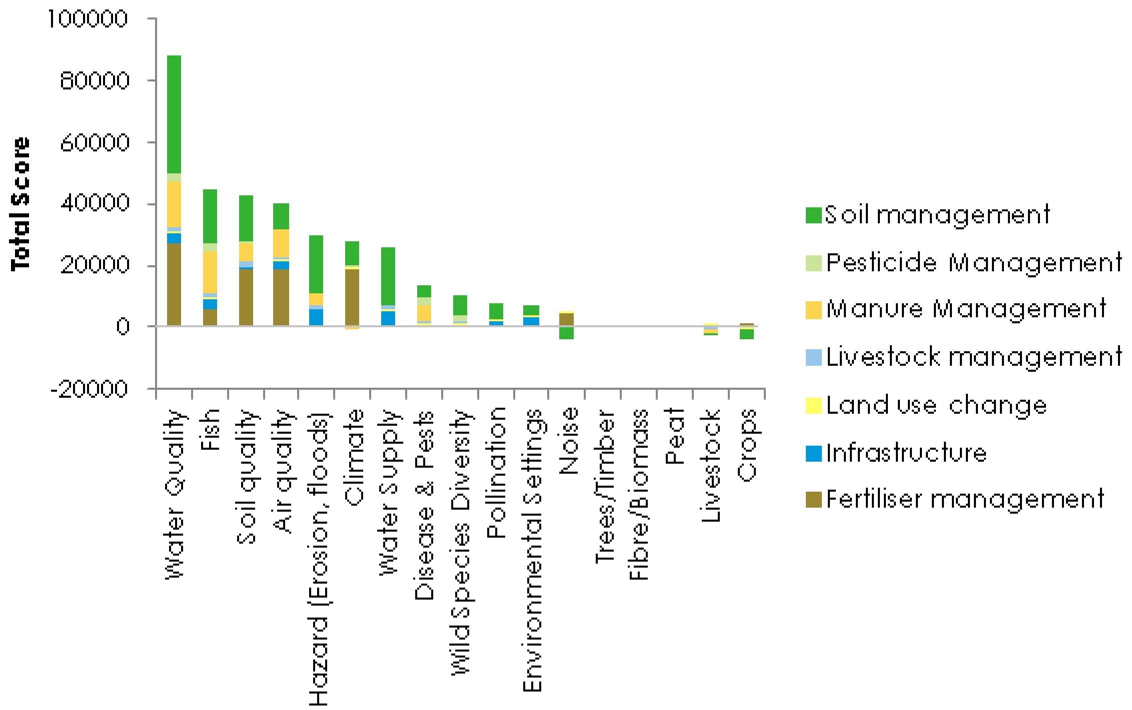
Despite CSF mitigation measures being designed primarily to reduce water pollution from agriculture, this assessment considers the environmental impacts of CSF across the full spectrum of ecosystem services: climate regulation; pollination; soil quality; air quality; hazards (flooding and erosion); noise; disease and pests; biodiversity; environmental settings (recreation and amenity); food and biomass production; water supply; and water quality.

The positive and negative impacts of individual CSF measures on defined ecosystem services were described and then scored to provide a semi-quantitative estimate of the magnitude and location of benefits at a national and catchment scale. The results provide a relative measure of the level of benefit to each ecosystem service and do not necessarily reflect the absolute magnitude or monetary value of the benefit (Figure 15).

The majority of impacts considered were assessed as having a high degree of confidence. Impacts on water quality, air quality and climate regulation had the highest degree of confidence as the assessment was based heavily on a systemic review of available scientific evidence.

Figure 15. Total score by ecosystem service for different categories of mitigation measures

The impact score takes arbitrary units and provides a semi-quantitative indication of the degree to which CSF has enhanced the delivery of a particular ecosystem service. It should be interpreted as a relative measure of the level of benefit to each ecosystem service.



The results indicate that measures promoted through CSF deliver multiple benefits that go well beyond the project's core objective of improving water quality. Although water quality impacts are the single largest ecosystem service benefit, they account for a small minority of the total benefit. At a national scale, the most significant wider ecosystem service benefits are for fisheries, soil quality, air quality, hazards (floods and erosion), climate regulation and water supply.

A small number of individual measures contribute disproportionately to the impact of CSF. The top five measures are cultivate compacted tillage soils; in-field buffer strips; do not apply P fertiliser to high P index soils; riparian buffer strips; and, use of a fertiliser recommendation system. Taken together, these account for 42 per cent of the total impact of CSF.

There are some clear win-win opportunities for CSF to promote measures that deliver multiple benefits, but also some trade-offs that need to be considered to limit pollution swapping or other unintended consequences.

Using an ecosystem service mapping approach, there is scope to enhance CSF targeting to maximise benefits across a range of spatially-variable ecosystem service benefits. However, our analyses also highlight the importance of the local context in determining the benefits that accrue from any particular management intervention.

3. Factors underpinning CSF outcomes

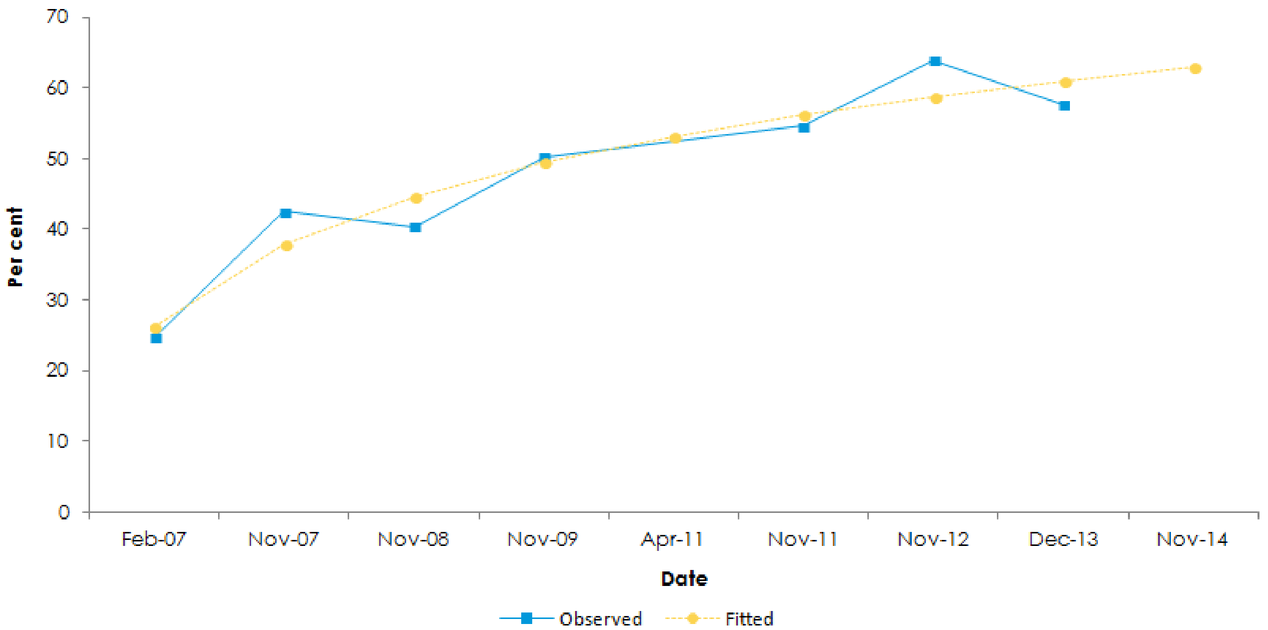
Understanding the effectiveness of the farmer engagement and advice delivery process underpins our overall evaluation of environment-focused outcomes. In this section we present the main findings from data and information on farmer awareness and attitudes (Ipsos MORI, 2014); advice delivery (Environment Agency, 2014); implementation of mitigation measures; case-studies; and research, to provide insight into why the CSF project has been successful.

Farmer awareness of CSF

Raising awareness of CSF is essential to encourage farmers to engage with, and seek more detailed advice from, the project. CSFOs undertake a range of general awareness raising activities, including circulating newsletters and attending county shows and other local events.

Although CSF is primarily focussed on high priority target areas within wider river catchments, it is evident that awareness of the project has increased significantly over time across the CSF catchments. For example, 58 per cent of farmers surveyed across the Phase 1 Priority Catchments are now aware of the project and awareness is predicted to continue to rise in future years (Figure 16).

Figure 16. Awareness of CSF project across Phase 1 farmers, 2006 – 2014[18] (Ipsos Mori, 2014)



(Logarithmic model, Y= $\beta_0 + \beta_1 \log(\text{Wave})$; p-value for β_1=0.001; R^2=91.9%)

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[18] Data based on response to the following question asked to farmers: have you heard of the CSF project?

Effective farmer engagement and advice delivery

Our modelling has shown extensive engagement is important to ensure water quality benefits are realised. Over the three phases of the project, CSF has provided advice to farm holdings covering 2,311,527 hectares of land. This represents 42 per cent of the total land covered by holdings within the CSF catchments. Overall, 16,133 farm holdings have received CSF advice, through a combination of one-to-ones (13,055 holdings), group events (9,047 holdings) and clinics (906 holdings).

The CSF project has become the single most important initiative in terms of helping farmers make changes to reduce water pollution, across the CSF catchments. 23 per cent of farmers across the Phase 1 Priority Catchments cite the CSF project, eclipsing Environmental Stewardship (ES), the other main scheme, in our 2012 and 2013 farmer surveys (Figure 17).

There is significant variation in the extent of advice delivery across CSF catchments (Figure 18). A combination of the following factors are responsible:

- catchment size (Egford Borehole at 5 km^2 to Little Ouse at 2,594 km^2) and numbers of farm holdings (10 for Egford Borehole to 5,164 for the Somerset Levels & Moors)
- farm type – most advice was targeted to cereals or general cropping, except in the North West (grazing livestock), Severn (mixed farming) and South West (dairy), with different sectors requiring different engagement strategies and advice
- farm size – on average, engaged holdings in Northumbria were three times, and those in Anglian, Thames and the South East were twice, the size of those in the Severn, North West and South West, requiring more time and resources to deliver farm-specific advice
- water quality issues present – priority pollutants (phosphorus, nitrate, sediment, pesticides or FIOs) and environmental receptors (for example, bathing waters or abstractions)
- duration of advice delivery in a catchment
- continuity and profile of those responsible for advice delivery

These factors help explain why some catchments are likely to need CSF in place for a longer time than others to ensure similar environmental outcomes are delivered.

Satisfaction amongst those that have engaged with the CSF project is high. The project is generally seen by farmers as effective in terms of raising their awareness of water pollution and providing useful and relevant advice that is genuinely helping them make changes to reduce water pollution.

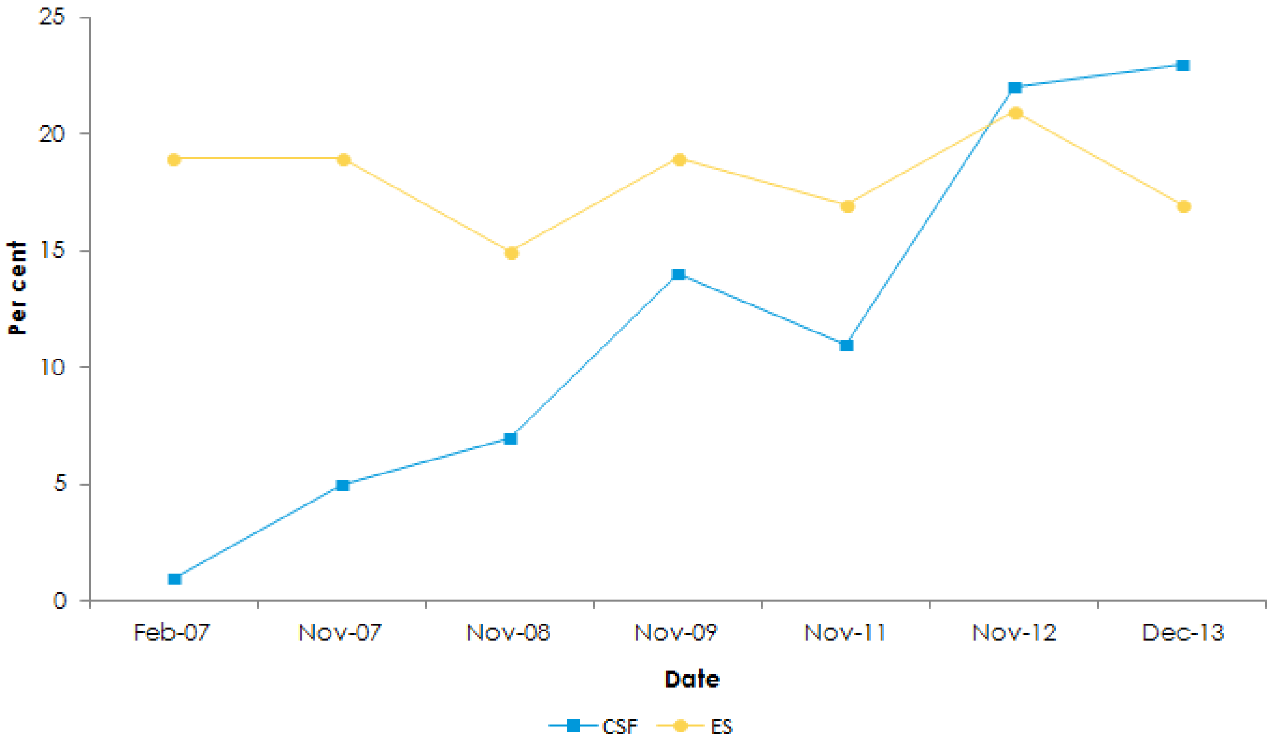
Specifically, farmers indicate that working with CSF increases the priority they give to water pollution (85 per cent of those engaged one-to-one); provides them with ideas for reducing water pollution (86 per cent); confirms planned changes will be effective (82 per cent); and helps them make changes more effectively and more quickly (76 per cent).

Encouragingly, few farmers are turning down CSF services. When they do it is mainly due to time constraints or where they do not think the specific services are relevant, or offer new information, to them.

Using a range of delivery options

CSFOs deliver advice through a combination of one-to-one engagement, group events and clinics (for example at auction marts). Overall, one-to-one advice has been provided to18 per cent of farm holdings; 12 per cent of holdings have received advice through group events and 1 per cent through clinics.

Figure 17. 'Schemes' helping farmers to make changes to mitigate water pollution[19] (Ipsos Mori, 2014)



Farmer surveys provide clear evidence that one-to-one engagement is most effective across a range of metrics. For example, farmers engaged one-to-one (as opposed to through events) are more likely to agree that:

- CSFOs understand the individual needs of their farms (94 per cent vs. 69 per cent)
- they receive enough advice to enable them to introduce new ideas or changes to their farm (84 per cent vs. 70 per cent)
- officers help them overcome practical barriers to making changes (71 per cent vs. 49 per cent)
- they are satisfied with the advice received (92 per cent vs. 79 per cent)

A clear link is also apparent between one-to-one engagement and trust and confidence in the project's effectiveness in tackling water pollution. 70 per cent of one-to-one engaged farmers state they have trust and confidence in the project, compared to 50 per cent of those attending only group events.

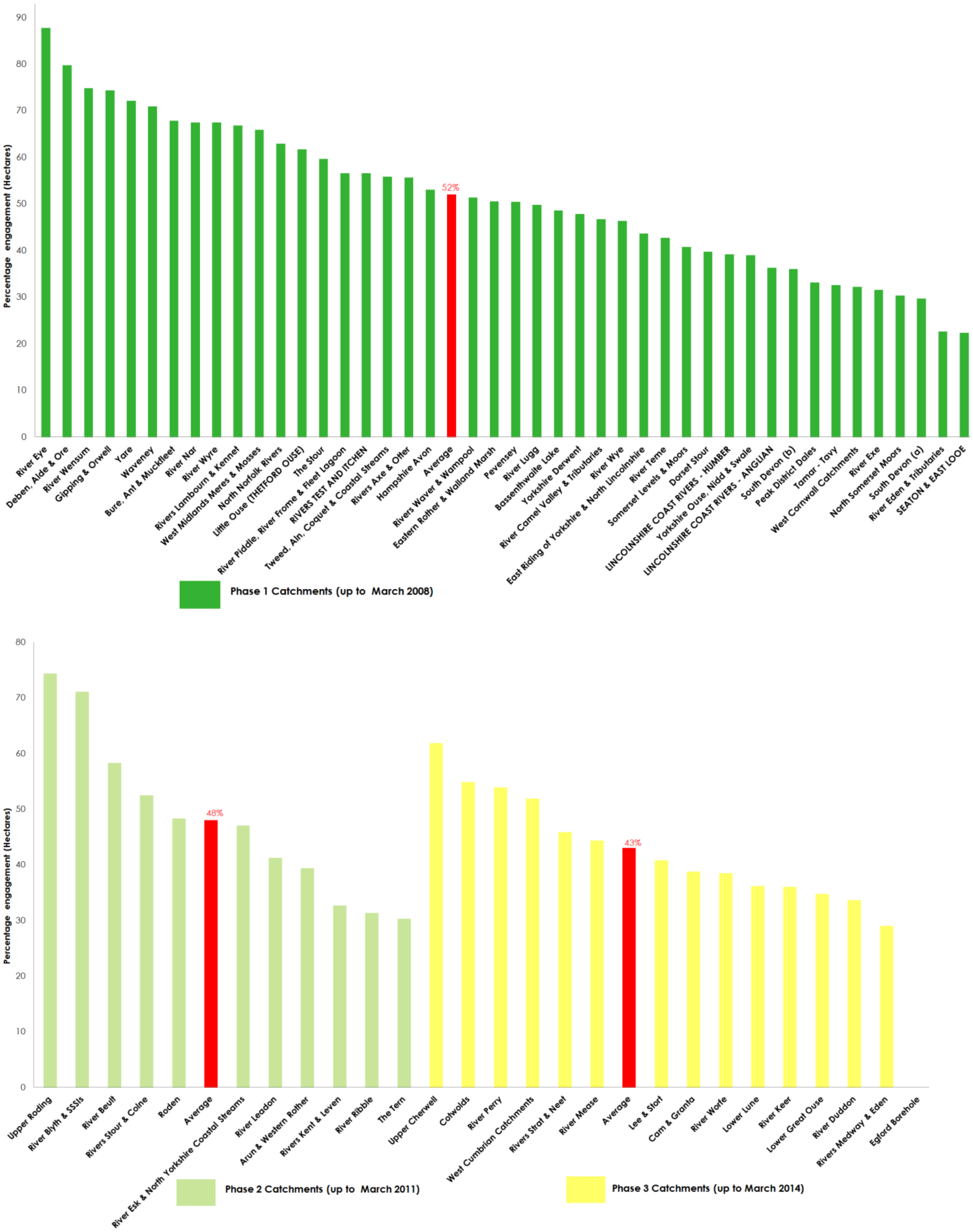
The engagement figures show CSFOs understand this and utilise this route to a greater degree. Overall, our evidence shows the more closely engaged farmers are, the greater their understanding of what they can do to reduce water pollution seems to be.

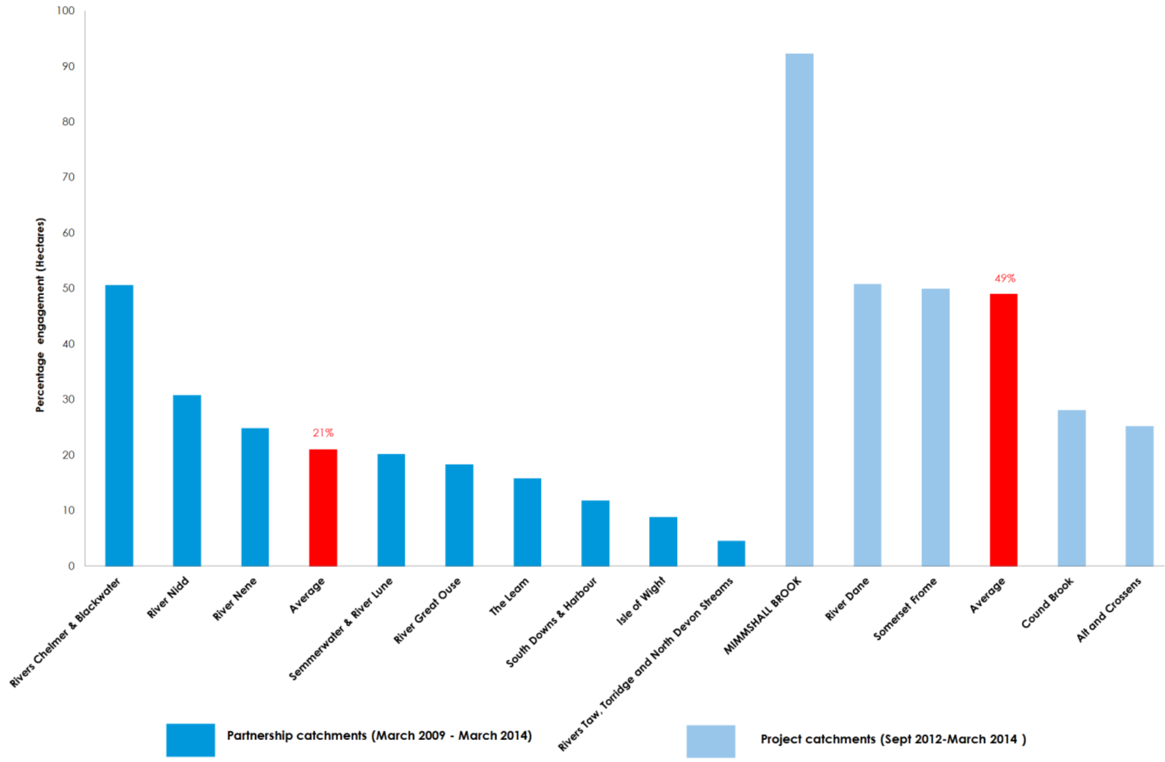
Group events are, however, used effectively within the CSF project. They provide an important way of introducing farmers to the project, before following-up with more

[19] Data based on the question to farmers - Did any agricultural scheme or initiative help or prompt you to make any of these changes? If yes, which scheme or initiative was that?

specific one-to-one advice. Group events delivered in partnership with other catchment initiatives, agronomy firms and industry bodies, also provide an effective way of linking up

Figure 18. Percentage engagement of total holding area across the CSF catchments





delivery at a catchment scale. There is also evidence to indicate advice can be promoted effectively in a practical farm setting where farmers learn from each other's experiences and visualise benefits in a tangible way (Fish, 2014). Such peer group interactions allow confidence and skills to be developed and help establish CSF as a good farming 'norm'. A mix of one-to-ones and group events, as practiced within CSF, can therefore be seen as optimal for effective delivery.

Building effective CSFO-farmer relationships

Impressions of CSFOs and their helpfulness are good and an increasing number of farmers have had direct contact with their officer (for example, 33 per cent across the Phase 1 Priority Catchments).

Overall, farmers who have met their CSFO trust them and agree they have the qualities that make them willing to engage with and more likely to follow their advice. Farmers state that officers are helpful, encouraging and that they listen to their views and concerns.

More than 90 per cent of farmers state that trust in the CSFO; their showing commitment to the farming community; and their understanding of individual farms and farming systems are important in terms of their willingness to engage. CSFOs' knowledge of potential funding mechanisms is also at the forefront of many farmers' interactions with them. That officers are knowledgeable, pragmatic, friendly and understanding are also important factors.

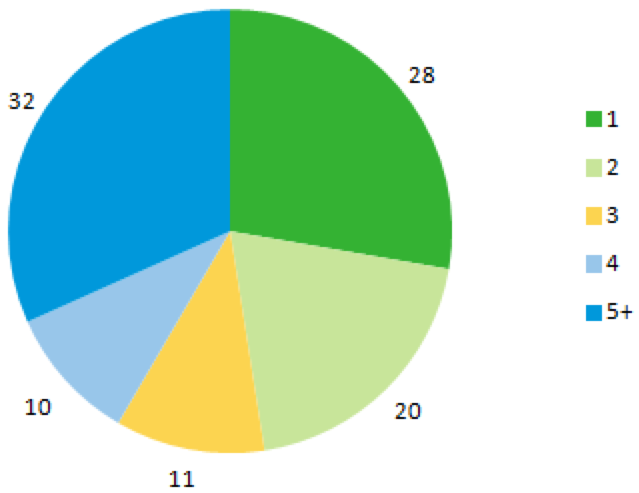
Experienced CSFOs identify very similar factors as being key to their success (WRc, 2013), including:

- developing a trusting relationship with the farmer
- providing an authoritative source of advice
- understanding the farm business
- providing locally-relevant evidence of water pollution
- being able to back-up advice with grant funding

Most farmers still feel that they are getting new information from their CSFO and agree that their officer has a broad understanding of farming issues, as well as those on individual farms. We know that time in a catchment to develop effective working relationships across the farming community is crucial to the project's success. This is reflected in the engagement figures which show that overall 72 per cent of holdings have been engaged on more than one occasion and 32 per cent have been engaged five times or more (Figure 19).

Across the CSF catchments, there is significant variation in the level of farmer re-engagement. This is primarily driven by time in a catchment and catchment size and reflects the 'maturity' of the CSF project in a particular catchment. For example, the River Eye is one of our smallest catchments and has the highest level of re-engagement at 35 per cent.

Figure 19. Number of CSF engagements per farm holding



Robust evidence base

The CSF project places significant emphasis on evidence in terms of identifying catchments and target areas within them as the main focus for advice delivery; developing and communicating local evidence to encourage farmer engagement; and evaluating project outcomes.

It is often difficult to 'see' water pollution and this can be confounded by the fact that impacts manifest themselves not on the farm but in the wider landscape. Convincing farmers that there is a specific water quality issue that can be tackled via action on their farms has been a challenge that the project has done much to overcome. CSFOs utilise a range of solutions, such as:

- developing and presenting evidence at an appropriate local scale - farmers are less likely to be convinced by evidence that is drawn from general statistical models, or other geographic areas, and then assumed to apply to their particular locality
- presenting quantitative information in easily accessible visual formats, such as simple graphs and using maps to contextualise pollutant risks (for example, topography, soil type, and land use)
- using 'before and after' photographs and water quality monitoring case studies to demonstrate the positive impact of farmers' actions
- involving figures of authority and trust when presenting the case for action

- being clear where information is drawn from and the assumptions on which it is based

To support CSFOs, the CSF Evidence Team:

- undertake local monitoring studies and assessments to confirm issues and demonstrate successful solutions (see River Wyre modelling case study and River Frome water quality monitoring case study)
- survey CSFOs to understand the priority 'evidence gaps' and then work with relevant researchers (for example, from the Defra-Environment Agency Demonstration Test Catchments Project) to address them
- provide summaries of key datasets and documents, including new understanding provided through wider research projects
- develop guidance and best practice; for example on engaging farmers in water quality monitoring projects
- provide a range of data tools; for example to allow development of customised catchment maps of geology, land use, rainfall, modelled pollutant loadings, and monitored water quality

We have developed the *CSF Evidence Prospectus* for CSFOs to access the latest information across these areas.

Motivating farmers

Farmers are individuals and motivated to engage and respond positively to CSF for a range of different reasons. The majority indicate they want to do more to reduce water pollution (for example, 67 per cent of those engaged one-to-one) but fewer than half (for example, 33 per cent across Phase 1 Priority Catchments) believe it is possible for them to do so, even if barriers are removed. However, our surveys indicate CSFOs are providing new information to the farmers they engage and this is helping raise awareness of what more they can do. This is likely to be an important enabler for action.

Overall, farmers stating they want to do more to reduce water pollution indicate they are motivated by a desire to act responsibly towards the environment and countryside (82 per cent). The reputation or image of the farm (22 per cent) and financial benefits (14 per cent) are also important factors. The latter is highlighted in a series of case-studies with farmers engaged with the CSF project (Test Research, 2008). These clearly show the importance of free advice; reduced running costs (for example, through reduced fertiliser applications); and grants for capital investment. By continuing to emphasise the environmental benefits of making changes alongside financial or reputational benefits, the project may re-enforce environmental concerns amongst farmers and empower them to take further action, both on water pollution, and, potentially, on other issues.

There is evidence to indicate that although engagement with the CSF project increases farmers' understanding of the potential to make changes, it simultaneously increases awareness of the potential barriers (for example, 45 per cent of farmers engaged via one-to-ones perceive barriers compared to 28 per cent across Phase 1 Priority Catchments). Looking to the future, the project needs to keep tackling these inter-related issues in order to deliver further significant progress.

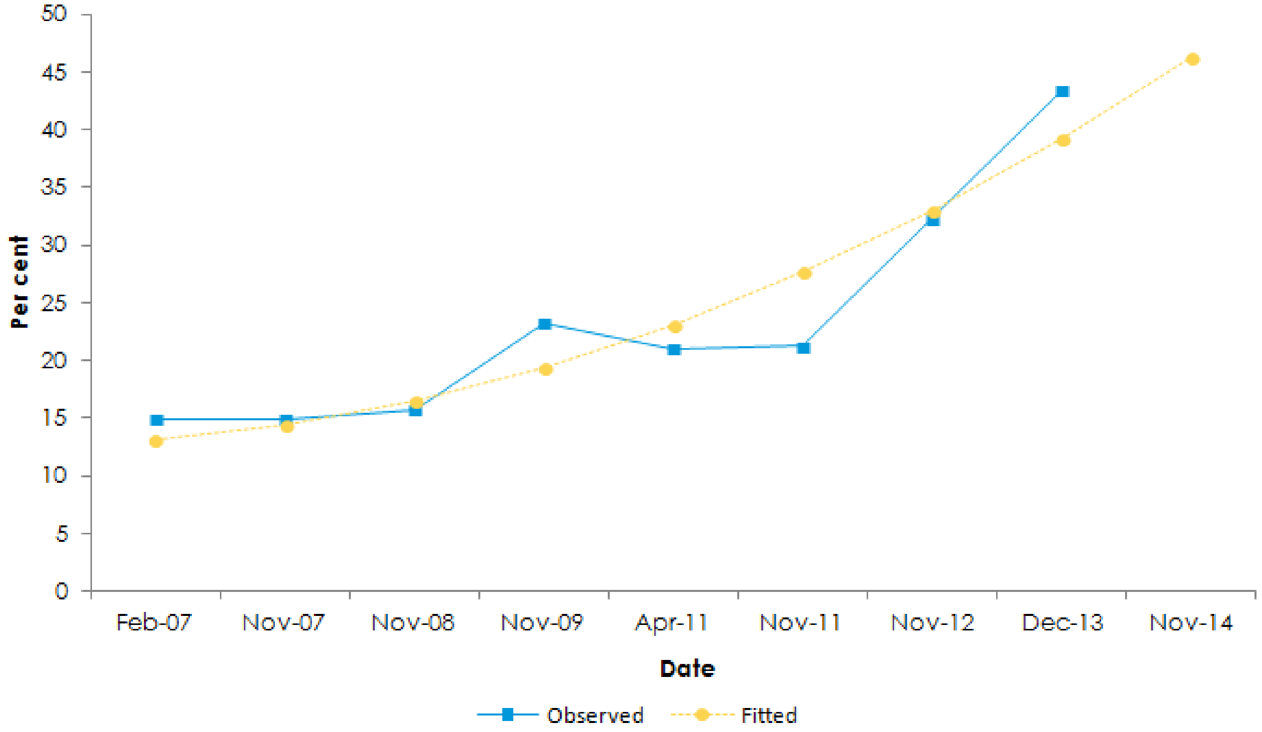
Changing attitudes to water pollution

Gaining understanding and acceptance that water pollution from farming is a real issue that farmers can influence helps drive change in practices to reduce the problem. Furthermore, many of the mitigation measures are only effective once the farmer has an understanding of the impacts, such as avoiding spreading manures or applying pesticides during likely run-off periods. The project is generally seen by farmers as effective in terms of raising awareness of water pollution and providing useful and relevant advice that is genuinely helping them make changes to reduce it. We know from farmers who have been engaged, that CSF has helped them by:

- giving up-to-date authoritative advice on water pollution
- giving them ideas to reduce it
- increasing the priority they give to the issue

There is increasing acceptance amongst farmers within CSF Priority Catchments that agriculture contributes to water pollution, with evidence of increasing momentum in the last few years (Figure 20). Farmers, on the whole, also acknowledge that activities on their own farms contribute, at least a little, to water pollution. Those farmers directly engaged through CSF are more likely to acknowledge this (73 per cent of farmers receiving one-to-one advice compared to 66 per cent of farmers across the wider Phase 1 catchments).

Figure 20. Agreement of Phase 1 farmers that agriculture contributes to water pollution[20] (Ipsos Mori, 2014)



(Quadratic model, Y= $\beta_0 + \beta_1$Wave2; p-value for β_1=0.001; R^2=88.1%. o Outliers)

An adaptable and integrated approach

CSF is one of a range of initiatives and organisations providing advice to farmers. There is good evidence to indicate that CSF plays a lead role in delivering advice on mitigating water pollution and also that CSFOs are integrating related advice sources, taking a lead in providing farmers with a clear appreciation of the issues and priority actions.

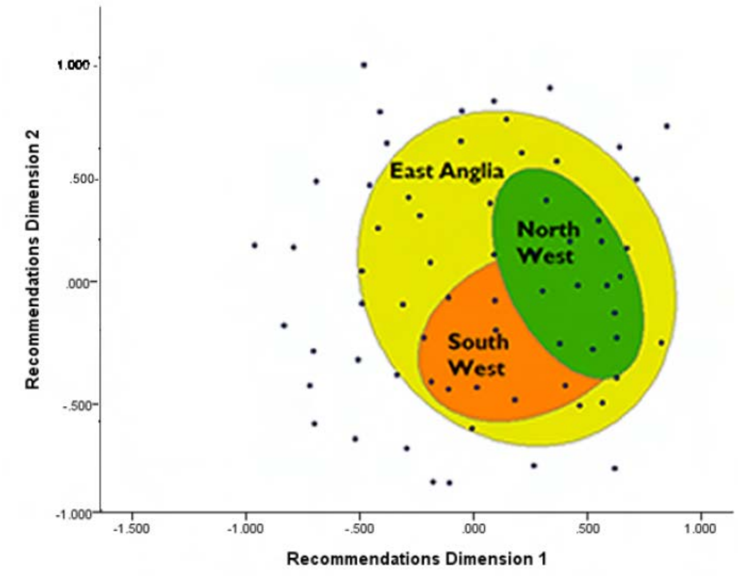
[20] Based on question asked to farmers - To what extent do you feel and understand that agriculture contributes at least a fair amount to water pollution in your catchment area?

Research by a PhD student from the University of East Anglia has investigated the 'niche' of CSF with regards to the mitigation measures being recommended by advisors and the mechanisms being used to encourage uptake (Vrain, 2014).

When CSF is considered in isolation (based on measures recommended in CSF catchments in East Anglia, North West and South West) there is significant overlap but regional differences are apparent (see Figure 21). This clearly demonstrates the flexible approach adopted within CSF. Officers in East Anglia provide a wider range of advice, whereas those in the North West and South West focus on a narrower range of measures, such as yard infrastructure, track management and fencing.

Comparing CSF with other advice sources (Figure 22), it is apparent that CSFOs are promoting a wider range of measures than Environment Officers[21] (Environment Agency) and Land Management Advisers (Natural England). To do this they are utilising a wider array of mechanisms, including incentives (grants), voluntary advice, signposting other advice sources, and regulatory advice. By exploiting the full range of measures and mechanisms available to farmers this naturally expands the range of possibilities for behavioural change.

Figure 21. 81 farm advisors plotted on a two-dimensional scale using PROXSCAL



(Results based upon the mitigation measures recommended, with one standard deviation ellipses for CSFOs in the three regions - advisors that are located near each other in the space are more likely to have recommended similar measures)

'Environmental organisations' (including wildlife trusts, rivers trusts and the RSPB) provide advice across a wide range of measures in two of the three regions. The analysis suggests a degree of adjustment and integration of roles, with CSF taking on a broader role where environmental organisations are more focussed (e.g. in East Anglia) and a narrower role where they provide a broader range of advice (e.g. in the North West and South West).

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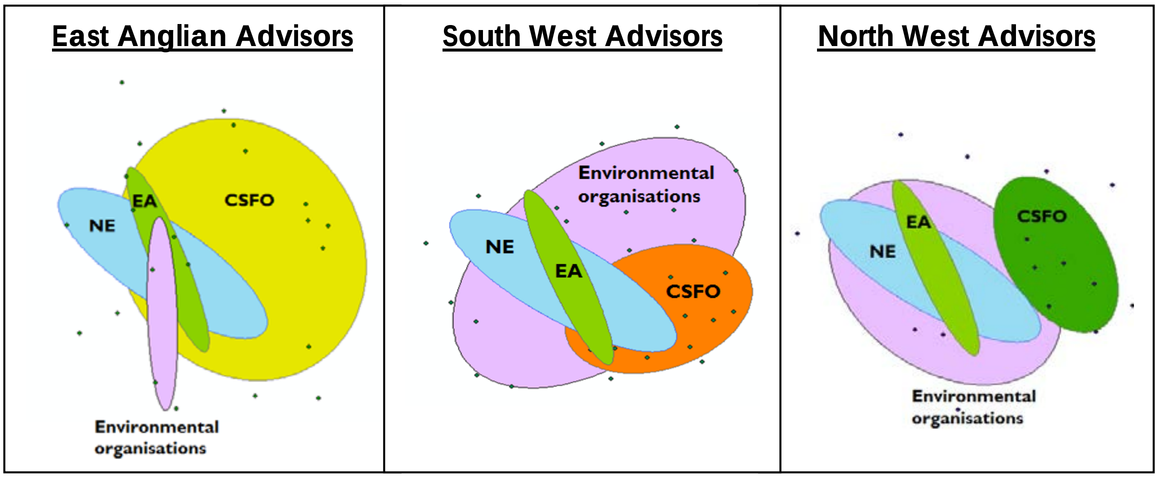
21 Environment Agency and Natural England data are pooled nationally as the role of Land Management Advisers relates specifically to agri-environment scheme options and the role of Environment Officers to regulatory measures.

Figure 22. Advisors from each region plotted on a two-dimensional scale with one standard deviation ellipses for CSFOs, Natural England Land Management Advisers , Environment Agency Environment Officers and 'environmental organisations' (including wildlife trusts, rivers trusts, and the RSPB)



Integrating CSF and Environmental Stewardship

One of the key roles for CSFOs is to provide farmers with information on the support available to them to tackle water pollution issues, over and above that provided directly through CSF.

Entry Level Stewardship (ELS) and Higher Level Stewardship (HLS) are two important agri-environment schemes that provide funding to farmers in return for delivering environmental management on their land.

One of the objectives of ELS is to 'protect natural resources by improving water quality and reducing soil erosion and surface run-off'. There are a range of water quality options within ELS, including hedgerow restoration; buffer strips; beetle banks; management of field corners; management of maize crops to reduce erosion and run-off; maintenance of watercourse fencing; and winter cover crops.

HLS also includes a range of options specifically designed to improve soil structure and water infiltration and reduce the transport of sediment (and associated pollutants) to water bodies. Each HLS target area has its own target statement and only features identified in these statements can be covered within agreements. Outside of target areas, HLS priorities are defined through themes, one of which is 'improving the quality of nationally important water bodies and/or habitats adversely affected by diffuse water pollution from agriculture'.

CSFOs do not have direct control over ELS and HLS, but they can influence the options selected by farmers through their general awareness raising and work with targeted farmers. CSF Capital Grant Scheme applicants in Environmental Stewardship also have a greater chance of success through a higher points weighting, designed to encourage ELS uptake and align capital works and land management measures.

To assess the impact of CSF on uptake of relevant ELS options, we compared the number of points accrued by the resource protection options within ELS agreements inside and outside CSF catchments. This indicated a consistent 2-3 per cent increase in the number of points within CSF Priority Catchments between April 2011 and June 2013. CSFOs also reported on the proportion of advised mitigation measures where implementation was 'influenced' by ELS and HLS. This indicated that 1 per cent of implemented measures were influenced by ELS and 2 per cent by HLS.

This assessment indicates that overall Environmental Stewardship is of limited importance as a mechanism for increasing uptake of CSF measures. Key reasons for this are the fact that farmers who engage with CSF are much less likely to be in Environmental Stewardship than the farming population as a whole (for example, the dairy sector) and the lack of control advisors have over farmers' choice of options. Having said this, there are specific examples of how HLS and ELS have been successfully integrated with CSF to deliver common objectives (see the eleven 'Environmental Stewardship' case studies at http://www.naturalengland.org.uk/ourwork/farming/csf/casestudies.aspx).

Advice supported by a Capital Grant Scheme

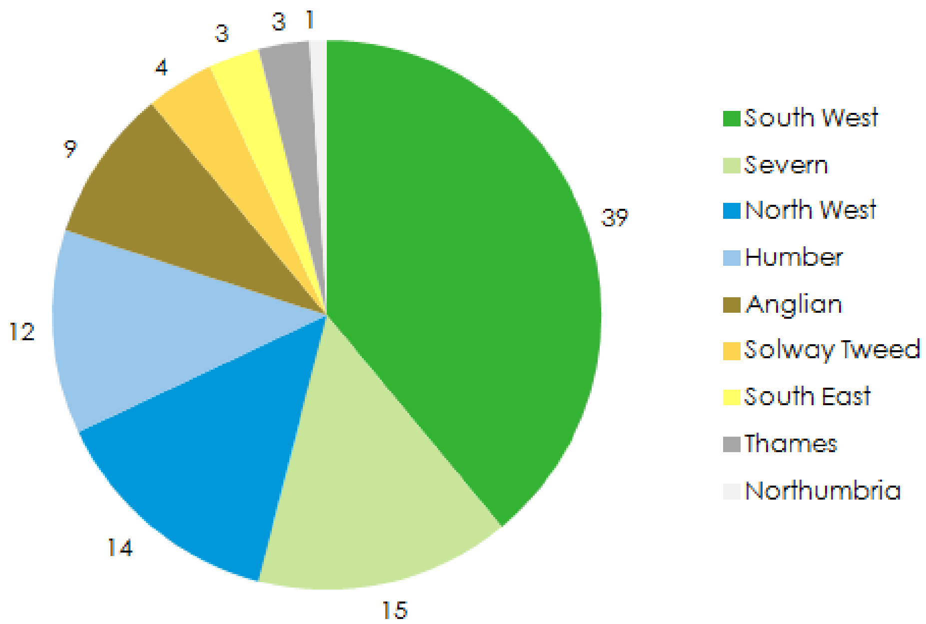
Between 2007 and 2013, the CSF Capital Grant Scheme (CGS) funded farmers to make relatively low-cost infrastructure improvements within priority areas of each catchment[22].

In total, the scheme has contributed to approximately £80M of improvements, a total that was match-funded by the recipient farmers. The CGS funds a range of farm improvements, although, approximately 80 per cent of funding has been for just five items:

- yard works for clean and dirty water separation
- roofing manure stores and livestock gathering areas
- watercourse fencing
- livestock and farm machinery tracks
- livestock troughs

There is clear variation across the RBDs in terms of both the scale and nature of CGS funding (Figure 23). Most grants were received in the South West (39 per cent) with the least in Northumbria (1 per cent).

Figure 23. Percentage distribution of CGS grants across the River Basin Districts



[22] The CGS was available to the Catchment Partnerships from 2012

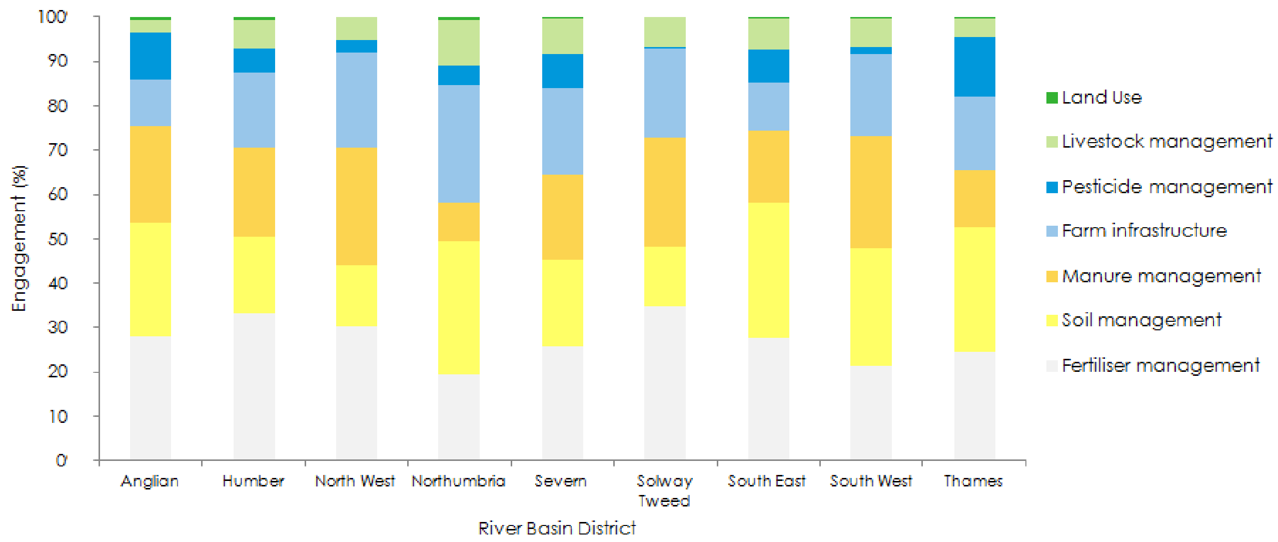
An estimated 35 per cent of engaged farmers within the CSFO and Partnership Catchments have received a CGS grant(s) whilst approximately 9 per cent of implemented CSF measures were funded through the scheme. This suggests the influence of the scheme is much greater than the measures it directly funds, with the scheme being an important 'catalyst' for farmers to take further action / implement further measures to reduce water pollution.

A lack of financial incentive is the single most significant barrier identified by farmers as preventing them taking action to mitigate water pollution. The CGS and other funding sources are clearly important in this context and we have seen a reduction in farmers highlighting finance as a barrier since CGS funding increased in 2011.

Uptake of CSF advice

Overall 167,788 individual mitigation measures have been advised to farmers engaged by the project. The majority relate to fertiliser management (27 per cent), soil management (23 per cent), manure management (22 per cent), and farm infrastructure (16 per cent). Pesticide management (6 per cent), livestock management (5 per cent) and land use (1 per cent) have been advised to a much more limited extent. Although there is variation across the River Basin Districts (RBDs) in measures recommended, in all manure management, soil management, fertiliser management and farm infrastructure account for over 80 per cent of the total (Figure 24).

Figure 24. Variation in recommended mitigation measures across RBDs



The diversity of engagement is revealed on an individual practice level by looking at the proportion of holdings each measure has been advised to:

- five of the 119 measures were each advised to over 30 per cent of holdings: separate clean and dirty water from farmyards and roofs (51per cent); analyse soils regularly (49 per cent); adopt and follow a nutrient management plan (46 per cent); adopt and follow a recognised manure management plan (35 per cent); integrate fertiliser and manure nutrient supply (32 per cent)
- 54 measures were each advised to between 5 per cent and 30 per cent of holdings
- 40 measures were recommended to less than 5 per cent of holdings

This clearly demonstrates that the advice provided through the project is highly tailored to specific situations.

Across the Priority Catchments, 62 per cent of mitigation measures recommended through one-to-one advice had been implemented by March 2014. At 64 per cent of holdings, half or more of the recommended measures had been implemented. Uptake of advice from group events was 54 per cent and from clinics was 57 per cent (figures derived from holdings also receiving one-to-one advice for different mitigation measures). Uptake of one-to-one advice was similar for the Catchment Partnerships (60 per cent) and Catchment Projects (54 per cent).

Uptake of CSF advice is affected by time, cost, farm type, location, and the nature of the advice. We now have a clearer understanding of the importance of these factors in influencing the scale of benefits delivered by CSF.

Advice uptake is highest for mixed, cereals and general cropping farm types and lowest for horticulture, less favourable area grazing livestock and dairy (Figure 25) and this is also reflected in differential uptake across the RBDs (Figure 26).

Figure 25. Percentage uptake of mitigation measures by farm sector

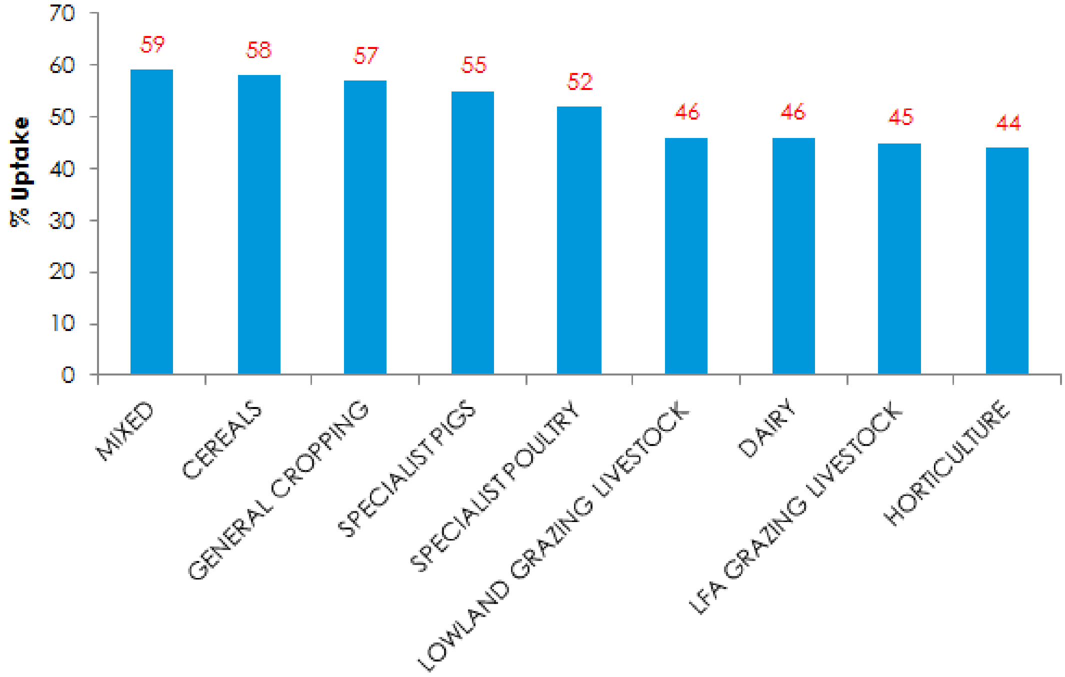
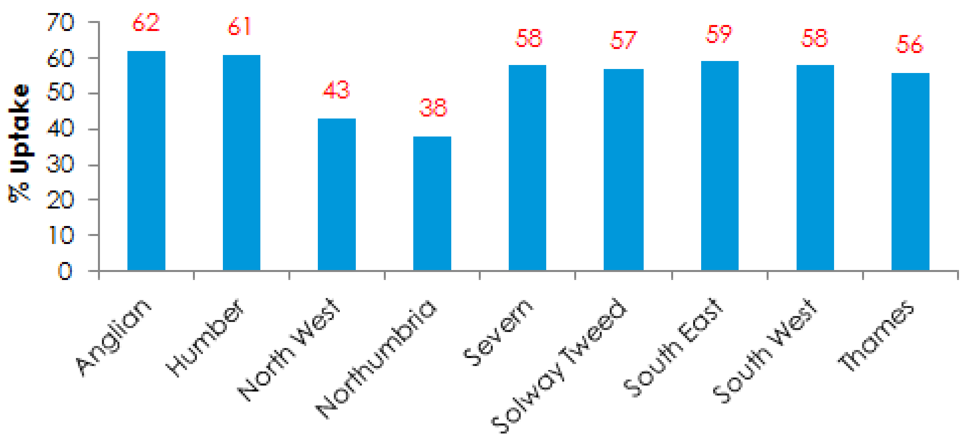
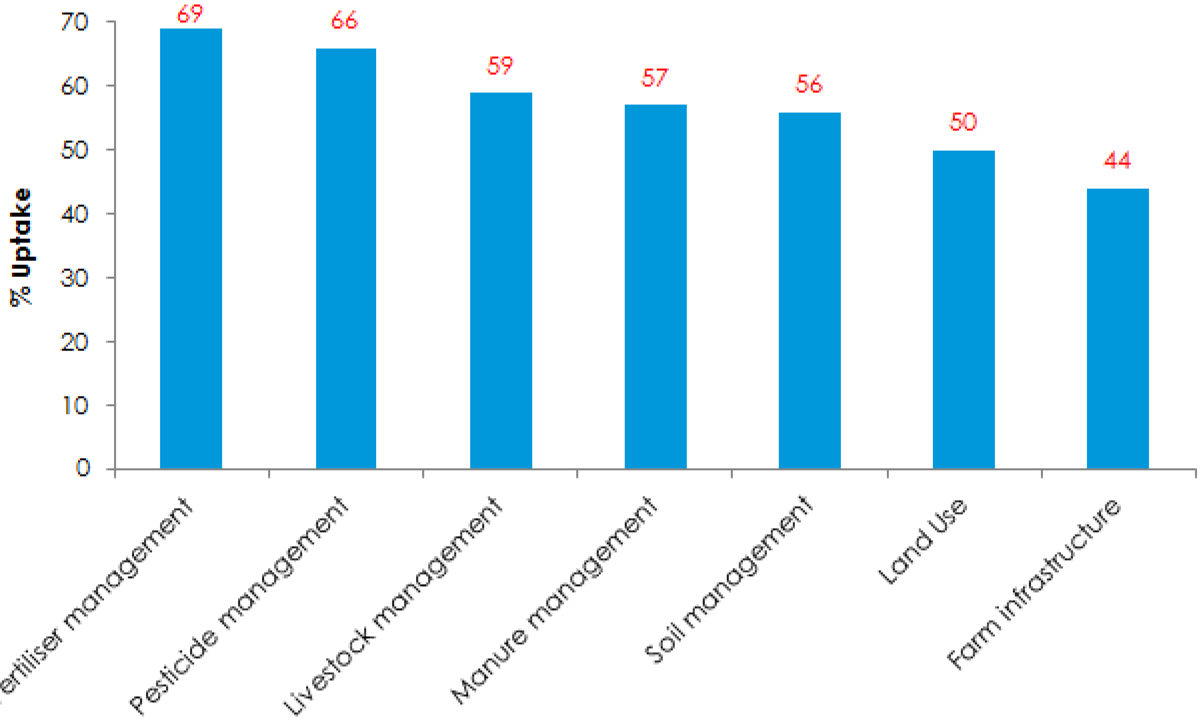


Figure 26. Percentage uptake of mitigation measures by RBD



Fertiliser management and pesticide management measures have the highest overall uptake with more ‘costly’ farm infrastructure and land use measures the lowest (Figure 27).

Figure 27. Percentage uptake of mitigation measures by measure category



The extent of advice uptake is clearly dependent on the length of time elapsed since recommendations were first made. 46 per cent of practices recommended in the first two years of Phase 3 (2011/12 and 2012/13) were implemented by March 2014, whereas 71 per cent of recommendations first made in Phase 1 and 70 per cent of those first made in Phase 2 had been actioned at this point in time. This indicates there is typically a lag of around three years for farmers to implement measures (for example, to incorporate them into cropping cycles). If we consider only measures initially advised over three years ago, the overall uptake of CSF measures is 70 per cent.

Comparing the uptake of advice first provided in Phase 1 with that first provided in Phase 2, there is no evidence to suggest a decline in the implementation of older advice. This may, at least in part, be due to repeat farmer engagement reinforcing previous advice delivery.

The overall uptake of measures providing a cost saving to the farmer was 71 per cent whereas those measures associated with a net cost had a 56 per cent uptake. This indicates that CSF is helping target and accelerate changes that might be expected through general trends towards improved farming practice, whilst also delivering significant additional changes.

Case study

CSF in the River Waveney catchment

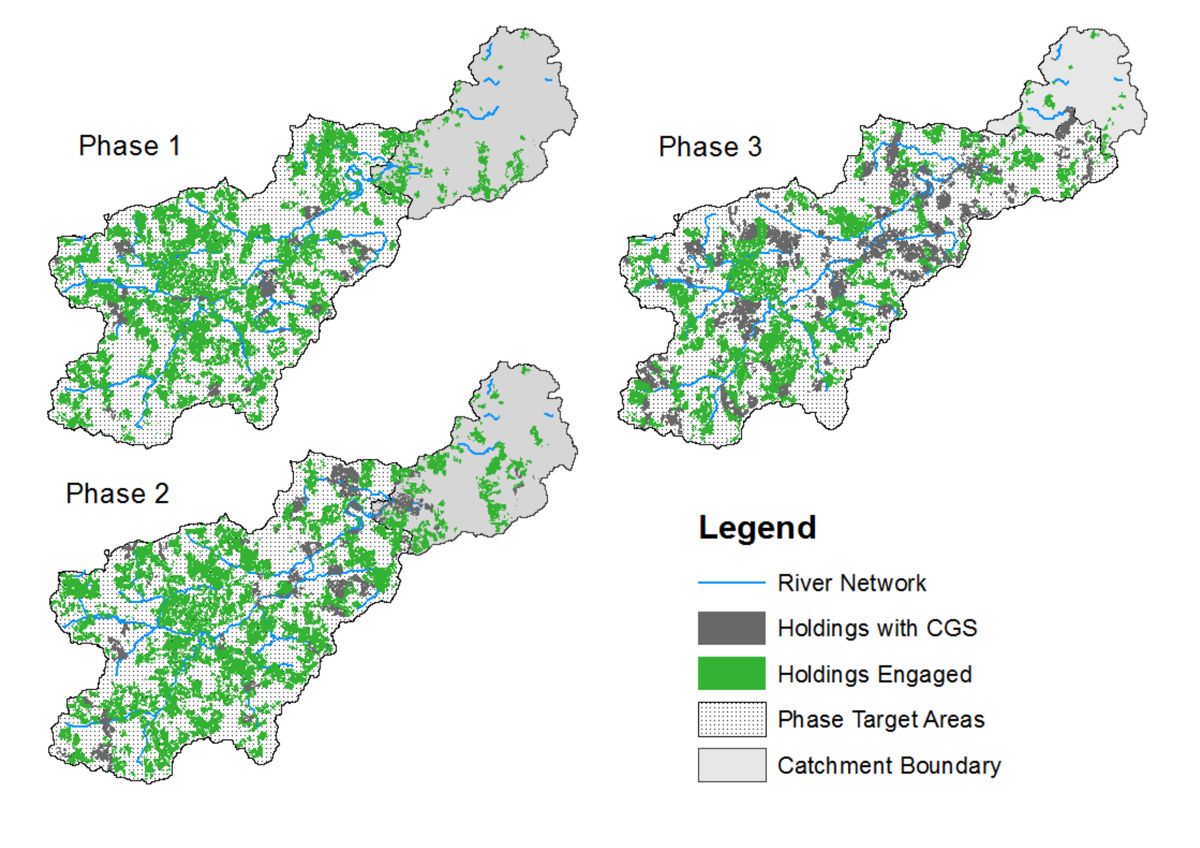
Located in the Anglian River Basin District, the River Waveney is a Phase 1 Priority Catchment. With 1,024 farm holdings, the Waveney covers 863km^2. The catchment is intensively land tiled and drained with high connectivity to the river system. Large arable farms of winter cereals and oil seed rape dominate the catchment with a high concentration of pig and poultry farms in the west.

Targeting priorities

Across the Phase 1 target area, farm yard manure and slurry applications were tackled to address excessive nitrate and phosphate losses. Farm holdings along the length of the river and on steeper slopes were targeted to limit soil erosion. Local knowledge and published research led the officer to focus additional resources to tackle run-off issues from poor tramline management.

Phases 2 and 3 saw continued advice delivery in the upper catchment (Figure 28). Activity focused on areas neighbouring and upstream of priority areas to contribute to water quality improvements for SSSIs, Surface Water Drinking Water Protected Areas and WFD ecological status.

Figure 28. Advice delivery within the Wavney catchment, CSF Phases 1-3



During Phase 3 the Waveney target area was extended by 101km^2, increasing coverage to 88 per cent of the catchment. The extended target area covered additional Protected Areas to the east impacted by agricultural pollution.

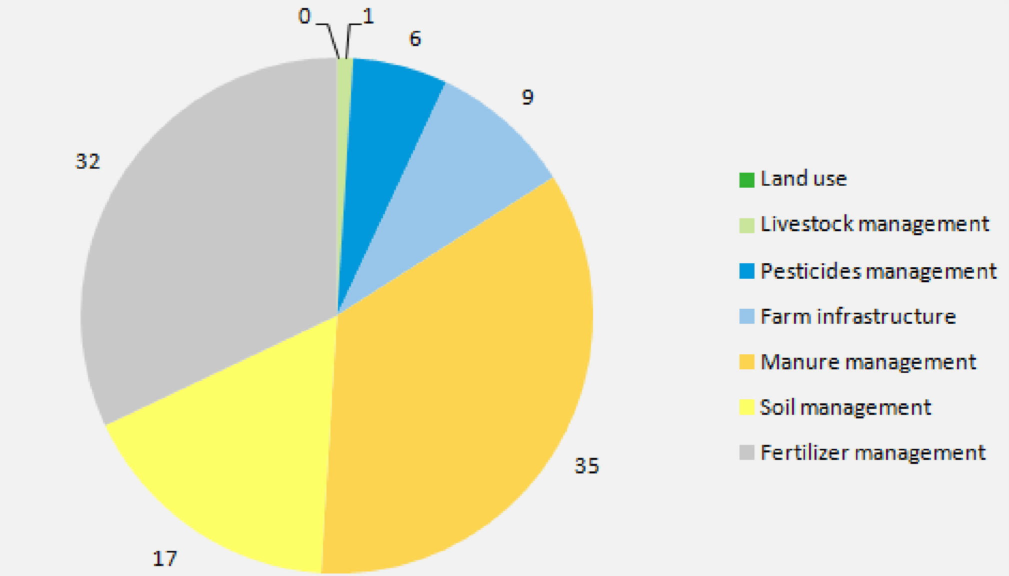
Advice delivery

To raise awareness among farmers and other farm advisors, the CSFO uses newsletters, articles in the farming press, social media videos and attends agricultural events.

CSF events, such as soil workshops and farm walks, are very popular among the farming community. These are typically followed up with one-to-one farm visits, allowing the CSFO or contactor to identify specific issues and provide specialist advice tailored to the farm holding.

With a mix of arable and livestock farms in the Waveney, different approaches are used to promote one-to-one farm visits. Figure 29 shows the variation in advice delivered in the Waveney since the start of Phase 1. The offer of free soil and manure testing has proven to be an effective strategy to engage farms where crop nutrient management is an issue. For livestock holdings, infrastructure audits are particularly popular and typically lead to capital grant scheme applications.

Figure 29. Waveney percentage advice by category



The CSFO also works closely with The Voluntary Initiative to promote pesticide best practice across the catchment. Expert advice, local decision trees and weather forecast text messages are all made available to farmers and agronomists.

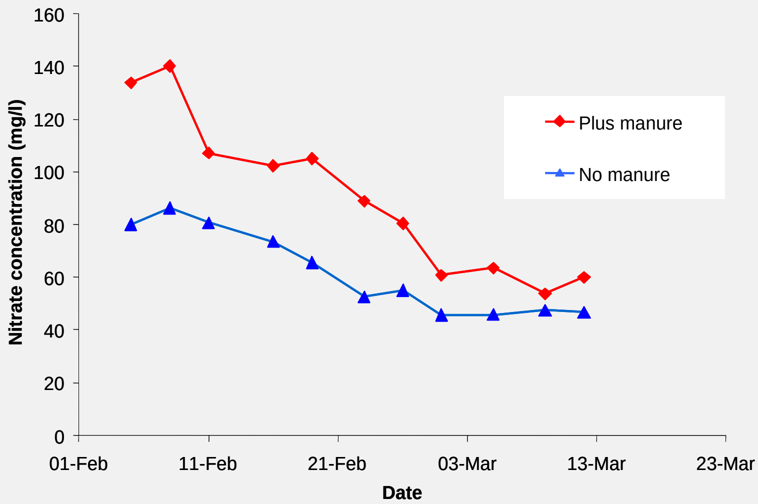
Working closely with the farming community since Phase 1 the CSFO has developed a good reputation as a trusted source of information, especially regarding NVZ regulations. Working in partnership with the Farm Advice Service has helped strengthen this status. As a result farmers actively engage with, and refer others to, CSF.

Increasing understanding of water pollution

In 2010, ten farmers took part in a pilot participatory monitoring project in the Waveney catchment. The aim was for farmers to improve their understanding of the links between farming actives and water quality and take ownership of the impacts and solutions. Farmers maintained a log of water quality measurements from their field drains. The results were then analysed and presented at a workshop (see Figure 30).

Results re-emphasised that main losses of nitrate were associated with particular manure application practices, demonstrating how farm manure management can reduce losses and provide financial savings. Manure management recommendations are now being adopted across the catchment, through formal CSF engagement but also as best practice communicated through the farmer “grape vine”.

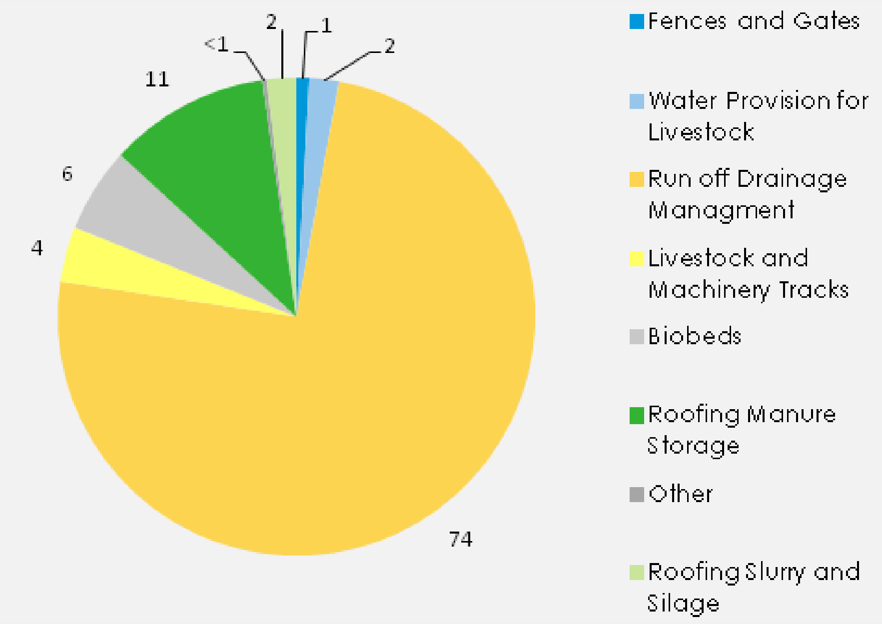
Figure 30. Nitrate concentrations in drainage water from winter cereal land (ADAS, 2010. Final Workshop Presentation, 25/04/2010)



CGS uptake

The CSF grant scheme provides an important incentive for farmers to engage with the project. In total there have been 349 successful grant applications in the Waveney. Yard works for clean and dirty water separation are the most popular grant items (Figure 31).

Figure 31. Percentage Waveney grant scheme items by category



4. Maximising CSF Outcomes

Targeting

Using understanding from our evaluation, we are able to identify catchments where CSF is most likely to be successful in influencing farmers to take action and where the mitigation measures themselves will make the greatest contribution to water quality improvement. We have developed a method that considers:

- the scope for reduction of farm pollution – based on modelled assessment of the scale of pollution from agricultural sources
- the likelihood of success of CSF – based on uptake of mitigation measures by farm type within existing catchments
- the priority of an area for environmental improvement - based on the project's priority objectives

We used this method to inform targeting within the project.

Understanding the potential future contribution of CSF

Our model scenario results have a potentially important role, alongside local sources of information, in informing future targeting of CSF resources to maximise resulting water quality outcomes.

Modelling optimised CSF activity (see Table 1) demonstrates where intensive targeted CSF activity has the potential to make the greatest impact. Further analysis indicates that with widespread coverage of the most successful CSF measures the end effect can be significantly more successful, for example:

- 40 per cent of the proportional target is met in all 30 priority bathing water catchments
- 50 per cent or more of the proportional pragmatic SSSI target is achieved in two-thirds of the modelled catchments
- 50 per cent or more of the proportional WFD status targets are achieved in one-third of failing river waterbodies
- 50 per cent or more of the proportional target is met in 95 per cent of WFD water bodies assessed that are failing due to sediment

This scenario involves applying a number of measures to all farms and is therefore not likely to happen in practice. However, it does highlight where the potential effect of CSF is greatest, and can be used to help identify future target areas and objectives for the project.

A further use of this scenario, in conjunction with the current CSF reductions, is to identify target areas and catchments where the reductions achieved by CSF to date are close to the theoretical maximum. The value of this is in terms of informing decisions around when additional benefits may be difficult to achieve and project resources may be better deployed elsewhere. For example, based on our initial assessment we have identified target areas in at least five catchments where current pollutant reductions are relatively close to our estimate of optimised CSF reductions.

In contrast, there are some areas where even our scenario designed to estimate the maximum possible reduction achievable through the measures CSF has at its disposal does not come close to achieving status targets. This is true for all pollutants, even those that we would consider primarily agricultural, such as sediment. For example, even our maximum scenario plus a 25 per cent reduction in point sources of FIOs fails to deliver the reduction required in nine priority bathing water catchments failing to meet sufficient targets for *E. coli*. In these areas the impact of CSF will be very limited unless pollution sources from other sectors are addressed.

5. Conclusions

Evaluation is essential to inform decisions on the future of the CSF project.

This report provides a robust evaluation of CSF. It presents clear evidence that CSF is delivering improvements in water quality that contribute to achievement of Protected Area, SSSI and WFD good status targets:

- Working with partners, including The Voluntary Initiative, CSF is significantly reducing pesticide levels in river catchments through voluntary uptake of best practice, backed up by capital works for handling facilities and bio-beds.
- Modelling results indicate that improved management practices are delivering significant load reductions across a range of other pollutants. The scale of response varies from catchment to catchment and between different pollutants.
- Sediment shows a clear response to CSF activity. We have been able to show modelled reductions that correlate with decreases in monitored concentrations across representative CSF catchments. Intensive monitoring in the upper Dorset Frome catchment also demonstrates a reduction in sediment pressure.
- For the first time we have provided evidence, at a national scale, that ecological communities are responding to reduced sediment concentrations resulting from CSF.
- When we consider the contribution to proportional targets, we estimate CSF will make a significant contribution to reducing the gap to status targets for Protected Areas, SSSIs and WFD good status across a number of catchments and pollutants.
- We have shown that CSF requires a minimum amount of time in a catchment for effective relationships to be established with farmers and for advice to be fully implemented. Our water quality assessments; and advice uptake data indicate a lag of around three years before we start to see real benefits on the ground. This helps explain why it is difficult to detect the significant modelled reductions in our water quality monitoring data
- Positive results are presented from an initial analysis of groundwater monitoring data. There is a reduction in the number of monitoring points with increasing nitrate trends once CSF has been implemented and an increase in the number of monitoring points showing a decreasing trend. This is an early indication that CSF is likely to be contributing to tread reversal in groundwater quality.
- Extending current CSF activity across existing target areas can be expected to significantly increase current pollutant reductions. We have shown that in smaller catchments targeted action may produce ‘quick wins’. However, in larger catchments improvement requires significant CSF activity and wide coverage of measures.
- The mitigation measures promoted through CSF deliver benefits that go beyond improving water quality. At a national scale, significant wider ecosystem service benefits are expected for fisheries, soil quality, air quality, hazard (floods and erosion), climate regulation and water supply.

The report also presents a summary of the reasons for the project’s success:

- CSFOs have built effective working relationships with farmers in their catchments and farmers indicate they trust them.
- The project is effective in terms of raising awareness and providing useful and relevant advice and this is helping farmers make changes to reduce water pollution.

- CSFOs are integrating a range of related advice sources, taking a lead in providing farmers with a clear appreciation of the issues and priority actions.
- 16,133 farm holdings have received CSF advice, through an effective combination of one-to-ones, group events and clinics.
- The project has brought about improvements to soil and land management practices through the uptake of targeted advice and a dedicated capital grant scheme. Within the CSF Priority Catchments, CSF is rated by farmers as the single most important agricultural scheme or initiative in terms of helping or prompting them to make changes to reduce water pollution. To date, 167,788 individual practices have been advised to farmers engaged by the project. Across the Priority Catchments, 62 per cent of mitigation measures recommended through one-to-one advice have been implemented and it is evident that CSF is helping target and accelerate changes that might be expected through general trends towards improved farming practice, whilst also delivering significant additional changes.

Our evaluation has been, and will continue to be, used to improve the effectiveness of the CSF project and contribute to the wider knowledge base for mitigating water pollution from agriculture. Specific examples include:

- use of environmental modelling to target advice to geographic locations where it is likely to be most successful in influencing farmers to take action and where the mitigation measures will make the greatest contribution to catchment improvement
- identifying locations where CSF is unlikely to yield further significant improvements and project resources could be better deployed elsewhere
- understanding the wider benefits of CSF and how multiple objectives can be integrated within delivery – this will be progressed through a pilot project on gaseous ammonia emissions during 2014
- developing monitoring case studies; links to catchment research / researchers; and a CSF ‘Evidence Prospectus’, providing CSFOs with the evidence to encourage farmer engagement
- developing and reporting key metrics (including farm engagement; farmer awareness; and advice implementation) to support effective project delivery

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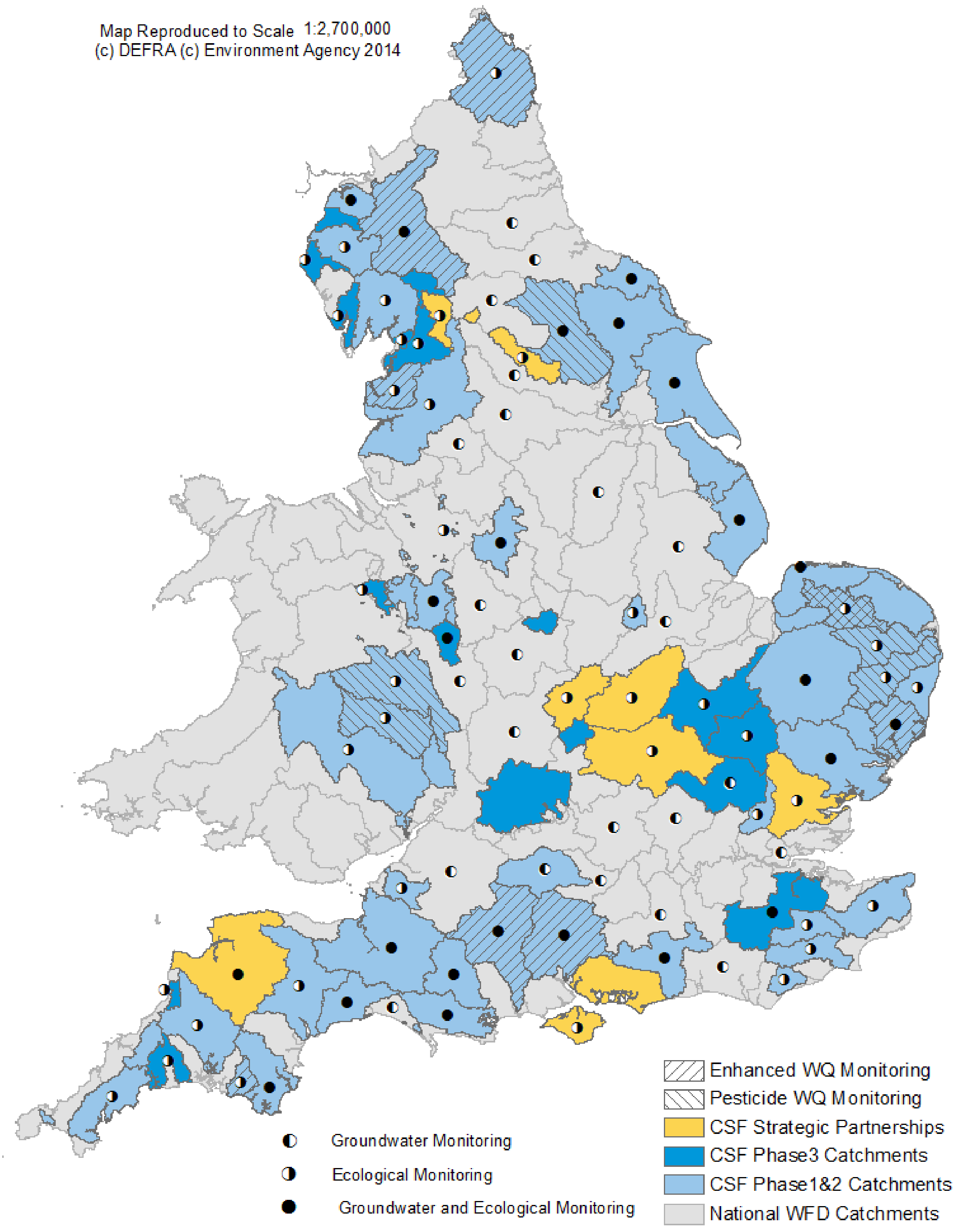
Glossary

ASPT	Average Score Per Taxon
CCM	Catchment Change Matrix
CGS	Capital Grant Scheme
CSF/O	Catchment Sensitive Farming / Officer
DEFRA	Department for Environment Food and Rural Affairs
DPI	Diffuse Pollution Inventory
DWPA	Diffuse Water Pollution from Agriculture
EA	Environment Agency
ELS	Entry Level Stewardship
FIO	Faecal Indicator Organism
FWAG	Farming and Wildlife Advisory Group
FWFD	Freshwater Fish Directive
FWMC	Flow Weighted Mean Concentration
GIS	Geographic Information System
HLS	Higher Level Stewardship
INCA	Integrated Catchment Model
LOCAR	Lowland Catchment Research
NE	Natural England
NERC	Natural Environment Research Council
NVZ	Nitrate Vulnerable Zone
TDI4	Observed / Expected Trophic Diatom Index
OP	Orthophosphate
OSR	Oil Seed Rape
P	Phosphorous
P/R ratio	Gross primary production/community respiration ratio
PROXSCAL	Proximity scaling
PSI	Proportion of Sediment-sensitive Invertebrates
RBD	River Basin District
ROAMEF	Rationale, Objectives, Appraisal, Monitoring, Evaluation, Feedback
RSPB	Royal Society for the Protection of Birds
SAGIS	Source Apportionment GIS
SPA	Special Protection Area
SS	Suspended Solids
SSSI	Site of Special Scientific Interest
WFD	Water Framework Directive

Appendix A

Catchment Sensitive Farming Monitoring data sources



Cover photo:
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Catalogue Code: NE585 ISBN: 978-1-78367-155-7

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Catchment Sensitive Farming (CSF) is delivered in partnership by Natural England, the Environment Agency and Defra.

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Funding is from the European Agricultural Fund for Rural Development: Europe investing in rural areas.