LM0308: Catchment Management for Water Quality

Year 2 report

April 2016

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Executive Summary: LM0308 Year 2 Report

The aims of the Catchment Management for Water Quality initiative are:

- to provide better access to data and modelling through the development of a web-based data and modelling platform;
- to explore approaches to enable more integrated modelling to deliver holistic solutions for multiple pollutants, services & policies;
- to support the development of a community of practitioners, policy makers and scientists to develop future questions and encourage joint working.

A key outcome of the project is the establishment of the Community Forum and the identification of important current and emerging questions relating to policy development and implementation in the area of water quality management through consultation across the community. Data and models selected to explore these questions have been prioritised for making available on the Catchment Management Integrated Data and Modelling Platform to be launched in 2017. Analysis of the benefits realised through coupling of models for each question will also be hosted on the platform as a series of Case Studies to provide a resource for the community.

As part of Task 1 (The Catchment Management Science-Policy-Practice Forum), a third workshop for the Community Forum was held in year 2. Approximately 218 people were invited to attend the workshop and the interest in attending was so great that attendance had to be capped at 60 (in line with previous workshops). The invitee list was determined on a first come first served basis. 56 people subsequently attended from 37 different organisations. The workshop aims were to update members on progress in developing the Case Studies and to present the initial design of the Catchment Management Platform which will provide access to the outputs from these case studies, as well as data and models and other resources. Breakout groups were used to provide feedback on a number of aspects of the prototype platform including the platform 'look and feel', the data catalogue, the model database, the model selection and evaluation tools, and how case study resources are hosted on the platform. Comments, advice and suggestions from the groups will be used to inform the final development of the platform in year 3.

A prototype web-based platform was developed by Task 2 (Integrated Modelling Platform and Interface) in year 2 which incorporates the functionality in the original project specification:

- A model selection tool that enables the user to tailor a search around particular catchment issues, scale and water quality (nitrogen, FIO, etc.)
- A model metadata catalogue including metadata about how the model has been applied
- A metadata catalogue describing the datasets of the models inputs and outputs
- Summaries of the case studies presented as web pages as well as full detailed case studies downloadable as pdf.
- Community forum pages documenting the workshops and outputs
- A discussion forum for the modelling community

The platform structure has been enhanced and refined through a series of small user group meetings throughout year 2, in addition to the Community Forum workshop described above.

Outputs from Task 3 (Selection and Evaluation of Models; Answering of User Questions) in year 2 include the Database for Model Selection and the Model Evaluation Protocol which describes the database structure and format of the model catalogue and provides templates for capturing information on model metadata and pedigree and past performance. The model metadata catalogue on the platform has been developed and populated with model descriptions and model applications for the models used in the case studies. The case studies themselves were implemented in year 2, and the project team have completed preliminary model runs for all case studies. In consultation with the members of Forum Management Group assigned to each case study, the study teams also began in year 2 to refine the model applications and scenarios in each study and determine the best outputs and presentations of the studies for the web platform. These activities will continue in year 3. A seventh case study was identified in year 2 to fill gaps in the overall program as identified by the funding bodies. This case study addresses policy drivers related to the Water Framework Directive, Farm Payment Schemes, Climate Change Abatement Agreements, and Conservation Targets.

The database catalogue established by Task 4 (Compilation and Integration of Data) for the web platform in year 2 has been populated with 110 datasets. The datasets in the catalogue have been identified from the project outline, the stakeholder workshops, and the data requirements of the models being used in the case studies, including the new models commissioned for the case studies by the project's Community Fund. An approach to signposting datasets already available on the web (outside of this project) has been developed, and information about these datasets has been collated and included within a standards-compliant metadata catalogue.

Two reports were produced by Task 5 (Modelling Framework, Integration & Coupling) in year 2: opportunities and barriers for integrated modelling; and core model input requirements. Both reports have been submitted to Defra. The core Case Study models and datasets have been ingested into, or sign-posted from, the platform. Preliminary results from the case studies in year 2 have been ingested into the portal. These first presentations of the models, data and case studies on the platform have been reviewed by the Community Forum and the Forum Management Group and their feedback is being incorporated in the refinement of the platform structure.

Funding to enhance the case studies was awarded by Task 6 (Community Forum Fund) in year 2 to ensure maximum user impact and uptake. The Community Forum Fund was established for the Project with an initial balance of £140,000. A Community Fund Panel (CFP) has been established to assess priorities and practicalities of suggested resources to be funded. This Panel consists of representatives of each consortium member and a representative from each of the funders. Three grant awards were made in year 2.

- £26,226 to provide a model of Faecal Indicator Organisms (FIOs) mobilisation and transport;
- £24,126 to provide a model for Metaldehyde mobilisation and transport;
- £6,587 to provide the SEPARATE model national scale output from Defra Project WQ0223.

Year three will see completion of the case studies and launch of the web platform with emphasis on Community Forum engagement for evaluation and refinement of the platform and its model and data tools. Detailed summaries of the activities to date, progress on year 2 milestones, and activities planned for year 3 are given below for each work package (task).

Task 1. The catchment management science-policy-practice forum

Lead: Atkins – JHI (CREW) Contributors: All Cost £119,000

1.1 Aim: To establish and run a forum of policy makers, regulators, industry, advisors and scientists who, together, will co-construct the key questions facing land, water and air management, helping to address policy objectives.

1.2 Objectives:

- To establish a stakeholder and user forum to improve communication between users and modellers so that the key questions of users and ways to answer them are co-constructed
- Identify who the stakeholders and users are and to understand their interests and requirements
- Identify the 5 key questions to be addressed in Tasks 3-5
- Developing an improved dialogue between model developers and users so the development meets the users' needs
- Delivery the tools and model outputs to the user community
- Create a forum to achieve project legacy

1.3 Activities to date

The overall objective of this task is to establish a stakeholder and user forum such that the direction and the outcome from the project, is driven by the needs of the catchment management community. The Forum also establishes the basis for the long term engagement which might continue beyond the life of the LM0308 project. The process by which the Forum helped to define the key stakeholder questions and Case Studies, and to further develop the Case Studies is outlined in the following sections and supporting appendices (1A through 1E).

1.3.1 Stakeholder and user identification process (March / April 2014)

A stakeholder map was produced covering contacts from a wide range of organisations involved in catchment management from a policy, practice or research angle, e.g.:

- Governments of England, Wales and Scotland;
- Policy makers from Defra, SEPA and DoE Northern Ireland covering aspects including water, soils, air, economics, flooding, ecosystems and biodiversity, climate change and farming, amongst others including the Forestry Commission
- The research community e.g. NERC, Universities;
- Regulators: EA, NE, SEPA, NRW, NIEA etc. covering a range of catchment management technical areas e.g. modelling, flooding, land management etc.
- 3rd Sector organisations: e.g. representatives from NFU, CLA, Scottish Agricultural; College, Angling Trust, Rivers Trust (and the CaBA network), WWF, RSPB, CRT etc.
- Water Industry: contacts from the major water companies in the UK, as well as UKWIR and DWI.

Names, roles and contact details were sourced for this range of organisations and roles to form the basis for engaging stakeholders. Appendix 1-A (attached as a separate excel file) sets out the range of stakeholders engaged with through the various stages of the LM0308 Forum.

1.3.2 Communications release (April 2014)

A 2-pager introductory note was produced and sent out to the stakeholder contacts to notify them of the project, disseminate some information on what the objectives are and to let stakeholders know that that we would be making contact. This note was sent out to all the contacts identified in the initial stakeholder mapping described previously. Appendix 1-B contains the Communications note.

Catchment Management for Water Quality
Science-Policy-Practice Forum

What is the problem?

A major challenge facing the UK today is how to balance competing demands on the water environment. Cross cutting policy areas such as those relating to land and food, energy, health, climate change and biodiversity all have impacts on, or could potentially benefit from, catchment management for water quality.

The ambitious objectives set by the Water Framework Directive to protect and improve the water environment will only be met by a sound understanding of the complex biogeochemical and hydrological processes driving water quality problems, and their solutions. While the wealth of modelling tools and environmental datasets available for the UK are key to achieve water policy objectives, there is too little integration between them to appropriately address complex questions.

Modelling frameworks for catchment management need to give outputs at both a national and a local scale, be able to account for variations in land use, climate or geology and the effect of variables such as climate change, uptake of mitigation measures and socio-economic factors such as changes in food markets. Outputs need to be useable and understandable.

What is the project doing?

This project aims to improve the access to and integration between data and models that help address the key questions in catchment management for water quality and wider ecosystem services. This integration will allow for more complex issues across many policy areas to be understood and addressed and as a result a more holistic view to inform both policy development and the impacts of policies on the water and wider environment.

To achieve this, the project will bring together and test datasets and models relevant to these challenges. Outputs will be made freely available through a web-based platform for use by the research, policy and implementation community.

How can you get involved?

Identifying what these challenges are is a key first step for the project. We want to establish a forum of scientists, policy makers and practitioners to identify and co-construct the key questions in catchment management for water quality in the UK. This will be established in June 2014 and will run for three years via discussion groups and a series of workshops. Involvement will give you an opportunity to discuss these issues with key scientific experts and other industry leaders to help with policy development, implementation and the achievement of objectives. Putting user needs up front and sharing data and models will help ensure the best use of science to help achieve the goals of UK water policy now and into the future.

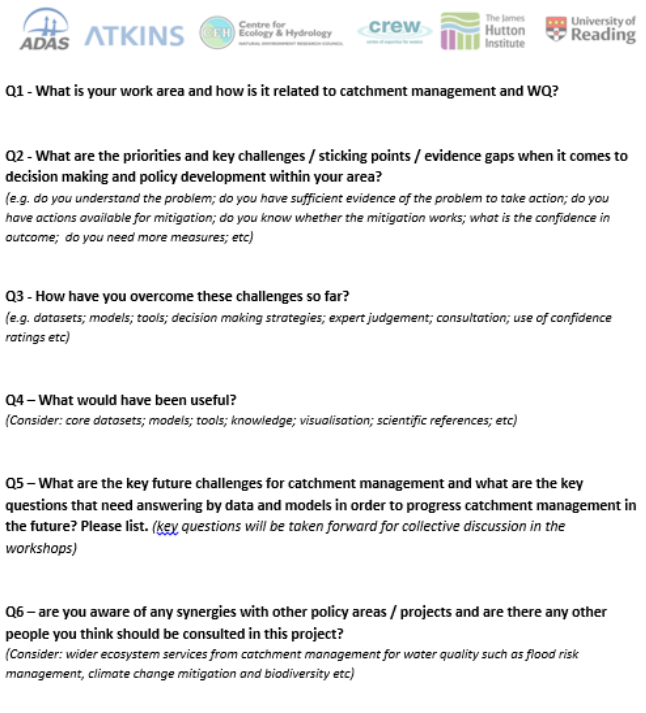
From the project funders:

As a key member of the UK's catchment management community we would like to invite you to participate in the forum and be part of this important project to identify the main questions for catchment science to help us achieve water policy and wider environmental goals.

1.3.3 Proforma development (April 2014)

In recognition that catchment management is a broad topic area, covering many different disciplines, it was decided that some standardisation was needed in terms of how we conducted the pre-consultation task. We therefore developed a question "proforma" which essentially acted as a guide to all pre-consultation meetings and telephone discussions so that the technical emphasis and subsequent conversations were not biased towards the experience and expertise of the person conducting the interview.

Appendix 1-C accompanying this report gives the proforma template sent to pre-consultation participants and used as the basis for telephone discussions.



Q1 - What is your work area and how is it related to catchment management and WQ?

Q2 - What are the priorities and key challenges / sticking points / evidence gaps when it comes to decision making and policy development within your area?
(e.g. do you understand the problem; do you have sufficient evidence of the problem to take action; do you have actions available for mitigation; do you know whether the mitigation works; what is the confidence in outcome; do you need more measures; etc)

Q3 - How have you overcome these challenges so far?
(e.g. datasets; models; tools; decision making strategies; expert judgement; consultation; use of confidence ratings etc)

Q4 – What would have been useful?
(Consider: core datasets; models; tools; knowledge; visualisation; scientific references; etc)

Q5 – What are the key future challenges for catchment management and what are the key questions that need answering by data and models in order to progress catchment management in the future? Please list. *(key questions will be taken forward for collective discussion in the workshops)*

Q6 – are you aware of any synergies with other policy areas / projects and are there any other people you think should be consulted in this project?
(Consider: wider ecosystem services from catchment management for water quality such as flood risk management, climate change mitigation and biodiversity etc)

1.3.4 Proactive user engagement (April/May 2014)

Pre-consultation was carried out with a range of stakeholder contacts with whom we either had good relationships and / or the stakeholder contacts would have specific contributions to make that could help start the project prior to the workshops. A day of meetings was held at Defra to see different policy experts including water, soils and biodiversity so that the basis of the stakeholder questions ultimately selected were informed by policy needs. These meetings were followed by telephone conversations as required. Similar discussions were held with Scottish and Welsh contacts so that the information gathered was not restricted to England.

Telephone interviews were also held with a range of representatives from the EA, NE, and some 3rd sector organisations such as the NFU, the RSPB, WWF and the Rivers Trust. Discussions were also held with some water industry contacts. Overall, pre-consultation was undertaken with approximately 47 people across 14 different organisations. The range of representation is reflected in Figure 1**Error! Reference source not found.**. The questions raised through this route formed the basis of discussions during Workshop 1.

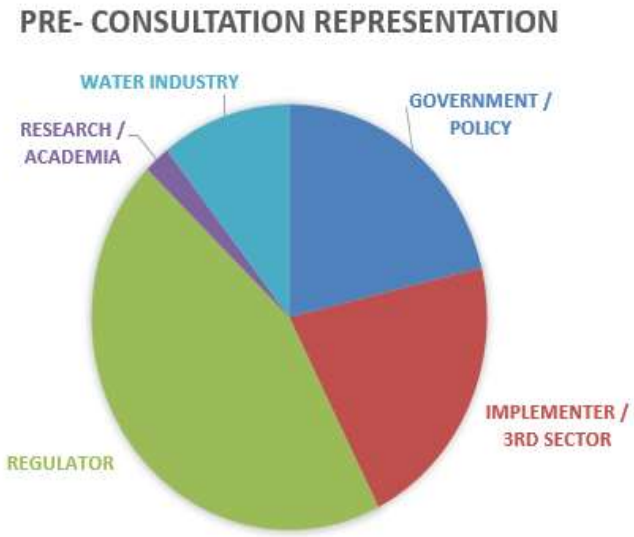


Figure 1: Pre-consultation representation

1.3.5 Workshop 1 (July 2014)

The invitee list was cast wide for this workshop, with 191 people from a range of 70 organisations being invited.

58 people attended on the day, from a range of 40 different organisations (the broad representation groups are shown in Figure 2**Error! Reference source not found.**).

The invitations were sent out at the start of June 2014, and the workshop design was then planned throughout the remainder of June, including

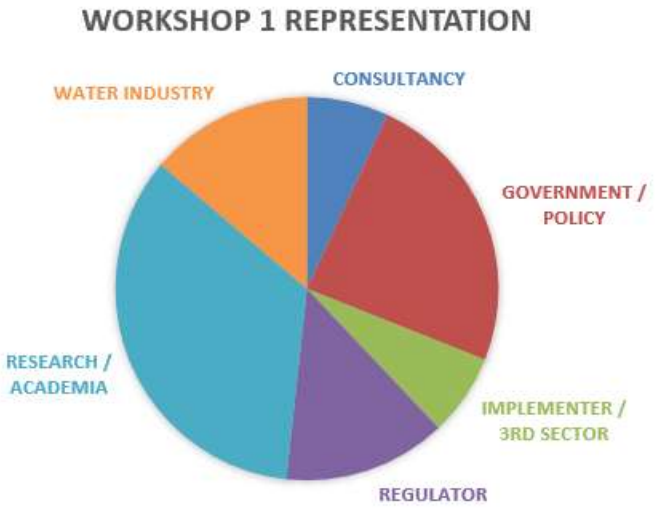


Figure 2: Workshop 1 representation

logistics, venues, pre-work and information releases, poster presentation development etc.

The workshop was conducted on 1st July with the format of the day consisting of presentations (focused around dissemination of information relative to the purpose of the project) followed by breakout sessions which were structured around the questions gathered through the pre-consultation stage.

The outputs for the day were written up and disseminated but the main output from this workshop was the identification of a wider range of questions from the stakeholder attendees, structured broadly around scale (national (mainly policy and regulators), catchment (regulators and water industry) and land-holding (mainly 3rd sector organisations and other practitioners).

Appendix 1-D attached gives the write up from Workshop 1.

1.3.6 Question collation and condensing (July – September 2014)

Following Workshop 1, the questions raised by the stakeholders throughout pre-consultation and the first workshop were collated into a single "Long List" of questions (285 questions which were collated in an excel spreadsheet):

- The **pre-consultation** exercise resulted in approx. 195 questions from consultees (policy / regulatory / water industry / implementers)
- A further 33 questions emerged from the **Environment Agency's Significant Water Management Issues (SWMI) Evidence Review**
- **Workshop 1** raised a further 57 questions

These questions were then assigned "general themes" and the number of questions against each theme is shown in Figure 3.

The long list of questions was then condensed and duplication in meaning was removed by a translation exercise; where questions were unique they were left in the long list verbatim. Some questions were consistently and repeatedly raised by stakeholders and therefore these were condensed (148 individual questions were thus condensed into 24 questions and a record of this has been kept in the spreadsheet as an audit trail).

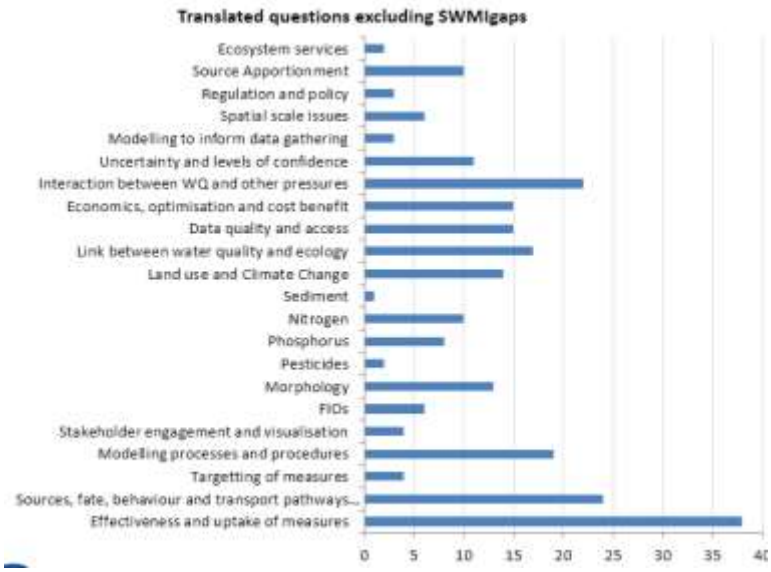


Figure 3: Recurring themes within the long list of questions collated

For a number of questions it wasn't appropriate or clear how to translate or collate them into one question; these were left marked "as per specific question raised" to avoid them being lost or overlooked in the stages that followed.

The Environment Agency's SWMI evidence gap questions were then also excluded as they represent fundamental gaps in our collective scientific understanding i.e. there aren't sufficient models / data associated with them and so were considered out of scope for this project.

Figure 3 above indicates the number of questions (x axis) raised against each theme defined. There are some clear priorities around effectiveness of measures and better understanding models and data, and the interaction between pressures. The word cloud below (Figure 4) was created on the long list of questions raised by Forum members as a simple way of visualising some of the recurring themes at this stage of the process. The larger the text, the more frequently the word was encountered in the stakeholder questions and feedback.

Figure 4: Word Cloud based on the long list of questions

In order to further condense the questions to take forward for consideration within the Case Studies, each member of the consortium then reviewed the list of questions and assigned a score as follows:

- Category 1 = Question already answered elsewhere
- Category 2 = Question potentially to be included in LM0308
- Category 3 = Question considered out of scope and highlighted for future research
- Category 4 = I don't know enough about this to be able to assign a classification

Once each consortium member had assigned categories to the questions, the results were discussed in a lengthy teleconference and CEH as the consortium lead made the final decision on what questions to focus on within the Forum Management Group.

Appendix 1-E of this report is an excel file containing the long list of questions, collated from stakeholder consultation through the Forum Task, as well as the consolidated list of questions (with associated categorisation by consortium members).

1.3.7 The Forum Management Group (FMG) (September 2014)

The consortium's original tender response proposed that the five Case Studies would be selected from the first workshop. The enthusiasm of stakeholders and subsequently the large number of stakeholder questions raised following consultation, meant that an additional step was required to further condense the questions and come to a consensus on the priorities to take forwards.

This additional step was undertaken via establishment of a smaller, more focused stakeholder group called the "Forum Management Group". This additional group was formed from a range of selected stakeholder organisations (18 people from 13 organisations) and a further workshop was held on 11th September in Birmingham, during which the consolidated list of approximately 100 questions was discussed and subsequently the seven Case Study titles were developed using these questions. These titles formed the basis of further FMG discussions to scope of the Case Studies.

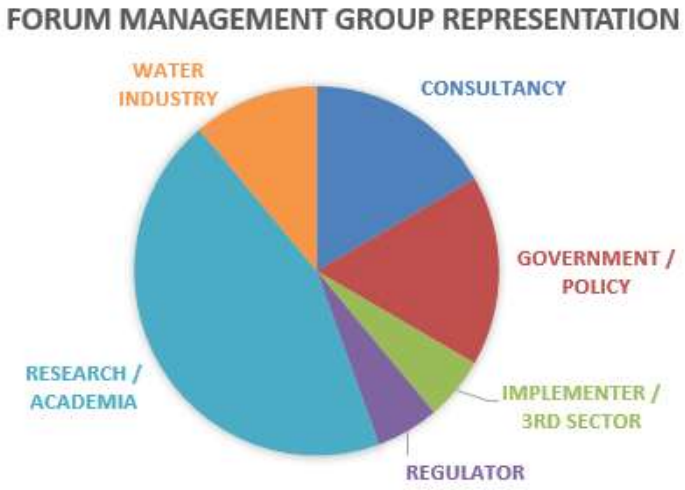


Figure 5: FMG Representation

The representation for the FMG is given in Figure 5.

The Case Studies defined by this process were as follows:

- **Case Study 1:** Multiple pollutant and ecosystem services responses to land management policies and agri-environment interventions at the farm to catchment scale
- **Case Study 2:** Effectiveness of land management policies and agri-environment interventions for reducing pollutant loads and maintaining environmental quality at the national scale
- **Case Study 3:** Costs and benefits of mitigation measures to reduce pollutant concentrations for the protection of drinking water in river systems upstream of intakes
- **Case Study 4:** Effectiveness of pollution control measures under scenarios of future climate and land cover change at the catchment scale
- **Case Study 5:** Uncertainty in ecological responses to water quality control measures at the river basin scale
- **Case Study 6:** Effects of input data quality and quantity on evaluation of land management policies and agri-environment interventions at catchment to national scales
- **Case Study 7:** Interpolation of data from catchment to national and monitored to non-monitored catchments.

In summary, over 280 individual questions were gathered from representatives of over 40 organisations. These questions were summarised into 22 issues according to the topics they address. There were common themes across the long list of questions, and many of these themes are addressed in the case studies to varying degrees.

1.3.8 Workshop 2 (October 2014)

The purpose of this workshop was to present the draft case studies and further develop the scope of the case studies with the stakeholders, including the ways in which the case study questions could be answered using models and data.

41 people attended from 29 organisations, with broad representation shown in Figure 6.

Figure 6: Workshop 2 Representation

The format of the day consisted of brief presentations of the Case Studies followed by break out groups that considered the individual Case Studies. The workshop participants were asked to select two Case Study "tickets" allowing them the opportunity to participate in their development. During the breakout sessions, participants were asked to discuss and comment on:

- If the scope of the draft case study is correct and useful, or whether it needs adjusting
- What scenarios it should cover (e.g. what control measures / scale / outputs / formats etc.)
- Who the likely users might be and what outputs / outcomes they might be interested in
- What policy instruments are the case studies relevant to.

During these discussions it was also requested that stakeholders make notes on post-it notes to help the Consortium identify appropriate and desirable data / models for inclusion in the framework.

The information gathered in this second Form workshop was then used to flesh out the detail of the Case studies which were released as part of the first funding call to the Community Fund (April 2015). Additional input to the Case Studies was funded via the community fund form the University of East Anglia (Case Study 3) and WRM (Case Study 1)

1.3.9 Workshop 3 (January 2016)

The key aim of the day was to update the forum on progress to date in developing the Case Studies and presenting the initial design of the Catchment Management Platform which will provide access to the outputs from these case studies, as well as data and models and other resources.

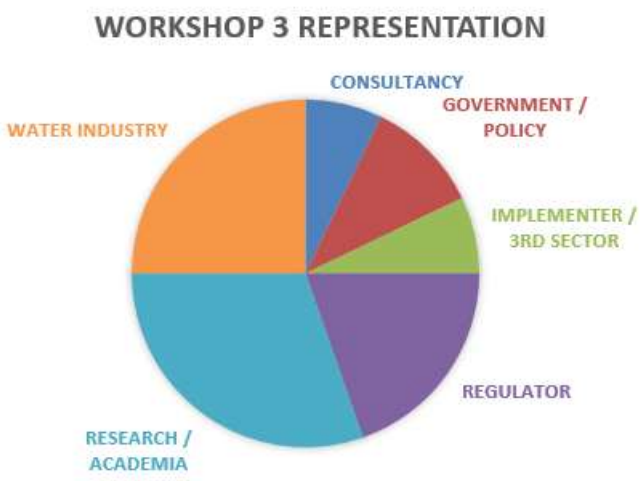


Figure 7: Workshop 3 Representation

Approximately 218 people were invited to attend the workshop. The intention was again to cast the net wide and encourage participation. A large number of stakeholders expressed interest in attending the workshop and as a result attendance had to be capped at 60 in line with previous workshops; the invitee list was determined on a first come first served basis.

56 people subsequently attended from 37 different organisations, with representation reflected in Figure 7.

The morning session consisted of a number of presentations, informing stakeholders of progress with the Case Studies and demonstrating the web-based platform and the model/data log. The afternoon session consisted of breakout groups to provide attendee feedback on a number of aspects of the prototype platform:

1. Feedback on 'look and Feel' of the platform, it's usability, and priorities for changes or additions (to undertake now or in the future dependent on project resources) (discussion leads Mike Brown (CEH) and Paul Whitehead (Oxford University))
2. Feedback on data catalogue, its usability and what is missing (discussion leads Matt Fry (CEH) and Richard Gooday (ADAS))
3. Feedback on how case study resources are hosted on the platform. Have we got it right? (Discussion leads Bridget Emmett (CEH) and Peter Daldorph (Atkins))
4. Feedback on the model database, selection tool and evaluation tool. Would you find it useful? What is missing? (Discussion leads Jack Cosby (CEH) and Andy Wade(University of Reading))

Feedback from the groups was gathered and will be taken into account in the development of the prototype platform and to inform the user testing process. Appendix 1-F accompanying this report provides a write up of Workshop 3.

1.4 Progress on Milestones

Milestone 1.1: Establish User Forum – Complete

Milestone 1.2: Establish Key Questions – Complete

Milestone 1.3: Stakeholder input to selection of models to test – Largely complete (partly covered in pre-consultation, workshops 1&2 and also as part of the call for community funding which is currently underway)

1.5 Plans for Year 3.

Further activities of the Forum Task over the next year will aim to support delivery of the project. We propose to approach these activities as follows:

Activities proposed	Consortium approach
1. User testing of the Platform via a small group of self-selected end-users who will act as organisational leads	Case study stakeholder leads are in place; the suitability of these leads will be reviewed with regard to their ability to test the platform and willingness to input. CREW will then formalise these leads as a group and the case study modelling leads will liaise with them to undertake platform testing.
2. Documentation on how to use the tools will be produced and distributed via the website	Lead modellers to provide the material for www/platform. CREW /Atkins to review and edit for readability and language accessibility.
3. Establish a self-managing practitioner group to enable users to share best practice and support each other in using the tools	As above (1) stakeholder case study leads will ensure their organisations are aware and take part. CREW to ensure this happens.
4. A user group forum will be developed on the website to allow users to share knowledge and contact other users	Exact approach in discussion within the consortium.
5. Recommendations will be provided on how further support to the user community might be maintained beyond the life of the project.	Atkins/CREW to add to final report.
6. Key outputs form the modelling work related to the key questions will be distributed to users, managers and policy users via reports, maps and data files and support in interpreting these provided	Lead modellers to prepare outputs with CREW/Atkins having an editorial role.
7. Feedback will be sought from the users on these activities	Via output from item 4 above

Subsequent to this, there will be a final dissemination workshop (4). The design of this is to be confirmed during the coming months, however, it is likely to be consistent with the previous Workshop 3, i.e. a morning of presentations followed by an afternoon of breakout groups focusing on how to use the Platform.

Task 2. Integrated Modelling Platform and Interface

Lead: CEH Contributors: All Cost: £75,000

2.1 Aim: To provide a web-based data and modelling platform to allow the discovery and download of the major modelling and data resources assembled by the project. To work with modelling user groups to address the standards and common formats required to promote integration of their use across this community.

2.2 Objectives: The task will deliver a web-based platform and user interface that can provide researchers and users with a range of resources developed in other tasks including:

- data storage, discovery and retrieval services (Task 4),
- model database including documentation and tutorials (Task 3 & 5)
- model evaluation documentation (Task 3)
- archiving and retrieval of analysis results (Task 3)
- visualization and comparison tools (Tasks 3 & 5)
- alignment and compatibility with the NERC E4A (Environmental Assessment: Archive, Access and Analysis)

2.3 Activities to date

A first iteration of the platform has been developed incorporating the functionality in the original specification and includes:

- A model selection tool that enables the user to tailor a search around particular catchment issues, scale and water quality (nitrogen, FIO, etc.)
- A model metadata catalogue including metadata about how the model has been applied
- A metadata catalogue describing the datasets of the models inputs and outputs
- Summaries of the case studies presented as web pages as well as full detailed case studies downloadable as pdf.
- Community forum pages documenting the workshops and outputs
- A discussion forum for the modelling community

Linkages between pages ensure users can easily navigate from issues to models to data to case study and vice versa to help users understand the models available how they have been used and the input and output datasets produced. The platform was showcased to the user community in early 2016 and a series of breakouts were run to gather feedback on look and feel and functionality. The outputs of these breakouts have been collated and will be prioritised by the project board to define the next development cycle for the platform.

2.4 Progress on Milestones

Milestone 2.1: Development web-interface and modelling platform – A platform has been developed. Iterative development of the platform is ongoing with project team and stakeholders.

Milestone 2.2: Complete model documentation and conditioning (develop standard metadata descriptions and liaison with model owners) – a model metadata catalogue has been developed and populated with model descriptions and model applications for the models identified by the case studies.

Milestone 2.3: Ingestion of Core models with appropriate documentation. – To date 7 models have been ingested and are available from the platform. We are working with the modelling community to obtain the descriptions of the final 3 or 4 models into the catalogue

Milestone 2.4: Ingestion of data. (Conditioning of data with data holders funded in Task 4) – 110 datasets have been ingested into the metadata catalogue of the platform.

2.5 Plans for year 3.

Year 3 will involve a further iteration for the development of the platform before we move into completion of testing of the platform with the Community Forum (Task 2.5) and the ingestion of any additional models and data prioritised by the Community Forum (Task 2.6). Delivery of final integrated data and modelling platform (Tasks 2.7 and 2.8; joint deliverable with Task 5) is on schedule for the end of year 3.

Task 3. Selection and Evaluation of Models; Answering of User Questions

Leads: Reading and ADAS Contributors: CEH, JHI, Atkins Cost: £112,000

3.1 Aim: To collate and transfer knowledge of model pedigree and performance to the user community.

3.2 Objectives:

- to provide a methodology by which users can select the most appropriate models for a particular job, along with an understanding of the advantages and disadvantages of each model, and a knowledge of model pedigree and past performance;
- to provide supporting evidence on model pedigree and performance to underpin the model selection tool;
- to assess the confidence in model-based assessments of environmental issues through comparison of different modelling methodologies;
- to provide answers to the policy questions raised by the users as part of the forum.

3.3 Activities to date

A document describing the Database for Model Selection and the Model Evaluation Protocol was produced and submitted to DEFRA on the 12 February 2015. The document describes the database structure and format of the model and application data fields, the templates for capturing information on model metadata and pedigree and past performance and the method for implementing the database. The templates have been completed for the INCA-N, INCA-Pathogens,

LUCI, NIRAMS II, QUESTOR and SAGIS models to describe both the model metadata and initial evaluations.

Following two community forums and one steering committee meeting, the case studies were agreed. A summary of the progress delivering each Case Study is presented below. Details of the current status of each Case Study are available in Appendix 2.

Case study 1 is not yet complete. In discussion and review, the community forum decided that this case study required the inclusion of a model of Fecal Indicator Organisms (FIOs). Such a model was not available from the consortium members. The model was obtained through a competitive bid process supported by the LM0308 community fund, but the process of obtaining the model has delayed the case study schedule. Other models to be used in the case study were already available from consortium partners. As of this year 2 report, the key models for case study 1 are now all in place and baseline simulations have been run for all models in the Conwy catchment in Wales. Scenarios based on the Welsh Glastir and Glastir Advanced schemes for the Conwy will be run next.

Case Study 2 has completed its first phase (Task 3.4). The Farmscoper tool was used to determine the costs and impacts of a set of diffuse pollution mitigation methods which were identified by the Case Study management representatives as comparable to common Countryside Stewardship options. These resultant reductions in the agricultural pollutant loads were combined with the SEPARATE database to determine the impacts on total pollutant loads (i.e. the combined agricultural and non-agricultural loads) for both the local waterbody and the accumulated upstream catchment. The results were presented at the Community Forum on the 28 January 2016 and discussed with the stakeholder partners during a telecon. The results have not yet been ingested into the project web-platform.

Case study 3 uses models to test the impacts of catchment measures on water company operations (e.g. treatment requirements) and on drinking water compliance. In particular, the case study looks at these issues in relation to pesticide, metaldehyde and nutrients (phosphorus and nitrate). The case study uses the SWAT model, a well-established, hydrologically based time series water quality model (which has been modified to simulate metaldehyde through a grant from the LM0308 community fund) to simulate these chemicals in the River Wensum in Norfolk (one of the Demonstration Test Catchments). SWAT is used to simulate metaldehyde whilst nutrients have been modelled using SAGIS; a key river basin planning model used by the Environment Agency and the water industry. Building the modified SWAT model was the first stage of this part of the case study and outputs from the scenarios are not yet available.

Case Study 4 has completed its first phase1 (Task 3.4). The models have been run as specified in the case study description, the results were summarised in a report and ingested into the project web-platform as a web-page and short document. The results were presented at the Community Forum on the 28 January 2016 and discussed with the stakeholder partners during a telecon and by email.

Case Study 5 is progressing with QUESTOR and SAGIS set-up for the River Thames and some initial runs looking at the effects of riparian shading on algal biomass (as chlorophyll-a concentrations) done. These initial runs were presented at the January 2016 forum. The format for the presentation of the results and a prioritised list of scenarios to be run were agreed with the stakeholder partners. Questor has been run using measured driving data for the agreed study period, 2010-2012. This is

the baseline run. SAGIS has been set up for the same period on the River Thames to model total phosphorus, ortho-phosphate and nitrate under the baseline condition and for two further scenarios of on-farm nutrient loss interventions. Outputs from these three model runs were supplied to CEH. The phosphorus data from SAGIS correspond to the points where Questor takes inputs from measured data. CEH will run the QUESTOR model using these driving data by the end of March. We have made a decision to look only at phosphorus given the resources available.

Case study 6 is not yet complete. This case study is a more technical aspect of the development of the Integrated Modelling Platform. This case study will draw on the results of case studies 1-5, using those as base cases against which changes in model output arising from different or uncertain input datasets can be compared. It will not be possible to examine uncertainty arising from all inputs for all five case studies. Instead, as case studies 1-5 are completed, a selection of pollutants, measures, and scenarios from each will be used in this exemplar case study to examine how uncertainty can be assessed and expressed within the context of the Integrated Modelling Platform. In turn, the uncertainty results presented in this case study will inform and contribute to the other case studies.

Case study 7 is just beginning. In the original implementation of the project, the seventh case study was not initially defined by the forum. Rather, the focus of the case study was left open until the forum–led case studies had all been identified. The purpose of the seventh case study was to fill gaps in the overall program identified by the funding bodies. At a recent meeting (March, 2106) with Defra, EA and others, the content of this case study was agreed in principle. This case study addresses the following policy drivers (identified to date – others may be included as the case study develops): Water Framework Directive (good chemical and/or ecological status), Farm Payment Schemes, Climate Change Abatement Agreements, and Conservation Targets.

3.4 Progress on Milestones

Milestone 3.1: Database for model selection – Complete.

Milestone 3.2: Protocol for model evaluation – Complete

A report describing the database for model selection and the model evaluation protocol was produced and submitted to DEFRA on the 12 February 2015. Task 2 has developed web forms for ingesting the relevant model information onto the Project's prototype platform and these have been completed for the INCA-N, INCA-Pathogens, LUCI, NIRAMS II, QUESTOR and SAGIS models.

3.5 Plans for Year 3.

The Database for Model Selection and the Model Evaluation Protocol will be populated with further models available in the consortium (e.g. Farmscoper, SWAT, SEPARATE) and invitations will be sent to bring in external models. The initial model runs done as part of the case studies in Task 3.3 will be completed, with the remaining reports uploaded to the platform along with the model evaluation forms (Task 3.4). Towards the end of year 3, revised summary reports will be produced for each case study (Task 3.5).

Task 4. Compilation and Integration of Data

Lead: CEH/ADAS/JHI Contributors: All Cost: £75,000

4.1 Aim: To develop a database of key national datasets to underpin national integrated water quality modelling.

4.2 Objectives:

- gain a full understanding of the data requirements of an integrated water quality modelling framework, based on the requirements of the models selected and of the expert panel;
- source and collate the required datasets;
- assess the datasets available for suitability within the framework in order to produce a viable long-term solution.

4.3 Activities to date

An initial preliminary list of datasets was identified from the project outline and the first stakeholder workshop. This was added to following an assessment of the data requirements of all of the models being used within the projects, including those commissioned for application within the case studies. An approach to signposting datasets already available on the web has been developed, and information about these datasets has been collated and included within a standards-compliant metadata catalogue.

4.4 Progress on Milestones

Milestones completed in year 1, and described in the year 1 annual report, were:

Milestone 4.1: Draft list of required datasets - completed

Milestone 4.2: Final list of required and relevant datasets - completed

Key milestones related to Task 4 in year 2 are:

Milestone 4.3: National database for water quality modelling (due in August 2015) - approximately 80% complete. There was an initial delay in starting the work in gathering datasets while the model selection was finalised. Completion of the database is inter-linked with development of the platform, and is reliant on data provision from other project partners.

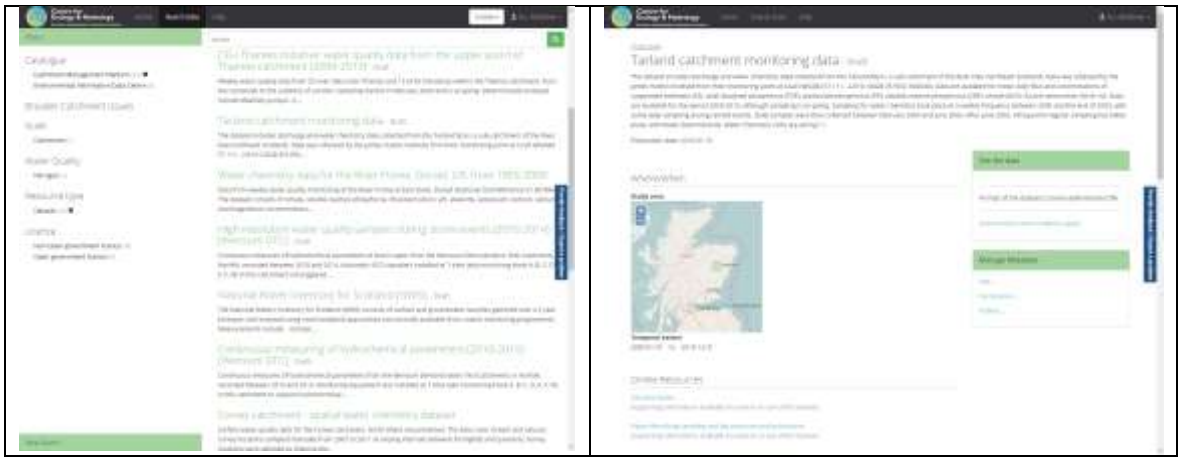
A data catalogue for catchment water quality has now been created. This includes 120 datasets covering those identified in the list in Milestone 4.2, and many additional datasets. This represents a comprehensive description of datasets that do or could underpin catchment water quality modelling in the UK.

The approach to collation of datasets has varied. The focus of the activity has been to improve understanding of and access to data for catchment water quality modelling in the UK. A key activity has therefore been improving the descriptions of existing data resources, and making these descriptions available as standardised, UK-Location and INSPIRE compliant metadata records within the catalogue. Where this metadata exists already (e.g. data.gov.uk) it has been imported either in

its current form where (very rarely) the metadata provides an adequate description, or amended to improve the description. In other cases datasets are available online, but there is no metadata, and we have used any information available to create metadata for the dataset, linking out to the existing resource.

Existing catalogues, web-portals and projects have been researched in order to identify important datasets to include, e.g. MAGIC, CABA, Defra SIP, SEPAWeb, etc. DTC datasets are currently only available for the Wensum catchments (which have been included), although discussions with the DTC data centre suggest other catchment datasets will be available soon.

Data are readily discovered through the catalogue interface within the platform. The list of datasets can be filtered by searching for specific terms, or through filtering by “facets” predefined by the project: Broader catchment issues (e.g. agri-environment, ecosystem services, pollution source attribution); scale (catchment / national); water quality (e.g. nitrogen / phosphorous).



For some new key data resources the project will be hosting the datasets. Longevity will be ensured by ingesting the dataset into the CEH Environmental Information Data Centre, NERC’s long-term data centre for terrestrial and freshwater sciences. As part of this process licensing agreements need to be signed and work is required to ensure formatting and description of the datasets is adequate for future users. New datasets to be made available through LM0308:

- Farmscoper: Diffuse agricultural and non-agricultural pollution for England and Wales (Water Management Catchments) and Scotland (WFD water bodies)
- SEPARATE: Modelled load and apportionment of sediment, nitrogen, dissolved and total phosphorous for 4500 WFD water bodies in England and Wales.
- SAGIS: currently in discussion with Atkins in relation to provision of SAGIS data and pre-run SAGIS models for the UK for the platform.
- JHI: catchment monitoring data for the Tarland

We feel this has been a very successful activity, and the data catalogue created already meets the minimum requirement for the milestone and represents a collation of information that would improve access to data for water quality modelling. However we would like to continue the activity to identify further useful datasets, improve descriptions of the datasets we have, undertake more

focussed user-testing, and to respond to comments from stakeholders both from the forum and from the user-testing, to make the database even more comprehensive.

4.5 Plans for Year 3

Further work on the database will include full ingestion the above mentioned new datasets into the CEH long-term archive. Metadata records for these datasets will be made available via the platform data catalogue.

A viewer for these datasets is being considered, allowing users to visualise the SEPARATE, Farmscoper and SAGIS outputs, as well as locations of monitoring data (NRFA, WIMS, Harmonised Monitoring, etc.). These are large datasets to download, and a visualisation tool allows users to identify if the data contained is appropriate for their use before downloading. In the case of the WIMS data, it is no currently possible to identify sampling locations or the availability of data prior to making a data request to EA / NRW, which has to be for a whole region, and a visualisation would allow users to save time for themselves and the regulator by checking first if data is available, and making a more specific request.

Further work is required on the catalogue in specific areas, e.g. from ADAS on farm practice data, from JHI on further monitoring data (e.g. Lunan), and by CEH in adding further DTC datasets when available as well as some datasets that have been more difficult to obtain (e.g. SEPA WFD catchments).

As part of achieving milestone 4.4, the project will assess the accessibility of the datasets collated and described, and discuss whether the data catalogue approach is the best long-term solution. Issues over data standardisation, data quality, accessibility, and data licensing will be discussed and any remaining barriers to data access for water quality modelling will be highlighted, with options for resolving them in future.

Task 5. Modelling framework / integration / coupling

Lead: Reading / CEH Contributors: All Cost: £100,000

5.1 Aim: To develop flexible and robust solutions to link models data and other information such that complex questions or uncertainties can be resolved

5.2 Objectives:

1. To synthesise and review the opportunities and barriers to linking models and data for catchment systems to answer multiple pressures
2. Document codes (languages, data storage, state visibility, and discretisation) and implementation of standards for data exchange and model modularity of models prioritised by users and tested in task 3
3. Options to be determined by users
    a. Extend current meta-models / modelling frameworks (SAGIS, Farmscoper, LUCI) to embed other specialised models and explore uncertainty

b. Enhancements of specialist models to increase their interface for users and/or coupling to other specialist models
c. Source and assess value of existing tools to aid in model comparison, uncertainty and evaluation.
d. Web-enable prioritised models to enable user access and implementation in the cloud environment thus benefitting from transparency and repeatability of model applications workflow tracking, greater security, ease of user access etc.

4. Implementation in the web platform

5.3 Activities to date

The production of the reports outlining opportunities and barriers (Task 5.1) and core model input requirements (Task 5.2) are now complete and these documents have been submitted to Defra.

The main work of Task 5 is the integration and coupling of models and data, and the development of a framework to allow users ready access to the models and data on the platform. Both require that the initial core models and datasets have been ingested into, or sign-posted from, the platform. Now the Case Studies have been defined (Appendix 2) the core models and datasets have been identified and are being ingested into the portal. This work has been undertaken in collaboration with Task 4, enabling datasets in the platform catalogue to be listed against the models they could be useful for, or model applications in which they have been used.

5.4 Progress on Milestones

Key milestones related to Task 5 in year 2 are:

Milestone 5.1: Paper / report outlining opportunities and barriers to integrated modelling including: Why, when and how would integrated modelling be necessary and /or beneficial; trade-offs and benefits; technical options and standards for inter-operability - This task is complete.

Milestone 5.2: Documentation of core model input requirements, develop improved standards for all models on the platform - This task is complete.

Milestone 5.3: Development of core model output standards to enable improved integration and thus enhance likely usability of model output library – The development of core model output standards is proceeding, but activity on this milestone was delayed to give due consideration to feedback from the community forums about model output format and visualisation tools.

5.5 Plans for Year 3

Completion of task 5.3 is estimated as 31 May 2015. Year 3 activities will build on additional resources brought in through the Community Fund (see next section), and will focus on: the ingestion of selected tools and /or enhanced models or modelling framework/ meta-models on to the web platform (Task 5.5); and final testing / iteration/refinements of the platform (Task 5.6); and delivery of the final integrated data and modelling platforms (Task 5.6).

Task 6. Community Forum Fund

Lead: CEH Contributors: All Cost: £150,000

6.1 Aim: Provide funding for critical resources to be brought into the project to ensure maximum user impact and uptake.

6.2 Objectives:

1. Establish an assessment panel to consider requests for funding to being on board a range of assets and resources from the community external to the consortium
2. Award funding on an objective and competitive basis ensuring licensing and IPR arrangements are in compliance with Defra requirements

The Community Fund was established for the Project with an initial balance of £140,000. A Community Fund Panel (CFP) has been established to assess priorities and practicalities of suggested resources to be funded. This Panel consists of representatives of each consortium member and a representative from each of the funders. The fund is administered by CEH with purchase orders / subcontracts issued ensuring appropriate IPR / licensing arrangements consistent with Defra requirements.

The CFP set the following guidelines for administration of the Community Fund. To be successful applications need to satisfy the following requirements:

- Be essential to the case studies or for future legacy of the platform.
- Typical award amount £10-35k (an exceptional case could be £50k).
- Be practical and aligned to technical requirements of the platform.
- Be deliverable in a time frame to ensure the Platform can benefit. Last award will be agreed 1st March 2016 with delivery required 6 months before project end on 29th Feb 2017.
- Any tool must be provided under the licensing and IPR arrangement required by the funders i.e. freely available and downloadable from the platform.
- No model development per se will be funded (e.g., no new code).

Examples of activities eligible for funding could include:

- involvement in / data provision for case studies
- provision and conditioning of critical national data
- provision of a critical model, potentially with enhancement to make more user friendly / suitable for user needs, all with documentation;
- model conditioning for integration with other models
- visualisation / ensemble tools

6.3 Activities to date

The first call for proposals to the Community Fund was issued 19 March, 2015 (in Year 1 of the project) for three specific project area needs in for implementation (in Year 2) of the Case studies agreed with the Community Forum):

Area 1) – Faecal Indicator Organisms (FIOs) mobilisation and transport - Case Study 1 will be exploring effectiveness of land management interventions at the catchment scale. A FIO mobilisation and transport model is sought to complement this work.

Area 2) – Metaldehyde pollution - Case Study 3 will be exploring the benefits of pollution control measures and water treatment costs. Expertise and tools which would expand this work to include metaldehyde is sought.

Area 3) - Data-rich catchment exemplars - Case study 6 will be exploring the effects of data quality and quantity on evaluation of land management interventions at a catchment/local scale. Exemplar sites which are rich in data are sought to provide a test-bed for the Case Study together with an ecosystem service mapping/modelling tool to compare to outputs from models in Case Studies 1-5.

Three proposals were received in response to the First Community Fund Call call (one proposal in each area) in year 2. The proposals were evaluated according the criteria above and proposals in areas 1 and 2 were funded in year 2. The contracts awarded (nos. 1 and 2) are described below.

In addition, and in consultation with the CFP, the Community Fund also provided funds in Year 2 to bring the SEPARATE model and the SEPARATE application at national scale from Defra Project WQ0223 into Case Studies 1 and 2 of this project. This was done as a sole source contract intended to link activities in two Defra funded projects (WQ02233 and LM03038), and was not a subject of an open call to the community. This contract (no. 3) is described below.

Grants Awarded in Year 2

Contract No. 1

Amount: £26,226

Duration: 1 Sept, 2015 – 31 August 2016

To: Water Resources Associates, Wallingford, Oxfordshire

Objective: To provide a version of INCA developed for pathogens (FIO). The model simulates the stores of pathogens in soils, sediments, rivers and groundwaters and can account for diffuse inputs of pathogens from agriculture, urban areas or atmospheric deposition. The model also allows for point source discharges from intensive livestock units or from sewage treatment plants or any industrial input to river systems.

Contract No. 2

Amount: £24,126

Duration: 1 Sept, 2015 – 31 August 2016

To: School of Environmental Sciences, University of East Anglia

Objective: To develop a SWAT model which can be applied to quantify the impacts of pollution control measures on diffuse metaldehyde pollution within the Wensum catchment and assess the impacts of those measures on local compliance for metaldehyde under the EU Drinking Water Directive.

Contract No. 3

Amount: £6,578

Duration: 1 Nov, 2015 – 31 March 2017

To: Rothamsted Research Ltd.

Objective: Supply SEPARATE tool; Support project team in the delivery and reporting of Case Study 1 and 2; Attend project workshops and participate in additional project conference calls as required;

6.4 Progress on Milestones

Milestone 6.4: First Awards – First Call issued 19 March, 2015, Three grants awarded in year 2.

6.5 Plans for Year 3.

The CFP will continue to meet quarterly (or as needed; Task 6.5) to prepare the next call for proposals required to advance the Project goals.

Additional calls are anticipated in year 3 if they can contribute effectively before the end of the project.

Appendices

Appendix 1-A – Stakeholder attendance at the first three Community Forum events.

Appendix 1-B – Catchment Water Forum Note: Introductory note for stakeholder contacts.

Appendix 1-C – Proforma Template: Guide for pre-consultation meetings and telephone discussions.

Appendix 1-D – Summary of the First Community Forum

Appendix 1-E - Long list and consolidated list of stakeholder questions

Appendix 1-F – Summary of the Third Community Forum

Appendix 2 – Details of the current status of the seven Case Studies.

LM0308: Catchment Management for Water Quality

Year 2 report

April 2016

Appendix 1-A

Stakeholder attendance at the first three Community Forum events.

Stakeholder attendance at the first three Community Forum events.

The overall objective of this project is to establish a stakeholder and user forum such that the direction and the outcome from the project, is driven by the needs of the catchment management community. The Forum also establishes the basis for the long term engagement which might continue beyond the life of the LM0308 project. Names, roles and contact details for Forum attendees are compiled in this appendix.

Community Forum 1 – Individual Attendance Record

Community Forum 1 Organisation	Community Forum 1 Name	Community Forum 1 Grouping
Aberystwyth	David Kay	RESEARCH / ACADEMIA
ADAS	Steven Anthony	CONSULTANCY
ADAS	Richard Gooday	CONSULTANCY
Affinity Water	Alister Leggatt	WATER INDUSTRY
Anglian Water	Joff Edevane	WATER INDUSTRY
Anglian Water	Simon Eyre	WATER INDUSTRY
Angling Trust	Mark Owen	IMPLEMENTER / 3RD SECTOR
Atkins	Claire Allaway	CONSULTANCY
Atkins	Peter Daldorph	CONSULTANCY
CEH	Bridget Emmett	RESEARCH / ACADEMIA
CEH	Richard Williams	RESEARCH / ACADEMIA
CEH	Bethanna Jackson	RESEARCH / ACADEMIA
CEH	Jack Cosby	RESEARCH / ACADEMIA
CREW	Janette MacDonald	RESEARCH / ACADEMIA
Defra	Victor Aguilera	GOVERNMENT / POLICY
Defra	Judith Stuart	GOVERNMENT / POLICY
Defra	Oliver Edmonds	GOVERNMENT / POLICY
Defra	Mara Waters	GOVERNMENT / POLICY
Defra	Susie Willows	GOVERNMENT / POLICY
Defra	Dan McGonigle	GOVERNMENT / POLICY
Defra	Ashley Holt	GOVERNMENT / POLICY
Defra	Tristan Ibrahim	GOVERNMENT / POLICY
DoE NIEA	Wendy McKinley	GOVERNMENT / POLICY
Durham University	Sim Reaney	RESEARCH / ACADEMIA
DWQR	Phillip Anderson	RESEARCH / ACADEMIA
EA	Louise Webb	REGULATOR
EA	Paul Bryson	REGULATOR
EA	Hannah Green	REGULATOR

Community Forum 1 Organisation	Community Forum 1 Name	Community Forum 1 Grouping
EA & Defra	Stuart Kirk	GOVERNMENT / POLICY
Forest Research	Tom Nisbet	GOVERNMENT / POLICY
Forestry Commission	Vince Carter	GOVERNMENT / POLICY
Glasgow University	Robert Willows	RESEARCH / ACADEMIA
James Hutton Institute	Sarah Dunn	RESEARCH / ACADEMIA
Leeds	Adrian MacDonald	RESEARCH / ACADEMIA
NE	Russ Money	REGULATOR
NE	Bob Middleton	REGULATOR
NE	Helen Wake	REGULATOR
NERC	Chloe Onoufriou	RESEARCH / ACADEMIA
Newcastle University	Paul Quinn	RESEARCH / ACADEMIA
NFU	Nicola Dunn	IMPLEMENTER / 3RD SECTOR
Oxford University	Paul Whitehead	RESEARCH / ACADEMIA
Reading University	Andy Wade	RESEARCH / ACADEMIA
Rivers Trust	David Johnson	IMPLEMENTER / 3RD SECTOR
Rothamstead Research	Adrian Collins	RESEARCH / ACADEMIA
Scottish Agricultural Colleges	Bill Crools	RESEARCH / ACADEMIA
Scottish Water	Zoe Frogbrook	WATER INDUSTRY
SEPA	Mark Hallard	REGULATOR
SEPA	Punam Khaira	REGULATOR
Southern Water	Jonny Burke	WATER INDUSTRY
Ulster	Mairead Shore	RESEARCH / ACADEMIA
United Utilities	Luke Pearson	WATER INDUSTRY
University of York	Piran White	RESEARCH / ACADEMIA
Welsh Government	James Dowling	GOVERNMENT / POLICY
Wessex Water	Alex Martin	WATER INDUSTRY
Westcountry Rivers Trust	Russell Smith	IMPLEMENTER / 3RD SECTOR

Community Forum 1 Organisation	Community Forum 1 Name	Community Forum 1 Grouping
WICS	Lucy Reid	GOVERNMENT / POLICY
York	Dave Rafaelli	RESEARCH / ACADEMIA
Yorkshire Water	Ed Bramley	WATER INDUSTRY

Community Forum 2 – Individual Attendance Record

Community Forum 2 Organisation	Community Forum 2 Name	Community Forum 2 Grouping
Aberystwyth	David Kay	RESEARCH / ACADEMIA
ADAS	Steve Anthony	CONSULTANCY
ADAS	David Lee	CONSULTANCY
Affinity Water Limited	Sophie Mortimer	WATER INDUSTRY
Anglian Water Group	Sam Carr	WATER INDUSTRY
Atkins	Claire Allaway	CONSULTANCY
Atkins	Peter Daldorph	CONSULTANCY
Canals Trust	Alice Hill	IMPLEMENTER / 3RD SECTOR
CEH	Bridget Emmett	RESEARCH / ACADEMIA
CEH	Jack Cosby	RESEARCH / ACADEMIA
CEH	Richard Williams	RESEARCH / ACADEMIA
CEH	Matt Fry	RESEARCH / ACADEMIA
CREW	Jannette MacDonald	RESEARCH / ACADEMIA
DEFRA Agri Environment Policy	Oliver Edmonds	GOVERNMENT / POLICY
DEFRA Joint Water Evidence Group	Stuart Kirk	GOVERNMENT / POLICY
Defra R&D	Dan McGonigle	GOVERNMENT / POLICY
Defra R&D	Tristan Ibrahim	GOVERNMENT / POLICY
Dwr Cymru Welsh Water	Philippa Pearson	WATER INDUSTRY
Environment Agency	Hannah Green	REGULATOR
Environment Agency	Tom Rolls	REGULATOR
Environment Agency	Nick Hopwood	REGULATOR
Environment Agency	Alwyn Hart	REGULATOR

Community Forum 2 Organisation	Community Forum 2 Name	Community Forum 2 Grouping
Environment Agency	Linda Pope	REGULATOR
Environment Agency	Neil Murdoch	REGULATOR
Forestry Commission	Vince Carter	GOVERNMENT / POLICY
Forestry Commission	Tom Nisbet	GOVERNMENT / POLICY
Glasgow University	Robert Willows	RESEARCH / ACADEMIA
James Hutton Institute	James Sample	RESEARCH / ACADEMIA
James Hutton Institute	Andy Vinten	RESEARCH / ACADEMIA
Leeds University	Adrian McDonald	RESEARCH / ACADEMIA
National Farmers Union	Nicola Dunn	IMPLEMENTER / 3RD SECTOR
Natural England - Biodiversity delivery	Russ Money	REGULATOR
Northern Ireland	Rachel Cassidy	GOVERNMENT / POLICY
Northumbrian Water Group	Teresa Meadows	WATER INDUSTRY
Oxford University	Paul Whitehead	RESEARCH / ACADEMIA
Reading University	Andy Wade	RESEARCH / ACADEMIA
Rivers Trust	Dave Johnson	IMPLEMENTER / 3RD SECTOR
Rothamstead	Adrian Collins	RESEARCH / ACADEMIA
Sheffield University / DTC	Bob Harris	RESEARCH / ACADEMIA
Thames Water	Raquel Coca Fernandez	WATER INDUSTRY
Westcountry Rivers Trust	Russell Smith	IMPLEMENTER / 3RD SECTOR

Community Forum 3 - Individual Attendance Record

Community Forum 3 Organisation	Community Forum 3 Name	Community Forum 3 Grouping
ADAS	Richard Gooday	CONSULTANCY
Affinity Water	Alister Leggatt	WATER INDUSTRY
Agri-Food and Biosciences Institute	Rachel Cassidy	WATER INDUSTRY
Anglian Water	Richard Reynolds	WATER INDUSTRY

Community Forum 3 Organisation	Community Forum 3 Name	Community Forum 3 Grouping
Atkins	Laura Nieuwenhoven	CONSULTANCY
Atkins	Claire Neale	CONSULTANCY
Atkins	Peter Daldorph	CONSULTANCY
Bristol Water	Matt Pitts	WATER INDUSTRY
Cambridge Water	Jennifer Thomas	WATER INDUSTRY
CEH	Bridget Emmett	RESEARCH / ACADEMIA
CEH	Jack Cosby	RESEARCH / ACADEMIA
CEH	Matt Fry	RESEARCH / ACADEMIA
CEH	Mike Brown	RESEARCH / ACADEMIA
Cranfield	Jim Harris	RESEARCH / ACADEMIA
Defra	Alastair Rennie	GOVERNMENT / POLICY
Defra	Rob Davies	GOVERNMENT / POLICY
Defra	Victor Aguilera	GOVERNMENT / POLICY
Environment Agency	Alwyn Hart	REGULATOR
Environment Agency	Claire Bell	REGULATOR
Environment Agency	Helen Green	REGULATOR
Environment Agency	Kirsten Foot	REGULATOR
Environment Agency	Paul Bryson	REGULATOR
Environment Agency	Tom Rolls	REGULATOR
Essex and Suffolk Water	Ian Skinner	WATER INDUSTRY
Forestry Commission	Tom Nisbet	GOVERNMENT / POLICY
Hutton Institute	Andy Vinten	RESEARCH / ACADEMIA
Hutton Institute	Jannette MacDonald	RESEARCH / ACADEMIA
Lancaster	Jessica Bellarby	RESEARCH / ACADEMIA
Natural England	Helen Wake	REGULATOR
Natural England	Kat Broadhead	REGULATOR
Natural England	Rachel Webster	REGULATOR
NERC	Vicky Morgan	RESEARCH / ACADEMIA
NFU	Rob Howells	IMPLEMENTER / 3RD SECTOR
Northern Ireland Environment Agency	Robert Bailie	REGULATOR
Orion Innovations	Alison Cavey	RESEARCH / ACADEMIA

Community Forum 3 Organisation	Community Forum 3 Name	Community Forum 3 Grouping
Orion Innovations	Juliet Kauffman	RESEARCH / ACADEMIA
Oxford University	Paul Whitehead	RESEARCH / ACADEMIA
Portsmouth Water	Chris Manning	WATER INDUSTRY
Rivers Trust	Michelle Walker	IMPLEMENTER / 3RD SECTOR
RSPB	Simon Wightman	IMPLEMENTER / 3RD SECTOR
Scottish National Heritage	Sarah Hutchen	GOVERNMENT / POLICY
SEPA	Mark Hallard	REGULATOR
Severn Trent Water	Katharine Filby	WATER INDUSTRY
South East Water	Steve Howe	WATER INDUSTRY
South Staffordshire Water	Nina Yiannoukos	WATER INDUSTRY
Southern Water	Paul Linwood	WATER INDUSTRY
Thames Water	Graham Welland	WATER INDUSTRY
UK Water Partnership	Faith Culshaw	RESEARCH / ACADEMIA
University of East Anglia	Kevin Hiscock	RESEARCH / ACADEMIA
University of Reading	Andy Wade	RESEARCH / ACADEMIA
University of Reading	Prof Richard Tiffin	RESEARCH / ACADEMIA
University of York	Dave Raffaelli	RESEARCH / ACADEMIA
Welsh Government	Anne Humble	GOVERNMENT / POLICY
Wessex Water	Jeremy Graham	WATER INDUSTRY
Wessex Water	John Bagnall	WATER INDUSTRY
WWF	Dominic Gogol	IMPLEMENTER / 3RD SECTOR

Community Forum Institutional Attendance Record

Community Forum 1 Organisations represented	Community Forum 2 Organisations represented	Community Forum 3 Organisations represented
Aberystwyth	Aberystwyth	ADAS
ADAS	ADAS	Affinity Water
Affinity Water	Affinity Water Limited	Agri-Food and Biosciences Institute
Anglian Water	Anglian Water Group	Anglian Water

Community Forum 1 Organisations represented	**Community Forum 2 Organisations represented**	**Community Forum 3 Organisations represented**
Angling Trust	Atkins	Atkins
Atkins	Canals Trust	Bristol Water
CEH	CEH	Cambridge Water
CREW	CREW	CEH
Defra	DEFRA Agri Environment Policy	Cranfield
DoE NIEA	DEFRA Joint Water Evidence Group	Defra
Durham University	Defra R&D	Environment Agency
DWQR	Dwr Cymru Welsh Water	Essex and Suffolk Water
EA	Environment Agency	Forestry Commission
EA & Defra	Forestry Commission	Hutton Institute
Forest Research	Forestry Commission	Lancaster
Forestry Commission	Glasgow University	Natural England
Glasgow University	James Hutton Institute	NERC
James Hutton Institute	Leeds University	NFU
Leeds	National Farmers Union	Northern Ireland Environment Agency
NE	Natural England - Biodiversity delivery	Orion Innovations
NERC	Northern Ireland	Oxford University
Newcastle University	Northumbrian Water Group	Portsmouth Water
NFU	Oxford University	Rivers Trust
Oxford University	Reading University	RSPB
Reading University	Rivers Trust	Scottish National Heritage
Rivers Trust	Rothamstead	SEPA
Rothamstead Research	Sheffield University / DTC	Severn Trent Water
Scottish Agricultural Colleges	Thames Water	South East Water
Scottish Water	Westcountry Rivers Trust	South Staffordshire Water
SEPA		Southern Water
Southern Water		Thames Water
Ulster		UK Water Partnership

Community Forum 1 Organisations represented	**Community Forum 2 Organisations represented**	**Community Forum 3 Organisations represented**
United Utilities		University of East Anglia
University of York		University of Reading
Welsh Government		University of York
Wessex Water		Welsh Government
Westcountry Rivers Trust		Wessex Water
WICS		WWF
York		
Yorkshire Water		

LM0308: Catchment Management for Water Quality

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Appendix 1-B

Catchment Water Forum Note: Introductory note for stakeholder contacts.

Catchment Water Forum Note: Introductory note for stakeholder contacts.

A two page introductory note was produced and sent out to the stakeholder contacts to notify them of the project, disseminate some information on what the objectives are and to let stakeholders know that that we would be making contact. This note was sent out to all the contacts identified in the initial stakeholder mapping described in the body of the year 2 report.

Catchment Management for Water Quality

Science-Policy-Practice Forum

What is the problem?

A major challenge facing the UK today is how to balance competing demands on the water environment. Cross cutting policy areas such as those relating to land and food, energy, health, climate change and biodiversity all have impacts on, or could potentially benefit from, catchment management for water quality.

The ambitious objectives set by the Water Framework Directive to protect and improve the water environment will only be met by a sound understanding of the complex biogeochemical and hydrological processes driving water quality problems, and their solutions. While the wealth of modelling tools and environmental datasets available for the UK are key to achieve water policy objectives, there is too little integration between them to appropriately address complex questions.

Modelling frameworks for catchment management need to give outputs at both a national and a local scale, be able to account for variations in land use, climate or geology and the effect of variables such as climate change, uptake of mitigation measures and socio-economic factors such as changes in food markets. Outputs need to be useable and understandable.

What is the project doing?

This project aims to improve the access to and integration between data and models that help address the key questions in catchment management for water quality and wider ecosystem services. This integration will allow for more complex issues across many policy areas to be understood and addressed and as a result a more holistic view to inform both policy development and the impacts of policies on the water and wider environment.

To achieve this, the project will bring together and test datasets and models relevant to these challenges. Outputs will be made freely available through a web-based platform for use by the research, policy and implementation community.

How can you get involved?

Identifying what these challenges are is a key first step for the project. We want to establish a forum of scientists, policy makers and practitioners to identify and co-construct the key questions in catchment management for water quality in the UK. This will be established in June 2014 and will run for three years via discussion groups and a series of workshops. Involvement will give you an opportunity to discuss these issues with key scientific experts and other industry leaders to help with policy development, implementation and the achievement of objectives. Putting user needs up front and sharing data and models will help ensure the best use of science to help achieve the goals of UK water policy now and into the future.

From the project funders;

As a key member of the UK's catchment management community we would like to invite you to participate in the forum and be part of this important project to identify the main questions for catchment science to help us achieve water policy and wider environmental goals.

Further details

What kinds of questions can be addressed?

The focus of this project is on the needs of policy makers and practitioners involved in the development and implementation of water policy in the UK, and on the wider ecosystem services related to this. Broad areas could include measures to help achieve WFD objectives, Natural Flood Management in relation to water quality, and Ecosystem Services within a water and WFD context. Specific questions, for example, could be *"What is the uncertainty in catchment scale predictions of water quality and how does that impact potential ecological status*?" or "*What would be the benefits of different diffuse pollution source control options within a test catchment on water quality objectives and wider ecosystem services*?"

What models and datasets could this application include?

There are many models in existence all of which tackle different aspects of catchment science. Which models really answer your questions and what more could be achieved by linking them? The consortium has contributed some key datasets and models as a starting point to explore these questions. These include catchment water quality models (e.g. INCA, NIRAMS), source apportionment models (e.g. SAGIS), in-stream ecological models (e.g. QUESTOR, Kennet), decision support tools for diffuse pollution (FARMSCOPER) and ecosystem services (LUCI). The project will explore the benefits of integrating these or other models to deliver answers to complex environmental problems. To ensure the use of all relevant models there is potential to add to the current suite via the Science-Policy-Practice Forum and a Community Funding Pot[1] where a need to access additional models, tools and datasets is identified by the needs of the forum members.

How will this work in practice?

The forum will take the shape of a series of workshops over the next three years, supported by smaller meetings and one to one discussions. The initial workshop in June 2014 will introduce the project, the benefits and discuss potential catchment management questions to be addressed by the project. This will be followed by two more focused workshops to further define the requirements and assess against the modelling capability. A final workshop will be held to disseminate the outcomes and provide training.

What about the long term?

It is intended that the project will establish a Legacy Forum for the future, where scientists, policy makers and practitioners across the UK can come together to network and discuss future challenges thereby helping to steer future research effort in this area.

How to get in touch

A website will be launched in June and in the meantime please contact
catchmentforwater@gmail.com

[1] To be administered via the project's Modelling Community Fund. How to apply will be described via the forum and on the website.

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Appendix 1-C

Proforma Template: Guide for pre-consultation meetings and telephone discussions.

Proforma Template: Guide for pre-consultation meetings and telephone discussions.

In recognition that catchment management is a broad topic area, covering many different disciplines, it was decided that some standardisation was needed in terms of how we conducted the pre-consultation task. We therefore developed a question "proforma" which essentially acted as a guide to all pre-consultation meetings and telephone discussions so that the technical emphasis and subsequent conversations were not biased towards the experience and expertise of the person conducting the interview.

What are we trying to do? The Forum task of the project is focused towards:

- Identifying the key questions / priorities / challenges / sticking points when it comes to catchment management for water quality;

  i.e. what more do you need to know in order to progress catchment management?

- Identifying what models and datasets already exist to help answer these questions / solve these challenges / increase the evidence base for decision making, and understanding why they aren't currently being used;

  i.e. what is currently out there, by way of data and models, that could help?

- Breaking down the barriers to encourage more wide spread use of data and models to support catchment management for water quality

  i.e. how can access and usability be improved so that it is more useful to you?

- Considering what's out there, what more is needed?

  i.e. what are the remaining evidence gaps that need consideration in future

The key focus is on catchment management for water quality; this therefore includes elements of flood risk management, ecosystem services, climate change, economics etc where directly linked to water quality and WFD. These sub-elements should also be considered. This project is about evidence gaps in relation to catchment management; this includes data, models, tools, general understanding and scientific knowledge.

A review of Challenges and Choices showed some consistent evidence gaps across multiple different pressures, including:

- ➔ Uncertainties about ecological responses to pressures and measures (response magnitude and timescales)
- ➔ Uncertainty on how pressures act in combination, and subsequent uncertainty around effectiveness of measures dealing with multiple pressures
- ➔ Uncertainty on relative cost-effectiveness of measures – uncertainty on technical effectiveness and on cost of implementation, also uncertainty about scaling up cost effectiveness from river / catchment / country level
- ➔ Uncertainty about future trends e.g. climate change, population growth, land use change, economics and effects on pressures and measures
- ➔ We also don't know how far ongoing research will take us to closing evidence gaps

Lack of evidence, or availability of evidence summarised in a useful manner, means it is sometimes challenging to make the right policy decision and be certain of the desired outcome. It also means that opportunities for wider benefits in other policy areas could be missed.

This project is aimed at closing that uncertainty by making useful data, models and tools available at the right scale of application, for use in integrated policy formation.

Q1 - What is your work area and how is it related to catchment management and WQ?

Q2 - What are the priorities and key challenges / sticking points / evidence gaps when it comes to decision making and policy development within your area?
(e.g. do you understand the problem; do you have sufficient evidence of the problem to take action; do you have actions available for mitigation; do you know whether the mitigation works; what is the confidence in outcome; do you need more measures; etc)

Q3 - How have you overcome these challenges so far?
(e.g. datasets; models; tools; decision making strategies; expert judgement; consultation; use of confidence ratings etc)

Q4 – What would have been useful?
(Consider: core datasets; models; tools; knowledge; visualisation; scientific references; etc)

Q5 – What are the key future challenges for catchment management and what are the key questions that need answering by data and models in order to progress catchment management in the future? Please list. *(key questions will be taken forward for collective discussion in the workshops)*

Q6 – are you aware of any synergies with other policy areas / projects and are there any other people you think should be consulted in this project?
(Consider: wider ecosystem services from catchment management for water quality such as flood risk management, climate change mitigation and biodiversity etc)

Things to consider / prompts:

1. **Understanding the problem:**
    - *a.* Sources
    - *b.* Activities
    - *c.* Pathways
    - *d.* Pollutant interactions
    - *e.* Environmental sensitivity
    - *f.* Catchment characteristics
    - *g.* Existing interventions
    - *h.* Future trends

2. **Solving the problem:**
    - *a.* Measures available
    - *b.* Alternative approaches (targeting alternative pressures to achieve outcome)
    - *c.* Ecological outcome and confidence
    - *d.* Multiple benefits
    - *e.* Costs to implement
    - *f.* Cost effectiveness
    - *g.* Scaling up to catchment / country level
    - *h.* Scaling down to water body level
    - *i.* Resilience to future pressures
    - *j.* Legalities
    - *k.* Sectoral impacts
    - *l.* *Implementation support*

3. **Pressures**
    - a. Phosphate, nitrate, ammonia, sediment
    - b. Physical modification
    - c. Abstraction & flow
    - d. Dissolved oxygen, BOD
    - e. Specific pollutants
    - f. Fecal contamination and sanitary pollutants
    - g. Invasive non native species
    - h. Pressure on groundwater
    - i. Priority substances
    - j. pH
    - k. Temperature
    - l. Fish stocking
    - m. Other pollutants

4. Sectors

a. Agriculture and rural land management
b. Government (including Defra, EA, NE)
c. Construction
d. Energy Production
e. Food and Drink
f. Forestry
g. Local Authorities / Public Sector
h. Manufacturing and retail
i. Mining
j. Ports
k. Water Industry

5. Other considerations

a. Protected areas
b. Drinking waters
c. Economics
d. Ecosystem services
e. Natural flood management
f. Air quality
g. Forestry
h. Biodiversity
i. Climate change
j. Soils
k. Consultations and making information available
l. Data gathering from the bottom up, not just top down
m. Intellectual property rights management and data security

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Appendix 1-D

Summary of the First Community Forum

Summary of the First Community Forum (July 2014)

The outputs for the day from the first Community Forum were written up and disseminated (this Appendix), but the main output from this workshop was the identification of a wider range of questions from the stakeholder attendees, structured broadly around scale (national (mainly policy and regulators), catchment (regulators and water industry) and land-holding (mainly 3rd sector organisations and other practitioners).

Catchment for Water Forum

Workshop 1 - Summary

Thank you everyone who attended the workshop on 1st July, it was a highly successful day - fantastic to see everyone so engaged and interacting.

Thanks also to people who have contributed to the process via email before the workshop, and to those of you who have been in touch with more information following the workshop.

We have gathered a lot of information so far in this project and here we summarise these contributions in a brief note for your information.

NEXT STEPS...

1. Please review the key questions raised by each user group.

2. Please would you let us know if you do not agree with any of the points raised, if you feel there are any major gaps or generally if you have anything further to add after reflecting on these notes. The deadline for feedback on these summary notes is 15th August.

3. Our next steps within the consortium will be to condense these questions and points raised so far into a few key questions / theme areas to investigate further between now and October.

4. In the meantime, **we need your help to identify key datasets and models that could be used to answer some of these questions**. We will then be able to investigate the potential for getting them included within this framework. If you have any suggestions of datasets and models that could be applied to answer some of the key questions, or specific case study examples of where they have been put to use, please would you email catchmentforwater@gmail.com with the details by 15th August.

We look forward to updating you with progress over the summer.

Introduction

This project aims to improve the access to and integration between data and models that help address the key questions in catchment management for water quality and wider ecosystem services. Identifying what these challenges are is a key first step for the project.

- The aim of the day was to introduce the project and get a common understanding of the drivers, direction and outcomes of the work.
- The scope of the project is limited to catchment management activities for water quality, but including the co-benefits and trade-offs for wider ecosystem services.
- The key focus of this workshop was to discuss the main catchment challenges and questions that need answering through the outcomes of this project.

Introductory presentations were given from the funders, on the project, on the background to the models currently available and on the initial long list of key questions from initial discussions with policy makers, regulators, the water industry, implementers and researchers.

Summary of the key points raised during the Forum introductory session:

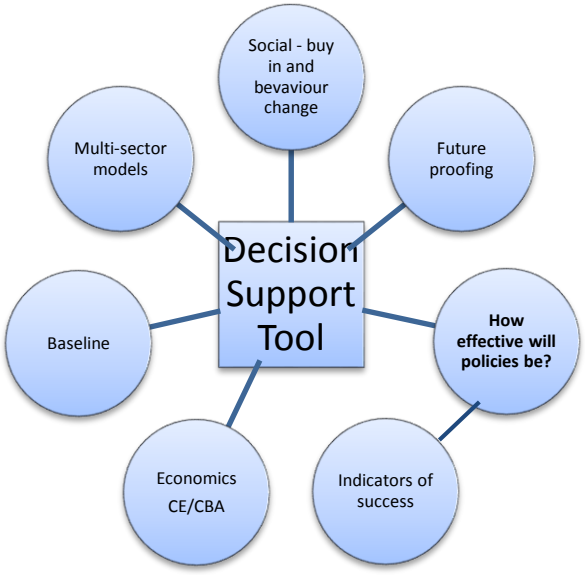
- This is not about new models, it's about making modelling capability available and more transparent - the enhancement of the collation, integration and presentation of the evidence base so people can see and understand why decisions are being made.
- The other idea of this project is also to translate what is developed in the research community and make these readily available – transfer of the knowledge between research and users
- Who are the models for – who are the decision makers? With Catchment Based Approach the decision maker audience is broader than it used to be. The remaining challenges are about behaviour and therefore the solution is about dealing with these issues in the proper social context. Water management has a big social construct; we need to take the people with us. Catchment management is now very local and involves people who live in the catchment and we need to be able to engage on the right level. People are key– it is behaviour change that will improve water quality. Links need to be made to the catchment approach and models need to be transparent and robust enough to start engagement and engender trust
- From a water industry perspective, regulators need to be fully engaged. Our understanding of the problems and solutions needs to be sufficiently robust (as in formed by models and or data) such that if necessary, we can challenge Europe better on timelines for implementation - it's better to do the right thing, late, rather than the wrong thing on time. We need this project to help make progress about communicating which models need to be used.
- Clear advice and guidance is needed to accompany models so that people can carefully communicate the limitations of models
- A plea from the audience on data sharing and availability – this aspect is fundamental and hopefully this is going to be resolved through this process. Data is such a problem in terms of making outputs available to end users.
- The focus is on water quality, but should not forget water quantity and flows alongside this as this is important to understand pollutants at a catchment level and also impacts of low flows on water quality.
- Levels of confidence in model results – Water Companies need to take decisions about spending bill payer money on catchment management and in doing so can affect farmers/land manager's livelihoods, so it's vital to demonstrate confidence in models. So this isn't just about who is the user in this framework but also who is the audience of those users.
- Scotland and Northern Ireland have challenges that aren't always seen elsewhere – e.g. with issues with colour in Scotland. Northern Ireland also has an interest in source apportionment in lakes and effectiveness of measures.
- This framework should not forget the near-shore – e.g. bathing waters and warning systems
- Analytical and visualisation tools need to be written in open source code and shouldn't be locked into this framework – they are usable from elsewhere so they can be integrated into other visualisation tools and frameworks and made use in the widest possible sense.

Summaries of the key points raised in the afternoon sessions are set out in the following sections.

Workshop group 1: National

The key points for the National group are listed below:

1. **Decision Support Tool** – Multi-sector/pressure/response with (or that can link to) cost-benefit/cost-effectiveness for appraising policy options. Needs to be spatially explicit and incorporate social models/behaviour change. 'Where do I get most bang for buck' - Scenarios
    a. Criteria (including social and legal) need to be agreed up front for model acceptability
    b. Baseline and temporal contingencies (i.e. incorporation of external factors) are a critical component e.g. links to WFD no deterioration requirement
    c. Need buy-in from audience at different levels/scales – how? What does Good Ecological Status mean in terms of recreation? Investment in achieving moderate status is likely to have greater benefits than getting to good.
2. **How wrong would we be?** Using different data sets e.g. agricultural census versus farm specific data or using real-time stream sensors versus grab samples **not** in terms of estimated load etc but in terms of the need and type of intervention
3. **Other questions included (and may well be part of 1)**
    a. Source apportionment within the agricultural sector is needed
    b. Other pressures including urban and morphology will need to be included
    c. Morphology is a major pressure – can models help e.g. predict link to ecology?
    d. Land use and management change beyond agriculture e.g. forestry
4. **When will my policy be successful?** Links to the Decision Support Tool above
5. **How will we know it has been successful?** Need outcome indicators to show direction of travel as well as modelled prediction. Need to understand why there are deviations from modelled prediction.
6. **Future proofing –** climate change and other impacts
7. **Other issues**
    a. Social and economics important – optimising uptake
    b. Catchment scale useful for optimising uptake – then upscale. What is the level of uptake required? And where?
    c. Source apportionment and ecological impacts
    d. Time lags
    e. Link models to monitoring
    f. Link local and national models
    g. Multiple outcomes
    h. A need to monitor and evaluate past policies and appreciate ongoing impact on today's signal



Summary of key questions raised by the group previously through discussions / feedback (national group)

- **What models exist and what do they tell us**? How robust are they and well do they represent real life (are they well calibrated?) and what are the limitations of applying the model to specific circumstances
- **Are there missing measures from the first RBMP? Effectiveness of measures & certainty in outcomes** w.r.t. WFD classes? What sources of diffuse pollution are not covered by current measures? And do we have tools for source apportionment? Should source apportionment of nutrients also be based on ecological impact rather than just contribution to loads?
- **Morphology is a significant pressure**. Can models help with the link to ecology and response to measures?
- **Drinking water** - How effective is catchment management at improving water quality and maintaining water supply? Can we detect long term changes in raw water quality?
- **Climate and land use change** – impacts on effect of measure?
- **Combined impact of multiple pressures, biological response and effect of multiple measures**
- **Impact of specific policy mechanisms** – mileage in existing policy e.g. baseline, incentives, NELMS etc – how far will existing policy mechanisms get us and what more is needed to reach our targets?
- **Cost of reaching our targets and how this falls to different sectors?**
- **Scaling up** from field → catchment →national (scientific knowledge as well as economics) and is it appropriate to use these tools to do so or do we lose too much information in this process?
- **Synergies** across policies and measures; are there win-wins for biodiversity, soil, flood risk, climate change etc policy areas by implementing specific measures / mechanisms.
- **Tradeoffs -** How to trade off one outcome e.g. biodiversity, when optimising for another e.g. WQ – are there datasets and models out there that could inform a model that seeks to quantify the level of synergy that could be delivered by options? And to what degree is the level of environmental outcome achieved compromised when trying to deliver multiple benefits?
- **Costs and benefits of measures that incorporate a full range of Ecosystem Services**
- **Decision support tool** – combining model outputs for science and economics into decision making tool that visualises and communicates the weight of evidence used in decision making.
- **Tool to conceptualise and explain the key issues and bring stakeholders into the process:** working to a common understanding of the issues and what to do about them
- **Account for ecosystem services** and natural capital in a standard and understandable way
- **Social aspects of measures uptake** – what makes people choose measures? How can we motivate people to select the right measures? How can we spatially target certain mechanisms and justify doing so?
- **Improve reliance on actual data of evidence** rather than just modelled data e.g. event based data and Demonstration Test Catchment datasets
- **Greater clarity on what is in the modelled diffuse component**
- **Better link to activity** causing the issue when it comes to diffuse, not just sector
- **What biogeochemical processes are going on** in the catchment that might look like "diffuse" pollution?
- How to move away from concentration based limits to ecological based limits
- How long does ecology take to respond?
- How will climate change affect the baseline for "good status"

Workshop group 2: Catchment (Regulators)

Synopsis:
The question posed within the group was: what do we need to understand in order to progress catchment management and planning at a catchment level? The detail of the questions is given in the table below, however it was agreed at the end of the session that the top 6 questions / theme areas for prioritising were:

Priority 1:
1. Integrated Management Planning and role of models to influence behaviour
2. Modelling future pressures – impact on objectives (e.g. what are realistic objectives given future pressures e.g. agricultural intensification or climate change)
3. Improved modelling of socio economic consequences and drivers

Priority 2:
4. Source apportionment availability and model outputs that breakdown to seasonal / activity level, not just sector / system snapshot.
5. Common consensus on what measures will deliver – including ability to target specific parameters / objectives / ESS etc.
6. Multifunctional benefits / synergies /ecosystem services

Other headlines: The wider questions that were raised during the workshop session are set out below.

Theme	Specific question raised within the group discussion
Future pressures and extrapolation of impacts	Impact of the future on WQ – e.g. agricultural intensification and climate change
Effectiveness of measures / mechanisms	How effective is the current programme and how far will it get us? The difference between implementation in full and the reality of implementation ("messiness" factor)
	Scenario modelling of effectiveness of measures: Planning timeframe scenarios need to be modelled to show land management measures longevity for example – what will the effect be in 5 yrs compared with 25 years. Scenario modelling needs to let us understand how fast, how far and how effective we need to be.
Source apportionment	Source apportionment – need this to be available and we need a way of modelling not just sector responsible but activities within that sector. Also needed not just spatially but also temporally and how the apportionment changes under different flow and weather conditions.
Socio-economics	Economics data is normally top-down coming from a national dataset, however when planning at a catchment level it is more appropriate to use local economics information and upscale; in this way, stakeholders can see that local level economic considerations are taken into account in catchment planning rather than standard-national level data. Need scenario modelling of sector financial impacts – not just agricultural sector but all sectors contributing
Evidence of outcome	Monitoring data and visualisation just as important as modelling. Examples of how models have led to action and outcomes. Need to capture actual data on effectiveness of measures as this then reinforces model outputs when convincing farmers who often distrust models until verified by data. CHANGE – need these models to map change to reflect implementation of measures and progress
Uncertainty, confidence and communication	There are issues around confidence of models and underlying data and we need to be able to communicate confidence in a way that convinces stakeholders that the model may not be perfect, but it's good enough. Cost benefits need to be couched in terms of ranges rather than absolute.
Ecosystem Services	Use of ecosystem services to translate model outputs
Contextualisation of the problem and solution	Outputs of models need to be couched in a way that reaches individual stakeholders – e.g. for the farming industry the currency of discussion needs to be profitability, not necessarily Kg phosphate / year for example. Costs and benefits are difficult to measure and express in a common currency across

	sectors but if we're going to get shared ownership of the problem and solutions at a catchment level this needs to happen.
Inclusion of local catchment characteristics, objectives and data	We need a national level framework in terms of core datasets and models to use in catchment planning, but with the ability to combine local level data and thereby improve the weight of evidence to achieve local persuasion. Models need to be able to be adjusted in terms of input data to fit specific catchments – e.g. take account of actual numbers of cows, % dairy etc so that planning can happen on a catchment –specific basis rather than a "standard" farm type e.g. how FARMSCOPER works
	Policy area priorities need to be set at a local scale – e.g. bankside grazing exclusion to protect water quality can jeopardise certain biodiversity objectives e.g. for vegetation management for damselfly. Local and site specific priorities need to be captured and considered when picking suitable measures
Integration / focus / scaling	Need the ability to have multi objective models and integration but not lose the resolution of single focus where there may be a localised and specific issue.
	Integration of models across different water categories – especially important e.g. bathing waters and near shore issues where for example Faecal Indicator Organisms are an issue and the source (and controls) are further up the catchment.
	Tools need to be multifunctional to allow the wide array of catchment stakeholders to come together and engage, rather than sector specific. A shared understanding of the problem and a shared evidence base of the potential solutions for discussions to go ahead.

Summary of key questions raised by this group previously through discussions / feedback (catchment planner / regulator group)

- Understanding combined impacts of multiple pressures and multiple measures
- Costs and benefits of measures that incorporate a full range of ecosystem services including benefits for water treatment and water industry
- Link between land use activity and ecological water quality on a catchment specific basis
- Source apportionment – ecologically based?
- Decision support tools -scale and nature of interventions required?
- Scaling up and down
- Prioritisation →decision basis
- Targeting measures on a catchment/site specific basis?
- Taking account of uncertainty in ecological outcomes
- Course and fine sediment dynamics
- Urban diffuse pollution - toxics
- Can we demonstrate the link between land use activity and ecological water quality on a catchment specific basis?
- Understanding of ecological response times in general and ecological benefit
- Relationship between hydromorphological functioning and GES
- Cost/Effectiveness of diffuse pollution measures at a catchment scale rather than a site specific scale
- Need to understand the C/B of measures in the context of wider ecosystem services
- Not just spatial but temporal detail – e.g. a failure of EQS in summer will need a different remedy compared with a failure in winter, yet we use annual averages most of the time.
- On what basis should we prioritise catchments for the protection of aquatic ecosystems?
- How can we target mitigation measures on a catchment/site specific basis?
- How can we resolve the challenges between the need for the targeting of mitigation measures and the difficulties in implementing and administering a targeted approach?
- Can we evaluate the resilience of aquatic ecosystems and the probability of recovery?
- How can uncertainty in ecological outcomes be incorporated in decision making processes?
- We can predict climatic trends, but this may not accurately reflect localised or extreme weather events which would increase risks to water quality. This uncertainty gives more of a focus on the need to increase farm resilience

Workshop group 3 Catchment (water industry)

The key questions raised by the group were as follows:

1. How do we make data (who does what, where, when) more readily available (and up to date e.g. from water companies). What about qualitative data?

2. How do we get repeatable outputs from models? Calibration, consistency, good practice, model development protocols, learning from other fields

3. 'Develop' protocols for risk assessment and mapping

4. Capture uncertainty in effectiveness of measures – understanding timescales of response and implications for economics

5. How do measures affect peaks?

6. What spatial scale should we be targeting for understanding processes and evaluating standards (don't look at water quality in isolation – bigger picture)

7. What are the implications of climate change and agricultural intensification for water quality?

Summary of key points raised by this group previously through discussions / feedback (catchment planner / water industry group)

- What is the value of models?
- Cost of developing and maintaining models is high and this is a barrier to their use as well as uncertainty on which models to invest in.
- Water company staff can rarely dedicate much of their time to modelling work and knowledge and skills are also a limitation
- Value consistency of approach so results from different studies and initiatives can be compared.
- Important to model costs of measures as well as impacts to feed into business planning (e.g. technical feasibility of measures, disproportionate costs)
- Pesticides are a key issue for water companies but models in this area are mainly looking at risk. Important to also look at impact of measures in relation to both surface and groundwater.
- Can high risk contaminant sources in specific environments be identified (influence of soil types, hydrology, rainfall, cropping patterns, farming practices such as tillage and under-drains, topographic features such as slope and proximity to water courses); and also the fate and behaviour of specific contaminants in the environment (use, timing and methods of application, leachability, persistence, biodegradation etc)
- Can models help to target measures and provide an estimate of the level of confidence that they will work – no point in investing customers money if uncertainty high
- What are the uncertainties associated with modelling the impacts of different measures?
- Can models be used to help decide where to invest in sampling and other evidence gathering?
- Can a consistent modelling approach be developed to look at sources of pesticides and their transport to receptors (e.g. surface water abstractions and boreholes).
- Can the ecological benefits of measures be modelled to help identify where best to apply measures

Workshop group 4 Land holding

Synopsis – modelling as a form of persuasion to address change at the holding scale. Steps 1 to 6 are a looped process. Step 7 has to happen at the end.

1. Conceptual model – persuasion there is a problem and why? Verification to support underlying beliefs. (Scored poorly)
2. Land management and use/what do we target? Triage phase. (Not being dealt with elsewhere)
3. What tools are available that map to elements of the problem –info in a repository is required?
4. Can we work with the modellers? Collaborative modelling – pair-wise working (e.g. ECM+ – farmers believed output as involved in process). Collaborate during learning phase and application.
5. What is the farmers role – what is the measure for each farmer to implement, when will the measure yield benefits, convince the measure will work, what level of uptake is required, what tools best achieve uptake of measures/buy-in?
6. What are the co-benefits – is there a tool to help persuade farmers to enact change?
7. How can we achieve final sign off by the regulators, but focus on benefits?

Headlines – to achieve successful land use/management change;

1. Need concept to be clear and transparent
2. Need tools that make difference between land use and management explicit
3. Tools that are modular – map elements to problems in hand.
4. Public access to model and modellers
5. Tool that makes explicit quantification of small set of target measures
6. Tool that gives estimate of extent of uptake and timescales
7. Tool must encourage action and response
8. Information of co-benefits so more of an incentive to engage
9. Ideally tool will be useful for regulatory signoff.
10. Choose case studies – don't want to risk detrimental impact to modelling reputation.

Other things of note:

- Produce a 'Strength of Evidence' table. Score evidence. What would you need to do to verify that piece of evidence?
- Modelling for persuasion…. What to believe and what to do?
- Do we need a large IT platform to deliver this? Work in Cloud? (e.g. Google in Cloud). Can run models on Cloud but need to pay to run.
- Can you identify different types of problem – ones that need to be tailored to situation, ones that are 'reproducible'?

Summary of key questions raised by this group previously through discussions / feedback (implementer / land holding group)

- **Access to actual data** (e.g. compliance data, walkover data etc)
- **We don't need more models,** we need existing models to be made available, with source data, and support is needed from model developers to interpret model outputs / help when something doesn't look right
- **Source apportionment** – need access to SAGIS and input data
- **Guidance needed** on when to use a specific model and when not to;
- **Transparency in partnership working**: need access to same data and information upon which decisions are made
- **Mechanics of pollutant loading and effect of measures for land managers**
- **Effectiveness of measures needs better understanding on a site/catchment basis** (not just theoretical FARMSCOPER basis)
- **Communication and engagement** - ability to share data to a village / town / river level without data protection / licensing issues.
- **Confidence in models and ability to communicate and engage stakeholders is crucial**
  It is experienced people on the ground that matter most

List of workshop participants (pm)

Name	Affiliation
Chloe Onoufriou	NERC
James Dowling	Welsh Government
Nicola Dunn	NFU
Stuart Kirk	EA & Defra
Vince Carter	Forestry Commission
Victor Aguilera	Defra
Bridget Emmett	CEH
Dave Rafaelli	York
Janette MacDonald	CREW
Lucy Reid	WICS
Judith Stuart	Defra
Phillip Anderson	DWQR
Oliver Edmonds	Defra
Mara Waters	Defra
Susie Willows	Defra
Wendy McKinley	DoE NIEA
Dan McGonigle	Defra
David Kay	Aberystwyth
Luke Pearson	United Utilities
Alex Martin	Wessex Water
Joff Edevane	Anglian Water
Simon Eyre	Anglian Water
Jonny Burke	Southern Water
Alister Leggatt	Affinity Water
Zoe Frogbrook	Scottish Water
Piran White	University of York
Ed Bramley	Yorkshire Water
Russell Smith	Westcountry Rivers Trust
Adrian Collins	Rothamstead Research
Bill Crools	Scottish Agricultural Colleges
Paul Quinn	Newcastle University
Richard Williams	CEH
Mark Owen	Angling Trust
Bethanna Jackson	CEH
David Johnson	Rivers Trust
Tom Nisbet	Forest Research
Ashley Holt	Defra
Russ Money	NE
Sim Reaney	Durham University
Louise Webb	EA
Paul Bryson	EA
Paul Whitehead	Oxford University
Robert Willows	Glasgow University
Mairead Shore	Ulster
Tristan Ibrahim	Defra
Hannah Green	EA
Bob Middleton	NE
Helen Wake	NE
Mark Hallard	SEPA
Punam Khaira	SEPA
Adrian MacDonald	Leeds
Claire Allaway	Atkins
Peter Daldorph	Atkins

Sarah Dunn	James Hutton Institute
Steven Anthony	ADAS
Richard Gooday	ADAS
Jack Cosby	CEH
Andy Wade	Reading University

LM0308: Catchment Management for Water Quality

Year 2 report

April 2016

Appendix 1-E

Long list and consolidated list of stakeholder questions

Long list and consolidated list of stakeholder questions

This appendix contains the long list of questions (n = 286), collated from stakeholder consultation through the Forum Task, and the consolidated list of questions (n = 102) used by consortium and stakeholders to define the Case Studies. See the body of this report for details of the consolidation and categorization procedures.

Long List - User Group	Long List – Theme	Long List – Question Unique ID	Long List - Specific question raised
Implementer	Measures selection and optimisation	IMP_06	What is the farmers role – what is the measure for each farmer to implement, when will the measure yield benefits, convince the measure will work, what level of uptake is required, what tools best achieve uptake of measures/buy-in?
Policy	Source Apportionment	POL_10	Source apportionment and ecological impacts
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_02	Another major gap to add to your list is regarding the pollution contribution via drain flow. We know a lot of pollutant transfer happens via drains but have very limited / no effective measures to address this. Ideally we would like a range of sensible practical mitigation measures for this pathway to use in addition to those we have to address things at source. For example: IN ditch wetlands, 3d buffers, end of field corner wetland . I am aware of work at Newcastle University at Nafferton farm on the use of in ditch systems with p stripping but don't have the detail of this
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_21	As the Environment Agency does not routinely monitor Drinking Water Protected Areas (DrWPAs) for bacterial contamination, we rely on water companies to monitor their supplies and alert us if they detect an issue. FIOs can cause pollution of drinking water sources and present a risk to human health
Policy	Source-Pathway-Receptor Evidence	POL_14	Primary research into biological response (thresholds, resilience, recovery characteristics)
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_38	need to better understand the relationship between hydromorphological functioning and good ecological status
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_39	Suitable end-points. Lack of evidence around ecological response and ecological benefit
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_40	A better link between chemical change and ecological change
Water industry	Source-Pathway-Receptor Evidence	WIND_12	Can the ecological benefits of measures be modelled to help identify where best to apply measures

Long List - User Group	Long List – Theme	Long List – Question Unique ID	Long List - Specific question raised
Policy	Source Apportionment	POL_15	How to move away from concentration based limits to ecological limits? How long could the ecology take to respond to improvements? How sensitive is the ecology to changes in the environment. How will climate change alter the baseline for "good" status?
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_01	Bringing the evidence baseline for FIOs up to the standard of other pollutants
Water industry	Source-Pathway-Receptor Evidence	WIND_03	Can a consistent modelling approach be developed to look at sources of pesticides and their transport to receptors (e.g. surface water abstractions and boreholes).
Water industry	Source-Pathway-Receptor Evidence	WIND_01	Can high risk contaminant sources in specific environments be identified (influence of soil types, hydrology, rainfall, cropping patterns, farming practices such as tillage and under-drains, topographic features such as slope and proximity to water courses);
Water industry	Source-Pathway-Receptor Evidence	WIND_05	Can models be used to help decide where to invest in sampling and other evidence gathering?
Water industry	Evidence of outcome	WIND_04	Can models help to target measures and provide an estimate of the level of confidence that they will work – no point in investing customers money if uncertainty high
Water industry	Effectiveness of measures / mechanisms	WIND_08	Capture uncertainty in effectiveness of measures – understanding timescales of response and implications for economics
Policy	Effectiveness of measures / mechanisms	POL_09	Catchment scale useful for optimising uptake – then upscale. What is the level of uptake required? And where?
Catchment Planner / regulator	Future pressures and extrapolation of impacts	CP/R_23	Climate change impacts on river flow up to 2030–2050 are too uncertain to base any forecasts on impact on annual average concentrations in watercourses. The impact of forecast population change to 2030 needs further consideration although the current presence of ubiquitous chemicals from wastewater treatment works may mean that there will be little change to status

Long List - User Group	Long List – Theme	Long List – Question Unique ID	Long List - Specific question raised
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_28	Combinations of pressures – we need to understand more about the effects of pressures acting in combination on a water body (such as abstraction, barriers to fish migration and sediment).
Implementer	Contextualisation of the problem and solution	IMP_04	Conceptual model – persuasion there is a problem and why? Verification to support underlying beliefs. (Scored poorly)
Policy	Decision support	POL_04	Decision Support Tool – Multi-sector/pressure/response with (or that can link to) cost-benefit/cost-effectiveness for appraising policy options. Needs to be spatially explicit and incorporate social models/behaviour change. 'Where do I get most bang for buck' - Scenarios a. Criteria (including social and legal) need to be agreed up front for model acceptability b. Baseline and temporal contingencies (i.e. incorporation of external factors) are a critical component e.g. links to WFD no deterioration requirement c. Need buy-in from audience at different levels/scales – how? What does Good Ecological Status mean in terms of recreation? Investment in achieving moderate status is likely to have greater benefits than getting to good
Water industry	Source-Pathway-Receptor Evidence	WIND_07	Develop' protocols for risk assessment and mapping
Catchment Planner / regulator	Measures selection and optimisation	CP/R_32	Development of measures to control and mitigate the impacts of invasive species
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_17	Evidence is not available on the effectiveness of specific measures on reducing pressure from ammonia and BOD. For example the impact of Catchment Sensitive Farming and Environmental Stewardship schemes on reduced pressure from sanitary pollutants
Catchment Planner / regulator	Effectiveness of measures / mechanisms	CP/R_30	Flow regulation – we need to gather more evidence on the effectiveness of various mitigation measures for heavily modified river systems.

Long List - User Group	Long List – Theme	Long List – Question Unique ID	Long List - Specific question raised
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_33	For all species we need more information on the pathways of introduction and ecological impacts
Policy	Future pressures and extrapolation of impacts	POL_07	**Future proofing –** climate change and other impacts
Implementer	Evidence of outcome	IMP_08	How can we achieve final sign off by the regulators, but focus on benefits?
Water industry	Source-Pathway-Receptor Evidence	WIND_09	How do measures affect peaks?
Water industry	Model / data awareness, availability and application	WIND_06	How do we get repeatable outputs from models? Calibration, consistency, good practice, model development protocols, learning from other fields
Catchment Planner / regulator	Evidence of outcome	CP/R_41	Need to capture actual data on effectiveness of measures as this then reinforces model outputs when convincing farmers who often distrust models until verified by data.
Policy	Evidence of outcome	POL_16	Trialling and demonstration with detailed monitoring before/after recommendations put in place in order to validate/refine modelled approaches. Accounting for uncontrollable variables when analysing results from trials into models – e.g. weather variations.
Implementer	Evidence of outcome	IMP_09	Data so that we can ground truth modelling outpus. This includes EA data but also data from local partnerships.
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_42	Evidence of the problem – data from monitoring can be sparse or monitoring locations not ideally placed. • Insufficient evidence for the relative importance of different sources
Implementer	Source-Pathway-Receptor Evidence	IMP_10	need real data, not just modelled oupuyts
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_43	A national scale verification of point source locations (main concern would be water company assets)

Long List - User Group	Long List – Theme	Long List – Question Unique ID	Long List - Specific question raised
Policy	Uncertainty, confidence and communication	POL_17	How wrong would we be? Using different data sets e.g. agricultural census versus farm specific data or using real-time stream sensors versus grab samples not in terms of estimated load etc but in terms of the need and type of intervention
Catchment Planner / regulator	Effectiveness of measures / mechanisms	CP/R_44	How effective is the current programme? How far will existing national policy get us and what more is needed?
Catchment Planner / regulator	Effectiveness of measures / mechanisms	CP/R_45	What is the impact of existing national policy on a specific catchment?
Catchment Planner / regulator	Effectiveness of measures / mechanisms	CP/R_46	Need to model not just the efficacy of measures but also a certain % uptake or "messiness" factor – assuming not everyone will do the measures, or do them right. Need to be able to play tunes on this in terms of scenarios of uptake and the outcome range it could result in. (sensitivity analysis)
Catchment Planner / regulator	Effectiveness of measures / mechanisms	CP/R_47	Planning timeframe scenarios need to be modelled to show land management measures longevity for example – what will the effect be in 5 yrs compared with 25 years and this will help provide drivers for longer policy planning horizons as well as give farmers an idea of length of sign-up. Many measures are actually a culture shift rather that just specific actions for a discreet amount of time and then back to old ways
Catchment Planner / regulator	Effectiveness of measures / mechanisms	CP/R_48	Scenario modelling needs to let us understand how fast, how far and how effective we need to be – it may be a low level of action across the catchment or it may also be a high level of action in specific areas, e.g. source protection zones. Also need to be able to model what you can achieve for a specific amount of money.
Policy	Effectiveness of measures / mechanisms	POL_18	With regards to NELMS we will need to be able to measure the impact of specific measures
Policy	Effectiveness of measures / mechanisms	POL_19	potential efficacy of measures

Long List - User Group	Long List – Theme	Long List – Question Unique ID	Long List - Specific question raised
Implementer	Effectiveness of measures / mechanisms	IMP_11	how we measure the benefits of say using buffer strips to contain ag diffuse or suds for urban diffuse on a catchment basis
Implementer	Effectiveness of measures / mechanisms	IMP_12	need data on where are we in terms of meeting baseline info; then on top of that other models look at incentivised
Implementer	Effectiveness of measures / mechanisms	IMP_13	need to understand the measures pick list and how far they will get us over and above the regulatory baseline e.g. CSF or agri-environment - how far will that get us towards GES?
Policy	Effectiveness of measures / mechanisms	POL_20	Need to understand the relative impacts of different types of policy instrument e.g. regulations, voluntary measures, incentivised
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_49	Data on catchment management actions is patchy and scheme-specific. You cannot recommend measures until you know exactly what is in place already
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_50	Data on farm assets is also hard to obtain. CSF, EA, Rivers Trusts record actions taken by farmers but we don't readily record the quality of those installations or management
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_51	ELS/HLS/CSF/EA/Rivers Trusts all record information on farm visits. A data standard to allow this data to be combined would be useful
Policy	Effectiveness of measures / mechanisms	POL_03	How effective is catchment management at improving water quality and maintaining water supply? Can we detect long term changes in raw water quality?
Policy	Environmental economics / socio-economics	POL_21	Spatial differences in costs to farmers for instance is important
Catchment Planner / regulator	Environmental economics / socio-economics	CP/R_52	the cost-effectiveness of diffuse pollution measures at a catchment rather than site scale
Catchment Planner / regulator	Measures selection and optimisation	CP/R_53	Insufficient grasp of the scale and nature of catchment interventions required – a clearer pathway to achieving the objective in any given catchment. Requires better predictive tools for assessing effectiveness of measures

Long List - User Group	Long List – Theme	Long List – Question Unique ID	Long List - Specific question raised
Policy	Environmental economics / socio-economics	POL_22	Cost benefit - will it work and how much is it going to cost?
Water industry	Environmental economics / socio-economics	WIND_13	Important to model costs of measures as well as impacts to feed into business planning (e.g. technical feasibility of measures, disproportionate costs)
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_54	how we relate nitrogen air pollution loads to in lake total N targets. So how much of that deposited in the catchment reaches a lake
Policy	Source Apportionment	POL_02	How will climate change alter the baseline for "good" status?
Catchment Planner / regulator	Future pressures and extrapolation of impacts	CP/R_55	Impact of the future on WQ – e.g. agricultural intensification and climate change – need to understand how this will affect multiple parameters N, P, Sediment.
Implementer	Source-Pathway-Receptor Evidence	IMP_03	Inaccurate records / insufficient means of recording structures, highways inputs, and INNS
Catchment Planner / regulator	Integration / focus / scaling	CP/R_56	Need the ability to have multi objective models and integration but not lose the resolution of single focus where there may be a localised and specific issue.
Catchment Planner / regulator	Integration / focus / scaling	CP/R_57	Integration of models across different water categories – especially important e.g. bathing waters and near shore issues where for example FIOs are an issue and the source (and controls) are further up the catchment.
Catchment Planner / regulator	Integration / focus / scaling	CP/R_58	Tools should be tailored towards identifying synergies between policy areas
Policy	Integration / focus / scaling	POL_23	Impact of spatial targeting of measures and having the evidence base available to justify spatial targeting

Long List - User Group	Long List – Theme	Long List – Question Unique ID	Long List - Specific question raised
Policy	Measures selection and optimisation	POL_24	the potential trade-off in one outcome (e.g. biodiversity) when optimising for another, (say water quality). Are there datasets out there that could inform a model which seeks to quantify the level of synergy that could be delivered by options? And to what degree is the level of environmental outcome achieved compromised when trying to deliver multiple benefits through options? And does this relationship vary depending on different circumstances e.g. landscape/catchment type, farming system, scale of intervention? • For example, could ecological network and pollution pathway catchment models be integrated to quantify the level of synergy delivered and possibly seek to identify how to optimise for both?
Policy	Measures selection and optimisation	POL_25	Need to understand the wider benefits – models / datasets need to do this either as a new dataset or by integration
Policy	Measures selection and optimisation	POL_26	Biodiversity perspective – synergies between WQ and biodiversity needed ; targeting measures for multiple wins; catchment opportunity mapping (tailor A-E based on this where WQ is target rather than biodiversity – co delivery opportunities etc)
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_59	Integrating hydrological routing with pollution modelling – hydrologists are hardly ever involved in developing pollution models, and environmental chemists are never involved in hydrological modelling. Since pollution pathways are so important this issue is critical for developing better models
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_60	Integrating simulation of point and diffuse loads – we shouldn't have any more investment in models that only deal with one or other. We need models with equal resolution of both

Long List - User Group	Long List – Theme	Long List – Question Unique ID	Long List - Specific question raised
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_61	Models that try and do everything (at least in a useful way) can be too expensive or time-consuming to use. Modularising catchment and in-water models, which can then link up where necessary, is probably the best approach. Also, if you have a decent handle on the chemical dose- biological response/risk (e.g. through research models or observational/experimental research) then operationally you can focus on pollution load/concentration as the end-point
Policy	Source-Pathway-Receptor Evidence	POL_27	Other pressures including urban and morphology will need to be included
Policy	Source Apportionment	POL_01	Is good status achievable with all the other demands on the environment?
Catchment Planner / regulator	Uncertainty, confidence and communication	CP/R_07	It is difficult to know **the extent to which ongoing research will close evidence gaps**
Catchment Planner / regulator	Effectiveness of measures / mechanisms	CP/R_18	It is not possible to assign the proportion of water company improvement that relates directly to reduced pressure from sanitary pollutants
Consultant	Source-Pathway-Receptor Evidence	CONSULT_03	key question for ecological impact – under what circumstances will higher P result in excessive growth – models need to be able to predict this and correlate with WFD compliance. Even in the total biomas growth it may matter a lot exactly which organisms are going barmy – e.g. toxic blue greens much more serious than some macrophytes – is this so??, what are the other factors??
Implementer	Measures selection and optimisation	IMP_05	Land management and use/what do we target? Triage phase. (Not being dealt with elsewhere)
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_37	Land use and management change beyond agriculture e.g. forestry
Implementer	Source-Pathway-Receptor Evidence	IMP_02	Limited information about the true status of our Trac waters and marine waters, and their connections to the river ecosystem
Policy	Integration / focus / scaling	POL_13	Link local and national models

Long List - User Group	Long List – Theme	Long List – Question Unique ID	Long List - Specific question raised
Policy	Evidence of outcome	POL_12	Link models to monitoring
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_08	Links between P (in its different forms) and **ecological responses** are complex. This leads to uncertainty in deriving standards, and the need for a weight of evidence approach to confirming eutrophication.
Catchment Planner / regulator	Contextualisation of the problem and solution	CP/R_62	Simple web based tools for viewing key GI datasets at catchment and sub catchment level
Catchment Planner / regulator	Contextualisation of the problem and solution	CP/R_63	There is a distinct lack of easy to use and explain visualisation tools
Implementer	Contextualisation of the problem and solution	IMP_14	We've also shared a GIS project with pre-prepared legends, map templates and guidance notes: http://www.catchmentbasedapproach.org/images/PDFS/CaBAGISDataPackageGuidancev3.pdf
Implementer	Contextualisation of the problem and solution	IMP_15	Need Visualisation – pre-prepared GIS legends for model outputs – e.g. group layers showing PSYCHIC outputs with full descriptions of fields and attributes, and clear labels. Formatted for main GIS packages
Catchment Planner / regulator	Evidence of outcome	CP/R_64	Examples of how models have led to action and outcomes
Implementer	Model / data awareness, availability and application	IMP_16	access to reports e.g. UKWIR reports - for free.
Catchment Planner / regulator	Model / data awareness, availability and application	CP/R_65	Getting away from data and product licensing and moving to open source code
Catchment Planner / regulator	Model / data awareness, availability and application	CP/R_66	Access to information: data and models and IPR and capability - EA bottleneck

Long List - User Group	Long List – Theme	Long List – Question Unique ID	Long List - Specific question raised
Implementer	Model / data awareness, availability and application	IMP_17	Need visibility of what's been used to make decisions on - core datasets on compliance, lidar, RPA etc - actual data not estimated data - all the bits of data that go into classification and coming up with a classification for example. Also, REASONS FOR FAILURE data
Implementer	Model / data awareness, availability and application	IMP_18	need to have access to SAGIS
Catchment Planner / regulator	Model / data awareness, availability and application	CP/R_67	National databases to be more accessible for example the EA WIMS and WISKI databases
Catchment Planner / regulator	Model / data awareness, availability and application	CP/R_68	the project would be best concentrating on access to the different models and any data needed to go into the models, but also any modelling runs/outputs, so that work does not need to be redone if the run has already been undertaken
Implementer	Model / data awareness, availability and application	IMP_19	Some Trusts have been involved in projects where modelling had been undertaken and have found limiting factors to include: insufficient funding to expand modelling beyond pilot areas, and lack of capacity to re-run models with updated data sets (absence of funding, or no access to the models / software
Implementer	Model / data awareness, availability and application	IMP_20	Most of the models which rivers trusts have used most successfully to support decision-making, including ECM+, Scimap and Farmscoper are freely available, the input data are relatively easy to obtain and/or affordable and we have been able to work closely with the model developer to build and extend understanding, and to train lots of people in how to use the model. Free open source software and making training videos available online has helped a lot.
Implementer	Source-Pathway-Receptor Evidence	IMP_21	need access to fundamental data and information, not really models e.g. catchment walkover data etc complinace data from RPA.

Long List - User Group	Long List – Theme	Long List – Question Unique ID	Long List - Specific question raised
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_69	Make sure the existing models are updated with new data. As you know we had this problem with SAGIS using old Ag census and point source data, which makes it meaning less if you then wasn't to communicate and use the results to influence people on the ground as it is not credible
Implementer	Source-Pathway-Receptor Evidence	IMP_22	Access to / a better understanding of CSF modelling work would be good to show likely routes of erosion and areas susceptible to erosion, and to demonstrate these to wider stakeholders, landowners and others
Implementer	Uncertainty, confidence and communication	IMP_23	Need to understand what goes into SAGIS so the input datasets from PSYCHIC and also the flows datasets
Implementer	General points	IMP_24	need interim model outputs, not just the final model outputs
Catchment Planner / regulator	General points	CP/R_70	I would not want the project to spend loads of time trying to integrate models together, as although this may be useful, I don't think there is any point until we have done the above first (improve access, improve documentation on models and make sure models are updated with most recent data e.g. ag census) and make the most of what we already have. I would have thought that the above would be plenty to try to tackle in your project, as I think that alone is quite a tall order from my experience
Water industry	Model / data awareness, availability and application	WIND_14	How do we make data (who does what, where, when) more readily available (and up to date e.g. from water companies). What about qualitative data?
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_11	Measurements and predictions of nitrate loading to the environment, and the benefits of diffuse pollution control measures have a high level of uncertainty. We can measure nitrate concentrations in waters, but this doesn't necessarily help make the cause and effect link between sources and the effectiveness of measures

Long List - User Group	Long List – Theme	Long List – Question Unique ID	Long List - Specific question raised
Catchment Planner / regulator	Contextualisation of the problem and solution	CP/R_71	Outputs of models need to be couched in a way that reaches individual stakeholders – e.g. for the farming industry the currency of discussion needs to be profitability, not necessarily Kg phosphate / year for example. Costs and benefits are difficult to measure and express in a common currency across sectors but if we're going to get shared ownership of the problem and solutions at a catchment level this needs to happen.
Catchment Planner / regulator	Contextualisation of the problem and solution	CP/R_72	The ability to value the benefits in a way communities can fully understand, engage with and take on board
Policy	Contextualisation of the problem and solution	POL_28	Need to contextualise issues: e.g. damage costs of N& P
Policy	Source-Pathway-Receptor Evidence	POL_05	Morphology is a major pressure – can models help e.g. predict link to ecology?
Consultant	Decision support	CONSULT_04	Need more emphasis on the ability to model the solutions such as farmscoper or the SAGIS IT tool for optimisation and economic impacts on multi sector basis against WFD standards (however they are expressed). The ultimate aim of all of this will after all be to use models to find the optimal solutions, cost them and get them in an agreed programme of measures
Catchment Planner / regulator	Contextualisation of the problem and solution	CP/R_73	Decision support tools (including models) which fit with stakeholder engagement processes (i.e. technical modelling needs to fit with engagement work – and not be separate) but also decision support tools that do not require vast amounts of monitoring data to use, and can factor in anecdotal evidence from stakeholders. Better integrated decision support tools, which can run on commonly available platform(s) and don't need specialist skills or resources
Policy	Decision support	POL_29	Need to be able to combine model outputs into a decision making tool that visualises and communicates the weight of evidence used in decision making

Long List - User Group	Long List – Theme	Long List – Question Unique ID	Long List - Specific question raised
Catchment Planner / regulator	Decision support	CP/R_74	Integrating the various separate decision making processes and different action schemes (e.g. point source control versus diffuse pollution, and water quantity with quality and flood risk). Some of these systems tend to be dominated by national, top down decision making processes (e.g. Water Industry Price Review process) where as others (e.g. river restoration schemes) are very bottom up. We need an integrated decision making framework that operates at the three main levels for water planning, national, River Basin District and Catchment. This framework is required as a first step at the policy level so we understand what it is we are trying to achieve. Once we understand this we can then develop appropriate decision support tools (including modelling).
Policy	Decision support	POL_30	Decision support tools designed with cost benefit and societal decision making in mind - the inputs of which can be informed in part by modelling outputs
Catchment Planner / regulator	Environmental economics / socio-economics	CP/R_75	Economics and social side of catchment planning of measures – how to approach the polluter pays principle and balance that across economics and social aspect of specific catchments where agriculture for example may be the heart of the catchments economy.
Catchment Planner / regulator	Environmental economics / socio-economics	CP/R_76	Economics data is normally top-down coming from a national dataset, however when planning at a catchment level it is more appropriate to use local economics information and upscale; in this way, stakeholders can see that local level economic considerations are taken into account in catchment planning rather than standard-national level data.
Catchment Planner / regulator	Environmental economics / socio-economics	CP/R_77	Scenario modelling of sector financial impacts – not just agricultural sector but all sectors contributing

Long List - User Group	Long List – Theme	Long List – Question Unique ID	Long List - Specific question raised
Policy	Environmental economics / socio-economics	POL_31	Above needing a focussed R&D effort with a clear end point in mind- that being societal choices informed by a better understanding of costs benefits and trade-offs
Policy	Decision support	POL_32	Need stuff that helps make decisions – cost effectiveness and decision support
Catchment Planner / regulator	Inclusion of local catchment characteristics, objectives and data	CP/R_78	We need a national level framework in terms of core datasets and models to use in catchment planning, but with the ability to combine local level data and thereby improve the weight of evidence to achieve local persuasion.
Catchment Planner / regulator	Inclusion of local catchment characteristics, objectives and data	CP/R_79	Need a way of factoring in local level knowledge e.g. behaviour of certain farmers when predicting the measures effectiveness (again, linked to the "messiness factor"
Catchment Planner / regulator	Inclusion of local catchment characteristics, objectives and data	CP/R_80	Models need to be able to be adjusted in terms of input data to fit specific catchments – e.g. take account of actual numbers of cows, % dairy etc so that planning can happen on a catchment –specific basis rather than a "standard" farm type e.g. how FARMSCOPER works
Catchment Planner / regulator	Inclusion of local catchment characteristics, objectives and data	CP/R_81	Policy area priorities need to be set at a local scale – e.g. bankside grazing exclusion to protect water quality can jeopardise certain biodiversity objectives e.g. for vegetation management for damselfly. Local and site specific priorities need to be captured and considered when picking suitable measures
Implementer	Integration / focus / scaling	IMP_25	National level models can be inaccurate when applied at the local level, either as local datasets are more or less detailed than national sets
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_82	Insufficient detail on the spatial distribution of risks to be able to plan well targeted catchment interventions.

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Consultant	Source-Pathway-Receptor Evidence	CONSULT_02	Need to be clear that problem is excessive biological activity not P conc per se. Therefore need to understand conditions leading to this. Account not just chemistry but residence times / temperature and light intensity – function of weather and shading. – any other factors?? E.g. seed populations coming from releases from ponds or canals of high residence then multiplying in river which was otherwise flushed clean.
Consultant	Source-Pathway-Receptor Evidence	CONSULT_01	On good status / moderate, regarding P will depend on UKTAG definitions of respective P concs for given settings. Also for P if not good status then may not really make a difference because P need to be below a threshold – I don't think this is a linear relationship so need to be clear about the nature of the thresholds of P and N or others on removing limits on the growth of different nuisance species – I assume there are ranges for different organisms
Catchment Planner / regulator	Future pressures and extrapolation of impacts	CP/R_10	Potential effects of **future trends** such population growth, climate change; land use change, food security and nutrient supply need to be better quantified
Catchment Planner / regulator	Evidence of outcome	CP/R_16	Sediment pressures are assessed by a link to biological element failures, we do not routinely monitor sediment run-off or in-river siltation, so there is limited collation of regional-to-national data available. This also relates to Natura 2000 sites
Policy	Environmental economics / socio-economics	POL_08	Social and economics important – optimising uptake
Policy	Environmental economics / socio-economics	POL_33	Need to understand the social science side of why choose which policy mechanism and how those decisions affect uptake in different areas
Catchment Planner / regulator	Source Apportionment	CP/R_83	Need a way of modelling not just sector responsible but activities within that sector. Activity -> behaviour -> response

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Catchment Planner / regulator	Source Apportionment	CP/R_84	Source apportionment – need this to be available and not just spatially distributed along the river but also temporally and how the apportionment changes under different flow and weather conditions. This is an important link because depending on the temporal response of the pollutant / sources, the selection of specific measures will be different.
Policy	Source Apportionment	POL_34	Diffuse vs. point source contributions – the difficulties in source apportionment when there are still unknowns in the data: is the problem being overstated due to lack of data, is the data biased in any way?
Policy	Source Apportionment	POL_36	Still don't fully understand the diffuse component of pollution – is everything from unknown (and potentially point sources) attributed to diffuse? What activities are causing diffuse pollution and how much can it be reduced to? What biogeochemical processes are going on in the whole system that might look like "diffuse" pollution?
Consultant	Source Apportionment	CONSULT_ 05	Important to consider the source apportionment between agricultural and agricultural sources because of the disproportionate impact of STW outputs which even if not as great as annual average are critical in low flows when they make up more of flow. Also effluent higher proportion of soluble P than runoff which the TP may have large part sediment attached and not as active. This could be more explicitly expressed – especially to draw on work of Mike Bowes of CEH
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_85	The temporal aspect of issues. A failure of an EQS in summer will need a different remedy to a failure in the winter, yet we use annual averages most of the time. Linked to this the frequency distributions of diffuse inputs could be better understood
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_86	A frequency-duration curve of modelled diffuse inputs or similar
Policy	Source Apportionment	POL_37	Source apportionment within the agricultural sector is needed

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Catchment Planner / regulator	Contextualisation of the problem and solution	CP/R_87	It's about convincing both farmers and Defra (or equivalent)
Policy	Contextualisation of the problem and solution	POL_38	anything that is done needs to carry all the interested parties and we need the tools to explain and contextualise issues: Need to take an approach that uses the technology as a decision support and puts it into a context for consumption by non specialists
Policy	Contextualisation of the problem and solution	POL_39	it's about benefits and options now – the number crunching needs to support a conversation couched in those terms
Policy	Contextualisation of the problem and solution	POL_40	Decision support tools that can be used for combinations of measures that are transparent and accessible to all stakeholders and delivery partners
Policy	Contextualisation of the problem and solution	POL_41	Decision support tools designed with stakeholders in mind
Implementer	Contextualisation of the problem and solution	IMP_26	need to be able to share data with stakeholders in a way that engages them
Implementer	Contextualisation of the problem and solution	IMP_27	need to visualise data and evidence of the problems and solutions and be able to show people on the fine scale e.g. river reach, field etc. - spatial resolution very important in local engagement and impact
Implementer	Contextualisation of the problem and solution	IMP_28	Sometimes getting the message across is more important than whether the model actually works or not
Catchment Planner / regulator	Contextualisation of the problem and solution	CP/R_88	Better tools for explaining and visualising what we do know – i.e. that help the conversation with local stakeholders on what the problems are in a catchment and what the most cost-beneficial solutions might be
Catchment Planner / regulator	Effectiveness of measures / mechanisms	CP/R_89	Catchment planners want tools to translate national policies at the local scale and to get local support
Catchment Planner / regulator	Evidence of outcome	CP/R_90	Need a way of Justifying significant investment to achieve outcomes that are uncertain and won't be realised for several political cycles

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Catchment Planner / regulator	Uncertainty, confidence and communication	CP/R_91	There are issues around confidence of models and underlying data and we need to be able to communicate confidence in a way that convinces stakeholders that the model may not be perfect, but it's good enough.
Catchment Planner / regulator	Uncertainty, confidence and communication	CP/R_92	Tools need to be multifunctional to allow the wide array of catchment stakeholders to come together and engage, rather than sector specific. A shared understanding of the problem and a shared evidence base of the potential solutions for discussions to go ahead.
Implementer	Uncertainty, confidence and communication	IMP_29	it's about having the confidence in a model to be able to stand by it in the public eye.
Policy	Uncertainty, confidence and communication	POL_42	Stakeholders need to be able to see what's gone into justifying a policy
Implementer	Uncertainty, confidence and communication	IMP_30	Confidence in how to interpret and combine datasets is a big barrier for non-specialists
Catchment Planner / regulator	Effectiveness of measures / mechanisms	CP/R_12	The extent of the gap between where current measures will take us and WFD objectives is not well quantified, and a large programme of investigations is ongoing
Water industry	Source-Pathway-Receptor Evidence	WIND_02	the fate and behaviour of specific contaminants in the environment (use, timing and methods of application, leachability, persistence, bidegradation etc)
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_22	The limitations of the monitoring programme means that our understanding of the presence or otherwise of chemicals in the environment is patchy, especially for those that enter watercourses via diffuse routes
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_20	The majority of bathing waters and shellfish waters that have problems, have multiple diffuse sources of FIOs. The main evidence gap is identifying where the FIOs are coming from, which is very difficult as there are so many potential pathways and sources

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Implementer	Source-Pathway-Receptor Evidence	IMP_01	the need for more work on septic tank locations and their contribution to water pollution, on highways inputs, and on sub-surface land drainage systems, both from a Water Quality perspective but also in relation to their contribution to flood peaks.
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_13	There are currently no formal nitrate standards for lakes and other freshwaters within the WFD although there are thresholds in the Defra/EA methodology for the Nitrates Directive
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_25	There are currently significant gaps in our understanding of species/habitat/pressure relationships
Catchment Planner / regulator	Effectiveness of measures / mechanisms	CP/R_26	There are currently significant gaps in our understanding of the costs and effectiveness of hydromorphological improvement measures
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_03	There are significant uncertainties in many cases regarding **ecological responses** to pressures and as a result to measures, both in terms of the magnitude and the time scales of response
Catchment Planner / regulator	Evidence of outcome	CP/R_34	There are still concerns over whether sustainable ecological recovery will occur. Water quality improvements have not always resulted in a corresponding recovery in freshwater biological communities. This lack of improvement has been linked to land management and peaks in acidity during rainfall events
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_24	There is a great deal more we can and are doing to improve our understanding of the nature and impacts of hydromorphological pressures on aquatic ecosystems
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_19	There is limited evidence to clearly link the long term effects of activities that cause sanitary pollution to ammonia and BOD pressures on the water environment.
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_27	This information is being updated but the lack of data on the extent and nature of physical modification pressures is a cause of major uncertainty

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Policy	Evidence of outcome	POL_11	Time lags
Catchment Planner / regulator	Environmental economics / socio-economics	CP/R_05	We are uncertain about the **relative cost-effectiveness of measures** to deal with many pressures. Uncertainties relate both to technical effectiveness and costs
Catchment Planner / regulator	Future pressures and extrapolation of impacts	CP/R_06	We do not enough about how **future trends** of population and climate will affect pressures
Catchment Planner / regulator	Effectiveness of measures / mechanisms	CP/R_15	We have little field data to verify the effectiveness of measures across wide scales such as catchments, and the contributions of different pathways can make a significant difference to load reductions.
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_14	We know that sediment pressure acts in combination with other pressures such as morphology, chemicals and nutrients. However we do not fully understand how these pressures combine to affect ecological status
Catchment Planner / regulator	Environmental economics / socio-economics	CP/R_09	We lack contemporary information on damage costs of eutrophication and a recent assessment of **costs versus benefits of control options**. The latter in particular are needed, along with improved apportionment and options appraisal tools, to inform national deliberations about measures and alternative objectives
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_36	We need more event based monitoring rather than more modelling This is especially true for ecological data, sediment and pathogens such as FIOs. With the new BW directive and tighter hygiene standards for Shellfisheries we need better coverage of FIO data and more event based FIO data, we only have these from academic research projects and detailed EA investigations. We need this sort of data u/s and d/s of mitigation measures at the farm and subcatchment scale.
Catchment Planner / regulator	Future pressures and extrapolation of impacts	CP/R_35	We need to develop a better understanding of how recovery is being compounded by other stresses such as land use change and climate change

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Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_31	We need to know more about how our (generally pressure based) WFD biological tools are affected by invasive species. The UKTAG alien species group is attempting to collate available evidence (even where anecdotal) with the aim of commissioning more work and filling in gaps
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_29	We need to understand more about the role of, flow variability, in maintaining ecological integrity.
Catchment Planner / regulator	Source-Pathway-Receptor Evidence	CP/R_04	We only have limited evidence about **how pressures act in combination**. As a result there are uncertainties regarding the effectiveness of measures in dealing with multiple pressures
Implementer	Measures selection and optimisation	IMP_07	What are the co-benefits – is there a tool to help persuade farmers to enact change?
Water industry	Future pressures and extrapolation of impacts	WIND_11	What are the implications of climate change and agricultural intensification for water quality?
Policy	Model / data awareness, availability and application	POL_43	need a clear understanding of which models are available where and what they will tell us
Implementer	Model / data awareness, availability and application	IMP_31	Less IT spend and more spend on working with modellers and communications and support
Implementer	Model / data awareness, availability and application	IMP_32	need abetter background into the applicability of models and when to use them, when not to use them etc.
Catchment Planner / regulator	Model / data awareness, availability and application	CP/R_93	need very good documentation to go along with the models and any outputs/data, for example metadata, good explanation of what was done, assumptions and limitations and for the models themselves good user guides and easy to use interfaces where needed
Implementer	Model / data awareness, availability and application	IMP_33	not sufficiently aware of what is already available

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Implementer	Model / data awareness, availability and application	IMP_34	A general guide to existing models and the datasets they depend on would therefore be of benefit.
Implementer	Model / data awareness, availability and application	IMP_35	not knowing what models are out there
Implementer	Model / data awareness, availability and application	IMP_36	We've also produced or used guidance documents which are really important in flagging datasets and models which can be used – for example: http://www.catchmentbasedapproach.org/images/PDFS/WRT_ESS_Visualisation_Manual_v1-1-smaller.pdf
Implementer	Model / data awareness, availability and application	IMP_37	Need access to model developers and/or expertise
Implementer	Uncertainty, confidence and communication	IMP_38	would not feel confident defending the outputs of models due to a limited understanding of their use and limitations
Implementer	Uncertainty, confidence and communication	IMP_39	not understanding the outputs of a model and the limitations
Implementer	Uncertainty, confidence and communication	IMP_40	Understanding the information and model outputs is another big challenge particularly where outputs are shared without any explanation of the attributes or the best way to interpret and represent information
Catchment Planner / regulator	Uncertainty, confidence and communication	CP/R_94	Confidence in model outputs and underlying data needs visibility

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Policy	Uncertainty, confidence and communication	POL_44	Questions over the robustness of the various models used and their ability to replicate and predict real situations. Questions over the limitations in the data underpinning models such as spatial and temporal variations and how well these are expressed. Are all the models using the same data sets and are they based on enough data points for some of the extrapolations they are used for. Applicability of modelled/summarised/averaged data to individual locations – are they able to be used for site specific recommendations?
Implementer	Uncertainty, confidence and communication	IMP_41	Being clear on assumptions and limitations of the models so that they are used appropriately.
Implementer	Uncertainty, confidence and communication	IMP_42	not having the confidence in the predictions
Implementer	Model / data awareness, availability and application	IMP_43	What tools are available that map to elements of the problem –info in a repository is required?
Implementer	Model / data awareness, availability and application	IMP_44	Can we work with the modellers? Collaborative modelling – pair-wise working (e.g. ECM+ – farmers believed output as involved in process). Collaborate during learning phase and application.
Catchment Planner / regulator	Evidence of outcome	CP/R_95	Monitoring data and visualisation just as important as modelling
Implementer	Integration / focus / scaling	IMP_45	Being able to drill down into the data from the model
Catchment Planner / regulator	Integration / focus / scaling	CP/R_96	Ability to be able to draw down data specific to catchments
Catchment Planner / regulator	Integration / focus / scaling	CP/R_97	Tools to enable simple analysis (e.g. of WQ time series plots, summary means etc) to be run at catchment and sub-catchment scale
Policy	Integration / focus / scaling	POL_45	Need to be able to play tunes on scale
Water industry	Effectiveness of measures / mechanisms	WIND_15	Linking catchment management activities to deployable output for Water Co interventions

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Policy	Effectiveness of measures / mechanisms	POL_46	Understanding combined impact of multiple pressures, biological response, and the effectiveness of measures
Policy	Environmental economics / socio-economics	POL_47	The social side (levels of existing uptake, feasibility in convincing farmers to do it, and breakdown between different sectors) • The economics/costs – how much will it cost, will this vary between sectors • The benefits – for water quality, wider environmental and social benefits
Catchment Planner / regulator	Environmental economics / socio-economics	CP/R_98	Identification of the economic benefits of a range of best farming practices
Catchment Planner / regulator	Environmental economics / socio-economics	CP/R_99	Better grasp of the economic impacts on agriculture of raising environmental performance and reducing pollution.
Implementer	Environmental economics / socio-economics	IMP_46	we need to understand cost benefits and how these have been modelled by the EA
Policy	Environmental economics / socio-economics	POL_48	Need ESS and natural capital - and standardisation of this as it's done differently everywhere
Catchment Planner / regulator	Environmental economics / socio-economics	CP/R_100	Cost benefits need to be couched in terms of ranges rather than absolute.
Catchment Planner / regulator	Uncertainty, confidence and communication	CP/R_101	Cost benefits need to be couched in terms of ranges rather than absolute.
Water industry	Effectiveness of measures / mechanisms	WIND_16	Pesticides are a key issue for water companies but models in this area are mainly looking at risk. Important to also look at impact of measures in relation to both surface and groundwater
Catchment Planner / regulator	Ecosystem Services	CP/R_102	Use of ecosystem services to translate model outputs
Policy	Ecosystem Services	POL_49	Costs and benefits of measures that incorporate a full range of Ecosystem Services

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Catchment Planner / regulator	Ecosystem Services	CP/R_103	Understanding the cost and benefits of measures, and the value of ecosystem services (multiple outcome approaches) relative to 'single issue' approaches is a key gap
Catchment Planner / regulator	Ecosystem Services	CP/R_104	need an ecosystem services approach that can be understood and used by a broad range of stakeholders
Water industry	Uncertainty, confidence and communication	WIND_17	What are the uncertainties associated with modelling the impacts of different measures?
Water industry	Environmental economics / socio-economics	WIND_18	Prioriotisation of interventions and cost effectiveness of measures
Water industry	Source-Pathway-Receptor Evidence	WIND_10	What spatial scale should we be targeting for understanding processes and evaluating standards (don't look at water quality in isolation – bigger picture)
Policy	Effectiveness of measures / mechanisms	POL_06	When will my policy be successful? How will we know it has been successful? Need outcome indicators to show direction of travel as well as modelled prediction. Need to understand why there are deviations from modelled prediction
Policy	Contextualisation of the problem and solution	POL_51	· Morphology – links to ecological response and prediction of recovery. Confidence in current classification tool? Links to wider pressures?
Policy	Contextualisation of the problem and solution	POL_52	· Missing Measures – effective process in place. What is missing? Links to source apportionment the identification of any additional (practical) cost-effective measures
Policy	Contextualisation of the problem and solution	POL_53	· Impact of buffers on morphology – what is the relationship between buffer width and natural recovery ?
Policy	Contextualisation of the problem and solution	POL_54	· Abstraction ponds – where and what size in relation to typology and cropping?

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Regulator	Contextualisation of the problem and solution	CP/R 100	· Morphology – MIMAS tool for classification. What confidence do we have in hazard data? What is the impat of river typology? Need tools to link to ecology and predict response.
Regulator	Contextualisation of the problem and solution	CP/R 101	· Missing Measures - effective process in place. What is missing? Links to source apportionment the identification of any additional (practical) cost-effective measures
Regulator	Contextualisation of the problem and solution	CP/R 102	· Coarse and fine sediment dynamics
Regulator	Contextualisation of the problem and solution	CP/R 103	· Prediction of alkalinity for new P standards
Regulator	Effectiveness of measures / mechanisms	CP/R 104	· Impact of measures eg low P animal feeds on P inputs to waters
Regulator	Contextualisation of the problem and solution	CP/R 105	· Urban diffuse pollution – toxics
Regulator	Effectiveness of measures / mechanisms	CP/R 106	· Effectiveness of specific measure like Rural SuDS
Regulator	Model / data awareness, availability and application	CP/R 107	· Data to validate and develop SAGIS
Regulator	Measures selection and optimisation	CP/R 108	· Opportunity mapping to help target measures
Policy/Reg	Future pressures and extrapolation of impacts	CP/R 109	· Do we have long term trends and forecasts for the quality of Scotland's drinking water sources? Do we understand the impact of climatic factors on them? Raw water deterioration-fact or fiction?
Policy/Reg	Effectiveness of measures / mechanisms	CP/R 110	How can we mitigate changes in raw water quality in our catchments to minimise level of treatment required?

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Industry	Effectiveness of measures / mechanisms	WIND 19	How effective is catchment management at improving water quality and maintaining water supply?
Industry	Effectiveness of measures / mechanisms	WIND 20	Do we have the monitoring data / modelling capabilities to evaluate this?
Industry	Effectiveness of measures / mechanisms	WIND 21	How do we know when is it more cost-effective to undertake catchment management or to improve the water treatment process?
Industry	Effectiveness of measures / mechanisms	WIND 22	How does this effectiveness vary with different water quality parameters and different measures?
Industry	Future pressures and extrapolation of impacts	WIND 23	Does this affect both short term and long term changes in water quality / water supply?
Industry	Effectiveness of measures / mechanisms	WIND 24	How can we ensure implementation of catchment management measures? What approach should be taken to achieve this, e.g. increased regulation / legislation, education?
Industry	Future pressures and extrapolation of impacts	WIND 25	Can we detect long term changes in raw water quality?
Industry	Future pressures and extrapolation of impacts	WIND 26	Do we have sufficient baseline data to make this evaluation?
Industry	Future pressures and extrapolation of impacts	WIND 27	Is this changing on a temporal / spatial basis? – can we identify future risk areas?
Industry	Future pressures and extrapolation of impacts	WIND 28	Which water quality parameters are more susceptible to change?
Industry	Future pressures and extrapolation of impacts	WIND 29	How significant is this change?
Industry	Effectiveness of measures / mechanisms	WIND 30	If changes are taking place will the water still be treatable to provide a wholesome supply?
Industry	Effectiveness of measures / mechanisms	WIND 31	How best can we support and evaluate our systems model approach?

Long List - User Group	Long List – Theme	Long List – Question Unique ID	Long List - Specific question raised
Industry	Future pressures and extrapolation of impacts	WIND 32	What are the potential impacts of climate change on drinking water quality?
Industry	Contextualisation of the problem and solution	WIND 33	Which water quality parameters are at greatest risk of changing?
Industry	Contextualisation of the problem and solution	WIND 34	Can we predict these impacts both temporally and spatially?
Industry	Effectiveness of measures / mechanisms	WIND 35	Can mitigation measures help reduce this? How successful are these measures?
Industry	Effectiveness of measures / mechanisms	WIND 36	How will these changes impact on the capability of the treatment process?
Industry	Future pressures and extrapolation of impacts	WIND 37	How does changing land use impact on drinking water sources, what are the primary concerns?
Industry	Future pressures and extrapolation of impacts	WIND 38	What will be the impact of agricultural intensification on drinking water quality? What is likely to be the key pressure(s) in the future?
Industry	Future pressures and extrapolation of impacts	WIND 39	What changes in land use pose the greatest risk to drinking water quality and supply e.g. windfarms, conversion to different crop types?
Industry	Future pressures and extrapolation of impacts	WIND 40	How does this vary spatially?
Industry	General points	WIND 41	There is a need to establish better data sharing opportunities and for better links between data holders.
Regulator	Ecosystem Services		· Diffuse pollution and habitat connectivity/biodiversity
Regulator	Ecosystem Services	CP/R 111	· Knowledge gaps around FWPM
Industry	General points		· Succinct outputs needed not alleged user friendly interfaces
Industry	General points		· Impacts of climate change on measures incl regulations

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Implementer	General points	IMP 47	The data sets and the methodology used by the regulating bodies for designation should not be ignored in this process.
Implementer	General points	IMP 48	Providing a mechanism and outlining a methodology for easy access to data should be a priority
Implementer	General points	IMP 49	If the primary aim of this project is to succeed all data sets will need to conform to a clear and understood definition
Implementer	General points	IMP 50	With reference to my point on data sets one method of achieving this would be to establish, based on a regulatory data set, a real world "test" data set that can serve as a common link across the models chosen.
Implementer	General points	IMP 51	This approach will also help toward creating more realistic and transparent export coefficients which remain a necessary tool for linking mechanistic models to land management practices.
Implementer	Future pressures and extrapolation of impacts	IMP 52	1. As you know we can predict climatic trends, but this may not accurately reflect localised or extreme weather events which would increase risks to water quality. This uncertainty gives more of a focus on the need to increase farm resilience through adoption of a range of strategies which could minimise risks to water quality – so nutrient management, benchmarking and improvement in resource use (via farm carbon accounting), irrigation plans, floodplain management, farm resilience planning etc. would be key and have benefits for both the farm in terms of resource use, climate change mitigation and adaptation, plus the water environment.

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Implementer	Future pressures and extrapolation of impacts	IMP 53	1. This is a lot of data out there; the forum will be useful in highlighting the range of information, gaps and how you can add to this to make it more informative to land managers and their advisers. However as we have seen with nutrient management, adoption of these schemes and plans at the farm scale takes time; the 'win-win' approach is not always sufficient to drive demand from land mangers. The (uncertain) impacts of climate change will bring an added dimension of complexity to this.
Regulator	Contextualisation of the problem and solution	CP/R 100	· Can we demonstrate the link between land use activity and ecological water quality on a catchment specific basis?
Regulator	Future pressures and extrapolation of impacts	CP/R 101	· What is the evidence to suggest that the sustainable intensification of agriculture is achievable within the context of the targets of the WFD?
Regulator	Contextualisation of the problem and solution	CP/R 102	· Should source apportionment of nutrients also be based on ecological impact rather than just contribution to loads?
Regulator	Effectiveness of measures / mechanisms	CP/R 103	· On what basis should we prioritise catchments for the protection of aquatic ecosystems?
Regulator	Contextualisation of the problem and solution	CP/R 104	· Can we disentangle the role of multiple stressors in constraining ecological recovery?
Regulator	Contextualisation of the problem and solution	CP/R 105	· How can we target mitigation measures on a catchment/site specific basis?
Regulator	Effectiveness of measures / mechanisms	CP/R 106	· How can we resolve the challenges between the need for the targeting of mitigation measures and the difficulties in implementing and administering a targeted approach?
Regulator	Effectiveness of measures / mechanisms	CP/R 107	· How has the decline in advisory services impacted on aquatic ecosystems and our ability to protect/restore waterbodies?

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Regulator	Future pressures and extrapolation of impacts	CP/R 108	· How will climate change impact on the effectiveness of mitigation measures and the recovery of aquatic ecosystems?
Regulator	Contextualisation of the problem and solution	CP/R 109	· Can we evaluate the resilience of aquatic ecosystems and the probability of recovery?
Regulator	Contextualisation of the problem and solution	CP/R 110	· How can uncertainty in ecological outcomes be incorporated in decision making processes?
Policy/science	Integration / focus / scaling	POL 55	- Upscaling of sensitivity data from freshwater ecosystems for regional and national-scale assessments to understand the interactions between water temperature, water quality and water quantity on priority habitats and species and the regulation of water quality for the natural environment and human use. Most information is currently only available at site level.'
Policy/science	Future pressures and extrapolation of impacts	POL 56	- Exploration of the role that the environment plays, in addition to climate, in determining raw water quality; how these things may change under future climate and environmental conditions and how water quality changes may be monitored is required. The associated consequences for water provision and on priority habitats and species need to be better understood.
Policy/science	Contextualisation of the problem and solution	POL 57	- Exploration into the combined effects of climate change and the point or diffuse sources of pollutants that may lead to eutrophication and unwanted algal growth.
Policy/science	Contextualisation of the problem and solution	POL 58	- Exploration into the relationship between current abstraction rates and implications for biodiversity under drought conditions and future climate change.

Consolidated List – General Theme	Consolidated List – Translated Question
Source-Pathway-Receptor Evidence	Bringing the evidence baseline for FIOs up to the standard of other pollutants
Source-Pathway-Receptor Evidence	Another major gap to add to your list is regarding the pollution contribution via drain flow. We know a lot of pollutant transfer happens via drains but have very limited / no effective measures to address this. Ideally we would like a range of sensible practical mitigation measures for this pathway to use in addition to those we have to address things at source. For example: IN ditch wetlands, 3d buffers, end of field corner wetland . I am aware of work at Newcastle University at Nafferton farm on the use of in ditch systems with p stripping but don't have the detail of this
Source-Pathway-Receptor Evidence	Can high risk contaminant sources in specific environments be identified (influence of soil types, hydrology, rainfall, cropping patterns, farming practices such as tillage and under-drains, topographic features such as slope and proximity to water courses);
Source-Pathway-Receptor Evidence	the fate and behaviour of specific contaminants in the environment (use, timing and methods of application, leachability, persistence, bidegradation etc)
Source-Pathway-Receptor Evidence	Can a consistent modelling approach be developed to look at sources of pesticides and their transport to receptors (e.g. surface water abstractions and boreholes).
Source-Pathway-Receptor Evidence	the need for more work on septic tank locations and their contribution to water pollution, on highways inputs, and on sub-surface land drainage systems, both from a Water Quality perspective but also in relation to their contribution to flood peaks.
Source-Pathway-Receptor Evidence	Limited information about the true status of our Trac waters and marine waters, and their connections to the river ecosystem
Source-Pathway-Receptor Evidence	Inaccurate records / insufficient means of recording structures, highways inputs, and INNS
Source-Pathway-Receptor Evidence	On good status / moderate, regarding P will depend on UKTAG definitions of respective P concs for given settings. Also for P if not good status then may not really make a difference because P need to be below a threshold – I don't think this is a linear relationship so need to be clear about the nature of the thresholds of P and N or others on removing limits on the growth of different nuisance species – I assume there are ranges for different organisms
Source-Pathway-Receptor Evidence	Need to be clear that problem is excessive biological activity not P conc per se. Therefore need to understand conditions leading to this. Account not just chemistry but residence times / temperature and light intensity – function of weather and shading. – any other factors?? E.g. seed populations coming from releases from ponds or canals of high residence then multiplying in river which was otherwise flushed clean.
Source-Pathway-Receptor Evidence	key question for ecological impact – under what circumstances will higher P result in excessive growth – models need to be able to predict this and correlate with WFD compliance. Even in the total biomas growth it may matter a lot exactly which organisms are going barmy – e.g. toxic blue greens much more serious than some macrophytes – is this so??, what are the other factors??

Consolidated List – General Theme	Consolidated List – Translated Question
Decision support	Need more emphasis on the ability to model the solutions such as farmscoper or the SAGIS IT tool for optimisation and economic impacts on multi sector basis against WFD standards (however they are expressed). The ultimate aim of all of this will after all be to use models to find the optimal solutions, cost them and get them in an agreed programme of measures
Source-Pathway-Receptor Evidence	We need more event based monitoring rather than more modelling This is especially true for ecological data, sediment and pathogens such as FIOs. With the new BW directive and tighter hygiene standards for Shellfisheries we need better coverage of FIO data and more event based FIO data, we only have these from academic research projects and detailed EA investigations. We need this sort of data u/s and d/s of mitigation measures at the farm and subcatchment scale.
Source Apportionment	Is good status achievable with all the other demands on the environment? E.g. is sustainable intensification achievable within WFD targets
Source Apportionment	How will climate change alter the baseline for “good” status?
Evidence of outcome	Can models help to target measures and provide an estimate of the level of confidence that they will work – no point in investing customers money if uncertainty high
Source-Pathway-Receptor Evidence	Can models be used to help decide where to invest in sampling and other evidence gathering?
Effectiveness of measures / mechanisms	How (cost) effective is catchment management at improving drinking water quality and maintaining water supply?
Model / data awareness, availability and application	How do we get repeatable outputs from models? Calibration, consistency, good practice, model development protocols, learning from other fields
Source-Pathway-Receptor Evidence	Develop’ protocols for risk assessment and mapping
Effectiveness of measures / mechanisms	Capture uncertainty in effectiveness of measures – understanding timescales of response and implications for economics
Source-Pathway-Receptor Evidence	How do measures affect peaks? (should monitoring be load or conc based to detect change?)
Source-Pathway-Receptor Evidence	What spatial scale should we be targeting for understanding processes and evaluating standards (don’t look at water quality in isolation – bigger picture)
Future pressures and extrapolation of impacts	What are the implications of climate change and agricultural intensification for water quality?
Contextualisation of the problem and solution	Conceptual model – persuasion there is a problem and why? Verification to support underlying beliefs. (Scored poorly)
Measures selection and optimisation	Land management and use/what do we target? Triage phase. (Not being dealt with elsewhere)
Measures selection and optimisation	What is the farmers role – what is the measure for each farmer to implement, when will the measure yield benefits, convince the measure will work, what level of uptake is required, what tools best achieve uptake of measures/buy-in?

Consolidated List – General Theme	Consolidated List – Translated Question
Measures selection and optimisation	What are the co-benefits – is there a tool to help persuade farmers to enact change?
Evidence of outcome	How can we achieve final sign off by the regulators, but focus on benefits?
Decision support	Decision Support Tool – Multi-sector/pressure/response with (or that can link to) cost-benefit/cost-effectiveness for appraising policy options. Needs to be spatially explicit and incorporate social models/behaviour change. 'Where do I get most bang for buck' - Scenarios a. Criteria (including social and legal) need to be agreed up front for model acceptability b. Baseline and temporal contingencies (i.e. incorporation of external factors) are a critical component e.g. links to WFD no deterioration requirement c. Need buy-in from audience at different levels/scales – how? What does Good Ecological Status mean in terms of recreation? Investment in achieving moderate status is likely to have greater benefits than getting to good
Source-Pathway-Receptor Evidence	Morphology is a major pressure – can models help e.g. predict link to ecology? (Is there a relationship between buffer width, typology and natural recovery)
Source-Pathway-Receptor Evidence	Land use and management change beyond agriculture e.g. forestry
Effectiveness of measures / mechanisms	When will my policy be successful? How will we know it has been successful? Need outcome indicators to show direction of travel as well as modelled prediction. Need to understand why there are deviations from modelled prediction
Future pressures and extrapolation of impacts	Future proofing – climate change and other impacts
Environmental economics / socio-economics	Social and economics important – optimising uptake
Effectiveness of measures / mechanisms	Catchment scale useful for optimising uptake – then upscale. What is the level of uptake required? And where?
Source Apportionment	Source apportionment and ecological impacts
Evidence of outcome	Time lags
Evidence of outcome	Link models to monitoring
Integration / focus / scaling	Link local and national models
Source-Pathway-Receptor Evidence	Biologial / ecological / chemical responses to pressures and measures
Evidence of outcome	How does the model output relate to actual effectiveness of measures? Is the model calibrated and verified? What evidence exists for these aspects?
Uncertainty, confidence and communication	How does using different input datasets affect the model outputs and hence the evidence base upon which to base action?

Consolidated List – General Theme	Consolidated List – Translated Question
Effectiveness of measures / mechanisms	How effective are the measures both within existing baseline regulations, existing delivery mechanisms and also outside of existing delivery mechanisms? How widely are measures currently being implemented and what more is needed / can be done in order to get us to where we need to be? Are the existing measures and mechanisms enough to deliver GES given the issues around applicabiliy to different catchments, uptake and implementation efficiency and uncertainty in outcome? ie what measures may be missing from RBMP 1? (requires accuate source apportionment)
Environmental economics / socio-economics	How far can we get for a given amount of money; how far do we need to get to and by when; what's the best way of getting there and what should we do first; what kind of magnitude of intervention is appropriate ;what are the costs and effectiveness of different measures applied at different geographical scales (local - national)?
Source-Pathway-Receptor Evidence	How much air nitrogen ends up in the catchment and subsequently in the lakes?
Future pressures and extrapolation of impacts	How will future land use and climate change affect pressures e.g. N,P,Sediment in water
Integration / focus / scaling	Integration of models across receptors / objectives to identify co-benefits and trade offs; to help justify / prioritise action depending on local objectives, priorities and characteristics
Contextualisation of the problem and solution	Making information available: reports, data, models, model outputs, evidence base for model verification; visualisation
Contextualisation of the problem and solution	Model outputs need to be usable for stakeholder engagement and this means making the outptus accessible to different audiences; including visualisation, communication and couching the outputs in a language different sectors understand whilst working off a common currency across the sectors. e.g. Cost impacts of specific pressures and the cost benefits of specific measures to different sectors
Decision support	Need to be able to combine model outputs across different pressures / receptors / objectives into a simple decision making tool that sets out and communicates the weight of evidence (scientific, economic and social), visualises the issues and potential solutions and is scalable geographically and can be used for stakeholder engagement
Inclusion of local catchment characteristics, objectives and data	Need to be able to use national / standard set of models and datasets but with the ability to run it on catchment specific data and local objectives rather than just national datasets. Use data used by regulators eg in designations.
Environmental economics / socio-economics	Social science and uptake of measures / motivation and how it affects outcomes
Source Apportionment	Source apportionment tools need to go into more detail than currently (sector responsible and loads); needs to go to specific activities and be expressed temporally so that it can be taken into context with flows, rainfall, and land use activity such that measures can be targeted appropriately (what measures, applied when, and likely outcome)Should source app be based on ecological impact?

Consolidated List – General Theme	Consolidated List – Translated Question
Source Apportionment	Source apportionment tools need to go into more detail than currently (sector responsible and loads); needs to go to specific activities and be expressed temporally so that it can be taken into context with flows, rainfall, and land use activity such that measures can be targeted appropriately (what measures, applied when, and likely outcome). Should source app be based on ecological impact?
Contextualisation of the problem and solution	Stakeholder engagement for a range of audiences
Model / data awareness, availability and application	What data and models are available, what do they do, when is it appropriate to apply them, what is the uncertainty around the datasets and model outputs? where can I go to for support, who should I speak to when there is a problem or I don't understand something?
Evidence of outcome	What is any given model output based on, what is the uncertainty associated with it's prediction and how do the outputs relate to different scales of application?
Effectiveness of measures / mechanisms	What is the actual outcome of different catchment management options in terms of Water Company deployable outputs?
Effectiveness of measures / mechanisms	What is the combined impact of multiple pressures, biological response, and the effectiveness of measures
Environmental economics / socio-economics	What is the cost-benefit of specific measures within sector and across sectors and at different spatial scales, incorporating a full range of Ecosystem services and natural capital; C/B in terms of ranges rather than absolute, reflecting the uncertainty in C/B
Effectiveness of measures / mechanisms	What is the effectiveness of measures to address pesticides in water company sources? (GW and SW)
Ecosystem Services	What is the outcome of a specific measure in terms of ecosystem services, and what do ecosysem services mean to different audiences / stakeholders? Note there is isterest from flooding policy in Scotland and Scottish Natural Heritage in links beteen RBMP implementation and habitat/biodiversity benefits
Uncertainty, confidence and communication	What is the uncertainty associated with modelling the different effectiveness of measures?
Environmental economics / socio-economics	What measures should we focus on, and in what order should we approach it, for a given amount of money in order to maximise our outcome?
Effectiveness of measures / mechanisms	Can we detect and forecast long term changes in raw water quality? Is there enough baseline data? Which parameters most susceptible? Spatial and temporal factors? Future risk araes?
	Can we evaluate the resilience of aquatic ecosystems and the probability of recovery?
Contextualisation of the problem and solution	Need understanding of coarse (in river) and fine sediment dynamics (links to morphology questions)
Contextualisation of the problem and solution	How can we target mitigation measures on a catchment and site specific basis? (impact of decline in advisory services?) (resolve challenges between the need to target and the difficulties in implementing a targeted approach?

Consolidated List – General Theme	Consolidated List – Translated Question
Source-Pathway-Receptor Evidence	There are significant uncertainties in many cases regarding ecological responses to pressures and as a result to measures, both in terms of the magnitude and the time scales of response.Can we demonstrate the link between land use and ecology on a catchment specific basis?
Source-Pathway-Receptor Evidence	We only have limited evidence about how pressures act in combination. As a result there are uncertainties regarding the effectiveness of measures in dealing with multiple pressures
Environmental economics / socio-economics	We are uncertain about the relative cost-effectiveness of measures to deal with many pressures. Uncertainties relate both to technical effectiveness and costs
Future pressures and extrapolation of impacts	We do not enough about how future trends of population and climate will affect pressures
Uncertainty, confidence and communication	It is difficult to know the extent to which ongoing research will close evidence gaps
Source-Pathway-Receptor Evidence	Links between P (in its different forms) and ecological responses are complex. This leads to uncertainty in deriving standards, and the need for a weight of evidence approach to confirming eutrophication.
Environmental economics / socio-economics	We lack contemporary information on damage costs of eutrophication and a recent assessment of costs versus benefits of control options. The latter in particular are needed, along with improved apportionment and options appraisal tools, to inform national deliberations about measures and alternative objectives
Future pressures and extrapolation of impacts	Potential effects of future trends such population growth, climate change; land use change, food security and nutrient supply need to be better quantified
Source-Pathway-Receptor Evidence	Measurements and predictions of nitrate loading to the environment, and the benefits of diffuse pollution control measures have a high level of uncertainty. We can measure nitrate concentrations in waters, but this doesn't necessarily help make the cause and effect link between sources and the effectiveness of measures
Effectiveness of measures / mechanisms	The extent of the gap between where current measures will take us and WFD objectives is not well quantified, and a large programme of investigations is ongoing
Source-Pathway-Receptor Evidence	There are currently no formal nitrate standards for lakes and other freshwaters within the WFD although there are thresholds in the Defra/EA methodology for the Nitrates Directive
Source-Pathway-Receptor Evidence	We know that sediment pressure acts in combination with other pressures such as morphology, chemicals and nutrients. However we do not fully understand how these pressures combine to affect ecological status
Effectiveness of measures / mechanisms	We have little field data to verify the effectiveness of measures across wide scales such as catchments, and the contributions of different pathways can make a significant difference to load reductions.

Consolidated List – General Theme	Consolidated List – Translated Question
Evidence of outcome	Sediment pressures are assessed by a link to biological element failures, we do not routinely monitor sediment run-off or in-river siltation, so there is limited collation of regional-to-national data available. This also relates to Natura 2000 sites
Source-Pathway-Receptor Evidence	Evidence is not available on the effectiveness of specific measures on reducing pressure from ammonia and BOD. For example the impact of Catchment Sensitive Farming and Environmental Stewardship schemes on reduced pressure from sanitary pollutants
Effectiveness of measures / mechanisms	It is not possible to assign the proportion of water company improvement that relates directly to reduced pressure from sanitary pollutants
Source-Pathway-Receptor Evidence	There is limited evidence to clearly link the long term effects of activities that cause sanitary pollution to ammonia and BOD pressures on the water environment.
Source-Pathway-Receptor Evidence	The majority of bathing waters and shellfish waters that have problems, have multiple diffuse sources of FIOs. The main evidence gap is identifying where the FIOs are coming from, which is very difficult as there are so many potential pathways and sources
Source-Pathway-Receptor Evidence	As the Environment Agency does not routinely monitor Drinking Water Protected Areas (DrWPAs) for bacterial contamination, we rely on water companies to monitor their supplies and alert us if they detect an issue. FIOs can cause pollution of drinking water sources and present a risk to human health
Source-Pathway-Receptor Evidence	The limitations of the monitoring programme means that our understanding of the presence or otherwise of chemicals in the environment is patchy, especially for those that enter watercourses via diffuse routes
Future pressures and extrapolation of impacts	Climate change impacts on river flow up to 2030–2050 are too uncertain to base any forecasts on impact on annual average concentrations in watercourses. The impact of forecast population change to 2030 needs further consideration although the current presence of ubiquitous chemicals from wastewater treatment works may mean that there will be little change to status
Source-Pathway-Receptor Evidence	There is a great deal more we can and are doing to improve our understanding of the nature and impacts of hydromorphological pressures on aquatic ecosystems
Source-Pathway-Receptor Evidence	There are currently significant gaps in our understanding of species/habitat/pressure relationships
Effectiveness of measures / mechanisms	There are currently significant gaps in our understanding of the costs and effectiveness of hydromorphological improvement measures
Source-Pathway-Receptor Evidence	This information is being updated but the lack of data on the extent and nature of physical modification pressures is a cause of major uncertainty
Source-Pathway-Receptor Evidence	Combinations of pressures – we need to understand more about the effects of pressures acting in combination on a water body (such as abstraction, barriers to fish migration and sediment).

Consolidated List – General Theme	Consolidated List – Translated Question
Source-Pathway-Receptor Evidence	We need to understand more about the role of, flow variability, in maintaining ecological integrity.
Effectiveness of measures / mechanisms	Flow regulation – we need to gather more evidence on the effectiveness of various mitigation measures for heavily modified river systems.
Source-Pathway-Receptor Evidence	We need to know more about how our (generally pressure based) WFD biological tools are affected by invasive species. The UKTAG alien species group is attempting to collate available evidence (even where anecdotal) with the aim of commissioning more work and filling in gaps
Measures selection and optimisation	Development of measures to control and mitigate the impacts of invasive species
Source-Pathway-Receptor Evidence	For all species we need more information on the pathways of introduction and ecological impacts
Evidence of outcome	There are still concerns over whether sustainable ecological recovery will occur. Water quality improvements have not always resulted in a corresponding recovery in freshwater biological communities. This lack of improvement has been linked to land management and peaks in acidity during rainfall events
Source-Pathway-Receptor Evidence	We need to develop a better understanding of how recovery is being compounded by other stresses such as land use change and climate change

LM0308: Catchment Management for Water Quality

Year 2 report

April 2016

Appendix 1-F

Summary of the Third Community Forum

Summary of the Third Community Forum (January 2016)

The outputs for the day from the first Community Forum were written up and disseminated (this Appendix), but the main output from this workshop was the identification of a wider range of questions from the stakeholder attendees, structured broadly around scale (national (mainly policy and regulators), catchment (regulators and water industry) and land-holding (mainly 3rd sector organisations and other practitioners).

Catchment Management for Water Quality Forum - Workshop 3
28th January 2016 – London
Meeting Notes

The key aim of the day was to update the Forum on progress to date in developing the Case Studies and to present the initial design of the Catchment Management Platform. This will provide access to these case studies, data and models and other resources.

56 people attended the workshop from 38 different organisations; a full delegate list is supplied at the end of this document.

Bridget Emmett, as the consortium lead from CEH, gave an introductory presentation. The content of this presentation, and the other presentations mentioned herein, is not repeated in this document but the presentations have been made available to the forum via a fileshare facility.

Following this we also welcomed four guest speakers to present information on some related projects and initiatives. Faith Culshaw presented on the UK Water Partnership (http://www.theukwaterpartnership.org/) Alison Cavey presented on the WaterInnEU programme (http://www.waterinneu.org/) Prof. Richard Tiffin presented on the Agrimetrics project (http://www.agrimetrics.co.uk/) and Matt Fry (CEH) presented on the Environment Information Platform (https://eip.ceh.ac.uk/)

Following on from this, each Case Study lead gave a brief update on the development of the Case Studies:

No.	Case Study Title	Case Study Lead
1	Multiple pollutant and ecosystem services responses to land management policies and agri-environment interventions at the farm to catchment scale	Jack Cosby (CEH)
2	Effectiveness of land management policies and agri-environment interventions for reducing pollutant loads and maintaining environmental quality at the national scale	Richard Gooday (ADAS)
3	Costs and benefits of mitigation measures to reduce pollutant concentrations for the protection of drinking water in river systems upstream of intakes	P Daldorph (Atkins)
4	Effectiveness of pollution control measures under scenarios of future climate and land cover change at the catchment scale	Andrew Wade (University of Reading
5	Uncertainty in ecological responses to water quality control measures at the river basin scale	Andrew Wade (University of Reading
6	Effects of input data quality and quantity on evaluation of land management policies and agri-environment interventions at catchment to national scales	Jack Cosby (CEH)
7	Interpolation of data from catchment to national and monitored to non-monitored catchments.	Jack Cosby (CEH)

The afternoon session primarily took the form of breakout groups, followed by a feedback discussion and Q&A.

There were four breakout groups (below) with each having the opportunity to contribute to four different discussion topics

1. Feedback on **'look and Feel' of the platform**, it's **usability**, and priorities to change or add now or in the future (dependent on project resources) (discussion leads Mike Brown (CEH) and Paul Whitehead (Oxford University))
2. Feedback on **data catalogue, its usability and what is missing** (discussion leads Matt Fry (CEH) and Richard Gooday (ADAS))
3. Feedback on **how case study resources are hosted on the platform**. Have we got it right? (Discussion leads Bridget Emmett (CEH) and Peter Daldorph (Atkins))
4. Feedback on the **model database, selection tool and evaluation tool**. Would you find it useful? What is missing? (Discussion leads Jack Cosby (CEH) and Andy Wade(University of Reading))

The delegate breakout groups were as follows:

Group A	Group B	Group C	Group D
Anne Humble (Welsh Government)	**Kevin Hiscox** (UEA)	**David Rafaelli** (York Uni)	**Robert Bailie** (NIEA)
Kat Broadhead (Natural England)	**Graham Welland** (Thames Water	**Tom Nisbet** (Forestry Commission)	**Ian Skinner** (Essex & Suffolk Water)
Helen Wake (Natural England	**Simon Wightman** (RSPB)	**Michelle Walker** (Rivers Trust)	**Paul Linwood** (Southern Water)
Paul Bryson (Environment Agency)	**Sarah Hutcheon** (SNH)	**Claire Bell** (Environment Agency)	**Victor Aguilera** (Defra)
Rachel Webster (Natural England)	**Matt Pitts** (Bristol Water)	**John Bagnall** (Wessex Water)	**Richard Reynolds** (Anglian Water)
Jessica Bellarby (Lancaster Uni)	**Katharine Filby** (Severn Trent Water)	**Jennifer Thomas** (Cambridge Water)	**Rob Howells** (NFU)
Vic Morgan (NERC)	**Rachel Cassidy** (Agri-Food and Biosciences Institute)	**Nina Yiannoukos** (South Staffordshire Water)	**Juliet Kauffman** (Orion Innovations)
Rob Davies (Defra)	**Kirsten Foot** (Environment Agency)	**Jim Harris** (Cranfield)	**Steve Howe** (South East Water)
		Andy Vinten (Hutton Institute)	**Jeremy Graham** (Wessex Water)
		Mark Hallard (SEPA)	**Alwyn Hart** (Environment Agency)
			Laura Nieuwenhoven (Atkins)




Feedback from each of the discussion groups is summarised below:

1. **Feedback on 'look and Feel' of the platform, it's usability, and priorities to change or add now or in the future (dependent on project resources)** (discussion leads Mike Brown (CEH) and Paul Whitehead (Oxford University))

There were many Ideas/suggestions from the groups for setup etc.—what people would like to see, with suggestions including:

a) Ways to search the platform, for example:
   - By key words
   - By question/issue (e.g. how do you model climate change?)
   - By water type (river, lake, first order stream , whole catchment)
   - By model type (e.g. long term models (annual) , short term (weeks , monthly) or fast dynamics (daily), steady state or export coefficient or process based)
   - By scales (local, catchment, regional, national)
   - Use a Map of the UK (as per BESS) to click on applications around the country—giving person/contact who did the application- so users could contact them directly.

b) There was also the suggestion of a User Forum - so that people could exchange information, ask questions, talk to other users etc.

c) A way of providing feedback to web managers/data managers/model suppliers was suggested – including the ability to make suggestions back to developers

d) Users expressed the desire for papers, reports and user manuals

e) A downloadable document facility was suggested so people can read up about the models

f) The group identified the need for long term support and the question arose as to who will support the system in the longer term – NERC, DEFRA, EA?

g) A video was suggested - make video clips available to show people how to use the models, provide training, show mitigation measures

h) A breadcrumb trail was suggested so users can see what they have looked at

i) It was also suggested that the platform be found using a Google search – ensuring it is high up in the search returns so it is easy to find

2. **Feedback on data catalogue, its usability and what is missing** (discussion leads Matt Fry (CEH) and Richard Gooday (ADAS))

Suggestions from the groups with respect to this discussion topic included:

a) Adding a section describing common misconceptions about data availability, e.g. people thinking you cannot get detailed agricultural survey data.

b) Access to water company data (both monitoring data but also other data they hold on farm practices such as mitigation implementation – e.g. number of bio-beds installed). It was noted that Water Companies would be nervous about the inclusion of monitoring data in case it was used inappropriately.

c) Provide links to all key data sources, such as IACS (field boundary data) & agri-environment scheme uptake data. This is particularly important so that people know what is currently happening in terms of mitigation implementation (e.g. CSF, Glastir).
d) When searching the data and selecting e.g. nitrate, what is the logic behind the ordering of the list of items returned? Should this be clear in the search results (e.g. newest, greatest spatial coverage) as this may become more relevant if further data and models are added.
e) Provide additional guidance on the map search option. There are filters for data such as national coverage or catchment scale, but if you want to look for a specific area, the search feature for this is somewhere else.
f) Link to other data portals – although the metadata for some of the data items links to the other data sources, it might be nice to have an explicit link to them on the front page. Other portals include:
    - EA Catchment Data Explorer
    - EA Geostore
    - EIP
    - MAGIC
    - LLE (Welsh Government Geo-Portal)
    - SE Web
    - Catchment Sensitive Farming
g) What are the 3 datasets that have significant IPR issues? Could these be stated explicitly and the (best) alternatives to them listed, e.g. European Soils data rather than Cranfield soils data.
h) Where did the list of data on the platform come from and could this be made clearer? (the answer being that the data was identified through reviewing datasets used by the models in the project, other datasets held by the consortium members, , datasets identified at first stakeholder forum, and data identified as part of progressing Case Study development)
i) How will the data be updated? Because the meta-data is often a link to the original data owners, it is generally their responsibility to update.
j) How will the data be maintained – will people be able to edit and update the existing metadata? Will people be able to add new datasets?
k) Could there be a list of 'controlled vocabulary', such that if someone searches for "flow" they also get the results for "discharge". Such as approach has been used in the DTC.
l) Can we provide links to the UKEOF catalogue of monitoring activities and sites?
m) Will there be a testing period before the platform goes live.
n) The models state what data they have used, would it be possible to invert this, so that the data items say what models they can be used for?
o) Will there be the potential to flag up new data, or datasets in the pipeline that will be useful, e.g. new free satellite data from Sentinel 2, Landcover+
p) Could the metadata say the approximate size and format of the data to be downloaded? (There is already a place within the metadata for the format to be specified.)

3. Feedback on **how case study resources are hosted on the platform**. Have we got it right? (Discussion leads Bridget Emmett (CEH) and Peter Daldorph (Atkins))

Key points raised across all groups were as follows:

a) The relevance of the case studies beyond their local context (i.e. to other catchments) needs to be explained. Contextual information is required (also in relation to previous studies – e.g. what is new)
b) The case studies should reference where the input data comes from and its availability to the user community. This includes information on how the measures were designed/quantified. **
c) Outputs should be accessible and clear
d) As well as sharing powerpoint presentations, it would be useful if a spoken commentary/video could be provided and distributed
e) The process of developing the case study should be documented including 'lessons learnt' and 'what to avoid'.
f) Any intellectual property rights issues need to be highlighted to make clear if similar studies can readily be carried out by others
g) Trialling the tools in a small group on a 'case study' would be a useful way to test the tools
h) Project management standards for catchment studies would be useful to frame the case studies
i) Consideration needs to be given to how robust the data and models are in different contexts (planning, legal, regulatory etc.). A health warning/disclaimer would be useful to prevent the outputs being used inappropriately **
j) A set of simple questions should be present – 'How Can I? Also key words.
k) Non expert language summaries should be presented with each case study (e.g. science journalism style). Visualisation should also be simple and transparent and tested with users to make sure this is the case **
l) The user might describe their level of knowledge at the start and be directed to the appropriate content.
m) Reporting of uncertainty should be consistent and clear
n) Make clear why the catchment in the Cast Studies were chosen?
o) Make clear what outputs are designed to be used for.

(** some points were noted by more than one group, as recurring themes)

4. Feedback on the model database, selection tool and evaluation tool. Would you find it useful? What is missing? (Discussion leads Jack Cosby (CEH) and Andy Wade(University of Reading))

A number of general points were made by the groups, including:

a) The need for moderation of model reviews – who will check accuracy, should this be through Wikipedia style updates or could someone take this role on?
b) Commercial models should be included in the database;
c) It would be useful to search the model database with a Boolean string of key words
d) Include in model metadata – key assumptions, and ecosystem type (e.g. river, lake, wetland)
e) The users would welcome an opportunity to play with the web-site and provide feedback on the model and evaluation metadata;
f) Don't forget a link to the UK Environmental Observation Framework data/meta-data;
g) Useful to have a summary of model advantages and limitations as a table, rather than having to keep note of these for comparison.

Further to the more general points described, a range of specific points were also made:

h) Guidance on data format for specific models; will data be re-formatted to help ingestion into models?
i) Useful to have a forum (discussion page) to enable questions and answers, perhaps along the lines of Research Gate. Experts register for topic areas, every so often questions are mailed to those experts in a relevant topic.
j) Other suggested models to consider for ingestion included:
    - EA N-Tool
    - SCIMAP
    - Natural Capital Appraisal Tool
    - ADAS PSYCHIC, NEAP-N
    - The Integrated Model (Ian Bateman)
k) Function to help keep an audit trail of model choice
l) Make sure version of model used is documented in evaluation reports and case studies
m) Clarity on degree on coupling being achieved (e.g. linked models or truly integrated), perhaps through a schematic diagram.

Other feedback and offers of help and support were noted through an open feedback session following on from the discussion groups; this feedback primarily related to:

- The need to de-jargon and make this accessible for all levels from policy development down to catchment based approach.
- The roll out process for the platform including aspects of system testing and training; this included offers of user acceptance testing
- The future of the platform and the forum after the project has finished
- Suggestions on how to promote and communicate the Platform

This feedback has been passed to the project team to take forward over the forthcoming months.

Attendees

Affiliation	Name
ADAS	Richard Gooday
Affinity Water	Alister Leggatt
Agri-Food and Biosciences Institute	Rachel Cassidy
Anglian Water	Richard Reynolds
Atkins	Laura Nieuwenhoven
Atkins	Claire Neale
Atkins	Peter Daldorph
Bristol Water	Matt Pitts
Cambridge Water	Jennifer Thomas
CEH	Bridget Emmett
CEH	Jack Cosby
CEH	Matt Fry
CEH	Mike Brown
Cranfield	Jim Harris
Defra	Alastair Rennie
Defra	Rob Davies
Defra	Victor Aguilera
Environment Agency	Alwyn Hart
Environment Agency	Claire Bell
Environment Agency	Helen Green
Environment Agency	Kirsten Foot
Environment Agency	Paul Bryson
Environment Agency	Tom Rolls
Essex and Suffolk Water	Ian Skinner
Forestry Commission	Tom Nisbet
Hutton Institute	Andy Vinten
Hutton Institute	Jannette MacDonald
Lancaster	Jessica Bellarby
Natural England	Helen Wake
Natural England	Kat Broadhead
Natural England	Rachel Webster
NERC	Vicky Morgan
NFU	Rob Howells
Northern Ireland Environment Agency	Robert Bailie
Orion Innovations	Alison Cavey
Orion Innovations	Juliet Kauffman
Oxford University	Paul Whitehead
Portsmouth Water	Chris Manning
Rivers Trust	Michelle Walker
RSPB	Simon Wightman
Scottish National Heritage	Sarah Hutcheon
SEPA	Mark Hallard
Severn Trent Water	Katharine Filby

Affiliation	Name
South East Water	Steve Howe
South Staffordshire Water	Nina Yiannoukos
Southern Water	Paul Linwood
Thames Water	Graham Welland
UK Water Partnership	Faith Culshaw
University of East Anglia	Kevin Hiscock
University of Reading	Andy Wade
University of Reading	Prof Richard Tiffin
University of York	Dave Raffaelli
Welsh Government	Anne Humble
Wessex Water	Jeremy Graham
Wessex Water	John Bagnall
WWF	Dominic Gogol

LM0308: Catchment Management for Water Quality

Year 2 report

April 2016

Appendix 2

Details of the current status of the seven Case Studies.

Case Study 1. Multiple pollutant and ecosystem services responses to land management policies and agri-environment interventions at the farm to catchment scale.

Jack Cosby[1], Richard Gooday[2]

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[2]ADAS, Pendeford House, Pendeford Business Park, Wolverhampton, WV9 5AP

Summary
In this case study potential trade-offs and co-benefits are examined for a suite of ecosystem services at the farm to catchment scale that may be potential 'by-products' of agri-environment schemes designed to reduce total multi-pollutant loads entering watercourses.

Key findings (to date)

Case study not yet complete. In discussion and review, the community forum decided that this case study required the inclusion of a model of Fecal Indicator Organisms (FIOs). Such a model was not available from the consortium members. The model was obtained through a competitive bid process supported by the LM0308 community fund, but the process of obtaining the model has delayed the case study schedule. Other models to be used in the case study were already available from consortium partners. As of this year 2 report, the key models for the case study are now all in place and baseline simulations have been run for all models in the Conwy catchment in Wales. Scenarios based on the Welsh Glastir and Glastir Advanced schemes for the Conwy will be run next. Key findings will emerge in the next few months.

Policy drivers, anticipated end users and end user questions relating to the case study
This case study addresses the following policy drivers: Water Framework Directive (Good Chemical Status); Farm Payment Schemes (Glastir and Glastir Advanced), Climate Change Abatement Agreements, Conservation Targets, Flood Risk Mitigation. The case study also addresses the following end-user questions: Effectiveness of measures and mechanisms; integration, focus and scaling; uncertainty, confidence and communication. Anticipated end users of the case study would primarily be Government Agencies (DEFRA, EA, NRW), Catchment Managers, Conservation Agencies, Local Authorities, River Trusts.

Approach and modelling
Within this case study, the Farmscoper tool (Gooday et al., 2014) is applied for each of the Water Management Catchment (WMC) in Wales using a new catchment scale version of the tool (Gooday et al., 2015) to determine the impacts of a number of mitigation measures that are comparable to common options selected as part of Glastir agreements. Long term impact of the implementation of mitigation methods representing major / common options within Glastir and Glastir Advanced are examined. These include reduction of fertilizer application, change in stocking density, woodland edge expansion, streamside corridor tree planting, and bracken control. The SEPARATE database (Zhang et al., 2014) contains Water Framework Directive (WFD) catchment scale sector apportionment data for nitrate, phosphorus & sediment. Applying the reductions predicted by Farmscoper to the data in SEPARATE determines the overall impact of the selected Glastir and Glastir advanced options on the total load from all sectors. The LUCI model and the INCA FIO model are then run on the same option reductions to determine potential co-benefits and tradeoffs arising from the Glastir options. It is this integration of models and modelling approaches that demonstrates the added value of the integrated modelling approach looking at intended and unintended consequences in a wholistic analysis.

The use of multiple models for multiple pollutants allow for a robust uncertainty analysis (unlike single use single model assessments). As for the Farmscoper/Separate combination, both LUCI and INC provide estimates of N and

P loading to streams and sediment yield or sediment potential. The case study will investigate the uncertainty in estimated co-benefits and tradeoffs by determining the sensitivity of the LUCI outputs to spatial datasets of different quality (e.g., soils, landcover, topography). It will also provide cross-model estimates of uncertainty by comparing the N, P and sediment estiamtes derived

Outputs

Final outputs for this case study are not yet available. This report summarizes progress to date in implementing the newly obtained INCA FIO model, and shows example outputs of the LUCI ecosystem service maps developed for the baseline simulations in the Conwy.

Farmscoper/SEPARATE models

Approach and modelling

The Farmscoper tool (Gooday et al., 2014) determines the pollutant loads at farm or catchment scale, and then the costs and impacts of current and future scenarios of mitigation measure implementation. The pollutant loads are the long-term annual average values and are calculated from a series export coefficients derived from existing models used for policy support, with the losses expressed in terms of a detailed source apportionment system. Inputs to Farmscoper include crop areas and fertiliser rates and livestock numbers and manure management – the tool is pre-populated with data for the WMCs in England using the 2010 agricultural census data and British Survey of Fertiliser Practice. There are a number of assumptions made within Farmscoper (e.g. fertiliser and manure application timings) that were required in order to run the source models that generated the export coefficients with Farmscoper and that allow the impacts of certain mitigation methods to be derived.

The SEPARATE database (Zhang et al., 2014) contains nitrate, phosphorus and sediment data at WFD waterbody scale for the following sectors: agriculture, bank erosion, urban diffuse, sewage treatment works, storm tanks, sceptic tanks, combined sewer overflows, direct deposition and groundwater. The loads were derived from modelled and monitored data as appropriate for the sector.

As the Farmscoper and SEPARATE data are at different scales, the WMC scale data predicted by Farmscoper was downscaled to WFD scale. This was achieved by expressing the calculated WMC data as a per hectare value for the different soil type and climate zones represented within Farmscoper and then multiplying the results for the relevant WMC by the areas of each WFD catchment in each soil type and climate zones.

Outputs for the Farmscoper/SEPARATE models are similar to those shown in case study two of this report , but in this case study they will be for scenarios driven by Gastir options and the maps will be for the Conwy catchment in Wales, available in the next 2-3 months.

INCA FIO model

The INCA-Pathogens Model has been designed to simulate the transport pathways and fluxes of generic pathogens in the land, water column, riverbed sediment, and groundwater phases. By generic we mean that the model equations have been written so that, in theory, any pathogen can be simulated provided the appropriate input sources and die-off and regrowth rates are utilised in any model application. The processes of both suspended sediment deposition, and riverbed sediment entrainment are simulated based on the INCA-Sediment model. The landscape mass balances of water and pathogens are based on a 1 km^2 cell and the inputs to the model and the model constants can vary on a sub-catchment basis and according to soil or land-use type. These two factors allow the mass stored, process rates and hydrological pathways to vary spatially based on preconceived notions of variations in soil moisture, temperature, adsorption potential and land management

practices. The water volumes and the mass of pathogens are summed based on the relative amounts of each land use or soil type within a sub-catchment and the output passed to the instream routing model (Figure 1).

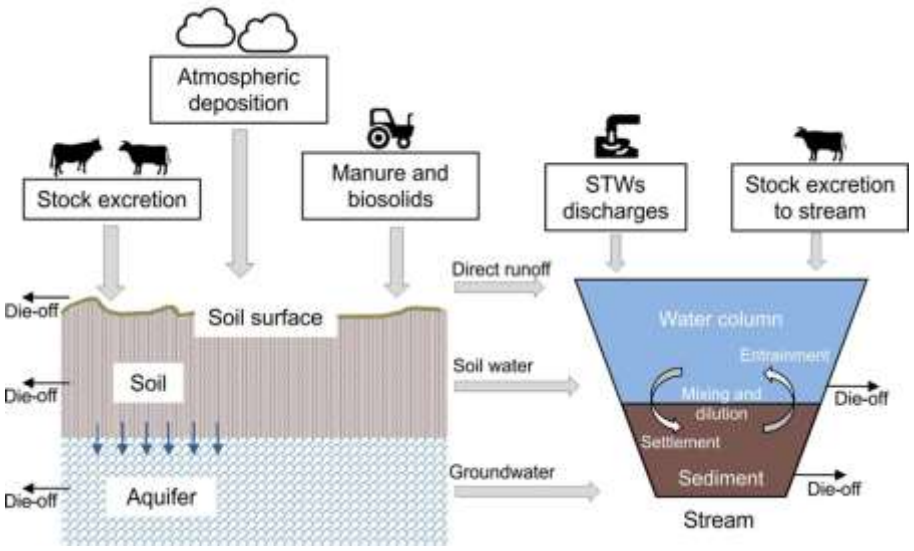

Figure 1. Schematic of the INCA-pathogens model, from Whitehead et al. (2016)**.**

Details of the INCA Pathogens model are given in Whitehead et al. (2016). The preliminary application to the Conwy is summarized here. Figures 2-5 show the model results in terms of total coliform concentration in the water and in the bed sediment for the River Conwy at Cwn Llanerch, Llanrwst, Dolgarrog bridge and Tal-yCafn bridge. The model obtained satisfactory results (given the high uncertainty in modelling pathogen processes) in reproducing both water pathogens and sediment pathogens. It can be noticed that an anomalous peak of coliforms in summer 2013 was systematically underestimated, probably due to some processes not included in the model, such as an unknown point source of coliforms. On the other hand, both the winter 2013/14 and the summer 2014 concentrations are reproduced correctly.

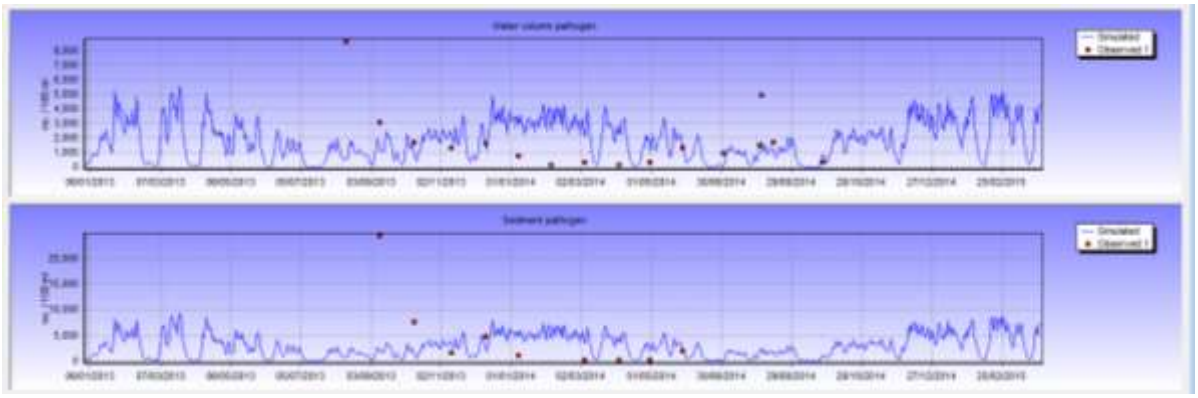

Figure 2. Results of the INCA-Pathogens model at reach 4. Top: total coliform concentration in water, bottom: total coliform concentration in bed sediment. Red: observed, blue: simulated.

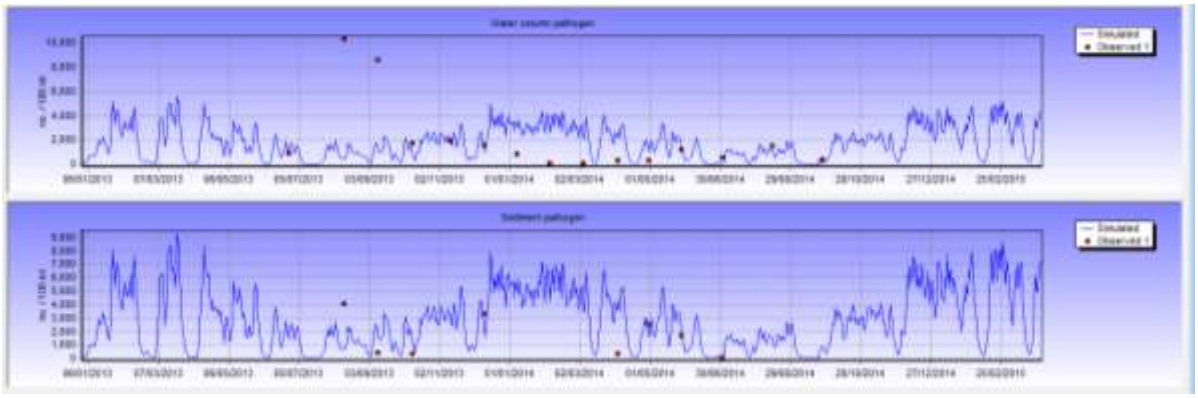

Figure3. Results of the INCA-Pathogens model at reach 5. Top: total coliform concentration in water, bottom: total coliform concentration in bed sediment. Red: observed, blue: simulated.

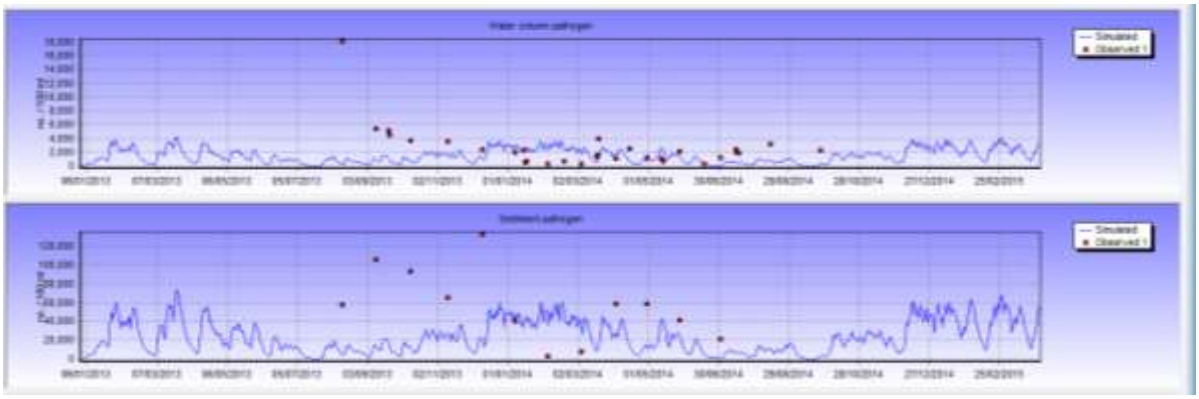

Figure4. Results of the INCA-Pathogens model at reach 6. Top: total coliform concentration in water, bottom: total coliform concentration in bed sediment. Red: observed, blue: simulated.

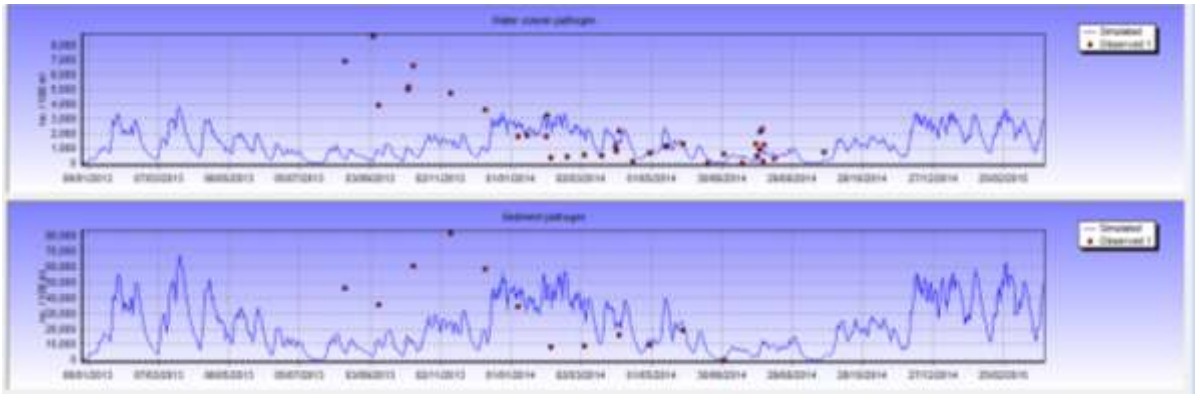

Figure5. Results of the INCA-Pathogens model at reach 7. Top: total coliform concentration in water, bottom: total coliform concentration in bed sediment. Red: observed, blue: simulated.

LUCI Ecosystem Services model

The LUCI ecosystem services model provides mapped estimates of ecosystem services at a 5m resolution. Examples of the baseline outputs of LUCI are given below (Figures 6-7). LUCI is being used in the Glastir Monitoring and Evaluation Programme (GMEP) for Wales and is details of the model are available in reports from that project.

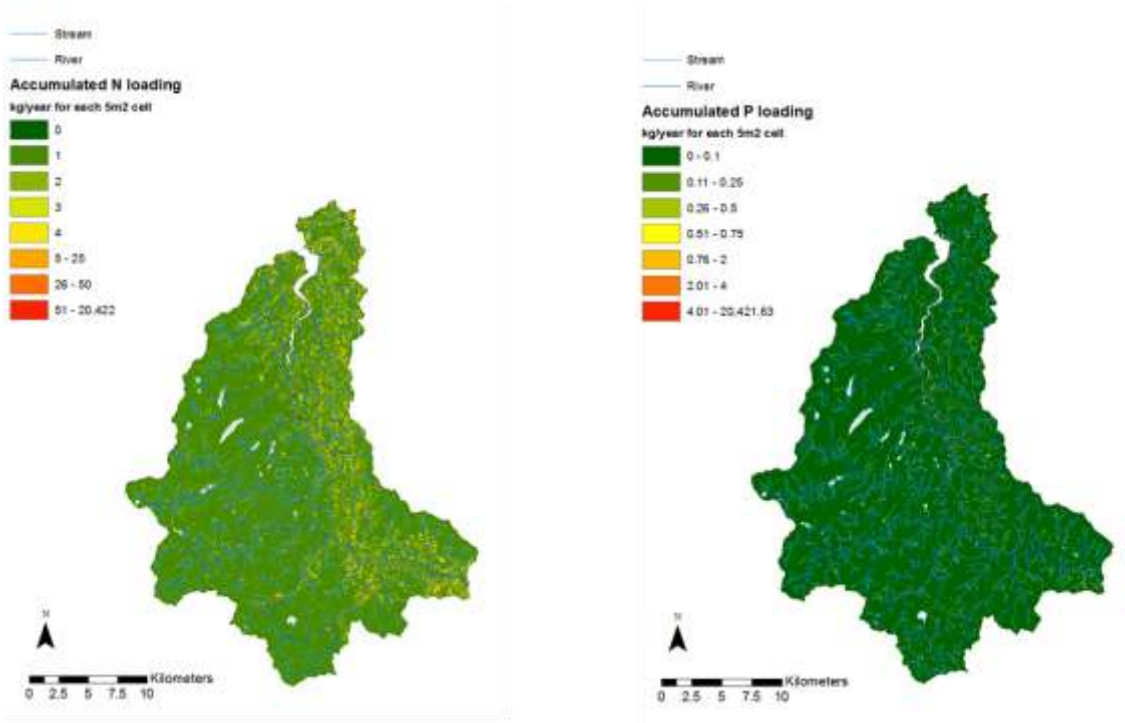

Figure 6. Luci map of (left) accumulated N loading to streams, and (right) accumulated P loading to streams.

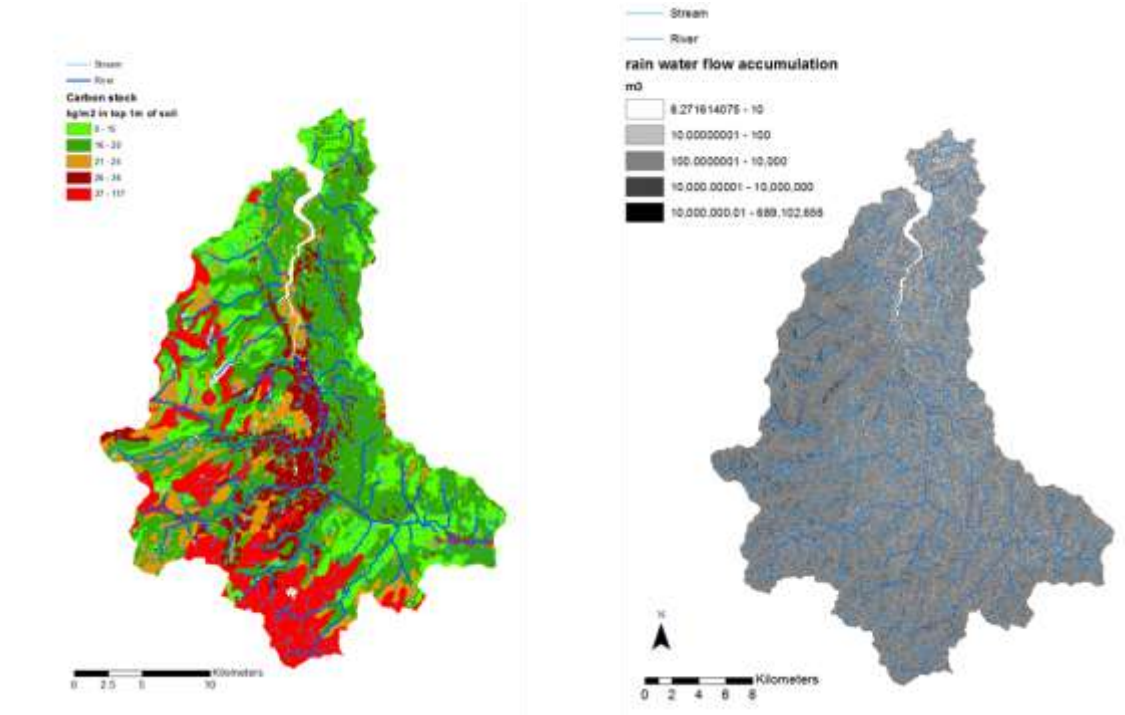

Figure 7. Luci map of (left) carbon stock on the landscape, and (right) accumulated water flow to streams.

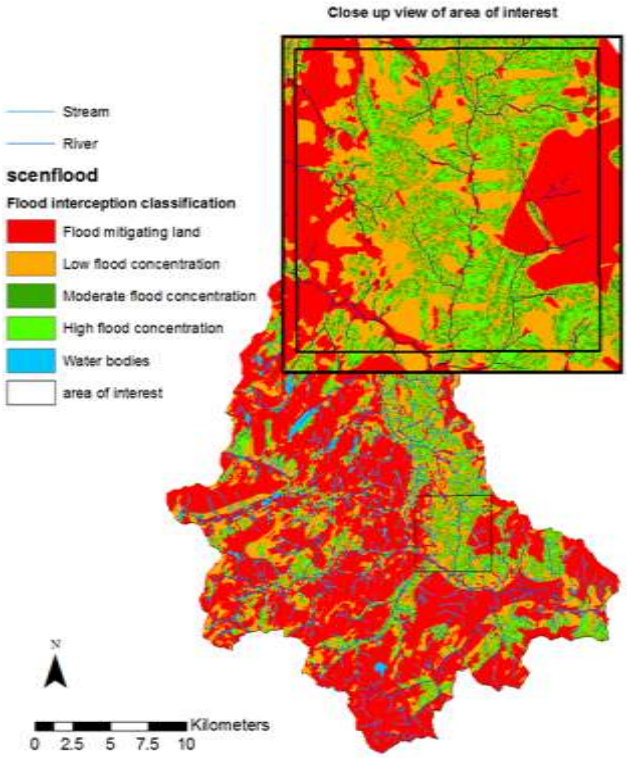

Figure 8. Luci map showing flood interception classification regions for the Conwy.

Evaluation

In this case study to date, we have demonstrated that the Farmscoper tool and SEPARATE database can be easily be combined to predicted changes in the total load from all sectors due to implementation of different agricultural pollution control measures (as was also done in Case Study 2). We have also implemented a model of riverine FIO transport, and mapped baseline ecosystem services in the Conwy. Final evaluation of the integrated model approach awaits completion of the Glastir scenario simulations.

Appendix – further details

Summary

Pollutants: Nitrate, Phosphorous, Sediment, Fecal Indicator Organisms (FIO), Flood Potential, Carbon loss (and Sequestration), Biodiversity Loss
Scale: Catchment
Location: Wales

Data and models used

Models:
Farmscoper, SEPARATE, INCA FIO, LUCI

Datasets:
British Survey of Fertilizer Practice (contained within Farmscoper)
Agricultural Census Data (contained within Farmscoper)
Soil Type, Landcover, topography, river flow, and climate data (INCA and LUCI)

Next Steps

The next stages in the case study will connect the outputs from Farmscoper/SEPARATE, driven by the Glastir and Glastir Advanced options, to the INCA FIO and LUCI models.

References

Gooday, R.D., Anthony, S.G., Chadwick, D.R., Newell-Price, P., Harris, D., Duethmann, D., Fish, R., Collins, A.L. & Winter, M. 2014. Modelling the cost-effectiveness of mitigation methods for multiple pollutants at farm scale. *Science of the Total Environment*, 468-469, 1198-1209.

Gooday, R., Anthony, S., Durrant, C., Harris, D., Lee, D., Metcalfe, P., Newell-Price, P. & Turner, A. 2015. Developing the Farmscoper Decision support tool. Final Report for Defra Project SCF0104.

Whitehead PG, Leckie H, Rankinen K. Butterfield D. Futter MN and Bussi G. An INCA model for pathogens in rivers and catchments: Model structure, sensitivity analysis and application to the River Thames catchment, UK. *Science of the Total Environment,* 2016 xxx-xxx (in press).

Zhang, Y., Collins, A.L., Murdoch, N., Lee, D. & Naden, P.S. 2014. Cross sector contributions to river pollution in England and Wales: updating waterbody scale information to support policy delivery for the Water Framework Directive. *Environmental Science & Policy*, 42. 16-32

Case Study 2. Effectiveness of land management policies and agri-environment interventions for reducing pollutant loads and maintaining environmental quality at the national scale.

Richard Gooday[1], Kirsten Foot[2], Murray Hart[3], Stuart Kirk[3], Neil Murdoch[4], Adrian Collins[5], Peter Daldorph[6]

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Summary
In this case study the effectiveness of common options selected under the Countryside Stewardship scheme to reduce pollution to water and GHG emissions was examined. The analysis accounted for the non-agricultural loads (e.g. sewage treatment works and urban losses) to correctly interpret the changes achieved in the agricultural sector.

Key finding
Countryside Stewardship options have the potential to impact on national and local losses of phosphorus and sediment, even taking into account the non-agricultural contributions to the total pollutant loads. They will also help to reduce GHG emissions.

Policy drivers, anticipated end users and end user questions relating to the case study
This case study addressed the following policy drivers: Water Framework Directive, Countryside Stewardship. The case study also addressed the following end-user questions: effectiveness of measures, uncertainty. Anticipated end users of the case study would primarily be government agencies.

Approach and modelling
Within this case study, the Farmscoper tool (Gooday et al., 2014) was applied for each of the Water Management Catchment (WMC) in England using a new catchment scale version of the tool (Gooday et al., 2015) to determine the impacts of a number of mitigation measures that are comparable to common options selected as part of Countryside Stewardship agreements. The SEPARATE database (Zhang et al., 2014) contains Water Framework Directive (WFD) catchment scale sector apportionment data for nitrate, phosphorus & sediment. Applying the reductions predicted by Farmscoper to the data in SEPARATE allows for the overall impact of the Countryside Stewardship options on the total load from all sectors to be determined. The case study investigated the uncertainty in the reductions associated with Countryside Stewardship by doing a boundary analysis on the effectiveness and current uptake of the different options.

Outputs
The calculated reductions in agricultural nitrate losses are over 10% in intensive arable areas, but lower in grass land areas. As agriculture is the dominant sector for nitrate losses, comparable reductions are found in the overall load (Figure 1). Reductions in the agricultural phosphorus load are over 20% in many catchments, but on average agriculture only contributes 30% of the load, so the overall reductions are much lower, typically under 5% (Figure 2). National reductions in the agricultural loads of sediment, nitrous oxide and carbon dioxide from energy use are 19%, 2% and 9% respectively. The total cost to the farmer for implementation of the group of mitigation measures was £300m – these costs are greater than the calculated monetised environmental benefit, thus confirming the need for targeting of measures where they are most (cost) effective.

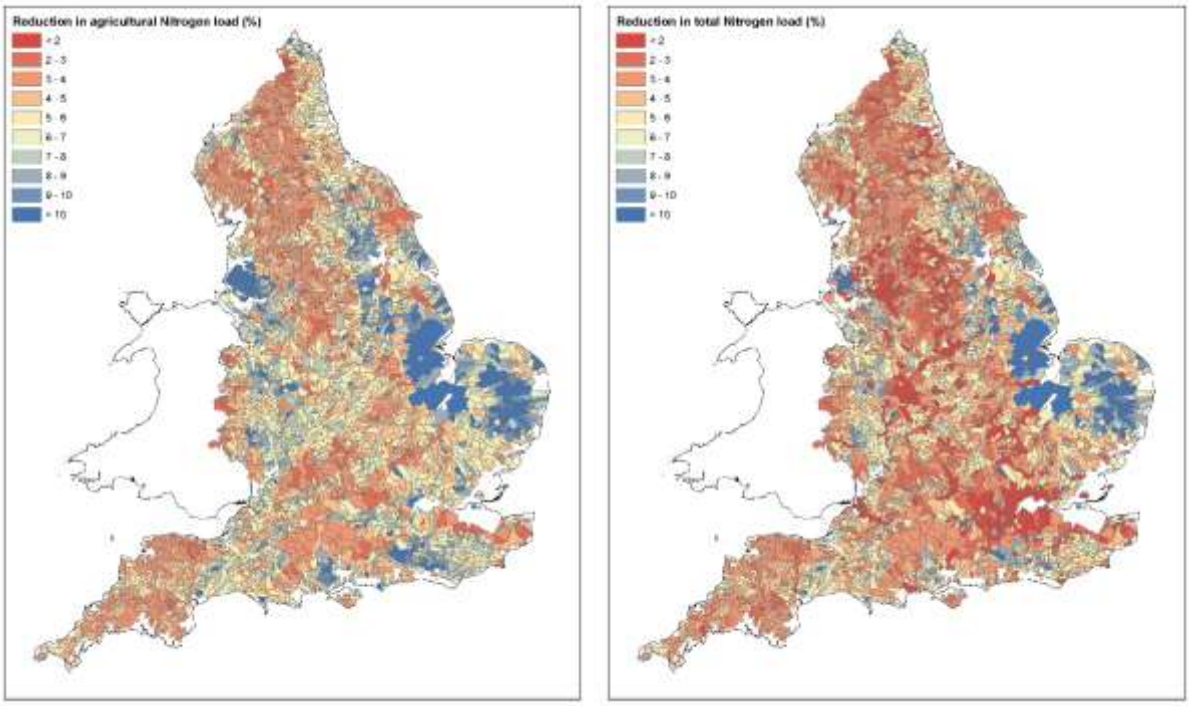

Figure 1. *Reductions in the annual average agricultural nitrate load for each WFD waterbody due to maximum uptake of the Countryside Stewardship options (left), and the same agricultural reduction, but expressed as a function of the total load from all sectors in that waterbody.*

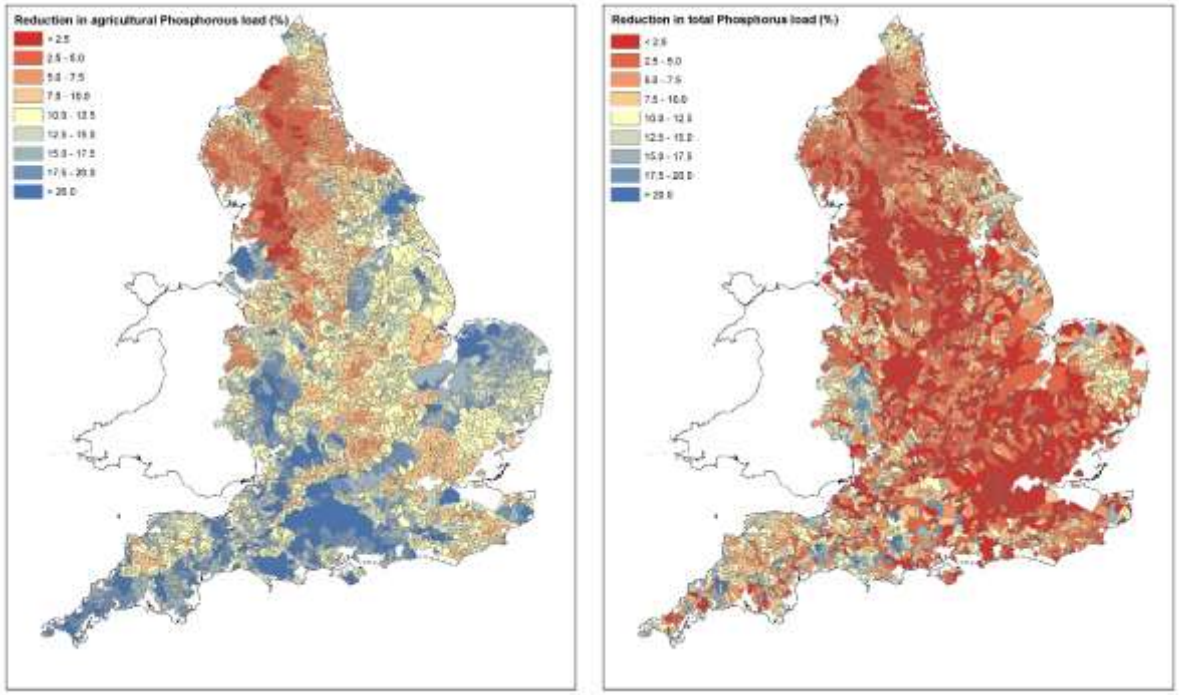

Figure 2. *Reductions in the annual average phosphorus nitrate load for each WFD waterbody due to maximum uptake of the Countryside Stewardship options (left), and the same agricultural reduction, but expressed as a function of the total load from all sectors in that waterbody.*

Evaluation

In this case study we have demonstrated how the Farmscoper tool and SEPARATE database can be easily be combined to predicted changes in the total load from all sectors due to implementation of different agricultural pollution control measures. This is important as the contribution of the agricultural sector can vary and so the overall effectiveness of measures can be misrepresented without placing the results in context.

Appendix – further details

Summary

Pollutants: Nitrate, Phosphorus, Sediment, Ammonia, Methane, Nitrous Oxide, Carbon Dioxide from Energy Use
Scale: National
Location: England

Data and models used

Models:
Farmscoper, SEPARATE
Datasets:
British Survey of Fertilizer Practice (contained within Farmscoper)
Agricultural Census Data (contained within Farmscoper)
Soil Type
Climate data

Approach and modelling

The Farmscoper tool (Gooday et al., 2014) determines the pollutant loads at farm or catchment scale, and then the costs and impacts of current and future scenarios of mitigation measure implementation. The pollutant loads are the long-term annual average values and are calculated from a series export coefficients derived from existing models used for policy support, with the losses expressed in terms of a detailed source apportionment system. Inputs to Farmscoper include crop areas and fertiliser rates and livestock numbers and manure management – the tool is pre-populated with data for the WMCs in England using the 2010 agricultural census data and British Survey of Fertiliser Practice. There are a number of assumptions made within Farmscoper (e.g. fertiliser and manure application timings) that were required in order to run the source models that generated the export coefficients with Farmscoper and that allow the impacts of certain mitigation methods to be derived.

The SEPARATE database (Zhang et al., 2014) contains nitrate, phosphorus and sediment data at WFD waterbody scale for the following sectors: agriculture, bank erosion, urban diffuse, sewage treatment works, storm tanks, sceptic tanks, combined sewer overflows, direct deposition and groundwater. The loads were derived from modelled and monitored data as appropriate for the sector.

As the Farmscoper and SEPARATE data are at different scales, the WMC scale data predicted by Farmscoper was downscaled to WFD scale. This was achieved by expressing the calculated WMC data as a per hectare value for the different soil type and climate zones represented within Farmscoper and then multiplying the results for the relevant WMC by the areas of each WFD catchment in each soil type and climate zones.

In order to assess the uncertainty in the results predicted by Farmscoper, the values within the tool for the current implementation of measures and the impacts of measures were altered to their highest and lowest values within their expected ranges and the analysis was repeated. As all values were assumed to be at their highest or lowest at the same time, the values predicted are the absolute bounds of the uncertainty.

Scenarios used

The modelling assumed 100% implementation of the following mitigation measures on all appropriate land: cover crops, management of over-winter tramlines, in-field grass buffer strips, riparian buffer strips, use of clover in place of fertiliser nitrogen, reduced field stocking rates when soils are wet, installation of covers to slurry stores, minimising the volume of dirty water, fencing off rivers and streams from livestock, construction of bridges for livestock crossing rivers/streams, re-siting gateways away from high-risk areas, farm track management, creation

of new hedges, establishment of artificial wetlands for steading runoff and tree shelter belts around livestock housing. These had been identified as the most appropriate measures out of the list of 100 within Farmscoper.

Further evaluation

The case study assumed 100% implementation of all measures on all appropriate land, and thus represents the maximum reductions that could be achieved with these measures. A logical next step would be to constrain implementation rates based upon either the actual rates as derived from scheme agreements or using expert judgement of likely uptake. It would also be beneficial to combine the load reductions with measured water quality data to see if the pollutant reductions achieved are enough for any catchments to achieve the standards required by the WFD.

In the uncertainty analysis within this case study, the current implementation and measure effectiveness values were all assumed to be at their highest or lowest at the same time, and thus the values predicted are the bounds of the uncertainty. For robust policy-relevant output it would be advisable to carry out more thorough uncertainty analyses to assess the distribution of the data between the bounds calculated in this case study.

References

Gooday, R.D., Anthony, S.G., Chadwick, D.R., Newell-Price, P., Harris, D., Duethmann, D., Fish, R., Collins, A.L. & Winter, M. 2014. Modelling the cost-effectiveness of mitigation methods for multiple pollutants at farm scale. *Science of the Total Environment*, 468-469, 1198-1209.

Gooday, R., Anthony, S., Durrant, C., Harris, D., Lee, D., Metcalfe, P., Newell-Price, P. & Turner, A. 2015. Developing the Farmscoper Decision support tool. Final Report for Defra Project SCF0104.

Zhang, Y., Collins, A.L., Murdoch, N., Lee, D. & Naden, P.S. 2014. Cross sector contributions to river pollution in England and Wales: updating waterbody scale information to support policy delivery for the Water Framework Directive. *Environmental Science & Policy*, 42. 16-32

Case Study 3: Costs and benefits of mitigation measures to reduce pollutant concentrations for the protection of drinking water in river-systems upstream of intakes.

Peter Daldorph[1], Andrew Wade[2], Simon Eyre[3], Zoe Frogrook[4], Claire Bell[5], Russell Smith[6]

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[2]Department of Geography and Environmental Science, University of Reading, Whiteknights, Reading, RG6 6DW
[3]Anglian Water, Milton House, Cowley Road, Cambridge, CB4 0AP
[4]Scottish Water, Fairmilehead Office, 55 Buckstone Terrace, Edinburgh, EH10 6XH
[5]Environment Agency, Horizon House, Deanery Road, Bristol BS1 5AH
[6]Westcountry Rivers Trust, Kyl Cober Parc, Raincharm House, Stoke Climsland, Callington PH17 8PH

Summary
The aim of this case study is to use models to test the impacts of catchment measures on water company operations (e.g. treatment requirements) and on drinking water compliance. In particular, the case study looks at these issues in relation to pesticide, metaldehyde and nutrients (phosphorus and nitrate). Metaldehyde is an important issue for the water industry because it is difficult to treat using the standard approach of ozone and Granular Activated Carbon and has consequently caused compliance problems in recent years; particularly in South East England and the Midlands. Nitrate is important because it is, likewise, difficult and expensive to treat at water treatment works. Phosphorus can result in excessive growth of algae that sometimes cause treatment problems, raising the cost of treatment and reducing the output from works.

The case study models these chemicals in the River Wensum in Norfolk which is one of the Demonstration Test Catchments. Metaldehyde has been modelled using SWAT; a well-established, hydrologically based time series water quality model whilst nutrients have been modelled using SAGIS; a key river basin planning model used by the Environment Agency and the water industry. The models have been used to assess the impacts of upstream measures at Anglian Water's water supply intake at Costessey Pits. In addition, for phosphorus, impacts on the associated surface water reservoir are considered.

The cost of the catchment measures will be compared to the potential benefits of reduced treatment costs at the works.

Key finding
Only small reductions in average phosphorus and nitrate concentrations could be achieved at Costessey Pits intake as a result of the catchment measures applied, partly because other sources such as sewage works, septic tanks and industry are important in the catchment. There is, however, some indication that the proportion of the time that nitrate exceeds the drinking water standard might be significantly reduced as catchment sources provide the bulk of the input during these events.

Building the SWAT model was the first stage of this part of the case study and outputs from the scenarios are not yet available.

Policy drivers, anticipated end users and end user questions relating to the case study
This case study addressed the following policy drivers: Water Framework Directive, Drinking Water Directive (Drinking Water Inspectorate), Economic regulation (OFWAT). The case study also addresses operational issues and associated costs related to water treatment.

Approach and modelling

Figure 1 presents example output (nitrate) from the existing calibrated SAGIS model of the River Wensum SAC (outputs for phosphorus are also available).

Agricultural measures were applied to reduce the catchment inputs of both nitrogen and phosphorus from the catchment, based on output from Farmscoper. The following measures were applied:

- Best practice voluntary measures
- Maximum measures

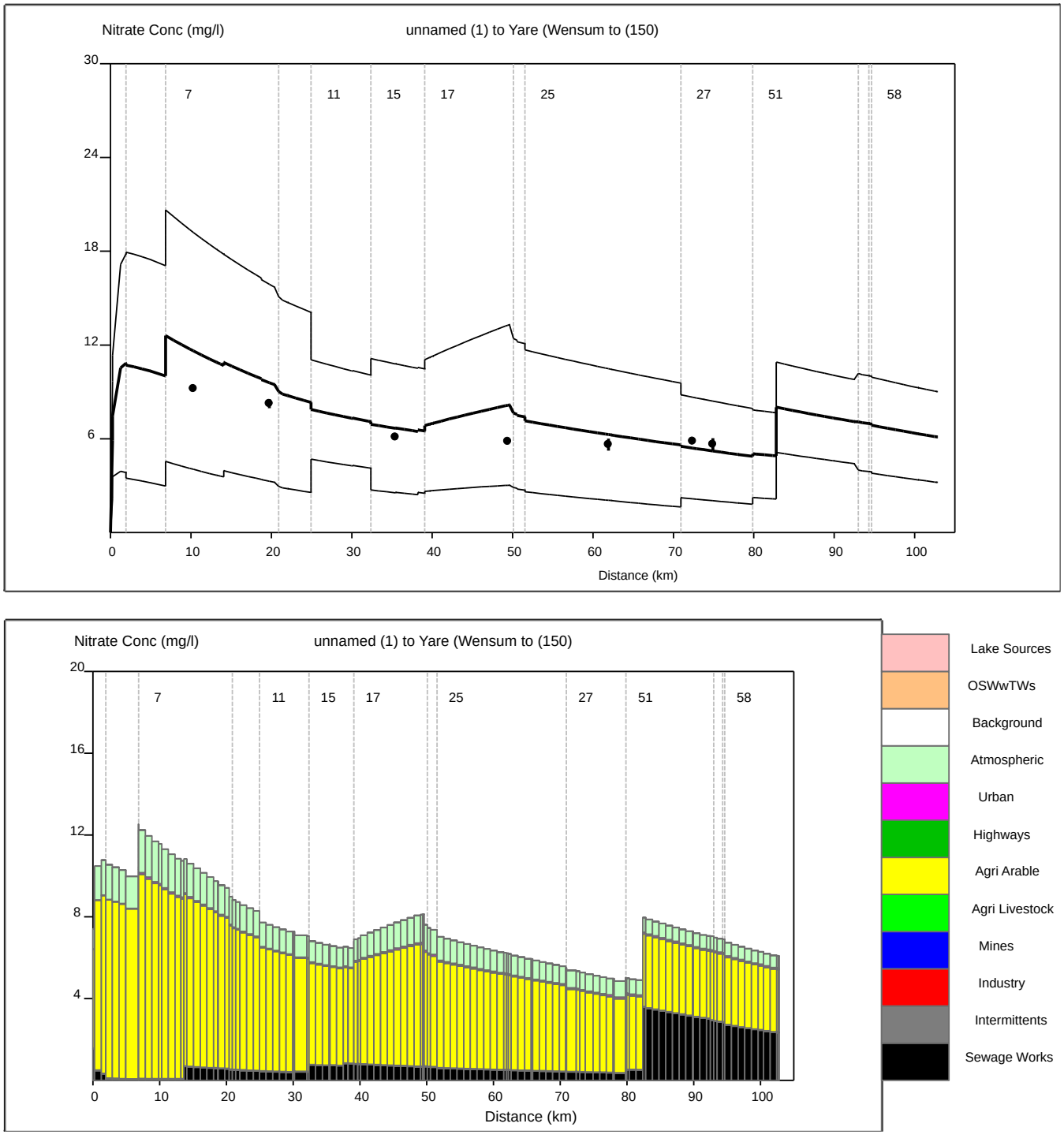

Figure 1 Simulated nitrate concentrations and source apportionment along the River Wensum

The SWAT model to simulate metaldehyde concentrations was built by University of East Anglia, using an existing model for phosphorus as the starting point. The model was extended to use daily driving hydrological data to produce daily output and to cover the Wensum catchment upstream of the water company intake at Costessey Pits. Figure 2 below shows model outputs for river flow and metaldehyde concentrations.

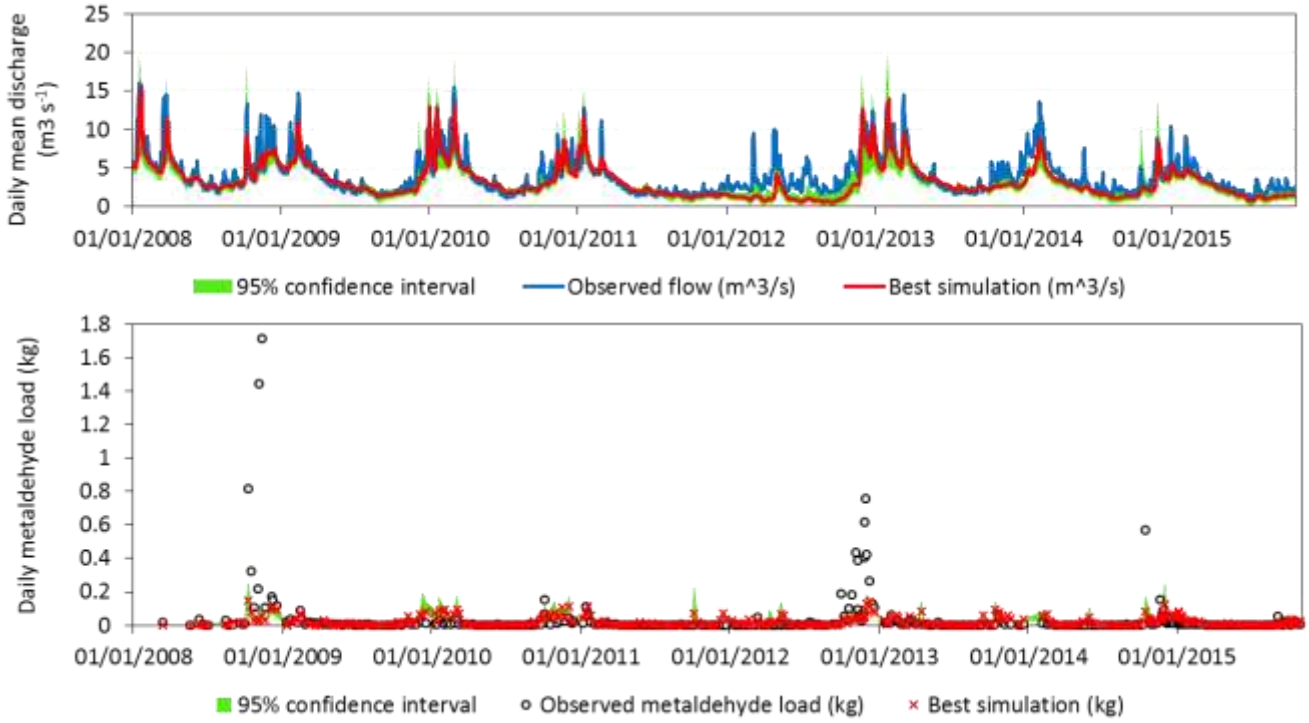

Figure 1 Model output from the SWAT metaldehyde model

The following model scenarios have been applied:

- Buffer strips of 6 m width (Entry Level Stewardship scheme compensation)
- Risk mapping – no applications to high risk areas (high slope and clay soils)
- Reduced maximum application rates (210 g ha^{-1} & 160 g ha^{-1})
- Cultural measures to reduce need for application
- Earlier preparation of seedbed to supress slug populations
- Measure slug populations to assess risk of crop damage
- No pellet applications when heavy rain is forecast

Outputs

Figure 3 provides examples of the outputs for modelled (SAGIS) changes in nutrient concentrations at the water supply intake. The analysis of changes in phosphorus concentrations in the water supply reservoir; Costessey Pits remains to be completed.

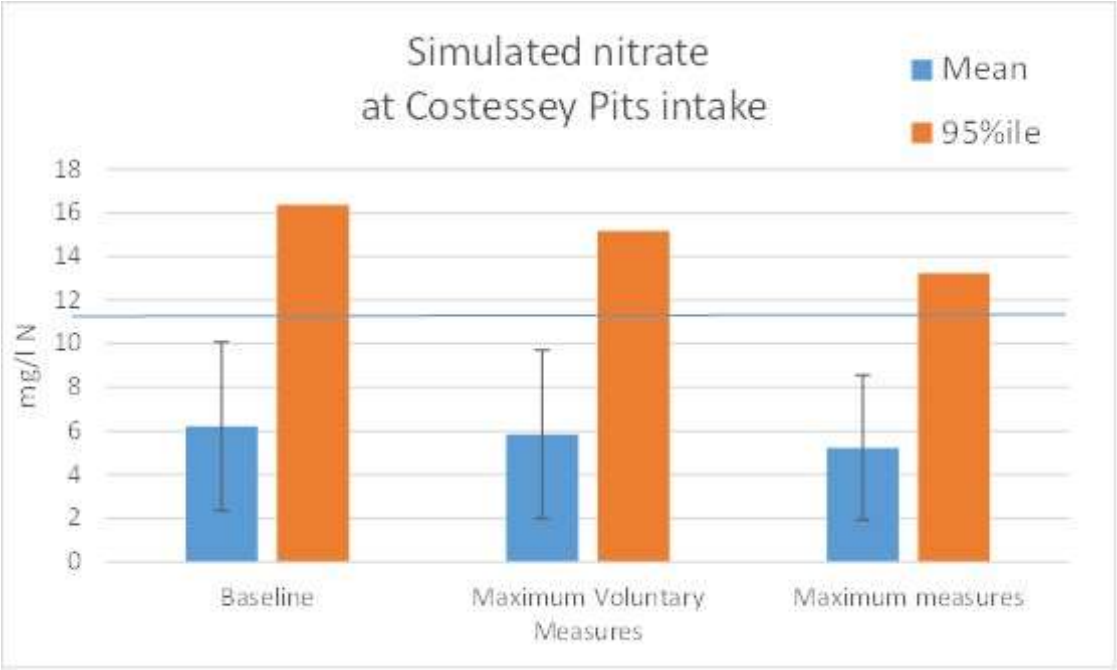

Figure 3 Changes in means and 95%ile nitrate concentrations related to the catchment measures.

Model outputs for SWAT are yet to be collated and therefore cannot be shown at this stage. It is planned to compare the costs of these measures with water treatment benefits and costs at the Heigham water treatment works in Norwich.

Evaluation

In this case study we have demonstrated how SWAT and SAGIS can be set up to explore how water quality (pesticides and nutrients) might respond to measures to reduce catchment inputs. Full evaluation of the value of the outputs is awaiting completion of modelling work.

Appendix – further details

Summary

Pollutants: Total phosphorus, ortho-phosphate, nitrate, metaldehyde
Scale: Catchment (129 km^2)
Location: River Wensum, Norfolk, England.

Data and models used

Models:
SWAT, SAGIS, FARMSCOPER
Datasets:
SAGIS model database containing wide range of hydrological and asset data
Agricultural Census Data
Anglian Water metladehyde monitoring data
Environment Agency rainfall and river flow data

Approach and modelling

SAGIS/SIMCAT models nutrient concentrations in rivers based on inputs from a range of point and diffuse sources and river flows derived from Lowflows 2000. Catchment phosphorus inputs are derived from the PSYCHIC model and nitrogen inputs are derived from NEAP N. Inputs from other sources are derived from Environment Agency and water company data (e.g. effluent monitoring data and MCERTS effluent flow data). SIMCAT is a Monte-Carlo based model that simulates water quality at the catchment scale over a range of flow conditions. It also applies a simple first order decay to simulate within river losses. The SAGIS model was calibrated for a separate study for UKWIR (UK Water Industry Research).

SWAT (Soil & Water Assessment Tool) is a river basin scale model developed to quantify the impact of land management practices in large, complex watersheds. It is a hydrology transport model with the following components: weather, surface runoff, return flow, percolation, evapotranspiration, transmission losses, pond and reservoir storage, crop growth and irrigation, groundwater flow, reach routing, nutrient and pesticide loading, and water transfer. It can produce outputs at a range of temporal scales; typically daily or monthly. The model was calibrated against observed metaldehyde concentrations using Environment Agency and Anglian Water monitoring data and observed river flow from the Environment Agency.

Scenarios used

SAGIS

Changes in farm practice

1. Current practice
2. Maximum voluntary measures (from Farmscoper)
3. All Farmscoper measures

SWAT

1. Buffer strips of 6 m width (Entry Level Stewardship scheme compensation)
2. Risk mapping – no applications to high risk areas (high slope and clay soils)
3. Reduced maximum application rates (210 g ha^{-1} & 160 g ha^{-1})
4. Cultural measures to reduce need for application
5. Earlier preparation of seedbed to supress slug populations
6. Measure slug populations to assess risk of crop damage
7. No pellet applications when heavy rain is forecast

Further evaluation

For N and P, the case study focused on change in mean and percentile annual instream concentration under a variety of different scenarios. The percentile output for nitrate gives a measure of the likelihood of exceeding the drinking water standard. For metaldehyde, the model output will be compared to the drinking water standard and the proportion of time that this is likely to be exceeded. In addition, costs of the catchment measures will be compared to the benefits for water treatment in terms of works output and treatment costs.

This report only presents output for some scenarios – further information will be provided in later iterations.

The model applications in this case study did not include any formal uncertainty or sensitivity analysis.

References

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http://swat.tamu.edu/

Case Study 4. Effectiveness of pollution control measures under scenarios of future climate and land cover change at the catchment scale.

Andrew Wade[1], Leah Jackson-Blake[2], Mark Hallard[3], Matthew Charlton[4], David Johnson[5]

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Summary
In this case study the effectiveness of pollutant control measures to reduce nitrogen and phosphorus concentrations in streams, under both current and future climate and land use, was examined. In particular, the dynamic (daily) response of three pollutants – suspended sediment, phosphorus (as total and total dissolved phosphorus) and nitrate – was assessed for a baseline (1981 – 2010) period and compared to model-based projections to explore the effects of: (1) measures to reduce nutrient status (e.g. reductions in inputs of fertilizer and manure, reductions in effluent inputs, land use change); (2) climate change; (3) land use change; (4) combined climate and land use change; and (5) combined climate and land use change plus a selection of effective measures. The last step allows us to check whether measures selected to improve chemical status are likely to be 'future proof', i.e. whether measures implemented to improve water quality today will still be effective in the future.

Key finding
Despite the uncertainty in future climate and land use, *large-scale* measures put in place today to improve water quality are likely to remain effective in the future.

Policy drivers, anticipated end users and end user questions relating to the case study
This case study addressed the following policy drivers: Water Framework Directive, New Environmental Land Measures Scheme, Scotland Rural Development Plan, Water Environment Fund, Land Use Strategy for Scotland. The case study also addressed the following end-user questions: future pressures and extrapolation of impacts, evidence of outcome, uncertainty, confidence and communication.

Approach and modelling
Within this case study, the nitrogen and phosphorus INCA models, INCA-N (Wade et al., 2002a) and INCA-P (Wade et al., 2002b) were applied. The models were run for a baseline period (1981-2010) using observed land cover and meteorological data, and then used to assess the effectiveness of different nutrient pollution control measures for this period. The control measures were reductions in fertiliser and manure applications to arable and improved pasture, reduction in Sewage Treatment Works final effluent concentration, and land cover change including an increase in woodland. The models were then re-run for a future period (2031-2060) with projected land cover and climate inputs, and then with the same pollution control measures in each future scenario. In each, mean concentrations in the last five years of each scenario run were calculated and compared to an equivalent concentration for the baseline period to estimate the percentage difference.

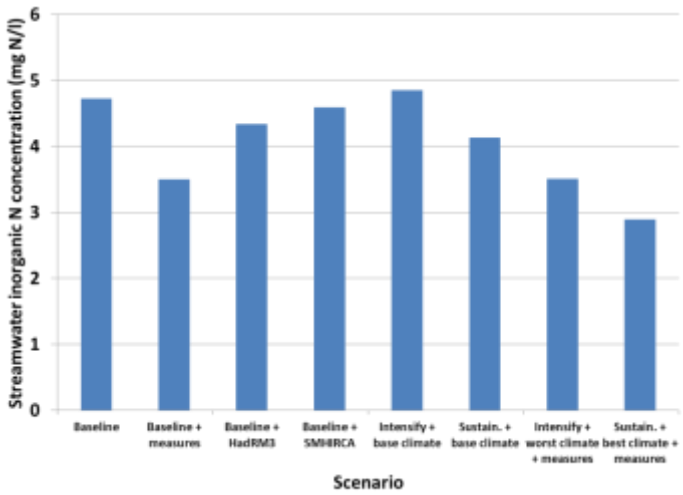

Figure 1. *Simulated mean streamwater nitrate concetrations in the Tarland Burn for the baseline (19810-2010) and scenario periods (2031-2060). The mean concentrations were estimated for last five years of the baseline and scenario periods, and the model set-up assumes a small groundwater store.*

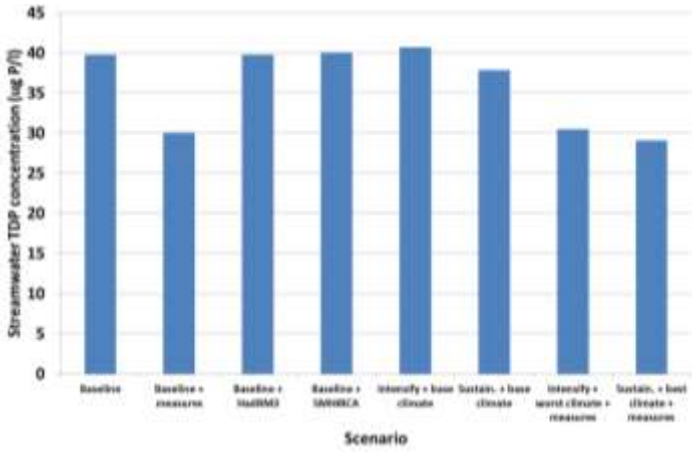

Figure 2. *Simulated mean streamwater total dissolved phosphorus concentrations in the Tarland Burn for the baseline (19810-2010) and scenario periods (2031-2060). The mean concentrations were estimated for last five years of the baseline and scenario periods, and the model set-up assumes a small groundwater store.*

Outputs

Projections of streamwater suspended sediment, total phosphorus, total dissolved phosphorus and nitrate daily concentrations were produced for the following model runs: baseline (1981-2010), baseline + measures, future climate and land cover (1981-2010), future climate and land cover + effective measures (Figures 1 and 2). When measures are implemented, the modelled outcomes show that mean streamwater nitrate and total dissolved phosphorus (TDP) concentrations decrease below those for the baseline. Projections of wetter winters and drier summers from two climate models (HadRM3, SMHIRCA) lead to concentrations similar to those observed presently. Only with a shift to arable intensification do the mean nitrate and TDP concentrations increase above the baseline. Irrespective of credible land cover distribution or climate scenarios, reductions in fertiliser applications and final effluent concentrations will reduce the mean stream nitrate and TDP concentrations.

Evaluation

In this case study we have demonstrated how INCA-N and INCA-P can be set up, calibrated and validated in a study catchment (Jackson-Blake et al., 2015), and then used to explore how water quality might respond to measures to reduce nutrient and sediment inputs and to changing climate and land use. We also took advantage of the dynamic nature of the models to explore how quickly a waterbody might respond to change. Significant effort was expended in collating the datasets to apply the models.

Appendix – further details

Summary

Pollutants: Suspended sediment, Total Phosphorus, Total Dissolved Phosphorus, Nitrate
Scale: Catchment (74 km^2)
Location: Tarland Burn, Aberdeenshire, Scotland

Data and models used

Models:
INCA-N, INCA-P
Datasets:
Met Office 5km gridded dataset.
British Survey of Fertilizer Practice
Land Cover Map of Scotland (2008)
50m Digital Elevation Model
Agricultural Census Data
EU FP6 ENSEMBLE climate predictions
Local observations of atmospheric deposition
Sewage effluent data
Observed river flows and streamwater nitrogen and phosphorus concentrations

Approach and modelling

INCA-P incorporates INCA-Sed (Lazar et al., 2010), which simulates sediment processes within the catchment. We used INCA-N v1.0.14 and INCA-P v1.4.1. The INtegrated CAtchment (INCA) suite of models has been applied in a wide range of ecosystem types over the last 20 years. INCA includes a process-based representation of the plant-soil system and in-stream hydrological and biogeochemical dynamics. The model is dynamic, i.e. the day-to-day variations in flow and water quality can be investigated following a change in input conditions, e.g. associated with changing hydrology or changing point or diffuse inputs. The model can also be used to investigate changes in land use. Dilution, natural decay and biochemical transformation processes are included, as well as interactions with plant biomass such as nutrient uptake by vegetation on the land surface or in-stream. INCA is semi-distributed, as the spatial variations in nutrient export are simulated separately for different land use types within sub-catchments of a river system, and the model then includes a multi-reach in-stream component that routes water and nutrients down the main river channel. The model then provides outputs of daily time series of flow and water quality at selected sites along the river, as well as daily and annual nutrient loads for all processes within each land use class. INCA-N and INCA-P were calibrated and tested using observations of flow and streamwater nitrate and phosphorus concentrations using a split-sample method.

Scenarios used

Climate: 2 GCM/RCM combinations from EU FP6 Ensembles (baseline: 1981-2010; future: 2031-2060). The Ensembles data is available free of charge for research, education and commercial work. The data policy is available at http://www.ensembles-eu.org/ and notes that appropriate acknowledgement must be given to the data source. The climate model runs have been biased corrected by the James Hutton Institute. Existing land use scenarios for the 2050s: these are consistent with the Land Use Strategy for Scotland (2011) targets, all scenarios incorporated an increase in woodland cover and two included an increase in arable land area. Four scenarios have been developed, broadly corresponding to the quadrants of the IPCC SRES scenarios representing “World Market” (A1), “National Enterprise” (A2), “Global Sustainability” (B1) and “Local Stewardship” (B2).

Further evaluation

The case study focused on change in mean annual instream concentration of N and P under a variety of different scenarios. Whilst this is most relevant for assessing compliance with chemical targets under the Water Framework Directive, in other situations it might be more appropriate to summarise the modelling results in different ways. For example, if the main aim was to improve ecological status rather than reduce mean annual nutrient concentrations, it might be more useful to focus on nutrient concentrations during baseflow conditions during ecologically sensitive periods of the year. Alternatively, if the main aim was to reduce nutrient loadings to a standing water body, then the same model output could be summarised in terms of annual load reductions.

The model applications in this case study did not include any formal uncertainty or sensitivity analysis. The two model parameterisations considered for INCA-N highlight the potentially large influence parameter-related uncertainty can have on model output. Although beyond the scope of this Case Study, for robust policy-relevant output it is advisable to carry out more thorough uncertainty analyses.

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Wade, A. J., Whitehead, P. G. & Butterfield, D. 2002b. The Integrated Catchments model of Phosphorus dynamics (INCA-P), a new approach for multiple source assessment in heterogeneous river systems: model structure and equations. *Hydrology and Earth System Sciences,* 6**,** 583-606.

Case Study 5. Uncertainty in ecological responses to water quality control measures at the river basin scale.

Richard Williams[1], Mike Hutchins[1], Andrew Wade[2], Peter Daldorph[3], Rachel Cassidy[4], Sian Davies[5], Matthew Charlton[6], Jo-Anne Pitt[7]

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[3]*Adkins Global, 5Wellbrook Court, Girton Road, Cambridge, CB3 0NA*
[4]*Agri-Food and Biosciences Institute,18a Newforge Lane, Belfast, Co Antrim, Northern Ireland, BT9 5PX*
[5]*Environment Agency, Red Kite House, Wallingford, OXON, OX10 8BD*
[6]*Environment Agency,* Horizon House, Deanery Road, Bristol BS1 5AH
[7]*Environment Agency, Station Road, Haddiscoe, Gt Yarmouth NR31 9JA*

Summary
This case study investigated the effectiveness of a range of measures aimed at reducing algal growth in the River Thames through a modelling study using the QUESTOR model. The QUESTOR model was driven with observed and modelled data (from INCA-P and SAGIS) for the baseline simulation and modelled data only for the scenario analysis. An additional scenario investigated the algal response to various levels of river shading relative to the base line.

Key finding
To be provided once modelling is completed.

Policy drivers, anticipated end users and end user questions relating to the case study
This case study addressed the following policy drivers: Water Framework Directive, New Environmental Land Measures Scheme. The case study also addressed the following end-user questions: future pressures and extrapolation of impacts, effectiveness of measures/mechanisms, uncertainty, confidence and communication.

Approach and modelling
A multi-model approach will be used in this case study in which the models will be run separately and in sequence. The aim is to estimate the uncertainty in the biological response of the river system that results from (1) possible errors in estimates of input loads (2) uncertainty caused by using different models and (3) uncertainty in the effectiveness of mitigation methods. The model chains will allow us to drive one model (QUESTOR) with the input loads from the other models (SAGIS, INCA-P) and assess the effect that using different models to estimate diffuse loads has on the modelled instream concentrations and biological response. This will be done for baseline cases representing current conditions (2010-2012) and a range of mitigation options for reducing chemical contaminations and hence undesirable biological response. The specific scenarios will be (1) River shading effects (2) Imposing stricter SRP consents at STPs (3) Changes in Farm Practice relative to current practice (increased uptake of measures and 100% uptake of measures).

The study will focus on phosphorus (but will include also include N where practicable) as the driver of biological change. We will develop metrics to define biological change, but it will likely include changes in predicted P concentration and algal growth and associated dissolved oxygen (DO) and Biochemical oxygen demand (BOD) change and quantified as days in excess of "unacceptable" threshold concentrations of BOD, DO and chlorophyll-a. Comparing changes in this metrics between the modelled baseline and the modelled scenarios shows the direction and magnitude of change. Only the shading scenarios have been run to date. The output data from SAGIS corresponding to the farm practice runs (plus baseline) have been generated and are being set up to drive QUESTOR. The data to run INCA-P have been collated and the model is being calibrated for the Thames network.

Outputs

Projections of N and P species, Chlorophyll-a, Temperature, Dissolved Oxygen and BOD have been generated for the baseline scenario using observed data to drive the QUESROR model and for scenarios of different levels of river shading in the upper Thames (shading changes down to Wallingford, simulations down to Runneymede). Other scenario runs are still to be completed.

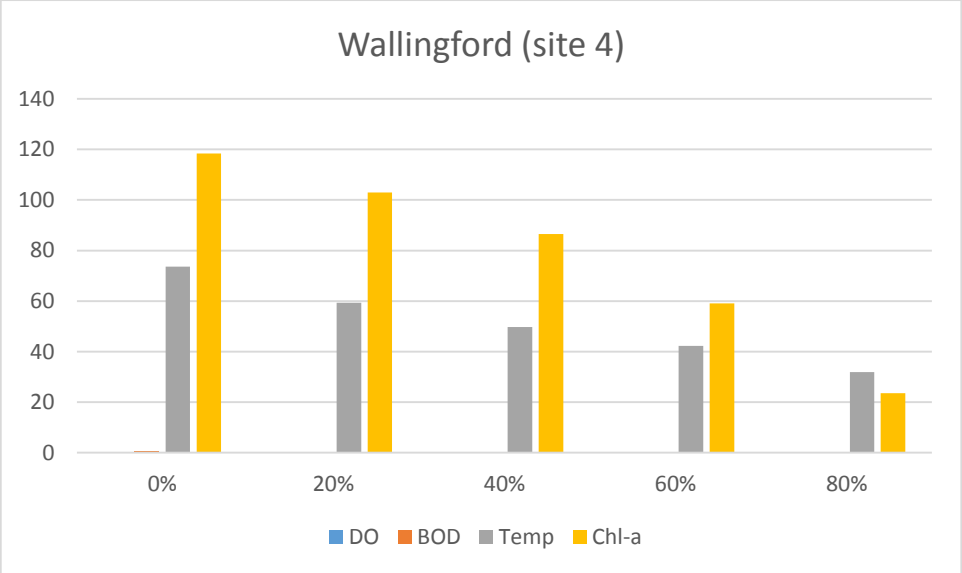

Figure 1. *Simulated (with QUESTOR) mean number of days with unacceptable water quality (<6 mg DO/L, >4 mg BOD/L, >20°C, >0.03 mg chl-a/L) at Wallingford with increased levels of shading of the river Thames down to Wallingford. Current shading extent is about 20%.*

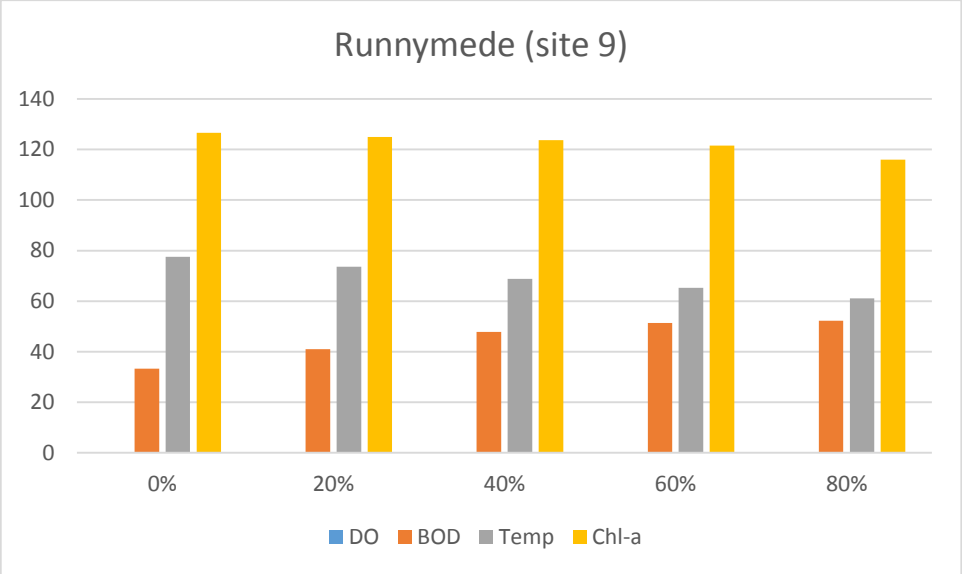

Figure 2. *Simulated (with QUESTOR) mean number of days with unacceptable water quality (<6 mg DO/L, >4 mg BOD/L, >20°C, >0.03 mg chl-a/L) at Runnymeade with increased levels of shading of the river Thames down to Wallingford. Current shading extent is about 20%.*

Evaluation

QUESTOR has been applied to the River Thames and calibrated against observed data. A shading scenario has been demonstrated.

Appendix – further details

Summary

Pollutants: ortho-P, Total P, Nitrate, TN, ammonium, Dissolved Oygen, Biochmeical Oxygen Demand, Temperature, Chlorophyll-a
Scale: Catchment – Main Stem of the River Thames from Wallingford to Runnymede (125 km)
Location: River Thames, Southern England

Data and models used

Models:
QUESTOR, SAGIS (with Farmscoper), INCA-P
Datasets:
Sewage effluent data
Observed river flows and stream water nitrogen and phosphorus concentrations
Solar Radiation data

Approach and modelling

The baseline version of the QUESTOR model was established for the River Thames. Weekly nutrient, temperature and chlorophyll-a data for sites along the River Thames and its major tributaries were provided through the CEH Thames Initiative research platform (Bowes et al., 2012). Continuous chlorophyll-a concentration, DO, temperature and flow data were supplied by the Environment Agency (EA) sensor network (Wade et al., 2012). Solar radiation inputs were modified by the effects of riparian tree shading upstream (as described by Waylett et al. (2013)). The model represents 126.4 km of river channel network (comprising the Cherwell and Thame tributaries and the main Thames; of lengths 14.9, 19.6 and 91.9 km respectively) split into 41 reaches. The model is fed by 23 tributaries and 7 major Sewage Treatment Works (STWs), and accounts for 2 abstractions and 22 weirs. Flow and water quality data to supply the model are available for all main tributaries. Other STWs (e.g. from the large town of Swindon) are represented indirectly by data from the tributaries into which their effluents flow. Monitoring data to test the model are available at 13 sites.

The SAGIS model (REF) was run for the same period under current conditions. The loading from agriculture were then scaled downward by percentages estimated for the Thames catchment from the Farmscoper model (REF). The aim was to use the output data from these runs (monthly averaged data for the simulation period) that were matched to the input points of the QUESTOR model to generate a set of water quality modelled data from QUESTOR.

The rest of this will be completed when the model runs are completed.

Scenarios used

4. River shading
5. Imposing stricter SRP consents at STWs
6. Changes in farm practice
    a. Current practice
    b. 100% uptake of measures
    c. Increased uptake of measures
    d. All Farmscoper measures
7. Imposing stricter nitrate consents at STWs

Further evaluation

Bowes M. J., Leach D. V. and House W. A., 2005. Seasonal nutrient dynamics in a chalk stream: the River Frome, Dorset, UK. *Science of the Total Environment*, 336, 225-241.

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Waylett, A. J., Hutchins, M. G., Johnson, A. C., Bowes, M. J.and Loewenthal, M., 2013. Physico-chemical factors alone cannot simulate phytoplankton behaviour in a lowland river. *Journal of Hydrology*, 497, 223-233.

Case Study 6. Effects of input data quality and quantity on evaluation of land management policies and agri-environment interventions at catchment to national scales.

Jack Cosby[1], Andrew Wade[2]

[1]Centre for Ecology and Hydrology, Environment Centre Wales, Deiniol Road, Bangor, Gwynedd LL57 2UW
[2]Department of Geography and Environmental Science, University of Reading, Whiteknights, Reading, RG6 6DW

Summary
In this case the sensitivity / uncertainty in outputs of models at various scales resulting from differences or uncertainties in input driving data is demonstrated.

Key findings (to date)

Case study six is not yet complete. This case study is a more technical aspect of the development of the Integrated Modelling Platform. This case study will draw on the results of case studies 1-5, using those as base cases against which changes in model output arising from different or uncertain input datasets can be compared. It will not be possible to examine uncertainty arising from all inputs for all five case studies. Instead, as case studies 1-5 are completed, a selection of pollutants, measures, and scenarios from each will be used in this exemplar case study to examine how uncertainty can be assessed and expressed within the context of the Integrated Modelling Platform. In turn, the uncertainty results presented in this case study will inform and contribute to the other case studies.

Policy drivers, anticipated end users and end user questions relating to the case study

This case study addresses the following policy drivers: Water Framework Directive (good chemical and/or ecological status), Farm Payment Schemes, Climate Change Abatement Agreements, Conservation Targets, Flood Risk Mitigation.

The case study also addresses the following end-user questions: Effectiveness of measures and mechanisms; evidence of outcome; uncertainty, confidence and communication.

Anticipated end users of the case study would primarily be Government Agencies, Catchment Managers, Conservation Agencies, Water Industry, NGO's.

Approach and modelling

The question of uncertainty in model outputs is obviously an open-ended one, and depends in part on the model used, the questions asked, the intended use of the answers, etc. In this suite of case studies (1-5) we are compounding this complexity by using a number of models driven by different types, quality and quantity of data, providing both spatial and temporal outputs, and addressing a broad range of questions. These case studies are intended to demonstrate the appropriateness of an Integrated Modelling (IM) approach and the utility of an IM platform.

Indeed, the application of IM to policy and decision-making raises a whole new class of uncertainty considerations that are moot in single model, single pollutant modelling activities. This case study (6) will demonstrate several approaches to evaluating uncertainty in an IM environment using a selection of the same models and data sets as in the first 5 case studies. The outputs of this case study are in no way definitive or exhaustive, rather they are

indicative of the types of uncertainty analyses that can be performed in an IM environment. It is intended that this case study demonstrate an important function of the IM platform, that it is never too late to go back to previously achieved results (the outcomes of studies 1-5) and ask relevant questions about the reliability or uncertainty of the results and the confidence that can be placed in them.

Outputs

Final outputs for this case study are not yet available. The model applications from case studies 1-5 to be examined here will be selected in the next 2 months. Alternate datasets to test uncertainty will be identified and the analyses will be run over the following 4 months.

Appendix – further details

Summary

Likely pollutants to be included in the uncertainty analyses: Nitrate, Phosphorous, Sediment, Fecal Indicator Organisms (FIO), Flood Potential, Carbon loss (and sequestration), Biodiversity Loss, metaldehyde

Scale: Catchment to National

Location: GB and Wales

Data and models used

Likely models to be used:
Farmscoper, SEPARATE, INCA N, INCA P, INCA FIO, LUCI, SWAT

Likely datasets to be used:
Dependent on Case Study but could include:

- Inputs
    - Agricultural census by Water Management Catchments (WMC)
    - Robust Farm Type counts by WMC
    - DEM data
    - Soils data
    - Landuse cover
    - Climate data
- Outputs
    - Agricultural pollutant reductions at WMC scale
    - Cost of scheme implementation at WMC scale
    - Net and Gross primary productivity
    - Soil carbon stocks and change
    - N and P in streams
    - Flood mitigation potential
    - Sediment and erosion potential
    - Green House gas emissions

Case Study 7. Interpolation of data from catchment to national and monitored to non-monitored catchments

Jack Cosby[1], Bridget Emmett[1]

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Summary

This case study addresses the issue that, even though we have many catchments where different management options have been tested and we have intensive data and models, we need protocols and methods: 1) to identify where similar outcomes could be expected at a national scale but where data are poor or non-existent; and 2) to understand how outcomes will depend not only on biophysical properties of the landscape but also on socio-economic characteristics of the communities.

Key findings (to date)

Case study 7 is just beginning. In the original implementation of the project, the seventh case study was not initially defined by the forum. Rather, the focus of the case study was left open until the forum–led case studies had all been identified. The purpose of the seventh case study was to fill gaps in the overall program identified by the funding bodies. At a recent meeting (March, 2106) with Defra, EA and others, the content of this case study was agreed in principle. It will now move forward to full development following the concepts presented below.

Policy drivers, anticipated end users and end user questions relating to the case study

This case study addresses the following policy drivers (identified to date – others may be includedas the case study develops): Water Framework Directive (good chemical and/or ecological status), Farm Payment Schemes, Climate Change Abatement Agreements, Conservation Targets.

The case study also addresses the following end-user questions (identified to date - others may be included as the case study develops): Effectiveness of measures and mechanisms; evidence of outcome; uncertainty, confidence and communication.

Anticipated end users of the case study would primarily be Government Agencies, Catchment Managers, Conservation Agencies, Water Industry, NGO's.

Approach and modelling

This case study exploits work being undertaken as part of the Defra Sustainable Intensification Project. (SIP2) This cross-project aspect of the study was particularly welcomed by the funders. As part of SIP2, CEH and the SIP2 consortium are developing a Dynamic Typology Tool (DTT) that will:

- Combine map datasets describing landscape character and management
- Identify homologous areas of agricultural potential, natural environment quality and risk.
- Provide national coverage and local output suitable for stakeholder engagement in study areas.
- Aid identification, targeting and prioritisation of land-use opportunities for sustainable intensification outcomes.

The DTT is a web-based interactive tool that allows users to combine datasets using their own pre-defined weights to produce maps of areas with similar environmental, economic and/or social characteristics (Figures 1 and 2). Typologies (landscape clusters with similar characteristics) developed from these weighted maps can then be used to identify regions with little or no data or modelling resources which are similar to other regions where data and models have been used to address policy questions. The concept is that all areas within a typology

would have the same responses to policy interventions and the results from the data rich regions could be interpolated and used to inform management in data poor regions within the same typology.

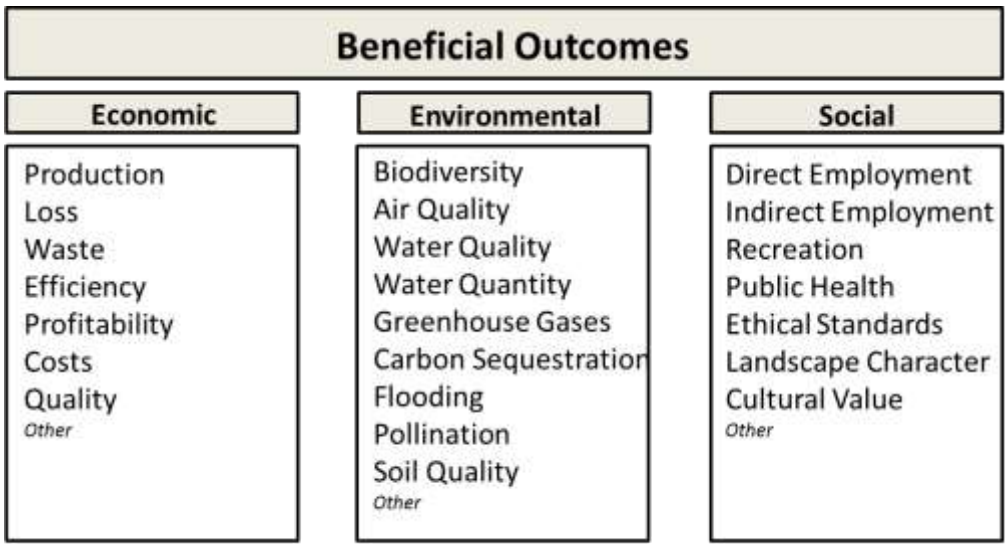

Figure 1: Sustainable Intensification Outcomes considered by the DTT.

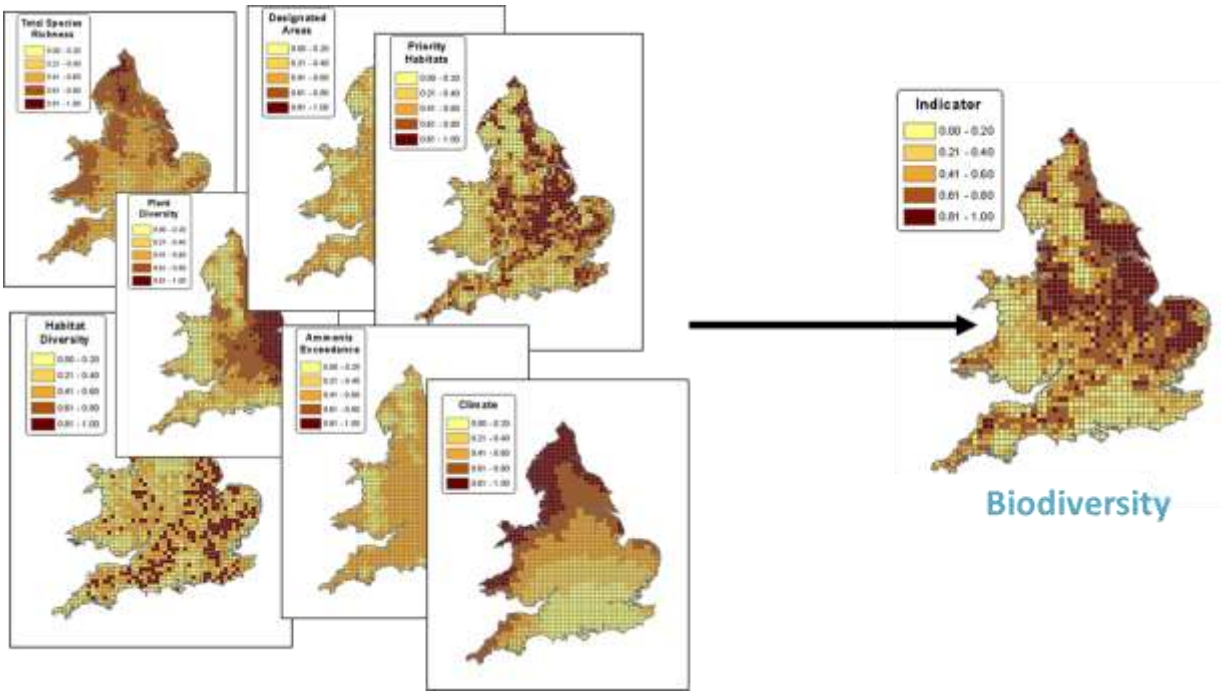

Figure 2: An example DTT outcome constructed as weighted overlay of many primary spatial datasets.

Outputs

Final outputs for this case study are not yet available. Figures 3-5 show screenshots of the current DTT web-based tool

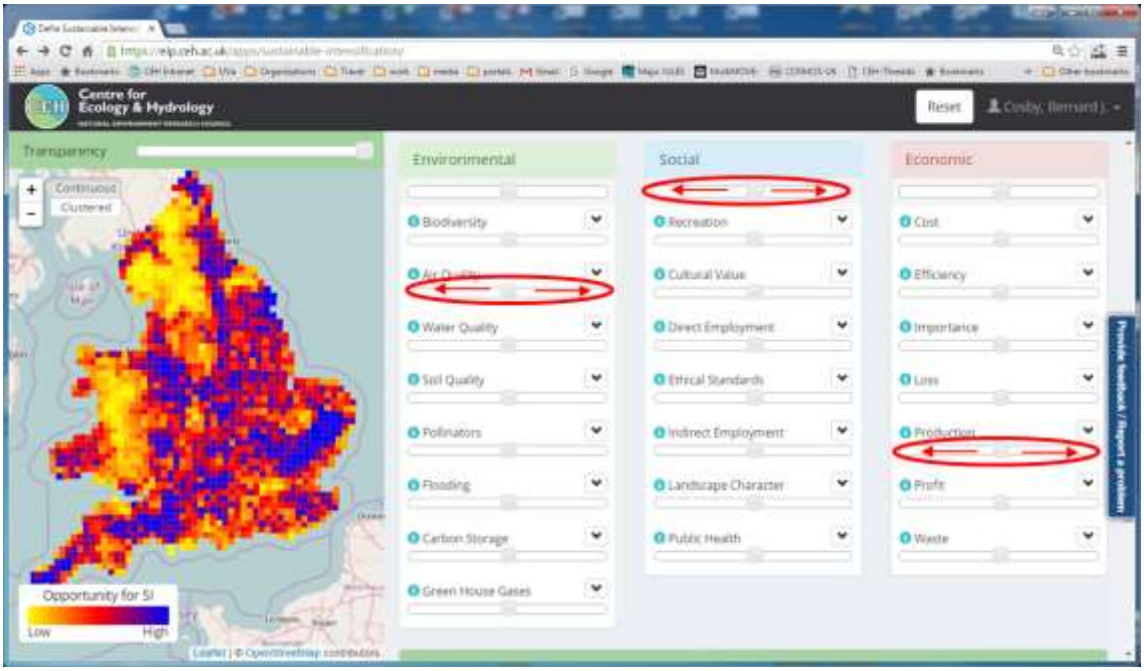

Figure 3. The DTT allows user selected weight on primary SI outcomes as well as underlying databases to be adjusted using slider bars.

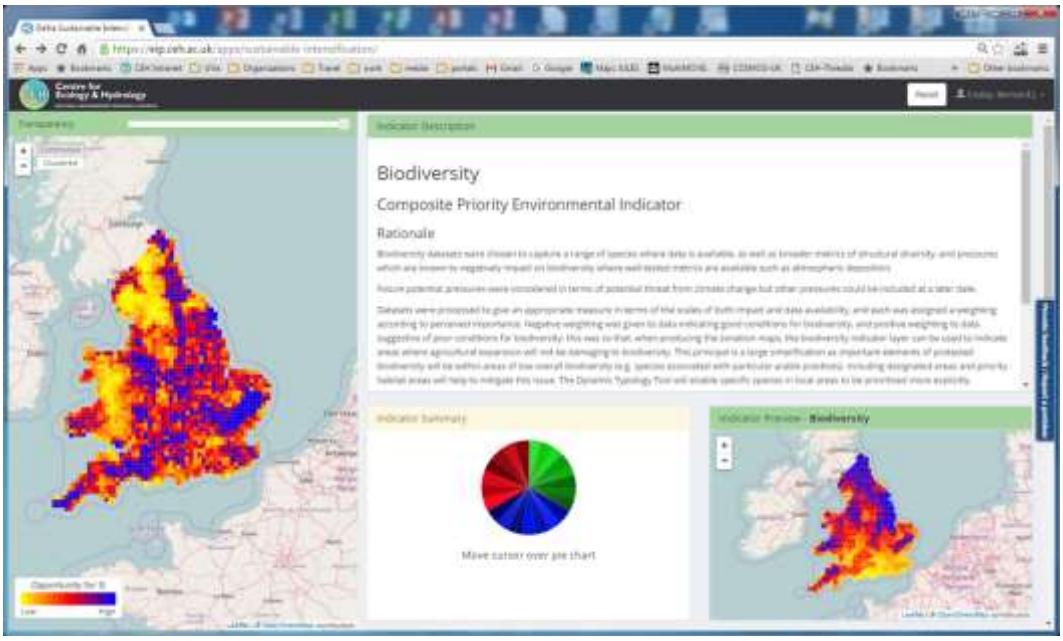

Figure 4. The underlying basic data layers are fully documented providing an evidence base for interpolated results.

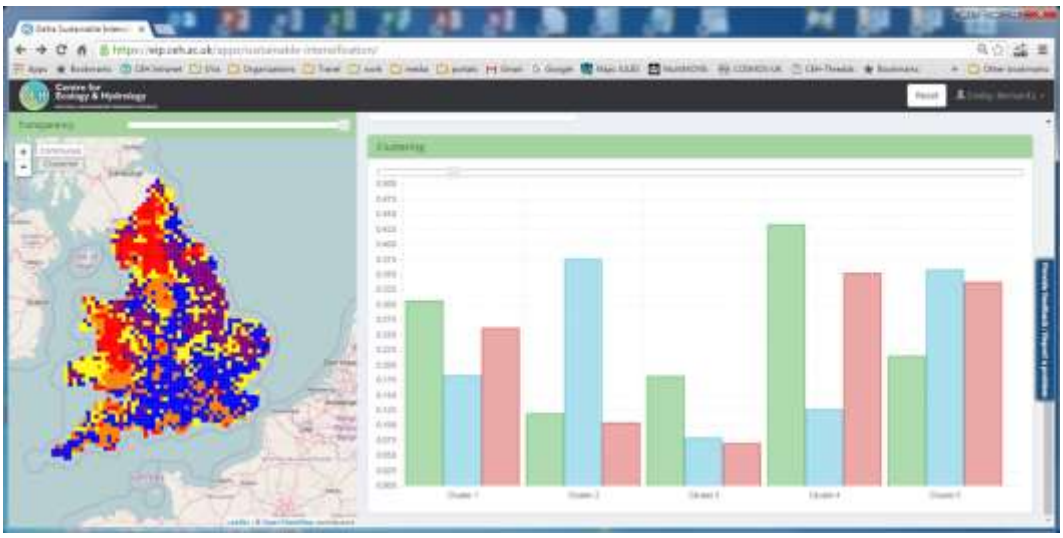

Figure 5. The number of typologies (degree of clustering) can be designated by the user, and the relative weighted importance of each of the three categories (environmental, economic, social) to the final typology illustrated graphically.

Next Steps – The proposed approach for Case Study 7

- To evaluate the biophysical elements of the tool using evidence from catchment sensitive farming outcomes for water quality (England)
- To assess the value of tool to predict likely uptake of management options due to socio-economic constraints (Wales)
- Feedback from Defra / EA requested during development as this case study is specifically requested by the funding agencies.