

**Environment Agency Science Project SC080031 Evidence and Measures – final review from  
Ben Surridge, January 2013**

Dr Ben Surridge  
Lancaster Environment Centre, Lancaster University  
b.surridge@lancaster.ac.uk; 01524 594516

**1. Introduction**

This document completes a series of external reviews focussed on material produced under the Environment Agency's Evidence and Measures (E&M) science project. For completeness, past review documents are appended, specifically: i) a first review of the E&M project as developed for the River Petteril in 2009 (Appendix A); and ii) an initial review and feedback related to the 'Causes' approach developed in 2012 for the Tidal Ribble (Appendix B).

There are two components to this current document. Firstly, a review of the Measures workshop for the Tidal Ribble that I attended in August 2012 as an external reviewer, considering how this workshop progressed and how the information on causes that was provided by the E&M team was used within the workshop. Secondly, I consider the wider need for an approach such as that developed within the E&M project, the specific advantages offered by the E&M approach, and issues to address when attempting to extend the E&M approach more broadly.

**2. Review of Causes workshop on the Tidal Ribble, August 2012**

The material below is organised around specific aspects of the Causes workshop that I was asked to focus on by the E&M project team:

- a. *Workshop attendees.* The workshop predominantly involved Environment Agency staff. This did not detract from the usefulness of the workshop, but raises two potentially important issues when considering wider roll-out of the E&M approach. Firstly, it is obviously challenging the secure the involvement of a diverse group of stakeholders (EA staff, NE staff, farmers, water companies, local councils, etc) throughout a process such as E&M – we are risking stakeholder fatigue given the number of requests for engagement in decision processes that these stakeholders are exposed to. It would be desirable to implement the E&M approach within an existing decision-making forum at which a diverse group of stakeholders are already engaged, an issue I return to later in this report. Secondly, the way in which the technical evidence that was included as part of the Measures workshop (and as part of the earlier Causes workshops) would be understood and used by a more diverse group of stakeholders deserves consideration. It is possible that the quality of the evidence would be challenged more strongly by stakeholders who did not work for

the EA. It is also possible that stakeholders who are not familiar with the technical data collected by the EA would find it more difficult to engage fully with this technical evidence. This latter issue could be resolved by running a sub-group of stakeholders (possibly as part of an initial Causes workshop) who engage fully with the technical evidence, followed by the full stakeholder group who consider the summary of the technical evidence in a second Causes workshop, and then use this summary to underpin discussions in the Measures workshop. Further insight into these issues should be taken from engagement with stakeholders in the Moston Brook case study under the E&M project.

- b. *Value of the E&M process.* The value of the Measures workshop as an opportunity to access local knowledge regarding the Tidal Ribble waterbodies, and to evaluate the outcomes of national/regional approaches to WFD implementation (e.g. RBC and initial classification results) in light of this local knowledge, was recognised by stakeholders who attended the workshop. The potential for initial integration across national and local forms of evidence within the E&M process is a broader benefit of the project that deserves recognition.
- c. *Spatial targeting of measures.* The workshop was particularly useful for discussion of measures which required local-scale spatial targeting, for example to specific farms, rural industrial sites, etc. Clearly the workshop will be less relevant to issues of national/regional-scale regulation where the potential for spatial targeting is reduced. However, it is discussion of local-scale measures, their targeting, their effectiveness and their wider costs/benefits that has been particularly lacking during the first cycle of RBMPs, and so this contribution of the E&M project is important.
- d. *Integration of multiple activities related to measures.* A range of activities with the potential to influence the ecological status of waterbodies in the Tidal Ribble, although not driven by the WFD, were discussed by stakeholders during the Measures workshop, for example activities related to CSO upgrades and communication between UU and the Local Authority regarding new housing developments. This reflects the value of a forum such as the Measures workshop for integrating and learning about diverse activities with the potential to influence the quality of water environments, regardless of the driver for these activities.
- e. *Use of the evidence base as provided by the E&M team.* The summary tables of evidence for waterbodies provided to stakeholders at the workshop were a key starting point for discussion. The messages within these tables were important influences on the subsequent discussion of measures within the breakout groups. These summary tables could represent an appropriate level at which to engage a broader range of stakeholders with the technical evidence, and may be something that is produced by a sub-group of stakeholders from their consideration of the full technical dataset. Later in the workshop, stakeholders began to examine parts of the evidence base in greater detail, moving beyond only the summary tables. At this point navigating the evidence as provided in hard copy became somewhat

challenging. It may be easier to provide digital copies of the evidence base that stakeholders can explore through laptops and projectors in future workshops. There was little discussion of the validity of the statements made in the summary tables, and therefore of the evidence base itself. This may reflect the extensive discussions that had already occurred during the two earlier Causes workshops. However, it may also reflect the composition of the stakeholder group involved in this workshop, and a more diverse group of stakeholders may be more reluctant to move beyond the evidence and begin a discussion of measures. Again, this issue should become clearer as part of experience gained with the Moston Brook case study currently underway in the E&M project.

- f. *Group dynamics.* The leader of each discussion group played a critical role in facilitating the debate and in driving the process forward from initial consideration of the summary tables of evidence towards a final list of agreed measures. This was a challenging task, and in my opinion is not a role that can be undertaken by a member of the group who also wants to participate fully in the discussion regarding measures. There may be a case for engaging facilitators as group leaders to drive the process forward, if these facilitators have sufficient technical knowledge to manage this process, leaving other participants free to engage in the debate. Stakeholders were reasonably slow to complete the process for the first waterbody. However, the speed of the process increased as stakeholders gained more experience. I would suggest leaving greater time for the first waterbody in subsequent workshops, enabling stakeholders to become more familiar with the process before moving on to subsequent waterbodies. Stakeholders moved between discussion groups as there was a need for their particular expertise. This was a useful and positive aspect of the workshop and should be encouraged and supported in subsequent workshops.

## **2. Summary comments regarding the overall E&M project**

The second component of this report considers three questions in the broader content of the overall E&M project, particularly with a view to wider roll-out of the outcomes of the project:

- i. What is the context/need for an approach such as that developed within the E&M project?
- ii. Given this context/need, what are the key opportunities offered by the E&M project?
- iii. Which issues might need to be considered as part of wider roll-out of the E&M approach?

*What is the context/need for an approach such as that developed within the E&M project?*

The decision problems that we are grappling with in the context of the WFD and catchment management more generally have been widely described as ‘wicked’ or ‘messy’ problems (Chapman, 2002; Rittel and Webber, 1973). These problems are characterised by:

- i. their location at the interface between science and society, as opposed to simply being scientific or technical problems that can be dealt with by organisations such as the EA;
- ii. multiple objectives and therefore a wide range of valid priorities and perspectives among stakeholders regarding what should be ‘done’ in catchments;
- iii. significant uncertainty in (scientific) understanding of the complex catchment systems that lie at the heart of the WFD and catchment management; and
- iv. a catchment management process that will not be ‘achieved’, but instead a process that will need to be repeated periodically, for example as part of each individual RBMP cycle under the WFD.

Despite the significant and valuable research activity that is underway within numerous academic projects and, increasingly, within collaborative research projects such as Defra’s Demonstration Test Catchments (DTC) programme, improved scientific knowledge is fundamentally unable to transform a wicked or messy management problem into one that is tame or benign, and one that could therefore be addressed by traditional command-and-control management approaches (e.g. Holling and Meffe, 1996). The key challenges in the context of these new decision problems are how to structure revised decision-making processes that enable action to be agreed and implemented by stakeholders even under the challenging conditions of i) to iv) above, and how to support these decision-making process with the best available knowledge/evidence base which includes, but is not limited to, scientific/technical evidence. It is these challenges that I believe define the most relevant context/need for the E&M project and this context should be recognised by those who are considering the value and utility of the E&M approach. These challenges go beyond only implementation of the WFD, although clearly this is a highly timely and important legislative framework for the project partners. The same challenges I highlight above are also relevant to issues that include the DTC programme, Defra’s Pilot Catchments project, and future work to implement management frameworks based on Ecosystem Services and the Ecosystem Approach.

*Given this context/need, what are the key opportunities offered by the E&M project?*

Having observed the development of the E&M project since 2009, I believe that the major outcome of the E&M project should be described as a *process* that supports stakeholders in their attempts to agree measures in the context of management challenges such as the WFD. There are a number of key components to this process:

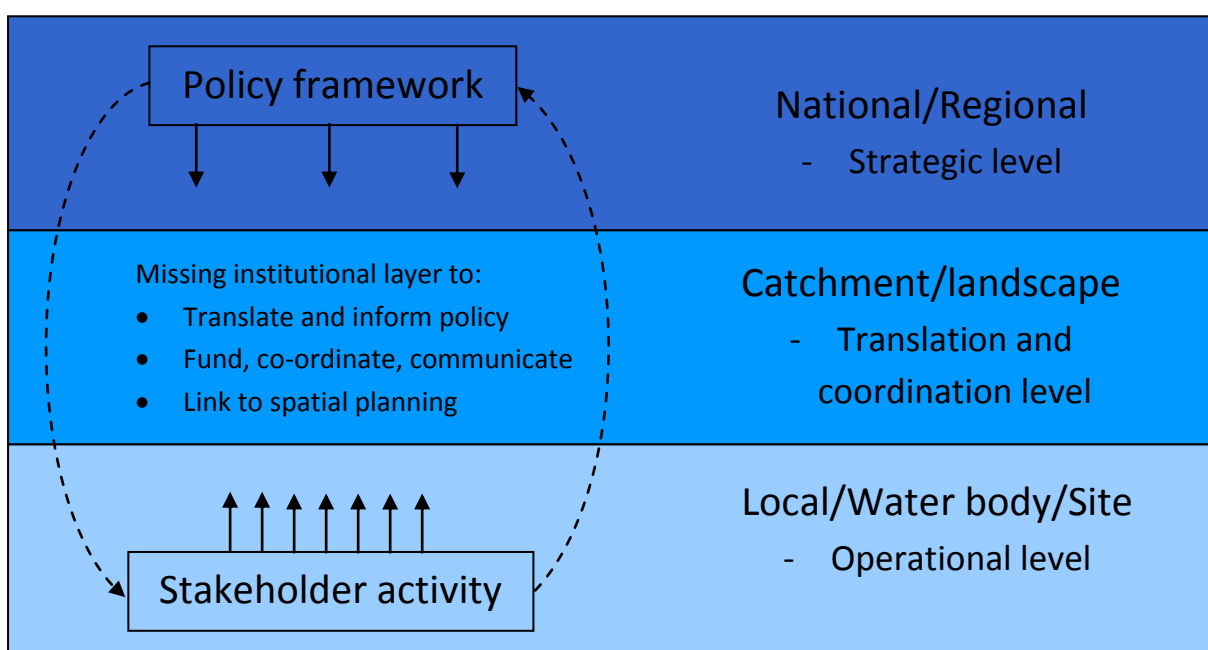
a) **The collation and presentation of a coherent evidence base for stakeholders.** This evidence base goes beyond traditional sources of empirical data, such as EA monitoring data, to incorporate historical datasets but also other forms of so-called ‘softer’ data and information that are often difficult to include within decision-making processes. In my experience of both the EdenDTC project and the Eden Pilot Catchment project, this coherent evidence base is often seen as an important resource by stakeholders involved in collaborative decision making processes, but is often not readily available. Whilst collation of this evidence base may be an activity that is thought to be undertaken currently by the EA, or to have been undertaken historically by the EA, my experience is that this is not the case and is therefore an important contribution from the E&M process.

b) **The presentation of key messages emerging from the evidence base.** Initial analysis of the evidence base by the E&M team adopts a weight-of-evidence or lines-of-evidence approach, looking for consistencies and inconsistencies across the evidence base in order to present summary messages to stakeholders for debate as part of workshops within the E&M process. Importantly, this analysis is not about developing new models (such as SIMCAT, PSYCHIC, SAGIS, etc), or about in-depth statistical analysis (such as that involved in NVZ designation based on statistical modelling). Such model and statistical activity is rightly undertaken elsewhere and is not directly part of the E&M process. However, the outputs from these model and statistical activities may contribute to the evidence base that the E&M project seeks to collate. The key advantage of the analysis within the E&M process is the potential to look across multiple lines of evidence and to present initial interpretations from a coherent evidence base for debate among stakeholders. In many respects this analysis is qualitative or semi-quantitative, which provides a suitable basis for engaging a range of stakeholders in the E&M process.

c) **A forum for open discussion of the evidence base.** The Causes workshops provide one forum for discussion of what is, and will likely remain, an uncertain evidence base. Given this uncertainty, the aim of the Causes workshops is to reach a sufficient level of agreement among stakeholders regarding the issues that should be addressed within a particular location, enabling progress to be made towards an agreed set of measures to address these issues. Without an explicit and open discussion of the evidence, it is likely that some stakeholders remain ‘stuck’ on the uncertainties within the evidence base and are unable, or unwilling, to move beyond these uncertainties and towards a set of measures that are agreed on the basis of acting with no regrets. Clearly, a range of other fora could benefit from open discussion of a coherently presented evidence base, including river basin liaison panels under the WFD and stakeholder fora under the Pilot Catchments project.

d) **An opportunity to access local-scale knowledge and information for the purpose of validation and targeting.** Both the Causes and Measures workshops that are part of the

E&M process provide opportunities to better integrate the outcomes of national/regional-scale approaches with local-scale priorities and knowledge. This relates both to local-scale validation of the risks/causes of management issues within catchments, for example as defined by national-scale approaches such as RBC1+2 and the initial classification results under the WFD, but also to the local-scale targeting of mitigation measures. The lack of an intermediate-scale of decision-making, located between local and regional/national scales (e.g. Figure 1), is often seen as a fundamental limitation of the approach developed for RBMP1, and has underpinned interest in catchment-scale approaches such as those developed under Defra’s Pilot Catchments project. The E&M process provides one example of an attempt to integrate knowledge across multiple scales as part of a catchment management process.



**Figure 1.** The missing institutional layer at intermediate, catchment-scale that currently constrains the success of legislative frameworks such as the WFD in England and Wales (Surridge *et al.*, 2009).

*Which issues might need to be considered as part of wider roll-out of the E&M approach?*

The E&M project has developed through three case studies involving the River Petteril, Tidal Ribble and Moston Brook. There is now interest in how the project could grow and be rolled-out more widely. When considering wider roll-out of the E&M process, I believe the following issues deserve consideration:

a) It is unlikely that the complete E&M process will be required for each of the approximately 7800 surface water bodies defined under the WFD in England and Wales. Application of the E&M process might best be organised at an intermediate spatial scale between individual water bodies and River Basin Districts. This intermediate-scale may

represent the catchment-scale as applied in projects such as Defra's Catchment Pilots, recognising that hydrological catchments can vary in size significantly. The E&M process would represent one tool within the tool kit of approaches available to address management challenges at this catchment scale. The application of the E&M process could then be tailored to the specific needs of an individual catchment. For example, where management issues and their causes are agreed to be reasonably clear among stakeholders, discussion could move rapidly onto measures without the need to collate and discuss the evidence base within Causes workshops, in effect representing a reduced version of the E&M process. However, within catchments where uncertainty over the management issues and their causes is such that agreement among stakeholders to discuss measures is lacking, a 'complete' version of the E&M process might be required.

b) A range of practical activities could be pursued in order to roll out the E&M project more widely. I would recommend a combination of:

i) Further application of the E&M process to example catchments. I would recommend both 'problematic' catchments within which the full E&M process might be required, and catchments in which only a reduced version of the E&M process is implemented. The E&M project would be disseminated through providing training and experience to stakeholders involved in the management of the additional catchments.

ii) Specific training activities for individuals who have initial experience of the E&M process. The training could focus on providing the necessary skills for individuals to organise and lead the implementation of the E&M process within their own areas of responsibility.

iii) Create learning networks related to the E&M project. I would recommend including individuals and organisations in this network who have been involved in the initial development of the E&M project on the River Petteril, Tidal Ribble and Moston Brook, but also individuals and organisations involved in parallel activities such as River Basin Liaison Panels, Pilot Catchments, Demonstration Test Catchments and Virtual Observatory projects. The aim of this network would be to provide an opportunity for dissemination and exchange of learning related to the E&M process, and for wider exposure of individuals and organisation to the principles of the E&M project.

c) Consider whether the EA/Defra are the best, or only, potential organisations to own and administer the E&M process. Wider roll-out could involve additional organisations leading the implementation of the E&M process, for example the Rivers Trusts in the context of the



Pilot Catchments project, with technical support provided by the core E&M team where required.

d) Use the opportunity provided by wider roll-out of the E&M project to communicate clearly with and manage the expectations of stakeholders. This relates particularly to the level of uncertainty in the current evidence base, the limitations in the extent to which more data will ultimately help stakeholders to address fundamentally wicked management problems, and to the likely lag times and uncertainty in response within catchments to measures given the historical legacy of human disturbance within these systems.

e) Emphasise that measures should include both short-term wins over more immediate timescales relevant to legislation such as the WFD, but also a longer-term aspiration or vision that could be delivered in the future as resources become available. The scope of the E&M process also deserves extension to ensure that the effects of the agreed measures are monitored as far as possible. We should not stop solely at implementation of measures, thereby missing opportunities to learn about how catchments function as a result of our management actions within these systems.

## References

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## Appendix A

### Environment Agency Science Project SC080031 'Evidence and Measures' – comments and suggestions from external reviewer

Ben Surridge  
Lancaster Environment Centre, Lancaster University  
b.surridge@lancaster.ac.uk; 01524 594516

#### Introduction

This review has been prepared in response to the specification for input from external reviewers provided by the Environment Agency. It is based on the author's knowledge of academic research related to diffuse water pollution from agriculture (DWPA), experience of engagement with local stakeholders involved in mitigating the effects of DWPA, and conversations with academic and non-academic colleagues working in related fields.

#### Responses to questions raised in EA specification

1. *From your knowledge of the management issues and choices we face in delivering environmental improvement in catchments, and the objectives of the project, what would you do?*

Firstly, I fully support the underlying rationale for the project. To my mind it is clear that mitigating the effects of DWPA will require a combination of regulatory measures developed at national or regional scales, alongside measures that are implemented at more local scales and may involve either voluntary or incentive-based delivery mechanisms. The challenge that underpins this project is that these so-called local measures have substantial uncertainties associated both with their effectiveness, and the additional benefits or dis-benefits that may occur as a result of their implementation. These uncertainties have prevented inclusion of many of these measures in the 1<sup>st</sup> cycle of River Basin Management Plans (RBMPs).

I broadly support the objectives of the project and the programme of work. However, my general feeling having examined the available project documentation is that applying a more coherent and logical structure to the project would be helpful. Firstly, I recommend that the uncertainties associated with the effectiveness of local measures are considered in a more systematic and structured way as part of the project. These uncertainties are the basis to the project, and a clear identification of them is required if later stages of the project are to be successfully delivered, and if the products that emerge from the project are to be useful. In my opinion, an analysis of the uncertainties associated with the effectiveness of these measures needs to capture the following elements:

- The project assumes DWPA is a significant source contributing to pressures (e.g. P, N, sediments), and that these pressures are responsible for status failures in receptors such as rivers and lakes. There are significant uncertainties associated with these core assumptions. Firstly, whilst DWPA is certainly one source that contributes to such pressures, the importance of DWPA relative to other potential sources is uncertain. Secondly, the extent to which individual pressures, and in turn individual sources of any particular pressure, are responsible for status

failures in receptors, particularly when these status failures are associated with biological quality elements, is also highly uncertain.

- Uncertainty associated with the processes responsible for the mitigation potential of individual measures. This covers basic issues such as the spatial and temporal scales at which individual measures need to be implemented to mitigate pollutants, the potential for swapping between individual forms of a particular pollutant or between individual pollutants as a result of the implementation of a particular measure, and identification of the wider benefits or dis-benefits that result from implementation of a particular measure.
- Uncertainty regarding the scaling effects associated with individual measures. For example, although a particular measure may mitigate DWPA at the field-scale, to what extent does the measure need to be implemented across larger sub-catchment and catchment scales to be effective at these scales? Is there a simple monotonic response of effectiveness to extent of implementation? Is there a threshold beyond which more extensive implementation results in no further improvement? To what extent is the effectiveness of a measure at larger spatial scales dependent on the spatial targeting of the measure?
- Uncertainty about the timescale of response and uncertainty due to hysteresis. The response of a particular chemical or biological parameter within a receptor, such as a stream or river, is likely to lag significantly behind the implementation of a measure within the landscape. This lag is likely to be compounded by legacy effects of previous actions, for example significant nutrient residues already exist in soils and in stream sediments that may continue to supply nutrients to groundwater and surface water even if other sources of these potential pollutants, such as fertilisers, are substantially reduced. In addition, the potential for hysteretic effects adds further uncertainty to our ability to predict the effectiveness of measures, particularly in terms of biological responses in receptors.
- Uncertainty surrounding the delivery mechanism for particular measures. Delivering a measure through voluntary or incentive-based mechanisms involves significant uncertainty in terms of the degree to which such a measure will be adopted by stakeholder communities. This compounds other sources of uncertainty, particularly those associated with the spatial extent to which a measure must be implemented to be effective at sub-catchment or catchment scales.
- Uncertainty due to the use of an individual measures as part of a programme of measures. There are likely to be interactions between individual measures that are implemented as part of a programme of measures within RBMP cycles. The magnitude of these interactions, and the extent to which they are conflicting or synergistic, is largely unknown.

The above points emphasise the challenge involved when seeking evidence of the effectiveness of measures, particularly when effectiveness is narrowly considered in terms of chemical and biological outcomes in receiving waters. Improvement in these environmental outcomes is only likely to emerge a considerable time after measures are implemented, perhaps decades or longer in some cases. It is also unlikely that simple cause-effect relationships will be identified between individual measures and environmental outcomes in receiving waters, particularly at the sub-catchment and catchment scales that are of interest to this project. I think it is important that the expectations associated with this project are managed in the light of the complexity and uncertainty associated

with the systems we are dealing with, and the objectives of the project should be reviewed by the project board and the project manager to ensure they are realistic and achievable given the financial and timescale constraints on the project.

In the context of the points raised above, how do I believe that the project should move forward? I make the following suggestions:

- With respect to the cause-effect relationship between DWPA and environmental outcomes in receiving waters, I would make two decisions. Firstly, I would make explicit that investigating the degree to which DWPA contributes to particular pressures relative to other potential sources is beyond the scope of this project. However, I would ensure that this project remains linked into the extensive source-apportionment work being conducted by the EA and others. Secondly, I would draw on the River Basin Characterisation (RBC) methodologies as a basis to evaluating the links between DWPA-related pressures and status classifications for the WFD in the Petteril. In particular, I would use this project as an opportunity to validate the nationally-developed RBC methodologies using local expertise within the Petteril, thereby reducing uncertainty in the causes of failure for water bodies in the Petteril. Establishing a framework within which local knowledge can be combined with RBC methodologies, for example drawing on approaches such as graphical/conceptual/mental models, could be a useful product to emerge from this project, and would deserve dissemination.
- I would use a clear conceptual model related to DWPA to structure the project. One of the most significant challenges facing members of the project team is the complexity of the DWPA problem, particularly when we consider these issues at the water body to catchment scales that are the focus of this project. If the project is to move forward successfully then a clear structure within which these complex issues can be organised is absolutely essential. Academic research related to the DWPA problem has developed a transfer continuum concept (e.g. Haygarth et al., 2005), similar to the source-pathway-receptor conceptual model that is used widely in the EA. The transfer continuum organises the DWPA issue around source, mobilisation, delivery and impact components. I would recommend that the transfer continuum is reviewed by the project team and potentially adopted as a conceptual framework around which later work within the project could be organised, as I outline below.
- I would use the transfer continuum as a way of structuring thinking within the project about the very wide range of potential measures that might be used to mitigate the effects of DWPA. Measures could be logically organised into those targeting sources (e.g. farm fertiliser management plans to optimise fertiliser applications), mobilisation (e.g. methods to improving soil structure and infiltration, thereby reducing surface runoff), and delivery (e.g. disconnecting transfer pathways by using field or riparian buffer strips). Identifying the specific part of the transfer continuum that is targeted by an individual measure would be a useful basis for later stages of the project that look for indicators, and for methods, to assess the effectiveness of the measure.
- The project should consider evidence of change along the entire transfer continuum as evidence of effectiveness. I'm aware of the difficulty of making this argument, particularly as the primary focus of effectiveness is on environmental outcomes in receptors. However, given the

complexity of the links between a measure related to DWPA and an environmental outcome, the likely time delays between cause and effect, issues of historical legacy and of hysteresis, I think the project should consider a broader suite of indicators as being useful for evaluating the effectiveness of a measure. For example, indicators related to changed behaviour or practice, to the scale of uptake and implementation of a particular measure, and to environmental outcomes that focus on changes to the input of pollutants to a landscape, rather than simply to the delivery of pollutants to a receptor, are, in my opinion, all relevant in the context of mitigating the effects of DWPA. It is interesting to note that similar arguments have been made for groundwater systems. Because of time lags and historical legacy, direct links between a measure and a change in the status of groundwater per se are unlikely to be observed for some time. As a consequence, indicators related to other parts of the groundwater system, such as the chemical quality of recharge leaving the soil zone, are increasingly recognised as valid indicators of the changes delivered by management actions. I believe similar arguments need to be made with respect to the surface water systems that are the focus of this current project.

- Having used the transfer continuum to structure our thinking about different measures and about different indicators of effectiveness, I think the project could use the outcomes to judge the value of the various approaches that are available for selecting effective measures. For example, statistical data analyses and process-based models may prove useful only for particular combinations of measure and indicator of effectiveness (often indicators related only to environmental outcomes, and often only at the delivery end of the transfer continuum). I would strongly recommend that the project also considers alternative methods for selecting effective measures that may be less strongly focussed on environmental outcomes in receiving waters, for example those based on weight-of-evidence approaches that may be applicable at other points along the transfer continuum.
- Given the voluntary and incentive-based delivery mechanisms that are likely to underpin many local measures, the social networks operating within any given catchment are likely to be extremely important. Alongside building conceptual models of the biophysical nature of the Petteril, I recommend that the project looks at characterising these social networks. Such knowledge would provide the basis for the EA and other partners to understand how these networks can be supported and influenced in order to deliver changes within the catchment that contribute to mitigating the effects of DWPA. Social network analysis is one formalised means by which such networks can be analysed. This work emphasises the delivery mechanism as an important constraint on the effectiveness of a measure.

2. *What data, tools and approaches or related work would you highlight as important for us to consider or incorporate in our trialling of methods?*

I note that a review of related material is a key workpackage within the project structure so I will not go into detail on any of individual item here. I would again highlight the importance of structuring the review of related work with reference to my earlier comments about the transfer continuum and about the range of indicators of effectiveness available along this continuum. The areas I recommend you cover within this review include:

- The significant body of work that has been completed by Defra investigating measures to address DWPA. I would include the Inventory of Methods to Control DWPA (Defra project ES0203, Cuttle et al. (2006)) that focussed on individual measures applied at the farm-scale, and the analysis of combinations of measures (policy packages) both at farm (Defra project ES0205, Anthony (2006)) and catchment (Defra Projects WQ0106 and WT0719CSF, Anthony and Lyons (2007)) scales. Each of these projects involves model-based assessments of the costs and effectiveness of measures, and they represent important background material for the current project.
- Defra work has also developed relatively simple cost-curve approaches for pollutants that are agriculturally-derived, including nitrate and phosphate (Defra projects PE0203, NT2511, and ES0121). Note that this work developed approaches for model farm systems and so may be less relevant to the specific conditions in the Petteril, and to water body or catchment scale assessments.
- As I'm sure you're already aware, there are many at least partially process-based models that have been developed, usually in an attempt to estimate loads of pollutants or to identify high risk locations with respect to DWPA. These models vary both in terms of their data input requirements, and in terms of the temporal and spatial resolution of their outputs. A thorough review of these models would be a useful element of the current project. I would highlight a number of models as priorities: Phosphorus Indicators Tool (PIT, Heathwaite et al. (2003)); Phosphorus and Sediment Yield Characterisation (PSYCHIC) model, both tier 1 and tier 2 (Davison et al. (2008)); PEDAL models 1 and 2 developed at Lancaster University – Trevor Page can provide further information ([t.page@lancaster.ac.uk](mailto:t.page@lancaster.ac.uk)); the SCIMAP risk mapping framework developed by Durham University; the NERM and PERM frameworks developed by Newcastle University. Some of these models are capable of simulating the effects of measures, for example the input files for the Psychic models can be varied to reflect future management scenarios. However, I would suggest that this work is still at the development stage for many of these models, and although of future interest may not be immediately useful for the current project.
- Background methodologies for cost-effectiveness and cost-benefit assessment of measures for the WFD have been developed as part of the Collaborative Research Programme by Defra and partners and may deserve review as part of the current project (see: <http://www.wfdcrp.co.uk/>).
- Review alternative methods for selecting measures. In particular I would review the weight-of-evidence and lines-of-evidence approaches that are being developed in other fora within the EA and Defra, and in academia. These approaches can vary from quantitative to more qualitative, and the review should capture the full range given the difficulties described earlier with respect to quantifying the cause-effect relationships between DWPA and environmental outcomes. I would also review criteria-based approaches to making assessments of measures to address DWPA, including material from Damian Crilly on approaches used by the EA for selecting measures for RBMPs.
- A range of approaches including mind mapping/graphical network modelling/conceptual modelling would be useful at various stages in the current project (e.g. in combining local knowledge with RBC methodologies). Selecting an appropriate approach through review of

existing literature on these options, and then disseminating experience gained during the current project with respect to this approach, would be a useful output of the current project.

- 3. In what circumstances might site-specific or catchment specific appraisal of options/assessment of management benefits be required? In what circumstances could a more generic appraisal of options and benefits provide sufficient evidence for River Basin Managers to select and recommend measures for the management of particular, impacted catchments?*

Whether a generic or a site-specific assessment of measures and their effectiveness is necessary is related to where along the transfer continuum the measure acts. For example, measures related to sources are likely to lend themselves to more generic appraisal, accepting broad-scale differences in farm size, type, and operation. Moving further along the transfer continuum towards measures that target mobilisation and particularly delivery stages, the need for site-specific appraisal increases significantly. The effectiveness of measures at this end of the transfer continuum is strongly dependent on local-scale factors, such as soil type, hydrological flowpath, and connectivity to receiving waters, and so does not lend itself to generic assessment.

In addition to these largely environmental factors, the delivery mechanism that is used to implement a particular measure will significantly influence whether generic or site-specific assessments are appropriate. For example, measures that are delivered through voluntary mechanisms are dependent on the social networks acting within a catchment. The way in which these networks influence the implementation of measures is likely to vary between different sub-catchments and catchments, and is not necessarily suited to generic appraisal.

- 4. What obstacles do you foresee? For example, are the tools sufficiently well-developed and peer-accepted for Agency to use them to provide evidence of cost-effective benefits associated with particular measures. Are necessary data available, of sufficient quality and quantity? Could such data be collected at reasonable cost? What would you do about any obstacles (even if you think this may not be possible for us)?*

The principal barrier is that we fail to recognise how unlikely it is that a simple cause-effect relationship linking the implementation of a measure to address DWPA with a change in an environmental outcome in a stream or river will either be established through statistical analysis of available data, or predicted using available models. We must fully recognise the issues of complexity, time lag, historical legacy, and hysteresis that I outline above. Having done so, we must also value a much wider range of indicators as evidence of the effectiveness of measures related to DWPA, and not focus solely on indicators related to environmental outcomes in receptors, particularly over short time scales. The current project is an opportunity to contribute to the shifts required in our thinking, and to enable evidence of change in the context of surface water systems to be considered in the light of alternative approaches, for example those developing with respect to groundwater systems.

A range of more specific obstacles will emerge as a result of the review of available methods to be conducted as part of the current project. As I'm sure you're only too well aware, this is likely to cover

issues of spatial and temporal data coverage for statistical analyses, spatial and temporal resolution of model inputs and outputs, and our ability to predict change within the social systems that determine the uptake and application of many of the local measures relevant to DWPA. I do not see that quick fixes to these problems will emerge over the duration of the current project. Instead, a critical test of this project will be the extent to which it recognises the limitations inherent in traditional searches for cause-effect linkages between measures and outcomes, and is able to develop robust alternatives in the light of these limitations.

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## Appendix B

### Initial feedback from Ben Surridge following Evidence and Measures 'Causes' teleconferences 27/4 and 8/5 2012

#### *Summary*

- The need and potential value of the Evidence and Measures (E&M) project is clear. The project is developing and testing a process that brings together different strands of information as part of building the evidence base to support a more collaborative approach to environmental management.
- Examples of the type of questions related to this process that I believe you are addressing through the E&M project include: What data are available to help us understand water bodies? How much evidence do stakeholders require before they are convinced of the need for action? What time and financial commitment is required to bring evidence together and begin to engage with stakeholders around this evidence? Are there recurring gaps in current data/evidence that limit understanding and agreement for action among stakeholders? etc etc
- One important objective of this process is to find agreement for the introduction of new measures/actions within catchments, and this is obviously the focus of the E&M project. However, don't ignore the potential for other benefits to emerge from this process, for example the development among stakeholders of a shared conceptual understanding of catchments, agreement to further investigate problem issues within catchments, etc etc.
- There are a number of drivers that create the need for this type of process as part of a new approach to environmental management. Obvious examples in the land and water arena include the introduction of the WFD, Defra's Catchment Based Approach, increasing interest in the Ecosystem Approach and Ecosystem Services, etc etc.
- Don't constrain the relevance of the process being developed and tested in the E&M project to 'problematic' water bodies. Given that new approaches to management under frameworks such as the WFD are likely to be required in nearly all catchments, processes to support these new management approaches will also be required widely.
- However, if others hearing about the E&M project are not convinced of the need for a new approach to management in order to deliver the objectives of drivers such as the WFD, they will not be convinced of the need for a process such as that being developed and tested by the E&M project. Under these circumstances, you will find it difficult to obtain broader buy-in to the E&M project and to roll the process out more broadly. The E&M project cannot, and should not, seek to compete with other more technical assessment exercises that may be applied to catchments.

#### *Approaches 1-3 to identification of causes*

- It is important to clearly define and communicate the purpose of the approaches that you have developed. To my mind this purpose is best described as bringing available data/information together to present key messages about the likely causes of problems/failures in water bodies, in order for stakeholders to consider these messages and provide their feedback. The approaches should not be presented as definitive, technical analyses of causes within water bodies because, at this level, they cannot compete with

- alternative approaches that are specifically designed with technical assessments in mind, e.g. models such as SIMCAT, NEAP, INCA, etc etc.
- Understanding cause-effect relationships given the complex and interlinked relationships within catchments is extremely challenging. In reality, there are always likely to be uncertainties in our understanding of these relationships, and some stakeholders, including some scientists, will always argue that 'more' data/information is needed. I would not disagree that further work to better understand cause-effect relationships is necessary. However, the challenge to a project such as E&M is can we identify cause-effect relationships over which there is sufficient agreement among stakeholders to implement measures/actions as part of a policy of no-regrets? I see your work to bring together the available evidence, and to engage with stakeholders in discussion regarding this evidence, as one means of identifying measures under a no-regrets policy framework.
  - When considering how useful each Approach is, I would examine feedback from the stakeholders at the causes workshops. If all the attendees without exception tell you that the messages coming out of the Approaches are obvious/well known then I think you need to re-assess the value of the Approaches. However, if the Approaches are providing new insights and stimulating new discussions among at least some stakeholders, then I believe that they are a valuable part of the process that the E&M project is trying to develop and test.
  - An important element of Approach 1 that I think should be stressed more clearly is that you are attempting to interpret observations about chemical water quality and biological quality within receiving waters through the characteristics of the catchment. This link between land-based activities and water bodies is key – we will not deliver the requirements of frameworks such as the WFD solely using in-channel measures and ignoring land management.
  - One obvious response to the outcomes of Approach 1 is that although the issues within the water bodies may be clear, and a range of possible causes for each issue may have been flagged, there is little insight into the relative importance of individual causes, and therefore into which causes should be targeted first for action/measures. In one sense, this reflects the need for better technical assessments of source-apportionment. However, as I note above, I think this type of technical assessment is beyond the scope of the E&M project. An alternative way forward is to develop agreement among stakeholders regarding multiple actions that can be taken to address the individual causes, without this agreement first requiring definitive source apportionment estimates. This is within scope for the E&M project.
  - Approach 2 provides clear evidence of the role of the UWWTD in addressing organic pollution of water bodies, both from a chemical water quality perspective (BOD, DO and NH<sub>3</sub> concentrations), but also from a biological quality perspective as BWMP and ASPT scores are based on the sensitivity of macroinvertebrates to organic pollution. The challenges that are emphasised by this approach are: i) that we have addressed the 'easy-win' of gross organic pollution from point sources through the UWWTD, and that delivering future improvements in water body status is likely to be a far more challenging and complex task, and ii) because the WFD, Defra's Catchment Based Approach, etc, are not accompanied by the step-change in regulation that came with the UWWTD, delivering future improvements in water bodies

will require new approaches to the implementation of measures. Both these challenges support the utility of the E&M project.

*Use and availability of data*

- It would be useful to establish whether RIVPACS/RICT predictions of ASPT scores under reference conditions exist for your monitoring stations, or what would be needed (time commitment) to generate these predictions. With these reference predictions in place, EQRs could be calculated allowing comparison of the status of macroinvertebrate communities across different water bodies.
- I expect that modifications to flow and to physical habitat conditions within the water bodies you are examining could be significant causes of failure for biological quality elements. I would encourage discussions in the second causes workshop to explore these causes, based on whatever evidence is currently available. The current focus on water quality reflects areas of greatest data/evidence availability, but also the traditional concerns of stakeholders involved in catchment management. I would encourage a broadening of these perspectives to incorporate causes and measures that relate to flow and physical habitat modifications.
- Leading from the comment above, consider using other metrics to evaluate macroinvertebrate communities at your monitoring sites that are designed to reflect the impact of modifications to flow and physical habitat conditions, such as the LIFE score. This would also require predictions of LIFE scores under reference conditions from RIVPACS or RICT, as described above for ASPT.
- Pollution events associated with rainfall-runoff may be indicative of diffuse agricultural sources, as well as urban/sub-urban sources such as CSO discharges. Although slope angles in the catchment are low and may limit surface runoff on agricultural land, agricultural fields may be under-drained thereby providing a pathway from land to receiving waters that is activated during rainfall-runoff. National-scale records of agricultural land drainage are notoriously weak, and this may be an area in which information could be sought from the local farming community.

*Priorities before second causes workshop*

- Make sure the historical GQA data has been fully examined for your sites. I presume you have access to the RQOs for these water bodies, the historical GQA chemistry, GQA biology and GQA nutrient classifications. There may also be additional data (e.g. pH, concentration of some metals, etc) in any River Ecosystem Classification data that exist for these sites.
- Obtain any information you can on modifications to flow and physical habitat conditions within the water bodies. Explore the RHS database for these sites. Have simulations been run using Low Flows 2000 for these water bodies to provide predictions of river discharge?
- Obtain whatever data may be available from national or regional assessments related to source apportionment, particularly for pollutant loads from urban and rural sources. However, keep in mind that the E&M project should not get involved in new technical work related to source apportionment.

