JUNE 2016

Options for a New Integrated Natural Resource Monitoring Framework for Wales

Project Document

Briefing note: Future Options for Freshwater Monitoring in Wales

Welsh Government Contract No. C147/2010/2011

Agreed Additional Work Requirement Dated 8th March 2016

NERC CEH Project: NEC05945

How to cite this document: Davey, A. (2016) **Options for a New Integrated Natural Resource Monitoring Framework for Wales; Phase 1, Project Document - Briefing note: Future Options for Freshwater Monitoring in Wales ;** Report to Welsh Government (Contract reference: C147/2010/11; Agreed Additional Work Requirement Dated 8th March 2016). NERC/Centre for Ecology & Hydrology (NERC CEH Project: NEC05945)

Options for a New Integrated Natural Resources Monitoring Framework for Wales

Project Document - Briefing note:

Future Options for Freshwater Monitoring in Wales

Andrew Davey (Catchment Management, WRc plc)

Acknowledgements

We would to thank the following people who kindly contributed information, opinions and constructive comments on this paper: David Allen, Alun Attwood, Tristan Hatton-Ellis, Dave Johnston, Helen Millband, Ben Wilson, Catherine Duigan (NRW), Tara Froggatt (DCWW), James Skates (WG), Bridget Emmett, Simon Smart (CEH), Jeremy Biggs (Freshwater Habitats Trust).

June 2016

Intentionally blank

Briefing note:
Future Options for Freshwater Monitoring in Wales

Executive Summary

The aim of this Briefing Paper is to suggest possible options that Welsh Government, in collaboration with other stakeholders, could explore for re-configuring freshwater monitoring activities in Wales to make more effective and efficient use of resources, which best deliver alignment and optimisation of monitoring activity for delivery across WG Departments and NRW.

Building on NRW's ongoing Monitoring Review and informed by discussions with monitoring experts from NRW and Dŵr Cymru Welsh Water, it envisages a future in which:

- all monitoring activities will be subject to a much more rigorous cost-benefit and affordability assessment;
- data collection will become increasingly multi-functional;
- monitoring activities will be better co-ordinated across the public, private and third sectors;
- freshwater monitoring will be more closely integrated with terrestrial and marine monitoring; and
- data will be shared more openly, facilitating the use of data for multiple purposes.

Seven areas are highlighted as possible options that WG, in collaboration with other stakeholders, may wish to consider in Phase 2 of the Future Options project.

1. define evidence needs to support natural resource management;
2. identify opportunities for greater co-operation and co-ordination between organisations;
3. optimise existing monitoring networks using a risk-based approach;
4. support closer integration of datasets and models;
5. consult on potential for wider collaboration;
6. promote and facilitate greater data sharing; and
7. assess opportunities presented by citizen science monitoring.

Case studies are provided to illustrate the successful application of some of these approaches.

1. Introduction

1.1. Aim and Objectives

Welsh Government (WG) and Natural Resources Wales (NRW) have established a Task and Finish Steering Group to identify future options for developing and adapting the Glastir Monitoring and Evaluation Programme (GMEP) into a new Natural Resources Monitoring Programme, phase 1 of which will be launched in 2017.

The focus of this “Future Options” project is on terrestrial monitoring but, as a precursor to a more in-depth review, WG has commissioned CEH and WRc to scope out possible options for re-configuring freshwater monitoring activities to yield cost savings and/or additional insight into the state and trend of natural resources in Wales.

The aim of this Briefing Paper is to suggest approaches that WG could explore in the second phase of the Future Options project. Specifically, it looks at:

- optimising existing monitoring networks and identifying efficiency savings (Chapter 2);
- making greater use of existing datasets through integrated monitoring and modelling (Chapter 3); and
- facilitating co-ordination and data sharing among organisations (Chapter 4).

Finally, Chapter 5 proposes for discussion some specific options that could be taken forward in future work packages.

1.2. Scope and Approach

The focus of this paper is on the monitoring of chemical, biological and microbiological quality of freshwaters (i.e. rivers, lakes, streams, ponds and groundwaters). Monitoring of fisheries, water quantity and alien species are not considered explicitly although the approaches outlined are equally applicable to these parameters, as well as to terrestrial, estuarine and marine monitoring programmes.

This paper builds on NRW’s ongoing Monitoring Review and has been informed by discussions with monitoring experts from NRW and Dŵr Cymru Welsh Water (DCWW). It looks beyond NRW’s own monitoring programmes to explore the broader challenges and opportunities facing freshwater monitoring in Wales and sets out options by which scarce monitoring resources could be used more effectively and efficiently. Case studies are included to illustrate how other organisations have applied some of the approaches presented in this paper to help improve their data gathering activities and minimise monitoring costs.

The use of earth observation, molecular genetics and citizen science techniques for freshwater monitoring are discussed briefly, but interested readers are referred to a set of parallel papers produced as part the Future Options project, which covers these issues in greater detail.

This paper does not consider how existing monitoring programmes might ultimately be amalgamated into a fully integrated natural resources monitoring programme to support implementation of the Environment (Wales) Act 2016.

2. Optimising existing monitoring programmes

2.1. Balancing cost vs risk

Data is collected not for its own sake, but rather to provide information to support management decisions.

With the exception of prescriptive, statutory requirements, decisions about monitoring should be informed by a cost-benefit analysis to determine whether the benefits accruing from the information that is generated outweigh the costs of gathering, transmitting, storing, managing, processing, and interpreting the data. Appendix A elaborates on the value of taking an objective, risk-based approach to designing monitoring programmes.

All else being equal, more data:

- allows parameters to be estimated more precisely;
- improves confidence (reduces uncertainty) in reported results;
- increases the power of the monitoring programme to detect non-compliance and measure change;
- leads to improved decision making; and
- reduces the risk of adverse environmental, social or economic impacts arising as a result of inadequate information.

The rule of diminishing returns applies, however, so a trade-off has to be made between cost (i.e. sampling effort) and risk.

This trade-off is complicated by the fact that sampling effort can be allocated in many different ways. In designing a monitoring network, one has to simultaneously consider: how many sites should be sampled, where these sites should be located, and at what frequency samples or measurements should be taken. Fortunately, statistical techniques such as ***stratification*** and ***optimal allocation*** can be used to make the most cost-effective use of limited resources. In this way it is possible to either minimise the level of sampling effort required to reduce risk to an acceptable level or, to maximise the level of risk reduction for a fixed monitoring budget.

Case studies 1 and 2 in Appendix B illustrate how these techniques have been used successfully to optimise monitoring programmes in similar settings.

2.2. State of the art in Wales

NRW has already undertaken a review of some of its core monitoring programmes, notably its Water Framework Directive operational monitoring network for rivers and microbiological sampling at Bathing Waters. The review has delivered cost savings by reducing monitoring effort (i.e. numbers of sites and frequency of sampling) closer to the statutory minimum amount permitted by relevant national Regulations and EU Directives. In some cases, these changes have been informed by a statistical assessment of the increased chance of mis-judging compliance or mis-classifying status class.

NRW intends to extend the review to other monitoring programmes. Two areas where there may be some significant flexibility to adjust the amount and allocation of sampling effort are:

1. freshwater Special Areas of Conservation (SACs) – the UK legal requirements for monitoring under the Habitats Directive are less prescriptive than for the Water Framework Directive;
2. the WFD surveillance monitoring network – was originally designed as an England and Wales-wide network and existing sites may not necessarily be fully representative of water bodies in Wales. The power of the network to quantify national and regional-level trends in status can now be tested using data from the first (2009-2015) river basin planning cycle, which will help reveal how cost savings may be delivered with minimum loss of information.

3. Making greater use of existing datasets

3.1. Integration of land and water monitoring

NRW's routine freshwater monitoring programmes currently focus on assessing the status of water bodies, and additional investigations are often necessary to understand the reasons for failure and quantify the relative contribution of different pollution sources. It is recognised, however, that monitoring needs to "go beyond water quality" by considering the impact of multiple stressors including hydrological and morphological modification. This will require NRW to integrate more closely its water quality, hydrometric and river habitat survey networks of sites.

Co-location of monitoring sites is an attractive concept because it facilitates the linking together of multiple datasets. However NRW's chemistry, biology and fisheries sampling points are already co-located as far as possible with river habitat survey sites and flow gauging stations, and there are practical and logistical constraints on where sites are located. For example: water chemistry samples can be taken quickly and cheaply from bridges, whereas biological surveys require bankside access to suitable stretches of river. Also, some parameters, notably river flow, can be predicted very accurately using hydrological models, vastly reducing the number of locations at which measurements need to be taken.

Earth observation (EO) techniques appear to be under-utilised at present in understanding how changes in land use and land management impact upon the freshwater environment. NRW's SAGIS-SIMCAT water quality model combines land cover information with export coefficients to undertake chemical source apportionment, but the spatial information has poor granularity. DCWW believes that remote sensing can assist greatly in mapping risks to water quality and reviewing the effectiveness of catchment solutions, at a landscape or local scale, and is currently exploring the potential of using aerial surveys to map cropping patterns at a field scale and identify high risk source areas. The potential applications of EO are being actively explored by NRW through the Defra funded and EA led Earth Observation Data Integration Pilot (EODIP) initiative.

3.2. Combining monitoring and modelling

Monitoring and modelling go hand in hand.

Models can be used to predict where pressures on the natural resources might be most severe and to help target monitoring activity as part of a risk-based approach.

Models can also be used to complement monitored data. For example, available resources allow only a small proportion of river water bodies to be monitored for water quality; unmonitored water bodies are classified using expert judgement or simple grouping rules. However, the unidirectional flow of water through dendritic river networks allows downstream changes in water quality to be modelled using tools such as SIMCAT and SIMPOL-ICM. At present, the ability of these, and other models, to predict water quality at unmonitored locations and reveal local anomalies is not fully utilised. There may be benefit, therefore, in integrating local data with information on catchment land use and upstream water quality to yield more accurate estimates of water body status.

But of course, models cannot completely substitute for monitoring. Sampling data is vital for calibrating and validating models, which must be grounded in reality to be accepted and useful. But there is a balance to be struck between having too few monitoring points, which make model calibration difficult and lead to large prediction errors, and having too many monitoring points, which leads to data redundancy. If models are to play a more prominent role in the future, then it is imperative to understand the impact that reductions in monitoring will have on model performance.

Making more effective use of existing and new modelling tools will require consideration of NRW's capability in this area.

3.3. Moving to a weight of evidence approach

Against a general trend of cut-backs in publicly-funded monitoring programmes, there is a growing need to make use of all available sources of information when assessing the state of natural resources. These supplementary sources of evidence may include: monitoring undertaken by private companies, NGOs or citizen scientists, earth observation data, predictive models, field observations, and expert judgment.

A wide variety of qualitative (e.g. logic tables) and quantitative (e.g. Bayesian MCMC models) techniques are available for combining disparate lines of evidence. Most of these techniques involve weighting individual lines of evidence to reflect differences in their importance or credibility, and then weighing the overall body of evidence to gauge how strongly it supports one or more hypotheses.

Advocates argue that a weight of evidence approach:

- is consistent with natural cognitive processes and considered to be good scientific practices;
- provides a consistent and transparent means of interpreting myriad types of data and information; and
- makes false conclusions less likely and allows decision makers to make better informed decisions.

On the downside, combining evidence can involve difficult qualitative judgments and require additional time, resources and expertise.

Case study 3 in Appendix B illustrates how the Environment Agency is making increasing use of weight of evidence techniques for assessing the impact of abstractions on aquatic ecology.

4. Multi-agency co-ordination

4.1. Co-ordination within Wales

Multiple organisations play a role in monitoring freshwaters in Wales. These include:

- government agencies – e.g. NRW;
- water companies – e.g. DCWW, Severn Trent Water, Dee Valley Water, United Utilities;
- research institutes – e.g. Centre for Ecology and Hydrology, British Geological Survey;
- NGOs – e.g. Rivers Trusts, Freshwater Habitats Trust (formerly Pond Conservation), Riverfly Partnership;
- local authorities – e.g. private water supplies; and
- universities (i.e. academic research projects).

At present, the monitoring activities carried out by these organisations are fragmented and unco-ordinated. There has been no systematic review of who is doing what and so it is not currently possible to comment on the nature and extent of any gaps and overlaps. It is recognised, however, that these organisations are responding to a multitude of drivers and that their activities differ with respect to:

- the geographic coverage;

- the parameters measured;
- the number of sites;
- the frequency of sampling;
- the methods used;
- the analytical limit of detection; and
- the degree of quality assurance.

For example, NRW and water companies have distinct drivers, with NRW having a very diverse and spatially extensive monitoring network and water companies collecting much more specific types of data from a smaller network of sites in critical areas (Table 1). The sensitivity of the analytical methods used depends on the water quality standards; for example, drinking water standards for pesticides are lower than the corresponding environmental quality standards. Other organisations may hold very specialised, high quality datasets for specific locations as a result of project-based or investigative monitoring, which complement broader, national datasets.

Table 1 Comparison of freshwater monitoring undertaken by NRW and water companies

Aspect	NRW	Water companies
Reasons for monitoring	To gather evidence to support the implementation of the Water Framework, Urban Waste Water Treatment, Nitrates and Habitats Directives.	To manage the impact of the business on the environment, measure the compliance performance of wastewater assets, and to support compliance with the Drinking Water Directive.
Parameters	A wide variety of chemical, biological and micro-biological parameters.	Restricted set of chemical and microbiological parameters for which there are drinking water or effluent quality standards.
Locations	Rivers, lakes and groundwaters across the country.	Predominantly rivers and reservoirs at the point of abstraction/discharge, with limited upstream and sub-catchment investigations. Mostly surface water, with some groundwater sampling.

4.2. Co-ordination with other UK nations

Natural resources management in Wales is now a full devolved responsibility, but that should not preclude NRW and other organisations from seeking opportunities to work collaboratively with their counterparts in England, Scotland and Northern Ireland. Several examples of successful partnership working already exist including: the WFD UK technical Advisory Group (UKTAG); the UK Environmental Observation Framework (UKEOF) and the less formal information sharing network among water companies serving western and upland parts of the UK (DCWW, Northern Ireland Water, Scottish Water and United Utilities).

Aside from the benefits for managing cross-border river catchments, the ability to draw on a larger body of environmental monitoring data and expertise from across the UK could:

- improve the precision and confidence of UK and nationally reported indicators;
- support the development of more sophisticated and more accurate predictive models; and
- share the costs of producing derived datasets and reported statistics.

4.3. Data sharing

From a natural resources management point of view, there would appear to be benefits to all stakeholders of greater data sharing, for example in:

- supporting the designation of Nitrate Vulnerable Zones to control nitrate pollution of drinking water sources;
- understanding sources of pollution in Drinking Water Protected Areas upstream of abstraction points; and
- analysing long-term trends in water quality to identify emerging issues and plan future management strategies.

At present there is some, limited sharing of freshwater monitoring data between organisations in Wales. Water companies submit their catchment and effluent monitoring data to NRW's WIMS database and NRW's own monitoring data is made available to stakeholders on request. NRW is currently in the process of making its data openly available via the Lle data platform (http://lle.wales.gov.uk/home). The Freshwater Habitats Trust has also established a national database, WaterNet, which is capable of holding both species and habitat data (including water quality) and designed to be accessible to both professional and non-professional workers.

4.4. Citizen science monitoring

A citizen science approach to freshwaters offers potential opportunities to complement, and extend cost-effectively, current freshwater monitoring work. For example, the Freshwater Habitats Trust, taking advantage of advances in eDNA technology and rapid test kits for nitrate and phosphate, has pioneered the wide-scale use of citizen science for monitoring headwater streams, ponds, small lakes and ditches (as illustrated by Case study 4 in Appendix B). Notably, a new national, volunteer-based, pond monitoring network, PondNet, has been established with the support of Defra, Natural England and the Heritage Lottery Fund and is currently being rolled-out to cover all of Wales and England. Potential benefits of citizen science include: the empowerment, engagement and education of landowners and the public; substantially greater coverage than existing monitoring programmes; cost-effective sampling of numerous, smaller water bodies; rapid screening for emerging issues. However, there are limitations (e.g. the sensitivity of the sampling methods used) and challenges (e.g. deriving a statistically valid and representative sample) that need to be explored and overcome.

5. Conclusions

Freshwater monitoring activities in Wales need to evolve to meet future challenges. Food security, population growth, climate change, invasive species are placing growing pressures on the aquatic environment that need to be understood and managed. Domestic legislation is placing new obligations on NRW to undertake an integrated assessment of the state of natural of natural resources. At the same time, funding for freshwater monitoring is shrinking.

This paper provides a starting point for stakeholders to discuss what the future of freshwater monitoring might look like and how the transition to a more integrated and cost-effective system of monitoring can be achieved. The following seven areas are highlighted as possible options that WG, in collaboration with other stakeholders, may wish to consider in Phase 2 of the Future Options project.

5.1. Define evidence needs to support natural resource management

WG could set out a vision for how freshwater monitoring activities might support a Natural Resource Management Monitoring Programme, including the assessment of ecosystem resilience and ecosystem service delivery, and articulate the economic, social and environmental benefits of basing management decisions on sound evidence. Through consultation, this vision could be translated into an agenda for collective action involving all stakeholders. In terms of ongoing governance, consideration could be given to establishing an expert Standing Panel on Environmental Change, which could (i) provide a consensus summary of the significance and causes of contemporary environmental trends, (ii) identify evidence gaps and future threats, and (iii) make recommendations to WG on priorities for monitoring and any need for tactical redeployment of monitoring or modelling effort.

5.2. Identify opportunities for greater co-operation and co-ordination between organisations

NRW, in partnership with Phase 2 of Future Options, could undertake a comprehensive review of all freshwater monitoring activities in Wales with the goal of identifying opportunities for greater co-operation and co-ordination. Building on earlier work by the UK Environmental Observation Framework (UKEOF), the review could seek to identify information gaps, areas of duplication and overlap, and opportunities to harmonise methods and standards. Meta-data for each monitoring programme could be consolidated and made publically available to facilitate future co-ordination.

5.3. Optimise existing monitoring networks using a risk-based approach

Proposed reductions to NRW's statutory monitoring networks could be subject to an impact assessment to understand the associated increase in risk. The implications could be communicated to interested parties so that they can adapt their own data gathering and reporting activities accordingly. A series of statistical and modelling approaches could be used to develop the most efficient and cost-effective approaches including a cost-benefit analysis.

5.4. Support closer integration of datasets and models

NRW, in partnership with Phase 2 of Future Options, could explore how core NRW freshwater monitoring networks might be supplemented by data and information from other sources. Working with other stakeholders, consideration could be given to the pros and cons of using models to integrate disparate data sources, and how separate lines of evidence could be combined to build a coherent, unified assessment of the state of natural resources.

5.5. Consult on potential for wider collaboration

NRW, in partnership with Phase 2 of Future Options, could explore the possible benefits to Wales of pooling data with environmental regulators in England, Scotland and Northern Ireland and co-operating on the development of future tools and models, including the advantages and disadvantages of modelled data. Lessons learned and new technologies being exploited by other countries could also be explored.

5.6. Promote and facilitate greater data sharing

WG could explore options for supporting the exchange of monitoring data between organisations in a way that encourages multifunctional data use. This could take the form of a consolidated data hub/warehouse or a de-centralised data sharing portal that allows organisations to retain ownership and control of their data. Existing data platforms such as WaterNet and the Lle Geo-Portal should be reviewed to identify how their use can be promoted and expanded.

5.7. Assess opportunities presented by citizen science monitoring

NRW, in partnership with Phase 2 of Future Options and relevant stakeholders such as the Freshwater Habitats Trust and Rivers Trusts, could investigate the potential for citizen science to complement and augment other established monitoring programmes. Taking into account the strengths and weaknesses of citizen-generated datasets and available sampling technologies (e.g. eDNA and water quality test kits), the review could identify opportunities to, for example, undertake large-scale biological surveys, monitor small water bodies and identify emerging issues.

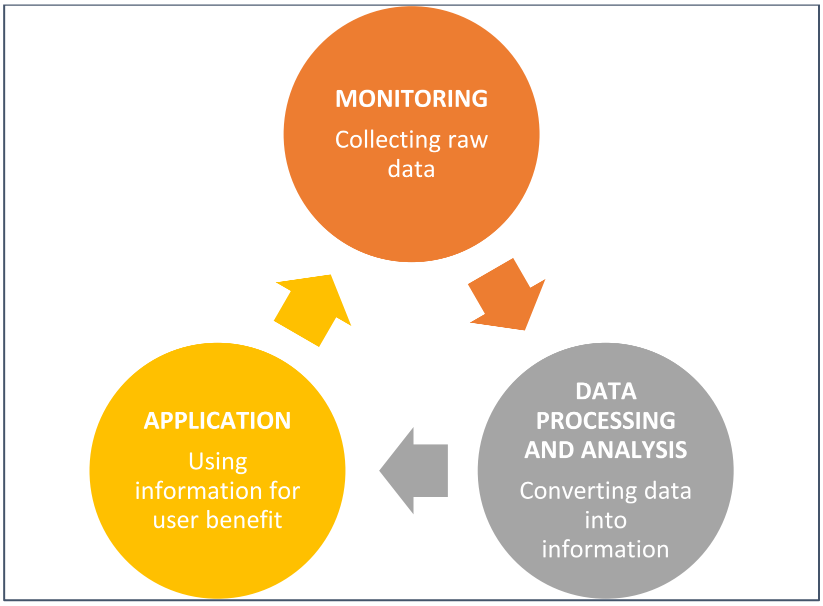
Further Reading

Appendix A: A strategic approach to monitoring

Justifying investment in monitoring

Data is collected not for its own sake, but rather to provide information to support management decisions. The collection of data should not be divorced from its subsequent application and data collection activities should be driven by the needs of end users, not the other way round. In practice, this should be a cyclical process, whereby the user reacts to information provided by the monitoring programme, and the monitoring programme evolves in response changing user needs (Figure 1).

Figure 1 The evidence cycle



Ultimately, decisions about monitoring strategy should be informed by a cost-benefit analysis to determine whether the benefits accruing from the information that is generated outweigh the costs of gathering, transmitting, storing, managing, processing, and interpreting the data. When viewed in this way, the central question shifts from “Can I afford to monitor?” to “Can I afford not to monitor?”.

In most cases, the costs of implementing a specified programme of monitoring can be calculated or reliably estimated; the main challenge is, therefore, to quantify and monetise the benefits of monitoring. These benefits can usefully be thought of in terms of reducing the risk of undesirable and costly outcomes.

Using monitoring to manage risk

Risk – the potential to lose something of value – is commonly thought of in terms of the ***likelihood*** that something might happen multiplied by the ***consequence*** of that event happening.

Monitoring is one way of gathering evidence that allows individuals, communities and organisations to devise and implement measures that reduce the likelihood or consequence of undesirable outcomes. In the context of natural resource management, monitoring is used to help prevent or reverse negative human impacts on the environment, so yielding economic and social (health and wellbeing) benefits. Monitoring can also yield financial benefits by helping to ensure that investments in natural resource management are effective and efficient. Table 2 provides some examples of the benefits that can accrue from monitoring activities.

Table 2 Benefits accruing from environmental monitoring

Reason for monitoring	Consequence of not monitoring	Benefit of monitoring
Monitoring is a statutory requirement	Imposition of penalty (fine, infraction) or other regulatory sanction if monitoring is not undertaken	Avoided penalty/sanction
To provide public information (e.g. bathing water sampling)	Bathers cannot take informed decision about where to swim, leading to human health impact	Reduced incidence of illness
To judge whether water quality or environmental status is compliant with relevant standards (e.g. WFD EQSs)	No knowledge of where environmental degradation is occurring so unable to implement a targeted management response (i.e. unnecessary investment in same areas; absence of investment in others)	Natural resources are protected only where necessary; efficient use of limited resources
To know whether or not natural resources are deteriorating (e.g. climate change warming of rivers)	Inability to implement timely management intervention; natural resources are degraded; more expensive interventions are needed later on	Natural resources are protected through timely and cost-effective mitigation measures
To evaluate the impact of management interventions (e.g. Glastir)	Risk of persisting with a policy/initiative that is failing to deliver the required level of improvement, or of failing to invest further in an effective policy/initiative	Effective and efficient use of limited resources

The recognition that monitoring can contribute to the management and reduction of risk leads naturally to to a ***risk-based approach***, whereby greater investment in monitoring is justified in situations where the risks, and therefore benefits/ or avoided costs, are highest.

Quantifying the performance of a monitoring programme

Data gathered from a monitoring programme is typically used to estimate a parameter, or calculate the value of an indicator or other derived metric. But because we cannot sample everywhere all of the time, and because people and equipment are less than perfect, there will almost always be some sampling error and measurement error. These errors mean that our calculated value is only an ***estimate*** of the true value; how close we are likely to be can be quantified by constructing a ***confidence interval*** around the estimate. The wider the confidence interval, the less ***precise*** (more uncertain) is the result.

Often, these statistics are subsequently used to, for example, assess compliance against a standard, make comparisons between sites, or to test whether there has been an improvement or deterioration over time. All these applications all involve some form of ***hypothesis testing***, in which the available data is used to decide which of two mutually exclusive (null and alternative) hypotheses is true. In the case of compliance assessment, for instance, the available data are used to determine whether or not the system being monitored is complying with the required standard. Attempting to discern the truth with imperfect information leads to two possible types of error:

- a ***Type I error*** of wrongly rejecting the null hypothesis – that is, thinking we've found something interesting when it is actually just due to chance (e.g. a false alarm); and

- a ***Type II error*** of failing to reject the null hypothesis when we ought to have done – that is, concluding that an apparent effect could just be due to chance when actually it was genuine (e.g.. failing to detect non-compliance).

These contrasting errors are illustrated in Figure 2. The ability, or ***power***, of a monitoring programme to detect a genuine effect (e.g. a change, difference, or non-compliance) is the inverse of the Type II error rate and it depends, amongst other things, on the level of confidence required and the amount of monitoring data available for analysis.

		True situation in population	
		Null hypothesis is true	Null hypothesis is false
Conclusion reached on basis of monitoring data	Accept null hypothesis	✓	**Type II error (β)**
	Reject null hypothesis	**Type I error (α)**	✓

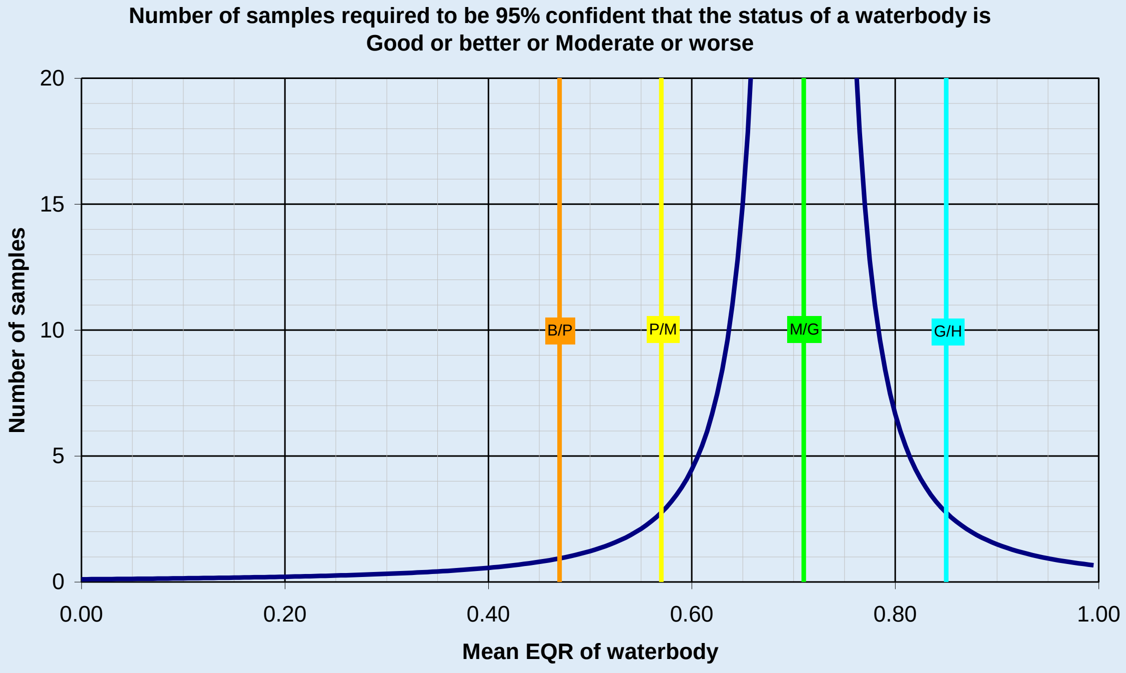
Figure 2 Type I and Type II errors associated with scientific hypothesis testing

Developing a monitoring strategy therefore requires decisions to be taken about that level of risk is acceptable, and trade-offs need to be made between risk and cost.

Appendix B: Case studies

Case Study 1: Optimising the Water Framework Directive operational monitoring programme in England

The Environment Agency's operational monitoring network is used to assess biological and physico-chemical status of rivers under the Water Framework Directive. Data from the network was analysed by WRc to quantify the typical level of temporal and spatial (between-site) variation and, in turn, to calculate the minimum number of sites / samples required to limit to 5% the risk of mis-classifying a water body as Good or better, or Moderate or worse status. Statistical rules were then developed as part of a decision support system to identify opportunities to reduce the level of monitoring effort without compromising the evidence base for implementing programmes of measures.

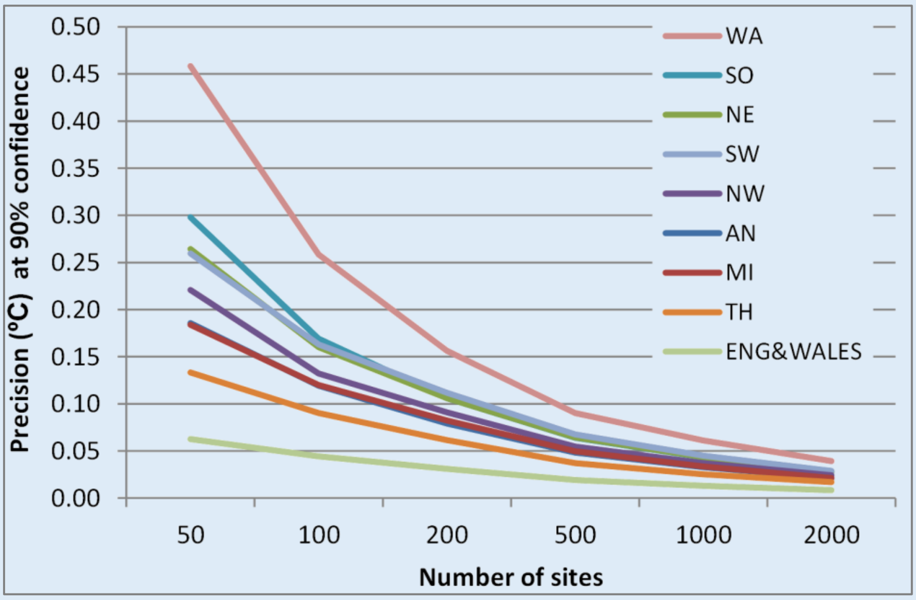


Case Study 2: Designing a dedicated river water temperature monitoring network for England and Wales

Climate change is predicted to lead to warmer air and river temperatures which, in turn, will influence stream chemistry and the health of freshwater plants and animals. Historically, the Environment Agency (EA) has monitored river water temperature in an *ad hoc* fashion, primarily as a by-product of routine water quality monitoring, but this approach is not adequate for reliably measuring the impact of climate change. A study was therefore undertaken by WRc to design a dedicated water temperature monitoring network to provide a national indicator of change in river water temperature.

Statistical analysis of archived time series data revealed that:

- At individual monitoring sites, spot sampling can be expected to reliably detect only major changes in mean temperature over long time (30+ years) periods; continuous (daily) monitoring is therefore necessary to quantify the magnitude of temperature change with a reasonable level of precision and confidence.
- Over a 10 year period, the national average rate of temperature change can be estimated to within ±0.03 ºC/decade with 95% confidence using a stratified sample of 200 monthly spot sampling sites or 110 continuous monitoring sites.



Case study 3: Integrating hydrological and ecological data to assess the impact of abstraction

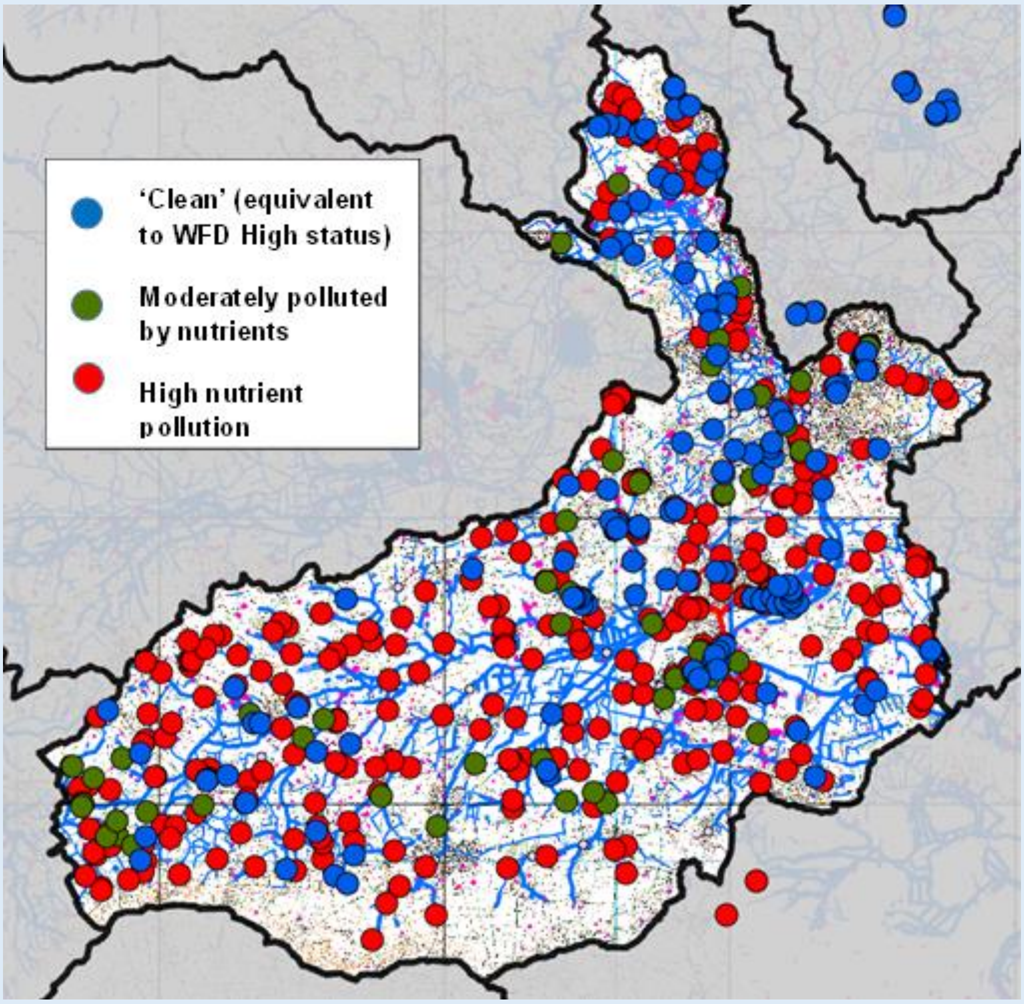
The Environment Agency uses a range of methods to assess the impact of abstractions on aquatic ecology, but the complex interplay between multiple pressures combined with limited information makes it difficult to regulate licenced abstractions in a fair and consistent manner. In 2015, the EA undertook to formalise the process of combining hydrological data, ecological data, expert knowledge and other available data into a coherent method that would allow clear, consistent and justified decisions to be made when reviewing existing abstraction licences. WRc and APEM reviewed a variety of weight of evidence methods to assess their ability to support risk-based decision making using diverse and variable information, and established a framework for assessing the weight of evidence on a case by case basis.

Case study 4: River Ock citizen-based water quality survey

In April 2016, Freshwater Habitats Trust organised a citizen-based survey of nitrate and phosphate levels on 570 sites (ponds, lakes, streams, rivers, ditches, fens) in the catchment of the River Ock, Oxfordshire, as part of the Clean Water for Wildlife project. This was slightly more than 1 waterbody per km^2 in this 470 km^2 catchment. Most sites are not currently monitored.

The kits were successfully able to separate ‘clean’ water (i.e. those at ‘High’ status under WFD) from more polluted waters. Nearly a third of sites were ‘clean’, predominantly ponds and lakes, with some streams and ditches. Most running waters experienced substantial nitrate or phosphate pollution.

The data are now contributing to a range of practical projects. A detailed technical manual for the use of rapid test kits will be published at the end of June.



Intentionally blank

NERC SCIENCE OF THE ENVIRONMENT

PEER

INVESTORS IN PEOPLE

Athena SWAN Bronze Award

BANGOR
Centre for Ecology & Hydrology
Environment Centre Wales
Deiniol Road
Bangor
Gwynedd
LL57 2UW
United Kingdom
T: +44 (0)1248 374500
F: +44 (0)1248 362133

EDINBURGH
Centre for Ecology & Hydrology
Bush Estate
Penicuik
Midlothian
EH26 0QB
United Kingdom
T: +44 (0)131 4454343
F: +44 (0)131 4453943

LANCASTER
Centre for Ecology & Hydrology
Lancaster Environment Centre
Library Avenue
Bailrigg
Lancaster
LA1 4AP
United Kingdom
T: +44 (0)1524 595800
F: +44 (0)1524 61536

WALLINGFORD - Headquarters
Centre for Ecology & Hydrology
Maclean Building
Benson Lane
Crowmarsh Gifford
Wallingford
Oxfordshire
OX10 8BB
United Kingdom
T: +44 (0)1491 838800
F: +44 (0)1491 692424

enquiries@ceh.ac.uk
www.ceh.ac.uk