



**British
Geological Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL



Water security
Knowledge exchange programme



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ENVIRONMENT
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NERC Water Security Knowledge Exchange Programme

Increased Resilience to Extreme Events (WSKEP 2.2)

Improving drought prediction, communication and impact assessment

Thursday 14th June 2012: 10.00 – 16.00

British Geological Survey, Keyworth, Nottingham, NG12 5GG

Participant pack

1. Aims and objectives
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1. Aims and objectives

This workshop will focus on identifying: how past and current research and scientific outputs can support improved drought prediction, communication and impact assessment; what research is still needed to meet the future challenges faced by decision makers and those that may be affected by drought and; the priority actions we need to take to improve our resilience to drought. It will complement the previous WSKEP workshop on sustainable and resilient management of drought.

Invitees to the workshop include:

- Representatives of water use industries (UK water companies, agriculture, manufacturing and food production);
- Conservation agencies and environmental groups;
- Researchers and consultants with an interest in drought prediction, communication and impact assessment and;
- Policy makers and regulators with responsibility for drought impact planning and impact management.

The workshop will comprise a number of interactive sessions that will: develop a shared understanding of the issues relating to drought prediction, communication and impact; examine the current state of research and knowledge; identify knowledge gaps and research needs and; establish opportunities for improved partnerships, collaboration and knowledge exchange.

The sessions will be led by the WSKEP Facilitator who, after introducing short scene-setting presentations, will seek to draw out views, knowledge, experience and opinions from workshop participants.

The outcomes of the workshop will be informed and shaped by the participants. Ideally they will include a prioritised list of future actions for improving drought prediction, communication and impact assessment that can inform future research priorities, establish improved communication pathways and identify evidence needs.



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2. Water Security Knowledge Exchange Programme

Increased Resilience to Extreme Events

“Improving drought prediction, communication and impact assessment” (WSKEP Event no 2.2)

Thurs 14th June 2012 at BGS, Keyworth, Nottingham

AGENDA

- 09:30 **Registration**
- 10:00 **Welcome and introduction to NERC WSKEP workshop**
- Dr Graham Leeks, CEH, Wallingford
 Mr Peter Woodward, WSKEP Facilitator
- Session 1 - The challenges of drought prediction, communication and impact assessment**
 – *Landscape*
- *Developing a shared understanding*
 Professor Denis Peach, Chief Scientist, British Geological Survey
 - Facilitated workshop and discussion
- 11:30 Break
- 11:45 **Session 2 - Making the most of current research**
- *Researcher's Point of View*
 Dr Ian Holman, Cranfield University
 - Facilitated workshop and discussion
- 12:45 Buffet lunch
- 13:45 **Session 3 Interactive Workshop on Drought Management *Research Funding***
- *Future Research – funding and collaborations*
 Neil Runnalls, CEH, Wallingford
 - Facilitated workshop and discussion
- 14:45 Break
- 15:00 **Session 4 Interactive Workshop on Drought Management *Networking***
- *Existing KE Networks and improving future collaboration*
 Hans Jensen, CEO, UKWIR Ltd
 - Facilitated workshop and discussion
- 16:00 **Summary and Close**



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3. Water Security Knowledge Exchange Programme

Increased Resilience to Extreme Events

“Improving drought prediction, communication and impact assessment” (WSKEP Event no 2.2)

Participant List

Chris	Atkinson	Senior Hydrogeologist	Severn Trent Water Ltd.	chris.atkinson@severntrent.co.uk
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4. Supporting Information

a) Session 1 - Setting the scene and making connections

WSKEP Introduction - Graham Leeks, CEH

Water Security Knowledge Exchange Programme Lead, CEH, Maclean Building, Crowmarsh Gifford, Wallingford, Oxon OX10 8BB

T: 01491 692203 E: gill@ceh.ac.uk

The Challenges of drought prediction, communication and impact assessment

Developing a shared understanding - Professor Denis Peach, Chief Scientist, BGS

T:0115 9363100 E: dwpe@bgs.ac.uk

The last two dry winters and the resulting drought have reminded us of the challenges of this major weather related natural hazard. The conditions that lead to drought develop slowly and often go unnoticed until the impacts start to be felt. Once drought has taken hold it can persist for long periods of time and lead to serious economic, social and environmental consequences.

If we look back at history, we know that we have experienced numerous periods of drought before and we know that they will happen again. What we don't have is good knowledge of when they will occur, how they will manifest themselves and how severe they will be. A further complication is climate change and how this will affect drought frequency, duration and spatial extent in the future.

It is important therefore that we develop a shared understanding of droughts and the challenges they bring. A period of notably low rainfall is a feature of all hydrological droughts but a distinction may be drawn between different types of drought: meteorological droughts (defined essentially on the basis of rainfall deficiency), hydrological droughts (where accumulated shortfalls of runoff or aquifer recharge are of primary importance), agricultural droughts (where the availability of soil water during the growing season is the critical factor) and socio-economic drought (where reliance of society and the environment on water introduces supply and demand pressures).

Within these categories further divisions can be seen, for example a hydrological drought may manifest itself as a surface water drought, a groundwater drought or both. In the UK, in water supply terms, the south east of England has rather different weather to the North West. Each is dependent of different types of water resource. The south east tends to be drier than the North West, but on the other hand has the benefit of extensive aquifers, in particular the Chalk Aquifer and has grown dependant on the storage provided by the Chalk. Neither area is immune to drought and in the last five years both areas have suffered from droughts with very different characteristics.

This year has been characterised by concerns that a groundwater drought in the south east of England was inevitable, and fears that a third dry winter might further limit groundwater recharge and lead us inexorably into a period of extreme water shortage in 2013. These are typical of the concerns that government, regulators and water industry might have. Beyond this, if climate change results in increases in extremes and/or shifts in 'average' conditions, this will lead to further concerns and potentially extend or change those areas sensitive to different types of drought.

So interest in drought prediction is growing. However seasonal weather prediction is still in its infancy. Therefore there is a question over whether the public, industry, and agricultural

requirements for information can be met in the short term. Communication of forecasts and even of scenarios plans may be fraught with difficulty. An example could be this current year. We are potentially heading for a continuing extreme groundwater drought even though we've had the wettest April on record and significant rain in May. The public may therefore be very doubtful about any predictions of groundwater drought.

So there are a number of topics to debate:

- What do we mean by drought
- How feasible is seasonal prediction
- What is our level of understanding of groundwater and can we deal with the geographic, heterogeneity and scale issues.
- Where in the UK are the main problems likely, and where globally our efforts should be concentrated.
- Do we need a programme of KE focussed at a variety of levels, government, regulators, industry and public

The purpose of the NERC Knowledge Exchange Programmes

NERC-funded research produces knowledge, expertise and skills that can provide significant benefits for the environment, for the economy and for the general well-being of society.

Knowledge exchange (KE) plays an important role in delivering these benefits.

The overarching purpose of the KE programmes is to accelerate the uptake of research and help inform the direction of future science. They will do this by conducting and coordinating a range of KE activities which:

- Effectively bring together the NERC-funded research community across all Research Centres and Higher Education Institutes that deliver science in the relevant programme area, and build on their strengths and multidisciplinary capabilities.
- Proactively engage current and potential users of NERC-funded research, particularly in business, but also among policy-makers, regulators and NGOs.
- Systematically identify the key needs and science challenges faced by end-users.
- Stimulate the exchange of knowledge, the flow of people and the creation of projects and partnerships that address the needs and capitalise on the opportunities these present.

In particular, the KE programmes will focus on specific areas where NERC's investments have produced considerable scientific strengths that meet key business, policy and societal needs.

The KE Programmes areas of activity

NERC has set up five KE Programmes on the following areas:

- Water Security
- Marine Renewable Energy
- Environmental Management for Food and Agriculture
- Resource Management
- Financial Services risk management and valuation

The Water Security and Marine Renewable Energy Programmes started in April 2011. The other 3 are in the planning process and due to start in 2012.

Connectivity with NERC Water Research

Science funded by NERC includes many research teams in universities and research centres. These have undertaken a wide range of research programmes including:

BESS - Biodiversity and Ecosystem Sustainability Programme

CWC - Changing Water Cycle Programme

ESPA - Ecosystem Services and Poverty Alleviation Programme

FREE - Flood Risk from Extreme Events Programme

LOCAR - Lowland Catchment Research Programme

LWEC - Living With Environmental Change Directorate

Macronutrient Cycles Programme

RELU - Rural Economy and Land Use Programme

Storm Risk Mitigation through Improved Prediction & Impact Modelling

VO - Virtual Observatory

Overall aims of the Water Security Knowledge Exchange Programme

The programme will establish a community of researchers and science users to develop networks for effective knowledge exchange. It will:

- Work with policy-makers, industry and civil society organisations to identify priority areas for accelerating knowledge exchange activities.
- Offer a first point of contact for information about water security related research.
- Facilitate a range of knowledge exchange events, bringing together key researchers and users.
- Help users communicate their needs to shape the development of new NERC research programmes.

The five Sub Areas of the Water Security Knowledge Exchange Programme

The programme has been structured into five sub-area as outlined below. The first three have been selected to form the focus of activity during the first 18 months of the Water Security Knowledge Exchange Programme. The remaining two Sub Areas will be addressed during the second eighteen month cycle of the programme, subject to reassessment of user needs and review of the first cycle.

1. Integrated Water management

The sustainable management of water resources at a catchment scale. This priority area concentrates on integrating an understanding of ecosystems with land and water management techniques to improve the management of water resources within a catchment, encompassing both rural and urban areas.

2. Increased resilience to Extreme Events

The prediction and mitigation of extreme events, with a focus on information management and coordination to increase resilience to events as they occur. This priority area will link with the LWEC Flooding Strategy which is currently being drafted.

3. Ensuring Water Resource Security

Water security is focused on preventing a gap between supply and demand. The threat of climate change may make this problematic and it will be essential for businesses, investors, regulators and government agencies to understand their water-related vulnerability, and the value of water-related ecosystem services. Understanding these factors is vital to protect both the environment and our economy. It is important to develop more accurate data about the services that water provides and the risks that it poses, and to transform this data into practical tools for stakeholders to use.

4. Coordination of Water Data

The focus of this area of impact is to support the coordination of global water data. Because of the complexities associated with managing water quality and supply across the world it is imperative that high-quality data is accessible to businesses, policy-makers and the public.

5. Sources, behaviour and control of persistent and emerging environmental contaminants

Pollution from industry, households and agriculture is widespread in the environment. The multiplicity of sources and of pollutants makes this difficult to control and to legislate against. On the other hand, waste has to be dealt with in a way which protects environmental and human health and potentially provides benefits.

Specific Priority subjects

During the first eighteen months of the programme, WSKEP will undertake smart KE activities directed at nine Specific Priority Subjects from the top three Sub Areas. The subjects were identified at the launch of the Water Security Knowledge Exchange Programme as being particular interest to users and researchers alike.

The Specific Priority Subjects are listed below:

Sub Area 1. Integrated Water Management

The sustainable management of water resources at different spatial scales. This priority area concentrates on integrating an understanding of ecosystems with land and water management techniques to improve the management of water resources encompassing both rural and urban areas.

Specific Priority Subject 1.1: Assessing upstream methods of land/water management that improve water quality and quantity

The management of agricultural land influences the quality and quantity of water in rivers and streams. As such, the objective of gaining 'good' status under the WFD can potentially be achieved through changes in land management and land use. This is especially relevant with respect to controlling nutrient pollution. Are there land management schemes that can provide concurrent improvement in both water quantity and quality downstream? Can we identify which land management options have effective impacts on water quantity and quality?

Specific Priority Subject 1.2: Understanding and managing the impacts of climate change on the ecology of catchments

The ecology of waterbodies is crucial in determining their status within the WFD. Ecological status reflects water quantity and quality, both of which are likely to be impacted by future climate change through, for example, changing flow regime and macro-nutrient cycling. Climate change will be a key consideration in the next phase of River Basin Planning under the WFD. Is there a sufficient knowledge base available on which to base management options with a view to adaptation and mitigation? What is the implication of climate change on the WFD?

Specific Priority Subject 1.3: Linking natural networks and communities across rural and urban systems

Many major towns/cities lie on, or are at the mouth of, rivers and yet our understanding of the connectivity between the urban centre and the rural catchment is weak. Is there an opportunity to make more use of nature, through understanding ecosystem services, for sustainable water management rather than relying on 'infrastructure'? Are there opportunities in understanding the importance of catchments as networks of interlinked communities?

Sub Area 2. Increased Resilience to Extreme Events

The prediction and mitigation of extreme events, with a focus on information management and coordination to increase resilience to events as they occur. This Sub Area will link with the LWEC Flooding Strategy which is currently being drafted.

Specific Priority Subject 2.1: Improving flood prediction, communication and impact assessment

Flooding leads to substantial costs to people and to the economy through impacts on a wide range of commercial sectors. There have been significant advances in flood risk estimation and in flood forecasting but flooding remains a prominent natural hazard. What work is now required to reduce uncertainties in flood prediction and risk assessment? Are the human and environmental impacts adequately understood?

Specific Priority Subject 2.2: Improving drought prediction, communication and impact assessment

Droughts tend to be regional in extent and so have widespread human health, environmental and commercial consequences. Although droughts build up slowly their prediction is difficult and uncertainties are large. What work is now required to reduce uncertainties in drought prediction and risk assessment? Are the human and environmental impacts adequately understood?

Specific Priority Subject 2.3: Supporting sustainable and resilient management of droughts

Even with improved prediction of droughts, managing these extreme events to minimise human and financial losses is a major challenge. Are there opportunities to make more use of water transfers?

Specific Priority Subject 2.4: Supporting sustainable and resilient management of extreme rainfall

Even with improved prediction of floods, managing these extreme events to minimise human and financial losses is a major challenge. Are there opportunities to make more use of 'natural' flood alleviation measures?

Sub Area 3. Ensuring Water Resource Security

Water security is focused on preventing a gap between supply and demand. The threat of population growth and climate change may make this problematic and it will be essential for businesses, investors, regulators and government agencies to understand their water-related vulnerability, and the value of water-related ecosystem services. Understanding these factors is vital to protect both the environment and our economy. It is important to develop more accurate data

about the services that water provides and the risks that it poses, and to transform this data into practical tools for stakeholders to use.

Specific Priority Subject 3.1: Assessing the value of water

Water is essential to the function of the natural environment, to human life and to businesses. What are the options for establishing the 'value' of water to all sectors, especially to ecosystem services, such that appropriate allocation of the available water resource can be made in space and time?

Specific Priority Subject 3.2: Assessing water-related business risks

Business interests and sectors are impacted by current water related risks, notably droughts and floods. Conversely, the water environment is impacted by the business and commercial sector through pollution and water abstraction. These risks are likely to change in the future as a result of climate change. Are the risks adequately known and quantified? Are we making the most of our data and models to explore future risk related scenarios?

Specific Priority Subject 3.3: Informing decision-making for water resources management

The management of the water environment and of water supply is a complex process undertaken and informed by a wide range of stakeholders. Are there opportunities to establish more 'joined-up' management approaches? Are appropriate models, tools and data available to inform the management process?

Aims and outcomes of the workshop

This workshop aims to:

- Inform the second phase of the programme.
- Increase awareness and uptake of research outputs relevant to water security.
- Identify user needs and potential future research.
- Strengthen research/user group collaboration and networks.

b) Session 2 - Current Research Activity

Sub Area 2. Increased Resilience to Extreme Events

Specific Priority Subject 2.2 Improving Drought Prediction communication and Impact assessment

Making the most of current research – A Researcher's Point of View

Dr Ian Holman, Cranfield University

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There have been a significant number of recent and ongoing research projects associated with the prediction, modelling and management of droughts, funded by government, Research Councils and the European Commission. In addition to those discussed within the earlier WSKEP drought workshop

(http://www.wskep.net/assets/documents/WSKEP%20SPS%202_3%20Workshop%20Session%202%20Current%20Research%20Droughts.pdf), a selection of further projects have been summarised

below. These projects have tended to focus on a number of key research themes:

- Improving the ability of climate models to simulate the climatic drivers of drought – climate models are improving, but their ability to simulate current and future precipitation is still problematic. Approaches taken to further improve this include constraining model parameters by observed sea surface temperature and ice cover (HYDRA) and improving land-atmosphere feedbacks (HydEF, SWELTER-21);
- Downscaling climate model output to a scale relevant for impact assessment and adaptation – because the spatial and temporal resolution of GCMs and RCMs is too coarse for many application, improved downscaling methods are needed to appropriately characterise the frequency, persistence and severity of droughts (HydEF, UKCP09);
- Developing better process-based hydrological representation within models – the ability of hydrological or land-surface models to simulate drought conditions can be limited by their representation of soil and groundwater hydrology. Efforts are being made to incorporate an improved representation of the groundwater system in such models (WATCH, HydEF);
- Understanding and managing the competing needs for water in times of drought – droughts and the changes in hydrological flows have multiple interacting impacts on human (public water supply, agriculture, industry, navigation, recreation) and environmental (in-river, lake and wetland ecology etc) water needs which need to be understood and considered within management interventions and responses (ARCC-Water, WaterSci, “Drought and Demand 2006”);
- How to make decisions within uncertain futures – the improving representation of uncertainty within impact assessment requires improved methods for making robust risk-based decisions (CRANIUM, SWERVE, ARCC-Water).

Constraining the response of the hydrological cycle, land surface and regional weather to global change (HYDRA)

Key Funder: NERC

Type of Project: Research Project

Start Date: 01/10/10 **End Date:** 30/09/2014

Research Project Contacts: Professor Myles Allen, University of Oxford (allen@atm.ox.ac.uk), Dr Philip Stier, University of Oxford (Philip.Stier@physics.ox.ac.uk), Professor Peter Cox, University of Exeter (P.M.Cox@exeter.ac.uk)

Website: http://gotw.nerc.ac.uk/list_full.asp?pcode=NE%2FI00680X%2F1&classtype=

The IPCC's CMIP-3 and CMIP-5 model inter-comparisons focus on uncertainty in the large-scale temperature response of the coupled atmosphere-ocean system to a given emissions or concentration scenario, treating uncertainty in downscaling, in the hydrological cycle and in the biosphere as additional sources of error. This fully coupled approach only permits relatively coarse-resolution global models and limited ensemble sizes, with large systematic errors and low signal-to-noise in hydrological variables, problems which persist in initialized decadal forecasts. As a result, precipitation observations play only a minor role in constraining precipitation forecasts, resulting in large and potentially unphysical ranges of uncertainty on high-impact variables such as the frequency of occurrence of extreme rainfall. Hence CMIP-style simulations have been found to be of limited use by what should be one of our key stakeholders, insurance risk modeling. Much of this uncertainty may be unnecessary since we know how sea surface temperatures and ice cover (SSTICs) have evolved over the past few decades and how the hydrological cycle has responded, so we should be using this information directly to constrain atmospheric and land-surface parameters. Moreover, all studies suggest a limited range of degrees of freedom in the large-scale externally-driven SSTIC change over the next few decades. Hence a powerful complementary approach to the CMIP 'emissions scenario driven' paradigm is the 'temperature scenario driven' approach under which a range of large-scale SSTIC changes are used to drive higher-resolution models, either directly or by relaxation in a simple model of the ocean mixed layer. This allows much larger ensembles and reduced bias over the recent observational period, providing a more systematic exploration of uncertainty in the atmospheric, hydrological and land-surface response. Detailed comparison with observations for the same years, including satellite-derived top-of-atmosphere fluxes, should allow much tighter constraints to be placed on atmospheric and land-surface parameters than is possible when coupled models are run free and comparisons are restricted to large-scale climatology and recent trends. A key challenge in quantitative comparison of simulated precipitation trends with observations is systematic biases in the location of precipitation features such as convergence zones. The project will address this using image-warping techniques developed for neuro-imaging which have been demonstrated on a pilot scale to correct feature-location biases in climate models. These will also provide a powerful tool to detect externally-driven shifts in feature location, such as an expansion of the Hadley circulation. We will run large ensembles of global atmospheric/land-surface models driven with observed SSTICs over the past 60 years together with projected changes to 2040 derived from a broad range of sources, including CMIP-3, CMIP-5 and the UKCP09 and climateprediction.net perturbed physics ensembles. Repeat simulations of the past 60 years with the estimated signature of anthropogenic influence removed will be used to address how far recent observed changes in precipitation, land-surface variables and run-off can be attributed to human influence. Multi-thousand-member ensembles will allow the distribution of hydrological and land-surface variables to be mapped in detail, largely eliminating stochastic uncertainty from predictions of their underlying statistical moments. A representative subset of these simulations will be used to drive nested regional models over Europe, and the output used to drive run-off models to evaluate their utility for flood and drought risk modeling. The modeling framework will be made available to

international partners to address other regions. All simulations will be performed using climateprediction.net public resource distributed computing, minimizing both their cost and environmental impact.

CRANIUM: Climate change Risk Assessment: New Impact and Uncertainty Methods

Key Funder: EPSRC

Type of Project: Research Project

Start Date: 26/09/2003 **End Date:** 25/09/2006

Research Project Contacts: Professor Chris Kilsby, Newcastle University (c.g.kilsby@ncl.ac.uk)

Website: <http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=GR/S18083/01>

The aim of this research was to develop new methodologies for analysing uncertainty and making robust risk-based decisions for infrastructure design and management in the face of climate change. It is structured around three tasks. Task 1 analysed uncertainties in key climate variable analysis of built environment, transport and utilities and provide means of communicating uncertainties to modellers and decision-makers. It developed new Bayesian and extreme value methods for incorporating a range of uncertainties in climate scenarios. Task 2 developed new methods assessing system response to uncertain climate forcing. It demonstrated methods for projecting uncertainties through system models and even numerical methods for reducing the computational expense of uncertainty analysis. Task 3 addressed how, in the light of these insights, decision making about operation of, or investment in, the system in question could be managed or modified to reflect potential climate change impacts and specifically the uncertainties surrounding them. It reviewed the decision contexts confronted by managers responsible for built environment, transport and utilities and evaluate the suitability of a range of decision-making techniques in these contexts. Task 3 was the main integrating mechanism within the project and will involve the project's eight stakeholder organisations. Methodological developments in each of these three tasks will be conducted in the context of case examples.

Drought and Demand in 2006: consumers, water companies and regulators

Key Funder: ESRC

Type of Project: Research Project

Start Date: 01/07/2006 **End Date:** 30/06/2007

Research Project Contacts: Dr William Medd, Lancaster University (w.medd@lancaster.ac.uk), and Dr Heather Chappells, Lancaster University (h.chappells@lancaster.ac.uk)

Website: <http://www.esrc.ac.uk/my-esrc/grants/RES-177-25-0001/read>

The drought conditions announced in many parts of the south east of England in 2006 presented a real challenge for water managers and regulators. As media coverage demonstrates only too clearly, the drought has reopened questions about current systems of water management, the assumptions of demand forecasting and management, and the possibilities of 'appropriate' alternatives and solutions. In particular strategies by the government, regulators and water companies to shape domestic water demand have provoked renewed discussion about water needs, rights, and responsibilities. This study involved a real-time qualitative sociological analysis of the 2006 drought in the south east of England, involving interviews with householders, water resource managers and regulators. The project aimed to reveal the assumptions about demand inherent in existing systems

of water practice and provision, to discover how far the drought might act as a catalyst for change in definitions of normal and necessary levels of water consumption, and to identify the dynamics of resilience in demand, both in relation to adaptation as well as persistence. The project is co-funded by UKWIR, DEFRA, OFWAT, the Environment Agency, Anglian Water, Essex and Suffolk Water, Folkestone and Dover Water, Three Valleys Water and South East Water.

Hydrological extremes and feedbacks in the changing water cycle (HydEF)

Key Funder: NERC

Type of Project: Research Project

Start Date: 01/02/2011 **End Date:** 31/01/2014

Research Project Contacts: Professor Andrew Wade, University of Reading (a.j.wade@reading.ac.uk), Dr Neil McIntyre, Imperial College London (n.mcintyre@imperial.ac.uk), Dr Richard Chandler, University College London (richard@stats.ucl.ac.uk), Dr Andrew Hughes, BGS (aghug@bgs.ac.uk)

Website: http://gotw.nerc.ac.uk/list_full.asp?pcode=NE%2FI00677X%2F1&classtype=

The prospect of significant climate change over the next decades means that society must urgently face up to the implications for the changing water cycle, in particular increasing risks from extreme floods and droughts. Guidance for policy-makers to support adaptation to these risks and to support mitigation strategies to combat climate change is urgently required. However, the ability of climate scientists and hydrologists to predict the possible magnitudes of floods and droughts, and the frequency with which they are expected to occur, is still limited. This is due largely to gaps in knowledge of how best to use available data and models; of particular concern is the limited ability of climate and hydrological models to produce realistic extremes and changing hydrological behaviour. For example, regional climate models produce data which often requires to be downscaled to finer resolutions, but questions arise about what properties of the downscaled data are critical and how the downscaling should be done. As another example, drought planning requires inter-annual and inter-regional rainfall and evaporation to be represented accurately, however there is little guidance about how this can best be achieved under future climate using available models. In addition, there are weaknesses in the simulation of hydrology (for example, groundwater storage, river flows and evaporation) which act as hurdles to development of next generation climate models; in particular models currently used to simulate feedbacks from the earth surface to the atmosphere neglect important hydrological processes. This research will produce the science and models needed to address these questions, integrating climate and hydrological science to take impact modelling beyond the current state of the art. Specifically, the research: 1. exploits current generation climate science and statistical methods to improve and enhance projections of potential change in hydrologically-relevant metrics over a time-scale of 10 to 60 years, in particular extremes of heavy precipitation and drought; 2. builds on the analysis of historical data to improve scientific understanding and develop innovative methods for the modelling of extremes and non-stationarity in the hydrological response to climate variability; 3. seeks to improve the representation of hydrological processes in land surface models, in particular, the enhanced modelling of surface and subsurface processes for simulation of land-atmosphere feedbacks. In addressing these gaps in knowledge, the proposed project will cross all four themes of NERC's Changing Water Cycle programme: land-atmosphere interactions; precipitation modelling; understanding of change; and innovative ways to assess consequences. Case studies will include the Thames catchment and the Eden catchment. These catchments are broadly representative of lowland and upland UK with

substantial climate and hydrological datasets from NERC and DEFRA-EA experimental programmes. This project will consider local to catchment scales, with the view that the resulting science and models will ultimately be integrated into global scale models. The main project outputs will be: 1) improved quantification of future variability and extremes of precipitation and evaporation over hydrologically relevant scales in the UK; 2) improved models of the hydrological water cycle response to these extremes, with the explicit inclusion of non-stationary conditions; 3) the inclusion of earth-atmosphere feedback processes and their effects in climate models, in particular the recognition and inclusion of unsaturated zone and groundwater storage and discharge. In all cases, new modelling tools will be developed to test the ideas of meteo-hydrological functioning.

Soil Water - Climate Feedbacks in Europe in the 21st Century (SWELTER-21)

Key Funder: NERC

Type of Project: Research Project

Start Date: 01/01/2011 **End Date:** 31/12/2013

Research Project Contacts: Dr Christopher Taylor, CEH (cmt@ceh.ac.uk), Professor Pier Luigi Vidale, University of Reading (p.l.vidale@rdg.ac.uk) and Professor John Remedios, University of Leicester (j.j.remedios@le.ac.uk)

Website: http://gotw.nerc.ac.uk/list_full.asp?pcode=NE%2FI006729%2F1&classtype=

Whilst computer predictions of future climate agree that rising concentrations of greenhouse gases will warm the earth's surface over the 21st century, there is less consensus concerning how this will affect the climate in a region such as Europe, in particular when considering changes in rainfall. Broadly speaking, northern Europe is likely to get wetter, particularly during the winter, and central and southern Europe are expected to experience drier and hotter summers. Although regional changes in rainfall are difficult to predict with confidence, these are critical features of a changed climate which decision makers need to plan for now. For example, the likelihood of the UK experiencing more frequent summer droughts in the future has implications for the planning and building of new reservoirs, for agriculture and for the maintenance of key habitats. Uncertainty in our predictions of the water cycle arises from inadequate representation of key processes in climate models. When considering the likelihood of future droughts, one key area is the relationship between the atmosphere and the land. During summer, soils dry, which in many parts of Europe limits evaporation of soil moisture into the atmosphere. When this happens, there is a change in the partition of solar energy absorbed by the land surface; less energy is used for evaporation and more is used to warm the atmosphere directly. This 'feedback' can affect the development of clouds and rainfall, especially the occurrence of local summertime storms which develop during the afternoon. Furthermore, when soil dries out over a large region, as happened for example across much of Western and Central Europe during 2003, the lack of land evaporation can affect much larger-scale weather systems. Warmer air temperatures are expected to produce notably drier soil conditions in the summers of the late 21st century through increased spring-time evaporation. As a result, we would expect the drier soils to start to feed back on the atmosphere earlier in the summer, and in more northerly regions which are currently wet. Our lack of detailed knowledge about how this feedback between soil wetness and precipitation operates provides one of the major uncertainties in predicting the likelihood of droughts in the coming decades. Studies have suggested that the drought of 2003 may have illustrated the shape of things to come, with dry spring soils implicated in the drought and associated heatwave which followed. This implies that future European summers

could become more variable from year to year, as droughts become 'locked in' by favourable soil conditions. This project will use a state-of-the-art computer model of the land surface and atmosphere combined with new compilations of data obtained from satellites to improve our understanding of how soil wetness influences rainfall. The research will use observations from periods of drought to see directly how temperatures rise as soil water declines. The research will use this knowledge to better represent evaporation over land in the UK Met Office climate model. The research will also examine where, within drought-affected regions, clouds and storms preferentially develop, over relatively wetter or drier landscapes. This will allow us to predict the conditions where dry soils suppress rainfall, thus prolonging drought. From the detailed observations the research will evaluate and improve climate models and their representation of soil wetness feedbacks. These improvements will feed into new Met Office predictions of climate change for Europe. The research would also be expected to improve the Met Office capability to predict whether the forthcoming summer will be hot and dry, as these seasonal predictions use the same computer model. Any improvements in prediction on either time scale would have direct benefits for the UK economy.

SWERVE - Severe Weather Events Risk and Vulnerability Estimator

Key Funder: EPSRC

Type of Project: Research Project

Start Date: 01/05/2008 **End Date:** 30/11/2011

Research Project Contacts: Dr Hayley Fowler, Newcastle University (h.j.fowler@ncl.ac.uk), Dr Stuart Barr, Newcastle University (s.l.barr@ncl.ac.uk) and Professor Jim Hall (jim.hall@eci.ox.ac.uk)

Website: <http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=EP/F037422/1>

There is now a broad scientific consensus that the global climate is changing in ways that are likely to have a large impact on our society and the natural environment over the coming decades. Global warming, and its impact on extreme weather events, may have a profound influence on the way we live in the future. Recent extreme weather events, such as the unusual number of hurricanes in the US 2005 hurricane season, the unprecedented flooding in central Europe in summer 2002, the tragic loss of life in the European heatwave the following summer, or the severity of flooding in the UK during autumn 2000, have been said to be a possible impact of global warming by the media. This has made us focus our attention on the possible impacts of future climate change on our society but most recent research has focussed on predictions of change in the future frequency and intensity of extreme weather events at a global or regional scale. However, to well-adapt our society to the future impacts of climate change and extreme weather events, we need to know how these events will affect local communities, how they may respond and what emergency and long term planning measures need to be undertaken to increase their resilience. The SWERVE (Severe Weather Events Risk and Vulnerability Estimator) tool examined these and other fundamental research questions through collaboration with other experts in the UK in an inter-disciplinary research programme called CREW: Community Resilience to Extreme Weather. SWERVE will use information from global climate models and a technique called downscaling to produce relevant information on extreme weather at the local, community level. This will allow estimates on how often different types of extreme weather, such as floods, storms, drought, heatwaves, etc., may happen both now and in the future. It will also allow 'hotspots' of risk to be identified, where communities may be vulnerable to more than one type of extreme weather event, e.g. they may suffer from floods in the winter and drought in the summer. Using additional modelling tools locations at risk from these types of

extreme weather events will be identified down to the postcode level. This information will then be used together with information on our society to identify communities and locations that are particularly vulnerable. The overall output will be a toolkit that decision-makers can use when faced with planning and management decisions for coping with extreme weather events. This will increase the ability of the community to deal with the aftermath and to plan to reduce the impacts of extreme weather. The CREW programme will be a pilot study for a toolkit that could be produced across the UK. The pilot study will focus on the SE London Resilience Zone and engage stakeholders from this region and others across the UK in the development of the toolkit. This will ensure that it is what you and local emergency services, town planners and local government need. The research also looked at whether the tool will be useful by applying it to some 'what-if?' cases together with local decision-makers and by testing it in local firms. This new toolkit can be used by managers to design systems that are robust to the impacts of climate change; climate change that, according to the Intergovernmental Panel on Climate Change's latest report in February this year, is very likely to be caused by human activities and is likely to cause an increase in extreme weather events.

Water availability and quality: natural environments, domestic use and food production (WaterSci)

Key Funder: EPSRC

Type of Project: Research Project

Start Date: 01/05/2009 **End Date:** 30/06/2012

Research Project Contacts: Professor William Davies, Lancaster University

w.davies@lancaster.ac.uk

Website: <http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=EP/G042683/1>

This project addresses perhaps the greatest challenge facing humankind: feeding a world population approaching 7 billion against a background of growing concern over our planet's capacity to adapt to a changing climate. The recent IPCC report (<http://www.ipcc.ch/>) highlights both a predicted increase of 2-4oC in global surface warming by 2100 and significant perturbation in patterns and intensity of rainfall predicted to lead to serious droughts and more frequent flooding, both severe problems for food production and for the maintenance of a safe and secure water supply. Now, possibly more than at any time in the past, is there a need for innovation to ensure we can successfully meet such a global challenge. Improvement in security of supply and quality of water would also have a significant positive impact on sustainable development and health in parts of the world increasingly important to the UK as emerging markets. To meet this challenge, we need innovation to: quantify agricultural water requirements; increase water and resource use efficiency in food production; quantify and ameliorate the extent, source, fate and health impacts of water contamination; develop new environmental modelling capabilities; adopt emerging intelligent environmental sensor technology and take greater use of biosolids and wastewater. The WaterSci bid from the Lancaster Environment Centre and several labs in China, a partnership which leads the world in sustainable water management, proposes to focus on the development and exploitation of tools to deliver on this global innovation challenge and market opportunity.

Water System Resilience (ARCC-Water)

Key Funder: EPSRC

Type of Project: Research Project

Start Date: 01/09/2009 **End Date:** 31/10/2012

Research Project Contacts: Professor Mark New, University of Oxford (mark.new@geog.ox.ac.uk) and Jim Hall, University of Oxford (jim.hall@eci.ox.ac.uk)

Website: <http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=EP/G061157/1>

Reliable water supply is fundamental to human health and wellbeing, and in the UK is underpinned by inter-linked infrastructure for abstraction, storage, treatment and conveyance of potable and wastewater. Climate change has the potential to affect the UK water system in a number of ways: through changes in the water available for abstraction and storage, especially through altered drought frequency and intensity, changes in demand and changing risk of infrastructure failure. This project aims to develop a set of analysis tools and data on climate change and future demand that will enable users to identify packages of options that results in heightened resilience of the UK water system to these uncertain future drivers. The multi-criteria approach to be developed will also allow alternative adaptation options to be assessed against other criteria, such as environmental sustainability, energy costs and public acceptability. The focus of the study is South and East England, an area that is already experiencing water system stress, and likely to be subject to additional stresses in the future due to climate change and demographic changes. The methods and results of this research will enable the UK to better plan for adaptation of the water system to climate change, and will help identify the policy and regulatory changes that would be needed for adaptation to take place. The project has been designed in collaboration with stakeholders from government (DEFRA, EA, OFWAT, GLA), the water industry (UKWIR, Water UK and a number of water companies) and NGOs with an interest in water. These same stakeholders will be involved throughout the project as project partners.

c) Session 3: Available Funding for Future Research

The following are a list of currently available sources of funding for research, innovation, knowledge exchange and demonstration activities in the general area of freshwater, particularly in regard to NERC's fields of interest of natural sciences. This list includes the entire spectrum of grants – from those supporting very basic fundamental research where there is limited scope for user involvement, to schemes designed to facilitate the transfer of knowledge from the science base into application by end users.

Funding schemes which are continuously open are listed first, while specific on-off Calls focussing on high priority issues are listed from page 6 onwards. Information about all NERC research programmes can be found at :

<http://www.nerc.ac.uk/research/programmes/>

Examples of programmes to fund immediate transfer of expertise from the research base to a user (government, industry or NGO) include :

NERC Connect A and B scheme;

NERC KE Fellows;

NERC Policy Placements

Similar schemes to the above are available through the other Research Councils

Technology Strategy Board – Knowledge Transfer Partnership (KTP's)

European Commission DG Environment Life+ Programme

European Commission DG Research – Support to SME's

Very small grants,(generally for field work costs) are available from some charities.

The Water Security KE Programme Secretariat may be able to provide you advice in where to look for research and knowledge transfer funding.

NERC Standard Grants

This is an open competition for curiosity-motivated basic, strategic or applied research.

Grants are for a minimum of £25,000 for directly incurred costs (total of costs under this heading). The primary criterion for assessment is scientific excellence, with all applications subjected to an Initial Review stage that makes decisions on which proposals should proceed to external review. Moderating Panels meet annually in June and December to grade the applications and make recommendations for funding.

Closing Dates: 1st July and 1st December

Eligibility : Research Organisation – Universities, public research organisations

Website: <http://www.nerc.ac.uk/funding/available/researchgrants/typesofaward/standards.asp>

NERC Large Grants

Large Grants are supported through responsive mode funding, but the size and nature of these awards mean that they will often incidentally have a strong strategic element.

The minimum funding level for large grant proposals is £1.2m, 100% (Full Economic Cost). The maximum funding level for large grant proposals is £3.7m, 100% (Full Economic Cost) with a duration of up to five years.

Applicants must first submit an outline proposal that will be assessed by members of the Peer Review College, plus independent experts as required. Selected proposals will then be invited to proceed to the full proposal stage.

Full proposals will be peer reviewed by international experts and the assessment process includes presentations by applicants at the moderating panel.

Closing Dates: The Consortium Grants scheme will in 2012 to operate via one grant round per year rather than two, and an outline stage assessed by members of the Peer Review College will be introduced.

Website: <http://www.nerc.ac.uk/funding/available/researchgrants/typesofaward/large.asp>

NERC Connect A Scheme

The Connect A scheme facilitates and promotes new partnerships between universities and research institutes and public/private sector science users (industry, business, commerce or public sector agencies). The funds are for planning and initiating collaborative research not eligible for funding through other schemes (LINK, KTP, CASE or contract research).

Funds will support two basic types of pump priming activities.

- Proof of concept proposals for a specific research activity relating to ideas emerging from the science base that have potential application but have a high degree of technical risk and perhaps lack a clearly defined end user. Project costs sought should be those eligible under standard NERC research grants.
- Costs for workshops or seminars on a theme both partners are interested in. Participants should be from both communities. Funding can be sought for accommodation, hire of audio-visual equipment, travel costs for speakers/rapporteurs and ancillary costs.

Applications are assessed according to the criteria below; NERC may seek the advice from the peer review college.

- Degree of user involvement in the proposed activity.
- How the UK economy will benefit.
- Novelty of the proposal.
- Cost effectiveness of approach.
- Need: urgency, and inability of other schemes to respond.
- Likelihood of this leading to a proposal for a co-funded project (e.g. Partnership Research Grant).

Awards

Awards are made up to £4 000 for the total directly incurred costs per application. NERC pays the standard proportion of full economic costs (see the NERC Research Grants Handbook for full details).

Closing Dates: There are **no closing dates** applications are accepted and processed at any time.

Website: <http://www.nerc.ac.uk/using/schemes/connecta.asp>

NERC Follow-on Fund

This is a 'proof of concept' fund to support the commercialisation of ideas arising from research funded by:

- Natural Environment Research Council
- Biotechnology & Biological Sciences Research Council
- Engineering & Physical Sciences Research Council
- Science & Technology Facilities Council

The Follow-on Fund is designed to help researchers maximise the societal and economic benefit of their research by extending its impact through commercial means.

The NERC fund is open to researchers with current or past NERC funding. Applications for follow-on support must build on the outputs of previous NERC-funded research activity.

There are two schemes to apply for:

Follow-on Fund Pathfinder

Pathfinder awards are available to carry out work that will help you develop a greater understanding of the commercial aspects and possibilities of your research, and hence a more robust, better informed application for a full Follow-on Fund grant.

Follow-on Fund

This is the main scheme. Applications must demonstrate a sound understanding of the market opportunity, as described above, and a clear and robust linkage between the proposed technology development plan and the strategy proposed for commercialising the project's outputs.

Closing Dates:

Follow-on Fund: Closing dates for 2012 are 1st February, 6th June and 3rd October.

Follow-on Fund Pathfinder: There is no closing date for this scheme; applications can be submitted at any time.

Website: <http://www.nerc.ac.uk/using/schemes/followonfund.asp>

NERC Knowledge Exchange Fellows

Proposals to host a KE Fellow are invited from schools or departments in approved UK Higher Education Institutes currently in receipt of NERC research funding.

KE Fellows can be employed for one to three years, for a minimum of 20% and a maximum of 80% of their time. It is anticipated that the fellows will already be employed by the host institution.

Proposals are welcomed for the Knowledge Exchange Fellowships in any area of policy, business or third sector with the aim of boosting the impact of any type of NERC funded science. It is a responsive, rather than a directed, scheme. Successful applicants whose proposal covers one or more of NERC's priority areas for knowledge exchange may be given the option of linking to wider NERC KE initiatives.

Four to six fellowships will be available for those who come forward with a work plan of their own choosing to generate impact from NERC funded research in their host institution. For these applicants, the fellowships will cover the KE Fellow's salary, including superannuation, NI and specific allowances, plus up to £40k for travel and other associated work plan costs.

Closing Dates:

There are two calls a year with a closing date in April and November of each year

Website: <http://www.nerc.ac.uk/using/schemes/kefellows.asp>

NERC Knowledge Exchange Call

NERC will run the KE Call Projects and the KE Fellowships opportunities concurrently; applicants may submit a proposal to both of these schemes at the same time. Proposals may be linked, if appropriate, although they will be assessed separately as stand alone applications. We welcome proposals for KE projects in any area of policy, business or third sector with the aim of boosting the impact of any type of NERC funded science. KE Call Projects is a responsive rather than a directed scheme.

Successful applicants whose proposal is in the area of one or more of NERC's Knowledge Exchange priorities may be given the option of linking to wider NERC KE initiatives.

Closing Dates: There are two calls a year with a closing date in April and November of each year

Website: <http://www.nerc.ac.uk/using/schemes/kecall.asp>

NERC Partnership Research Grants

In line with its strategy to embed end-user engagement into the research process, NERC has taken the decision to fully integrate its Partnership Research Grant scheme into the Standard Grant Scheme.

At present, Partnership Research Grants are assessed by the same panel as Standard Grants and using the same criteria. These aspects will not change. However, instead of having to apply via a separate mechanism, researchers will simply submit their proposals to the Standard Grant scheme, following the usual Standard Grant procedures, which already allow for the inclusion of end-user Project Partners.

Going forward, it is likely that certain Research Programmes will use Partnership Research-style grants to encourage end-user engagement in line with their own strategic objectives; such opportunities will be announced in the usual manner, as and when they arise.

Website: <http://www.nerc.ac.uk/using/schemes/partnershipgrants.asp>

EPSRC Follow-on Fund

The Follow-on Fund helps researchers to bridge the funding gap between traditional research grants and commercial funding by supporting the very early stage of turning research outputs into a commercial proposition. After completing the follow-on work, the prospective business idea should be in a much stronger position to secure further support from venture capital or seed funds.

The fund provides up to 12 months support for technical and business development activities that will establish the commercial potential of a concept by demonstrating both commercial feasibility and scientific/technical merit. Projects predominantly concerned with overcoming technical obstacles or extending the original research will not be accepted.

Closing Dates: The Follow-on Fund operates through calls for proposals; information on future calls will be published when available.

Website: <http://www.epsrc.ac.uk/funding/grants/business/schemes/Pages/followonfund.aspx>

EPSRC Network Grants

The main objective of Networks is to create new interdisciplinary research communities and topics, by developing interaction between the research community and appropriate science, technology and industrial groups. The aims are to:

- Transfer experimental techniques, models and scientific insights
- Promote mobility between academe, universities and industry.

Networks are expected to lead to new collaborative multidisciplinary research proposals and some may develop into virtual centres of excellence, providing critical mass of analytical expertise.

Under full economic costing there is no limit on the amount of funding that can be applied for, although the network should last for no longer than three years. Funding is intended to cover the operating and support costs of the Network and full justification for the sum requested should be included in the proposal. Funding will not be renewed beyond the original length of the grant.

Closing Dates: Network proposals may be submitted at any time in the Responsive Mode. However, EPSRC may also occasionally issue specific calls for proposals which have different objectives from those listed above. EPSRC has established various initiatives to set up Networks in specific programme areas.

Website: <http://www.epsrc.ac.uk/funding/grants/network/networks/Pages/default.aspx>

EPSRC Platform Grants

Platform Grants are a flexible mechanism of providing underpinning funding to well established, world leading research groups.

Platform Grant funding provides a baseline of flexible support (a platform) that can be used for the retention of key staff, feasibility studies, longer-term research and International Networking. This flexibility should enable the group to take a strategic view of their research which will be enhanced by the submission of responsive mode applications during the lifetime of the Platform Grant.

Applicants are required to have an internationally leading reputation and a high international profile. They must be able to demonstrate that their group has a strong track record in obtaining support from EPSRC and other funding sources. They should hold a substantial portfolio (a range of grants relating to the research area of the Platform Grant) of current EPSRC research grant funding, typically over £2 million in value which Platform Grant funding would underpin. In some cases funding from other sources (e.g. other Research Councils, EU, TSB, and Industry) may be taken into account depending on the nature of the funding, and type of grant. As a guide this portfolio should be at least double the level of resources that Platform Grant funding would provide. The portfolio that would be underpinned should be sustained to a significant degree during the period of the proposed Platform Grant.

Closing Dates: 27th January, 30th March, 25th May, 27th July, 28th September, 30th November 2012

Website: <http://www.epsrc.ac.uk/funding/grants/capacity/platform/Pages/default.aspx>

EPSRC Programme Grant Scheme

Programme Grants, which can be awarded for up to six years duration, are a flexible mechanism for providing funding to address significant major research challenges. Following a number of reviews, it is evident that giving leading researchers the stability of long-term funding allows them the flexibility to be creative, innovative and able to address some key challenges.

Specifically a Programme Grant is to support a suite of related research activities focusing on one strategic theme. Although it is expected that most proposals will be interdisciplinary and collaborative in nature, they can address key challenges in a single discipline. Programme Grants are not just large grants but must be strategic in nature.

The proposal must demonstrate that research of the highest quality will be undertaken by a world-leading team. The research programme should be ambitious, creative and innovative addressing key research challenges. It should be clearly stated why the challenges are ambitious; applicants should set the proposed research in context in terms of the current state of knowledge and other work under way in the field. The research programme should also be sustainable beyond the lifetime of the grant and have significant impact beyond its immediate group.

The principal investigator should have brought together a world-class team with complimentary expertise so as to enhance the potential to achieve the vision.

Closing Dates: 1st April and 1st October

Website: <http://www.epsrc.ac.uk/funding/grants/capacity/programme/Pages/default.aspx>

EPSRC Standard Research

EPSRC research base funding is very flexible. EPSRC fund projects ranging from small travel grants to multi-million pound research programmes. You can apply for whatever length of funding you require, whether it is a month or six years.

You can apply for funding for a wide range of activities, including research projects, feasibility studies, instrument development, equipment, travel and collaboration, and long-term funding to develop or maintain critical mass. EPSRC particularly want to encourage high-risk/high-return research proposals relating to new concepts or techniques. There are no closing dates so you can apply at any time.

Closing Dates: There is no closing date for this scheme; applications can be submitted at any time.

Website: <http://www.epsrc.ac.uk/funding/grants/rb/Pages/default.aspx>

Future Calls

Technology Strategy Board

Water Competition

The scope of the competition will be to help UK companies gain access to global markets by demonstrating the commercial and technical viability of step-change innovations that address the water security challenge.

There has not been a call for this yet, but will be due in the second quarter of 2012.

Website: <http://www.innovateuk.org/competitions.ashx>

NERC

NERC Macronutrients Programme

The Macronutrients Programme address key issues related to N, P and C cycling in catchments under a changing climate. This programme held its first main Call for proposals in late 2011 and successful projects were announced in late January 2011. A second Call is likely in early 2013 which will address gaps in science that are not covered by projects funded under the first Call. Total budget of approx £9.55 million.

Next Call Date : Probably early 2013.

Website : <http://www.nerc.ac.uk/research/programmes/macronutrients>

NERC Biodiversity and Ecosystem Service Sustainability (BESS) 2011-15

The Biodiversity and Ecosystem Service Sustainability Programme announced the results of its first Call for proposals in mid January 2012. A second Call targeting gaps in the science not covered by projects funding under the first round, will probably be made in early 2013.

Next Call : probably early 2013

Website : <http://www.nerc.ac.uk/research/programmes/bess/>

NERC Flooding from intense rainfall

(£5.2m, contributes to natural hazards theme)

Intense rainfall events commonly last for a few hours, or even a few minutes, but present flood forecasters and flood risk managers with major problems. Our knowledge of processes associated with such extremes is poor and we cannot predict associated flood risks with confidence.

This NERC-led, LWEC, UK-focused programme will reduce the risks of damage and loss of life caused by surface water and flash floods through improved identification, characterisation and prediction of interacting meteorological, hydrological and hydro-morphological processes that contribute to flooding associated with high-intensity rainfall events.

The programme will:

- Improve the length and accuracy of forecasts of the occurrence and intensity of rainfall associated with convective storms.
- Identify the susceptibility to high-intensity rainfall of different catchment types, based on characterisation of the properties that govern the dynamic, non-linear, hydrological and hydro-morphological processes which initiate, extend and intensify associated flood risks.
- Enhance flood risk-management through the development of both flood risk estimation and real-time forecasts of floods associated with high-intensity rainfall, integrating multiple meteorological and hydro-morphological processes occurring before, during and after intense precipitation events.

There has not been a call for this yet, but will be due in the second half of 2012.

Website: <http://www.nerc.ac.uk/research/themes/tap/tap-phase3.asp#flooding>

UK Droughts

(£6.5m, contributes to natural hazards and climate system themes)

Droughts can cause enormous socio-economic damage through their impact on water supply, health, food security, and infrastructure. They pose a significant hazard to the UK, and are likely to increase in frequency and severity as a result of climate change.

Decision-makers find it challenging to make informed adaptation and management choices in relation to droughts as it is difficult to predict their occurrence, duration, intensity and extent of their impact. Currently the many drivers of drought, both meteorological (eg anticyclonic blocking) and societal (eg supply & demand balance, water storage, transfer and utility trends), are often considered in isolation.

This programme will identify and predict the interrelationships between multiple drivers and impacts of UK droughts - over daily to multi-annual timescales and on spatial scales from metres to 500km - to inform adaptation and management decisions before, during and after drought events. The scientific goals are to:

- Characterise the historical occurrence, intensity, geographical pattern and impacts of drought in the UK through identification of the contribution of multiple drivers of drought, including antecedent conditions (eg cumulative dry winters¹³) and water utility patterns.
- Identify, model and predict the climate drivers of key drought types at lead times from months to years. A particular focus should be on the potential for exceeding the historical envelope, for example through the interaction of climate change with natural climate variability.
- Identify the nature, extent of impact, interaction and functioning of key ecological and hydrological systems during periods of water scarcity - addressing in particular non-linear responses, system thresholds and potential for recovery.
- Develop integrated tools to assess the risks associated with drought, by coupling new and existing models that describe the drivers, feedbacks and impacts, to support decision-making before, during and after drought events, and determine optimal adaptation and management strategies.

There has not been a call for this yet, but will be due in the third quarter of 2012.

Website: <http://www.nerc.ac.uk/research/themes/tap/tap-phase3.asp#drought>

d) Session 4: Alliances, networks and next steps

Existing KE Networks and improving future collaboration -Hans Jensen, CEO, UKWIR Ltd

T: 020 7344 1868 E: Hans.Jensen@ukwir.org.uk

ACE - Association for Consultancy and Engineering (<http://www.acenet.co.uk/home/57>)

ACE represents the business interests of its members and the consultancy and engineering industry in the UK. It is the leading business association in this sector, counting around 650 firms - large and small, operating across many different disciplines, as its members. ACE members are some of the world's leading consultancy and engineering businesses. Renowned for the quality and excellence of their work, they regularly win awards for engineering innovation and achievement.

BOND - UK NGO Network – Water Group (<http://www.bond.org.uk/pages/uk-water-network.html>)

The purpose of the UK Water Network is to increase the impact of its members by providing a forum where agencies can exchange information, enhance their analysis and coordinate their advocacy towards the UK Government and other relevant institutions on freshwater issues. This includes issues on water and sanitation, the preservation of the ecology and biodiversity of freshwater systems, food, energy production and leisure.

BARSC - British Association of Remote Sensing Companies (<http://www.barsc.org.uk/>)

The British Association of Remote Sensing Companies actively promotes the interests of all organisations and individuals who work with remote sensing technology and data. Remote Sensing (or Earth Observation) includes companies and organisations involved in satellite building and launching, processing, distributing and selling the collected data as well as offering expert services to make best use of this incredible resource. It is not surprising to know that Remote Sensing is an industry that contributes a huge amount of revenue to the UK economy and supports thousands of jobs.

BHS – British Hydrological Society (<http://www.hydrology.org.uk/>)

The British Hydrological Society (BHS) was formed in 1983 in response to a clear need for a new, broad-based national society for the advancement of hydrology.

The Society caters for all those with an interest in the inter-disciplinary subject of hydrology, and aims to promote interest and scholarship in scientific and applied aspects of hydrology and to foster the involvement of its members in national and international activities.

BHA – British Hydropower Association (<http://www.british-hydro.org/index.html>)

The BHA promotes the hydropower industry in the UK and abroad and aims to increase the awareness of its quality and scope in the wider world. Hydropower is one of the most reliable, predictable and least environmentally intrusive of all renewable energies. The BHA strives to ensure that its potential is realised.

The hydropower sector in the United Kingdom is going through an exciting phase. Government policy to limit carbon emissions has given us the opportunity to develop hydropower projects which previously would have been unviable. Businesses, communities and individuals are now involved and are playing their part in the fight against climate change. In turn this has stimulated interest in the manufacturing and service sectors. There is also a massive overseas market to be addressed. This will only get bigger as the importance of hydropower as a tried and tested renewable energy technology is realised.

The BHA is the only UK trade association which solely addresses the demands of the growing hydropower sector. The expertise we can call upon is the best and most experienced that is available.

CCN – Catchment Change Network (<http://www.catchmentchange.net/about>)

The Catchment Change Network (CCN) is a NERC-funded Knowledge Transfer Network that brings together university scientists with a broad interest in catchment management along with a wide range of practitioners to consider the assessment of future change in catchment systems.

The science of the natural environment is an uncertain science. Practitioners cannot make predictions for real problems without significant uncertainty in representing the processes involved. In catchment management, this inherent uncertainty is exacerbated by the additional complexities of future climate change, societal change and technical innovation. These are difficult to anticipate or quantify and suggest a need for an adaptive approach to management with a science need driven by existing and emerging legislation.

CCN will explore the ways in which the latest scientific methodologies can inform this process in the three Focus Areas of flood risk, water scarcity and diffuse pollution. Network activities will include mapping of future research needs in collaboration with a wide variety of potential users, the development of Guides of Best Practice in each focus area and the development of a range of professional training opportunities across our science user groups.

CIWEM – The Chartered Institution of Water and Environmental Management (www.ciwem.org)

A professional membership organisation providing professional qualifications for engineers, environmentalists and scientists working in the field of water and environmental management, with over 10,000 members.

CIRIA – Construction Industry Research and Information Association

(http://www.ciria.org/service/Home/AM/ContentManagerNet/HomePages/CIRIA_1502_20080929T115140HomePage.aspx?Section=Home)

CIRIA is the construction industry research and information association.

Operating across market sectors and disciplines CIRIA deliver a programme of business improvement services and research activities for our members and those engaged with the delivery and operation of the built environment. CIRIA is an independent member based, not-for-profit association.

CREW – Centre of Expertise for Water (<http://www.crew.ac.uk/>)

CREW is a partnership between the James Hutton Institute and all Scottish Higher Education Institutes which ensures that water research and expertise is available and accessible to the Scottish Government and its agencies, in a timely and effective manner.

EIC – Environmental Industries Commission (<http://www.eic-uk.co.uk/main.cfm>)

The EIC was launched in 1995 to provide environmental technology equipment and services suppliers with a strong and effective voice to influence the debate on the future of the industry among policymakers in Westminster, Whitehall and Brussels. It aims to promote constructive co-operation between the regulated, the regulators and the UK's environmental technology suppliers who serve them. Over 240 companies are members of the EIC and the number is growing rapidly.

Through its innovative Sector Working Groups, the EIC actively promotes a supportive legislative and fiscal framework that emphasises cost effective policies, coherent standards and practical solutions. The EIC facilitates the exchange of information and experience on R&D, market opportunities, funding and training.

ESKTN Environmental Sustainability Knowledge Transfer Network

(<https://connect.innovateuk.org/web/sustainabilityktn>)

KTNs have been set up by the Technology Strategy Board as 'open innovation' networks to drive the flow of knowledge within, in and out of specific communities. KTNs are funded to bring together diverse organisations and provide activities and initiatives that promote the exchange of knowledge and the stimulation of innovation in these communities. The ESKTN's mission is to accelerate the UK's transition to a low carbon, resource and energy efficient economy by connecting businesses, universities, other research organisations and government agencies, and catalysing innovation across a wide range of environmental technologies. Approximately 9000 people are currently members, across businesses, universities, government departments and other agencies, with approximately 25% of these falling into the water sector. Membership is free, and the KTN draws on a wide range of communication methods, including a large web presence (with interactive tools for partner searches, funding searches, research topic identification for Master's level research), meetings of different formats, technical workshops, publications, narrowcasting, social networking in many formats and so on.

FWR – Foundation for Water Research (<http://www.fwr.org/>)

The Foundation for Water Research (FWR) is an independent, membership based charity dedicated to education and information exchange. It is based in Marlow, Buckinghamshire, UK. It was founded in 1989 and its mission is to advance the education of the public in science, engineering and management of water through specialist forums, reviews of current knowledge, publishing and information support.

FBA – Freshwater Biological Association (<http://www.fba.org.uk/>)

The FBA, founded in 1929 and a charity since 1966, aims to promote the study and application of freshwater biology through membership services, research and information dissemination. As a membership organisation FBA work throughout the UK, with activities centred on two sites in Cumbria (Windermere) and Dorset (the River Laboratory). Historically closely associated with academics and professional water resource managers, FBA products and services are nowadays being designed also to appeal to those with a general interest in freshwater biology, including young people and amateur enthusiasts. FBA are regarded as one of the country's foremost providers of information about fresh waters, including identification guides, training courses, scientific meetings and both physical and electronic information holdings. FBA training courses attract as tutors the most highly respected experts in the UK.

FRMRC – Flood Risk Management Research Consortium (<http://www.floodrisk.org.uk/>)

This interdisciplinary research Consortium focuses on some of the more recently identified strategic research investigating the prediction and management of flood risk and is the primary UK academic response to this challenge. The Flood Risk Management Research Consortium (FRMRC) was formed with the express wish at its inception of linking academic and industrial research partners. The principal sponsor is the Engineering and Physical Sciences Research Council (EPSRC) in collaboration with the Environment Agency (EA), the Northern Ireland Rivers Agency (DARDNI), the United Kingdom Water Industry Research (UKWIR) Organisation, the Scottish Government (via SNIFFER), the Welsh Assembly Government (WAG) through the auspices of the Defra/EA and, uniquely, the Office of Public Works (OPW) in the Republic of Ireland.

The academic members of the Consortium currently comprise 16 Universities and in addition, a number of key collaborators (Proudman Oceanographic Laboratory (POL), Meteorological Office, Halcrow, CIRIA, HR Wallingford and UKWIR) are either heavily committed or form part of the Consortium.

HYDRA – Hydrosiences Research Association (<http://www.hydra.uk.net/>)

HYDRA is the **HYD**rosiences **R**esearch **A**ssociation for strategic multi-disciplinary research in water science, policy and management. HYDRA's aim is to help policy makers and managers find solutions to some of the most significant environmental challenges facing society in the next few decades.

Membership comprises the leading UK water science research groups in SE England and is also open to stakeholders and policymakers with interests in water science and management.

ICE – Institute of Civil Engineers (<http://www.ice.org.uk/>)

ICE is a global membership organisation that promotes and advances civil engineering around the world. The purpose of ICE is to qualify professionals engaged in civil engineering, exchange knowledge and best practice, and promote their contribution to society. ICE members help to create the structures and systems that sustain society. They are responsible for designing, building, maintaining and improving bridges, roads, canals, docks, office buildings, hospitals, schools, airports, power stations, railways, flood defences, water-treatment facilities.

IES – The Institution of Environmental Sciences (<http://www.ies-uk.org.uk>) a charitable professional body which promotes and raises public awareness of environmental science by supporting professional scientists and academics. A high proportion of the 2000 members are professionals in the water sector, and are either, or both, Chartered Environmentalists or Chartered Scientists.

IGD – Institute for Grocery Distribution (<http://www.igd.com/index.asp?id=0>)

IGD was formed in 1909 to provide education through information and training in handling products for people who worked in grocery stores. IGD charitable aims have not changed and today the need for education is still there, but it is different.

They now deliver public benefit as a charity by:

- Providing information and practical training that enables people working in the industry to deliver for consumers and to develop personally
- Helping people and the industry make informed choices on diet, health and nutrition
- Driving sustainable improvements in the industry through collaboration and sharing best practice along the supply chain

IWO – Institute for Water (<http://www.instituteofwater.org.uk/>)

As a membership organisation, the ultimate ownership and direction of the Institute of Water resides in the hands of members.

Regional activities are run by Area Committees made up of volunteers drawn from local membership. There are eight areas covering the UK.

The Institute of Water has a small Board of Directors and an Area Forum. The Board are responsible for managing the business, policy implementation and legal compliance. The Area Forum concentrates on sharing best practice whilst retaining the ability to influence overall strategy and policy-making.

ICID – International Commission on Irrigation and Drainage (<http://www.icid.org/>)

The Mission of ICID is to stimulate and promote the development and application of the arts, sciences and techniques of engineering, agriculture, economics, ecological and social sciences in managing water and land resources for irrigation, drainage, flood management and river training applications, including research and development and capacity building for achieving sustainable irrigated agriculture.

ICID has more than half-a-century of experience in the transfer of water management technology and in the handling of related issues. Building on its past experience, accomplishments, and the comprehensive water management framework, ICID strives to promote programs to enhance

sustainable development of irrigated agriculture. ICID has been involved in the global discussions leading to Agenda 21, World Water Vision, World Water Forums etc., which have become the focal point of several of its technical activities.

IAHS – International Association of Hydrological Sciences (<http://www.iahs.info/>)

IAHS aims to promote the study of Hydrology as an aspect of the earth sciences and of water resources;

- to study the hydrological cycle on the Earth and the waters of the continents; the surface and groundwaters, snow and ice, including their physical, chemical and biological processes, their relation to climate and to other physical and geographical factors as well as the interrelations between them;
- to study erosion and sedimentation and their relation to the hydrological cycle;
- to examine the hydrological aspects of the use and management of water resources and their change under the influence of man's activities;
- to provide a firm scientific basis for the optimal utilization of water resources systems, including the transfer of knowledge on planning, engineering, management and economic aspects of applied hydrology.

IAHS also aims to provide for discussion, comparison, and publication of research results and to initiate, facilitate, and coordinate research into, and investigation of, those hydrological problems which require international cooperation.

IWA – International Water Association (<http://www.iwahq.org/1nb/home.html>)

The International Water Association is a global reference point for water professionals, spanning the continuum between research and practice and covering all facets of the water cycle. Through its network of members and experts in research, practice, regulation, industry, consulting and manufacturing, IWA is in a better position than any other organisation to help water professionals create innovative, pragmatic and sustainable solutions to challenging global needs.

N8 Group Water Group – Water Business Development

(<http://www.lec.lancs.ac.uk/cswm/N8/home.php>)

The N8 Water group aims to create more effective business and academic partnerships to explore and exploit new models of science, engineering and technological commercialization. Creating such effective partnerships will help the N8 Group stakeholders address their long-term business and technology needs.

Through strategic engagement with industry, government bodies, regulators and others we are currently focusing on four key themes

- Catchment knowledge and technology integration
- Water cities
- Water for Life
- Water Footprints

NFU - National Farmers Union (<http://www.nfuonline.com/>)

The NFU champions British farming and provides professional representation and services to its Farmer and Grower members. It is the largest farming organisation in the UK, providing a strong, respected and independent voice for the industry.

The Rivers Trust (<http://www.theriverstrust.org/>)

The “Association of River Trusts” for England and Wales was launched in 2001 following extensive consultation with existing charitable rivers trusts and other related interests. The organisation changed its name to "The Rivers Trust" on 2nd August 2011. Rivers trusts now represent catchments across a large part of England and Wales and new ones are continually forming. In addition, a similar movement exists in Scotland, and there is excellent co-operation with the Rivers and Fisheries Trusts of Scotland (RAFTS).

The principles of RT are based on:

- Consent
- Subsidiarity - where RT will serve its members
- Partnership
- Education and technology transfer

The main aims of RT are, to co-ordinate, represent and develop the aims and interests of the member Trusts in the promotion of sustainable, holistic and integrated catchment management and sound environmental practices, recognising the wider economic benefits for local communities and the value of education.

RMS – Royal Meteorological Society (<http://www.rmets.org/>)

The Royal Meteorological Society is the Professional and Learned Society for Weather and Climate.

The Society serves not only those in academia and professional meteorologists, but also those whose work is affected in some way or other by the weather or climate, or simply have a general interest in the weather. The membership includes scientists, practitioners and a broad range of weather enthusiasts.

RMS administer the national qualifications of the profession and under the Royal Charter pursue the purpose of the advancement of meteorological science. As meteorological science has developed it has come to include not just the science of weather and climate itself, but the application of this to disciplines such as agriculture, aviation, hydrology, marine transport and oceanography, as well as the impacts of climate change and the interaction between the atmosphere and the oceans.

SNIFFER – Scotland and Northern Ireland Forum For Environmental Research - provides a service to its members and partners to manage and deliver knowledge relating to the environment and quality of life. Many of the research areas are of relevance to water security.

SWAN – Smart Water Networks Forum (<http://www.swan-forum.com/>)

SWAN - The Smart Water Networks Forum - is a worldwide industry forum promoting the use of data technologies in water networks, making them smarter, more efficient and more sustainable. SWAN brings industry leaders together to create and accelerate awareness and effective use of smart data systems for water networks.

The SWAN forum encourages targeted discussion to:

- Raise awareness for smart water networks
- Create and report upon the methodologies, standard performance indicators, and industry best practices
- Develop new approaches and solutions to improve network operations
- Share members’ experience, case studies and research

- Promote interoperability, synergy and common measurements

SWIG – Sensors in Water Interest Group (<http://www.swig.org.uk/>)

SWIG is a not for profit information, ideas-exchange, and networking group with a diverse UK-wide membership drawn from the water and process industries, sensor manufacturers and their distributors, academic institutions involved in sensor research, regulatory bodies and consultants working in the field of water management.

SWIG promotes the dissemination of information on sensor developments and fosters collaboration through targeted workshops. SWIG offers a cost effective way of maintaining an up to date knowledge of, and dissemination of, information on individual new technologies and/or sensor applications.

SWITCH – (www.switchurbanwater.eu) is a recently concluded major research partnership funded by the European Commission with a budget exceeding €20 million which ran over the period 2006 to 2011. It involved an implementing consortium of 33 partners from 15 countries.

SWITCH involved innovation in the area of sustainable urban water management often also referred to as integrated urban water management (IUWM).

SBWWI – Society of British Water and Wastewater Industries (<http://www.sbwwi.co.uk/>)

The Society of British Water and Wastewater Industries (SBWWI) is an active, not-for-profit, trade association representing the interests of UK manufacturers, contractors, consultants, distributors and others supplying the Water and Wastewater Industry.

Its aims are to develop an effective, consultative and innovative supply chain to the UK water industry and to help members serve the industry better by providing a forum for discussion and the dissemination of information.

ESKTN Environmental Sustainability Knowledge Transfer Network

(<https://connect.innovateuk.org/web/sustainabilityktn>)

KTNs have been set up by the Technology Strategy Board as ‘open innovation’ networks to drive the flow of knowledge within, in and out of specific communities. KTNs are funded to bring together diverse organisations and provide activities and initiatives that promote the exchange of knowledge and the stimulation of innovation in these communities. The ESKTN’s mission is to accelerate the UK’s transition to a low carbon, resource and energy efficient economy by connecting businesses, universities, other research organisations and government agencies, and catalysing innovation across a wide range of environmental technologies. Approximately 9000 people are currently members, across businesses, universities, government departments and other agencies, with approximately 25% of these falling into the water sector. Membership is free, and the KTN draws on a wide range of communication methods, including a large web presence (with interactive tools for partner searches, funding searches, research topic identification for Master’s level research), meetings of different formats, technical workshops, publications, narrowcasting, social networking in many formats and so on.

UK ADAPT Agricultural Diffuse Aquatic Pollution Toolkit (<http://www.uk-adapt.org.uk/>)

UK ADAPT is an initiative of ADAS, UKWIR and Water UK, with the full support of Defra, the EA and Scottish Government.

There is currently considerable activity as the UK starts to implement the Water Framework Directive, including research projects, consultations and numerous other stakeholder initiatives. UK ADAPT believe that now is the time to take stock of the lessons learnt so far about management of catchments to reduce rural aquatic pollution.

UK ADAPT is a resource for researchers and funders to make everyone aware of projects that contribute to our understanding of managing catchments to decrease diffuse pollution from agriculture.

UK GWF – UK Groundwater Forum (<http://www.groundwateruk.org>)

The aims of the UK Groundwater Forum are to: raise awareness of groundwater and the role it plays in supporting the environment and in water supply; Provide information on groundwater, targeted at specific groups such as decision makers, policy makers and schoolchildren; Improve groundwater education in schools by providing educational resources; Promote careers in groundwater-related professions ; Produce and disseminate information and facilitate discussion on topical groundwater issues within the water and environment community; Provide a means for those in the water and environment community to share information.

UKCEED – UK Centre for Economic and Environmental Development (<http://ukceed.org/>)

UK CEED is an independent not for profit charity that promotes and supports eco-innovation and the economic benefits of sound environmental practice. UKCEED support the growth and development of businesses in the cleantech and low carbon and environmental goods & services sectors whose innovative solutions are needed to create an economically and environmentally sustainable future in the UK. UKCEED have an excellent reputation and work with a large number of public and private sector partners from the UK, Europe and around the world.

UKIA – UK Irrigation Association (<http://79.170.40.182/iukdirectory.com/iuk/>)

UK Irrigation Association (UKIA) is the only independent organisation representing irrigation in the UK. UKIA are a voice for irrigation in the debate over the future of UK's water resources; they advocate the wise use of water in agriculture, in amenity and in sports and leisure; and they promote good irrigation design and management practices.

Irrigated agriculture is important in the UK's rural economy. More than 1,000 agri-businesses, large and small, depend on irrigation to supply high quality fresh fruit and vegetables to the nation's supermarkets - arguably one of the most sophisticated markets in the world. Irrigated agriculture employs over 50,000 people and annually contributes over £3bn to the rural economy.

Irrigation is also important in the urban environment - keeping sports turf in peak condition for play and providing high quality amenity and leisure facilities.

But today, irrigation faces new challenges - new regulations, increasing risks of droughts and floods, climate change, public pressures for greater accountability and environmental sustainability. UKIA helps members to meet these challenges.

UKWIR – Chemical Investigation Programme (www.ukwir.org) - Control over a wide range of potential contaminants is an important requirement of the Water Framework Directive. To meet this requirement, the CIP has been designed to investigate the management and control of concentrations of Priority Substances. All of the UK Water and Sewerage Companies are involved in this programme which concludes in 2012. The end result will be a comprehensive understanding of how the priority hazardous substances listed under the WFD daughter directive enter the water environment and how they can be effectively and economically eliminated.

UKWRIF – UK Water Research and Innovation Framework
(<http://www.lwec.org.uk/publications/author/29>)

The Framework is based on recognition that government, research organisations, academia, NGOs and industry working with other users of water need to provide the evidence to support effective decision-making, joined-up policies, and a co-ordinated coherent approach to the development and dissemination of new knowledge, technologies and skills.

Making changes to the way we manage and use water in the future will need a strong and robust evidence base supported by appropriate research and innovation. Collaboration within the UK, with the EU and its member states, and other international stakeholders will help the UK contribute to future global water security.

Urban Futures (www.urban-futures.org) is a four year research project which started in May 2008, funded by the Engineering and Physical Sciences Research Council (EPSRC). The project consortium is led by the University of Birmingham and includes the University of Exeter, Lancaster University, Birmingham City University and Coventry University.

VNN – Valuing Nature Network (<http://www.valuing-nature.net/>)

The Valuing Nature Network was set up to support interdisciplinary partnerships to scope, develop and promote research capacity in the valuation of biodiversity, ecosystem services and natural resources and facilitate the integration of such approaches in policy and practice in the public and private sectors.

Specific aims

- Articulating the challenge of valuing the contribution that the stock of natural capital and the flow of ecosystem services makes to human well-being, and developing meaningful methods of valuation.
- Identifying and developing the underpinning socio-ecological system knowledge that will enable robust monetary and non-monetary valuation to be achieved.

WaPUG – CIWEM's Urban Drainage Group (<http://www.ciwem.org/knowledge-networks/groups/wapug.aspx>)

WaPUG, now CIWEM's Urban Drainage Group, has a long history of promoting best practice in the field of urban drainage. Formed in 1984, it organises technical conferences and specialist workshops that attract delegates from all parts of the urban drainage community and at all levels, from trainees to senior managers.

WaPUG:

- Promotes best practice in sustainable planning, design and management of urban drainage systems
- Influences Government policy on urban flooding and pollution risk
- Provides a forum for discussion and debate on leading issues
- Enables members to socialise, develop their professional skills and share expertise
- Promotes technical excellence through Codes of Practice and technical guides
- Supports CIWEM by lobbying for policy development, responding to consultations, providing policy statements and providing spokespeople

Water UK - (<http://www.water.org.uk/home/about>)

Water UK represents all UK water and wastewater service suppliers at national and European level. The organisation provides a framework for the water industry to engage with government, regulators, stakeholder organisations and the public.

WERH – Welsh Environmental Research Hub (<http://www.werh.org/>)

The overall objective for WERH is to improve collaboration and effectiveness within the environmental science sector in Wales, and promote links to policy-makers so as to support delivery

of the objectives of the Wales Environment Strategy. WERH will assist in the co-ordination of environmental science research in Wales by identifying areas of synergy, helping to strengthen research links and increasing the leverage of research funding into Wales. WERH will provide a focal point for disseminating information on environmental expertise, infrastructure and funding opportunities. It will seek to enhance the performance of the environmental research sector by exploiting the unique coverage of terrestrial, freshwater and marine systems in Wales, and assisting in the development of the nation's pool of environmental scientists and researchers.

WMS –The Water Management Society (<http://www.wmsoc.org.uk/>)

The Water Management Society (WMSoc) has been in existence since 1970

By gathering together expertise from every sector of the industry the WMSoc can offer informed and experienced assistance in all matters relating to the responsible management of water in industry and commerce through publications, conferences and journals.

Members are represented on relevant government and industry Consultation panels and are regularly consulted on matters of immediate concern.

WMSoc members come from a wide of disciplines including water suppliers, scientists, engineers, manufacturers, consultants and facilities managers.

WEF Water – World Economic Forum-Water (<http://www.weforum.org/issues/water>)

The World Economic Forum is an independent international organization committed to improving the state of the world by engaging business, political, academic and other leaders of society to shape global, regional industry agendas.