## Groundwater Dependent Ecosystems
### 27th February 2013, Birmingham and Midland Institute

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>09.30</td>
<td>ARRIVAL &amp; COFFEE</td>
</tr>
<tr>
<td>10.00</td>
<td>INTRODUCTION</td>
</tr>
<tr>
<td>10.10</td>
<td>Invited Speaker - Dr Johan Schutten, SEPA</td>
</tr>
<tr>
<td></td>
<td>Protecting groundwater dependent wetlands from significant damage; recent experience and new threshold values</td>
</tr>
<tr>
<td>10.40</td>
<td>Natalie Phillips, Environment Agency</td>
</tr>
<tr>
<td></td>
<td>Comparison of approaches for assessing WFD significant damage to groundwater dependent wetlands from water quality</td>
</tr>
<tr>
<td>11.00</td>
<td>Dr Sarah Kimberley, Trinity College Dublin</td>
</tr>
<tr>
<td></td>
<td>Determination of nutrient threshold values relevant to groundwater-dependent terrestrial ecosystems (GWDTEs) in Ireland: progress and challenges</td>
</tr>
<tr>
<td>11.20</td>
<td>COFFEE</td>
</tr>
<tr>
<td>11.50</td>
<td>Megan Durrant, Mott MacDonald</td>
</tr>
<tr>
<td></td>
<td>Integrating hydrogeology, hydrology and ecology to assess the impact of abstractions on groundwater dependent ecosystems</td>
</tr>
<tr>
<td>12.10</td>
<td>Gareth Farr, Environment Agency</td>
</tr>
<tr>
<td></td>
<td>Groundwater Dependent Ecosystems in Karst: An Assessment of Pant y Llyn, Wales’ only turlough and comparison to Irish sites</td>
</tr>
<tr>
<td>12.30</td>
<td>Dr Bryan Wheeler, University of Sheffield</td>
</tr>
<tr>
<td></td>
<td>Devils and Details: hydrology and conservation ecology in small, calcareous, groundwater-fed fens</td>
</tr>
<tr>
<td>12.50</td>
<td>Anna Wetherell, Natural England</td>
</tr>
<tr>
<td></td>
<td>Newham Fen NNR, Northumberland – an example of GDE complexities?</td>
</tr>
<tr>
<td>13.10</td>
<td>LUNCH (Hydrogeological Group AGM 13.10 to 13.20)</td>
</tr>
<tr>
<td>14.10</td>
<td>Invited Speaker - Prof Mike Acreman, Centre for Ecology and Hydrology</td>
</tr>
<tr>
<td></td>
<td>Projecting uncertain impacts of climate change on wetlands: a risk-based web tool for England and Wales</td>
</tr>
<tr>
<td>14.40</td>
<td>David Macdonald, British Geological Survey</td>
</tr>
<tr>
<td></td>
<td>Decadal changes in shallow groundwater regime leading to biodiversity loss in a lowland floodplain meadow</td>
</tr>
<tr>
<td>15.00</td>
<td>Dr Ray Flynn, Queen’s University Belfast</td>
</tr>
<tr>
<td></td>
<td>Simulating the impact of regional groundwater changes on raised bog eco-hydrology</td>
</tr>
<tr>
<td>15.20</td>
<td>COFFEE</td>
</tr>
<tr>
<td>15.50</td>
<td>Dr Nick Robins, British Geological Survey</td>
</tr>
<tr>
<td></td>
<td>Coastal dune wetlands in England and Wales: Understanding rainfed groundwater dependent ecosystems to underpin conservation management</td>
</tr>
<tr>
<td>16.10</td>
<td>Rhoswen Leonard, Countryside Council for Wales</td>
</tr>
<tr>
<td></td>
<td>Mega-scale restoration of alkaline and calcareous groundwater-dependent fen communities, Cors Erddreiniog, Anglesey</td>
</tr>
<tr>
<td>16.30</td>
<td>Tim Johns, Environment Agency</td>
</tr>
<tr>
<td></td>
<td>Groundwater: the hidden groundwater dependent ecosystem</td>
</tr>
<tr>
<td>16.50</td>
<td>CLOSE</td>
</tr>
<tr>
<td>POSTERS</td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td></td>
</tr>
<tr>
<td>Refining conceptual and numerical models of groundwater-surface water interactions in areas of complex superficial geology: A case study from the Upper Colne Catchment, Hertfordshire</td>
<td></td>
</tr>
</tbody>
</table>
Matthew Ascott, Affinity Water |
| Waun Fawr - an investigation into high nutrients in a groundwater dependent ecosystem |
Rachel Breen, Environment Agency Wales |
| Integrated groundwater & ecological assessment of abstraction impact on an urban pond & river system in south London |
Ellie Creer¹, Andrew Brooks¹, Heather Williams¹, Cedric Laize², Simon Starling³ and Steve Tuck³ |
¹ AMEC, ² Centre for Ecology and Hydrology, ³ Thames Water Utilities Limited |
| An integrated hydro-ecological approach to the identification of sensitive groundwater dependent terrestrial ecosystems within wind farm Environmental Impact Assessment |
Helen Culshaw and Andrew Halcro-Johnston, Golder Associates (UK) Ltd |
| Calcareous, groundwater-fed fens in England: distribution, ecology and conservation |
Iain Diack¹, Phil Eades², Mark Parnell², Sue Shaw², Ros Tratt², Bryan Wheeler³ |
¹ Natural England, Independent Consultants, University of Sheffield |
| Subterranean biodiversity: ecology of a Chalk aquifer |
Jessica Durkota (PhD student), University College London |
| Rusland Valley mosses restoration: hydrogeology, hydro-ecology and landscape visualisation |
Alex Jones¹, Sam Bishop¹, Steve Rose¹, Nick Allin¹ and Matt Powell² |
¹ JBA Consulting, ² Natural England |
| Groundwater abstraction impact and long-term vegetation community survival in Greywell Fen, Hampshire |
Rob Low¹, Adrian Hutchings², Sue Morris² Helen Harfoot², Emma Goddard³ |
¹ Rigare Ltd, ² Jacobs Engineering Ltd, ³ South East Water |
TALK ABSTRACTS

Protecting groundwater dependent wetlands from significant damage; recent experience and new threshold values

Johan Schutten

Scottish Environmental Protection Agency, Stirling, Scotland

Groundwater dependent terrestrial ecosystems (GWDTEs) are protected from significant damage through the Water Framework Directive. A recent (2012) technical report by the EU Working Group C (Groundwater) has clarified what GWDTEs are and how they need to be considered during River Basin Planning. I will show how the UK developed new nitrate threshold values for GWDTEs on basis of best available scientific knowledge and will share our experience during the first River Basin Planning cycle and highlight areas that need further development.

Water quality threshold values to determine what groundwater concentrations of chemicals

Natalie Phillips¹, Mark Whiteman¹, Andrew Brooks²

¹ Environment Agency, ² Amec

The UK Technical Advisory Group (UKTAG) on the Water Framework Directive has published a working paper on the use of water quality threshold values to determine what groundwater concentrations of chemicals, if exceeded, could be (or actually is) causing damage to a groundwater dependent terrestrial ecosystem (GWDTE). The new approach uses empirically based nitrate trigger values, corresponding to different wetland types and altitudes, which if exceeded in the GWDTE may cause significant damage to the plant communities on the site. This is a significant departure from the previous methodology which grouped phosphate pressure into categories of high, medium and low, based upon relatively arbitrary thresholds and relied upon the UK’s National Vegetation Classification (NVC) to infer the sensitivity of the plant communities to nutrients. This paper compares the results from application of the two approaches for GWDTEs across England and Wales and investigates the implications at the site level using two case studies.
Determination of nutrient threshold values relevant to groundwater-dependent terrestrial ecosystems (GWDTEs) in Ireland: progress and challenges

S Kimberley¹, C Coxon¹, M Craig² and J Schutten³
¹ School of Natural Sciences, Trinity College Dublin
² Environmental Protection Agency, Richview, Dublin
³ Scottish Environmental Protection Agency, Stirling

Groundwater-dependent terrestrial ecosystems (GWDTEs) are wetlands that depend directly on groundwater contributions. The EU Water Framework Directive (2000/60/EC) requires assessment of the effects of groundwater pressures on GWDTEs as part of groundwater body (GWB) classification. Groundwater chemical threshold values (TVs) are a component of chemical status assessment and are concentrations of nitrate and/or phosphate within a groundwater body that when exceeded in conjunction with evidence of significant damage to a wetland triggers further site investigation. In Ireland, there are currently no proposed threshold values for GWDTEs and this paper focuses on on-going attempts to determine chemical threshold values for calcareous fens in Ireland. An approach developed by the UK Technical Advisory Group on the WFD to determine threshold values was applied to Irish calcareous fens. This approach involved establishing hydrogeological connections between calcareous fens and the drinking water and groundwater quality monitoring network. A lack of reliable information on the ecological condition of sites prevented the further step of grouping fens into ‘good’ and ‘poor’ ecological condition categories in order to examine the associated ranges of groundwater nutrients. Recently completed basic surveys of 44 fens with hydrogeologically connected groundwater monitoring points provide information on the dominant water inputs and the presence and extent of Annex I habitat types under the Habitats Directive.

Integrating hydrogeology, hydrology and ecology to assess the impact of abstractions on groundwater dependent ecosystems

Megan Durrant¹, Celia Figueira¹, Simon Starling², Jamie Riches² and Steve Tuck²
¹ Mott MacDonald, Demeter House, Station Road, Cambridge
² Thames Water Utilities Limited, Clearwater Court, Vastern Road, Reading

As part of the National Environmental Programme, investigations have been carried out into the impacts of Thames Water groundwater abstractions on the River Wye and Letcombe Brook in the Chalk of the Berkshire Downs and south west Chilterns.

A summary is presented of the analyses carried out to establish any potential impacts on the stream ecology, particularly macroinvertebrate and fish populations. In order to assess the magnitude and significance of these impacts, the investigations looked at mesohabitats, macroinvertebrate and fish data. A microscale assessment on the changes in water velocity and water depth imposed by abstraction and its relation with fish species’ habitat requirements was carried out to estimate the potential for abstraction to impact fish populations present in the stream. To integrate these assessments, conceptual hydrogeological models were developed to enable an evaluation of a range of abstraction scenarios and consequential impacts on river flows.

A critical review of the constraints of the methods employed is also presented, with proposed changes to the field methods to enable a more efficient integration of ecological and hydrological data.
Groundwater Dependent Ecosystems in Karst: An Assessment of Pant y Llyn, Wales’ only turlough and comparison to Irish sites

Gareth Farr¹, Owen Naughton², Tristan Hatton-Ellis³, and Jamie Bevan⁴

¹ Environment Agency, Ty Cambria, 29 Newport Road, Cardiff
² Department of Civil, Structural and Environmental Engineering, University of Dublin Trinity College
³ Countryside Council for Wales, Maes-y-Ffynnon, FforddPenrhos, Bangor, Gwynedd
⁴ Countryside Council for Wales, MaesNewydd, Llandarcy, Neath

Turloughs are ephemeral karst lakes resulting from high rainfall and, accordingly, high groundwater levels in topographic depressions in karstified limestone terrain. The ephemeral nature of turlough hydrology gives rise to a characteristic ecology as such turloughs have been designated as a Priority Habitat in the EU Habitats Directive (92/43/EEC). While there are recorded turloughs in the Republic of Ireland Pant-y Llyn is Wales’ and mainland Britain’s only recorded turlough; it is a key feature of Cernydd Carmel SSSI and SAC.

A collaborative investigation was carried out between Environment Agency Wales and Countryside Council for Wales (soon to be Natural Resources Wales). The main aims of this investigation were to:

- Improve the hydrogeological conceptual understanding.
- Review the water chemistry of Pant-y-Llyn and the surrounding groundwater.
- Compare the hydrology of Pant-y-Llyn with that of recorded Irish turloughs.
- Use existing data back model the turlough hydrograph.
- Provide evidence to confirm its status for the Habitats Directive.

The investigation has shown that Pant y Llyn has both a water quality and hydrological cycle. For the first time comparisons with Irish turloughs allow us to put Pant y Llyn into a wider turlough typology.

---

Devils and Details: hydrology and conservation ecology in small, calcareous, groundwater-fed fens

Bryan D. Wheeler

Department of Animal & Plant Sciences, University of Sheffield

An examination will be made of some difficulties inherent in relating the hydrogeology of small, calcareous, groundwater-fed fens to the occurrence and conservation of patches of internationally important mire vegetation. Particular attention will be given to some examples from East Anglia and to the relevance of patchiness and appropriate scale in investigations.
Newham Fen NNR, Northumberland – an example of GDE complexities?

Anna Wetherell, Senior Specialist - Hydrology & Hydrogeology, Natural England

GDEs are often complex features set in wider wetland landscapes, with multiple factors to be taken into account when trying to characterise them, manage them, or assign any impacts back to the associated groundwater body. Often the groundwater related interest only forms one part of the system.

Newham Fen NNR is one such example of a GDE. The NNR contains an alkaline fen, a classic groundwater fed habitat, set in the wider Embletons Bog which contains agricultural land which floods regularly, despite multiple attempts to drain it over the years. However, while research has been carried out on the site over the last 20 years, there are still questions about what the key groundwater source for the fen might be. Recent datalogger data has allowed water level responses to hydrological events to be analysed in more detail, and highlights the very different characteristics of the groundwater fed parts of the site compared with precipitation / surface water dominated areas. Combined with geological and vegetation data, more detailed characterisation of the site has become possible, providing an example of the analysis this type of site often requires.

Projecting uncertain impacts of climate change on wetlands: a risk-based web tool for England and Wales

M.C. Acreman, J. R. Blake
Centre for Ecology and Hydrology, Wallingford, Oxon

The UK climate is projected to continue changing over coming decades. Estimates produced in 2002 predicted wetter winters and drier summers, with the greatest changes in the south and east where, in summer, soils are likely to become drier for longer (UK Climate Impacts Programme, UKCIP02). These projections have been updated (UKCP09) and although the general pattern of change is broadly similar, the projections are now probabilistic in nature, allowing climate change impact uncertainty to be evaluated. Such changes will have significant implications for wetlands, which require periodic saturation or inundation. Changes to the hydrological regime of wetlands are likely to impact on the ecosystems services they provide including flood management, water quality improvement, provision of wildlife habitats and carbon sequestration. Future management, restoration and adaptation of wetlands, particularly delivery of the Wetland Vision in England, will thus require tools to help understand the potential impacts of climate change so that appropriate adaptation plans can be developed.

We have developed an open-access, web-based tool that quantifies the potential impacts of climate change on wetland hydro-ecology at the regional scale. The conceptual framework for the tool includes regional differences in climate change and different water supply mechanisms to wetlands (i.e. rain-fed, river-fed and groundwater-fed). New improved reduced-complexity models for these three end-member mechanisms have been developed that balance sufficient process representation with simplicity to make them fit for purpose. The models are computationally efficiency, enabling assessment of the 10,000 possible climate realisations available for each of the twelve Water Framework Directive river basin regions of England and Wales for the selected climate change time period and emissions scenario. For groundwater-fed wetlands, the new model is driven by projected groundwater levels produced by the Future Flows project. Results are presented in a risk-based framework and provide wetland managers, consultants and researchers with an initial assessment of the probable impacts of climate change on a
variety of interest features including wetland water levels, plant communities, birds and the historic environment.

Decadal changes in shallow groundwater regime leading to biodiversity loss in a lowland floodplain meadow

David Macdonald¹, Ann Williams¹, Majdi Mansour¹, Andy Dixon², David Gowing³, Irina Tatarenko³, Paul Morris⁴, Anne Verhoef⁵

¹ British Geological Survey, Groundwater Science Programme
² Groundwater Monitoring and Drilling Ltd
³ Open University, Department of Environment, Earth & Ecosystems
⁴ University of Reading, Department of Geography and Environmental Science

Floodplain meadows are dependent on hydrological conditions characterised by regular fluvial flooding and shallow groundwater. The area occupied by these meadows within the UK has decreased significantly since the early 20th Century, primarily due to intensified agriculture. Although much of this habitat is now protected, threats remain due to changing land use, climate and river management.

A case study site from the River Thames floodplain in the Oxford Meadows Special Area of Conservation is used to examine the range of factors affecting the hydrological regime and in turn the meadows’ plant communities. The site is well characterised as a result of surveying and monitoring required by the environmental regulators to assess the impact of gravel extraction which began in the locality in the late 1980s and through the dedication of local botanists. Water-level monitoring has shown an overall decrease in the depth to groundwater over the past three decades, and botanical surveys show a trend towards meadow plant species that prefer wetter conditions. Model simulations have been used to assess the potential underlying causes of this trend including; the sealing of the nearby gravel pits which reduces the volume of gravel through which the groundwater can flow; an increasing trend in summer rainfall coinciding with the period of gravel extraction; and a lack of maintenance of the drainage system. Environmental management implications are considered, which have broad applicability to floodplain meadow sites.
Simulating the impact of regional groundwater changes on raised bog eco-hydrology

Raymond Flynn\textsuperscript{1} and Shane Regan\textsuperscript{2}

\textsuperscript{1} School of Planning, Architecture and Civil Engineering, The Queen’s University of Belfast
\textsuperscript{2} School of Civil Engineering, Trinity College Dublin, College Green, Dublin

A conventional geotechnical view of Irish raised bogs considers them as sequences of compressible peat underlain by low permeability deposits. Consequently, the effects of changes in groundwater head in underlying units are considered to have a negligible effect on peatland ecohydrology, with the impact of drainage assumed to be restricted to peat. A widely-used rule-of-thumb assumes the effects of marginal drainage to extend less than 15m into uncut peatland. Work completed in Clara Bog, Co. Offaly (Clara), where widespread differential subsidence has occurred over large areas during the past 20 years, challenges this view.

A programme of coring on the south western side of Clara has revealed layers of calcareous sand and till/clay underlying the peat to form a northerly sloping substrate, while electrical conductivity measurements, coupled with piezometric data, suggest mineralised groundwater discharges from the peat substrate to marginal drains. Bog topographical simulations, generated using a one dimensional groundwater flow model, coupled to peat compressibility, indicate that substrate geometry plays an important role in determining the subsidence-related topography. Moreover, the model explains the recent development of lakes on the bog, explaining the paradox that marginal drainage can make some areas of the bog wetter.
Coastal dune wetlands in England and Wales: Understanding rainfed groundwater dependent ecosystems to underpin conservation management

N.S. Robins\textsuperscript{1} and C.J. Stratford\textsuperscript{2}

\textsuperscript{1} British Geological Survey, Wallingford, Oxon
\textsuperscript{2} Centre for Ecology and Hydrology, Wallingford, Oxon

Coastal dune wetlands are fragile ecological pockets that sit within larger and often very dynamic dune systems. The hydrological regime within the wetland, and in turn the flora and fauna that inhabit it, is influenced by combinations of natural and anthropogenic processes occurring throughout the dune system. A conceptual understanding of the processes controlling the hydrological regime both now and in the future is fundamental in underpinning effective conservation management at these sites. Management issues include felling tree plantations to revert to natural warren, mobilisation of dunes by vegetation control, scraping the upper organic layers in slack floors and grazing. However, conservation management also has to cope with coastal erosion and accretion which impact groundwater base levels, change in rainfall and other natural and sometimes overriding impacts. A number of initiatives are being carried out collaboratively between BGS, CEH and University of Southampton, Natural England, Sefton Council, Countryside Council for Wales and University of Groningen. These include predictive modelling of climate change scenarios at Ainsdale in Lancashire, quantitative analysis of change, groundwater flow modelling (Zoom), water profile monitoring and analysis (MIKE SHE) in the unsaturated zone in dune slacks at both Braunton Burrows in Devon and Whiteford Burrows on Gower, physical property, chemical and isotope profiling beneath high dunes in the unsaturated zone at Braunton Burrows, salinity monitoring of an embryo slack at Whiteford Burrows and high frequency water level monitoring at Braunton, Whiteford, Ainsdale, Newborough Warren in Anglesey and Sandscale in Furness. These investigations are carried out alongside detailed vegetation survey monitoring which has also required conceptual groundwater flow models to be developed at three additional east coast UK sites.
Cae Gwyn, the ‘White Field’, is located on the eastern flank of Cors Erddreiniog, a large rich-fen site on Anglesey. Before restoration a large proportion of the site was dry, with a 20-40 cm covering of mineral soil, of undetermined origin, over extensive peat and white marl deposits. The latter suggested that the site had been a location of active groundwater discharge (from the Carboniferous Limestone) and peat formation prior to extensive drainage, re-routing of spring discharge and agricultural improvement.

Under the ‘Restoration of Anglesey and Llŷn Fens’ EU-LIFE project, during early 2012, a peat and marl surface was exposed by removal of an average of 350 mm of topsoil over the 4.5 ha site; 20,000 m$^3$ of material was excavated and hauled from the site over a 12 week period. Springflows from the Carboniferous Limestone were re-routed to the upslope margin of the site, via a reedbed which is designed to reduce the high nitrate content of the incoming water. Water table drawdown within the site, by an adjacent deep ditch, has also been significantly reduced by installation of a plastic sheet-pile curtain.

The revised profile and hydrological functioning of the site was carefully designed, through consideration of the small-scale hydrogeology of the site, referring to the WETMECs scheme, to foster the complex hydrological supporting conditions for alkaline and calcareous fen communities. There are very encouraging signs that this restoration project, which is amongst the largest nature restoration projects attempted in the UK, will be successful in restoring a significant area of rare groundwater-dependent alkaline and calcareous fen communities to this area of Cors Erddreiniog.
Groundwater: the hidden groundwater dependent ecosystem

Tim Johns\(^1\), Lou Maurice\(^2\), Anne Robertson\(^3\), Lee Knight\(^5\), Debbie Allen\(^2\), James Sorensen\(^2\), Damiano Weitowitz\(^4\), Gareth Farr\(^1\)

\(^1\) Environment Agency
\(^2\) British Geological Survey
\(^3\) Roehampton University
\(^4\) British Geological Survey / Roehampton University
\(^5\) Hypogean Crustacea Recording Scheme

Britain’s aquifers support a range of microbial and invertebrate fauna, many of which are only found in groundwater. They provide a unique and important contribution to biodiversity, and help in the delivery of ecosystem services. Invertebrates only found in groundwater are called stygobites, the majority being small crustaceans, adapted to survive in the subsurface where there is no light and limited resources. There are eight stygobitic macro-invertebrate species known from England and Wales, one Niphargus glenniei being endemic to Devon and Cornwall. However, the spatial distributions and ecological function of our groundwater fauna remains poorly understood. Recent British studies aimed at improving this knowledge include: (1) investigating stygobites presence in different geological and chemical environments in southwest England. (2) Investigating regional variability in Chalk groundwater ecosystems and packer testing studies of groundwater fauna at different depths. (3) Genetic investigations into the different stygobitic Crustacea. These studies show that although Britain has a relatively low diversity of groundwater fauna, compared to other parts of the world, those present occur relatively frequently and in a range of geological environments. The presentation will introduce groundwater ecosystems, present results of recent studies, and discuss the importance of this hidden, often overlooked groundwater dependent ecosystem.
POSTER ABSTRACTS

Refining conceptual and numerical models of groundwater-surface water interactions in areas of complex superficial geology: A case study from the Upper Colne Catchment, Hertfordshire

Matthew Ascott, Affinity Water

The Upper Colne River is considered to be potentially at risk from groundwater abstractions from the chalk. 3D geological modelling and slug testing were used to further characterise the extent and hydraulic properties of superficial deposits overlying the chalk. Based on this work, the groundwater model domain was redeveloped at a small scale, giving an improved representation of physical hydrogeological processes. Model development, sensitivity analyses and naturalised model runs have been used for hypothesis testing which has furthered the conceptual understanding of the hydrogeology of the area. The study has shown the chalk to be overlain by a laterally extensive and continuous boulder clay which is overlain by a shallow gravel aquifer. Whilst abstraction from the chalk does not directly impact the river, changes in leakage across the boulder clay has the potential to affect baseflow contributions to the river from the gravels. It is hoped that the revised conceptual model of groundwater-surface water interactions will lead to more hydrogeologically defensible abstraction management. Adoption of a similar methodology may be useful when considering conceptual models and possible abstraction impacts on other groundwater dependent ecosystems.

Waun Fawr- an investigation into high nutrients in a groundwater dependent ecosystem

Rachel Breen, Environment Agency Wales

Waun Fawr is a groundwater dependent ecosystem made up of dry wet heath and marshy grassland and is a designated SAC and SSSI. It has been identified as being in unfavourable condition due to nutrient enrichment from both diffuse and point source pollution.

A failing septic tank on the southern boundary of the wetland resulted in sewage effluent seeping through the site. Improvements to the tank have been completed however it has left behind an area of enriched vegetation. Investigations have been undertaken to determine the extent of this enrichment and with the co-operation of EAW, CCW and National Trust it is due to be removed in the coming weeks.

The springs entering the site from the south have been consistently found to be high in nitrates. In order to determine the source stable isotopic measurements of dissolved nitrate and oxygen were undertaken. The results of this analysis showed that the nitrogen is mainly derived from soil organic nitrogen originally from inorganic fertiliser inputs. This coincides with the landuse surrounding the site which is predominantly agricultural.

It is proposed to visit the farms in the area and to try and identify any obvious sources of these nitrates and to encourage the farmers to adopt Nutrient Management Plans.
Integrated groundwater & ecological assessment of abstraction impact on an urban pond & river system in south London

Ellie Creer\textsuperscript{1}, Andrew Brooks\textsuperscript{1}, Heather Williams\textsuperscript{1}, Cedric Laize\textsuperscript{2}, Simon Starling\textsuperscript{3} and Steve Tuck\textsuperscript{3}

\textsuperscript{1}AMEC, \textsuperscript{2}Centre for Ecology and Hydrology, \textsuperscript{3}Thames Water Utilities Limited

Thames Water has completed a Low Flow Investigation of the Upper River Wandle and Waddon Ponds, Croydon, as part of the Environment Agency’s National Environment Programme, to assess the potential environmental impacts from licensed groundwater abstractions.

Observation data from boreholes close to the river and spot flow measurements have revealed subtle changes in local groundwater level conditions and river flows as a result of groundwater abstraction. Signal test analysis has also helped to update the conceptual understanding of catchment behaviour, highlighting the importance of preferential flow paths within the Chalk aquifer.

Assessment has been undertaken of the relationships between flows and the in-channel plants and invertebrates. Additionally, the influence of channel modification relative to the influence of flows on the invertebrate communities has been assessed using the DRIED-UP methodology. Results suggest that improvements in river habitat may produce greater improvements in ecological status than reductions in groundwater abstraction alone.

The investigation has highlighted the importance of combining both hydrological and ecological methods to assess the most cost effective way to improve river health. In this example, not taking the effects of channel modification into account may result in overly conservative reductions of groundwater abstraction being recommended.

An integrated hydro-ecological approach to the identification of sensitive groundwater dependent terrestrial ecosystems within wind farm Environmental Impact Assessment

Helen Culshaw and Andrew Halcro-Johnston, Golder Associates (UK) Ltd

The identification of groundwater dependent terrestrial ecosystems that may be affected by wind farm developments requires close collaboration between ecologists and hydrogeologists involved in the planning application Environmental Impact Assessment process. An integrated hydro-ecological approach to the identification of these sensitive systems has recently been made for a proposed site in Scotland to allow direct or indirect impacts to be avoided by design, or appropriate mitigation measures considered.

The National Vegetation Classification system is used to identify and map wetland vegetation communities in order to ecologically assess whether they are likely to be potentially groundwater dependent ecosystems. Wetland ecosystems lie on a continuum between being purely groundwater dependent and being purely surface water runoff dependent. A hydrogeomorphic classification is used to identify the degree of dependence that the wetland ecosystem is likely to have to groundwater. This classification is based on the nature of the superficial and bedrock geology at the site. A matrix, which combines the results of the ecological and hydrogeomorphic classifications, is applied to identify the potential sensitivity of the ecosystems to the proposed development. Where sensitive ecosystems are identified, mitigation measures may be required to protect the quality and quantity of groundwater reaching the area.
Calcereous, groundwater-fed fens in England: distribution, ecology and conservation

Iain Diack\textsuperscript{1}, Phil Eades\textsuperscript{2}, Mark Parnell\textsuperscript{2}, Sue Shaw\textsuperscript{2}, Ros Tratt\textsuperscript{2}, Bryan Wheeler\textsuperscript{3}

\textsuperscript{1} Natural England
\textsuperscript{2} Independent Consultants
\textsuperscript{3} University of Sheffield

Calcereous, groundwater-fed fens support distinctive, often species-rich plant communities. Several of these plant communities are of international importance and are included within the European Union Habitats Directive Annex 1 habitat ‘Alkaline Fen’. Many rare species (vascular plants, bryophytes and invertebrates) are particularly characteristic of, or confined to, this habitat. In 2012 Natural England commissioned a GIS Inventory of Annex 1 ‘Alkaline Fen’ habitat patches in England, based on existing datasets. Using this GIS Inventory, the distribution of calcereous, groundwater-fed fens in England is presented in relation to bedrock, and the ecology and conservation importance of key sites is described using case-studies from different regions.

Subterranean biodiversity: ecology of a Chalk aquifer

Jessica Durkota (PhD student), University College London

Groundwater is recognised as an internationally important resource for public water supply, agriculture and industry, but it also plays an essential role in the functioning of lotic ecosystems. Despite supporting a number of cryptic and endemic species, groundwater habitats have received relatively little research attention and are rarely included in freshwater monitoring programmes. This study assesses the distribution of invertebrates against environmental gradients of water quality and flow in benthic, hyporheic and phreatic habitats throughout a lowland chalk aquifer in southern England. Surveying twelve sites over four years, these habitats were found to support a range of both epigean and hypogean fauna, recording over one-hundred invertebrate species (including a previously undescribed amphipod). The results of this study suggest that benthic, hyporheic and phreatic invertebrate assemblages respond differently to changes in environmental parameters, suggesting that all three should be assessed to determine lotic ecosystem status. A greater understanding of the distribution and requirements of fauna inhabiting groundwater habitats is essential for the conservation of this community and the improvement of lotic monitoring programmes.
Rusland Valley mosses restoration: hydrogeology, hydro-ecology and landscape visualisation

Alex Jones¹, Sam Bishop¹, Steve Rose¹, Nick Allin¹ and Matt Powell²
¹ JBA Consulting, ² Natural England

Rusland Valley Mosses SSSI, South Cumbria, is a raised mire system with three distinct domes. The mire has been damaged by peat cutting and drainage activities in the past, and by the gradual encroachment of non-mire vegetation, including scrub and woodland. Natural England is committed to restoring the site to an intact, fully-functioning, peat bog.

JBA has been working with Natural England to develop a detailed conceptual understanding of the Mosses and to explore options for their restoration. The work has included detailed topographic analysis (using a DTM), vegetation mapping and the installation of a network of automatic water level monitoring devices in ditches and shallow boreholes. A wetness index (based mainly on vegetation and topographic features) has been developed and tested using the water level monitoring data. This index has proved to be a useful tool for identifying those areas on the site that require restoration.

One of the main challenges facing Natural England is the need to positively engage with local stakeholders to explain the need for restoration measures such as ditch blocking and tree felling. Clearly presented water level monitoring data and landscape visualisations will play a vital role in communicating the conservation issues and restoration proposals.

Groundwater abstraction impact and long-term vegetation community survival in Greywell Fen, Hampshire

Rob Low¹, Adrian Hutchings², Sue Morris², Helen Harfoot², Emma Goddard³
¹ Rigare Ltd, ² Jacobs Engineering Ltd, ³ South East Water

Greywell Fen (Odiham, Hampshire) is an elongate valley bottom fen which supports vegetation communities dependent on base-rich groundwater discharge from the underlying Chalk aquifer, most notably NVC M9b Carex diandra-Calliergon giganteum. The site has a long history of nature conservation having been included in Rothschild’s list of the 283 most important conservation sites in the UK in 1913.

The fen is split into northern and southern areas by higher ground on which is located South East Water’s Greywell pumping station which has abstracted Chalk groundwater at a rate of 6-7 ML/d since the early 1900s. The abstraction was included in the National Environment Programme to determine whether it was detrimental to the environment.

A 20-day abstraction shut-down test was undertaken during summer 2012 to assess the impact of the abstraction on fen hydrology. Prior to the test, the fen water table was c. 200-600 mm below ground level within a radius of around 200 m of the pumping station. After shut-down the water table rose extensively to and above the ground surface, a hydrological condition which is known to be favourable to the M9b community. It is therefore apparent that the abstraction has a critical effect on the conservation status of the fen, and moves are in hand to mitigate this effect. More interestingly, from an eco-hydrological viewpoint, it is clear that M9b and other wetland interest feature communities have survived under significantly sub-optimal hydrological conditions for around a century. This highlights the danger of assuming that the presence of a particular wetland vegetation community indicates the presence of favourable hydro-environmental supporting conditions for that community.