



## Managed Aquifer Recharge and AGM of the Hydrogeological Group

Burlington House, April 19<sup>th</sup> 2010

The meeting covered the current status and potential of Managed Aquifer Recharge schemes for groundwater management.

### Programme

- 13:00 Registration  
13.55 Introduction by Chair of first session: *Willy Burgess, UCL*  
14.00-14.25 Managed aquifer recharge for public supply in London: Operation & Development Potential *Mike Jones, TWUL*  
14.25-14.50 Aquifer Storage & Recovery – Wessex experiences  
*Paul Stanfield, Wessex Water*  
14.50-15.15 Managed Aquifer Recharge in Ground-sourced heating and cooling systems  
*David Birks, Parsons Brinckerhoff*

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- 15.15 Tea and **AGM of the Hydrogeological Group of the Geological Society**  
*Willy Burgess, UCL, Hydrogeological Group Chair*
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Chair of second session: *Sarah Beeson, Mott-Macdonald*

- 16.00-16.25 Managed Aquifer Recharge in rural India – how effective is the technique?  
*Ian Gale, BGS*  
16.25-16.50 ASR in the Sherwood Sandstone – Robbing the rich, windmills and floods  
*Mark Morton, Yorkshire Water*  
16.50-17.15 Proposed ASR Schemes in Birmingham  
*Matilda Beatty and Richard Winstanley, Severn Trent*  
17.15 Discussion  
17.30 Close; drinks reception

Convenors: William Burgess [william.burgess@ucl.ac.uk](mailto:william.burgess@ucl.ac.uk)  
Sarah Beeson [sarah.beeson@mottmac.com](mailto:sarah.beeson@mottmac.com)



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### Abstracts

#### **Managed Aquifer Recharge for Public Supply in London: Operation & Development Potential** *Mike Jones, Water Process & Network Modelling Manager, Thames Water*

Thames Water has a long history of artificial recharge and has operated the North London Artificial Recharge Scheme (NLARS) for public supply since 1995. NLARS abstraction from the confined Chalk enhances supply capability during drought. Its operation and benefits will be compared with the potential for a similar scheme, SLARS, in the Chalk of south London. In both of these schemes, artificial recharge assists in maintaining catchment water balances and they may be described as ASTR (Aquifer Storage, Transfer and Recovery) schemes. In contrast, Thames Water is also exploring the potential for Aquifer Storage and Recovery (ASR) in the confined Lower Greensand of north Kent. For all three cases, annual average demand is the supply-demand driver for public supply, and this provides the context for operation and development of environmentally and economically efficient MAR.

#### **Aquifer Storage and Recovery – The Wessex Experiences** *Paul Stanfield, Wessex Water*

In the 1990s, Wessex Water carried out Aquifer Storage and Recovery (ASR) trials in the confined Chalk aquifer of the Wareham Basin, South Dorset. The native groundwater was essentially potable, however elevated fluoride and iron levels would have made blending or treatment obligatory. This factor combined with low natural recharge rates indicated that the development of a significant, sustainable, conventional abstraction was not feasible. The ASR trials proved successful in terms of hydraulic performance of the borehole and aquifer under injection and abstraction, yield and storage potential and environmental sustainability. However, although successive cycles of injection and recovery halved fluoride levels, this parameter remained above pcv levels in the recovered water. This feature was almost certainly due to the dual porosity of the Chalk. Modelling work by Birmingham University and CH2MHill indicated that the confined Chalk aquifer has a huge storage potential and still, but for the fluoride, represents a significant water resource. The initial driver for the investigation of the confined Chalk was an attempt to solve a low flow problem by finding an alternative source to a large unconfined Chalk abstraction. The driver changed to investigate the efficacy of ASR to deliver significant new resource potential. In line with many aspects of the UK water industry the driver has changed again; from quantity to quality because one issue the investigations have demonstrated again and again is that the confined Chalk is a significant source of very low nitrate groundwater.

## **Managed aquifer recharge in ground-sourced heating and cooling systems**

**David Birks, Parsons Brinckerhof, and David Whitaker, Arup**

Legislation and corporate sustainability objectives have encouraged the adoption of ground-sourced heating and cooling (GSHC) as a low-carbon technology for buildings and associated infrastructure. This paper examines recent testing and operation of four large “open-loop” GSHC systems in London (Royal Festival Hall, Tate Modern Art Gallery & sites in Knightsbridge and on the Greenwich Peninsula). In each system groundwater is used for building heating and/or cooling before subsequent disposal by Managed Aquifer Recharge (MAR). Injection rates are comparable with public water supply, ranging from 1Ml/day to 3Ml/day. The chosen sites include the confined Chalk aquifer and the unconfined River Terrace Gravels (RTG) aquifer.

This paper draws on the collective experience of Parsons Brinckerhoff and Arup and discusses key findings from design, construction, operation and maintenance. In all examples there were particular challenges associated with the injection of groundwater back into the originating aquifers and the experience gained may provide helpful insights into the design and operation of other MAR schemes.

In the three GSHC systems installed in the Chalk, testing and subsequent operation confirmed that injection of groundwater under gravity into confined Chalk was possible without undue complication. Tracer testing indicated a surprising level of consistency in groundwater travel times under induced hydraulic gradients. At the Royal Festival Hall dye tracing between injection and extraction borehole indicated rapid fissure flow with peak breakthrough in 14 hours (Clarkson et al 2009). At the Tate Modern, testing confirmed injection rates up to 35 L/sec in single large diameter bores installed in the RTG.

The economics of MAR v surface disposal methods will be discussed as will be the preferential use of MAR in over-exploited aquifers where consumptive abstractions might not be sustainable. Conclusions are made in respect of the continuing viability for both MAR and GSHC at the chosen sites.

### References:

M.H. Clarkson, D. Birks, P.L. Younger, A. Carter and S. Cone. (2009). Groundwater cooling at the Royal Festival Hall, London. *Quarterly Journal of Engineering Geology and Hydrogeology* 2009; v. 42; p. 335-346

## **Managed Aquifer Recharge in rural India – how effective is the technique?**

**Ian GALE, British Geological Survey, Wallingford, Oxon. OX10 8BB. UK**

The construction of myriad aquifer recharge check dams and other interventions to harvest rainwater in rural India is successful in capturing the majority of available runoff, but this is not sufficient to replenish depleted aquifers in many areas without reduction of groundwater abstraction. Different hydro-meteorological and geological environments were selected and the results were interpreted in the context of the quantity of natural recharge in the watershed, availability of water and storage capacity in the aquifer, as well as likely downstream impacts. Natural recharge to the aquifers studied was estimated to be between 40 and 120 mm, to which recharge structures contributed an additional 5 to 12 mm equivalent volume, concentrated around the structures. This is a significant increase but only represents about 1% of rainfall in the semi-arid areas, the majority satisfying the soil moisture deficit and evapotranspiration. The density of recharge structures in the areas studied captured all available water from flowing out of the watershed and successfully augmented groundwater resources locally.

### **ASR in the Sherwood Sandstone – Robbing the rich, windmills and floods.**

*Mark Morton, Senior Hydrogeologist, Yorkshire Water*

Yorkshire water have developed an ASR scheme on the eastern side of the Vale of York. The scheme comprises a single borehole used to inject and then abstract a 'bubble' of treated water in the Sherwood Sandstone Permo-Triassic aquifer. The aquifer is confined by a thick layer of boulder clay drift that reduces recharge and gas exchange. The result is poor natural water quality making the groundwater unsuitable for water supply. The water source for injection is the River Derwent which passes through the site. Excess water is abstracted in the winter and used from the ASR to augment supplies in the summer. The site is therefore ideal in many ways for ASR.

Operation of the scheme started with a number of conditioning cycles with improving water quality. The last cycle however experience problems of ground heave and flooding of a chamber. The cause of these occurrences is not clear.

Significant changes to the site may have caused the problems. New filters were constructed recently changing ground loading. Two wind turbines were constructed with piled foundations that might have created pathways to the aquifer through the drift.

We are now starting to plan for further tests to establish if the ground movement and flooding are caused by the ASR or due to other factors. The tests will look at ground movement using a number of techniques, monitoring of drift and aquifer water levels and abstracted water quality.

### **Proposed ASR Schemes in Birmingham**

*Matilda Beatty and Richard Winstanley, Severn Trent Water*

*with contributions from Gerd Cachandt (Arup) and Mike Streetly (ESI)*

STWL's investment strategy for ensuring supply resilience to Birmingham includes the construction of two new ASR schemes which will provide a combined output of 30Ml/d.

STWL instigated a screening study to identify potential locations for ASR schemes within the STWL region. This was to identify potential sites that could assist peak demands, provide contingency in the event of major asset failure and/or provide resource in drought periods. This review was undertaken by Arup/ESI, who developed a short-list of favourable potential sites/schemes within the confined Sherwood Sandstone. This took into account a number of factors, including both hydrogeological and infrastructure considerations.

Following on from this work, STWL designed two schemes, each to provide 15Ml/d sites in the confined Birmingham aquifer. These will provide short term contingency supplies in the event of the failure of a major surface water source/ treatment works. Both these schemes have the potential to provide new water resource flexibility during longer dry periods; this will require longer injection cycles (5 year rolling licences) and more complex conjunctive use arrangements. Recharge water is to be provided from existing spare production capacity that is available during wet years from our works on the River Severn and/or our impounding reservoirs in Wales.

Further feasibility work will be undertaken in the 2010-15 period and the schemes are scheduled to be fully operational by 2020. Feasibility will identify and resolve outstanding uncertainties, namely: the aquifer properties beneath the selected sites; environmental impacts; changes to water quality during injection/recharge cycles; pre-and post-treatment requirements; deployment issues; rolling abstraction licensing arrangements and modelling of the optimum operational regime to achieve the desired scheme benefits. It is anticipated that further ASR sites in the Sherwood Sandstone in our Region could be developed if these schemes prove successful and there is a water resilience/resource need.