

GROUND SOURCE HEAT PUMP ASSOCIATION

Research Seminar

09:55	Open Systems	Chair: David Whitaker (DH) Recorder: Huw Williams (HW)
10:00	Development of Finite Element thermal groundwater models	Huw Williams
10:10	Sustainability assessment of GSHP Systems	Martin Preene (MP)
10:20	Discussion	
Chair DW	<p>OVERVIEW</p> <ul style="list-style-type: none"> • This is a short session, but of equal importance to all the others; • There is an essential role to be played by hydrogeologists in GSHP technology: from understanding water resources, hydrogeologists now face the challenge of assessing the thermal resources of an aquifer; • There must be a closer relationship between driller/designer/installer and operator in GSHP systems over and above that in traditional water resource work; • Sand ingress is an essential issue for GSHP applications, from the wear on the heat pump to structural issues from undermining a site; • There are issues with maintaining flow rates and pressure coming from a borehole and well as maintaining recharge boreholes; • Understanding flow and heat transport through fractures is essential in sustainability assessment; • Current research is focused on the boreholes used in GSHP systems and not the thermal resource of an aquifer – thermal aquifer management is essential if further thermal resource is to be utilised. 	
Speaker HW	<p>Development of Finite Element thermal groundwater models</p> <ul style="list-style-type: none"> • Clients are approaching designers, such as those at LoopMaster, with requests to investigate the feasibility of reversible open loop Aquifer Thermal Energy Store (ATES) systems, especially in the Chalk Aquifer of the London Basin; • The selection of the most suitable type of open loop system, either reversible or unidirectional must be governed by the geology hydrogeology at a site; • There are a number of key aspects to modelling each type of system, ATES Reversible systems require: <ul style="list-style-type: none"> ○ A suitable thermal store; ○ Groundwater gradient such that this store does not significantly flow off site; and ○ Fracture flow in the Chalk Aquifer Chalk aquifer that allows storage and transfer of heat from the bulk of the chalk mass to and from the boreholes. 	

	<p>Unidirectional systems require:</p> <ul style="list-style-type: none"> ○ Horizontal separation of the boreholes to minimise thermal interference; and ○ Thermal energy discharge or extraction does not exceed the rate of energy dissipation or replenishment within the aquifer between the abstraction and recharge borehole(s). <ul style="list-style-type: none"> ● Numerical thermal groundwater modelling is commonly undertaken on unidirectional systems, using the finite element software FEFLOW; ● FEFLOW is a finite element 2D and 3D model that allows temporal and spatial analysis of groundwater flow and heat transport; ● For reliable modelling results, it is essential to construct an accurate conceptual model from desk study, thorough site investigation and calibration; ● FEFLOW is capable of accurately capturing long-term groundwater flow, as demonstrated by comparing fracture modelling with Equivalent Porous Medium modelling and groundwater gradient sensitivity analysis; ● Lessons learnt from unidirectional modelling can be applied to ATES system modelling in terms of the heat store, fracture flow and heat transport; ● Other aspects of ATES systems can also be investigated through FEFLOW modelling, including sensitivity to: <ul style="list-style-type: none"> ○ Building load imbalances; ○ Groundwater gradient; ○ Short-term effects of fracture flow; ○ Borehole orientation and horizontal separation; ● Research carried out by LoopMaster to date has indicated that FEFLOW is a power tool for modelling open loop GSHP systems and can be used to test different scenarios to check the suitability and efficiency of these systems; ● FEFLOW should be used to establish the suitability of either an ATES system or unidirectional system according to the site characteristics and underlying geology and hydrogeology. 	
<p>Speaker MP</p>	<p>Sustainability assessment of GSHP Systems</p> <ul style="list-style-type: none"> ● Golder have undertaken an assessment of the sustainability of GSHP systems for the Ministry of the Environment in order to assist in the development of a series of regulations in one of the Canadian Provinces; ● Today’s talk will concentrate on these finding for open loop systems only; ● It is also worth noting that in Canada, there is a significant number of standing water systems, where a single borehole is used as an abstraction and recharge well (often this single well is also used for water supply); ● To assist in the development of these regulations, Golder undertook a review of the key international legislation, current and future technology as well as stakeholder consultation and review to invite 	

	<p>recommendations;</p> <ul style="list-style-type: none"> • The key environmental concerns as a driver for the legislation are: <ul style="list-style-type: none"> ○ Thermal sustainability (in terms of single system sustainability as well as how neighbouring GSHP systems affect each other); ○ Potential ecological impacts (which proved very difficult to quantify); ○ Geotechnical impacts; ○ Borehole drilling requirements; ○ The mining of the groundwater resource; ○ Groundwater mounding due to reinjection of groundwater; ○ Settlement or subsidence issues; and ○ Air quality concerns over the leakage of refrigerants. • Recommendations that came out of this extensive literature review and stakeholder consultations were that: <ul style="list-style-type: none"> ○ The legislation should not put up barriers to the development of GSHP technology; ○ Legislation should encourage balanced systems to be designed where possible. This is especially important for larger systems or systems that are likely to be in a cluster (e.g. urban area); ○ The legislation should be tiered, according to the size of the system, requiring more stringent rules apply to the larger systems while smaller systems can be installed without intensive investigation; ○ Systems with acceptable environmental impacts should be promoted and encouraged; and ○ Given predicted rising trends in the number of GSHP applications being installed, the legislation has to be flexible and capable of dealing with an increased volume of applications. 	
10:30	Recorder Summary – N/A	