Commercial Applications For Mono-bore Open Loop Systems

IGSHPA Conference Kansas City
Commercial Applications Session B

7th October 2015
Learning Objectives

• Application of Open Loop within limited space
• Importance of well design within Open Loop systems
• Potential to replicate in alternative strata
Acknowledgements

- Iain Howley – GSC Director & Project manager
- Zeb Etheridge – GSC Hydro-Geologist
- Les Morrice – GSC Site Supervisor
- Steve Bellamy – Drilling & Servicing Ltd
- Marc Bevan – WJ-Groundwater Ltd
- Paolo Chiarotti – Gregori Chiarotti

- Finally…Kering the Client…
Outline/Agenda

• Brief Introduction to GSC
• First concept of the Mono-bore open loop design
• First Application of Mono-Bore to fix problem system
• Kering – The Client
• Design of the Mono-bore for Kering
• Installation of the system
• Commissioning
• Operational Data
• Conclusions & Lessons Learnt
Ground Source Consult Ltd

- Directors are from a drilling background and therefore have a very strong understanding of designing & installing ground heat exchangers
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• Based in Nuneaton, Warwickshire, UK we specialise in the design and consultancy of commercial open and closed loop systems.

• Professional team headed by a Certified Geo-Exchange Designer, In House Hydrogeologist / Groundwater & Thermal Modeller and in house Drilling & Pipe Fusion Engineers.

• Been operating in Ground Source sector since early 1990’s since listening to Jack DiEnna at NGWA in Las Vegas. Completed schemes to date ranging from 5 kW to 3,500 kW.
London – Geology

- Main Aquifer is the Chalk.
- Sometimes some superficial deposits at surface
- Overlying strata above Chalk, in particular the London Clay is essentially impermeable
- Main fissures in Chalk in top 10 – 20 m of the strata.
- Environment Agency no longer permit abstraction of water for bleed off in many areas of London Chalk
Jermyn Street – London - 2005

- Site constraints of narrow footpath and 20 m x 15 m in length
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- Site constraints of narrow footpath and 20 m x 15 m in length
- Limited to one position with coal vaults
- Virtually no superficial deposits for re-charge
- Licensing restraints means no abstraction or bleed off
- Reasonably balanced heat rejection and heat absorption (old building)
- Proposed the packer system design but it was deemed to be too much of a risk by the client. Boilers and chillers went in and the upper floor was sacrificed!!
Previous contractor installed an open loop borehole into the Chalk and an injection borehole just 5m into the superficial deposits.

Superficial's would not take the water and water was being pumped to drain without Thames water permission and EA permission to abstract the water.

No space at all for a second borehole to the chalk.

So, our thinking turned to vertical separation within the Chalk itself in the one well they could use rather than horizontal separation between an abstraction and injection borehole.

Proposal was put to the client who had zero choice in the matter!
By this time, the original contractors had walked away from the rescue of this project.

Zeb researched the make up of the chalk aquifer and concluded that although there is potential for vertical fissures within the chalk, dissolution generally occurs in the horizontal plane.

The client did have the budget for geophysical logging and so we pulled the pump and logged the borehole.
## Eaton Place – Belgravia – London

### Composite Geophysical Log

**CLIENT:** Logphone 30 
**DATE:** 19/07/12 
**SITE:** Eaton Place 

<table>
<thead>
<tr>
<th>WELL</th>
<th>LOG Type</th>
<th>Interval</th>
<th>Description</th>
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<tbody>
<tr>
<td>30</td>
<td>Gamma</td>
<td>0-100</td>
<td>Natural Gamma</td>
</tr>
<tr>
<td>30</td>
<td>Density</td>
<td>100-200</td>
<td>Bulk Density</td>
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<tr>
<td>30</td>
<td>Neutron</td>
<td>200-300</td>
<td>Neutron</td>
</tr>
<tr>
<td>30</td>
<td>Acoustic</td>
<td>300-400</td>
<td>Acoustic</td>
</tr>
</tbody>
</table>

**Figure:** Composite Geophysical Log

![Graph showing geophysical data with marked intervals.](image)

*Note: The graph shows the results from the well log analysis at Eaton Place.*

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*Image details:*
- **Well Log Analysis:** The graph represents the well log analysis with specific intervals marked for detailed examination.
- **Key Parameters:** The log includes parameters such as Gamma, Density, Neutron, and Acoustic to evaluate the geological properties of the site.
- **Interval Markings:** The intervals from 0 to 80.5m are highlighted, indicating significant changes or anomalies in the geophysical data.

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*Additional Information:*
- **Location:** Eaton Place, Belgravia, London.
- **Purpose:** The analysis is crucial for understanding the subsurface properties for construction or other related projects.
- **Contact:** For further details, contact European Geophysical Services Ltd.

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*Disclaimer:* The information provided is for educational purposes and should be verified with professional geotechnical services for project-specific requirements.
• Logging had identified the large fissure at 88.9 m and other fissures below this point.
• The packer system was assembled and installed.
• The packer was left deflated and some testing work done on the pump and transducers and then inflated.
Eaton Place – Belgravia – London

- Logging had identified the large fissure at 88.9 m and other fissures below this point.
- The packer system was assembled and installed.
- The packer was left deflated and some testing work done on the pump and transducers and then inflated.
- The two pressures then immediately diverged and the system has been running ever since.
Kering – The Client

• Kering are leaders of world high end fashion – owners of Gucci, Yves Saint Laurent, Alexander McQueen, PUMA etc

• Kering Group policy is to install environmentally friendly / renewable energy systems

• The Kering London HQ situated at 6 Carlos Place Mayfair was to undergo refurbishment including new heating and cooling systems

• 6 Carlos Place is in a hugely sensitive residential area and Westminster City Council do not allow rooftop chilling plant – which effectively means…..no cooling without Geo!
The Mono-bore Solution

• With this site, we were starting from scratch with no existing well to “fix” and from first site visit it was clear there was limited space.

• We needed to investigate numerous avenues to provide the assurances to the client that it as feasible install a mono-bore system

• Whether we could identify fractures with flowing groundwater within the Chalk rock before drilling

• Whether a non-productive zone could be identified against which the packer could be placed

• Whether thermal performance could be predicted to show longer term sustainability (level of thermal interference)
The Feasibility
The Feasibility

- In 2005, we installed a system at the famous “Scotts” restaurant just 250 m from the Kering HQ site.
- We were able to assess the logs of this site, test pump data and tracer testing to assess the fracture formations in the Chalk.
The Load Profile

- Energy loads were established and fairly small.
- Peak heat rejection was approx 110 kW
- Peak heat absorption was about 80 kW
- Annual THR/THA reasonably balanced
The Thermal Models

- Finite Element Modelling with Fe-Flow completed
- Although potentially some thermal breakthrough as expected, modelling indicates the system is sustainable over the long term
The London Underground

- Just when we thought it was plain sailing, the TFL searches came back.
- The Jubilee line ran within 10m of the drilling location and the safety exclusion zone within 2 – 3 m of the borehole.
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• The Jubilee line ran within 10m of the drilling location and the safety exclusion zone within 2 – 3 m of the borehole.

• There is a good reason for this exclusion zone....
The Install

• We now have the one and only position of the borehole !!
• We bored through the roof of the vault under the footpath.
• Sourced a Victorian Coal Vault cover and installed it for the borehole.
The Install – July 2014
The optical imager showed the chalk formation, where visible, between 67.2 – 126.2m to be stable and competent with occasional fissured horizons. Notable fissures were recorded at: 68.6m, 70.2m, 71.9m, 74.0m, 74.6m, 77.7m, 78.2m, 79.6m, 80.6m, 85.0m, 91.3m, 106.0m, and 123.5m.
The Principal of Operation
The Abstraction & Injection Temps

Average Abstraction & Injection Temperatures

Date
27/01/2015 27/02/2015 27/03/2015 27/04/2015 27/05/2015 27/06/2015 27/07/2015 27/08/2015

°C
17
16
15
14
13
12
11
10
9
8
7

Abs temp
Inj temp
The Well Temperatures

Average Well Temperatures Above and Below Packer
The Pressures

Abstraction and Injection Zone Ground Water Pressure / Level

Date

27/01/2015 27/02/2015 27/03/2015 27/04/2015 27/05/2015 27/06/2015 27/07/2015 27/08/2015

mAOD

Lower water lvl
Upper water lvl
The End Result – Well Head
The End Result – Data Logger

<table>
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<th>Time</th>
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<th>Inj flow</th>
<th>Abs temp</th>
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<th>Upper water temp</th>
<th>Lower water lvl</th>
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<tr>
<td>Abs temp</td>
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<td></td>
<td></td>
<td>13.5</td>
<td></td>
<td></td>
<td></td>
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</table>
The End Result
Kerings System....

• Heats & Cools the entire facility year round with the Mitsubishi VRF/VRV system
• Benefits from over a 40% saving on CAPEX for the boreholes
• Huge environmental benefits ( efficiency / carbon reduction )
• Results to date show excellent thermal characteristics and in fact considerably better than a conventional abstraction and injection borehole system in this strata
• More complex downhole installation and packer pressure system required.
• Slightly more maintenance required but no significant increase in maintenance cost
• Risks are greater than with a standard doublet borehole system when trying to find fissures and none fissured zones although they can be mitigated as far as possible

The End Result

Drawbacks....
Replication Elsewhere

- There are very few reasons why the Mono-bore system could not be implemented in other strata.
- Birmingham UK has a large thickness of Triassic Sandstone and the same system could be used to isolate different inflow zones within the sandstone.
- Paris area has in parts limestone aquifers that exhibit similar characteristics to the Chalk
- Use of mine water from different flooded mines could be an option.
Questions?

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