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WP. 2.5 Integrated Cooling, Heating and Storage

GROUND SOURCE HEAT PUMPS AND THEIR INTERACTIONS WITH UNDERGROUND RAILWAY TUNNELS

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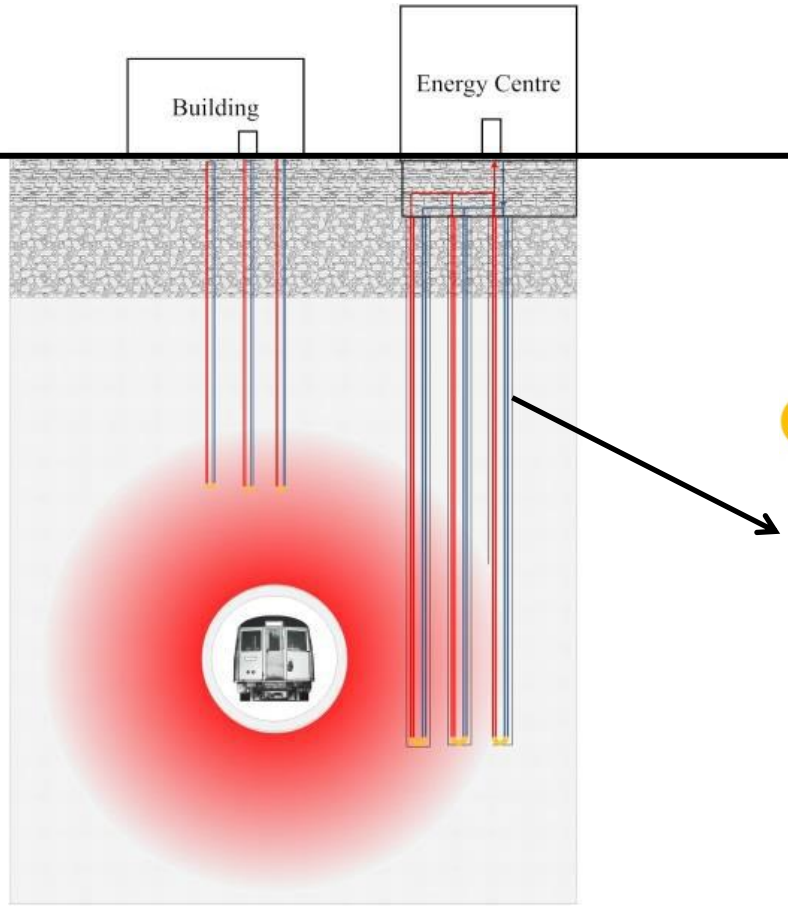
1. Intro

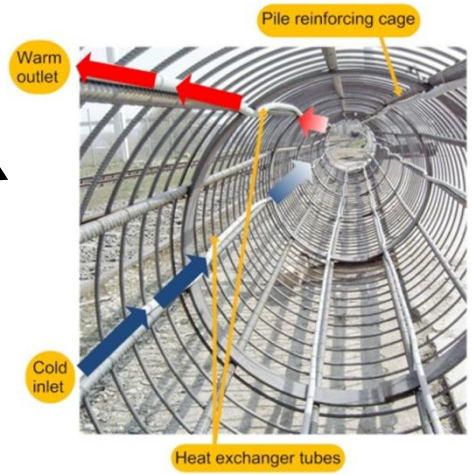
Background

- To investigate the interactions of underground railway (UR) tunnels and borehole heat exchangers (BHE)
- To investigate the potential indirect use of waste heat from the tunnels to heat buildings above ground

Deliverables

- Development of a model
- Case study materials





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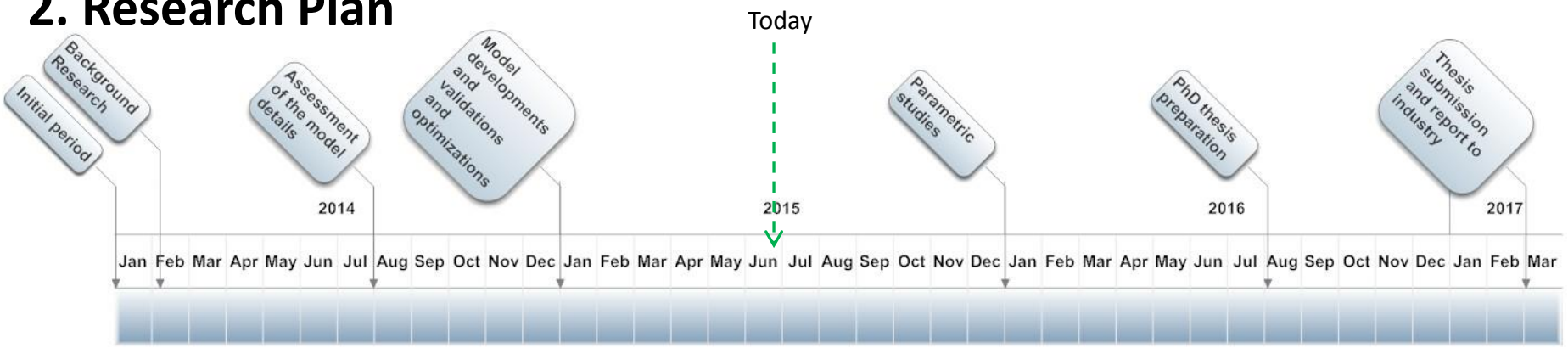
2. Research Plan



Activities:

- Site familiarization
- Literature review
- Evaluation of simulation software

Delivered:

- The literature review report

Up to Date Activities:

- Familiarization with the selected simulation software
- Development of modelling strategy
- Preliminary 2D model development
- Further development of the 2D model

Delivered:

- Conference paper for the ICR 2015

Planned Activities:

- Summary report on 2D model
- 3D model development

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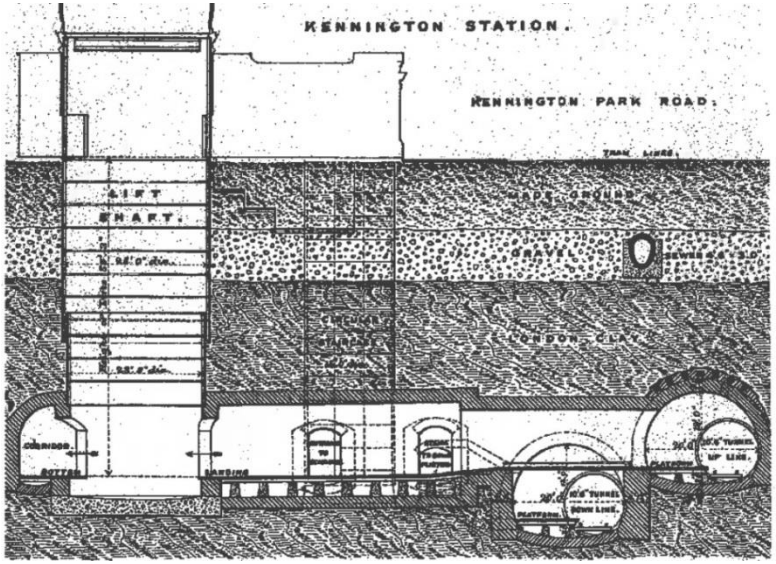
3. Preliminary model

A time dependent FE model.

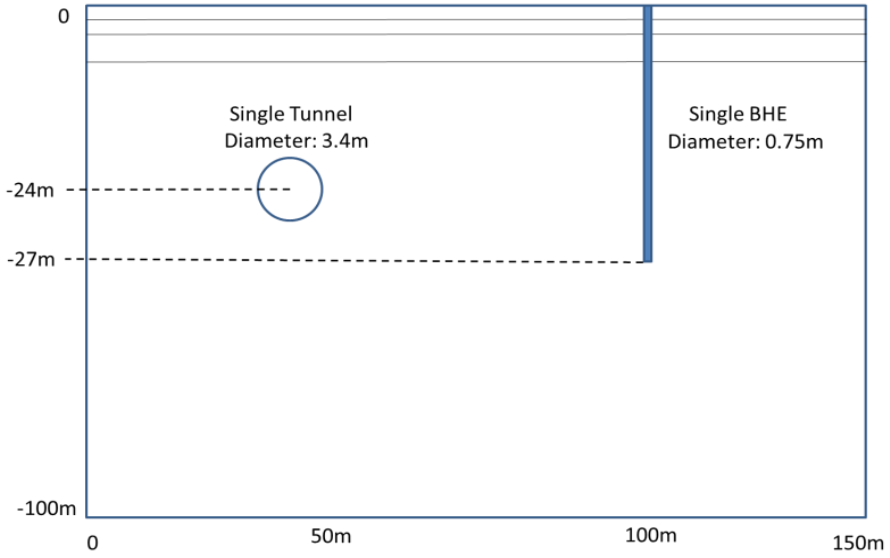
3.1. Modelling objectives:

- Thermal effects of UR and a BHE on undisturbed ground temperatures
- Thermal interactions of the two systems based on a certain set of conditions



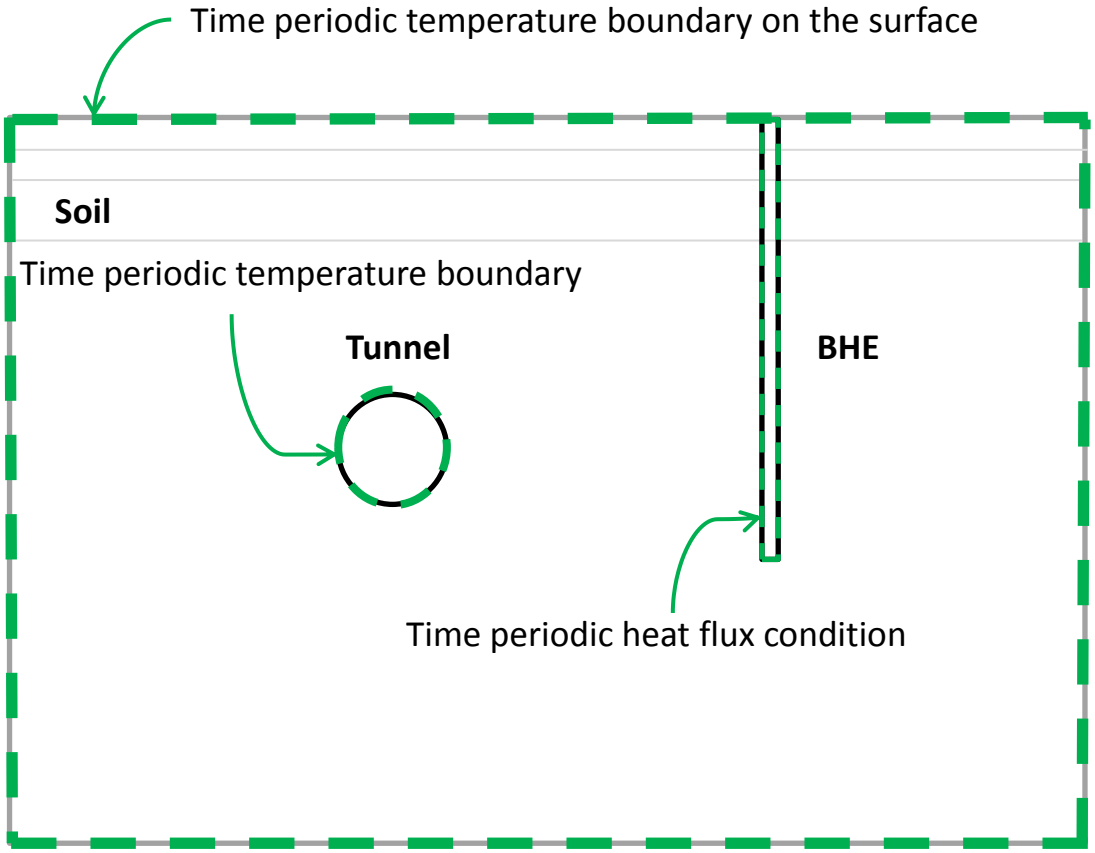
3.2. Generic Features:

- Two dimensional
- Simulation period of 6 years
- Geometrical parameters, material properties, initial, boundary and working conditions implemented within the model were based on typical conditions for London
- Groundwater movement has not been considered within the preliminary model



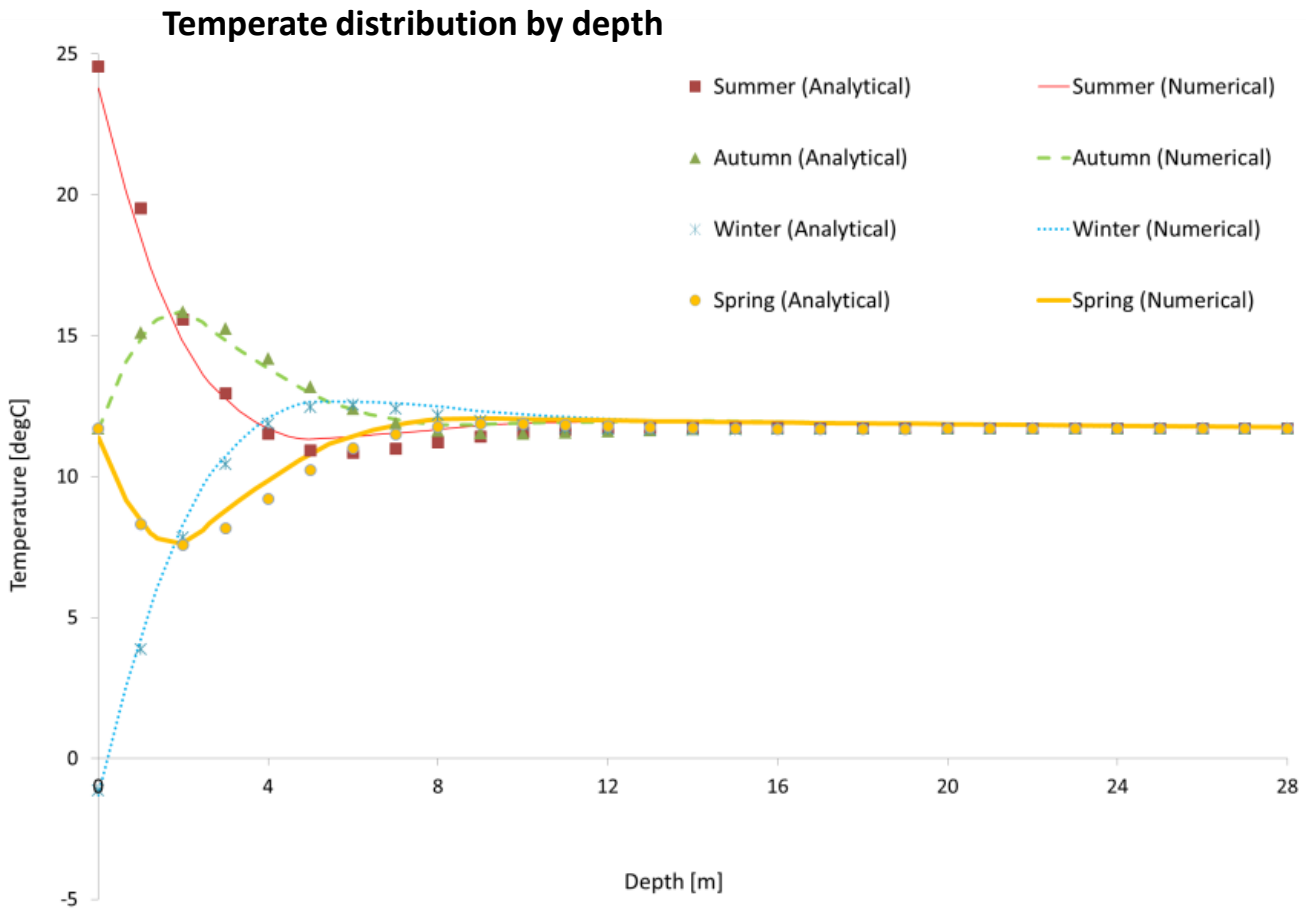
3.3. Initial and Boundary conditions:

The lateral and the bottom boundaries of the domain was assumed to be adiabatic



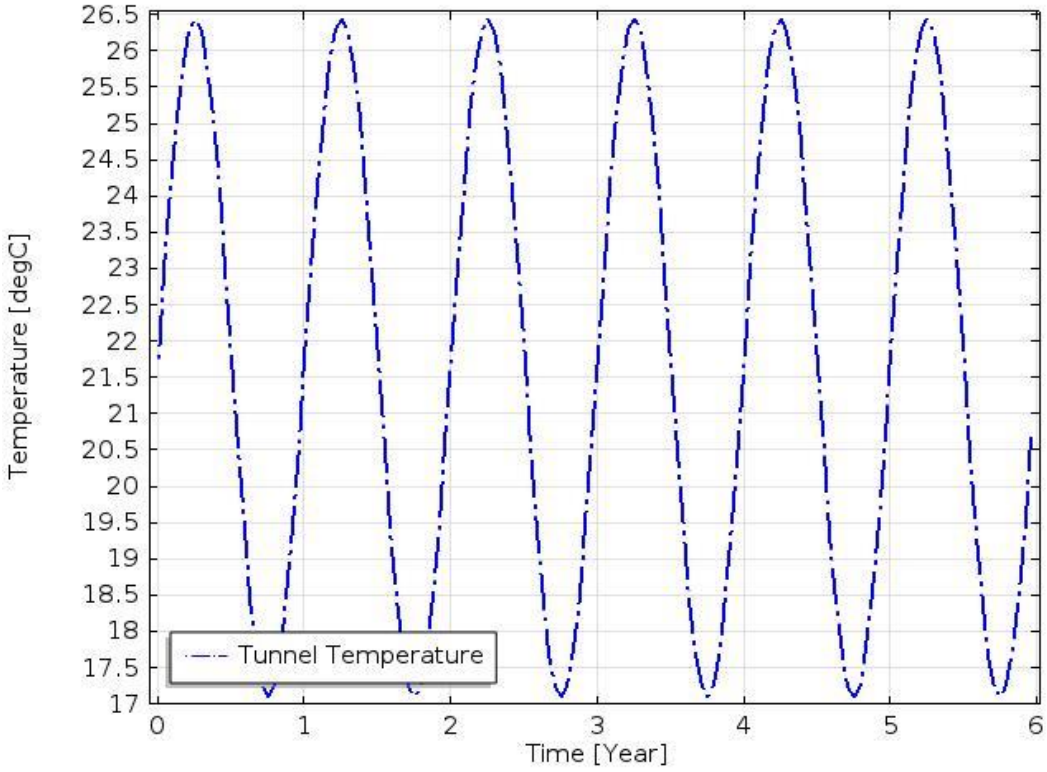
2.4. Validations:

Temperate boundary on the soil surface - validated against Brandl's, (2006) analytical solution.



The model predictions of the tunnel wall temperatures:

The simulated values were considered to be appropriate due to matching conditions reported by Thompson *et al*., (2008) and Gilbey *et al*. (2011).



Performance of the BHE heat flux:

Comparison to data obtained from thermocouples (LSBU). Only a few degrees Celsius of disparity between the two sets of data. The modelling assumption was maintained.

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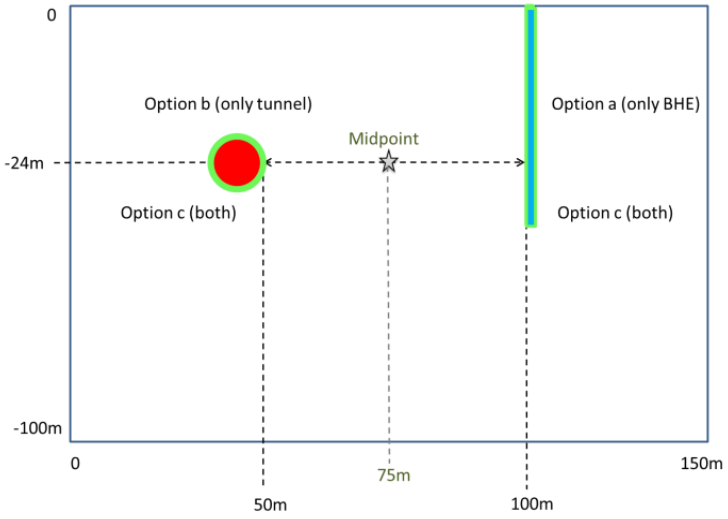
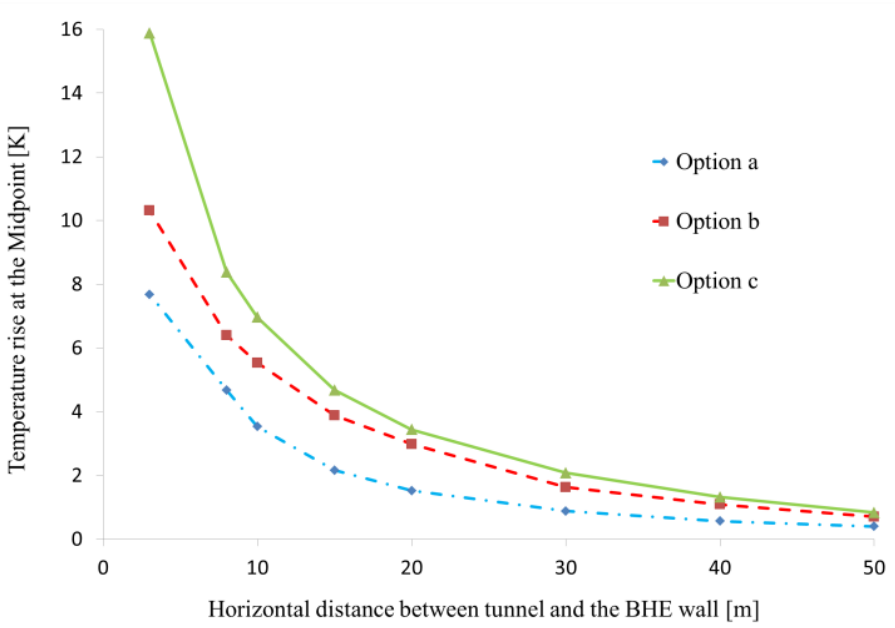
2.4. Analyses and results:

The effect of heat loads on initial ground temperature at a specific point was investigated through three different setups as follows:

- Option (a) only BHE heat load
- Option (b) only tunnel heat load
- Option (c) both heat loads





The key conclusion drawn from this study is that an UR tunnel has more significant effect on the surrounding soil temperature than a BHE.

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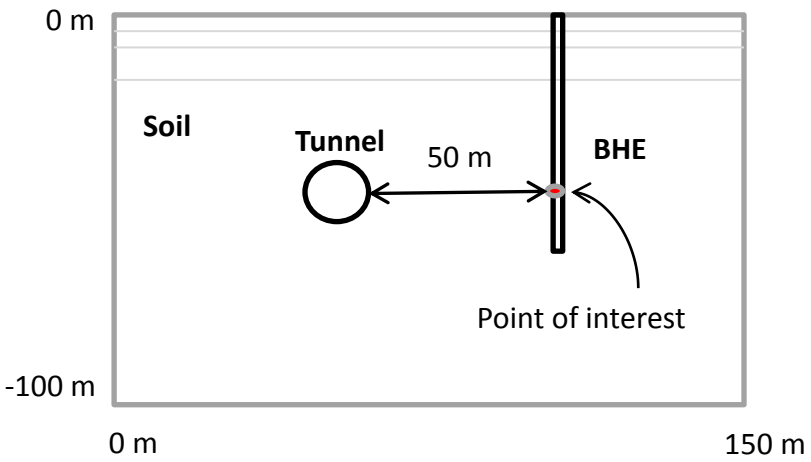
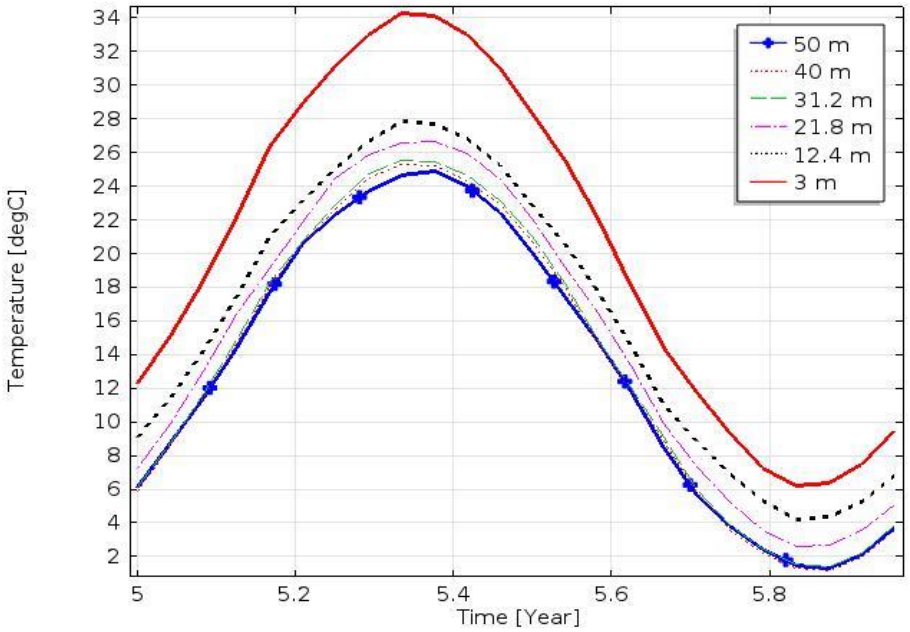
The second investigation aimed to study the interactions of the BHE and the tunnel by examining the temperatures at a point on the wall of the BHE in response to the closer proximity of the tunnel.





The preliminary results clearly demonstrate that:

- Interactions occur between URs and neighbouring GSHP installations.
- In heating mode, this could be beneficial to the efficiency of a GSHP.
- Likely to be disadvantageous for GSHPs operating in cooling mode.

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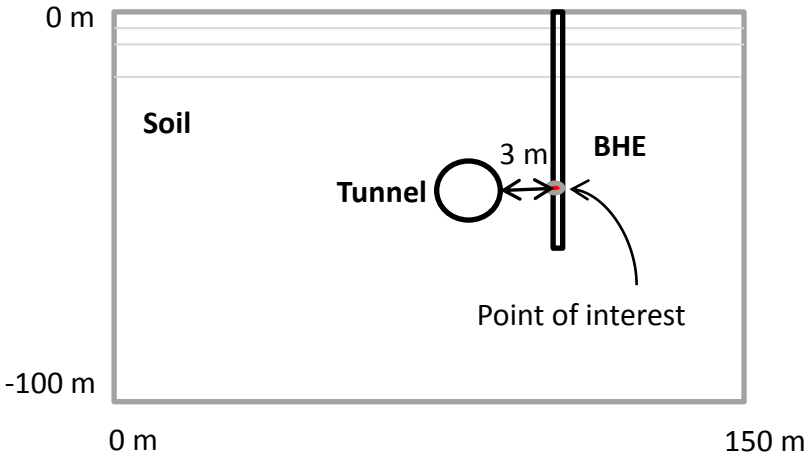

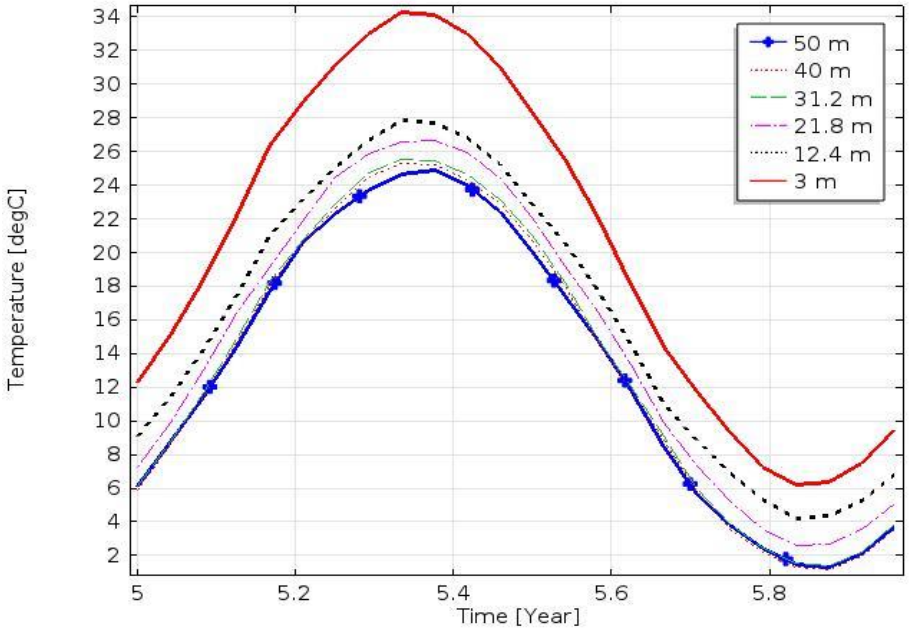

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2.5. Additional work within the 2D model:

Objectives	Status
• Incorporate sub-surface flow into the model (coupled heat and mass flow).	✓
• Investigate scenarios where tunnels are running through sands rather then clay.	✓
• Investigate the effects of parallel running tunnels on their surroundings.	✓
• Application of periodic heat flux condition on the tunnel wall surface.	✓
• Investigate the effect of flux from the Earth on the tunnel and its surroundings.	✓
• Incorporate tunnel wall and its material properties into to the model. Investigate its effect on temperature distribution.	✓
• Summarise 2D modelling results. Draft a report.	Ongoing

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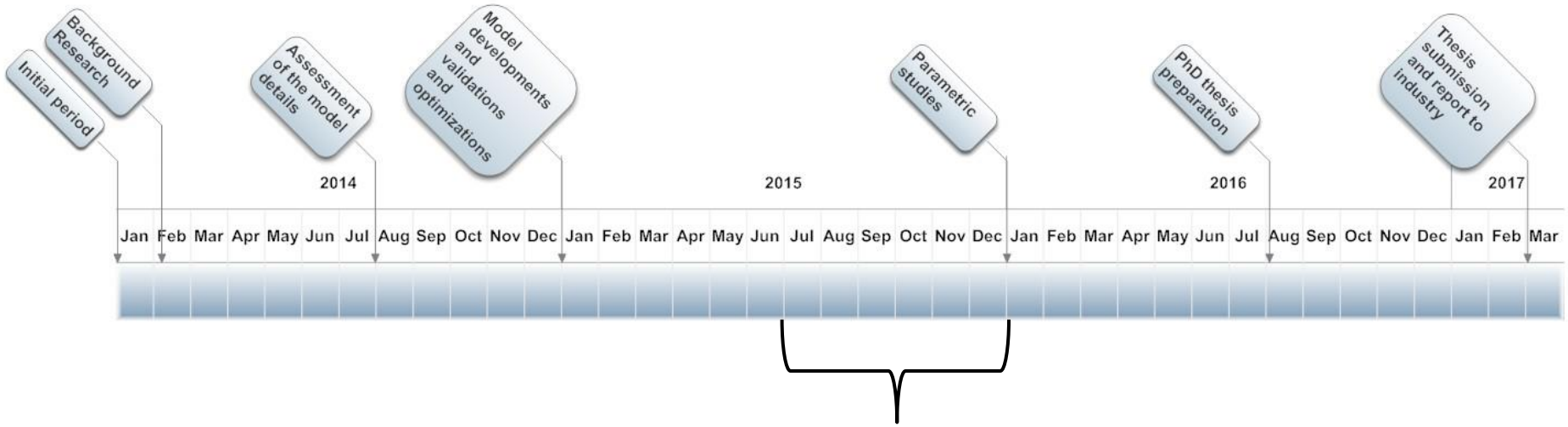
3. Next steps…



3D model developments and validations

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Questions