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TRT for Large Diameter Heat Exchangers

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Outline

- What is large?
- What's the problem?
- Possible solutions
  - Long Tests
  - Better Interpretation
  - Lab Testing
- Conclusions

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What is large?

- Size restrictions for TRT
  - IGSHPA >> 152 mm
  - GSHPA >> 200 mm
- Why?
  - Exponential Integral in line source model
  - Heat capacity of grout / concrete

$$\Delta T = qR_b + \frac{q}{4\pi\lambda}\left\{ln\left(\frac{4\alpha t}{r^2}\right) - \gamma\right\}$$

$$\Delta T = qR_b + \frac{q}{4\pi\lambda}\left\{Ei\left(\frac{r^2}{4\alpha t}\right)\right\}$$

$$Fo = \frac{4\alpha t}{r^2} \qquad Fo > 5$$

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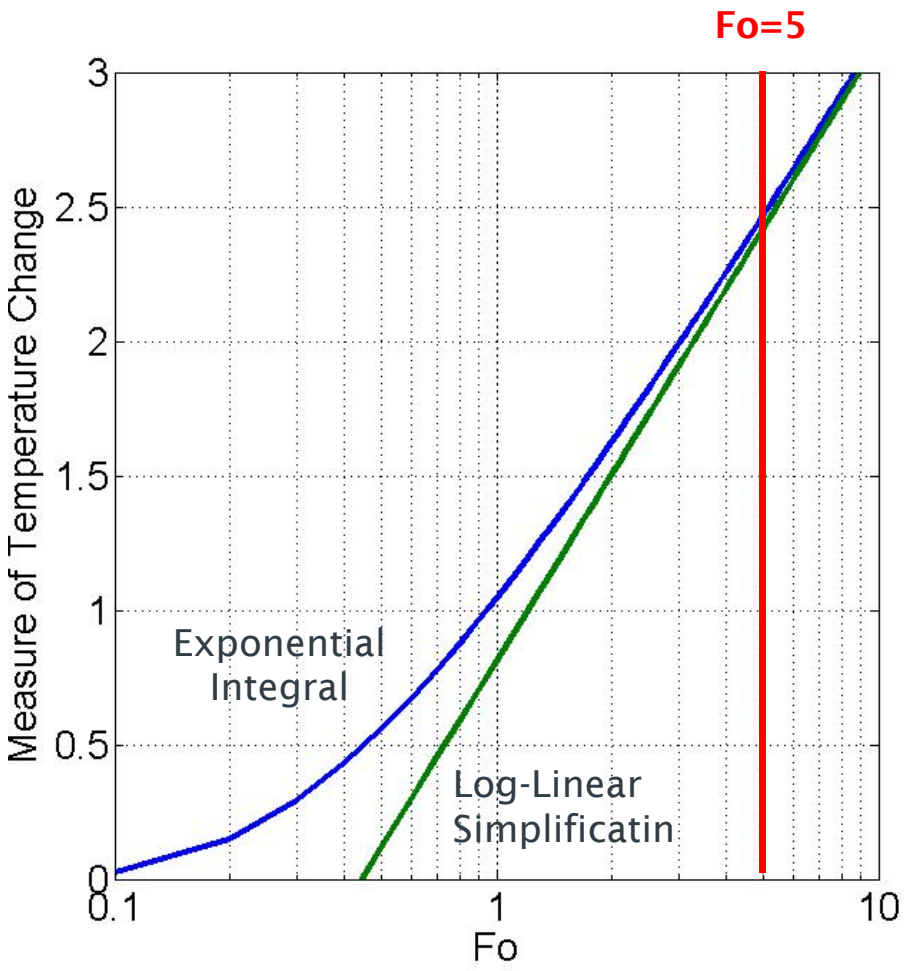
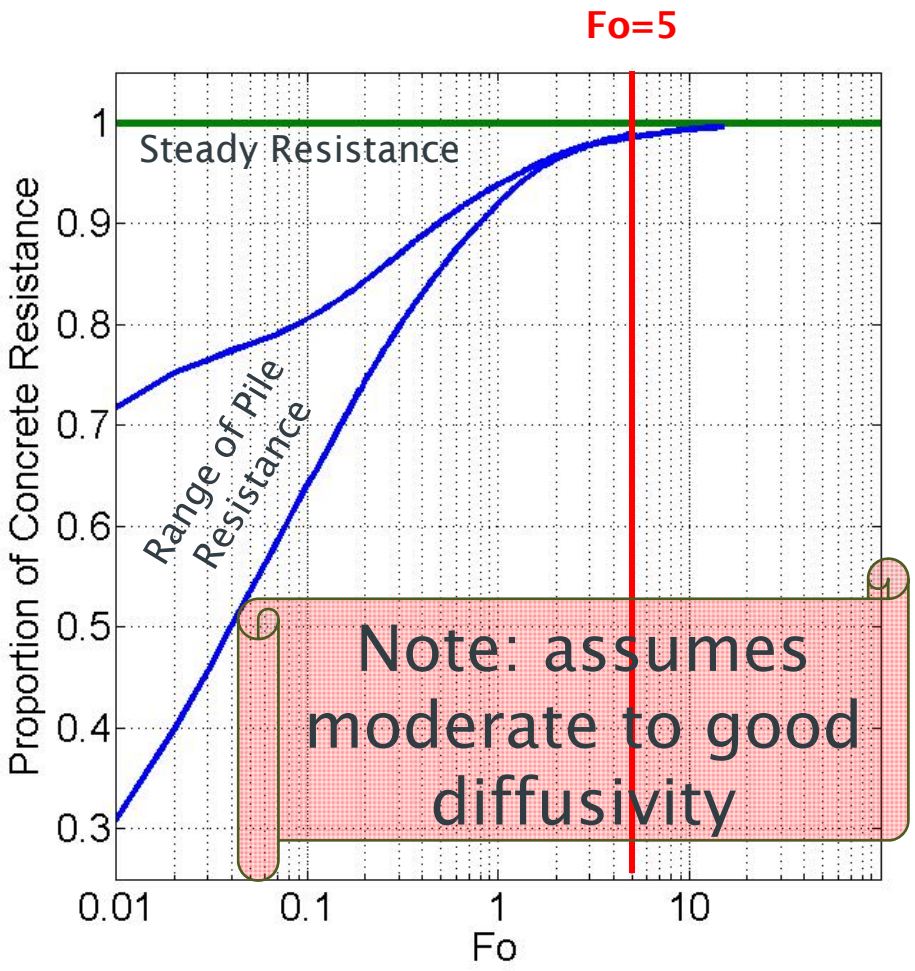
Quantification of Model Errors





Example: piles with 4 pipes

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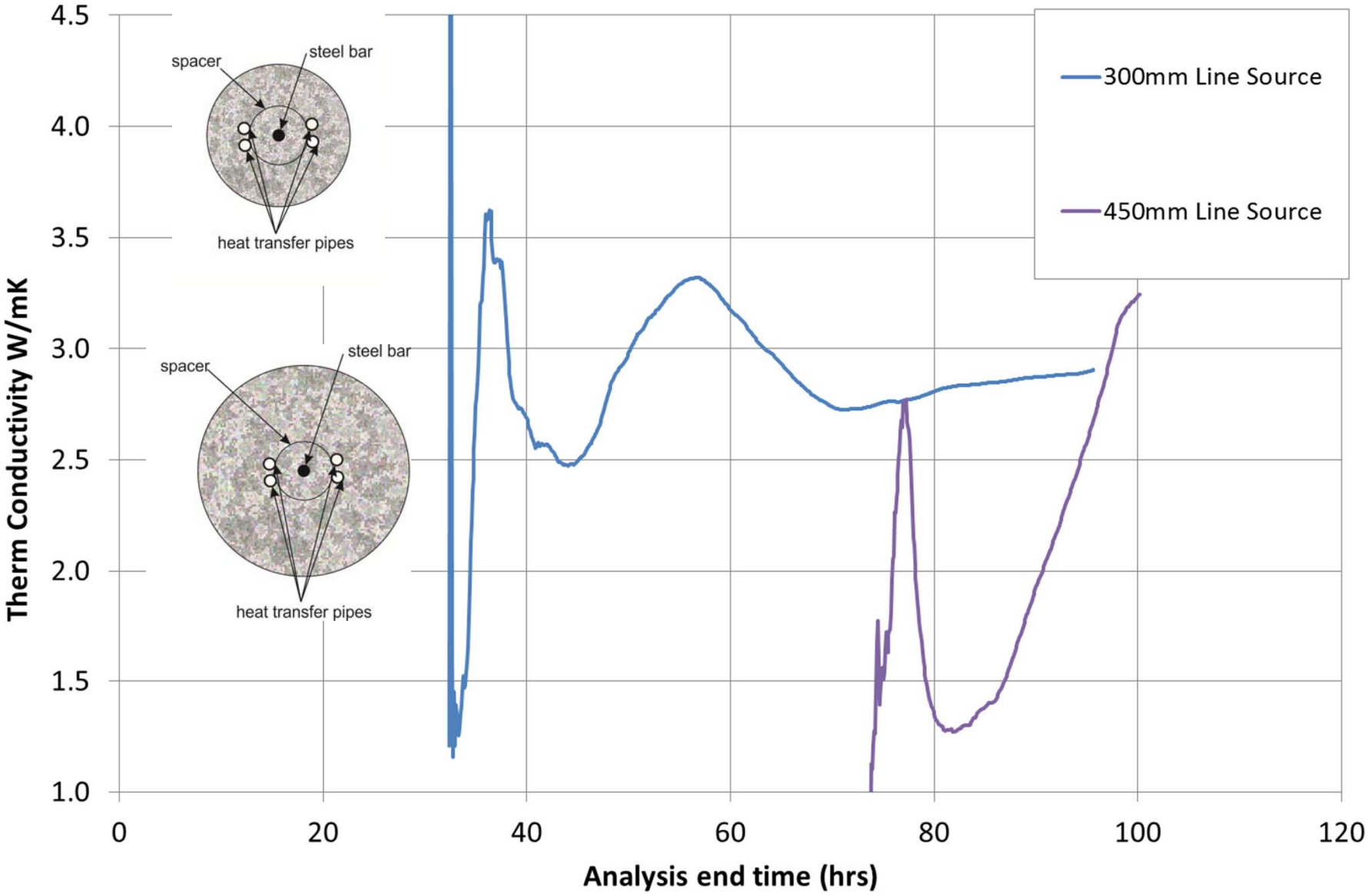
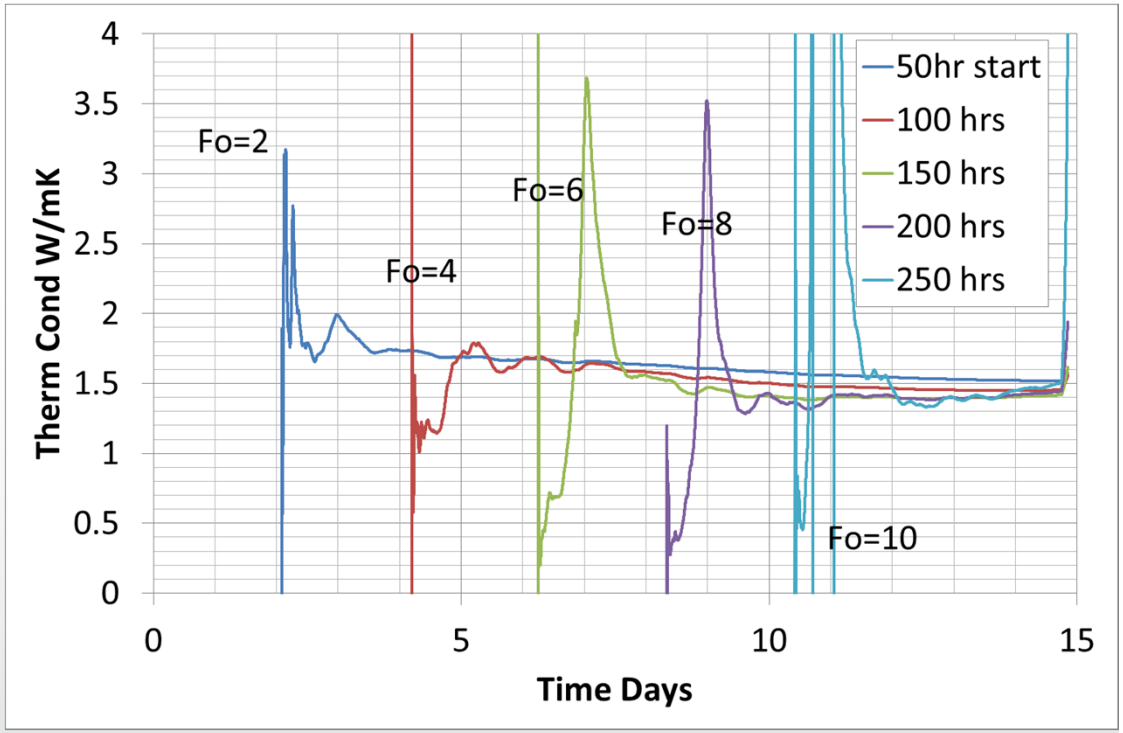


Solutions

- Longer duration tests
  - Costs
  - Power fluctuations
  - Axial effects due to short length
- Better interpretation methods
- Laboratory testing



Alternative Ground Models for Interpretation

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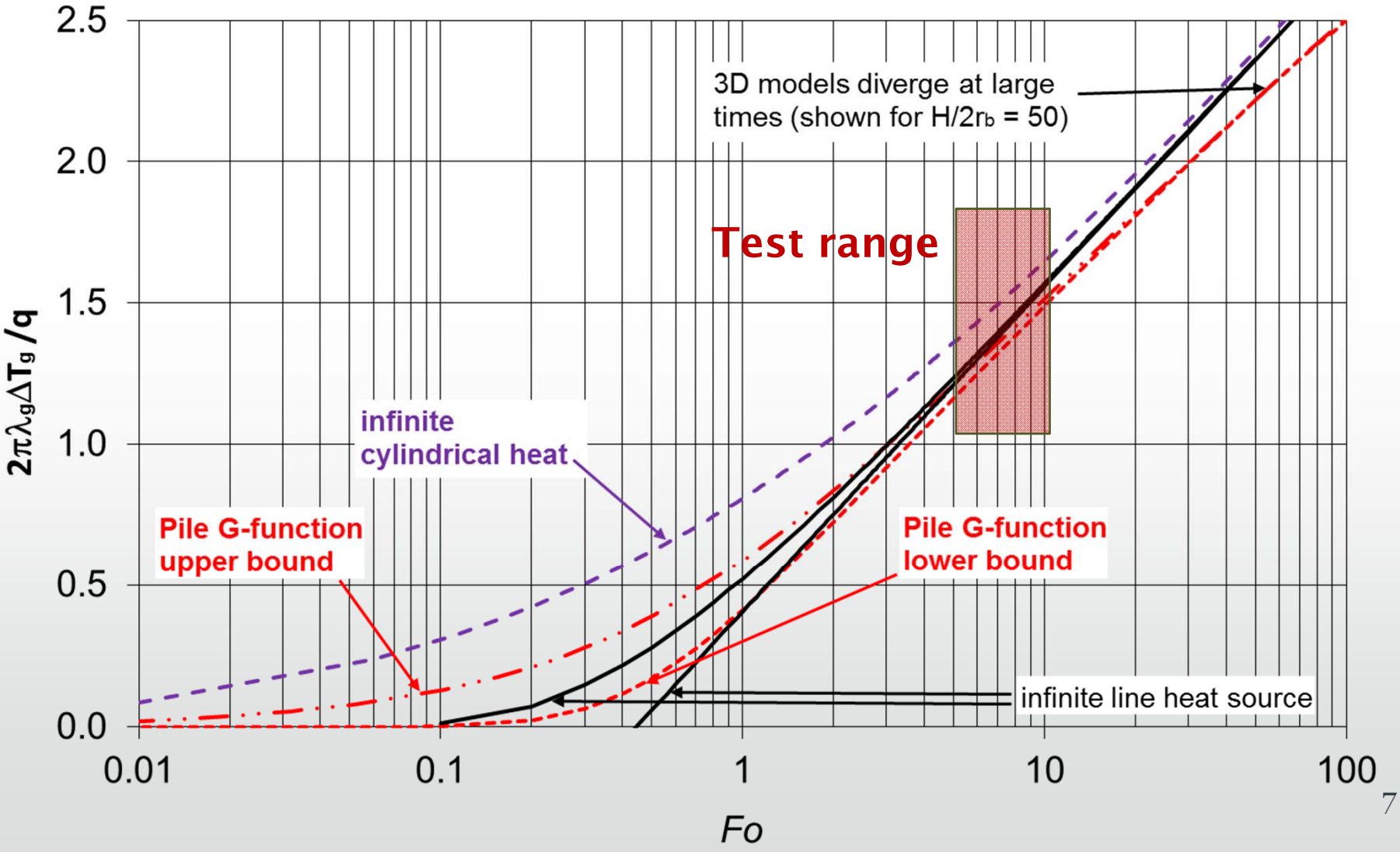
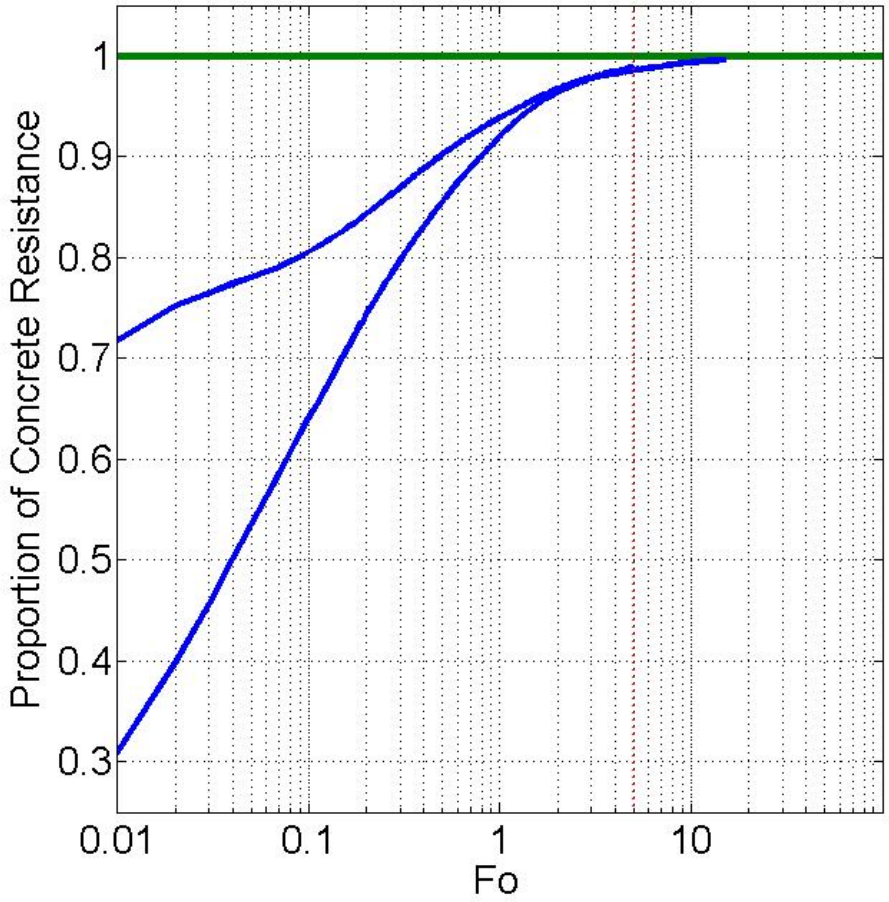


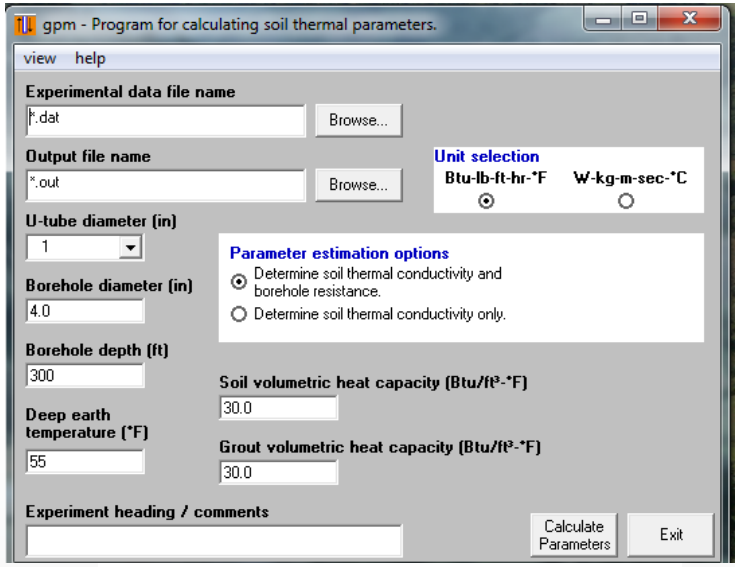
Alternative Pile Models

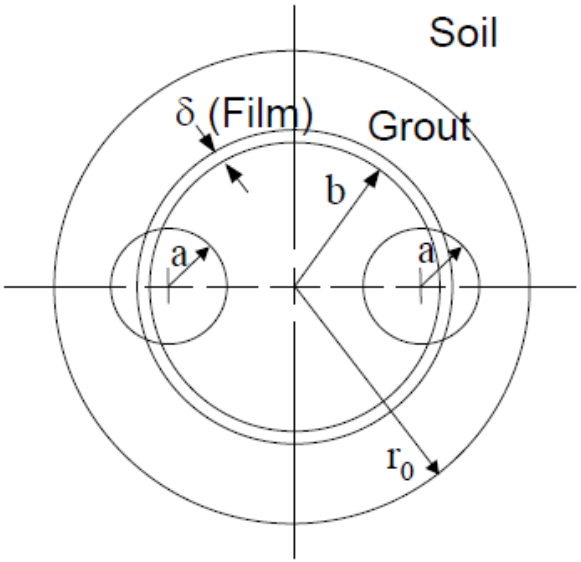
- Need to couple ground model with transient model of pile
- Empirical examples



Other Alternatives

- Tools that solve the ground and pile problem together
  - Analytical (e.g Javed & Claesson)
  - Geothermal Properties Measurement Tool
  - Other numerical
- Disadvantages
  - Not 3D (GPM, Javed & Claesson)
  - Can be time consuming (numerical)





Example: piles with 4 pipes

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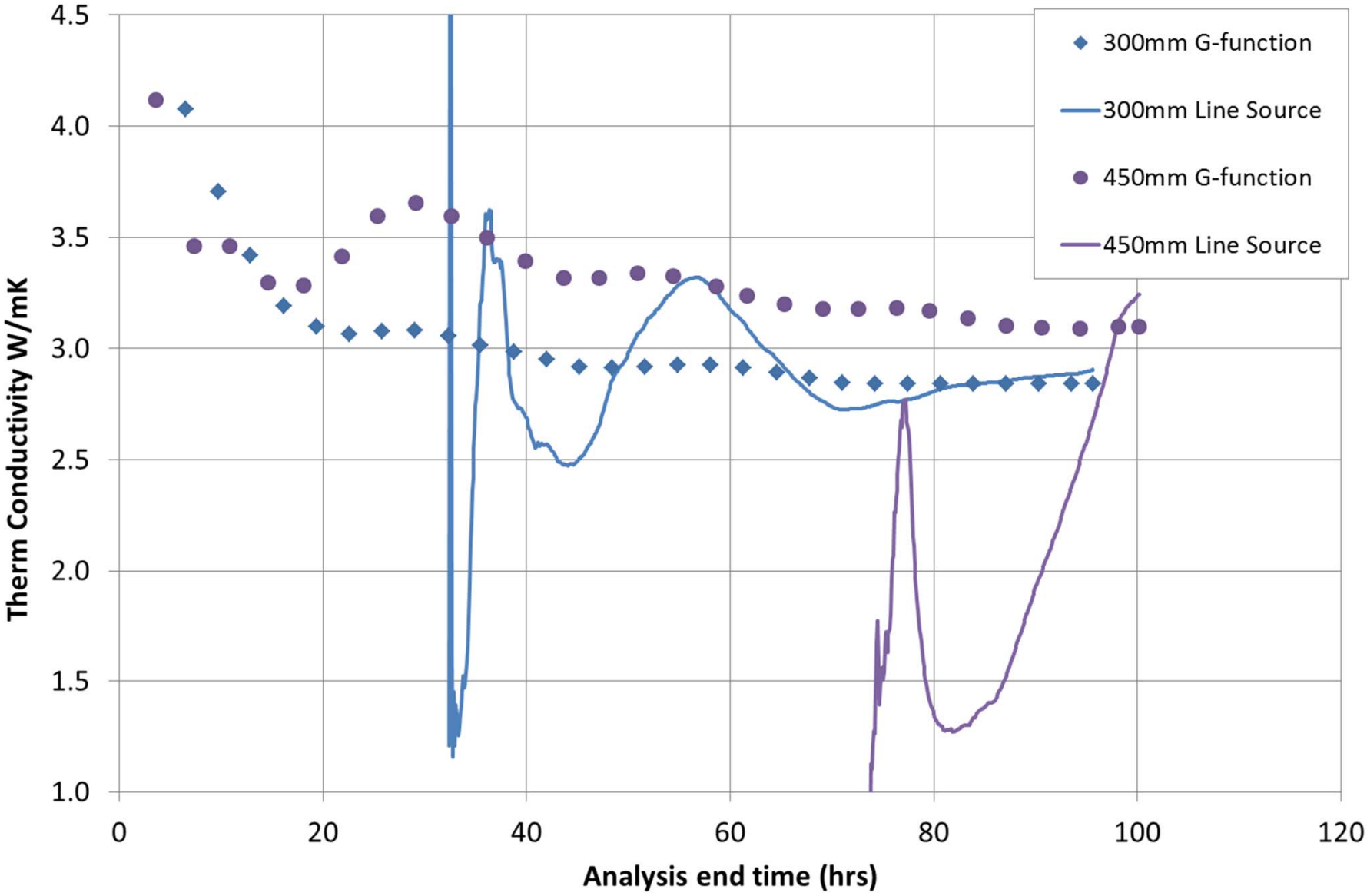

Example: pile with 2 pipes

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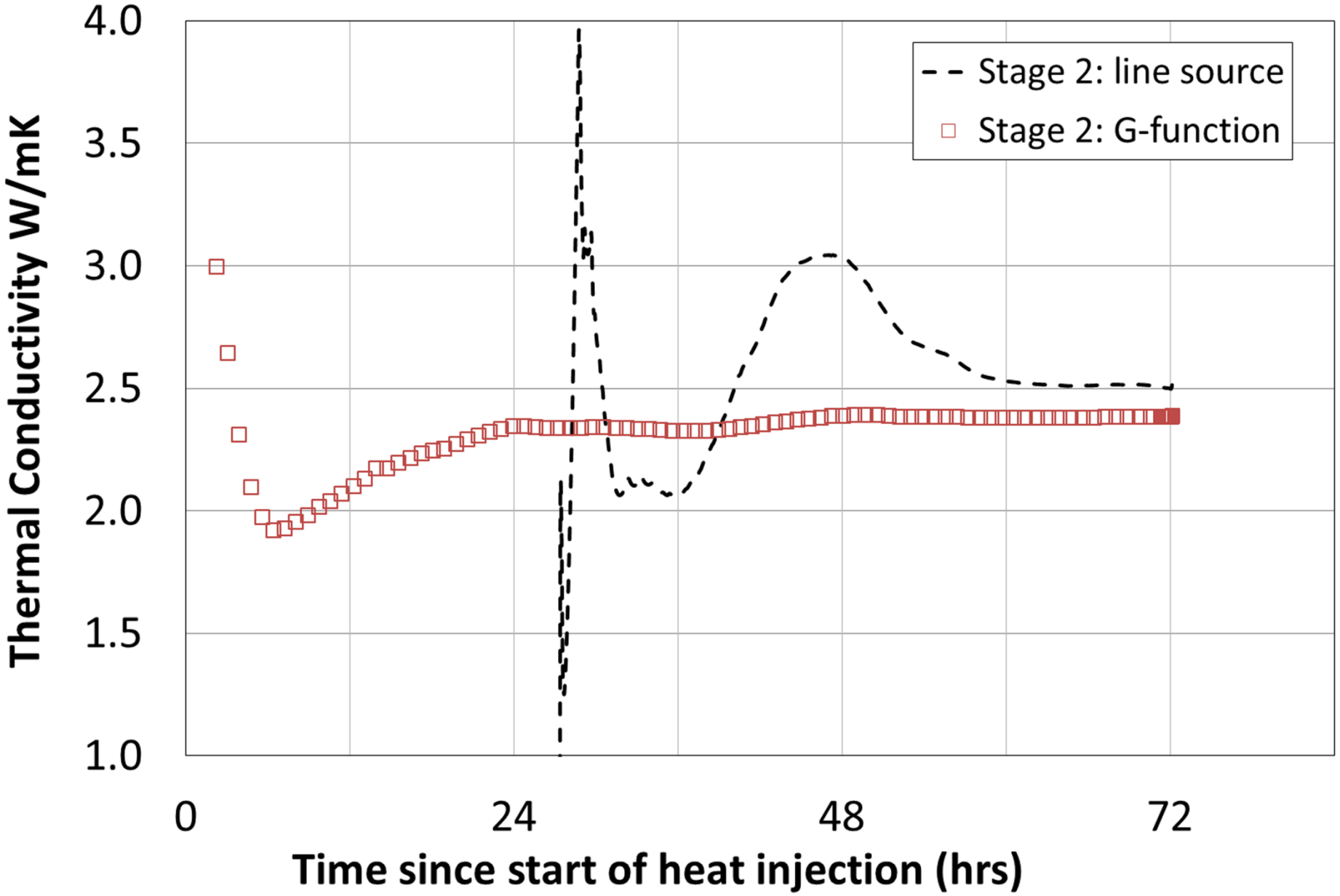
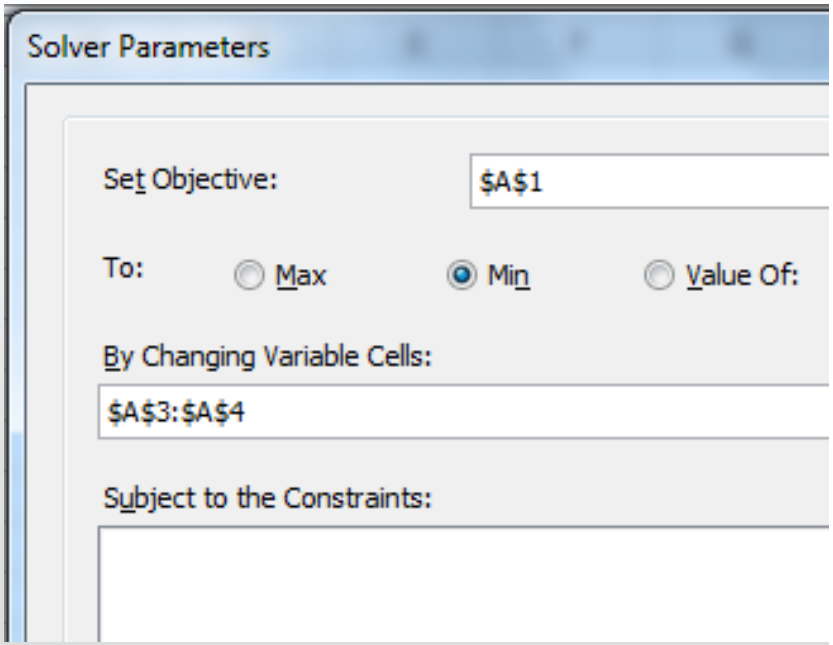


Practical Details

- Equation for G-functions much more complicated:

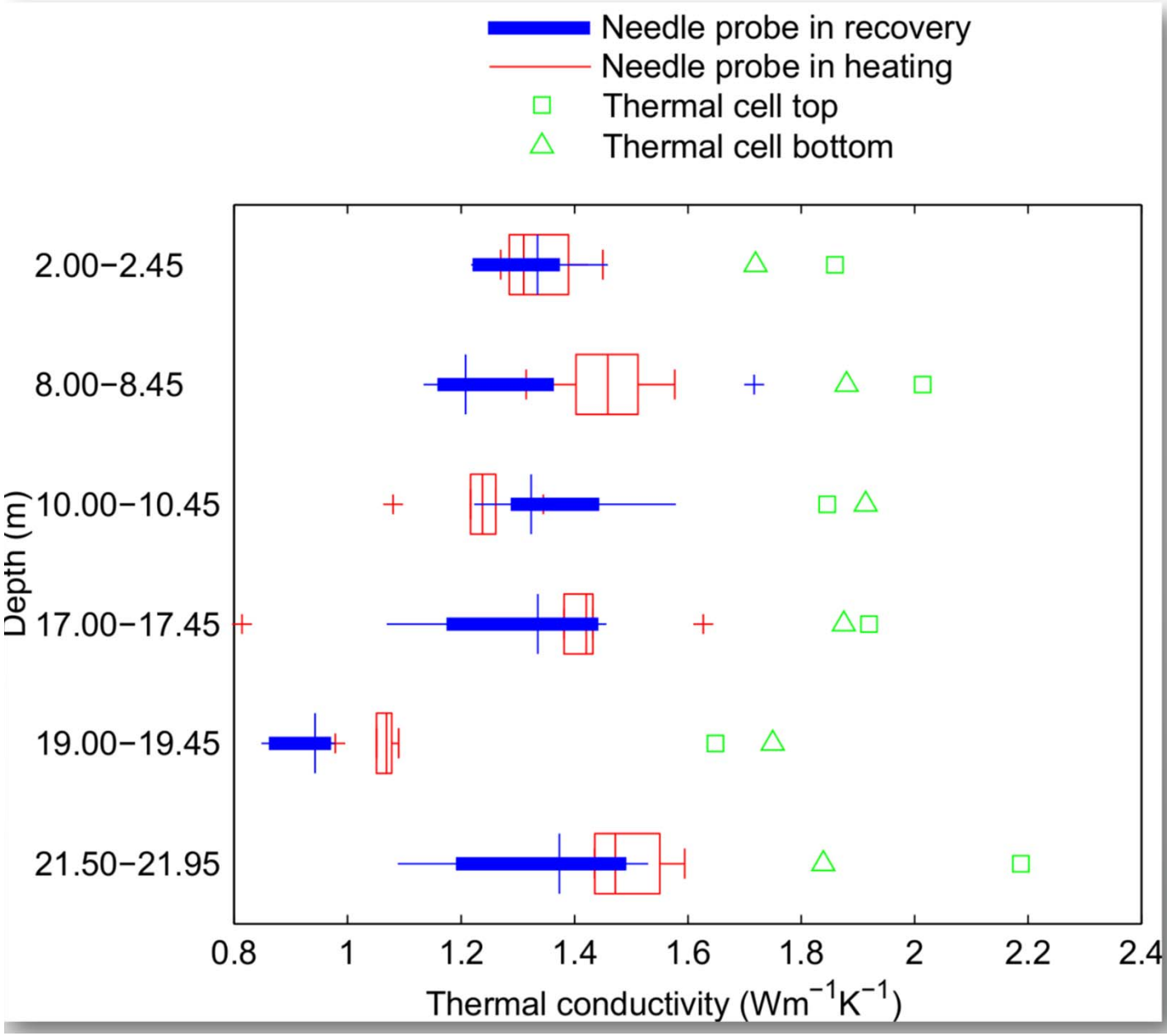
$$G = a[\ln(Fo)]^7 + b[\ln(Fo)]^6 + c[\ln(Fo)]^5 + d[\ln(Fo)]^4 + e[\ln(Fo)]^3 + f[\ln(Fo)]^2 + g[\ln(Fo)]\ h$$

- But actually easy to implement in Excel using “Solver”
- Minimise the difference between the measured temperature and calculated temperature.
- Applicable to any other model you want to apply



Laboratory Testing

- Steady vs Transient
  - Risk of moisture movement
  - Heat losses
- Issues of scale, fabric, discontinuities and groundwater
- Sampling disturbance >> changes in moisture content
- Loss of confining stress



TRT result:

2.5 W/mK

Help with further datasets requested

Conclusions

- Traditionally Interpreted TRT:
  - 300mm piles, single U, AR=50 >> probably OK
  - But need 3+ days of data, moderate diffusivity, stable power
- Larger diameter, more pipes:
  - Interpretation must treat concrete as transient
  - Longer tests ?
  - Low diffusivity?
- Laboratory Testing:
  - Transient approach better; understand limitations
- Important to communicate appropriate error bar

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Acknowledgements

- Professor William Powrie, Miss Jasmine Low
- Funding:
  - Mott MacDonald,
  - Engineering and Physical Sciences Research Council,
  - Royal Academy of Engineering
- Collaboration
  - Virginia Tech, Cambridge
  - Arup, Geothermal International, Berkel & Company