When Groundwater Meets Geophysics

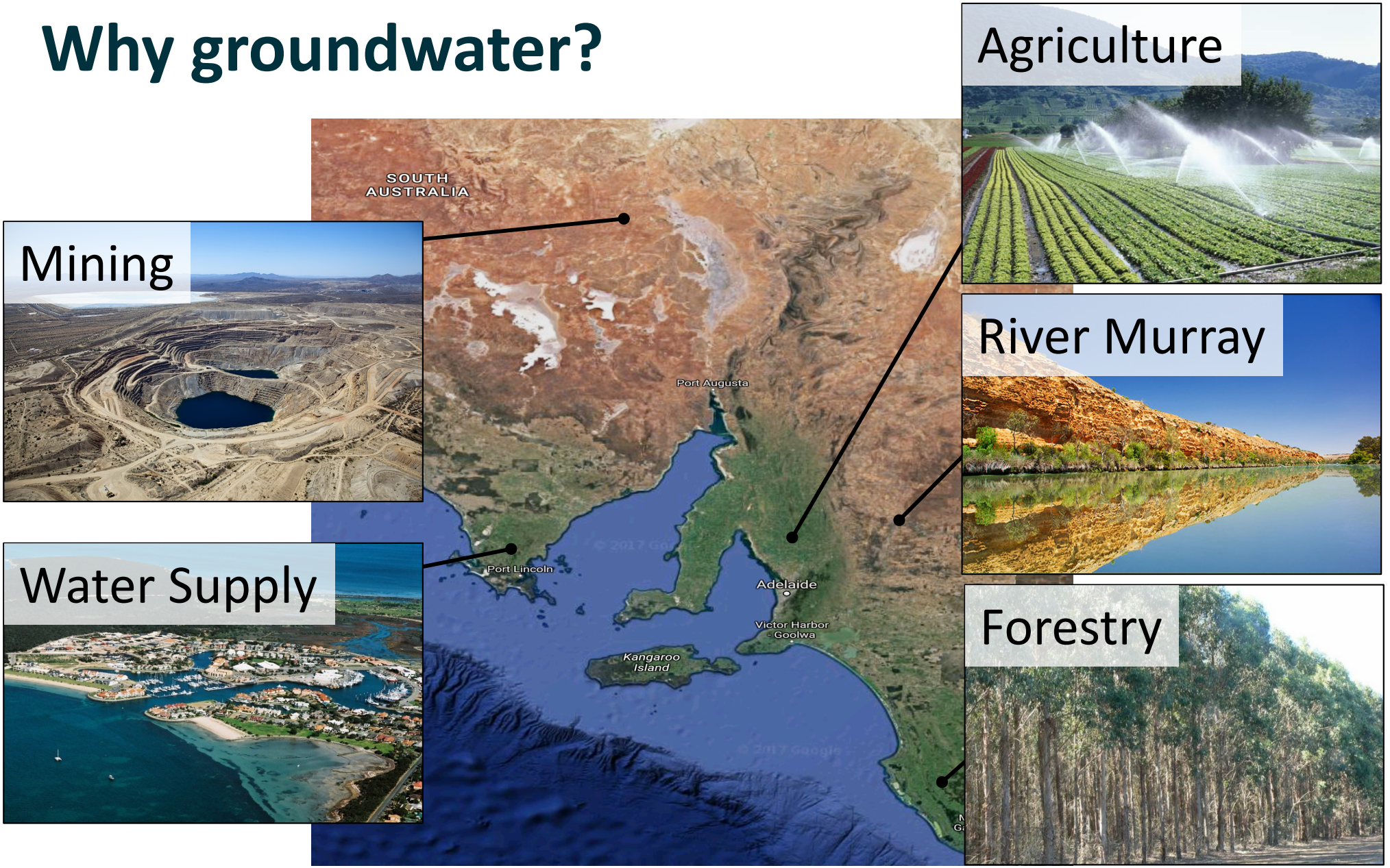
Improving next-generation hydrogeological models with geophysics

Chris Li | PhD

28 July 2017

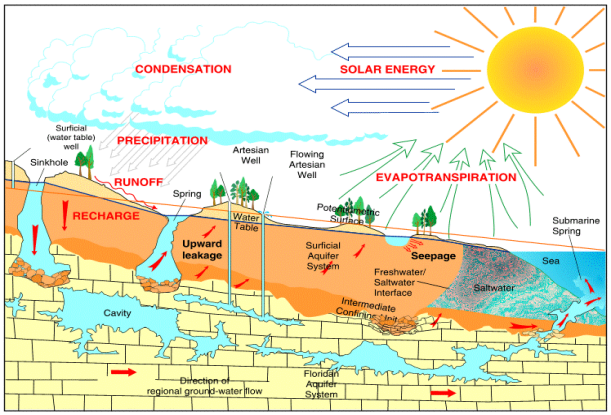
Supervisors: Graham Heinson (UoA)
Rebecca Doble (CSIRO)
Graham Green (DEWNR)

Why groundwater?

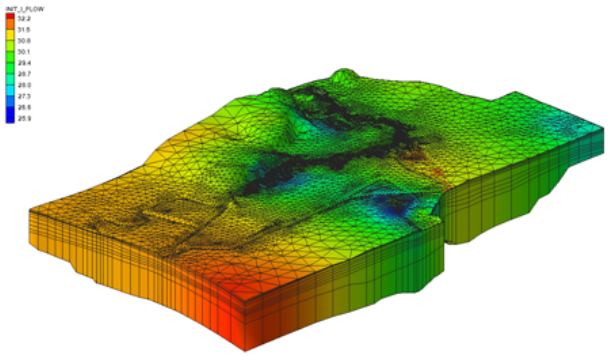


How do we manage groundwater?

Collect data



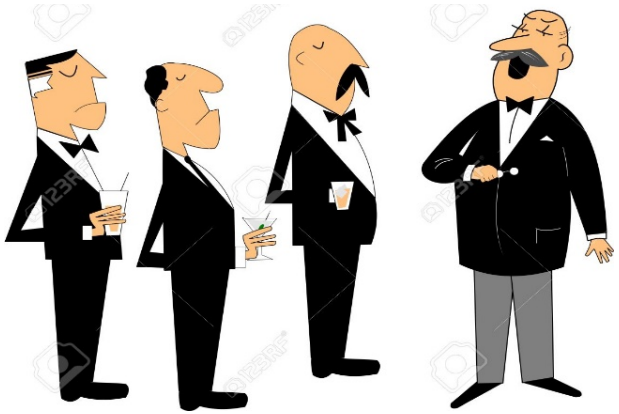
Conceptual model



Groundwater model

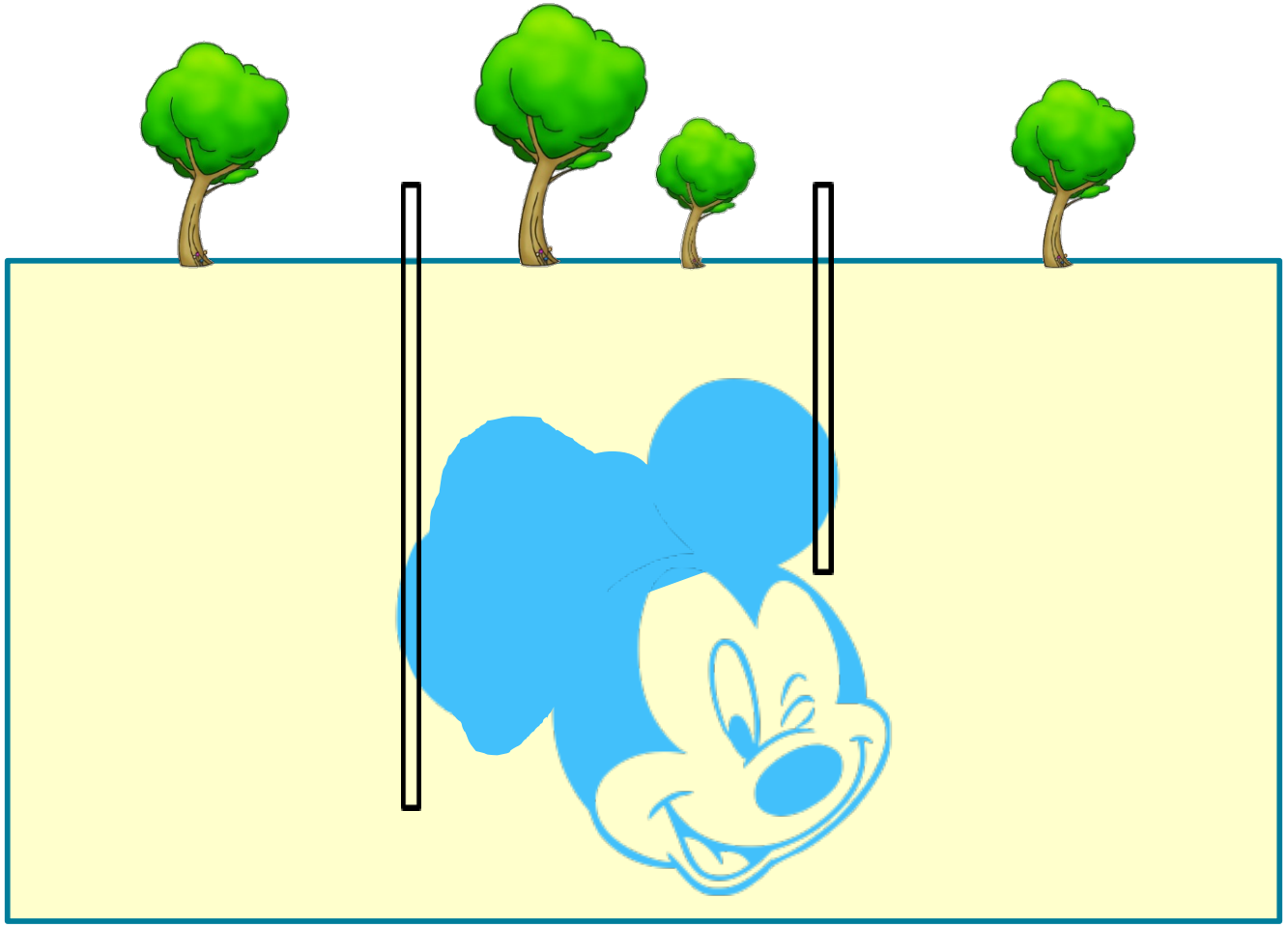
Calibration

Prediction

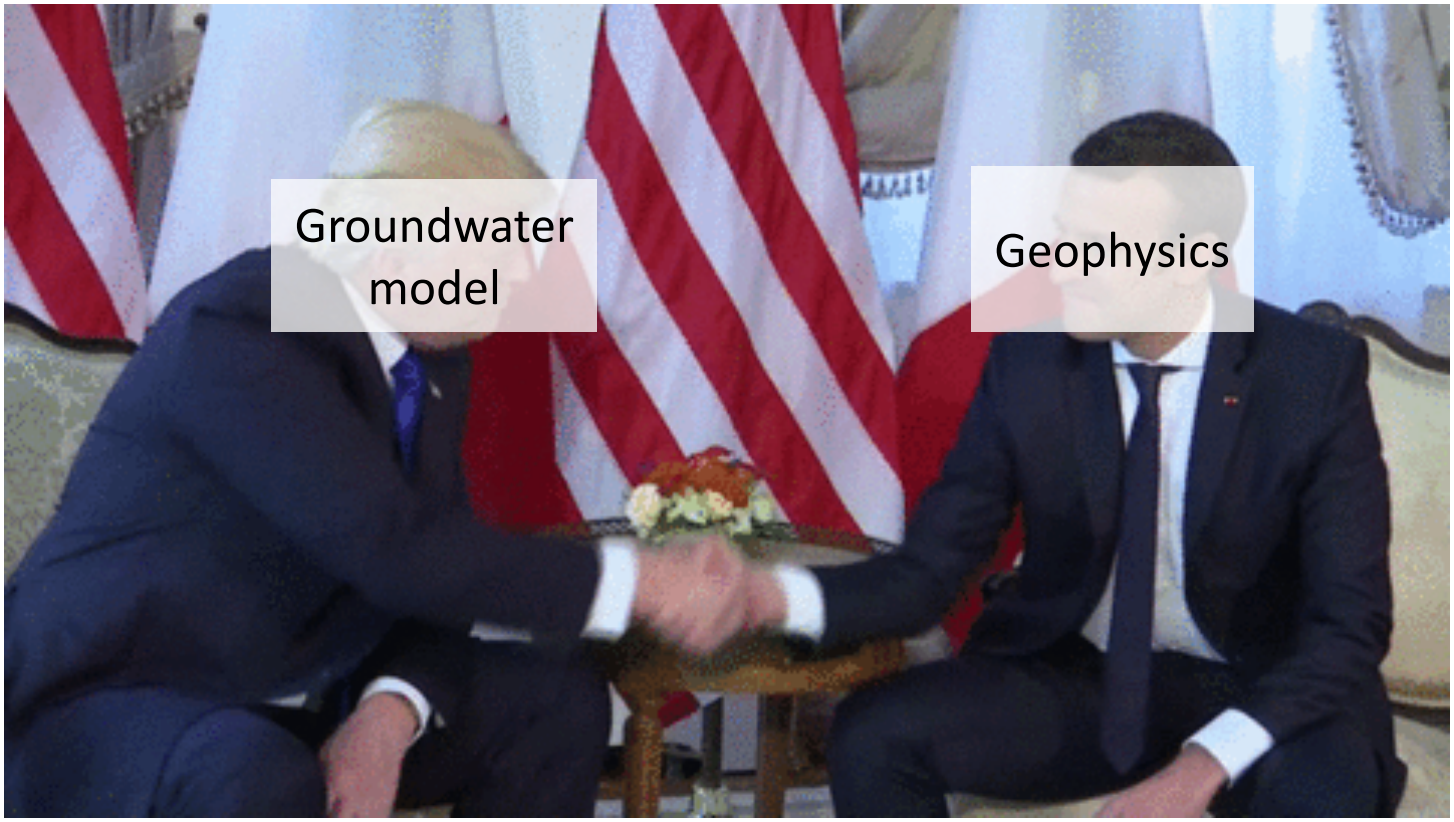


Decision makers

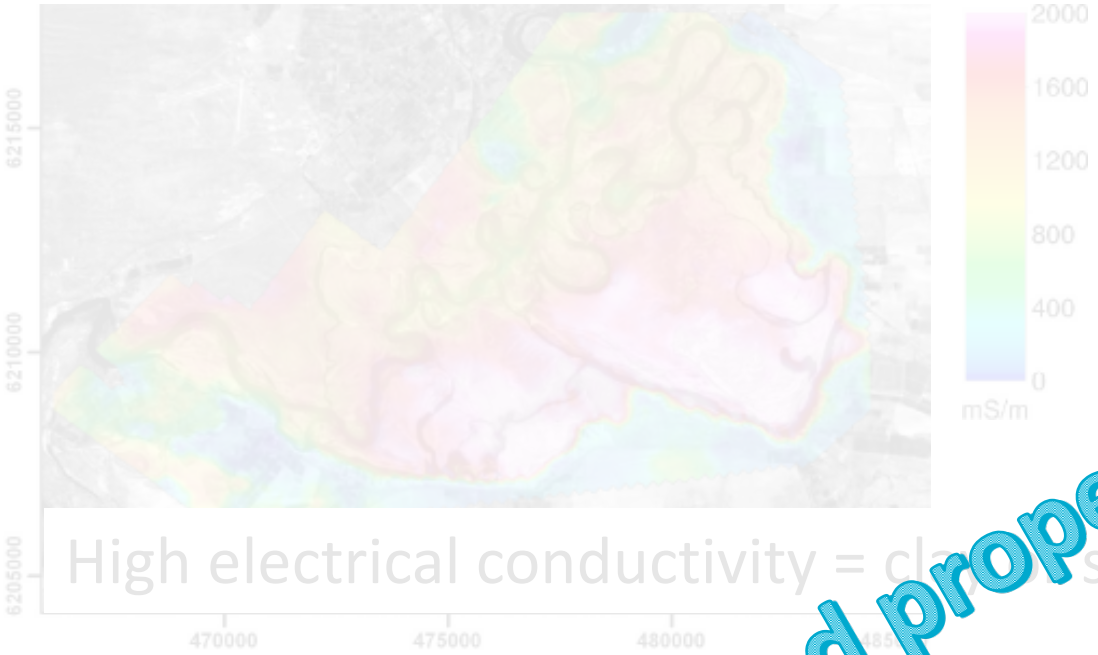
Limitations in groundwater modelling



What is my PhD about?



Limitations of geophysics for groundwater studies



High electrical conductivity = clay? saline groundwater?

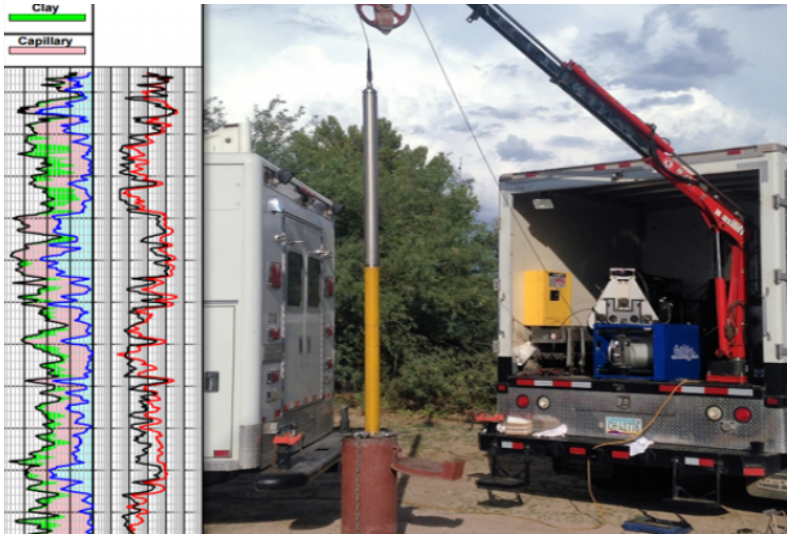
Inversion constraints may be unrealistic

Petrophysical relationship has high uncertainty

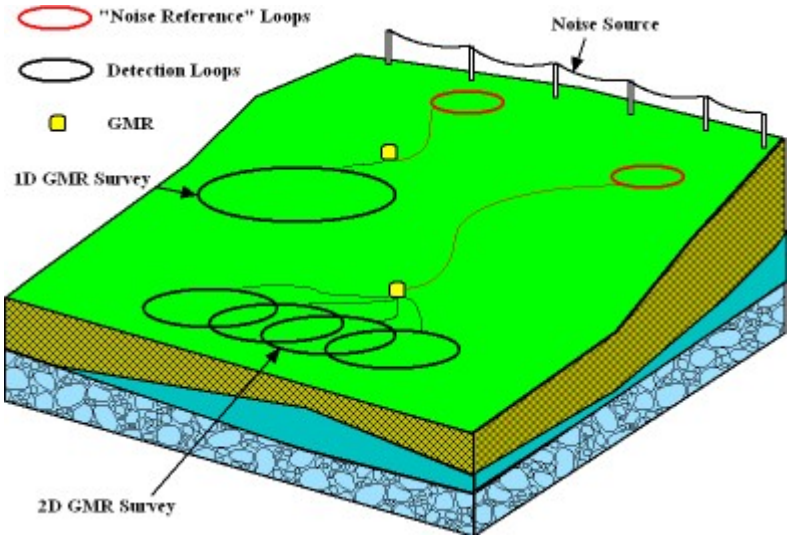
Groundwater-related properties are inferred

Nuclear Magnetic Resonance (NMR)

Magnetic Resonance Imaging (MRI)

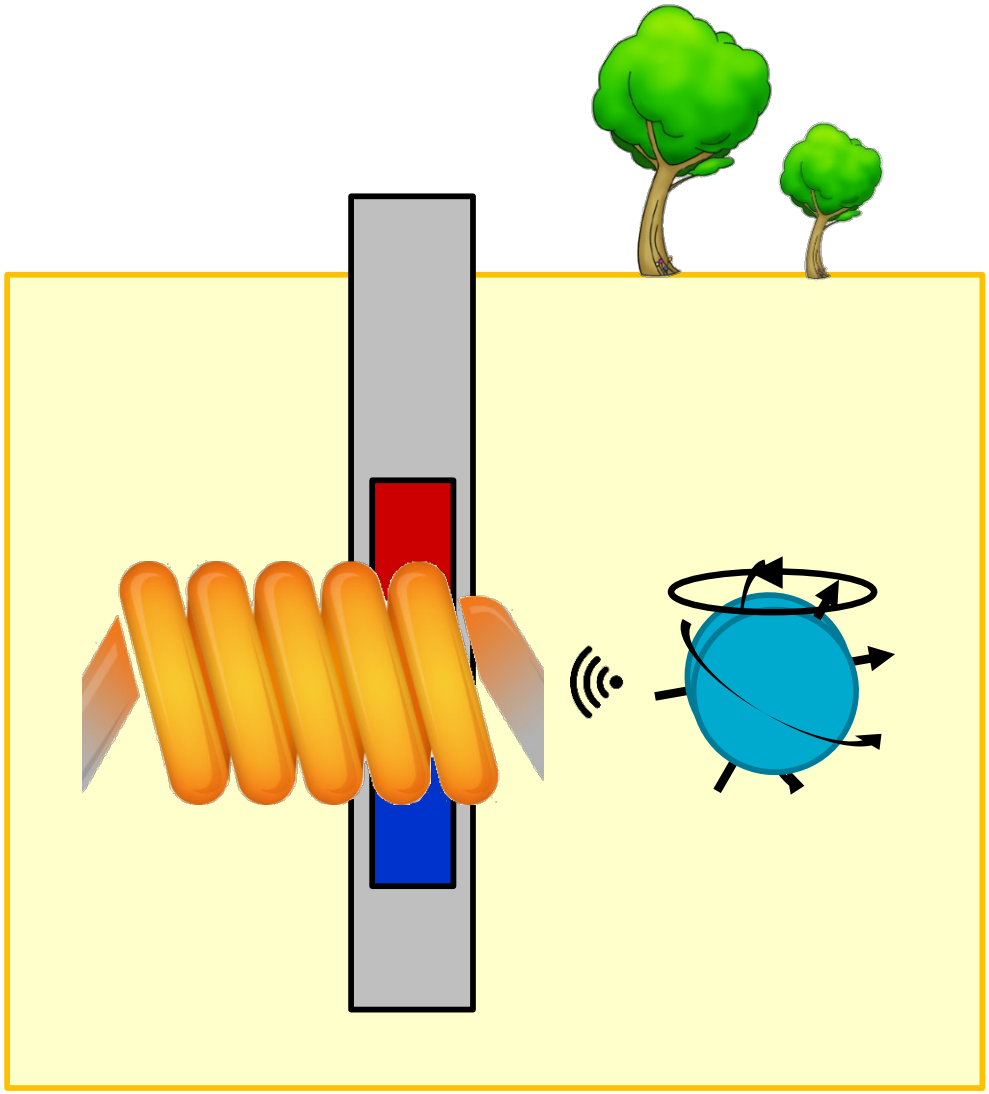


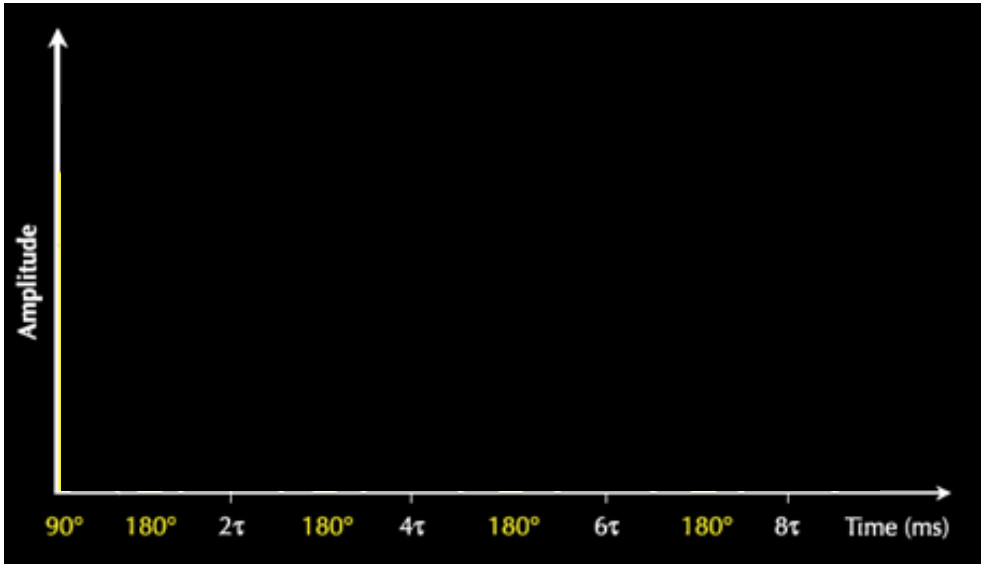
Borehole NMR



Surface NMR

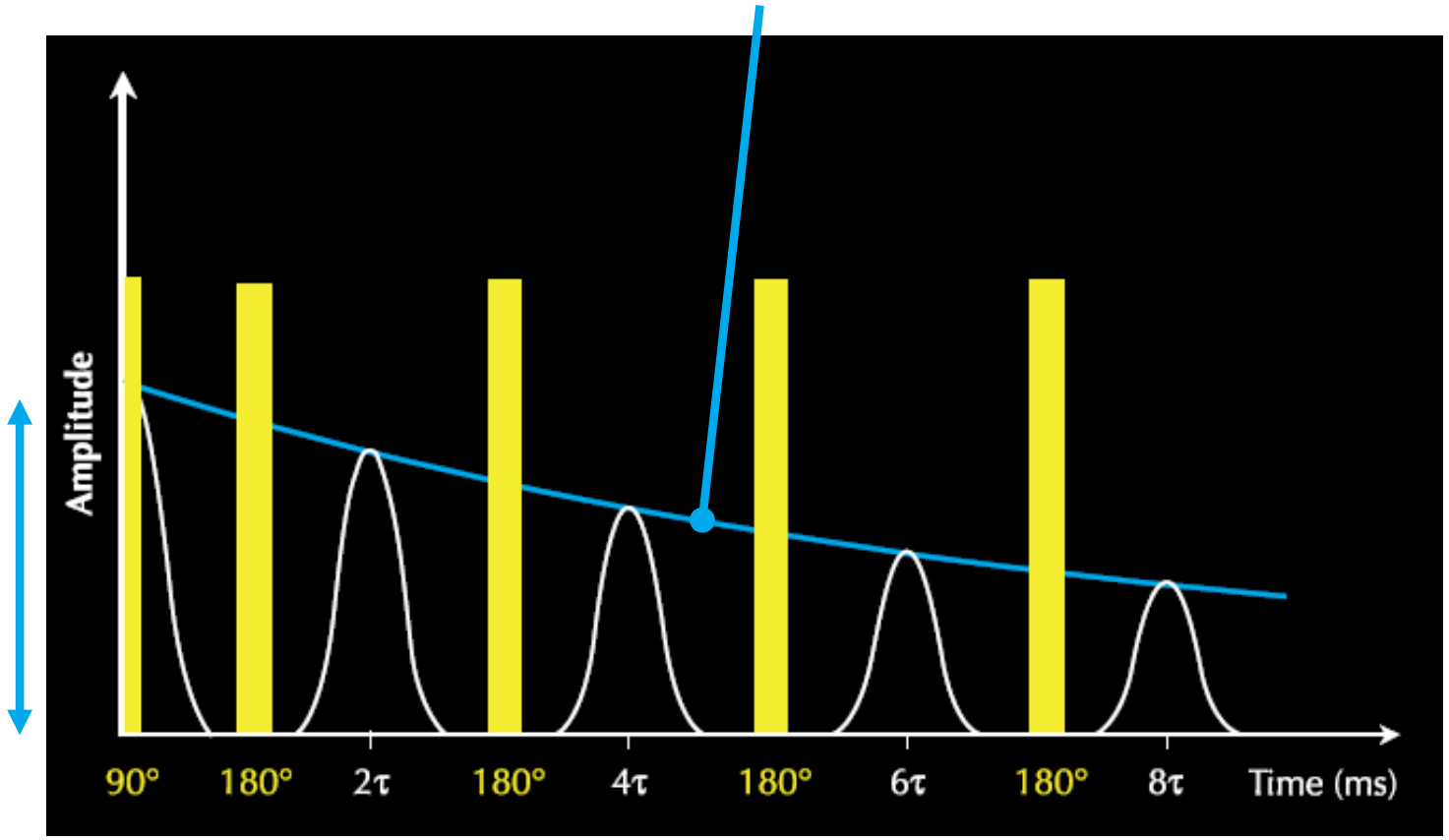
How does NMR work?





What can NMR tell us?

Signal decay pattern -> Time constant (T_2) -> Porosity and pore size distribution



Initial amplitude:
water content

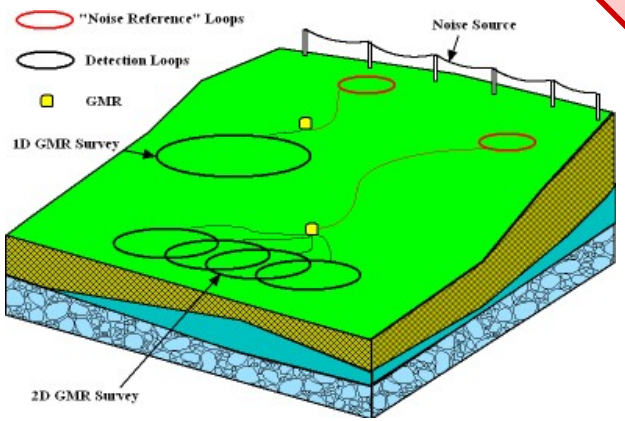
Schlumberger Droll Research equation:
Relative permeability

$$k = A\varphi^4 T_{2LM}^2$$

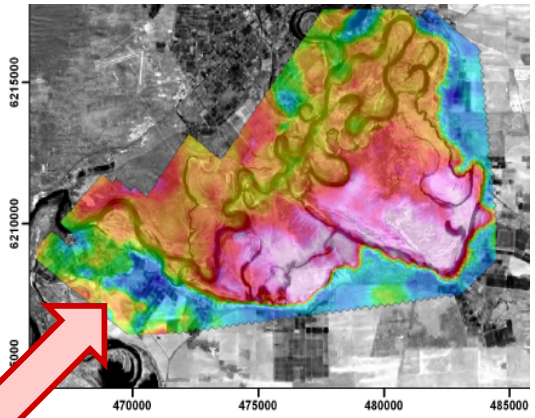
My research questions

EM

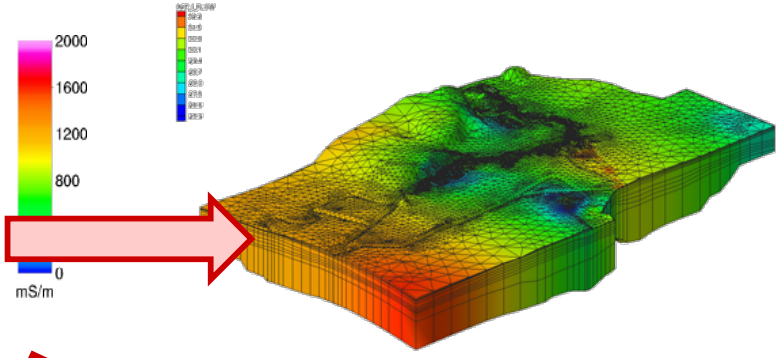
+



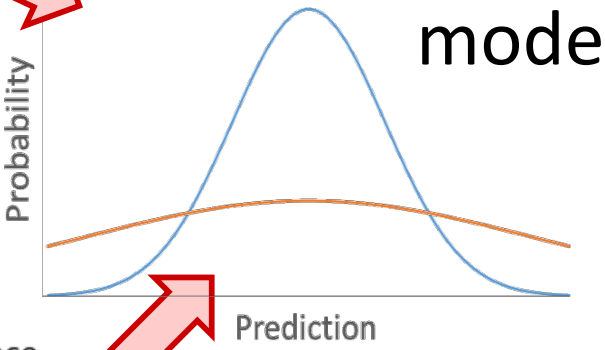
NMR

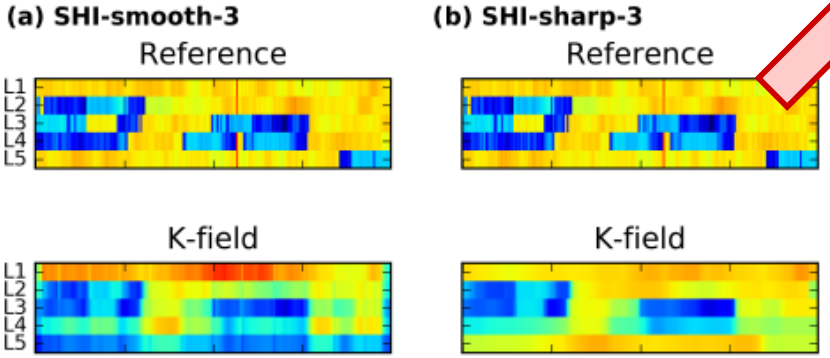


Groundwater Salinity



Groundwater model





Hydraulic conductivity

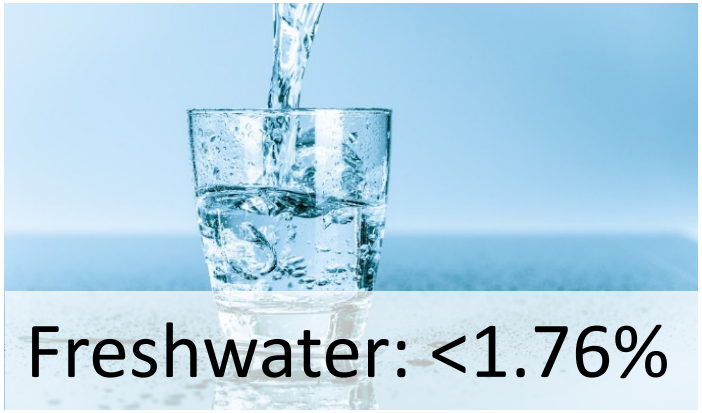
Thank you

Chris Li

PhD Student

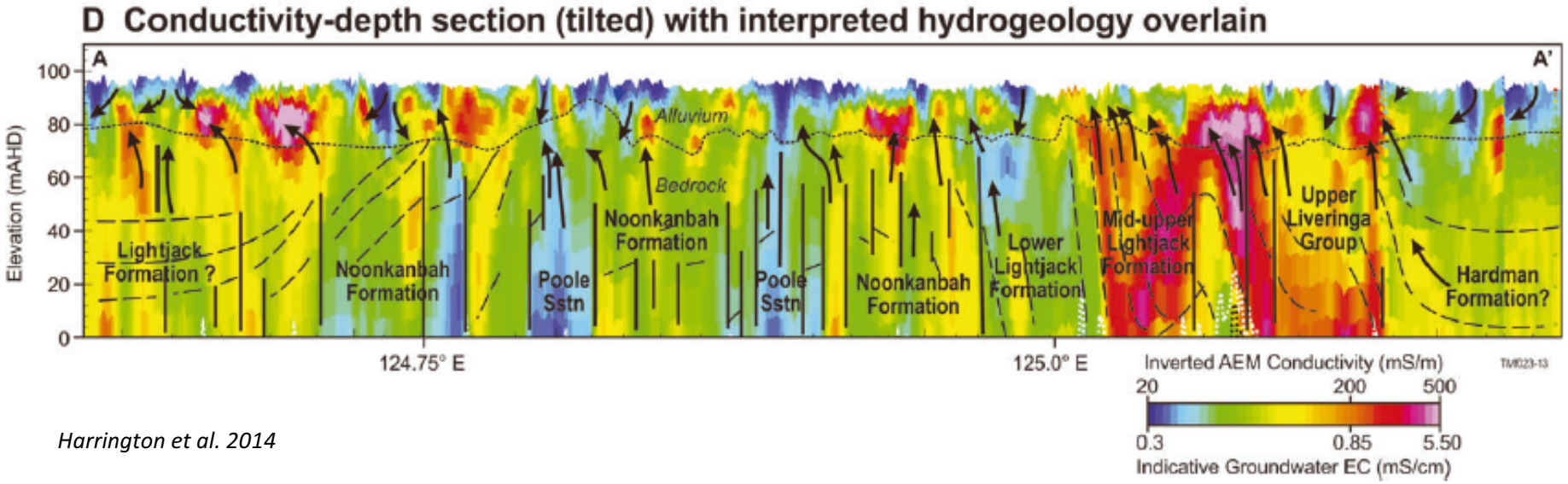
t +61 8 8303 8525
e chris.li@csiro.au
w www.csiro.au

Why groundwater?



Shiklomanov 1993

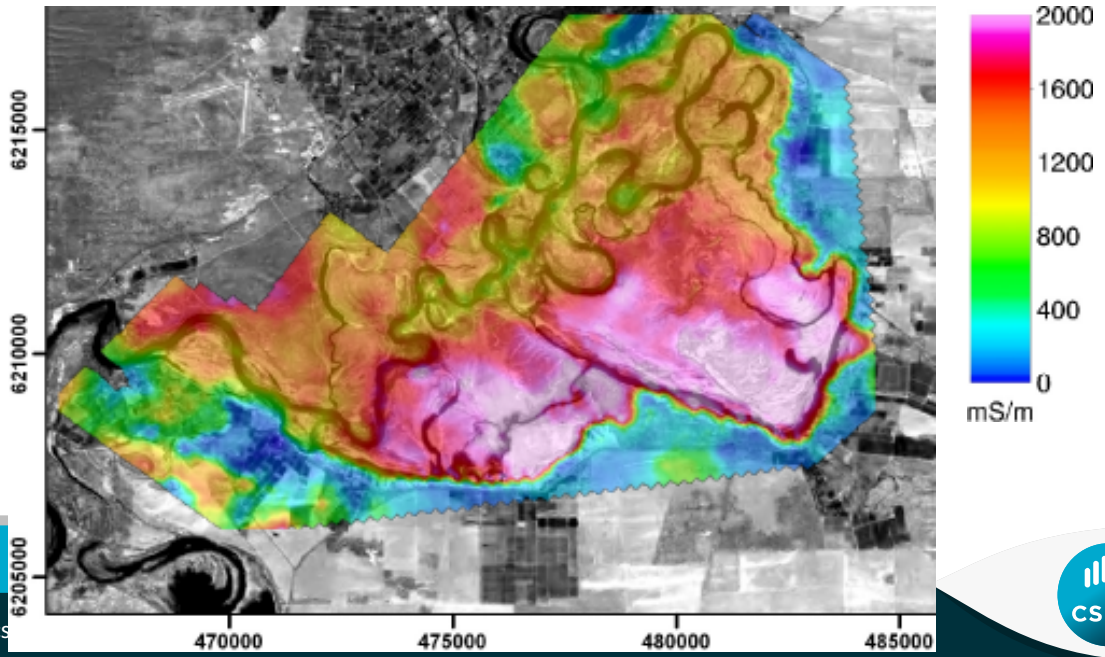
Using geophysics for groundwater studies



Harrington et al. 2014

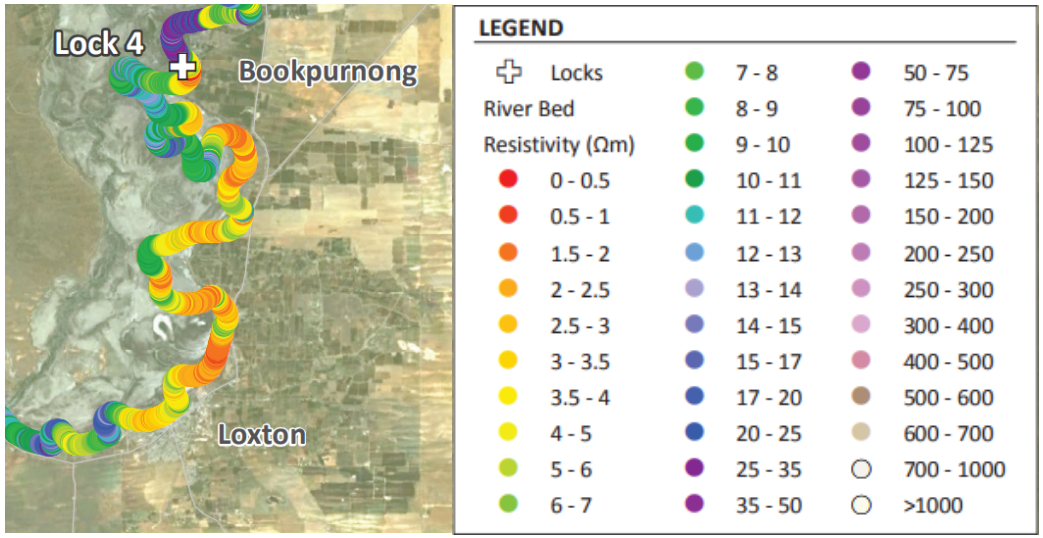
Hydrogeological characterisation

Groundwater salinity



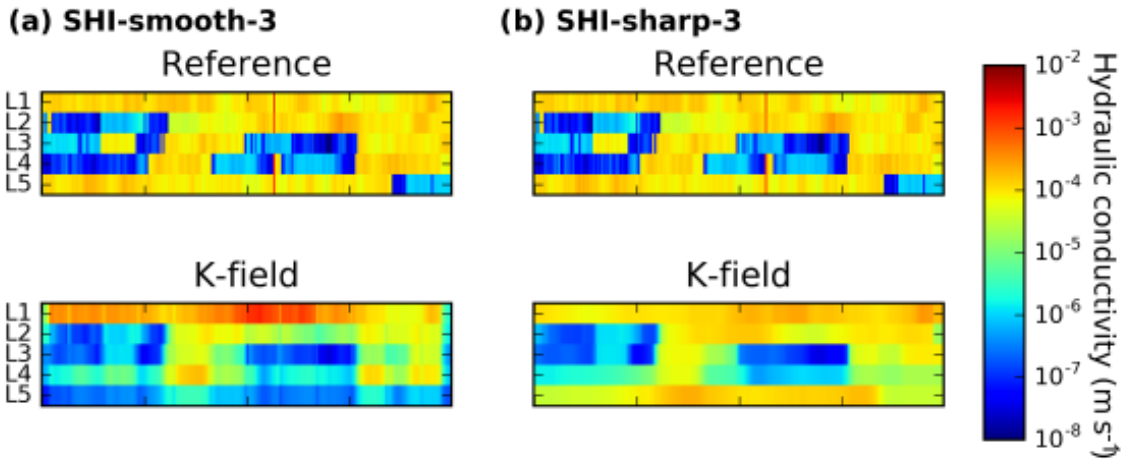
Fitzpatrick & Munday 2009

Using geophysics for groundwater studies



AWE 2011

Interactions with surface water



Christensen et al. 2017

Hydraulic conductivity

Study area

Government of South Australia
Department of Environment, Water and Natural Resources

Where is Calperum?

Why Calperum?

Cultural value

Ecological value

Icon site

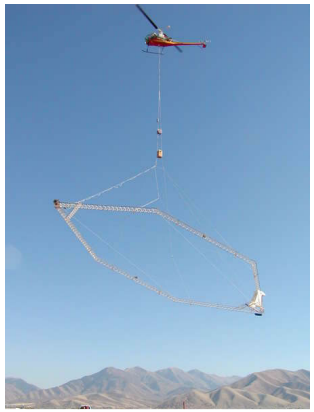
International significance

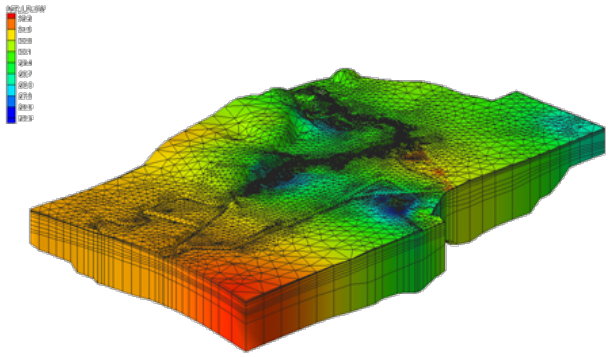
What I am going to do

Existing data

Field work

Groundwater modelling

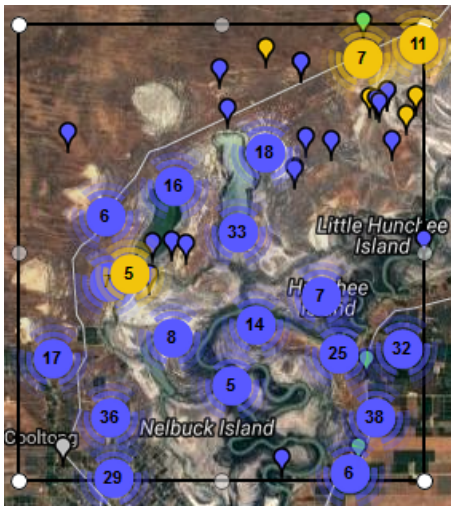


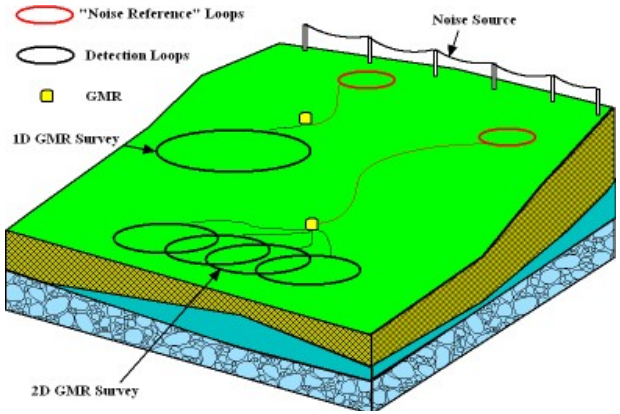


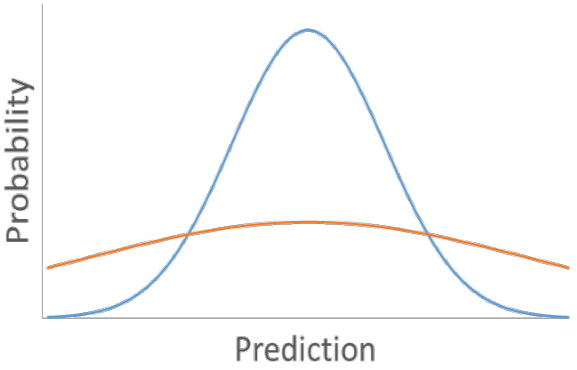
Airborne EM

EM

Incorporating geophysics







Boreholes

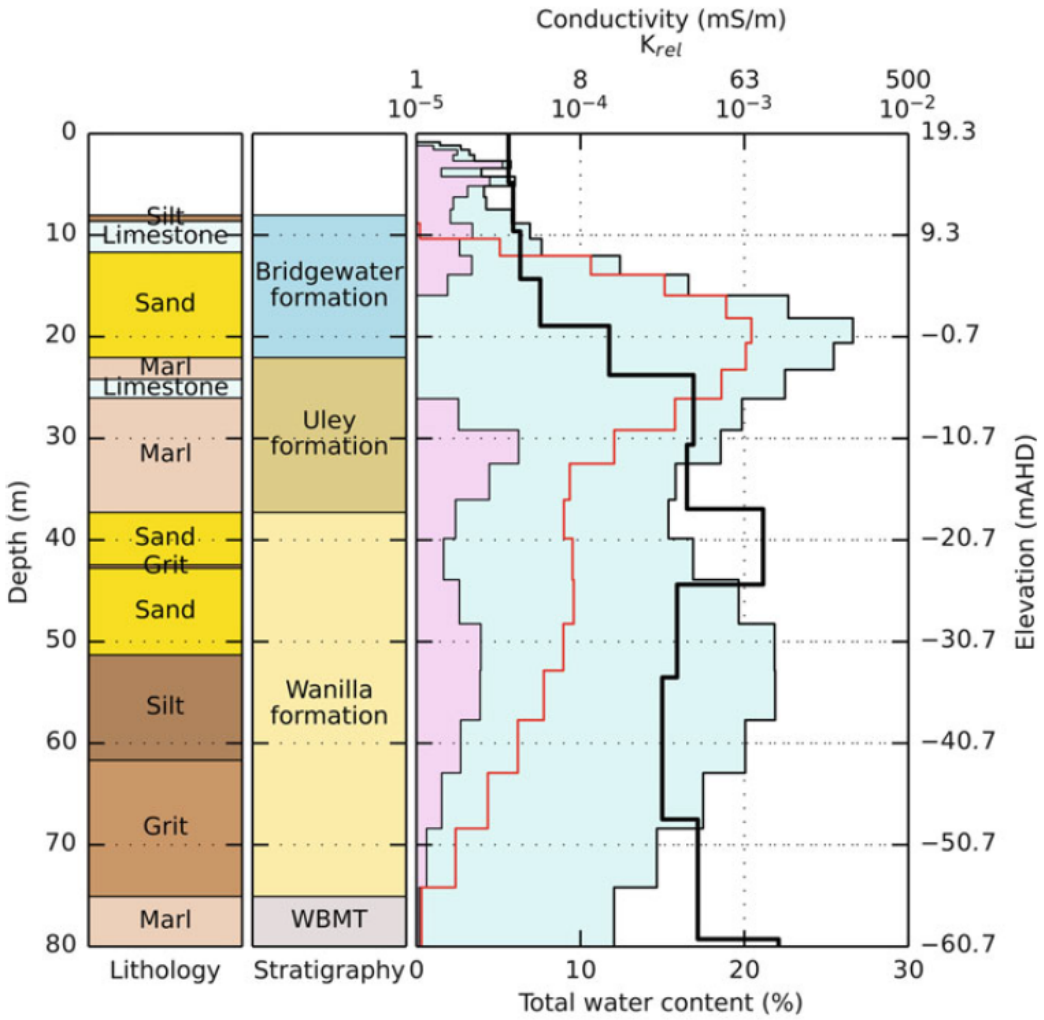
NMR

Reducing uncertainty

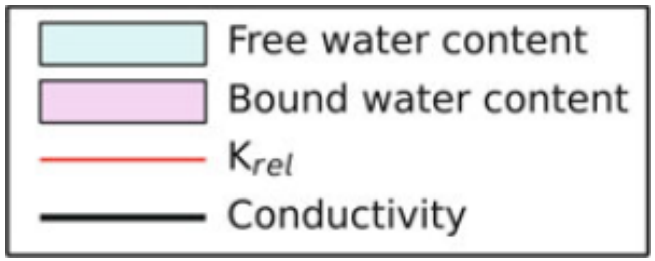
Conclusions

- Groundwater is important and needs to be managed properly
- Groundwater model is useful but hampered by large uncertainty
- Geophysics can assist groundwater modelling
  - However, most geophysical techniques can only infer groundwater-related properties
- Nuclear Magnetic Resonance (NMR) can measure groundwater-related properties directly
- This project is about using a combination of EM and NMR to improve groundwater modelling
  - Improving the accuracy of geophysically-derived data
  - Evaluating different ways of incorporating geophysics into groundwater models
  - Estimating how much model uncertainty is reduced by including geophysics

Using NMR for groundwater studies

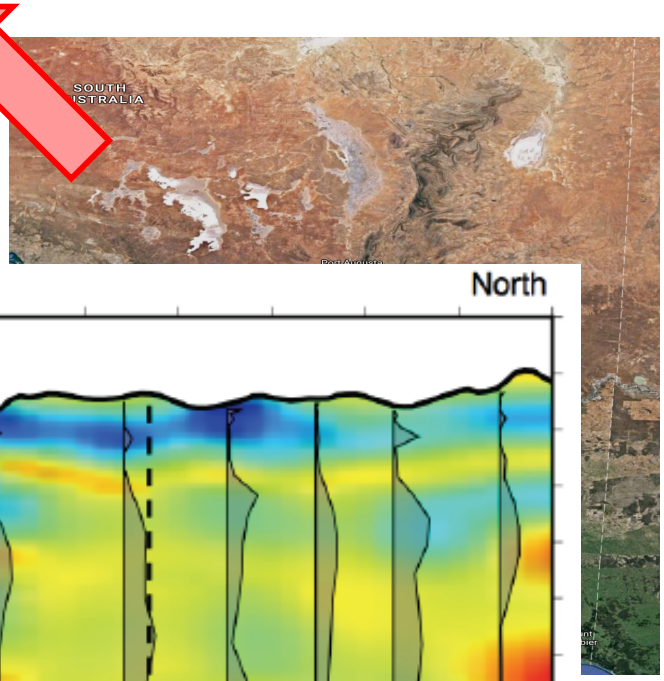


Davis et al. 2013



Using NMR for groundwater studies

APY Lands



Parsekian et al. 2013