AQUALINC

Modelling thermal interference from GSHP injection

H Rutter, M Fintoft, J Weir

GROUNDWATER | IRRIGATION | RESOURCE CONSENTS | FARM ENVIRONMENT PLANS | EFFLUENT MANAGEMENT | WATER MANAGEMENT

17 October 2017

Outline - Current issues

- Permitted to discharge into the Riccarton Gravels
- Mounding effects in shallow subsurface due to upward leakage
- Solutions…
  - Discharge to deeper aquifer
    - Temperature interference
  - Other possibilities

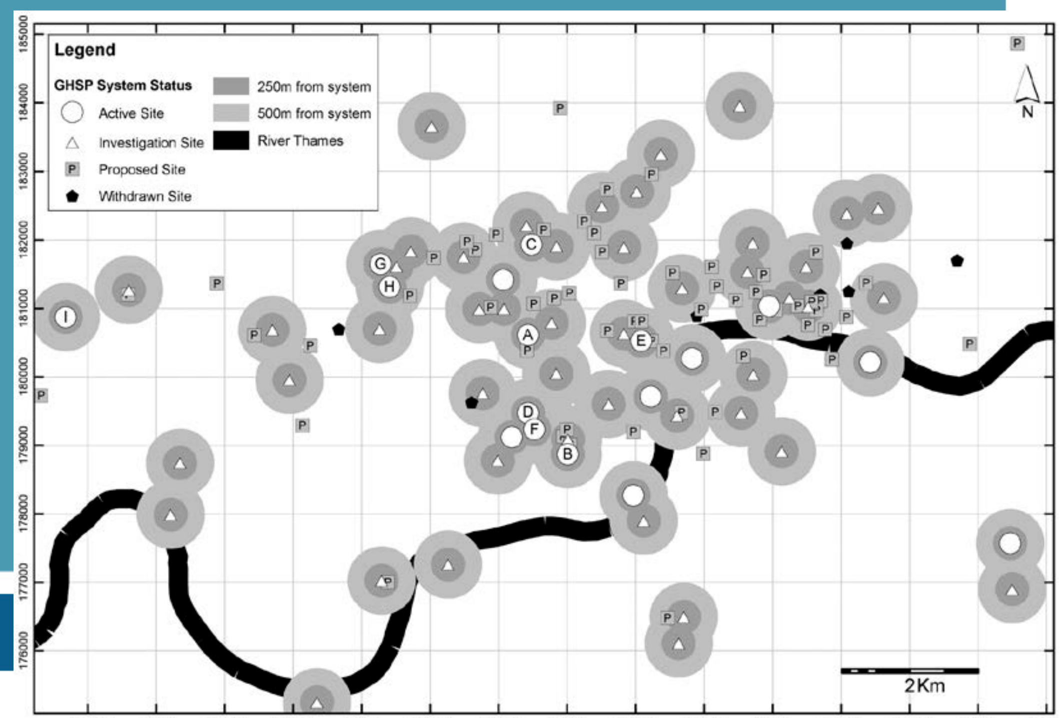
Thermal considerations of GSHP systems

- With long term operation of the system
  - Can the peak load be serviced by the aquifer without thermal interference between abstraction and injection bores?
  - Can the migration of thermal energy away from the site cause an unacceptable change to a temperature sensitive receptor?

(Williams and Preene - World Geothermal Congress 2015)

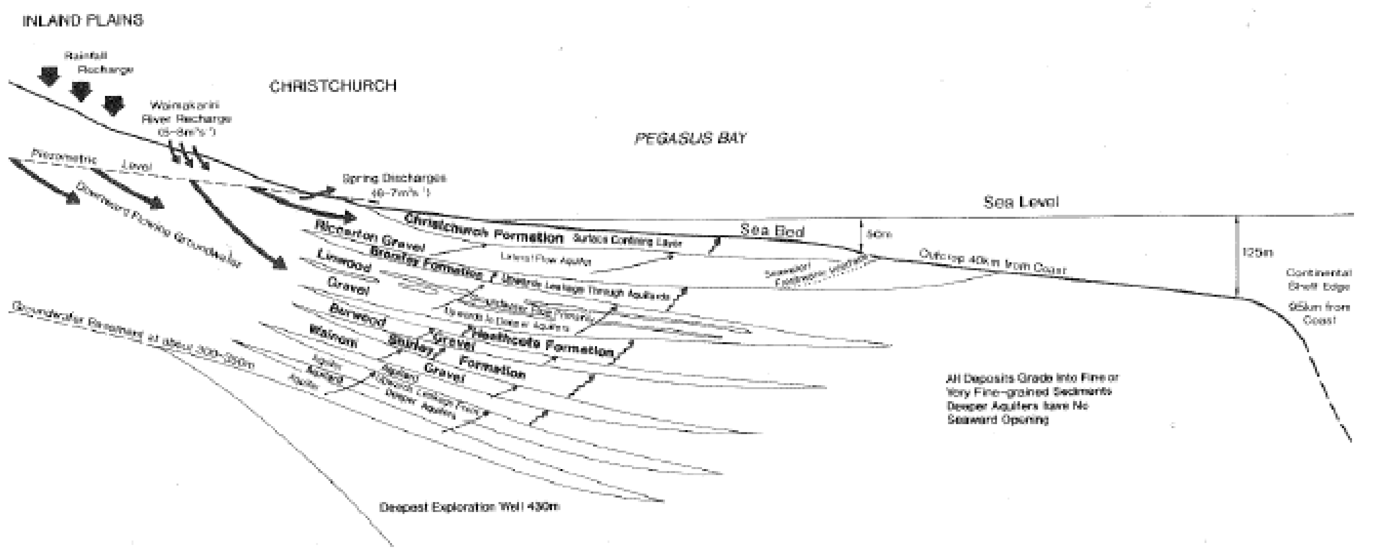
London

- Unconfined Chalk aquifer
- Open loop systems, mainly cooling
- Increasing density of systems leading to potential thermal interference
- Thermal breakthrough being observed in other areas



Christchurch geology

- Multi-layered system
- Advantages
  - Take from one aquifer, inject into another
  - No thermal interference
- Non consumptive take



Aquifer properties

	Depth	Thickness	Number of tests	Average well depth (m)	Highest GWL (m amsl)	Minimum Transmissivity (m^2/d)	Maximum Transmissivity (m^2/d)	Average Transmissivity (m^2/d)
Springston Formation	<13 m	≈10 m	4	9.2	3.2	3000	3500	3250
Riccarton Gravel	20-40 m	≈ 15m	53	25.2	5.1	100	20000	4124
Linwood Gravel	50-85 m	variable	34	59.5	3.2	36	3888	1204
Burwood Gravel	95-105 m	≈5 m	8	75.9	4.6	237	5292	1883
Wainoni Gravel	115-125 m	≈5 m	18	138.9	8.9	596	9000	3618
Aquifer No 5	>125 m		8	186.9	NA	1470	8500	4360

Existing systems

- Permitted activity rule - abstract from Linwood/Burwood Gravels (depths 30 – 100m) and reinject into Riccarton Gravels
- Limited permeability of Linwood/Burwood Gravels
  - Sand issues
- Wainoni Gravels may be used
- Riccarton Gravels – some issues with reinjection

Mounding

- Mounding issues
  - Modelling has raised issues about potential mounding in shallow sediments
- Can we discharge into a deeper aquifer?
- Potential thermal interference between abstraction and injection bores
  - Other issues

Numerical modelling

- Injecting into Linwood Gravels at depths of 57 – 65m
- Injecting
  - Maximum 80 l/s,
  - 48 l/s over 365 days
- Delta T
  - 6 degrees below ambient in autumn, winter and spring
  - 2 degrees above during summer
- ECan scheme had to be taken into account

Existing hydrogeological conditions

- Most existing bores shallower than 40m
- Increasing artesian head with depth

Depth (m bgl)	Average WL (m)
0 - 40 m	-2.65 m
40 - 80 m	+ 1.55 m
80 - 120 m	+ 5.79 m
120 - 160 m	+ 6.81
160 - 200 m	no data
200 - 240 m	+ 8.7 m

Modelling

- Numerical model developed
  - 2 x 4 km grid
  - 10 x 10m cell size
- Incorporating results from aquifer testing and using textbook values for matrix thermal conductivity, matrix bulk density, etc
- Transient simulation over 35 years

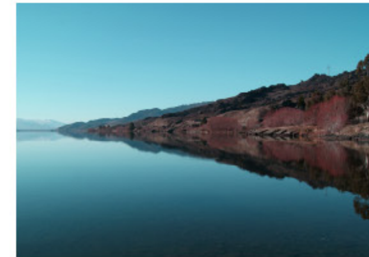
Model results - mounding

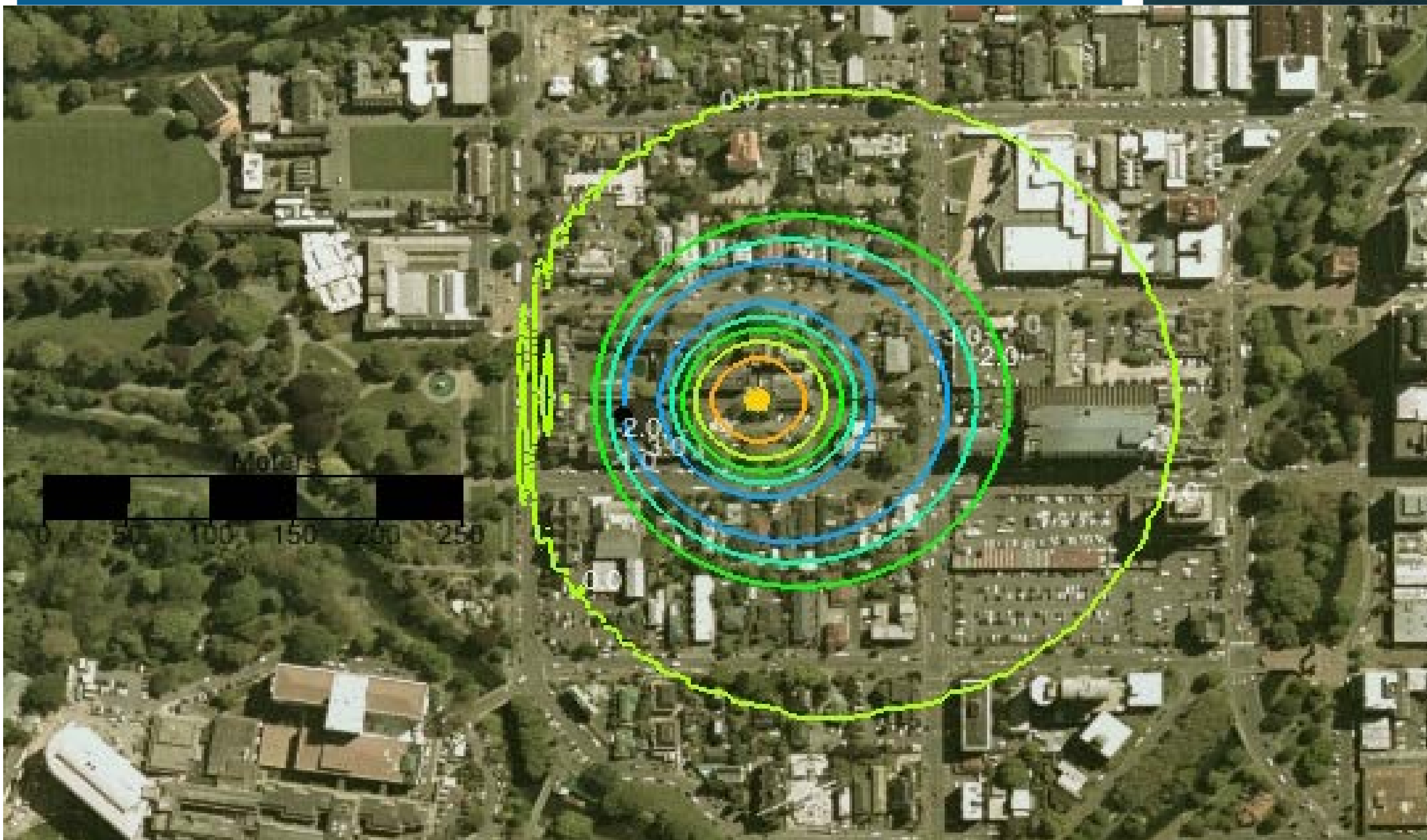
- Mounding reached steady state rapidly
  - After this, injected water balanced by water draining at boundaries
- Mounding measured at 15m at injection well
- Modelling suggested it dissipated away from injection wells
  - Less than 2m at property boundary

Model results - temperature

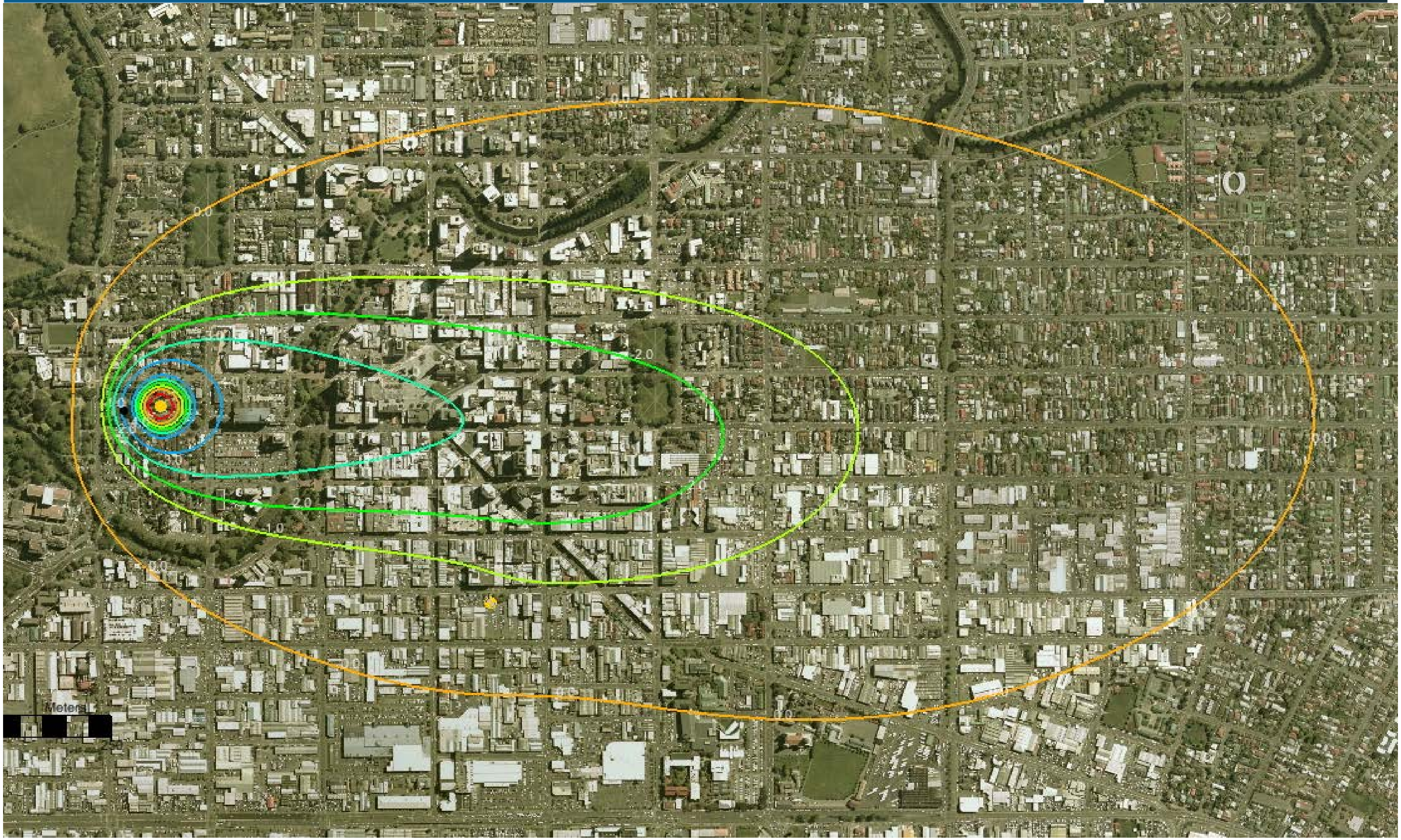
- Model based on:
  - 48 l/s of warm water with delta T of 6 degrees in Autumn, Winter, Spring
  - 48 l/s of cool water with delta T of 2 degrees in Summer
- Within 1 year, 6 degree delta T beyond property boundary
- Temperature plume reached steady state after 30 years
- Impacts on ECan scheme
  - Less than one degree
  - Slightly deeper aquifer

Predicted change in groundwater temperature after 1 year in the injection layer (3)





Predicted groundwater temperature plume after 35 year of continuous injection in Layer 3



Discussion

- Highlighted possibility for thermal interference if water is injected into an aquifer being used for abstraction for GSHP
- Simple modelling
  - Not calibrated
  - Aquifer heterogeneity
  - Simplistic GSHP operation
- Need for further monitoring of temperature as well as water levels

Conclusions

- Need to understand potential for mounding and resulting issues in shallow sediments
- Need to be thinking about alternatives
  - Possibly including injection into deeper layers
- Issues
  - Thermal interference
  - Greater artesian heads in injection layer
- Modelling suggested thermal interference could be an issue
  - How much of an issue?
  - We can model the T effects – need input from engineers to establish how much of an issue this would be for GSHP systems