

Shallow Groundwater Hazard in the Urban Environment

Monitoring, interpreting, and using high resolution data in an urban setting

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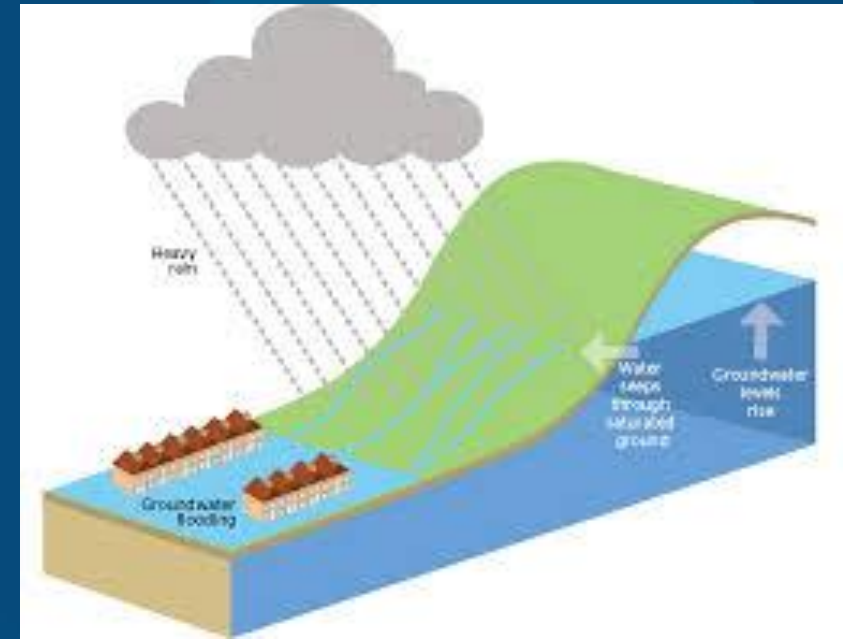


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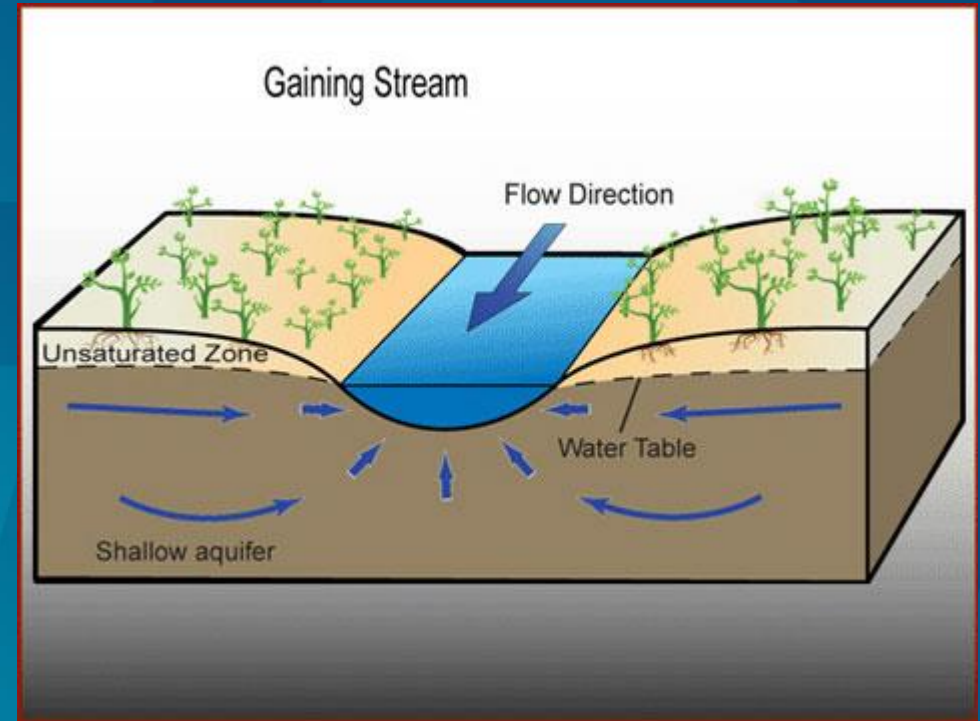
Shallow groundwater

- Focus on water resources
- In terms of hazards, focus on surface water
- Shallow groundwater now becoming a focus
 - Limited understanding as to how it varies in space and time



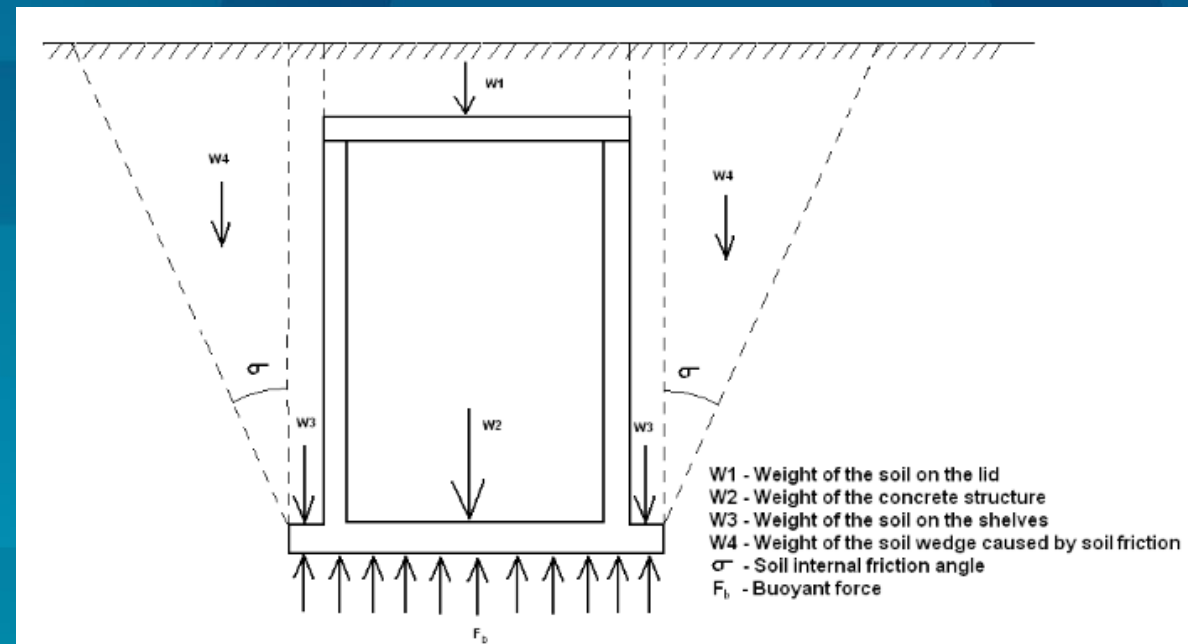
Why do we need to understand shallow groundwater?

- Shallow groundwater and surface water are linked
- Shallow groundwater is not far below ground



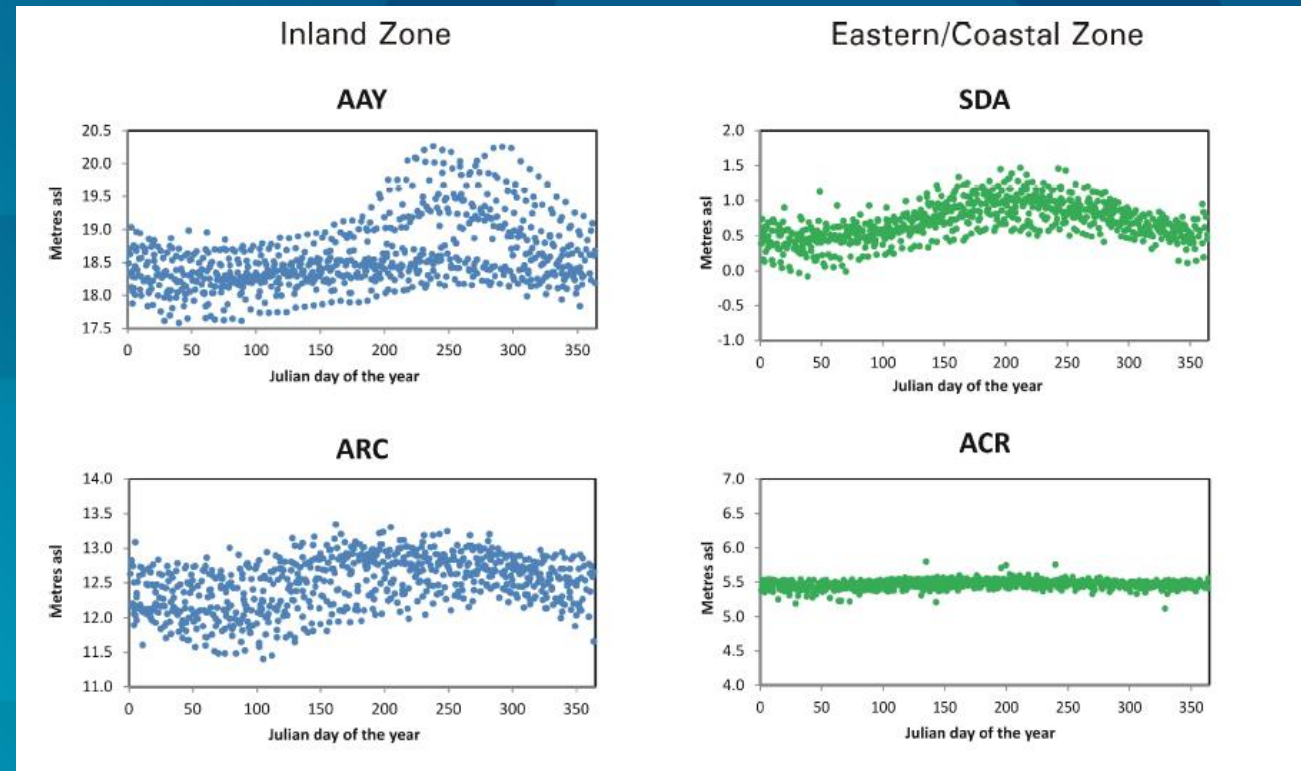
Consequences of higher-than-anticipated groundwater

- Flooding
- Liquefaction
- Inundation of services
- Roding
- Dewatering for construction
- Landscaping
- Post-construction solutions may be needed
 - prevent structural damage
 - limit infiltration
 - maintain serviceability



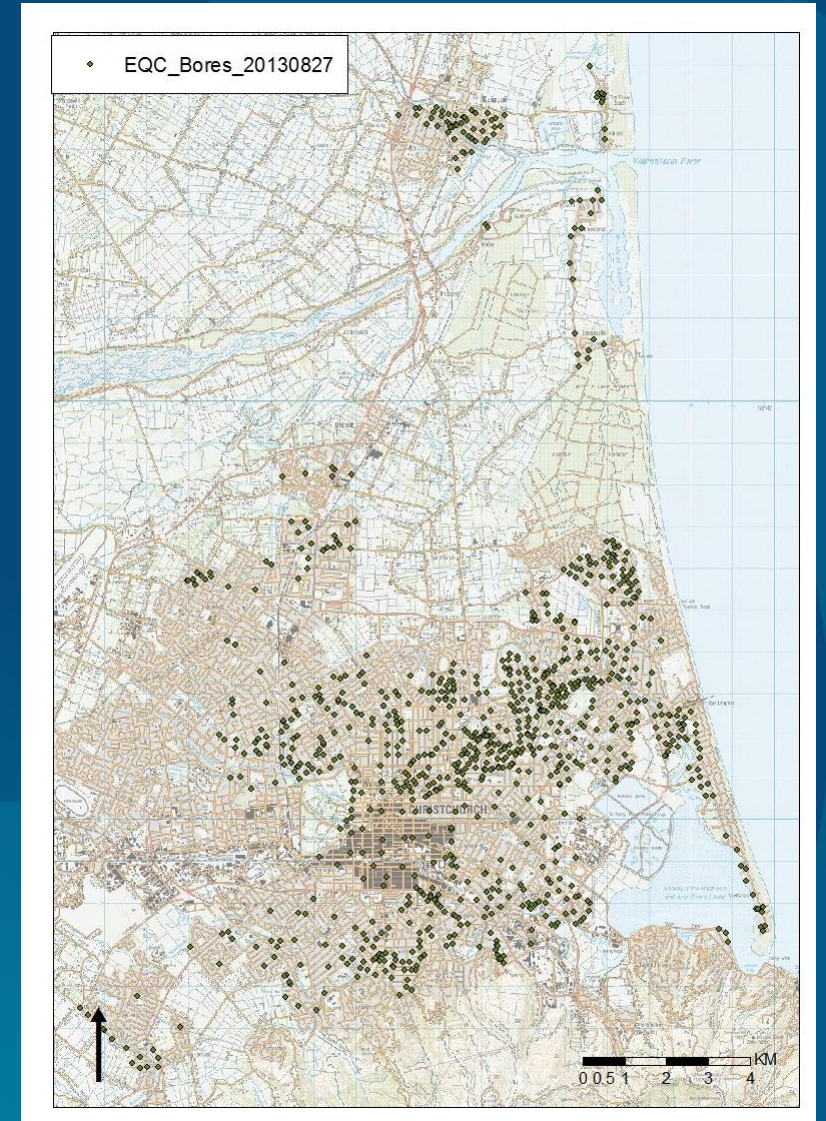
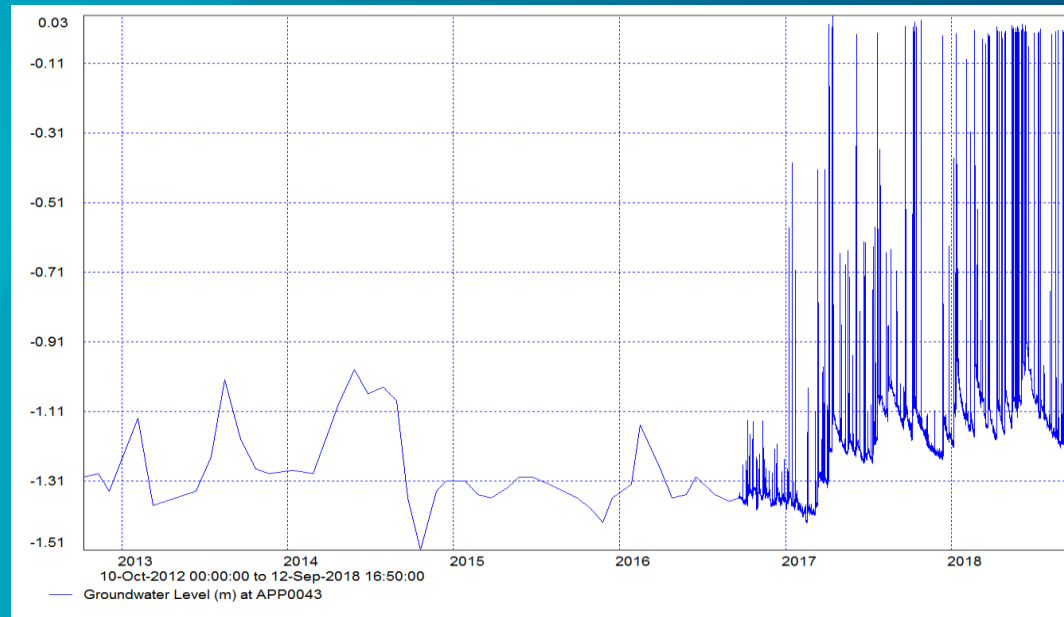
It's 4D problem!

- Groundwater is a 4-dimensional issue
- Varies:
 - In space
 - With depth
 - With time
- One off GWL measurements/short time series are not adequate



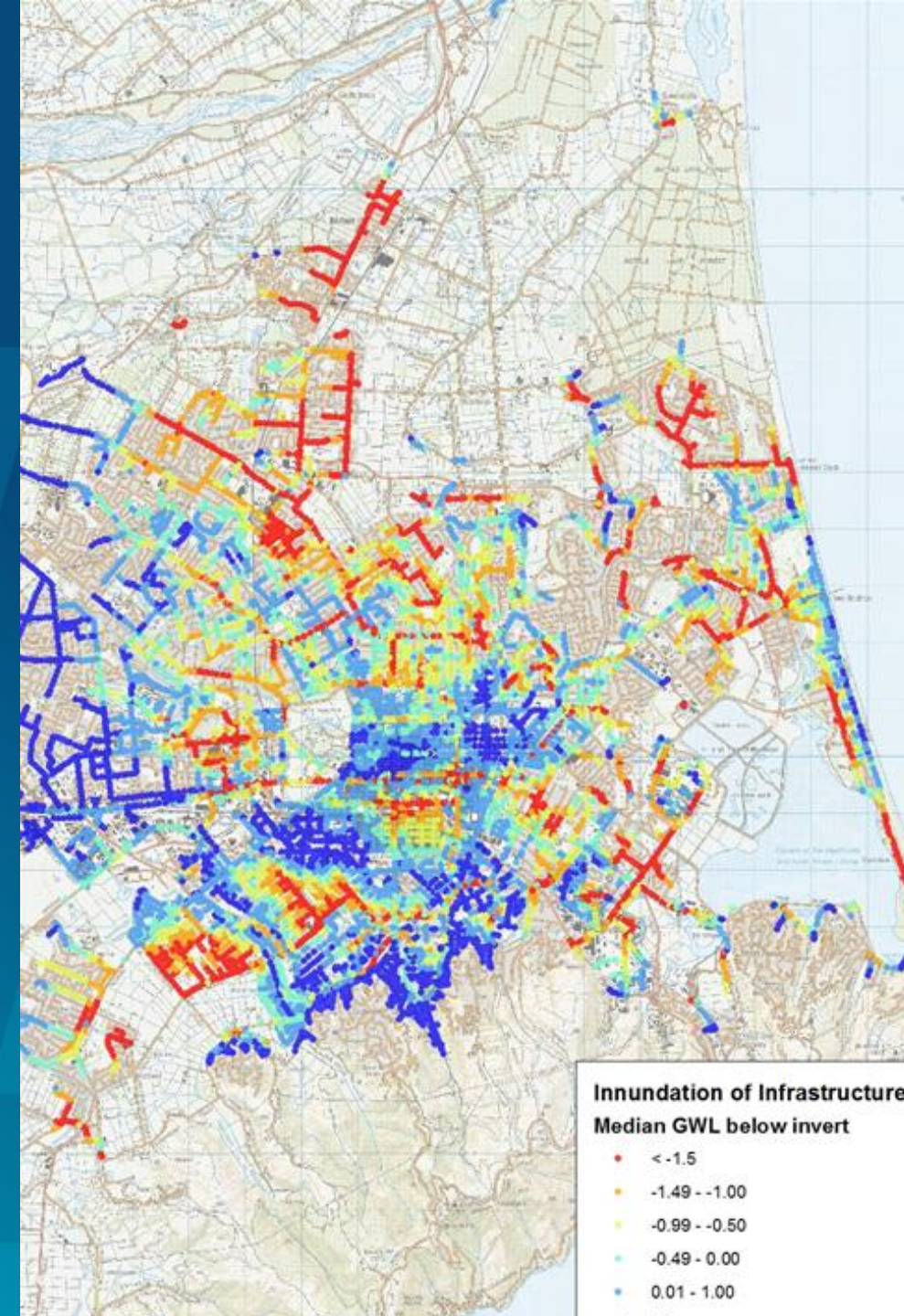
Limitations of available data

- Spatial distribution
 - Not usually optimum – developed for other purposes
- Temporal distribution
 - Representativeness
 - What do occasional GWL measurements data tell us?



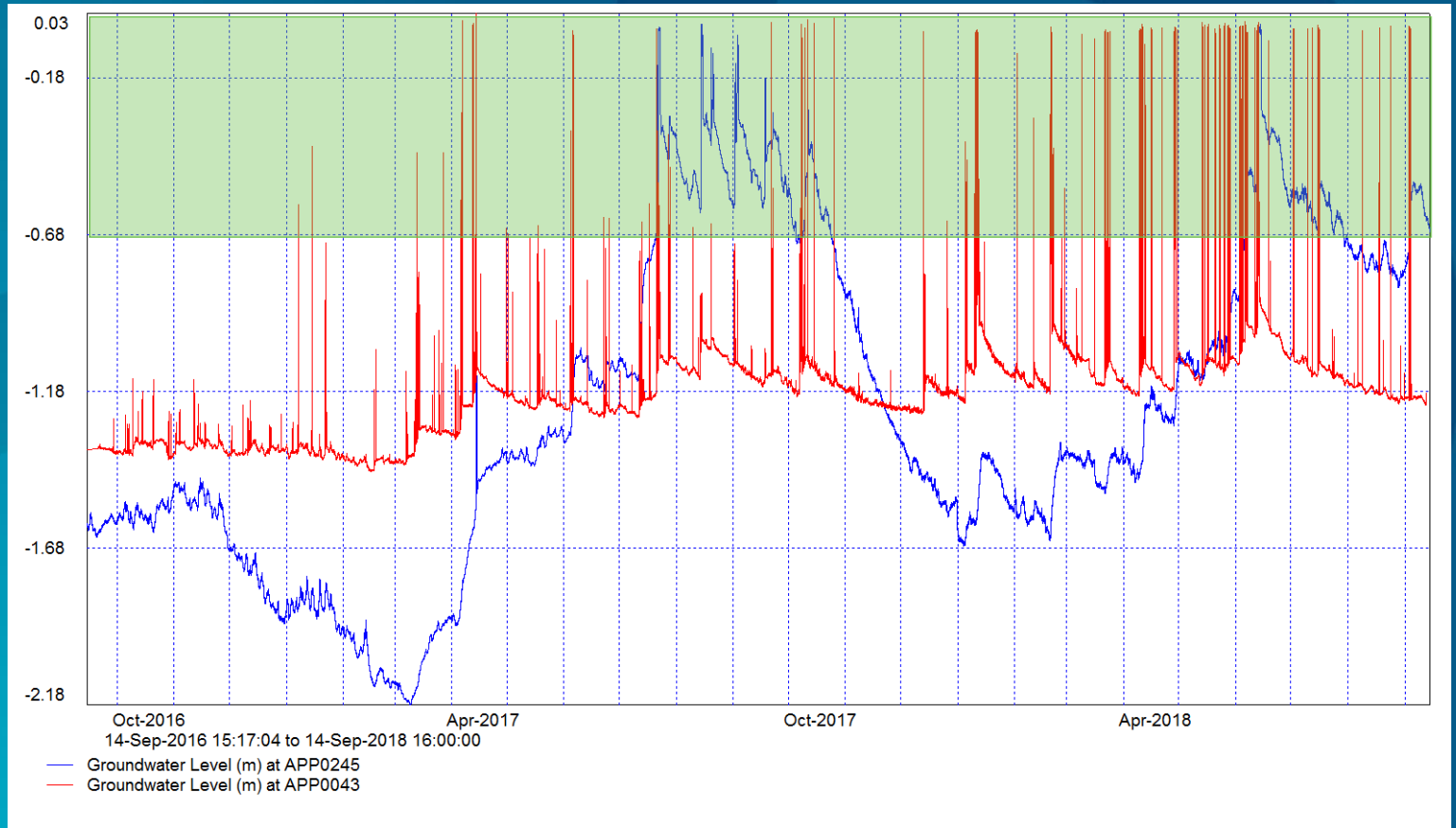
Developing our understanding

- If sufficient data, can develop “static” surface
 - High, low, mean groundwater levels
- Need good spatial coverage
- Adequate temporal coverage
- Useful for an overview



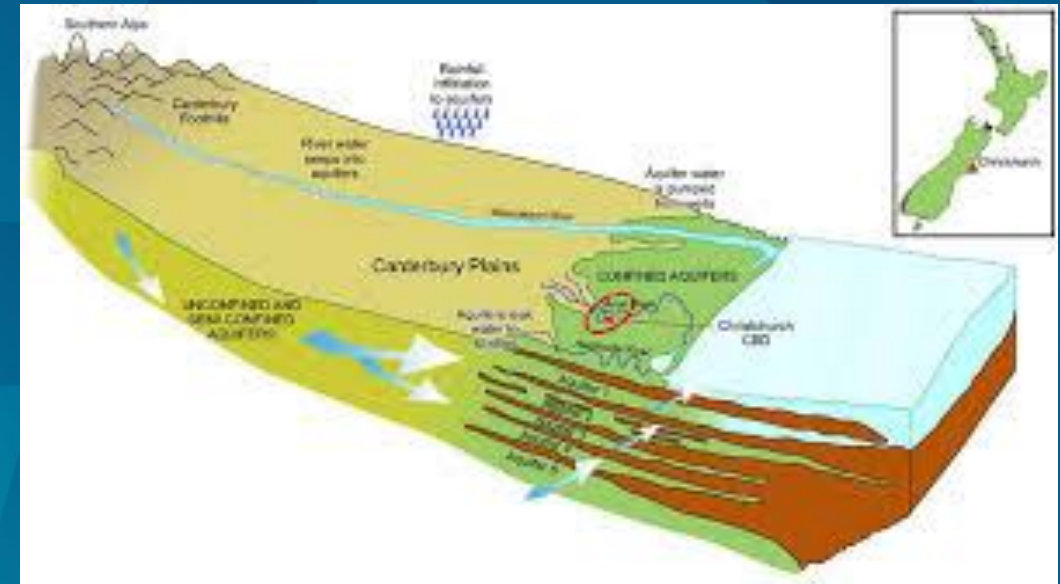
Hazard

- Hazard has magnitude and frequency
 - How long and how much are important
- Increasing concern about impacts of climate change and sea level rise
- Need to understand the dynamics much better



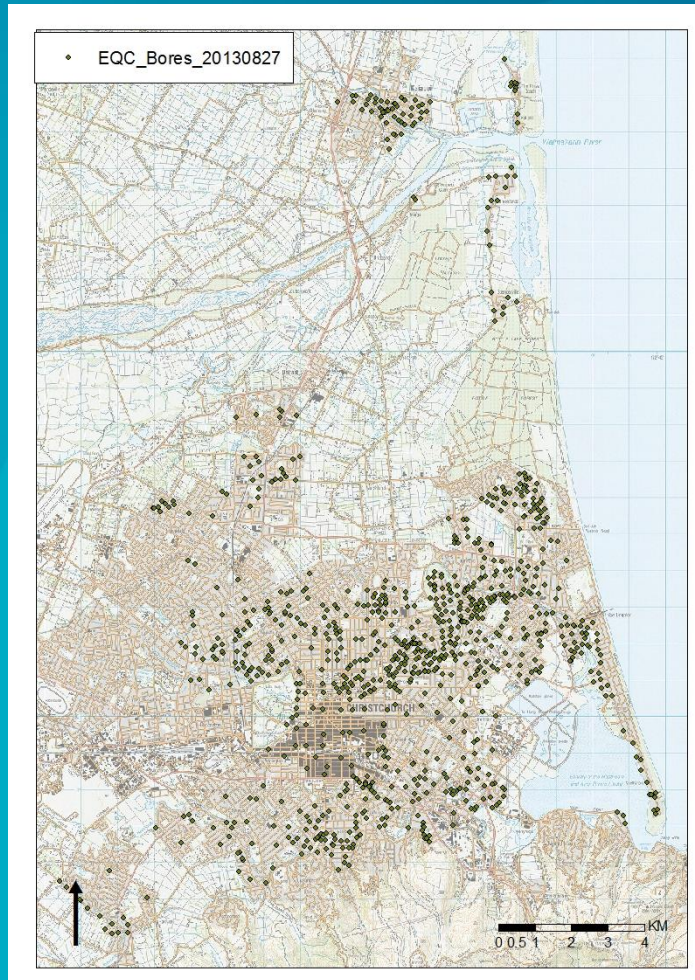
The Christchurch experience

- Setting
 - Mixed sediment types – gravels, sand silt, clays
 - Cut through by meandering rivers
- Multi-layered aquifer system at the end of the Canterbury Plains
- Earthquakes
 - Increased groundwater level monitoring
 - Unique shallow groundwater dataset

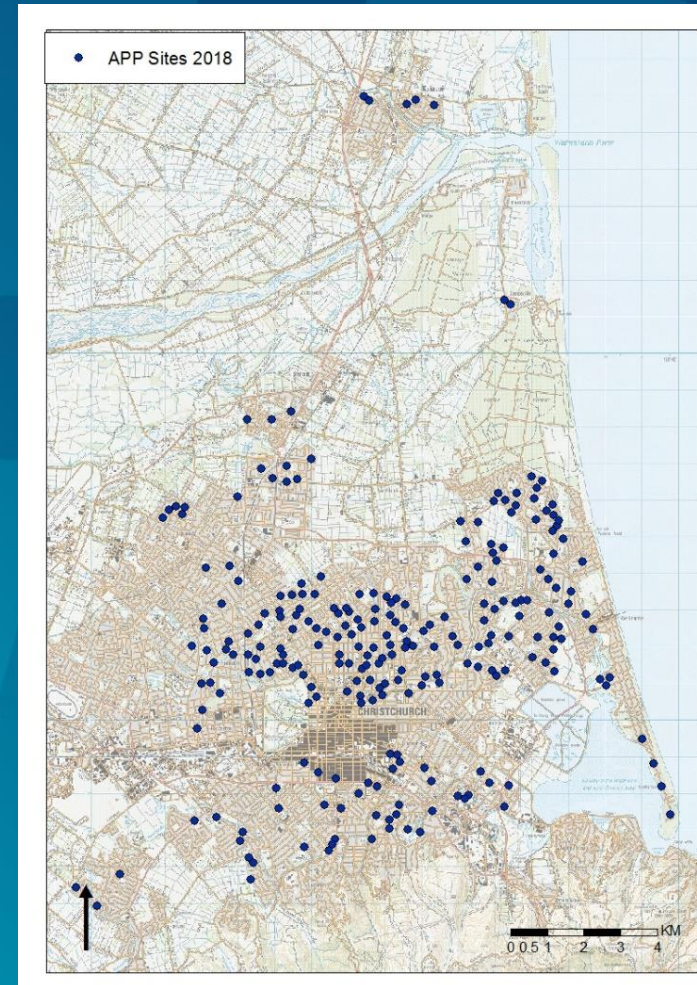


Christchurch: shallow groundwater network

- EQC network – 2011 - 2016

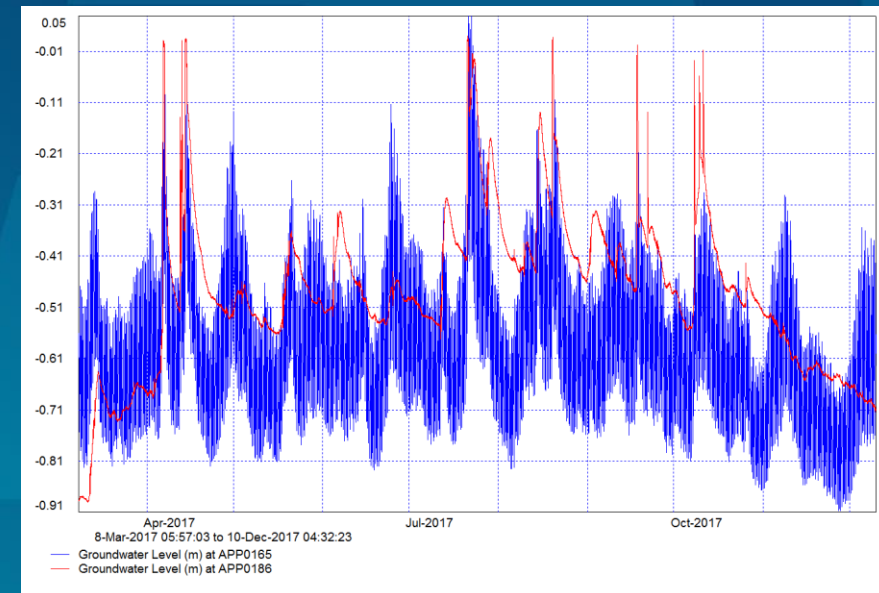
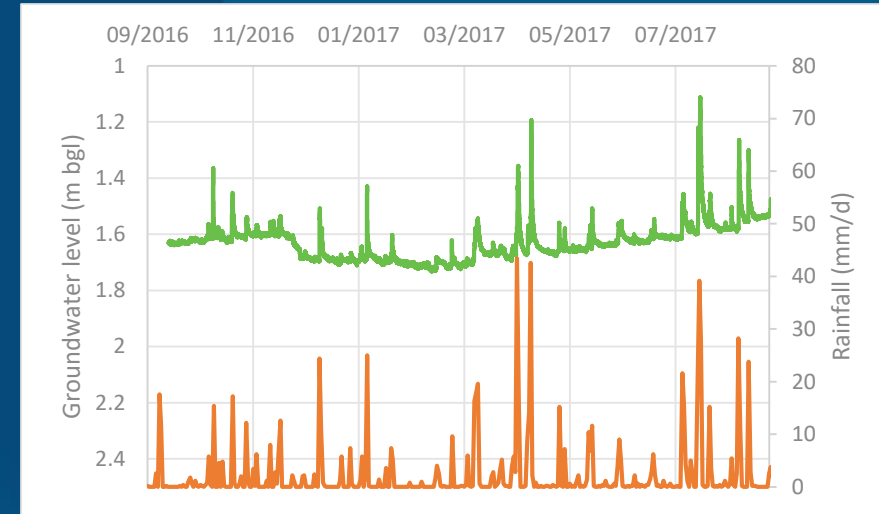


- APP network 2016 - present



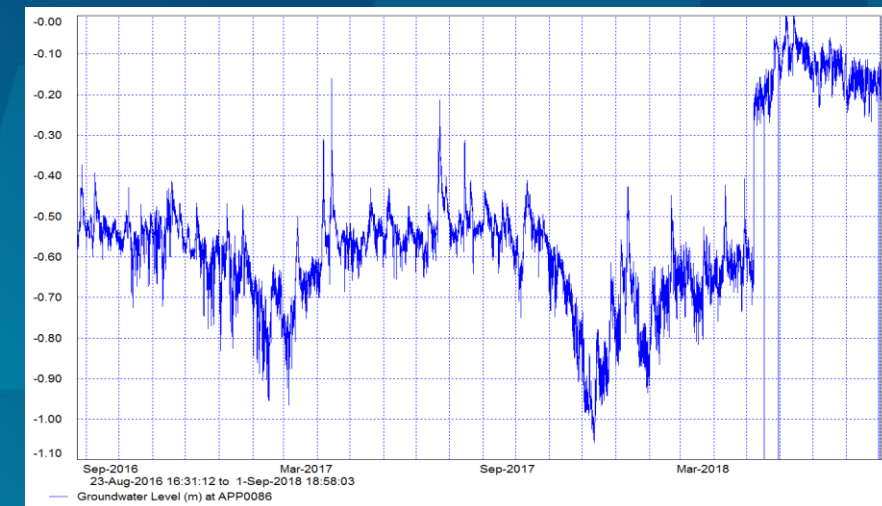
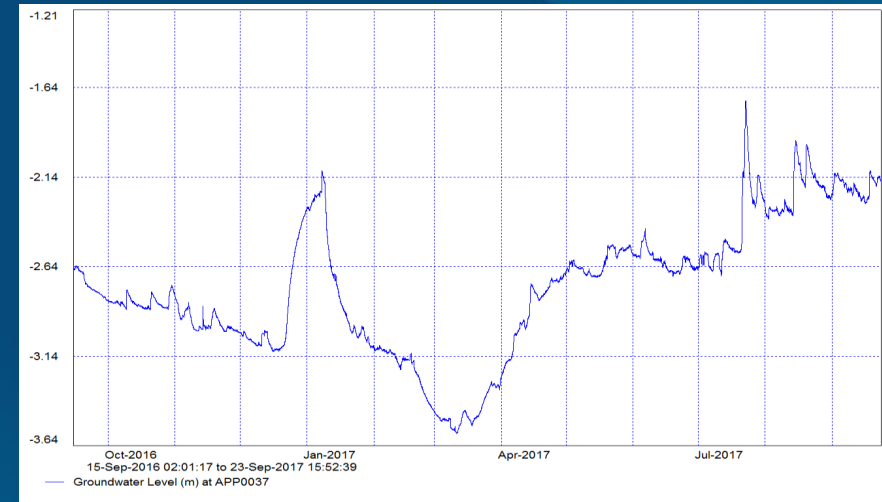
Shallow groundwater data

- High resolution data (10 minute) collected for 3 years
- Variability of responses
- Influences on GWLS
 - Rainfall recharge
 - Seasonal
 - Inter-annual
 - River recharge
 - Tides

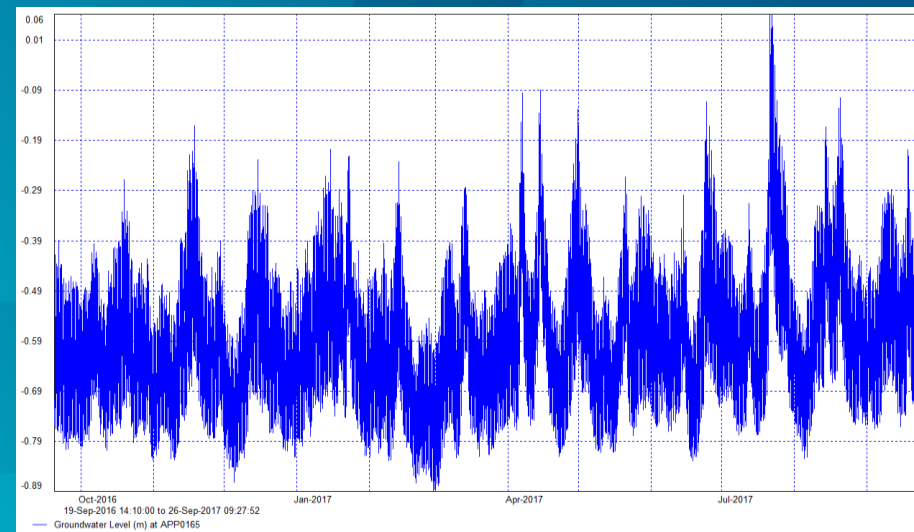
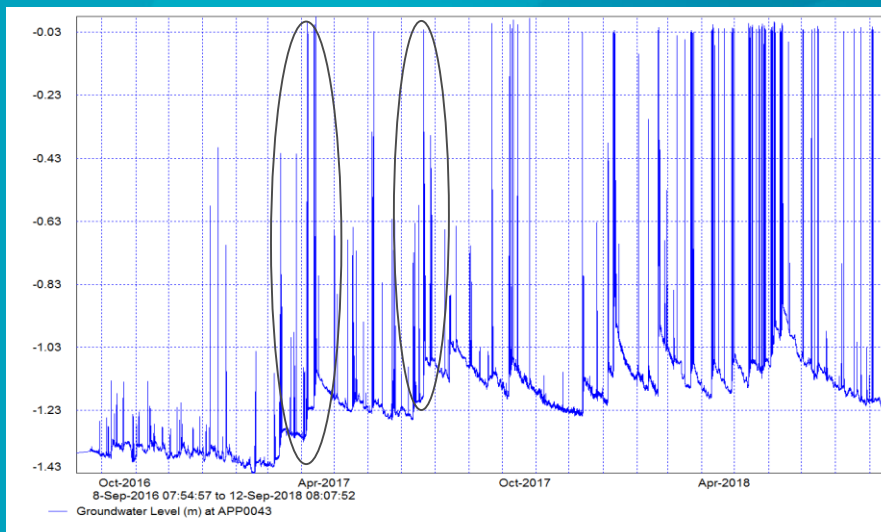
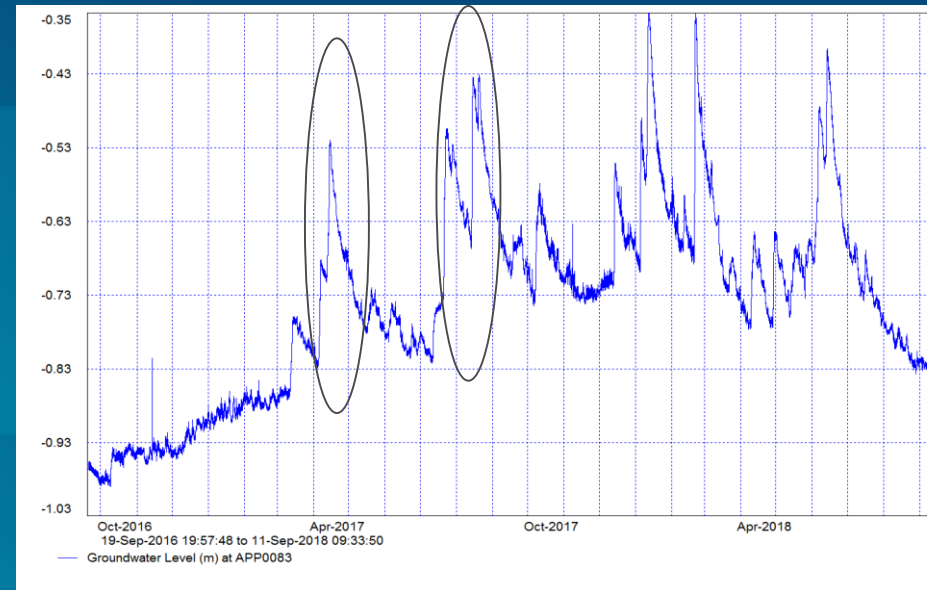
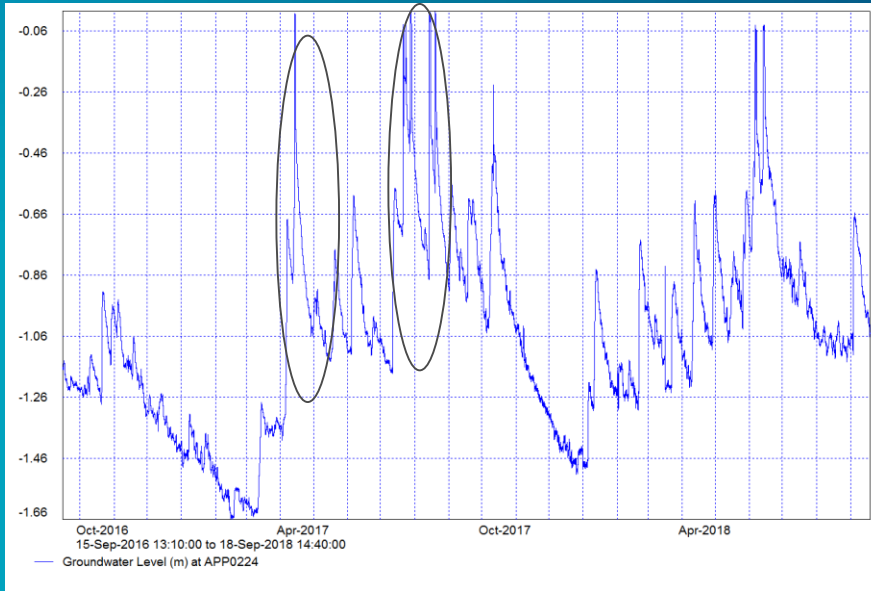


Other influences on groundwater levels

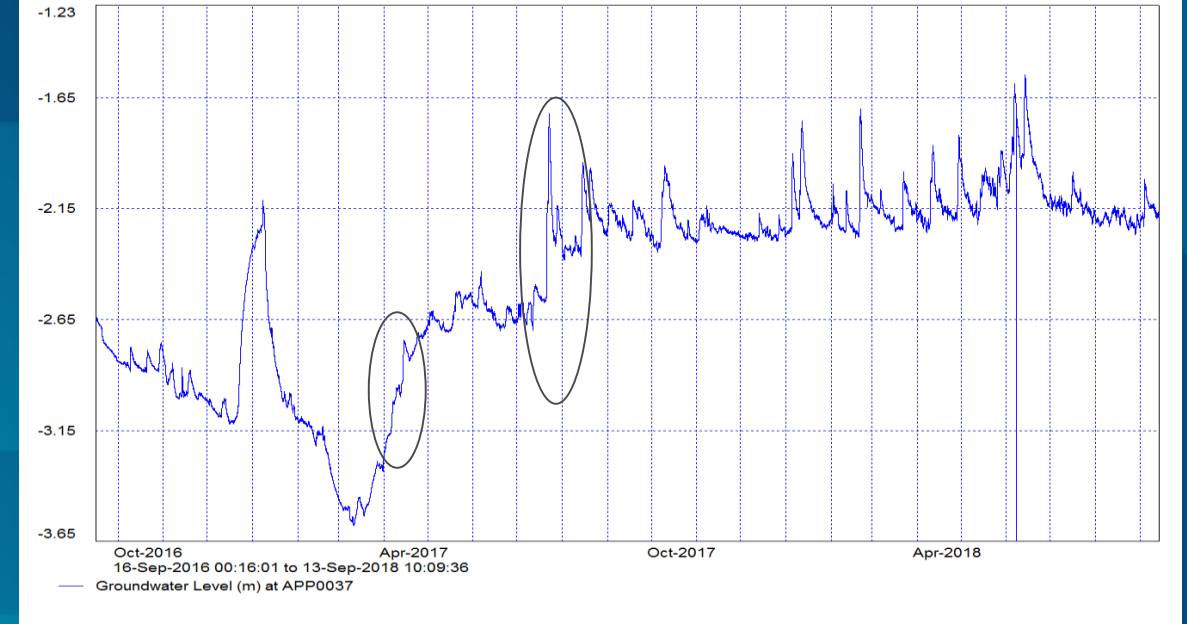
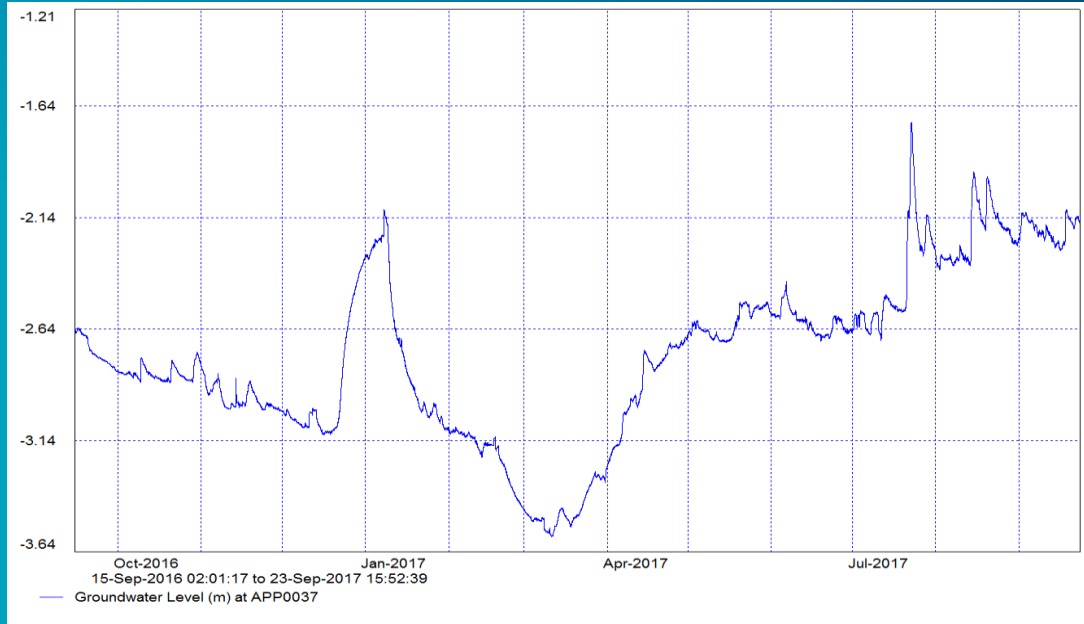
- Evapotranspiration
- Earthquakes
 - Subsidence
 - Dynamic responses
 - Long term changes
- Urban infrastructure
- Rebuild efforts
- Ground source heat pumps
- Climate change and sea level rise



Groundwater level responses and drivers



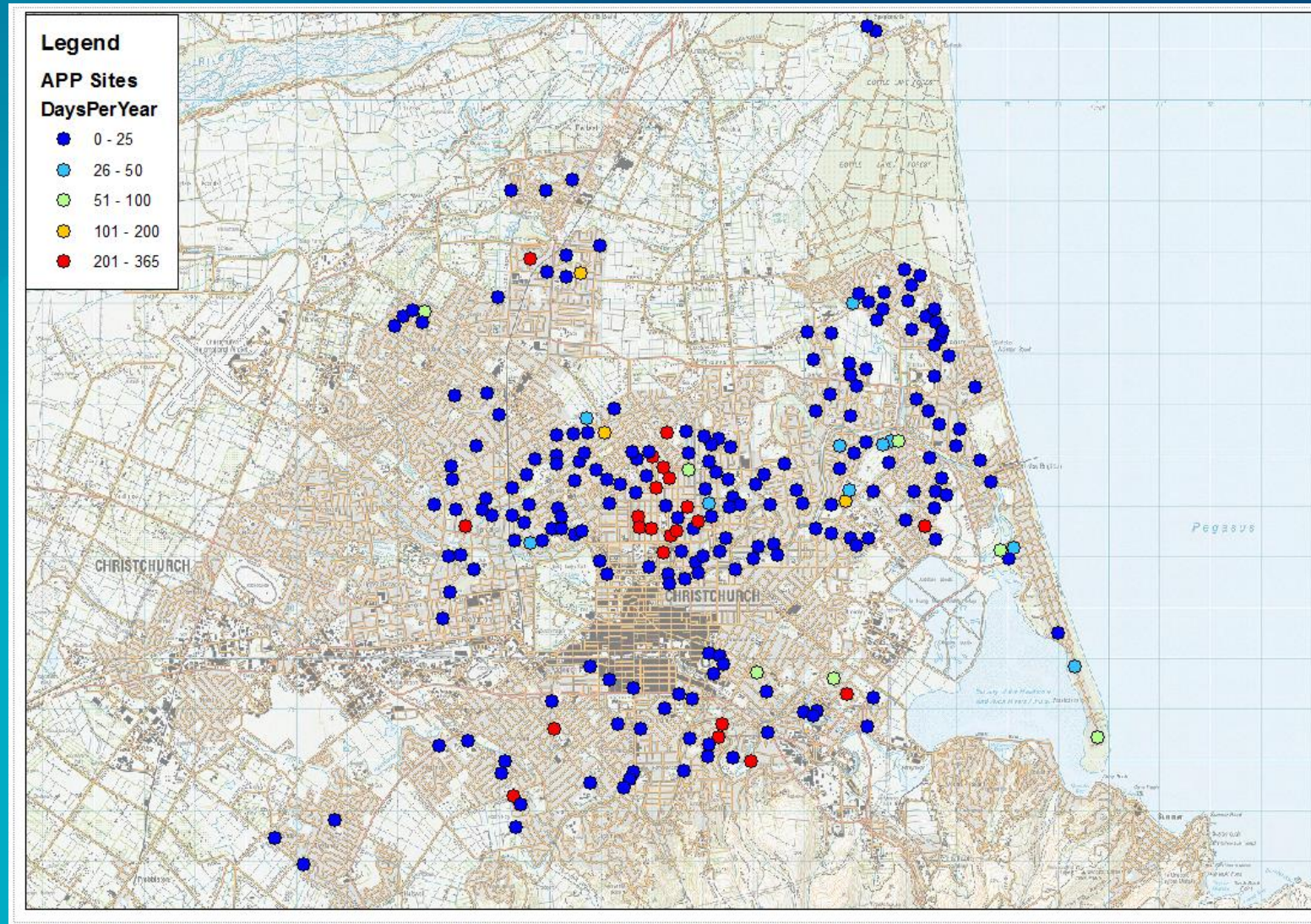
January high



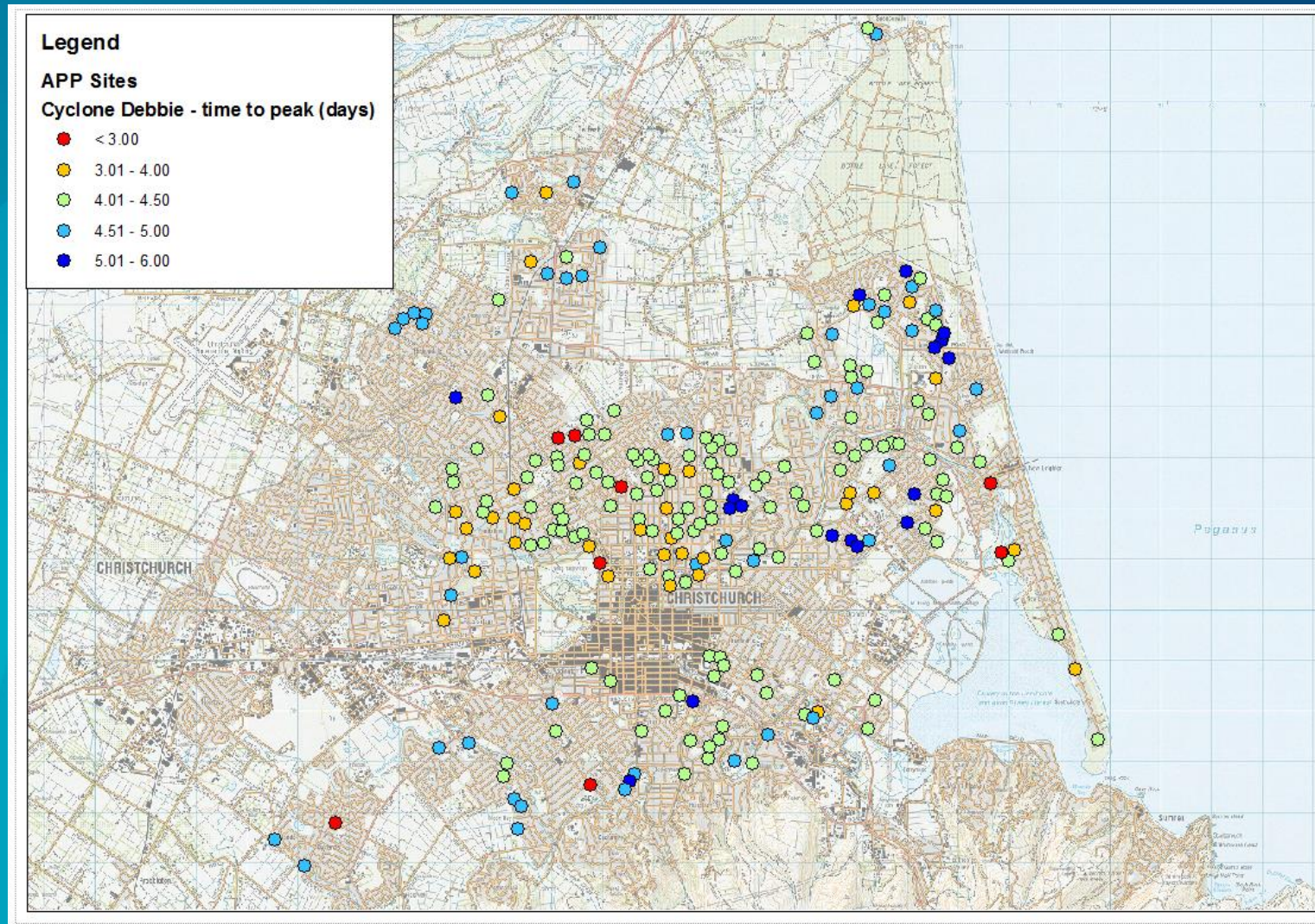
Analysis of responses

- Attempt to identify spatial patterns
- Important in terms of understanding responses in different areas and using the network for managing hazards
- Aim to classify areas that respond similarly
 - Average seasonal response to rain
 - Time to peak for different events
 - Time over threshold
- Complex
 - Different areas respond to different drivers
 - Cascading effects in any one area

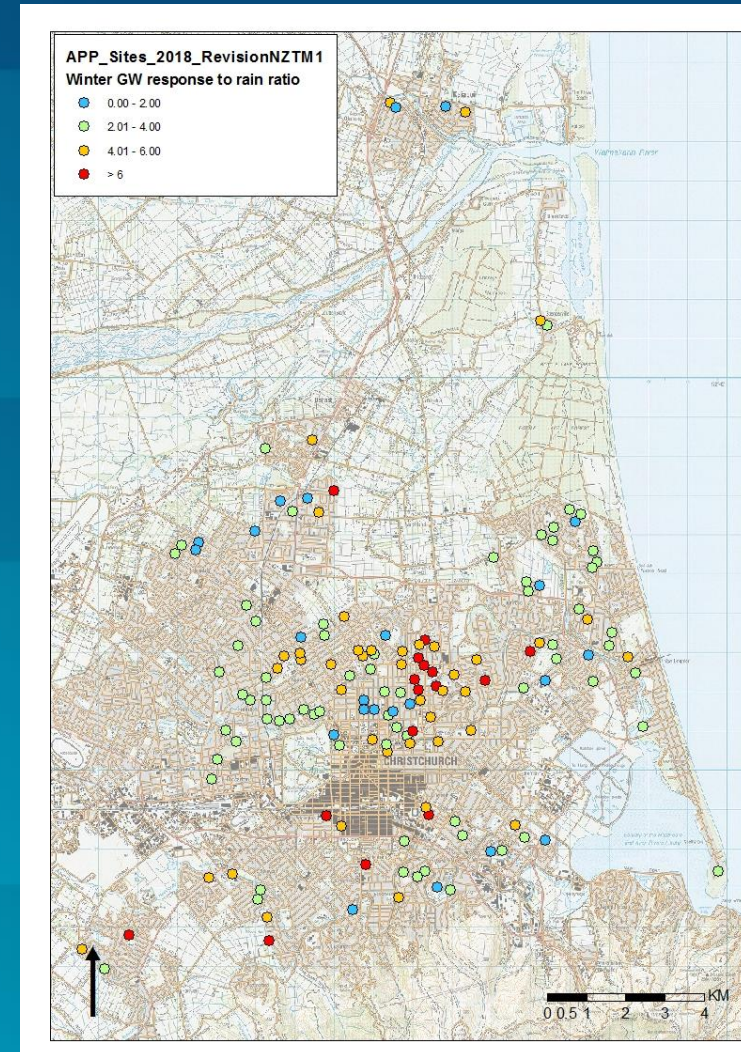
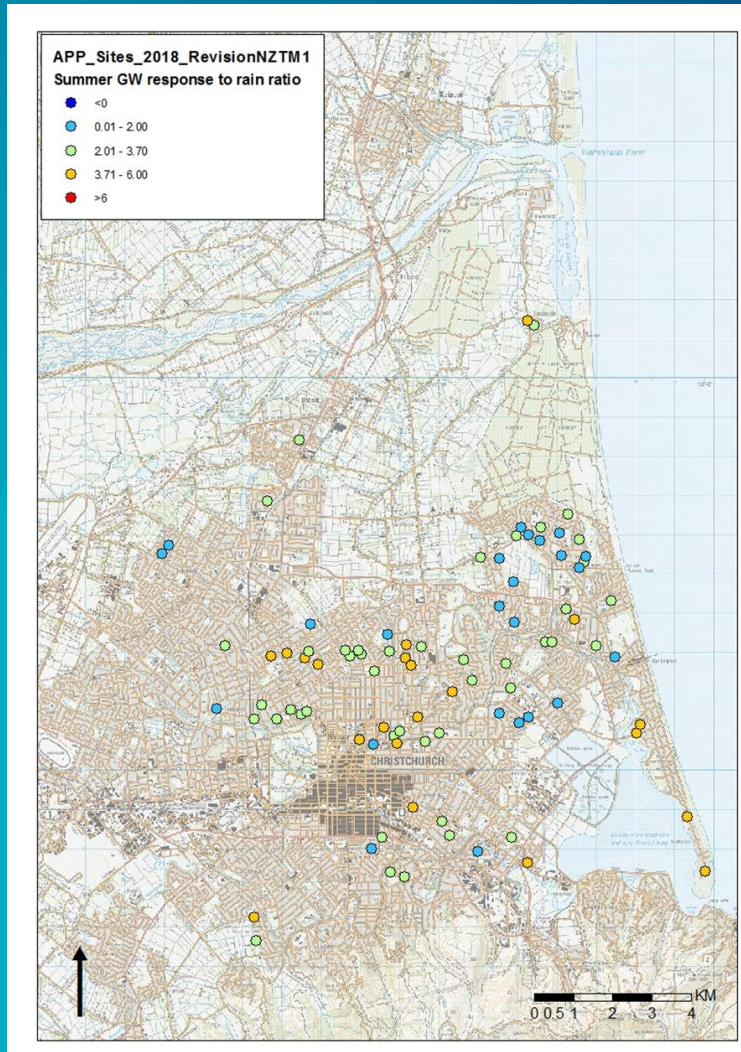
Days per year over threshold



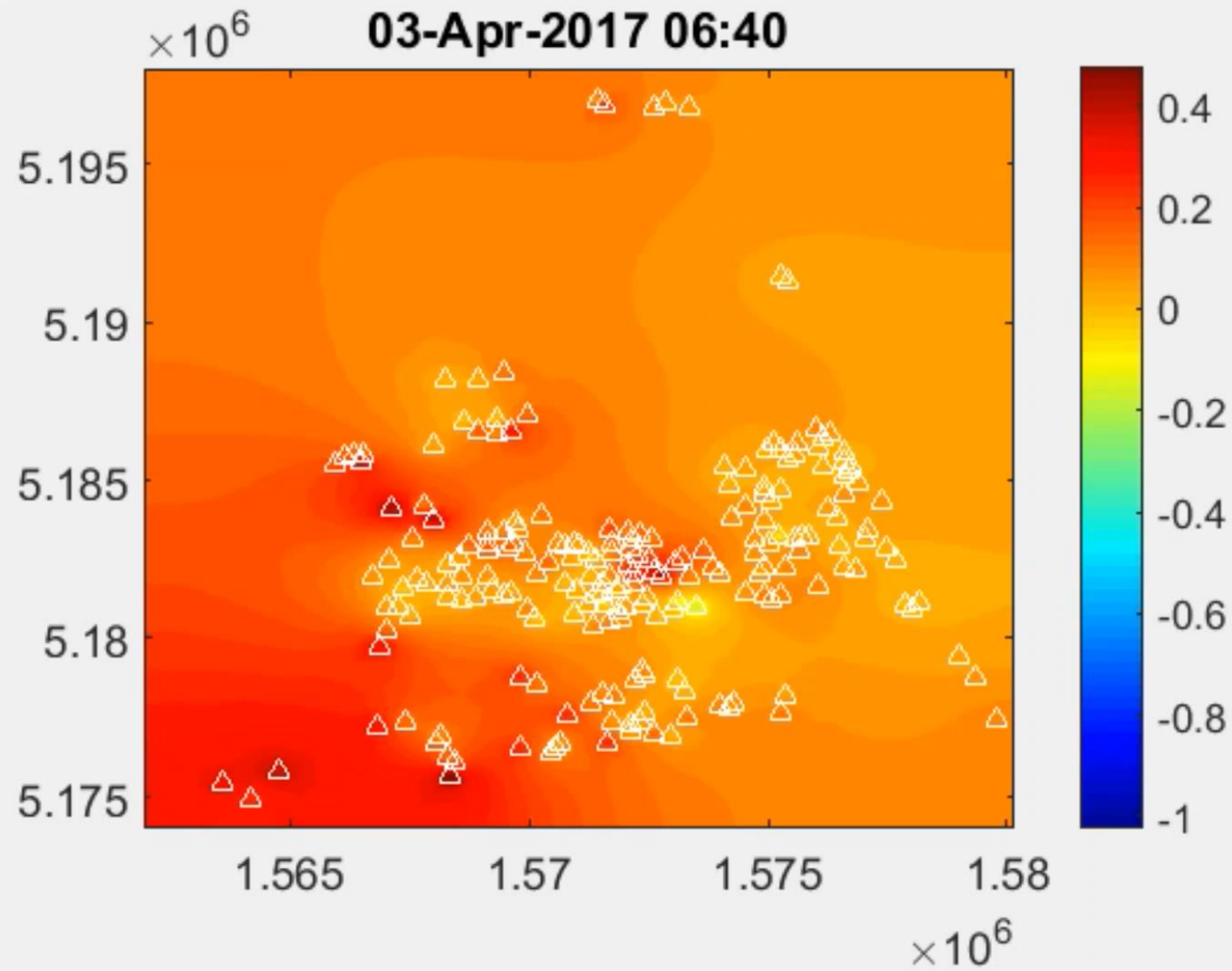
Time to peak – Cyclone Debbie



Seasonal response to rainfall



Integrating spatial and temporal data

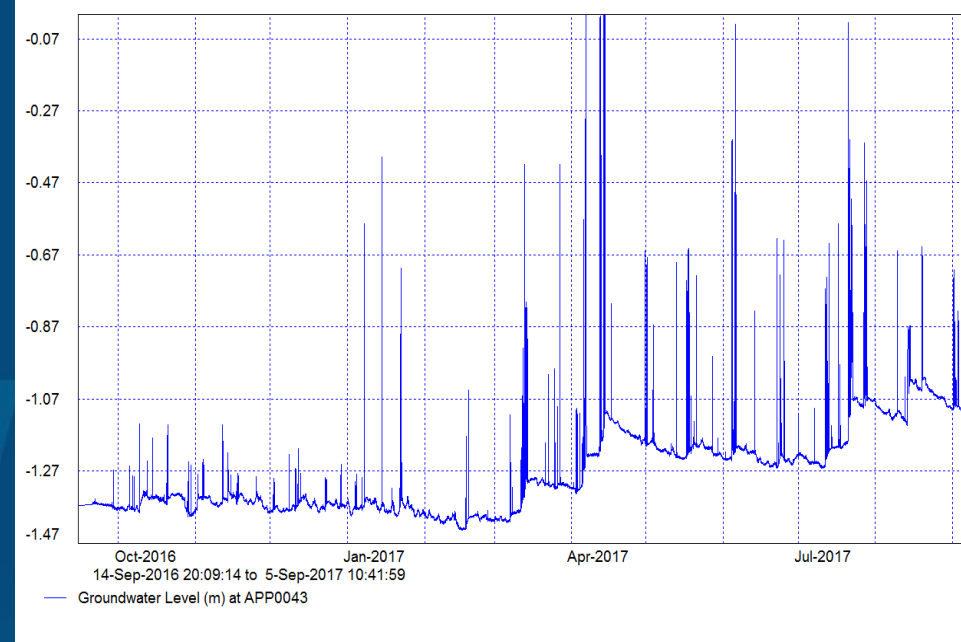


Hazard

- Need to define hazard in terms of depth to groundwater
- Hazard is complicated due to:
 - Many drivers of water level change
 - Different antecedent conditions
 - Spatial variability of lithologies
 - Superposition of anthropogenic systems
 - Infrastructure; Ongoing rebuild work and dewatering; Ground source heat pumps
- Each location will have a different combination of drivers and controls on groundwater levels, and hence on hazard

How can data/modelling be used?

- Operational:
 - Contribute to operational flood forecasting and management
 - Focus Civil Defence responses to earthquakes and flooding
- Develop understanding of:
 - Sewer infiltration
 - Longevity of groundwater flooding
 - Impacts of climate change on council infrastructure
- Infrastructure maintenance
 - Impacts of shallow groundwater on roads and pipe networks
- Construction - decisions about:
 - Timing of infrastructure works
 - Dewatering requirements
 - Design of basements and buildings
 - Planting



Take home messages

- Groundwater is a significant hazard and issue in the urban environment
 - 4D problem
- We don't understand it fully now
 - We are in a changing environment
 - Lost opportunity cost
- Need to collect data now
 - Focus on areas where there is a problem – now or future
 - Ensure good practices
 - Piezometer construction
 - Data collection
 - Data processing and maintenance
 - Think about how the data are going to be used – future modelling

Acknowledgements

- EQC
- GNS
 - Dr John Haines

Questions?

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