



# Unintended consequences:

Groundwater, climate change, urban development, and improving infrastructure

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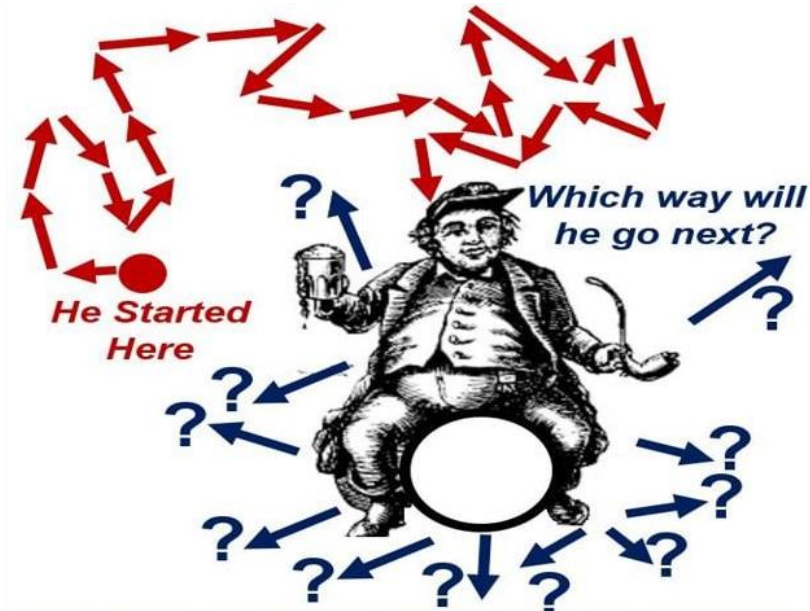
Simon Cox



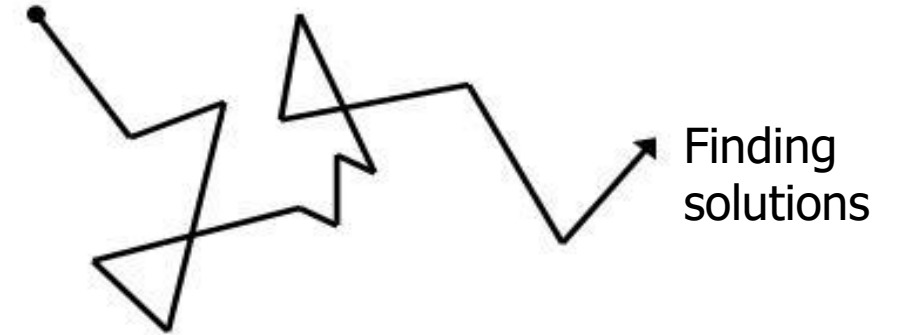
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**Stormwater 2024**  
15–17 May | Takina Wellington Te Whanganui-a-Tara

# What am I on about?



Understanding  
complex  
problem



- Shallow groundwater
  - Interaction with stormwater
  - What happens in urban areas?
  - What might happen under climate change?
- It's all interconnected.....

# Shallow Groundwater

# Shallow Groundwater

- Close to ground surface
  - May emerge at the surface
- Poorly understood
  - In space or in time
  - But it can hang around.....



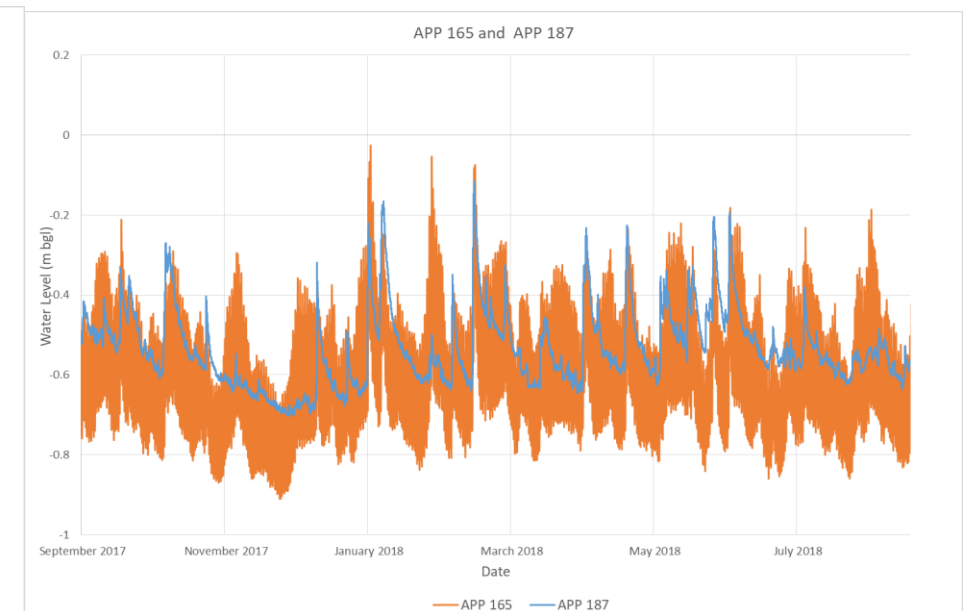
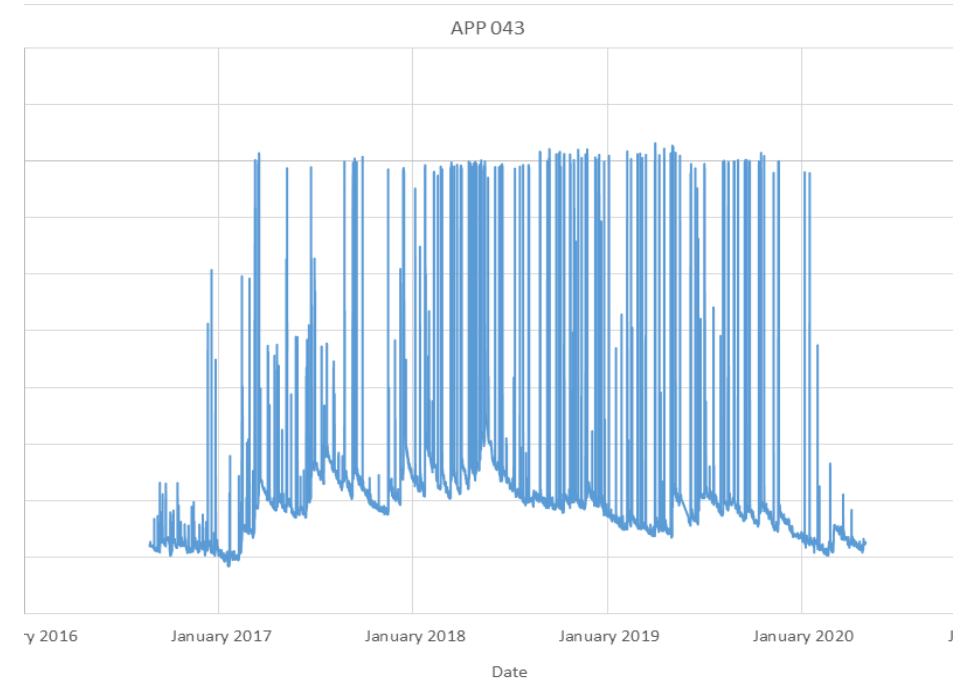


# Groundwater fluctuates

Vary in short and longer term

- Response to rainfall, rivers and tides
- Seasonal
- Interannual

Tells us about drivers



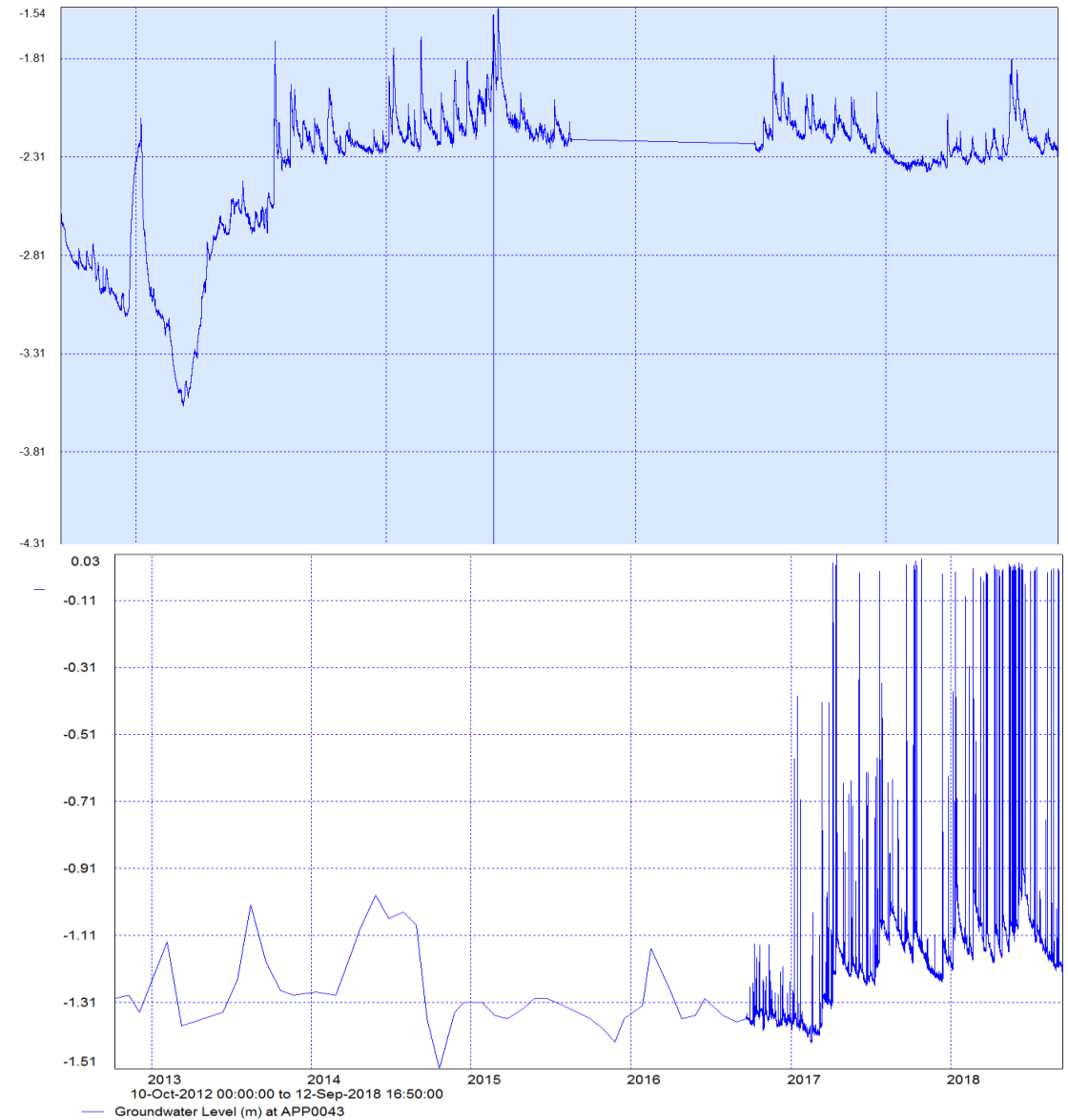
# Antecedent conditions

- Antecedent conditions are really important in terms of response



# Putting it in context

- Take care with short term and/or low resolution groundwater data



# What is the issue?

- Groundwater “daylighting”
- Adding to surface flooding
- Liquefaction susceptibility
- Dewatering
  - For infrastructure repairs
  - Permanent
- Roding damage
- Failure of planting
- Health consequences
- Stormwater disposal
- Wastewater disposal





# Urban development and stormwater

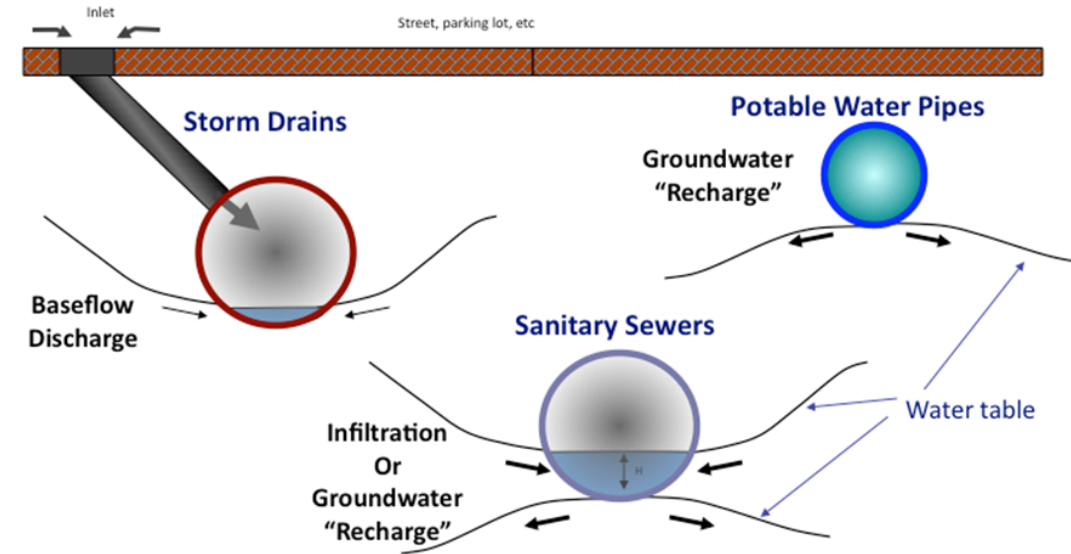
# Urban development

The problem with infrastructure.....

- Drinking water – leakage contribute to groundwater
- Wastewater – inflow and infiltration
- Stormwater
  - Infiltration
  - Disposal

“Urban karst”

- High permeability pathways along pipes and trenches
- Unknown fate of water and potential contaminants



# Stormwater

Urban areas generate stormwater

- Streams
- Basins
- Swales
- Soakage pits

Can increase or decrease recharge to groundwater



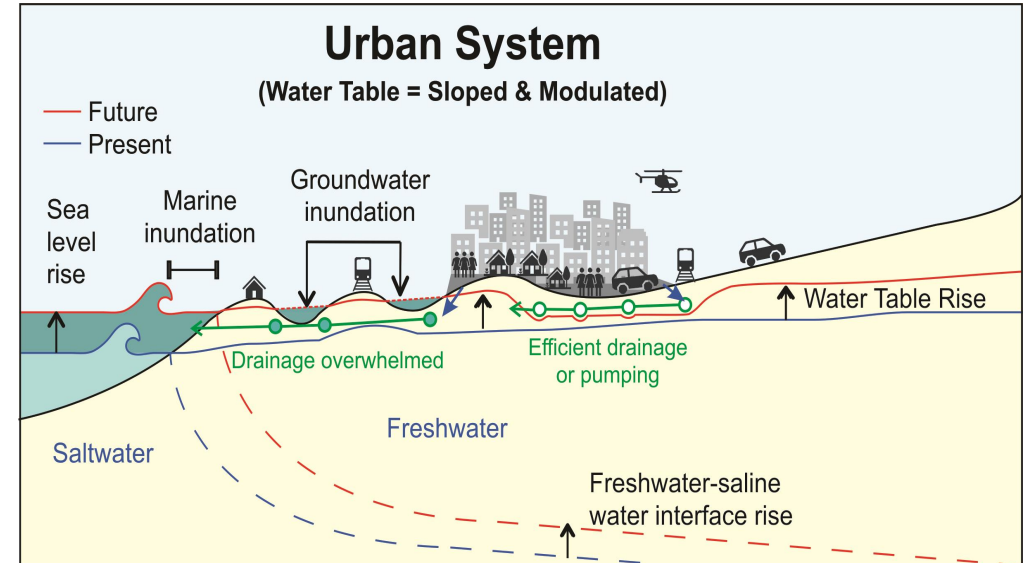
# Stormwater

How does it affect groundwater?

- Where does it go
- How rapidly

How much does groundwater affect stormwater?

- How much does groundwater limit stormwater disposal
  - Groundwater levels
  - Permeability



# Sponge city concepts

“Sponge cities” is used to describe urban areas with design intended to absorb rain and prevent flooding

Greater permeability for rainwater absorption

- parks
- drainage pavements
- rain gardens
- infiltration and retention wells
- urban gardens and plantations
- green walls and roofs

Recent study showed Auckland came out top!





# Climate change

# What might happen with climate change?

Thinking about groundwater.....

More extreme events

- More recharge
  - Rise in GWLs

Sea level rise

- Impacts groundwater further inland than inundation effects

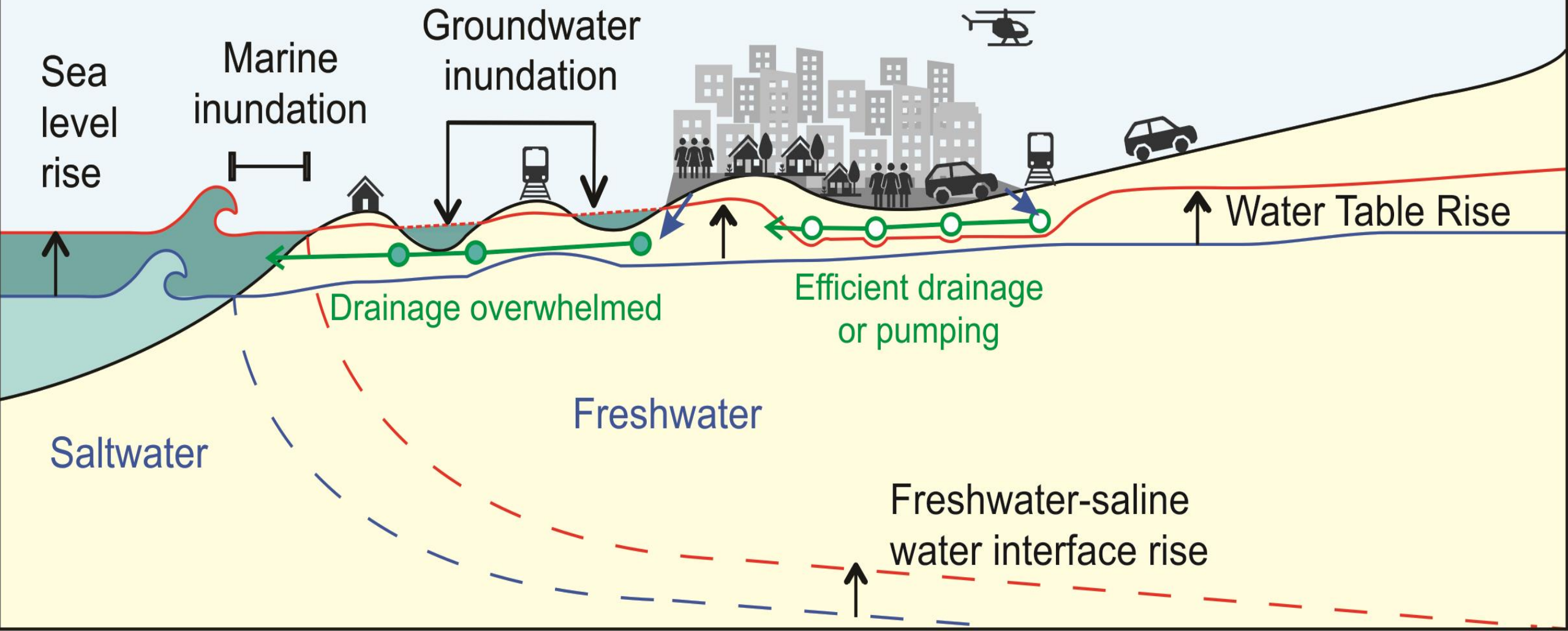
Thinking about stormwater.....

- Bigger peaks in stormwater generation

# Urban System

(Water Table = Sloped & Modulated)

— Future  
— Present



# Christchurch – impacts of SLR on shallow groundwater

Steady state effects of SLR modelled

- Boundaries adjusted to allow for sea level rise

Changes in groundwater added to baseline surface

Identified areas with shallow groundwater

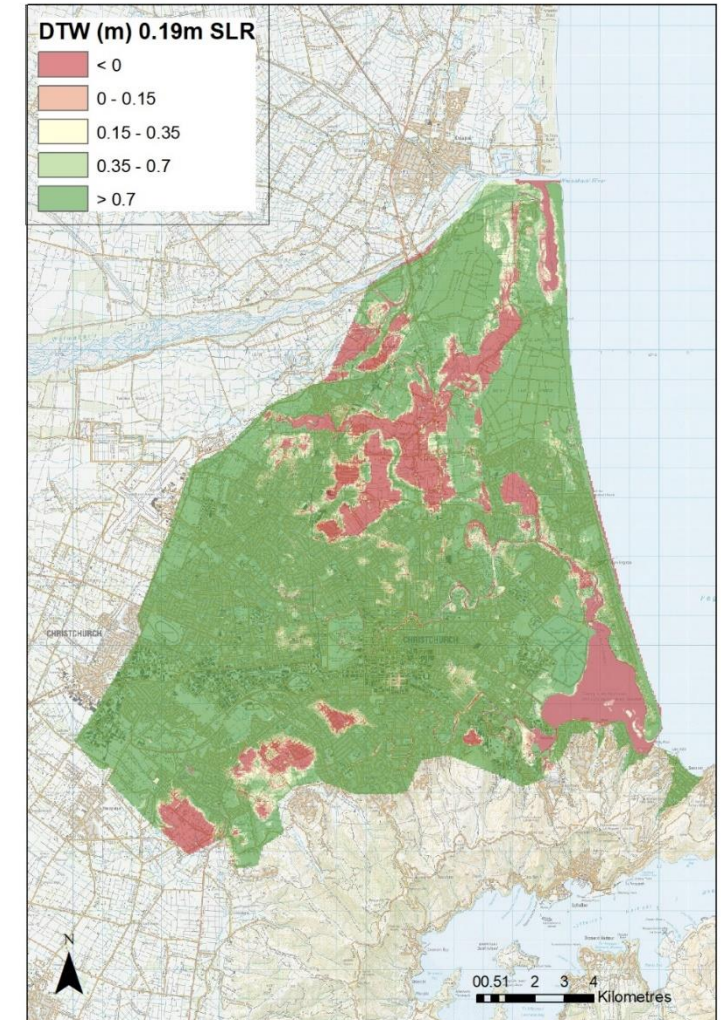
SLR effects propagate a long way inland

Groundwater effects likely to be worse than coastal inundation

- Stormwater infrastructure overwhelmed?

Static surface

- Need to add dynamic response



# So where is this all leading?

## Unintended consequences

Increased urbanisation

- Enabling more infiltration to groundwater?

Improving infrastructure

- Reducing infiltration into infrastructure

Climate change

Complex inter-relationship between many factors



# Unintended consequences: Increased urban areas

Increased recharge and localised mounding

Increased “urban karst”

- Makes prediction of effects difficult

May be areas where urban development shouldn't occur

- Existing/future groundwater issues
- Stormwater disposal

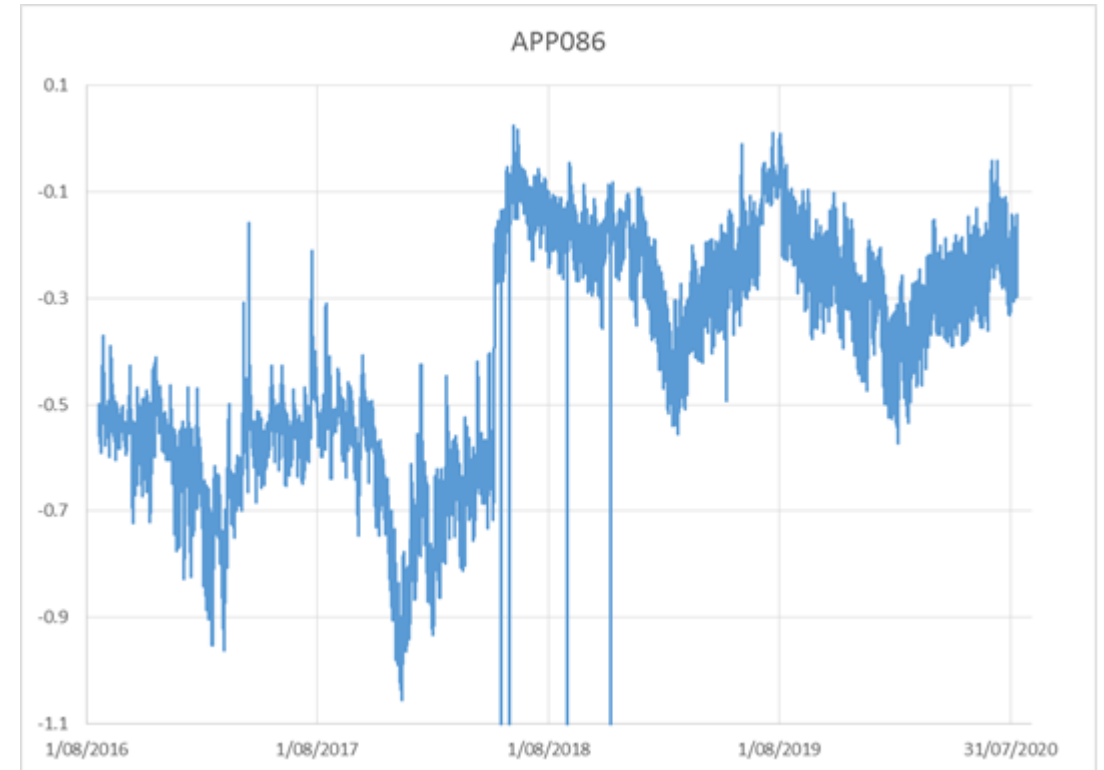
Sponge city concepts

- Understand the hydrology first
- Predict how groundwater responses will change



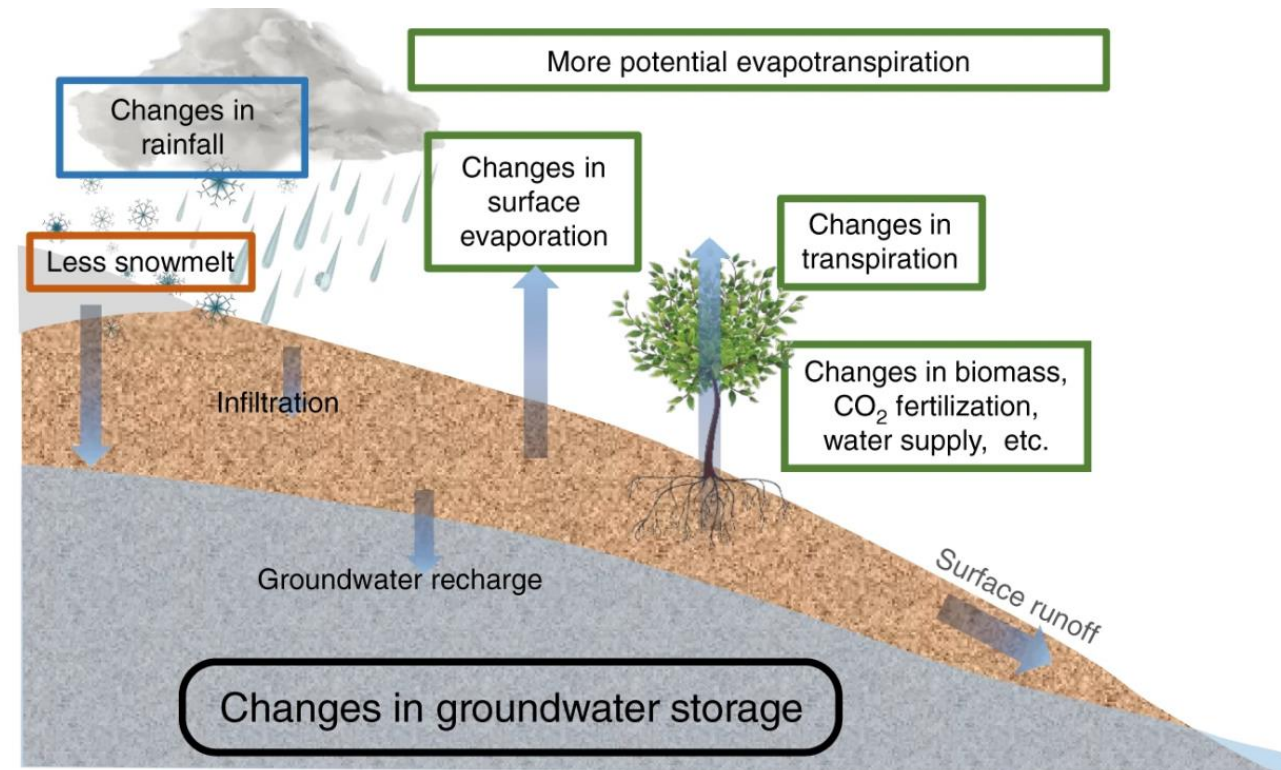
# Unintended consequences: Infrastructure repairs

- Less input into groundwater
- Loss of groundwater drainage



# Unanticipated consequences: Climate change

- Sea level rise
- Changes in groundwater storage/levels
  - Increased extreme events
  - Drought periods



# Auckland 2023

# Auckland 2023

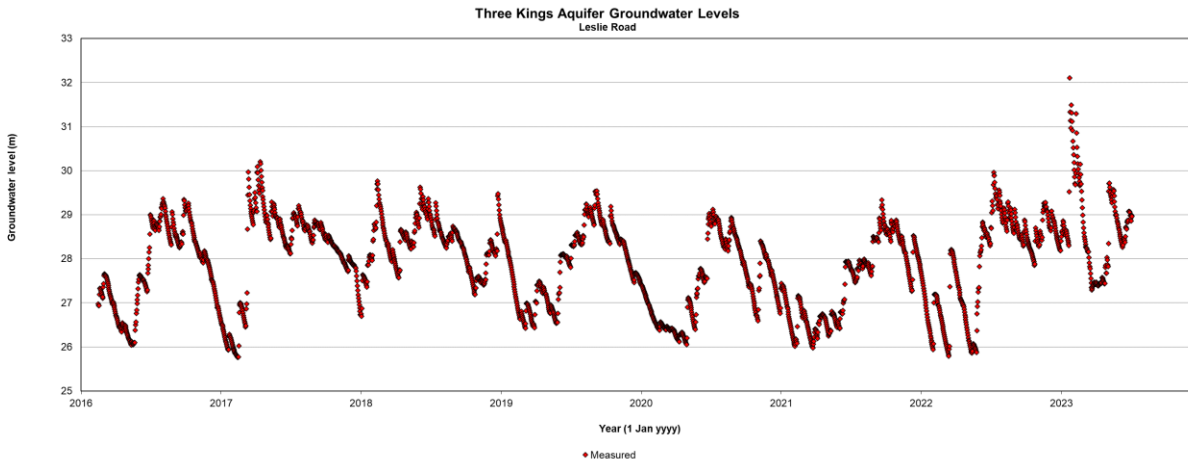
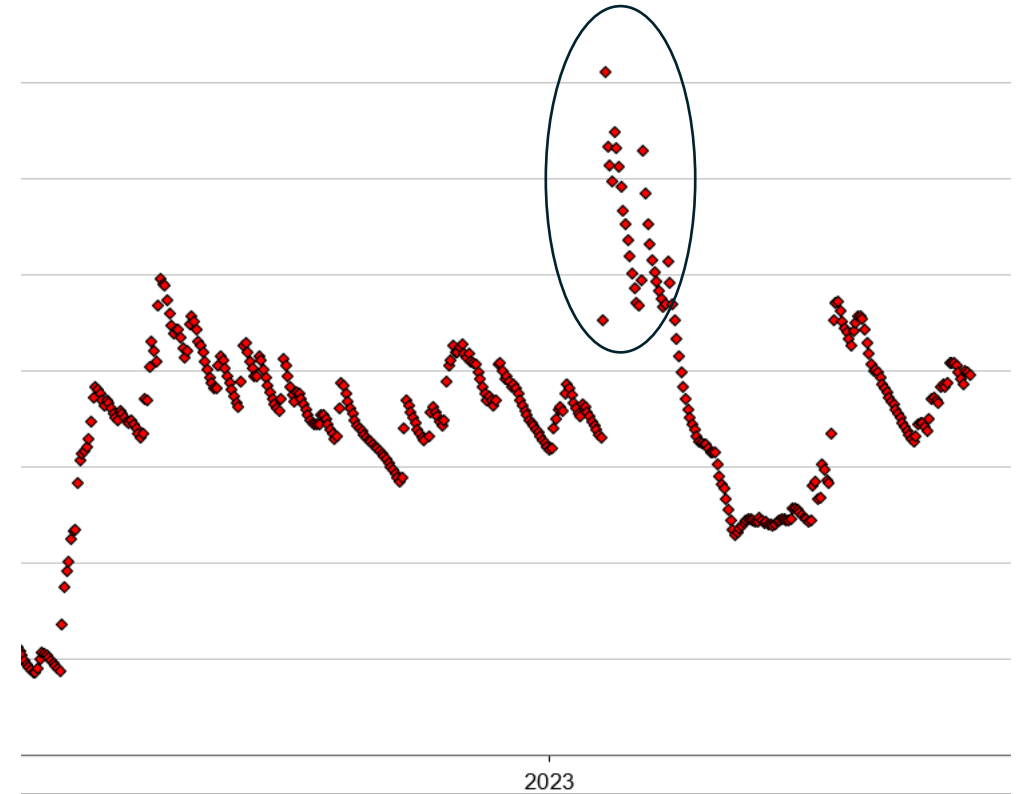
Global aquifer study (GAS)

- Implications of diverting stormwater to ground and additional recharge

January 2023: wettest month on record

February 2023: Cyclone Gabrielle

Groundwater flooding occurred





# Auckland 2023

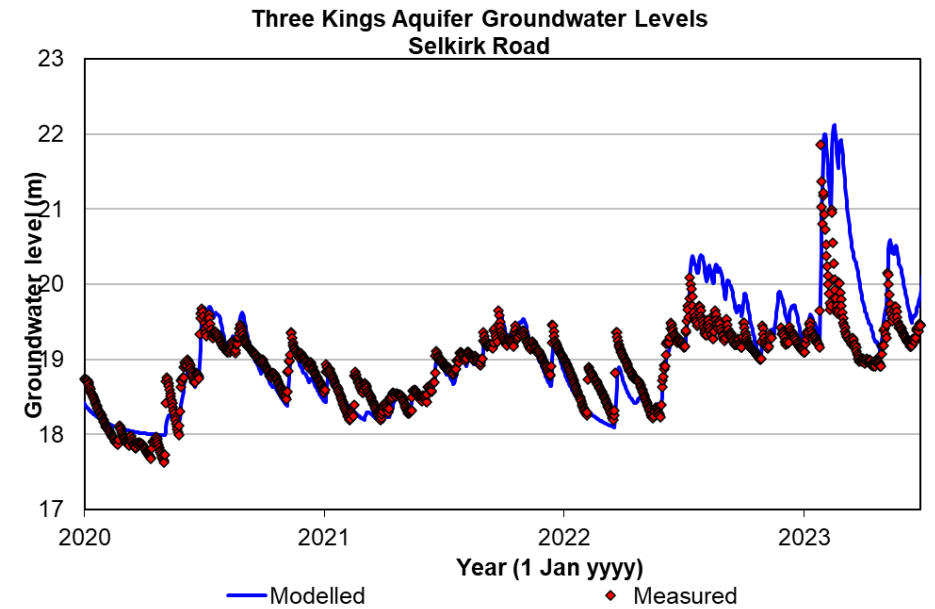
Flooding persisted beyond period of surface water flooding

Duration of groundwater flooding less than anticipated – why?



Talk of dealing with stormwater through “sponge city” concepts

What about groundwater – is the city already spongy enough?



# Summary

# What is needed?

Understand the issues

- Depth to groundwater
- How it varies spatially
- How it varies with time

Model and predict how it will change

- With increasing urbanisation
  - Increased impermeable surface, disposal to ground
  - Increased urban karst
  - Improvements to infrastructure
- With climate change



Prediction of shallow groundwater/groundwater flooding



Plan where to dispose stormwater

# If we get there...

Make informed decisions about development

- Are there/will there be issues with shallow groundwater
- Can we get rid of stormwater

Understand impacts of extreme events

Understand implications of change

- “Spongifying” cities
- Improving infrastructure



# Summary

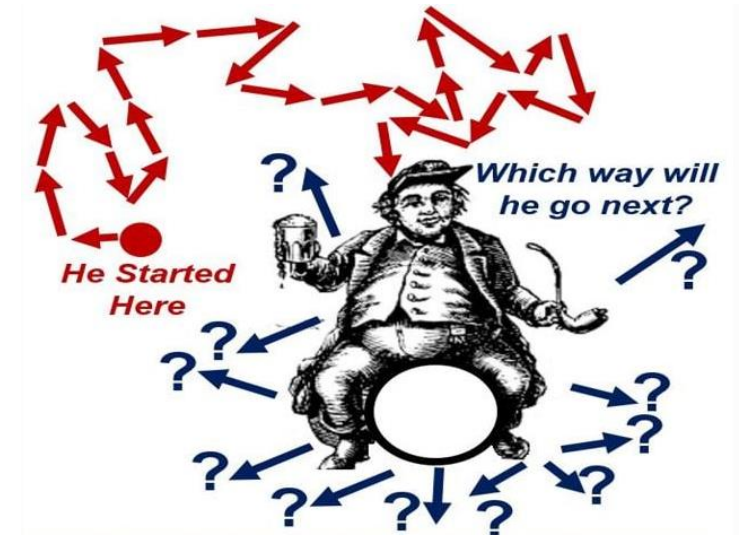
Shallow groundwater

- Poorly understood in space and time
- Infrastructure adds to the complexity

Will likely become a bigger problem with climate change

Interaction between stormwater and groundwater needs to be better understood

- Allowed for in planning/development
- Thought about when improving infrastructure





# Summary

Need holistic view of drivers of groundwater level change and cascading effects

- Work with nature
- Sponge city concepts need to be considered in light of other factors



**Thank you!**  
**Questions? Patai?**

# Research needs/approaches?

Determine what drivers dominate responses

- Modelling approaches

Develop techniques for mapping/monitoring

Classify areas that are likely to have similar responses

Determine impacts/risks

Determine triggers levels for action