Dunedin groundwater monitoring, spatial observations and forecast conditions under sea-level rise

Safety and Resilience Committee
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Dr Simon Cox (GNS)
Dr Jean-Luc Payan (ORC)

Otago Regional Council

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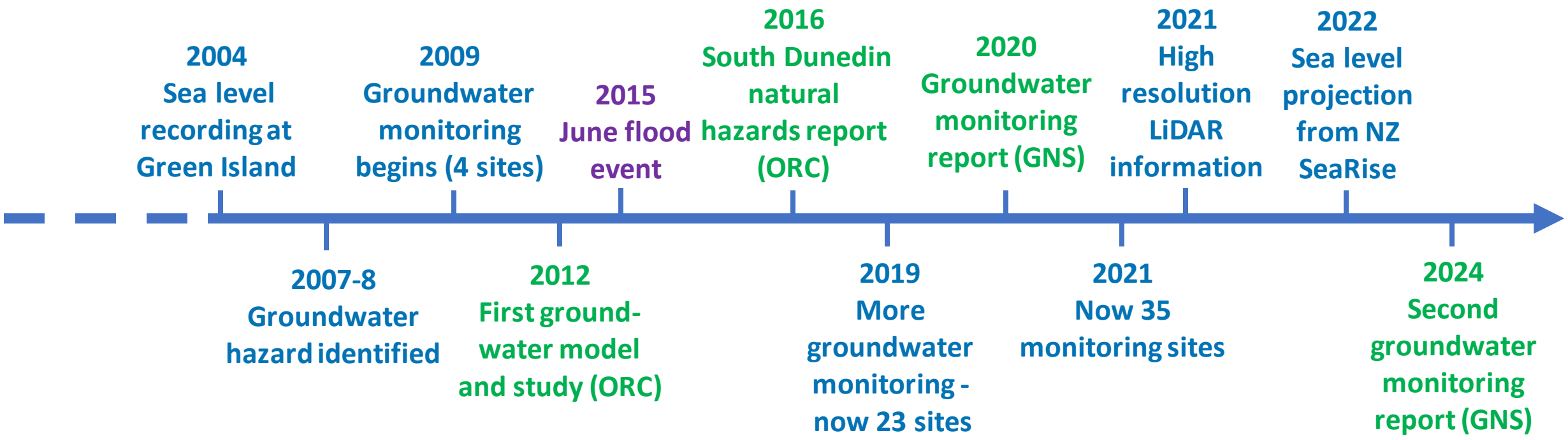
A programme of discovery – 20 years of science data



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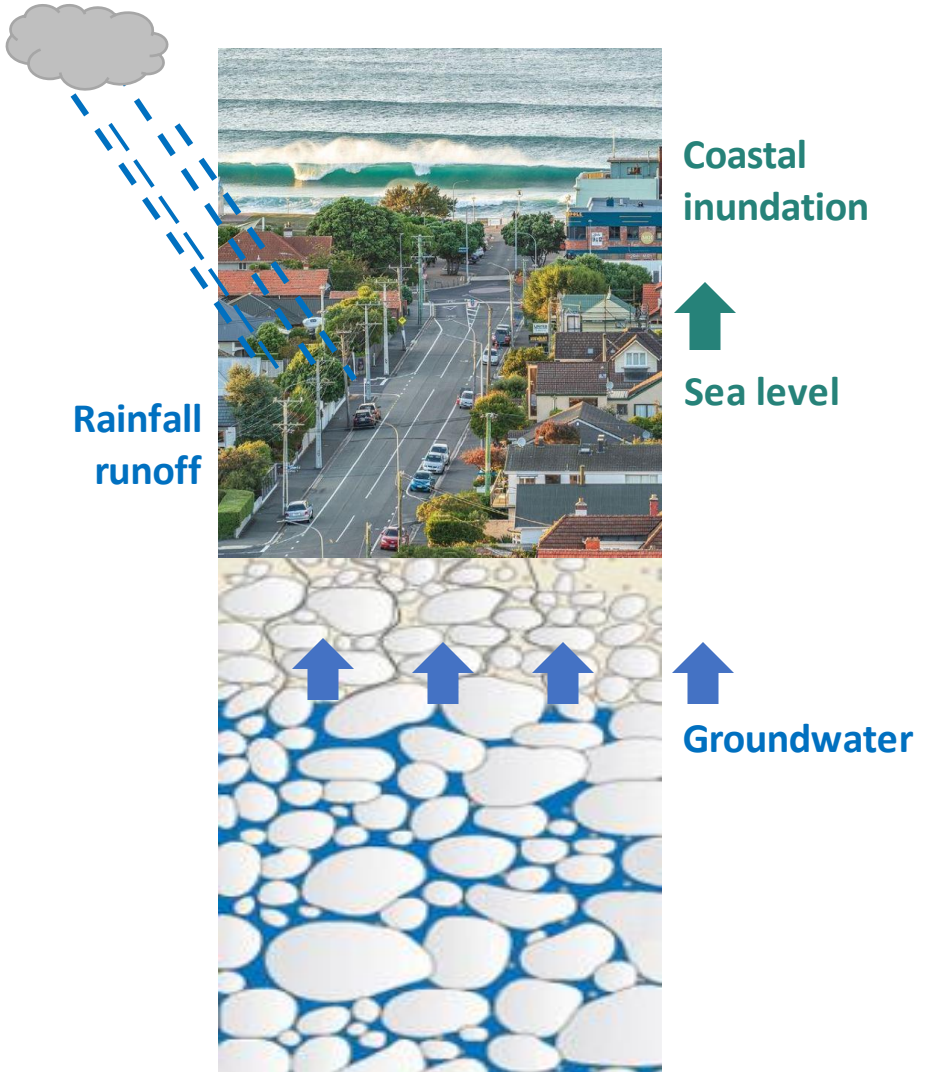
Dunedin research leads the way in forecasting the impact of rising groundwater

- Comprehensive groundwater monitoring (ORC)
- World-leading science
- Holistic overview and multi-hazard forecast
- Both episodic (event) & permanent processes
- Precision (site-specific not generalist)
- Less prone than feared
- South Dunedin Future program (adaptation)



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New research forecasts impact of rising groundwater

Dunedin groundwater monitoring, spatial observations and forecast conditions under sea-level rise

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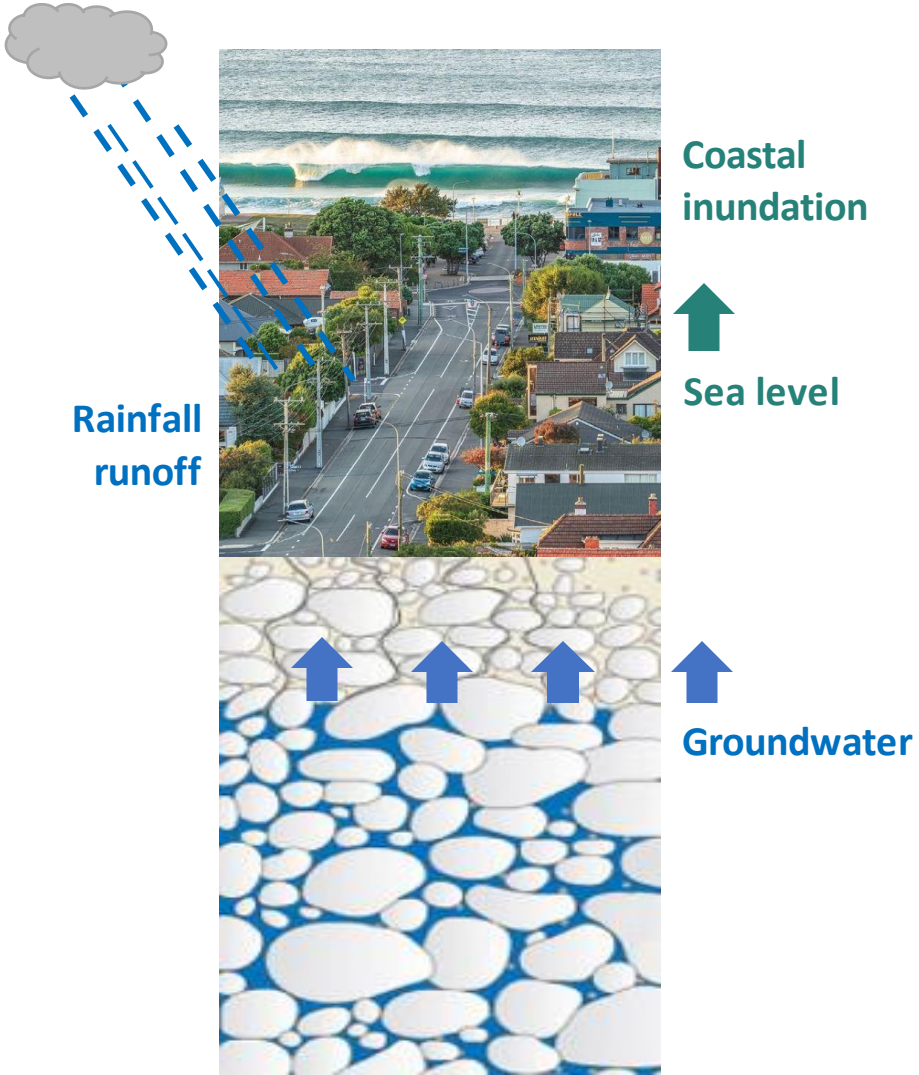
GNS Science Report 2023/43
December 2023

New report free from the GNS Science Online shop

Datasets available via Zenodo online archive



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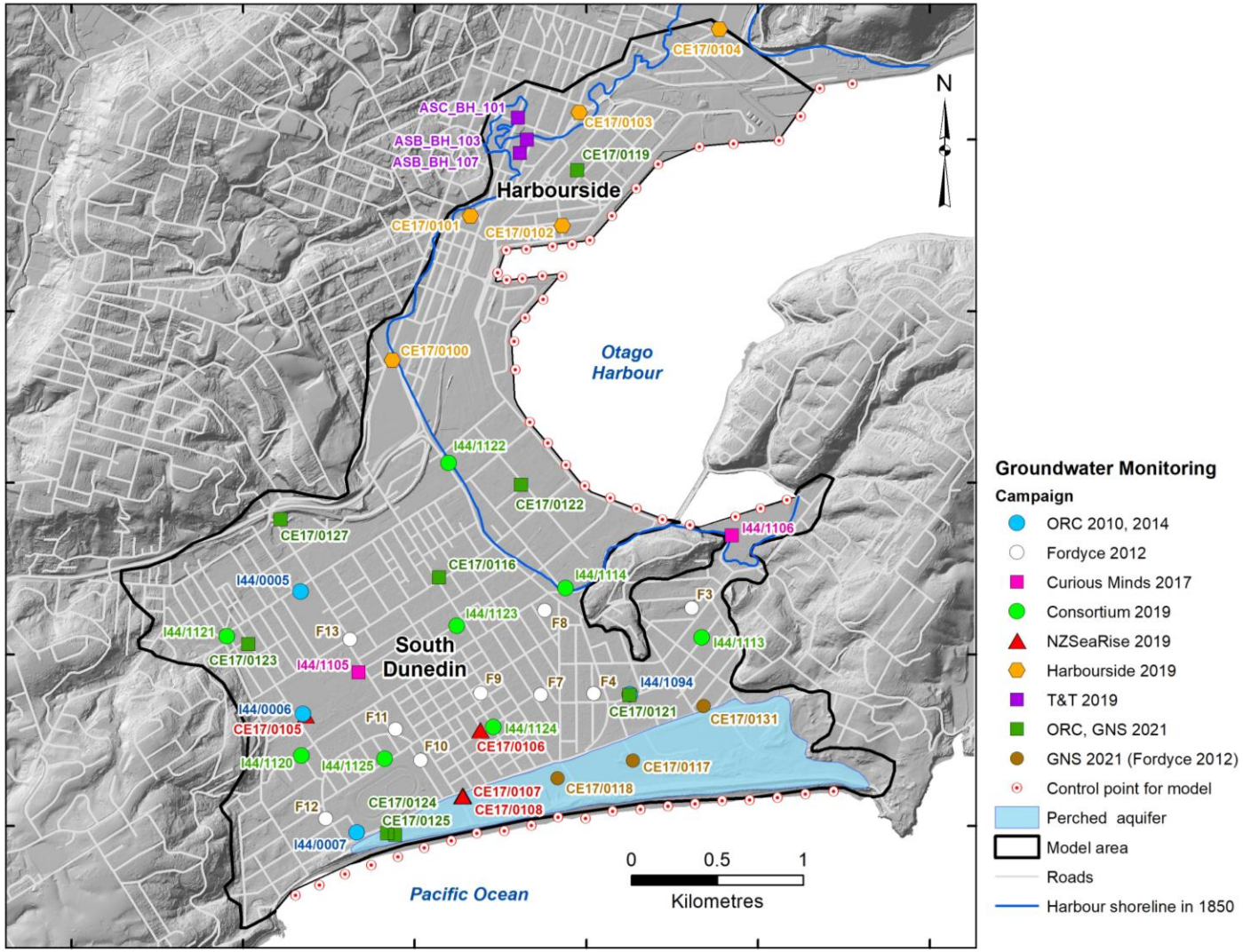
Based on Dunedin groundwater monitoring 2019-2023

Monitoring network data collected and managed by ORC. Analysis by GNS Science.

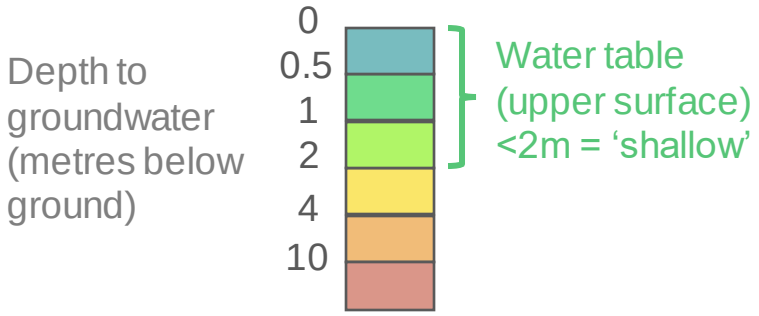
Examines present-day changes to groundwater levels, and causes such as tides, storm surge and rain.

Provides forecast of where and when groundwater will rise and cause issues in the future.

Map of monitoring network: 35 sites, pressure & temp measurements every 15 min



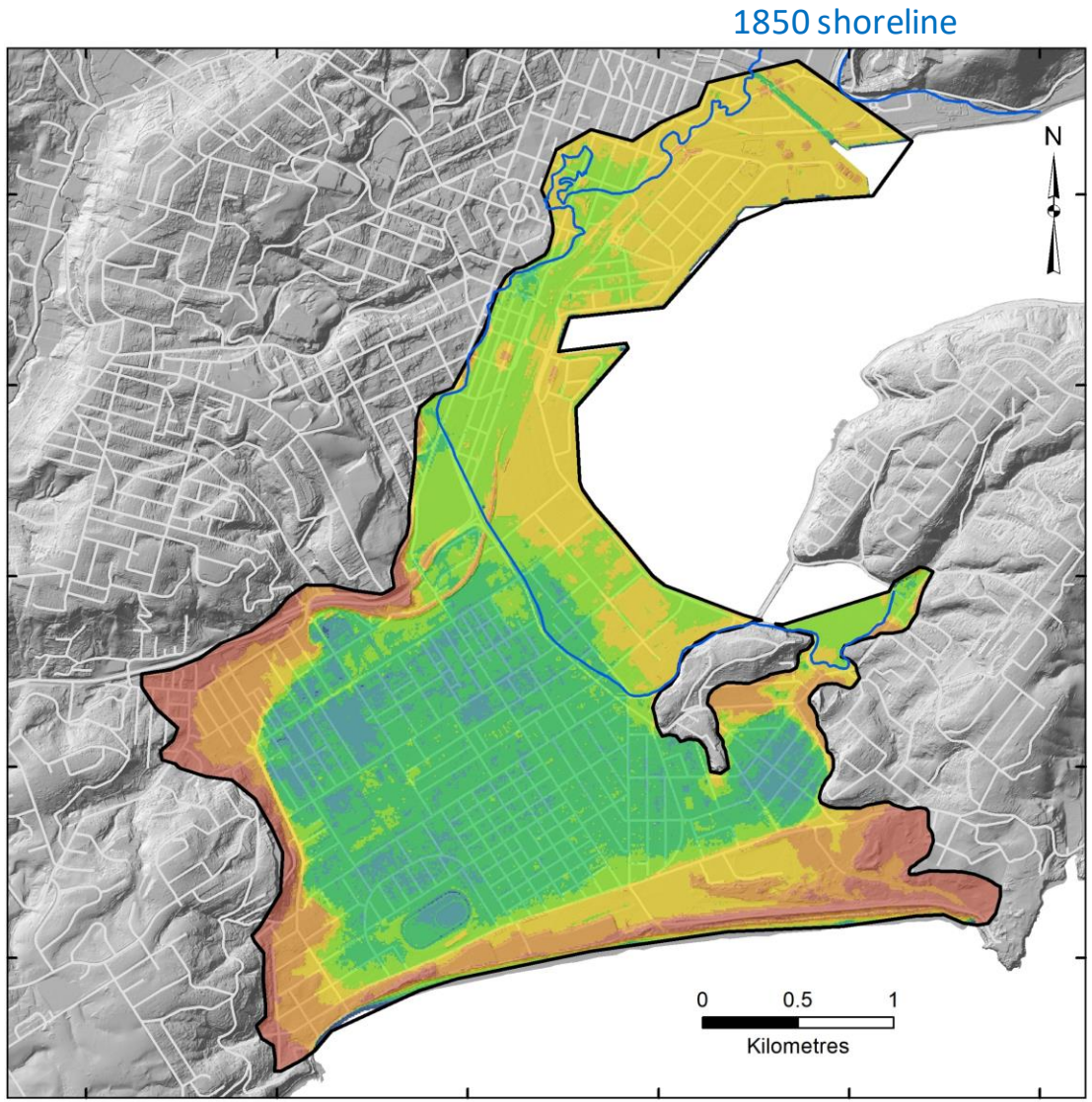
Dunedin has shallow groundwater



The flat-lying coastal land of Harbourside and South Dunedin has shallow groundwater.

The report provides depth to water (DTW) grids at median, min, max, p5, p95, high tide and storm surge (ESL) conditions.

Variability is characterised by annual exceedance probability (AEP) and average recurrence intervals (ARI) in years.

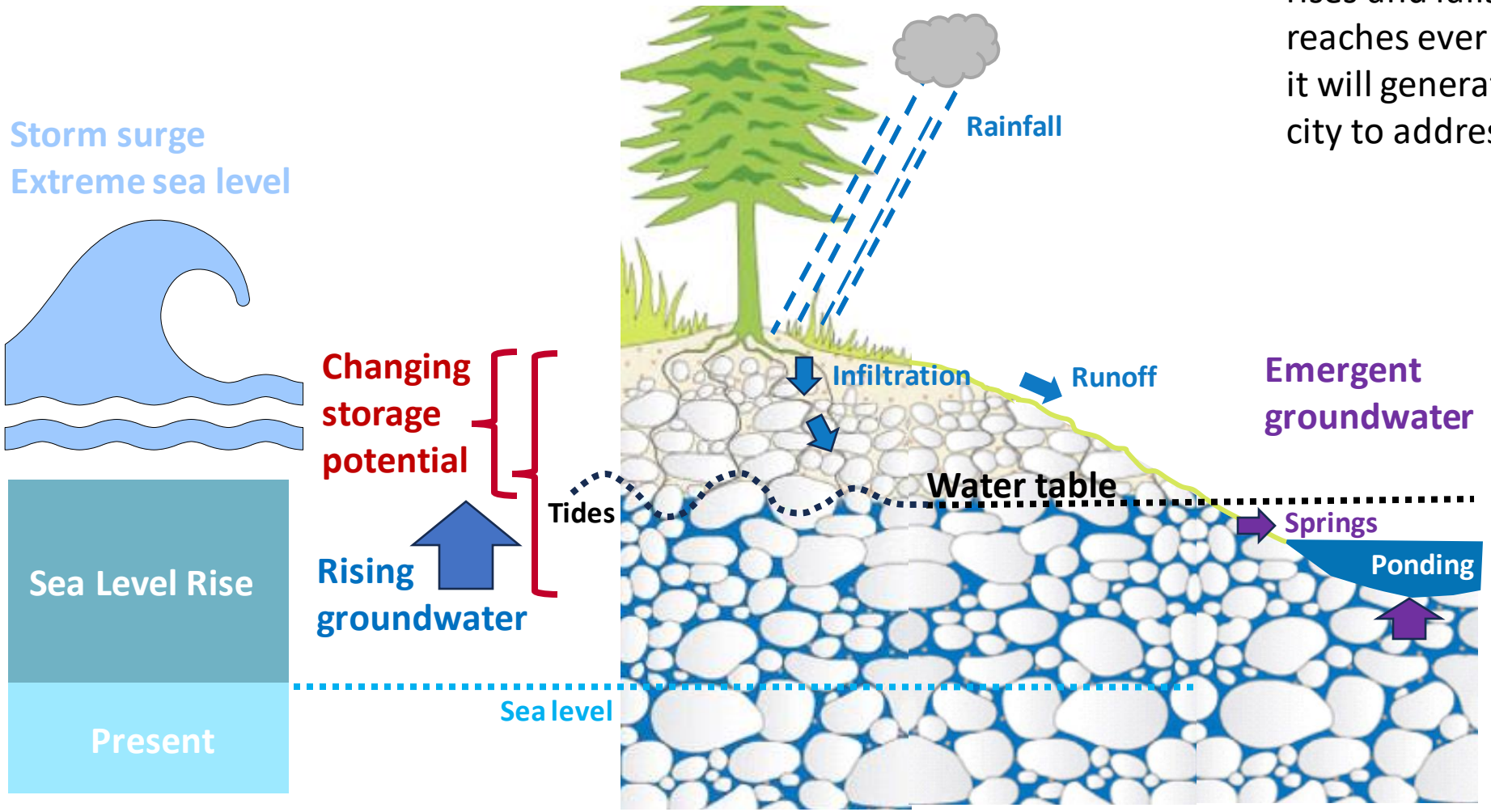


Map of present-day depth to groundwater (median)

Rising groundwater can create problems

Groundwater is expected to be affected by sea-level rise, and vulnerable to changes forced by the harbour and ocean.

The water table (upper surface) always rises and falls, but as its average position reaches ever closer to the ground surface it will generate a variety of issues for the city to address.



Impact of sea-level rise on groundwater and related hazards

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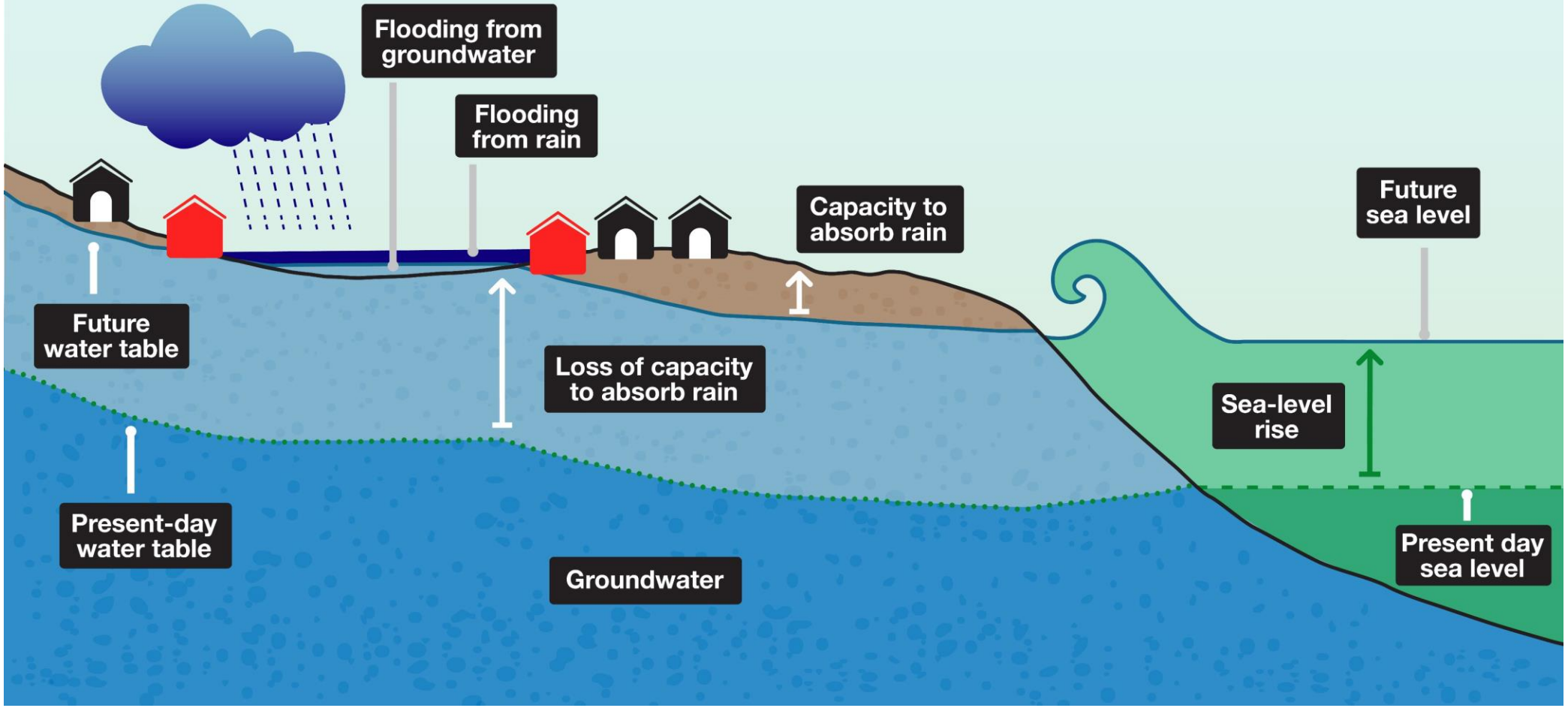
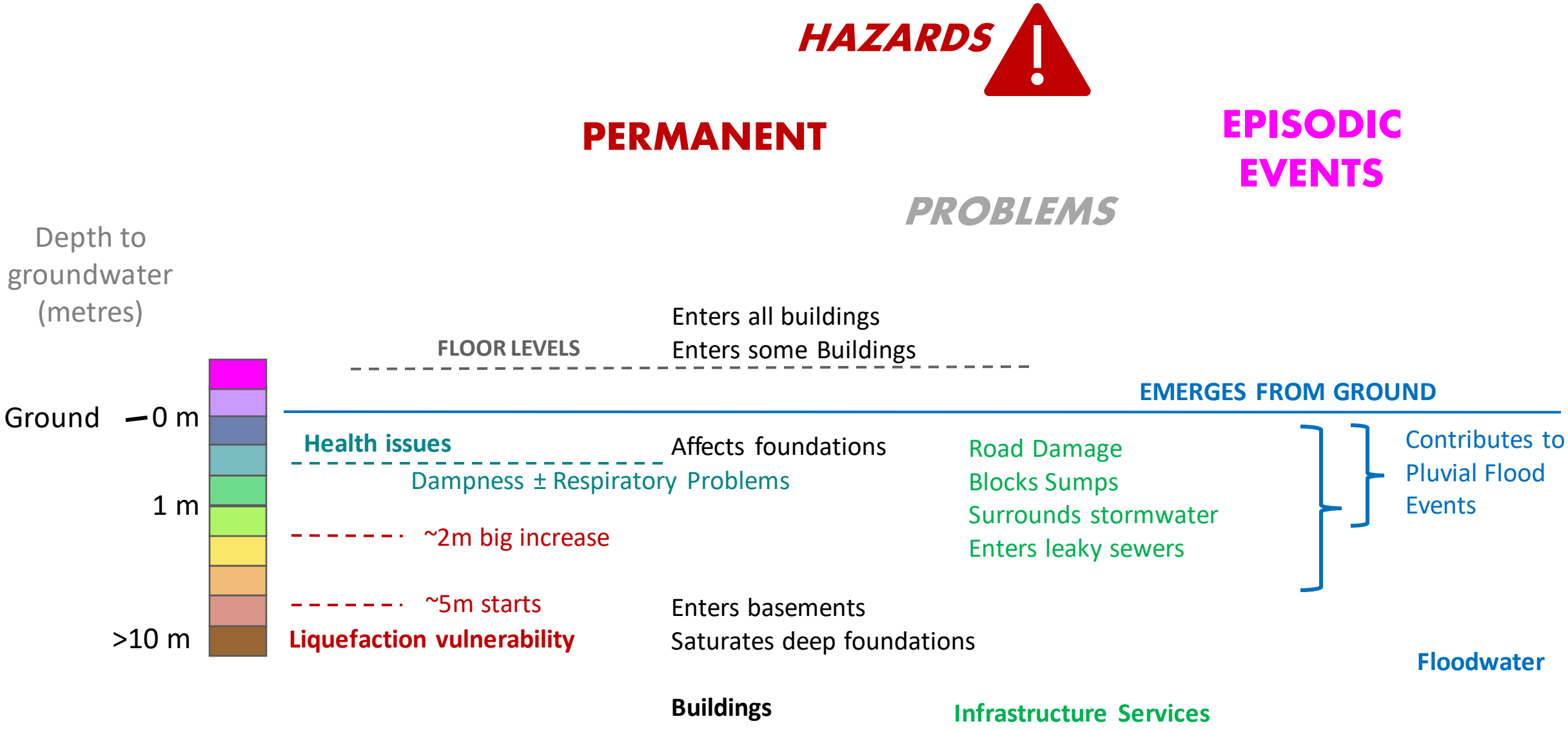


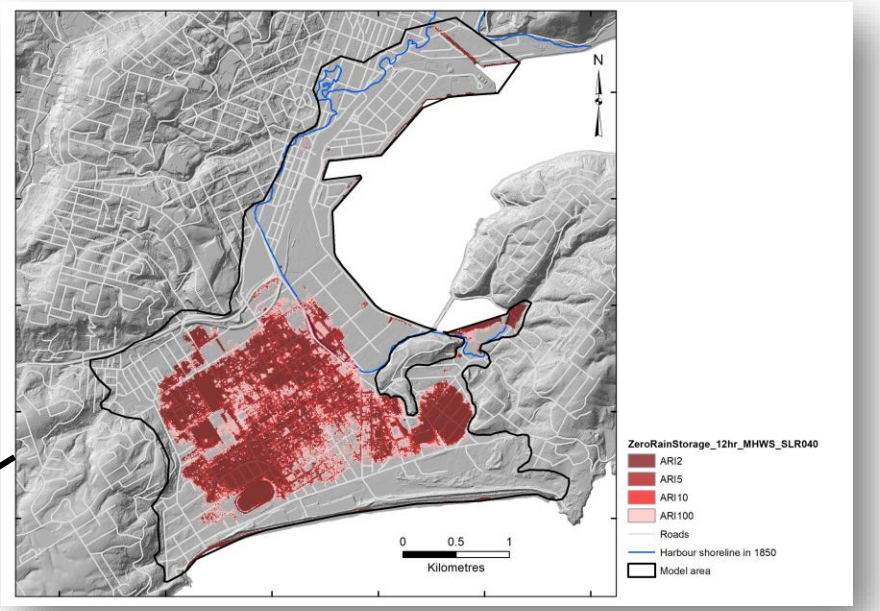
Some possible issues, problems and hazards

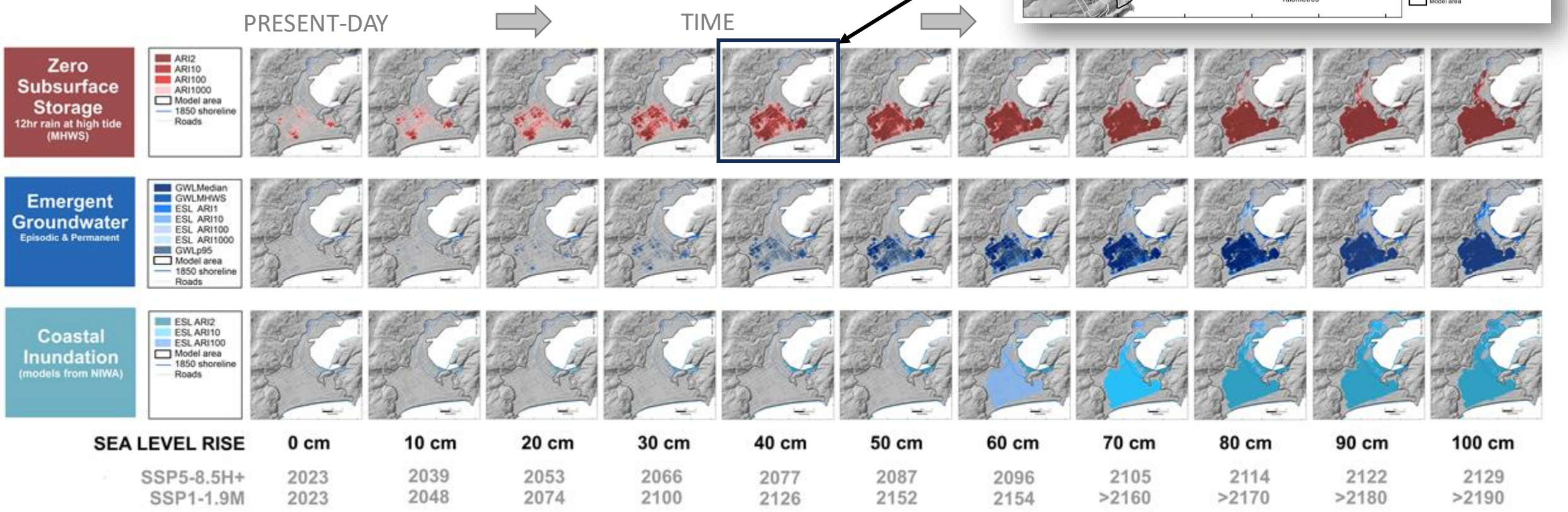


Report Forecast for Dunedin

Less prone to tidal flow and entry of seawater than initially feared.

Sources of flooding:
- rainfall and the loss of ground's capacity to store water
- rise of water table & emergence of groundwater
- direct coastal inundation

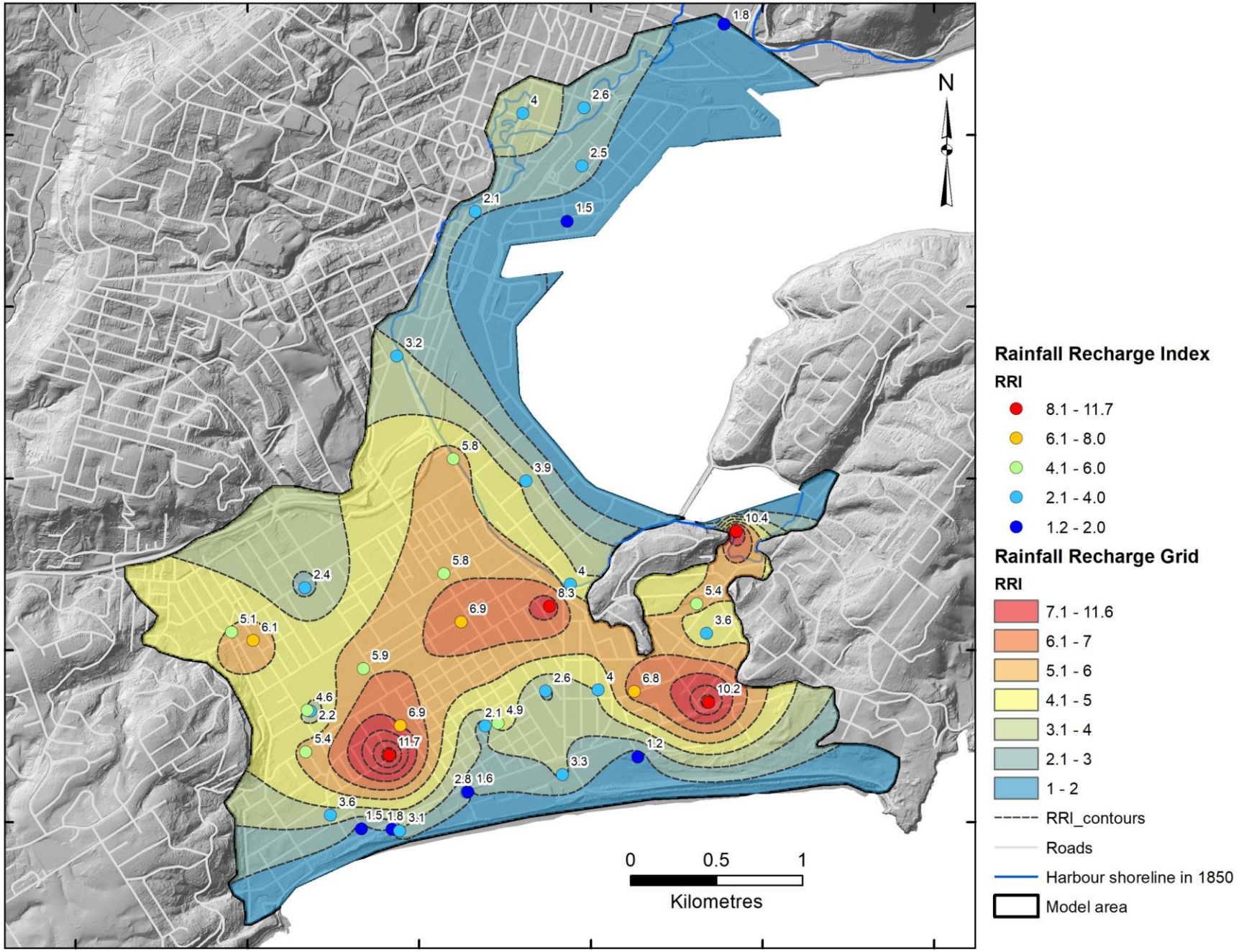


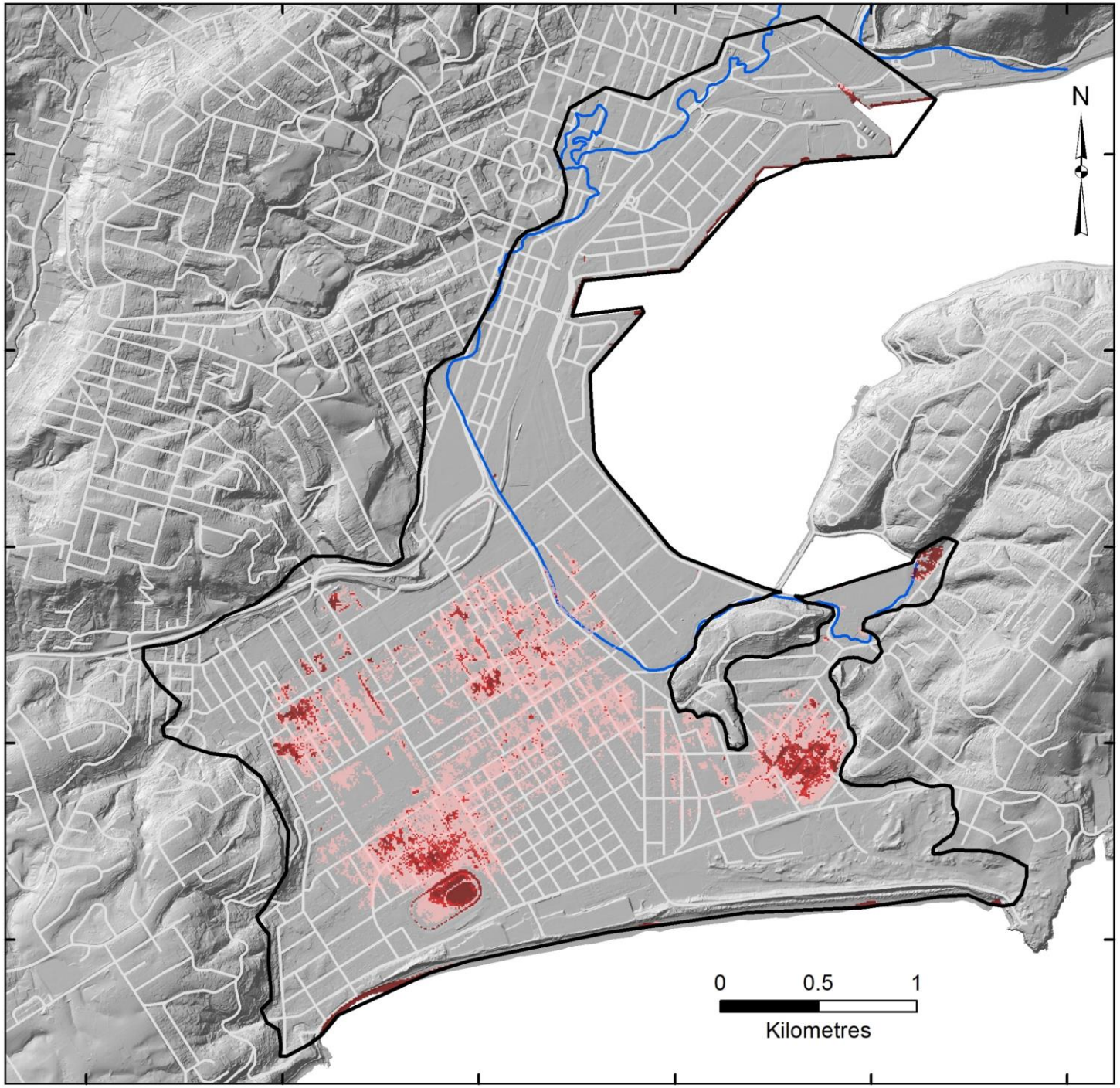


Groundwater response to rain

Map shows rise in GWL for every mm of rain

Subsurface storage capacity
(dependent on site RRI)

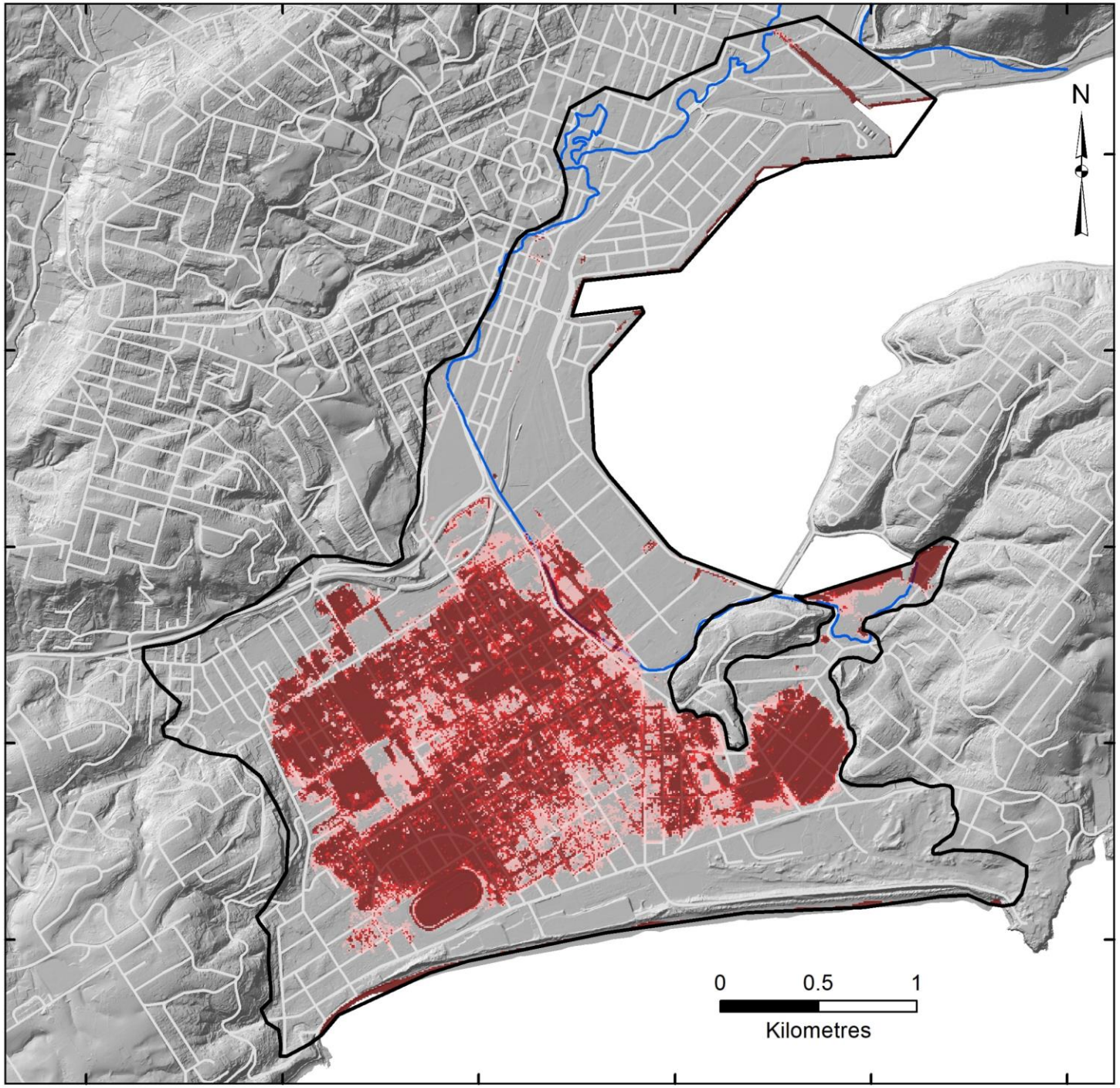




Example: Loss of storage capacity

SLR 0 cm
(Present-day)

No ability to store 12 hr rainfall at 2, 5, 10, 100 year average recurrence interval (ARI)



Example: Loss of storage capacity

SLR 40 cm
(Between 2077-2126)

No ability to store 12 hr rainfall at 2, 5, 10, 100 year average recurrence interval (ARI)

Forecasts based on sea level rise increments (not time)

40 cm SLR might be reached as early as 2077, or perhaps not until 2126 if CO_2 emissions are dramatically reduced

Sea-level rise is already happening but science cannot yet be specific about the timeframe of exactly how quickly.

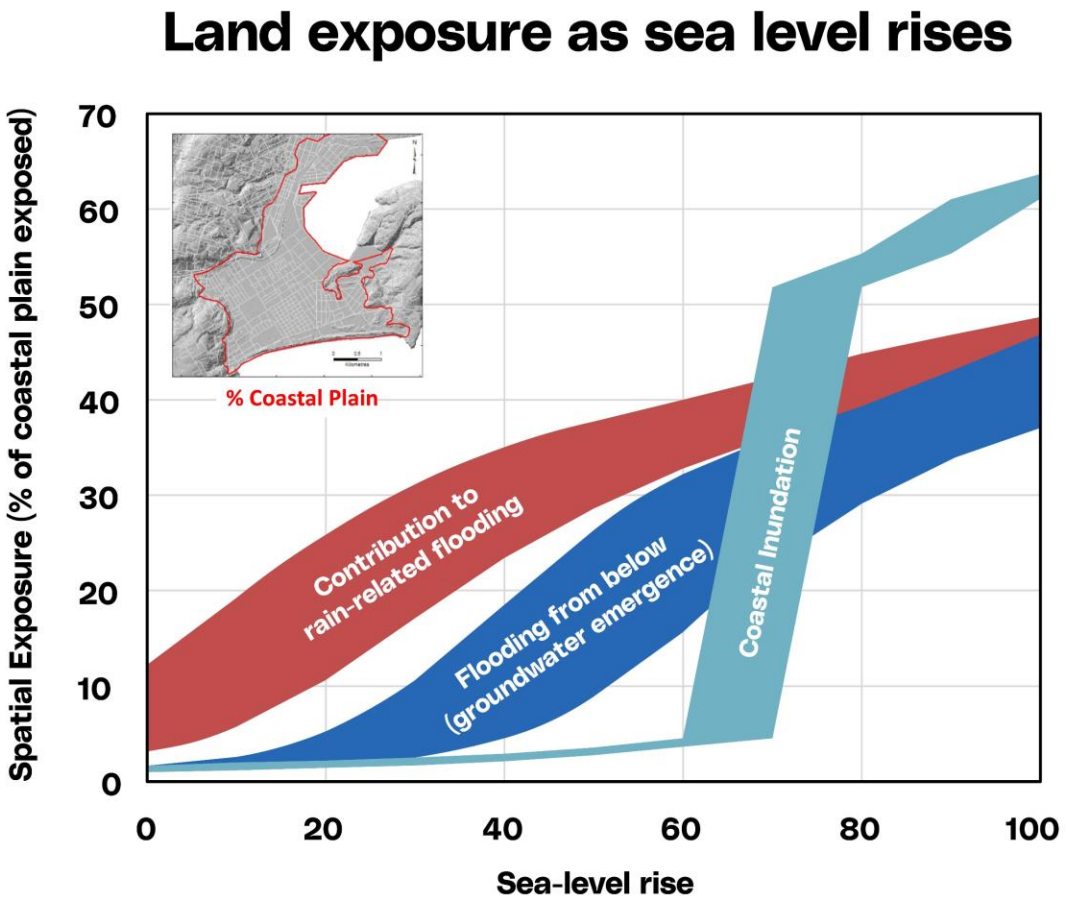
That depends on global warming and efforts to reduce emissions.

The report provides forecasts in 10cm increments of sea level rise, and a lookup table from which to plan for the possible times when this may happen.

Sea-Level Rise (cm)	10	20	30	40	50	60	70	80	90	100
Medium Confidence										
SSP1-1.9 M	2048	2074	2100	2126	2152	-	-	-	-	-
SSP1-2.6 M	2047	2069	2091	2112	2133	2154	-	-	-	-
SSP2-4.5 M	2043	2061	2078	2093	2108	2121	2134	2147	2158	-
SSP3-7.0 M	2042	2057	2071	2083	2094	2105	2114	2123	2132	2140
SSP5-8.5 H+	2039	2053	2066	2077	2087	2096	2105	2114	2122	2129
Low Confidence										
SSP1-2.6 L	2044	2064	2084	2104	2124	2144	2163	-	-	-
SSP2-4.5 L	2041	2058	2074	2089	2104	2117	2130	2142	2154	2166
SSP5-8.5 L	2052	2066	2077	2086	2094	2101	2108	2115	2120	2126

Lookup table outlining time at which various scenarios of sea level rise will be reached in Dunedin, referenced to 2023. Based on data for Site 4780 (St Clair) using RSLR data from NZSeaRise. (Table 2.4 from Cox et al. 2023).

Evolution of groundwater-related hazards



1. As groundwater rises, the ability to for rainfall to be absorbed into the ground like a sponge decreases. This exacerbates existing rain-related flood issues. This is likely to remain the dominant issue for the next 30 to 40 years.

2. Groundwater rising to the surface will move from periodic occurrences (at less than 40cm of sea-level rise, expected around 2080) to permanent springs and/or flooding (after 40cm of sea-level rise has been reached as easrly as 50 years from now).

3. Groundwater-related issues are expected to occur well before the sea inundates land, at least locally in South Dunedin due to the protection sand dunes offer against high-tide. Coastal inundation from the harbour is unlikely to occur until 60-70 cm of sea-level rise (expected around 2100 or later).

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Where to from here?

New GNS Report provides a holistic multi-hazard vision of the long-term challenges and Dunedin's future.

Sharing and explaining the new information.

Enables 'vision' of future for Dynamic Adaptive Planning.

South Dunedin Future Programme