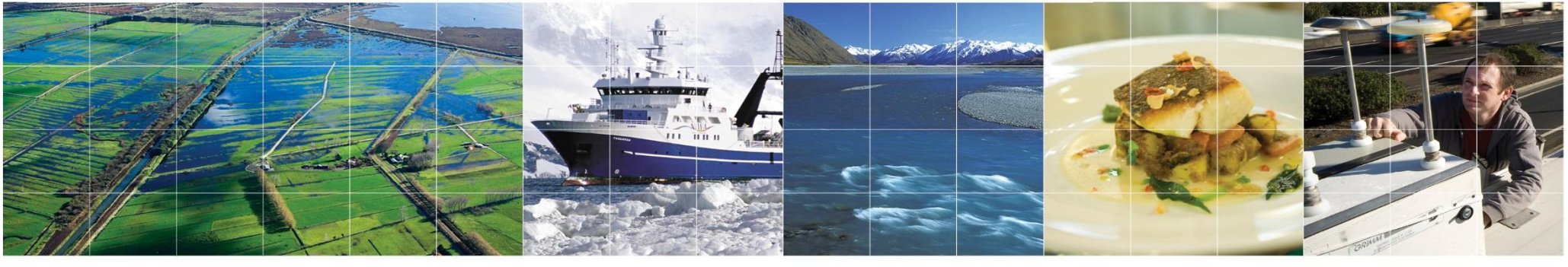
Emergent challenges adapting coastal stormwater and drainage systems

Rob Bell, Scott Stephens (NIWA), Judy Lawrence (VUW)

Stormwater Conference, Queenstown, 23-25 May 2018



Key climate-change drivers & impacts

NZ's top 3 physical drivers arising from CC

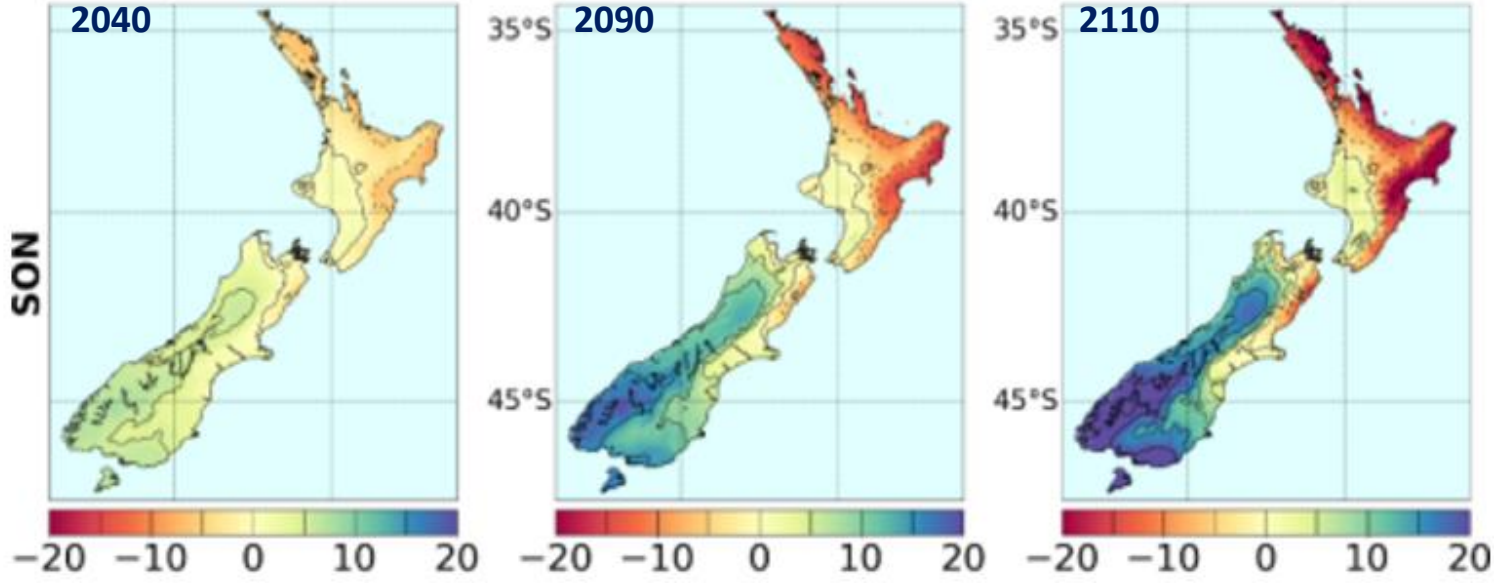
- Coastal areas - ongoing sea-level rise + more erosion
- Too much water – high-intensity rainfall, storms, g/w, sea/river overtopping
- Not enough water – increased frequency of droughts, winds (esp. east)

Implications for coastal SW infrastructure/assets

Legacy SW systems designed largely on a static likelihood basis . . . but

- Tailwater levels have risen (MSL, tides → g/w, storm-tides)
- Secondary or non-existent effects are emerging as majors:
  - Groundwater: infiltration, saline water, reduced field capacity
  - Changing intense rainfall occurrences (LOS)
  - Saltwater intrusion: corrosion, water quality, vegetation (BMPs)
  - Wave overtopping – damage and debris more common
  - Gravity systems less effective

Annual/seasonal precipitation changes



% change Spring (Sept- Oct-Nov): RCP8.5

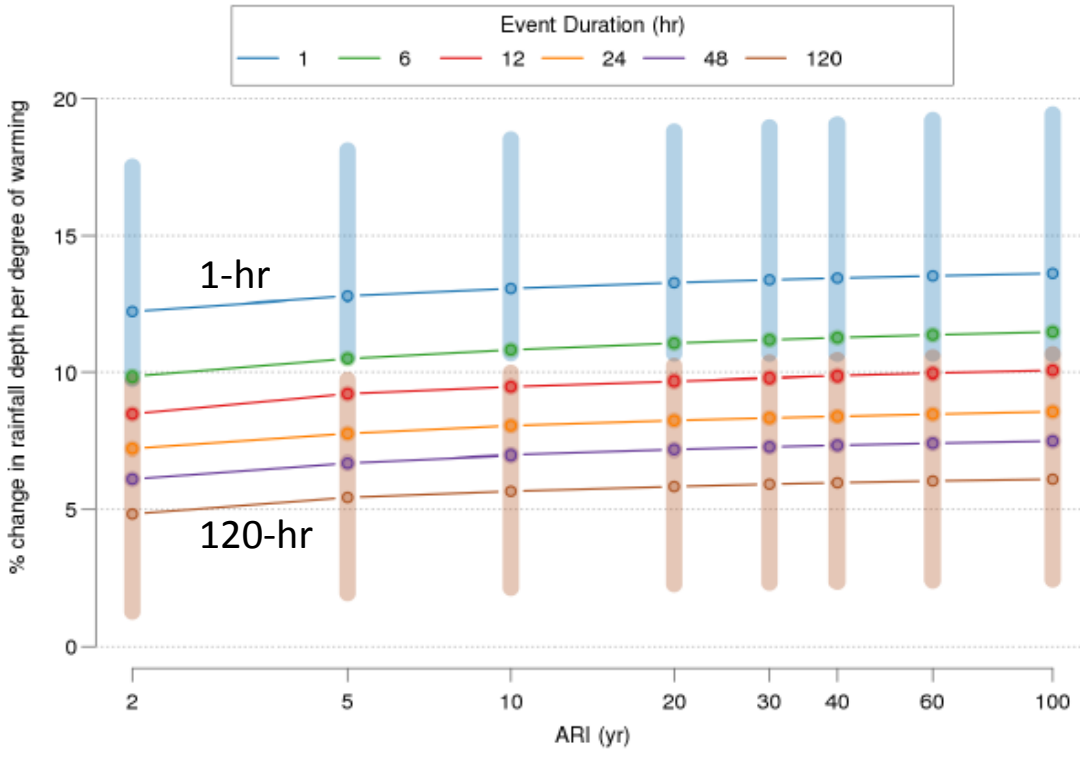
- Precipitation projections are highly variable by region and time and between models
- Overall pattern in annual precipitation trend is for a reduction in the north and east of the NI, and increases almost everywhere else, especially on the West Coast

- Dry days and drought – more in North & East North Island, lee of Alps

Key change driver: increased rainfall → flooding (HIRDS)

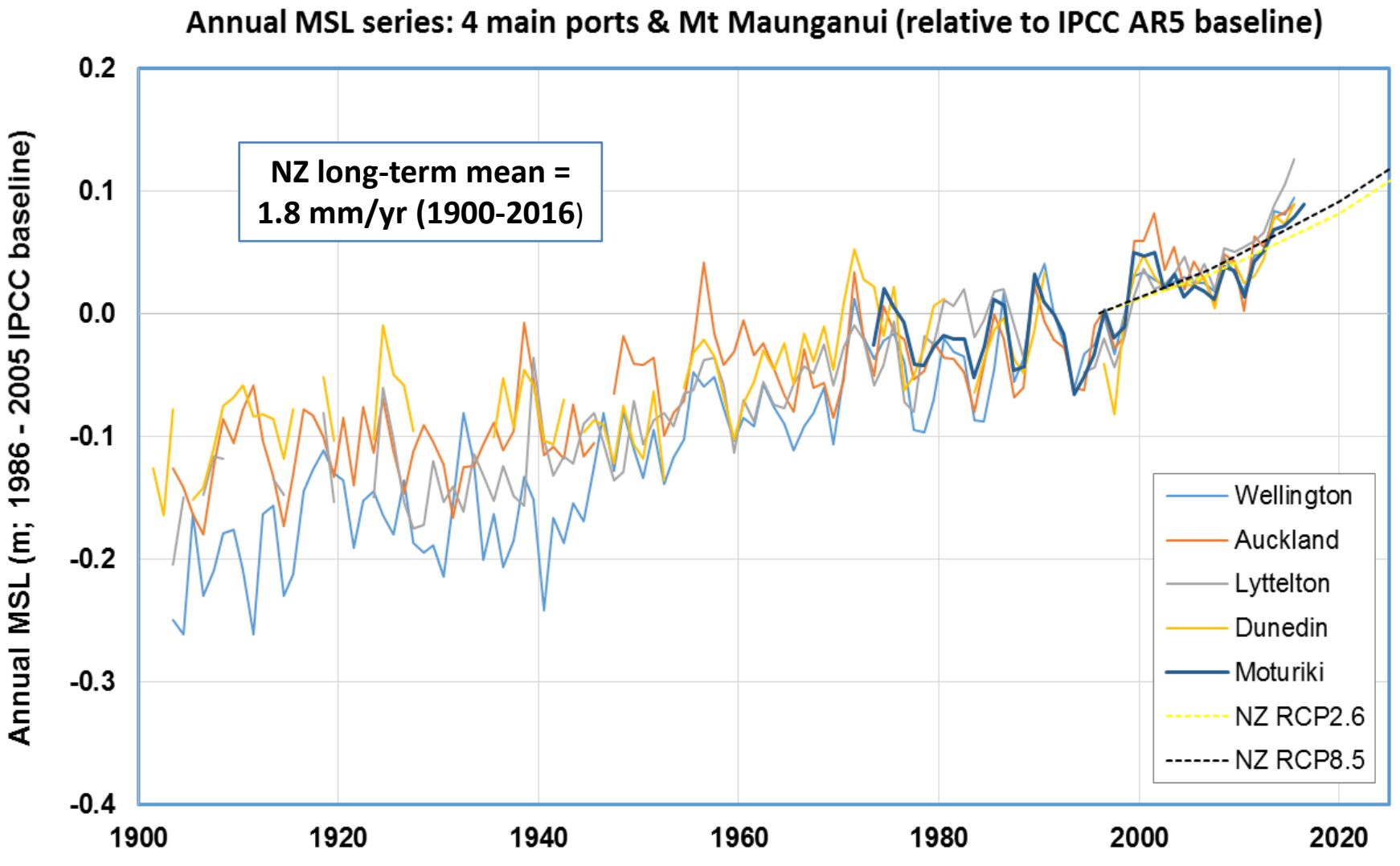
- Increasing risk of flooding, but widening uncertainty on amount of change for given design or planning timeframe (e.g. how global emissions track)
- Augmentation factor per °C warming: median varies from:
  - 5–6% increase (120-hr duration)
  - **12–14% increase (1-hr duration)**

  across 2–100 yr ARI events
- Regional variability of changes in 1-hour rainfall likely to be ~10–19% increase per °C
- Sub 1-hour duration changes would be even higher
- Would pose significant challenges esp. for legacy SW systems

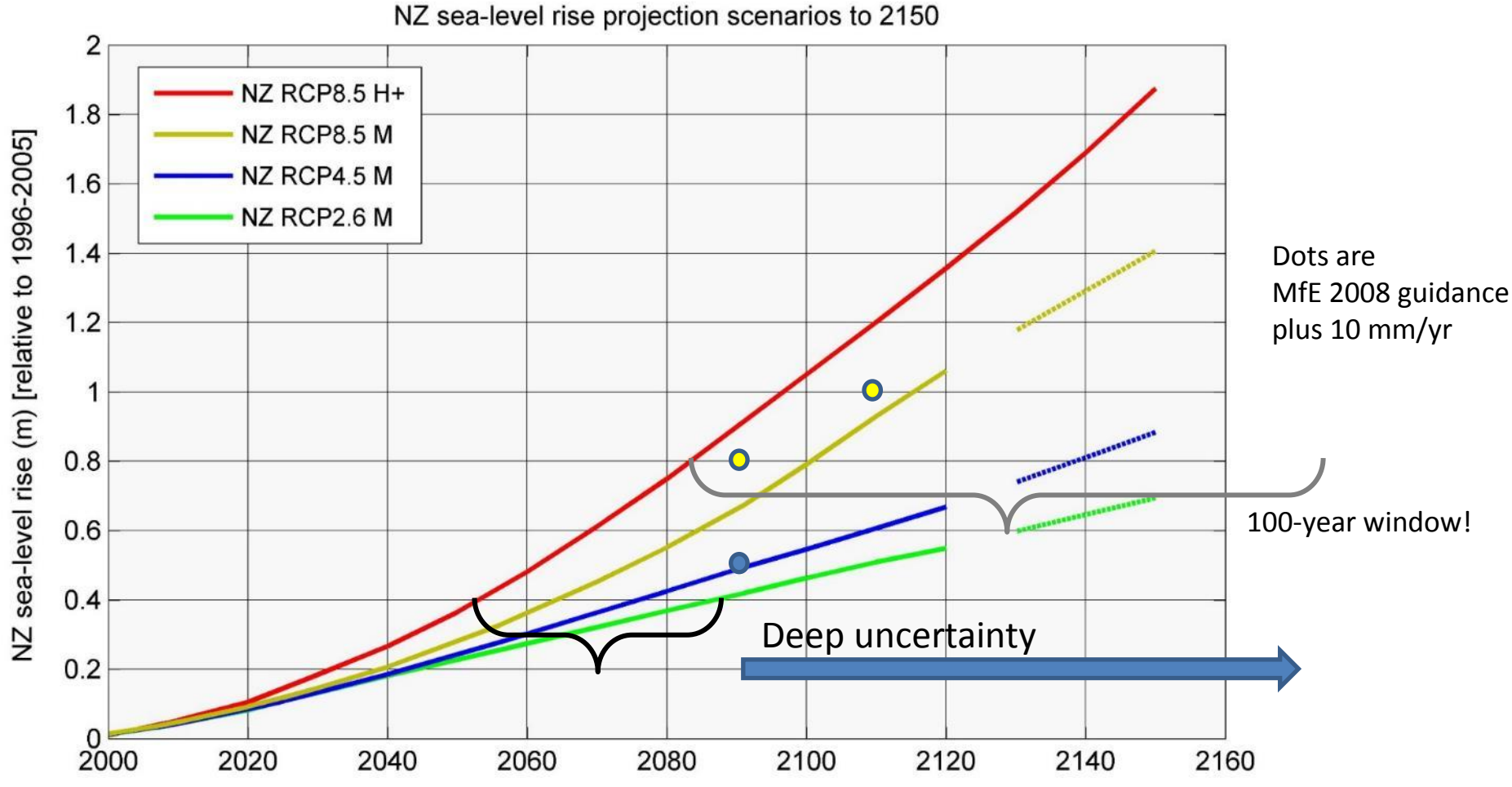


Carey-Smith et al., 2018

HIRDS v4 available soon *https://hirds.niwa.co.nz/*


Annual MSL series: 4 main ports & Mt Maunganui (relative to IPCC AR5 baseline)
NZ long-term mean = 1.8 mm/yr (1900-2016)
Annual MSL (m; 1986 - 2005 IPCC baseline)
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
1900
1920
1940
1960
1980
2000
2020
Wellington
Auckland
Lyttelton
Dunedin
Moturiki
NZ RCP2.6
NZ RCP8.5

New Guidance uses a 4-scenario suite for NZ-wide sea-level rise



Coastal flooding on the rise with higher sea level ….

Te Puru

Simon Stephens

5 Jan, 2018

Ruby Bay

Supplied via TDC

1 Feb, 2018

Present 1% AEP event becomes an annual occurrence on average – with modest sea-level rise and likelihood virtually certain (by around 2050-60s)

2.9 m spring-tide range

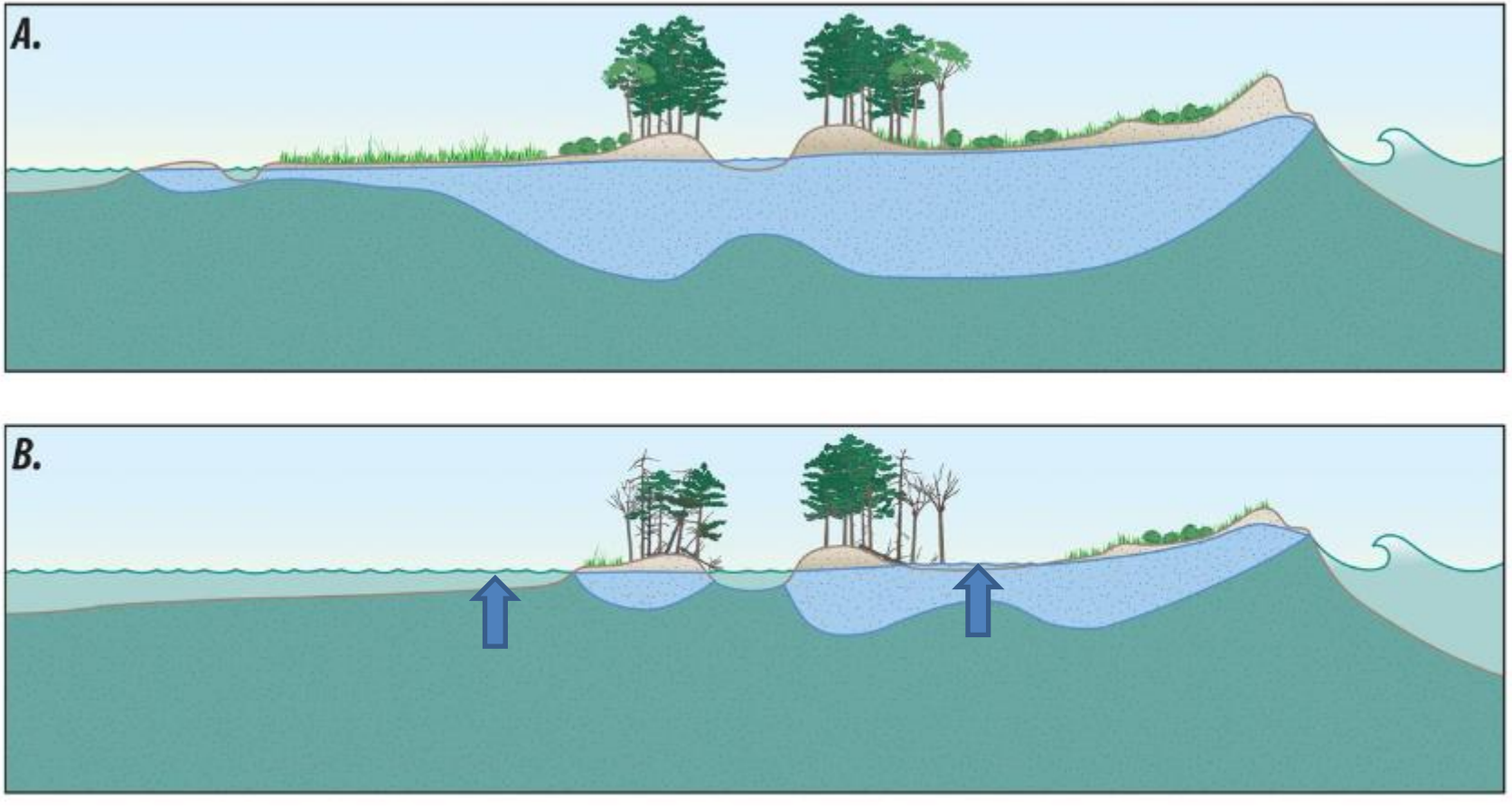
SLR	Auckland
0cm	Every 100 years
10cm	Every 35 years
20cm	Every 12 years
30cm	Every 4 years
40cm	Every 2 years
50cm	Every 6 months
60cm	Every 2 months
70cm	Every month
80cm	Every week
90cm	Twice a week
100cm	Every day

1.4 m spring-tide range

SLR	Wellington
0cm	Every 100 years
10cm	Every 20 years
20cm	Every 4 years
30cm	Once a year
40cm	Every 2 months
50cm	Twice a month
60cm	3 times a week
70cm	Every tide
80cm	Every tide
90cm	Every tide
100cm	Every tide

PCE (2015); NIWA (2015)

Coastal inundation from rising ground water



Masterson et al., 2014. Ecohydrology)

Coastal erosion & sea-level rise: relevant to SW

- Compounding effects on existing erosion-prone areas from SLR
  - Stormwater & higher groundwater exacerbates shoreline/beach erosion
  - Changes in catchment run-off & sediment after intense rainfall
  - Erosion & permanent inundation of estuarine & lowland river shorelines incl. wetlands & marshes (unless walls go up)

- Erosion opens pathway to coastal flooding & wave overtopping

- Erosion will remain a local-scale issue cf. to coastal flooding which will increasingly become the dominant coastal risk as seas rise

R Bell

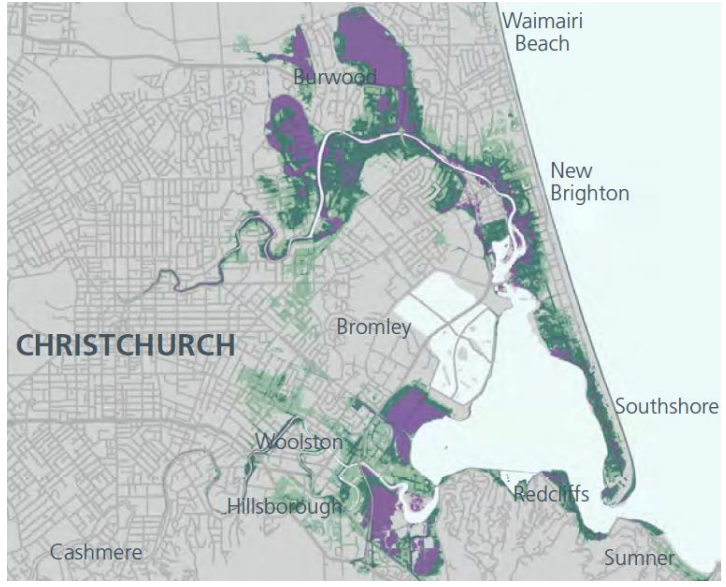
NZ's coastal risk exposure for ≤0.5 m above MHWS

A risk analysis based on **land elevation**: excl. stopbanks and **enumerating assets/residents**

- Population (NZ Census 2013)
  - **~46,000 residents** (excl. Red Zone)
- Buildings in NZ
  - Residential: **~9,000**
  - All types: **~13,000**
  - Replacement cost (**2011**): **NZ$3B**
- Roads
  - **924 km** (62% in Hauraki District)

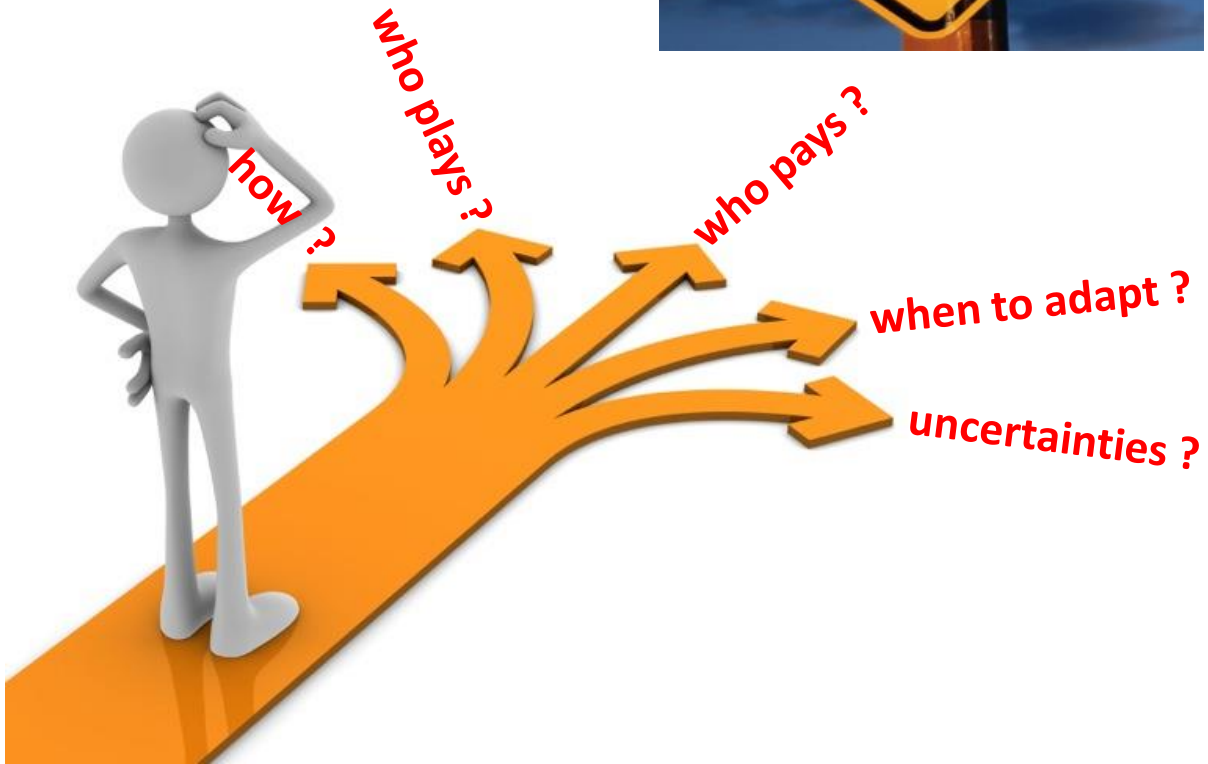
SW systems intricately tied to community viability

Purple: ≤ 0.5 m

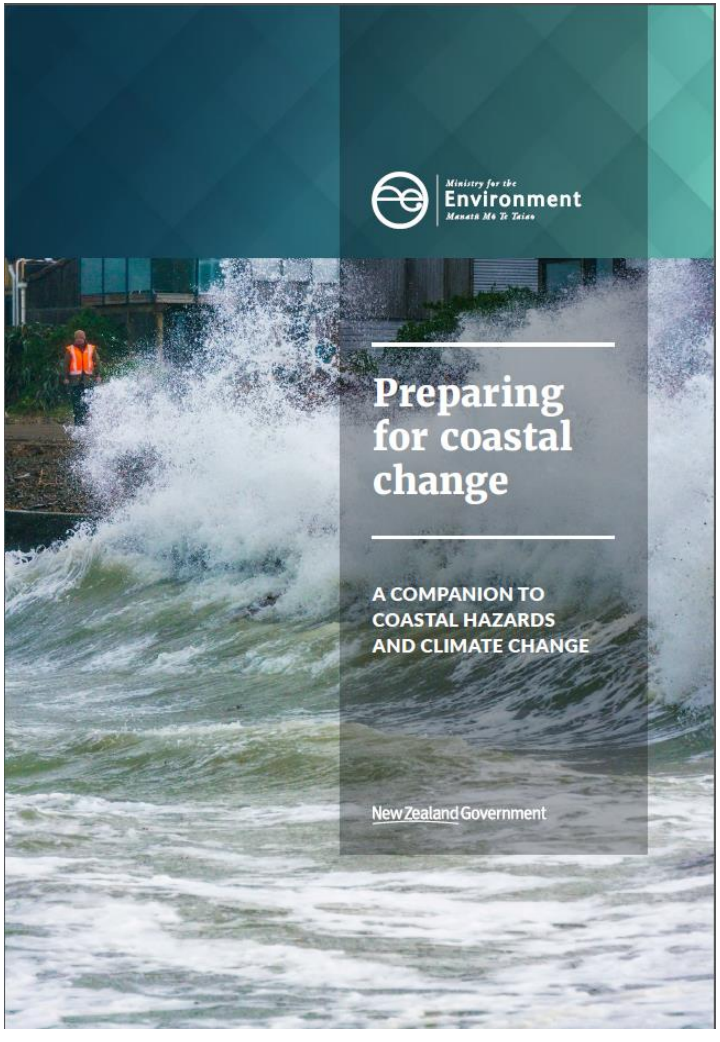


PCE (2015); NIWA (2015)


CHANGE
AHEAD


how ?
who plays ?
who pays ?
when to adapt ?
uncertainties ?

MfE coastal hazards & climate change guidance (Dec 2017)



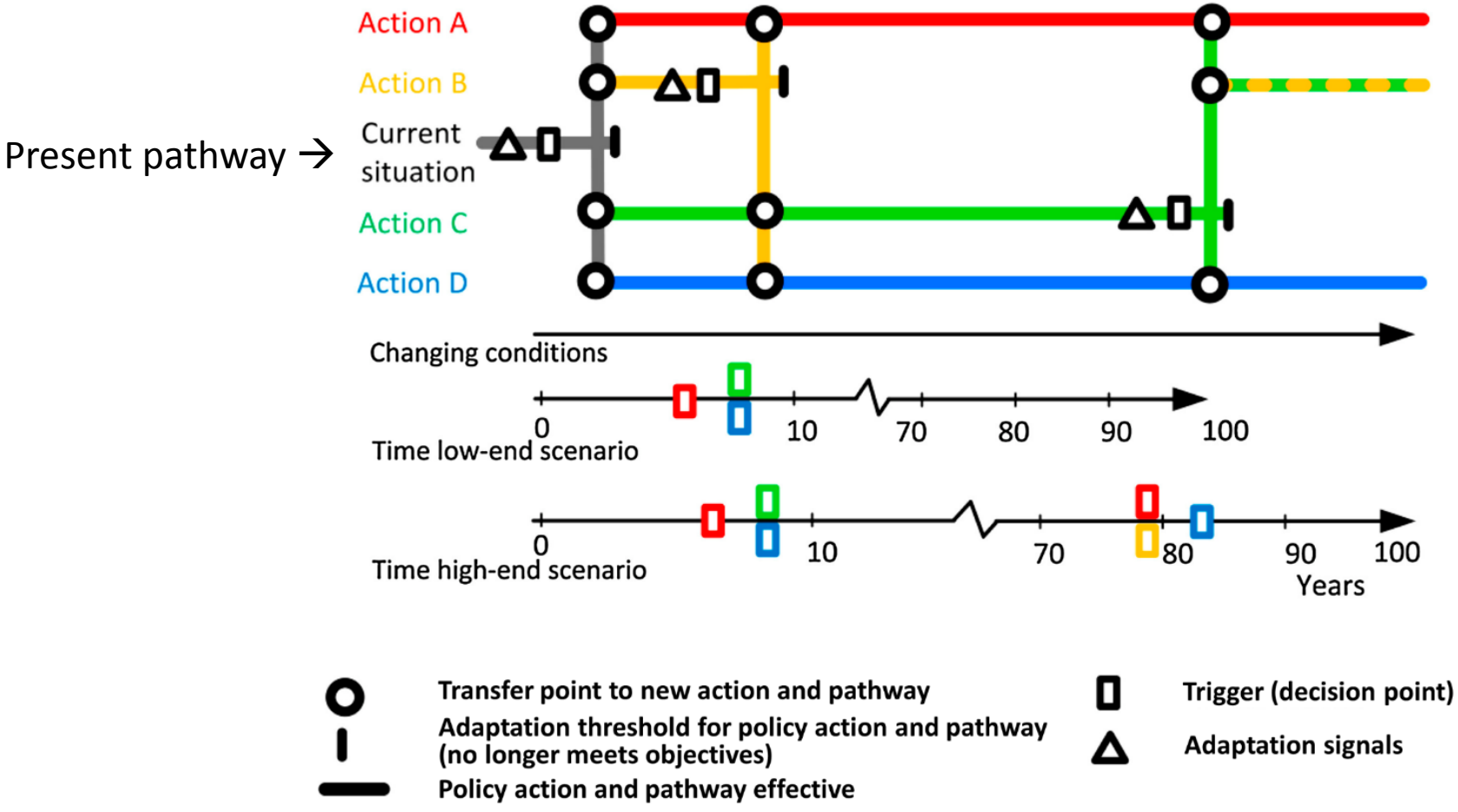
- *Risk* is "effect of **uncertainty** on **objectives/values**"
- Tiered risk assessments to **focus on assessing consequences** for a range of SLR scenarios (not assigning likelihoods, as widening uncertainty)
- ***Consequences*** = exposure & vulnerability/fragility
- Given **ongoing changing risk:** adaptation also requires input from broader vulnerability assessments
- **Engagement** with communities and stakeholders (guidance and principles)
- **Adaptive approach**, rather than picking a # or scenario. Adaptation threshold and triggers for switching pathways (informed by risk + vulnerability assessments and translating values → objectives)

Vulnerability assessments: inform triggers and adaptation thresholds

Braden Fastier

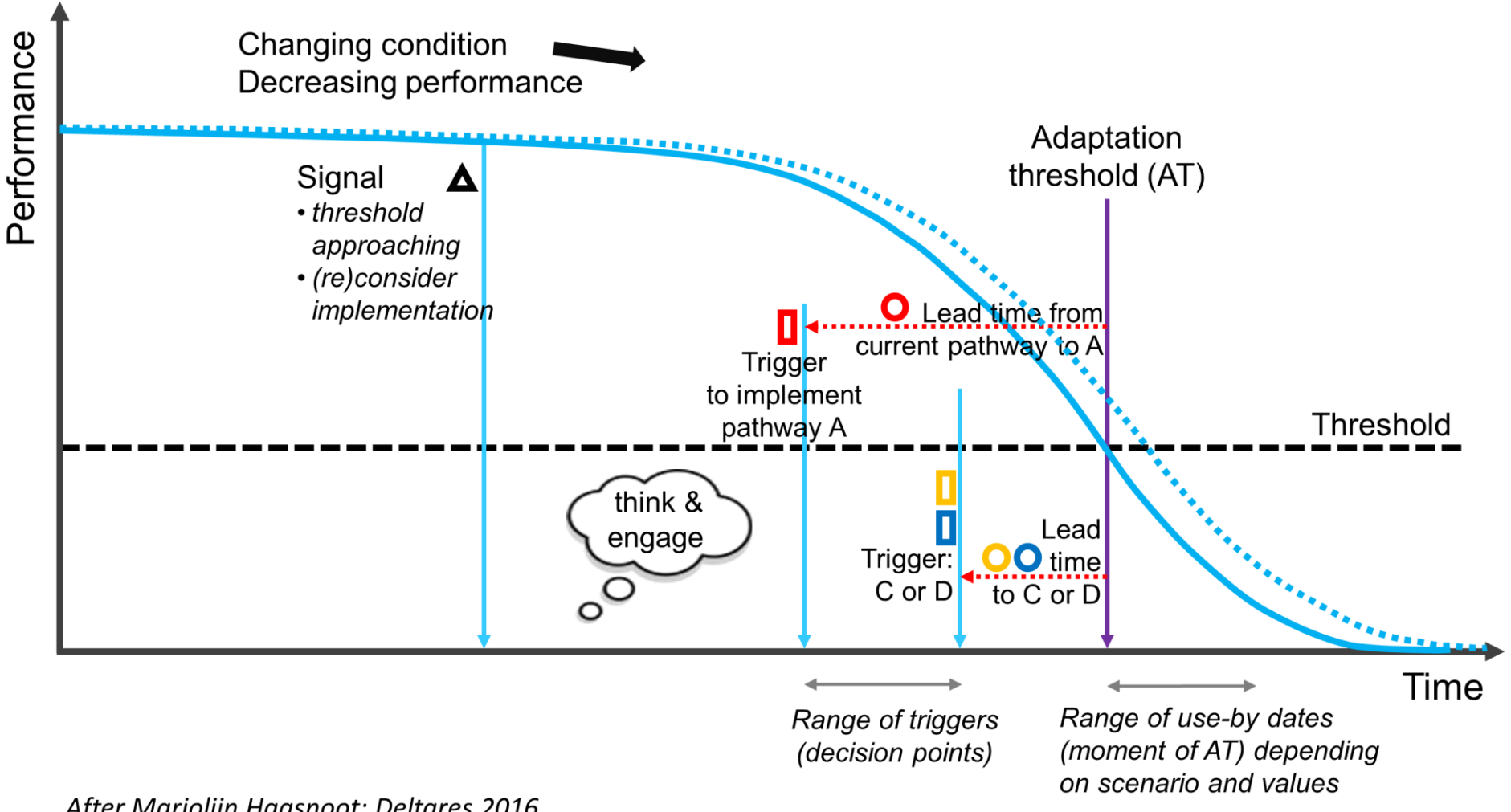
- Much broader than conventional risk assessments – interconnectedness of communities & services (social fabric)
- *Vulnerability* = Predisposition to be adversely affected
- Encompasses:
  - Susceptibility to harm or damage – feel safe?
  - Attachment to place or values e.g. loss of amenity, public access, cultural significance
  - Viability of local economy & businesses
  - Viable level of service (esp. SW and WW)
  - Social equity issues
  - Demographics
  - Capacity to cope and adapt (or not)
  - Insurance cover/excesses & mortgage access?

Dynamic adaptive pathways planning (DAPP)

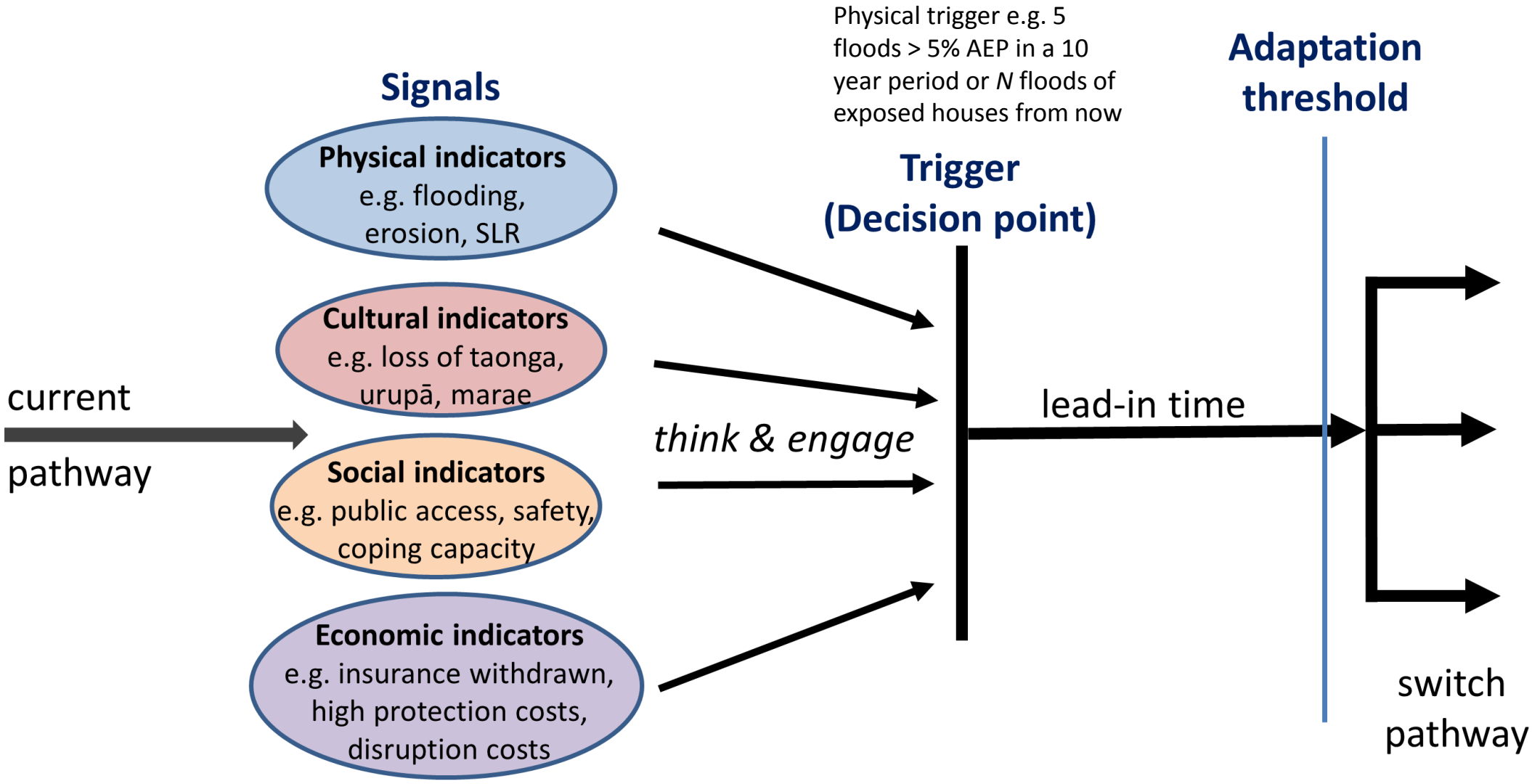


After Haasnoot et al. (2013), Hermans et al. (2017)

Monitoring: Signals, triggers and adaptation thresholds



After Marjolijn Haasnoot: Deltares 2016


Physical trigger e.g. 5 floods > 5% AEP in a 10 year period or N floods of exposed houses from now
Signals
Trigger (Decision point)
Adaptation threshold
Physical indicators
e.g. flooding, erosion, SLR
Cultural indicators
e.g. loss of taonga, urupā, marae
Social indicators
e.g. public access, safety, coping capacity
Economic indicators
e.g. insurance withdrawn, high protection costs, disruption costs
current pathway
think & engage
lead-in time
switch pathway
Informed by risk & vulnerability assessments, Matauranga Māori

Emerging impacts on SW systems

- **Compounding effects**: increasing rainfall and coastal storm events (+ SLR)
  - existing “pressure” on stormwater/drainage gravity systems
  - decrease in LOS of stormwater and flow-path networks
  - increased susceptibility of BMP’s (at low points: end-of-pipe or flowpath)
  - SW infiltration of sewerage and OSW systems (more overflows → water quality)
  - more hinterland development (new assets merged with legacy SW systems)

- **Groundwater and drainage at the coast**:
  - g/w (tidal) will continue to rise
  - gravity drainage more problematic
  - more freq. soil saturation + salinization
  - Building/road foundation instabilities (LQF)
  - salinization/salt exposure: wetlands/swales

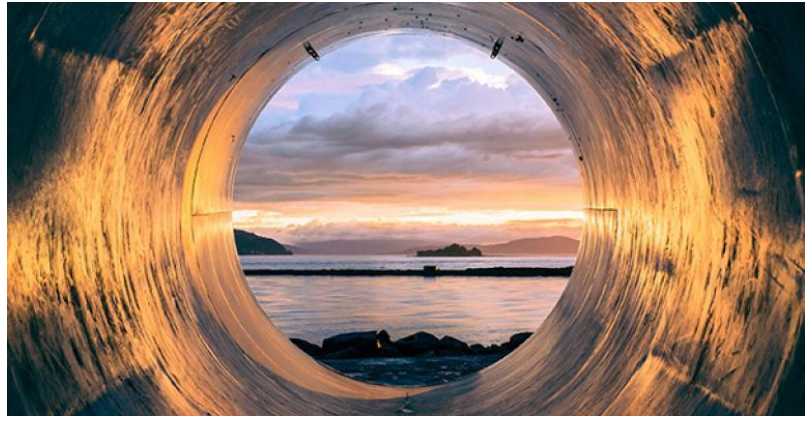
Seawater seepage

- **Climate sequencing**: Longer droughts punctuated by intense rainfall

Deep South Challenge: Dialogue process paper (SW/WW)

- 17,000 km of stormwater networks
- Roads are often designed or used as secondary stormwater routes
- Sea-level rise will affect ALL coastal infrastructure: *flood tailwaters, freq., corrosion, salinization of BMP detention*. Will be most costly areas to adapt

Question One: *What are the potential direct and indirect social, cultural, economic and environmental impacts of climate change on stormwater and wastewater systems?*



New Deep South project :
T + T, NIWA and Infometrics (+ Stakeholder Group)

A few implications of CC: SW/drainage systems

- Public expectation that the design and maintenance of assets & services will consider the implications of climate change (CC) *[often raised after an event]*
- CC will lead to increasingly changing environmental conditions & compounding risks – no longer a static regime. Historic design extremes no longer a useful guide for future
- Design and standards will need to be more adaptive to:
  - ✓ deal with **scenario uncertainty** (multiple possible futures) and **deep uncertainty** (known unknowns) – but not adapt prematurely (high present value) or too late (adverse risk)
  - ✓ incorporate **joint probabilities (AEPs)**: rainfall, storm-tide, g/w + SLR
  - ✓ build in signals and triggers (decision points) – **monitoring change** becomes crucial
  - ✓ **avoid locking in path dependence** (eg, a fix for today - but may have a short shelf life)
  - ✓ changing & wider range of **community expectations** of service levels and priorities
- Adaptive designs – "working with water" (water-sensitive), legacy ⟺ new

Some pointers relevant for SW/drainage

- **Ongoing change** in climate/ocean drivers is the new normal for coastal/estuarine areas
- Evidence-base: **national/regional stocktakes** on exposure of assets to coastal CC e.g. LGNZ project, Deep South- NIWA (but needs good geospatial info on assets/attributes)
- New **research initiatives** e.g. Deep South Challenge "2-waters" project, LG Risk Agency?
- WW and SW issues may be a gamebreaker (trigger) for **viability for some coastal settlements/suburbs** and lowland river areas e.g., road access diminishes, g/w, saltwater flooding, drainage, pumps, OSW's, outfalls
- More **engagement with communities**: service levels, expectations, increasing risks
- **Adaptive pathways planning** - with signals & triggers - provides a way to work around uncertainties (but still give communities a road map) → MfE Coastal Guidance

Benjamin Eitelberg

CLIMATE CHANGE & STORMWATER AND WASTEWATER SYSTEMS

An Executive Summary of Motu Note #28

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Coastal drains and pipes combined with climatic change, need thought and action.

http://www.deepsouthchallenge.co.nz/news-updates/new-zealands-water-systems-particularly-vulnerable-climate-change