Dune Restoration Trust of New Zealand

National Conference, 2013

Nelson – A Region of Coastal Diversity

Conference Presentation: Tasman Bay and Golden Bay - Risk Assessment and Sensitivity to Sea Level Rise

DUNE RESTORATION TRUST OF NEW ZEALAND

www.dunestrust.org.nz

Tasman Bay and Golden Bay - Risk Assessment and Sensitivity to Sea Level Rise

Eric Verstappen
Dune Restoration Trust Conference 2013, Nelson

Outline

- Risk, causes and probability
- Coastal sensitivity past and present – Coastal Explorer
- Sea Level Rise (SLR) projections – a reminder!
- The effect of SLR on storm tides
- The effect of SLR on storm waves and storm tides
- SLR and inundation hazard risk
- Future outlook

What are hazard risks?

The key hazard risks are:

- Coastal erosion
- Coastal inundation
- River flooding

A hazard risk is a potential event with harmful effects

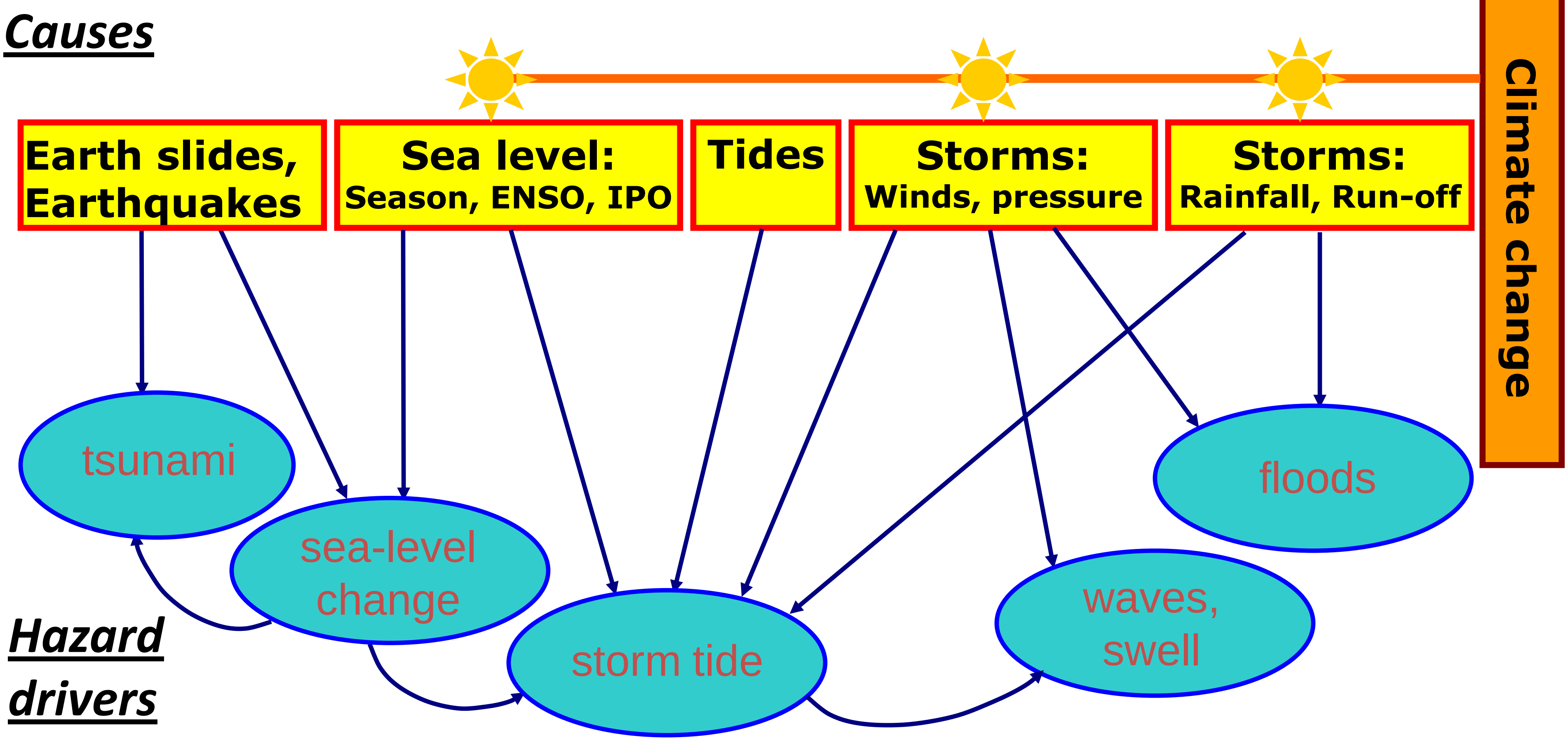
Risk has event **probability** and event **consequences**

Probability is the average likelihood per year or over a period of a given size of event (eg. 1%AEP or Q100)

Consequences include the scale and effects of the event

Climate change influences on hazard risks

- Climate change may :
  - increase the likelihood of intense weather - storms and large rainfalls, with
  - severe erosion and flooding effects
  - result in sea level rise, that worsens the event effects
- Sea level may rise by more than 0.8 m by 2100 with further rise beyond 2100



coastal inundation

Coastal hazards

R Bell

The Language of Exceedence Probability and Return Interval

Relationship between annual exceedance probability (AEP) and average recurrence interval (ARI).. AEP = $1 – e^{(-1/ARI)}$.

AEP (%)	99	86	63	39	18	10	5	2	1	0.5
ARI (Yrs)	0.2	0.5	1	2	5	10	20	50	100	200

Likelihood of an event with a specified probability of occurrence (AEP / ARI), occurring within planning lifetimes.
$P = 1 - e^{-L / ARI}$, where L = planning lifetime and P = probability of occurrence within planning lifetime

		Planning lifetime (years)						
AEP (%)	ARI (years)	2	5	10	20	50	100	200
39%	2	63%	92%	99%	100%	100%	100%	100%
18%	5	33%	63%	86%	98%	100%	100%	100%
10%	10	18%	39%	63%	86%	99%	100%	100%
5%	20	10%	22%	39%	63%	92%	99%	100%
2%	50	4%	10%	18%	33%	63%	86%	98%
1%	100	2%	5%	10%	18%	39%	63%	86%
0.5%	200	1%	2%	5%	10%	22%	39%	63%

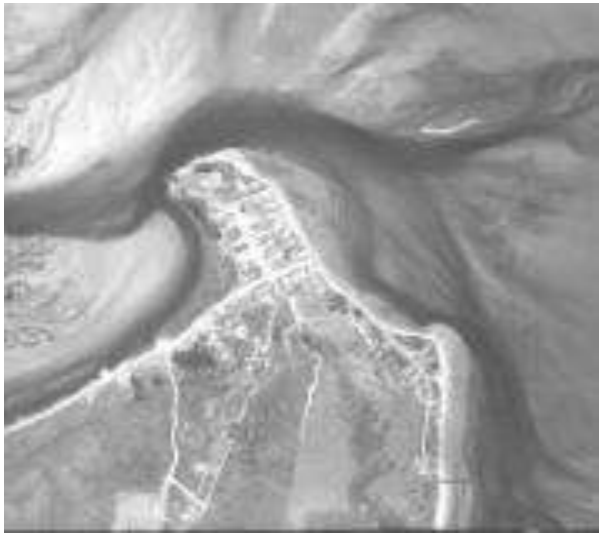
Likelihood Terms

>85% **Almost Certain** (Red)
60% - 84% **Likely** (Orange)
36 % - 59% **Possible** (Green)
16% - 35% **Unlikely** (Yellow)
<15% **Rare** (Blue)

Data courtesy R G Bell

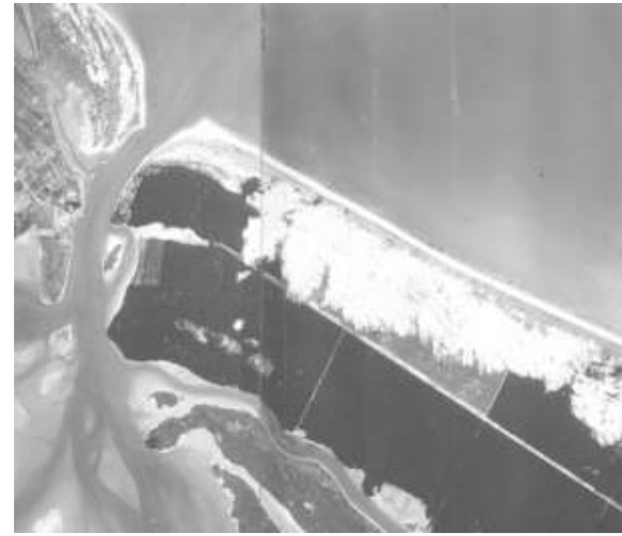
Significant Coastal Landform Change has occurred 1950-2010:

What additional effects will climate change and SLR impart?



Collingwood 1950

Paton Rock-Onahau Spit 1950



Rabbit Island West 1946

Collingwood 2009

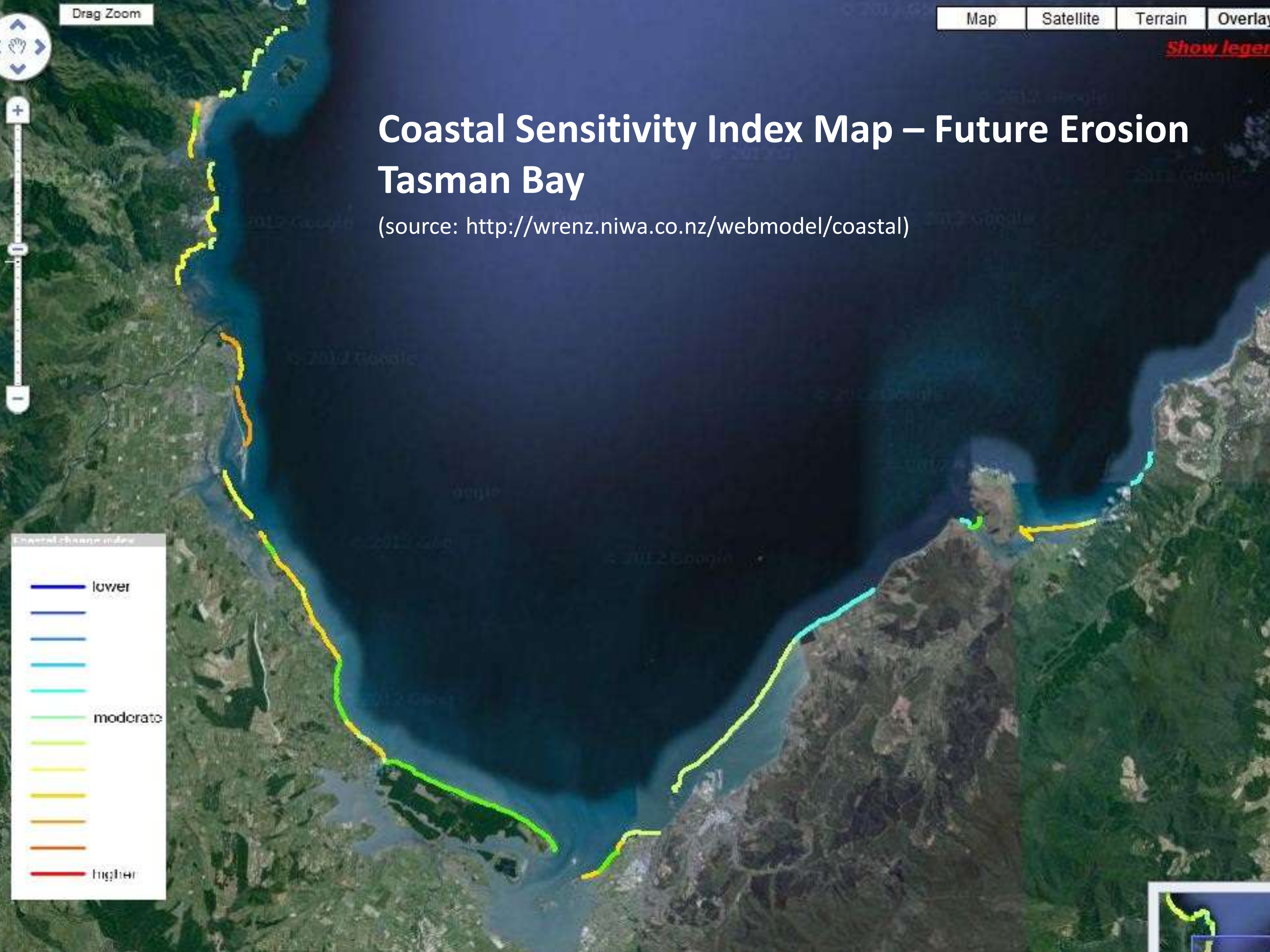
Paton Rock – Onahau Spit 2009

Rabbit Island West 2010

Erosion – Old Mill Walkway 2006

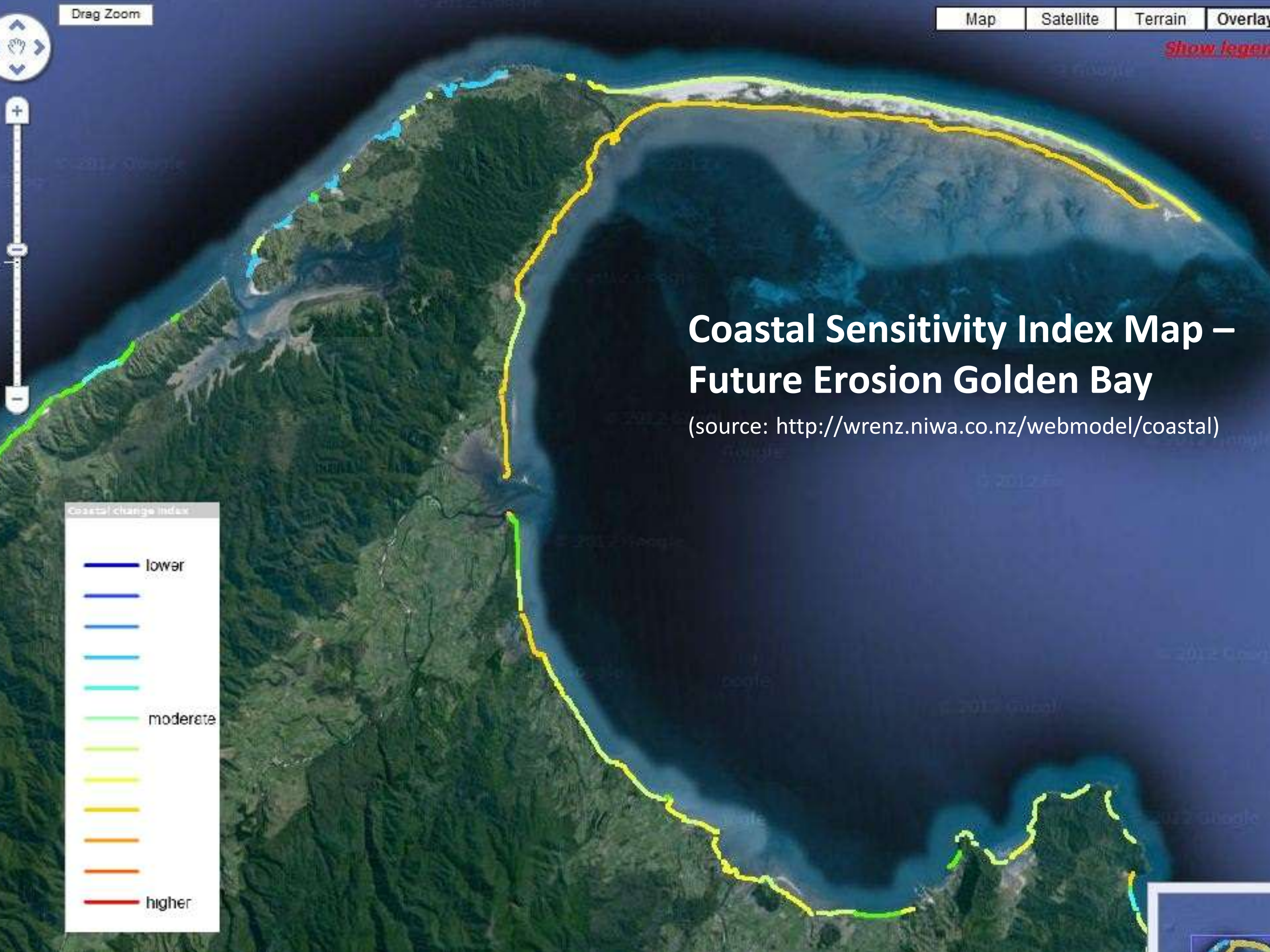
Coastal Sensitivity Index Map – Future Erosion Tasman Bay

(source: http://wrenz.niwa.co.nz/webmodel/coastal)



Coastal Sensitivity Index Map – Future Erosion Golden Bay

(source: http://wrenz.niwa.co.nz/webmodel/coastal)

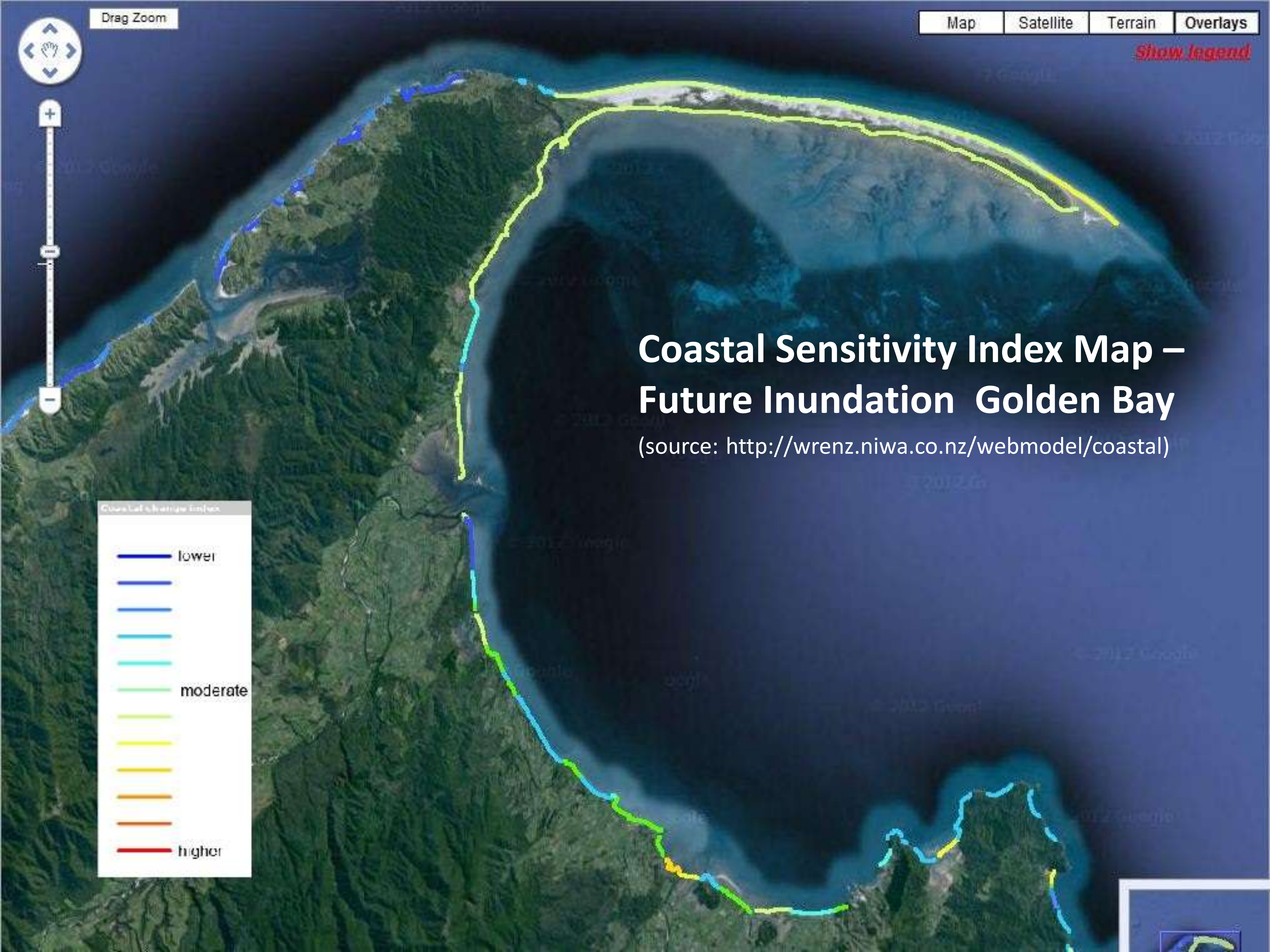


Coastal Sensitivity Index Map – Future Inundation Tasman Bay

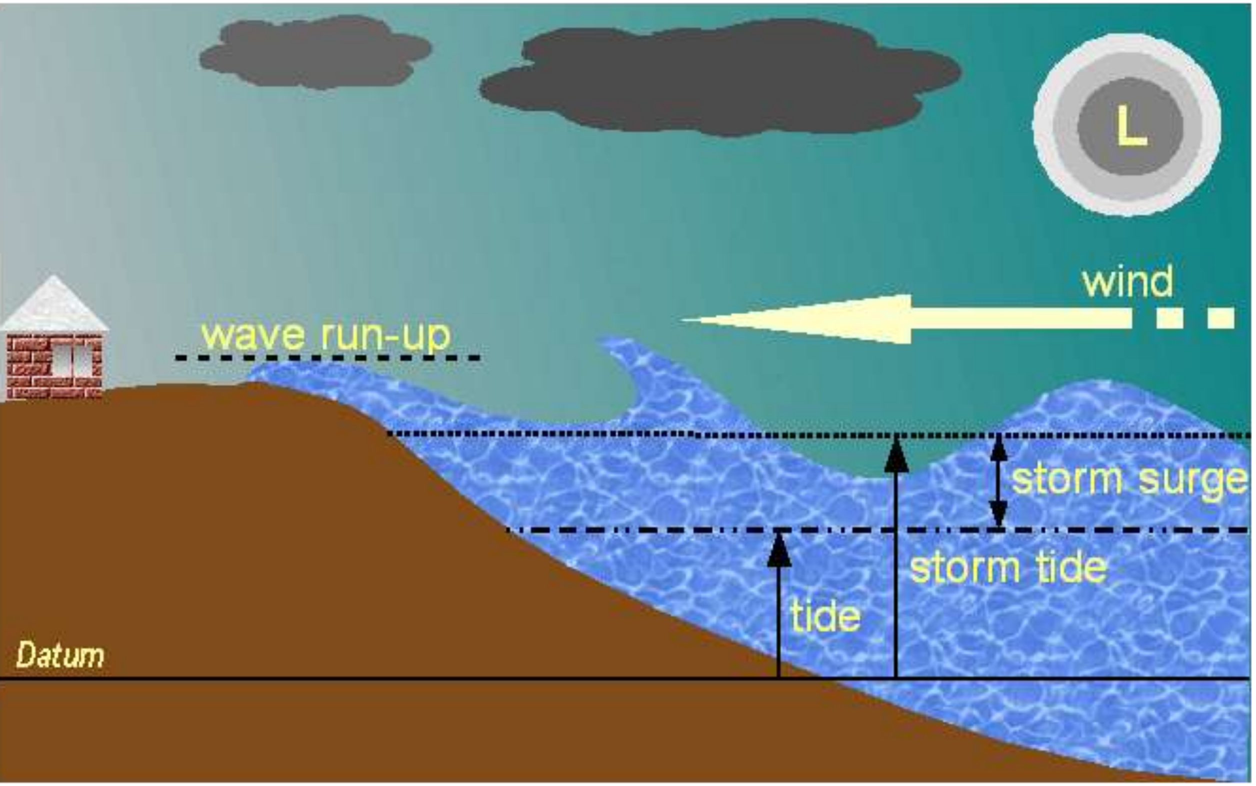
(source: http://wrenz.niwa.co.nz/webmodel/coastal)

Coastal Sensitivity Index Map – Future Inundation Golden Bay

(source: http://wrenz.niwa.co.nz/webmodel/coastal)



The Basics: Storm-tide & Wave Run-up



Storm-tide levels:

- Tides
- Storm surge (weather)
- Mean sea level variation
- Seiche – Tasman Bay
- Tsunami

Waves:

- Wave set-up inside surf zone
- Wave run-up over beach & low barriers

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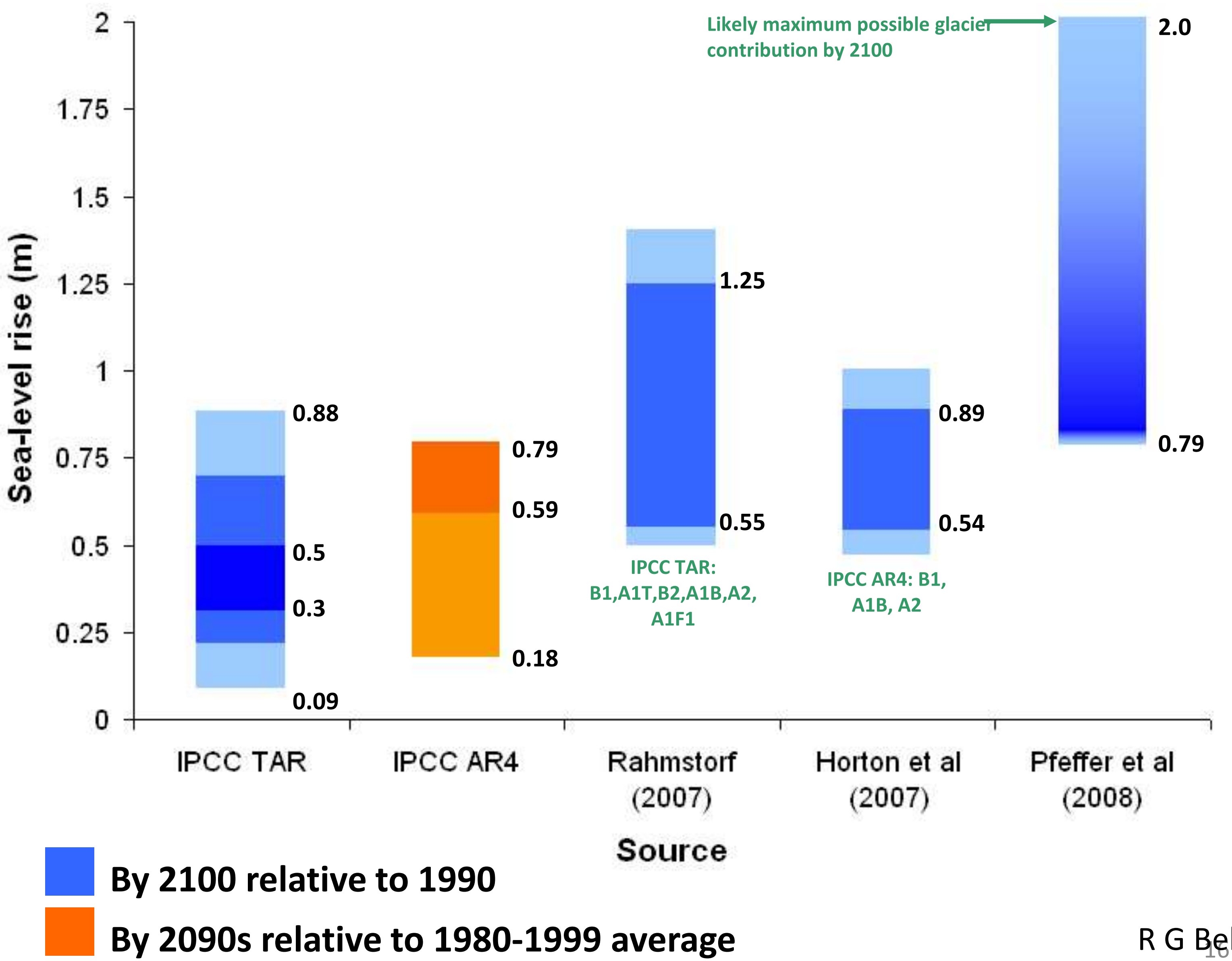
SLR Projections – a brief reminder!

Tasman DC

Various SLR Projections



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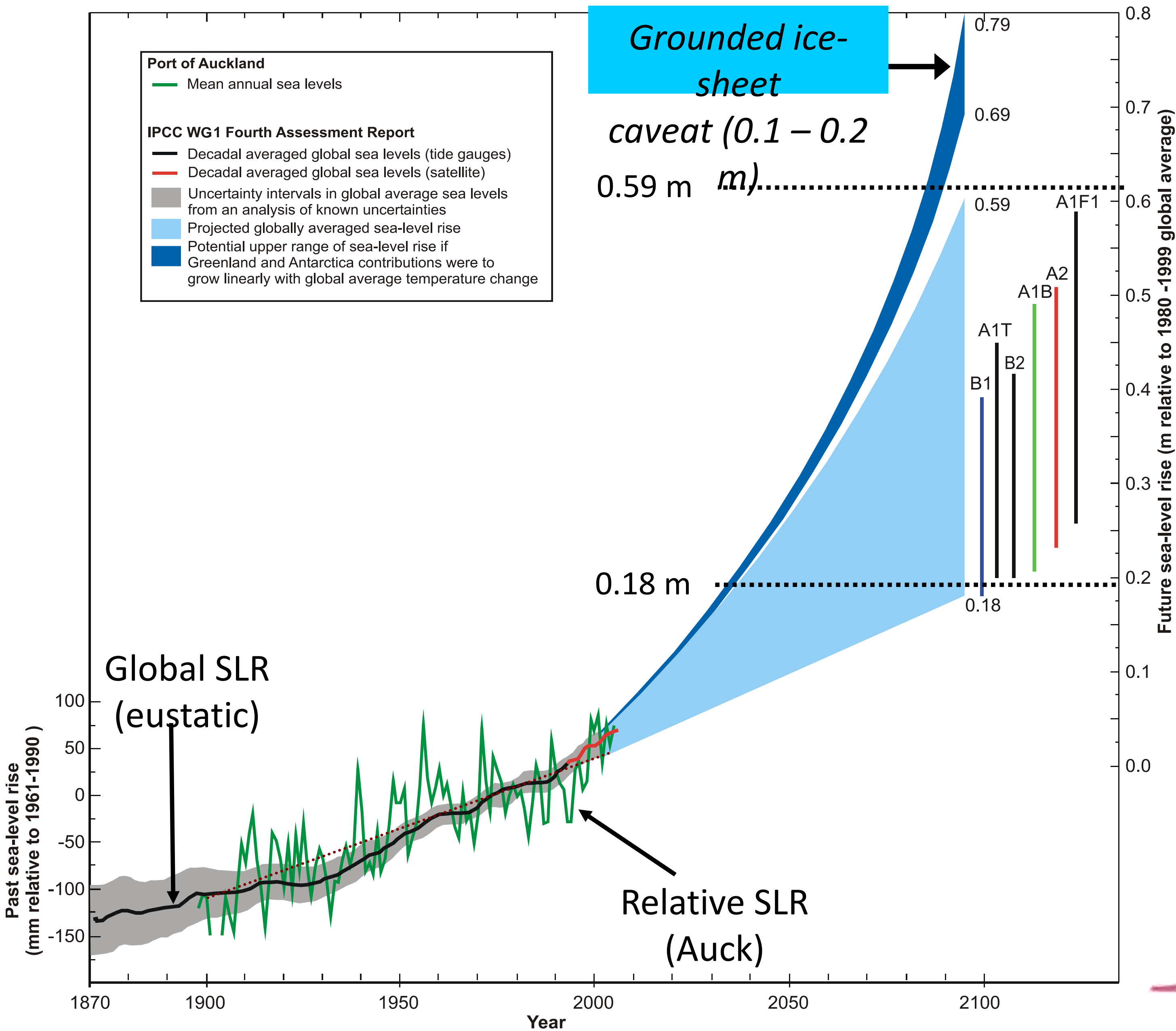
Global mean sea- level rise projections



IPCC 4th Assessment Report

Working Group I

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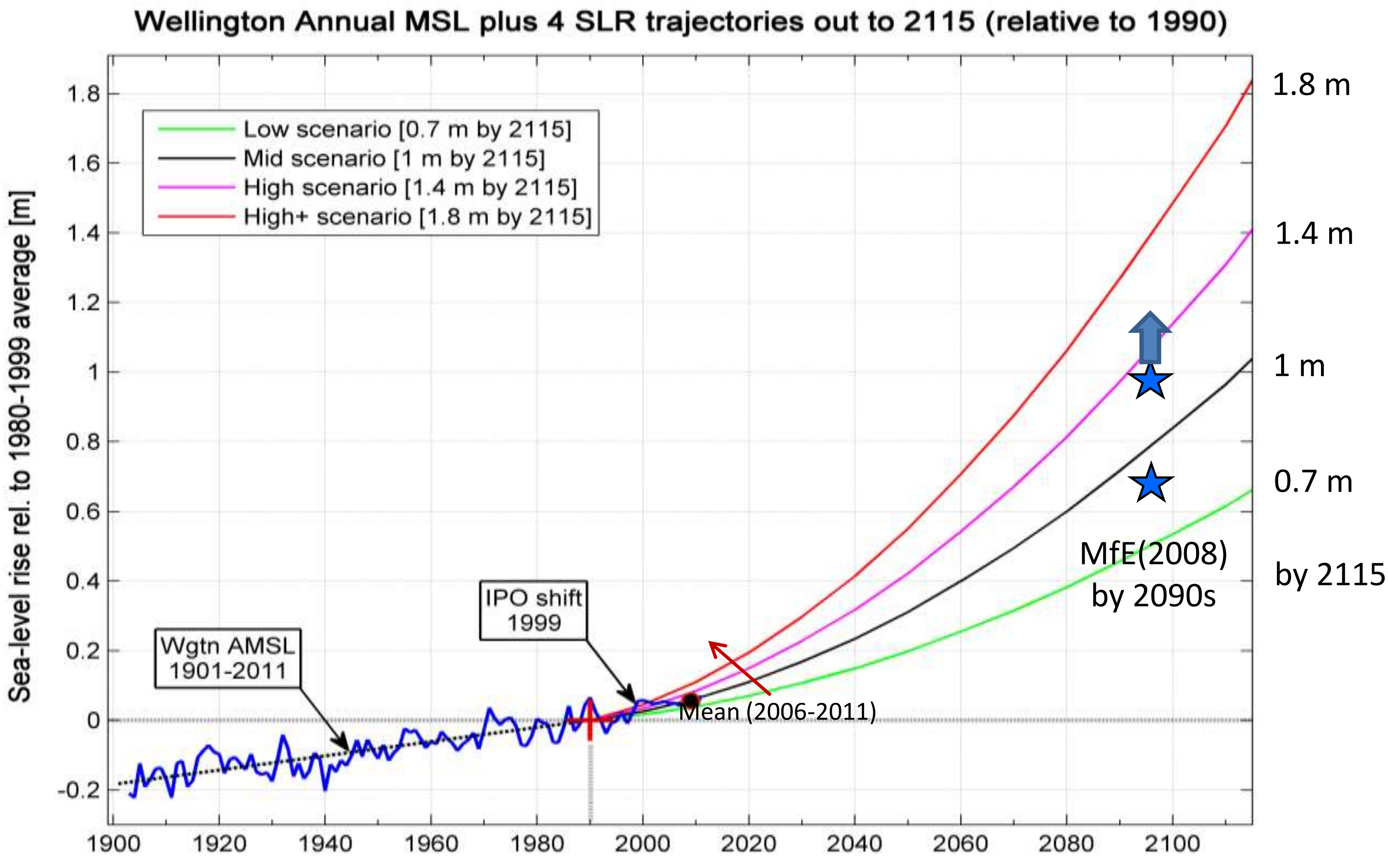
SLR tracking relative to a few credible scenarios



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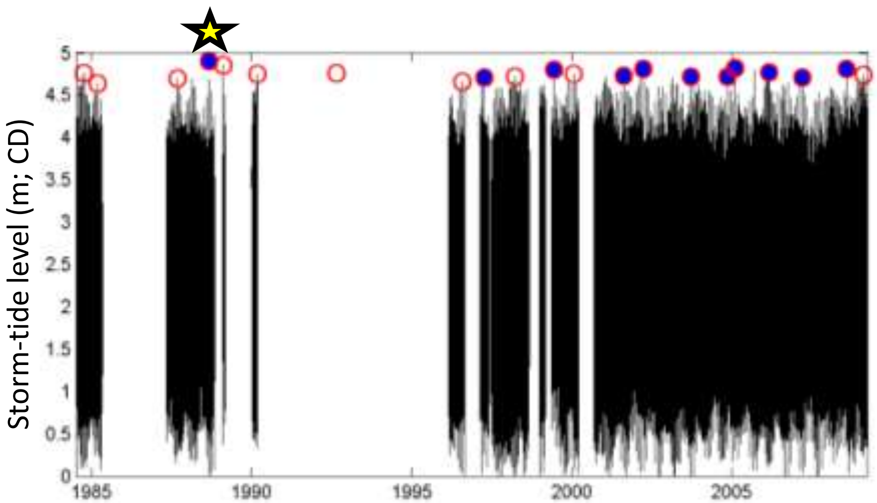
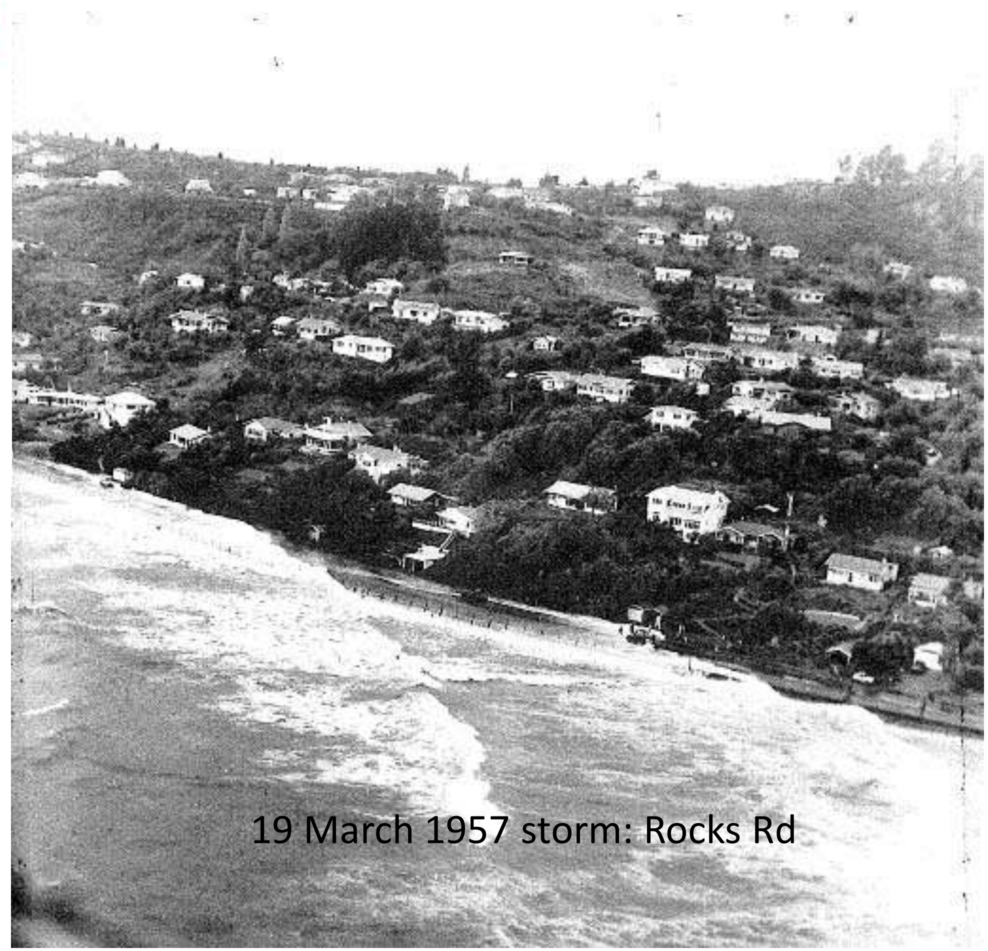
Recent Research:

NIWA - Nelson City Envirolink Reports



★ 2009 report (HAM2009 - 124):
Static storm-tide levels + SLR

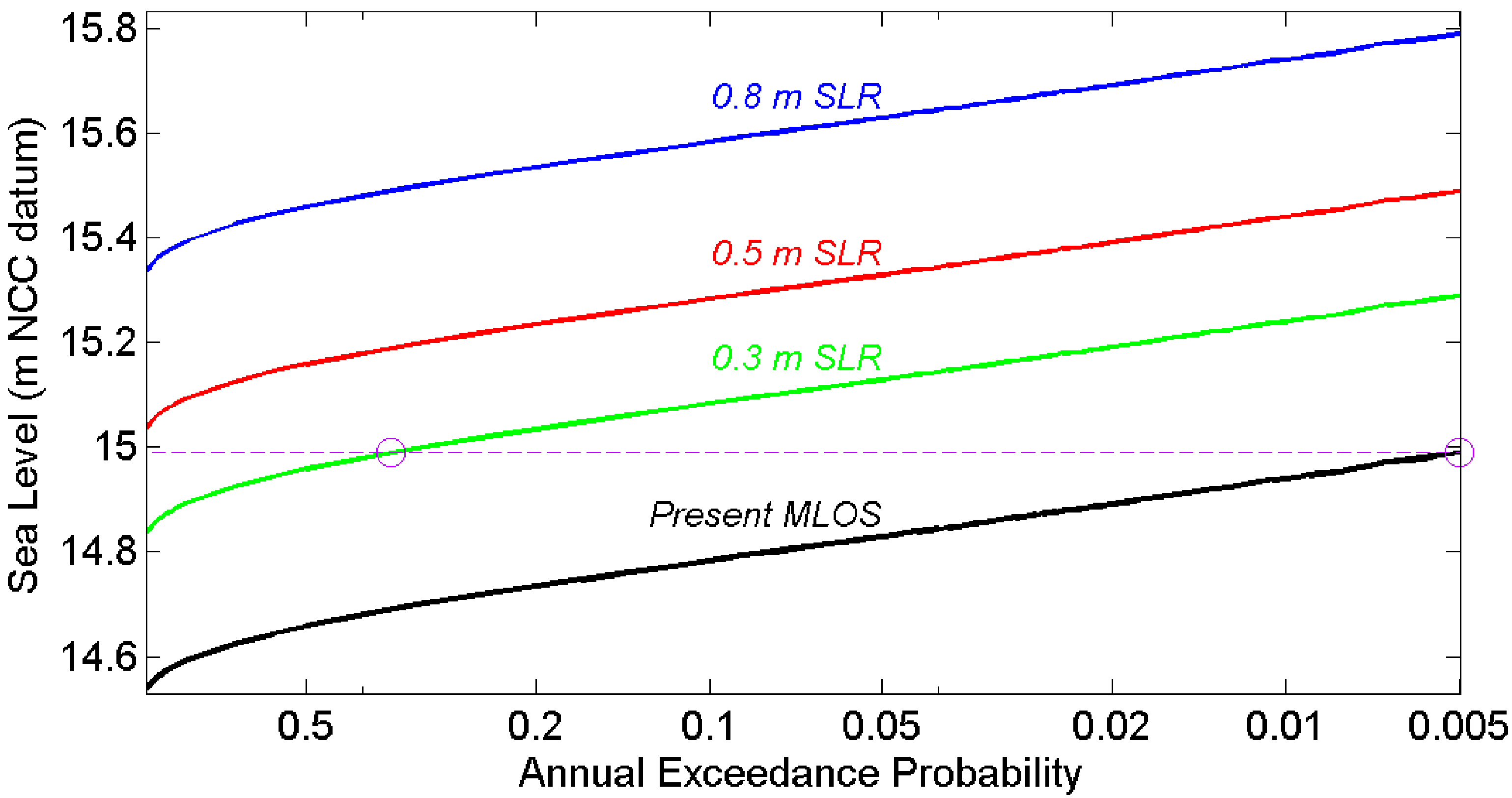
2012 report (HAM 2012 - 087):
Combined average recurrence interval for storm-tide and wave run-up



19 March 1957 storm: Rocks Rd

R G Bell

Nelson: Change in storm-tide AEP



Extreme-value storm-tide curve for present MLOS (including +0.1 m for uncertainty in MLOS), plus sea-level rise values of 0.3, 0.5 and 0.8 m. Example:, for present-day, a 0.5% (0.005 AEP) chance of a storm tide that equals or exceeds 15.0 m RL. With a 0.3 m sea level rise occurs, then the probability of the same storm-tide elevation being reached or exceeded in any given year increases to 36% (0.36 AEP or ARI of 2.7 years). For higher sea-level rises of 0.5 or 0.8 m, the 15 m RL elevation is expected to be exceeded at least once every year.

(Note: To convert NCC datum to NVD55 datum, subtract 12.07m)

R G Bell

Source: **S.A Stephens and RG Bell** NIWA Client Report HAM2009-124 August 2009
"Review of Nelson City minimum ground level requirements in relation to coastal inundation and sea level rise"

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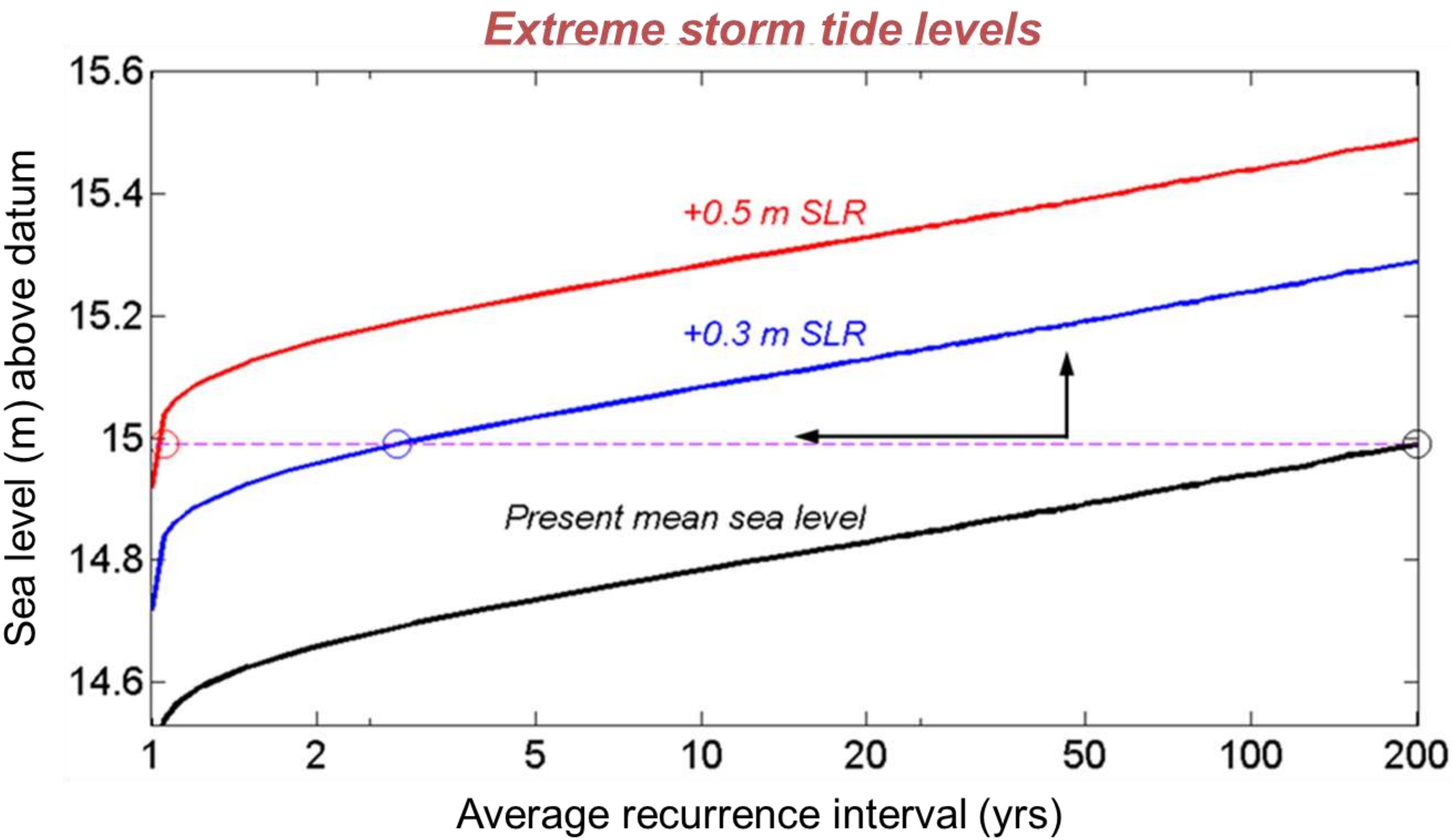
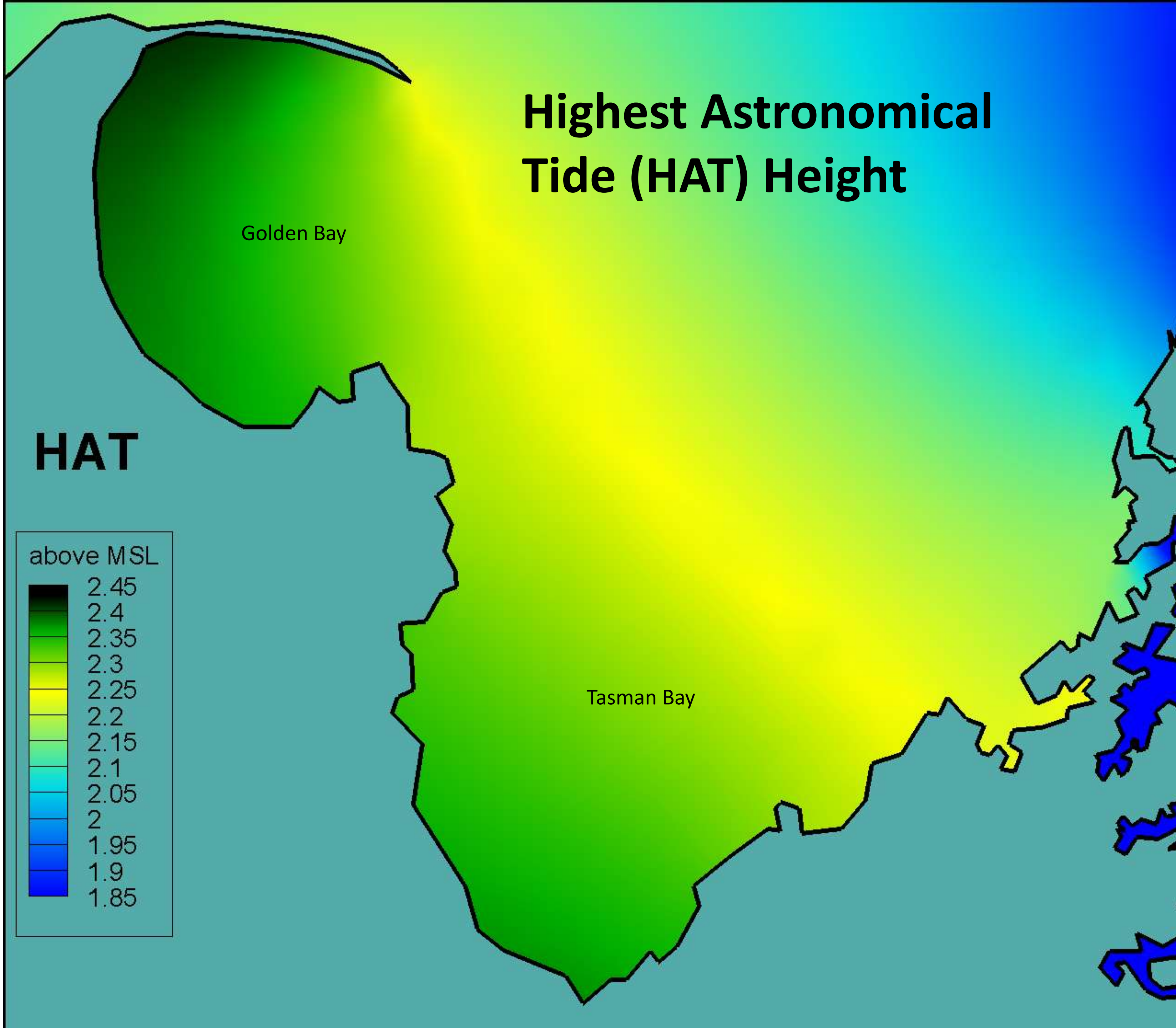
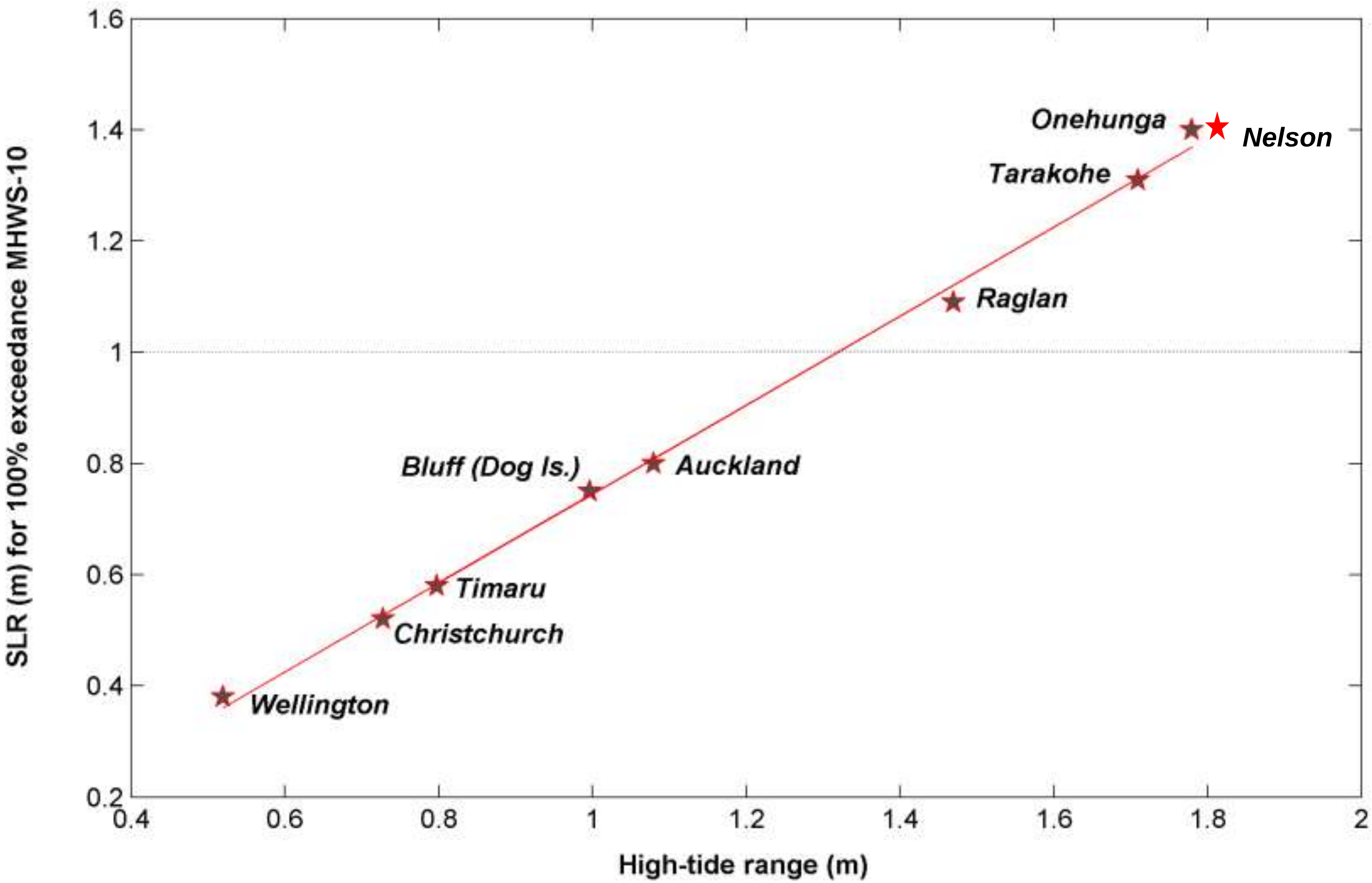
More frequent storm-tides … the first sign of SLR



R G Bell


Highest Astronomical Tide (HAT) Height
Golden Bay
HAT
Tasman Bay
above MSL
2.45
2.4
2.35
2.3
2.25
2.2
2.15
2.1
2.05
2
1.95
1.9
1.85

SLR needed for 100% high tide exceedance



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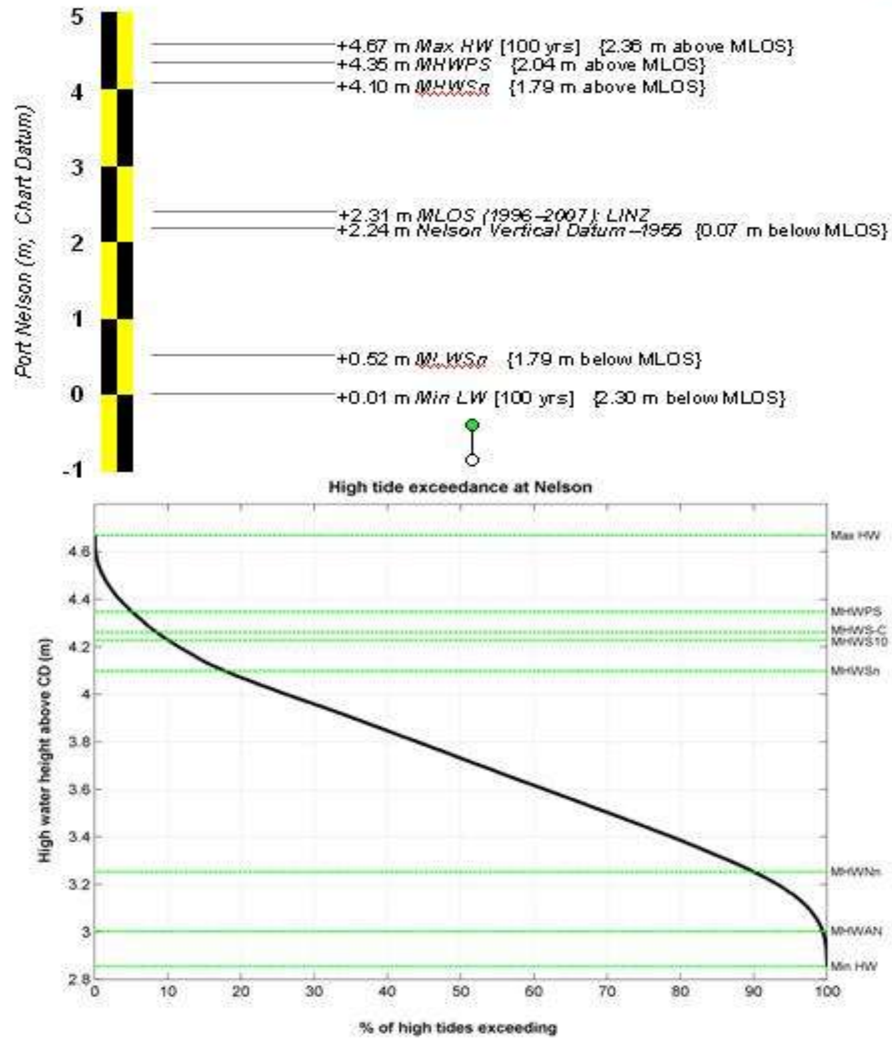
Tidal Range and Effect of SLR

- Tide heights & currents well-described by EEZ model
- Monitoring sites: Little Kaiteriteri & Tarakohe
- Largest spring tidal range in NZ (4.2 m)
- HAT up to 2.45 m above mean level of sea (GB)
- Higher tide ranges buffer SLR effects

Nelson Tide Marks (CD)



Max HW = Largest high water from 2000–2099 excl. sea-level rise [4.668 m] *Elevations: CD*

MHWPS = Mean High Water Perigean-Spring [4.347 m; exceeded by 5.1% HW's]

MHWS-C = Mean High Water Spring (LINZ cadastral value) [4.26 m; exceeded by 8.5% HW's]

MHWS10 = Mean High Water Spring (10% exceedance level) [4.228 m]

MHWSn = Mean High Water Spring (nautical definition) [4.098 m; exceeded by 17.8% HW's]

MHWNn = Mean High Water Neap (nautical definition) [3.253 m; exceeded by 90.0% HW's]

MHWAN = Mean High Water Apogean-Neap [3.003 m; exceeded by 99.4% HW's]

MLOS = actual Mean Level Of Sea (varies year by year)

MLWSn = Mean Low Water Spring (nautical definition) [0.522 m with 16.1% LW's below]

Min LW = Lowest tide from 2000–2099 [0.007 m] (Note: LAT in LINZ Almanac is 0.03 m)

NIWA accepts no liability for any loss or damage (whether direct or indirect) incurred by any person using this tide information.

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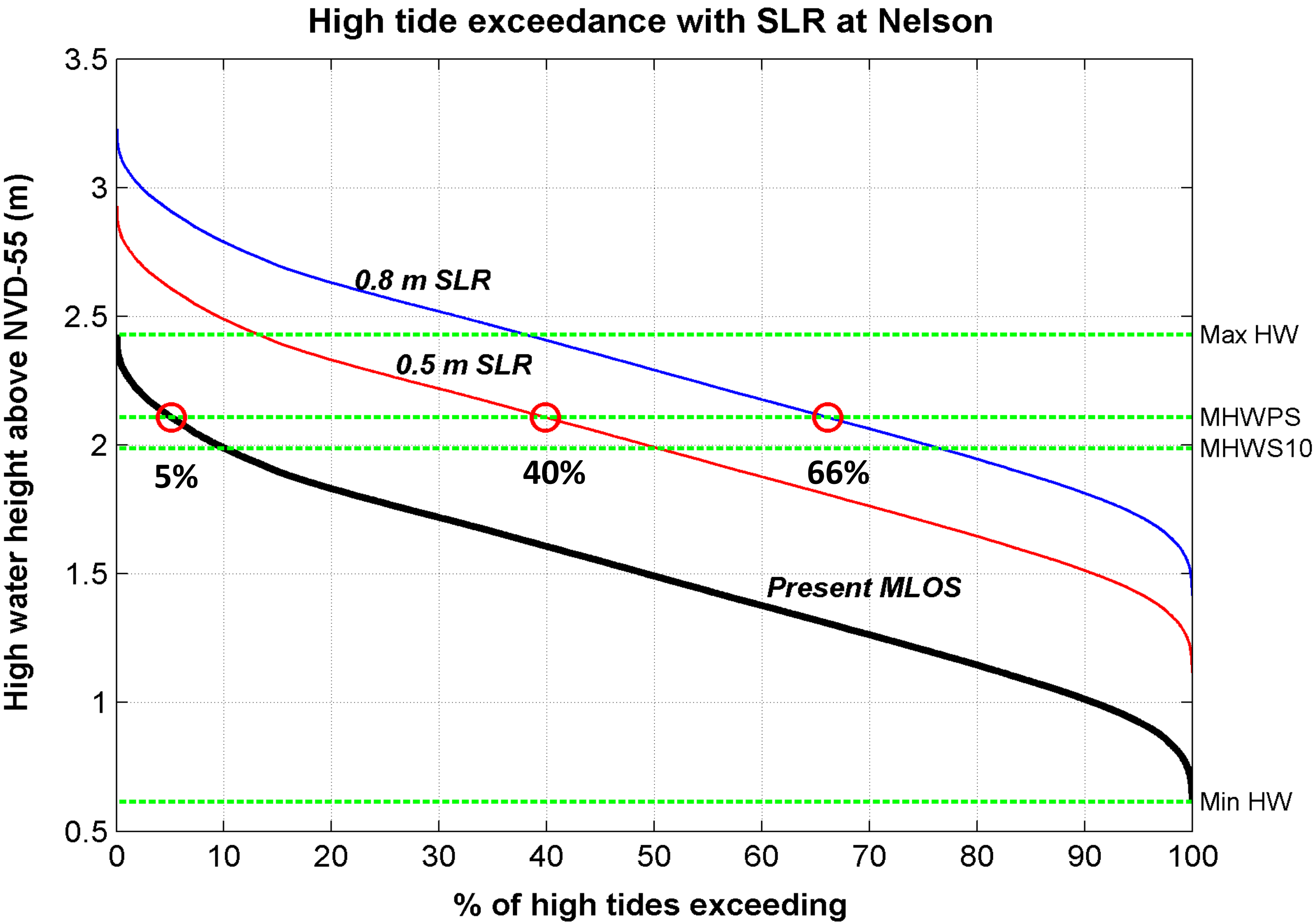
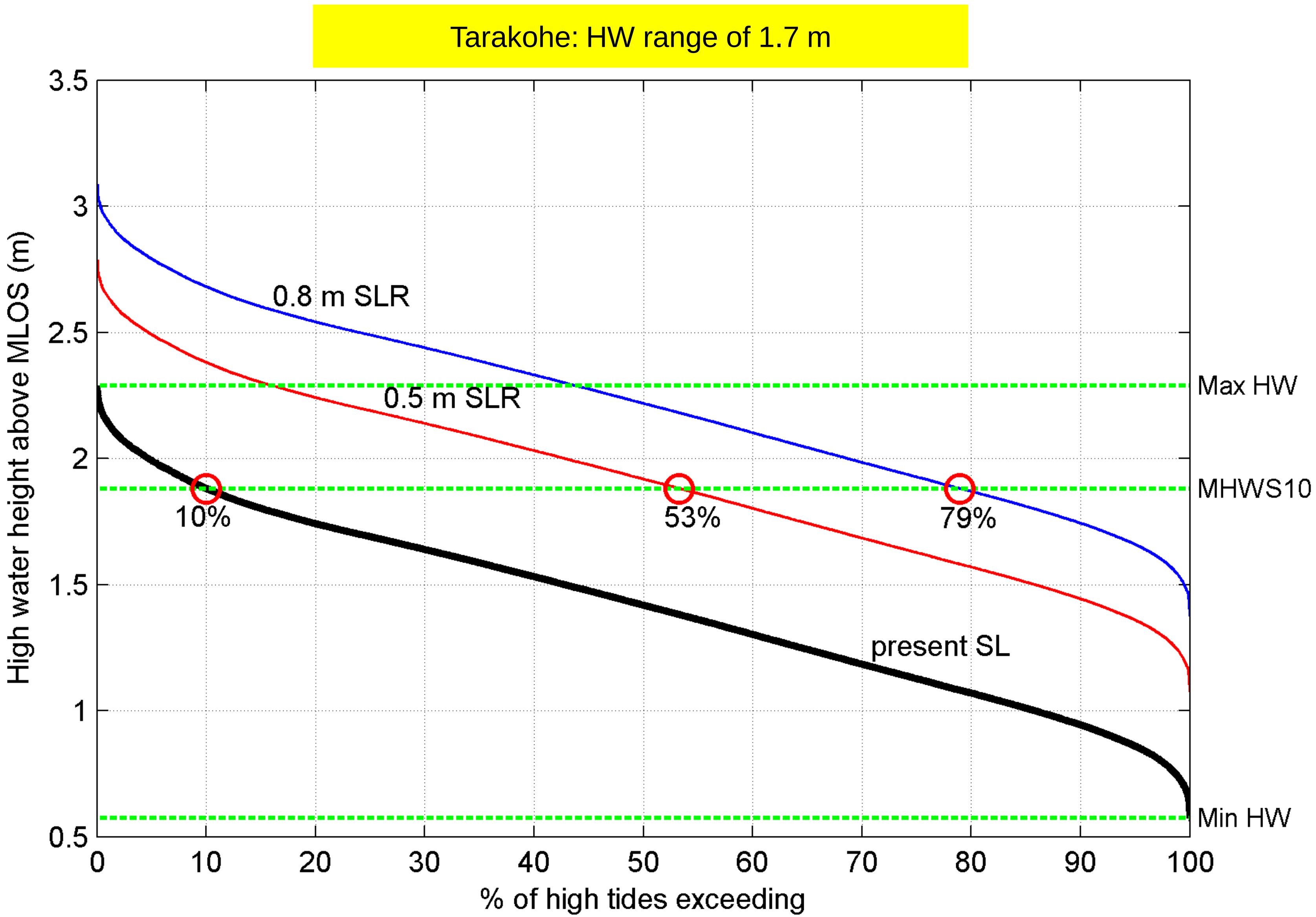


Would require a 1.49 m SLR for all high tides to exceed the current MHWPS mark R G Bell

High tide exceedance with SLR at Tarakohe



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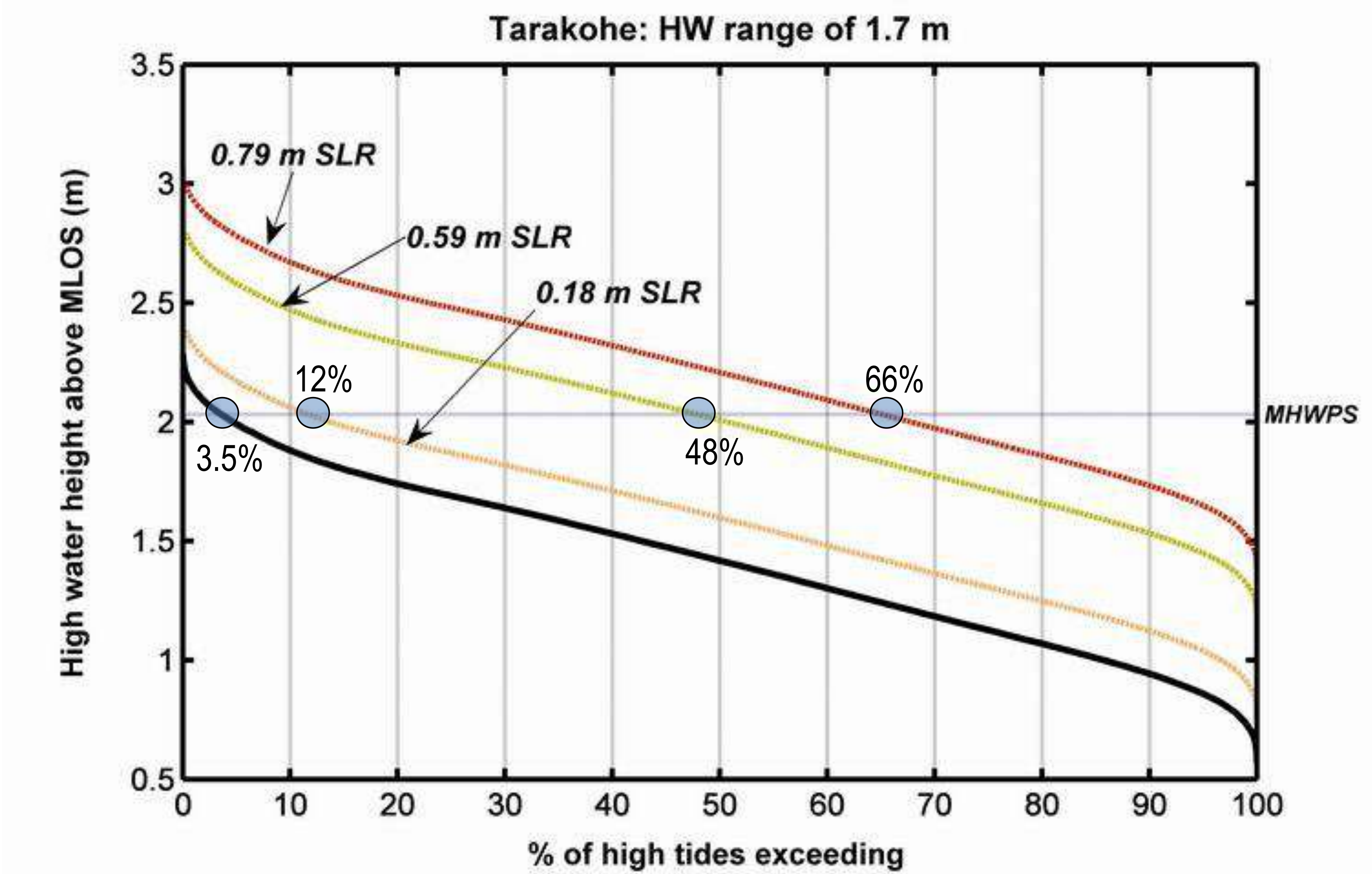
Sea-level rise: changes in frequency of high tides (1)



MHWPS level that would be exceeded by various SLR projections by 2090-99

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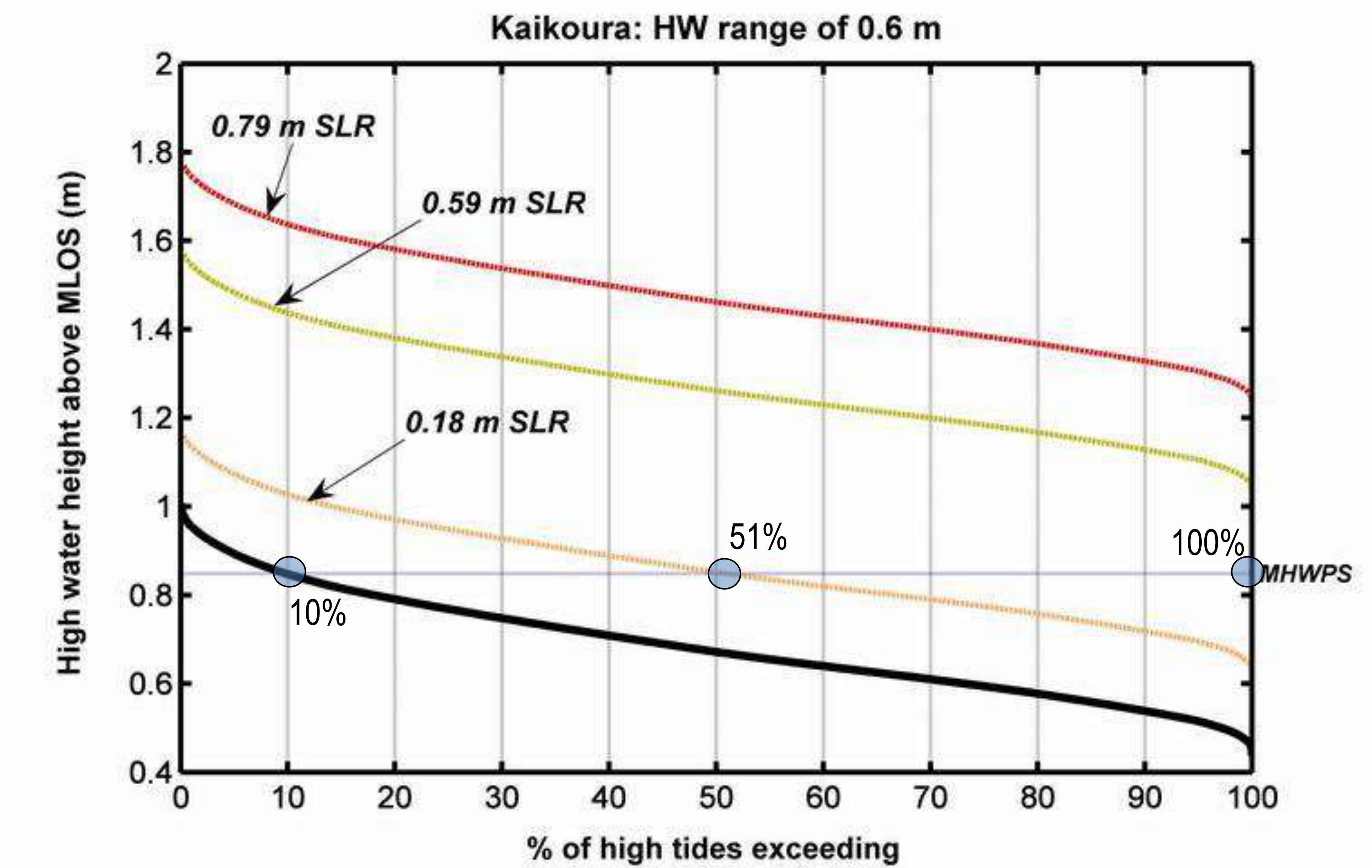
Sea-level rise: changes in frequency of high tides (2)



MHWPS level that would be exceeded by various SLR projections by 2090-99

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Summary: Effect of tide range on SLR

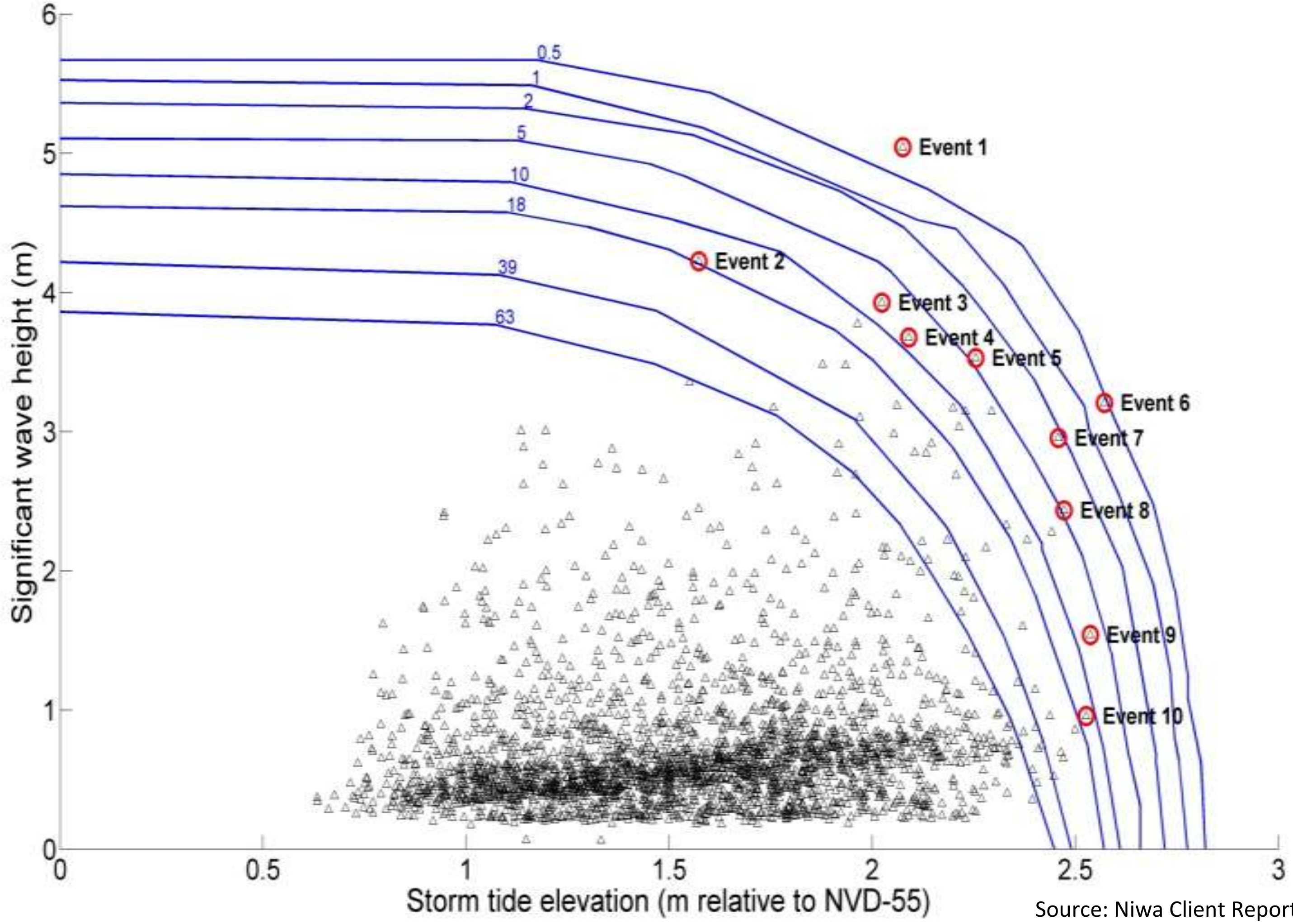
- **<u>Tarakohe</u>** (high tide range)
  - high-water range of **1.7 m**
  - needs a **1.4 m SLR** for all high tides to exceed the present "king tide" or MHWPS level
- **<u>Nelson</u>** (high tide range)
  - high-water range of **1.8 m**
  - needs **1.49 m SLR** for all (100%) high tides to exceed the present MHWPS level
- **<u>Kaikoura</u>** (low tide range)
  - high-water range of **0.6 m**
  - only needs **0.38 m SLR** for all (100%) high tides to exceed the present MHWPS level
- **<u>Conclusion:</u>**

  Lower tide-range regions (e.g. Kaikoura, east coasts) are more exposed to and hence at greater risk from the effects of storms and waves in a SLR future.

Combined Wave and Storm Tides

Joint probability curves imposed on a scatter plot of combined storm-tide peak and wave height peak for 2008-2012 at Nelson.

Numbered red circles depicted the events modelled in this report and blue contour labels represent the AEP in years for each probability curve. Significant wave height data was measured at the Port of Nelson Fairway gauge and storm tide elevation (NVD-55) was measured at the Port of Nelson tide gauge.



Source: Niwa Client Report HAM2012-087

Worked example for calculating joint <u>2%</u> AEP inundation levels for Tahunanui Beach.

Calculated relative to NVD-55, add 12.07 m for levels relative to NCC datum.

						Total inundation levels (m NVD-55)	
H_s significant wave height (m)	L_0 (m) [= H_s / 0.026]	β_s (needs to be measured in field or beach profiles)	Wave setup (m)	Wave run-up (m)	Storm tide (NVD-55)	Storm tide + setup (m)	Storm tide + setup + run-up (m)
2.18	84	0.02	0.09	0.59	2.54	**<u>2.63</u>**	3.13
2.39	92	0.02	0.10	0.64	2.50	2.60	3.14
2.61	100	0.02	0.11	0.70	2.46	2.57	3.16
2.83	109	0.02	0.12	0.76	2.42	2.54	3.18
3.05	117	0.02	0.13	0.82	2.37	2.50	**<u>3.19</u>**
3.26	125	0.02	0.14	0.88	2.30	2.44	3.18
3.48	134	0.02	0.15	0.94	2.24	2.39	3.18
3.7	142	0.02	0.16	1.00	2.15	2.31	3.15
3.92	151	0.02	0.17	1.06	2.06	2.23	3.12
4.13	159	0.02	0.18	1.11	1.90	2.08	3.01
4.35	167	0.02	0.19	1.17	1.68	1.87	2.85
4.57	176	0.02	0.20	1.23	1.30	1.50	2.53

Source: Niwa Client Report HAM2012-087

SLR and Extreme Storm Tide and Wave Height in Tasman Bay

Modelling:

•Wave and storm surge conditions hindcast around NZ coast for a 45 year period(1957-2002) under NIWA's WASP (Wave And Storm surge Prediction) project funded by MSI.

•Future wave and storm surge conditions predicted for 2 climate change scenarios (A2, B2).

•WASP future-casts for A2, B2 scenarios simulated for 2070-2100, with effects on storm tides and waves quantified by comparison to WASP predictions forced by a global climate prediction of the period 1970-2000.

•Changes calculated for one location in Tasman Bay and as they are large scale, are assumed to be applicable for whole bay.

Findings:

•Climate change will cause a small approximately 2% rise in both extreme storm tide (1.3%) and extreme significant wave height (1.8%) by 2100.

•This translates to a 10cm increase for a 5m high wave, or 6cm increase for a 2.8m storm tide.

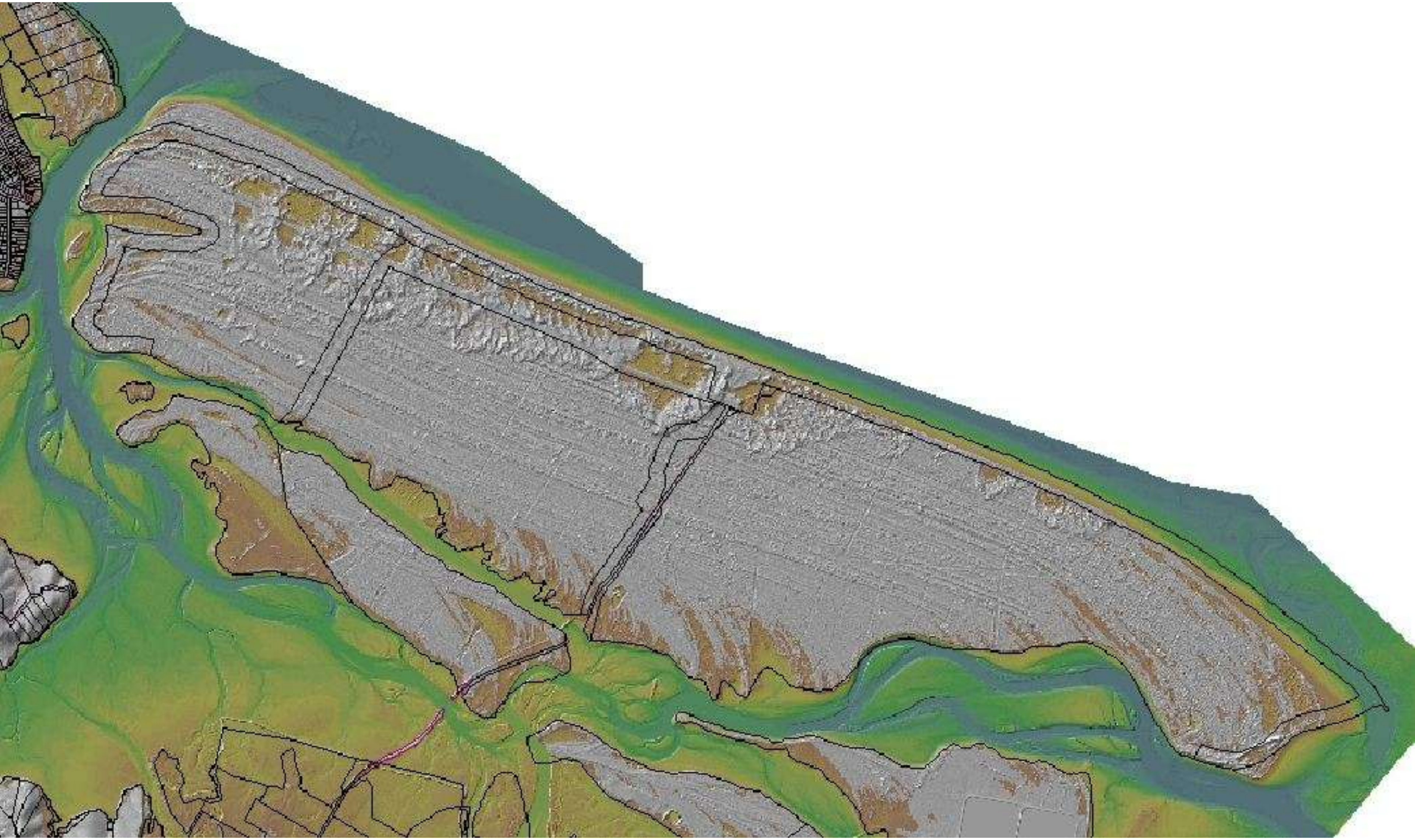
Summary:

Sea Level Rise provides the main impact on future coastal inundation levels, with erosion risk related to wave action and sediment supply.

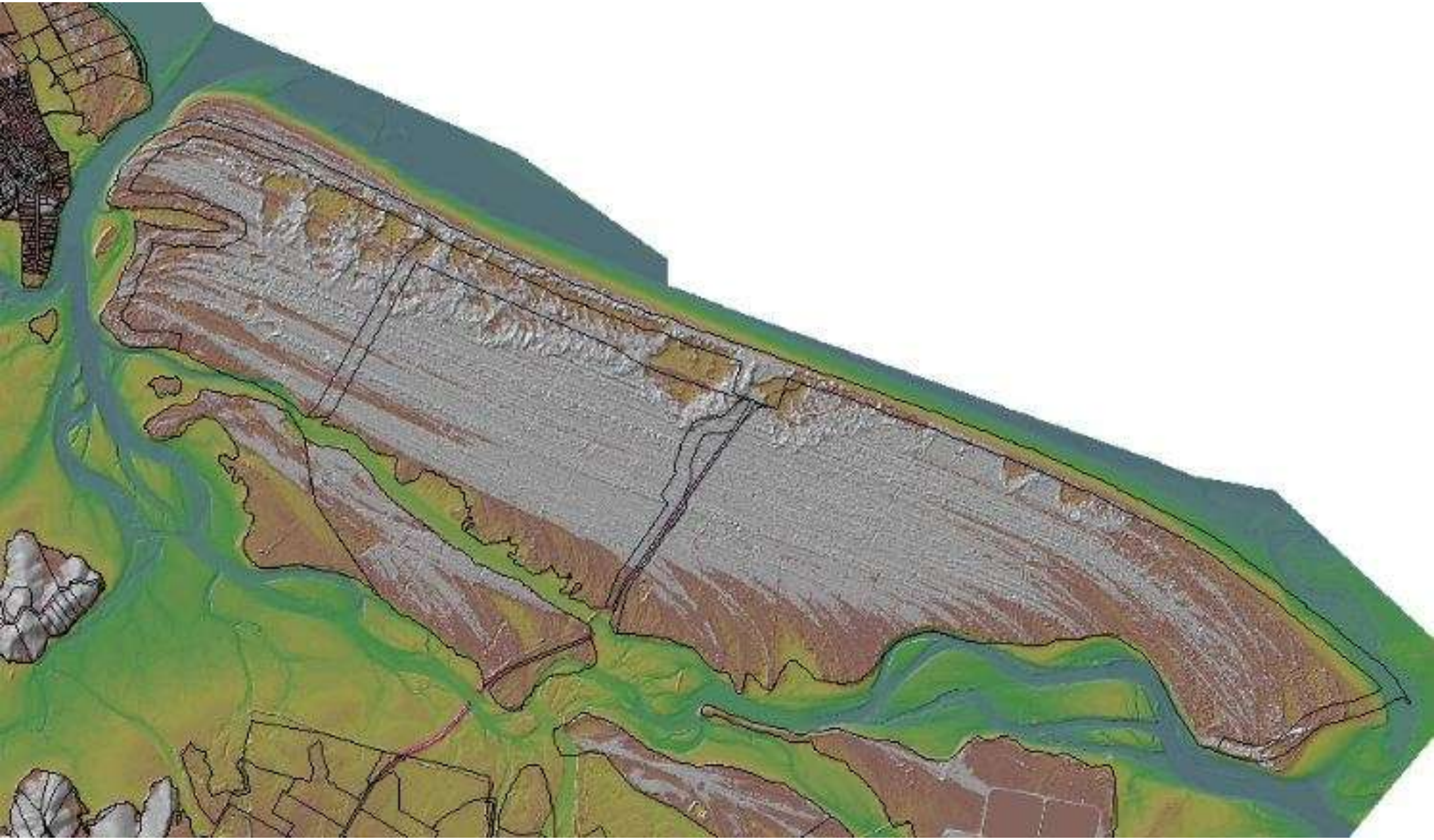
(Source: "Combined wave and Storm Tide Hazard for Southern Tasman Bay" NG Goodhue, SA Stephens, RG Gorman NIWA Report HAM2012-087)

SLR and Inundation Hazard Risk

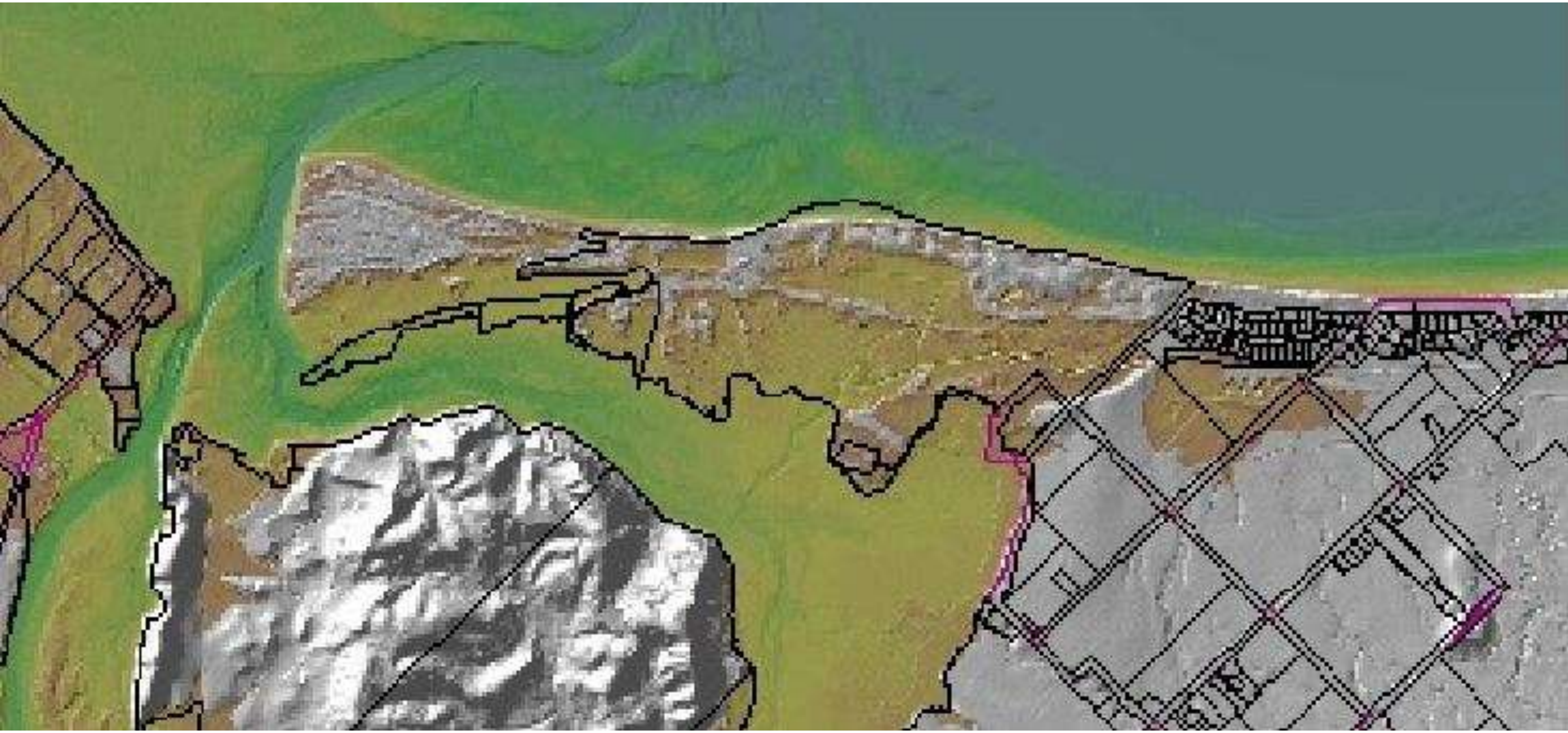
Rabbit Island – Tasman Bay: Inundation to RL 3.0m amsl



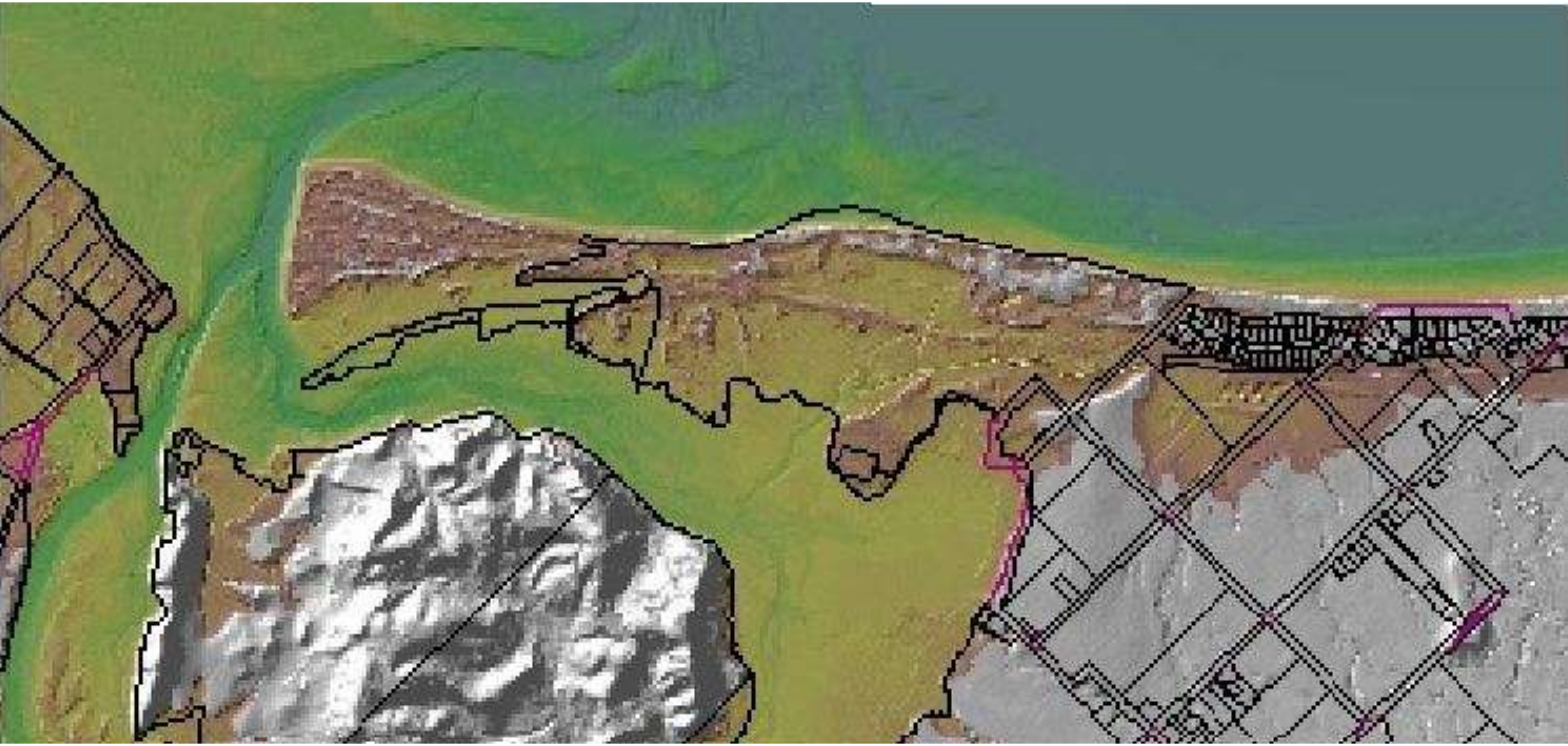
Rabbit Island – Tasman Bay: Inundation to RL 3.6m amsl



Motupipi – Golden Bay: Inundation to RL 3.0m amsl



Motupipi – Golden Bay: Inundation to RL 3.6m amsl



Future Outlook for Coastal Hazard Risks

Coastal hazard events occur and will continue

Climate change and sea level rise will worsen risks - increasing likelihood and effects of coastal erosion and inundation

Key factors in future coastal hazard risk are:

- Sea level and rate of sea level rise dominates
- Increase in severity of storm tide and wave height minor

Other factors that influence coastal hazard risk:

- Frequency of extreme cyclonic sea storms and waves
- Likelihood of sea storm and extreme high tide coinciding
- Tidal currents and sediment supply to the coast

Future-proofing the dunes – West Coast style!

Any Questions?