CHRISTCHURCH COASTAL RESIDENTS UNITED

Introduction

CCRU is committed to supporting community engagement and consensual adaptation to the effects of climate change. As a community partner with Regenerate Christchurch in their South New Brighton and Southshore Project, this initial review of Regenerate Christchurch's Baseline Review is in response to community questions and is presented as part of the partnership. It is not a formal expert peer review, although if requested we are able to provide such.

The purpose of the Regenerate Report is to share as much information as is to hand with the community to enable joint community-agency adaptive management & planning decisions to be taken in the full light of authoritative [or as authoritative as exists] information, or "…*a starting point for the conversations*…". Whilst informing, it also must not hinder community engagement. The full baseline information appears on the Regenerate Christchurch website, https://engage.regeneratechristchurch.nz/ss-snb-information-baseline-assessment?preview=true

and comprises five sections:

- Part 1 Natural Environment
- Part 2 Cultural Values
- Part 3 Human Environment
- Part 4 Natural Hazards
- Part 5 Management Framework

The section that has raised the most questions and conversation has been Part 4 Natural Hazards. Accordingly, this brief review[1] mostly (but not exclusively) focusses on that part. This review[2] is laid out thematically around what appear to be the main issues, but many are not about the underlying science, but instead about tone, clarity, interpretation of, and sometimes what seems like stretching facts. The cumulative unintentional effect of the Regenerate Report style raises questions about the fitness for purpose of this report in its current form. However, relatively minor changes could transform this report into a very much more useful and effective community asset.

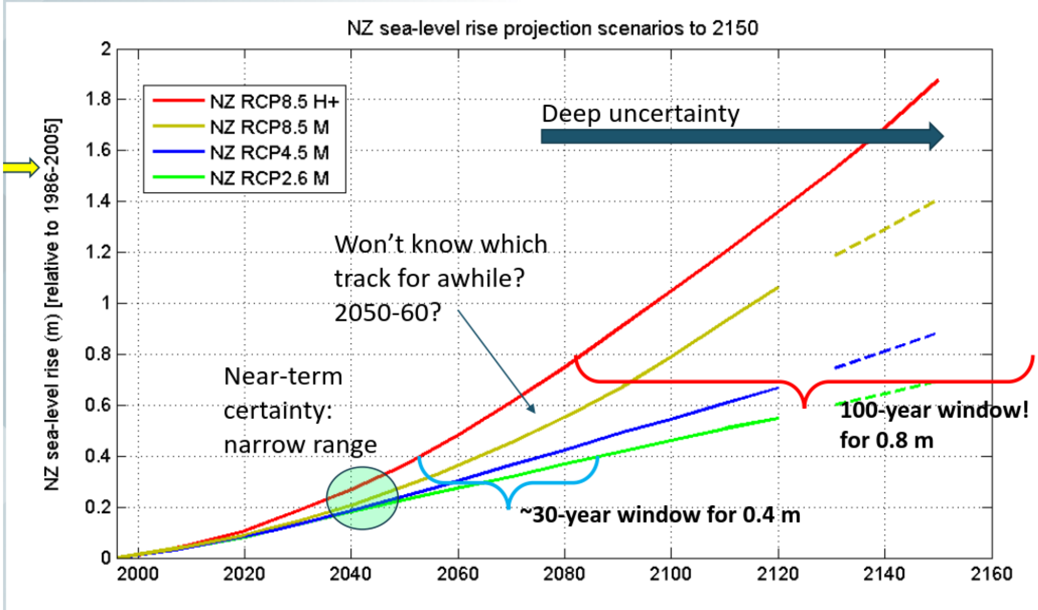
[1] CCRU wish to thank those of its professional members who have contributed to this brief review.
[2] Note accessible references are used throughout, but more primary fundamental references are available

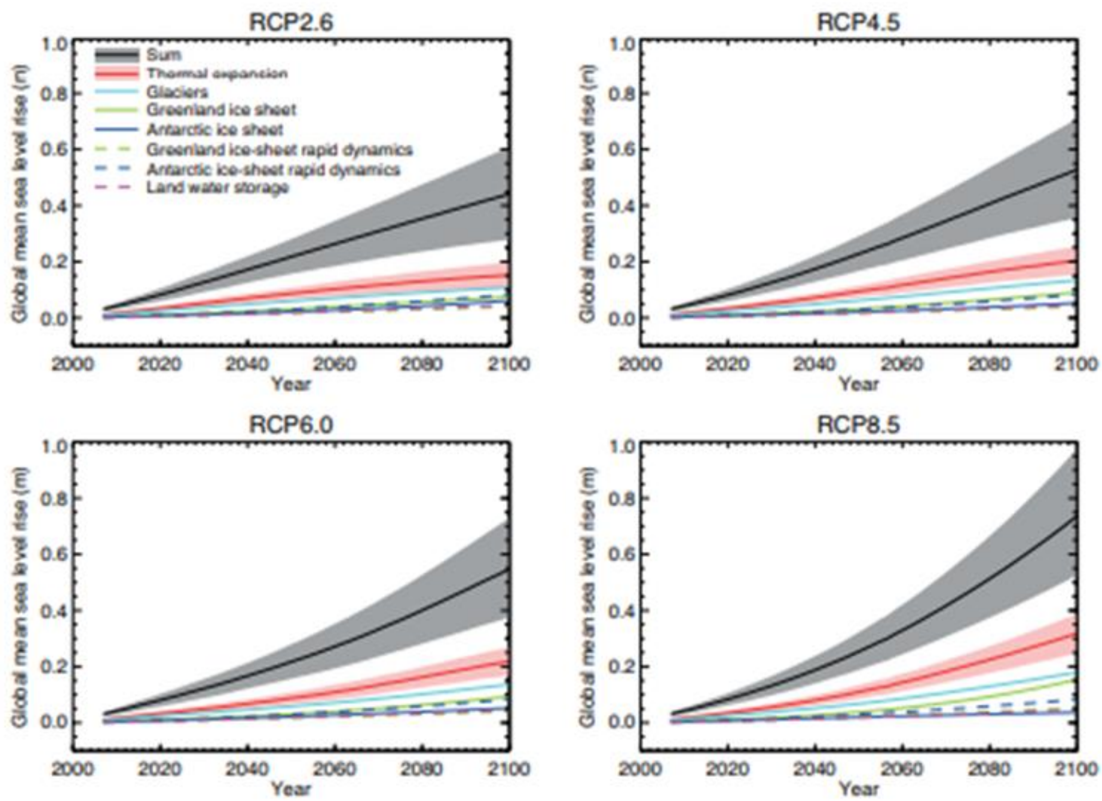
CCRU
CHRISTCHURCH COASTAL RESIDENTS UNITED

Thematic Areas

Sea Level Rise

pp5, Fig 2 Report and IPCC data 2014





models

a) Figure 2, p5 although not in the Dec 2017 MfE guidance, is well laid out and NZ (not global) sea level is used, (consistent with Figure Legend). NZ sea levels will be higher than global at the moment but will rise less steeply for the next 10-20 years (Pacific Decadal Oscillation)[3]. Note, a good thing about this figure is it does not include any reference to atmospheric CO_2, which often confuses people: (links not intuitively obvious between atmosphere and ocean ⇒ argument about models).

b) Is the 1995-2018 data on this figure actual measured NZ SLR? If not could it be added please, 1995 through to 2018 is enough time to be able to compare actuals with the models. Why is there a slope break at 2020?

c) Curiously, IPCC modelled sea level rises across the scale for RPC8.5 (and at least one other) seem significantly lower than those for NZ…this cannot be correct, what is the explanation?

d) RCP8.5+ originally a UK model pressure testing scenario, never designed to represent any real climate scenario, cannot be compared to the IPCC scenarios as it is so much higher than the IPCC "most extreme and very unlikely" RCP8.5, so we cannot compare this to any other reference.

e) p6 The implication of sea level rise for delivered weather is understood. However, we do not understand "..*set in motion a SLR of at least 200 – 400mm by 2065*.." [units converted from m to mm], given the statistically robust estimate of SLR[4] over the last 110 years (1900-2010) is 1.7-1.9mm a^{-1}, we might expect between 2020 and 2065 to get about 100mm: less than half of the model result.
    - there is going to have to be major acceleration soon to hit this model prediction.
    - robust models are able to back predict, this one appears not to be able to do that, (1995-2020 data). How then is it robust?

---

[3] Bell, R. Lawrence, J. Alan, S.Blackett, P. Stephens,S. [2017] Coastal Hazards and Climate Change: Guidance for Councils. Wellington, Ministry for the Environment Dec 2017.

[4] IPCC [2014], see point h) for fuller explanation.

f) *"..The current track is the RCP 8.5 scenario in which…"* This is incorrect and conflicts with Fig 2. We are currently on ALL four tracks, we will not know until about 2050 which track we are on[5].

g) p7 Fig 4 layout good but suggest for clarity Fig 4a and 4b. Re Fig 4b: Assuming the *y*-axis is the same units as 4a(?) These graphs are rather different with one predicting < 40 Gt CO_2 a^{-1} at 2020, (RCP8.5) and the other 55 (baseline)..this is a ~50% difference. Suggest harmonizing the numbers on (a) and (b) or explaining the difference.

Interpretation of actual data

h) One of the confusing things here is the relationship between the 'source' data and the model output data. At points it is unclear which is which, *i.e.* whether the dog is wagging the tail, or the tail is wagging the dog. The best example is the sea level data for which we have just over a 100y record. While we (CCRU) think that the rate of sea level rise will increase, our view is at the moment the record does not show consistent and robust evidence that the rate of sea level rise is increasing. The rate is also very sensitive to the time period of the measurement: exactly the reason that short term data are not used for this type of calculation. If we were less cautious, we might take the last 20 years of satellite data and conclude "it is 3mm per year", but the longer record is lumpy. We had similar or higher rates of sea level rise over a 30+ year period 1920s-1950s as those we have now, so we do not believe that there is currently robust evidence of a long term change of rate. This is consistent with the 2013 IPCC view:

"*…Tide gauges with the longest nearly continuous records of sea level show increasing sea level over the 20th century. There are, however, significant interannual and decadal-scale fluctuations about the average rate of sea level rise in all records. Different approaches show very similar long-term trends, but noticeably different interannual and decadal-scale variability. The rate from 1901 to 2010 is 1.7 [1.5 to 1.9] mm/year, which is unchanged from the value in AR4….*" [IPCC AR5 WG I Section 3.7.2]

[5] IPCC [2018] Kopp et al.

and again from IPCC 2013 re their Fig 3.5 below:

"…It is very likely that the mean rate of global averaged sea level rise was 1.7 [1.5 to 1.9] mm/year between 1901 and 2010 . . . and 3.2 [2.8 to 3.6] mm/year between 1993 and 2010. It is likely that similarly high rates occurred between 1920 and 1950…."

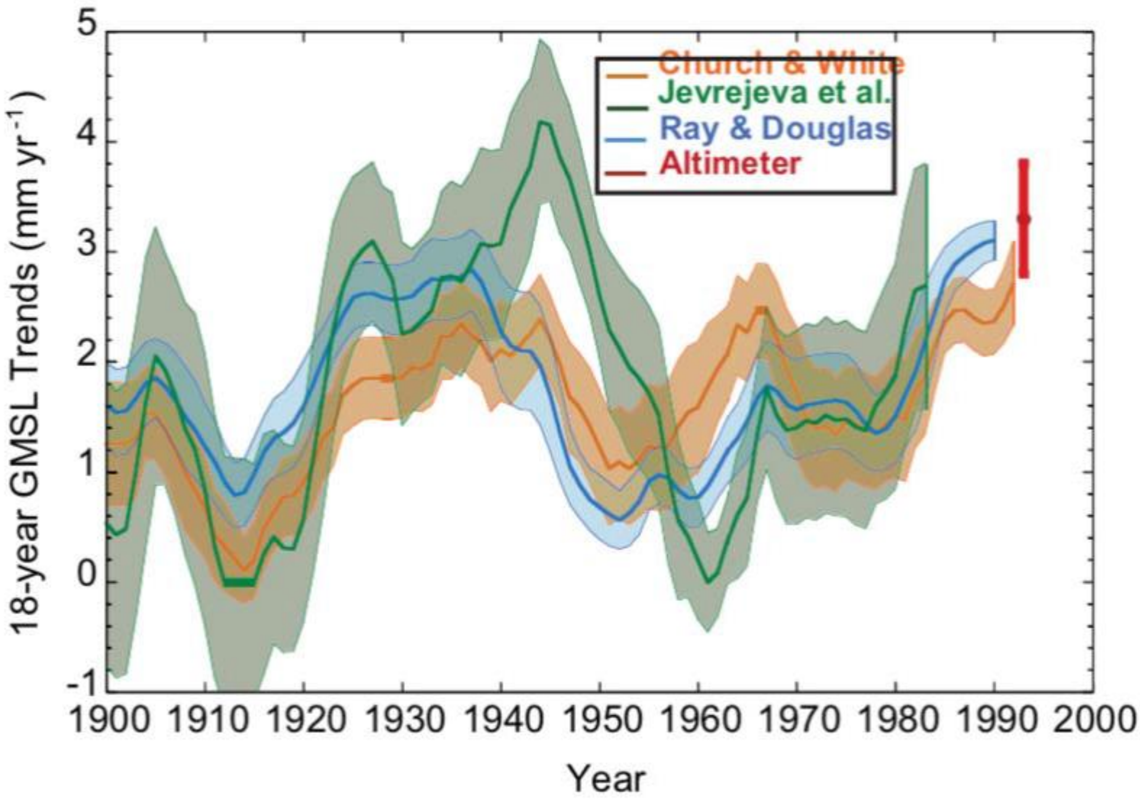


Figure 3.5 18 year trends of global mean sea level rise estimated at 1-year intervals. The time is the start date of the 18-year period and the shading represents the 90% confidence. The estimate from satellite altimetry is also given, with the 90% confidence given as an error bar. [IPCC AR5 WG 1 Chapter 3 Figure 3.14]

Since 2013, 6 further estimates of 20th century global sea level rise confirm the uncertainty but are not inconsistent with the 2013 IPCC 1901-2010 estimate of 1.7 mm a-1, see Table below (from Curry, 2018)[6]:

[6] Curry, J. (2018) Sea Level and Climate Change. Climate Forecast and Applications Network (Special Report).

Table 3.1: Recent estimates of 20th century mean global sea level rise

Source	Rate of SLR	Period
Jevrejeva et al (2014)	1.9 ± 0.3 mm/year	20th century
Kopp et al. (2016)	1.4 ± 0.2 mm/year	20th century
Mitrovica et al. (2015)	1.2 ± 0.2 mm/year	1900–1990
Hay et al. (2015)	1.2 ± 0.2 mm/year	1900–1990
Thompson et al. (2016)	1.7 ± 0.3 mm/year	20th century
Dangendorf et al. (2017)	1.1 ± 0.3 mm/year	1900–1990

IPCC estimates of global sea level rise from their current report (2018) is 3.2 - 9.4 mm a^{-1} by 2100. The bottom of this range is similar to the 1993-2010 sea level rise rate[7] of 3.2 mm a^{-1}, (medium confidence). Presumably this very high range, 3.2 - 9.4 mm a^{-1} has been back modelled from their work. However, the data is the data, and the 20 years of satellite data is simply not sufficient to be statistically significantly different from the existing much longer record, or the 30 years 1920s-1950s when the rates were higher (then) and for longer than the current satellite data derived rates (now).

It is also important to understand that global sea level rise can be very different from local sea level rise: there are circulations/currents and seabed/coastal topology that affect such measurements in different locations at different times. So around New Zealand, such considerations (*e.g.* the Pacific Decadal Oscillation) are likely to mean that local sea level rises more slowly or even falls for the next few years, whereas polar melting may mean it rises faster. This is consistent with the MfE guidance[3] released in Dec 2017.

Sediment Supply and Erosion

i) p14 (relevant to erosion as well as floods and inundation) Short term erosion: "…*Increased intensity of storm*s…". We understand that with more energy in the weather system, this will generate larger, more intense and hence more slow moving (damaging) storm systems. Within New Zealand we are curious as to whether as yet any data signal showing this? If so we would very much appreciate a link to this data. Otherwise

[7] IPCC 2013

report commentary on this point seems balanced. Maybe a few mitigation cartoons to give perspective?

j) p15 Fig 11 surprising that there is not much difference between the scenarios and time frames. See point (l) below.

k) p16&17 Figure 12 and text. "..*includes all four RCP scenarios*.."
   - which four, all IPCC or including RCP8.5+ ?
   - does this imply all of the scenarios give every similar results, or is this in fact just the highest RCP result shown on Figure?

l) p16&17 Figure 12 and text. To be fair if the text is read, the use of the word 'possible' rather than 'likely' noted, and the references followed, it soon becomes apparent that the uncertainties and assumptions underpinning Figure 12 make it make it rather difficult to construe substantive meaning for the future. However, most people will not (be able to) do this, and 'a picture paints a thousand words'. Detail is discussed in (m) below, but we recommend either losing this Figure, and awaiting the upcoming report, then reintroducing a more meaningful alternative, or, if it is felt that there must be a Figure here, then restrict it to the 50 year (more certain) part of the existing Figure.

m) Long term sediment supply: Apart from short term erosion events, longer term sediment supply also determines the sediment mass balance. We recognize the uncertainty around climate mediated changes in wave patterns, and concur with the Peer Review Panel[8] and Tomkin & Taylor[9] indicating a sparcity of reliable sediment supply data. We look forward to the further report on this which we understand is forthcoming. However, inbuilt assumptions in the final report of a reduction of sediment supply and the Waimakariri being the only sediment source, are in the current model results. Initial CCRU consideration of sediment budgets (conservative, assuming sole source from Waimakariri) indicates to us:

[8] Kenderdine, SE; Hart, DE; Cox, RJ; de Lange; WP; Smith, MH. (2016) Peer review of the Christchurch Coastal Hazards Assessment Report. Review report produced for the Christchurch City Council, 18 August 2016, 74 pp.
[9] Tonkin & Taylor (2017) Coastal Hazard Assessment for Christchurch and Banks Peninsula.

- a modest increase of sediment production in the Waimakariri from the increased soil erosion resulting from NIWA[10] medium term predictions
- increase of sediments from Waimakariri gravel extraction[11] or in an overmining situation (worst case) the banks being eroded to fund it. [Environmental implications of such processes, or the environmental stewardship role of Environment Canterbury in their management of these activities are not addressed here].
- The southward migration of the Waimakariri river mouth[12] with the erosion of southern spit provides 20-100,000 $m^3 a^{-1}$ of additional sediment, although not huge, part of this will support the current sediment flux.
- Sediment scenarios used are current and reduced – it is not obvious to us why there is no increased sediment scenario.

n) p16 para 1 "…*particularly areas at high risk of being affected*…". How is 'high risk' defined

Groundwater

o) p19 "…*Groundwater flooding could occur during large and/or prolonged rainfall events, seasonally, daily because of tides, or more permanently as a result rising sea levels*…" This is true. However there is very inexpensive technology for mitigation of seawater pumping of groundwater levels, maybe a cartoon to give perspective?

p) p20 suggestion based on reasoning outlined in (q) below which suggests that the groundwater levels used in the report are overestimations of the

[10] Mullan, B. Sood, A. Stuart, S. Carey-Smith, T. (2016) Climate Change Projections for New Zealand, NIWA. Prepared for Ministry for the Environment and published as Ministry for the Environment (2018) Climate Change Projections for New Zealand: Atmosphere Projections Based on Simulations from the IPCC Fifth Assessment 2e. Wellington, Ministry for the Environment.

[11] Rinaldi et al. (2008) Gravel Bed Rivers VI: from process to understanding river restoration. Elsevier. Kondolf, M. (1994) Geomorphic and environmental effects of instream gravel mining. Landscape and Urban Planning **28** pp225-243.

[12] Boyle, T. (2011) An investigation of the southward migration of the Waimakarir river mouth. Report#R11/121 Environment Canterbury ISBN 978-1-927257-74-6

long term situation, hence suggestion is to reduce certainty in the following statement: "…*As shown in figure 15, areas adjacent to the estuary edge north of South New Brighton Park and along parts of Rocking Horse Road in Southshore, like some other parts of Christchurch have the shallowest groundwater, occasionally at less than one metre below the ground surface. These areas could therefore be the most susceptible to current and future flooding from groundwater…*".

q) The groundwater level at any point is the balance between the amount of water going into the aquifer (usually rainfall) and the amount leaving the aquifer. This means that *when* a measurement is done, will determine the result. The most recent study[13] acknowledges this issue and caveats the uncertainty of having only three years data. Figure 1.3 below[13] summarises the variability of rainfall before and after the Christchurch Earthquake sequence. Clearly, ruling out any very short term systematic change to climate, the medians before and after the earthquake sequence should be within uncertainty very much the same. The groundwater measurements used[13] and relied on in the baseline document are median values based on three years monitoring. It can be seen in that three year period post the earthquake, during which the measurements were taken, the median rainfall is about 10% higher than that of the 20 years data beforehand. This means, assuming abstraction *etc.* had not changed, there was more water in the aquifers during the measurement period, hence the water levels were closer to the surface than would normally be the case. Other assumptions are that the state of the aquifers pre-earthquake are broadly similar to that post-earthquake, and also that the type of modelling issues recently outlined[14] affecting the post-earthquake South Dunedin groundwater modelling are not relevant here.

[13] S. van Ballegooy, S. C. Cox, C. Thurlow, H. K. Rutter, T. Reynolds, G. Harrington, J. Fraser, T. Smith, 2014. Median water table elevation in Christchurch and surrounding area after the 4 September 2010 Darfield Earthquake: Version 2. GNS Science Report 2014/18, 79 pages plus 8 appendices
[14] Cox, S. (2018)

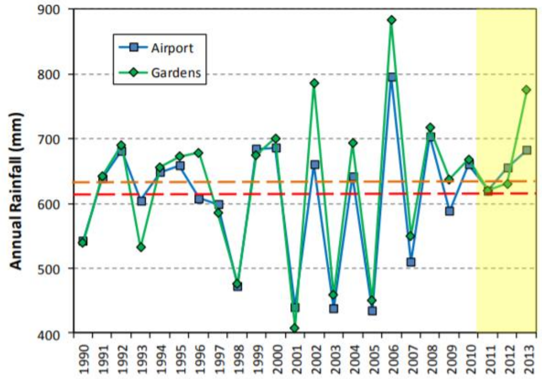


Figure 1.3 **Graph of total annual rainfall at Christchurch Airport and Gardens between 1990 and 2013. Dashed red and orange lines are median values of 616 mm (red = Airport) and 638 mm (orange = Gardens), respectively. Rainfall during the post-Darfield Earthquake period, highlighted in yellow, appears to be at, or slightly above, median values rather than near high or low limits that occurred between 2001-2006 (Data from NIWA Cliflo database, network numbers H32451 and H32561 http://cliflo.niwa.co.nz/).**

Inundation and Flooding

r) p13 Fig 9 again it is surprising that there is not much difference between the scenarios and time frames. Is this because at 300mm of sea level rise the vast majority of houses in the area are already flooded? (s) below related.

s) p13 Fig 10. Can we clarify? These maps do or do not have current flood mitigation (where permanent or temporary) in them? If the current floor level planning rules protect houses in a 1 in 200 year flood. These maps cannot be correct, because a current 1 in 200 year flood has 1m surge associated with it. It does not matter whether the 1m of water has come from sea level rise or a storm surge, by definition the houses are fine at this level of inundation. In addition these maps are very different to those prepared for the IHP (available on request). So there is an inconsistency here somewhere, but we cannot establish the source.

t) On a very related point, post-earthquake, the capacity of the estuary (a natural defensive structure) was radically reduced as the estuary filled with sediment. Do you have data of how much estuary capacity was lost or reduced? Understanding the role of the estuary in the drainage system of the City, we expect the drainage system was designed with pre-earthquake capacity in mind. Hence, we wonder how much of post-earthquake flooding is due to lack of capacity of the estuary rather than anything else.

u) p3 "…*For example, edge protection of the Estuary/Ihutai will not mitigate the risk from rainfall flooding or shallow groundwater*…". This is not true in our context: The Gary Teear proposal had a membrane under it that would exactly do this (again cartoon could work).

v) p8 Flood risk will increase, either from sea level rise, or more intense rainfall is clearly true. However, there are contradictory cognate statements which confuse: "…*Current climate change projections suggest that there will be lower annual average rainfall in eastern Canterbury*…" but a few words later the reference 12 to this says "…*Current Government projections estimate Christchurch could see a 16% increase in overall rainfall*…"

w) p8 "…*The council is legally*..." Something that this includes adaptive management is probably needed here.

x) p9 Your flood frequency analysis which can yield a probability of a flood of a particular height is interesting. Clearly because we do not have a record 500 years long, how have you generated a 500 year distribution from which the 500 year return period flood can be calculated? We are assuming you are using the average probability method/AEP method *e.g.* 1% = 1 in 100 year return period. Or are you using the PMF method?

y) p10 Fig 6 legend, worst case scenarios by the coincidence of unlikely events. So for example it is 2100, we have a meter of sea level rise already, rainfall intensity has increased by 16%, (fine, let's not argue about this). Then the maps are drawn with a series of additional assumptions: a 1 in 500 year tidal event with a 1 in 50 year rain event, *i.e.* a 1 in 25,000 event beyond the sea level rise and increased intensity of rainfall. The public are not going to easily understand that the maps are so extremely unlikely…In fact the IHP (Env Court Judges) accepted the evidence on exactly this point that this was not the correct way to do this (Simon Arnold), yet here again are the same maps.

Hard Mitigation Methods, Infrastructure and planning

z) p17 The important point here is that CCC avoid building anything of significance (despite the Coastal Policy Statement). This is a real issue for the area IMO. Rates are being taken out and not much invested back in.

Human Environment

aa) p10-11 Useful graphs:

- at first glance makes you think the area is doing ok from a property value perspective, but a closer look shows that it has done worse compared to almost all the others.
- The land value in particular is a bit misleading. You are comparing % change off a low base in Brighton/SS. The big thing though is that land values in the HFHMA have not been tracked, this is the data that will tell the real story. Very little in the area has been rebuilt but it is not mentioned that this is due to planning rules that block commercial development

Management Framework

bb) Apart from Fig 3, p5, and p9 Adaptive management is not mentioned in this part of the overall document, and the way it is written seems not to welcome the approach, in fact almost excludes it.

cc) p5 para 3 "…*The LGA requires councils to give regard to the avoidance or mitigation of natural hazards when performing its role in making decisions and undertake financial planning for risk reduction activities*…." Along with this, the NZ Coastal Policy Statement #26 talks of natural flood defences (dunes, wetlands..*etc*.), and #27 does not necessarily rule out hard structures as the start of an adaptation process, and case studies oversees initially use small hard structures to prevent maladaptation, *e.g.* raised cycleways.

dd) p11 "…*Avoiding increasing risk in areas subject to hazards which are unacceptable, such as areas likely to be subject to coastal inundation or erosion over at least the next 100 years, or flood waters of high depth* *and velocity which pose a risk to life*…" [my emphasis]. We cannot realistically assess the risks over the next 100 years for many areas, so how are councils and communities supposed to avoid maladaptation?