BEFORE INDEPENDENT HEARING COMMISSIONERS
IN CHRISTCHURCH

TE MAHERE Ā-ROHE I TŪTOHUA MŌ TE TĀONE O ŌTAUTAHI

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of the hearing of submissions on Plan Change 14 (Housing and Business Choice) to the Christchurch District Plan

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STATEMENT OF PRIMARY EVIDENCE OF DEREK JOHN TODD ON BEHALF OF CHRISTCHURCH CITY COUNCIL

COASTAL HAZARDS – EROSION

Dated: 11 August 2023

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EXECUTIVE SUMMARY

1. My full name is **Derek John Todd.** I am employed as Principal Coastal and Hazards Scientist at Jacobs New Zealand Limited.

2. I have prepared this statement of evidence on behalf of the Christchurch City Council (the **Council**) in respect of matters arising from the submissions on the proposed Qualifying Matter Coastal Hazard Risk Management Areas (**QM-CH**) for coastal erosion for Plan Change 14 to the Christchurch District Plan (the **District Plan**; **PC14**).

3. The base data for the determination of the QM-CH for coastal erosion is from the *Coastal Hazards Assessment for Christchurch District* (**CHA 2021**) by Tonkin & Taylor Limited (**Tonkin & Taylor**). The methodology employed in this assessment to calculate Areas Susceptible to Coastal Erosion (**ASCE**) are standard best practice that include the parameters listed in Policy 24 of the NZCPS, and in my opinion meets the test of precautionary approach under Policy 3 of the NZCPS. The calculations included the most recent relevant data and appropriate consideration of measured long-term accretion, short-term storm responses, wave climate sand gain size, and potential sea-level rise impacts on Christchurch City's open-coast shoreline.

4. The Jacobs *Risk Based Coastal Hazard Analysis for Land-use Planning Report* 2021 (**Jacobs 2021**) and subsequent addendums and updates (**Jacobs 2022, Jacobs 2023**) involved selecting the most appropriate Relative Sea Level Rise (**RSLR**) increments and probability thresholds from the CHA 2021 for defining high, medium and low risks for use in land-use planning. Jacobs 2023 recommended the following high-medium and low coastal erosion hazard zones for Christchurch City's open coast:

    (a) A High-Medium Hazard Coastal Erosion Zone defining the area from the existing shoreline to the 66% probability of erosion distance for 0.6 m Sea Level Rise (**SLR**) by 2080 with an additional 'dune resilience' width based on short term erosion in a 100-year ARI coastal storm event.

    (b) A Low Hazard Coastal Erosion Zone defining the area between the high hazard zone and the 10% probability of erosion with 1.2 m SLR by 2130 with an additional 'dune resilience' width based on short term erosion in a 100-year ARI coastal storm event.

5. I consider that the 'dune resilience factor' be included in the hazard zones to allow for future continuation of dune protection and to provide resilience to coastal hazards at the end of the planning timeframes. The inclusion of this factor aligns with NZCPS Policy 26 (Natural defences against coastal hazards). The width of the 'dune resilience factor' was calculated as being the width of the 'Short-term (ST)' Factor in the ASCE calculation.

INTRODUCTION

6. My full name is **Derek John Todd**. I am employed as Principal Coastal and Hazards Scientist at Jacobs New Zealand Limited (**Jacobs**), located in their Christchurch Office.

7. In preparing this evidence I:

   (a) Was the Technician Peer Reviewer of the CHA 2021.

   (b) Was a co-author of the coastal erosion section of the Jacobs 2021 and Addendum to the report in 2022, with responsibly for the SLR and coastal erosion threshold sections of the report. This report has subsequently been updated in March 2023.

   (c) Reviewed the submissions to PC14 relevant to QM-CH.

8. I am authorised to provide this evidence on behalf of the Council.

QUALIFICATIONS AND EXPERIENCE

9. I am a coastal geomorphologist and hold the qualifications of BSc and MSc (Hons) from the University of Canterbury. My post-graduate studies were in physical geography, including a thesis on the interaction of coastal and fluvial processes.

10. I have over 35-years working experience in investigating coastal processes, assessing potential future changes in shoreline stability, and providing technical assessments and advice for Resource Consent applications, Regional Coastal Plans, and District Plans.

11. I am also an adjunct of the Griffith Centre for Coastal Management, Griffith University on the Gold Coast, Australia and am a member of the New Zealand Coastal Society, a Technical Interest Group of Engineering New Zealand.

CODE OF CONDUCT

12. While this is a Council hearing, I have read the Code of Conduct for Expert Witnesses (contained in the 2023 Practice Note) and agree to comply with it. Except where I state I rely on the evidence of another person, I confirm that the issues addressed in this statement of evidence are within my area of expertise, and I have not omitted to consider material facts known to me that might alter or detract from my expressed opinions.

SCOPE OF EVIDENCE

13. My statement of evidence:

    (a) Explains the QM-CH and why it is required for coastal erosion hazards;

    (b) Identifies the current coastal erosion hazard provisions in the District Plan, and the areas to which the QM-CH for coastal erosion will apply;

    (c) Outlines the methodology for determining the QM-CH for coastal erosion, including the selection of future sea level magnitudes and timeframes, and the probability thresholds applied to determine the different risk categories;

    (d) Responds to points raised in submission #380 (K. Hay on behalf of SSRA) and #739 (Phillip Ridge) on the RSLR scenarios used in the determination of the QM-CH for coastal erosion; and

    (e) Responds to points raised in Submission #739 (Phillip Ridge) on the use of NIWA coastal sand budget in the determination of the QM-CH for coastal erosion.

14. I address each of these points in my evidence below.

QUALIFYING MATTER FOR COASTAL HAZARD RISK MANAGEMENT

15. Categories of risk from coastal hazards were defined in Jacobs 2021 based on the magnitude and extent of potential effects of coastal erosion and inundation with SLR identified in the CHA 2021. Under a risk-based approach as required by both the New Zealand Coastal Policy Statement (the **NZCPS)** and Environment Canterbury's Regional Policy Statement (the **RPS**), it is recognised that the level of risk to a land parcel exposed to

coastal hazards of erosion and inundation increases with time as sea level rises. However, there are some land-uses that are possible and appropriate for a period of time until the level of risk becomes intolerable.

16. In Jacobs 2021, 2022, 2023, the standard definition of risk[1] was applied, being the product of likelihood and consequence of the hazard. For coastal erosion, the consideration of likelihood included uncertainties in the magnitude and timing of SLR, and the extent of erosion that would occur within specified time frames. For consequence, it was recognised that the consequence of permanent loss of land due to erosion is always high, as the land is no longer present, but that consequence also increases the more intensely land exposed to the erosion hazard is used.

17. In the context of defining a qualifying matter for restricting intensification of residential land uses beyond that currently enabled by the District Plan, I have considered the following:

    (a) How far in the future do we need to consider the duration of the intensified development?

    (b) What are the likelihoods and uncertainties in projecting the magnitude of sea level and shoreline response over these time scales?

    (c) What is the residual risk to development from erosion beyond the specified area of the qualifying matter.

18. In CHA 2021, ASCE's and the extent of coastal inundation were mapped across the whole district. This mapping is at 0.2 m increments of RSLR[2] by 2050, 2080, and 2130, all relative to the 2020 mean sea level. The range of increments generally aligned with the range of SLR scenarios from MfE (2017) *Coastal Hazards and Climate Change: Guidance for Local Government in New Zealand*, which were sourced from the IPCC (2013) 5th Assessment Report on climate change[3,4]. As per the recommendation in

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[1] Risk in the context of Natural Hazards is often expressed in terms of a combination of consequences of an event (including changes in circumstances) and the associated likelihood of occurrence. From *Coastal Hazards and Climate Change: Guidance for Local Government in New Zealand.* (MfE, 2017).

[2] Relative Sea Level Rise (RSLR) combines both rising sea level from climate change and allowance for vertical land movements.

[3] IPCC (2013) Working Group I contribution to the IPCC 5th Assessment Report "Climate Change 2013: The Physical Science Basis". Report of Intergovernmental Panel on Climate Change.

[4] The MfE (2017) *Coastal Hazards and Climate Change: Guidance for Local Government in New Zealand* predates the Working Group I contribution to the IPCC 6th Assessment Report "Climate Change 2021: The Physical Science Basis". Report of Intergovernmental Panel on Climate Change. The IPCC 6th Assessment Report is addressed in the MfE (2022) *Interim guidance on the use of new sea-level rise projections.*

MfE (2017) Guidance, the CHA 2021 also included an additional higher SLR projection over a longer timeframe (i.e. 2150).

19. In Jacobs 2021 the following factors were investigated to determine appropriate criteria to define areas of low, medium and high-risk exposure to coastal erosion and coastal water inundation that could be used in future land use planning:

    (a) the range of SLR increments over various timeframes;

    (b) the erosion probability thresholds; and

    (c) the inundation depths from the CHA 2021.

20. For coastal erosion, this resulted in zones of high-medium risk exposure and low risk exposure over the next 100 years being defined along the Christchurch City's open coast, with a single zone of high-medium risk exposure also present around the Avon-Heathcote estuary. The extent of these zones is shown in **Appendix A**.

21. For the open coast, the high-medium coastal erosion risk exposure area has been included in the proposed High Risk Coastal Hazard Qualifying Matter Area, and the low coastal erosion risk exposure area has been included in the proposed Medium Risk Coastal Hazard Qualifying Matter Area. Although the likelihood of erosion in some of these areas may be low, the consequences based on the permanent loss of land will be high, such that they are appropriate in be included in the Medium Risk Coastal Hazard Qualifying Matter Area that limits the full intensification scenario envisaged by the NPS-UD.

22. Around the Avon-Heathcote estuary the high-medium coastal erosion risk exposure area does not include any land zoned Residential in the District Plan[5], so is not shown in either the High or Medium QM-CH Areas.

CURRENT COASTAL EROSION HAZARD PROVISIONS IN THE CHRISTCHURCH DISTRICT PLAN

23. The operative provisions of the District Plan do not currently identify any Coastal Erosion Hazard Management Areas, instead it relies on the Erosion Zones and related policies of the RPS and the relevant Erosion Zone Rules

[5] Is totally contained within the Open Space Coastal Zone (former Residential Red Zone), Open Space Natural Zone, and Open Space Water and Margins Zone, and other public land.

above the Mean High Water Spring Contour **(MHWS**) in the Canterbury Regional Coastal Environment Plan (**RCEP**).

24. For accreting coasts, such as Christchurch City's open coast, the RCEP identifies an Erosion Hazard Zone 1, which is also the "High Coastal Hazards Zone" defined in the RPS, within which development activities are restricted or prohibited. This zone covers the area from the Coastal Marine Area (**CMA**) boundary (i.e. MHWS position) to the landward limit of the active beach system. For the Christchurch open coast, this includes the full width of the dune system seaward of Marine Parade, and seaward of residential properties on the east side of Rockinghorse Road to the north of Tern Street. The only area of Christchurch City's open coast where residential properties are within this coastal hazard zone is south of Tern Street as shown in **Appendix B**.

AREAS WHICH THE PROPOSED QUALIFYING MATTER COASTAL HAZARD RISK MANAGEMENT AREAS FOR COASTAL EROSION WILL APPLY

25. The proposed High QM-CH for coastal erosion is a continuous narrow strip of land along the length of the open coast from Brooklands Lagoon to the south end of Rockinghorse Road, South Brighton Spit. It is largely contained within the existing dune environment, including the removed dune areas at Waimairi Surf Life Saving Club, North Brighton, New Brighton, South Brighton Surf Life Saving Club and Spit Reserve at the end of the South Brighton Spit. There are also isolated areas of beach at Sumner Beach and Taylors Mistake within the High QM-CH for coastal erosion. Within this High QM-CH, the only residential areas included are limited to the south end of Rockinghorse Road (zoned Residential Suburban), Marine Parade at North Brighton (zoned Residential Suburban Density Transition) and at the north end of Taylors Mistake (zoned Residential Hills Zone).

26. The Medium QM-CH for coastal erosion is also a continuous narrow strip of land along the length of the open coast from Brooklands Lagoon to the end of the South Brighton Spit that sits landward of the High QM-CH. This medium coastal hazard risk area is largely within the existing back dune environment or within the footprint of Marine Parade. However, there are also larger residential areas within the Medium QM-CH at Waimairi, North Brighton, New Brighton, and on the South Brighton Spit to the south of Tern

Street, all of which retain their existing District Plan rules relating to intensification under PC14.

27. There are also isolated areas of beach at Sumner Beach and Taylors Mistake that are located within the Medium QM-CH for coastal erosion which also includes some isolated residential properties.

28. As set out earlier, the high-medium coastal erosion risk exposure area around the Avon-Heathcote estuary does not include any residential properties, so has not been shown in either the High or Medium QM-CH Areas.

METHODOLOGY FOR DETERMINING THE QUALIFYING MATTER COASTAL HAZARD MANAGEMENT AREA FOR COASTAL EROSION

Coastal Hazards Assessment 2021 (CHA 2021)

29. For coastal erosion of the open coast within Christchurch City, the CHA 2021 calculated the width of future ASCE from the following equation:

$$\text{Future ASCE}_{Beach} = (LT \times T) + SL + ST + DS$$

where:

LT = Long-term rate of horizontal shoreline movement (m/yr)

T = Timeframe (years)

SL = Horizontal shoreline retreat caused by increase in mean sea level

ST = Short term changes in horizontal shoreline position related to singular storms or clusters of storms (m)

DS = Dune stability allowance (horizontal distance from eroded base of dune to dune crest at a stable angle of repose (m).

30. This is a standard best practice approach to determining the position of future open coast sand beach shorelines that includes the relevant factors listed in Policy 24 of the NZCPS[6]. As the technician peer reviewer of the CHA 2021, I found that the calculations included the most recent relevant data and appropriate consideration of measured long-term accretion, short-term storm responses, wave climate, sand gain size, and potential sea-level rise impacts on the Christchurch open-coast shoreline.

[6] Policy 24 NZCPS lists a number of factors to be taken into regard when identifying areas exposed to coastal hazard risks over at least 100 years. These factors include: (a) physical drivers and processes that cause coastal change including sea level rise; (b) short-term and long-term natural dynamic fluctuations of erosion and accretion; (c) geomorphological character; (e) cumulative effects of sea level rise, storm surge and wave heights under storm conditions; (f) influences that humans have had or are having on the coast; (h) effect of climate change on the above matters, storm frequency, storm intensity, storm surges and coastal sediment dynamics; taking into account national guidance and best available information on the likely effects of climate change.

31. For Christchurch City's open coast shorelines, the reference base shoreline from which ASCE distances are measured from is the dune toe or seaward edge of dune vegetation. This is standard practice for sand dune shorelines. Therefore, the future shoreline positions do not include the fore or back dune environments.

32. A different standard best practice equation[7] was used to calculate the future ASCE for the banks of the Avon-Heathcote Estuary. This was required given that the weakly consolidated material on the estuary banks is subject to only a one-way process of retreat unlike an open coast sand beach environment which can rebuild following erosion periods.

33. The CHA 2021 did not determine future ASCE in locations, such as the southern edge of the Avon-Heathcote Estuary, where the shoreline has been significantly modified by reclamation and hard protection structures, these modifications are extensive, and have been in place for very long periods of time (i.e. at least since the 1940s). I agree with this methodology for these areas.

34. For coastal erosion of both the Christchurch City open coast and Avon-Heathcote Estuary shorelines, the CHA applied a probabilistic approach to calculating the ASCE for each increment and timeframe of RSLR. Under this approach, an appropriate probability distribution for a plausible range of values for each of the input parameters is applied to obtain the probability of a range of ASCE outcomes for each increment and timeframe of RSLR. Again, this is standard practice for detailed coastal erosion hazard assessments and is recommended in the MfE (2017) Guidance. I agree with the use of the methodology employed to calculate the probabilities of erosion distances for each increment and timeframe of RSLR.

35. For Christchurch City's open coast coastal erosion analysis, the CHA 2021 applied a base scenario of no future change in sediment supply to the coastal sediment budget with climate change[8]. Based on the results of a study by Hicks et al (2018) into the future sand budget for Southern Pegasus Bay[9], sensitivity testing of 11% reduced supply and 28% increased supply scenarios were applied to the upper RSLR increment of

[7] Future $ASCE_{Bank} = (LT \times T) X SL + (Hc/\tan\alpha)$, where SL = Factor of potential increase in LT rate due to SLR effects, Hc = Height of bank (m), and α - the characteristic slope angle of the bank.
[8] Sediment supply reaching the Christchurch beaches depends on both the amount of sediment discharged by the Waimakariri River, and the amount of sediment which is transported southwards along the coast.
[9] Hicks M., Measures R., Gorman R., (2018) Coastal sand budget for Southern Pegasus Bay – Stage B: Future sand budget. NIWA report prepared for CCC.

+1.5 m by 2130. In my opinion this was an appropriate base scenario and sensitivity testing for determining sediment supply effects on open coast erosion.

Jacobs Risk Based Coastal Hazards Analysis (Jacobs 2021, 2022, 2023)

Selection of sea level rise Increments and scenarios

36. Jacobs 2021 involved selecting the most appropriate RSLR increments and probability thresholds from the CHA 2021 for defining high, medium and low risks for use in land-use planning.

37. The following underlying principles were applied to the selection of the most appropriate CHA 2021 increments of RSLR for use in land use planning:

    (a) There needs to be consistency between the selected RSLR increments for both inundation and erosion to define risk categories.

    (b) The RSLR scenarios selected need to reflect both timeframe and RSLR magnitude, as the ASCE are dependent on extrapolation of both the rate of long-term shoreline movements and of shoreline retreat due to the RSLR over the same period.

    (c) Timeframes are also important for defining the ‘certainty’ of the magnitude of RSLR. While the IPCC do not assign probabilities for the SLR scenarios presented in MfE (2017) and used in the CHA 2021, it can be assumed that they all have the same likelihood of occurrence. This is due to the possibility of which emission path underpinning the different SLR scenarios will occur is unknown, therefore IPCC determined that each scenario should be considered equally. However, what is certain is that there is much greater certainty that the lower projected magnitudes will occur over the assessment timeframes.

    (d) The timeframe is important to ensure that any land use activities enabled by the District Plan within various hazard categories have sufficient and reasonable time (for erosion), or lack of frequency of hazard (for inundation) for that activity to be carried out in an acceptable manner without the need for hazard mitigation measures.

(e) As shown in **Figure 1**, in applying a risk-based approach to selecting an appropriate RSLR magnitude within a specified planning timeframe, a generalised risk profile can be obtained by multiplying the likelihood of RSLR distribution curve by the consequences curve. This generalised example demonstrates that, in most cases, the peak of the risk curve within the specified timeframe will typically occur at a SLR above the mid-range SLR.

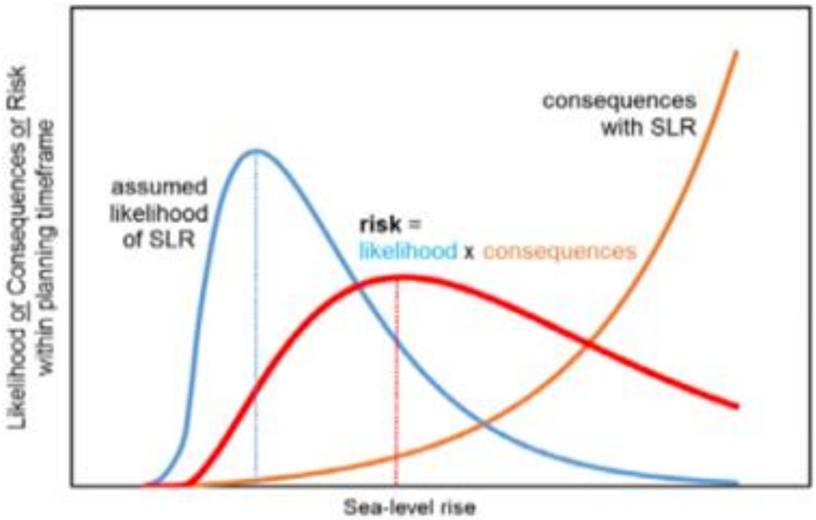


Figure 1: Generalised SLR probability and generic consequence curve (upper pane) resulting in the risk profile. Source MfE (2017)

38. As the author of Jacobs 2021, from considering the above principles, it was my recommendation that the most appropriate CHA 2021 RSLR increments to use for a risk-based approach to land-use planning were:

(a) 0.6 m RSLR by 2080; and

(b) 1.2 m RSLR by 2130.

39. As part of the Jacobs 2021 analysis, these selected increments were compared to the RSLR scenarios presented in MfE (2017). However, following release of the CHA 2021 the IPCC have presented their 6th assessment (IPCC 2021)[10]. In addition, the New Zealand SeaRise programme (2022)[11] have added local estimates of Vertical Land Movements (**VLM**) to the updated IPCC scenarios of SLR due to climate change to produce projections of RSLR for each of the IPCC scenarios

[10] IPCC (2021) Working Group I contribution to the IPCC 6th Assessment Report "Climate Change 2021: The Physical Science Basis". Report of Intergovernmental Panel on Climate Change.
[11] New Zealand SeaRise Programme tool for estimating RSLR: (https://searise.takiwa.co/). This tool presents VLM data at 2 km intervals around the whole NZ coast based on a short record of satellite imagery (2003-2011), with the assumption that land movements which occurred over this timeframe will continue into the future.

(**Updated RSLR Scenarios**). Therefore, the comparisons below are to the Updated RSLR Scenarios.

40. **Figure 2** shows the selected increments in relation to the average RSLR for Christchurch City's open coast from the "medium confidence" SLR scenarios from IPCC (2021) and an average VLM of -0.656 mm/yr from local open coast sites presented in the New Zealand SeaRise tool[12]. It is noted that there is a degree of variation in the recorded VLM rates along Christchurch City's open coast presented by the New Zealand SeaRise tool, and due to the short time scale of data collection of VLM rates (8 years) there is large uncertainty on the accuracy of applying these rates in future projections of RSLR.

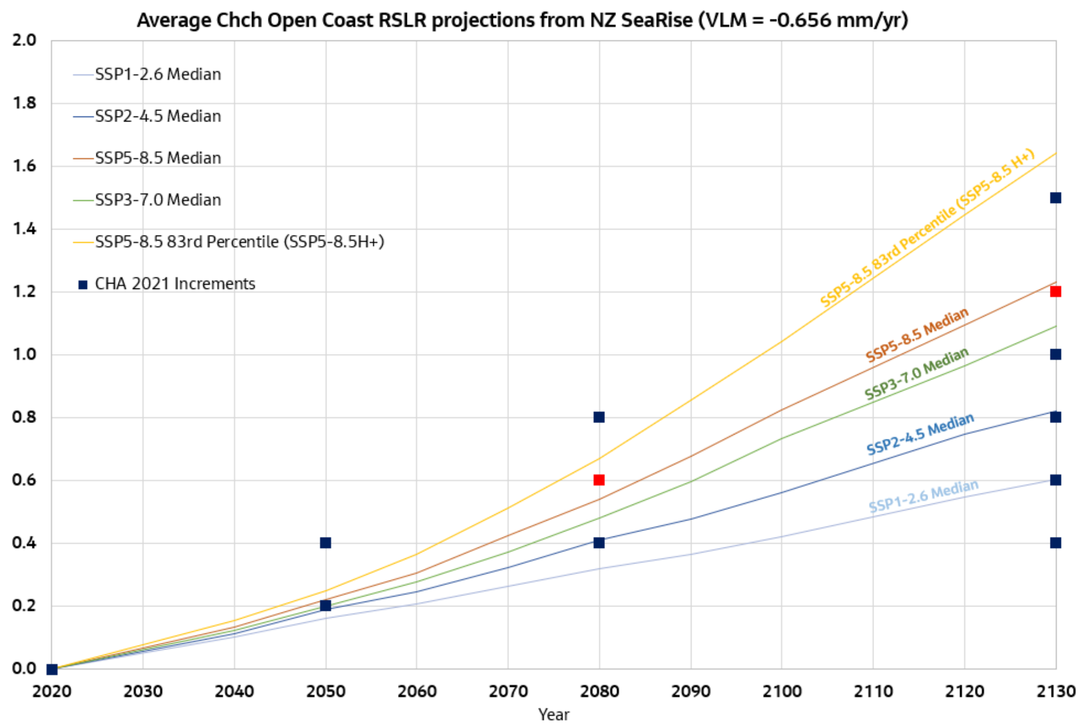


Figure 2: CHA 2021 increments of RSLR compared to scenarios from NZ SeaRise Programme (2022) with an average VLM of -0.656 mm/yr for the Christchurch open coast. The selected CHA 2021 increments for a risk-based approach to land-use planning are shown as red squares

41. From the comparison in **Figure 2**, it can be seen that the selected RSLR increments from the CHA 2021 are closest to the magnitude of projected rise in 2080 and 2130 from the medium value of the SSP5-8.5 scenario with locally averaged VLM.

42. I note that the selected increments in the CHA 2021 are below the projected sea level rise under the SSP5-8.5H+ scenario for 2130, recommended in

[12] Average from 14 sites on Christchurch open coast. Range of VLM from these sites from -2.78 mm/yr (North Brooklands) to 1.297 mm/yr (Scarborough).

Table 3 of the MfE (2022) *Interim guidance on the use of new sea-level rise projections,* where a transitional minimum allowance of SLR should be applied when considering land-use planning for intensification and new developments. This is to avoid long-term risks of coastal hazards to these developments.

43. However, in my view that MfE recommendation contradicts other statements in the MfE (2022) Guidance which I prefer. Specifically, that the SSP5-8.5H+ scenario "*should be used to stress-test plans, policies and adaptation options, and for risk screening to determine coastal areas "potentially affected under NZCPS Policy 24."*

44. From **Figure 2**, the magnitude of rise under the SSP5-8.5H+ scenario by 2130 would be 1.64 m from the 2020 base level, which is closer to the 1.5 m RSLR increment from the CHA 2021. However, for the following reasons, I consider that a 1.2 m RSLR by 2130 from the SSP5-8.5 (medium) scenario is appropriate to apply in land-use planning decisions for intensification and redevelopment:

    (a) The use of the SSP5-8.5 (medium) RSLR scenario is an appropriate precautionary approach to hazard planning, consistent with Policy 3 of the NZCPS, but not overly precautionary in not taking the highest scenario (i.e., SSP5-8.5H+).

    (b) The SSP5-8.5 (medium) scenario (adding the relevant rate of VLM) is the recommended upper scenario to be applied in the first *New Zealand National Adaptation Plan* (MfE, 2022a) for screening of hazards and risks in coastal areas.

    (c) There is a relative low likelihood (17%) that SLR would reach the 1.64 m level by 2130 even under the SSP5-8.5 scenario of continued very high global greenhouse gas emissions.

    (d) Although it is recognised that globally there are likely to be more serious emission mitigation efforts in the future, the scenario chosen is not dependent on global political responses to reduce emissions.

    (e) Under the SSP5-8.5 scenario, both increments are unlikely to occur much before the specified timeframe, (only 17% probability that 0.6 m SLR will occur before 2060, and that 1.20 m SLR will occur before 2110). Therefore, it is unlikely that the level of residual risk from coastal erosion increases beyond the QM-CH areas prior to the specified time frames.

(f) There is less certainty about the timing of the higher magnitudes of SLR, with the 1.2 m of rise possibly being delayed beyond a 100-year planning timeframe if global emission reduction is successful. However, there is still a medium degree of confidence that this magnitude of rise will occur within the next 100 years. Given this, this scenario should still be considered to ensure the District Plan is consistent with Policy 24 of the NZCPS.

(g) From **Figure 1**, under the lower SSP2-4.5 RSLR scenario, 1.2 m of RSLR by 2130 is likely to be close to the magnitude of SLR producing the greatest risk over this time frame, therefore some degree of planning control will be required over this timeframe to avoid increasing the level of risk from land-use intensification. Similarly, 0.6 m of SLR by 2080 is likely to be close to the magnitude of SLR producing the greatest risk over this shorter time frame.

45. In my opinion the use of a 50-year hazard time frame to 2080 is not too short when imposing restrictions on land use activities, and appropriate for defining areas of high risk for residential intensification. This is due to there being a number of land-use activities that are suitable for this time frame while giving a degree of certainty around their occupancy and/or use and at the same time recognising that extreme care will be required for decisions on levels and types of residential intensification in these areas.

46. I have a high degree of confidence that the lower magnitude of SLR (0.6 m) will occur sometime within a 100-year planning timeframe, even if global emission reductions are successfully implemented (i.e. is likely to occur within 2085-2130 timeframe under the SSP2-4.5 RSLR scenario – moderate future carbon emissions).

Selection of erosion probability thresholds and dune resilience factor

47. The Jacobs 2021 analysis also considered what is the appropriate probability threshold that erosion will occur to the calculated ASCE distance to be applied in the different risk categories. The principles applied in the selection of the probability threshold in Jacobs 2021 included:

(a) That there should be a higher probability, therefore higher certainty, that the stated erosion will occur for higher risk areas, and less certainty that the calculated ASCE will occur in lower risk areas.

(b) The distance between the probability thresholds defining different hazard risk categories needs to be sufficient for likely land-use activities to be reasonably able to be carried out in the zone between the thresholds. For example, the analysis considered that the use of thresholds which only produce 5 m wide hazard zones are not going to be acceptable.

48. Based on the principles above, a number of different probability thresholds were considered in Jacobs 2021, with the following being selected:

(a) A High - Medium Coastal Erosion Hazard Zone using the 66% probability of erosion distance for a 0.6 m RSLR by 2080. Erosion up to this distance is likely within a 50-year timeframe. There is a very high degree of certainty that it will occur over longer time frames (e.g. 100 years), although there is also a high residual risk (66%) that erosion will exceed this distance within the 50-year timeframe.

(b) A low Coastal Erosion Hazard Zone using the 10% probability of erosion distance for a 1.2 m RSLR by 2130. Greater areas of erosion are very unlikely within this longer 100-year timeframe.

49. As stated in Paragraph 29 of my evidence, for open coast shorelines the ASCE distances produced by the CHA 2021 represent the dune toe at the front of the beach. These erosion distances do not take account of any remaining width of the dune environment behind the beach, or whether it is sufficient to continue to provide protection from erosion and inundation hazards to the land behind. In some areas, erosion of the dune back to the ASCE position would increase the risk profile due to there being insufficient back dune elevation and/or width to provide natural hazard protection to both hazards.

50. Given this, Jacobs 2021 recommended that an additional area of land behind the mapped CHA 2021 ASCE position be included in the hazard zones to allow for future continuation of dune protection to provide resilience to coastal hazards at the end of the planning timeframes. This was termed a 'dune resilience factor'. This size of the recommended 'dune

resilience factor' underwent changes in the subsequent Jacobs reports, to be in Jacobs 2023 calculated as being the width of the 'Short-term (ST)" Factor in the ASCE calculation (i.e., the additional dune width required to withstand short-term erosion from a 100 year ARI coastal storm occurring at the end of the planning timeframe).

51. The inclusion of a 'dune resilience factor' aligns with the commentary of NZCPS Policy 26 (Natural defences against coastal hazards). The *DoC (2017) NZCPS Guidance notes, (Page 60*) states *"As a result of climate change, the protection, restoration and enhancement of natural defences will often require protective measures to ensure that a sufficient landward buffer is protected from development that would otherwise compromise the functioning of the natural defences over the long term by restricting its ability to migrate inland with sea-level rise (or as a result of long term coastal retreat for any other reason)".*

52. Therefore, the final high-medium and low coastal erosion hazard zones for Christchurch City's open coast were recommended in Jacobs 2023 to be:

    (a) A High-Medium Hazard Coastal Erosion Zone defining the area from the existing shoreline to the 66% probability of erosion distance for 0.6 m SLR by 2080 with an additional 'dune resilience' width based on short term erosion in a 100-year ARI storm event.

    (b) A Low Hazard Coastal Erosion Zone defining the area between the high hazard zone and the 10% probability of erosion with 1.2 m SLR by 2130 with an additional 'dune resilience' width based on short term erosion in a 100-year ARI storm event.

RESPONSE TO SUBMISSIONS ON SELECTION OF THE RELATIVE SEA LEVEL RISE (RSLR) SCENARIO USED TO DETERMINE THE QUALIFYING MATTER COASTAL HAZARD MANAGEMENT AREA

53. Submission #380 (K. Hay on behalf of the Southshore Residents Association (SSRA) and #739 (Phillip Ridge) raise concerns about the use of SSP5/RCP 8.5 and SSP5/RCP8.5H+ SLR scenarios as the basis for predicting areas likely to be exposed to future coastal hazards. The SSRA submission suggests that the 8.5 scenario is "*problematic, over cautious, and does not reflect the "likely effects" indicated in the NZCPS (Policy 24)"* based on statements of the scenario being "*unlikely or plausible*[13]"

[13] I believe this should be implausible not plausible.

attributed to the IPCC AR6 report (2021). Mr. Ridge's statement states that "*internationally the use of this scenario [RCP 8.5 and 8.5H+] is now accepted to be highly unlikely and requires the worst level of every variable to occur simultaneously"*. He seeks that a "*more reasoned, conservative, and practical pathway should be considered*".

54. I do not agree with the statements that the SSP5-8.5 scenario is not internationally accepted, is unlikely, or is implausible for the following reasons:

(a) The IPCC AR6 report (2021) does not attach likelihood to any of the climate change scenarios, with the SSP5-8.5 scenario being included as one of the five base scenarios. The statements of unlikelihood and implausibility of this high emission scenario in the IPCC AR6 report are referenced to other authors and are presented as part of the complete discussion. They are not statements of the IPCC's position.

(b) The IPCC AR6 report does note that "*the default concentrations aligned with RCP 8.5 or SSP5-8.5 and resulting climate futures derived by ESMs could be reached by lower emission trajectories than RCP 8.5 or SSP5-8.5*".

(c) The sea level rise chapter of IPCC AR6 (2021) report states there is *"medium confidence in the processes producing SLR under all SSP scenarios, including SSP5-8.5, the projections for SSP3-7.0 and SSP5-8.5 are consistent with a continuation of the GMSL satellite-observed rate and acceleration over the 1993-2018 period".*

(d) The MfE (2022) *Interim guidance on the use of new sea-level rise projections* states *"The upper-range scenario SSP5-8.5 (and its upper likely range of 8.5 H+) should continue to be used, given we are currently on a similar emissions trajectory, combined with the prospect of runaway polar-ice sheet instabilities and very long response time-lags (multi-decadal to centuries) in sea-level rise. This means impacts from sea-level rise will be distinctly different compared with other climate impacts that are more directly tied to global heating and therefore SSP scenarios".*

(e) As set out in Paragraph 41b, the *New Zealand National Adaptation Plan* (MfE, 2022a) directs councils to use the SSP5-8.5 scenario to

2130 (adding the relevant rate of VLM) to define areas of high risk of being affected by coastal hazards. Since November 2022, local government organisations are required 'have regard to' the National Adaptation Plan when making or changing regional policy statements or regional or district plans.

55. In my opinion the SLR increments from the CHA 2021 that are closest to the SSP5-8.5 scenario are appropriate for use in land-use planning and are constant with national guidance, which itself is based on international best practice science.

RESPONSE TO SUBMISSIONS ON USE OF NIWA COASTAL SAND BUDGET

56. Submission #739 (Phillip Ridge) raises concern that the coastal hazard planning has not incorporated the results of the NIWA coastal Sand Budget study (Hicks *et a*l 2018 as referred to paragraph 33), which Mr. Ridge states indicates that "*even under a RCP8.5 scenario, there are very significant time lags (up to 100 years) before any erosion may occur*".

57. As set out in Paragraph 33 of my evidence, for the Christchurch City open coast coastal erosion analysis, the CHA 2021 did apply a base scenario of no future change in river sediment supply and transport south from the Waimakariri River to the coastal sediment budget with climate change. This was used as the basis for the extrapolation of long-term rates of shoreline movement in the ASCE calculations (i.e. the 'LT' component in the ASCE equation given in paragraph 27). It was the ASCE results from this base scenario that was used in consideration of the hazard zone widths for each risk category in the Jacobs 2021 analysis. Under this scenario, there would be on-going accretion from the extrapolation of current sediment supply rates, with the rate of SLR required to convert to an eroding shoreline being 11.6 mm/yr, which is very close to the average rate required for a net RSLR of 1.20 m by 2130 proposed to be applied for defining the coastal hazard risk categories.

58. Therefore, very similar time lags to convert to net long-term erosion as indicated by Mr. Ridge are projected under this scenario. The reason why there is net erosion mapped in the ASCE prior to this time is due to the inclusion of short-term storm erosion (**ST**), and dune stability (**DS**) in the ASCE equations. These factors were not considered in Hicks et al (2018).

59. The CHA 2021 did include sensitivity testing of the effect of changes in sediment supply on future long-term rates of shoreline movement over the absolute limits of change in sediment supply due to climate change for an upper RSLR increment of +1.5 m by 2130. These sediment supply changes from Hicks *et al* (2018) were for a 11% reduction in supply, to a 28% increase in supply. As reported in the CHA 2021, these changes in sediment supply resulted in increased ASCE distances for decreased supply and decreased ASCE distances for increased supply. Hicks *et al* (2018) does not give likelihoods for either of these scenarios.

60. However, Hicks *et al* (2018) gives the 'most likely' future change in sand delivery rate as a 9% increase, but notes uncertainty around this figure. Although the effect of this increase in supply on projected erosion distances is not presented in CHA 2021, as the peer reviewer of the assessment I undertook sensitivity testing of this supply scenario together with other climate change effects on wave climate and hence sediment transport. This sensitivity testing revealed that the projected shoreline responses from these changes were very similar to those from the status quo scenario (i.e. less than 2 m differences) due to the effect of increased river sediment supply being matched by the reduced southward wave transport.

61. I also note that the addition of the 'dune resilience factor' in the proposed hazard zones removes any dependence on the certainty of future sediment supply scenarios used in the calculation of the ASCE in the CHA 2021.

62. It is therefore my opinion that the use of the status quo sediment supply scenario from CHA 2021 in the calculation of the coastal erosion hazard risk zones does not have any material effect on the position of the proposed QM-CH hazard zones.

CONCLUSIONS

63. The base data for the determination of the QM-CH for coastal erosion is from the CHA 2021. The methodology employed in this assessment to calculate ASCE are standard best practice that include the parameters listed in Policy 24 of the NZCPS, and in my opinion meets the test of precautionary approach under Policy 3 of the NZCPS. The calculations included the most recent relevant data and appropriate consideration of measured long–term accretion, short-term storm responses, wave climate sand gain size, and potential sea-level rise impacts on Christchurch City's open-coast shoreline.

64. The reference base shoreline from which ASCE distances are measured from is the dune toe or seaward edge of dune vegetation. This is standard practice for sand dune shorelines. Therefore, these erosion distances do not take account of any remaining width of the dune environment behind the beach, or whether it is sufficient to continue to provide protection from erosion and inundation hazards to the land behind.

65. The CHA 2021 applied a probabilistic approach to calculating the ASCE for each increment and timeframe of RSLR. Again, this is standard practice for detailed coastal erosion hazard assessments and is recommended in the MfE (2017) guidance.

66. The Jacobs 2021 analysis recommended that the most appropriate CHA 2021 RSLR increment to use for a risk-based approach to land-use planning were:

(a) 0.6 m RSLR by 2080; and

(b) 1.2 m RSLR by 2130.

67. These increments are close to the magnitude of projected rise in 2080 and 2130 from the medium value of RSLR under the SSP5-8.5 scenario with locally averaged VLM. In my opinion, this RSLR scenario is appropriate for use in land use planning, noting that is also consistent with both national guidance that is based on international best practice science.

68. From consideration of erosion probability thresholds, the Jacobs 2023 analysis recommended the following high-medium and low coastal erosion hazard zones for Christchurch City's open coast:

(a) A High-Medium Hazard Coastal Erosion Zone defining the area from the existing shoreline to the 66% probability of erosion distance for 0.6 m SLR by 2080 with an additional 'dune resilience' width based on short term erosion in a 100-year ARI storm event.

(b) A Low Hazard Coastal Erosion Zone defining the area between the high hazard zone and the 10% probability of erosion with 1.2 m SLR by 2130 with an additional 'dune resilience' width based on short term erosion in a 100-year ARI storm event.

69. I consider that the 'dune resilience factor' be included in the hazard zones to allow for future continuation of dune protection and to provide resilience

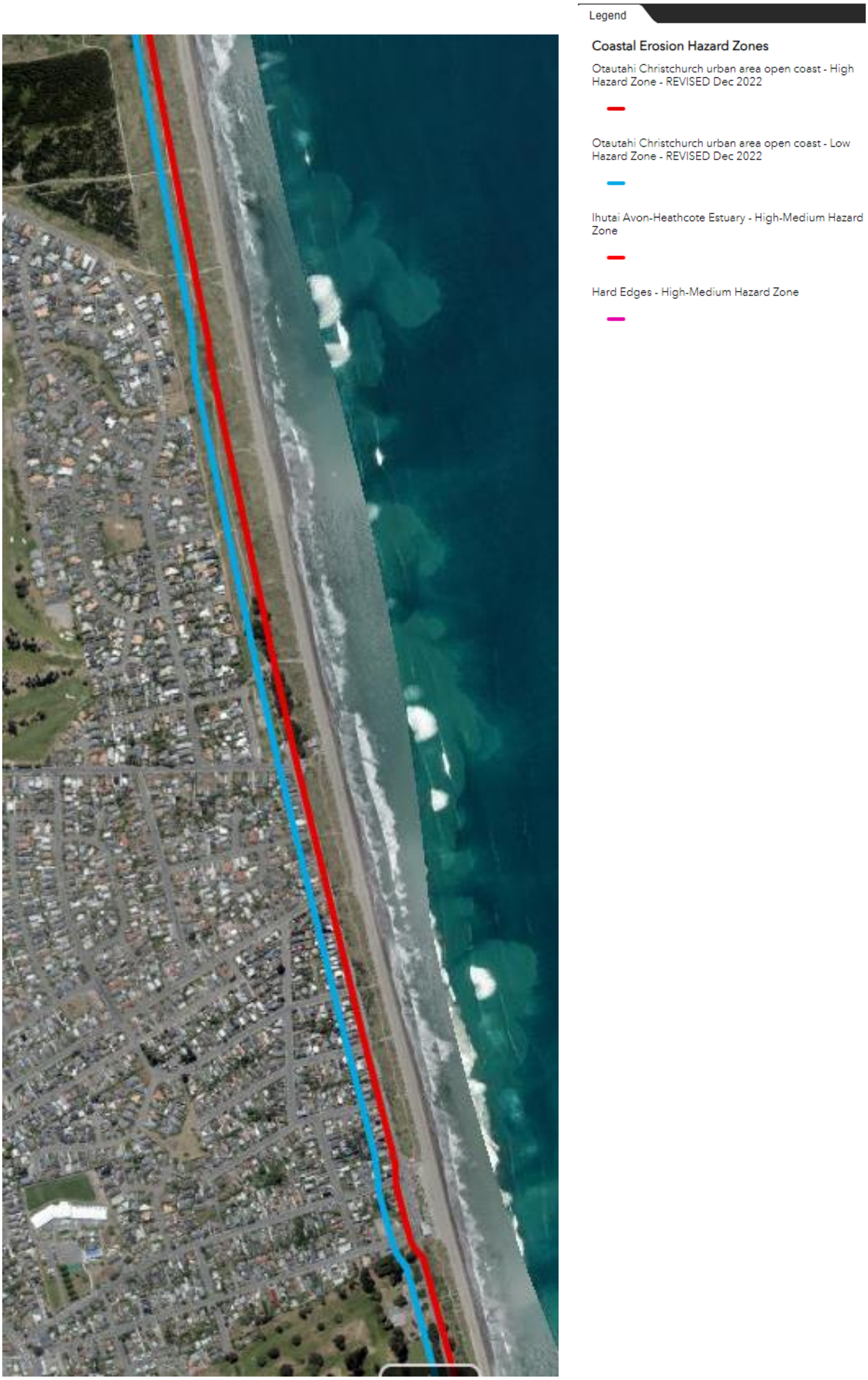
to coastal hazards at the end of the planning timeframes. The inclusion of this factor aligns with NZCPS Policy 26 (Natural defences against coastal hazards). The width of the 'dune resilience factor' was calculated as being the width of the 'Short-term (ST)" Factor in the ASCE calculation.

70. It is my opinion that the use of the status quo sediment supply scenario from CHA 2021 in the calculation of the coastal erosion hazard risk zones does not have any material effect on the position of the QM-CH hazard zones.

Dated: 11 August 2023

Derek John Todd

APPENDIX A - COASTAL EROSION HAZARD RISK ZONES FROM JACOBS 2021



Legend

Coastal Erosion Hazard Zones

Otautahi Christchurch urban area open coast - High Hazard Zone - REVISED Dec 2022

Otautahi Christchurch urban area open coast - Low Hazard Zone - REVISED Dec 2022

Ihutai Avon-Heathcote Estuary - High-Medium Hazard Zone

Hard Edges - High-Medium Hazard Zone

Legend

Coastal Erosion Hazard Zones

Otautahi Christchurch urban area open coast - High Hazard Zone - REVISED Dec 2022

Otautahi Christchurch urban area open coast - Low Hazard Zone - REVISED Dec 2022

Ihutai Avon-Heathcote Estuary - High-Medium Hazard Zone

Hard Edges - High-Medium Hazard Zone


0.4km

APPENDIX B - RCEP COASTAL HAZARD ZONE AT SOUTH BRIGHTON SPIT