South Dunedin Natural Hazards
Plan Review Report

Second Generation Dunedin City District Plan

Contents

Executive summary

This report reviews the effectiveness of the Second Generation District Plan for Dunedin (2GP) in managing natural hazard risk in South Dunedin. The review was prompted by new hazards information becoming available through the South Dunedin Future Risk Assessment. It also considers new natural hazards provisions in the proposed Otago Regional Policy Statement 2021 (pORPS), which came into effect in September 2025, and the National Policy Statement for Natural Hazards, released in December 2025 (NPS-NH).

To support the review, in April 2026 Otago Regional Council completed a risk assessment that considers the latest hazards information under the new NPS-NH and pORPS frameworks. The risk assessment showed that there are currently widespread areas of medium risk to buildings from rainfall events, and smaller areas at high risk from groundwater, with most of South Dunedin being exposed to significant (high or medium) risk due to rainfall, coastal inundation and groundwater hazards by 2100.

A new building built to the minimum floor level (MFL) required under the Building Code will have a significantly lower direct risk from rainfall flooding than older buildings built closer to ground level. However, these minimum floor levels do not protect people from the wider impacts of floodwater on the surrounding land and from effects on health and safety. Potential impacts include damage to other buildings and property, limiting road access, floodwater carrying pollutants and leaving behind hazardous residue, as well as longer term impacts on the physical and mental health of residents.

Climate adaptation planning is being undertaken as part of the South Dunedin Future programme. While adaptation measures that result from this programme will change the risk environment, the adaptation master plan has not yet been confirmed or funded. Therefore, the plan review has been undertaken on the basis of existing risk levels.

The plan review finds that the 2GP provisions are not giving effect to the NPS-NH or the pOPRS. The current ‘low’ Hazard 3 (coastal) overlay zoning for the South Dunedin does not accurately reflect the risk level and does not effectively manage intensification, potentially placing more people and property at risk over time. In addition, the relocatable buildings performance standard does not effectively ensure that buildings can be relocated in a practical and cost-effective way. Potential options for addressing the issues raised include amending the relocatable buildings performance standard to ensure it works more effectively, and making more substantive changes to the way subdivision and development is managed in South Dunedin.

While it is likely that future risk can be reduced through climate adaptation measures, there is currently uncertainty about the location, timing and funding of interventions. In the short term, natural hazard risk can be managed to an extent through building consent and resource management processes. However, changes to planning provisions will be needed to effectively and efficiently manage risk in the medium to long term. This could be achieved either through changes to the 2GP or through the new land use plan under the new Planning Act.

1 Introduction

1. The DCC is required to manage natural hazard risk associated with new development. Under the National Policy Statement for Natural Hazards 2025 (NPS-NH), natural hazard risk to people and property must be managed using a risk-based approach, which avoids or mitigates risk proportionate to the level of risk.

2. The DCC is also required by Section 35 of the Resource Management Act 1991 (RMA) to monitor the efficiency and effectiveness of policies, rules, or other methods in its District Plan (the 2GP), and take appropriate action if necessary.

3. The purpose of this report is to assess the efficiency and effectiveness of the 2GP's natural hazards provisions for South Dunedin in response to recent national and regional level guidance and a risk assessment prepared for the South Dunedin Future programme, all of which became available in 2025.

4. Section 2 of the report provides background context, including a brief summary of the South Dunedin hazards context, the legislative and higher policy framework for managing natural hazards, and a summary of the 2GP's current provisions. The section concludes with a brief outline of the risk assessments that have been undertaken since the development of the 2GP.

5. Section 3 of the report summarises ORC's South Dunedin Natural Hazards qualitative risk assessment, prepared in support of the current plan review. This assessment shows that some areas are already at significant risk from rainfall-induced flooding and high groundwater, and without mitigation there will be widespread significant risk from coastal hazards across much of South Dunedin by 2100.

6. Section 4 discusses the relevance of adaptation planning that is currently underway. Options to help South Dunedin's existing community and assets to adapt to climate-exacerbated natural hazard risk are being investigated as part of the South Dunedin Future (SDF) programme's Adaptation Master Plan. However, until such time that hazard adaptation projects are implemented, DCC needs to assess and respond to hazard risk based on the existing situation.

7. Section 5 evaluates the effectiveness of the current 2GP provisions for managing natural hazard risks in South Dunedin, concluding that the 2GP does not effectively manage the current or future natural hazards risk. It then briefly examines options for changes that could be made to planning provisions. These could be made either through changes to the 2GP or incorporated into the new land use plan prepared under the new Planning Act.

2 Background

2.1 South Dunedin context

8. South Dunedin is highly vulnerable to the effects of severe weather events and climate change due to a combination of mostly flat low-lying land, its function as a basin that collects water from surrounding hills, and patterns of development since reclamation began in the mid-1800s. The lowest lying parts of South Dunedin, often referred to as 'the Flat', were originally salt marshes, wetlands and lagoons, bordered by a tidal mudflat beside Otago Harbour and low sand dunes along the Pacific coast[1]. Prior to urbanisation, the area was an important part of a mahika kai network for Kai Tahu.[2]

9. South Dunedin is currently home to about 1,500 businesses and 13,500 people[3] living in a densely populated residential area. It also has a number of important schools, recreational and cultural facilities. It is exposed to a range of natural hazards including pluvial flooding, coastal inundation and high groundwater, and has experienced a number of damaging hazard events including significant impacts from heavy rainfall in 2015 and 2024. As South Dunedin is now a basin with no natural outfall to the sea, the area relies on pipes and pumps to remove excess water; however, this will become more difficult in future[4], with flood events being expected to increase in frequency and/or severity with the effects of climate change and sea level rise[5].

2.2 Legislative context and national policy framework for managing coastal hazards

10. The management of significant risk from natural hazards is a matter of national importance under the RMA.

11. The 2GP must give effect to a hierarchy of resource management documents. In managing the risk from natural hazards in coastal environments, such as South Dunedin, this includes the New Zealand Coastal Policy Statement 2010 (NZCPS), as well as the new National Policy Statement for Natural Hazards 2025 (NPS-NH) and the natural hazards provisions of the proposed Otago Regional Policy Statement (pORPS).

12. The NZCPS promotes locating new development away from areas prone to coastal hazard risks, taking account of climate change (Objective 5), and requires that in areas potentially affected by coastal hazards over at least the next 100 years, development must avoid increasing the risk of adverse effects and social, environmental and economic harm from the hazards (Policy 25).

13. The NPS-NH took effect on 15 January 2026 and sets national objectives and policies for risk management. It applies to all activities managed under the RMA except for infrastructure and primary production. The NPS-NH provides a minimum standard that must be complied with,

[1] https://www.orc.govt.nz/media/2217/the-natural-hazards-of-south-dunedin-report-july-2016.pdf, p. 6
[2] Aukaha, 2025, p. 6: https://www.dunedin.govt.nz/__data/assets/pdf_file/0009/1274427/south-dunedin-future-mana-whenua-risk-assessment-june-2025.pdf
[3] https://www.dunedin.govt.nz/council/council-projects/south-dunedin-future/adapting-south-dunedin
[4] https://www.dunedin.govt.nz/council/council-projects/south-dunedin-future/the-science-of-south-dunedin
[5] van Woerden, 2026, p. 7.

but it does not preclude managing hazard risk to activities that are not covered by the NPS-NH (such as infrastructure), or from taking a more conservative approach to managing risk.[6]

14. Under the NPS-NH, natural hazard risk to people and property must be managed using a risk-based proportionate approach. The NPS-NH includes a risk matrix that must be used when assessing risk, and natural hazard risk that is identified as very high must be avoided. High or medium natural hazard risk must be avoided or mitigated proportionate to the level of risk, and the potential impacts of climate change on risk out to at least 100 years must be considered.

15. The pORPS takes a similar approach; however, it categorises risk differently in its risk matrix (APP6). In general, the NPS-NH provides a more conservative assessment of risk. However, the pORPS takes a broader approach to health and safety risks as, unlike the NPS-NH, it includes consideration of the risks to physical and mental wellbeing.

16. In addition to national and regional guidance, in 2025 the Resource Management (Consenting and Other System Changes) Amendment Act 2025 inserted a new clause into the RMA (Section 106A). This allows local authorities to refuse to grant a land use consent, or to grant a consent subject to conditions, if it considers that there is a significant risk from natural hazards.

2.3 The 2GP natural hazards framework and current approach in South Dunedin

17. Section 11 of the 2GP contains the framework for natural hazards management in Dunedin. Objective 11.2.1 requires that land use and development is located and designed in a way that ensures that the risk from natural hazards, and from the potential effects of climate change on natural hazards, is no more than low, in the short to long term.

18. The 2GP manages natural hazards through policies and rules attached to eight different overlay zones and two mapped areas (swales and dune systems). The overlay zones are characterised by the type of hazard (flood, land instability, coastal and alluvial fan) and the potential level of risk – Hazard 1 being high, Hazard 2 moderate and Hazard 3 low.

19. The rules associated with the overlays vary according to the type of natural hazard, the risk it poses, and the sensitivity of the proposed activity to the hazard. Sensitive activities include activities such as residential activities, childcare centres and rest homes.

20. Currently, there is only one level of coastal hazard overlay in the 2GP, the Hazard 3 (coastal) Overlay Zone (hereafter referred to as the coastal hazard overlay zone). This indicates a low risk to people and property from coastal hazards. This overlay applies to much of the South Dunedin area, as shown in Figure 1 below.

[6] NPS-NH 1.3(4)

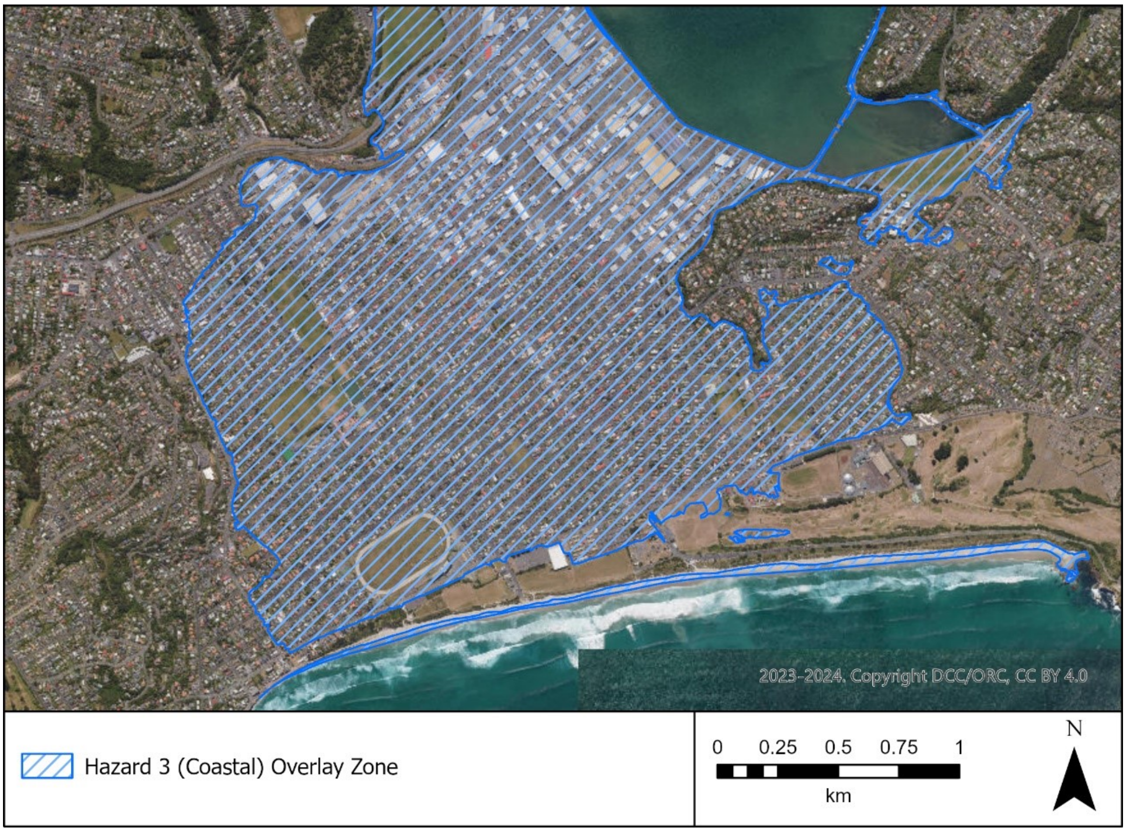

Figure 1: South Dunedin Hazard 3 (Coastal) Overlay Zone

21. New development in the Hazard 3 (coastal) Overlay Zone is subject to the relocatable buildings performance standard (Rule 11.3.3). This rule states that new buildings containing residential activity on the ground floor must be relocatable.

22. The term 'relocatable' is defined as:

For the purposes of the natural hazards provisions, relocatable means a building that is designed and constructed to be able to be either:

- *portable (designed to fit in one piece on a truck) or has wheels and can be towed; or*
- *safely deconstructed into parts (if required), lifted, and transported off site, by crane and truck. This includes buildings that can be transported either in one piece, or a limited number of pieces.*

23. Under Policy 11.2.1.8, resource consents that do not meet this standard can be granted where site constraints mean being relocatable is not practicable.

24. The relocatable buildings requirement works in conjunction with minimum floor levels (MFL) required under the Building Code. The Building Code requires that residential and communal buildings are designed to ensure that surface water from a 2% annual occurrence probability event (one in 50-year event) does not enter buildings. For South Dunedin, DCC Building Services guidance provides different options for achieving compliant MFL, including using flood data from 2015 and 2024.

25. In addition to the above, the risk from natural hazards must be considered when applying to subdivide a site.

2.4 Further hazards assessments since the 2GP

26. In 2025, a risk assessment of South Dunedin natural hazards was completed for the South Dunedin Future programme. The assessment focused on risks to people, property and assets in South Dunedin, in order to establish a risk baseline to support exploring adaptation options for the existing built environment.

27. The resulting report presented a comprehensive picture of the multi-hazard environment in South Dunedin, and the associated risk for the community over the coming decades. The report, *South Dunedin Future Risk Assessment Report* [7] showed that in some parts of Dunedin, buildings, roads, parks and infrastructure are already subject to high or medium risk from hazards, and that areas at risk will increase in extent over time[8].

28. Alongside the wider SDF risk assessment, a Mana Whenua Risk Assessment was prepared by Aukaha, with guidance and validation from a panel of Kai Tahu mana whenua experts[9]. This identified and rated risks to South Dunedin through a Kai Tahu lens, finding that without mitigation, the risk to the four Te Taki Haruru (DCC Māori Strategic Framework) values (Mana, Mauri, Whakapapa and Tapu and Noa) is significant.[10]

29. To support the review of the 2GP, Otago Regional Council has undertaken a further risk assessment, which builds on the work done for the SDF programme. This specifically assesses hazard risk based on the NPS-NH and pORPS risk management frameworks, which must guide a review of the 2GP provisions. The assessment, which is attached as Appendix 1, is summarised below.

3 South Dunedin Natural Hazards qualitative risk assessment

3.1 Introduction

30. The South Dunedin Natural Hazards Qualitative Risk Assessment[11] ('the risk assessment'), focuses on the most significant hazards for South Dunedin, which are: flooding from large pluvial (rainfall) events, shallow and emergent groundwater, coastal inundation, and coastal

[7] Kia Rōpine (2025). South Dunedin Future Risk Assessment Report. https://www.dunedin.govt.nz/__data/assets/pdf_file/0007/1124179/south-dunedin-risk-assessment.pdf
[8] Kia Rōpine (2025) p. 12.
[9] Aukaha (2025) South Dunedin Future Mana Whenua Risk Assessment Report, p. 3.
[10] Ibid, p. 24.
[11] Van Woerden, T. (2026). South Dunedin Natural Hazards Qualitative Risk Assessment. Otago Regional Council.

erosion. Each of these hazards is defined as a coastal hazard in the South Dunedin context: groundwater because it is directly influenced by sea level changes; and pluvial flooding because it is influenced by both future groundwater and sea level conditions.

31. The risk assessment relies on the modelling of rain-induced flooding, groundwater levels and coastal inundation undertaken for the SDF project, and has the same focus area. The assessment also discusses subsequent coastal erosion studies of the St Clair-St Kilda coastline. The risk assessment presents a baseline risk assessment of coastal hazards in South Dunedin prior to any mitigation that may be implemented through future adaptation plans and processes. Risk is considered until 2100, consistent with the expected economic life of a building (75-80 years[12]).

32. The risk assessment considers the likelihood of different natural hazards at the present day, mid-term (2060-70) and long term (2100), and examines the consequences of these events on buildings, roads and health and safety.

33. As required by the NPS-NH, risk level is determined using the likelihood x consequences risk matrix shown in Figure 2. For risk to roads, which are not covered by the NPS-NH, the pORPS risk matrix is used. In addition, the health and safety risk assessment is supplemented by a discussion of effects on broader mental and physical wellbeing (as provided for by the pORPS) to build up a more comprehensive picture of potential impacts on individuals and the community.

		Likelihood						
	Descriptor	**Almost Certain**	**Very Likely**	**Likely**	**Possible**	**Unlikely**	**Rare**	**Very Rare**
	ARI (years)	Up to 10	10-20	20-50	50-100	100-500	500-5000	> 5000
	AEP	10% or more	10% to 5%	5% to 2%	2% to 1%	1% to 0.2%	0.2% to 0.02%	< 0.02%
Consequence level	**Catastrophic**	Very High	Very High	Very High	High	Medium	Medium	Medium
	Major	Very High	Very High	High	High	Medium	Medium	Medium
	Moderate	High	High	High	Medium	Medium	Low	Low
	Minor	Medium	Medium	Medium	Medium	Low	Low	Low
	Negligible	Low	Low	Low	Low	Low	Low	Low

Note: The top end of the likelihood range includes the top end year, that is: Likely = over 20 years and up to and including 50 years.

Figure 2 NPS-NH risk matrix

34. The following sections present an overview of the coastal hazards affecting South Dunedin, including a discussion of their impacts and what this means for risk to people and property. Two emissions scenarios are considered. Where the risk assessment differs significantly

[12]Ministry of Business, Innovation and Employment (2023). Natural Hazard Provisions Guidance on complying with Sections 71 to 74 of the Building Act 2004, p.21: https://www.building.govt.nz/assets/Uploads/projects-and-consents/Planning-a-successful-build/Scope-and-design/natural-hazard-provisions-guidance.pdf

between them, this is identified below. For a more detailed breakdown of the methodology and hazard specific results, refer to the risk assessment.

3.2 Risk from coastal hazards

35. It is anticipated that the risk from a combination of coastal hazards will increase in extent and severity over the coming decades. By 2100, the risk assessment shows that most of South Dunedin will be exposed to significant (high or medium) risk, due to the combined impact of rainfall-induced flooding, rising groundwater and coastal inundation. A further potential source of risk arises from coastal erosion, and the risk of dune breach along the St Clair- St Kilda coastline and incursion of sea water into South Dunedin. These risks are discussed individually below.

3.2.1 Pluvial flooding

36. Flooding caused by large rainfall events is currently the most significant hazard facing South Dunedin. Based on modelled flood inundation depths and an assessment of consequences, there are currently widespread areas of medium risk from rainfall, which increase in extent over the medium to long term. In the affected areas, large (one in 100 year) storm events would be associated with 'moderate' damage to the buildings. This includes non-structural damage such as to wall linings, floor coverings and insulation resulting from flood waters reaching above floor levels.

37. The risk of flooding from rainfall on new residential and communal buildings is reduced substantially by the higher minimum floor levels (MFL) required under the Building Code. Buildings built above the level of flooding are assessed as being at low risk; however, the property in general and other assets, such as sheds, garages and gardens may still be at risk. In addition, it is not known if MFLs are sufficient to protect against more extreme flooding events or the effects of concurrent hazards such as elevated groundwater[13]. Extreme events are likely to be more frequent and intense in future due to climate change. Therefore, the current minimum floor levels may not be sufficient to lower the risk for buildings to an acceptable level over their lifetime.

38. The current risk to health and safety from pluvial flooding in terms of injury and fatalities is assessed under the NPS-NH as being medium in scattered areas of South Dunedin, with these areas gradually increasing in extent over the medium to long term. However, the pOPRS provides for a more nuanced assessment of health and safety risk that considers impacts on individual and community wellbeing. The risk assessment more fully explores the range of other potential health and safety consequences that may occur, based on information about previous flood events and research on climate adaptation and social wellbeing in South Dunedin[14].

39. As with the impact on buildings, some of the potential health and safety impacts will be largely mitigated by the MFL for new buildings. However, flooding may still expose people to floodwaters carrying contaminants such as chemicals or sewage, or put health at risk through road closures, disrupting access to emergency or routine healthcare for people who are already unwell. The potential mental health impacts described in the risk assessment

[13] van Woerden, 2026, p. 26
[14] Harrison et al (2022), cited in van Woerden (2026), p. 30

include negative impacts from property damage, financial stress from repeated flood exposure or inability to sell the property, as well as psychological distress from the anticipation of flooding. At a community scale, South Dunedin has a high level of social vulnerability because of underlying inequities including low incomes and mobility issues, and negative effects from natural hazards will be experienced disproportionately by those that are already vulnerable.[15]

40. Because the NPS-NH does not apply to infrastructure, a specific assessment was not carried out for this. Instead, the risk assessment draws on the South Dunedin Future Risk Assessment, noting that stormwater and wastewater pump stations and electrical substations may be at risk of failure from pluvial inundation, which would in turn worsen the impact of floods on residents and the environment.[16]

3.2.2 Groundwater

41. Groundwater may start to cause impacts on buildings when it is less than half a metre below ground level, as it can affect foundations and potentially result in dampness and respiratory issues. Once emergent, it can cause major structural damage to buildings, and damp and mould and may make houses uninhabitable over the long term[17]. This can also cause respiratory and other health issues. Shallow groundwater "limits the unsaturated ground available to store rain and runoff", contributing to pluvial and other flooding events[18]

42. There are isolated areas across South Dunedin where there is currently a high risk to buildings that results from shallow groundwater sitting half a metre or less below ground level. The spatial extent of shallow or emergent groundwater is predicted to increase significantly in the future due to sea level rise and climate change. Without measures being put in place to mitigate the risk, much of South Dunedin will be at high or (under the higher emissions scenario) very high risk from shallow or emergent groundwater by the end of the century.

43. For roading, damage may occur well before groundwater is emergent, and risk to roads is likely to be significant across a large part of South Dunedin by 2100. Damage to roads may also affect access to properties and the functionality of dwellings, as well as overall community wellbeing[19].

3.2.3 Coastal inundation

44. The risk assessment shows that by 2100 there will be widespread areas at medium risk from coastal inundation. Under the higher emissions scenario, there are also scattered areas at high risk. The flood hazard would occur from water overtopping Portsmouth Drive and flowing into South Dunedin in a one in 100-year storm surge event.

45. While MFLs required under the Building Code may provide some protection from shallow coastal inundation, they are not designed specifically to mitigate this hazard. Late century

[15] Harrison et al (2022), cited in van Woerden (2026), p. 31
[16] For further information, Kia Rōpine (2025) includes detailed assessments of risk of flooding on stormwater, wastewater and contaminated land (HAIL sites).
[17] van Woerden (2026), p. 40
[18] Cox et al (2023) Dunedin groundwater monitoring, spatial observations and forecast conditions under sea level rise. p. v.
[19] van Woerden (2026) p. 46

modelling of coastal inundation indicates depths that would greatly exceed MFLs designed for pluvial flooding. As described in the discussion of pluvial flood risk, flooding above floor level causes non-structural damage to houses. This can lead to temporary loss of use, displacement of residents, and create cold and damp conditions promoting mould growth, potentially leading to health issues. At depths of >2 metres buildings may be susceptible to structural damages.

46. Substantial areas of deep ponding could pose a direct health and safety impact, especially for vulnerable members of the community, as well as having other physical and mental wellbeing impacts, as described in the discussion of pluvial flood risk[20].

47. It should be noted that due to limitations with modelling, the inundation potential, and therefore the risk, may be over or under-estimated. Further investigation is required to have a higher degree of confidence about inundation extent and/or depths.[21]

3.2.4 Coastal erosion

48. The risk assessment does not classify the risk level for coastal erosion. However, the South Dunedin Future Risk Assessment identified building and roading assets in the vicinity of the coastal margin as being highly or extremely sensitive to coastal erosion. The risk assessment notes that there may be ‘moderate’ to ‘major’ consequences to land and buildings in directly exposed areas, although these areas are expected to be very localised. In addition, erosion at the closed Kettle Park Landfill may result in contaminated material entering the environment[22].

49. The risk assessment also discusses a potential cascading impact from coastal erosion where the eroded dune system along the St Clair-St Kilda coastline allows for the incursion of seawater into South Dunedin. Subsequent to the SDF risk assessment, modelling of overtopping scenarios at different timeframes has been undertaken[23], indicating that overtopping may occur beyond 2034, with the longest term scenario (2074) showing the resulting inundation extending up to 1.5km inland around Forbury Park. This would add to the coastal inundation hazard described earlier. The risk assessment also notes that the modelling may underestimate the likelihood or consequences of flooding from overtopping[24].

3.3 Summary of risk assessment

50. The risk assessment shows that at the present time there are localised areas of significant risk for both rainfall and groundwater hazards, with a trend of increasing risk over time. By 2100, without implementation of any additional hazard mitigations, much of South Dunedin will be exposed to significant risk due to rainfall, groundwater and coastal inundation hazards. Permanent changes to sea and groundwater levels will have chronic impacts and also exacerbate the severity of event-based storm hazards.[25]

[20] van Woerden (2026) p. 38
[21] ibid p. 33
[22] Ibid p. 47
[23] T&T, Bagg and Beetham, 2025
[24] van Woerden (2026) p. 47
[25] ibid p. 49

51. While the risk in the short term from rain-induced flooding to new houses and communal buildings is reduced through the use of minimum floor levels, the compounding risks of groundwater and coastal inundation, and their social, economic and environment impacts, point to an overall significant coastal hazard risk for low lying South Dunedin over the medium to long term.

4 Climate adaptation planning for South Dunedin and relevance to risk assessment

52. As described above, based on current risk levels (i.e. without further mitigation) much of South Dunedin will be subject to significant risk from a combination of coastal hazards by 2100. Mitigation and adaptation options are currently being considered through the South Dunedin Future programme[26].

53. This programme has been developing adaptation futures for South Dunedin to assist public and decision makers to understand potential choices and changes that may be needed to adapt to the changing climate. Following community engagement, a preferred future and climate adaptation masterplan for South Dunedin will be developed. Implementation could commence from 1 July 2027, subject to Council approval of workplans and budgets as part of the Long-Term Plan (2027-36) process.

54. All shortlisted adaptation futures involve a mix of infrastructure investment and land use change, with the nature and extent of those actions across South Dunedin varying between the three options. Under the adaptation futures, land use change may be required to enable public works such as new or upgraded infrastructure, raising of land, or creation of parks, wetlands and waterways to reduce flood risk. In areas where land use change may be required in the medium to long term, new development has the potential to make future adaptation works more difficult or more costly to implement. In other areas, adaptation measures may reduce long-term hazard risk to a level where new development would be more acceptable.

55. However, as the final preferred option is not yet known, and funding is not confirmed, the future (mitigated) risk level in any part of South Dunedin is not known. Therefore, this plan review has been undertaken on the basis of the existing environment, without considering any future mitigation.

56. Once a preferred future is chosen, and mitigation measures have been implemented, the risk environment will change. Further work will then be required to determine the appropriate planning response within this new context.

[26] https://www.dunedin.govt.nz/council/council-projects/south-dunedin-future

5 Evaluation of plan provisions for hazards in South Dunedin

5.1 Is the hazard overlay appropriate?

57. As set out in Section 2 above, the current 2GP Hazard 3 (coastal) overlay indicates that there is a 'low' risk from coastal inundation, arising from storm surge events, in South Dunedin. However, as outlined in Section 3, with the additional information that has become available since decisions on 2GP provisions were made, a more up-to-date and accurate picture of coastal hazard risk in the short, medium and long term has been developed. The risk assessment shows that risk to buildings and land from some hazards is already classified as significant in parts of South Dunedin, with the areas subject to medium or high risk becoming more widespread over the coming decades. By 2100, it is predicted that most of South Dunedin will be exposed to significant risk from the combined impact of pluvial flooding, rising groundwater and coastal inundation. In addition, the Mana Whenua Risk Assessment also found that risk to mana whenua values, and to the wider community when viewed through a Kāi Tahu lens, is significant.

58. In summary, the current 'low risk' classification used in the 2GP does not reflect the most recent information and is therefore no longer appropriate.

5.2 Is the relocatable buildings performance standard effective?

59. As outlined in Section 2, the current approach in the 2GP relies on relocatable building requirements for residential activities, allowing buildings to be easily relocated if managed retreat becomes a necessity over time, and so enabling communities to respond to the effects of climate change. This provision also signals that parts of the community may not have long-term viability due to increasing natural hazards risk.

60. However, in practice the relocatable building standard has not operated as intended, as the definition does not outline a clear test or measure of the practicality or cost effectiveness of relocation. In particular, there are different views on what "*safely deconstructed into parts (if required), lifted, and transported off site, by crane and truck…either in one piece, or a limited number of pieces*" means in practice. As a result, a very open interpretation has been taken and any building, no matter how challenging or expensive to deconstruct and relocate, has been treated as relocatable if claimed to be so.

61. Some buildings that are relocatable in theory may be cost prohibitive to relocate in practice. For example, house-moving companies advise that moving a house in two parts is over twice as expensive as moving it in a single shift. There are also increased costs associated with preparing some houses for relocation, such as removing brick cladding or detaching a house from a concrete slab.

62. A further concern is that the standard only applies to buildings with residential activity on the ground floor. New buildings for other land uses, or those with residential activity only on upper floors, are equally subject to hazard risk (noting that the risk to people may vary depending on the use). In addition, all buildings could potentially hinder the implementation of future adaptation options, depending on their location.

63. Consequently, the current performance standard is not effectively managing future risk to housing.

5.3 Are the current rules for intensification in South Dunedin appropriate in terms of risk?

64. Intensification allows more people to live in the area and be subject to risk from natural hazards. Much of the South Dunedin residential area is zoned General Residential 2 (GR2), which allows for a higher density of housing than the General Residential 1 zone. The 2GP provides for intensification in the GR2 zone as a permitted activity for duplexes (subject to performance standards), and as a restricted discretionary activity for multi-unit development (three or more residential units on a single site). For multi-unit development, matters of discretion are focused on effects on streetscape amenity and character, and infrastructure provision (not hazard risk).

65. Hazard risk must be managed under the NPS-NH, which requires that local authorities take a proportionate risk-based approach for significant risk. Currently, hazard risk is not addressed under the 2GP provisions. Consequently, the current plan provisions are not effectively managing natural hazard risk for intensification in South Dunedin.

5.4 Section 106 and 106A of the Resource Management Act

66. Section 106A of the RMA, which was introduced in 2025, provides for councils to refuse, or place conditions on, land use consents where there is a significant risk. This provision applies where a resource consent is required for a land use activity. An equivalent provision, section 106, allows subdivision to be managed in the same way. In the Dunedin context, this allows consideration of hazard risk for all subdivision, multi-unit development, and any residential development that requires resource consent due to a breach of a performance standard. Sections 106 and 106A do not apply to permitted activities, for example single dwellings, detached minor residential units or duplexes that meet the relevant performance standards.

67. These provisions therefore allow some management of hazard risk through the resource consent process. However, there is less certainty for applicants and consents processing staff than would be the case if the 2GP contained an appropriate suite of hazard risk management provisions.

5.5 What management approach may be more appropriate for South Dunedin?

68. There are a range of options for changing how subdivision and development may be managed under the district plan, some of which are outlined below. Options could vary spatially, depending on the risk level and the adaptation actions that may be required in that area.

69. A ‘do minimum’ option would be to make minor changes to the relocatable buildings performance standard to ensure that the relocation of residential buildings would be

practical and economically feasible. Further, adding guidance on when resource consent should be granted for non-relocatable buildings would also improve effectiveness.

70. A further option could involve extending the relocatable buildings standard requirement to other building types (for example buildings with residential activity on upper floors only, and/or to community buildings). Any new buildings that do not meet the relocatable building standard would be a non-complying activity.

71. A more substantive change would be to limit subdivision and density of new buildings in South Dunedin, for example to one dwelling per 300m^2 site area (rather than the current habitable rooms density standard of one habitable room per 60m^2 site area). This is likely to discourage multi-unit development and result in fewer new dwellings. Detached minor residential units (granny flats / ancillary residential units) could still be permitted.

72. The most stringent option would be to make all subdivision that creates new sites, and all development that increases the number of dwellings (including detached minor residential units), a non-complying activity. Additions to a dwelling that increase the number of habitable rooms could also be made non-complying, while replacement buildings of the same size would be permitted.

73. Further assessment and community engagement is required to determine the most appropriate option or options.

6 Conclusion

74. This report has considered whether the current 2GP provisions are appropriate in light of updated hazards information for South Dunedin, and in the context of new regional and national direction on natural hazards.

75. Overall, it is considered that the 2GP provisions for managing the risk of natural hazards in South Dunedin are no longer fit for purpose and do not give effect to 2GP Objective 11.2.1, or the objectives of the NPS-NH or pORPS because:

- The current ‘low’ Hazard 3 overlay does not reflect the assessed risk.
- The relocatable building standard is not effective at ensuring that buildings can be cost-effectively relocated if areas need to be retreated from, and does not apply to all buildings.
- The 2GP provisions for South Dunedin provide for intensification, putting more landowners at risk, and there is a lack of guidance in the 2GP to help apply s106A of the RMA.

76. These findings support changing how natural hazard risk in South Dunedin is managed under the planning framework. The Government has set out clear direction that development in areas of significant (high or medium) natural hazard risk must be managed, either through avoiding activities in areas of highest risk, or through mitigation that is proportionate to the level of risk.

77. Although it is likely that future risk can be reduced through climate adaptation measures, there is currently uncertainty about the location, timing and availability of funding of interventions and the extent of any residual risks that would remain.

78. In the short term, natural hazard risk can be managed to an extent through existing building consent and resource management consent processes. However, changes to planning provisions will be needed to fully manage risk in the medium to long term, and to do so in a more efficient manner.

79. Further investigation of potential options together with community engagement is required to determine the best approach for amended planning provisions. This could be implemented either through changes to the 2GP or through the new land use plan under the Planning Act.

Appendix 1

Applying the NPS-NH risk framework – South Dunedin Natural Hazards Risk Assessment

Otago Regional Council

Applying the NPS-NH risk framework

South Dunedin Natural Hazards Qualitative Risk Assessment

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Contents

Executive Summary

Introduction

The South Dunedin suburbs are exposed to a range of natural hazards, some of which have had notable impacts in past events, and are expected to pose a significant future challenge to the South Dunedin community. This report classifies and maps levels of natural hazard risk in South Dunedin for different elements at risk, for both the present-day and future timeframes, primarily using the National Policy Statement for Natural Hazards (NPS-NH) risk framework.

The objective of the risk analysis reported is assess the significance of natural hazard risk for South Dunedin, to inform the need for a natural hazards-focused plan change. This report builds on and complements the risk assessment report completed by Kia Rōpine for the South Dunedin Future (SDF) work programme (Cowper-Heays, 2025), providing an overview of risks for selected hazard types and scenarios, sufficient to provide information on the 'significance' of natural hazard risks for South Dunedin.

Scope

Natural hazard risk in South Dunedin is qualitatively assessed and mapped for pluvial inundation, coastal inundation, and groundwater hazards. Coastal erosion hazard is discussed, but risk levels for this hazard are not assessed as the projected future shoreline positions do not have an associated likelihood.

As an initial screening, assessments are limited to a single likelihood scenario for each hazard type, for present-day, mid-century (2060-2070) and late-century (2100) timeframes. Consequences are assessed for property (buildings) and health and safety, through definition of vulnerability relationships which relate hazard characteristics (e.g. inundation depth) to a consequence criteria. Risks to lifelines infrastructure are assessed only by identifying those assets most vulnerable impact from each natural hazard type.

The risk assessment is intended to support decision making for a specific, high-level purpose (in this case, potential plan changes within the 2GP); it is not intended to provide a detailed property-level assessment of risk.

Summary of risk assessment findings

For the present day, assessments show localised areas of *Significant* (i.e., *medium*, *high*, or *very high*) risks for pluvial inundation and groundwater hazards. Although there is uncertainty in the timing of changes, there is a clear overall trend of increasing risk levels through time, with much larger extents identified as being exposed to *Significant* risk due to pluvial inundation, coastal inundation, and groundwater hazards by mid- and end-century timeframes. The only hazard identified as '*very high*' risk in this assessment is for areas of emergent groundwater, which becomes a widespread impact only in late-century timeframes.

This analysis has considered each natural hazard type and element-at-risk individually, however, these multiple natural hazard threats coexist with South Dunedin, and when considered collectively, the overall cumulative risk level from the multi-hazard landscape will be higher.

The natural hazard risks in South Dunedin are assessed for a 'status quo' scenario with no new hazard mitigation interventions in place, and there is too much uncertainty to account for any potential mitigations being developed through the SDF work programme within this risk assessment at this stage. However, we note that progression towards those mitigation approaches is relatively well advanced, and if implemented, would act to reduce potential event consequences and therefore risk levels.

Pluvial inundation

There is widespread *medium* risk for existing buildings in a present-day 100-year ARI pluvial inundation scenario, with the extent of higher risk increasing in scenarios for future timeframes. For locations which experience inundation causing a 'moderate' consequence in more frequent events of 50-year ARI or less, then risk level would be classified as *high,* but this event has not been assessed in the current analysis.

The application of minimum floor levels means that the potential consequence to new buildings from pluvial flooding will be substantially reduced. Properties with an elevated floor level may still experience some disruptive impacts resulting from pluvial inundation events however, for example flooding of garages, sheds or gardens, as well as indirect effects such as road closures.

Health and safety risks from pluvial inundation for a 100-year ARI event are *low* or *medium,* but could be classed as *high* for locations of more frequent flooding impact. Consequences of pluvial inundation are not limited to direct, physical impacts of pluvial flooding (i.e., potential drowning hazard), but may also include indirect health and wellbeing consequences, which would be exacerbated by known community vulnerabilities.

The lifelines infrastructure assets most sensitive to damages from floodwater inundation are electrical substations, pump stations, and the wastewater network.

Coastal inundation

Coastal inundation of South Dunedin occurs via inundation from the Otago Harbour once sea level rise drives storm surge to overtop the reclaimed land along the Otago Harbour backshore, this occurs with approximately 0.6 m relative sea level rise (RSLR) in the 1% AEP event. Eventually, a direct overland connection between the coast and inland South Dunedin occurs with 1.5 m RSLR, after which point the South Dunedin area may become permanently tidal or inundated if flood water is not prevented from entering, or being drained or pumped out. Coastal inundation in South Dunedin is also possible due to an overtopping of the St. Kilda–St. Clair dune system, if erosion was to impact the effectiveness of the protection provided by this natural buffer.

For present-day and mid-century timeframes, exposure to coastal inundation is limited to small areas of *medium* risk to buildings alongside Portsmouth Drive. For late-century timeframes, there are widespread areas of *medium* risk in South Dunedin, and in the high-end (SSP8.5) scenario this includes broad areas of scattered *high* risk. Late-century scenarios show substantial areas of deep ponding (>1.2 m) within the South Dunedin area. This hazard may, therefore, pose a direct health and safety risk, especially to children and the elderly.

Groundwater hazard

South Dunedin has relatively shallow groundwater levels, and these are expected to gradually (but permanently) increase with the influence of a rising sea level. Shallow groundwater begins to have adverse impacts even before groundwater levels reach the surface to become emergent, and may cause a wide range of chronic impacts to health, buildings, and infrastructure. Without interventions to manage groundwater levels, most of South Dunedin will become persistently waterlogged and effectively uninhabitable.

Risks to land and buildings due to groundwater are interpreted as *high* or *very high* risk for locations in South Dunedin where groundwater is shallow (<0.5 mbgl) or emergent. For the present-day, these areas of higher risk are only scattered, but become very widespread by mid-century timeframes.

Health and safety consequences for shallow groundwater hazards are closely related to those for buildings, as when groundwater rises to within 0.5 m of the ground surface, it can lead to rising damp and wet floors and fittings, which then begins to impact people's health through dampness and mould issues.

The lifelines infrastructure assets most sensitive to damages from shallow groundwater levels are roads

Coastal erosion

Exposure to direct coastal erosion impacts is limited to locations adjacent to the St. Kilda-St. Clair coastline. Buildings and roading assets are highly sensitive to coastal erosion damages, and direct impact may result in 'moderate' or 'major' consequences to land and buildings, but the areas exposed to potential impacts are very localised. A potential cascading impact following extensive coastal erosion would be the eroded dune system providing ineffective protection and, therefore, allowing for coastal inundation into the South Dunedin plain from the St. Clair–St. Kilda coastline.

1. Introduction

1.1. Background

The South Dunedin suburbs are exposed to a range of natural hazards, of which some have had notable impacts in past events (e.g. pluvial flooding in 2015 and 2024), and some of these hazard impacts are expected to increase in frequency and/or severity with the effects of climate change (e.g., groundwater and coastal inundation hazards).

These hazards are expected to pose a significant future challenge to the South Dunedin community, which has a population of around 13,500, and is a base for 1500 businesses. In response to this challenge, the Otago Regional Council (ORC) and the Dunedin City Council (DCC) are collaboratively working to develop a natural hazards adaptation plan through a work programme named *South Dunedin Future* (SDF)[1].

Over the last 10+ years, a substantial number of new natural hazards investigations have been completed, greatly advancing the understanding of the South Dunedin hazardscape, including for pluvial and coastal inundation, groundwater characteristics, coastal erosion, and seismic hazards (listed in Appendix A). In early 2025, the available natural hazards information was drawn together in a comprehensive natural hazards risk assessment by Kia Rōpine for the SDF work programme (Cowper-Heays, 2025), referred to in this report as the 'SDF risk assessment'. The risk assessment was completed with the aim of outlining the 'case for change' and to inform spatial adaptation planning for South Dunedin. Since completion of the SDF risk assessment in early 2025, additional natural hazards information is now available, including assessment of long-term coastal evolution at the St. Clair to St. Kilda dune system (Atkin and Conroy, 2025), and modelling of coastal inundation impacts at this future eroded coastline (Bagg and Beetham, 2025).

1.2. Second Generation District Plan (2GP)

Land-use planning for the Dunedin City district is controlled by the Second Generation Dunedin City District Plan (2GP). The last full review of the district plan commenced in 2012. The 2GP was notified in September 2015 and was made partially operative in August 2024. Currently, the South Dunedin area is subject to the *Hazard 3 (coastal) overlay zone* under the 2GP, which indicates a low risk to property (Policy 2.2.1.4 and Table 11.1.4A of the 2GP).

[1] South Dunedin Future

In this zone, new buildings containing residential activity on the ground floor must be relocatable[2] (Policy 11.3.3). The plan does not currently include consideration of the updated natural hazards information generated for the South Dunedin Future work programme since the plan review commenced.

In addition to the new information generated for the SDF programme, a new National Policy Statement for Natural Hazards (NPS-NH) and the Otago Regional Policy Statement (pORPS) have now been notified.

The National Policy Statement for Natural Hazards (NPS-NH, MfE 2025) was notified in December 2025 and came into effect on 15 January 2026. The NPS provides high-level national direction on managing natural hazard risk, intended to "set out a balanced way for councils to manage natural hazard risks in new developments, based on the level of risk involved". The NPS includes a methodology for natural hazard risk assessment, and for definition of 'significant' natural hazard risk. The NPS-NH overrides the pORPS in relation to the hazards and activities it applies to, with some key limitations, for example, the NPS-NH does not apply to natural hazard risk to existing development or to infrastructure.

ORC notified a new Regional Policy Statement (proposed Otago Regional Policy Statement 2021, pORPS) in June 2021. An Environment Court order has been issued for the natural hazards chapter of the pORPS, and it is, therefore, beyond legal challenge and can be considered operative. The pORPS also introduces a methodology for natural hazard risk assessment (APP6) that defines how natural hazard risk is determined. District Plans need to give effect to an operative RPS and have regard to a proposed RPS when setting objectives, policies, methods, and rules for managing activities and resources. However, for policies relating to new development, the pORPS is overridden by the NPS-NH, which is a higher order planning document. If councils already have policies in place that are more stringent than the NPS-NH, these should be followed.

With the NPS-NH, pORPS, and the latest information available about the exposure and impacts of natural hazards on South Dunedin, DCC is evaluating whether the 2GP is managing the risk in South Dunedin appropriately, including whether it gives effect to the NPS-NH and pORPS. The evaluation will investigate the appropriateness of the current hazard overlay zone and related provisions for managing risk for new activities. For this purpose, the ORC Natural Hazards Team is supporting DCC in the interpretation of the updated natural hazard information and risk assessment described above.

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[2] Where 'relocatable' means a building that is designed and constructed to be able to be either:

- portable (designed to fit in one piece on a truck) or has wheels and can be towed; or
- safely deconstructed into parts (if required), lifted, and transported off site, by crane and truck. This includes buildings that can be transported either in one piece, or a limited number of pieces.

1.3. SDF risk assessment (Cowper-Heays, 2025)[3]

The SDF risk assessment provides a comprehensive review of natural hazard risks in South Dunedin. The study considers the main natural hazard types present, timeframes from present-day to late-century (2100), and a wide range of asset types (Table 1.1).

The assessment was aligned with the principles of the approach described in the pORPS, i.e., a qualitative risk assessment based on consideration of event likelihood and consequences. The pORPS risk assessment approach is designed to be applied over broad areas, and the approach used by Kia Rōpine was tailored to meet the needs of the South Dunedin Future programme, with adjustment of the methodology to better provide asset-specific risk information. Although the SDF risk assessment aligned with the pORPS risk assessment approach, each approach used a different description of the risk levels, and an interpretation is needed to transfer the SDF risk assessment into the pORPS methodology, i.e., to place the information of the more detailed SDF risk assessment results within the broader risk assessment framework of the pORPS.

The SDF risk assessment results for each combination of hazard type, asset, and timeframe are presented in tabular form and graphically, with asset-scale risk scores aggregated to larger spatial extents.

Table 1.1: Natural hazard types, timeframes, and assets considered by the SDF risk assessment completed by Kia Rōpine (Cowper-Heays 2025).

Natural hazard	Timeframes	Assets
- Pluvial flooding - Coastal inundation (includes sea level rise) - Groundwater - Coastal erosion - Landslide - Liquefaction	- Present-day - Mid-century - Late-century	- Buildings - Parks and sports fields - Ecological areas - Roads and associated infrastructure - Rail infrastructure - Water supply infrastructure - Wastewater infrastructure - Stormwater infrastructure - Contaminated land - Telecommunication infrastructure - Energy infrastructure

1.4. Purpose of this report

This report builds on and complements the SDF risk assessment report and is intended to consider the natural hazard risk in South Dunedin under both the NPS-NH and pORPS

[3] Kia Rōpine is a consortium of WSP New Zealand Limited (WSP), Beca Limited (Beca) and Tonkin + Taylor Limited (T+T).

frameworks to support DCC in determining whether the current plan is fit for purpose. It does this by classifying and mapping levels of natural hazard risk in South Dunedin for different elements at risk such as buildings, and health and safety, for both the present-day and future timeframes.

This current report is not a reassessment or an extensive assessment across all natural hazard risks, as this has been already detailed in the recent SDF risk assessment. Instead, this document relies heavily on the SDF risk assessment to provide an overview of risks for selected hazard types and scenarios, sufficient to provide information on the significance of natural hazard risks for South Dunedin when assessed within the NPS-NH and pORPS frameworks.

1.5. Study extents

The geographic extent for the current assessments is the same as the focus area for the South Dunedin Future adaptation programme and the SDF risk assessment by Kia Rōpine (Cowper-Heays, 2025), an area including the South Dunedin, St. Kilda North and St. Kilda South, and parts of St. Clair, Caversham, Tainui, and Musselburgh (Figure 1.1).

1.6. Scope

The scope of this assessment is to use existing information to qualitatively interpret natural hazard risk in South Dunedin, applying the risk framework presented in the NPS-NH. The natural hazards, timeframes, and types of consequences considered by this assessment are listed in Table 1.2. The NPS-NH does not apply to infrastructure, so consequences for lifelines infrastructure are not assessed using the NPS-NH framework, but key points regarding infrastructure vulnerabilities are described.

The remainder of this report is structured in the following key sections;

- Section 2 identifies the natural hazards considered in this assessment.
- Section 3 describes the risk assessment frameworks used.
- Section 4 discusses the key limitations in this risk analysis.
- Section 5 describes the datasets used to support analysis.
- Sections 6–9 present risk analysis and associated commentary for pluvial inundation, coastal inundation, groundwater hazard, and coastal erosion.
- Section 10 summarises the key conclusions and provides discussion on topics including hazard mitigation, cascading risks, risk tolerance, and possible further analysis.

Table 1.2: Natural hazard types, timeframes, and assets considered by this current risk assessment completed by ORC.

Natural hazard	Timeframes	Consequences
- Pluvial flooding - Coastal inundation (includes sea level rise) - Groundwater - Coastal erosion	- Present-day - Mid-century - Late-century	- Injuries and fatalities - Buildings - Lifelines infrastructure

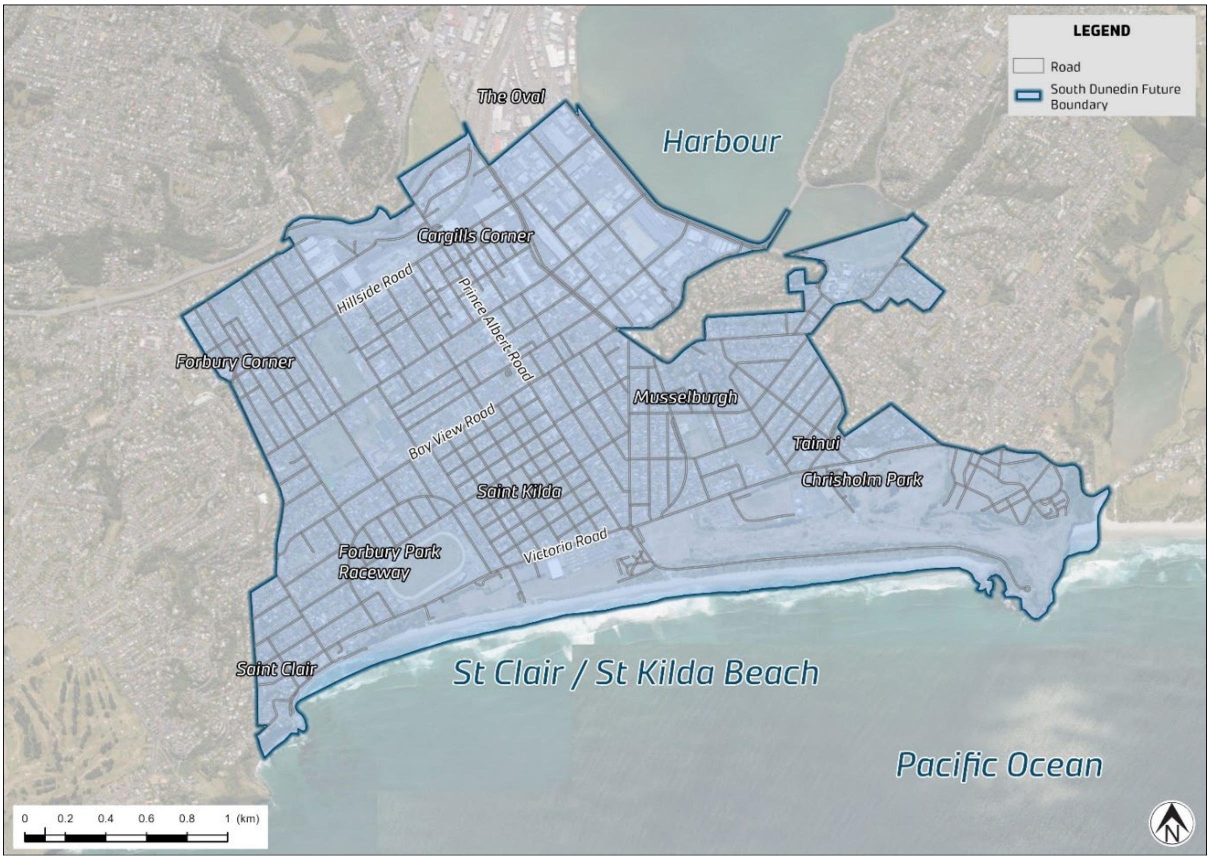


Figure 1.1: Spatial extent for both this risk assessment and those by Kia Rōpine, 2025.

2. Natural hazards identification

The South Dunedin study area is potentially exposed to a range of natural hazards, including (ORC 2016; Cowper-Heays 2025):

- Pluvial inundation;
- Coastal inundation;
- Groundwater;
- Coastal erosion;
- Landslide;
- Liquefaction;
- Tsunami.

This current risk assessment considers pluvial inundation, coastal inundation, groundwater, and coastal erosion hazards. Landslide, liquefaction, and tsunami hazards are not considered for the following reasons:

> Landslides may occur only on the hillslopes around the margins of the study area, but not within the South Dunedin coastal plain. Landslide hazards were identified as relatively low risk by the SDF risk assessment (2025), and land-use planning responses are already covered by aspects of the 2GP.
>
> Liquefaction risks were identified as relatively low risk for all assets except wastewater infrastructure by the SDF risk assessment (2025), and there is currently insufficient spatial resolution to map variations in liquefaction susceptibility across South Dunedin.
>
> Tsunami hazards were not considered in the SDF (2025) risk assessment, as the modelled 1% annual exceedance probability (AEP) tsunami extent is less extensive than that for the 1% AEP coastal inundation event. This hazard is also not considered here for the same reason.

3. Risk assessment process

The NPS-NH is the primary risk assessment framework used in this assessment, as the NPS-NH policies are those which must be applied to risk assessments for new development. However, infrastructure is specifically excluded from the NPS-NH, so, if needed, risks to lifelines infrastructure may be assessed using the pORPS framework.

The NPS-NH and pORPS risk policies and assessment frameworks are briefly described in the sections below, with further details provided in Appendices C and D. Appendix E provides a comparison of the risk frameworks in order to review the similarities and differences between these two approaches.

3.1. National Policy Statement for Natural Hazards (NPS-NH)

The National Policy Statement for Natural Hazards (NPS-NH) was notified in December 2025 and came into force on 15 January 2026. The NPS provides direction under the RMA for managing natural hazard risk associated with subdivision, use, and development, and must be applied to hazards including flooding, coastal inundation, and coastal erosion.

Appendix D presents the qualitative risk assessment framework of the NPS-NH. This framework uses classification tables for likelihood and consequences, and a risk matrix to assign risk levels based on the determined likelihood and consequence (Table 3.2). Consequences are assessed for damage to property (land and buildings) and the potential for injury or fatalities. The NPS-NH does not apply to infrastructure, so impacts on lifelines utilities are not considered. When classified using this matrix, ‘significant’ natural hazard risk means natural hazard risk assessed as ‘medium’, ‘high’, or ‘very high’.

The policies of the NPS-NH are listed in Table 3.1. The implementation section of the NPS-NH details requirements for hazard risk management depending on risk levels (Section 3.3(2)):

> *When managing natural hazard risk associated with subdivision, use and development, decision-makers must apply mitigation measures, including location and design, for the purposes of ensuring that:*
>
> *(a) very high natural hazard risk is avoided;*
>
> *(b) high or medium natural hazard risk is avoided or mitigated proportionate to the level of risk; and*
>
> *(c) any creation of, or increase in, significant natural hazard risk on other sites is avoided or mitigated proportionate to the level of natural hazard risk.*

Assignment of an estimated risk level using the NPS-NH for a particular location, therefore, has practical implications for natural hazard management through land-use planning frameworks (e.g., zoning or consenting decisions, or a district plan change). For example, if the natural hazard risk is determined to be ‘very high’, then that natural hazard risk is to be avoided, and if ‘high’ or ‘medium’, then the natural hazard risk is to be avoided or proportionately mitigated.

Table 3.1: NPS-NH policies.

Policy 1	When considering natural hazard risk associated with subdivision, use, or development, the risk level must be assessed using the risk matrix.
Policy 2	Natural hazard risk associated with subdivision, use, and development must be managed using an approach that is proportionate to the level of natural hazard risk.
Policy 3	Where subdivision, use, or development is assessed as having very high natural hazard risk, that risk must be avoided.
Policy 4	Where subdivision, use, or development, including any associated mitigation measures, will create or increase significant natural hazard risk on other sites, that risk must be avoided or mitigated using an approach that is proportionate to the level of natural hazard risk.
Policy 5	Natural hazard risk assessment and decisions must be based on the best available information and must be made even when that information is uncertain or incomplete.
Policy 6	The potential impacts of climate change to at least 100 years into the future must be considered.

Table 3.2: NPS-NH risk matrix.

		Likelihood						
	Descriptor	**Almost Certain**	**Very Likely**	**Likely**	**Possible**	**Unlikely**	**Rare**	**Very Rare**
	ARI (years)	Up to 10	10–20	20–50	50–100	100–500	500–5000	>5000
	AEP	10% or more	10% to 5%	5% to 2%	2% to 1%	1% to 0.2%	0.2% to 0.02%	<0.02%
Consequence level	**Catastrophic**							
	Major							
	Moderate							
	Minor							
	Negligible							

Note: The top end of the likelihood range includes the top end year, that is, likely = over 20 years and up to and including 50 years.

Legend:	**Low**	**Medium**	**High**	**Very High**
		'Significant' natural hazard risk		

3.2. Proposed Otago Regional Policy Statement (pORPS) risk assessment framework

The proposed Otago Regional Policy Statement (pORPS) presents a methodology for natural hazard risk assessment in Appendix 6 (ORC, 2025). This appendix (APP6) of the pORPS outlines a two-stage process for natural hazard risk assessment: a qualitative assessment, followed by (if required) a quantitative assessment. The pORPS approach is consistent with international standards (e.g., the 'risk analysis' component of the ISO3100:2018) and has been applied elsewhere in Otago in a number of natural hazard settings.[4]

Appendix C summarises the four steps of the risk assessment process and presents the full text of the APP6 methodology.

3.3. Discussion on risk assessment frameworks

Although the NPS-NH overrides the pORPS as a higher order planning document, this does not restrict assessments of natural hazard risks to make use only of the NPS-NH framework. The NPS-NH specifically allows for use of other hazard management approaches, noting that it "*does not preclude decision-makers from managing natural hazard risk beyond the application of this National Policy Statement, including risks from other natural hazards and activities not otherwise covered, or from applying a more conservative approach to managing the natural hazard risks*".

There are several aspects where the pORPS risk assessment framework can be used to complement the NPS-NH and provide additional risk context:

The NPS-NH risk assessment approach can be applied to estimate risk levels for both existing and new buildings, but the policies of the NPS-NH are designed to apply only to new development. For decision making regarding management of existing natural hazard risk, the policies of the pORPS are applied (e.g., HAZ-NH-P4), and a risk assessment using the pORPS framework would be required. Because the purpose of this study is to assess natural hazard risks for a potential plan change with implications for new development, use of the NPS-NH is sufficient in this case.

The NPS-NH is not designed for application to infrastructure, so the pORPS can be used to assess risks to lifelines infrastructure (e.g., transport, energy, and Three Waters networks). In practice, however, assessment of consequences for these assets in South Dunedin within the pORPS risk framework is not straightforward, because these consequence criteria rely on estimation of both the duration that an asset is out of service and the proportion of a city's population that is affected by that outage, as well as consideration of vulnerability conditions including level of service, condition, material, and age. In this report, we highlight which types

[4] - Glenorchy flooding and seismic hazards. Beca Ltd for ORC, 2024.
- Clutha Delta seismic hazards. Tonkin + Taylor Ltd for ORC, 2025.
- Roxburgh Debris Flow and Debris Flood Study. WSP for ORC, 2026.
- Southern Corridor (Jack's Point area) flooding and seismic hazards. Beca Ltd for QLDC.

of lifelines are considered most vulnerable to impact from each natural hazard type, based on the assessments of asset vulnerability completed for the SDF risk assessment, but generally do not classify or map a level of risk.

Assessments of consequences to property (e.g., buildings) in the NPS-NH are defined in terms of the severity of structural damages, while the pORPS frames consequence as loss of functionality (for buildings) or impacts to service (lifelines infrastructure). This means that areas of widespread non-structural damages, such as flooding of buildings to above floor levels and requiring remediation, could be classified as a 'major' or 'catastrophic' consequence by the pORPS (>20% of buildings in the hazard impact area have their functionality compromised), but would only be a 'moderate' consequence in the NPS-NH (because damages are non-structural). An understanding of risk levels through both of these approaches can provide complementary risk information to give a broader context.

The pORPS identifies a range of additional considerations in assessment of consequences, including:

- Individual and community vulnerability and resilience;
- Impacts on individual and community health and safety;
- Impacts on social, cultural, and economic wellbeing;
- Impacts on infrastructure and property, including access and services.

In general, the NPS-NH has a broader, more inclusive definition of 'significant' risk, but it is important to note that the term 'significant' is defined differently within each risk framework:

- The pORPS framework uses the term 'significant' as one of three risk level classes (*Acceptable*, *Tolerable,* and *Significant*).
- The NPS-NH defines four risk level classes (*Low*, *Medium*, *High,* and *Very high*), and then uses the term 'significant' as a collective term for risks that are identified as medium, high, or very high risk. This NPS-NH definition of 'significant' is more expansive (i.e., it encompasses a wider range of risk levels) and would include some risks classified as *Tolerable* or even *Acceptable* by the pORPS.

Table 3.3. illustrates how risk levels for an event of comparable likelihood and consequence may be classified differently by each risk framework:

- An event of 50- to 100-year ARI with a 'major' consequence (labelled 'A' in Table 3.3) is a *Tolerable* risk in the pORPS, but a *high* (significant) risk in the NPS-NH framework.
- An event of 50- to 100-year ARI with a 'minor' consequence (labelled 'B') is an *Acceptable* risk in the pORPS, but a *medium* (significant) risk in the NPS-NH framework.
- An event of 500- to 1000-year ARI with a 'moderate' consequence (labelled 'C') is a *Tolerable* risk in the pORPS, but a *low* (not significant) risk in the NPS-NH framework.

These differences in risk level have potential real-world implications because the policies of both the NPS-NH and pORPS contain actions that are linked to risk levels, and hazard mitigation is required to be 'proportionate' to risk levels.

In this assessment, we primarily use the NPS-NH framework, but this is supplemented by reference to the pORPS, for example, where commenting on wider community wellbeing impacts.

Table 3.3: Comparison of the pOPRS (upper) and NPS-NH (lower) risk matrices, aligned to show risk levels with comparable likelihood classification, and assuming that the consequence levels are approximately aligned between the two frameworks. The extent of 'significant' risk as defined by the pORPS framework is outlined as a dashed black line in each matrix, and 'significant' risk in the NPS-NH framework as a blue dotted outline. Labelled cells (A, B, C) in each table identify events of the same likelihood and consequence, which are mentioned in the report text.

pORPS		**Likelihood**								
		<10	**10 to 20**	**20 to 50**	**50 to 100**	**100 to 500**	**500 to 1000**	**1000 to 2500**	**2500 to 5000**	**>5000**
Consequence	**Catastrophic**		***Significant risk***							
	Major				**A**					
	Moderate				***Tolerable risk***		**C**			
	Minor				**B**					
	Insignificant							***Acceptable risk***		

NPS-NH		**Likelihood**								
		<10	**10 to 20**	**20 to 50**	**50 to 100**	**100 to 500**	**500 to 1000**	**1000 to 2500**	**2500 to 5000**	**>5000**
Consequence	**Catastrophic**		***Very high risk***							
	Major			***High risk***	**A**					
	Moderate				***Medium risk***		**C**			
	Minor				**B**					
	Negligible						***Low***			

4. Limitations

As for the South Dunedin Future risk assessment by Kia Rōpine (Cowper-Heays, 2025), there are inherent limitations and sources of uncertainty regarding this assessment of natural hazard risk for South Dunedin. This current assessment makes use of the same natural hazards datasets and asset vulnerability information as the SDF risk assessment (Cowper-Heays, 2025); therefore, the limitations described in Section 2.5. of that report are also relevant to this assessment.

The key limitations for this report include the following.

- The risk assessment is intended to support decision making for a specific, high-level purpose (in this case, potential plan changes within the 2GP); it is not intended to provide a detailed property-level assessment of risk.
- This baseline risk assessment does not consider socio-economic projections or any potential new hazard mitigation measures, including possible future outcomes resulting from the South Dunedin Future adaptation work programme.
- A wide range of limitations and uncertainties are present for each of the asset classes, hazard types, and vulnerability classifications. The limitations and assumptions applied in this assessment could, therefore, lead to the under- or overestimation of risk.
- This report refers to several draft reports from in-progress assessments for the South Dunedin Future work programme (e.g., Van Nieuwkerk, 2025; Zhu and Foster, 2026). There may be changes or adjustments to the analysis or conclusions in the finalised versions of those reports.
- The natural hazard risks in South Dunedin are assessed for a 'status quo' scenario with no new hazard mitigation interventions in place, and there is too much uncertainty to account for any potential mitigations being developed through the SDF work programme within this risk assessment at this stage. However, we note that progression towards those mitigation approaches is relatively well advanced. Three potential adaptation futures for South Dunedin have been short-listed, and further evaluation of those is underway (e.g., van Nieuwkerk (2025); Zhu and Foster (2026)). This report, therefore, provides a relatively conservative view of natural hazard exposure and risk, as in the longer term it is anticipated that the risk mitigation interventions being developed through the SDF work programme will be implemented, and these interventions will reduce (but not eliminate) levels of hazard risk for South Dunedin. This assessment takes a 'broad brush' view of risks, generalised based largely on the natural hazard characteristics. A more granular view would identify variable risk levels within the same pockets of development, taking into account local-scale mitigating factors such as compliance of buildings with minimum floor level requirements.

- As a first-pass risk screening, this assessment considers only a limited number of hazard likelihood scenarios (100-year ARI for each hazard type, a ‘possible’ likelihood in the NPS-NH); however, a wider range of likelihood scenarios could be included at a later stage. In some cases, consideration of a higher-likelihood event (e.g., 20- or 50-year ARI) could result in an increased risk level classification. For example, a ‘moderate’ consequence for the 100-year ARI event is classed as a *medium* risk, but the same consequence for a 50-year ARI event is a *High* risk. We have not considered a maximum credible event (MCE) scenario in risk assessments, as this hazards data is not currently available.

5. Datasets and timeframes

The natural hazards datasets used in natural hazard risk assessments for South Dunedin are listed in Table 5.1.

Hazards modelling assessments for future scenarios are generally completed for changes in physical parameters (e.g., increments of sea level rise (SLR)) rather than for specific dates or years into the future. Ministry for the Environment guidance (MfE 2024) is then used to assign date ranges and a scenario classification (e.g., mid- or high-range) for those increments of change, as shown in Table 5.2.

These hazard modelling projects have used a variety of dates to represent “present-day” conditions, ranging from 2005 (coastal inundation) to 2024 (pluvial flooding). This means that there is a small difference (around 0.03 to 0.04 m) between the ‘present-day’ mean sea level referenced in these studies.

The timings of the sea level rise increments in Table 5.2 are in terms of relative sea level change (i.e., including vertical land movement). However, in Dunedin, the component of vertical land movement (VLM) makes only a small difference to projected future sea levels,[5] and would mean that a particular increment of sea level rise would only arrive ~5 years ‘sooner’ (Cox et al., 2023).

[5] e.g. NZ SeaRise site 4780 (St Clair beach) has an estimated VLM rate of -0.2 ± 1.8 mm (-2.0 to +1.6 mm) per year.

Table 5.1: Timeframes and likelihoods for natural hazards information.

Hazard type	Timeframes/scenarios	Likelihood	Reference
Pluvial flooding	Present day (2024) 2070 (SSP2 4.5, 8.5) 2100 (SSP2 4.5, 8.5)	1% AEP 2% AEP 10% AEP	Beca, 2024. ICMP Hydrodynamic modelling results issued specifically to meet the scenario requirements and timeframes of the South Dunedin Future Programme.
Coastal inundation	Present day (2005) 0.1 m increments of RSLR[6] to 2 m above present-day MSL	1% AEP 2% AEP 10% AEP	NIWA, 2023. Mapping New Zealand's exposure to coastal flooding and sea level rise.
Groundwater	Present day (2023) 0.1 m increments of SLR to 1 m[7]	Median MHWS p95 (95th percentile)	GNS Science (Cox et al.), 2023. Dunedin groundwater monitoring, spatial observations and forecast conditions under sea level rise.
Coastal erosion	Present day 2034, 2049, 2074		eCoast, 2025. Technical Support Services for Modelling the St. Clair to St. Kilda Coastal Plan: Baseline Modelling.

[6] Estimates of relative sea-level rise (RSLR), or sea-level rise relative to the local landmass.
[7] The calculated groundwater elevations of Cox et al (2023) do not account for possible changes in land elevation (i.e. uplift or subsidence), but this study notes that vertical land motion does not appear to be a significant influence along the Dunedin coast. The estimated timing of when various scenarios of sea level rise may be reached, does take into account relative sea level rise, using data from the NZ SeaRise project.

Table 5.2: Date ranges for increments of sea level rise (as relative sea level change, i.e., including vertical land movement).

Timeframe	Date range[1]	Increment of sea level rise (m)	
		Mid-range: SSP2–4.5	High end: SSP5–8.5
Present day	2005–2023	0	0
Mid-term	2060–2070	0.3	0.5
Long term	2100	0.6	1.1

[1] Date ranges are presented as a range to reflect differences in 'present day' timeframes used in pluvial flood modelling, groundwater, and coastal hazard assessments (2024, 2023, and 2005 sea levels, respectively).

6. Pluvial inundation hazard risk analysis

South Dunedin is prone to rainfall-induced flooding. The area has no major watercourses or natural connection to the coast, so it relies on the piping and discharge of stormwater into Otago Harbour via pump stations.

South Dunedin has experienced severe flooding on many occasions (e.g., 1923, 1929, 1960, 2015, 2018, and 2024 (Kia Rōpine, 2025), causing widespread inundation and damage to buildings within the affected areas. The flooding hazard is expected to increase in extent and severity in future, due to the interacting influences of changes to sea level, groundwater levels, and rainfall intensity.

Risk analysis for pluvial inundation is based on stormwater modelling completed by Beca Ltd. for the DCC (Beca 2024), with scenarios representing present-day, mid-century, and late-century conditions, at both mid-range and high-end climate change/SLR influences (Table 5.1).

Consequences considered are damage to property, potential for injury or fatalities, and lifelines infrastructure. The following section describes how these consequences were assessed and risk levels determined for each asset type.

6.1. Pluvial inundation risk to property (buildings)

To understand the spatial distribution of risk, hazard impact areas of similar hazard characteristics (and, therefore, severity of consequences) have been mapped, based on the available natural hazards information (i.e., modelled inundation depth).

This approach does not consider the specific locations or types/floor levels of existing buildings, but considers the possibility for buildings to be present in any location within the study area. This provides information on the general risk to the land area, allowing for consistent comparison of relative risk levels for both developed and undeveloped land in the land-use planning context. Areas of similar consequence characteristics are mapped using depth thresholds relating inundation depth to consequence (Table 6.1).

Floor levels for buildings in South Dunedin were assessed through visual observation by DCC staff in October 2024, with a summary of this floor level information included in Appendix B. Those observations show widespread areas within South Dunedin where many buildings have floor levels of 0.3 m or less; therefore, this depth threshold is used to identify locations where widespread consequences to buildings may occur. This is an approximation only, as some buildings may be vulnerable to damage even where flood levels approach but do not exceed floor level; an economic assessment for the SDF work programme (Zhu and Foster, 2026) applies damages of NZD 10,000 per property for flooding between floor level and 100 mm below floor level.

Structural damage[8] is highly unlikely for pluvial flooding in South Dunedin due to relatively shallow inundation depths.[9] We classify areas where flooding may reach above the average floor level as having a 'moderate' consequence, mainly being due to a 'loss of use' as a consequence of post-flood repairs and remediation required (e.g., to repair or replace flooded floor coverings, wall linings, and insulation (BRANZ 2021)).

Table 6.1: Consequence assessment for pluvial inundation to buildings.

Inundation depth	Consequence (NPS-NH)
No flooding, or depth < 0.05 m ('nuisance' flooding)	**Negligible:** No loss of use, no building repairs required.
0.05 to 0.3 m	**Minor:** Minor damage to land and building(s). No loss of use, minimal repairs required.
≥0.3 m (assuming a median floor level of ~0.3 m)	**Moderate:** Some damage to land and non-structural damage to building(s). Limited loss of use, repairs required.
≥2 m	**Major:** Major damage to land and building(s), including structural damage. Loss of use and substantial repair required.

[8] Structural damage describes damage to structural elements in the building (e.g. foundation, frame, columns, beams). Non-structural damage describes superficial damage (e.g. to cladding, gib, flood, roofing, windows, doors, contents) (Wolter et al, 2024).

[9] e.g. A lower threshold at which structures may be susceptible to damage from flood waters has been defined as Depth ≥ 2.0 m, or Velocity ≥ 2.0 m/s, or DxV ≥ 1.0 m^2/s (the H5 threshold of the AIDR guidance, adopted by Auckland Council's flood risk framework (Donnelly 2025)). This framework also notes that; "Whether damage actually occurs depends on many factors. These include the depth and velocity of flow, debris loading, direction of flow relative to building orientation, how much of the structure is exposed to floodwater, the duration of exposure, and the type of foundations and building structure and cladding".

6.1.1.Analysis and results

The risk classification for pluvial flooding damages to property (buildings) using the NPS-NH risk framework is presented in Table 6.2, and mapped risk extents are presented in Figure 6.1 for both present day and future timeframes.

- For areas where inundation depths are modelled to exceed 0.3 m depth in the 100-year ARI scenario, consequences are estimated as 'moderate', and risks are classified as *Medium* (Table 6.2).
- For areas where inundation depths are modelled to be in the range of 0.05–0.3 m depth in the 100-year ARI scenario, consequences are estimated as 'minor', and risks are classified as *Medium*.
- If flooding is not present, or if inundation depths are negligible (<0.05 m), consequences are 'negligible' and risk levels are assessed as *Low*.

For locations which experience inundation causing a 'moderate' consequence in more frequent events of 50-year ARI or less, then risk level would be classified as *high*. Because the depth threshold for 'moderate' consequence is relatively shallow (0.3 m), the resulting area of *high* risk may be extensive.

Because the pORPS frames consequence for buildings as loss of functionality, this means that pluvial flooding in the more vulnerable areas of South Dunedin would be classified as a 'major' or 'catastrophic' consequence by the pORPS (>20%, or >50% of buildings in the hazard impact area have their functionality compromised), If applying the pORPS risk framework, areas where inundation depths are modelled to exceed 0.3 m depth in the 100-year ARI scenario, consequences are estimated as 'catastrophic', and risks are classified as *Significant*.

This assessment maps the spatial distribution of pluvial flooding risk across South Dunedin and is valuable for understanding the locations more likely to be impacted by pluvial flooding, for the present day and into the future.

However, the assessment and mapping of risk levels for pluvial flooding makes the assumption that both existing buildings and new developments have comparable floor levels, and, thus, a similar vulnerability to impact from flooding events. This is not the case for South Dunedin, and the following section discusses the impact of minimum floor level requirements on the assessment of risks to property.

Table 6.2: Estimated NPS-NH risk classification for buildings for pluvial inundation in South Dunedin for a 100-year ARI ('possible') event. The cells with a heavy outline border indicate the estimated risk levels for areas of each consequence class.

		Likelihood						
	Descriptor	**Almost Certain**	**Very Likely**	**Likely**	**Possible**	**Unlikely**	**Rare**	**Very Rare**
	ARI (years)	Up to 10	10–20	20–50	50–100	100–500	500–5000	>5000
	AEP	10% or more	10% to 5%	5% to 2%	2% to 1%	1% to 0.2%	0.2% to 0.02%	<0.02%
Consequence level	**Catastrophic**							
	Major							
	Moderate							
	Minor							
	Negligible							

Note: The top end of the likelihood range includes the top end year, that is, likely = over 20 years and up to and including 50 years.

Legend:	**Low**	**Medium**	**High**	**Very High**
		'Significant' natural hazard risk		

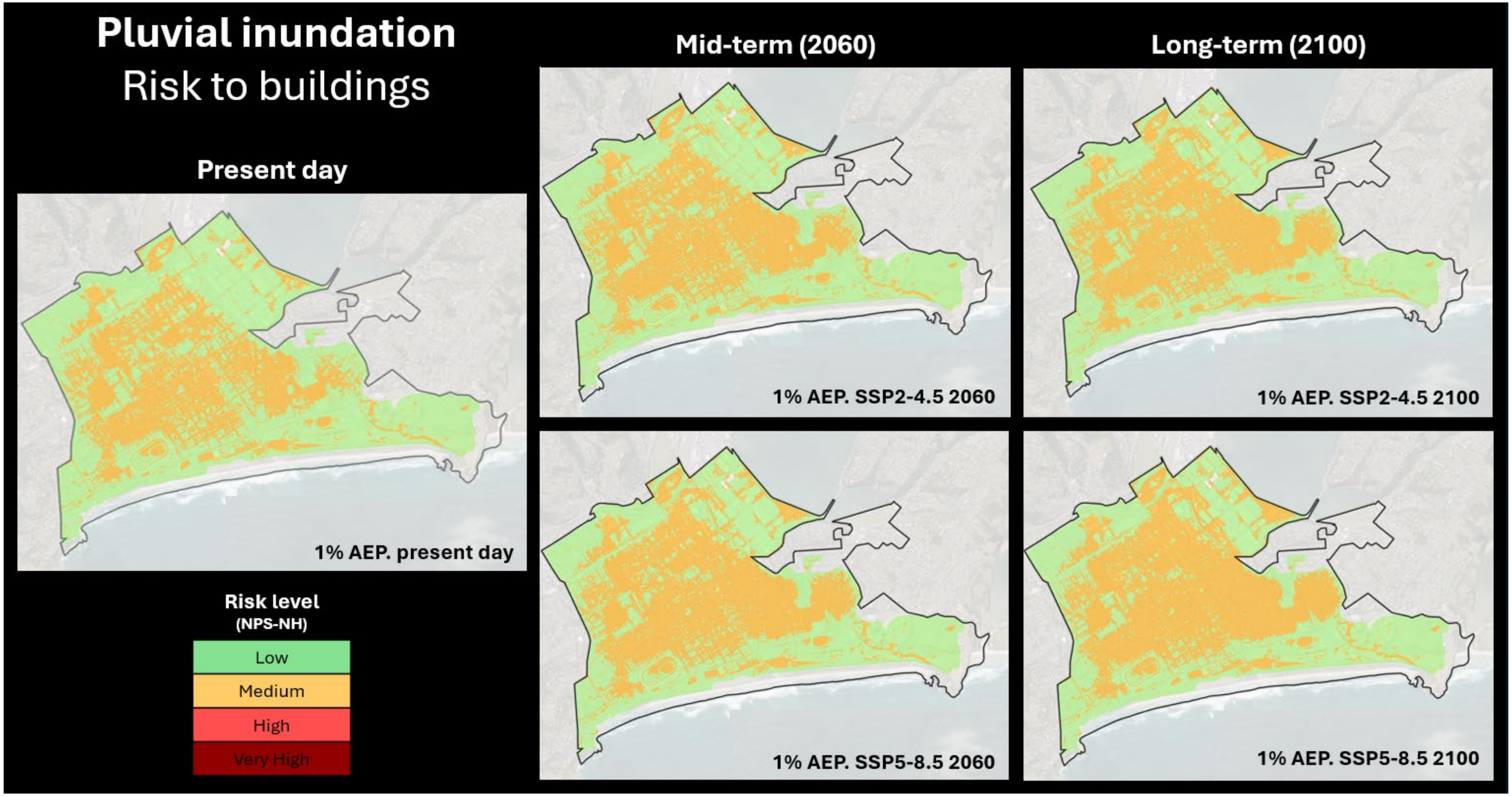


Figure 6.1: Pluvial inundation risk to property (buildings) assessed using the NPS-NH risk framework for a 100-year ARI scenario, applying the consequence assessment criteria of Table 6.1.

6.1.2. South Dunedin minimum floor levels

The assessment in the previous section does not include consideration of the minimum floor level (MFL) requirements for buildings. Any new residential development within South Dunedin must meet the minimum floor level (MFL) requirement of the Building Code, which specifies that "Surface water, resulting from an event having a 2% probability of occurring annually, shall not enter buildings" (NZ Building Code, Section E1.3.2).

DCC guidance provides three options for establishment of minimum floor levels in South Dunedin.[10] For areas where flooding in the July 2015 or October 2024 heavy rain events extended onto the property, the minimum required floor level is 400 mm above the highest flood water level.

The application of minimum floor levels means that the potential consequence to those new buildings from pluvial flooding will be substantially reduced: if floor levels are above the level of flooding and the functionality of buildings in the affected area is not compromised, then the level of consequence would be assessed as 'negligible' and risk level as *low*. Properties with an elevated floor level may still experience some disruptive impacts resulting from pluvial inundation events however, for example flooding of garages, sheds or gardens, as well as indirect effects such as road closures.

The DCC MFL requirements are based on floor levels relative to inundation depth observed during the (large, but not extreme) July 2015 and October 2024 flooding events, with the addition of a freeboard of 400 mm. The rainfall that caused those previous flooding events in South Dunedin was generally in the range of 40- to 140-year ARI, depending on duration (Carey-Smith, 2025). It is not known if the current approach to setting MFL is sufficient to account for pluvial flooding due to a future 100-year ARI rainfall event exacerbated by climate change, rainfall events of larger magnitude (e.g., 500-year ARI), or the effects of potential coincident hazards impacts (e.g., a large-magnitude pluvial event coinciding with coastal inundation or a period of elevated groundwater levels and, therefore, reduced subsurface storage).

6.2. Pluvial inundation risk to health and safety

Health and safety consequences for fluvial or pluvial inundation are typically assessed based on floodwater depth, or a function of floodwater depth and velocity, to classify the severity of hazard to people. For low-velocity floodwater (<0.5 m/s), commonly applied flood vulnerability classification thresholds (e.g., Menke et al., 2024; Debski, 2022) are those of the Australian Rainfall and Runoff Guide (AR&R, Ball et al., 2019). In this vulnerability classification, floodwaters are considered:

- Hazardous for adults if depth is ≥1.2 m (hazard vulnerability class H4);
- Hazardous for children/elderly if depth is 0.5–1.2 m (H3);

[10] https://www.dunedin.govt.nz/services/building-services/planning-your-project/minimum-floor-levels

- Potential for minor, non-life-threatening injuries if depth is 0.3–0.5 m (H2);
- Generally safe for people if depth is <0.3m (H1).

Applying the AR&R vulnerability classification, health and safety consequences of pluvial inundation are assessed using Table 6.3 (these criteria are also used for assessment of coastal inundation in Section 6).

Table 6.3: Consequence assessment for pluvial inundation to health and safety.

Inundation depth	Consequence (NPS-NH)
<0.3 m	**Negligible:** No injuries.
0.3 to 0.5 m	**Minor:** Isolated minor injuries possible.
0.5 to 1.2 m	**Moderate:** Unsafe for people, with potential for injuries, although expected to be minor.
≥1.2 m	**Major:** Unsafe for people, with potential for many injuries, or critical injuries and/or fatalities.

6.2.1. Analysis and Results

In South Dunedin, the inundation depth is relatively shallow, generally <0.5 metres depth. Even in the longest-term scenario considered here (100-year ARI, SSP5-8.5, for the year 2100), only localised areas of modelled flooding exceed 0.6 metres depth.

Applying the 'injury and fatalities' consequences criteria of the NPS-NH, we assess the consequence level associated with pluvial flooding of <0.3 metres depth as 'negligible', defined as "no injuries". For deeper floodwaters of >0.3 or >0.5 metres, we infer a consequence level of 'minor' ("isolated minor injuries possible") or 'moderate' ("unsafe for people, with potential for injuries, although expected to be minor"), as injury is possible, especially for more vulnerable members of the community (e.g., children, elderly, or those with disabilities).

For a 100-year ARI pluvial flooding scenario, the risk level would, therefore, range between *low* and *medium* risk, and these areas of *medium* risk would be considered *Significant* risk within the NPS-NH framework (Table 6.4). For locations which experience inundation causing a 'moderate' consequence in more frequent events of 50-year ARI or less, then risk level would be classified as *high*. However, a focus on the potential for physical injuries or fatalities in determining hazard consequence for pluvial events does not fully capture the wide range of health and wellbeing impacts that may occur in the South Dunedin context; this is discussed in the following section.

Table 6.4: Estimated NPS-NH risk classification for injuries/fatalities for pluvial inundation in South Dunedin for a 100-year ARI ('possible') event. The cells with a heavy outline border indicate the estimated risk levels for areas of each consequence class.

	Likelihood							
	Descriptor	**Almost Certain**	**Very Likely**	**Likely**	**Possible**	**Unlikely**	**Rare**	**Very Rare**
	ARI (years)	Up to 10	10–20	20-50	50–100	100–500	500–5000	>5000
	AEP	10% or more	10% to 5%	5% to 2%	2% to 1%	1% to 0.2%	0.2% to 0.02%	<0.02%
Consequence level	**Catastrophic**	Very High	Very High	Very High	High	Medium	Medium	Medium
	Major	Very High	Very High	High	High	Medium	Medium	Medium
	Moderate	High	High	High	Medium	Medium	Low	Low
	Minor	Medium	Medium	Medium	Medium	Low	Low	Low
	Negligible	Low	Low	Low	Low	Low	Low	Low

Note: The top end of the likelihood range includes the top end year, that is, likely = over 20 years and up to and including 50 years.

Legend:	**Low**	**Medium**	**High**	**Very High**
		'Significant' natural hazard risk		

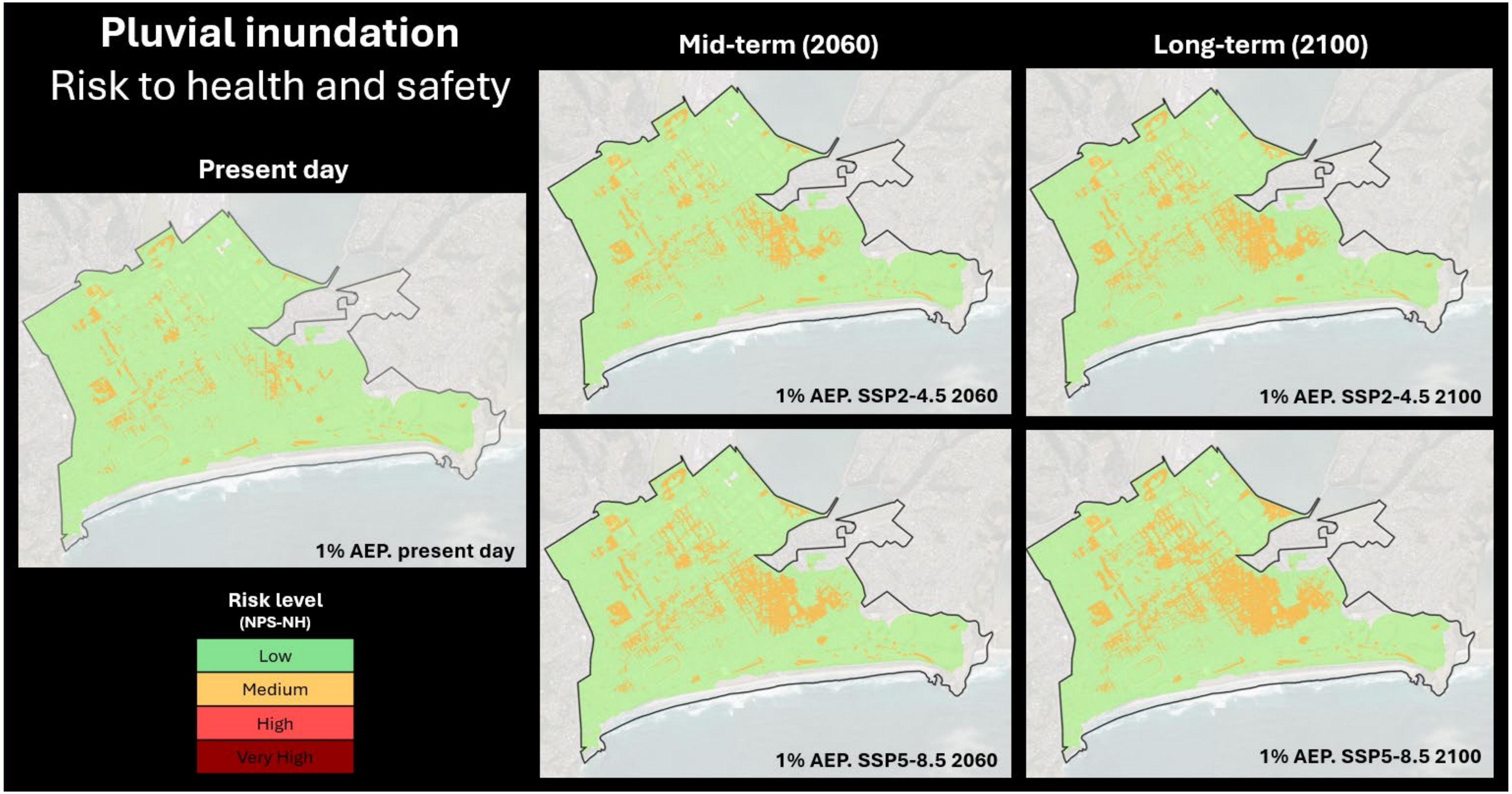


Figure 6.2: Pluvial inundation risk to health and safety assessed using the NPS-NH risk framework for a 100-year ARI scenario, applying the consequence assessment criteria of Table 6.

6.2.2. Discussion on health and safety risks

Following the pORPS requirement to consider a range of additional factors in assessment of consequences (e.g., community vulnerability and resilience, impacts on social wellbeing, impacts to access and services), this section provides further discussion on health and safety aspects of flooding impacts in South Dunedin.

The assessment approach in the previous section suggests that health and safety risks from pluvial flooding for a 100-year ARI event are *low* or *medium,* but could be classed as *high* for locations of more frequent flooding impact. However, an assessment of flooding consequences based only on direct, physical impacts of pluvial flooding (i.e., potential drowning hazard) does not well represent the full range of potential health and safety consequences of flooding in the South Dunedin context.

It is known from experience of previous flooding events (e.g., June 2015, October 2024) and other assessments (Harrison et al., 2022) that flooding may result in substantial negative effects to individual and community health and wellbeing for those in South Dunedin, for example, those described in the following paragraph and the wellbeing impacts listed in Table 6.5.

Following the 2015 South Dunedin flooding event, analysis of hospitalisation rates by Baillie (2024) demonstrated that there was "an observed pattern of more hospitalisations with injuries, gastrointestinal infections and skin diseases, and respiratory illness, as well as possible differences in cardiovascular and cerebrovascular diagnoses".

Table 6.5: Potential impacts to individual and community health and wellbeing relevant to flooding events in South Dunedin (Harrison et al., 2022).

Mental wellbeing	• **Lived or anticipated experience of flooding increases the risk of negative mental wellbeing outcomes such as depression, anxiety, sleep disturbance, general psychological distress, and post-traumatic stress disorder.** • **Negative mental health outcomes may result from experiences of trauma during a flood, as well as evacuation and displacement, disruption, damage to housing, and the long-term effects of repeated flood exposure.** • **Post-flood financial stresses arise from the need to replace or repair flood-damaged items and difficulties selling flood-affected properties.** • **Experience of flooding can also lead to a loss of sense of safety, place, and belonging in one's home or neighbourhood, with negative implications for mental wellbeing.**
Physical wellbeing	• Death or injury from contact with debris or drowning, exposure to hazardous chemicals and toxic materials, carbon monoxide poisoning from using gasoline-powered generators to dry out damp housing, and electrocution from downed power lines or other damaged electrical wiring.

[redacted]	• Increased risk in the spread of infectious disease where flooding and sea level rise result in water contamination, overcrowding, and unhygienic living conditions. • Flood damage to housing can also create or exacerbate the cold, damp conditions that promote mould growth and increase the risk of respiratory and cardiovascular illnesses. • Flooding can also disrupt access to emergency services and routine healthcare for those with non-communicable diseases such as cancer, diabetes, and cardiovascular disease, increasing the risk of acute exacerbation or death.

It is challenging to precisely classify or integrate these types of indirect health and wellbeing consequences within the NPS-NH risk classification framework, as there is uncertainty whether illness, mental health, or physical wellbeing impacts (e.g., those described in Table 6.5) caused or exacerbated by a flood event are considered 'injuries' within the NPS-NH criteria.

The South Dunedin community context must also be considered in assessment of health and safety consequences because negative effects from natural hazard events will be experienced disproportionally by those already vulnerable due to experiencing inequities (Harrison et al., 2022); these include Māori and Pasifika, disabled people, the elderly, low-income households, renters, and those with existing health conditions. Data relating to these vulnerability measures include:;

- Most of the lowest-lying areas in South Dunedin have social deprivation scores[11] of between 8 and 10, where 10 is most deprived on a 1–10 scale (McKenzie et al., 2017).
- 18% of the South Dunedin population reported having at least some difficulty walking, which is significantly higher than that of the wider Dunedin population (7.2%) (Statistics NZ 2018, in: Cowper-Heays, 2025).
- 42% of the South Dunedin households live in rental accommodation (Cowper-Heays. 2025).

Some of these potential impacts (e.g., those due to loss of use for housing, and contents damage) should be largely mitigated for new development by implementation of minimum floor level requirements. However, residents may be affected by some of these potential impacts even if their dwelling is not directly impacted due to being elevated to meet MFL requirements, or located in an area of only shallow inundation (e.g., anxiety and psychological distress, loss of access due to road closures or cancellation of public transport routes, and effects of disrupted access to emergency services and routine healthcare).

In conclusion, considering the known community vulnerability and the wide range of potential impacts due to pluvial flooding, we highlight that the health and safety of residents should be an important factor considered in any plan change process. Due to the known indirect and chronic impacts of pluvial flooding events in South Dunedin, we suggest that this hazard

[11] The social deprivation index captures communication, income, as well as income from benefits, employment, qualifications, home ownership, support, living space, and transport. Accounting for so many aspects of people's welfare means it is a useful aggregate measure of social vulnerability.

should be treated more conservatively than would be warranted based solely on injury-focused risks due to direct, physical impacts of pluvial flooding. The previous section identifies health and safety risks from pluvial flooding as up to *medium* or *high* risk in the NPS-NH framework. A more conservative classification of these risks may more accurately account for the broader range of impacts discussed in this section, and it should be considered what degree of hazard management is 'proportionate' to that level of natural hazard risk, a requirement of the NPS-NH (e.g. Policy 4).

6.2.3. Pluvial inundation risk to lifelines

The NPS-NH does not apply to infrastructure, so risks to lifelines infrastructure are not classified through that framework. The pORPS risk assessment framework can be applied for lifelines infrastructure; however, assessment of consequences for these assets within the pORPS risk framework is complex and would require further input from the infrastructure managers, because these rely on estimation of both the duration that an asset is out of service and the proportion of a city's population that is affected by that outage, as well as consideration of asset-specific vulnerability conditions including level of service, condition, material, and age. Due to these challenges, we have not classified a level of risk for lifelines infrastructure but, instead, highlight which types of lifelines are considered most vulnerable to impact from each natural hazard type.

Based on the SDF risk assessment by Kia Rōpine (2025, Table 6.6), the assets most sensitive to damages from floodwater inundation are electrical substations, pump stations, and the wastewater network. For roading and underground cable assets, the potential consequences and, therefore, risk levels are relatively low.

Table 6.6: Vulnerability criteria for lifelines assets to pluvial inundation, drawn from Appendix C of Cowper-Heays (2025).

Asset	Vulnerability considerations	Vulnerability class (Kia Rōpine)
Roads	Roads and associated infrastructure have low vulnerability to flooding.	**Low**, for all road assets.
WW/SW pump stations	Flooding of SW pump stations may damage the switchboard, resulting in pump station failure. Flooding of Musselburgh Pump Station may flood the dry well. Flood water at Tahuna WWTP may cause damage and prevent operation.	**Extreme**, for Musselburgh PS if depth > 0 m. **High**, for SW pump stations and Tahuna WWTP if depth > 0 m.
WW/SW pipes and manholes/nodes	Pipe surcharging results in widespread reduction in LoS which results in environmental contamination and associated breaches of consent conditions. Increase in the severity of scour damage to surrounding areas in steep zones.	**High,** for all wastewater pipes. **Low,** for all pipes except a steep zone at Sandringham St and Forbury Rd, which is Moderate.

Water supply infrastructure	Network unlikely to be vulnerable to flooding.	**Very low,** for all parts of network.
Overhead distribution lines	Poles and towers may be sensitive to waterlogged soils as a result of flooding, which can cause failure.	**Moderate**, for all poles and towers.
Underground cables	Not affected, unless in locations where erosion may occur.	**Very low**, for all cables.
Substation	Some (but not all) substation assets could start to be affected if exposed to flood depths of >0.2 m.	**High**, if inundation > 0.2 m.

7. Coastal inundation hazard risk analysis

South Dunedin is potentially exposed to coastal inundation hazard from both Otago Harbour (to the north) and the Pacific Ocean (St. Clair and St. Kilda beaches) to the south. Modelling of potential coastal inundation in South Dunedin from Otago Harbour has been completed under a range of return events and sea level rise increments by NIWA (Paulik et al., 2023). Modelling of coastal inundation impacts from a future eroded St. Clair–St. Kilda coastline has been developed by Tonkin + Taylor Ltd (Bagg and Beetham, 2025).

The NIWA coastal inundation modelling may be conservative (i.e., result in higher risk) as it is based on a 'bathtub with a threshold' approach that assumes inundation of all areas lower than the calculated extreme sea level and hydraulically connected to the coastline, and, therefore, does not account for the time-varying nature of a storm event. However, the modelling assumes no connectivity or permeability of the raised land/dune systems within the proximity of the coast (e.g. the St Clair-St Kilda dune system), and, for this reason, may underestimate the inundation potential (Cowper-Heays, 2025). Further investigations would be required to determine a higher degree of confidence in coastal inundation extent and/or depths.

Under these modelled scenarios, coastal inundation of South Dunedin occurs via inundation from the Otago Harbour once sea level rise drives storm surge to overtop the reclaimed land along the Otago Harbour backshore; this occurs with approximately 0.6 m relative sea level rise (RSLR) in the 1% AEP event. As mean sea level progressively rises nearer to the threshold at which overtopping into South Dunedin may occur, the likelihood of an overtopping event becomes increasingly likely (i.e., a smaller-magnitude storm surge event is required to reach that overtopping threshold). Eventually, a direct overland connection between the coast and inland South Dunedin occurs with 1.5 m RSLR,[12] after which point the South Dunedin area may become permanently tidal or inundated if flood water is not prevented from entering, or being drained or pumped out. In longer-term timeframes (i.e., 2100) and if this hazard is not

[12] NZ Sea Rise data for site 4780 (St Clair) estimates that for a high-end scenario (SSP-8.5 + VLM), a RSLR of 1.5m is reached in 2140-2150 (p50).

mitigated, the NIWA modelling indicates broad areas of deep inundation (>2 m) across much of the South Dunedin plain.

Modelling of coastal inundation from a future eroded St. Clair–St Kilda coastline illustrates that overtopping may occur for timeframes beyond 2034, and in the longest-term scenario (2074), the resulting inundation extends up to 1.5 km inland in the area around Forbury Park (Figure 9.2). In some locations the maximum inundation depths exceed 0.5 m, and have a velocity of at least 1–2 m/s. Mapping of the risks from these St. Clair–St. Kilda inundation scenarios is beyond the scope of this current report, but we highlight that the consequences of this hazard may be hazardous, and should be considered further. Inundation with the characteristics noted above (D > 0.5 m, V > 1 m/s) would be classified with a flood hazard vulnerability of H3 (Unsafe for vehicles, children, and the elderly) or H4 (Unsafe for vehicles and people). This highlights the importance of the dune system as a natural buffer providing protection for South Dunedin, and the value of maintaining this dune system to provide an effective buffer against coastal inundation events.

7.1. Coastal inundation risk to buildings

To understand the spatial distribution of risk, hazard impacts areas of similar hazard characteristics (and, therefore, severity of consequences) have been mapped, based on the available natural hazards information (i.e., modelled inundation depth).

Risk mapping for coastal inundation follows the same consequences thresholds and risk classification as applied for pluvial inundation hazard (Tables 6.1 and 6.2). Based on these thresholds, the maximum consequence level for property damage would be 'major', as structural damage is possible. However, in the event that the South Dunedin area becomes 'permanently tidal or inundated', I suggest that a higher consequence classification of 'major' is justified across a wider area, as this could be considered 'major damage to land', and have a substantial impact on the usability of dwellings.

7.1.1. Results

The risk classification for coastal inundation damages to property (buildings) using the NPS-NH risk framework is presented in Table 7.1:

- For areas where inundation depths are modelled to exceed 2.0 m depth in the 100-year ARI scenario, consequences are estimated as 'major', and risks are classified as *high* (Table 7.1).
- For areas where inundation depths are modelled to exceed 0.3 m depth in the 100-year ARI scenario, consequences are estimated as 'moderate', and risks are classified as *medium*.

- For areas where inundation depths are modelled to be in the range of 0.05–0.3 m depth in the 100-year ARI scenario, consequences are estimated as ‘minor’, and risks are classified as *medium*.
- If flooding is not present, or if inundation depths are negligible (<0.05 m), consequences are ‘negligible’, and risk levels are assessed as *low*.

Table 7.1: Estimated NPS-NH risk classification for buildings for coastal inundation in South Dunedin for a 100-year ARI (‘possible’) event. The cells with a heavy outline border indicate the estimated risk levels for areas of each consequence class.

		Likelihood						
	Descriptor	**Almost Certain**	**Very Likely**	**Likely**	**Possible**	**Unlikely**	**Rare**	**Very Rare**
	ARI (years)	Up to 10	10–20	20–50	50–100	100–500	500–5000	>5000
	AEP	10% or more	10% to 5%	5% to 2%	2% to 1%	1% to 0.2%	0.2% to 0.02%	<0.02%
Consequence level	**Catastrophic**							
	Major							
	Moderate							
	Minor							
	Negligible							

Note: The top end of the likelihood range includes the top end year, that is, likely = over 20 years and up to and including 50 years.

Legend:	**Low**	**Medium**	**High**	**Very High**
		‘Significant’ natural hazard risk		

7.1.2. South Dunedin minimum floor levels

The minimum floor level (MFL) requirements for new residential development within South Dunedin are designed specifically as a mitigation response to pluvial flooding hazard, and are based on observed depths of pluvial inundation, plus a freeboard component.[13] These elevated floor levels may provide some mitigation against building inundation due to shallow

[13] DCC also specify an approach to setting a minimum floor level for ‘coastal areas’ based on factors including sea level rise, storm surge height, tectonic settlement and a freeboard amount (Lilley and Oakley 2022). but it appears this is not applied within South Dunedin, as their guidance notes that “For South Dunedin rainfall events are the dominant factor when establishing MFL.”

coastal inundation. However, coastal inundation may differ in characteristics from pluvial flooding events (e.g. location, velocity, duration, effect of wave action), and the effectiveness of these required floor levels as mitigation for shallow coastal flooding, or the impact on potential consequence or risk levels has not been assessed. Properties with an elevated floor level may still experience some disruptive impacts resulting from coastal inundation events, for example flooding of garages, sheds or gardens, as well as indirect effects such as road closures.

For late-century timeframes, coastal inundation modelling indicates eventual occurrence of a direct overland connection between the coast and inland South Dunedin, and of modelled inundation depths expected to greatly exceed the floor levels required as a mitigation for pluvial flooding. In this case, coastal inundation would be expected to impact even those buildings which meet the MFL requirements, and therefore these would provide little mitigating impact on risk levels.

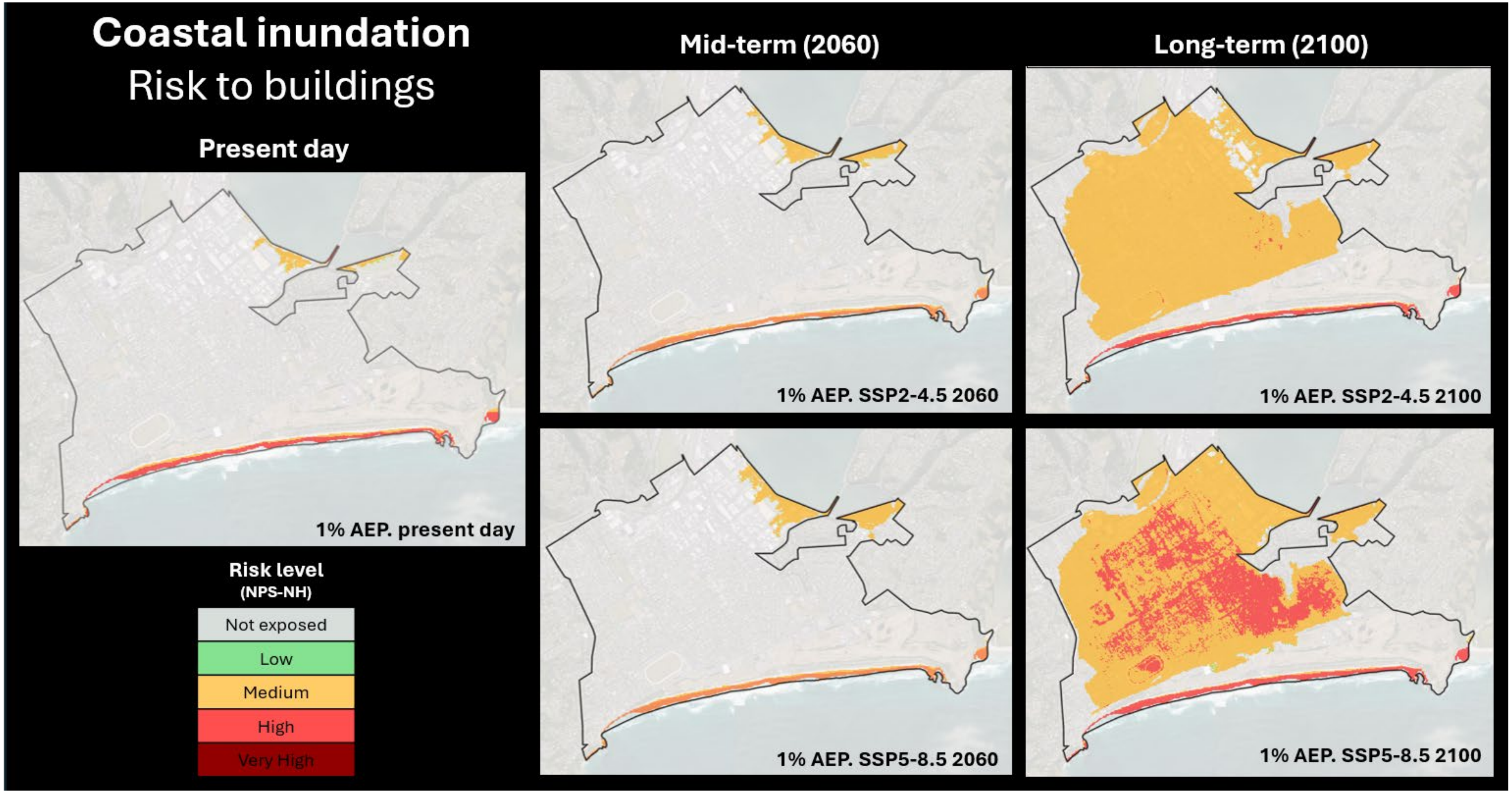


Figure 7.1: Coastal inundation risk to buildings, assessed using the NPS-NH risk framework for a 100-year ARI scenario, applying the consequence assessment criteria of Table 6.1.

7.2. Coastal inundation risk to health and safety

Direct physical impact risks (i.e., drowning hazard) due to coastal inundation would be most hazardous in the immediate coastal margin where overtopping/breach is occurring. For example, modelling for coastal inundation following a breach of the St. Clair dune system shows the depth and velocity of floodwaters decreasing inland (Bagg and Beetham, 2025; e.g., Figure 9.2).

Modelling of coastal inundation for late-century scenarios shows substantial areas of deep ponding (>1.2 m) within the South Dunedin area. This hazard may, therefore, pose a direct health and safety risk, especially to children and the elderly, although a more detailed assessment of potential consequence should consider the speed of onset, ability for early warning and evacuation, and the limitations associated with the 'bathtub'-type modelling approach for this hazard.

In addition, as discussed for health and safety risks due to pluvial flooding and groundwater, there may be a substantial community mental/physical health and wellbeing impact due to the occurrence of even shallow flooding or other events causing dampness within buildings.

8. Groundwater hazard risk analysis

South Dunedin has relatively shallow groundwater levels, and these are expected to gradually (but permanently) increase with the influence of a rising sea level. Present-day and future groundwater scenarios for the South Dunedin area have been modelled by GNS Science (Cox et al., 2023).

Groundwater hazard has been described as "flooding from below" (Cox et al., 2023), and shallow groundwater begins to have adverse impacts even before groundwater levels reach the surface to become emergent. Shallow or emergent (at surface) groundwater may cause a wide range of adverse effects to health, buildings, and infrastructure, summarised in Figure 8.1. Without interventions to manage groundwater levels, most of South Dunedin will become persistently waterlogged and effectively uninhabitable, with any area developing widespread persistent water ponding on the surface described as effectively becoming an "uninhabitable swamp area" (van Nieuwkerk, 2025).

In assessment of groundwater drainage options for South Dunedin, van Nieuwkerk (2025) use a 'success criteria' of a required drainage depth of 0.7 m below ground level, a depth below which moisture ingress into foundations and crawl spaces beneath buildings and weakening of soils beneath roads and hardstand areas. The South Dunedin Future risk assessment (Cowper-Heays, 2025) uses similar depths of 0.4–0.6 m as the threshold at which buildings and roads may begin to be impacted.

Although hazards due to groundwater are chronic (due to repeated or prolonged long-term exposure), the effects of shallow groundwater are also a key exacerbating factor in episodic events such as pluvial flooding.

Assessments of future groundwater condition, and of tolerance and threshold levels (e.g., fragility functions) are subject to significant uncertainty (Cox et al., 2023), so the risk commentary below should be considered only an indicative review of the risks, not a precise analysis.

Although there have been preliminary assessments into the viability of options to alleviate groundwater drainage issues in South Dunedin (e.g., van Nieuwkerk (2025)), there is no certainty as to if or when a mitigation approach could be implemented. This assessment, therefore, assumes a continuation of the status quo, i.e., conditions with no new mitigation in place for management of groundwater hazard. If effective groundwater management was feasible and successfully implemented, this would substantially reduce the risk levels assessed in this report.

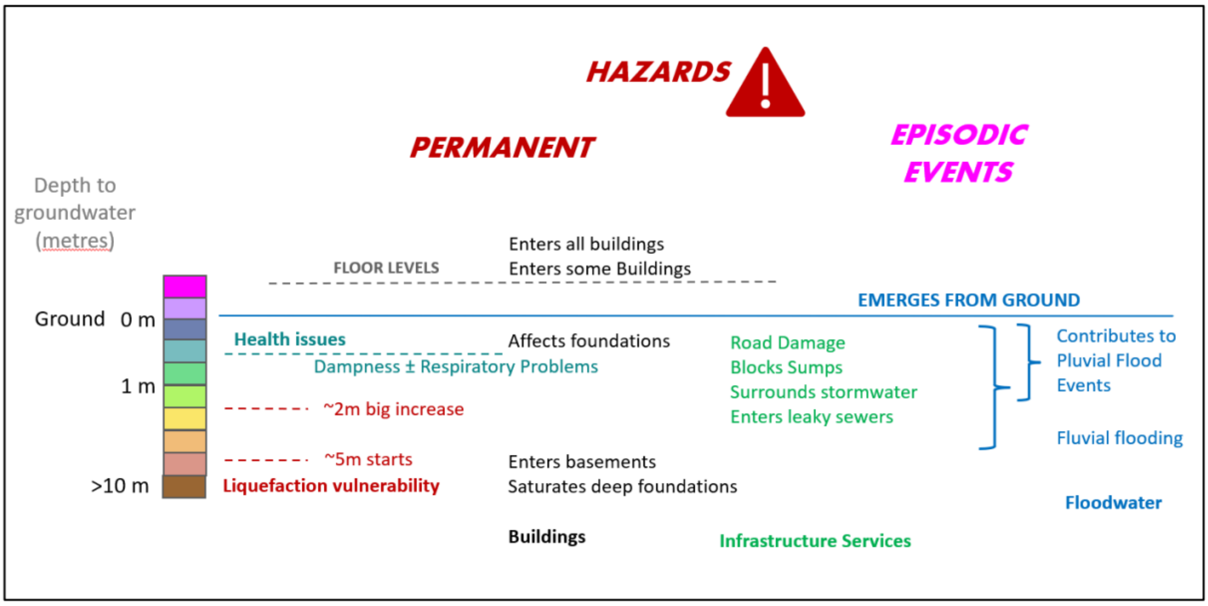


Figure 8.1: Summary of thresholds at which groundwater may become a direct hazard or indirectly contribute to another hazard. Note that there is a relatively poor understanding of these tolerance and threshold levels, and little quantification of fragility functions due to groundwater impacts (Cox et al., 2023).

8.1. Groundwater risk to buildings

To understand the spatial distribution of risk, hazard impacts areas of similar hazard characteristics (and, therefore, severity of consequences) have been mapped, based on the available natural hazards information (i.e., modelled groundwater depth).

Areas of similar consequence characteristics are mapped using depth thresholds relating groundwater depth to consequence for buildings (Table 8.1), which are simplified from those used by Kia Rōpine (2025). For each future timeframe, the modelled median groundwater scenario developed by Cox et al. (2023) is treated as the event of 'almost certain' likelihood.

Table 8.1: Building vulnerability criteria developed for South Dunedin by Kia Rōpine, adapted from Table C-1-3 of Cowper-Heays (2025).

Vulnerability		Groundwater
	Vulnerability considerations relating to hazard and rating category.	**Emergent groundwater is likely to cause dampness and mould in buildings, which would render them uninhabitable over the long term. Near-surface groundwater would impact functionality of buildings, potentially disrupting access and posing a threat to health.**
Extreme	Sudden collapse/failure causing potential risk to life.	
High	Acute hazards: Damage sustained resulting in the building being uninhabitable for >1 month. Chronic hazards: No moisture barrier and inefficient drainage for the removal of stormwater (residential and non-residential buildings).	No information regarding private drainage or moisture barrier. Therefore, all buildings included in this category when exposed to emergent groundwater.
Moderate	Acute hazards: Damage sustained resulting in the building being uninhabitable for < 1 month. Chronic hazards: No moisture barrier but good drainage for stormwater (residential buildings).	No information regarding private drainage or moisture barrier. Therefore all residential buildings when exposed to groundwater 0–0.5 mbgl (access and health related).
Low	Chronic hazards: No moisture barrier but good drainage for stormwater (non-residential buildings).	No information regarding private drainage or moisture barrier. Therefore, all non-residential buildings when exposed GWL 0–0.5 mbgl.
Very low	No loss of service or repairs.	n/a*

* n/a assigned due to insufficient information to differentiate vulnerability between ratings

Table 8.2: Consequence assessment for shallow groundwater impact to buildings, based on the information in Table 8.1.

Groundwater depth	Consequence (NPS-NH)
>0.5 m below ground level	**Negligible:** No loss of use, no building repairs required.
0 to 0.5 m below ground level	**Moderate:** Some damage to land and non-structural damage to building(s). Limited loss of use, repairs required.
Emergent (i.e., at ground level)	**Major:** Major damage to land and building(s), including structural damage. Loss of use and substantial repair required.

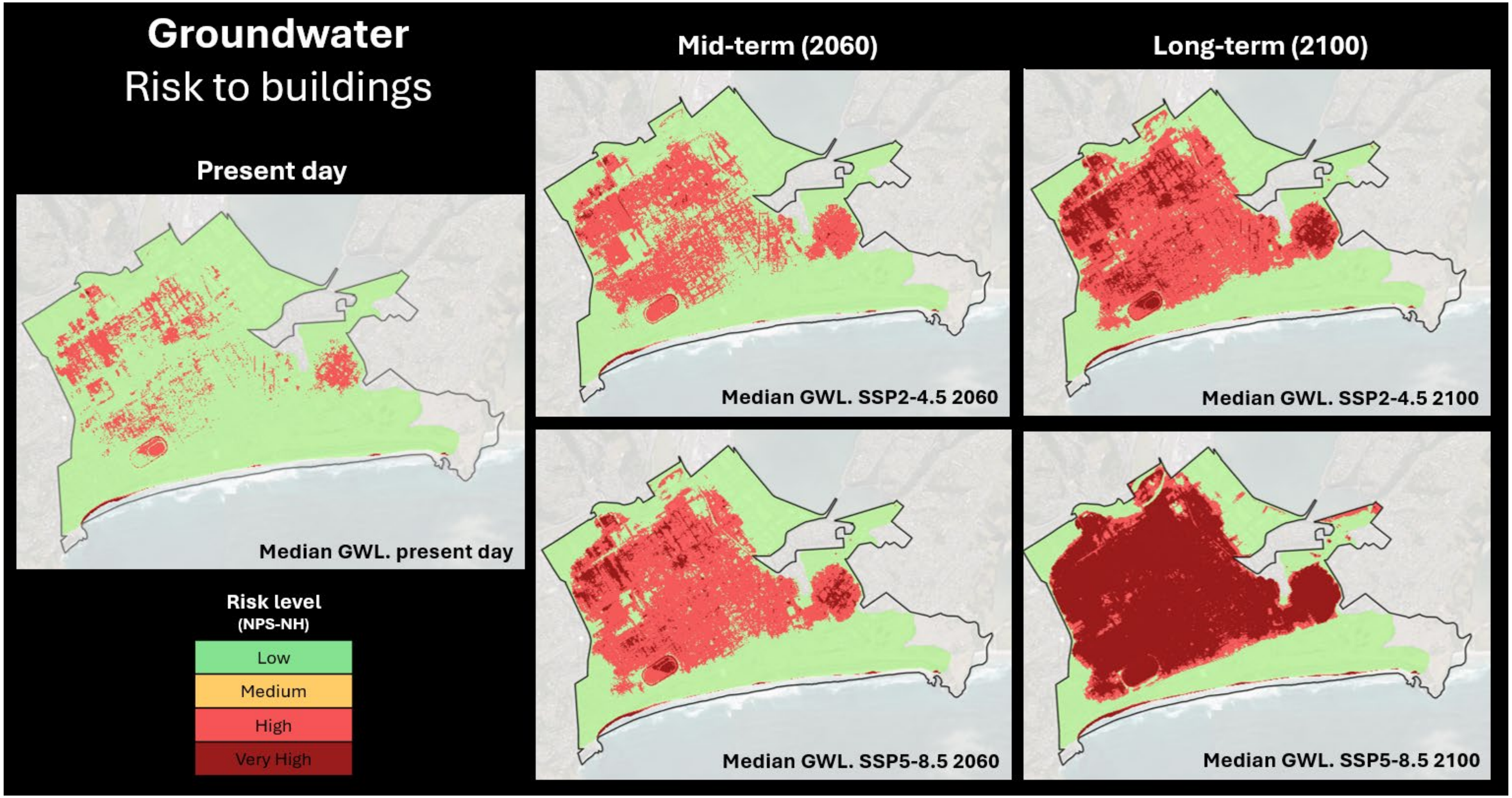


Figure 8.2: Groundwater risk to buildings, assessed using the NPS-NH risk framework for a median groundwater level scenario, applying the consequence assessment criteria of Table 8.2.

8.1.1.Results

Classification of consequence for property within the NPS-NH is focused on the severity of damages. For this assessment, we have assumed that the presence of emergent groundwater has a ‘major’ consequence for property, due to causing ‘major damage to land’, and having long-term impacts on building habitability.

Within the NPS-NH classification framework, for a modelled median groundwater level, we interpret risks to buildings due to groundwater as *Significant* (*high* or *very high* risk) for locations in South Dunedin where groundwater is shallow (<0.5 mbgl) or emergent (Table 8.3).

Because assessments of future groundwater condition, and threshold levels (e.g., fragility functions) are subject to significant uncertainty (Cox et al., 2023), the spatial mapping of risk levels in Figure 8.2 also includes the same level of uncertainties.

Table 8.3: Estimated NPS-NH risk classification for buildings for groundwater hazard in South Dunedin for the modelled median groundwater level. The cells with a heavy outline border indicate the estimated risk levels for areas of each consequence class.

		Likelihood						
	Descriptor	**Almost Certain**	**Very Likely**	**Likely**	**Possible**	**Unlikely**	**Rare**	**Very Rare**
	ARI (years)	Up to 10	10–20	20–50	50–100	100–500	500–5000	>5000
	AEP	10% or more	10% to 5%	5% to 2%	2% to 1%	1% to 0.2%	0.2% to 0.02%	<0.02%
Consequence level	**Catastrophic**							
	Major							
	Moderate							
	Minor							
	Negligible							

Note: The top end of the likelihood range includes the top end year, that is, likely = over 20 years and up to and including 50 years.

Legend:	**Low**	**Medium**	**High**	**Very High**
		‘Significant’ natural hazard risk		

8.1.2. South Dunedin minimum floor levels

The minimum floor level (MFL) requirements for new residential development within South Dunedin are designed specifically as a mitigation response to pluvial flooding hazard, and are based on observed depths of pluvial inundation, plus a freeboard component.

The effectiveness of these mitigations as a mitigation response to shallow or emergent groundwater is not known, as groundwater hazard differs significantly from pluvial inundation in terms of timing and duration (e.g. chronic vs event-based), and the types of damage which may occur. Due to these differences, the impacts of MFL requirements on potential consequences or risk levels for buildings or health and safety have not been assessed. Regardless of the resilience of a buildings to groundwater hazard impact, the surrounding land area would remain subject to the effects of shallow groundwater, with substantial impact if groundwater was to be emergent.

8.2. Groundwater risk to health and safety

Health and safety consequences are closely related to those for buildings, as when groundwater rises to within 0.5 m of the ground surface, it can lead to rising damp and wet floors and fittings, which then begins to impact people's health through dampness and mould issues (Cox et al., 2023).

Because health and safety consequences due to shallow groundwater are expected to correspond very closely to the functionality of the building and the usability of the surrounding land, we have not assessed health and safety consequences separately. The general pattern of risk levels for health and safety due to chronic exposure to dampness resulting from shallow/emergent groundwater are, therefore, expected to align with those presented in Figure 8.2.

Similar to the assessments for pluvial flooding, the NPS-NH risk assessment framework has a focus on injuries and fatalities, and it is challenging to precisely classify or integrate risks arising from these types of chronic/indirect health and wellbeing consequences in that framework.

8.3. Groundwater risk to lifelines

The NPS-NH does not apply to infrastructure, so consequences for lifelines infrastructure are not assessed qualitatively, but these are summarised using the vulnerability criteria developed by Kia Rōpine for groundwater hazard to lifelines infrastructure (Table 8.4).

These show that the assets most sensitive to damages from shallow groundwater levels are roads. For others, such as pump stations, substations, and underground cables, the potential consequences and, therefore, risk levels are relatively low.

For roads, it is important to note that impacts may occur well in advance of groundwater becoming emergent (when groundwater level reaches within 0.4–0.6 m of the surface), and so by late-century could have widespread and severe impacts on wider community (if not mitigated through management of groundwater levels).

Table 8.4: Vulnerability criteria for shallow groundwater impacts to lifelines assets.

Asset	Vulnerability considerations	Vulnerability class (Kia Rōpine)
Roads	Groundwater level applies to all roads and includes damage and loss of all utilities.	**High**, for heavily trafficked roads if groundwater within 0.6 m of surface. **High**, for all other roads if groundwater within 0.4 m of surface. **Moderate**, for all other roads, related to widespread high groundwater.
WW & SW pipes and manholes	Material and/or age are the main factors determining pipe vulnerability.	Depends on pipe material/age.
WW/SW pump stations	The main issue relates to groundwater infiltration into the drywell; however, as this is a slow process, leaks will be detected and fixed with no risk to the function.	**Very low,** for all pump stations.
Overhead distribution lines	Poles and towers may be sensitive to waterlogged soils as a result of rising groundwater, which can cause instability. Unlikely to be vulnerable from a service perspective, as this is a chronic risk with impacts that can be managed over time.	**Low,** if GWL is emergent. **Very low,** for all other poles and towers.
Underground cables	Buried cables are designed to resist moisture - vulnerability low.	**Very low**, for all cables.
Substation	Some assets could be affected, to differing degrees over time. Most likely to be managed proactively, limiting impacts.	**Low**, for all substations.

Assessment of consequence level for roading infrastructure using the pORPS framework focuses on the extent and duration of closure, e.g., a 'major' consequence is defined as "*Out of service for 1 week–1 month (affecting ≥20% of the town/city population) OR suburbs out of service for 6 weeks to 6 months (affecting <20% of the town/city population)*".

Table 8.5 shows estimated pORPS consequences for roading damages in response to shallow groundwater levels; however, there is significant uncertainty regarding the severity of damages and the expected duration of repairs. Further advice would be required to understand the expected duration of repairs needed in response, and the extent to which unaffected alternative routes could be utilised to reduce the spatial footprint of disruptions.

If consequence is ‘major’, and the likelihood was ‘almost certain’ (as may eventually become the case as mean groundwater levels progressively rise nearer the surface), then risk levels would be classed as *Significant* using the pORPS framework.

Even if new development in South Dunedin is designed to be resilient to impacts from hazards such as pluvial inundation or groundwater levels, the usability of road access may also affect the functionality of the dwelling and the community’s wellbeing.

Table 8.5: Consequence assessment for shallow groundwater impact to roads, based on the information in Table 8.4.

Groundwater depth	Vulnerability description (Kia Rōpine, 2025)	Consequence (RPS)
Emergent (i.e., at ground level)	Damage sustained so that asset is not functional until repairs are made.	**Major:** Suburbs out of service for 6 weeks to 6 months (affecting <20% of the town/city population).
0 to 0.4 m below ground level	Damage sustained so that asset is not functional until repairs are made.	**Moderate:** Suburbs out of service for 1 week to 6 weeks (affecting <20% of the town/city population).
>0.4 m below ground level	Damage sustained that can be repaired without any loss of functionality.	**Insignificant:** Suburbs out of service for up to 1 day (affecting <20% of the town/city population).

9. Coastal erosion hazard risk analysis

The SDF risk assessment report reviewed coastal erosion risk based on findings of a district-wide coastal hazards screening project completed by WSP (Riddle and Farley, 2024). The WSP assessment showed that coastal erosion risk is relatively low along the Otago Harbour coastline but higher along the St. Kilda to St. Clair dune system. This information was of a high-level nature with a number of associated limitations and was, therefore, not used to inform adaptation planning along the St. Clair–St. Kilda coastline.

Following completion of the SDF risk assessment report, further assessment of coastal erosion hazard was undertaken by eCoast Ltd (Atkin and Conroy, 2025). The study included modelled assessments of future shoreline evolution (defined as the position of the 0 m isobath) for medium-term (2034) and long-term future timeframes (2034 to 2049, and 2049 to 2079). Modelling scenarios for future timeframes include two pathways; to either hold or remove the existing defences (geotextile containers) at Kettle Park

Assessments of mean sea level (MSL) position for the longest-term scenario (2074) and with removal of the existing defences show limited exposure of assets within the potentially impacted area (Figure 9.1). These include a short section of Victoria Road near the southwestern extent of Forbury Park, and a small number of buildings (<10). The Te Whanau

Arohanui hall is considered a building of social importance and is located at/near the limit of modelled shoreline retreat. The majority of the current land use is parks and open spaces (although erosion at the Kettle Park Landfill may result in contaminated material entering the environment).

We have not classified risk level or mapped risks resulting from coastal erosion, as the projected future shoreline positions do not have an associated likelihood.[14] However, buildings and roading assets are identified as being highly or extremely sensitive to coastal erosion damages by Kia Rōpine (Cowper-Heays, 2025). Areas directly exposed to coastal erosion may result in 'moderate' or 'major' consequences to land and buildings when assessed using the NPS-NH framework, but these areas exposed to potential impacts are very localised. The overall risk to the wider South Dunedin is relatively low, but locally where directly exposed to erosion impact the risk levels would be higher.

A potential cascading impact following extensive coastal erosion would be the eroded dune system providing ineffective protection and, therefore, allowing for coastal inundation into the South Dunedin plain from the St. Clair–St. Kilda coastline. A series of overtopping scenarios at St. Clair–St. Kilda have been developed by Tonkin + Taylor Ltd. for future eroded coastlines (T+T, Bagg and Beetham, 2025) for the epochs 2024, 2034, 2049, and 2074. Modelling results indicate that overtopping may occur for timeframes beyond 2034, and in the longest-term scenario (2074), the resulting inundation extends up to 1.5 km inland in the area around Forbury Park (Figure 9.2). However, the modelling results may underestimate the likelihood of flooding or consequence of flooding for a given likelihood due to the limitations involved, for example, the assessment represents inundation resulting from only a single high tide, and does not simulate dynamic evolution (e.g., widening or lowering) of the breach due to wave action.

[14] These WSP (2024) projections were developed using a deterministic rather than probabilistic modelling approach, and therefore are best considered to be "as likely as not", i.e. the probability that erosion will occur to position shown is at best 50%.

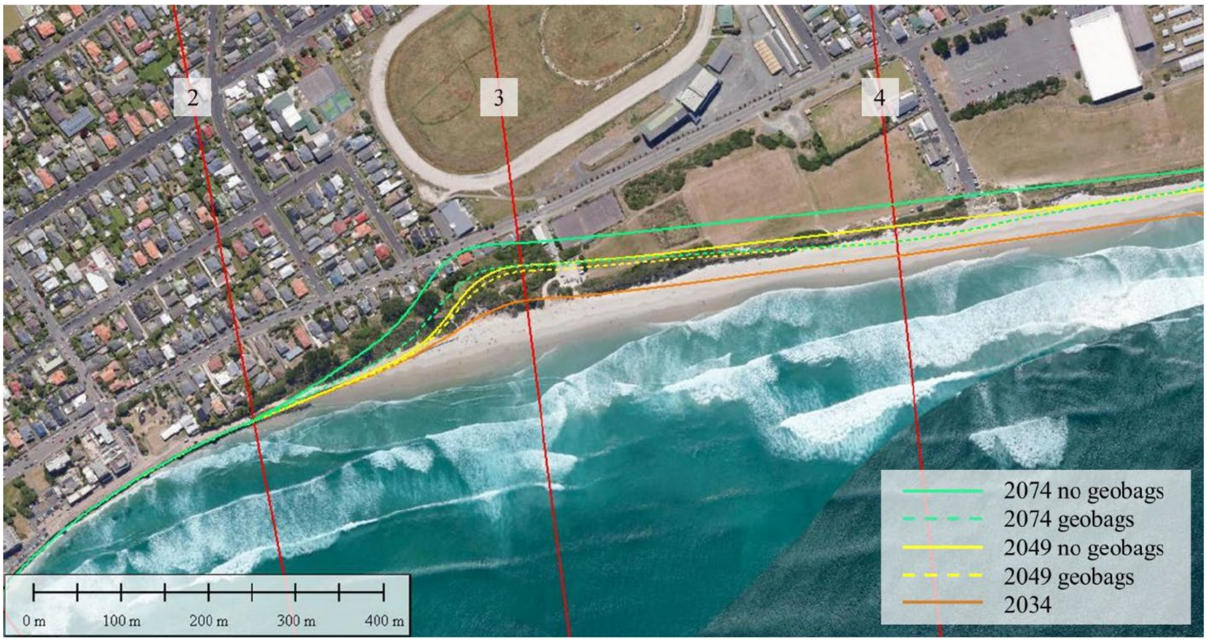


Figure 9.1: Future shoreline positions at St. Clair for scenarios with and without the geotextile containers at Kettle Park (figure from Bagg and Beetham (2025), based on modelling by Atkin and Conroy (2025)).

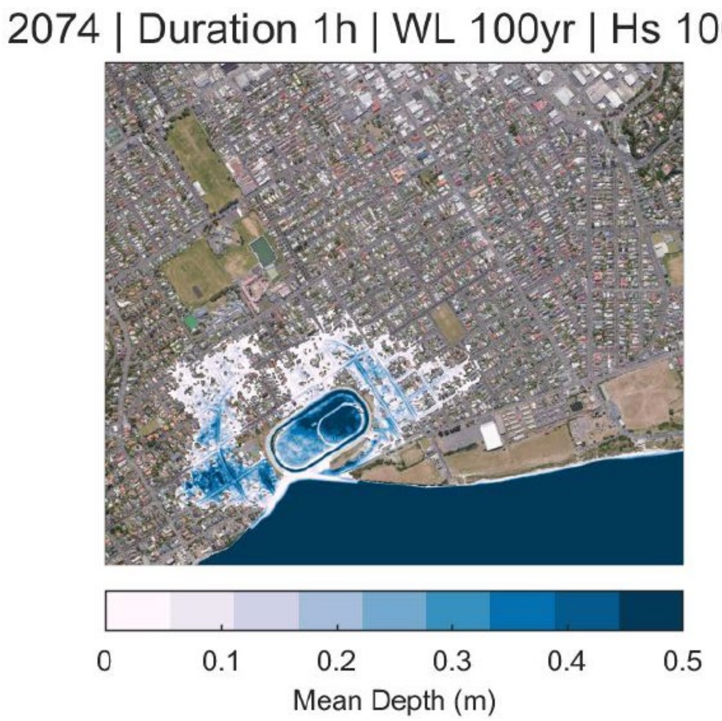


Figure 9.2: Modelled coastal inundation for a 2074 scenario, with 100-year ARI water level and 100-year ARI significant wave height (Bagg and Beetham, 2025).

10. Conclusions and discussion

10.1. Summary of results

Findings from this natural hazard risk review are summarised in Table 10.1. For the present day, assessments show localised areas of *Significant* (i.e., *medium*, *high*, or *very high*) risks for pluvial inundation and groundwater hazards (e.g., Figures 6.1 and 8.3). Although there is uncertainty in the timing of changes, there is a clear overall trend of increasing risk levels through time, with much larger extents identified as being exposed to *Significant* risk due to pluvial, coastal inundation, and groundwater hazards by mid- and end-century timeframes (Figures 6.1, 7.1, 8.2, and 8.3). The only hazard identified as 'very high' risk in this assessment is for areas of emergent groundwater, which becomes a widespread impact only in late-century timeframes.

A major sea level rise 'tipping point' in South Dunedin is identified with approximately 0.6 m relative sea level rise, when widespread emergent groundwater is likely across South Dunedin and coastal inundation of inland South Dunedin is modelled to occur during the 1% AEP storm event. These sea level rise thresholds and the tipping point are illustrated in Figure 10.1, from Cox et al. (2023).

The key point to note is that although several hazard events are event-based, with a likelihood of episodic occurrence (e.g., pluvial flooding, coastal inundation), changes to sea level and groundwater levels are permanent changes that will have both chronic impacts and will also exacerbate those episodic hazards.

Based on the findings of this analysis, many of the individual risks are relatively high and considered *Significant* within the NPS-NH framework. However, these multiple natural hazard threats coexist with South Dunedin, and when considered collectively, the overall cumulative risk level from the multi-hazard landscape will be higher.

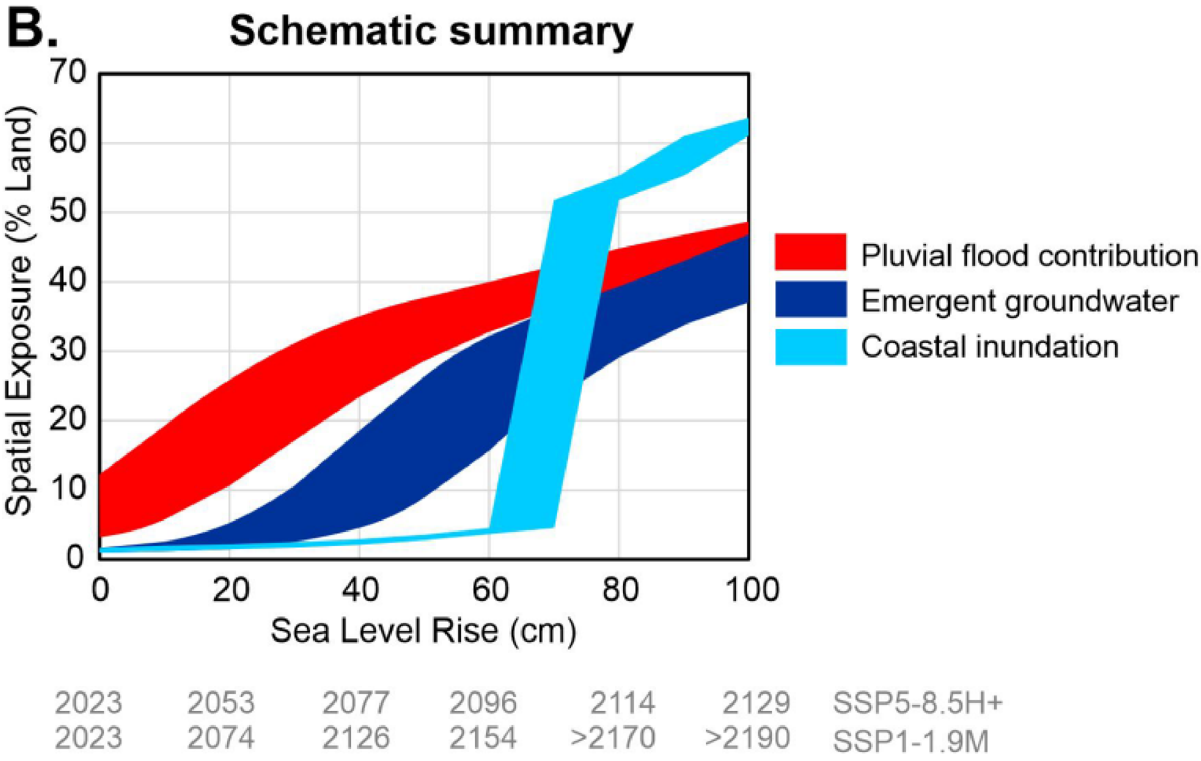


Figure 10.1: Schematic summary showing the percentage of the South Dunedin plain exposed to hazards processes (Cox et al., 2023), illustrating a gradual increase in pluvial flooding and groundwater hazards over time, and a rapid increase in coastal inundation potential at about 0.6 m sea level rise.

Table 10.1: Summary of natural hazard risks in South Dunedin, assessed using the NPS-NH risk framework.

Hazard	Asset	Timeframe Present-day	Mid-century	Late-century	Comment
Pluvial flooding	Property (buildings)	Widespread areas of *Medium* risk (collectively identified as areas of 'Significant' risk)	Increasing extents of *Medium* risk (collectively identified as areas of 'Significant' risk)	Increasing extents of *Medium* risk (collectively identified as areas of 'Significant' risk)	For areas of new development, the minimum floor level requirement will substantially reduce consequence and risks to buildings
Pluvial flooding	Health & safety	Scattered, localised areas of *Medium* risk, when considering only potential for injury or death, however may also result in a wide range of indirect health and wellbeing impacts.			
Pluvial flooding	Lifelines infrastructure	The assets most sensitive to damages from floodwater inundation are electrical substations, pump stations, and the wastewater network.			
Coastal inundation	Property (buildings)	No exposure in urban areas except a small area of *Medium* risk alongside Portsmouth Drive.	No exposure except a small area of *Medium* risk alongside Portsmouth Drive.	Widespread areas of *Medium* risk. In the SSP8.5 scenario this includes broad areas of scattered *High* risk.	Coastal inundation is also possible due to a breach of the St. Kilda–St. Clair dune system
Coastal inundation	Health & safety	No exposure in urban areas except alongside Portsmouth Drive.	No exposure in urban areas except alongside Portsmouth Drive.	Widespread deep (>1.2m) inundation which may pose a direct health and safety risk. Consequence would depend on the speed of onset, and ability for early warning and evacuation	
Groundwater	Property (buildings)	Scattered areas of *High* risk, but risk otherwise *Low*	Widespread areas of *High* risk, with scattered areas of *Very high* risk	Increasing areas of *Very high* risk, very extensive in the SSP8.5 scenario.	

Groundwater	Health & safety	Risk levels and spatial distribution are closely aligned with those for buildings	
Groundwater	Lifelines infrastructure	The assets most sensitive to damages from shallow groundwater levels are roads.	
Coastal erosion	Property and lifelines	Buildings and roading assets are highly or extremely sensitive to coastal erosion damages, but exposure is limited to the vicinity of the coastal margin	

10.2. Hazard mitigation

The natural hazard risks in South Dunedin are assessed for a ‘status quo’ scenario with no new hazard mitigation interventions in place, where the main property-scale existing hazard mitigations are requirements for minimum floor levels and use of ‘relocatable’ buildings.

Minimum floor level requirements and their influence on natural hazard risk levels are discussed in Sections 6.12, 7.12, 8.12, and 10.2.1.

The South Dunedin Future work programme is developing a climate adaptation master plan for South Dunedin, which will propose a portfolio of longer-term hazard mitigation approaches. This work programme is discussed in Section 10.2.2.

10.2.1.1. Minimum floor levels

The current minimum floor level (MFL) requirements are designed to mitigate for the pluvial flooding hazard and should be effective for mitigation of building damage for pluvial flooding events of comparable magnitude to those which occurred in 2015 and 2024. The risks from pluvial flooding to new buildings complying with the required minimum floor level are, therefore, reduced, but although the dwelling itself may be no longer exposed to direct impact by pluvial inundation, the property (and neighbouring properties and the wider community) remain vulnerable to indirect impact through disruption of the supporting infrastructure systems, such as closure of local road access, or disruptions to critical services such as wastewater.

The current approach to setting MFL is based on observations of flooding depths in recent large events but was not specifically developed to mitigate for very large pluvial events such as a maximum credible event (MCE) scenario. It is also not known whether the MFL is sufficient to account for the effects of potential coincident hazards impacts on pluvial flooding (e.g., a pluvial event coinciding with coastal inundation or a period of elevated groundwater levels and, therefore, reduced subsurface storage).

Minimum floor levels for new buildings are not designed specifically as mitigation against the effects of coastal inundation or shallow groundwater. These hazard types differ in characteristics from pluvial inundation events, and there is not currently any information available to guide evaluation of any mitigation benefits which minimum floor levels may provide.

10.2.2. South Dunedin Future

The longer-term adaptation pathways being investigated and developed by the South Dunedin Future work programme (e.g., Robichaux et al., 2023; Kuparinen and Taylor-Silva., 2025) are designed to develop a climate adaptation master plan for South Dunedin. The programme vision is "a safer and better South Dunedin, where sustainable urban regeneration leads to improved community resilience and wellbeing".

However, the interventions making up these SDF programme pathways are not currently funded, and no decisions have been made about timing or implementation of major infrastructure or land-use changes for hazard mitigation. It is, therefore, too uncertain to account for any potential mitigations developed through the SDF work programme within risk assessments at this stage, meaning that these risk levels may be viewed as being relatively conservative. Progression towards those SDF hazard mitigation approaches is relatively well advanced, and selected mitigation interventions are expected to be implemented in the medium to long term. However, it is important to note that any implemented hazard mitigation approach will not fully eliminate a risk, and there will be some residual risk remaining (e.g., in case of a super-design event, or failure of critical infrastructure).

10.3. Cascading and cumulative risks

Although the risk for each type of natural hazard is considered individually in this assessment, the hazards processes are not independent, and, in reality, are interrelated and are likely to have exacerbating effects on each other. For example, sea level rise influences groundwater level, causing impacts to buildings and health, but also reduces subsurface storage and so exacerbates pluvial flooding.

In addition to cascading interactions between natural hazards processes, there is also a strong likelihood of cascading consequences occurring across a number of domains, e.g., social impact, buildings and infrastructure, economic, and environmental (illustrated in Figure 10.2).

The likelihood of an event from any hazard type having a substantial consequence impacting South Dunedin within a future timeframe will be greater than the likelihood assessed for each hazard type individually. Similarly, these independent natural hazards events (e.g., pluvial flooding, groundwater rise, or coastal inundation) may occur concurrently or in close succession, and the resulting consequences may be much more severe than when assessed individually.

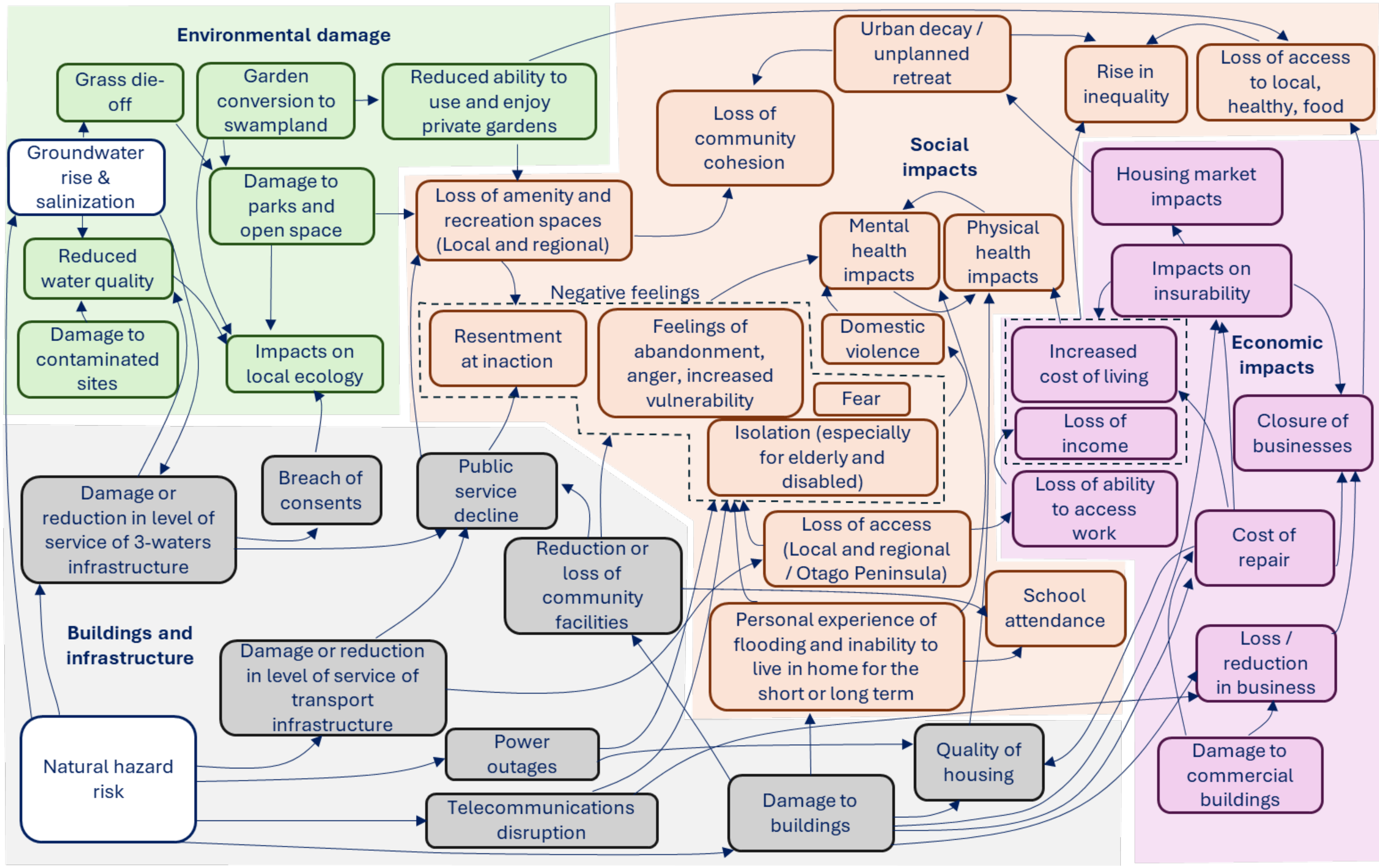


Figure 10.2: Overview of cascading risk arising from natural hazard and climate change risk to South Dunedin (Figure E-2 of Cowper-Heays, 2025)

10.4. Risk tolerance

In addition to the level of the natural hazard risks assessed, the tolerability of those risks to the community and other stakeholders should also be considered. The South Dunedin Future work programme has completed extensive community and stakeholder engagement regarding natural hazards adaptation and potential adaptation options, which provides a guide to community opinions on risk tolerability.

During 2025, community feedback on a range of seven potential adaptation futures indicated a strong dissatisfaction for an approach of 'keep doing what we are doing', where almost 73% of respondents indicated that 'Future 1 – Status quo' is taking South Dunedin in the wrong direction (Greenshields, 2025).

Specific engagement feedback regarding the potential for water to enter homes due to flooding is also a guide to the community tolerance for natural hazard risks. Approximately 83% of the 270 responses indicated that South Dunedin would become 'unliveable' if flood water entered their homes (Figure 10.3). Many respondents also said that water in their garage, local shops, and workplaces was unliveable if it occurred every 5 years.

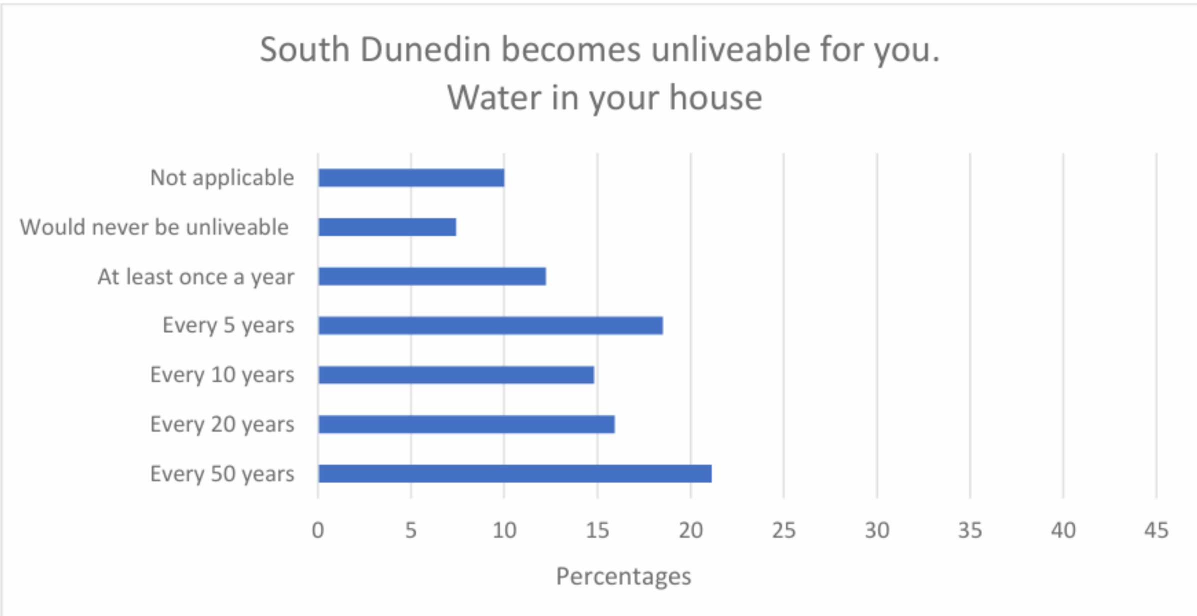


Figure 10.3: Community engagement responses to the tolerability of flooding inside their house (Greenshields, 2025). A total of 7% of the 270 respondents indicated that South Dunedin would never become unliveable if flood water entered their homes, and the question was considered not applicable by another 10% of respondents. The remaining 83% of respondents indicated that South Dunedin would become 'unliveable' for them if flood water entered their homes.

The high levels of community disapproval of the direction of the status quo approach, and for impacts due to flooding, indicate a relatively low tolerance of current risk levels. As severity and likelihood of natural hazards impacts increase, it is, therefore, expected that that the natural hazard risks will be considered increasingly unacceptable in the coming decades.

This risk tolerance information from community feedback can be used to complement the assessed risk analysis information in this report and Cowper-Heays (2025). In some cases, if a particular risk is assessed (for example) as *medium* (NPS-NH) or *Tolerable* (pORPS), a strong community view of that risk as socially unacceptable may be used as justification for 'upgrading' the risks to a higher level of *high* or *Significant*.

If needing to provide more specific guidance regarding the tolerability of these risks, the outcomes of community engagement could be used to assist development of a risk classification matrix tailored to the South Dunedin setting. Any assessment of risk tolerance specific to South Dunedin should take into account not just the views of community members/groups, but also those of all other stakeholders, including Councils (e.g., building, planning, governance), Civil Defence and other emergency services, infrastructure operators, the science community (researchers and engineering consultants), iwi, and insurance providers (Toka Tū Ake EQC 2023).

The considerable effort and resources invested in development of the South Dunedin Future work programme to date demonstrate the relatively low tolerance of both Councils (both governance and staff) to the present-day and projected future South Dunedin riskscape, and the desire to improve the situation through adaptation planning.

10.5. Possible further analysis

If wanting to more comprehensively assess South Dunedin natural hazard risks to support a plan change process, we suggest a review of the appropriateness and dependability of the natural hazards datasets, and consideration of the need for further hazards modelling/analysis or other data collection. These could include the following:

- Consideration of risks for events over a wider range of natural hazards likelihood scenarios, e.g., to include higher likelihood (i.e., more frequent) event scenarios, and a larger-magnitude scenario such as the MCE.
- Further discussion regarding how best to account for chronic or indirect health and safety impacts within the NPS-NH risk framework, which is focused specifically on injuries and fatalities.
- The hazards datasets used in this analysis include a number of key assumptions and uncertainties, and this uncertainty carries over into assessment of risks using those datasets. To help understand the uncertainties and level of confidence associated with this risk mapping, there may be benefit in further describing or classifying the level of confidence associated with each hazard dataset or modelling approach and testing the sensitivity to key assumptions.

- Groundwater hazard to buildings is identified in this assessment as *very high* within the NPS-NH framework, which would have implications under Policy 3 of the NPS, "*Where subdivision, use or development is assessed as having very high natural hazard risk, that risk must be avoided*". We suggest that this hazard risk is investigated further to provide additional confidence to this preliminary assessment of risk levels.
- NIWA's coastal inundation modelling is based only on a 'bathtub' approach that assumes inundation of all hydraulically-connected areas lower than the calculated extreme sea level. A hydrodynamic modelling approach for this hazard would provide higher-confidence modelling outputs to identify the extents and inundation depths of the area potentially exposed. These new modelling findings should be integrated with the hydrodynamic modelling already completed by T+T for the St. Clair–St. Kilda coastline.
- Review of the effectiveness of MFL requirements as mitigation for larger-magnitude pluvial inundation events and the influence of climate change, and their benefit for mitigation against coastal inundation or shallow groundwater hazards.
- Reviewing community/stakeholder engagement feedback from the South Dunedin Future work programme to refine/develop risk tolerability thresholds specific to the South Dunedin community.

11. References

Atkin E and Conroy T, 2025. Technical Support Services for Modelling the St Clair to St Kilda Coastal Plan: Baseline Modelling. Report prepared by eCoast for Dunedin City Council.

Bagg J and Beetham E, 2025. Coastal Inundation Assessment from Dune System Failure – Saint Clair / Saint Kilda. Report prepared by Tonkin + Taylor Ltd for Dunedin City Council.

Baillie RF, 2024. Exploring hospitalisation patterns before and after the 2015 South Dunedin flood. Master of Public Health dissertation, University of Otago, Dunedin.

Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors). Australian Rainfall and Runoff: A Guide to Flood Estimation, © Commonwealth of Australia, (Geoscience Australia), 2019. Report link.

Beca, 2024. ICMP Hydrodynamic modelling results issued specifically to meet the scenario requirements and timeframes of the South Dunedin Future Programme.

BRANZ (Building Research Association of New Zealand_, 2021. Restoring a home after flood damage. BRANZ Bulletin BU666.

Carey-Smith T, 2025. Analysis of October 2024 Otago rainfall event. Report prepared by NIWA for Otago Regional Council. Report link.

Cowper-Heays K, 2025. South Dunedin Future risk assessment report. Report prepared by Kia Rōpine for Otago Regional Council and Dunedin City Council. Report link.

Cox S et al., 2023. Dunedin groundwater monitoring, spatial observations and forecast conditions under sea-level rise. GNS Science Report 2023/43. Report link.

Donnelly R, 2025. Framework for assessing flood risk at the property-level. Report prepared by Richard Donnelly Ltd for Auckland Council. Report link.

Debski D, 2023. Inpatient Building Flood Risk Assessment. Report prepared by Jacobs Ltd for the Minister of Health. Report link.

Dunedin City Council (DCC), 2024. South Dunedin Floor Level – Observational Assessment Specification.

Greenshields G, 2025. South Dunedin Future Engagement Report. Stage 4 Engagement: Spatial long list. Report prepared by Kia Rōpine for Otago Regional Council and Dunedin City Council. Report link.

Harrison S, Macmillan A, Bond S and Stephenson J, 2022. Climate change adaptation decision-making for health and wellbeing in South Dunedin Report on the use of causal mapping for stakeholders. Published by the Department of Preventive and Social Medicine, School of Geography, and Centre for Sustainability University of Otago. Report link.

Kuparinen E and Taylor-Silva M, 2025. South Dunedin Futures Shortlisted Pathways. Prepared by Beca, WSP & Tonkin + Taylor for Dunedin City Council and Otago Regional Council.

Lilley S and Oakley R, 2022. 2021 Update to Methodology for Determining Minimum Floor Levels. Report prepared by Stantec Ltd for Dunedin City Council. Report link.

Menke R, Hoetjes M and Punt A, 2024. Glenorchy and Kinloch Natural Hazards Risk Analysis Report. Prepared by Beca Ltd for Otago Regional Council. Report link.

Ministry for the Environment, 2024. Coastal hazards and climate change guidance, Wellington: Ministry for the Environment.

Ministry for the Environment (MfE), 2025. National Policy Statement for Natural Hazards 2025. Link.

New Zealand Lifelines Council, 2025. Terms of Reference, June 2025. Link.

Otago Regional Council (ORC), 2025. Proposed Otago Regional Policy Statement June 2021, clean appeals version dated 17 October 2025. Link.

Paulik, et al., 2023. National assessment of extreme sea-level driven inundation under rising sea levels. Frontiers in Environmental Science, 10(2633). Link.

McKenzie L, Stephenson J and Orchiston C, 2017. User's Guide to the Greater South Dunedin Geodatabase. Link.

Riddle A and Farley I, 2024. District Coastal Hazards Screening. Report prepared by WSP for Dunedin City Council.

Robichaux L, Smart N, Carvajal C and Coulton M, 2023. South Dunedin Future: Long list of generic adaptation approaches. Prepared by WSP NZ Ltd for

Stephenson J et al, 2018. Communities and climate change: Vulnerability to rising seas and more frequent flooding. Motu Note 29, January 2018. Link.

Toka Tū Ake EQC, 2023a. Risk Tolerance Methodology. Report link.

Van Nieuwkerk E, 2025. South Dunedin Future Groundwater Drainage Options Assessment – draft for client review. Report prepared by WSP for Dunedin City Council.

Wolter A, Easterbrook-Clarke LH, Lin SL and Boyes AF, 2024. RNC2 Weather & Wildfire Landslide Project: Analysis of recent rainfall-induced landslide datasets for vulnerability functions. GNS Science report 2024/21, July 2024.

Zhu C and Foster L, 2026. South Dunedin Future Shortlist Economic Evaluation – draft for review. Report prepared by WSP for Dunedin City Council.

12. Acronyms

Acronym	Definition
2GP	Second Generation Dunedin City District Plan
AEP	Annual Exceedance Probability
AIFR	Annual Individual Fatality Risk
APP6	Appendix 6 of the Proposed Otago Regional Policy Statement 2021, *Methodology for natural hazard risk assessment*
APR	Annual Property Risk
ARI	Average Recurrence Interval
DCC	Dunedin City Council
GNS	GNS Science, a Crown Research Institute now part of Earth Sciences New Zealand
GWL	Groundwater level
mbgl	Metres below ground level
MCE	Maximum Credible Event
MFL	Minimum floor level
NIWA	National Institute of Water and Atmospheric Research, a Crown Research Institute now part of Earth Sciences New Zealand
NPS-NH	National Policy Statement for Natural Hazards 2025
ORC	Otago Regional Council
pORPS	Proposed Otago Regional Policy Statement 2021
RMA	Resource Management Act 1991
RPS	Regional Policy Statement
RSLR	Relative sea level rise, the change in sea level due to the combined movement of both water and land
SDF	South Dunedin Future, a joint ORC and DCC natural hazards adaptation work programme
SLR	Sea level rise
SSP	Shared socio-economic pathway
VLM	Vertical Land Movement

13. Appendices

Appendix A: Natural hazards and risk information created for the South Dunedin area since 2016

Hazard type	Reference
Pluvial flooding	• Beca, 2024. ICMP Hydrodynamic modelling results issued specifically to meet the scenario requirements and timeframes of the South Dunedin Future Programme
Groundwater	• GNS Science (Cox et al.), 2020. Dunedin Groundwater Monitoring and Spatial Observations • GNS Science (Cox et al.), 2023. Dunedin groundwater monitoring, spatial observations and forecast conditions under sea-level rise
Coastal inundation	• NIWA, 2023. Mapping New Zealand's exposure to coastal flooding and sea-level rise.
Coastal erosion	• WSP, 2024. Dunedin Coastal Hazard Screening. • eCoast, 2025. Modelling the St. Clair to St. Kilda Coastal Plan: Baseline Modelling • Tonkin + Taylor, 2025. Coastal Inundation Assessment from Dune System Failure – Saint Clair/Saint Kilda
Liquefaction	• GeoSolve, 2020. Review of Liquefaction Data: South Dunedin • Tonkin + Taylor, 2025. South Dunedin Liquefaction Hazard Groundwater Sensitivity Assessment
Multi-hazard risks	• Kia Rōpine, 2025. South Dunedin Future Programme: Risk Assessment Report
Risk mitigation/ adaptation	• Kia Rōpine, 2025. South Dunedin Future Programme: Potential adaptation futures – Context summary

Appendix B: South Dunedin observed floor height above ground

Floor levels for buildings in South Dunedin were assessed through visual observation (i.e., not surveyed) by DCC staff in October 2024; this map is copied below and was also included in Cowper-Heays (2025) (as Figure C1-1). Observational assessments were completed for the primary building within each property in South Dunedin, with the data collection approach recorded in a DCC document 'South Dunedin Floor Level – Observational Assessment Specification' (DCC, 2024).

Estimated floor heights were recorded as being in one of the following four categories:

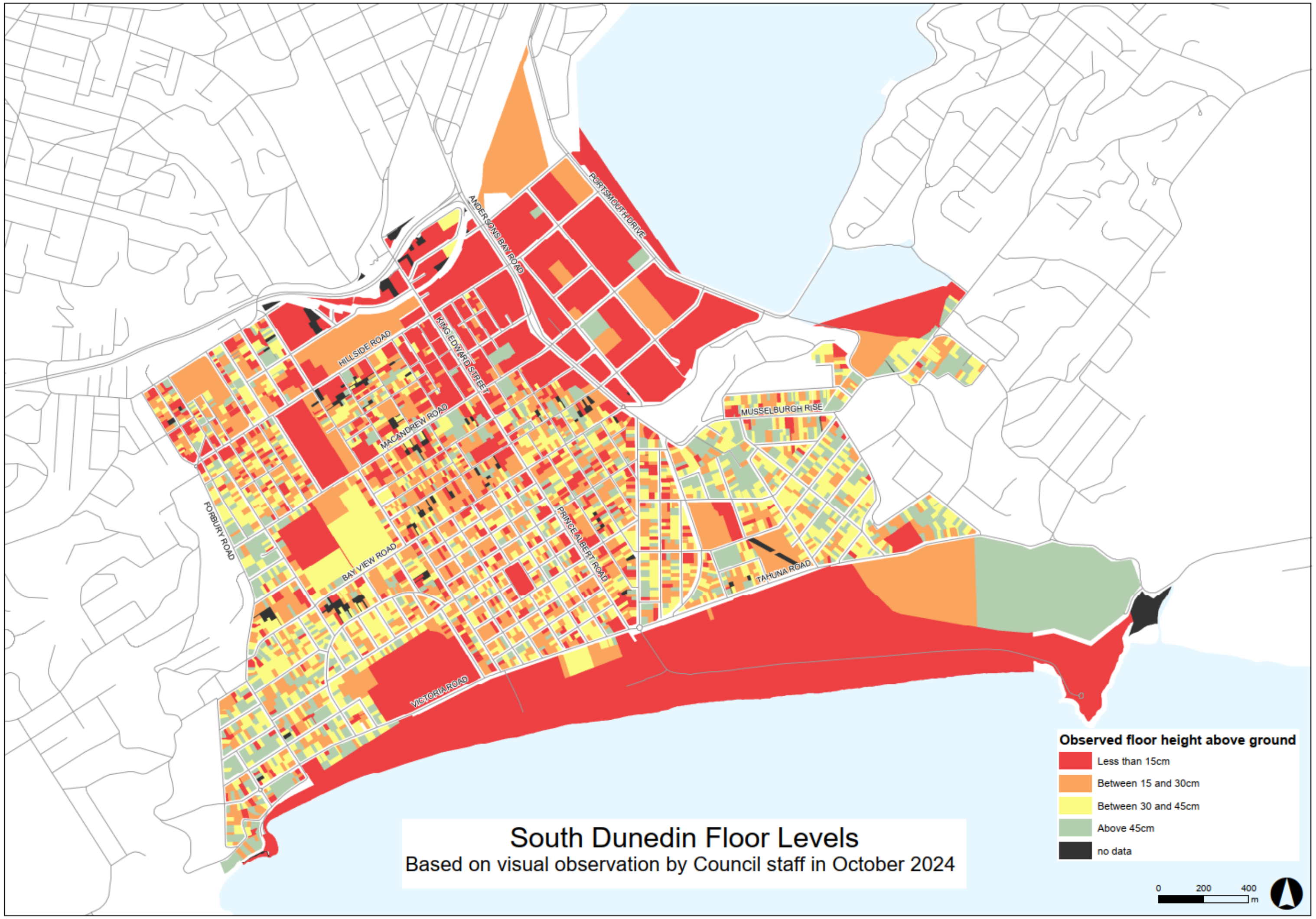
- 0–15 cm (at or near ground level);
- 15–30 cm (at least one step above adjacent ground level);
- 30–45 cm (at least two steps above adjacent ground level);
- 45 cm+ (at least three steps above adjacent ground level).

Excluding 171 properties where floor level was recorded as 'null' or 'no data', and another 8 properties where use category was recorded as 'null', there are estimates of floor levels for 6282 properties in South Dunedin. The breakdown of these properties by building category and estimated floor height is shown as Table B1.

Of these properties, ~57% are identified as having floor levels of <30 cm. For the 5617 residential properties assessed, approximately half (52%) are identified as having floor levels of <30 cm. A large majority of commercial buildings are very low lying, with 75% having floor levels of <15 cm, and 85% lower than 30 cm.

Table B1: Summary of building floor level information for South Dunedin (DCC, 2024).

Category	Estimated floor height				
	0--15 cm	15--30 cm	30–45 cm	45 cm +	Grand Total
Residential	902	2056	1657	991	**5606**
Residential Institution	4	4	2	1	**11**
Commercial	502	67	31	25	**625**
School	7	10	5	4	**26**
Church	4	3	3	4	**14**
Grand Total	**1419**	**2140**	**1698**	**1025**	**6282**


South Dunedin Floor Levels
Based on visual observation by Council staff in October 2024
Observed floor height above ground
Less than 15cm
Between 15 and 30cm
Between 30 and 45cm
Above 45cm
no data
0
200
400
m
ANDERSONS BAY ROAD
PORTSMOUTH DRIVE
HILLSIDE ROAD
KING EDWARD STREET
MACANDREW ROAD
MUSSELBURGH RISE
FORBURY ROAD
PRINCE ALBERT ROAD
BAY VIEW ROAD
TAHUNA ROAD
VICTORIA ROAD

Appendix C: Proposed Otago Regional Policy Statement risk assessment framework

C1: Summary of the proposed Otago Regional Policy Statement risk assessment process (APP6)

13.1.1. **Step 1:** Determine likelihood

Assess the likelihood of magnitudes of natural hazard event, for scenarios representing a high likelihood, median, and the maximum credible event, including consideration of the effect of climate change. Likelihood descriptors are assigned for each scenario using the scale presented in Table C1.

Table C1: Likelihood scale of the proposed Otago RPS (ORC 2025).

Likelihood	Indicative frequency
Almost certain	Up to once every 50 years (2% AEP)
Likely	Once every 51 – 100 years (2 – 1% AEP)
Possible	Once every 101 – 1,000 years (1 – 0.11% AEP)
Unlikely	Once every 1,001 – 2,500 years (0.1 – 0.04% AEP)
Rare	2,501 years plus (<0.04% AEP)

13.1.2. **Step 2:** Natural hazard consequence

Natural hazard consequence for each hazard scenario is determined for the effects on life and injury (public health and safety) and the built environment, including buildings and lifelines, by considering both the matters listed in Table C2 and the consequence descriptors in Table C3.

Table C2: Matters to be considered in assessment of natural hazard consequence (ORC, 2025).

1. The nature and scale of existing activities in the area;
2. The natural and scale of the activity proposed or provided for and any hazard mitigation measures;
3. Individual and community vulnerability and resilience;
4. Impacts on individual and community health and safety;
5. Impacts on social, cultural and economic wellbeing;
6. Impacts on infrastructure and property, including access and services;
7. Available and viable risk reduction and hazard mitigation measures;
8. Lifeline utilities, essential and emergency services, and their co-dependence;
9. Implications for civil defence agencies and emergency services;
10. The changing natural hazard environment;
11. Cumulative effects including multiple and cascading hazards, where present;
12. Factors that may exacerbate a natural hazard event including the effects of climate change.

Table C3: Consequence classification descriptors (ORC, 2025).

Severity of Impact	Built				Health & Safety
	Social/Cultural	*Buildings*	Critical *Buildings*	Lifelines	
Catastrophic (V)	≥25% of *buildings* of social/cultural significance within hazard impact area have functionality compromised	≥50% of *buildings* within hazard impact area have functionality compromised	≥25% of critical facilities within hazard impact area have functionality compromised	Out of service for > 1 month (affecting ≥20% of the town/city population) OR suburbs out of service for > 6 months (affecting < 20% of the town/city population)	> 10 dead and/or > 1001 injured
Major (IV)	11-24% of *buildings* of social/cultural significance within hazard impact area have functionality compromised	21-49% of *buildings* within hazard impact area have functionality compromised	11-24% of *buildings* within hazard impact area have functionality compromised	Out of service for 1 week – 1 month (affecting ≥20% of the town/city population) OR suburbs out of service for 6 weeks to 6 months (affecting < 20% of the town/city population)	1 – 10 dead and/or 101 – 1000 injured
Moderate (III)	6-10% of *buildings* of social/cultural significance within hazard impact area have functionality compromised	11-20% of *buildings* within hazard impact area have functionality compromised	6-10% of *buildings* within hazard impact area have functionality compromised	Out of service for 1 day to 1 week (affecting ≥20% of the town/city population) OR suburbs out of service for 1 week to 6 weeks (affecting < 20% of the town/city population)	11 – 100 injured
Minor (II)	1-5% of *buildings* of social/cultural significance within hazard impact area have functionality compromised	2-10% of *buildings* within hazard impact area have functionality compromised	1-5% of *buildings* within hazard impact area have functionality compromised	Out of service for 2 hours to 1 day (affecting ≥20% of the town/city population) OR suburbs out of service for 1 day to 1 week (affecting < 20% of the town/city population	10 injured
Insignificant (I)	No *buildings* of social/cultural significance within hazard impact area have functionality compromised	< 1% of *buildings* within hazard impact area have functionality compromised	No damage within hazard impact area, fully functional	Out of service for up to 2 hours (affecting ≥20% of the town/city population) OR suburbs out of service for up to 1 day (affecting < 20% of the town/city population	No dead No injured

When assessing consequences within this matrix, the final level of impact is assessed on the 'first past the post' principle, in that the consequence with the highest severity of impact applies. For example, if a *natural hazard* event resulted in moderate severity of impact across all of the categories, with the exception of critical *buildings* which had a 'major' severity of impact, the major impact is what the proposal would be assessed on. If a *natural hazard* event resulted in all of the consequences being at the same level (for example, all of the consequences are rated moderate), then the level of consequence is considered to be moderate.

Consequence is to be assessed for Health and safety, lifelines, and buildings, including buildings of social/cultural importance or considered critical. Critical or social/cultural buildings are not specifically assessed in this risk review, as risk to buildings in general provides a better spatial overview of risk distribution applicable to potential new development.

Lifeline utilities are the essential infrastructure and services that support a community. These are defined in the pORPS as meaning utilities provided by those entities listed in the CDEM Act (2002)[15]. These include:

a. Utility services such as water, wastewater and stormwater, electricity, gas, and telecommunications;
b. Transportation networks including road, rail, airports and ports;
c. Fuel production and distribution.

Fast-moving consumer goods (FMCGs, i.e., supermarkets) and banking services are identified as 'lifeline-adjacent sectors' (NZ Lifelines Council, 2025) and are sometimes also included within lifelines assessments for risk assessment.

'Functionality compromised' is a key term in the assessment of consequence to buildings. This term is not defined in the RPS, but there is reasonable consensus amongst previous studies that have applied the pORPS or similar methodologies (Table C4).

For this assessment, a building is considered functionally compromised when it cannot continue to be used for its intended use immediately after an event. It is assumed that any flood inundation above the floor level of a building will result in its functionality being compromised.

[15] Schedule 1 of the Civil Defence Emergency Management Act 2002

Table C4: Definitions of 'functionality compromised' for assessment of consequence to buildings.

<table>
<tr><th>Reference</th><th>Definition</th></tr>
<tr><td>Tonkin + Taylor Ltd. (M Waugh and M Ogden), 2025. Clutha Delta Qualitative Risk Assessment (Seismic)</td><td>The following criteria have been developed for considering the proportion of buildings that are functionally compromised:
The building cannot continue to be used for its intended use immediately after the event; and/or
The building is not repairable without relocation of its occupants for more than four weeks.</td></tr>
<tr><td>Beca Ltd. (R Menke, M Hoetjes and A Punt), 2024. Glenorchy and Kinloch Natural Hazards Risk Analysis Report.</td><td>For the purposes of this study a building is considered functionally compromised when it cannot continue to be used for its intended use immediately after an event. This may be due to the building being unable to provide its primary function of providing shelter. Also, the building may be in a temporary or permanent condition that poses a health and safety risk to occupants (physical or biological).

In this study, it is defined that a building has its functionality compromised as soon as the building footprint is flooded.</td></tr>
<tr><td>WSP Ltd. (H Porter and S Hill), 2026. Roxburgh Debris Flow and Debris Flood Study - Hydrogeomorphic Modelling and Quantitative Risk Assessment Report.</td><td>A building is considered to have its functionality compromised when it cannot be used for its intended purpose immediately after an event. This may include the following:
If the building has sustained significant damage.
If the building is Red/Yellow stickered under the Building Act.
If key utilities are not operative (e.g. water supply, wastewater, power).
If safe access/egress is not possible.
We assume that any debris flood inundation above the floor level of a building will mean that the building cannot be used for its intended purpose immediately following an event and therefore is classified as functionality compromised.</td></tr>
<tr><td>Bay of Plenty Regional Policy Statement. Appendix I – Methodology for risk assessment</td><td>A degree of discretion will need to be exercised in determining whether buildings would have been "functionality compromised" and in determining whether a lifeline utility is out of service or just has service compromised.

In the context of damage to buildings, "functionally compromised" will generally occur when a building cannot continue to be used for its intended use immediately after an event.

However, the nature and duration of loss of functioning will be relevant and judgement will need to be made as to whether the extent of likely damage has a serious or manageable impact on normal social and business functioning.</td></tr>
</table>

13.1.3. **Step 3:** Assessing natural hazard risk

Determine the qualitative risk level for each hazard and scale of event using the risk matrix shown in Table 3.4, based on the likelihood and consequence assigned in Steps 1 and 2. Risk levels are described qualitatively using three risk descriptors:

a. Acceptable risk;
b. Tolerable risk ;
c. Significant risk.

These descriptors imply an assessment of the tolerability of risks, however, they are provided only as a regional-scale baseline, and a more detailed understanding of risk level thresholds may be developed at a district or community scale following a consultation process.

Table C5: pORPS risk matrix.

Likelihood	**Consequences**				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain					
Likely					
Possible					
Unlikely					
Rare					
Green: Acceptable *Risk* Yellow: Tolerable *Risk* Red: Significant *Risk* Hatching: *Quantitative assessment required*					

13.1.4. **Step 4:** Undertake a quantitative risk assessment

The pORPS guidance specifies that a quantitative assessment[16] of risk is to be carried out for any risks located within the hatched area of Table C5. Risks are to be calculated as Annual Individual Fatality Risk (AIFR) and Annual Property Risk (APR) for a range of natural hazards scenarios, and risk values can then be compared with the risk thresholds provided for both areas of existing and new development.

[16] A method that uses numerical, explicit values for both likelihood and consequences.

C2: Appendix 6 (APP6) of the proposed Otago Regional Policy Statement (**October 2025 version following completion of mediation**).

APP6 – Methodology for *natural hazard* risk assessment

Undertake the following four step process to determine the *natural hazard* risk.

Step 1 – Determine the likelihood

(1) Assess the likelihood of three *natural hazard* scenarios occurring, representing a high likelihood, median likelihood, and the maximum credible event, using the best available information.

(2) Use table 6 to assign a likelihood descriptor to the three natural hazard scenarios.

(3) The likelihood assessment shall include consideration of the *effect* of *climate change* and should use the Shared Socio-Economic Pathway (SSP) scenarios or Representative Concentration Pathways (RCP) scenarios provided in the National Adaptation Plan.

Table 6: Likelihood scale

Likelihood	Indicative frequency
Almost certain	Up to once every 50 years (2% AEP)
Likely	Once every 51 – 100 years (2 – 1% AEP)
Possible	Once every 101 – 1,000 years (1 – 0.11% AEP)
Unlikely	Once every 1,001 – 2,500 years (0.1 – 0.04% AEP)
Rare	2,501 years plus (<0.04% AEP)

Step 2 – *Natural hazard* consequence

The matters listed in (1) to (11) below, are used to inform the consequence (catastrophic, major, moderate, minor, or insignificant) of the *natural hazard* scenarios identified in Step 1 for Table 7 considering:

(1) the nature and scale of existing activities in the area,

(1A) the natural and scale of the activity proposed or provided for and any hazard mitigation measures,

(2) individual and community vulnerability and *resilience*,

(3) impacts on individual and community health and safety,

(4) impacts on social, cultural and economic well-being,

(5) impacts on *infrastructure* and property, including access and services,

(6) available and viable risk reduction and hazard mitigation measures,

(7) *lifeline utilities*, essential and emergency services, and their co-dependence,

(8) implications for civil defence agencies and emergency services,

(9) the changing *natural hazard* environment,

(10) cumulative *effects* including multiple and *cascading hazards,* where present, and

(11) factors that may exacerbate a *natural hazard* event including the *effects* of *climate change*.

Table 7: Consequence table

Severity of Impact	**Built**				**Health & Safety**
	Social/Cultural	*Buildings*	Critical *Buildings*	Lifelines	
Catastrophic (V)	≥25% of *buildings* of social/cultural significance within hazard impact area have functionality compromised	≥50% of *buildings* within hazard impact area have functionality compromised	≥25% of critical facilities within hazard impact area have functionality compromised	Out of service for > 1 month (affecting ≥20% of the town/city population) OR suburbs out of service for > 6 months (affecting < 20% of the town/city population)	> 10 dead and/or > 1001 injured
Major (IV)	11-24% of *buildings* of social/cultural significance within hazard impact area have functionality compromised	21-49% of *buildings* within hazard impact area have functionality compromised	11-24% of *buildings* within hazard impact area have functionality compromised	Out of service for 1 week – 1 month (affecting ≥20% of the town/city population) OR suburbs out of service for 6 weeks to 6 months (affecting < 20% of the town/city population)	1 – 10 dead and/or 101 – 1000 injured
Moderate (III)	6-10% of *buildings* of social/cultural significance within hazard impact area have functionality compromised	11-20% of *buildings* within hazard impact area have functionality compromised	6-10% of *buildings* within hazard impact area have functionality compromised	Out of service for 1 day to 1 week (affecting ≥20% of the town/city population) OR suburbs out of service for 1 week to 6 weeks (affecting < 20% of the town/city population)	11 – 100 injured
Minor (II)	1-5% of *buildings* of social/cultural significance within hazard impact area have functionality compromised	2-10% of *buildings* within hazard impact area have functionality compromised	1-5% of *buildings* within hazard impact area have functionality compromised	Out of service for 2 hours to 1 day (affecting ≥20% of the town/city population) OR suburbs out of service for 1 day to 1 week (affecting < 20% of the town/city population	10 injured
Insignificant (I)	No *buildings* of social/cultural significance within hazard impact area have functionality compromised	< 1% of *buildings* within hazard impact area have functionality compromised	No damage within hazard impact area, fully functional	Out of service for up to 2 hours (affecting ≥20% of the town/city population) OR suburbs out of service for up to 1 day (affecting < 20% of the town/city population	No dead No injured

When assessing consequences within this matrix, the final level of impact is assessed on the 'first past the post' principle, in that the consequence with the highest severity of impact applies. For example, if a *natural hazard* event resulted in moderate severity of impact across all of the categories, with the exception of critical *buildings* which had a 'major' severity of impact, the major impact is what the proposal would be assessed on. If a *natural hazard* event resulted in all of the consequences being at the same level (for example, all of the consequences are rated moderate), then the level of consequence is considered to be moderate.

Step 3 – Assessing natural hazard risk

Using the information within steps 1 and 2 above, complete Table 8 for each of the hazard scenarios considered, and identify if the risk from each of the scenarios is acceptable, tolerable, or significant.

Table 8: Risk table

Likelihood	**Consequences**				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain					
Likely					
Possible					
Unlikely					
Rare					

Green: Acceptable Risk
Yellow: Tolerable Risk
Red: Significant Risk
Hatching: *Quantitative assessment required*

Notes:

Table 8 above has been included as a region-wide baseline. As set out in HAZ-NH-M2(1) *local authorities* are required to undertake a consultation process with communities, stakeholders and partners regarding risk levels thresholds and develop a risk table at a district or community scale. This region-wide baseline is to be used in the absence of a district or community scale risk table being developed.

Step 4 – Undertake a quantitative risk assessment

While Steps 1-3 will qualitatively categorise *natural hazard* risk based on a community's understanding and acceptance level of risk, it will not provide quantitative understanding of the risk a *natural hazard* presents to the built environment, or health and safety.

If the assessment undertaken in Steps 1-3 determines that one of the three *natural hazard* scenarios generate risk with major consequences with an almost certain or likely likelihood, or catastrophic consequence with an almost certain, likely, or possible likelihood, then a quantitative risk assessment is required. If appropriate, there is discretion for local authorities to also require a quantitative risk assessment for risk that does not come within these categories. A quantitative risk assessment will be undertaken using the following methodology:[177]

(1) Based on the likelihood of a *natural hazard* event within the hazard zone (see Step 1), and including the potential impacts of *climate change* and sea level rise, select a representative range of at least three hazard scenarios with varying likelihoods to model,[178] including the maximum credible event.

(2) Model the Annual Individual Fatality Risk (AIFR)[179] and Annual Property Risk (APR)[180] for the range of hazard scenarios across the hazard zone, and create loss exceedance distributions.

(3) Analyse loss exceedance distributions and determine losses.

(4) Assign the risk level:

    (a) for areas of new development where the greatest AIFR or APR is:

        (i) less than 1×10^{-6} per year, the risk is re-categorised as acceptable,

        (ii) between 1×10^{-6} and 1×10^{-5} per year, the risk is re-categorised as tolerable, or

        (iii) greater than 1×10^{-5} per year, the risk is re-categorised as significant.

    (b) for areas with existing development, where the greatest AIFR or APR is:

[177] This methodology has been developed in general accordance with the Australian Geomechanics Society, 2007 methodology, which may usefully provide additional guidance.
[178] The model should include an analysis of uncertainty.
[179] Annual probability that an individual most at risk is killed in any one year as a result of the hazards occurring.
[180] Annual probability of total property loss (relating to permanent structures) as a result of the hazards occurring.

        (i) less than 1×10^{-5} per year, the risk is re-categorised as acceptable;

        (ii) between 1×10^{-5} and 1×10^{-4} per year, the risk is re-categorised as tolerable; or

        (iii) greater than 1×10^{-4} per year, the risk is re-categorised as significant.

AIFR and APR are the selected risk metrics as they represent the likely consequences of a wide range of *natural hazards*. For example, some *natural hazards*, generally, do not have the capacity to cause fatalities, but may result in widespread damage to property, while other *natural hazards* have a high capacity to cause fatalities. A first-past-the-post principle to the re-categorisation of risk is applied to ensure that decisions are based on the greatest risk present between the two metrics.

If the level of knowledge or uncertainty regarding the likelihood or consequences of a *natural hazard* event precludes the use of Step 4, then a precautionary approach to assessing and managing the risk should be applied, as set out in HAZ-NH-P5.

Appendix D: Appendix 1 of the National Policy Statement for Natural Hazards 2025: Risk matrix, likelihood and consequence tables

When undertaking an assessment of natural hazard risk, the following risk matrix and associated tables must be applied to enable assessment of the consequence level and likelihood level and to determine the level of natural hazard risk applicable.

Figure 1: Risk matrix

		Likelihood Level						
		Almost Certain	Very Likely	Likely	Possible	Unlikely	Rare	Very Rare
	ARI (years)	up to 10	10-20	20-50	50-100	100-500	500-5000	> 5000
	AEP	10% or more	10% to 5%	5% to 2%	2% to 1%	1% to 0.2%	0.2% to 0.02%	< 0.02%
Consequence Level	Catastrophic	Very High	Very High	Very High	High	Medium	Medium	Medium
	Major	Very High	Very High	High	High	Medium	Medium	Medium
	Moderate	High	High	High	Medium	Medium	Low	Low
	Minor	Medium	Medium	Medium	Medium	Low	Low	Low
	Negligible	Low	Low	Low	Low	Low	Low	Low

Note: The top end of the likelihood range includes the top end year, that is: Likely = over 20 years and up to and including 50 years.

Table 1: Likelihood table

Likelihood level	Annual exceedance probability (AEP)	Average recurrence interval (ARI) or 'return period'
Almost certain	10% or more	Up to and including 10 years
Very likely	10% to 5%	Over 10 and up to and including 20 years
Likely	5% to 2%	Over 20 and up to and including 50 years
Possible	2% to 1%	Over 50 and up to and including 100 years
Unlikely	1% to 0.2%	Over 100 and up to and including 500 years
Rare	0.2% to 0.02%	Over 500 and up to and including 5,000 years
Very rare	Less than 0.02%	More than 5,000 years

Table 2: Consequence table

Consequence level	Damage to property	Potential for injury or fatalities
Catastrophic	Severe damage to land and building(s), potential for collapse or total destruction of structures. Building(s) need to be demolished, rebuilt or relocated.	High threat to life safety, with probable fatalities and/or critical injuries.
Major	Major damage to land and building(s), including structural damage. Loss of use and substantial repair required.	Unsafe for people, with potential for many injuries, or critical injuries and/or fatalities.
Moderate	Some damage to land and non-structural damage to building(s). Limited loss of use, repairs required.	Unsafe for people, with potential for injuries, although expected to be minor.
Minor	Minor damage to land and building(s). No loss of use, minimal repairs required.	Isolated minor injuries possible.
Negligible	No loss of use, no building repairs required.	No injuries.

Appendix E: Comparison of the pORPS and NPS-NH risk assessment frameworks

Both the pORPS and NPS-NH follow the same general approach and key steps to qualitative assessment, both utilising a classification of likelihood and consequence, followed by assessment of risk levels using a risk matrix.

However, inconsistency in definitions and terminology between the two risk frameworks means that risk levels are not directly comparable. For example, both frameworks use a similar series of terms for naming likelihood classes, but the same likelihood terms vary in definition between the pORPS and NPS-NH (Table E1).

Both frameworks assess consequences within five classes (Table E2), with consistent terminology except for the lowest impact class, which is termed Insignificant (pORPS) or Negligible (NPS-NH). Each of the five consequence levels in each framework are approximately aligned, but there are differences in how the pORPS and NPS-NH frameworks describe consequences. For property damage (buildings and lifelines), the pORPS focuses on functionality or impacts to service, while the NPS-NH focuses on severity of damages. For health and safety risks, the pOPRS specifies numbers of injuries or fatalities within each consequence class, while the NPS-NH describes these qualitatively.

The pORPS and NPS-NH risk matrices are not directly comparable due to their differences in likelihood classification and consequence description. Table E3 shows both risk matrices reformatted with comparable likelihood classification and with consequences as rows in the table (transposing the pORPS matrix).

The term 'significant' is used to describe risks in both risk frameworks:

- The pORPS framework uses the term 'significant' as one of three risk level classes (*Acceptable*, *Tolerable,* and *Significant*).
- The NPS-NH defines four risk level classes (*Low*, *Medium*, *High,* and *Very high*), and then uses the term 'significant' as a collective term for risks that are identified as medium, high, or very high risk. This NPS-NH definition of significant is more expansive and would include some risks classified as *Tolerable* or even *Acceptable*[17] by the pORPS (Table E3).

[17] e.g. An event of 50-100 year ARI with 'Minor' consequence would be classified as an *Acceptable* risk in the pORPS, but a *Medium* risk in the NPS-NH and therefore within the *Significant* risk grouping.

Table E1: Comparison of likelihood classifications by the pORPS and NPS-NH risk assessment frameworks.

Likelihood class (pORPS)	Likelihood (ARI)	Likelihood class (NPS-NH)
Almost Certain	**up to 10**	Almost Certain
	11–20	Very Likely
	21–50	Likely
Likely	**51–100**	Possible
Possible	**101–500**	Unlikely
	501–1000	Rare
Unlikely	**1001–2500**	
Rare	**2501–5000**	
	>5000	Very Rare

Table E2: Comparison of the consequences classifications used by the pORPS (left) and NPS-NH (right) risk assessment frameworks.

pORPS				NPS-NH	
Consequence description			Consequence level	Consequence description	
Health and Safety	**Buildings***	**Lifelines**		**Damage to property**	**Potential for injury or fatalities**
>10 dead and/or >1001 injured	≥50% of buildings within hazard impact area have functionality compromised.	Out of service for >1 month (affecting ≥20% of the town/city population) OR suburbs out of service for >6 months (affecting <20% of the town/city population).	**Catastrophic**	Severe damage to land and building(s), potential for collapse or total destruction of structures. Building(s) need to be demolished, rebuilt or relocated.	High threat to life safety, with probable fatalities and/or critical injuries.
1–10 dead and/or 101–1000 injured	21–49% of buildings within hazard impact area have functionality compromised.	Out of service for 1 week–1 month (affecting ≥20% of the town/city population) OR suburbs out of service for 6 weeks to 6 months (affecting <20% of the town/city population).	**Major**	Major damage to land and building(s), including structural damage. Loss of use and substantial repair required.	Unsafe for people, with potential for many injuries, or critical injuries and/or fatalities.
11–100 injured	11–20% of buildings within hazard impact area have functionality compromised.	Out of service for 1 day to 1 week (affecting ≥20% of the town/city population) OR suburbs out of service for 1 week to 6 weeks (affecting <20% of the town/city population) .	**Moderate**	Some damage to land and non-structural damage to building(s). Limited loss of use, repairs required.	Unsafe for people, with potential for injuries, although expected to be minor.
10 injured	2–10% of buildings within hazard impact area have functionality compromised.	Out of service for 2 hours to 1 day (affecting ≥20% of the town/city population) OR suburbs out of service for 1 day to 1 week (affecting <20% of the town/city population.	**Minor**	Minor damage to land and building(s). No loss of use, minimal repairs required.	Isolated minor injuries possible.
No dead No injured	<1% of buildings within hazard impact area have functionality compromised.	Out of service for up to 2 hours (affecting ≥20% of the town/city population) OR suburbs out of service for up to 1 day (affecting <20% of the town/city population.	**Insignificant/ Negligible**	No loss of use, no building repairs required.	No injuries.

* Assessment of buildings consequences in the pORPS also includes separate criteria for social/cultural and critical buildings.

Table E3: Comparison of the pOPRS (upper) and NPS-NH (lower) risk matrices, aligned to show risk levels with comparable likelihood classification. The extent of 'significant' risk as defined by the pORPS framework is outlined as a dashed black line in each matrix, and 'significant' risk in the NPS-NH framework as a blue dotted outline.

pORPS		Likelihood								
		<10	10 to 20	20 to 50	50 to 100	100 to 500	500 to 1000	1000 to 2500	2500 to 5000	>5000
Consequence	Catastrophic		Significant risk							
	Major									
	Moderate				Tolerable risk					
	Minor							Acceptable risk		
	Insignificant									

NPS-NH		Likelihood								
		<10	10 to 20	20 to 50	50 to 100	100 to 500	500 to 1000	1000 to 2500	2500 to 5000	>5000
Consequence	Catastrophic		Very high risk							
	Major				High risk					
	Moderate				Medium risk					
	Minor						Low			
	Negligible									