Science and Resilience Committee
4 June 2025

Meeting will be held in the Council Chamber at Level 2, Philip Laing House
144 Rattray Street, Dunedin
ORC Official YouTube Livestream

Members:
Cr Gary Kelliher (Co-Chair)
Cr Alan Somerville (Co-Chair)
Cr Alexa Forbes
Cr Michael Laws
Cr Kevin Malcolm
Cr Lloyd McCall
Cr Tim Mepham
Cr Andrew Noone
Cr Gretchen Robertson
Cr Elliot Weir
Cr Kate Wilson

Senior Officer: Richard Saunders, Chief Executive
Meeting Support: Cara Jordan, Governance Support Officer

04 June 2025 01:00 PM

Agenda Topic Page

1. WELCOME

2. APOLOGIES

No apologies were submitted prior to publication of the agenda.

3. PUBLIC FORUM

No requests to address the Committee under Public Forum were received.

4. CONFIRMATION OF AGENDA

Note: Any additions must be approved by resolution with an explanation as to why they cannot be delayed until a future meeting.

5. DECLARATION OF INTERESTS

Members are reminded of the need to stand aside from decision-making when a conflict arises between their role as an elected representative and any private or other external interest they might have. Councillor interests are published on the ORC website.

6. PRESENTATIONS

There are no presentations scheduled.

8. OPEN ACTIONS FROM THE RESOLUTIONS OF THE COMMITTEE

There are currently no open actions for this Committee.

Safety and Resilience Committee
MINUTES

Minutes of an ordinary meeting of the Safety and Resilience Committee held in the Council Chamber, Level 2 Philip Laing House, 144 Rattray Street, Dunedin on Thursday 6 March 2025, commencing at 8.30am.

https://www.youtube.com/watch?v=oj1xj1kUe8c&t=21s

PRESENT

Cr Alan Somerville	*(Chair)*
Cr Gary Kelliher	
Cr Alexa Forbes	
Cr Kevin Malcolm	
Cr Tim Mepham	
Cr Andrew Noone	
Cr Gretchen Robertson	*(Online)*
Cr Elliot Weir	
Cr Kate Wilson	*(Online)*

1. WELCOME

Chair Somerville welcomed Councillors, members of the public and staff to the meeting at 8.30am with a karakia. Staff present included Richard Saunders (Chief Executive), Tom Dyer (GM Manager Science and Resilience), Joanna Gilroy (GM Environmental Delivery), Amanda Vercoe (GM Strategy and Customer, Deputy CE), Anita Dawe (GM Regional Planning and Transport), Kylie Darragh (Governance Support), Cara Jordan (Governance Support), Brett Patterson (Team Leader Programme Management), Jean-Luc Payan (Manager Natural Hazards), Ann Conroy (Team Leader Natural Hazards Adaptation) and Ariane Bray (Natural Hazards Adaptation Specialist).

2. APOLOGIES

Resolution: Cr Forbes Moved, Cr Weir Seconded

That the apologies for Cr Laws, Cr McCall be accepted.

MOTION CARRIED

3. PUBLIC FORUM

No requests to address the Committee under Public Forum were received.

4. CONFIRMATION OF AGENDA

The agenda was confirmed as published.

5. DECLARATIONS OF INTERESTS

No changes to Councillor Declarations of Interests were noted.

6. PRESENTATIONS

No presentations were held.

7. CONFIRMATION OF MINUTES

Resolution: Cr Somerville Moved, Cr Kelliher Seconded

That the minutes of the Safety and Resilience Committee meeting held on 7th November 2024 be confirmed as a true and accurate record.

MOTION CARRIED

8. OPEN ACTIONS FROM RESOLUTIONS OF THE COMMITTEE

There are currently no open actions for this committee.

Cr Noone joined the meeting at 8.37am.

9. MATTERS FOR CONSIDERATION

9.1. Programme Update - Climate Resilience and RiF Tranche 1

[YouTube 10.35] This paper provided an update on the progress of the Otago Regional Council Climate Resilience and Regional Infrastructure Fund (RiF) Tranche 1 programmes. Brett Patterson, Team Leader Programme Management, was available to answer questions.

Resolution SRC25-101: Cr Malcolm Moved, Cr Kelliher Seconded

That the Committee:

1) ***Receives*** *this report.*

2) ***Notes*** *the progress with Otago Regional Council Climate Resilience and Regional Infrastructure Fund (RiF) Tranche 1 programmes.*

MOTION CARRIED

9.2. Programme Update - Renewals projects

[YouTube 21.30] This paper provided an update on the progress of projects within the Otago Regional Council Engineering renewals programme and presented the projects planned for Otago Regional Council Engineering assets intended to be underway within year 1 of the 2024 - 2034 long term plan. Projects that are receiving central government funding are excluded from this report as they are reported separately. Brett Patterson, Team Leader Programme Management, was available to answer questions.

Resolution SRC25-102: Cr Kelliher Moved, Cr Weir Seconded

That the Committee:

1) ***Receives*** *this report.*
2) ***Notes*** *the progress with Otago Regional Council Engineering Renewals programme.*

MOTION CARRIED

Cr Somerville Moved, Cr Weir seconded

The agenda be changed to hear matter 9.4 before matter 9.3 due to availability of staff.

Cr Weir left the meeting at 9:21 am.
Cr Weir returned to the meeting at 9:36 am.
Cr Noone left the meeting at 9:45 am.
Cr Noone returned to the meeting at 9:46 am.
Cr Robertson left the meeting at 9:49 am.

9.4. Clutha Delta Natural Hazards Adaptation

[YouTube 38.00] This paper updated Council on progress with the Clutha Delta natural hazards adaptation programme including natural hazards assessments, and programme and engagement planning. Ann Conroy, Team Leader Natural Hazards Adaptation, Jean-Luc Payan, Manager Natural Hazards, and Tom Dyer, GM Science and Resilience, were available for questions.

Resolution SRC25-103: Cr Malcolm Moved, Cr Noone Seconded

That the Committee:

1) ***Notes*** *this report.*

MOTION CARRIED

Cr Forbes left the meeting at 9:59 am.
Cr Forbes returned to the meeting at 10:03 am.

9.3. Flood Forecasting and Public Information

[YouTube 1.32.14] This paper described the flood warning system and service provided by the Otago Regional Council. Jean-Luc Payan, Manager Natural Hazards, and Tom Dyer, GM Science and Resilience, were available for questions.

Resolution SRC25-104: Cr Noone Moved, Cr Weir Seconded

That the Committee:

1) ***Notes*** *this report.*

MOTION CARRIED

12. CLOSURE

There was no further business and Chair Somerville declared the meeting closed at 10.12am with a karakia.

_________________________ _________________

Chair Date

9.1. Otago Deep Water Lakes TAG update

Prepared for:	Science and Resilience Committee
Report No.	GOV2545
Activity:	Governance Report
Author:	Ben Mackey, Manager Science
Endorsed by:	Tom Dyer, General Manager Science and Resilience
Date:	4 June 2025

PURPOSE

[1] The purpose of this paper is to provide an update to the Science and Resilience Committee on the progress of the Otago Deep Water Lakes Technical Advisory Group, as requested in the December Environmental Science and Policy Committee.

[2] The Technical Advisory Group seeks feedback from the Committee on a preferred funding level for proposed deep lake monitoring and research programmes, on which to base a more developed proposal.

EXECUTIVE SUMMARY

[3] The Otago Deep Water Lakes Technical Advisory Group (TAG) was formed in April 2024 at the request of the Otago Deep Water Lakes Management Working Group (MWG). The TAG's purpose is to provide technical advice to the Management Working Group, primarily regarding potential monitoring and research programmes to enable informed management of lake health.

[4] Building on previous work identifying knowledge gaps and key research questions, the TAG has prepared a report outlining potential research and monitoring programmes (Attachment 1).

[5] The report outlines three potential research and monitoring programmes, at three different levels of investment, over a nominal 10-year period:

- Proposal 1 seeks a substantial improvement in knowledge, at a cost of approximately $20 million.
- Proposal 2 would generate a moderate improvement in knowledge, at a cost of $7-12 million.
- Proposal 3 would aim for an incremental increase in knowledge over the status quo lake monitoring programme, at a cost of ~$2.5 million.

[6] The TAG is seeking feedback on a preferred investment pathway for deep lakes research and monitoring, prior to more detailed programme development.

RECOMMENDATION

That the Committee:

1) ***Notes*** *this report.*
2) ***Requests*** *the Technical Advisory Group to develop a more detailed research and monitoring plan at a funding level aligned with Proposal X.*

3) ***Requests*** *that the Technical Advisory Group works to identify funding opportunities from external sources.*

BACKGROUND

[7] The TAG has meet ~monthly since May 2024. A progress report was presented to the MWG in September 2024, and subsequently to the Council Environmental Science and Policy Committee in December 2024. The next step was for the TAG to develop potential work programmes for consideration by the MWG, and ultimately Council.

[8] The TAG's Terms of Reference outlined three key deliverables of the TAG, paraphrased as:

a. Review the nature and extent of existing research on Otago's deep lakes;
b. Recommend key research questions; and
c. Develop recommendations for a coordinated programme of research to enable evidence-based management of the lakes and their catchments.

[9] The September 2024 report outlined the state of knowledge, identified knowledge gaps, and compiled key questions in relation to the deep lakes: this effectively addressed points a) and b) above. Attachment 1 endeavours to satisfy requirement c), in recommending a set of potential research programmes for the Lakes. The proposals were presented to the MWG on 29 April 2025, and the attached version has had minor updates for clarity and to incorporate feedback from the MWG.

[10] These research programmes were developed by the TAG during a 2-day in person workshop in Wanaka in February 2025.

DISCUSSION

[11] The TAG has prepared three potential monitoring and research programmes to enable evidence-based management of Otago's deep-water lakes.

[12] The intent of the attached report has not been to provide fully detailed work programmes, but rather to outline a) the level of understanding that could be anticipated from a given level of investment, and b) how this would enable evidence-based lake management.

[13] The report has been structured around 5 key knowledge gap areas identified in the September 2024 report. These are 1) budgets and physical processes, 2) food webs and ecological processes, 3) future and historic trajectories, 4) lake management and community engagement, and 5) Mātauraka Māori.

[14] Each potential work programme is described, and assessed against the following key questions:

a. How the proposed programme addresses the knowledge gaps?
b. Where would the proposal get us in terms of understanding?
c. What understanding would we not gain?
d. How would the programme enable evidence-based lake management?

[15] The report also discusses the deficiencies in Proposals 2 and 3, compared to the more comprehensive Proposal 1. Examples of costed work programmes for each funding level have been provided.

[16] Proposal 1 (approximately $20 million over 10 years) aims to fill the previously identified knowledge gaps, generating a high level of understanding to enable proactive evidence-based management of the lakes. Under proposal one there would be a significant increase in monitoring of lakes and inflowing rivers, and intensive study of food webs and ecological processes, with a deliberate focus on collecting data to minimise uncertainty. Coupled catchment-lake models would be a priority. A comprehensive lake history would be developed through the acquisition of lake cores, and reconstructing a detailed history of catchment land use. Significant effort would go to community engagement and increasing awareness of the lakes and their management.

[17] Proposal 2 is a scaled back version of Proposal 1, with an indicative cost of $7-12 Million over 10 years. The reduced scope of Proposal 2 would come via reducing the extent or number of parameters monitored, or through focussing efforts on only one or two of the three lakes. Food web research would be scaled back, and the past and future lake trajectories would lack the detail of proposal one. Proposal 2 would represent a major increase on the current state of knowledge and provide an evidence base to underpin lake management decisions, although with more uncertainty than provided by Proposal 1.

[18] Proposal 3 (approximately $2.5 Million over ten years) provides for an augmentation of ORC's existing monitoring programme with some additional monitoring, and one-off studies. It would rely more on expert judgement or literature reviews to build knowledge, rather than locally collected data. The confidence in datasets would improve as the length of record increases, but Proposal 3 would be focussed on identifying trends rather than predicting lake response to catchment or climate changes. Ambiguity about whether a trend is within normal range or is unprecedented and a risk to the lakes would remain.

[19] Table 1 below compares the anticipated implications for lakes management for the three proposals. As the level of investment increases, there is an accompanying decrease in uncertainty, and increased ability to proactively manage lake health. The alternatives to an evidence-led management approach could include conservative catchment management, or reactive management as trends or changes in the lake become apparent.

Table 1 – Indicative lake management outcomes for the three proposals.

	Proposal 1	**Proposal 2**	**Proposal 3**
Indicative cost	**$20 million over 10 years**	**$7-12 million over 10 years**	**$2.5 million over 10 years**
Anticipated management outcomes	This programme would enable proactive management decisions on water quality, water allocation and invasive species management within the lakes and their catchments with medium	This programme would improve the existing knowledge base for the lake(s) that would be investigated. Improved ability to assess how land use scenarios / future climate could impact the	Results generated are under this proposal would be based on continuation of existing datasets and literature values. The level of certainty of Proposal 1's results would not enable confident

	to high confidence. This would maximise the chance of timely identification of issues enabling prompt and evidence-backed actions to be taken to protect the lakes and their values into the future.	lakes in a semi-quantitative way. The increased uncertainty arising from this approach (cf. Prop. 1) means that planning approaches are likely to need to incorporate precautionary approaches.	forecasting of lake trophic state/ecological outcomes. Likely reliance on a risk-based planning approach, and reacting to trends and issues.

[20] The TAG requests direction from the Council on the preferred level of investment for any future lakes monitoring and research programme. With this guidance, the TAG would be positioned to develop a detailed programme for further consideration by the MWG and the Council.

[21] Work to improve the water quality in Otago's deep lakes will continue with non-regulatory activities and iniatives. Without a more detailed understanding of the how the lakes function and the stress they face, it will be challenging to make significant policy shifts to benefit long-term lake health.

[22] Any future research and monitoring programme development would include considered sequencing and prioritisation of monitoring and research efforts. In particular, it will identify and prioritise what can be done in the short term to ensure lake managers have the best available information, while the longer-term programme is implemented and operational.

[23] The TAG appreciates this is potentially a substantial investment for the Council and is available to provide any further information or context to help with evaluation and consideration of these proposals.

OPTIONS

[24] Options are laid out in Table 1.

CONSIDERATIONS

Strategic Framework and Policy Considerations

[25] An increased lake monitoring and research programme will contribute towards healthy ecosystems, clean water, and arresting biodiversity loss. It will also enable ORC to predict and address emerging environmental issues affecting the deep lakes before they arise.

Financial Considerations

[26] Any of the three proposed monitoring and research proposals, if adopted, will require a funding increase to support the work, or re-prioritisation within existing budgets.

Significance and Engagement

[27] If a proposed research and monitoring plan is adopted, the funding mechanism may require substantial consultation through a long-term plan process or similar.

Legislative and Risk Considerations

[28] N/A

Climate Change Considerations

[29] Future climate change is predicted to have an impact on the ecosystems and physical processes within the lakes. Some of the proposals include capacity to model the impact of potential climate change scenarios on Otago's deep lakes.

Communications Considerations

[30] N/A

NEXT STEPS

[31] If the committee identifies a preferred option, the TAG will develop a comprehensive work plan for further consideration.

[32] The TAG is available to assist the MWG and Council if further information or advice is requested prior to identification of a preferred option.

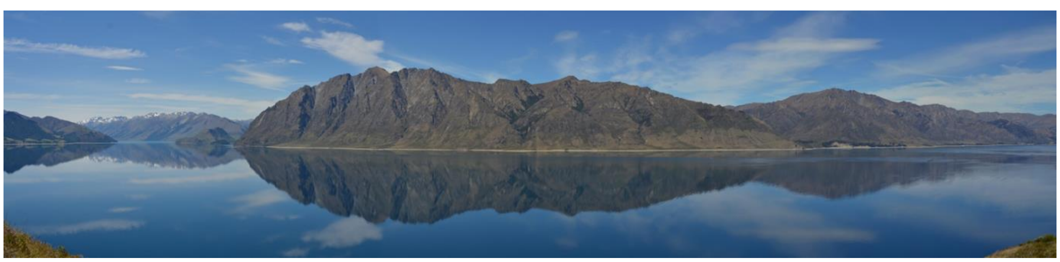
[33] TAG members and ORC staff will explore options for external funding of a future work programme for the deep-water lakes.

ATTACHMENTS

1. Proposed work programmes [**9.1.1** - 28 pages]

Otago Deep Water Lakes Technical Advisory Group
April 2025 Report to:
Otago Deep Water Lakes Management Working Group

Potential Work Programmes to Inform Evidence-Based Management of Otago's Deep Water Lakes



1. Context

1.1. New Zealand's Deepwater Lakes

New Zealand's eleven large deepwater lakes (here defined as lakes deeper than 100 m and larger than 50 km^2) are world class in terms of water quality, fisheries, recreation and scenic beauty. These traits are highly valued by residents and visitors to our lakes, alike. As these lakes and catchments attract people and industries, the human pressure on these lakes grows. And, at the same time, the global climate is changing, which is also impacting our deepwater lakes. Safeguarding Lakes Whakatipu, Wānaka, and Hāwea is important for New Zealand's economy and global status as a country that maintains, and profits from, its high-quality environment.

Unfortunately, little is known about how our large lakes function, their resilience to pressures, or about how to monitor their stressors and responses effectively. The level of scientific study and monitoring to date does not correlate to their national importance. Experience from large, pre-alpine lakes overseas indicate that such systems are not resilient to pollution or degradation (e.g., Lake Constance in Germany/Switzerland/Austria).

The large size and great depths make the lakes inherently challenging to study and monitor compared to shallower, smaller, lakes. As a result, our understanding of diverse pressures on these lakes is in its infancy. To improve understanding of stressors and responses in Otago's deepwater lakes, the University of Otago proposed a Southern Great Lakes research programme to the MBIE Endeavour Fund in 2022. While the proposal was not funded, it served to bring together 15 national and international collaborators, raise awareness about the lack of knowledge about our iconic lakes in general, and improve understanding of how to properly monitor and manage them.

In 2023, Don Robertson of Wai Wānaka and the Guardians of Lakes Wānaka and Hāwea wrote to the Parliamentary Commissioner for the Environment (PCE) raising the lack of knowledge about these lakes and the lack of attention paid to their condition, especially in relation to the rapid pace of agricultural and urban development in the lakes' catchments. In late 2023, the PCE engaged in discussions with the Otago Regional Council (ORC) about these issues and this resulted in the formation of the Otago Deep Water Lakes Management Working Group.

1.2. Maintaining High Values Necessitates Careful Management

While little is known about the lakes' stressors and response currently, research on other lakes has demonstrated that once degraded, large, deep lakes are very costly to restore. For example, it has been estimated that the European Union spent €3.5 billion (approx. 6.6 billion NZD) to restore Lake Constance from the polluted/eutrophic state it progressed to between the 1950s and the 1980s. The lake was eventually restored with the substantial investment in lake restoration by the European Union.

In New Zealand, the protection and restoration of Lake Taupō and the lakes in the Rotorua region and have received substantial amounts of funding. A partnership between the Bay of Plenty Regional Council, District Council, and the Te Arawa Lakes Trust committed $200 million to improve the water quality of twelve Rotorua lakes. In addition, in 2008, Central Government granted $72.1 million to help implement the Rotorua Lakes Protection and Restoration Programme, specifically aimed at Lakes Rotorua, Rotoiti, Rotoehu and Ōkareka. This funding was matched ($72.1 million) by the Bay of Plenty Regional Council and the Rotorua District Council with additional funding for the protection and restoration of the other eight Rotorua lakes in. Therefore, in total, the Rotorua Lakes have received closed to $350 million in taxpayer and ratepayer funding, specifically for the protection and restoration of the lakes. In the early 2000s, an $81.5 million fund was created with contributions coming from the Taupō District Council (22 percent), Waikato Regional Council (33 percent), and central government (45 percent) (Lake Taupo Protection Trust 2014) to permanently reduce nitrogen leaching in the Lake Taupō catchment- an investment specifically targeted at preventing further degradation of the lake.

In Otago's deep water lakes, recent results have highlighted concerning patterns and the limitations of the existing monitoring programme. ORC monitoring data shows that algal biomass in these lakes has doubled in the past 9 years, at a time when invasive zoo- and phytoplanktonic species have gained a foothold, and climate change signals have been observed in the region. It is not clear exactly why or how the productivity of the lakes is increasing, because the current monitoring programme is not able to elucidate the stressor-response relationships of the lakes limiting its utility in active lake management.

1.3. The Otago Deep Water Lakes Technical Advisory Group

To address the knowledge gaps about the lakes, the Otago Deep Water Lakes Management Working Group subsequently commissioned the formation of the Otago Deep Water Lakes Technical Advisory Group in April 2024. The Deep-Water Lakes Management Working Group who noted[1] "The TAG role is critical to ensuring the science for policy development and lakes management decision is as accurate and complete as possible". The TAG's purpose is to advise the Management Working Group in the following areas:

a) Provide a review and assessment of the nature and extent of existing data and research available for Lakes Whakatipu, Wānaka and Hāwea and their catchments, and the suitability and sufficiency of this research for lakes management decision making.
b) Recommend key research questions for approval by the ORC Otago Deep Lakes Management Group.
c) Developing recommendations for a coordinated programme of research to fill any important information gaps, with the primary goal of informing evidence-based management to support the NPS-FM (2023), NPS-IB (2023), and ORC Land and Water Plan, as they relate to the Lakes Whakatipu, Wānaka and Hāwea and their catchments.

The TAG has met approximately monthly since April 2024 and traversed the state of existing knowledge of the lakes, risks to the lakes, and has identified a set of knowledge gaps. A report[2] was presented to the Management Working Group in September 2024, and at the ORC's December Environmental Science and Policy committee meeting. This work largely addressed tasks a) and b), above.

The next step for TAG was to develop proposals for science programmes to fill the knowledge gaps and to inform evidence-based management of the lakes.

In February, the TAG met in person at a 2-day workshop in Wānaka to develop potential workplans, which are presented in this report.

2. Report Structure

This report is structured into the following sections:

- An introduction to knowledge gaps, stressors, and responses.
- A review of the knowledge gaps, which are organised into 5 main themes:
  - Budgets/physical processes
  - Food webs and ecological processes

[1] Otago Deepwater Lakes Technical Advisory Group Terms of Reference

[2] Otago Deep Water Lakes Technical Advisory Group September 2024 Progress report to: Otago Deep Water Lakes Management Working Group. 34p.

    - Future and historical trajectories
    - Lake management and community engagement
    - Mātauraka Māori
- Presentation of three different work programmes developed for different levels of knowledge building and investment:
    - Proposal 1 – Substantial knowledge acquisition (approximately $20 million over 10 years)
    - Proposal 2 – Moderate knowledge acquisition (approximately $7-12 million over 10 years)
    - Proposal 3 – Incremental knowledge acquisition (approximately $2.5 million over 10 years)
- For each proposal, we provide a rationale which includes:
    - How the proposed work programmes address the knowledge gaps
    - Where the proposals get us in terms of understanding
    - What understanding would we not gain
    - How would the programmes improve lake management?

The report ends with a discussion providing additional context and highlighting some issues raised in the development of the proposals.

3. Knowledge Gap Analysis

3.1 Stressors, Responses and Resilience

Pro-active management of Otago's deepwater lakes requires good knowledge about how current and potential **stressors** affect the key **values** of the lakes. The values can be thought of as key lake **responses** within a stressor-response framework (Fig. 1). Examples of important values of these lakes include: potable water, high water clarity, and productive fisheries. Threatening these values are stressors such as pollutants (sewage, nitrates, phosphorus, contaminants in stormwater, etc.), invasive species, and a changing climate. Studies on other lakes have revealed that different values respond to stressors in different ways (Fig. 1). Some values may respond to stressors in a linear manner, while other stressor-response relationships may exhibit non-linear responses in values to changes in stressor levels, potentially characterised by tipping points where small changes in a stressor level results in a large change in the lake value.

To undertake proactive management of lakes, it is important to know whether there are tipping points in a stressor-response relationship and, if so, how far the lake currently is from a tipping point. This knowledge would help planners determine how much stress the lake ecosystem can tolerate determine safe operating spaces with low risk of degrading the values.

Although one might assume that the Otago deep water lakes might be very resilient to stressors due to their large size, experience from other similar lakes in Europe, China and North America shows that such lakes can also become degraded. Also, as discussed above, the size and depth of Otago's deepwater lakes makes it challenging to monitor these lakes, which may delay the detection of degradation. Understanding the resilience of our lakes to change is important for successful lake management. We currently have little information on the specific characteristics of our lakes that may make our lakes either resilient or vulnerable to various stressors.

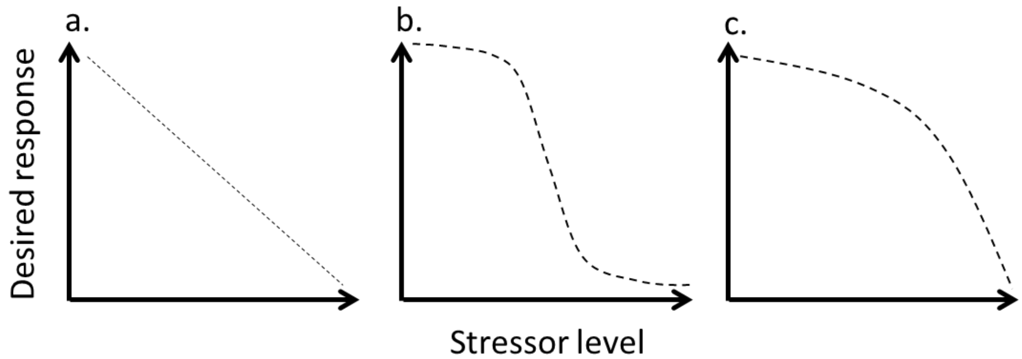


Fig. 1. Examples of different stressor-response relationships, showing potential responses of lake values to anthropogenic stressor levels. High values are associated with low stressor levels, but the degree of resilience to stressors varies among the relationships. In a. there is no tipping point where a small change in stressor might cause a large decline in the value. In b. and c., the relationships show tipping points, but the stressor levels that define the tipping points differs.

4. Otago Deep Water Lakes' Knowledge Gaps

This section summarises the five general areas of knowledge gaps previously identified by the TAG[3]. Brief descriptions of these knowledge gaps are presented below, in addition to the management implications of a lack of knowledge in these areas. The knowledge gaps table presented previously was organised into five general themes: physical processes, ecological processes, future and historic trajectories, lake management, and Mātauraka Māori. These groupings are broadly interconnected, as displayed in Figure 2.

Our current knowledge gaps of the lake catchments and functioning, limit our capacity for land or catchment management to safeguard lake values. Without a comprehensive grasp of the interconnected processes in Figure 2, management strategies risk being reactive or precautionary, and conservative in nature, rather than being proactive. This increases the risk of mismanagement, potentially leading to unintended consequences or missed opportunities for ecosystem restoration. Filling these knowledge gaps enables more informed decision-making, fosters ecosystem and community resilience, and supports the long-term sustainability of biodiversity, recreation, and the regional economy.

[3] A more comprehensive explanation is provided in the September TAG governance update report (https://www.orc.govt.nz/media/eb4abazs/20241204-environmental-science-policy-agenda.pdf

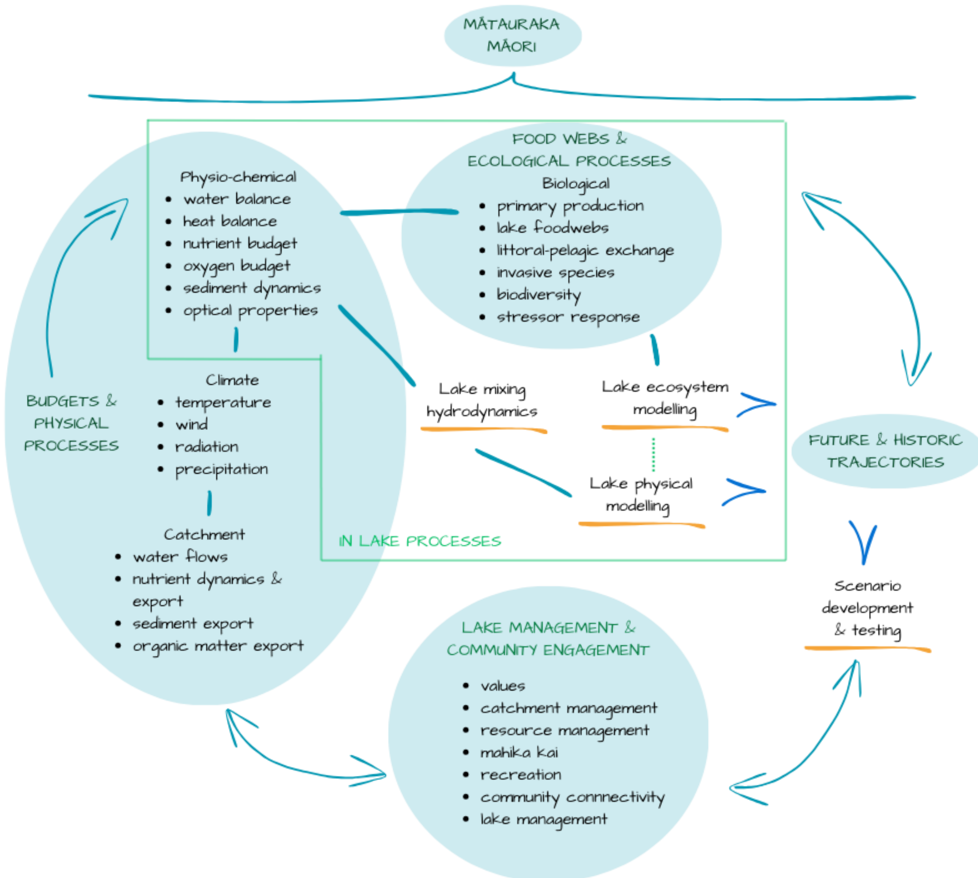


Figure 2. Diagram showing the five knowledge gap themes, and how these are interconnected. The box denotes in-lake vs external factors and processes.

4.1 Lake Budgets/Physical Processes

Lake budgets of water, heat, nutrients, and oxygen mathematically link what is going into a lake, what is leaving the lake, and what is processed within the lake. As such, budgets are essential for lake management, limit setting, and monitoring change as they link inputs from the catchment and atmosphere to standing stocks within the lakes.

As most of the inputs (streams, rainfall, groundwater) to the lakes are not currently monitored, there is a limited understanding of the water, heat, and nutrient budgets of Otago's deepwater lakes. Nutrient loads have been estimated using catchment models for the Otago region, including for the lake catchments. However, these were developed based on a regional model and have high uncertainty. This limits their utility in informing lake management in these particularly sensitive systems. No water, heat, or oxygen budgets have ever been completed.

4.2 Food webs and Ecological Processes

Food webs influence key values of the lakes including fisheries, water clarity, and algal biomass (e.g., via zooplankton grazing on algae). The term 'food web' is used here to describe the interconnected food chains within the lakes, through which energy flows between trophic levels via feeding relationships. The base of the food web is the plant and algal productivity that ultimately provides the nutrients and energy for all lake biota, including the fisheries. Understanding how the plant and algal energy fuels the rest of the components of the lake food webs is important for our understanding of how changes in lake productivity (e.g., algal and macrophyte biomass) could affect zooplankton, invertebrates and fish productivity. Furthermore, invasive species alter the energy flow in lakes, potentially creating or alleviating energy bottlenecks. Thus, knowledge about how the unique food webs in these lakes function is essential for being able to interpret how changes in nutrient inputs and algal productivity manifest in terms of other key values, such as water clarity and fisheries.

Without understanding linkages and energy flow through food webs, suitable nutrient targets or land-use controls to provide for community outcomes cannot be derived. As nutrient inputs to the lakes are thought to drive ecological processes, understanding the relationship between nutrient inputs and food web / ecological response is critical for lake management. The lack of suitable nutrient targets clearly linked to the protection of lake values constrains lake management to either a precautionary or reactive approach.

As very few studies have been undertaken on the food webs within these lakes, there is only a basic conceptual understanding of how the food webs function within the lakes. No studies have investigated food web interactions from nutrients through to fish, nor have any studies investigated the importance of recycled, organic forms of nutrients to algal biomass or chlorophyll *a* in these lakes. For example, because phosphorus concentrations are low in the lakes, the rate of phosphorus cycling may be more important to the level of algal productivity on a seasonal or interannual basis than the phosphorus inputs to, or concentrations in, the lakes. In contrast, because of the long water residence times of these lakes (likely on the order of a decade), inputs of nutrients from the catchment may only drive longer-term changes (e.g., decadal scale) in lake productivity. Therefore, information on biological nutrient cycling within the lakes is important for interpreting the causes of observed changes in the chlorophyll *a* concentration in recent years.

4.3 Future and Historic Trajectories

Understanding future and historic trajectories provides knowledge about the “natural” range of conditions the lakes have experienced previously and allows for predictions of how the lakes may respond to future scenarios (e.g., management actions, invasive species, or climate change). Historical trajectory is important for management as it aids in setting lake-specific targets by determining how the lakes may have deviated from a more natural, or a “reference”, condition. For example, we don’t know whether the recently elevated concentrations of chlorophyll *a* in the lakes falls within the natural range or whether they are historically unprecedented. Investigating potential future trajectories in anthropogenic and natural environmental factors is important as this provides an indication of how the lakes may experience and respond to future environmental variability and to possible management scenarios.

Currently, there are relatively short-term datasets for select attributes flowing into and within the lakes, meaning that only short-term trends can be analysed. To date, little work has been done on how land use practices within the lakes’ catchments, or the management of these, have changed over time.

4.4 Lake Management and Community Engagement

This knowledge gap relates to both the communities’ understanding of the lakes and to the need for tools to inform decisions about lake management. Community understanding of the determinants of, and risks to, lake health is important for enabling management decisions. Decision support tools help integrate community values and preferences with scientific evidence regarding lake health. Such tools also help weigh-up competing values and can demonstrate how outcomes of management actions may impact upon the various lake values held by the community.

Currently, ORC is running a catchment action planning process in partnership with mana whenua and the community with the aim to produce a catchment action plan (CAP) that will help identify environmental restoration and management gaps and priorities for the Queenstown Lakes area. The CAP is developed through a series of workshops with the Upper Lakes Integrated Catchment Group which comprises 20 to 25 members representing mana whenua, DoC, LINZ, QLDC, Fish & Game, a range of environmental organisations as well as farms and the tourism industry. This process aims at having a draft CAP ready by August 2025, which will address some of the gaps identified by the TAG, such as the Upper Lakes Integrated Catchment Group's values for the natural environment (terrestrial and aquatic), as well as their knowledge and perception of the health status of the lakes and the importance of the pressures impacting these values. Mātauraka Māori is included alongside other types of knowledge and values, while a cultural narrative, provided by Aukaha, provides a foundation for the CAP.

4.5 Mātauraka Māori

It is recommended that Mātauraka Māori be formally included in the next phases of the design and delivery of any work or projects that emerge, particularly in relation to cultural monitoring and associated activities.

Incorporating iwi knowledge systems in the project design phase will ensure that cultural values, perspectives, and aspirations are meaningfully reflected in both the technical and strategic development of the program. This should apply not only to the core program elements but also to any related workstreams that arise through implementation or further scoping.

Establishing dedicated space for iwi participation and Mātauraka Māori will:

- Strengthen the cultural integrity of monitoring and environmental assessments
- Enhance the relevance and responsiveness of the program to iwi priorities and aspirations
- Uphold ORC Strategic Direction through genuine partnership
- Provide a more holistic foundation for long-term planning and investment decisions

This recommendation supports a proactive and inclusive approach that ensures iwi voices and indigenous knowledge systems are integrated as a core part of ongoing program development.

5. Proposal development

TAG members went through a process to identify the requirements of a technical work programme to inform evidence-led management of Otago's deepwater lakes. This process identified knowledge requirements to understand the hydrodynamic, physio-chemical and biological processes within these lakes, and the extent to which this knowledge is available. Recognising the large scale and scope (and, therefore, cost) of the programme arising from this process across three large lakes and catchments, the TAG also undertook an exercise to rationalise components of the work programme. The purpose of this process was to scale potential ORC-coordinated monitoring and modelling research programmes to different levels of resourcing, and to document the risks associated with alternative (i.e. lower cost) options.

The technical advisory group (TAG) has developed three high-level programme proposals with differing investment levels:

- Proposal 1 seeks to fill knowledge gaps with information suitable for proactive management of the lakes and is estimated to cost approximately $20 million over 10 years. This proposal was created by tasking TAG members to develop a comprehensive work programme to address the knowledge gaps. Proposal 1 has a distinct preference for collecting locally measured data to inform modelling approaches and to minimize uncertainty where possible.

- The second proposal seeks to address only some of the knowledge gaps, or forfeits one or two of the lakes, to fit within the $7-12 million funding level. Where knowledge gaps are not addressed uncertainty is increased, potentially by reducing spatial coverage of sampling sites. This could necessitate using modelled climate data rather than field measurements, by transferring measurements or understanding taken from one lake or catchment to another, or by assuming the lakes function like other deep lakes that have been studied elsewhere.
- The third proposal represents a modest increase to ORC's existing investment level, harnessing work that can be done by a limited increase in monitoring effort, by targeted one-off studies, and by analysing pre-existing datasets. This proposal is estimated to cost approximately $2.5 million over 10 years. Other research institutes, universities or community groups may continue research into the lakes in addition to the ORC monitoring, but the level and direction of this work would be uncertain, sporadic, fragmented, and would be unlikely to be co-ordinated in line with ORC priorities.

The three proposals are summarised in Table 1 below, with a detailed cost breakdown provided in Appendix 1. *All proposals assume that ORC continues with the existing level of monitoring, and the costed investment would be in addition to current lake monitoring and science programmes.*

The proposals are intended to provide a level of detail that illustrates what sort of research, monitoring, or modelling could be done with different levels of funding without going into substantial technical detail. These proposals provide the base of a business case to inform an initial funding range decision by the MWG/Council. It is proposed that a full, detailed, proposal could be developed for whichever level of funding MWG/Council chooses.

To facilitate understanding of the outcomes of the proposals, a brief description of the type of programme used to fill each knowledge gap is provided in the sections below, with a detailed breakdown of the proposed programmes in Appendix 1. The outcomes of each proposal are then discussed using a question-based framework. Narrative outcomes of completed programmes are provided for key questions:

- Summary
- How would the proposed programme address the knowledge gaps?
- Where would the proposed programme get us in terms of understanding?
- What understanding would we not gain?
- How would the programme enable informed lake management?

6. Proposal 1 (approximately $20 million over 10-years)

6.1 Summary

This proposal aims to fill the significant knowledge gaps, bringing the capacity for managing the lakes to a high level. The significant knowledge gained would inform a robust integrated catchment management capability by identifying the evidence-based limits to anthropogenic pressures that would ensure that the aquatic values are protected. The significant investment in research would be in line with that afforded to the Rotorua Lakes and highly valued lakes in other developed countries. If this proposal were funded, it would leverage co-funded collaborations with overseas experts in large lake research and management, providing for knowledge sharing and learning from experiences from similar lakes overseas.

Proposal 1 would see a significant improvement in monitoring discharge, temperature, nutrients, and sediments in inflows to the lakes. It would also have an expanded biological lake sampling programme focused on:

- lake productivity and risks of eutrophication,
- nutrient cycling within the lake biota,

- lake food webs and how biomass at the base of the food web fuels higher trophic levels such as fish,
- invasive species and how they perturb the flow of energy and nutrients throughout the food webs, and
- the potential for restoring migratory fish to the lakes and lake food webs.

In addition, this proposal will undertake: climate monitoring, the deployment of satellite buoys, lake monitoring buoys, current meters, and benthic chambers.

The data collected from these sources would be used to create catchment models and high resolution 3-D lake models. Significant research into nutrient cycling and food webs would seek to explain biological responses to stressors. Multiple sediment cores would be collected from each lake to reconstruct comprehensive catchment histories and understand historic changes in the state of the lakes. This proposal also includes sustained investment in community partnerships and programmes, including cultural monitoring where appropriate.

6.2 How does the proposed programme address the knowledge gaps?

6.2.1 Water Budgets, Nutrient Budgets & Physical Processes

The Water and Nutrient Budgets and Process Programme would establish:

- Additional water quality and flow monitoring for the major inflows to the lakes including monitoring of all major inflows, targeted event-based water quality monitoring (e.g. high-intensity sampling during high flow events) for more accurate load estimates.
- Additional in-lake monitoring including buoys/current meters/drogues to inform the development of hydrodynamic models that model how water mixes and moves within these lakes. This is important to understand how nutrients/sediment/contaminants move within each lake. Additional climate stations and rain gauges would be installed to increase coverage within each of the catchments and these would be used to inform the development of catchment climate and hydrology models.

A comprehensive monitoring network is proposed in this programme to cover most of the major tributaries/catchments in each of the lakes, in addition to monitoring points at multiple locations within the lakes. This is critical as land use/land cover, topography, and climate vary widely within the lake catchments, as does the lake bathymetry (e.g., deep water vs large shallow embayments).

The additional monitoring data will be used to create high-resolution, coupled[4] catchment and lake models to provide a fundamental understanding of the lakes' water quality, water balance and internal hydrodynamics, as well as water quality in the lake outflows (Clutha, Kawarau and Hāwea Rivers) that could impact the water quality downstream of the lakes.

The models developed under this proposal would be suitable for informing decision-making regarding the consequences of different land use/land management practices and evaluating the consequences of different catchment management scenarios for water quality outcomes in these lakes. Comparisons between modelled and measured data will reveal how the models and our understanding of how the lakes function can be refined and improved over time. These models could also be used to consider how these lakes may change under various climate change scenarios, such as changing temperature, rainfall patterns, or wind.

[4] Coupled models are models that are developed in a way that they are connected so that the outputs of one model (e.g. catchment hydrology model) directly flow through to the connected model (e.g. lake water balance, hydrodynamics and heat model). Another example would be catchment water quality models that predict catchment concentrations/loads flowing into the lake model.

6.2.2 Food Webs and Ecological Processes

A lake food web encompasses the plant productivity (i.e., algae and macrophytes) at the base of the food web as well as the other biological components of lakes that are fuelled by the plant productivity (e.g., fish). In Proposal 1, we would investigate microbial recycling of organic matter, which we believe is an important contributor to the biomass of algae and other biota in these lakes. We would characterise the lake food webs, the links between different biotic components, any energy bottlenecks, as well as the effects of invasive species on energy flow and biomass. The information gathered in this programme would be used to quantify the strength of linkages between nutrients/other stressors and ecological responses culminating in the development of lake-specific targets for ecological attributes. These targets could also be used in modelled scenarios. This work would provide a mechanistic understanding of stressor-response relationships, allowing consideration of the biological consequences of predictions from lake-wide hydrodynamic modelling. Through this work, impacts of important invasive pelagic species (*Lindavia* and invasive *Daphnia*) on lake resilience would be identified.

6.2.3 Historic and Future Trajectories

The Trajectories Programme would use sediment cores, historical imagery and historical information to explore how catchment land-use (rural and urban) and the state of these lakes has changed over time. This could be used to inform target states and ecological outcomes for each of the lakes.

Sediment cores from the beds of the three lakes would aim to describe the historic "state" of the lakes over at least 1000 years. Analysis of pollen in different layers of the core would indicate changes in catchment vegetation, while the composition of diatoms in the core can indicate how diatom communities have changed through time, which may help infer changes in trophic state and nutrient status over historical and pre-historical time. Analysis of aerial and satellite imagery and historical records (such as photos, diaries) as well as interviewing land managers would enable assessment of changes in land-use/farming practices over time. This combination of approaches would provide historical reconstruction of catchment events through multiple lines of evidence, to investigate whether changes in land use have affected the trophic state of these lakes.

Effects of potential future land and lake management scenarios could be evaluated by using the targets proposed in the Food Web and Ecological Processes programme in combination with the models of the Nutrient and Water Budgets and Physical Processes programme. Climate change projections would be scaled appropriately (i.e., to a higher spatial resolution) to better reflect the likely variations in climate within the lakes' catchments and these projections would be used along with the models developed in the Water Budgets, Nutrient Budgets & Physical Processes programme to explore how changes in climate may affect the functioning of the catchments and lakes.

6.2.4 Lake management and community engagement

The Lake Management and Community Engagement Programme would partner with existing community groups to fund a multi-year citizen science programme which would help to fill programme gaps. ORC's catchment action plan process would be updated and interwoven with the technical understanding generated through the proposed work programme. To facilitate decision making, decision analysis tools (such as multi-criteria decision analysis) would be developed for each lake with an interface that makes the knowledge accessible to the community.

6.2.5 Mātauraka Māori

Suggestion: This programme will initiate engagement with interested runaka with a view to building relationships with Mātauraka Māori specialists. We would hope to be able to incorporate some Mātauraka Māori into the workstreams, where feasible, but this may take some time. This engagement could involve the enhancement of fish migration into and out of the lakes by improving the trap and transfer programmes co-facilitated by Contact Energy.

6.3 Where does the proposed programme get us in terms of understanding?

Proposal 1 is a comprehensive research and monitoring programme that would provide the knowledge base needed to allow for a robust integrated catchment/lake management plan to be developed and implemented. This proposal provides the minimum of information required for planners and decision-makers to ensure the sustainable development of the Queenstown Lakes District. It provides for proactive, medium to high confidence, management decisions on water quality, water allocation, and invasive species management within the lakes and their catchments, enabling protection of the lakes and their values into the future. The programme investigates the relationships between diverse lake values and the growing, diverse anthropogenic pressures being placed on them using a stressors response framework, ultimately helping to define the safe operating space to safeguard the lakes' key values. Mātauraka Māori could be interwoven throughout the programme including in the development of targets and trajectory. Upon completion, this proposal would provide a similar level of understanding to that gained under the Rotorua Lakes Protection and Restoration Programme.

If this proposal were to be funded, it would provide an attractive opportunity for international researchers who are experts in large lake science and management. For example, large, deep lakes to the north and south of the European Alps have experienced quite severe degradation and stronger impacts of climate change than the Otago lakes have. A well-funded monitoring and research programme on the Otago lakes would result in a critical mass of research that would likely attract visiting overseas researchers to add value to the research programme through co-funded visiting scientist programmes. Other well-funded monitoring programmes in New Zealand, such as that for Lake Rotorua, have already attracted significant interest from international researchers.

The proposed $20M budget is a moderate investment relative to the economic (e.g. tourism marketing, tourism, fishery value, water supply) and intrinsic value of these lakes and is substantially lower than the likely cost of actions required to restore these iconic lakes from a position of significant degradation. Restoration projects in large European lakes have shown that the cost of remediation of large lakes can be extremely high, suggesting that research to support proactive management is far more cost-effective than reactive remediation.

6.4 What understanding would we not gain?

The key risks involved in this programme are:

1. Uncertainty in predicting the most likely future pressure and management scenarios
2. Engagement with Mātauraka Māori specialists and incorporation of Mātauraka Māori into monitoring and models

Predicting future scenarios is always uncertain to some degree. The Historic and Future Trajectories programme will analyse historical trajectories and engage with specialists regarding probable future development and climate scenarios. Risk analyses will be undertaken to assess the probability of future invasions by aquatic species.

The TAG recognises that engagement with runaka requires the building of long-term relationships which don't yet exist. With the funding of a 10-year programme will provide a good opportunity to build relationships that could ultimately result in fruitful engagement of Mātauraka Māori specialists in as a core part of the research programme.

6.5 How would the Proposal 1 enable informed lake management?

Under this programme, Council would have increased confidence in forecasting future land use/management changes and robust management targets to suitably protect the lakes values. In addition, it would have a sound understanding of the historical trajectory, current state, and greatly improved knowledge of how future climate change may affect these lakes. Therefore, Council would have robust information to undertake detailed assessments of the risks to the lake, ecosystems, and to the community arising from different development and management scenarios.

The robust evidence base developed to support management decisions and policy development, is likely to be especially helpful if such management interventions are contentious (e.g. restrictions on development or land use types), costly (e.g. requirement for high-cost septic systems or significant infrastructure development), or unpopular. By design, the research proposal links key lake values to manageable stressors and stressor levels, incorporating ecological tipping points, feed backs, resilience and sensitivities. These are key concepts for guiding future lake management. Decision makers and policy planners would have an improved ability to model and assess how certain land use scenarios might impact lake and catchment ecology. Therefore, the knowledge gained should be directly applicable to limit-setting and to sustainable development of the Queenstown Lakes District. An ecosystem services approach informed by this research would also allow impacts on targeted ecosystem services (water purification, water regulation, food provision etc.) to be quantified and understood in economic terms with regard to their social value and impact.

7. Proposal 2 (approximately $7-12 million over 10-years)

7.1 Summary

When developing Proposal 2, TAG members started with Proposal 1 and explored options to reduce cost. Options to reduce cost include fewer monitoring sites, measuring fewer parameters, reduced sampling frequency, or reducing the number of high flow events sampled. Food web research could be scaled back, and aspects such as lake coring, reconstructing catchment history, and community engagement could be reduced in scope. Other options could include dropping components of programmes altogether (such as historical trajectory) or minimising the investigation of a lake(s) from the programme (e.g. Lake Hāwea) and extrapolating results from more intensively studied lakes.

If this investment level is selected, TAG proposes to work with the Deep Lakes Management Working Group and/or Council to determine community or research priorities before scaling the programme to the indicative budget. It is likely that it would not be possible to address all knowledge gaps, in all lakes, for this investment level. The level of uncertainty associated with predictions based on this proposal would be higher in comparison to Proposal 1.

7.2 How does the Proposal 2 address the knowledge gaps?

7.2.1 Budgets/physical processes

Under this investment level, the Budgets and Physical Processes programme reduces the in-lake sites from Proposal 1 down to only a few sites additional to the existing State of the Environment monitoring sites. It would reduce the spatial resolution of the lake models, prioritising sub-catchments based on size (i.e. flow), likely contribution to nutrient loads, and land use, to ensure that the sites sampled are as representative as possible of a range of environmental conditions in the catchment(s). Unmonitored locations would be estimated with modelled predictions based on the available monitoring sites, which would increase the uncertainty associated with estimates of flow and water quality for modelled sub-catchments, and therefore in estimates of total loads to the lake(s).

The north-south climate gradients within the lakes may not be fully reflected in monitoring data introducing further uncertainty to the models. Depending on funding and priorities, monitoring of one lake or two lakes, may need to be scaled back. Inputs to the lake models would suffer from gaps in water quality and flow data to be filled with modelled values instead of locally collected data. This would substantially increase the uncertainty associated with model predictions and the models produced using this approach would be suitable for informing relative change between different scenarios.

7.2.2 Food Webs and Ecological Processes

The Food Web Programme under this investment level would characterize the base of the food web focusing on linkages between nutrients through to primary production and zooplankton. It would not be possible to characterize the whole food web in all three lakes at this level of resourcing. Where possible, stressor response relationships would be used to develop targets. One option to reduce cost would be to limit studies to one or two lakes and apply results to the unstudied lakes increasing uncertainty in these systems.

7.2.3 Future and Historic Trajectories

Under this funding level, the scope of the historical component could be reduced, for example by reducing the number of lake cores analysed and by foregoing interviews with land managers. This would limit the ability to put the current “state” in the context of historical variation and would reduce understanding of how land management practices in these catchments have changed over time. However, the programme would still increase our understanding of natural variability in some aspects of the state of these lakes. TAG proposes that the scope of the historical trajectory component of this programme will be determined based on available funding and following discussion of research priorities with the MWG/Council.

To evaluate potential future trajectories, the targets developed through the Food Web Stressor Response Programme would be used in combination with the models created in the Water and Nutrient Budgets and Physical Processes Programme. In Proposal 2, the uncertainties arising from the scaled-back investigations will affect the confidence in target states/outcomes and model outputs. This will mean that models are likely most suitable for predicting relative change in response variables. Further, depending on the level of funding and priorities identified by MWG/Council, models may only be developed for one or two lakes limiting the ability to assess change in the unmodelled catchments. Climate change projections would not be downscaled to resolutions high enough to reflect variation within the lakes’ catchments meaning that it will only be possible to make high-level statements about how these lakes may respond to different climate change scenarios/projections.

7.2.4 Lake Management and Community Engagement

Under this proposal, this programme could include hosting engagement activities within the lakes’ area to increase awareness on the sensitivity of the lakes. ORC’s catchment action plan process will be updated and interwoven with the technical understanding generated through the technical work programme. To facilitate decision making, decision analysis tools will be developed for the selected lake(s) and extended to the other lake(s) using expert knowledge. Community monitoring and citizen science initiatives may have to be developed under this funding level to enable monitoring at a spatio-temporal resolution and replication acceptable for decision making. However, with citizen science and community monitoring introduces additional risks to data consistency and accuracy. It will be necessary to provide training to those conducting the monitoring to reduce risks and uncertainties.

7.2.5 Mātauraka Māori

Under this investment level, the Mātauraka Māori programme relies on close partnership with ORC’s integrated catchment management programme to maintain relationships and input from Mana Whenua.

7.3 Where does the proposed programme get us in terms of understanding?

While Proposal 2 represents a major increase in funding for lake monitoring and research over current levels (which are focussed on monitoring only), this programme would improve the knowledge base for the lake(s) in less detail and with less geographic coverage than Proposal 1. Lake monitoring and modelling would be done with lower spatial resolution, meaning that bays or open water sites may be less well simulated and predicted. Biological investigations would only cover certain components of the food web, making it difficult to link energy flow in the lakes from algae to fish and, therefore, to predict how future changes in trophic state or invasive species could influence water clarity or fisheries. As a result, fewer of the key lake values will be linked to stressors and, therefore, the outcomes of management actions will be less certain and less detailed. Studies to understand the historical trajectories of the lakes will be pared back as will the ability to generate robust future development scenarios.

The increased uncertainty arising from the approach used in this proposal means that either reactive or precautionary planning approaches may result. The level of technical understanding of the lakes would be better than most lakes in New Zealand but would be less than that of the Rotorua Lakes. The knowledge base would be comparable to that of Lake Hayes.

A large lakes research programme funded to this level would likely still attract the interest of overseas experts on large lake science and management. It is possible that such research could collaborate on our research on the Otago lakes, sharing their expertise, and knowledge about how large lakes in other parts of the world have responded to increased pressures and restoration attempts. Any such collaborations would likely have to be funded by the overseas researchers themselves.

7.4 What understanding would we not gain relative to Proposal 1?

Under this proposal, the level of data collection to inform both models and food web studies would be scaled back relative to Proposal 1. Some of the data gaps (compared to Proposal 1) could be filled with proxies, where possible (e.g., modelled data, interpolations, expert judgement), but this would introduce uncertainty. Other areas of knowledge, such as those related to the biological functioning of the lakes would be fragmentary, precluding a whole system-level understanding of how stressors impact lake values. This would make it difficult to interpret the causes of any changes in water quality that might occur in the future. An alternative to knowledge fragmentation could be that investigations could focus on only one of two of the lakes.

Finally, whole workstreams in Proposal 1, such as historical trajectories, could be scaled back or omitted from Proposal 2. The result of scaling back will either leave council with knowledge for only a subset of the lakes or with fragmentary knowledge about how the lakes function and respond to stressors, compared to Proposal 1. Uncertainty associated with future scenarios and modelled predictions of climate change impacts would be higher than for Proposal 1. Information related to stressors and responses that would be useful for limit setting will be produced, but this information will be based on fewer data (and possibly for only a subset of the lakes). Therefore, confidence in the limits and their outcomes will be somewhat diminished compared to Proposal 1.

7.5 How would Proposal 2 enable informed lake management?

Under this programme, council could predict changes resulting from differing land use and/or land management practices and a better understanding of the current state and functioning of a subset of the lakes. Information on historic changes in water quality would inform how land development and climate change projections could affect the lakes. Council would have an improved information base which would allow it to undertake assessments of the risk to the lake, ecosystems, and the community arising from different future stressor and management scenarios.

By design, the research proposal links key lake values to stressors and stressor levels, some of which can be managed. The research will inform lake managers about ecological tipping points, feedbacks, resilience and sensitivities – concepts that guide prudent management. Therefore, the knowledge gained should be directly informative within limit-setting and sustainable development contexts. Decision makers and policy planners would have an improved ability to model and assess how certain land use scenarios might impact lake and catchment ecology. An ecosystem services approach informed by this research would allow impacts on targeted ecosystem services (water purification, water regulation, food provision etc.) to be quantified and understood in economic terms with regard to their social value and impact. If water quality outcomes are not being met, there will be some uncertainty regarding the magnitude of reductions in nutrient loadings that may be required to achieve target states

Compared to Proposal 1, the models and predictions produced following the approach in Proposal 2 will have higher uncertainties, resulting in a greater risk of degradation in the state of one or more of these lakes, with flow on effects to the Clutha mainstem and downstream lakes. Scientific uncertainty could result in the adoption of restrictive planning policies and may, therefore, limit future opportunities for development and economic opportunities for local communities.

Although Proposal 2 does not reach the same level of understanding as Proposal 1, the TAG stresses that it represents a major advance over the current state of knowledge. This programme would provide a useful evidence base to support management decisions and policy development related to limit setting.

8. Proposal 3 (approx. $2.5 million over 10 years)

8.1 Summary

Proposal 3 would augment ORC's existing lake and catchment monitoring programme with limited additional monitoring sites and measured parameters, support for one-off studies (e.g., urban water quality), and reliance on remote sensing or national datasets to reconstruct the catchment history. In addition, some high flow sampling of rivers and a modest coring programme (potentially 1 lake) are also proposed. There would be increased reliance on literature reviews or expert judgement to fill gaps, in comparison to Proposals 1 and 2, and communication and outreach efforts would rely on existing programmes.

8.2 How does the Proposal 3 address the knowledge gaps?

8.2.1 Budgets/physical processes

Proposal 3 does not seek to provide detailed nutrient budgets/physical processes for all lakes. Data available for each of these lakes would be used in existing 1-D models to gain a better understanding of current lake state. For example, findings from NIWA's ongoing Lake Wānaka modelling efforts could be applied conceptually, using expert judgement, to the other lakes at a high level with an unknown level of uncertainty.

8.2.2 Food Webs and Ecological Processes

A conceptual model of how the lakes' food web function would be developed, and a literature review of food webs of other large lakes would be conducted to provide targets. Studies could be undertaken on microbial nutrient cycling with the aim of developing this as a monitoring tool. However, the ability to connect nutrient availability to components of the food web will be rudimentary. Therefore, our understanding of stressor-response relationships will not be highly informative with respect to limit-setting.

8.2.3 Future and Historic Trajectories

A limited lakebed coring programme would provide some information on lake history. Existing land use databases/spatial layers, such as LUCAS, AgriBase, LCDB, would be analysed to provide a coarse indication of land use change within the lakes' catchments. Other sources of information to reconstruct historic land use change could include rating or resource consent databases, land fragmentation records, building consents, and aerial imagery. ORC's existing models would be used to provide an indication of the magnitude of changes in nutrient loads under a simplistic type of land use scenario, but with high uncertainty. Potential effects of climate change projections would be considered using expert opinion.

8.2.4 Lake Management and Community Engagement

Existing programmes, such as the catchment action plan processes would be utilised to increase awareness of lake environmental and management issues. No decision support tools would be developed. Similar to Proposal 2 – citizen science and monitoring may be required to fill data gaps and requirements, however under this funding level, training may have to be outsourced.

8.2.5 Mātauraka Māori

Under this investment level, the Mātauraka Māori programme relies on close partnership with ORC's integrated catchment management programme to maintain relationships and input from Mana Whenua, possibly with some cultural monitoring, if appropriate.

8.3 Where does Proposal 3 get us in terms of understanding?

The level of understanding associated with Proposal 3 would build on the current level of knowledge. It is anticipated that understanding of the lakes will improve as monitoring datasets become longer and trends can be identified with greater confidence. However, the ability to interpret any causal relationships that are driving trends will be weak. Proposal 3 would carry forward the existing monitoring programme (current State of the Environment monitoring), and augment it with targeted one-off studies, literature reviews, and expert opinion to increase our understanding of the state of the lakes and the pressures on them. Assessments of the state of the lakes and/or changes in pressures would primarily be directional (increasing/decreasing) and relative. For example, monitoring may indicate a clear trend in algal biomass or trace nutrient concentrations, but under Proposal 3 there may be limited context or confidence about why the trend exists. This uncertainty would mean that management would be informed mostly by expert opinion underpinned by rudimentary data.

8.4 What understanding would we not gain relative to proposal 1 or 2?

Proposal 3 does not include the collection of additional medium- to long-term datasets or involve developing new coupled land use and lake models. Instead of trying to develop lake-specific targets, a literature review of other similar lakes would be used to establish the best available information. The suitability of the collated targets for the Otago lakes is uncertain.

8.5 How would Proposal 3 enable informed lake management?

Results generated under this proposal would be based on the continuation of existing monitoring datasets, literature values and expert judgement. The level of certainty of the outputs arising from this proposal would not enable confident forecasting of lake trophic state and/or ecological outcomes which would mean that either reactive or precautionary approaches to planning/policy development would likely result. This form of planning introduces significant risks for both the health of the lakes and the community; instead of having an expected in-lake target/outcome, the programme would rely on implementing a risk-based planning approach and reacting to trends.

The levels of ambiguity or uncertainty may be similar to those currently faced in relation to the question of whether apparent trends are within the historical norm for the lakes, or whether current lake conditions are unprecedented. Risks of this approach include degradation of the lakes, and Clutha mainstem including downstream lakes, or the implementation of overly restrictive planning policies.

The risks posed under this example above are acute in the sense that uncertainties can be compounded when engaging in secondary research to fill knowledge and data gaps. *If land use scenario "x"* increased inputs of nutrients by *"y"* as suggested in the literature, then a precautionary approach would be taken to limit land or lake use given the input values considered to ensure lake degradation does not occur. However, there is no order of magnitude of responses, nor resulting degradation understood or monitored, and so limiting the land and lake use (ie. Limiting agricultural or urban development) may be unnecessary and create opportunity and future costs for both individuals, council, and the regional economy of $”z”.

9. Summary of Proposals 1-3

Table 1 below endeavours to summarise the preceding sections 6-8. Table 1 compares the recommended workstreams in Proposals 1-3, and compares the management outcomes and risks of each proposal.

Table 1: Summary table comparing Proposals 1, 2 and 3

	Proposal 1	Proposal 2	Proposal 3
Indicative cost	**$20 million over 10 years**	**$7-12 million over 10 years**	**$2.5 million over 10 years**
Project Components			
Water Budgets, Nutrient Budgets and Physical Processes	Monitoring of all major sub-catchments of lakes including event-based sampling during high flows	Some additional monitoring of major sub-catchments of lakes including some event-based sampling during high flows.	Current State of the Environment monitoring in catchments, with limited additional monitoring sites. Some high flow sampling.
	Additional in-lake monitoring including buoys/current meters/drogues, climate stations, rainfall gauges to inform model development	Some additional in-lake monitoring, additional climate and rainfall sites only when essential and most climate data will be drawn from existing sources or modelled data.	Current State of the Environment monitoring in lakes, no additional monitoring sites. Upgrades to buoys.
	Development of high-resolution coupled catchment and lake models	Development of coupled catchment and lake models for one or more lakes but based on a mix of measured and modelled data.	Use of existing 1-D models to gain a better understanding of current lake state. Findings from the NIWA Wānaka model are conceptually applied, using expert judgement, to the other lakes at a high level with unknown applicability.
Food Webs and Ecological Processes	Studies to characterize the food web in the lakes, including food web structure, links, strength of linkage, and stressor response. Leads to innovative, cost-effective monitoring methods for	Food web studies to characterize the base of the food web focusing on nutrients through to primary production and zooplankton.	One-off studies and literature reviews.

	greatly increased information value.		
	Quantify the strength of linkages between nutrients/other stressors and ecological responses culminating in the development of lake-specific targets for ecological attributes	Stressor response relationships from the literature (where available) would be used to develop targets, where possible.	
	Development of lake-specific targets for water quality, ecological and human-use attributes		
Historic and future trajectories	Sediment coring, historical imagery and historical information would be used to explore how catchment land-use (rural and urban) and the state of these lakes has changed over time.	Scaled back core programme (e.g., 2 lakes, fewer parameters) Some assessment of catchment history.	Modest core programme (e.g., 1 lake only)
	Historic information would be used in conjunction with coupled catchment and lake models to consider how climate change may affect the state of the lakes and their ecological values. Reliance on models to forecast lake responses to historically unprecedented climate changes.	Limited historic information used to develop a conceptual model of how climate change projections may affect the state of the lakes and their ecological values.	One-off studies, analysis of existing data and literature reviews.

Lake Management and Community Engagement	Partnership with existing community groups to fund a multi-year citizen science programme which would help to fill programme gaps. The Catchment Action Plan process would be updated and interwoven with the technical understanding generated through the TAG proposed work programme. To facilitate decision making, decision analysis tools (such as multi-criteria decision analysis) would be developed bespoke for each lake with an interface which makes the knowledge accessible to the community.	Lake management and community engagement programme will host engagement activities within the lakes area to increase awareness on the sensitivity of the lakes. ORC's catchment action plan process will be updated and interwoven with the technical understanding generated through the technical work programme. To facilitate decision making, decision analysis tools will be developed for the selected lake(s) and extended to the other lake(s) using expert knowledge. Accessible interfaces may not be developed under this proposal.	Largely reliant on existing programmes such as Catchment Action Plan framework.
Mātauraka Māori	If appropriate, Mātauraka Māori would be interwoven into all workstreams within the project with funded PhD's or full-time position. Potential cultural monitoring programmes.	ORC's integrated catchment management programme would maintain relationships and input from Mana Whenua.	ORC's integrated catchment management programme to maintain relationships and input from Mana Whenua.
Potential international collaborations	Highly likely and likely to be co-funded. This will inform the science and management of Otago's lakes in relation to increasing development and climate change pressures that have already been experienced in other, similar lakes overseas.	International collaborations may occur. These would need to be externally funded.	Unlikely that international collaborations would occur.

Anticipated management outcomes	This programme would enable proactive management decisions on water quality, water allocation and invasive species management within the lakes and their catchments with medium to high confidence. This would maximise the chance of timely identification of issues enabling prompt actions to be taken to protect the lakes and their values into the future.	This programme would improve the existing knowledge base for the lake(s) that would be investigated, and this information can be used to evaluate relative change and some future scenarios in a semi-quantitative way. The increased uncertainty arising from this approach means that planning approaches are likely to need to incorporate precautionary principles.	Results generated would be based on existing data and literature values. The level of certainty of results the outputs of this proposal would not enable confident forecasting of lake trophic state/ecological outcomes which means either reactive or precautionary approaches to planning/policy development are likely to be necessary. This form of planning introduces significant risks for both the health of the lakes and the community.
	This proposal would provide a similar level of understanding to that of gained under the Rotorua Lakes or Lake Taupo projects.	Technical understanding of one or more of these lakes would be better than many lakes in New Zealand but would be less than that of Taupo and the Rotorua Lakes.	This option would improve understanding of some aspects of these lakes that may inform lake management.
Limitations	The programme may be unable to link food webs and physical modelling after the biological studies have been completed. Currently, the food webs are not well understood. To fully link the physical processes within these lakes through to food webs in a model would likely require further work. In the meantime, assumptions will have to made to integrate biology into the models.	It would not be possible to investigate drivers of productivity and the food webs of all three lakes.	Limited understanding of physical and ecological processes across full spatial and temporal scales. Restricted ability to predict the changes in the water quality of the lakes in the context of climate change and changes in the land use.

10. Discussion

TAG has provided three proposals for consideration by the Otago Deep Water Lakes Management Working Group. The objective of this paper has been to present proposals at three different levels of knowledge gain and investment. Each proposal has been explained in terms of how it will inform evidence-based management of the lakes, a key requirement in the TAG's Terms of Reference.

Proposal 1 would provide a comprehensive understanding of how the lakes function, allowing for proactive management of all three lakes to safeguard values. Proposal 2 would substantially increase the fundamental knowledge of the lakes but has a more modest budget than Proposal 1 through a combination of either (a) reducing the collection of real-world data that will be used in catchment and lake models (b) focussing only on a subset of the lakes (s), and/or (c) reducing the scope of the investigations undertaken in these lakes. Proposal 3 would build on existing monitoring programmes, and analyse existing datasets from New Zealand, and abroad, to gain as much understanding as possible. As the level of knowledge and certainty decreases under the second and third proposals, the level of knowledge/certainty may not be sufficient to enable proactive, evidence-based management. As a result, precautionary or reactive management approaches may result.

10.1 An argument for investment into research and monitoring to safeguard the lakes

The proposals presented here are predicated on the assumption that current levels of monitoring and research will be insufficient to inform evidence-based management of lake values, as the nature and magnitude of pressures on the lakes increase into the future. In the absence of an improved level of understanding, regulations on land use or development in the catchments could be implemented without a strong evidence base linking catchment activity and lake response, leaving management policies or decisions vulnerable to challenge.

There are a range of risks associated with taking a less-informed, more precautionary approach in favour of a science-informed, evidence-based approach to the management of Otago's iconic, deep lakes. If environmentally conservative regulation is implemented, there is the potential for restrictions on activities and behaviours associated with land and lake use. For a region that is developing at the fastest rate in New Zealand, and with a tourism economy centred around the amenity and recreational value of the lakes and their surrounds, the negative economic and social impact created by a precautionary and conservative approach could be high.

10.2 Programme Sequencing

The order of investigations and research projects undertaken will be addressed at the detailed programme development stage. For example, given the ~10-year time frame of these proposals, it would be useful to focus on monitoring and data collection for the initial period, and to develop some of the data-dependent modelling and research components later in the programme. It is proposed that some of these works would be delivered by PhD and MSc students, and the duration of the dissertations may influence the timeframes for delivery and staging of these components.

Any future research and monitoring programme development would include considered sequencing and prioritisation of monitoring and research efforts. In particular, it will identify and prioritise what can be done in the short term to ensure lake managers have the best available information, while the longer-term programme is implemented and operational.

10.3 Co-funding considerations

In addition to developing the above proposals, TAG identified some aspects of the proposal that may be suitable for external funding (grants or other sources) or co-funding. For example, if Proposal 1 were to be funded, it is expected that collaborations with researchers from overseas would attract at least some co-funding from external organisations. Generally, TAG's view is that any council investment should be leveraged to gain additional funding from external sources from both within and beyond New Zealand.

However, TAG also acknowledges that securing external funding prior to commencing may mean delays in implementing the selected research programme, with these delays flowing through to policy development. Such delays pose a risk to lake management, as water quality could decline in the time taken to secure funding, or continuing development in these catchments could increase pressure on these lakes. To mitigate this risk, council may choose to resource the programme fully. This would provide sufficient certainty in the immediate term to implement monitoring sites and start the programme while supplementary external funding could be sought. External funding bids are also more likely to be successful if the programme is already under way. If external bids are successful, the budget from council can be reallocated and replaced with external funding.

10.4 Comparing the investment levels

The TAG considers that the benefits from investment in the research and monitoring programmes described here increase disproportionately with the amount invested. This comes about for four reasons:

1. Economies of scale
2. Synergies between projects
3. Attraction of external funding
4. Uncertainties should diminish with greater diversity, and amounts of, knowledge

Larger programmes allow for more specialisation within the programme. For example, researchers can focus on their areas of specialisation because resources would be available to contract out work that lies outside their areas of expertise. In addition, analysis of larger numbers of samples usually results in savings in costs per sample. Similarly, the use of more boat time may allow for the negotiation for more favourable boat user charges. Furthermore, achieving a critical mass of research allows for the allocation of FTEs for programme management and administration, which allows scientists to devote more of their time to their areas of excellence.

Larger programmes contain more projects, which can provide for synergies among projects in terms of resource and data sharing. More data available often allows for opportunities to use the data in other innovative ways. A well-funded 10-year monitoring and research programme would attract many collaborators who would be able to access external co-funding for the programme. As the 10-year programme progresses, new findings will generate new ideas for research. The larger the programme, the more likely it is that spin-off projects attracting external funding will eventuate.

Finally, a programme that aims to build understanding about stressors-responses relationships in complex systems will benefit from studying more components of the complex system. If key components of the system are neglected, assumptions will have to be made and uncertainty in the modelled system will increase.

For these reasons, Proposal 1 would deliver better value per dollar than Programmes 2 and 3.

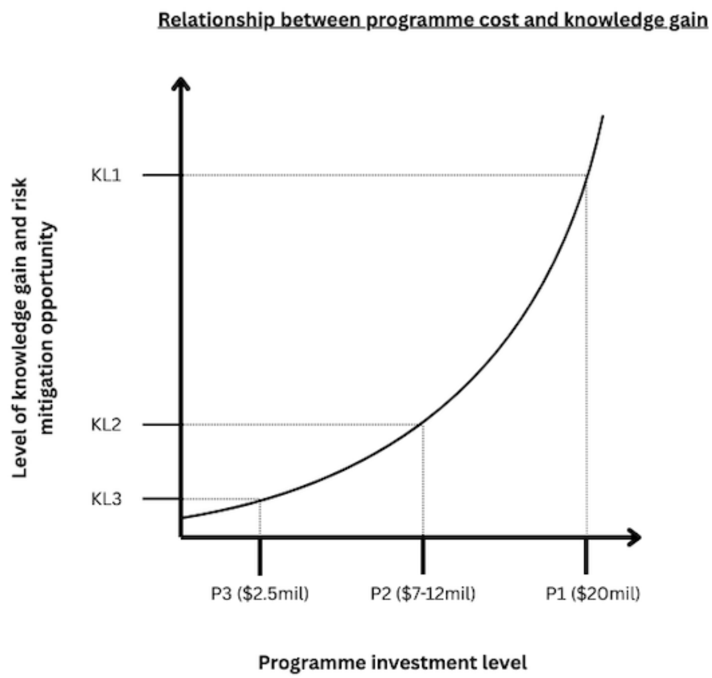


Figure 3: Conceptual graph illustrating the comparative level of knowledge gained at the three investment levels.

10.5 Next steps

To progress to full proposal development, TAG requests direction on whether there is appetite for an expanded Deep Lakes monitoring and research programme, and if so, the preferred level of funding for this research.

TAG has a clear preference for Proposal 1 as it addresses the previously identified knowledge gaps, minimises uncertainty, has the greatest potential for efficiency and synergy between disciplines, and best enables evidence-led management of the lakes.

Of the three proposals, Proposal 2 has the most flexibility in developing a full work programme. If Proposal 2 is the preferred option of the MWG and Council, TAG would request a meeting with the Management Working Group and/or wider Council to discuss options to modify the work programme to fit the chosen level of funding. This discussion would include prioritisation of workstreams/components of workstreams resulting in a reduction in the scope of data collection that will be used in catchment and lake models, focussing the programme on certain lakes, or reducing the scope of the research programme.

Appendix 1

The following tables present a more detailed breakdown of potential work programmes than described in the report body. These are example work programmes for the three proposed funding levels, with approximate but realistic costings provided. Reference to 'PhD projects' was used as a representative unit of expense/effort in a given topic, and these components could variably be undertaken by ORC, as funded PhD projects, or completed by consultants or research institutes.

Proposal 1

Theme	Topic	Proposal 1 - Details	Cost breakdown	Accumulated cost
Budgets	**Water balance**	Install flow recorders in major inflows (Makarora, Hunter, Greenstone, Vonn, Locky, Dingle burn). Added Rainfall gauges. Additional Lake level recorder x3. High res bathymetry for Hawea. Ground water programme needed for major inflows, tracer studies to distinguish GW and SW sources. Potential outflow monitoring improvement? LINK TO HEAT Need temp on flow gauges	Additional Monitoring=$1,000,00 a year; $300,000 one off cost for 2 SWAT models; $100k for new GW bores	$10,400,000
	Nutrient budget	Regular sampling of both "traditional" and a wider set of variables (DOM, DOC, POM, Silica/trace element, etc.) of as many inflows see above as possible, potential continuous (or at least event flow sampling) of as many tribs as possible -> aimed at loads. DGT/passive samplers? May require alternative lab processing techniques (concentrating first before "measuring). Additional in lake sites. Additional subcatchment monitoring potentially weighted towards anthropocentric landuse changes. Ground water network gap -> ORC to check in on. Catchment model. Benthic sampling, atmospheric deposition monitoring.		
	Heat budget	Long wave radiation sensors/climate stations for all lakes including top of lake sites. Review of stations and whether coverage is sufficient; Evaporation analysis; surface heat flux (possibly covered by met data, perhaps validation from sampling); Absorbance spectra down profile; temperature on all inflows.	$150k for 2 climate stations per catchment (6 total) with long wave radiation sensors	$450,000
	Oxygen budget	Deploy satellite buoys in littoral zone of all three lakes; benthic chambers; atmospheric flux measurements	$300,000 for AM3D hydrodynamic models in 2 lakes; mooring/buoys- 4 totalling $150,000 one off; $100k one-off benthic chambers	$550,000
Fundamental lake processes	**Mixing dynamics/hydrodynamics**	High res 3-D models; aimed at under flow/currents (off flow sites). ADCP current measurements (potentially 6 per lake?); Additional Moorings with temp sensors (low priority)->; more important in Wanaka due to arms/bays; partical tracking	300,000 for AM3D hydrodynamic models; 500,000 for moorings and extra water quality sampling	$500,000
	Food webs	Energy flow including stable isotopes (2x Ph.D.); Daphnia and productivity (1x Ph.D.); Taonga species (2 Ph.D.+1 Masters);	$1,050,000	$1,050,000
	Invasive species / missing species	Lindavia effects on bethic ecology (1 Ph.D.); Daphnia vs. Lindavia (1 masters); Microbial intercations (1 Ph.D.); Future invaders (1 Ph.D.)	$650,000	$650,000
	Nutrient behaviour/cycling in lakes/effects on primary production in lake	Nutrient cycling quantification method development; Characterization of dissolved organic matter (1 Ph.D.); microbial consortia associated with lake snow (1 Ph.D.); Trace element limitations (1 Ph.D.); PicoCyanobacteria (1 Ph.D.); Climate on phytoplankton (1 Ph.D.)	$1,500,000	$1,500,000
	Stressors response summary	Analysis of above concepts- stressor response relationships- multivariate.	$100,000	$100,000
Historical data/trajectory	**Quantify Historic / changing land use and hydrology**	2 masters evaluating Local archives, on farm practice change; and a farm scale change assessment	$300,000 for 2xMSc plus $500,000 for farm scale understanding	$800,000
	Historical variability of water quality of the lakes	3 x Lake cores each Lake to understand natural range; long-term change; and event based sediment loads from land slides/earthquakes	$1,000,000	$1,000,000
	Future Trajectory	Climate change modelling; social economic benefits of future scenarios using models from other knowledge gaps; Future invasives; future water quality	$1,100,000	$1,100,000
Mātauraka	**Iwi values**	Continuous partnership with mana whenua, Mātauraka Maori related to catchments and lakes interwoven into the trajectories and general programme including targets. Potential monitoring programmes.	2 joint PhD's ($600k), monitoring ($50k/yr)	$1,100,000
Lake management and community engagement	**Public awareness of lake degradation risk; and science and monitoring results**	Citizen science project- Annual fund for Wai Wanaka to use in partnership with TAG to fill any gaps in desired knowledge base and CAP type process with additional technical input	$50k per year for Wai Wanaka or Whakatipu conservation alliance	$500,000
	Spatial/temporal decision support framework	Catchment Action Plan (CAP) type process including integrated community view on stressor response MCDA extended limit setting, User friendly interface to MCDA type analysis developed which can be co-opted in other catchments in NZ	$500k over two years for post doc	$500,000
Total				**$20,200,000**

Proposal 2

Theme	Topic	Proposal 2 - Details	Cost breakdown	Accumulated cost
Budgets	**Water balance**	Prioritize Hunter, Makarora for flow monitoring; Catchment modelling; Substitute in rainfall/flood model from ORC hazards to model hydrology gaps.	$500k/yr for additional monitoring; $300k for 2 SWAT models;	$5,300,000
	Nutrient budget	More traditional variable set of water quality varaibles, synoptic sampling of wider variable set, retain event based sampling for load estimates, more targetted catchment programmes (including urban), Leverage existing urban datasets (Wai Wanaka and QLDC)		
	Heat budget	Temp on key inflows even if ungauged. Fewer radiation sensors. Weather models to overcome gaps. Model heat budgets	$50,000	$50,000
	Oxygen budget	Enhanced 1-D modelling; or basic 3-D model; Potential mooring in Stevensons Arm	$325,000	$325,000
Fundamental lake processes	**Mixing dynamics/hydrodynamics**	3-D Modelling sans additional moorings (cost benefit consideration)	$300,000 for AM3D hydrodynamic models	$300,000
	Food webs	Energy flow including stable isotopes (2x Ph.D.); Daphnia and productivity (1x Ph.D.);	$600,000	$600,000
	Invasive species / missing species	Lindavia effects on bethic ecology (1 Ph.D.); Microbial intercations (1 Ph.D.);	$400,000	$400,000
	Nutrient behaviour/cycling in lakes/effects on primary production in lake	Nutrient cycling quantification method development; Characterization of dissolved organic matter (1 Ph.D.); Trace element limitations (1 Ph.D.); Climate on phytoplankton (1 Ph.D.)	$1,100,000	$1,100,000
	Stressors response summary	Analysis of above concepts- stressor response relationships- multivariate.	$50,000	$50,000
Historical data/trajectory	**Quantify Historic / changing land use and hydrology**	1 masters evaluating Local archives, No on farm practice change; and a farm scale change assessment	$150,000	$150,000
	Historical variability of water quality of the lakes	Scaled back lake cores effort to understand natural range; long-term change	$800,000	$800,000
	Future Trajectory	Climate change modelling; social economic benefits of future scenarios using models from other knowledge gaps; No future invasives work.	$900,000	$900,000
Mātauranga	**Iwi values**	Close collaboration with ORC's Integrated Catchment Management programme which is conducted in partnership with mana whenua, potential monitoring programmes.	$50000, monitoring at $30k/yr.	$350,000
Lake management and community engagement	**Public awareness of lake degradation risk; and science and monitoring results**	lab in box/ field day workshops, lake symposiums	$60,000	$60,000
	Spatial/temporal decision support framework	Decision support network developed for one lake and exported without consultation to the other lakes	$150k PhD student	$150,000
Total				**$10,535,000**

Proposal 3

Theme	Topic	Proposal 3 - Details	Cost Breakdown	Accumulated cost
Budgets	**Water balance**	Rainfall run off, high uncertainty water balance from existing data, potential rainfall site or two installed, localised ground water/ sensitivity/uncertainty understanding	$40k/yr	$400,000
	Nutrient budget	Retain current sampling and use existing catchment models with improved uncertainty understanding through potential event base uncertainty. Potentially better off understanding limitations/uncertainty of existing models.	$100,000	$100,000
	Heat budget	Retain buoys (potentially upgrade buoy maintenance, capability) ; Heatflux R package/model	$10k/yr	$100,000
	Oxygen budget	Retain buoys (potentially upgrade buoy maintenance); optimize 1-D models	$10,000	$10,000
Fundamental lake processes	**Mixing dynamics/hydrodynamics**	Existing profile and R package: lake analyzer/ use existing 1-D, understand uncertainty/sensitivities (is it useful)	$10,000	$10,000
	Food webs	Conceptual model of food web. Analyze existing samples	$80,000	$80,000
	Invasive species / missing species	Qualitative review/expert analysis on risk from new relative invasive species (perch, and others)	$20,000	$20,000
	Nutrient behaviour/cycling in lakes/effects on primary production in lake	Retain regular nutrient monitoring; add high flow sampling to gain an understanding of loads; Urban water quality study	$350k for urban studies, $50k/yr additional sampling	$850,000
	Stressors response summary	Lit review of targets for large lakes	$15,000	$15,000
Historical data/trajectory	**Quantify Historic / changing land use and hydrology**	LCDB/LUCAS change profiles for lake catchments; pull data or mirror southland economic data; (had things like stock rate, etc.)	$50,000	$50,000
	Historical variability of water quality of the lakes	Modest coring programme, lit review of large lake behaviour; historical imagery	$50k, + $300k for coring and analysis	$350,000
	Future Trajectory	Use exsiting models for relative change; asssess applicability of model more widely;	$50,000	$50,000
Mātauranga	**Iwi values**	Continuous partnership with mana whenua from CAP process; Cultural narrative (will likely be done by Aukaha for the Upper Lakes Integrated Catchment Plan development process). Some monitoring	$50,000, monitoring at $15k/yr)	$200,000
Lake management and community engagement	**Public awareness of lake degradation risk; and science and monitoring results**	Expert panel discussion piece/council papers	$10,000	$10,000
	Spatial/temporal decision support framework	Existing CAP process	~$5k/yr support	$50,000
Total				**$2,295,000**

9.2. Annual Air Quality Report 2024

Prepared for: Science and Resilience Committee

Report No. GOV2542

Activity: Governance Report

Author: Sarah Harrison, Scientist – Air Quality

Endorsed by: Tom Dyer, General Manager Science and Resilience

Date: 4 June 2025

PURPOSE

[1] This report presents the results of the State of the Environment (SOE) monitoring for air quality for the calendar year 2024.

EXECUTIVE SUMMARY

[2] This report provides an analysis on the 2024 air quality data only. State and Trends reports, which contain long and short-term trend analysis, are produced every five years, the most recent one was published in June 2024.

[3] Monitoring of PM_{10} (particulate matter with a diameter less than 10 micrometres) was undertaken in the Alexandra, Arrowtown, Central Dunedin and Mosgiel airsheds in 2024. Alexandra, Arrowtown and Mosgiel recorded exceedances of the National Environmental Standard for Air Quality (NESAQ) during the winter months. The NESAQ limit for PM_{10} is 50 µg/m³ for a 24-hour average. There were a total of 28 exceedances of the NESAQ in 2024, which is eleven more than 2023. Alexandra and Arrowtown recorded 11 and 16 exceedances, respectively, and Mosgiel recorded one.

[4] $PM_{2.5}$ (particulate matter with a diameter less than 2.5 micrometres) was monitored in Arrowtown, Central Dunedin, Clyde, Cromwell, Milton, Mosgiel and Wānaka in 2024. A new site in Frankton was also set up in late 2024. The sites with the highest annual averages were Clyde and Mosgiel, both with 13 µg/m³. The site with the highest 24-hour average was Milton, with 97 µg/³ on 23 June 2024.

[5] Monitoring of black carbon (BC) was undertaken at Arrowtown. BC is a component of particulate matter, however there are no standards or guidelines for it. The data shows strong seasonal and daily patterns, similar to that of PM_{10}. The highest 24-hour average was 7 µg/m³, occurring on 4/07/2024.

RECOMMENDATION

That the Committee:

1) ***Notes*** *this report.*

BACKGROUND

[6] Otago has several towns where air quality is considered degraded during winter, namely Alexandra, Arrowtown, Clyde, Cromwell and Milton. The main pollutant of concern in Otago is particulate matter (PM) which is a product of combustion. In Otago, the main source of PM is home heating emissions in winter (Wilton, 2019). Long-term exposure to PM_{10} and $PM_{2.5}$ contributes to the risks of developing and exacerbating existing

cardiovascular and respiratory conditions, which makes them a serious threat to human health. Furthermore, recent research provides evidence that air pollution is dangerous at lower concentrations than previously thought, and supports the lowering of existing limits (WHO, 2021).

[7] ORC operates an SOE monitoring network for air quality monitoring and is required to report[1] exceedances of the NESAQ (50 µg/m³, 24-hour average for PM_{10}). The SOE network is currently being upgraded to include monitoring for $PM_{2.5}$ as well as expanded to add new sites including a new mobile site. The upgrade process includes a period of co-location and subsequent equivalence testing of the new instruments compared to the existing ones. Further comparison data is still required to be able to correct for the new instruments and accurately report some of their data, but once completed, any data corrections can be backdated. During 2024, PM_{10} was monitored at four sites and $PM_{2.5}$ at seven sites.

AIR QUALITY ASSESSMENT FRAMEWORK

[8] Under the Resource Management Act (RMA), councils are required to monitor air quality according to the NESAQ. PM_{10} and $PM_{2.5}$ can be compared to 24-hour and annual limits for the NESAQ 2004, the proposed NESAQ 2020 and the World Health Organization guidelines 2021 (Table 1). The proposed NESAQ shows that $PM_{2.5}$ limits are being considered in Aotearoa New Zealand, but it is uncertain what they will be since they are no longer in line with current health research like the WHO guidelines. The update of the NESAQ is currently indefinitely delayed.

Table 1: Standards and guidelines for PM_{10} and $PM_{2.5}$

Pollutant	Averaging Time	NESAQ 2004		Proposed NESAQ 2020		WHO 2021	
		Value (µg/m³)	Allowable exceedances	Value (µg/m³)	Allowable exceedances	Value (µg/m³)	Allowable exceedances
PM_{10}	24-hour	50	1 per annum	50	1 per annum	45	3-4[b]
	Annual	20[a]	NA	NA	NA	15	NA
$PM_{2.5}$	24-hour			25	3 per annum	15	3-4[b]
	Annual			10	NA	5	NA

[a] Ambient Air Quality Guideline (AAQG) limit, applies here because there is no equivalent NESAQ limit

[b] 99th percentile, there can be 3-4 exceedances per year

[9] The air quality results can also be categorised according to the Ministry for the Environment (MfE) Environmental Performance Indicators (EPI)[2]. The EPI categories indicate an appropriate action according to the concentrations (Table 2).

[1] Currently ORC reports exceedances by way of public notice in the Otago Daily Times every month exceedances occur.

[2] From the Ambient Air Quality Guidelines (AAQG, 2002).

Table 2: **Ministry for the Environment Environmental Performance Indicators for air quality**

Category	Monitoring result compared to guideline	Description
Action	Exceeds the guideline	Unacceptable and action is required to reduce emissions
Alert	66-100%	Warning level which could lead to exceedances if trends are not curbed
Acceptable	33-66%	Maximum values might be a concern in sensitive locations, urgent action is not warranted
Good	10-33%	Peak measurements not likely to affect air quality
Excellent	0-10%	Not recommended for PM_{10} monitoring, PM_{10} in this range is classified as good instead

SOE MONITORING RESULTS: PM_{10}

[10] PM_{10} was monitored continuously at four sites across the region in 2024: Alexandra, Arrowtown, Central Dunedin and Mosgiel. A summary of the key PM_{10} indicators for 2024 are given in Table 3 and a list of the NESAQ exceedances are shown in Appendix 1. The highest annual mean occurred at the Alexandra site with 16 µg/m³, which is an exceedance of the WHO guideline (15 µg/m³). All the other annual averages are just below the WHO guideline. The highest daily concentration was also recorded at Alexandra, with a concentration of 88 µg/m³ recorded on 27/07/2024. The most frequent number of exceedances occurred at the Arrowtown site, with daily concentrations exceeding the limit 16 times. Data capture was at least 95% at all four sites, although it should be noted that the Alexandra site was missing data during winter-time between 21-26/06/2024 and 31/07/2024 – 05/08/2024 due to instrument errors.

Table 3: **Key PM_{10} indicators for 2024**

Site	Annual mean (µg/m³)	Winter mean (µg/m³)	Maximum daily concentration (µg/m³)	2nd highest daily concentration (µg/m³)	Number of NESAQ exceedances	Data capture (%)
Alexandra	16	28	88	62	11	95
Arrowtown	14	28	80	72	16	98
Central Dunedin	14	14	35	32	0	96
Mosgiel	13	17	66	44	1	95

[11] Figures 1 and 2 show the seasonal patterns of the 24-hour average data and the distribution of data, respectively, in relation to the NESAQ limit and WHO guideline. Alexandra and Arrowtown have extreme seasonal variation (Figure 1), with high PM_{10} concentrations coming very close to and exceeding the limits. This can be seen in Figure 2, particularly in Arrowtown, where the distribution is skewed to the right because the

majority of the 24-hour averages consist of very low concentrations reflecting excellent air quality during summer and shoulder seasons. This data also shows that the concentrations can frequently be high (>40 µg/m³) without becoming an exceedance. Mosgiel data also shows a slight seasonal pattern, but the Central Dunedin site has no annual variation (Figure 1), and the distribution of concentrations are distributed fairly evenly around the mean (Figure 2).

[12] This data is reflective of PM sources in each airshed; Central Dunedin does not show a seasonal variation as home heating emissions are not an important source, compared to vehicle emissions and industrial activity. Mosgiel has a mixture of sources, while Alexandra and Arrowtown PM sources are primarily from winter home heating.

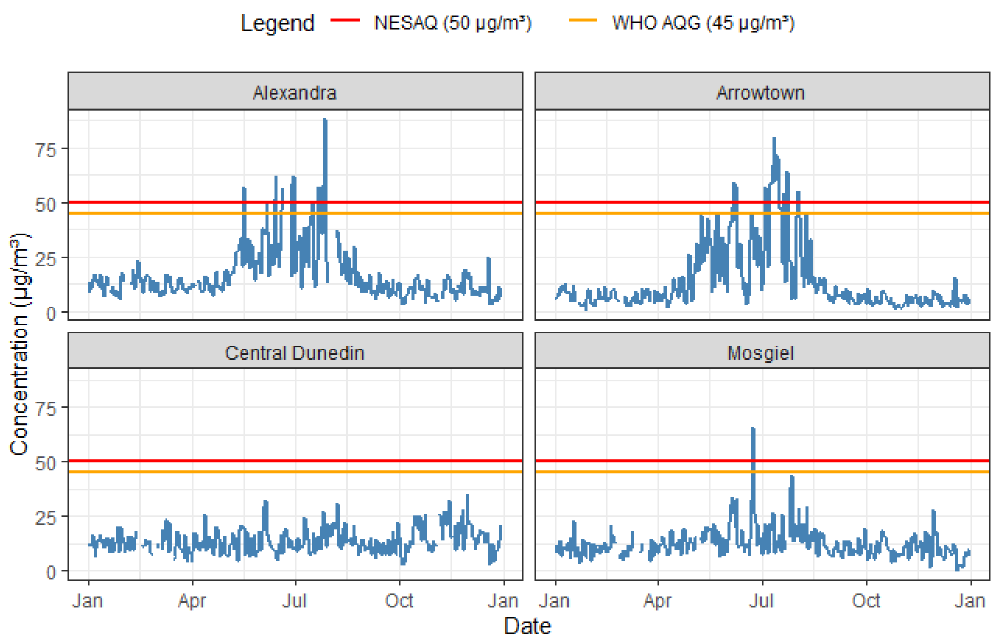


Figure 1: PM_{10} concentrations for 2024 (24-hour average).

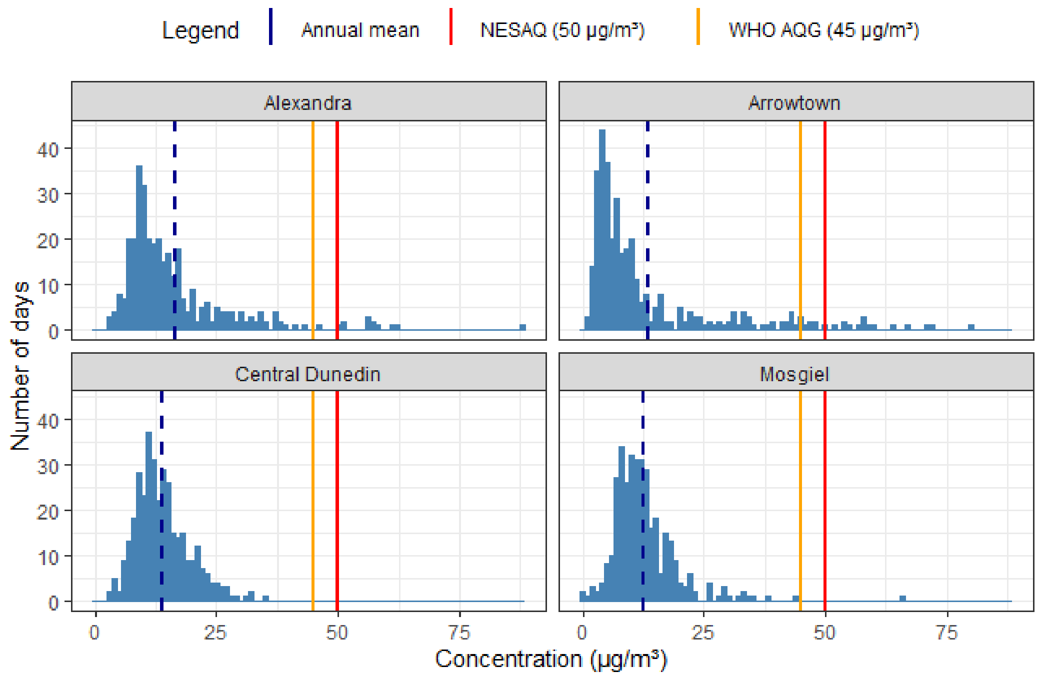


Figure 2: Distribution of daily PM_{10} concentrations for 2024 (24- hour average), in comparison to the NESAQ and WHO standards. Annual averages are 16 µg/m³ (Alexandra), 14 µg/m³ (Arrowtown and Central Dunedin) and 13 µg/m³ (Mosgiel). Histogram bin width is 1.

[13] When the PM_{10} data is sorted into the MfE indicator categories (Figure 3), all sites have over 70% of days in the "good" category. Alexandra and Arrowtown have approximately 10% of their data divided into the "alert" and "action" categories. Central Dunedin only had one day that can be categorised as "alert". The Mosgiel data showed that less than 5% of days were in either the "alert" or "action" categories.

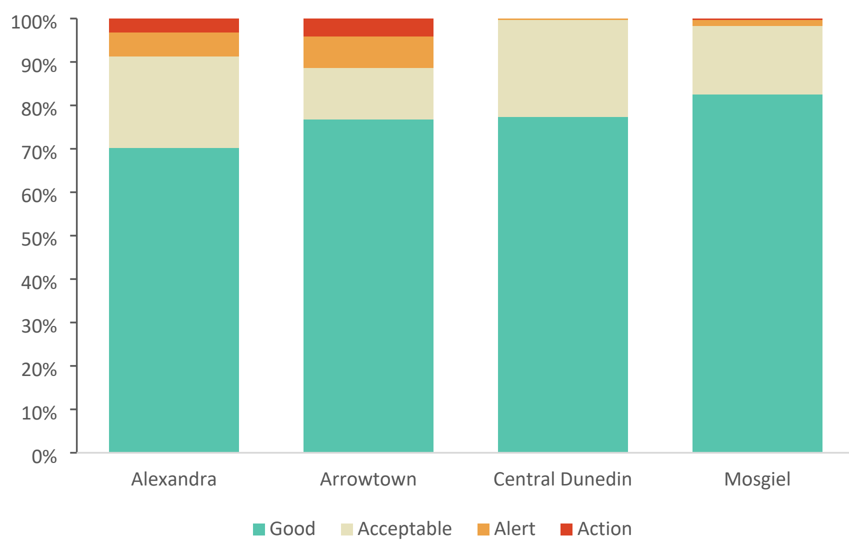


Figure 3: PM_{10} concentrations as air quality indicator categories for 2024 (24- hour average)

SOE MONITORING RESULTS: $PM_{2.5}$

[14] $PM_{2.5}$ was monitored continuously at seven sites across the region in 2024: Arrowtown, Central Dunedin, Clyde, Cromwell, Milton, Mosgiel and Wanaka. An eighth site was also set up in Frankton, Queenstown, towards the end of the year. The results from this site will be reported from the next annual report onwards. The instruments at Arrowtown, Central Dunedin and Mosgiel are considered equivalent to reference methods[3]. As such they will be able to be compared to standards and guidelines. However, a twelve-month period of co-location needs to be undertaken in order to establish a correction factor. As this has not been undertaken yet, none of the $PM_{2.5}$ data has been compared to limits or guidelines.

[15] A summary of the key $PM_{2.5}$ monitoring indicators for 2024 are given in Table 4. The highest annual mean occurred in Clyde and Milton, each with concentrations of 13 µg/m³; the lowest annual means occurred in Wānaka and Central Dunedin with concentrations of 5 µg/m³ and 6 µg/m³, respectively. The highest winter mean for 2024, 31 µg/m³, was recorded at the Clyde site. The highest daily concentration occurred in Milton followed by Clyde with 97 µg/m³ and 93 µg/m³, respectively. The data in Figure 3 shows very high winter concentrations in Arrowtown, Clyde, Cromwell and Milton, and to a lesser extent but still seasonal patterns in Mosgiel and Wānaka. Central Dunedin does not show seasonal variation for $PM_{2.5}$. These patterns match those of PM_{10}. Data capture for these sites was between 100% for most sites; the Arrowtown site had a data gap between 27/02/2024 11:50 and 04/03/2024 04:10 and the Mosgiel site had a data gap between 14/09/2023 04:30 and 26/02/2024 08:50. Both of these cases were due to instrument failure.

Table 4: Key $PM_{2.5}$ indicators for 2024

Site	Annual mean (µg/m³)	Winter mean (µg/m³)	Maximum daily concentration (µg/m³)	2nd highest daily concentration (µg/m³)	Data capture (%)
Arrowtown	11	25	77	69	91
Central Dunedin	6	7	16	15	100
Clyde	13	31	93	89	100
Cromwell	10	26	73	72	100
Milton	13	25	97	75	100
Mosgiel	8	13	76	46	84
Wānaka	5	10	28	23	100

[3] Monitoring methods required by NESAQ

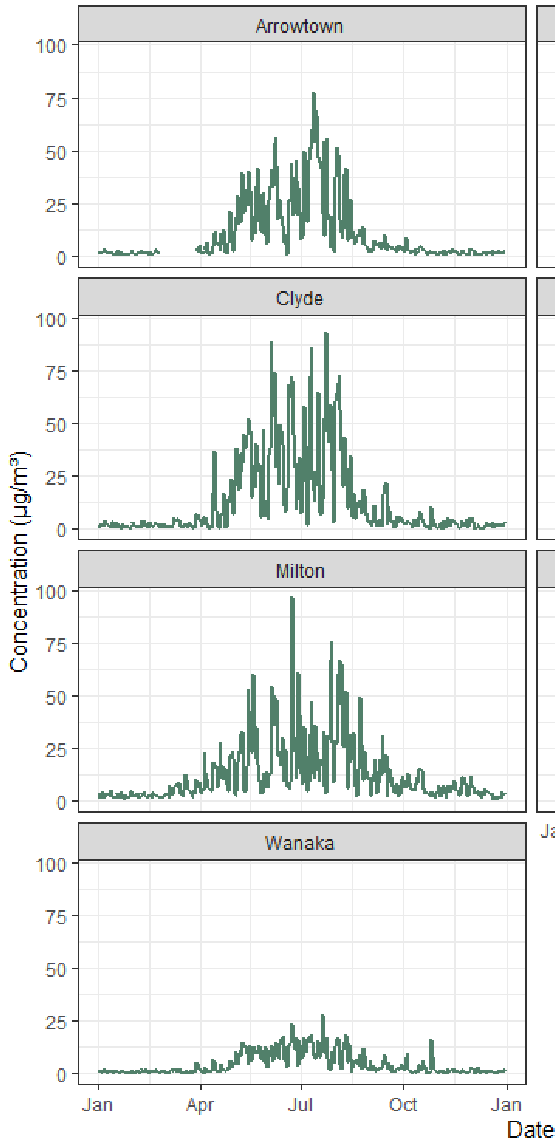


Figure 4: $PM_{2.5}$ concentrations for 2024 (24-hour average)

OTHER RESULTS: BLACK CARBON

[16] Black carbon (BC) is both a climate change pollutant and human health pollutant as a component of particulate matter. BC was monitored in Arrowtown during 2024, and the data shows very similar seasonal and daily patterns (Figure 5) to PM_{10}. BC is highest between the hours of 8:00 and 11:00 in the morning and then again between 19:00 and midnight (Figure 6). Because BC is only produced by combustion emissions, compared to PM_{10} which has other sources in Arrowtown such as dust and pollen, it is comparatively very low during non-winter seasons, as seen in the monthly graph in Figure 6.

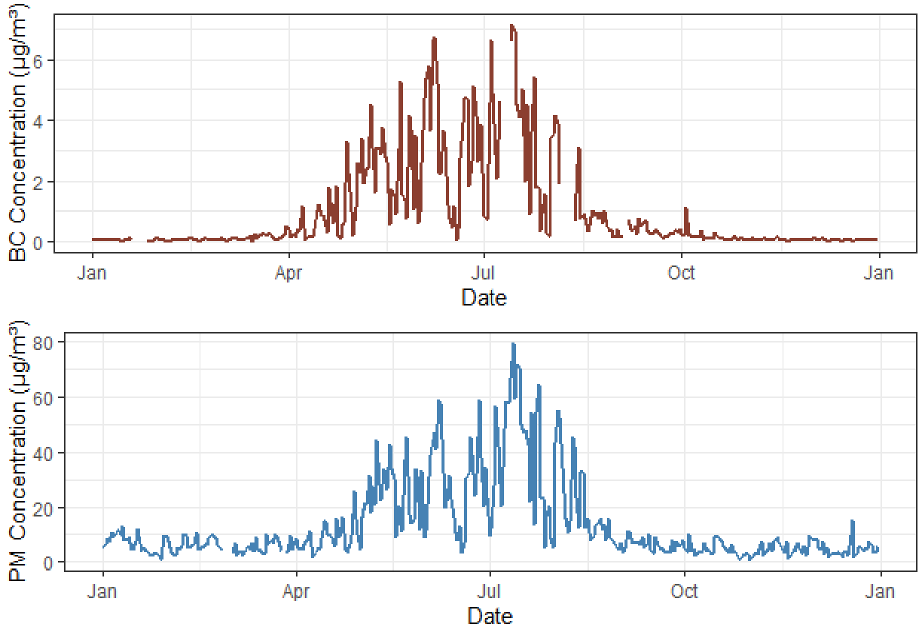


Figure 5: Black carbon and PM_{10}, Arrowtown 2024 (24-hour average)

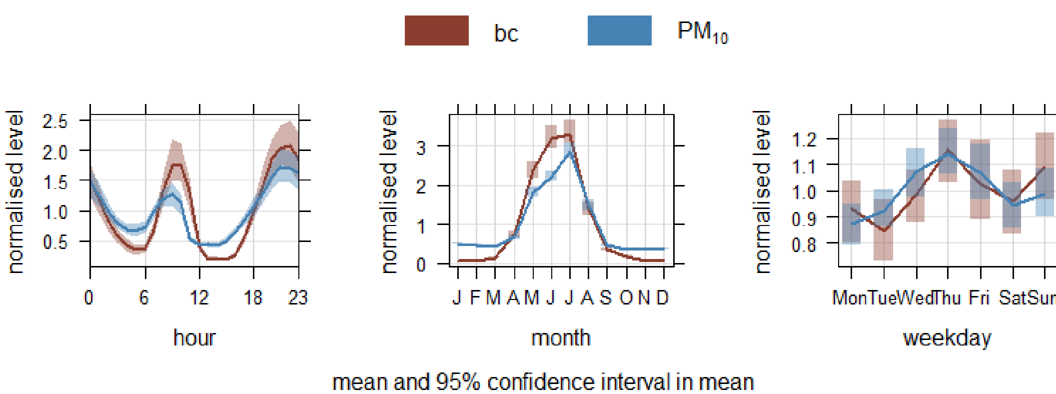


Figure 6: **Arrowtown normalised means of black carbon and PM_{10} at Arrowtown for hour of the day (left), month (middle) and day of the week (right). Shading represents 95% confidence interval of the mean. Data have been normalised (divided by their means) for comparison on the same scale.**

CONSIDERATIONS

Strategic Framework and Policy Considerations

[17] Monitoring Otago's air quality contributes towards the environmental element of the Strategic Directions of healthy air and managing air sustainably.

[18] The data will be available for the Air Plan and Strategy reviews.

Financial Considerations

[19] The air quality monitoring programme is a planned LTP activity for Science and Environmental Monitoring.

Significance and Engagement

[20] N/A

Legislative and Risk Considerations

[21] Managing air quality is a regional council requirement in accordance with the NESAQ.

Climate Change Considerations

[22] Monitoring black carbon contributes to ORC's understanding of this pollutant as a climate driver.

Communications Considerations

[23] Air quality communications will continue during 2025 with the Burn Dry Breathe Easy campaign.

[24] Due to a data recording error the data entering ORC's database was subject to the same offset twice for the Arrowtown site. Consequently, the number of exceedances recorded in Arrowtown was incorrect prior to data validation. This incorrect number (25 exceedances) was reported in an ORC media release and will be corrected (16 exceedances) in the media release for this report.

NEXT STEPS

[25] Monitoring network upgrades will continue in 2025.

[26] The next SOE State and Trends five-yearly report is due in 2029.

REFERENCES

Wilton, E., 2019. Wanaka, Cromwell and Clyde Air Emission Inventory – 2019. Environet Ltd. https://www.orc.govt.nz/media/12354/emissions-inventory_-clyde-cromwell-and-wanaka-2019.pdf

World Health Organization, 2021. WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. https://iris.who.int/handle/10665/345329

APPENDIX 1: PM_{10} Exceedance table for 2024

Site	Alexandra	Arrowtown	Central Dunedin	Mosgiel
Date	**Concentration (µg/m³) 24-hour average**			
17/05/2024	56			
6/06/2024	51			
7/06/2024		59		
8/06/2024		58		
13/06/2024	51			
14/06/2024	61			
20/06/2024	56			
23/06/2024				66
26/06/2024		59		
28/06/2024	58			
30/06/2024	62			
4/07/2024		57		
9/07/2024		58		
10/07/2024		58		
11/07/2024		67		
12/07/2024		80		
13/07/2024		60		
14/07/2024		72		
15/07/2024		71		
21/07/2024		54		
22/07/2024	57			
23/07/2024	56	54		
24/07/2024		64		
26/07/2024	57			
27/07/2024	88			
2/08/2024		55		
3/08/2024		53		
Total number of exceedances	**11**	**16**	**0**	**1**

ATTACHMENTS

Nil

9.3. Update on Regional Indigenous Biodiversity Monitoring

Prepared for: Science and Resilience Committee

Report No. SCI2501

Activity: Governance Report

Author: Pete Ravenscroft, Team Leader Biodiversity

Endorsed by: Tom Dyer, General Manager Science and Resilience

Date: 4 June 2025

PURPOSE

[1] This paper provides and update on the development of monitoring programmes for indigenous biodiversity.

EXECUTIVE SUMMARY

[2] Indigenous biodiversity monitoring has been established to monitor wetlands, rare terrestrial ecosystems, freshwater fish, and the coastal and estuarine environments.

[3] This paper provides an overview of the establishment of indigenous biodiversity ecosystem monitoring methods and networks. Initial efforts have gone into developing monitoring methods/protocols and establishing sites.

[4] A comprehensive paper outlining the Science biodiversity programme will be presented to the Science and Resilience Committee later in 2025.

RECOMMENDATION

That the Committee:

1) ***Notes*** *this report*

BACKGROUND

[5] Monitoring indigenous biodiversity is a relatively new area for Otago Regional Council (ORC), primarily driven by requirements in national policy statements, including the NPS-FM and NPS-IB.

[6] There are broadly four indigenous biodiversity ecosystems currently monitored by ORC, which are: freshwater, estuaries and coast, rare and threatened terrestrial ecosystems, and natural wetlands.

[7] This paper presents an overview of the state of indigenous biodiversity monitoring, recognising than many monitoring programmes have only recently been established.

FRESHWATER ECOSYSTEM MONITORING

[8] The Freshwater ecology programme is instrumental in the developing the science that supports and the development of minimum flow processes. This work entails designing catchment studies, (developing the questions) undertaking instream habitat models, and ultimately providing flow recommendations.

[9] There are four core activities that comprise the freshwater fish ecology programme, notably State of the Environment (SoE) fish monitoring, additional fish monitoring, salmonid removal, and fish passage. The two fish monitoring programmes are relevant to indigenous biodiversity ecosystem monitoring.

SoE Fish Monitoring Programme

[10] The current SoE fish monitoring programme is an NPS-FM requirement and consists of two groups of sites; one group is monitored annually and the second group which is monitored every other year. Monitoring started in the Lindis catchment in 2007/08, and the number of sites has increased overtime, with last site being established in Spec Creek in 2020.

[11] SoE Fish monitoring uses the New Zealand Freshwater Fish Sampling Protocols (Joy, David and Lake 2013). The electrofishing protocols consist of monitoring a 150-metre reach (divided into 10 sub-reaches). All fish are identified and counted and the first 50 of each species (cumulative over the entire reach) are measured (total length and weight). Once the threshold of 50 measured individuals is reached for a species:

- All remaining individuals of that species in the same sub-reach are also measured.
- In subsequent sub-reaches, individuals of that species are counted only, with no further measurements taken.
- Additional information recorded includes fishing effort and measures of habitat type/fish cover.

[12] Results from the SoE Fish monitoring programme will be collated, and data analysed and reported next financial year.

Other Fish monitoring programmes

[13] This programme monitors native freshwater fish populations or ecosystems of high regional importance.

[14] A recent example is the programme monitoring the Lowland longjaw galaxias in the Kakanui catchment. Results and observations made during this monitoring programme prompted the Kauru River groundwater/river interaction study which was presented to Council in February 2025.

[15] Two monitoring programmes have been set up in Boundary Creek and Pigroot Creek in the upper Shag River catchment. These creeks are the focus of salmonid removal projects, and monitoring is required as part of the Otago Fish and Game removal licence. The objective of this monitoring is an attempt to capture the response of the galaxiid numbers to the removal of salmonids. It is too early in the monitoring regime to make any statement on the impact of salmonid removals on indigenous biodiversity.

[16] A further project is revisiting historic monitoring locations, where fish were individually tagged in past decades, and therefore can be individually identified (Figures 1-2). This work provides critical information about the life cycle and longevity of native fish species. Key locations are Burnt Creek (Waipori catchment) and Schoolhouse and Yellow Creek (Nevis catchment). Recently a programme to tag galaxiids has commenced in the Pomahaka catchment.

Figure 1: Nevis galaxias – Tag # 55F – Tagged. Tagged in 2012 and last captured 2024.

Figure 2: Photograph of a dusky galaxias (Tag V93) - Tagged in 2004 last caught in 2024 in Burnt Creek, Waipori. Estimated age 30 years (Photo: P. Ravenscroft).

COASTAL AND ESTUARY ENVIRONMENTS

[17] There are two separate programmes established to monitor Otago's coastal marine area. The first is the coastal programme focusing from the coast (outside the estuaries) to 12 nautical miles offshore. The second is the estuary monitoring programme.

Coastal Ecosystem Monitoring

[18] The coastal programme to date has focused on gathering data and information to inform the pending coast plan review and to meet the regulatory requirements of the Council. The two main ecosystem monitoring components in the coast programme are a) kelp forest monitoring, and b) marine significant ecological area mapping programme and the subsequent ground truthing.

Kelp forest monitoring programme

[19] Kelp forests are significant habitats along the coast that are hotspots of biodiversity and important both culturally and economically. Leigh Tait, the lead scientist on this project from NIWA was quoted saying that "the *macrocystis* kelp forest off the Otago coast near Moeraki is one of the most diverse kelp forests he has surveyed in New Zealand" which highlights the significance of these systems in Otago. It is important to have a monitoring programme that gathers the appropriate data to allow for management of sediment from land and other stressors to build the resilience of these ecosystems to better handle warming water temperatures.

[20] The kelp forest monitoring programme is in its 4th year out of a planned 5 year programme.

[21] The 1st year included a report that looked at kelp forest extent versus temperature and turbidity to determine change in kelp cover over 10 years in relation to those stressors. The report (which was presented to council in April 2023) highlighted how during marine heat waves the areas of the coast with higher turbidity (suspended sediment) experienced greater loss of kelp forest coverage than areas with clearer water, emphasising the compounding effect of multiple stressors on kelp extent.

[22] There will be a comprehensive report on kelp forest monitoring at the completion of the 5-year monitoring programme.

Marine significant area mapping

[23] The marine significant area mapping work was presented to Council in April 2023. Subsequent work has involved validating this mapping by inspecting mapped offshore ecosystems with drop and tow cameras. This work is ongoing, but an update is presented in the accompanying June 2025 Coast and Estuary programme update.

Estuary programme

[24] There are two principal components to the estuary programme: the estuary State of the environment programme and the estuary investigation/management programme. The estuary SoE monitoring programme is relevant to indigenous biodiversity ecosystem monitoring.

[25] The estuary state of the environment programme focusses on monitoring and reporting on the state and health of Otago's estuaries, with reports presented to council in October 2020, June 2021, June 2023, December 2024. A summary of the state of Otago's estuaries regarding sediment is presented to in the accompanying June 2025 Science and Resilience committee paper.

Otago Intermittently Closed Estuaries (ICEs) Programme

[26] Along the Otago coast, numerous drains, creeks, streams, and rivers make their way to the sea. Where they reach the sea, the mixing of freshwater and seawater occurs resulting in an estuarine environment. When access to the ocean is periodically blocked from beach or berm growth, some estuaries become periodically closed until there is sufficient flow or water pressure to cut a new outlet channel. These sites are known as intermittently closed estuaries (ICE). Prominent examples are the Kaikorai and Tomahawk estuaries.

[27] Otago's larger open estuaries are currently being monitored by the estuary SoE monitoring programme described above. In comparison, the smaller ICEs have represented a gap in monitoring.

[28] A programme was established to develop an SOE monitoring framework for Otago's ICEs by systematically identifying the systems and summarising existing information, both empirically determined through field study as well as information inferred from remote sensing imagery and catchment models. A detailed report, inventory and webpage[1] have

[1] https://www.orc.govt.nz/environment/water-care/wetlands-and-estuaries/intermittently-closed-estuaries/

been developed outlining information such as location, extent, type, values, pressures and threats, and discussing approaches for assessing their intrinsic vulnerability to anthropogenic inputs as well as approaches for prioritising sites for ecological monitoring and assessment (please see the website and linked reports for more details).

[29] A research project with the University of Otago has been initiated where selected ICEs will be monitored using the newly designed and framed monitoring protocols.

TERRESTRIAL BIODIVERSITY MONITORING

[30] The terrestrial programme has focused on terrestrial indigenous species, their habitats, and the ecosystems they inhabit in the Otago Region. The programme has included providing insights on the unique indigenous species and ecosystems only found in Otago, assessing the threat status of select species (taxonomic) groups, and developing or establishing monitoring of species and naturally uncommon ecosystems.

Terrestrial Ecosystem Monitoring

[31] This programme is developing an understanding of terrestrial ecosystems in the Otago Region. Work has focused on identifying, describing and mapping ecosystems, and establishing monitoring for some ecosystems in the Region.

[32] Monitoring to date has focussed on Otago's naturally uncommon ecosystems. A lot of upfront effort has been to develop monitoring methodologies and protocols for these rare and threatened ecosystems.

[33] The development of monitoring programmes for two naturally uncommon ecosystems, inland saline (Figure 3) and coastal turfs, started in 2022, as presented to the Environment, Science and Policy Committee in 2023. These ecosystems are now in their third year of monitoring.

[34] Monitoring programmes are being developed for three additional naturally uncommon ecosystems: active sand dunes, shingle beaches, and inland outwash gravels.

Figure 3: *Lepidium kirkii* or salt pan cress are only known to occur on inland saline sites in the semi-arid region of Otago. This habitat varies from highly weathered bedrock schist to the gravels and silts of old terrace surfaces, and usually supports only a few other highly specialised plant species. Photo: John Barkla.

NATURAL WETLANDS

[35] Following the new national guidelines (NPS-FM 2020) a detailed and comprehensive regional wetland mapping programme was developed. The programme consisted of mapping wetlands in three phases. In phase I and II, which stretched over two years (FY 2021-22 and 2022-2023), natural wetlands in the Upper Taieri Scroll Plains (Figure 4) and regionally Significant Wetlands/Wetland Management Areas were re-defined and their boundaries revised.

[36] Phase III of the programme is to map all natural wetlands in the region that are larger than 500 m^2 (and smaller if ephemeral wetland and/or known to contain threatened species). This represents a significant body of work and may take several years to complete, as Otago contains large areas of dissected hill country and upland landforms, that will contain tens of thousands of smaller and ephemeral wetlands.

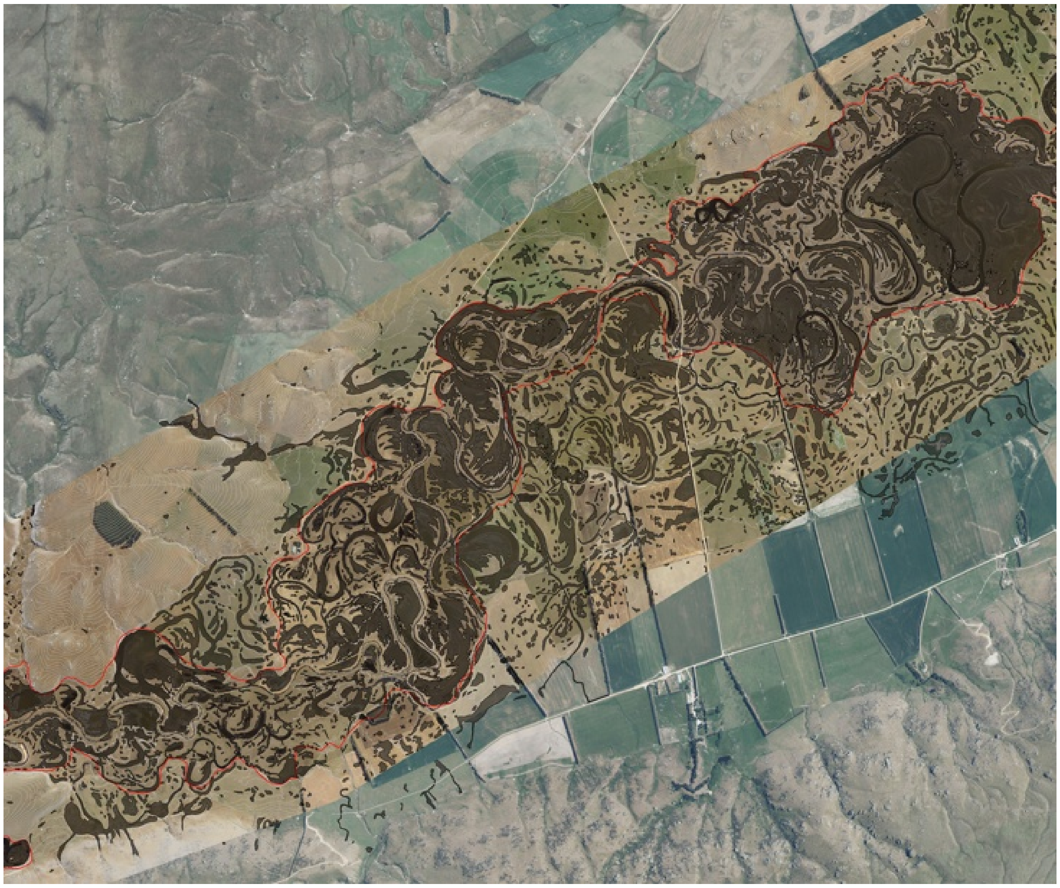


Figure 4: Potential Wetland Polygons in the Upper Taieri Scroll Plain. Red line denotes original Regionally Significant Wetland boundary.

Wetland monitoring

[37] The monitoring component of the wetland programme has been comparatively modest, with priority given to completing the regional wetland mapping work.

[38] The NPS-FM 2020 sets out the values of interest regarding wetlands and provides a clear context for developing a wetland condition and extent monitoring framework. ORC wetland scientists worked with Landcare Research to develop a wetland monitoring methodology and protocol for Otago.

[39] Establishing a wetland monitoring site involves assessing biodiversity values, threats, regional and national significance, elevation, and wetland type and condition. On-site monitoring includes vegetation assessment, soil measurements, recording depth to water, water chemistry, a prescribed photographic record, and a survey of birds and other animals present.

[40] Wetland monitoring in Otago began with a project with Manaaki Whenua Landcare Research (MWLR) to better understand the ecology of the Upper Taieri Scroll Plain Wetland Complex. The monitoring is intended to inform a broader Scroll Plain management and monitoring plan. The work included assessing vegetation and soil condition in 151 plots across the Scroll Plain.

[41] In 2023-2024 the monitoring network was extended by adding four more Regionally Significant Wetlands: Tahakopa River Bogs, Lake Tuakitoto Wetlands, Upper Black Swamp Marshes (Beaumont River catchment), and Fortification Creek Wetland Management Area (Lake Onslow catchment).

[42] Otago Regional Wetland Monitoring Protocols outline that these wetlands will be monitored at a ten-year interval to be able to document wetland condition. Each of the ecosystem components is measured against interventions (such as new regulations and rules, and non-regulatory tools) and / or threats.

DISCUSSION

[43] This paper has provided an overview of the ORC's indigenous biodiversity ecosystem monitoring in Otago.

[44] Most of the monitoring networks have recently been established and there is insufficient data to establish trends at this stage.

OPTIONS

[45] This paper is for noting only.

CONSIDERATIONS

Strategic Framework and Policy Considerations

[46] Ecosystem monitoring helps to ensure that ecosystems are healthy and biodiversity loss is arrested across the region. It also enables early detection of emerging environmental issues.

Financial Considerations

[47] Ecosystem monitoring is a planned and budgeted work programme.

Significance and Engagement

[48] N/A.

Legislative and Risk Considerations

[49] Some of this work has been mandated by national policy statements which are currently under review.

Climate Change Considerations

[50] Monitoring ecosystems enables the effects of climate change on biodiversity to be monitored and allows prediction of the impact of future climate changes on species and ecosystems.

Communications Considerations

[51] N/A.

NEXT STEPS

[52] A comprehensive update on the broader biodiversity science work programme will be presented to Council later in 2025.

ATTACHMENTS

Nil

9.4. Land and Soil Monitoring Update

Prepared for:	Science and Resilience Committee
Report No.	GOV2549
Activity:	Governance Report
Author:	Erik Button, Scientist - Land and Soil Mark Crawford, Scientist - Land and Soil
Endorsed by:	Tom Dyer, General Manager Science and Resilience
Date:	4 June 2025

PURPOSE

[1] This report provides an annual update on the Land and Soil work programme.

EXECUTIVE SUMMARY

[2] A new and updated version of the land use map has been completed. This captures recent land use changes and improves the methodology and land use classification that will be carried forward into future versions.

[3] The third of five years of expansion of the soil health monitoring programme has increased the represented areas and different land uses. The results demonstrate that soil compaction, depletion of organic reserves, and nutrient imbalances affect between a few to half of all sites. Reference ranges used to interpret the programme results are currently being redeveloped.

[4] NIWA and ORC have signed a Data Sharing Agreement. This means that data sharing between the two organisations will become easier and faster in the future. ORC also gets access to NIWA-owned climate and environmental monitoring site data which will, among others, expand the Otago soil microclimate network from 7 to 18 sites.

[5] A five-year S-Map (soil maps) expansion campaign is on track to be completed later this year. This will increase the total area of Otago mapped to 36%, including 98% of the most productive soils which are the highest Land Use Capability classes (1-3).

[6] Two collaborative research projects have been established and are ongoing to improve regional data and understanding. Project 1 aims to develop a background dataset of contaminant concentrations in soil for the management of contaminated and excess soil. Project 2 explores alternative winter forage varieties to increase farm system resilience and minimise environmental impacts, by a controlled trial and case study farms.

RECOMMENDATION

That the Committee:

*1) **Notes** this report.*

BACKGROUND

[7] The ORC's land and soil programme was revitalised in 2021. Since then, it has focussed on developing and managing key maps and datasets relating to land use, soil health and quality, and technical information for a range of different audiences. These resources

are being utilised across ORC and by the community for different applications, including nutrient modelling, economics, policy development, catchment management, and farm scale mitigations.

LAND USE MAP

[8] A current classification of land use and land cover is necessary for ORC to implement national regulations, including the National Policy Statements concerning Indigenous Biodiversity, Freshwater Management, and Highly Productive Land. The land use map is a key dataset that serves as a reference point for measuring future changes and aids in managing Otago's natural resources.

[9] Land use mapping of Otago was undertaken in 2021 and 2022 by Great South, Southland Regional Development Agency. The mapping drew on a range of ORC data and external information (including Agribase managed by AsureQuality) to generate a best estimate of land use at the property scale. Land use maps require regular updating to correct identified errors, and account for any land use changes and updates to source datasets (e.g. annual updates from Agribase). In addition, methodological improvements can be implemented to improve the accuracy and address any identified misclassifications.

[10] In 2024, Pearsons Environmental Consulting (PEC) updated the regional base and technical land use maps[1]. PEC have a strong track record in spatial mapping and developed land use maps for the Tasman and Marlborough Unitary Councils. The base map (Figure 1) was created at the property scale, using council valuation boundaries and LINZ's primary parcels as the spatial framework, combined with specific council data, national public data on land use, land cover, and protected areas, and new commercial data from Agribase. The map is available online[2] and on the ORC website[3].

[1] Report documenting the process, details of the categories and the limitations of the method: https://www.orc.govt.nz/media/1ucbsqba/pec-otago-land-use-map-final-250325.pdf

[2] https://orcnz.maps.arcgis.com/home/item.html?id=3e670a19b23840ebb69c7fd669105cfe#overview

[3] https://www.orc.govt.nz/environment/land-care/land-use-in-otago/

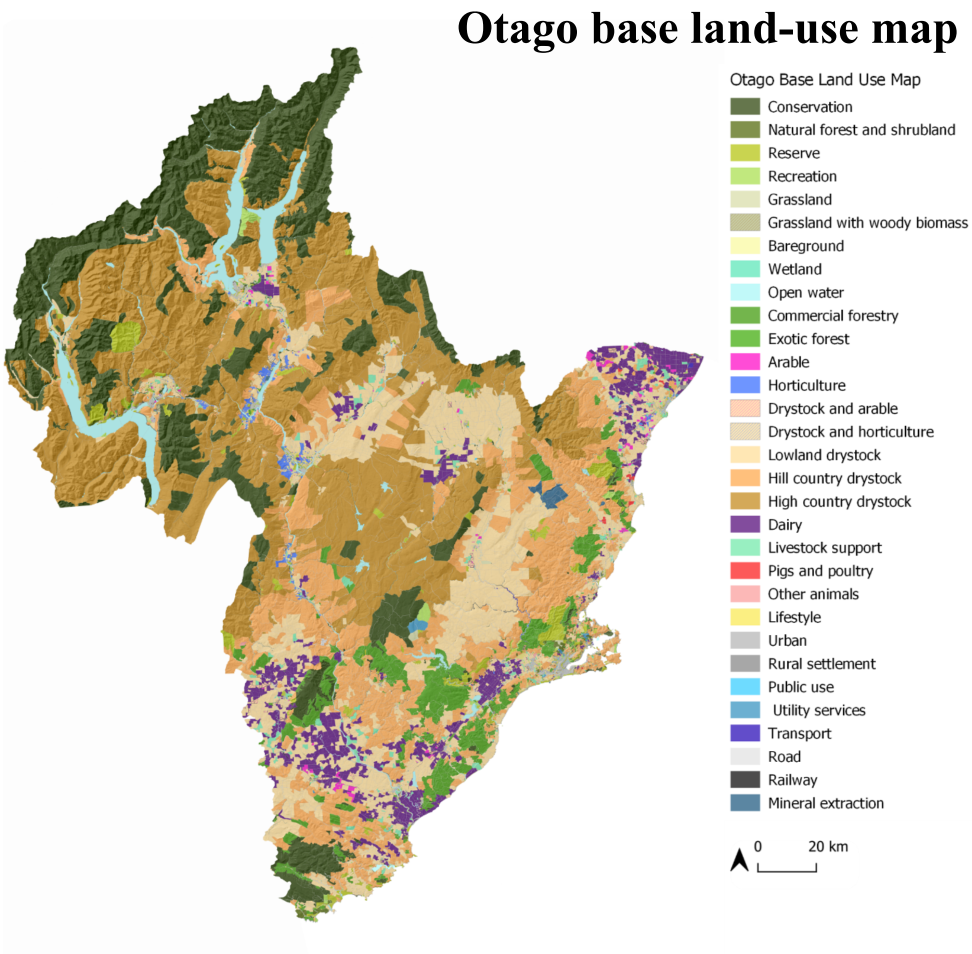


Figure 1. The updated land-use map with the new classification system.

[11] The base land-use dataset includes a new and more intuitive classification of land-uses (Table 1) that can still be correlated with previous iterations and models that use land-use classification. It also differentiates drystock classes by dominant property area for more nuance in relation to management and stocking rates, using the following criteria:

- Lowland (<600 m above sea level, slopes < 8 degrees)
- Hill country (<600 m above sea level, slopes between 8 – 21 degrees)
- High country (majority of property above 600 m above sea level, mixed slope)

Table 1. Summary of the primary land use areas and their extents in the Otago region ordered by largest to smallest area.

Primary land use	Primary land use area (ha)	Regional extent (%)
High country drystock	952,161	29.45
Conservation	689,718	21.33
Hill country drystock	515,181	15.93
Lowland drystock	475,139	14.69
Dairy	141,110	4.36

Commercial forestry	137,589	4.26
Open water (inc. coastal marine)	97,727	3.02
Reserve	63,718	1.97
Road	43,319	1.34
Livestock support	23,751	0.73
Lifestyle	13,738	0.42
Horticulture	11,822	0.37
Arable	8,929	0.28
Recreation	8,904	0.28
Urban	8,451	0.26
Drystock and arable	7,101	0.22
Natural forest and shrubland	6,455	0.20
Mineral extraction	4,955	0.15
Utility services	3,471	0.11
Grassland	3,178	0.10
Grassland with woody biomass	2,947	0.09
Rural settlement	2,869	0.09
Drystock and horticulture	2,492	0.08
Exotic forest	2,130	0.07
Other animals	2,015	0.06
Pigs and poultry	1,416	0.04
Railway	1,044	0.03
Transport	999	0.03
Public use	613	0.02
Wetland	367	0.01
Bareground	164	0.01
Total	**3,233,475**	**100**

[12] A technical map was made by combining the base map with a spatial depiction of land cover and accompanying details about the land’s surface and natural features that dictate landscape vulnerability to contaminant loss. It includes data on vegetation health (using infrared technology) and farming practices like irrigation and winter grazing. Land use, combined with the physical characteristics of the soil and landscape, are key inputs into regional nutrient loss modelling.

SOIL HEALTH MONITORING

[13] In 2024, the third year of the Soil Health SOE Monitoring programme, 19 new sites were established. This includes seven sites that have no land use (natural) serving as reference sites. The total current number of monitoring locations is 56, spanning nine land uses and six New Zealand Soil Classification (NZSC) soil orders (Figure 2). For the first time, the latest round of sampling included arable land, wetlands, and native forest.

[14] Soil indicators are a National Environmental Monitoring Standard designed to assess the condition of the soil against target ranges[4]. The current state of the soil health monitoring sites demonstrates a range of potential concerns. Up to 28% of sites are considered compacted to some extent as evidenced by bulk density and macroporosity results, with most of these sites being dairy and intensive drystock (Figure 3 and 4). Soil compaction reduces permeability to water, air, and roots, which increases surface ponding and runoff potential contributing to environmental impacts[5]. Low organic carbon, Olsen phosphorus, total nitrogen, and anaerobically mineralisable nitrogen at some sites demonstrate a relatively consistent sign of loss and/or depletion of organic matter reserves. A reduction in organic matter impacts the capacity of soils to perform their key functions of water and carbon storage, nutrient cycling, decreases soil resilience to drought, and is linked to lower yields[6]. At some sites, high total nitrogen, anaerobically mineralisable nitrogen[7], and Olsen phosphorus[8] concentrations highlight greater risks of nutrient mobilisation to receiving environments due to oversupply.

[15] While there are areas of concern, it is important to highlight that most of the sites are meeting the 'adequate' range (Figure 4), demonstrating the sustainable land use practices that are being undertaken in the region.

[4] National Environmental Monitoring Standard, 2022. Soil Quality and Trace Elements. Sampling, Measuring, and Managing Soil Quality and Trace Element Data. Version 1.0.0.

[5] Batey, T., 2009. Soil compaction and soil management–a review. *Soil use and management*, *25*(4), pp.335-345.

[6] Weil, R.R. and Magdoff, F., 2004. Significance of soil organic matter to soil quality and health. *Soil organic matter in sustainable agriculture*, pp.1-43.

[7] Cameron, K.C., Di, H.J. and Moir, J.L., 2013. Nitrogen losses from the soil/plant system: a review. *Annals of applied biology*, *162*(2), pp.145-173.

[8] Taylor, M.D. Drewry, J.J, Curran-Cournane F, Pearson L, McDowell RW, Lynch B , (2016). Soil quality targets for Olsen P for the protection of environmental values. In: Integrated nutrient and water management for sustainable farming. http://flrc.massey.ac.nz/publications.html. Occasional Report No. 29. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.

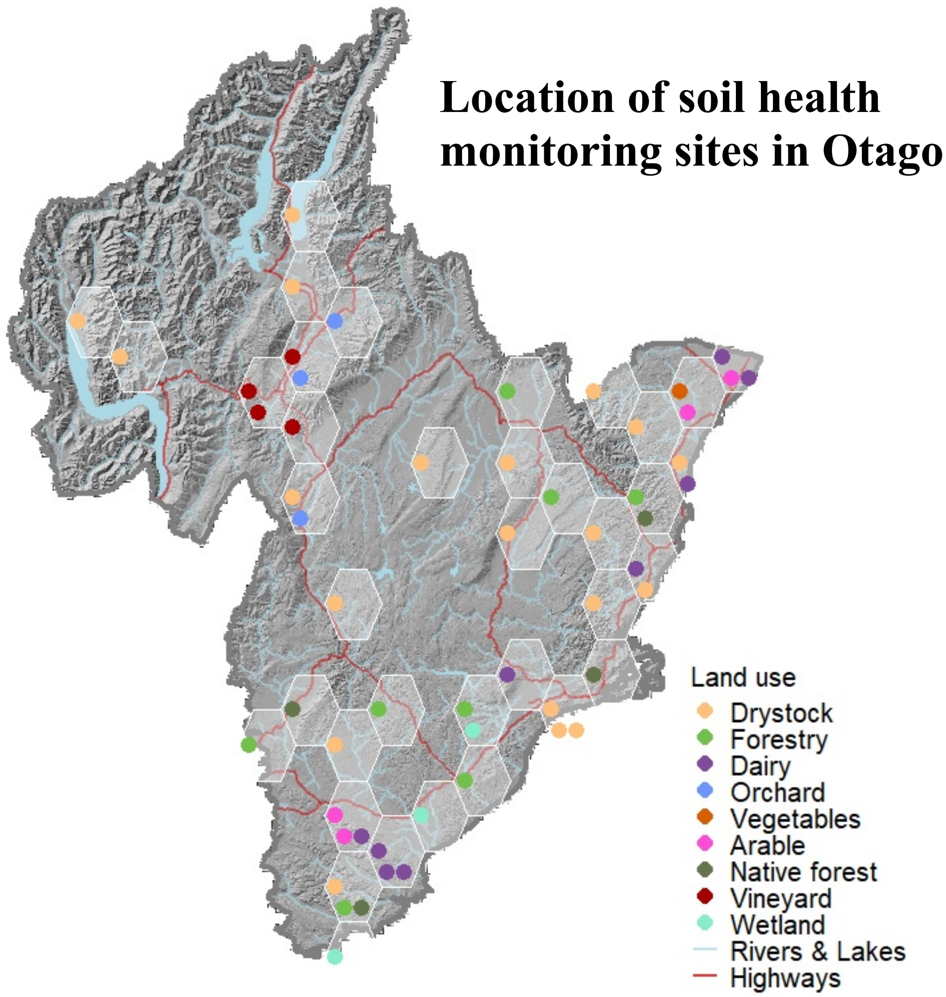


Figure 2. Map of the 56 soil-health monitoring sites and their land use in Otago with topography, rivers, lakes, and highways for context. The hexagons represent the area within which the monitoring sites are located. The position of the points, representing monitoring sites, is fixed within the hexagons to anonymise their precise location to conform with landowner access agreements.

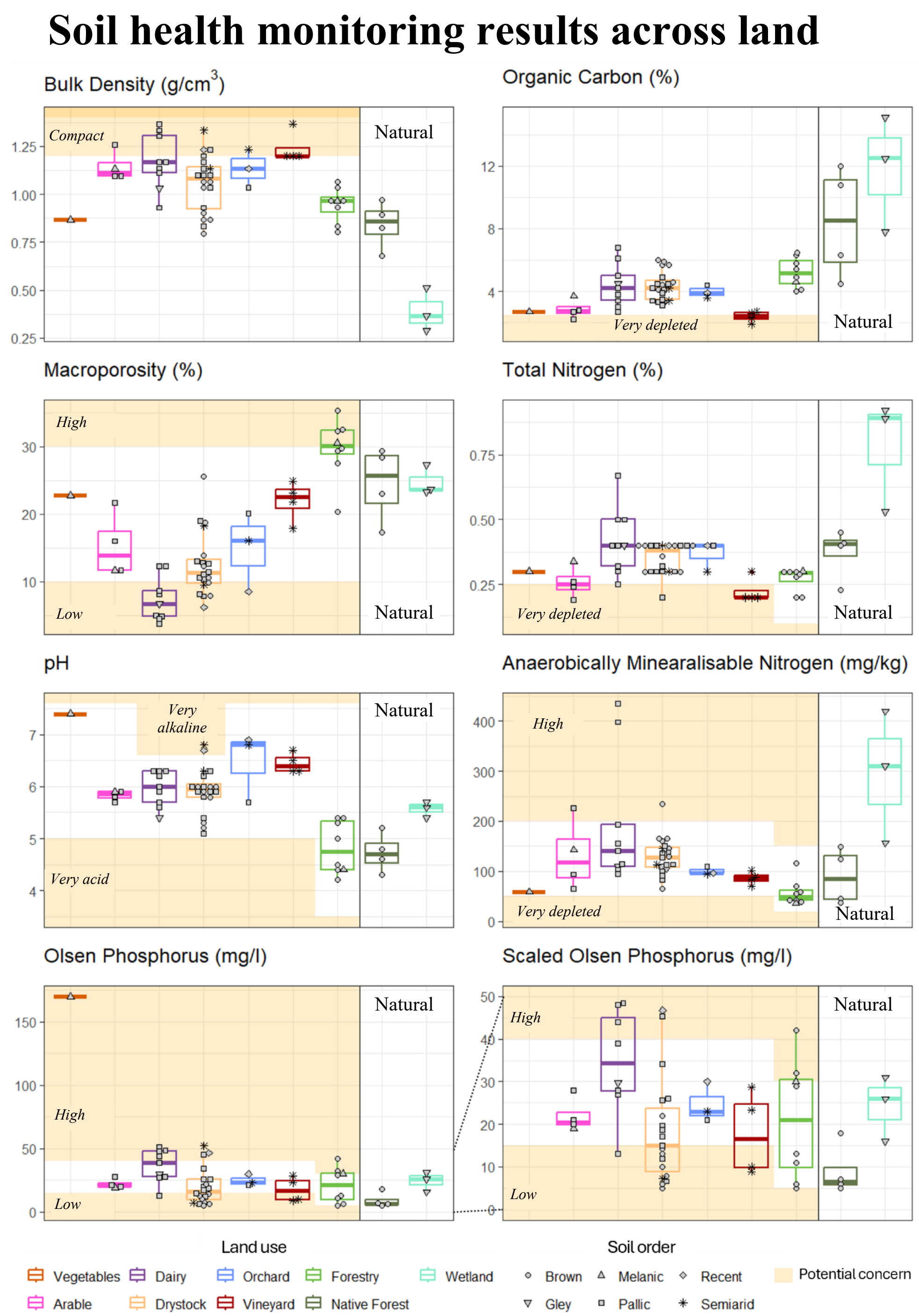


Figure 3. Results from the soil health monitoring programme. Boxplots of the land uses (Drystock n=20; Dairy n=9; Forestry n=8; Arable n=4; Vineyard n=4; Native Forest n=4; Orchard n=3; Wetland n=3; Vegetables n=1) with points representing NZSC soil orders. The boxes show the median (horizontal line), upper and lower quartiles (limits of the box or interquartile range), and the

minimum and maximum of the data (vertical lines). The orange areas are of potential concern and are based on developed reference ranges[9,10] that are being revised.

[16] The reference ranges used to interpret the data and for reporting regionally and nationally were first developed in 2008[1]. These preliminary reference ranges were partially updated in 2013[2] with the intention for future revision. A current Manaaki Whenua Landcare Research project funded via an EnviroLink Tools grant is updating these reference ranges based on newly available data and emerging understanding, allowing for more nuanced interpretation in the future. ORC is part of the working group of this project.

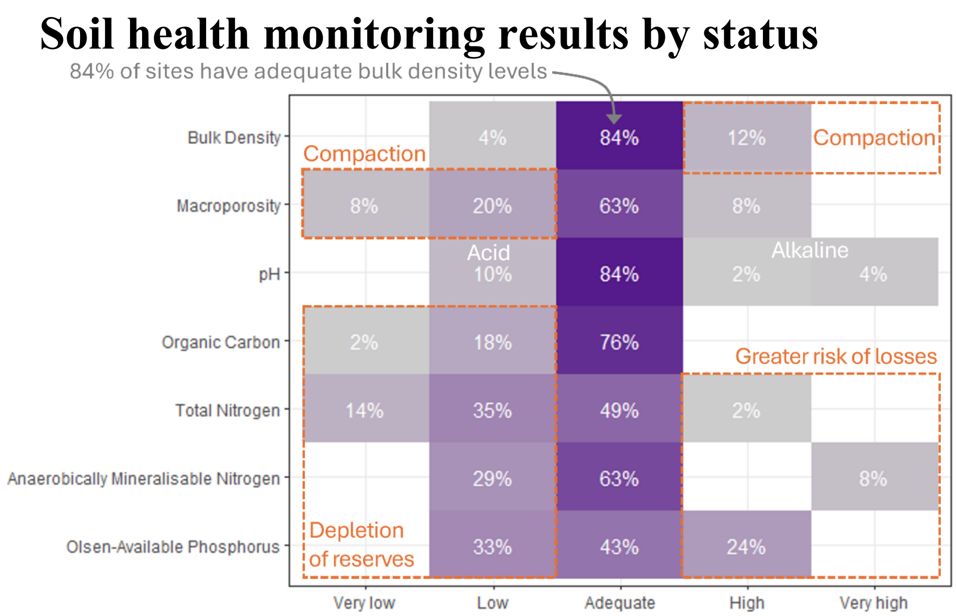


Figure 4. Heatmap of the proportion of the total primary industry land uses included in the soil health monitoring programme (*n* = 49*)* that meet the statuses for each soil parameter and what soil issues these statuses are generally indicative of. Native Forests (*n* =4) and Wetlands (*n* = 3) are excluded as these are considered to represent ecosystems in natural states and not primary industry activities.

[17] Two more years of programme expansion are planned (2025-2026) with 44 new locations planned to target land uses and Freshwater Management Units (FMU) and Rohes that are poorly represented. This will bring the total number of soil monitoring sites to 100, which is comparable to other regions with established soil monitoring programmes. Remaining priorities include sites in the Manuherekia FMU, sites under tussocks, sites in urban areas, and additional vegetable growing (market gardening)

[9] Sparling G., Lilburne, L., Vojvodić-Vuković M. 2008. Provisional targets for soil quality indicators in New Zealand. Landcare Research Science Series no. 34. Manaaki Whenua Press, Lincoln, New Zealand. First published in 2003 by Landcare Research New Zealand Ltd, reissued in 2008, with minor amendments.

[10] Mackay A., Dominati E., Taylor M.D. 2013. Soil quality indicators: the next generation. Report prepared for Land Monitoring Forum of Regional Councils. Client report number: RE500/2012/025. Hamilton, AgResearch Ltd.

sites. In 2027, resampling will begin with sites revisited after five years to establish long-term trends in soil health.

Soil Biological Health Monitoring

[18] With support from an EnviroLink grant and in collaboration with Massey University and Otago University, three different soil biological methods were included in the soil health monitoring programme from 2023-2024. The primary aim of this project was to assess the state of soil biology in the regional monitoring network. Additionally, the aim was to understand the relationship of these results with the standard suite of measurements, compare the accuracy and feasibility of different methods, and inform the development of a national biological soil indicator. There has also been significant landowner interest in the soil's biology. Consequently, the results from individual sites will be reported back to landowners.

[19] Three methods have so far been applied across 34 locations from two years of soil health monitoring. These methods vary in the organisms they target, level of identification achieved, and time, skill, and cost needed. In brief, these are:

1. An in-field Visual Soil Assessment[11] method for the counting and identification of macrofauna (>2 mm).
2. Collection and identification of extracted soil cores for the counting and identification of mesofauna (0.1-2 mm) in collaboration with Massey University.
3. Samples collected for the extraction, amplification, and sequencing of DNA for fungi, bacteria, and invertebrates in collaboration with Otago University.

[20] Data collection and analysis are ongoing. Figure 5 shows a selection of invertebrates found in the samples. Once collection and processing of samples and data has concluded, the information will be analysed and interpreted to summarise these in individual landowner reports and an aggregated regional report.

[11] Shepherd, T.G.; Ross, C.W.; Basher, L.R.; Saggar, S. 2000: Visual soil assessment, Volume 2. Soil management guidelines for cropping and pastoral grazing on flat to rolling country. horizons.mw & Landcare Research, Palmerston North. 44p.

Invertebrates found in soil samples

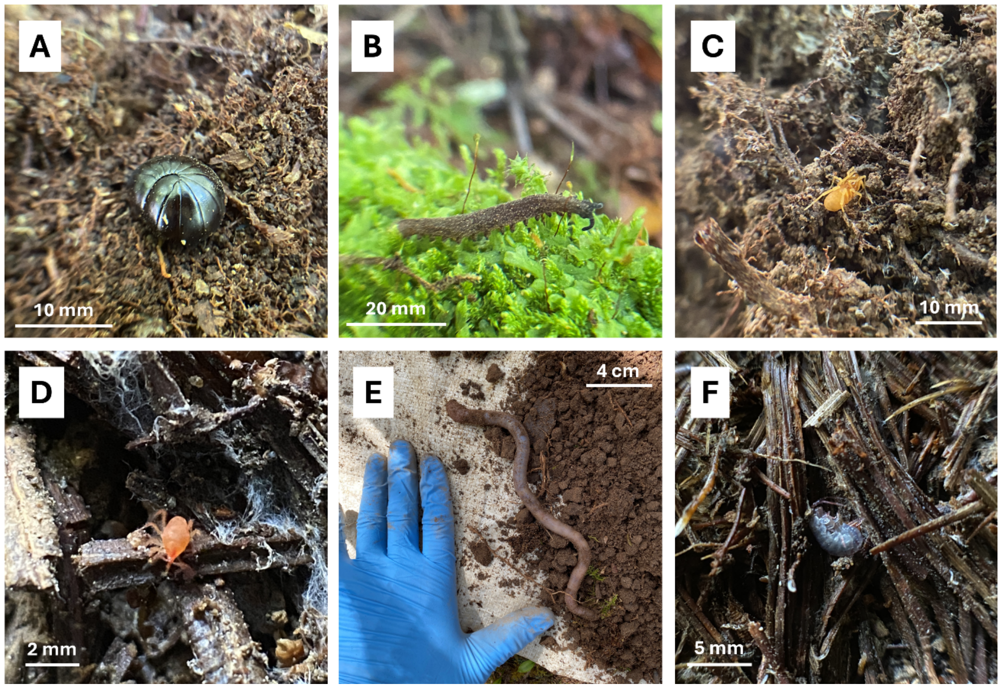


Figure 5. Selection of soil invertebrates counted and identified to broad taxonomic level during the additional soil biological method implemented in the soil health monitoring programme. A) A native slater (Isopoda) rolled into a defensive armoured ball; B) The charismatic ngāokeoke or velvet worm (Onychophora) found in a native forest. The so-called 'living fossil' recently received the 2025 New Zealand Bug of the Year crown[12]; C) A distinct orange spider (Araneae) in the leaf litter of a beech forest; D) One of often hundreds of mites (Acari) found in a plantation forest; E) Large native earthworm (Oligochaeta) from a Kānuka forest; F) A shrimp-like landhopper (Amphipoda), a type of terrestrial crustacean. Scale bars are approximate.

NIWA-ORC DATA SHARING AGREEMENT

[21] After over a year, discussion and liaison within the Council and with the Crown Research Institute, the National Institute for Water and Atmosphere (NIWA) have concluded with the signing of the NIWA-ORC Data Sharing Agreement in April 2025. This agreement sets out the terms and conditions for sharing environmental data, with the aim of helping NIWA fulfil its research and applied science services objectives and assisting ORC with its operational duties and responsibilities in environmental management. ORC now joins nine other regional and unitary councils that have signed this agreement with NIWA.

[22] This agreement allows ORC to gain access to the extensive climate and environmental monitoring network that NIWA manages in our region. For the land and soil programme, this means that ORC's real-time soil moisture monitoring network of seven sites will be augmented with data from eleven NIWA sites (Figure 6). This will fill the gaps in our network and provide valuable information to farmers and growers for water and effluent irrigation scheduling to maximise efficiency and minimise losses as well as to

[12] Entomological Society of New Zealand. New Zealand Bug of the Year competition 2025. Peripatus (velvet worm) won with 2,652 votes. https://bugoftheyear.ento.org.nz/

Council for drought and flood monitoring and modelling. Site data will be hosted on the Environmental Data Portal[13].

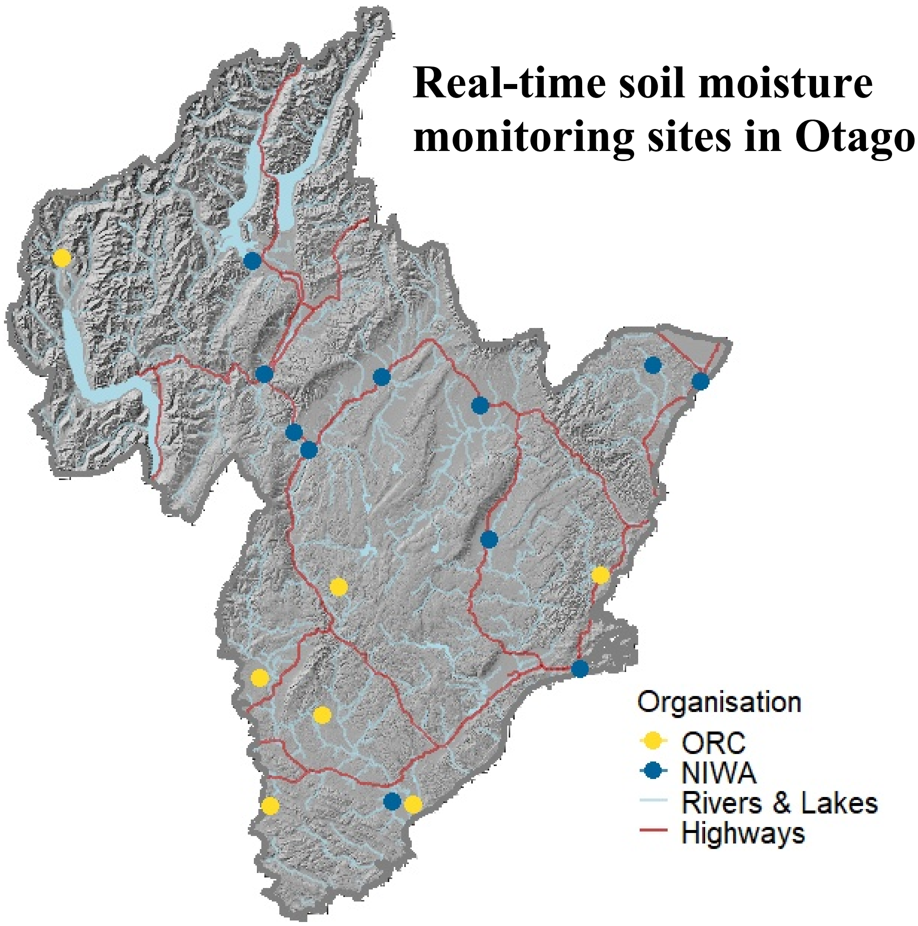


Figure 6. Soil moisture monitoring sites managed by ORC and NIWA in Otago.

SOIL BACKGROUND CONCENTRATIONS

[23] ORC has secured an $80,000 EnviroLink-funded grant for Manaaki Whenua Landcare Research to develop a regional dataset of background concentrations of potentially toxic elements (arsenic, cadmium, chromium, copper, nickel, lead, and zinc). These elements are naturally occurring in soils but may be elevated due to geological processes and human activities. At certain levels, exposure to these elements can cause significant harm to human and environmental health.

[24] To effectively assess contamination and compliance with clean fill thresholds for health protection and waste minimisation, accurate background soil concentrations are needed. This data will enable better management of soil, particularly in the land development industry. For example, concentrations of toxic elements in excess soil generated from earthworks can be compared to guidelines to minimise waste to land fill

[13] https://envdata.orc.govt.nz/AQWebPortal/Data/Map/Parameter/Soil%20Moisture/Interval/Latest

and maximise reuse, where safe to do so. Currently, ORC relies on nationally derived values which both over- and underestimate the soil background concentrations in Otago. This has been an issue in the Queenstown/Wānaka area where naturally occurring levels of Arsenic in soil can breach national background concentrations requiring expensive treatment or disposal.

[25] The project is led by Manaaki Whenua Landcare Research together with regional and national contaminated land practitioner advisors. It is in collaboration with Environment Southland, ensuring consistent management approaches across borders. The project is possible due to both the extensive surveys across the two regions conducted by the Institute of Geological and Nuclear Sciences (GNS) and the additional soil data collected as part of the soil health monitoring programme.

ALTERNATIVE PASTURE-BASED ANIMAL WINTERING

[26] With the large extent of grazed downland and hill country on rolling to steeper terrain overlaying less versatile soils, winter forage cropping in Otago can be a high-risk activity. Even with mitigations in place and best practice followed, environmental risks remain with intensive winter grazing due to the generation of stock-trodden bare-soil paddocks that are prone to contaminant loss through surface runoff (sediment, phosphorus loss, pathogens) or subsurface drainage (nitrogen losses from stock urine due to the high concentrations of stock in a confined unvegetated area during winter months). Bare paddocks are especially vulnerable during heavy rainfall where sediment can be washed off and into waterways.

[27] AgResearch is leading a multi-year project in collaboration with ORC and Environment Canterbury to evaluate innovative, alternative pasture-based approaches to the current practice of intensive winter grazing. A research trial based at Invermay will compare the performance of two different varieties of pasture species against a standard wintering forage practice. Two case-study farms in Otago which are focused on reducing their winter forage area will be implementing a pasture-based wintering approach in combination with strategies relevant to the farm system. On-farm monitoring will start in May 2025. Three Canterbury farms will also be monitored as part of the wider project.

[28] This project builds upon a 2024 ORC-supported EnviroLink-funded literature review[14] into active field-based research. The aim is to improve the uptake of the results coming out of the package of planned research and to provide scientific robustness to farmers innovating on farm in Otago.

SOIL MAPPING PROGRESS

[29] S-Map is the national digital soil map for Aotearoa New Zealand. It is freely available and is a valuable tool for managing primary industry activities, a key input in Overseer nutrient budgeting software, and useful for developing effective farm plans. S-Map consists of a wealth of data that can be used as an input to hydrology and erosion models.

[14] Monaghan, R., Stevens, D., 2024. Alternative field-based approaches to animal wintering that deliver some improved environmental and animal welfare outcomes: A stock-take of current knowledge. AgResearch Ltd. Report Number RE450/2024/023.

[30] In Otago, contiguous areas of the highest capability land have been prioritised and 34% of the region have been mapped with the support of ORC (Table 2). S-Map is produced by Manaaki Whenua Landcare Research and recent mapping in Otago has been 80% co-funded by the Ministry for Primary Industries with the remainder met by the ORC land and soil programme.

[31] Around 75,000 ha of Otago are currently being mapped and will be available online in August (Figure 7). Beyond this, ORC plans to support expanding S-Map further with co-funding from central government, where available.

Table 2. Summary of the locations in Otago where S-Map coverage exists or work is ongoing.

Location	Year	Status	Area (000's ha)	Proportion of Otago (%)
Otago lowlands	2005	Completed	820	26
Deep stream	2020	Completed	43	1
Catlins	2023	Completed	146	5
Moa flat and Tuapeka West	2024/2025	Moa Flat Completed Tuapeka West ongoing Online August 2025	130	4
Macraes, Dunback, Goodwood	2025	Work started Online August 2025	10	0.3
Total			1,149	36

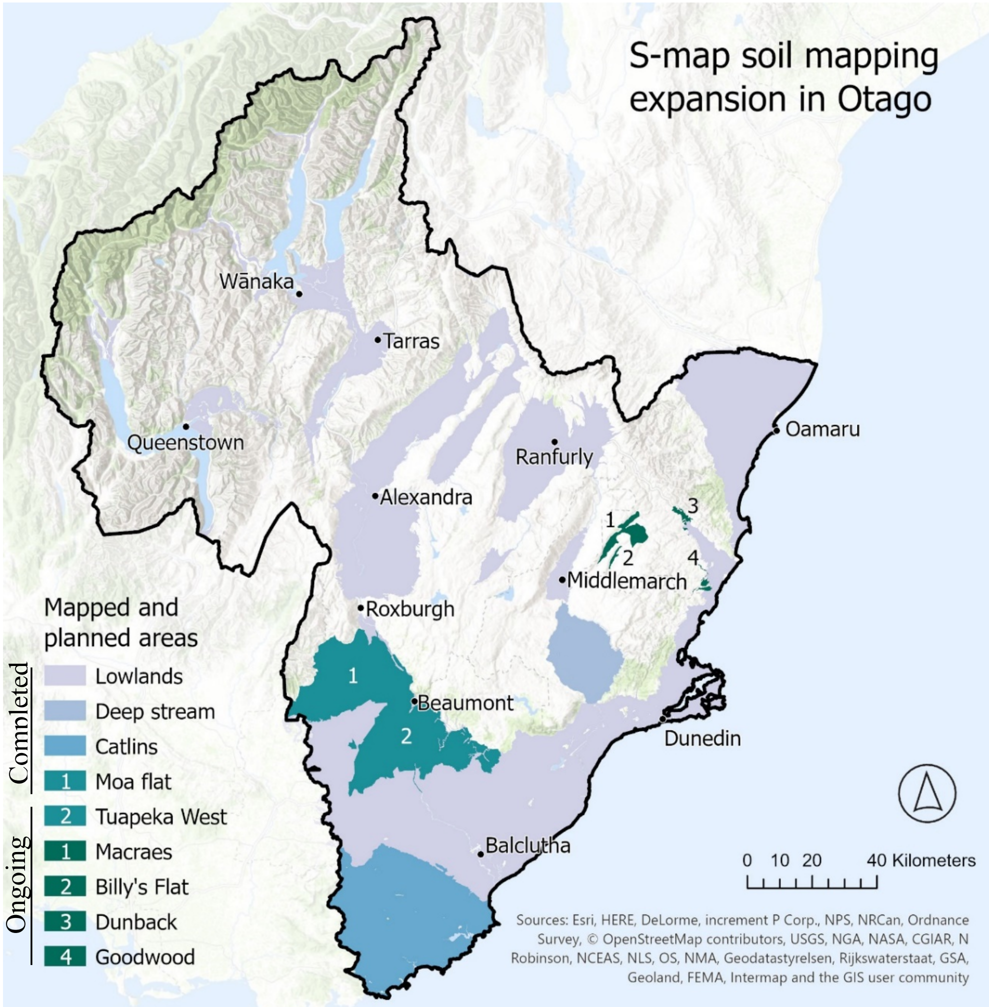


Figure 7. Map of the areas in Otago that have S-Map coverage and where mapping is ongoing. Ongoing mapping will be completed and online by August 2025.

3D PRINTED LANDSCAPES

[32] The use of a 3D printer to generate landscape models is a powerful way to explore and communicate landscapes and their features. To date, several models have been created, inspiring many conversations internally and with the community about topography, land use, natural hazards, and hydrology.

[33] The 3D printer was recently used to create a multi-part model of the deep lakes catchments in Otago (Figure 8), which was shown at the Wānaka A&P Show in March and to the Upper Lakes Integrated Catchment Groups during their April meeting. This model will reside in the new Queenstown office reception. Smaller models of Dunedin were printed as prizes for enthusiastic winners of an ORC science quiz at April's Wild Dunedin Festival. Three additional landscape projects are lined up and a potential practical application for the monitoring team, demonstrating the variety of application and demand of this new tool. We plan to offer to create models for Otago catchment and other environmental groups to support their work, where capacity allows.

Figure 8. The seven-part 300 x 650 mm model of the Queenstown-Lakes District (green) with alpine zone (white), native forest cover (dark green), rivers (blue), lakes (blue), and the high-resolution bathymetry of Lake Wānaka (bathymetry courtesy of NIWA).

OPTIONS

[34] This paper is for noting only.

CONSIDERATIONS

Strategic Framework and Policy Considerations

[35] This work promotes best practice land management, for soil conservation, water quality, and water use efficiency.

Financial Considerations

[36] The Land and Soil work programme is a funded and planned work stream under ORC's Long-Term Plan.

Significance and Engagement

[37] N/A

Legislative and Risk Considerations

[38] N/A

Climate Change Considerations

[39] Monitoring networks are designed with climate change as a key consideration which will help to monitor any environmental changes in response to climate change.

Communications Considerations

[40] N/A

NEXT STEPS

[41] The projects will continue as outlined above.

ATTACHMENTS

Nil

9.5. Coast and Estuaries Monitoring Programmes

Prepared for:	Science and Resilience Committee
Report No.	GOV2550
Activity:	Governance Report
Author:	Sam Thomas, Senior Scientist – Coast
Endorsed by:	Tom Dyer, General Manager Science and Resilience
Date:	4 June 2025

PURPOSE

[1] The purpose of this report is to provide the committee with an update on the current state of estuary sedimentation in Otago estuaries and the next steps in the estuary programme.

[2] The report also highlights the current monitoring occurring in the coastal space and the next steps for the impending coast plan.

EXECUTIVE SUMMARY

Estuary programme

[3] The intertidal sedimentation monitoring summary (Intertidal sedimentation monitoring summary) provides a snapshot of sedimentation trends and current state in Otago's estuaries, with these indicators used as part of a wider suite of estuarine indicators to inform estuarine health. The data and information will be used to inform the coast plan review and management of these systems.

[4] Sedimentation rates and mud content vary across each estuary, with most estuaries having a sedimentation rate above the current national guideline (upper limit of 2mm/yr) in some or all measured sites of the estuary. This includes the estuaries with more than 5 years monitoring data, the Catlins, Shag, Waikouaiti, Kaikorai, and Tokomairiro.

[5] Most of the estuaries in Otago have areas of the estuary that have a high mud content (>25%) mud. However, there are still estuaries within Otago with low mud content across the estuary area, such as Blueskin Bay, Purakanui Inlet, and Waipati/Chaslands estuaries (plus others not measured, see Intertidal sedimentation monitoring summary).

Coastal programme

[6] The ground truthing of marine significant ecological areas is part of the coastal state of the environment programme work schedule. The information will be used to further refine the monitoring programme and inform the coast plan review.

[7] Ground truthing of the significant biogenic habitats off the coast is currently underway. This involves inspection of selected parts of the sea floor with drop or tow cameras. There has been some significant biogenic habitat surveyed, including sponge gardens and bryozoan reefs.

[8] A comprehensive state of the environment report for the open coast and the estuaries will be produced by the end of the calendar year for the coast plan review. This report will detail the state and health of these environments using all the indicators currently measured in the estuary and all available data in the coastal space, as well as what is presented in this report. It will also identify threats and issues facing parts of the coastal environment, for example catchments at high risk of sediment loss, or vulnerable coastal habitats.

RECOMMENDATION

That the Committee:

1) ***Notes** this report.*
2) ***Notes** that next steps include a comprehensive estuary and coastal state of the environment report for the coast plan, including catchment threats, habitat threats and issues to provide not only information for the coast plan, but also for targeted management. These reports will be presented to the Council.*

ESTUARY SEDIMENTATION

Background

[9] In December 2024, the previous summers monitoring (2023/24 season), was presented to the Council both the broad scale and fine scale monitoring which highlighted the current ecological state of those estuaries. The estuaries reported on were the Catlins, Shag, Waikouaiti, Pleasant River, and Tautuku. This report outlines the current sedimentation rate and mud content of all the 11 estuaries monitored as part of the estuary State of the Environment programme. This report provides longer term data and trends for some estuaries while focusing on sediment.

[10] Sediment is the major stressor in estuaries (more so than N, for example) and therefore understanding sediment erosion/deposition and mud content within estuaries is important to inform management through both regulatory and non-regulatory means. Sediment plate monitoring and sediment mud content monitoring is undertaken as part of the wider estuary SOE monitoring programme (which includes other indicators). Targeted sediment plate monitoring is set up as needed when issues are detected, as in the Akatore Estuary due to high sedimentation rates. There are now 11 estuaries with sediment plate and mud content monitoring occurring in Otago.

[11] The attached report (Intertidal sedimentation monitoring summary) shows the trends in sedimentation and mud content for 11 estuaries across Otago, with corresponding mud content. The national guideline limit for sediment is 2mm/yr with deposition above this not considered natural (this is currently being reviewed). Mud content starts to influence the macrofaunal community once it reaches ~25% mud anywhere in the estuary and starts influencing productivity and biogeochemical cycling at lower levels of mud content. Understanding what the sedimentation rate and mud content is for each estuary is important to allow for targeted management and investigations.

Discussion

[12] Sediment plate monitoring shows that all the estuaries in Otago (except Waikouaiti) have sedimentation rates above the national guideline in some areas monitored (see Figure 1 and Intertidal sedimentation monitoring summary). The minimum monitoring record to get an idea of sedimentation rate is a 5-year record and ideally 10 years to properly see a trend in sedimentation. Therefore, where the record is less than 5 years

drawing strong conclusions is not advised. Only 5 of the currently monitored 11 estuaries have enough data to draw a trend with none of them having 10 years of data. Sedimentation fluctuates constantly over the year and between years in the estuary which is why a longer timeframe is needed to provide any accuracy in trends of sediment.

[13] The reasons for the different sedimentation rates across the estuaries and sites within the estuaries are likely due to a combination of factors. Some of the high sedimentation rates will be due to natural movement of sediment within the estuary, especially if sites are by the estuary mouth or channel which can cause erosion. Equally increased sedimentation rates will be due to catchment influences from multiple land uses that creates large volumes of sediment, particularly during floods which exacerbates the high-risk land use activities. This brings pulses of sediment to an estuary as captured in some of the monitoring (see Intertidal sedimentation monitoring summary). These pulses of sediment can be very damaging to the health of estuary habitats.

[14] Sediment mud content monitoring has shown that there are a range of conditions across Otago's estuaries with many estuaries having areas above 25% mud content. The estuaries with the highest mud content are Shag, Pleasant, Kaikorai, Akatore, Tokomairiro and Tautuku estuary. The estuaries with some of the lowest mud content are Blueskin Bay, Waikouaiti, Purakanui and lower Catlins. Estuaries are zones of natural deposition, however, many of these estuaries have higher mud content due to additional sedimentation from higher risk land use activities in the catchment from both current and potentially some historic sedimentation. Increased mud content reduces the biodiversity within the estuary and reduces its functioning.

Table 4. Sediment depth change from baseline (CFB) and average annual sedimentation rate in Otago estuaries, November 2024. Condition rating colour scheme shown in Table 3.

Estuary	Site	CFB (mm)	Sedimentation (mm/yr)
Shag	A	25.9	3.3
	B	2.7	0.3
Pleasant River (Te Hakapupu)	A*	6.4	2.2
	B*	6.3	2.1
Waikouaiti	A	-3.7	-0.7
	B	6.5	1.3
	C	-20	-2.6
Blueskin Bay	A*	3.6	0.9
	B*	8.3	2.2
Pūrākaunui Inlet	A*	7	7.4
	B*	4.5	4.8
Kaikorai	A	24.6	3.6
	B	31.2	4.6
	D	17.6	3.1
Akatore Estuary[1]	A*	3.4	1.7
	B*	31.8	16.2
Tokomairiro	B	33.8	4.9
	C	-6.2	-0.9
Catlins (Pounawea)	A	32.7	6.7
	B	49.3	6.2
Tautuku	A*	13.1	4.4
	B*	14.4	4.9
Waipati River (Chaslands)	A*	3.8	4
	B*	25.5	27.3

* A longer time series is requred to inform a meaningful trend.
1. Akatore post-flood monitoring in October 2024 was not used to calculate annualised sedimentation rates.

Figure 1: Average Sedimentation rates in the 11 estuaries monitored and the change from baseline in sedimentation over the plates at each site (Intertidal sedimentation monitoring summary).

[15] Sedimentation rates and mud content are important indicators of estuarine health and reflect the issues from the major stressor to the estuaries. However, these indicators need to be looked at in a wider context of other factors and indicators in the estuary SOE monitoring to help inform current management. Due to the higher sedimentation rates and mud content in some of the estuaries in Otago, management of higher risk land use activities that generate added sediment will need to be prioritised in these catchments.

[16] To prioritise management of Otago's estuaries an estuary programme review is currently underway. Also, a comprehensive state of the environment report for all of Otago's estuaries including threats issues and at-risk catchments will be produced for the coast plan.

COASTAL PROGRAMME

Background

[17] A requirement of the NZCPS, RMA and coast plan (current and impending coast plan) is to identify and map the marine significant ecological areas in the coast. This was undertaken and reported to Council in April 2023 (Brough et al. 2022). Ground truthing of biogenic habitat off the coast is now occurring. There is approximately 15 days of ground truthing occurring using tow cameras and drop cameras to determine the benthic habitat and if it matches what was previously mapped. This information will directly feed into the coastal plan to help determine policy and management options in the coastal area and help understand what levels of management and where this needs to occur.

Discussion

[18] Marine Significant ecological area mapping has been undertaken in 2022 and now ground truthing of the biogenic significant habitats mapped in the NIWA report (Identification of significant ecological areas for the Otago coastal marine area) is currently occurring. The purpose of the ground truthing is to determine whether what was identified as significant biogenic habitat is present and if it is significant. Biogenic habitat was selected to ground truth as it is a habitat that is vulnerable to disturbance, and there is a lot less information available for this habitat as opposed to rocky reefs, or demersal fish areas for example. This information in combination with the mapping will be used within the new Otago coast plan to fulfil Otago Regional Council's (ORC) obligations.

[19] Below are some photos of this work highlighting some of the unique habitats off the coast to prioritise for management.

Figure 2: Bryozoan beds

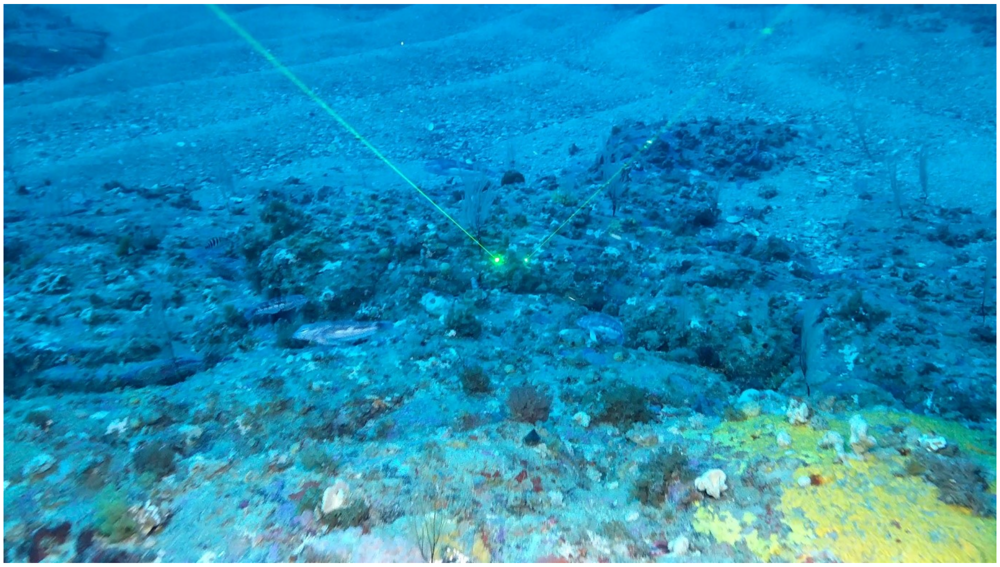


Figure 3: Possible black coral (waiting on identification)

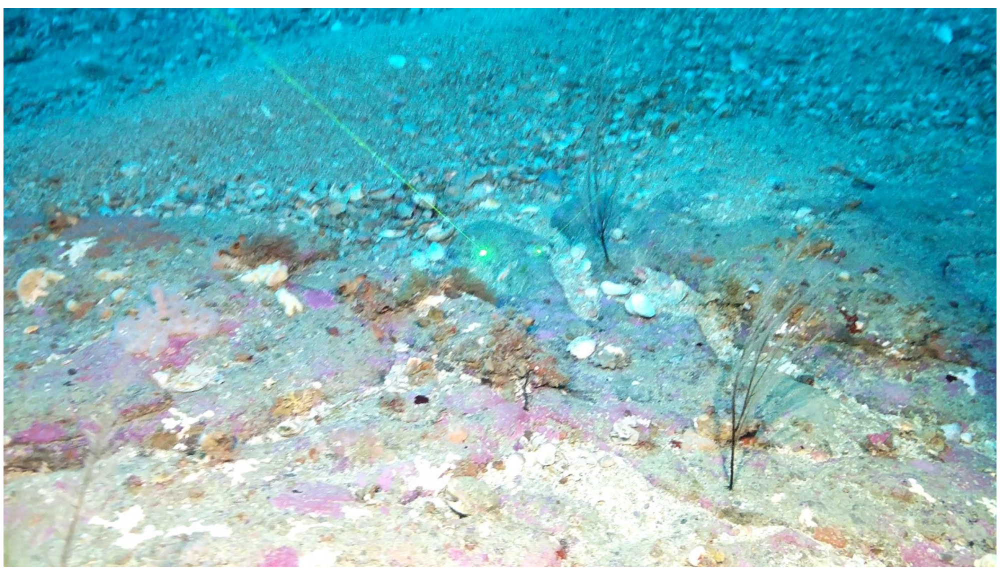


Figure 4: Possible black coral (ID waiting to happen)

Figure 5: Sponge garden habitat with blue cod.

[20] The data gathered from this ground truthing work will be analysed to determine if what was mapped as significant, is significant or if it is not. This will then be used in the coast plan to help prioritise management of these ecosystems along the coast and help to inform policy within the coastal plan. A comprehensive coastal state of the environment report will be produced pulling together this information gathered during ground truthing and all the other coastal information to provide an overview of the state of ecology and water quality on the coast.

OPTIONS

[21] This report is for noting – no options are presented.

CONSIDERATIONS

Strategic Framework and Policy Considerations

[22] The sedimentation information provides information to make decisions to address environmental issues before they arise and to make management decisions to maintain healthy estuarine and coastal ecosystems.

[23] The ground truthing provides data that will help ensure our coastal regional plan is effective at managing our resources within biophysical limits.

[24] The sedimentation estuary SOE information and the coastal ground truthing work will be used in the coast plan review to inform the new coast plan. Reports will be provided to policy.

Financial Considerations

[25] Budget is allocated for the estuary review and ground truthing.

Significance and Engagement

[26] Engagement will be ongoing between stakeholders and iwi that operate in the estuarine space.

Legislative and Risk Considerations

[27] ORC needs to gather appropriate data to inform regulatory plans such as the land and water plan and regional plan: coast in order to meet its obligations.

Climate Change Considerations

[28] Understanding the potential these habitats off the coast and the state of the estuaries allows for management in the face of climate change.

Communications Considerations

[29] Communication between iwi and key stakeholders will occur on a project-by-project basis.

NEXT STEPS

[30] To continue the current sediment monitoring programme for the 2025/26 as planned.

[31] To create a comprehensive estuary state of the environment report highlighting threats and issues and providing the date needed for both the coast plan and for management by the end of the calendar year.

[32] To use the ground truthing data to feed into a coastal state of the environment plan and to provide evidence to underpin the marine significant ecological area.

ATTACHMENTS

Nil

9.6. Type Localities of Terrestrial Animals, Plants and Fungi in the Otago Region

Prepared for:	Science and Resilience Committee
Report No.	GOV2547
Activity:	Governance Report
Author:	Ben Mackey, Manager Science
Endorsed by:	Tom Dyer, General Manager Science and Resilience
Date:	4 June 2025

PURPOSE

[1] This paper provides an overview of the type localities for terrestrial species found in Otago, which are those species formally described in the scientific literature from type specimens collected in the Region.

EXECUTIVE SUMMARY

[2] A type locality refers to the location permanently linked to the type (i.e. holotype) where a new species is collected and formally described in the scientific literature.

[3] Type localities are important for taxonomy and conservation, with their type specimens treated as the ‘crown jewels’ in many herbaria, fungaria and museums and are included in the Antiquities Act 1975 as ‘Protected Objects’.

[4] A total of 1453 records of type specimens for terrestrial species have been identified in the Region, representing 1161 species. Of these species, plants and fungal records have 900 type specimens and for animals 553 type specimens.

[5] Knowledge of type localities can: 1) inform protection of biodiversity if they continue to be included as a criterion in the National Policy Statement of Indigenous Biodiversity and the Regional Policy Statement, and 2) highlight areas for future surveys in the Region, especially those that have type localities and have been assessed as ‘Data Deficient’.

[6] The report will support council staff, iwi partners, territorial authorities in the Region, stakeholders, landowners, and community groups by providing an inventory of type localities to inform biodiversity management in the Region.

RECOMMENDATION

That the Committee:

1) ***Notes** this report.*
2) ***Notes** this work is part of a broader programme to inform management of biodiversity in the Otago Region.*

BACKGROUND

[7] When a new species is described, the name is permanently linked to a single ‘type specimen’ (the ‘holotype’) and to the location from which the specimen was collected (the ‘type locality’).

[8] From a taxonomic perspective, any future interpretation of this species is dependent on the 'type', and often also on other specimens mentioned during the first publication when a species is described (i.e. 'type specimens').

[9] From a conservation perspective the type locality becomes an important asset for two reasons. First, it represents a set of environmental conditions where the species naturally occurs and could be one of only a few known locations. Knowing these locations is important for obtaining future information on the species (e.g. genetics, abundance, traits). Second, the type locality may represent the environmental conditions where the species once occurred but no longer does. Many type localities will have undergone significant environmental change, and the indigenous biota may no longer be present. Many species in Aotearoa New Zealand have not been fully assessed for their risk of extinction.

[10] Moreover, many species are considered 'Data Deficient' under the New Zealand Threat Classification System (NZTCS), which is when information is so lacking that an assessment is not possible (Rolfe et al. 2022). Two key metrics for the NZTCS are geographical distribution and population size. The latter is often difficult to gauge for many species (e.g. due to their mobility, short life spans, different life stages, and difficulty with identification). Consequently, an understanding of geographical distribution and location becomes the critical metric for biodiversity and conservation assessments.

Figure 1. A screenshot of the holotype for *Orocrambus punctellus* (Hudson 1950), initially described using a specimen collected at Portobello in Ōtepoti Dunedin and named *Crambus punctellus,* Hudson 1950 but later transferred to the genus *Orocrambus* in 1975. The holotype is held at the Museum of New Zealand Te Papa Tongarewa. The species has only ever been recorded from its type locality and is assessed nationally as Data Deficient.

[11] In the National Policy Statement of Indigenous Biodiversity (NPSIB) type localities are a criterion for designation of Significant Natural Areas (SNAs) and have been included in the ORC's proposed Regional Policy Statement (RPS). While the identification of type localities in accompanying report is informative, their use will depend on the outcomes of the pause on identification of SNAs by Territorial Authorities. Other Councils have already used type localities, in combination with other criteria, to identify SNAs.

[12] In the accompanying report, an explanation is provided on what are types and type localities, how the information for species type locality data has been sourced is provided, and an overview of the inventory of type locality information for animals, plants and fungi is provided for Otago.

DISCUSSION

[13] A total of 1453 type specimens have currently been collated for Otago, representing 1161 species.

[14] Around one third of the type localities for vascular plants and fungi have associated bounding-box uncertainties in the Region. This means these locations have been verified, with a bounding box of the likely area that sampling would have taken place estimated. A square-based system was used for plant plots.

[15] Most terrestrial arthropods have bounding box uncertainties. A radius was used to estimate uncertainty because invertebrate sampling is typically based on a transect or ad hoc searching rather than a square-based system which is often used for plant plots. In total, 161 standardised locations have been identified across the Region.

[16] For many type localities the associated uncertainty is not possible to estimate due to imprecision in the available locality data, and many are old names associated with simply with 'Otago'. Some taxa are also extinct globally, e.g. out of the 13 bird species with type localities in the Region, nine of them have disappeared entirely.

[17] Further resolution of type localities for extant species may be possible in some case, by examining annotations and notes associated with the original collections, or from cotemporaneous collections.

[18] Knowledge of type localities included in the inventory of the accompanying report can inform biodiversity management in the Otago Region. In particular, the inventory can be used in two main ways: 1) to inform protection of biodiversity if type localities are to be included as a criterion in the NPSIB and the RPS, and 2) to highlight areas for future surveys of species in the Region, especially those that have type localities and have been assessed as 'Data Deficient'. For example, 23 indigenous vascular plant species have been assessed as 'Regionally Data Deficient' with type localities in Otago. Such surveys could help to establish the threat status of these species if they were located.

OPTIONS

[19] This report is for noting only.

CONSIDERATIONS

Strategic Framework and Policy Considerations

[20] The terrestrial ecology programme contributes towards the Healthy water, soil and coast, and Healthy diverse ecosystems strategic priorities.

[21] The work outlined in this paper aligns with visions in ORC's Biodiversity Strategy Plan: Our Living Treasure | Tō tatou Koiora Taoka and with visions and outcomes in the Biodiversity Action Plan | Te Mahi hei Tiaki i te Koiora.

[22] Type localities are a criterion for designation of SNAs under the NPSIB and have been included in ORC's proposed Regional Policy Statement. The identification of type localities in this report is informative, but their use will depend on outcomes of the pause on identification of SNAs by Territorial Authorities.

Financial Considerations

[23] The work is funded and was part of the planned work programme.

Significance and Engagement

[24] Engagement is ongoing with mana whenua, government agencies, stakeholders, and landowners who work in biodiversity management through the Otago Biodiversity Forum. This report provides an overview of type localities for terrestrial species and can inform future policy and strategy development.

Legislative and Risk Considerations

[25] ORC has statutory obligations to maintain indigenous biodiversity. This report provides an evidence base to inform the management of biodiversity in the Region.

Climate Change Considerations

[26] Type localities represent environmental conditions where a species has naturally occurred. If a species is still present at a locality, then it may also represent one of the few known locations, because many species are uncommon and their distribution poorly documented. The known locations of these species are important, particularly under climate change.

Communications Considerations

[27] The report and accompanying spreadsheet will be publicly available. This includes the documents being available on the ORC webpage in its Biodiversity section.

[28] The report and accompanying spreadsheet will be provided to members of the Otago Biodiversity Forum, whose memberships include mana whenua, territorial authorities, and other agencies.

NEXT STEPS

[29] The report and accompanying spreadsheet will be provided to Strategy for consideration on how can inform biodiversity management in the region.

[30] Further work to compile type localities where there are considerable gaps, particularly animal species.

[31] Encouragement and support should be provided to national initiatives on the digitisation of specimens and the georeferencing of locality information. Comprehensive digitisation of records would increase the availability of biodiversity data digitally, especially through aggregators such as the Global Biodiversity Information System (GBIF). For example, while type specimens for Otago arthropods may now my high, this is not the case for non-type material. The New Zealand Arthropod Collection, although having >290k records digitally available, this quates to only 17% of the collection. In the context of this paper and accompanying report, such digitisation is important to give information on the 'complete' geographical distribution of a species (and thus whether a species is 'in' or 'out' of a province) and can help infer information on population sizes (e.g. relative abundance, occupancy).

ATTACHMENTS

1. Type Localities in Otago [**9.6.1** - 99 pages]

Type localities of terrestrial animals, plants and fungi in the Otago Region

Scott Jarvie

April 2025

Otago Biodiversity Series 2

Otago Regional Council

orc.govt.nz


1 cm
NEW ZEALAND CO
McPhees Rock, 1400m
14 Apr. 1983
JS Dugdale
Illustrated
D.W. Helmore
6.9.85
HOLOTYPE
Asraia orientalis
Dugdale
NZAC
NZ Arthropod Collection
NZAC04023399

Type localities of terrestrial animals, plants, and fungi in the Otago Region

April 2025 – Otago Biodiversity Series Volume 2

Scott Jarvie
Otago Regional Council, Ōtepoti Dunedin

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Festuca matthewsii subsp. *pisamontis* Connor. CHR 74046 – Holotype. Photograph by © *Landcare Research*

Aoraia orientalis Dugdale, 1994. NZAC04023399 – Holotype. Photograph by © *Landcare Research*

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The views published in this report on the conservation statuses reflect the views of independent panels and are not necessarily the view of the Otago Regional Council.

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In the interest of forest conservation, we support paperless electronic publishing.

Executive Summary

Councils are required to protect areas with significant native biodiversity under the Resource Management Act 1991 (RMA). An attribute used for designation of Significant Natural Areas (SNAs) by Councils in Aotearoa New Zealand is the presence of the 'type locality' of an indigenous species. This report provides an overview of type localities, what type of Types should be prioritised for protection, and an inventory of terrestrial animals, plants and non-lichenised fungi for the Otago Region. A total of 1453 records of type specimens, representing 1161 species have been collated in the Region so far. Of these species, plants (vascular and non-vascular) and fungal records contain 900 records of type specimens, representing 342 vascular plants, 128 lichens, 97 fungi, 71 mosses, 23 liverworts, and 20 algae. The number of animals was 553 records of type specimens, representing 452 invertebrates (mainly arthropods), 13 birds, nine reptiles, and one Onychophora ('peripatus' or velvet worm). In addition to the terrestrial species, five freshwater fishes with type localities in the Region are provided. The report will support the Otago Regional Council, iwi partners, territorial authorities in the region, stakeholders, landowners, and community groups to provide an evidence base to inform biodiversity management across the Region. This includes highlighting terrestrial biota (flora, fauna, and fungi) in Otago who have had their type localities recorded, which other Councils in Aotearoa New Zealand have used as a basis to protect land for native biodiversity.

Table of Contents

Introduction

Councils are required to protect areas with significant native biodiversity under the Resource Management Act 1991 (RMA). An attribute that has been used for designation of Significant Natural Areas by Councils in Aotearoa New Zealand is the presence of the 'type locality' of an indigenous species.

A type locality refers to the location permanently linked to the type (i.e., holotype) where a new species is collected and formally described in the scientific literature. From a taxonomic perspective, any future interpretation of this species is dependent on the 'type', and often also on other specimens mentioned during the first publication when a species is described (i.e., 'type specimens'). Type specimens, therefore, underpin decisions on the designation of new species resulting from the splitting of existing species concepts, and the amalgamation of different names as synonyms of a single species.

From a conservation perspective the type locality becomes an important asset for two main reasons. First, it represents a set of environmental conditions where the species naturally occurs. Knowing these locations is important for obtaining future information on the species (e.g., genetics, abundance, traits). Second, the type locality may represent the environmental conditions where the species once occurred but no longer does. Many type localities will have undergone significant environmental change, and the indigenous biota may no longer be present. However, if a species is still present at a locality, then it may also represent one of the few known locations. Many species are uncommon and their distribution poorly documented, and their status remains Data Deficient under the New Zealand Threat Classification System (NZTCS[1]; Rolfe et al. 2022). The known locations of Data Deficient species are important for future assessments.

Due to the importance type localities have for taxonomy and conservation, type specimens are treated as the 'crown jewels' in many herbaria, fungaria and museums and they are included in the Antiquities Act 1975 as 'Protected Objects'[2]. In this report, an explanation is provided on what are types and type localities, how the information for species type locality data has been sourced is provided for the report, and an overview of the inventory of type locality information for animals, plants and fungi is provided for the Otago Region.

[1] https://nztcs.org.nz/
[2] https://www.legislation.govt.nz/act/public/1975/0041/latest/DLM432116.html

What are Types and Type-localities?

The taxonomy and nomenclature of organisms are inter-twined but distinct activities. Taxonomy is the process of classifying organisms into species, genera, families etc. The characters selected to define a species and how it differs from another species are taxonomic opinions (concepts) based on the available evidence at the time and according to the author(s). The taxonomic evidence-base, and the associated taxonomic opinions, often change over time. Nomenclature deals with the formulation of names that should be applied to the resulting taxon concepts. It is the legalistic objective framework divorced from individual opinion, and the designation of 'types' is part of that nomenclatural framework.

The scientific naming of organisms is governed by several different codes of nomenclature. For animals it is the International Code of Zoological Nomenclature (ICZN). For algae, fungi and plants (and some protozoans) it is the International Code of Nomenclature for algae fungi and plants (ICN). For bacteria and archaea it is the International Code of Nomenclature of Prokaryotes (ICNP). When a new name is introduced, the modern versions of these codes generally require the author to designate a single type specimen to anchor the application of that name. Consequently, type specimens are valuable objects, and in Aotearoa New Zealand they have a legally protected status under schedule 4 of the Protected Objects Act 1975.

Why are there multiple types to Type?

However, the term 'type' is used quite broadly in the non-technical biological literature. The use is often an implicit reference to the holotype specimen, but there are several types of type. The variety of types, their meaning, and their original or subsequent designation can lead to considerable complexity in the associated data, which has consequences for determining type localities.

Below are terms associated with the report and its data sets mostly applying under the ICN. The other codes may have additional terms, or different terminology for the same concepts. Much of the below is modified from Cooper 2024[3].

Protologue: everything associated with a name when it was first published, e.g., description, diagnosis, illustrations, references, synonymy, geographical data, citation of specimens, discussion, and comments. The type-status of a specimen forms a critical component of the protologue.

[3] https://www.envirolink.govt.nz/assets/2437-ORC013-Potential-development-of-a-verified-type-locality-database-of-species-to-support-the-protection-of-indigenous-biodiversity-by-local-government-authorities-.pdf

Typification statement: within the protologue will indicate which collections are types, when, where and by whom they were collected, and where they are preserved.

Typified name: the original published name anchored to the type (specimen) for that name. The preferred/accepted name for a species (and its associated collections) may change over time, but the status of a specimen as a type remains fixed and applies only to the typified name.

Holotype: the one specimen or illustration either explicitly indicated by the author as the nomenclatural type or used by the author of a taxon when no type was indicated. As long as it exists, it fixes the application of the name concerned. The designation of a specimen as the holotype can only place, explicitly or implicitly in the protologue and cannot be subsequently designated.

Isotype: any duplicate of the holotype and is always a specimen.

Syntype: any specimen cited in the protologue when there is no stated single holotype (usually older published protologues). If the protologue does not explicitly refer to any type collections, then all specimens from of a single gathering of the taxon at a particular time and location are syntypes.

Isosyntype: a duplicate of a syntype.

Paratype: any specimen cited in the protologue that is neither the holotype nor an Isotype. The list of paratypes may be numerous where many specimens were cited as part of the original description because it provides information on intra-species variation and distribution, according to the author's taxon concept.

Lectotype: a specimen or illustration subsequently selected from the original material as the nomenclatural type if the name was published without specifying a holotype, or if the holotype is lost or destroyed, or if a type is found to belong to more than one taxon. If the original publication mentioned several specimens without explicitly designating a type (prior to 1958 under ICN), then by definition these were originally syntypes, and one may be selected as the lectotype. Under ICN if the lectotype is lost or destroyed then the remaining syntypes are available for specifying a replacement lectotype. This marks a difference between ICN and ICZN were the designation of a lectotype means the remaining syntypes are designated as **paralectotypes** and can serve no future role in typification.

Isolectotype: a duplicate of a lectotype specimen.

Neotype: a specimen or illustration selected to serve as nomenclatural type if no original material is extant, or if it is missing.

Isoneotype: a duplicate of the neotype.

Epitype: is a specimen or illustration selected to serve as an interpretative type when the holotype, lectotype, or previously designated neotype, or all original material associated with a validly published name, are demonstrably ambiguous and cannot be critically identified for purposes of the precise application of the name to a taxon. This is only available under ICN since 1994.

Isoepitype: a duplicate of the epitype.

Allotype: a specimen of the opposite sex to the holotype. The term is not regulated by the ICZN.

Topotype: a specimen collected from the same locality as the holotype and usually on a different date. A topotype has no formal standing, and is not regulated by the ICZN.

It is critically important to note that the status of a specimen as a holotype is permanently bound to the name for which it is a designated type (typified name). Other kinds of types are bound by varying degrees, through to paratypes which are not nomenclaturally bound.

Sources and verification of information on type localities

To compile information on type localities for terrestrial species in Otago, sources were:

1. Recently completed regional conservation status reports for six taxonomic groups (bats, 2023b; indigenous vascular plants, 2024a; birds, 2024b; reptiles, Jarvie et al. 2024c; mushroom fungi, i.e., selected species of non-lichenised agarics, boletes and russuloid fungi, Jarvie and Cooper 2024; amphibians, Jarvie 2024; see website link for more information: www.orc.govt.nz/environment/biodiversity/regional-threat-assessments/).
2. Recently completed compilations of species lists for two groups (lichen and non-lichenised fungi; fungi from 2005 report by Hitchmough et al., excluding those taxa included in the de Lange et al. 2018 report).
3. Recently completed spreadsheets for three groups (hornworts and liverworts, Pritchard 2025a; mosses, Pritchard 2025b; freshwater fish, Campbell 2025; Onychophora, Jarvie 2024d; see pages of the following website link for more information: www.orc.govt.nz/environment/biodiversity/otago-species/).
4. For online data, the Global Biodiversity Information Facility (GBIF, www.gbif.org/) was used because it captures data from many institutions with standardised terminology, where they have been digitised. GBIF has become the 'go-to' aggregator for such information and has directly enabled a steady increase in scientific publications[4] and a 1:12 societal benefit[5]. Part of the GBIF standard data-set is the information on type status and type locality, although the degree of inclusion of type-related data is variable. The data standard underlying GBIF data is the Darwin Core[6]. The recommendation for the Darwin Core 'typeStatus' field is a concatenation of the status, the typified name, and the place of publication.
5. To get to other online data that might not be available on GBIF, information was compiled from other websites. For example, type locality information for reptiles was from the Reptile Database (https://reptile-database.reptarium.cz/), for birds from Avibase (https://avibase.bsc-eoc.org/avibase.jsp) and the Checklist of the Birds of New Zealand (https://www.birdsnz.org.nz/society-publications/checklist/), and for vascular plants, bryophytes and non-lichenised fungi from the Biota of New Zealand (https://biotanz.landcareresearch.co.nz/).
6. While Manaaki Whenua – Landcare curators regularly upload data to GBIF, they were contacted as they are the custodians of the largest collections of plant specimens (>800,00) in Aotearoa New Zealand at the Allan Herbarium – Te Kohinga Tipu o Aotearoa (CHR), the largest collection of dried fungal specimens (>100,00 collections) in the New Zealand Fungarium - Te Kohinga Hekaheka o Aotearoa (PDD), and the most comprehensive coverage of terrestrial invertebrates (6.5 million

[4] More than 10,000 scientific papers enabled by GBIF-mediated data
[5] Report reveals return on investments in GBIF
[6] Darwin Core Standard https://dwc.tdwg.org/

specimens, with >1 million pinned) in the New Zealand Arthropod Collection – Ko te Aitanga Pepeke o Aotearoa (NZAC). The CHR, PDD and NZAC are designated as Nationally Significant Databases and Collections, being government-funded biological and physical collections or databases that are considered important and significant to Aotearoa New Zealand. The NSCDs are held on behalf of all New Zealanders, as continued provision, maintenance and utilisation are critical for science to deliver public benefit.

7. For other sources of data, contact was made with the curators of Tūhura Otago Museum (OMNZ), Canterbury Museum (CMNZ), Museum of New Zealand – Te Papa Tongarewa Herbarium (WELT or MONZ), Otago Regional Herbarium – Te māra Otaota o Otago (OTA), Allan Herbarium – Te Kohinga Tipu o Aotearoa (CHR), Auckland Museum Herbarium – Tāmaki Paena Hira (AK), and Lincoln University (LUNZ), as these collections either don't publish, or have limited records, on GBIF. Responses were received from every institution.
8. Information was also compiled from the Flora and eFlora Series (Breitweiser et al. 2023; specifically Flora Vol. 1, Vol. 2 and Vol. 3; Allan, 1961; Moore and Edgar, 1976, and Edgar and Connor, 2010, respectively), as well as recent publications describing new species in Otago, including Breitweiser and Ford (2022), Burrows (2008), Burrows (2009), Burrows (2011), de Lange et al. (2013), de Lange and Blanchon (2023), Edgar and Connor (2010), Heads (1998), Heads (1990), Heenan (2017), MacMillan (1991), Meudt and Prebble (2018), Meudt (2008), Meudt et al. (2020), Moore and Edgar (1976), Prebble et al. (2022), Saldivia (2023), and Thorsen and de Lange (2016).

Based on the rationale of Cooper (2024, p. 12, section 4.7), type specimens were filtered to include 'epitype', 'holotype', 'lectotype', 'neotype', or 'type'. In addition, 'allotype' and 'syntype' were included for animals. Specimens labelled 'paratype' were not included, to align with the terms used by Cooper (2024). For all records with GPS coordiantes, a geographical filter was then applied using the GIS layer for the Otago Regional Council's administrative boundary (Appendix 1; https://datafinder.stats.govt.nz/layer/120946-regional-council-2025/).

For text associated with locations, there was considerable variation. This is not surprising as the specimens have been collected and recorded by many different people over a wide time span during which standards of recording have changed. However, it also reflects variation in how people input the text into databases and represents a mix of verbatim and interpreted information. For example, variation associated with records from the Rock and Pillar Range included: Rock & Pillar Range; Rock + Pillar Ra; Rock + Pillar Ra. Ridge; Rock and Pillar Ra; Rock and Pillar Ra, Otago; Rock and Pillar Ra. Such duplication was removed for terrestrial invertebrates only, and locations were grouped based on textual descriptions to create a set of standard locations.

Geographical coordinates (latitude and longitude in decimal degrees) from the standard locations for those species analyses from the text were verified based on online searches, predominantly using Topomap (www.topomap.co.nz), and sometimes Google maps (www.google.com/maps). During this process (and for those with GPS coordinates) an uncertainty in metres was estimated using the above online tools and expert knowledge to assign the likely area that sampling would have taken place. A radius was used to estimate uncertainty for invertebrate sampling is typically based on a transect or ad hoc searching rather while for plants a square-based system which is often used for plant plots.

Summary of data assembly

Type locality information has been captured for many terrestrial plants (vascular and non-vascular – bryophytes and algae), birds, reptiles, with data less complete data for fungi and some invertebrate groups (Table 1). In addition, five freshwater fish have had type locality information recorded. On-going work should continue to improve type locality data, including by verifying locations.

Table 1. The number of mainly terrestrial species with type localities in Otago by different functional groups with different orders (ordered initially by functional groups then the order with the most species). The common name for the order is provided where relevant. Note that some species will have more than one type specimen record.

Functional group	Order name	Common name	Number of species
Invertebrates (n = 452)			
	Diptera	Flies	119
	Lepidoptera	Moths	78
	Hymenoptera	Wasps, bees, ants	48
	Hemiptera	True bugs, scale insects	46
	Coleoptera	Beetles	39
	Sarcoptiformes	Mites (feather, skin mites, next-dwelling dust)	39
	Several groups	*Primitive insects	16
	Trichoptera	Caddisflies	15
	Plecoptera	Stoneflies	15
	Opilliones	Harvestmen	10
	Orthoptera	Weta, grasshoppers	10
	Entomobryomorpha	*Springtails	6
	Araneae	Spiders	5
	Neuroptera	Lacewings	2
	Blattodea	Cockroaches	1
	Chordeumatida	Millipedes	1
	Isopoda	Slaters	1
	Pseudoscorpiones	Pseudoscorpions	1
Vascular plants (n = 342)			
	Poales	Grasses	85
	Asterales	Daisies, sunflowers	59
	Lamiales	Mint	43
	Apiales	Carrots, ivies, and allies	20
	Brassicales	Mustards and allies	19
	Fabales	Legumes, peas, beans	16
	Genianales	Gentians, dogbanes, madders, and allies	13
	Boraginales	Borages, for-me-nots	12
	Ranunculales	Buttercups	10
	Rosales	Roses	10
	Caryophyllales	Pinks, cactuses, and allies	8
	Ericales	Heathers, balsams, primroses, and allies	8
	Malvales	Mallow	7
	Myrtales	Myrtles, evening primroses, and allies	6
	Fagales	Beeches, oaks, walnuts, and allies	5
	Asparagales	Agaves, orchids, irises, and allies	4
	Oxalidales	Woodsorrels, quandongs, and allies	4
	Saxifragales	Saxifrages, stonecrops, and allies	3
	Malpighiales	Nances, willows, and allies	2
	Alismatales	Aroids, water-plantains, seagrass, and allies	1
	Crossosomatales	Rockflowers, bladdernuts, and allies	1
	Cucurbitales	Begonias, gourds, and allies	1
	Geraniales	Geraniums, bridal wreaths, and allies	1

Continued on next page

Type localities in Otago

Type localities continued

Functional group	Order name	Common name	Number of species
	Hymenophyllales	Filmy ferns and bristle ferns	1
	Laurales	Laurels, spicebushes, and allies	1
	Polypodiales	Polypod ferns or rockcap ferns	1
	Solanales	Nightshades, bindweeds, gooseweeds, and allies	1
Lichens (n = 128)			
	Lecanorales	Shield lichens, rim lichens, and allies	74
	Peltigerales		12
	Caliciales		9
	Teloschistales	Sunburst lichens and allies	9
	Pertusariales	Wart lichens, water lichens, and allies	8
	Verrucariales		5
	Agyriales	Wart lichens, script lichens, and allies	3
	Arthoniales		3
	Baeomycetales		1
	Gyalectales		1
	Lecideales		1
	Sclerococcales		1
	Umbilicariales		1
Fungi (n = 97)			
	Agaricales	Common gilled mushrooms and allies	26
	Pucciniales	Rush fungi	23
	Chaetosphaeriales		6
	Pyrenulales	Sac fungi	5
	Boletales		3
	Glomerales	Boletes and allies	3
	Helotiales		3
	Polyporales	Shelf fungi	3
	Rhytismatales	Tarspot fungi	3
	Russulales	Brittlegills and milkcaps	3
	Atractiellales	Jelly fungi	2
	Diversisporales		2
	Hypocreales		2
	Ostropales	Earth tongue	2
	Phyllachorales	Tropical tar spot fungi	2
	Pleosporales		2
	Chytridiales		1
	Entorrhizales		1
	Filobasidiales		1
	Mycocaliciales		1
	Phallales	Stinkhorns and allies	1
	Ustilaginales	Smut fungi	1
	Xylariales		1
Non-vascular plants (bryophytes; n = 94)			
	Jungermanniales	Liverworts (scale-mosses)	22
	Grimmiales	Mosses	13
	Bryales	Mosses	11
	Dicranales	Mosses	11
	Pottiales	Mosses	11
	Orthotrichales	Mosses	9
	Hypnales	Feather mosses	8
	Polytrichales	Mosses	3
	Andreaeales	Rock mosses	2
	Bartramiales	Mosses	1
	Lycophodiales	Club mosses	1
	Pseudoditrichales	Mosses	1
	Metzgeriales	Simple thalloid liverworts	1

Continued on next page

Type localities continued

Functional group	Order name	Common name	Number of species
Algae (n = 20)			
	Ceramiales	Red algae	5
	Gigartinales	Red algae	5
	Bryopsidales	Green algae	3
	Cladophorales	Green algae	1
	Nemaliales	Red algae (threadweed or sea noodles)	1
	Prasiolales	Green algae	1
	Rhodymeniales	Red algae	1
	Siphonocladales	Green algae	1
	Ulotrichales	Green algae	1
	Ulvales	Green algae	1
Birds (n = 13)			
	Dinornithiformes	Moa	4
	Anseriformes	Waterfowl	2
	Podicipediformes	Grebes	2
	Gruiformes	Cranes, rails, and allies	1
	Sphenisciformes	Penguin	1
	Suliformes	Gannets, cormorants, and allies	1
	Pelecaniformes	Pelicans, herons, ibises, and allies	1
	Strigiformes	Owl	1
Reptiles (n = 8)			
	Squamata	Lizards and snakes*	8
Freshwater fishes (n = 5)			
	Galaxiiformes	Galaxiids	5
Onychophora (n = 1)	*Phylum/Genus*		
	Onychophora/ *Peripatoides*	Velvet worms or peripatus	1

*Note that terrestrial snakes are not resident indigenous species in Aotearoa New Zealand

A total of 1453 type specimens have currently been collated, representing 1161 species. Around one third of the type localities for vascular plants and fungi now have associated bounding-box uncertainties, while for terrestrial invertebrates the majority have bounding box uncertainties (in total, this was 161 standard locations across the Region).

For many type localities the associated uncertainty is not possible to estimate due to imprecision in the available locality data, and many are old names associated with simply with 'Otago'. Some taxa are also extinct globally, e.g., out of the 13 bird species with type localities in the Region, nine of them have disappeared. Further resolution of type localities for extant may be possible in some case, by examining annotations and notes associated with the original collections, or from cotemporaneous collections.

Summary and conclusions

Otago has diverse species reflecting the region's contemporary landscapes, geological past and climatic history. Alpine areas, river valleys, dryland ecosystems and coastal landscapes are among the many ecosystems that contribute to this biodiversity. This reports documents that many of these species have been formally described in the scientific literature from specimens collected in the region.

Although identified many type localities within Otago, there are likely to remain animal, plant and fungal type specimens to be ascertained. At times, this is because there is no currently accessible digital footprint to indicate type locality. Some can be detected from newly captured information on typification statements, like occurred in this project, but more work would be needed to digitise locality, geo-references and uncertainty for those entries. Type localities for animals remains a substantial gap.

Recommendations

- Identification and verification of the type localities for animal species remains a significant gap. Although over 550 type records for over 450 species were collated in this project, a preliminary survey of GBIF type-associated data suggests around 2,000 additional type localities for the kingdom animalia may be present in Otago. Further work should happen to identify type localities for the remainder of animal species, many of whom will be aquatic species.

- The geo-referencing and uncertainty associated with GBIF cited collections and with PDD fungal collections remains incomplete.

- The absence of typified names in the GBIF data is a significant omission by data-providers, who should be encouraged to provide it according to defined Darwin Core standard.

- To complete the identification and verification of type localities, the most efficient approach would be to assess type-status, type localities and uncertainty at the national level, with the subsequent identification of regional-level records. Encouragement and support should be provided to national initiatives on the digitisation of specimens and the georeferencing of locality information (Cooper and Greer 2024).

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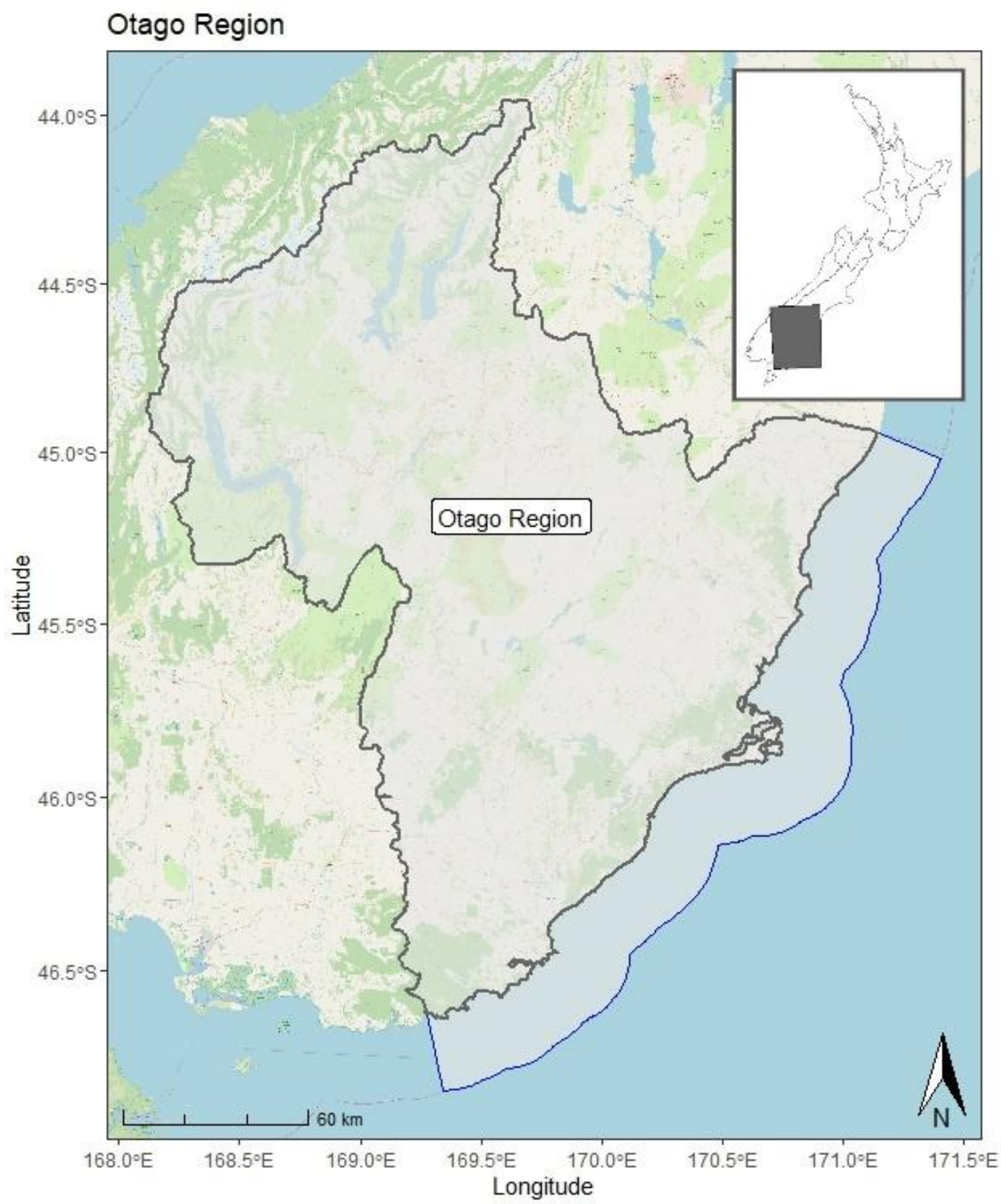
Appendices

Appendix 1: Map of the Otago Region, showing the coastal marine area.

Inset map shows Otago relative to the three main islands of Aotearoa New Zealand.



Appendix 2: Terrestrial invertebrates with type localities in Otago

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Acalitus carpatus	Mites	Holotype	NZAC02005476	2532985297	Arachnida	Trombidiformes	Eriophyidae	Catlins, Tautuku Beach
Aceria microphyllae	Mites	Holotype	NZAC02005546	2610525323	Arachnida	Trombidiformes	Eriophyidae	Lake Wakatipu
Aculops propinquae	Mites	Holotype	NZAC02017010	2805383302	Arachnida	Trombidiformes	Eriophyidae	Otago*
Aculops serrati	Mites	Holotype	NZAC02005602	2805371301	Arachnida	Trombidiformes	Eriophyidae	Catlins, Tautuku Beach
Agauopsis novaezelandiae	Mites	Holotype	NZAC02005562	2610526304	Arachnida	Trombidiformes	Halacaridae	Portobello
Algidia marplesi	Daddy longlegs	Holotype	A764		Arachnida	Opiliones	Triaenonychidae	Dunedin
Aoraki meridalis	Daddy longlegs	Holotype	152142	3095873911	Arachnida	Opiliones	Pettalidae	Kidds Bush Reserve
Asca porosa	Mites	Holotype	NZAC02005585	2610542323	Arachnida	Mesostigmata	Ascidae	Coronet Peak
Austrachipteria novazealandica	Mites	Holotype	NZAC03027562	2824092372	Arachnida	Sarcoptiformes	Achipteriidae	Old Man Range
Bdellodes tanta	Mites	Holotype	AA.000132		Arachnida	Trombidiformes	Bdellidae	Portobello
Bdellodes vireti	Mites	Holotype	AA.000144		Arachnida	Trombidiformes	Bdellidae	Dunedin, Opoho
Cantuaria lomasi	Spiders	Holotype	AS.000058		Arachnida	Araneae	Idiopidae	Makarora
Cenefia sorenseni hawea	Daddy longlegs	Holotype	2005.135.390		Arachnida	Opiliones	Triaenonychidae	Lake Hawea
Cultroribula otagoensis	Mites	Holotype	NZAC03027564	2824095354	Arachnida	Sarcoptiformes	Astegistidae	Old Man Range
Dicrotegaeus incurvus	Mites	Holotype	NZAC03027575	2824093340	Arachnida	Sarcoptiformes	Cerocepheidae	Old Man Range
Dicrotegaeus mariehammerae	Mites	Holotype	NZAC03027571	2824103345	Arachnida	Sarcoptiformes	Cerocepheidae	Pisa Range
Epeira sublutia	Spiders	Holotype	2005.135.110		Arachnida	Araneae	Araneidae	Dunedin
Flabellifrontipoda smithi	Mites	Holotype	AA.000123		Arachnida	Trombidiformes	Oxidae	Upper Shag River
Haplinis marplesi	Spiders	Holotype	AS.000615		Arachnida	Araneae	Linyphiidae	Dunedin, Allans Beach
Kritaturus jacundus	Mites	Holotype	AA.000071		Arachnida	Trombidiformes	Aturidae	Upper Shag River

Continued on next page

Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Kritaturus vinnulus	Mites	Holotype	AA.000143		Arachnida	Trombidiformes	Aturidae	Upper Shag River
Lanceoppia trapezoides	Mites	Holotype	NZAC03027582	2830856347	Arachnida	Sarcoptiformes	Oppiidae	The Remarkables
Macrogena abbreviata	Mites	Holotype	NZAC03027579	2824089335	Arachnida	Sarcoptiformes	Ceratozetidae	Old Man Range
Macrogena brevisensilla	Mites	Holotype	NZAC03027580	2830854351	Arachnida	Sarcoptiformes	Ceratozetidae	The Remarkables
Macrogena hexasetosa	Mites	Holotype	NZAC03027577	2824099323	Arachnida	Sarcoptiformes	Ceratozetidae	Old Man Range
Magellozetes crassisetosus	Mites	Holotype	NZAC03027568	2824103361	Arachnida	Sarcoptiformes	Ceratozetidae	Pisa Range
Mecognatha parilis	Mites	Holotype	NZAC02005659	2610527309	Arachnida	Trombidiformes	Mecognathidae	Wanaka
Megalopsalis marplesi	Daddy longlegs	Holotype	AH.000048		Arachnida	Opiliones	Neopilionidae	Dunedin
Metafroneta subversa	Spiders	Allotype	AS.000725		Arachnida	Araneae	Linyphiidae	Dunedin, Saddle Hill
Metafroneta subversa	Spiders	Holotype	AS.000724		Arachnida	Araneae	Linyphiidae	Dunedin, Saddle Hill
Microlamellarea minuta	Mites	Holotype	NZAC03027565	2824085348	Arachnida	Sarcoptiformes	Lamellareidae	Old Man Range
Migas lomasi	Spiders	Holotype	AS.000059		Arachnida	Araneae	Migidae	Makarora
Neophysobates incrassatus	Mites	Holotype	NZAC03027572	2824103360	Arachnida	Sarcoptiformes	Tegoribatidae	Pisa Range
Neophysobates zealandicus	Mites	Holotype	NZAC03027574	2824097306	Arachnida	Sarcoptiformes	Tegoribatidae	Pisa Range
Neotryssaturus pallidus	Mites	Holotype	AA.000095		Arachnida	Trombidiformes	Aturidae	Tributary of the Tahakopa River on Tahakopa Rd, 5km from Waikawa Valley Rd
Nuncia roeweri callida	Daddy longlegs	Allotype	2005.135.345		Arachnida	Opiliones	Triaenonychidae	Taieri Plains
Nuncia roeweri callida	Daddy longlegs	Holotype	2005.135.323		Arachnida	Opiliones	Triaenonychidae	Taieri Plains

Continued on next page

Type localities in Otago

Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Nuncia roeweri unica	Daddy longlegs	Allotype	2005.135.177		Arachnida	Opiliones	Triaenonychidae	Lake Hawea
Nuncia roeweri unica	Daddy longlegs	Holotype	2005.135.173		Arachnida	Opiliones	Triaenonychidae	Lake Hawea
Pedunculozetes ovatum	Mites	Holotype	NZAC03027567	2824090354	Arachnida	Sarcoptiformes	Chamobatidae	Pisa Range
Planaturus pileatus	Mites	Holotype	AA.000293		Arachnida	Trombidiformes	Aturidae	Upper Shag River
Pontiolaelaps salinus	Mites	Holotype	AMNZ21854	3323005355	Arachnida	Mesostigmata	Digamaseilidae	Otago Portobello, Marine Biology Laboratory
Porallozetes badamdorji	Mites	Holotype	NZAC03027578	2824089320	Arachnida	Sarcoptiformes	Punctoribatidae	Old Man Range
Prasma mulsa	Daddy longlegs	Allotype	2005.135.384		Arachnida	Opiliones	Triaenonychidae	Lake Hawea
Prasma mulsa	Daddy longlegs	Holotype	2005.135.407		Arachnida	Opiliones	Triaenonychidae	Lake Hawea
Prasma regalia	Daddy longlegs	Allotype	2005.135.383		Arachnida	Opiliones	Triaenonychidae	Royal Terrace, Dunedin
Prasma regalia	Daddy longlegs	Holotype	2005.135.377		Arachnida	Opiliones	Triaenonychidae	Royal Terrace, Dunedin
Pristobunus acuminatus	Daddy longlegs	Syntype	7183-55	208074710	Arachnida	Opiliones	Triaenonychidae	Hollyford River, Lake Wakatipu*
Pseudotryssaturus dictydermis	Mites	Holotype	AA.000044		Arachnida	Trombidiformes	Aturidae	MacLennan River at bridge on Aurora Creek Road
Pterochthonius roynortoni	Mites	Holotype	NZAC03027561	2824096377	Arachnida	Sarcoptiformes	Atopochthoniidae	Pisa Range
Rakaia sorenseni digitata	Daddy longlegs	Allotype	2005.135.511		Arachnida	Opiliones	Pettalidae	Chaslands
Rakaia sorenseni digitata	Daddy longlegs	Holotype	2005.135.506		Arachnida	Opiliones	Pettalidae	Chaslands
Safrobates gerdi	Mites	Holotype	NZAC03027573	2824086345	Arachnida	Sarcoptiformes	Oribatellidae	Pisa Range
Safrobates insignis	Mites	Holotype	NZAC03027569	2824086373	Arachnida	Sarcoptiformes	Oribatellidae	Pisa Range
Scapheremaeus gibbus	Mites	Holotype	NZAC03027566	2824091359	Arachnida	Sarcoptiformes	Cymbaeremaeidae	Old Man Range

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Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Scapheremaeus luxtoni	Mites	Holotype	NZAC03027563	2824087378	Arachnida	Sarcoptiformes	Cymbaeremaeidae	Pisa Range
Synsphyronus lineatus	Pseudoscorpion	Holotype	NZAC03016336	1315595797	Arachnida	Pseudoscorpiones	Garypidae	Alexandra, Observation Hill
Tripiloppia alpina	Mites	Holotype	NZAC03027576	2824088354	Arachnida	Sarcoptiformes	Oppiidae	Old Man Range
Tripiloppia frigida	Mites	Holotype	NZAC03027570	2824094350	Arachnida	Sarcoptiformes	Oppiidae	Pisa Range
Zealandozetes southensis	Mites	Holotype	NZAC03027581	2830848348	Arachnida	Sarcoptiformes	Maudheimiidae	The Remarkables
Zelandobates clevatus	Mites	Holotype	AA.000031		Arachnida	Trombidiformes	Hygrobatidae	MacLennan River at bridge on Aurora Creek Road
Schedotrigona trisetosum	Millipede	Lectotype	2000.121.13300		Diplopoda	Chordeumatida	Schedotrigonidae	Dunedin
Austrodontella monticola	Springtails	Holotype	AI.033054		Entognatha	Poduromorpha	Odontellidae	Pisa Range
Cryptopygus subalpina	Springtails	Holotype	AI.000352		Entognatha	Entomobryomorpha	Isotomidae	Humboldt Range, Bold Peak
Dicyrtomina novazealandica	Springtails	Holotype	AI.000346		Entognatha	Symphypleona	Sminthuridae	Dunedin, Sullivan's Dam
Entomobrya nigraoculata	Springtails	Holotype	AI.000254		Entognatha	Entomobryomorpha	Entomobryidae	Humboldt Range, Bold Peak
Folsomia pusilla	Primitive insects	Holotype	AI.000312		Entognatha			Humboldt Range, Bold Peak
Katianna perplexa	Primitive insects	Holotype	AI.000292		Entognatha			Humboldt Range, Bold Peak
Lepidosira anomala	Primitive insects	Holotype	AI.000098		Entognatha			Ben Lomond
Parasalina boldensis	Primitive insects	Holotype	AI.000116		Entognatha			Humboldt Range, Bold Peak

Continued on next page

Type localities in Otago

Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Parasalina dorsanota intermedia	Primitive insects	Holotype	AI.000201		Entognatha			Dunedin, Sullivan's Dam
Parisotoma confusoculata	Primitive insects	Holotype	AI.000131		Entognatha			Humboldt Range, Bold Peak
Parisotoma dividua	Primitive insects	Holotype	AI.000144		Entognatha			Humboldt Range, Bold Peak
Paronana dorsanota	Primitive insects	Holotype	AI.000146		Entognatha			Mt Cargill
Proisotoma haweaensis	Springtails	Holotype	AI.000189		Entognatha	Entomobryomorpha	Isotomidae	Kidds Bush Reserve
Promesira bifasciata	Primitive insects	Holotype	AI.000113		Entognatha			Humboldt Range, Bold Peak
Pseudoparonellides cryptodontus	Springtails	Holotype	AI.000136		Entognatha	Entomobryomorpha	Entomobryidae	Flagstaff Hill
Regatarma salmoni	Primitive insects	Holotype	AI.000448		Entognatha			Lake Wakatipu
Setanodosa quinseta	Primitive insects	Holotype	AI.000315		Entognatha			Dunedin, Signal Hill
Sminthurinus tunicatus	Primitive insects	Holotype	AI.000377		Entognatha			Dunedin, Allans Beach
Urewera bisecta	Primitive insects	Holotype	AI.000115		Entognatha			Humboldt Range, Bold Peak
Urewera obscura	Primitive insects	Holotype	AI.000271		Entognatha			Flagstaff Hill
Womersleyella niveata	Primitive insects	Holotype	AI.000257		Entognatha			Flagstaff Hill
Adelencyrtoides pilosus	Parasitoid wasps	Holotype	NZAC04000326	4134510963	Insecta	Hymenoptera	Encyrtidae	Kidds Bush Reserve
Adelencyrtoides proximus	Parasitoid wasps	Holotype	NZAC04000327	4134510965	Insecta	Hymenoptera	Encyrtidae	Kidds Bush Reserve
Adelencyrtoides tridens	Parasitoid wasps	Holotype	NZAC04000330	4134543080	Insecta	Hymenoptera	Encyrtidae	Owaka

Continued on next page

Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Adelencyrtoides unicolor	Parasitoid wasps	Holotype	NZAC04000332	4134510082	Insecta	Hymenoptera	Encyrtidae	Makarora West, South of Mt Aspiring National Park
Adelencyrtoides variabilis	Parasitoid wasps	Holotype	NZAC04000331	4134510951	Insecta	Hymenoptera	Encyrtidae	Kidds Bush Reserve
Aka dunedinensis	True Bugs	Holotype	NZAC04000020	1315596835	Insecta	Hemiptera	Cixiidae	Ross Creek Reservoir
Aletia lata	Moths	Holotype	AI.000546		Insecta	Lepidoptera	Noctuidae	Vanguard Peak, Harris Range
Allograpta pseudoropala	Flies	Holotype	NZAC04021610	1315638442	Insecta	Diptera	Syrphidae	Dunedin
Amarophilus lomodensis	Beetles	Holotype	AMNZ31970	3323005827	Insecta	Coleoptera	Carabidae	Ben Lomond
Amarophilus wanakensis	Beetles	Holotype	AMNZ31959	3323010836	Insecta	Coleoptera	Carabidae	Lake Wanaka, Minaret Peak
Amblyaspis breviscutellaris	Parasitoid wasps	Holotype	NZAC04045203	4134521351	Insecta	Hymenoptera	Platygastridae	NE of Makarora, Camerons Creek Valley
Amphineurus molophilinus	Flies	Holotype		1319081506	Insecta	Diptera	Limoniidae	Dunedin
Amphineurus operculatus	Flies	Holotype		1322118579	Insecta	Diptera	Limoniidae	Junction Creek, Glenorchy
Amphineurus otagensis	Flies	Holotype		1320382788	Insecta	Diptera	Limoniidae	Waitati
Amphineurus perarmatus	Flies	Holotype		1321793671	Insecta	Diptera	Limoniidae	Waitati
Amphineurus senex	Flies	Holotype		1322960482	Insecta	Diptera	Limoniidae	Old Man Range
Amphineurus tumidus	Flies	Holotype		1322174502	Insecta	Diptera	Limoniidae	Paradise
Anabarhynchus fuscofemoratus	Flies	Holotype	IV6907		Insecta	Diptera	Therevidae	Portobello
Aneurus brevipennis	True Bugs	Holotype	NZAC04000172	1315594734	Insecta	Hemiptera	Aradidae	Remarkables, Nevis Burn
Aoraia macropis	Moths	Holotype	NZAC04023389	1315608144	Insecta	Lepidoptera	Hepialidae	Old Man Range, South

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Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Aoraia oreobolae	Moths	Holotype	NZAC04023347	1315603244	Insecta	Lepidoptera	Hepialidae	Blue Mountains
Aoraia orientalis	Moths	Holotype	NZAC04023399	1315623186	Insecta	Lepidoptera	Hepialidae	Rock and Pillar Range, McPhees Rock
Aoraia senex	Moths	Holotype	AI.000491		Insecta	Lepidoptera	Heplialidae	Mt Aurum, Wakatipu
Aotearoazeus coronetus	Parasitoid wasps	Holotype	NZAC04128348	4134516127	Insecta	Hymenoptera	Ichneumonidae	Coronet Peak
Aphenochiton pronus	True Bugs	Holotype	NZAC02002480	2447667188	Insecta	Hemiptera	Coccidae	Rock and Pillar Range, summit, Stonehenge
Aphobetus cultratus	Parasitoid wasps	Holotype	NZAC04000382	4134510957	Insecta	Hymenoptera	Pteromalidae	Kidds Bush Reserve
Aphrophila luteipes	Flies	Holotype		1319169954	Insecta	Diptera	Limoniidae	Alexandra
Apoctena flavescens	Moths	Holotype	AMNZ21958	3323008356	Insecta	Lepidoptera	Tortricidae	Waitati
Archyala culta	Moths	Holotype	AMNZ21741	3323008345	Insecta	Lepidoptera	Tineidae	Dunedin, Opoho
Asaphodes sericodes	Moths	Holotype	AI.000492		Insecta	Lepidoptera	Geometridae	Mt Earnslaw, Wakatipu
Asilis annulicornis	Beetles	Holotype	NZAC04069891	1315635246	Insecta	Coleoptera	Cantharidae	Old Man Range
Aspilota angusta	Parasitoid wasps	Holotype	NZAC04015540	4134545879	Insecta	Hymenoptera	Braconidae	Lake Wakatipu, Bob's Cove
Aspilota parecur	Parasitoid wasps	Holotype	NZAC04015736	4134547261	Insecta	Hymenoptera	Braconidae	Coronet Peak
Asterivora chatuidea	Moths	Syntype	AMNZ14054	3322997983	Insecta	Lepidoptera	Choreutidae	Dunedin, Andersons Bay
Asterivora chatuidea	Moths	Syntype	AMNZ14053	3322996986	Insecta	Lepidoptera	Choreutidae	Dunedin, Andersons Bay
Australoberis refugians	Flies	Lectotype	NZAC04021439	1315634936	Insecta	Diptera	Stratiomyidae	Ranfurly
Australothis volatilis	Moths	Type	IV17876		Insecta	Lepidoptera	Noctuidae	Central Otago*
Austrocidaria callichlora	Moths	Holotype	AMNZ21770	3322924343	Insecta	Lepidoptera	Geometridae	Waitati Bush
Avibrissina laticornis	Flies	Holotype	NZAC04019265	2447668502	Insecta	Diptera	Tachinidae	Old Man Range, Obelisk

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Type localities in Otago

Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Balanococcus acerbus	scale insects	Holotype	NZAC02002717	1315634465	Insecta	Hemiptera	Pseudococcidae	Rocklands Station
Barycnellus conlisus	Parasitoid wasps	Holotype	NZAC04037092	4134512977	Insecta	Hymenoptera	Ichneumonidae	Glenorchy State Forest, Dart River
Batrachedra astricta	Moths	Allotype	AMNZ16139	3322918078	Insecta	Lepidoptera	Batrachedridae	Dunedin, Opoho
Batrachedra astricta	Moths	Holotype	AMNZ21744	3322925347	Insecta	Lepidoptera	Batrachedridae	Dunedin, Opoho
Berisina caliginosa	Flies	Holotype	NZAC04021456	1315616074	Insecta	Diptera	Stratiomyidae	Dunedin
Celatoblatta quinquemaculata	Cockroaches	Allotype	2000.121.22315		Insecta	Blattodea	Blattidae	Old Man Range, Obelisk
Celatoblatta quinquemaculata	Cockroaches	Holotype	2000.121.22314		Insecta	Blattodea	Blattidae	Old Man Range, Obelisk
Ceratanaphes monticola	Parasitoid wasps	Holotype	NZAC04000372	4134511054	Insecta	Hymenoptera	Mymaridae	Coronet Peak
Ceratomerus earlyi	Flies	Holotype	NZAC04070419	1315629748	Insecta	Diptera	Brachystomatidae	Mount Aspiring National Park, Pearl Flat
Cerius otagensis	Beetles	Holotype	NZAC04041466	1315642942	Insecta	Coleoptera	Anthribidae	Kawarau Gorge, Gentle Annie Creek
Cerodontha angustipennis	Flies	Holotype	NZAC04019126	1315624142	Insecta	Diptera	Agromyzidae	Otago*
Chaetocnema aotearoa	Beetles	Holotype	NZAC04070560	1315614386	Insecta	Coleoptera	Chrysomelidae	Old Man Range
Chalcolampra apicula	Beetles	Holotype	AMNZ31351	3322921803	Insecta	Coleoptera	Chrysomelidae	Routeburn Valley
Chalepistes dugdalei	Beetles	Holotype	NZAC04069732	1315611257	Insecta	Coleoptera	Curculionidae	Rock and Pillar Range
Chelipoda brevipennis	Flies	Holotype	NZAC03028303	3417649328	Insecta	Diptera	Empididae	Rock and Pillar Range, McPhees Rock
Chersodromia zelandica	Flies	Holotype	NZAC04021395	1315628143	Insecta	Diptera	Hybotidae	Dunedin, Warrington Beach

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Type localities in Otago

Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Chinamiris zygotus	True Bugs	Holotype	NZAC04000057	1315610287	Insecta	Hemiptera	Miridae	Rock and Pillar Range, summit, Stonehenge
Chloroclystis minima	Moths	Holotype	AI.000557		Insecta	Lepidoptera	Geometridae	Ida Valley
Chloroclystis modesta	Moths	Holotype	AI.000559		Insecta	Lepidoptera	Geometridae	Humboldt Range, Bold Peak
Chloroclystis rubella	Moths	Holotype	AI.000594		Insecta	Lepidoptera	Geometridae	Humboldt Range, Bold Peak
Chorebus paranigricapitis	Parasitoid wasps	Holotype	NZAC04014622	4134547388	Insecta	Hymenoptera	Braconidae	Dunstan Mountains, Bendigo Mines
Coelopencyrtus maori	Parasitoid wasps	Holotype	NZAC04000337	4134510087	Insecta	Hymenoptera	Encyrtidae	Makarora West, South of Mt Aspiring National Park
Coelopidae	Flies	Type	2007.219.1559		Insecta	Diptera	Coelopidae	Waikouaiti
Corticaria lata	Beetles	Holotype	NZAC04040161	1315640725	Insecta	Coleoptera	Latridiidae	Sutton, Salt Lake
Crambus punctellus	Moths	Holotype	AI.000592		Insecta	Lepidoptera	Crambidae	Portobello
Ctenarytaina thysanura	True Bugs	Holotype	NZAC02015081	1315613685	Insecta	Hemiptera	Aphalaridae	Dunedin
Ctenolimnophila alpina	Flies	Holotype	USNMENT0133116 3	1317678862	Insecta	Diptera	Limoniidae	Ben Lomond
Culiseta novaezealandiae	Flies	Holotype	NZAC04021368	1315627478	Insecta	Diptera	Culicidae	Tahakopa
Dasyuris callicrena	Moths	Holotype	2007.199.2576		Insecta	Lepidoptera	Geometridae	Kinloch
Dasyuris fulminea	Moths	Holotype	AI.000522		Insecta	Lepidoptera	Geometridae	Humboldt Range, Bold Peak
Dichromodes ida	Moths	Lectotype	AI.000541		Insecta	Lepidoptera	Geometridae	Ida Valley
Dichromodes simulans	Moths	Syntype	AI.000603		Insecta	Lepidoptera	Geometridae	Ida Valley

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Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Dicranomyia acanthophallus	Flies	Holotype	USNMENT01331018	1321530361	Insecta	Diptera	Limoniidae	Glenorchy
Dicranomyia allani	Flies	Holotype	USNMENT01331156	1317958104	Insecta	Diptera	Limoniidae	Otago Harbour, Dunedin
Dicranomyia cinerella	Flies	Holotype	USNMENT01331974	1321597700	Insecta	Diptera	Limoniidae	Paradise
Dicranomyia circularis	Flies	Holotype	USNMENT01331980	1317711716	Insecta	Diptera	Limoniidae	Queenstown
Dicranomyia evidens	Flies	Holotype		1320260144	Insecta	Diptera	Limoniidae	Dunedin
Dicranomyia megastigmosa	Flies	Holotype		1322029243	Insecta	Diptera	Limoniidae	Ben Lomond
Dicranomyia otagensis	Flies	Holotype		1319992085	Insecta	Diptera	Limoniidae	Junction Creek, Glenorchy
Dicranomyia paradisea	Flies	Holotype		1322974528	Insecta	Diptera	Limoniidae	Paradise
Dicranomyia primitiva	Flies	Holotype		1317471891	Insecta	Diptera	Limoniidae	pipeline between Dunedin and Waitati*
Dinotrema barrattae	Parasitoid wasps	Holotype	NZAC04015231	4134559731	Insecta	Hymenoptera	Braconidae	Blue Mountains
Diomocoris punctatus	True Bugs	Holotype	NZAC04000151	1315637226	Insecta	Hemiptera	Miridae	Kawarau Gorge, MOW road
Diomocoris punctatus	True Bugs	Allotype	NZAC04066813	1315596358	Insecta	Hemiptera	Miridae	Kawarau Gorge, MOW road
Dioxycanus fusca	Moths	Lectotype	NZAC04041346	1315603649	Insecta	Lepidoptera	Hepialidae	Humboldt Range, Bold Peak
Dolichopeza fenwicki	Flies	Holotype		1320648790	Insecta	Diptera	Tipulidae	Glenorchy
Dolichopeza howesi	Flies	Holotype		1322251180	Insecta	Diptera	Tipulidae	Mt Ida
Drepanacra binocula	Lacewings	Type	2007.189.132		Insecta	Neuroptera	Hemerobiidae	Old Botanic Gardens, Dunedin

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Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Dryptops undosus	Beetles	Syntype	IV6997		Insecta	Coleoptera	Colydiidae	Outram
Duvaliomimus taieriensis	Beetles	Holotype	NZAC04067145	1315617492	Insecta	Coleoptera	Carabidae	Taieri Mouth
Edpercivalia schistaria	Caddisflies	Holotype	2007.191.816		Insecta	Trichoptera	Hydrobiosidae	Swampy Summit
Empidadelpha pukekeao	Flies	Holotype	IV122562		Insecta	Diptera	Empididae	Dunedin, Sullivan's Dam
Empidadelpha torrentalis	Flies	Holotype	NZAC04021411	1315637861	Insecta	Diptera	Empididae	Humboldt Mountains
Ephydrella spathulata	Flies	Holotype		1318407569	Insecta	Diptera	Ephydridae	Queenstown
Epichorista tenebrosa	Moths	Allotype	AMNZ13391	3322912947	Insecta	Lepidoptera	Tortricidae	Ben Lomond
Epichorista tenebrosa	Moths	Holotype	AMNZ21948	3322930345	Insecta	Lepidoptera	Tortricidae	Ben Lomond
Eriococcus argentifagi	scale insects	Holotype	NZAC02002326	1315633830	Insecta	Hemiptera	Eriococcidae	Catlins, Purakaunui Scenic Reserve
Eriococcus crenilobatus	scale insects	Holotype	NZAC02002332	1315611702	Insecta	Hemiptera	Eriococcidae	Lake Wakatipu, Lumberbox Creek
Eriococcus latilobatus	scale insects	Holotype	NZAC02002330	1315640156	Insecta	Hemiptera	Eriococcidae	Lake Wakatipu, Lumberbox Creek
Eriococcus myrsinae	scale insects	Holotype	NZAC02002282	1315633580	Insecta	Hemiptera	Eriococcidae	Southland, Picnic Point
Eriococcus nothofagi	scale insects	Holotype	NZAC02002299	1315600425	Insecta	Hemiptera	Eriococcidae	Owaka
Errolium piceum	Parasitoid wasps	Holotype	NZAC04000452	4134543190	Insecta	Hymenoptera	Platygastridae	Makarora
Eumetriochroa aethalota	Moths	Holotype		4134391482	Insecta	Lepidoptera	Gracillariidae	Dunedin
Eupsenella insulana	Parasitoid wasps	Holotype	IV6951		Insecta	Hymenoptera	Bethylidae	Alexandra
Exsul tenuis	Flies	Holotype		1322485088	Insecta	Diptera	Muscidae	Fenwick
Gauldiana aspiringa	Parasitoid wasps	Holotype	NZAC04036045	1850152113	Insecta	Hymenoptera	Ichneumonidae	Makarora

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Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Gelechia dividua	Moths	Holotype	AI.000512		Insecta	Lepidoptera	Gelechiidae	Paradise
Gelechia sparsa	Moths	Holotype	AI.000609		Insecta	Lepidoptera	Gelechiidae	Dunedin
Glyphipterix barbata	Moths	Holotype	AMNZ21763	3322923351	Insecta	Lepidoptera	Glyphipterigidae	Waitati
Gonatopus zealandicus	Parasitoid wasps	Holotype	NZAC04000466	4134519014	Insecta	Hymenoptera	Dryinidae	Kawarau Gorge
Gonomyia oliveri	Flies	Holotype		1322036704	Insecta	Diptera	Limoniidae	Junction Creek, Glenorchy
Gracilicera politiventris	Flies	Holotype	NZAC04019294	2447668644	Insecta	Diptera	Tachinidae	Roxburgh
Gynoplistia aculeata	Flies	Holotype	USNMENT01331050	1320212373	Insecta	Diptera	Limoniidae	Paradise
Gynoplistia aurantiopyga	Flies	Holotype		1319410067	Insecta	Diptera	Limoniidae	Lake Wakatipu
Gynoplistia bidentata	Flies	Holotype		1319462870	Insecta	Diptera	Limoniidae	Ben Lomond
Gynoplistia hirsuticauda	Flies	Holotype	USNMENT01333041	1322986891	Insecta	Diptera	Limoniidae	Queenstown
Gynoplistia hirtamera	Flies	Holotype		1320144145	Insecta	Diptera	Limoniidae	Waipori
Gynoplistia laticosta	Flies	Holotype	USNMENT01333510	1320764511	Insecta	Diptera	Limoniidae	Glenorchy
Gynoplistia otagana	Flies	Holotype		1320164057	Insecta	Diptera	Limoniidae	Otago*
Harmologa oblongana	Moths	Holotype	AMNZ21956	3323006350	Insecta	Lepidoptera	Tortricidae	Woodhaugh Valley
Helicopsyche howesi	Caddisflies	Holotype	NZAC04070091	1315597222	Insecta	Trichoptera	Helicopsychidae	Dunedin
Helophilus cargilli	Flies	Holotype	NZAC04021604	1315601814	Insecta	Diptera	Syrphidae	Dunedin, Mount Cargill
Hemiandrus maia	Weta	Holotype	AI.031569		Insecta	Orthoptera	Anostostomatidae	Kurinui, Hampden
Heteria flavibasis	Flies	Holotype		1319755284	Insecta	Diptera	Tachinidae	Ben Lomond
Hexamera huttoni	Flies	Holotype		1319018232	Insecta	Diptera	Tachinidae	Humboldt Range, Bold Peak

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Type localities in Otago

Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Hierodoris gerontion	Moths	Holotype	NZAC04067102	1315624578	Insecta	Lepidoptera	Oecophoridae	Old Man Range
Hierodoris polita	Moths	Holotype	NZAC04067246	1315626203	Insecta	Lepidoptera	Oecophoridae	Clutha Valley, Craig Flat
Hilara philpotti	Flies	Holotype	NZAC04021410	1315627873	Insecta	Diptera	Empididae	Purakanui, Long Beach
Hilara vector	Flies	Holotype	NZAC04021429	1315613433	Insecta	Diptera	Empididae	Queenstown
Hilarempis kaiteriensis	Flies	Holotype	NZAC04021416	1315611797	Insecta	Diptera	Empididae	Dunedin, Roslyn
Holcaspis bathana	Beetles	Holotype	2007.163.4733		Insecta	Coleoptera	Carabidae	Mount St Bathans
Holcaspis implica	Beetles	Holotype	NZAC04011177	1315612940	Insecta	Coleoptera	Carabidae	Lake Wakatipu, Bob's Cove
Holcoperla magna	Stoneflies	Holotype	NZAC03001395	1315601087	Insecta	Plecoptera	Gripopterygidae	Dart Valley, Headlong Peak
Huttonina claripennis	Flies	Holotype	NZAC04021613	1315629309	Insecta	Diptera	Huttoninidae	Routeburn
Hydriomena clarkei	Moths	Holotype	AMNZ21753	3323001356	Insecta	Lepidoptera	Geometridae	Flagstaff Hill
Hydriomena paucita	Moths	Holotype	AI.000586		Insecta	Lepidoptera	Geometridae	Portobello
Hydrobiosis taumata	Caddisflies	Holotype	2007.191.1506		Insecta	Trichoptera	Hydrobiosidae	Old Woman Range
Hydrobiosis torrentis	Caddisflies	Holotype	2007.191.1425		Insecta	Trichoptera	Hydrobiosidae	Old Man Range
Hylaeus matamoko	Bees	Holotype	NZAC04031591	4134579885	Insecta	Hymenoptera	Colletidae	Old Man Range, Obelisk
Hypselosoma acantheen	True Bugs	Holotype	NZAC04000041	1315606946	Insecta	Hemiptera	Schizopteridae	Dart Hut
Ichneutica arotis	Moths	Holotype	2007.222.2386		Insecta	Lepidoptera	Noctuidae	Ross Creek Reservoir
Ichneutica empyrea	Moths	Lectotype	AMNZ21739	3323003345	Insecta	Lepidoptera	Noctuidae	Routeburn Valley
Ichneutica fenwicki	Moths	Allotype	AMNZ1183	3322999355	Insecta	Lepidoptera	Noctuidae	Flagstaff Hill
Ichneutica fenwicki	Moths	Holotype	AMNZ21780	3322925349	Insecta	Lepidoptera	Noctuidae	Flagstaff Hill

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Type localities in Otago

Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Isodermus maculosus	True Bugs	Holotype	AMNZ21730	3322921349	Insecta	Hemiptera	Aradidae	Waitati
Isoplectron armatum	Weta	Holotype	2021.17.3		Insecta	Orthoptera	Rhaphidophoridae	Dunedin
Ixodiphagus taiaroaensis	Parasitoid wasps	Allotype	AI.025069		Insecta	Hymenoptera	Encyrtidae	Taiaroa Head
Ixodiphagus taiaroaensis	Parasitoid wasps	Holotype	AI.025066		Insecta	Hymenoptera	Encyrtidae	Taiaroa Head
Izatha gekkonella	Moths	Holotype	NZAC04067131	1315606500	Insecta	Lepidoptera	Oecophoridae	near Sutton
Josemiris carvalhoi	True Bugs	Holotype	NZAC04000101	1315638334	Insecta	Hemiptera	Miridae	Carrick Range, Watts Rock
Kiwi barrattae	Parasitoid wasps	Holotype	NZAC04034530	4134514088	Insecta	Hymenoptera	Ichneumonidae	Old Man Range
Kiwimiris niger	True Bugs	Allotype	NZAC04067610	1315602953	Insecta	Hemiptera	Miridae	Coronet Peak
Kiwimiris niger	True Bugs	Holotype	NZAC04000060	1315623723	Insecta	Hemiptera	Miridae	Coronet Peak
Koroana lanceloti	True Bugs	Holotype	NZAC04000007	1315614565	Insecta	Hemiptera	Cixiidae	Dart Hut
Koroana lanceloti	True Bugs	Allotype	NZAC04080947	1315627868	Insecta	Hemiptera	Cixiidae	Dart Hut
Lagynodes hecaterapterus	Parasitoid wasps	Holotype	NZAC04000462	4134543198	Insecta	Hymenoptera	Megaspilidae	Owaka, Table Hill Reserve
Leptacis arcuata	Parasitoid wasps	Holotype	NZAC04049645	4134521352	Insecta	Hymenoptera	Platygastridae	NE of Makarora, Camerons Creek Valley
Leptacis fuscalata	Parasitoid wasps	Holotype	NZAC04049256	4134521354	Insecta	Hymenoptera	Platygastridae	NE of Makarora, Camerons Creek Valley
Leptotarsus mesocerus	Flies	Holotype		1321089382	Insecta	Diptera	Tipulidae	Dunedin
Leptotarsus minutissimus	Flies	Holotype		1317377169	Insecta	Diptera	Tipulidae	Mt Ida
Leptotarsus montanus	Flies	Type	2007.194.741		Insecta	Diptera	Tipulidae	Humboldt Mountains
Leptotarsus rufibasis	Flies	Holotype		1322403591	Insecta	Diptera	Tipulidae	Dunedin
Leptotarsus vulpinus	Flies	Type	2007.194.899		Insecta	Diptera	Tipulidae	Queenstown
Leschenea richardi	Beetles	Holotype	NZAC04095789	1315624100	Insecta	Coleoptera	Staphylinidae	10.5 km Northwest Glenorchy

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Type localities in Otago

Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Leucania innotata	Moths	Lectotype	AI.000543		Insecta	Lepidoptera	Noctuidae	Dunedin
Leucaspis albotecta	scale insects	Holotype	NZAC02008535	1315625952	Insecta	Hemiptera	Diaspididae	Lake Roxburgh
Leucaspis trilobata	scale insects	Holotype	NZAC02008364	4142849885	Insecta	Hemiptera	Diaspididae	Aramoana
Limnophila oliveri	Flies	Holotype		1321485159	Insecta	Diptera	Limoniidae	Glenorchy
Lincolnia lucernina	True Bugs	Holotype	NZAC04000142	1315600324	Insecta	Hemiptera	Miridae	Maniototo County, Kyeburn
Liriomyza flavocentralis	Flies	Syntype		3440075237	Insecta	Diptera	Agromyzidae	Otago*
Liriomyza flavocentralis	Flies	Syntype		3440075216	Insecta	Diptera	Agromyzidae	Otago*
Liriomyza oleariae	Flies	Holotype	AI.000431		Insecta	Diptera	Agromyzidae	Dunedin, Opoho
Liriomyza vicina	Flies	Holotype	NZAC04019141	1315598848	Insecta	Diptera	Agromyzidae	Crown Range
Lorelus obtusus	Beetles	Holotype	NZAC04095624	1315597910	Insecta	Coleoptera	Tenebrionidae	Owaka, 38km South, Waipati Beach
Lythria siris	Moths	Lectotype	AI.000605		Insecta	Lepidoptera	Geometridae	Old Man Range
Makarora obesa	Parasitoid wasps	Holotype	NZAC04000356	4134513624	Insecta	Hymenoptera	Eulophidae	Otago Lakes area, Mt. Aspiring Nat. Park nr Makarora
Mallobathra cataclysma	Moths	Holotype	AMNZ21778	3323008346	Insecta	Lepidoptera	Psychidae	Upper Routeburn River, Harris Saddle
Mallochomacquartia nigrihirta	Flies	Holotype	NZAC04019290	2447667404	Insecta	Diptera	Tachinidae	Leith Valley
Malpha muiri	True Bugs	Holotype	NZAC04000052	1315631887	Insecta	Hemiptera	Cixiidae	Wanaka, Mt Alpha
Maoricicada nigra	Cicadas	Holotype	NZAC04000121	1315613493	Insecta	Hemiptera	Cicadidae	Old Man Range, Obelisk
Maoricicada phaeoptera	Cicadas	Holotype	AI.000474		Insecta	Hemiptera	Cicadidae	Sentinel Peak, Wanaka

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Type localities in Otago

Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Maoritrechus nunni	Beetles	Holotype	NZAC04067089	1315619374	Insecta	Coleoptera	Carabidae	Port Chalmers, Deborah Bay
Mecodema hector	Beetles	Holotype	AI.000036		Insecta	Coleoptera	Carabidae	Hector Mountains
Mecodema minax	Beetles	Holotype	AI.000053		Insecta	Coleoptera	Carabidae	Owaka, Table Hill Reserve
Mecyclothorax otagoensis	Beetles	Holotype	AMNZ38518	3322927154	Insecta	Coleoptera	Carabidae	Idaburn
Melanchra boldensis	Moths	Holotype	AI.000500		Insecta	Lepidoptera	Noctuidae	Humboldt Range, Bold Peak
Melanchra meridiana	Moths	Holotype	AI.000555		Insecta	Lepidoptera	Noctuidae	Portobello
Melanchra molis	Moths	Lectotype	AI.000560		Insecta	Lepidoptera	Noctuidae	Dunedin
Metacorneolabium zanotium	Beetles	Holotype	NZAC04065733	1315628585	Insecta	Coleoptera	Staphylinidae	Owaka, Glenomaru Reserve
Metagerra truncata	True Bugs	Holotype	NZAC04000139	1315603564	Insecta	Hemiptera	Rhyparochromidae	Waipori Pond, Otago
Metalimnophila howesi	Flies	Holotype	USNMENT01333094	1321940929	Insecta	Diptera	Limoniidae	Dunedin
Metalimnophila penicillata	Flies	Holotype		1321026434	Insecta	Diptera	Limoniidae	Ben Lomond
Metalimnophila producta	Flies	Holotype		1321679082	Insecta	Diptera	Limoniidae	Dunedin
Metalimnophila simplicis	Flies	Holotype		1317355861	Insecta	Diptera	Limoniidae	Lake Wakatipu
Metalimnophila unipuncta	Flies	Holotype		1322642437	Insecta	Diptera	Limoniidae	Dunedin
Meterana pascoei	Moths	Lectotype	AMNZ55076	3323018942	Insecta	Lepidoptera	Noctuidae	Queenstown
Microctonus alpinus	Parasitoid wasps	Holotype	NZAC04000301	4134512464	Insecta	Hymenoptera	Braconidae	Coronet Peak
Millerina hudsoni	Flies	Type		1320829474	Insecta	Diptera	Muscidae	Fenwick
Mimopeus elongatus	Beetles	Type	2007.203.1111		Insecta	Coleoptera	Tenebrionidae	Otago*
Mimopeus elongatus	Beetles	Type	2007.203.1112		Insecta	Coleoptera	Tenebrionidae	Otago*

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Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Molophilus analis	Flies	Holotype		1322824895	Insecta	Diptera	Limoniidae	Glenorchy
Molophilus basispina	Flies	Holotype		1322417488	Insecta	Diptera	Limoniidae	Glenorchy
Molophilus denticulatus	Flies	Holotype	USNMENT01332269	1320153765	Insecta	Diptera	Limoniidae	Otago*
Molophilus lindsayi	Flies	Holotype		1321879591	Insecta	Diptera	Limoniidae	Lake Wakatipu
Molophilus luteipennis	Flies	Holotype	USNMENT01333704	1318519170	Insecta	Diptera	Limoniidae	Otago*
Molophilus luteipygus	Flies	Holotype	USNMENT01333713	1321281211	Insecta	Diptera	Limoniidae	Dunedin
Molophilus morosus	Flies	Holotype		1320337648	Insecta	Diptera	Limoniidae	Glenorchy
Molophilus pictipleura	Flies	Holotype		1318732604	Insecta	Diptera	Limoniidae	Waipori
Molophilus recisus	Flies	Holotype		1317679727	Insecta	Diptera	Limoniidae	Woodhaugh Valley
Molophilus submorosus	Flies	Holotype		1321218481	Insecta	Diptera	Limoniidae	Junction Creek, Glenorchy
Montanococcus petrobius	scale insects	Holotype	NZAC02003110	1315637033	Insecta	Hemiptera	Eriococcidae	Rock and Pillar Range, East of Summit Rock
Montanococcus thriaticus	scale insects	Holotype	NZAC02006639	1315630855	Insecta	Hemiptera	Eriococcidae	Rock and Pillar Range, East of Summit Rock
Morrisonia pansicolor	Moths	Lectotype	AI.000584		Insecta	Lepidoptera	Noctuidae	Dunedin, Vauxhall
Mycomya quadrimaculata	Flies	Allotype	IV122842		Insecta	Diptera	Mycetophilidae	Dunedin, Kew
Mycomya quadrimaculata	Flies	Holotype	IV154944		Insecta	Diptera	Mycetophilidae	Dunedin, Kew
Napaeosciomyza spinicosta	Flies	Holotype	NZAC04021637	1315639156	Insecta	Diptera	Helosciomyzidae	Dunedin
Neoaphelomera opaca	Flies	Holotype	NZAC04021323	1315597569	Insecta	Diptera	Mycetophilidae	Queenstown
Neolimnia repo	Flies	Holotype	NZAC04021628	1315612502	Insecta	Diptera	Sciomyzidae	Routeburn
Neolimnia ura	Flies	Holotype	NZAC04021615	1315620569	Insecta	Diptera	Sciomyzidae	Routeburn

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Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Neolimnia vittata	Flies	Holotype	NZAC04021627	1315598926	Insecta	Diptera	Sciomyzidae	Routeburn
Nepticula erechtitus	Moths	Lectotype	AI.000514		Insecta	Lepidoptera	Nepticulidae	Dunedin
Nepticula fulva	Moths	Syntype	AI.000524		Insecta	Lepidoptera	Nepticulidae	Dunedin
Nesoperla patricki	Stoneflies	Holotype	IV7222		Insecta	Plecoptera	Gripopterygidae	Swampy Summit
Nola parvitis	Moths	Holotype	AMNZ21735	3323001355	Insecta	Lepidoptera	Nolidae	Otago Peninsula, Broad Bay
Nothochromus maoricus	True Bugs	Holotype	NZAC04000204	1315614746	Insecta	Hemiptera	Artheneidae	Humboldt Range, Bold Peak
Nothodixa otagensis	Flies	Holotype		1317966611	Insecta	Diptera	Dixidae	Ben Lomond
Notodusmetia coroneti	Parasitoid wasps	Holotype	NZAC04000340	4134511025	Insecta	Hymenoptera	Encyrtidae	Carrick Range, Watts Rock
*Notogaster suckling*i	Parasitoid wasps	Holotype	NZAC04045208	4134545039	Insecta	Hymenoptera	Braconidae	Carrick Range, Watts Rock
Notoreas galaxias	Moths	Holotype	AI.000527		Insecta	Lepidoptera	Geometridae	Old Man Range
Novolopa maculata	True Bugs	Holotype	NZAC04000019	1315614427	Insecta	Hemiptera	Cicadellidae	Coronet Peak
Novolopa montivaga	True Bugs	Holotype	NZAC04000190	1315601041	Insecta	Hemiptera	Cicadellidae	Old Man Range
Novothymbris castor	True Bugs	Holotype	NZAC04000220	1315624582	Insecta	Hemiptera	Cicadellidae	Lake Mahinerangi
Novothymbris tararua	True Bugs	Holotype	NZAC04000066	1315598866	Insecta	Hemiptera	Cicadellidae	Wanaka, Mt Alpha
Oeconesus angustus	Caddisflies	Holotype	2007.191.2136		Insecta	Trichoptera	Oeconesidae	Lee Stream
Ogcodes brunneus	Flies	Type	2007.192.3173		Insecta	Diptera	Acroceridae	Wanaka
Ogcodes leptisoma	Flies	Holotype		1318282917	Insecta	Diptera	Acroceridae	Queenstown
Oligota watti	Beetles	Holotype	NZAC04065728	1315626558	Insecta	Coleoptera	Staphylinidae	Port Chalmers
Olinga christinae	Caddisflies	Holotype	2007.191.1952		Insecta	Trichoptera	Conoesucidae	Maungatika
Olinga fumosa	Caddisflies	Holotype	AMNZ21970	3323002349	Insecta	Trichoptera	Conoesucidae	Waitati
Oopterus nanus	Beetles	Holotype	NZAC04183910	1825746587	Insecta	Coleoptera	Carabidae	Old Man Range

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Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Oopterus taieriensis	Beetles	Holotype	NZAC04183889	1829415406	Insecta	Coleoptera	Carabidae	Taieri Mouth
Orchymontia otagensis	Beetles	Holotype	NZAC04061318	1315621775	Insecta	Coleoptera	Hydraenidae	Coronet Peak, on Skippers Rd
Orocrambus clarkei	Moths	Allotype	AMNZ10670	3322997815	Insecta	Lepidoptera	Crambidae	Lake Wanaka, Minaret Peak
Orocrambus clarkei	Moths	Holotype	AMNZ21808	3322923353	Insecta	Lepidoptera	Crambidae	Lake Wanaka, Minaret Peak
Orocrambus cultus	Moths	Syntype	NZAC04041443	1315639964	Insecta	Lepidoptera	Crambidae	Cecil Peak
Orocrambus geminus	Moths	Holotype	NZAC04041354	1315636001	Insecta	Lepidoptera	Crambidae	Lammermoor Range
Orocrambus scoparioides	Moths	Holotype	NZAC04041324	1315602713	Insecta	Lepidoptera	Crambidae	Ben Lomond
Oropezella nigra	Flies	Holotype	NZAC04021420	1315597790	Insecta	Diptera	Hybotidae	Mosgiel, Silver Stream
Orthenches semifasciata	Moths	Holotype	AI.000599		Insecta	Lepidoptera	Glyphipterigidae	Queenstown
Paracladura curtisi	Flies	Holotype		1321861052	Insecta	Diptera	Trichoceridae	Ben Lomond
Paracladura howesi	Flies	Holotype		1322039108	Insecta	Diptera	Trichoceridae	Leith Valley
Paracladura lyrifera	Flies	Holotype		1317986393	Insecta	Diptera	Trichoceridae	Leith Valley
Paracoccus albatus	scale insects	Holotype	NZAC02002715	1315615927	Insecta	Hemiptera	Pseudococcidae	Makarora
Paracoccus leptospermi	scale insects	Holotype	NZAC02002746	1315623122	Insecta	Hemiptera	Pseudococcidae	Catlins State Forest
Paradorydium sertum	True Bugs	Holotype	NZAC04000049	1315614571	Insecta	Hemiptera	Cicadellidae	Coronet Peak
Parectopa panacifinens	Moths	Lectotype	AI.000580		Insecta	Lepidoptera	Gracillariidae	Dunedin
Parectopa panacitorsens	Moths	Lectotype	AI.000581		Insecta	Lepidoptera	Gracillariidae	Dunedin
Parentia fuscata	Flies	Lectotype	2007.211.5		Insecta	Diptera	Dolichopodidae	Otago*
Pasiphila humilis	Moths	Holotype	2007.199.4094		Insecta	Lepidoptera	Geometridae	Ben Lomond
Pasiphila malachita	Moths	Syntype	AMNZ4848	3323000536	Insecta	Lepidoptera	Geometridae	Ben Lomond

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Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Pasiphila malachita	Moths	Syntype	AMNZ4849	3322919534	Insecta	Lepidoptera	Geometridae	Ben Lomond
Pericoma barbata	Flies	Holotype	NZAC04021186	1315629841	Insecta	Diptera	Psychodidae	Leith Valley
Pericoptus stupidus	Beetles	Lectotype	EC6771	1212533626	Insecta	Coleoptera	Scarabaeidae	Otago*
Pharmacus chapmanae	Weta	Allotype	IV7924		Insecta	Orthoptera	Rhaphidophoridae	Matukituki Valley
Pharmacus chapmanae	Weta	Holotype	IV7927		Insecta	Orthoptera	Rhaphidophoridae	Matukituki Valley
Pharmacus cochleatus rawhiti	Weta	Holotype	AI.052290		Insecta	Orthoptera	Rhaphidophoridae	Mt Tūwhakarōria, Hector Mountains
Pharmacus concinnus	Weta	Holotype	AI.052298		Insecta	Orthoptera	Rhaphidophoridae	Symmetry Peaks, Eyre Mountains
Pharmacus notabilis	Weta	Holotype	AI.052296		Insecta	Orthoptera	Rhaphidophoridae	Remarkables Ski-field Access Road
Pharmacus senex	Weta	Holotype	AI.052294		Insecta	Orthoptera	Rhaphidophoridae	Old Man Range, Obelisk
Pharmacus vallestris	Weta	Holotype	AI.052302		Insecta	Orthoptera	Rhaphidophoridae	French Ridge, Matukituki Valley
Philorheithrus lacustris	Caddisflies	Holotype	NZAC03016103	1315612961	Insecta	Trichoptera	Philorheithridae	Kingston
Physetica longstaffii	Moths	Holotype	AMNZ21781	3322923352	Insecta	Lepidoptera	Noctuidae	Dunedin, Tomahawk
Phytomyza clematadi	Flies	Holotype	AI.000406		Insecta	Diptera	Agromyzidae	Dunedin, Opoho
Platygaster novaezealandiae	Parasitoid wasps	Holotype	NZAC04049463	4134521355	Insecta	Hymenoptera	Platygastridae	NE of Makarora, Camerons Creek Valley
Plethochaetigera fenwicki	Flies	Holotype		1317668116	Insecta	Diptera	Tachinidae	Humboldt Range, Bold Peak

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Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Plethochaetigera isolata	Flies	Holotype	2007.223.730		Insecta	Diptera	Tachinidae	Routeburn
Plethochaetigera setiventris	Flies	Holotype		1321781020	Insecta	Diptera	Tachinidae	Humboldt Range, Bold Peak
Podagritus digyalos	Social wasps	Holotype	IV6816		Insecta	Hymenoptera	Vespidae	Old Man Range, Obelisk
Pollenia consanguinea	Flies	Holotype	NZAC04019238	1315622819	Insecta	Diptera	Polleniidae	Old Man Range, Hyde Rock
Pollenia eurybregma	Flies	Holotype	NZAC04019235	1315604758	Insecta	Diptera	Polleniidae	Old Man Range, Hyde Rock
Pollenia hispida	Flies	Holotype	NZAC04019239	1315598633	Insecta	Diptera	Polleniidae	Old Man Range, Hyde Rock
Pollenia immanis	Flies	Holotype	NZAC04019231	1315621637	Insecta	Diptera	Polleniidae	Old Man Range
Pollenia uniseta	Flies	Holotype	NZAC04019243	1315602996	Insecta	Diptera	Polleniidae	Old Man Range
Polyozus galbanus	True Bugs	Holotype	NZAC04063103	1315598054	Insecta	Hemiptera	Miridae	Outram
Polyozus galbanus	True Bugs	Allotype	NZAC04070762	1315598626	Insecta	Hemiptera	Miridae	Outram
Polyplectropus puerilis	Caddisflies	Holotype	AMNZ21971	3323005361	Insecta	Trichoptera	Polycentropodidae	Dunedin
Prodontria bicolorata	Beetles	Holotype	NZAC04067229	1315643901	Insecta	Coleoptera	Scarabaeidae	Alexandra
Prodontria montis	Beetles	Holotype	NZAC04067156	1315601711	Insecta	Coleoptera	Scarabaeidae	Rock and Pillar Range, McPhees Rock
Prodontria pinguis	Beetles	Holotype	NZAC04067289	1315639447	Insecta	Coleoptera	Scarabaeidae	The Remarkables
Prodontria regalis	Beetles	Holotype	NZAC04067075	1315629504	Insecta	Coleoptera	Scarabaeidae	Crown Range
Prosynopeas notaulicum	Parasitoid wasps	Holotype	NZAC04092834	4134547408	Insecta	Hymenoptera	Platygastridae	Dunstan Mountains, Bendigo Mines
Pseudocoremia insignita	Moths	Holotype	AMNZ21799	3322925350	Insecta	Lepidoptera	Geometridae	Otago Peninsula, Sandymount
Pseudocoremia monacha	Moths	Holotype	AMNZ21953	3323005360	Insecta	Lepidoptera	Geometridae	Queenstown

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Type localities in Otago

Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Pseudoeconesus paludis	Caddisflies	Holotype	2007.191.2297		Insecta	Trichoptera	Oeconesidae	Swampy Summit
Pseudoexeirarthra hlavaci	Beetles	Holotype	NZAC04095755	1315607902	Insecta	Coleoptera	Staphylinidae	Leith Saddle
Pseudolycoriella hauta	Flies	Holotype	NZAC02028878	2863625301	Insecta	Diptera	Sciaridae	Catlins, Purakaunui Scenic Reserve
Pseudolycoriella plicitegmenta	Flies	Holotype	NZAC02028879	2863616302	Insecta	Diptera	Sciaridae	Catlins, Purakaunui Scenic Reserve
Pseudolycoriella porehu	Flies	Holotype	NZAC02028877	2863625305	Insecta	Diptera	Sciaridae	Catlins, Purakaunui Scenic Reserve
Pseudolycoriella subtilitegmenta	Flies	Holotype	NZAC02028893	2865765412	Insecta	Diptera	Sciaridae	Catlins, Purakaunui Scenic Reserve
Psychoda formosa	Flies	Holotype	NZAC04021190	1315611517	Insecta	Diptera	Psychodidae	Leith Valley
Psychoda pulchrima	Flies	Holotype	NZAC04021212	1315623785	Insecta	Diptera	Psychodidae	Leith Valley
Psychoda simplex	Flies	Holotype	NZAC04021213	1315597349	Insecta	Diptera	Psychodidae	Dunedin
Psychoda tridens	Flies	Holotype	NZAC04021223	1315618547	Insecta	Diptera	Psychodidae	Leith Valley
Psylla carmichaeliae	True Bugs	Holotype	NZAC04220315	2247697865	Insecta	Hemiptera	Psyllidae	Crown Range
Psyllaephagus pilosus	Parasitoid wasps	Holotype	NZAC04000344	4134513588	Insecta	Hymenoptera	Encyrtidae	Lake Wakatipu, Bob's Cove
Pycnocentria patricki	Caddisflies	Holotype	2007.191.2471		Insecta	Trichoptera	Conoesucidae	Pisa Range, Princess Burn
Pycnocentrodes aeris	Caddisflies	Holotype	AMNZ21975	3323007357	Insecta	Trichoptera	Conoesucidae	Kinloch
Pyrgotis humilis	Moths	Holotype	AMNZ21791	3323005352	Insecta	Lepidoptera	Tortricidae	Mt Maungatua
Rhabdomastix callosa	Flies	Holotype	USNMENT01331824	1321054474	Insecta	Diptera	Limoniidae	Otago*
Rhabdomastix neozelandiae	Flies	Holotype		1319124634	Insecta	Diptera	Limoniidae	Waipori
Rhabdomastix otagana	Flies	Holotype		1317878450	Insecta	Diptera	Limoniidae	Dunedin

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Type localities in Otago

Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Rhopus anceps	Parasitoid wasps	Holotype	NZAC04000345	4134567908	Insecta	Hymenoptera	Encyrtidae	Rocklands Station
Rhypodes celmisiae	Seed bugs	Holotype	NZAC04000166	1315612346	Insecta	Hemiptera	Lygaeidae	Coronet Peak
Rhypodes celmisiae	Seed bugs	Allotype	NZAC04064613	1315634545	Insecta	Hemiptera	Lygaeidae	Old Man Range
Rhypodes koebelei	Seed bugs	Allotype	NZAC04064842	1315596124	Insecta	Hemiptera	Lygaeidae	Tarras
Rhypodes longiceps	Seed bugs	Holotype	NZAC04000131	1315640687	Insecta	Hemiptera	Lygaeidae	Coronet Peak
Rhypodes longiceps	Seed bugs	Allotype	NZAC04065835	1315597550	Insecta	Hemiptera	Lygaeidae	Coronet Peak
Romna oculata	True Bugs	Holotype	NZAC04000221	1315599367	Insecta	Hemiptera	Miridae	Wanaka, Mt Alpha
Romna oculata	True Bugs	Allotype	NZAC04073344	1315642148	Insecta	Hemiptera	Miridae	Wanaka, Mt Alpha
Sciacharis tautukuensis	Beetles	Holotype	NZAC04095542	1315629420	Insecta	Coleoptera	Staphylinidae	Tautuku Reserve, Owaka
Scoparia pascoella	Moths	Allotype	NZAC04041384	1315627787	Insecta	Lepidoptera	Crambidae	Tooth Peak
Scoparia pascoella	Moths	Holotype	NZAC04041517	1315610481	Insecta	Lepidoptera	Crambidae	Tooth Peak
Scoparia tuicana	Moths	Holotype	AMNZ21796	3323008347	Insecta	Lepidoptera	Crambidae	Waitati
Scoriodyta patricki	Moths	Holotype	NZAC04023519	1315638359	Insecta	Lepidoptera	Psychidae	Portobello
Scorpiurus aramoana	Flies	Allotype	IV101545		Insecta	Diptera	Dolichopodidae	Aramoana
Scorpiurus aramoana	Flies	Holotype	IV101542		Insecta	Diptera	Dolichopodidae	Aramoana
Scythris nigra	Moths	Holotype	AMNZ21797	3323009349	Insecta	Lepidoptera	Scythrididae	Mt Maungatua
Selidosema terrena	Moths	Holotype	AI.000617		Insecta	Lepidoptera	Geometridae	Humboldt Range, Bold Peak
Setascutum pallidum	Weta	Holotype	NZAC03015582	1315622170	Insecta	Orthoptera	Rhaphidophoridae	Old Man Range
Shireplitis bilboi	Parasitoid wasps	Holotype	NZAC04045187	4134502557	Insecta	Hymenoptera	Braconidae	Dunstan Range
Shireplitis frodoi	Parasitoid wasps	Holotype	NZAC04048842	4134516214	Insecta	Hymenoptera	Braconidae	Coronet Peak

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Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Shireplitis tolkieni	Parasitoid wasps	Holotype	NZAC04049517	4134502944	Insecta	Hymenoptera	Braconidae	Catlins State Forest Park, Shaw Road
Sierola berryae	Parasitoid wasps	Holotype	NZAC04033868	4134572342	Insecta	Hymenoptera	Bethylidae	Clyde
Sierola lucyae	Parasitoid wasps	Allotype	NZAC04034428	4134517940	Insecta	Hymenoptera	Bethylidae	Old Man Range
Sigara infrequens	True Bugs	Holotype	2007.182.1131		Insecta	Hemiptera	Corixidae	Berwick
Sigaus childi	Weta	Holotype	IV6824		Insecta	Orthoptera	Acrididae	Galloway
Spilogona argentifrons	Flies	Type		1318269569	Insecta	Diptera	Muscidae	Fenwick
Stathmopoda albimaculata	Moths	Holotype	AMNZ21803	3323007348	Insecta	Lepidoptera	Stathmopodidae	Taieri, Woodside
Stathmopoda mysteriastis	Moths	Holotype	AMNZ21804	3323008348	Insecta	Lepidoptera	Stathmopodidae	Otago Peninsula, Broad Bay
Stegococcus flagellatus	scale insects	Holotype	NZAC02006523	1315629087	Insecta	Hemiptera	Eriococcidae	Rock and Pillar Range, Brookdale Conservation Covenant
Stigmella hakekeae	Moths	Holotype	AI.000688		Insecta	Lepidoptera	Nepticulidae	Dunedin
Stigmella kaimanua	Moths	Holotype	NZAC04023332	1315632671	Insecta	Lepidoptera	Nepticulidae	Woodhaugh Valley
Stigmella lucida	Moths	Syntype	NZAC04023339	1315643177	Insecta	Lepidoptera	Nepticulidae	Waitati
Stigmella lucida	Moths	Syntype	AMNZ21785	3322921352	Insecta	Lepidoptera	Nepticulidae	Waitati
Stigmella lucida	Moths	Syntype	AMNZ17997	3322912178	Insecta	Lepidoptera	Nepticulidae	Waitati
Synopeas trifolii	Parasitoid wasps	Holotype	NZAC04093368	4134561162	Insecta	Hymenoptera	Platygastridae	Rocklands Station
Synopeas wardi	Parasitoid wasps	Holotype	NZAC04092717	4134546607	Insecta	Hymenoptera	Platygastridae	Kawarau Gorge, Roaring Meg
Syrphetodes cirrhopogon	Beetles	Holotype	NZAC04128031	1315607488	Insecta	Coleoptera	Ulodidae	Mt Aspiring NP, Rob Roy Glacier
Taenarthrus obliteratas	Beetles	Holotype	2007.163.15261		Insecta	Coleoptera	Carabidae	Leith Valley
Taraperla johnsi	Stoneflies	Holotype	IV7215		Insecta	Plecoptera	Gripopterygidae	Blue Mountains
Tasiocera bituberculata	Flies	Holotype	USNMENT01331669	1317237162	Insecta	Diptera	Limoniidae	Glenorchy

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Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Tatosoma monoviridisata	Moths	Holotype	AMNZ21807	3322925351	Insecta	Lepidoptera	Geometridae	Waitati
Tauroscopa howesi	Moths	Holotype	NZAC04041497	1315638168	Insecta	Lepidoptera	Crambidae	Old Man Range, Obelisk
Tephritis thoracica	Flies	Allotype	2007.192.5791		Insecta	Diptera	Trypetidae	Lake Luna
Tephritis thoracica	Flies	Holotype	2007.192.5790		Insecta	Diptera	Trypetidae	Queenstown
Thelyphassa brouni	Beetles	Holotype	NZAC04069882	1315614319	Insecta	Coleoptera	Oedemeridae	Taieri Mouth
Thinempis otakouensis	Flies	Holotype	NZAC04021426	1315630666	Insecta	Diptera	Empididae	St Kildas Beach (Ocean Beach)
Tinea furcillata	Moths	Holotype	AMNZ21812	3322930339	Insecta	Lepidoptera	Tineidae	Dunedin, Andersons Bay
Tingena aurata	Moths	Allotype	AMNZ14870	3322918016	Insecta	Lepidoptera	Oecophoridae	Dunedin, Opoho
Tingena aurata	Moths	Holotype	AMNZ21765	3322922361	Insecta	Lepidoptera	Oecophoridae	Dunedin, Opoho
Tingena lassa	Moths	Holotype	AMNZ21746	3322929342	Insecta	Lepidoptera	Oecophoridae	Leith Valley
Tiphobiosis cataractae	Caddisflies	Holotype	2007.191.1873		Insecta	Trichoptera	Hydrobiosidae	Pisa Range
Tiphobiosis fulva	Caddisflies	Holotype	NZAC04070503	1315632176	Insecta	Trichoptera	Hydrobiosidae	Humboldt Mountains
Tiphobiosis montana	Caddisflies	Holotype	NZAC04070193	1315606448	Insecta	Trichoptera	Hydrobiosidae	Ben Lomond
Tmetolophota purdii	Moths	Holotype	2007.222.2493		Insecta	Lepidoptera	Noctuidae	Fairfield, Dunedin
Trichopsida popei	Beetles	Holotype	NZAC04070298	1315641815	Insecta	Coleoptera	Carabidae	Rock and Pillar Range
Tricimba dugdalei	Flies	Holotype	NZAC04019157	1315602197	Insecta	Diptera	Chloropidae	Rock and Pillar Range
Tricyphona novaezelandiae	Flies	Holotype		1319899312	Insecta	Diptera	Pediciidae	Dunedin
Trioza gourlayi	True Bugs	Allotype	NZAC04220148	2247697851	Insecta	Hemiptera	Triozidae	Skippers Bridge
Trioza gourlayi	True Bugs	Holotype	NZAC04220582	2247697860	Insecta	Hemiptera	Triozidae	Skippers Bridge
Trupanea watti	Flies	Holotype	2007.192.5624		Insecta	Diptera	Tephritidae	Mt Cargill
Ventrispina dugdalei	scale insects	Holotype	NZAC02002374	1315615649	Insecta	Hemiptera	Pseudococcidae	Old Woman Range

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Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Vesicaperla celmisia	Stoneflies	Holotype	IV7258		Insecta	Plecoptera	Gripopterygidae	Otago*
Waitatia bellicosa	Beetles	Holotype	AMNZ25228	3322923507	Insecta	Coleoptera	Staphylinidae	Waitati
Wesmaelius maorica	Lacewings	Holotype	NZAC04069877	1315614333	Insecta	Neuroptera	Hemerobiidae	Dunedin
Woldstedtius gauldius	Parasitoid wasps	Holotype	NZAC04036688	4134577246	Insecta	Hymenoptera	Ichneumonidae	Coronet Peak
Xanthorhoe stricta	Moths	Holotype	AI.000612		Insecta	Lepidoptera	Geometridae	Humboldt Range, Bold Peak
Xenophyes kinlochensis	True Bugs	Holotype	NZAC04000246	1315604079	Insecta	Hemiptera	Peloridiidae	Kinloch
Xenophyes kinlochensis	True Bugs	Allotype	NZAC04041852	1315606682	Insecta	Hemiptera	Peloridiidae	Kinloch
Zeadelium senile	Beetles	Holotype	NZAC04095703	1315639606	Insecta	Coleoptera	Tenebrionidae	Old Man Range
Zeanillus montivagus	Beetles	Holotype	NZAC04232214	3059618376	Insecta	Coleoptera	Carabidae	North Rough Ridge
Zelandobius auratus	Stoneflies	Holotype	NZAC03001054	1315634724	Insecta	Plecoptera	Gripopterygidae	Alexandra, Conroy's Road
Zelandobius childi	Stoneflies	Holotype	NZAC03001069	1315628351	Insecta	Plecoptera	Gripopterygidae	Rock and Pillar Range
Zelandobius edwardsi	Stoneflies	Holotype	NZAC03000777	1315642954	Insecta	Plecoptera	Gripopterygidae	Hector Mountains, Ben Nevis
Zelandobius foxi	Stoneflies	Holotype	NZAC03001210	1315635879	Insecta	Plecoptera	Gripopterygidae	Mt Teviot
Zelandobius inversus	Stoneflies	Holotype	NZAC03000931	1315604241	Insecta	Plecoptera	Gripopterygidae	Pisa Range
Zelandobius macburneyi	Stoneflies	Holotype	NZAC03000741	1315628759	Insecta	Plecoptera	Gripopterygidae	Rock and Pillar Range
Zelandobius mariae	Stoneflies	Holotype	NZAC03000778	1315628840	Insecta	Plecoptera	Gripopterygidae	Pisa Range
Zelandobius montanus	Stoneflies	Holotype	NZAC03000784	1315608930	Insecta	Plecoptera	Gripopterygidae	Dart Valley, Headlong Peak
Zelandobius patricki	Stoneflies	Holotype	NZAC03000822	1315599655	Insecta	Plecoptera	Gripopterygidae	Rock and Pillar Range, The Wandle

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Type localities in Otago

Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Zelandomyia otagensis	Flies	Holotype		1318884313	Insecta	Diptera	Limoniidae	Queenstown
Zelandonota rufiscutum	Parasitoid wasps	Holotype	NZAC04048784	4134521357	Insecta	Hymenoptera	Platygastridae	NE of Makarora, Camerons Creek Valley
Zelandoperla fenestrata	Stoneflies	Holotype	2006.34.1146		Insecta	Plecoptera	Gripopterygidae	Gorge Creek, Old Man Range
Zelandoperla tillyardi	Stoneflies	Holotype	IV7265		Insecta	Plecoptera	Gripopterygidae	Leith Saddle
Zelandoperla tillyardi	Stoneflies	Allotype	IV7268		Insecta	Plecoptera	Gripopterygidae	Leith Valley
Zelleria maculata	Moths	Holotype	AMNZ21824	3323010351	Insecta	Lepidoptera	Yponomeutidae	Mt Maungatua
Zelostemma brevistriatum	Parasitoid wasps	Holotype	NZAC04099520	4134546840	Insecta	Hymenoptera	Platygastridae	Coronet Peak
Zelostemma laevicornu	Parasitoid wasps	Holotype	NZAC04099660	4134561258	Insecta	Hymenoptera	Platygastridae	Old Man Range
Zelostemma longipedicellatum	Parasitoid wasps	Holotype	NZAC04099765	4134578840	Insecta	Hymenoptera	Platygastridae	Makarora
Zelostemma medionitens	Parasitoid wasps	Holotype	NZAC04099870	4134561213	Insecta	Hymenoptera	Platygastridae	Old Man Range
Zelostemma popovicii	Parasitoid wasps	Holotype	NZAC04099702	4134519704	Insecta	Hymenoptera	Platygastridae	Rock and Pillar Range, Leaning Ledge
Zemacrosaldula kapekape	True Bugs	Holotype	NZAC04051643	1315614235	Insecta	Hemiptera	Saldidae	Mt Aspiring NP, Cameron Flat
Zolus unisetosus	Beetles	Holotype	NZAC04184320	1829415225	Insecta	Coleoptera	Carabidae	Mt Aspiring NP, Blue Pools Walk
Styloniscus otakensis	Slaters	Syntype	2015.149.1806		Malacostraca	Isopoda	Styloniscidae	Dunedin
Styloniscus otakensis	Slaters	Syntype	2015.149.1807		Malacostraca	Isopoda	Styloniscidae	Dunedin
Styloniscus otakensis	Slaters	Syntype	2015.149.1808		Malacostraca	Isopoda	Styloniscidae	Dunedin
Styloniscus otakensis	Slaters	Syntype	2015.149.1809		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill

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Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Styloniscus otakensis	Slaters	Syntype	2015.149.278		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.279		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.280		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.281		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.282		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.283		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.284		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.285		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.286		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.287		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.288		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.289		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.290		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.291		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.292		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.293		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.294		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.295		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill

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Type localities in Otago

Terrestrial invertebrates continued

Scientific name	Common name	Type	Catalogue number	GBIF ID	Class	Order	Family	Locality
Styloniscus otakensis	Slaters	Syntype	2015.149.296		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.297		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.298		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.299		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.300		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.301		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.302		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.303		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.304		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.305		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.306		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.307		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.308		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.309		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.310		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.311		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.312		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Styloniscus otakensis	Slaters	Syntype	2015.149.313		Malacostraca	Isopoda	Styloniscidae	Flagstaff Hill
Tasmanentulus intermedius	Primitive insects	Holotype	NZAC02016059	1315625204	Protura	Protura	Acerentomidae	Old Man Range

Appendix 3: Vascular and non-vascular plants with type localities in Otago

Scientific name and authority	Order	Type	Catalogue number	Locality
Althenia bilocularis (Kirk) Cockayne	Alismatales	Syntype	SP060351	Lake Waihola
Althenia bilocularis (Kirk) Cockayne	Alismatales	Syntype	SP060352	Lake Waihola
Althenia bilocularis (Kirk) Cockayne	Alismatales	Syntype	SP060353	Lake Waihola
Althenia bilocularis (Kirk) Cockayne	Alismatales	Syntype	SP060354	Lake Waihola
Althenia bilocularis (Kirk) Cockayne	Alismatales	Syntype	SP063601	Lake Waihola
Althenia bilocularis (Kirk) Cockayne	Alismatales	Syntype	SP063602	Lake Waihola
Althenia bilocularis (Kirk) Cockayne	Alismatales	Syntype	SP063603	Lake Waihola
Althenia bilocularis (Kirk) Cockayne	Alismatales	Type (possible)	SP060350	Lagoon at Waikouaiti, close to Railway Station
Andreaea nitida Hook.f. & Wilson	Andreaeales	Type	CHR 625099	Milton
Andreaea nitida Hook.f. & Wilson	Andreaeales	Type	CHR 625099	Milton
Andreaea nitida Hook.f. & Wilson	Andreaeales	Type	CHR 625094	Waipahi
Andreaea nitida Hook.f. & Wilson	Andreaeales	Isotype	1907-0000030	Mount Bonpland
Aciphylla aurea W.R.B.Oliv.	Apiales	Holotype	SP005373	Swampy Summit
Aciphylla aurea W.R.B.Oliv.	Apiales	Isotype (possible)	SP013760	Swampy Summit
Aciphylla aurea W.R.B.Oliv.	Apiales	Isotype (possible)	SP013761	Swampy Summit
Aciphylla flexuosa W.R.B.Oliv.	Apiales	Holotype	SP002988	Mount Alta
Aciphylla glaucescens W.R.B.Oliv.	Apiales	Holotype	SP005401	Swampy Summit
Aciphylla kirkii Buchanan	Apiales	Syntype	AK6541	Mount Alta
Aciphylla kirkii Buchanan	Apiales	Type (possible)	SP013819	Mount Alta
Aciphylla kirkii Buchanan	Apiales	Type (possible)	SP011641	Mount Alta
Aciphylla lecomtei J.W.Dawson	Apiales	Holotype	SP065502	Hector Mountains
Aciphylla lecomtei J.W.Dawson	Apiales	Isotype	SP065503	Hector Mountains
Aciphylla scott-thomsonii Cockayne & Allan	Apiales	Holotype	CHR 11226	Catlins River Valley
Aciphylla scott-thomsonii Cockayne & Allan	Apiales	Holotype	CHR 11227	Tokomairaro River mouth
Aciphylla scott-thomsonii Cockayne & Allan	Apiales	Type	CHR 521532	Milton

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Plants continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Aciphylla simplex Petrie	Apiales	Syntype (possible)	SP054824	Mount Pisa
Aciphylla simplex Petrie	Apiales	Syntype	AK6543	Mount Cardrona
Aciphylla simplex Petrie	Apiales	Lectotype	SP002123	Mount Cardrona
Aciphylla spedenii Cheeseman	Apiales	Syntype	AK6536	Cecil Peak
Aciphylla spedenii Cheeseman	Apiales	Syntype	AK6537	Cecil Peak
Aciphylla spedenii Cheeseman	Apiales	Syntype	AK6538	Cecil Peak
Aciphylla verticillata W.R.B.Oliv.	Apiales	Holotype	AK6512	Mount Kyeburn
Anisotome aromatica var. *dissecta* Allan	Apiales	Holotype	CHR 76104	Lake Waihola
Anisotome cauticola J.W.Dawson	Apiales	Holotype	SP005115	Nevis Valley, rock outcrops
Anisotome cauticola J.W.Dawson	Apiales	Isotype (possible)	SP005116	Nevis Valley, rock outcrops
Anisotome flabellifolia G.Simpson	Apiales	Holotype	CHR 75688	Whiskey Gully, Tapanui
Anisotome imbricata (Hook.f.) Cockayne	Apiales	Type	G-G-263084/1	Otago
Anisotome lanuginosa (Kirk) J.W.Dawson	Apiales	Lectotype	SP001166	Hector Mountains
Gingidia enysii (Kirk) J.W.Dawson	Apiales	Holotype	SP001132	Naseby
Gingidia grisea Heenan	Apiales	Isotype	AK288114	Trotters Gorge Scenic Reserve
Hydrocotyle hydrophila Petrie	Apiales	Syntype	SP054648	Wickliffe Bay, between the Pyramids
Hydrocotyle hydrophila Petrie	Apiales	Lectotype	SP068306	Wickliffe Bay, between the Pyramids
Hydrocotyle hydrophila Petrie	Apiales	Isolectotype	AK6239	Wickliffe Bay, between the Pyramids
Pachyschistochila subhyalina var. *grandidentata* J.J.Engel & R.M.Schust.	Apiales	Holotype		Mount Maungatua,
Drymoanthus flavus St George & Molloy	Asparagales	Holotype	CHR 482355	Galloway, near Alexandra
Drymoanthus flavus St George & Molloy	Asparagales	Isotype	AK229877	Tahakopa Bay Scenic Reserve
Drymoanthus flavus St George & Molloy	Asparagales	Isotype	CANB 625883.1	Tahakopa Bay Scenic Reserve
Drymoanthus flavus St George & Molloy	Asparagales	Isotype	SP080019	Tahakopa Bay Scenic Reserve
Gastrodia minor Petrie	Asparagales	Syntype (possible)	SP019055	Near Northern Cemetery, Town Belt, Dunedin
Gastrodia minor Petrie	Asparagales	Syntype	SP019064	Near Northern Cemetery, Town Belt, Dunedin
Gastrodia minor Petrie	Asparagales	Syntype	SP019081	Near Northern Cemetery, Town Belt, Dunedin

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Type localities in Otago

Plants continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Gastrodia minor Petrie	Asparagales	Syntype	AK3688	Near Northern Cemetery, Town Belt, Dunedin
Abrotanella caespitosa Petrie ex Kirk	Asterales	Lectotype	AK10466	Mount Kyeburn
Abrotanella caespitosa Petrie ex Kirk	Asterales	Paralectotype	SP002099	Mount Kyeburn
Abrotanella caespitosa Petrie ex Kirk	Asterales	Paralectotype	SP057801	Mount Kyeburn
Abrotanella caespitosa Petrie ex Kirk	Asterales	Syntype	SP057804	Mount Kyeburn
Abrotanella inconspicua Hook.f.	Asterales	Type fragment	CHR 402986	Tautuku Bay
Abrotanella inconspicua Hook.f.	Asterales	Isolectotype	SP057814	Mount Alta
Brachyglottis buchananii (J.B.Armstr.) B.Nord.	Asterales	Syntype	AK35247	Mount Cargill
Brachyglottis buchananii (J.B.Armstr.) B.Nord.	Asterales	Holotype	CHR 29513	Kyeburn
Brachyglottis lagopus (Raoul) B.Nord.	Asterales	Holotype	CHR 72733	Kyeburn
Brachyglottis lagopus (Raoul) B.Nord.	Asterales	Holotype	CHR 24175	Mole, Aramoana, Otago Peninsula
Brachyscome brevifolia G.Simpson	Asterales	Neotype	CHR 76317	Mount Maungatua
Brachyscome humilis G.Simpson & J.S.Thomson	Asterales	Neotype	CHR 199636	Mount Maungatua
Brachyscome humilis G.Simpson & J.S.Thomson	Asterales	Type	SP041374	Rock and Pillar Range
Brachyscome longiscapa G.Simpson & J.S.Thomson	Asterales	Neotype	CHR 112471	Mount Maungatua
Brachyscome thomsonii var. *dubia* Kirk	Asterales	Lectotype	AK9389	Cape Wanbrow
Celmisia argentea Kirk	Asterales	Syntype	AK9970	Mount Maungatua
Celmisia argentea Kirk	Asterales	Type (possible)	SP045695	Mount Maungatua
Celmisia argentea Kirk	Asterales	Isotype	SP045695	Mount Maungatua
Celmisia bonplandii (Buchanan) Allan	Asterales	Neotype	CHR 6301	Swampy Summit
Celmisia brevifolia Cockayne	Asterales	Syntype (possible)	SP045774	Old Man Range
Celmisia brevifolia Cockayne	Asterales	Syntype	AK34925	Mount Ernest
Celmisia haastii var. *tomentosa* G.Simpson & J.S.Thomson	Asterales	Holotype	CHR 50011	Swampy Summit
Celmisia haastii var. *tomentosa* G.Simpson & J.S.Thomson	Asterales	Type	CHR 549665	Taiaroa Head and Aramoana, Otago Heads
Celmisia haastii var. *tomentosa* G.Simpson & J.S.Thomson	Asterales	Syntype	AK106430	Runnels on the Rock and Pillar Range
Celmisia hookeri Cockayne	Asterales	Lectotype	SP047043	Horse Range
Celmisia hookeri Cockayne	Asterales	Syntype (possible)	SP047031	Macrae's Flat

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Type localities in Otago

Plants continued

Scientific name and authority	**Order**	**Type**	**Catalogue number**	**Locality**
Celmisia hookeri Cockayne	Asterales	Syntype (possible)	SP047032	Horse Range
Celmisia prorepens Petrie	Asterales	Lectotype	AK 9762	Old Man Range
Celmisia ramulosa var. *tuberculata* G.Simpson & J.S.Thomson	Asterales	Holotype	CHR 50003	Taiaroa Head and Aramoana, Otago Heads
Celmisia ramulosa var. *tuberculata* G.Simpson & J.S.Thomson	Asterales	Type	CHR 550039	Taiaroa Head and Aramoana, Otago Heads
Celmisia ramulosa var. *tuberculata* G.Simpson & J.S.Thomson	Asterales	Syntype	AK170505	Rough Peaks
Celmisia semicordata subsp. *aurigans* Given	Asterales	Holotype	CHR 175190	Taiaroa Head and Aramoana, Otago Heads
Celmisia thomsonii Cheeseman	Asterales	Isotype	CHR 10321	Taiaroa Head and Aramoana, Otago Heads
Celmisia thomsonii Cheeseman	Asterales	Syntype	AK9976	Eyre Mountains
Celmisia walkeri Kirk	Asterales	Isotype	CHR 288140	Taiaroa Head and Aramoana, Otago Heads
Celmisia walkeri Kirk	Asterales	Isolectotype (possible)	SP004530	Above Lake Harris
Celmisia walkeri Kirk	Asterales	Isolectotype (possible)	SP004548	Above Lake Harris
Celmisia walkeri Kirk	Asterales	Isolectotype (possible)	SP045260	Above Lake Harris
Celmisia walkeri Kirk	Asterales	Lectotype	SP003287	Above Lake Harris
Craspedia argentea Breitw. & K.A.Ford	Asterales	Type	CHR 588519	Old Man Range / Kopuwai
Forstera sedifolia G.Forst.	Asterales	Isolectotype	AK37199	Humboldt Mountains
Forstera sedifolia G.Forst.	Asterales	Lectotype	AK9291	Humboldt Mountains
Forstera sedifolia var. *oculata* Cheeseman	Asterales	Isolectotype	CHR 295225	Cromwell Gorge
Helichrysum simpsonii Kottaim.	Asterales	Isotype	CHR 154063	Crown Range
Helichrysum simpsonii Kottaim.	Asterales	Holotype	CHR 76018	Pisa Range
Helichrysum simpsonii Kottaim.	Asterales	Holotype	CHR 87837	Mount Pisa
Helichrysum simpsonii Kottaim.	Asterales	Isotype	CHR 76014	Mount Pisa
Lagenophora cuneata Petrie	Asterales	Isotype	CHR 333540	Bold Peak, Humboldt Mountains
Lagenophora cuneata Petrie	Asterales	Lectotype	SP044165	Flagstaff Hill
Lagenophora cuneata Petrie	Asterales	Isolectotype (possible)	SP044168	Flagstaff Hill
Lagenophora petiolata Hook.f.	Asterales	Isotype	CHR 333571	Bold Peak, Humboldt Mountains

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Type localities in Otago

Plants continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Leptinella albida (D.G.Lloyd) D.G.Lloyd & C.J.Webb	Asterales	Lectotype	CHR 68186	Trotters Gorge, Trotters Creek
Leptinella albida (D.G.Lloyd) D.G.Lloyd & C.J.Webb	Asterales	Isolectotype	AK10388	Old Man Range and Mount Cardrona
Leptinella albida (D.G.Lloyd) D.G.Lloyd & C.J.Webb	Asterales	Isolectotype	AK212127	Old Man Range and Mount Cardrona
Leptinella conjuncta Heenan	Asterales	Holotype	CHR 592259	Pine Hill
Leptinella goyenii (Petrie) D.G.Lloyd & C.J.Webb	Asterales	Isotype	CHR 68173	Shag Point
Leptinella goyenii (Petrie) D.G.Lloyd & C.J.Webb	Asterales	Isolectotype (possible)	SP057709	Mount Pisa
Leptinella goyenii (Petrie) D.G.Lloyd & C.J.Webb	Asterales	Lectotype (possible)	SP057612	Mount Pisa
Leptinella goyenii (Petrie) D.G.Lloyd & C.J.Webb	Asterales	Isolectotype	AK10391	Mount Pisa
Leptinella maniototo (Petrie) D.G.Lloyd & C.J.Webb	Asterales	Lectotype	SP057515	Maniototo plain
Leptinella pectinata (Hook.f.) D.G.Lloyd & C.J.Webb subsp. *pectinata*	Asterales	Isolectotype	AK209500	Near Mount Earnslaw
Leptinella pectinata (Hook.f.) D.G.Lloyd & C.J.Webb subsp. *pectinata*	Asterales	Lectotype	AK24966	Near Mount Earnslaw
Leptinella pectinata subsp. *willcoxii* (Cheeseman) D.G.Lloyd & C.J.Webb	Asterales	Isotype	CHR 155497	Horse Range
Leptinella pectinata subsp. *willcoxii* (Cheeseman) D.G.Lloyd & C.J.Webb	Asterales	Holotype	CHR 75701	Horse Range
Leptinella pectinata subsp. *villosa* (G.Simpson) D.G.Lloyd & C.J.Webb	Asterales	Lectotype	CHR 76029	Moeraki Beach to Moeraki Point
Lobelia glaberrima Heenan	Asterales	Holotype	CHR 468987	Pine Hill
Olearia bullata H.D.Wilson & Garn.-Jones	Asterales	Isolectotype	AK210589	Flagstaff Hill
Olearia bullata H.D.Wilson & Garn.-Jones	Asterales	Isolectotype	AK22899	Flagstaff Hill
Olearia bullata H.D.Wilson & Garn.-Jones	Asterales	Lectotype	CHR 75715	Black Head
Olearia fragrantissima Petrie	Asterales	Syntype (possible)	SP032534	Catlins River
Olearia fragrantissima Petrie	Asterales	Syntype (possible)	SP032529	Catlins River
Olearia fragrantissima Petrie	Asterales	Syntype (possible)	SP032535	Tomahawk
Olearia fragrantissima Petrie	Asterales	Syntype (possible)	SP032528	Vauxhall
Olearia fragrantissima Petrie	Asterales	Syntype (possible)	SP032533	Vauxhall
Olearia fragrantissima Petrie	Asterales	Syntype (possible)	SP032516	Near Dunedin
Olearia fragrantissima Petrie	Asterales	Syntype	AK9627	Dunedin

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Plants continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Olearia odorata Petrie	Asterales	Syntype	SP032636	North of Roxburgh
Olearia odorata Petrie	Asterales	Syntype	SP057338	Cromwell
Olearia odorata Petrie	Asterales	Syntype	SP032640	Between Roxburgh and Speargrass Flat
Olearia odorata Petrie	Asterales	Syntype	SP057340	Speargrass Flat
Olearia odorata Petrie	Asterales	Syntype	SP032630	Maniototo to Lake Hawea
Raoulia apicinigra Kirk	Asterales	Syntype	SP044812	Ben Lomond
Raoulia buchananii Kirk	Asterales	Syntype	AK10095	Mount Alta
Raoulia petriensis Kirk	Asterales	Type	SP048520	Mount Saint Bathans
Raoulia petriensis Kirk	Asterales	Syntype	AK10127	Mount Saint Bathans
Raoulia petriensis Kirk	Asterales	Syntype	AK30643	Mount Saint Bathans
Raoulia rubra Buchanan	Asterales	Syntype	AK10086	Otago Alps
Senecio carnosulus (Kirk) C.J.Webb	Asterales	Isoneotype	AK264208	Black Head
Senecio lautus Willd.	Asterales	Neotype	CHR 87642	Mole, Aramoana, Otago Peninsula
Wahlenbergia rupestris G.Simpson	Asterales	Isotype	CHR 550042	Near Prophets Rock, Old Man Range
Wahlenbergia rupestris G.Simpson	Asterales	Isotype	CHR 550043	Alexandra
Wahlenbergia rupestris G.Simpson	Asterales	Holotype	CHR 76430	Alexandra
Conostomum pusillum var. *otagoensis* Fife	Bartramiales	Holotype	CHR 428537	Mount Watkin / Hikaroroa
Conostomum pusillum var. *otagoensis* Fife	Bartramiales	Paratype	CHR 480497	Mount Watkin / Hikaroroa
Conostomum pusillum var. *otagoensis* Fife otagoensis	Bartramiales	Paratype	CHR 511292	Mount Watkin / Hikaroroa
Conostomum pusillum var. *otagoensis* Fife	Bartramiales	Paratype	CHR 512315	Mount Watkin / Hikaroroa
Myosotis antarctica Hook.f. subsp. *antartica*	Boraginales	Holotype	CHR 75720	Near Oamaru
Myosotis cheesemanii Petrie	Boraginales	Type fragment	CHR 97407	Pelichet Bay, Dunedin
Myosotis cheesemanii Petrie	Boraginales	Lectotype	SP002696	Mount Pisa
Myosotis glauca (G.Simpson & J.S.Thomson) de Lange & Barkla	Boraginales	Type	CHR 550036	Near Oamaru
Myosotis glauca (G.Simpson & J.S.Thomson) de Lange & Barkla	Boraginales	Holotype	CHR 75722	Near Oamaru
Myosotis goyenii Petrie	Boraginales	Syntype	AK7474	Arrowtown
Myosotis goyenii Petrie	Boraginales	Syntype	AK7475	Arrowtown
Myosotis hikuwai Meudt, Prebble & G.M.Rogers	Boraginales	Holotype	SP108906	Clutha River / Mata Au, Wānaka

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Plants continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Myosotis oreophila Petrie	Boraginales	Holotype	SP002393	Mount Ida
Myosotis pygmaea Colenso	Boraginales	Holotype	CHR 75720	Near Oamaru
Myosotis tenericaulis Petrie	Boraginales	Lectotype	SP002689/B	Edge of Inch Clutha, near Romahapa
Myosotis tenericaulis Petrie	Boraginales	Syntype	SP002691	Edge of Inch Clutha, near Romahapa
Myosotis tenericaulis Petrie	Boraginales	Syntype	SP002574	Edge of Inch Clutha, near Romahapa
Myosotis tenericaulis Petrie	Boraginales	Syntype	AK7445	Edge of Inch Clutha, near Romahapa
Myosotis umbrosa Meudt, Prebble & Thorsen	Boraginales	Holotype	SP089905	Rock and Pillar Range
Myosotis uniflora Hook.f.	Boraginales	Type fragment	CHR 97402	Rock and Pillar Range
Cardamine dimidia Heenan	Brassicales	Holotype	CHR 586035	Blue Mountains
Cardamine exigua Heenan	Brassicales	Holotype	CHR 199634	Blue Mountains
Cardamine grandiscapa Heenan	Brassicales	Holotype	CHR 617195	Flagstaff Hill
Cardamine heleniae Heenan	Brassicales	Holotype	CHR 616824	Flagstaff Hill
Cardamine mutabilis Heenan	Brassicales	Holotype	CHR 420058	Flagstaff Hill
Cardamine reptans Heenan	Brassicales	Holotype	CHR 514169	Flagstaff Hill
Cardamine sciaphila Heenan	Brassicales	Holotype	CHR 514168	Flagstaff Hill
Cardamine thalassica Heenan	Brassicales	Holotype	CHR 619275	Flagstaff Hill
Lepidium crassum Heenan & de Lange	Brassicales	Holotype	CHR 609777 A	Above Karoro Creek, Willsher Bay Reserve
Lepidium crassum Heenan & de Lange	Brassicales	Isotype	CHR 609777 B	Above Karoro Creek, Willsher Bay Reserve
Lepidium juvencum Heenan & de Lange	Brassicales	Isotype	CHR 609785 A	Above Karoro Creek, fWillsher Bay Reserve
Lepidium juvencum Heenan & de Lange	Brassicales	Holotype	CHR 609785 B	Buckler Burn, Lake Wakatipu
Lepidium kirkii Petrie	Brassicales	Syntype	SP030096	Below Gimmerburn farms, Maniototo Plain
Lepidium kirkii Petrie	Brassicales	Lectotype (possible)	SP030098	Below Gimmerburn farms, Maniototo Plain
Lepidium kirkii Petrie	Brassicales	Syntype	01176229	Maniototo Plain
Lepidium kirkii Petrie	Brassicales	Syntype	SP030099	Maniototo Plain
Lepidium sisymbrioides Hook.f.	Brassicales	Isolectotype	Z-000005071	Kawarau
Lepidium sisymbrioides Hook.f.	Brassicales	Syntype	CHR 329235	Buckler Burn, Lake Wakatipu

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Scientific name and authority	Order	Type	Catalogue number	Locality
Lepidium sisymbrioides Hook.f.	Brassicales	Syntype	SP028592	Kawarau River, near Gibbston
Lepidium sisymbrioides Hook.f.	Brassicales	Isotype	CHR 329230	East slope of Old Man Range
Lepidium sisymbrioides Hook.f.	Brassicales	Syntype	SP028593	Kawarau River, near Gibbston
Lepidium sisymbrioides Hook.f.	Brassicales	Syntype	SP028588	2 miles west of Victoria Bridge, Kawarau River
Lepidium solandri Kirk	Brassicales	Isolectotype	Z-000005072	Alexandra
Lepidium tenuicaule Kirk	Brassicales	Syntype	AK4482	Cape Wanbrow
Lepidium tenuicaule Kirk	Brassicales	Lectotype	SP030070	Cape Wanbrow
Lepidium tenuicaule Kirk	Brassicales	Syntype (possible)	SP030071	Cape Wanbrow
Lepidium tenuicaule Kirk	Brassicales	Syntype	AK4483	Oamaru
Pachycladon exile (Heenan) Heenan & A.D.Mitch.	Brassicales	Holotype	CHR 511014	Lake Wakatipu
Pachycladon wallii (Carse) Heenan & A.D.Mitch.	Brassicales	Holotype	CHR 329555	Leith Valley Road, near Reservoir, Dunedin
Pachycladon wallii (Carse) Heenan & A.D.Mitch.	Brassicales	Holotype	CHR 331403	Headwaters of Rastus Burn, Remarkables
Pachycladon wallii (Carse) Heenan & A.D.Mitch.	Brassicales	Isotype	CHR 329556	Cardrona Road, north of Saddle
Bryum appressifolium Broth.	Bryales	Isosyntype	CHR 514104	Mount Maungatua
Bryum appressifolium Broth.	Bryales	Isolectotype	CHR 514106	Mount Maungatua
Bryum appressifolium Broth.	Bryales	Syntype	CHR 517042	Mount Maungatua
Bryum appressifolium Broth.	Bryales	Type	BM001086384	Kelso
Bryum appressifolium Broth.	Bryales	Type	BM001086386	Kelso
Bryum appressifolium Broth.	Bryales	Type	90206915	Kelso
Bryum appressifolium Broth.	Bryales	Syntype (possible)	M011832	Kelso
Bryum clavatum (Schimp.) Müll.Hal.	Bryales	Type	CHR 335161	Mount Maungatua
Bryum clavatum (Schimp.) Müll.Hal.	Bryales	Type	CHR 335142	Mount Maungatua
Bryum clavatum (Schimp.) Müll.Hal.	Bryales	Type	CHR 335139	Mount Maungatua
Bryum duriusculum Hook.f. & Wilson	Bryales	Type	CHR 514098	Mount Maungatua
Bryum duriusculum Hook.f. & Wilson	Bryales	Isotype	1907-0001830	Pine Hill
Bryum laevigatum Hook.f. & Wilson	Bryales	Lectotype	CHR 514101	Mount Maungatua
Bryum mucronatum Mitt.	Bryales	Isolectotype	M012370	Otago

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Scientific name and authority	Order	Type	Catalogue number	Locality
Pohlia elongata Hedw.	Bryales	Lectotype	BM000983722	Evans Flat
Pohlia elongata Hedw.	Bryales	Isotype	4009765	Evans Flat
Bryopsis foliosa Sonder	Bryopsidales	Type	CHR 52801	Mount Maungatua
Bryopsis otagensis V.J.Chapm.	Bryopsidales	Holotype	CHR 69210	Mount Maungatua
Bryopsis vestita J.Agardh	Bryopsidales	Isotype	A002345	Otago Harbour
Bryopsis vestita J.Agardh	Bryopsidales	Isotype	A000003	Warrington
Chenopodium allanii Aellen	Caryophyllales	Lectotype	CHR 1064	Silver Peaks
Colobanthus brevisepalus Kirk	Caryophyllales	Syntype	SP050959	Gorge Creek
Colobanthus buchananii Kirk	Caryophyllales	Syntype	AK4090	Manuherikia Valley
Colobanthus monticola Petrie	Caryophyllales	Syntype	SP050960	Bald Hill Flat, near Clutha River
Colobanthus muelleri Kirk	Caryophyllales	Syntype	AK4071	Otago
Montia sessiliflora (G.Simpson) Heenan	Caryophyllales	Lectotype	CHR 60027	Fortification Creek, Lake Onslow
Crouania willae R.E.Norris	Ceramiales	Paratype	CHR 230886 A	Old Man Range / Kopuwai
Crouania willae R.E.Norris	Ceramiales	Paratype	CHR 230886 B	Old Man Range / Kopuwai
Polysiphonia abscissa Hooker f. & Harvey	Ceramiales	Syntype	A009541	Two km north of Kakanui
Polysiphonia adamsiae Womersley	Ceramiales	Paratype	A009540	Two km north of Kakanui
Coriaria angustissima Hook.f.	Cucurbitales	Syntype	AK5090	Mount Alta
Amphidium tortuosum (Hornsch.) Cufod.	Dicranales	Syntype	4004277	Lake Wakatipu
Dicranella gracillima (Beckett) Paris	Dicranales	Syntype	CHR 532393	Waipahi
Dicranella gracillima (Beckett) Paris	Dicranales	Syntype	CHR 532394	Akatore Creek mouth, Taieri Mouth
Dicranella gracillima (Beckett) Paris	Dicranales	Syntype	CHR 532395	Macs Valley, near Milton
Dicranella gracillima (Beckett) Paris	Dicranales	Syntype	CHR 532396	Macs Valley, near Milton
Ceratodon purpureus (Hedw.) Brid.	Dicranales	Isolectotype	CHR 585955	Long Beach, Pūrākaunui
Chrysoblastella chilensis (Mont.) Reimers	Dicranales	Syntype	CHR 491883	Silver Peaks
Chrysoblastella chilensis (Mont.) Reimers	Dicranales	Syntype	CHR 491884	Silver Peaks
Chrysoblastella chilensis (Mont.) Reimers	Dicranales	Syntype	CHR 491886	Silver Peaks
Chrysoblastella chilensis (Mont.) Reimers	Dicranales	Syntype	CHR 491888	Silver Peaks
Dicranoloma platycaulon Dixon	Dicranales	Isolectotype	CHR 543119	Rock and Pillar Range

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Scientific name and authority	Order	Type	Catalogue number	Locality
Dicranoloma robustum (Hook.f. & Wilson) Paris 1904	Dicranales	ISOSyntype	MEL 0028722A	Near Lake Wakatipu
Ditrichum rufoaureum (Hampe) J.H.Willis	Dicranales	Type	M015821	Styx Creek, Rock and Pillar Range
Fissidens taylorii var. *epiphytus* (Allison) I.G.Stone & J.E.Beeve	Dicranales	Holotype	CHR 454226	Cecil Peak
Fissidens taylorii var. *epiphytus* (Allison) I.G.Stone & J.E.Beeve	Dicranales	Isotype	CHR 489342	Victoria Bridge, Kawarau Gorge, Kawarau River
Fissidens taylorii var. *epiphytus* (Allison) I.G.Stone & J.E.Beeve	Dicranales	Isotype	MEL 0047388A	Near Roxburgh
Pleuridium arnoldii (R.Br.bis) Paris	Dicranales	Type	BM000964967	Swampy Summit
Pleuridium longirostre Dixon	Dicranales	Holotype	BM000964969	Kelso
Dracophyllum muscoides Hook.f.	Ericales	Syntype	AK7046	Mount Alta
Dracophyllum politum (Cheeseman) Cockayne	Ericales	Isolectotype	SP033366	Mount Maungatua
Dracophyllum politum (Cheeseman) Cockayne	Ericales	Lectotype	AK7033	Mount Maungatua
Dracophyllum prostratum Kirk	Ericales	Isolectotype	CHR 332686	Tucker Hill, Alexandra
Dracophyllum prostratum Kirk	Ericales	Isolectotype	SP032891	Above Lake Harris
Dracophyllum frondosum (G.Simpson) S.Venter	Ericales	Holotype	CHR 87407 A	Billy Creek, branch of Lochy River, Rough Peaks Range
Dracophyllum frondosum (G.Simpson) S.Venter	Ericales	Isotype	SP033374	Deep Stream, Dunedin - Middlemarch Road, near bridge
Dracophyllum frondosum (G.Simpson) S.Venter	Ericales	Isotype	SP033375	Deep Stream, Dunedin - Middlemarch Road, near bridge
Gaultheria crassa Allan	Ericales	Holotype	CHR 93594	Chatto Creek
Carmichaelia australis R.Br.	Fabales	Lectotype	CHR 45532 A	Flagstaff Hill
Carmichaelia australis R.Br.	Fabales	Isolectotype	CHR 45532 C	Flagstaff Hill
Carmichaelia australis R.Br.	Fabales	Isolectotype	CHR 45532 D	Flagstaff Hill
Carmichaelia australis R.Br.	Fabales	Isolectotype	CHR 45532 E	Flagstaff Hill
Carmichaelia australis R.Br.	Fabales	Isolectotype	CHR 45532 F	Flagstaff Hill
Carmichaelia australis R.Br.	Fabales	Isolectotype	CHR 45532 G	Flagstaff Hill
Carmichaelia australis R.Br.	Fabales	Isolectotype	CHR 45532 H	Flagstaff Hill
Carmichaelia compacta Petrie	Fabales	Lectoparatype	CHR 45904 C	Flagstaff Hill
Carmichaelia compacta Petrie	Fabales	Isolectotype	AK211346	Clyde
Carmichaelia compacta Petrie	Fabales	Isolectotype	AK4929	Clyde

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Scientific name and authority	Order	Type	Catalogue number	Locality
Carmichaelia compacta Petrie	Fabales	Type	Z-000022567	Clyde
Carmichaelia compacta Petrie	Fabales	Isolectotype	SP026306	Dunstan Gorge, near Clyde
Carmichaelia compacta Petrie	Fabales	Lectotype	SP053661	Entrance to Dunstan Gorge, Clyde
Carmichaelia compacta Petrie	Fabales	Type	6376	Dunstan Gorge
Carmichaelia compacta Petrie	Fabales	Lectotype	CHR 45904 B	Flagstaff Hill
Carmichaelia crassicaulis subsp. *racemosa* (Kirk) Heenan	Fabales	Lectotype	SP084571	Near Lindis Pass
Carmichaelia curta Petrie	Fabales	Cotype	CHR 213010	Port Chalmers
Carmichaelia curta Petrie	Fabales	Cotype	CHR 213026	Port Chalmers
Carmichaelia curta Petrie	Fabales	Isolectotype	CHR 45906 B	Port Chalmers
Carmichaelia hollowayi G.Simpson	Fabales	Lectoparatype	CHR 213032	Port Chalmers
Carmichaelia hollowayi G.Simpson	Fabales	Lectoparatype	CHR 213048	Port Chalmers
Carmichaelia hollowayi G.Simpson	Fabales	Lectotype	CHR 45804	Port Chalmers
Carmichaelia kirkii Hook.f.	Fabales	Syntype	SP026733	Waianakarua River, Otepopo
Carmichaelia kirkii Hook.f.	Fabales	Syntype	SP026736	Otepopo
Carmichaelia kirkii Hook.f.	Fabales	Syntype	SP026735	South of Otepopo tunnel
Carmichaelia kirkii Hook.f.	Fabales	Isolectotype	CHR 45771 D	Port Chalmers
Carmichaelia juncea Colenso ex Hook.f.	Fabales	Isolectotype	CHR 45814 A	Port Chalmers
Carmichaelia juncea Colenso ex Hook.f.	Fabales	Isolectotype	CHR 45814 B	Port Chalmers
Carmichaelia juncea Colenso ex Hook.f.	Fabales	Lectoparatype	CHR 45815 B	Mount Cargill
Carmichaelia juncea Colenso ex Hook.f.	Fabales	Lectotype	CHR 45814 C	Mount Cargill
Carmichaelia juncea Colenso ex Hook.f.	Fabales	Lectoparatype	CHR 45815 A	Mount Cargill
Carmichaelia juncea Colenso ex Hook.f.	Fabales	Lectoparatype	CHR 45815 C	Mount Cargill
Carmichaelia juncea Colenso ex Hook.f.	Fabales	Lectoparatype	CHR 45815 D	Mount Cargill
Carmichaelia juncea Colenso ex Hook.f.	Fabales	Lectoparatype	CHR 45815 E	Mount Cargill
Carmichaelia juncea Colenso ex Hook.f.	Fabales	Lectoparatype	CHR 45815 F	Mount Cargill
Carmichaelia juncea Colenso ex Hook.f.	Fabales	Lectoparatype	CHR 45815 G	Mount Cargill
Carmichaelia juncea Colenso ex Hook.f.	Fabales	Lectoparatype	CHR 45815 H	Mount Cargill
Carmichaelia petriei Kirk	Fabales	Isolectotype	AK209787	Otago

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Scientific name and authority	Order	Type	Catalogue number	Locality
Carmichaelia petriei Kirk	Fabales	Isolectotype	AK4873	Otago
Carmichaelia petriei Kirk	Fabales	Syntype	SP026109	Dunstan Gorge
Carmichaelia petriei Kirk	Fabales	Syntype	SP026193	Cromwell Gorge
Carmichaelia petriei Kirk	Fabales	Lectotype	SP026194	Dunstan Gorge
Carmichaelia petriei Kirk	Fabales	Syntype	SP026195	Cromwell Gorge
Carmichaelia petriei Kirk	Fabales	Lectotype	CHR 213070	Mount Cargill
Carmichaelia petriei Kirk	Fabales	Lectoparatype	CHR 213071	Mount Cargill
Carmichaelia petriei Kirk	Fabales	Lectoparatype	CHR 213072	Mount Cargill
Carmichaelia petriei Kirk	Fabales	Lectotype	CHR 45748 A	Mount Cargill
Carmichaelia petriei Kirk	Fabales	Lectotype	CHR 45809 C	Morrisons Burn, Leith Valley
Carmichaelia petriei Kirk	Fabales	Isolectotype	CHR 45809 B	Mount Cargill
Carmichaelia australis R.Br.	Fabales	Isolectotype	CHR 45572 B	Saddle between Leith and Waitati Valleys
Carmichaelia australis R.Br.	Fabales	Isolectotype	CHR 45572 C	Saddle between Leith and Waitati Valleys
Montigena novae-zelandiae (Hook.f.) Heenan	Fabales	Lectotype	CHR 48114	Goat Island / Rakiriri, Otago Harbour
Montigena novae-zelandiae (Hook.f.) Heenan	Fabales		CHR 48139	Goat Island / Rakiriri, Otago Harbour
Coprosma areolata Cheeseman	Gentianales	Syntype	AK211646	Dunedin
Coprosma areolata Cheeseman	Gentianales	Syntype	AK211647	Dunedin
Coprosma areolata Cheeseman	Gentianales	Syntype	AK8785	Dunedin
Coprosma decurva Heads	Gentianales	Isotype	CHR 489340	Roxburgh
Coprosma decurva Heads	Gentianales	Isotype	NSW413944	Bethune's Gully, Mount Cargill
Coprosma decurva Heads	Gentianales	Holotype	AK231764	Bethune's Gully, Mount Cargill
Coprosma decurva Heads	Gentianales	Isotype	SP080001	Bethune's Gully, Mount Cargill
Coprosma intertexta G.Simpson	Gentianales	Type	CHR 550909	Roxburgh
Coprosma intertexta G.Simpson	Gentianales	Type	CHR 63000 A	Trotters Creek, Trotters Gorge
Coprosma intertexta G.Simpson	Gentianales	Type	CHR 63000 B	Trotters Creek, Trotters Gorge
Coprosma petriei Cheeseman	Gentianales	Syntype	AK9125	Otago
Coprosma petriei Cheeseman	Gentianales	Syntype	AK9126	Otago
Coprosma petriei Cheeseman	Gentianales	Syntype	AK9127	Otago

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Scientific name and authority	Order	Type	Catalogue number	Locality
Coprosma petriei Cheeseman	Gentianales	Syntype	AK9128	Maniototo Plain
Coprosma petriei Cheeseman	Gentianales	Syntype	AK9124	Cromwell
Coprosma petriei Cheeseman	Gentianales	Syntype	AK9123	Mount Saint Bathans
Coprosma rubra Petrie	Gentianales	Syntype	AK211963	Dunedin
Coprosma rubra Petrie	Gentianales	Syntype	AK8921	Dunedin
Coprosma rubra Petrie	Gentianales	Syntype	AK8922	Dunedin
Coprosma rubra Petrie	Gentianales	Syntype	AK8923	Dunedin
Coprosma rubra Petrie	Gentianales	Syntype	AK8924	Dunedin
Coprosma rubra Petrie	Gentianales	Syntype	AK8925	Dunedin
Coprosma rubra Petrie	Gentianales	Syntype	AK8926	Dunedin
Coprosma rubra Petrie	Gentianales	Syntype	AK8927	Dunedin
Coprosma rubra Petrie	Gentianales	Syntype	AK8928	Dunedin
Coprosma rubra Petrie	Gentianales	Syntype	AK8929	Dunedin
Coprosma rubra Petrie	Gentianales	Syntype	AK8930	Dunedin
Coprosma rubra Petrie	Gentianales	Lectotype	SP048848	Lower Leith Valley
Coprosma rugosa Cheeseman	Gentianales	Syntype	AK8968	Dunedin
Coprosma rugosa Cheeseman	Gentianales	Syntype	AK8969	Dunedin
Coprosma rugosa Cheeseman	Gentianales	Syntype	AK8970	Dunedin
Coprosma rugosa Cheeseman	Gentianales	Syntype	AK8971	Near Dunedin
Coprosma virescens Petrie	Gentianales	Syntype	SP048838	Near Dunedin
Coprosma virescens Petrie	Gentianales	Syntype	AK211964	Dunedin
Coprosma virescens Petrie	Gentianales	Syntype	AK8933	Dunedin
Coprosma virescens Petrie	Gentianales	Syntype	AK8934	Dunedin
Coprosma virescens Petrie	Gentianales	Syntype	AK8935	Dunedin
Coprosma virescens Petrie	Gentianales	Syntype	AK8936	Dunedin
Coprosma virescens Petrie	Gentianales	Syntype	AK8937	Dunedin
Gentianella lilliputiana (C.J.Webb) Glenny	Gentianales	Isotype	AK209141	Upper Lauder Creek, Dunstan Mountains
Gentianella lilliputiana (C.J.Webb) Glenny	Gentianales	Isotype	CANB 404182.1	Upper Lauder Creek, Dunstan Mountains

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Scientific name and authority	Order	Type	Catalogue number	Locality
Gentianella lilliputiana (C.J.Webb) Glenny	Gentianales	Isotype	MEL 0222754A	Upper Lauder Creek, Dunstan Mountains
Gentianella lilliputiana (C.J.Webb) Glenny	Gentianales	Type	NSW283814	Upper Lauder Creek, Dunstan Mountains
Gentianella lilliputiana (C.J.Webb) Glenny	Gentianales	Isotype	AD 99050292	Upper Lauder Creek, Dunstan Mountains
Gentianella montana (G.Forst.) Holub subsp. *montana*	Gentianales	Isolectotype	AK7191	Lake Harris
Veronica densifolia (F.Muell.) F.Muell.	Gentianales	Type fragment	CHR 682444	Pine Hill
Nertera villosa B.H.Macmill. & R.Mason	Gentianales	Holotype	CHR 113477	Goat Island / Rakiriri, Otago Harbour
Geranium potentilloides L'Hér. ex DC.	Geraniales	Syntype	AK22911	Flagstaff Hill
Geranium potentilloides L'Hér. ex DC.	Geraniales	Syntype	AK22912	Flagstaff Hill
Blastophyllis calliblepharoides (J.Agardh) D'Archino & W.A.Nelson	Gigartinales	Lectotype	A001261	Warrington
Fulgeophyllis cerasina D'Archino, Showe M.Lin & Zuccarello	Gigartinales	Holotype	A033540	Karitane Beach
Stauromenia australis D'Archino & W.A.Nelson	Gigartinales	Holotype	A024360	Cape Saunders
Stauromenia australis D'Archino & W.A.Nelson	Gigartinales	Isotype	A031201	Cape Saunders
Trematocarpus acicularis (J.Agardh) Kylin	Gigartinales	Type	A001289	Warrington
Zuccarelloa ceramoides (Levring) D'Archino & W.A.Nelson	Gigartinales	Lectotype	A022958	Kaka Point
Zuccarelloa ceramoides (Levring) D'Archino & W.A.Nelson	Gigartinales	Isotype	A022959	Kaka Point
Zuccarelloa ceramoides (Levring) D'Archino & W.A.Nelson	Gigartinales	Isotype	A022960	Kaka Point
Zuccarelloa ceramoides (Levring) D'Archino & W.A.Nelson	Gigartinales	Isotype	A022961	Kaka Point
Zuccarelloa ceramoides (Levring) D'Archino & W.A.Nelson	Gigartinales	Isotype	A022962	Kaka Point
Zuccarelloa ceramoides (Levring) D'Archino & W.A.Nelson	Gigartinales	Holotype	WELT A022958	Oamaru
Grimmia basaltica Mitt.	Grimmiales	Isolectotype		Dunedin
Grimmia basaltica Mitt.	Grimmiales	Isolectotype		Dunedin
Grimmia inaequalis Dixon & Sainsbury	Grimmiales	Isotype		Mount Watkin
Grimmia incrassicapsulis B.G.Bell	Grimmiales	Paratype	CHR 98685	Queenstown
Grimmia incrassicapsulis B.G.Bell	Grimmiales	Isotype	CHR 486071	Dunstan Mountains
Racomitrium striatipilum Cardot	Grimmiales	Paratype	CHR 161531	Mount Maungatua
Racomitrium striatipilum Cardot	Grimmiales	Paratype	CHR 539375	Mount Maungatua
Racomitrium striatipilum Cardot	Grimmiales	Paratype		Rock and Pillar range, southeast of Museum Rock

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Scientific name and authority	Order	Type	Catalogue number	Locality
Racomitrium curiosissimum Bedn.-Ochyra & Ochyra	Grimmiales	Paratype	CHR 510543	Mount Maungatua
Racomitrium crispulum (Hook.f. & Wilson) Hook.f. & Wilson	Grimmiales	Paratype	CHR 477683	Mount Maungatua
Racomitrium crispulum (Hook.f. & Wilson) Hook.f. & Wilson	Grimmiales	Paratype	CHR 592208	Mount Maungatua
Racomitrium crispulum (Hook.f. & Wilson) Hook.f. & Wilson	Grimmiales	Paratype	CHR 651139	Abbotts Hill
Racomitrium crispulum (Hook.f. & Wilson) Hook.f. & Wilson	Grimmiales	Paratype		Rock and Pillar Range, Summit Rock
Racomitrium crispulum (Hook.f. & Wilson) Hook.f. & Wilson	Grimmiales	Paratype		Rock and Pillar Range, Summit Rock
Racomitrium crispulum (Hook.f. & Wilson) Hook.f. & Wilson	Grimmiales	Isotype		Roxburgh
Racomitrium crispulum (Hook.f. & Wilson) Hook.f. & Wilson	Grimmiales	Isotype		Roxburgh
Racomitrium crispulum (Hook.f. & Wilson) Hook.f. & Wilson	Grimmiales	Paratype	CHR 577912	Hillside to west of Roxburgh
Racomitrium ptychophyllum (Mitt.) Mitt,	Grimmiales	Paratype	CHR 583303	Mount Maungatua
Hymenophyllum australe Willd.	Hymenophyllales	type		Lake Wakatipu
Hymenophyllum australe Willd.	Hymenophyllales	Isotype	CHR 293758	Mount Cardrona
Brachythecium campestre (Müll.Hal.) Schimp.	Hypnales	Holotype	CHR 379104	Mount Maungatua
Brachythecium campestre (Müll.Hal.) Schimp.	Hypnales	Isotype	CHR 428443	Mount Maungatua
Cryphaea tenella (Schwägr) Müll.Hal.	Hypnales	Paratype	CHR 413841	Mount Maungatua
Calliergon richardsonii (Mitt.) Kindb. ex G.Roth	Hypnales	Paratype	CHR 343075	Dunedin
Calliergon richardsonii (Mitt.) Kindb. ex G.Roth	Hypnales	Isotype	http://id.luomus.fi/HA.H3026905	Diamond Lake
Calliergon richardsonii (Mitt.) Kindb. ex G.Roth	Hypnales	Type	http://id.luomus.fi/HA.H3300144	Diamond Lake
Calliergon richardsonii (Mitt.) Kindb. ex G.Roth	Hypnales	Isotype	http://id.luomus.fi/HA.H3300145	Diamond Lake
Fifea aciphylla (Dixon & Sainsbury) H.A.Crum	Hypnales	Isotype	CHR 527853	Papanui Inlet, Otago Peninsula
Fifea aciphylla (Dixon & Sainsbury) H.A.Crum	Hypnales	Holotype (possible)	M005678/A	Conical Hill
Rhynchostegium laxatum (Mitt.) Paris	Hypnales	Holotype	267968	Northeast Valley
Acrobolbus tenellus (Taylor ex Lehm.) Trevis.	Jungermanniales	Type	G-G-246489/2	Dunedin
Acrobolbus tenellus (Taylor ex Lehm.) Trevis. var. *tenellus*	Jungermanniales	Type	1266257	Dunedin
Chiloscyphus conistipulus Steph.	Jungermanniales	Type	G-G-129566/1	Lake Wakatipu
Chiloscyphus hispidus Steph.	Jungermanniales	Type	G-G-130201/1	Lake Wakatipu

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Scientific name and authority	Order	Type	Catalogue number	Locality
Cryptolophocolea mitteniana var. *obtusa* (J.J.Engel) L.Söderstr.	Jungermanniales	Isotype	CHR 558819	Silver Peaks
Cryptolophocolea mitteniana var. *obtusa* (J.J.Engel) L.Söderstr.	Jungermanniales	Holotype	C0000113F	Mount Maungatua
Chiloscyphus parvispineus J.J.Engel	Jungermanniales	Isotype	CHR 558815	Silver Peaks
Chiloscyphus parvispineus J.J.Engel	Jungermanniales	Holotype	C0000110F	South side of Mount Cargill, just below summit
Diplophyllum obtusifolium subsp. *domesticum* (Gottsche) Váňa	Jungermanniales	Isotype	CHR 545139	Rock and Pillar Range
Diplophyllum obtusifolium subsp. *domesticum* (Gottsche) Váňa	Jungermanniales	Holotype	C0171745F	Below and west of Mount Shrimpton
Diplophyllum obtusifolium subsp. *domesticum* (Gottsche) Váňa	Jungermanniales	Isotype	AK280049	Below and west of Mount Shrimpton
Diplophyllum novum J.J.Engel & G.L.Merr.	Jungermanniales	Isotype	CHR 558809	Old Man Range / Kopuwai
Diplophyllum novum J.J.Engel & G.L.Merr.	Jungermanniales	Holotype	C0000085F	Unnamed peak immediately northeast of Mount Cargill
Cuspidatula kirkii (Steph.) K.Feldberg, Váňa, Hentschel & Heinrichs	Jungermanniales	Type	CHR 685672	Bold Peak, Humboldt Mountains
Lepidozia fugax J.J.Engel	Jungermanniales	Holotype	NSW496560	Summit area of Haast Pass
Lepidozia ornata J.J.Engel	Jungermanniales	Isotype	CHR 600042	Nevis Valley
Lepidozia ornata J.J.Engel	Jungermanniales	Holotype	C0000642F	Below and west of Mount Armstrong
Leptoscyphus beckettianus (Steph.) R.M.Schust. ex J.J.Engel	Jungermanniales	Type	G-G-144809/11	Lake Wakatipu
Pachyschistochila virescens (R.M.Schust.) R.M.Schust. & J.J.Engel	Jungermanniales	Isotype	CHR 359539	Kyeburn
Tricholepidozia lindenbergii var. *complanata* (J.J.Engel & G.L.Merr.) E.D.Cooper	Jungermanniales	Paratype	C0009971F	Whare Flat
Tricholepidozia lindenbergii var. *complanata* (J.J.Engel & G.L.Merr.) E.D.Cooper	Jungermanniales	Holotype	C0000573F	Whare Flat
Tricholepidozia lindenbergii var. *mellea* (J.J.Engel & G.L.Merr.) E.D.Cooper	Jungermanniales	Holotype	CHR 547426	West Matukituki Valley, Big Creek
Tricholepidozia lindenbergii var. *mellea* (J.J.Engel & G.L.Merr.) E.D.Cooper	Jungermanniales	Isotype	C0000576F	Near Herbert
Tricholepidozia lindenbergii var. *mellea* (J.J.Engel & G.L.Merr.) E.D.Cooper	Jungermanniales	Isotype		Near Herbert
Tricholepidozia lindenbergii var. *mellea* (J.J.Engel & G.L.Merr.) E.D.Cooper	Jungermanniales	Holotype		Near Herbert

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Scientific name and authority	Order	Type	Catalogue number	Locality
Tricholepidozia lindenbergii var. *mellea* (J.J.Engel & G.L.Merr.) E.D.Cooper	Jungermanniales	Holotype		Near Herbert
Neolepidozia patentissima var. *ampliata* (J.J.Engel & G.L.Merr.) E.D.Cooper	Jungermanniales	Holotype	C0000566F	Mount Maungatua
Euphrasia dyeri Wettst.	Lamiales	Isotype	SP004855	Mount Kyeburn
Glossostigma diandrum (L.) Kuntze	Lamiales	Type	Z-000028411	Lake Waikola
Mazus arenarius Heenan, P.N.Johnson & C.J.Webb	Lamiales	Isotype	CHR 532707	Otago Harbour
Mazus arenarius Heenan, P.N.Johnson & C.J.Webb	Lamiales	Holotype	CHR 494723 B	Otago Harbour
Mazus arenarius Heenan, P.N.Johnson & C.J.Webb	Lamiales	Holotype	CHR 494723	Southern base of Flagstaff Hill
Mazus arenarius Heenan, P.N.Johnson & C.J.Webb	Lamiales	Isotype	AK229880	False Islet
Mazus arenarius Heenan, P.N.Johnson & C.J.Webb	Lamiales	Isotype		False Islet
Mazus arenarius Heenan, P.N.Johnson & C.J.Webb	Lamiales	Isotype	AD 99646366	False Islet
Mazus arenarius Heenan, P.N.Johnson & C.J.Webb	Lamiales	Isotype	SP080009	False Islet
Plantago lanigera Hook.f. 1864	Lamiales	Holotype	AK8666	Mount Kyeburn
Veronica biggarii Cockayne	Lamiales	Paralectotype	AK37937	Eyre Mts
Veronica biggarii Cockayne	Lamiales	Lectotype	CHR 332289	Waitahuna
Veronica birleyi N.E.Br.	Lamiales	Isotype	AK8415	Mount Bonpland
Veronica buchananii Hook.f.	Lamiales	Syntype	AK8146	Mount Kyeburn
Veronica buchananii Hook.f.	Lamiales	Isolectotype	AK8138	Mount Alta
Veronica chionohebe Garn.-Jones	Lamiales	Lectotype	AK8335	Mount Pisa
Veronica chionohebe Garn.-Jones	Lamiales	Syntype	SP041628	Mount Pisa
Veronica chionohebe Garn.-Jones	Lamiales	Syntype	SP121645	Mount Pisa
Veronica cockayneana Cheeseman	Lamiales	Isolectotype	CHR 331810	Waipori Falls
Veronica cockayneana Cheeseman	Lamiales	Isolectotype	CHR 331811	Waipori Falls
Veronica cockayneana Cheeseman	Lamiales	Isolectotype	SP047652	Humboldt Mountains
Veronica cockayneana Cheeseman	Lamiales	Syntype	SP047679	Earnslaw Burn, below glacier
Veronica cockayneana Cheeseman	Lamiales	Lectotype	AK8054	Humboldt Mountains
Veronica densifolia (F.Muell.) F.Muell	Lamiales	Syntype	AK8289	Otago
Veronica densifolia (F.Muell.) F.Muell	Lamiales	Isolectotype	AK107847	Rough Peaks

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Scientific name and authority	Order	Type	Catalogue number	Locality
Veronica densifolia (F.Muell.) F.Muell.	Lamiales	Lectotype	CHR 75709	Remarkables
Veronica densifolia (F.Muell.) F.Muell	Lamiales	Lectotype	CHR 70216	Remarkables
Veronica densifolia (F.Muell.) F.Muell	Lamiales	Lectotype	CHR 75709 P	
Veronica densifolia (F.Muell.) F.Muell	Lamiales	Lectotype	CHR 70216 P	Remarkables
Veronica hectorii subsp. *demissa* (G.Simpson) Garn.-Jones	Lamiales	Holotype	CHR 48080 A	Mount Ida
Veronica hectorii subsp. *demissa* (G.Simpson) Garn.-Jones	Lamiales	Isotype	CHR 48080 B	Mount Ida
Veronica hectorii subsp. *demissa* (G.Simpson) Garn.-Jones	Lamiales	Type	CHR 195571	Ida Range
Veronica hectorii Hook.f. subsp. *hectorii*	Lamiales	Isolectotype	AK22921	Rock and Pillar
Veronica hectorii Hook.f. subsp. *hectorii*	Lamiales	Paralectotype	AK22922	Rock and Pillar
Veronica leiophylla Cheeseman	Lamiales	Paralectotype	AK7876	Blue Mountains
Veronica macrocalyx var. humilis (G.Simpson) Garn.-Jones	Lamiales	Isotype	CHR 243479	Mount Ida
Veronica macrocalyx var. *humilis* (G.Simpson) Garn.-Jones	Lamiales	Lectotype	CHR 76135	Mount Ida
Veronica macrocalyx var. *humilis* (G.Simpson) Garn.-Jones	Lamiales	Holotype	CHR 550051	
Veronica matthewsii Cheeseman	Lamiales	Lectotype	AK 7955	Humboldt Mountains
Veronica matthewsii Cheeseman	Lamiales	Lectotype	AK7955	Humboldt Mountains
Veronica pauciramosa (Cockayne & Allan) Garn.-Jones	Lamiales	Isolectotype	AK107674	Lake Harris
Veronica petriei (Buchanan) Kirk	Lamiales	Isolectotype	AK8283	Mount Bonpland
Veronica poppelwellii Cockayne	Lamiales	Isotype	CHR 331861	
Veronica propinqua Cheeseman	Lamiales	Lectotype	AK 8258	Mount Maungatua
Veronica propinqua Cheeseman	Lamiales	Lectotype	AK8258	Mount Maungatua
Veronica quadrifaria Kirk	Lamiales	Isolectotype	AK8174	Mount Alta
Veronica rakaiensis J.B.Armstr.	Lamiales	Holotype	CHR 18230	Mount Ida
Veronica subalpina Cockayne	Lamiales	Type	CHR 549641	Dunedin
Veronica subalpina Cockayne	Lamiales	Holotype	CHR 33029	Mount Ida
Veronica subalpina Cockayne	Lamiales	Isolectotype	AK22161	Estuary Burn, Lake Wānaka
Veronica thomsonii (Buchanan) Cheeseman	Lamiales	Holotype	AK8334	Mount Pisa
Veronica thomsonii (Buchanan) Cheeseman	Lamiales	Isotype	CHR 329268	Pisa Flats
Veronica vernicosa Hook.f.	Lamiales	Lectotype	AK8029	Dunedin

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Veronica zygantha Garn.-Jones	Lamiales	Isotype	AK8423	
Veronica zygantha Garn.-Jones	Lamiales	Isotype	AK8424	
Lycopodium fastigiatum R.Br.	Lycopodiales	Type	1406084	Dunedin
Melicytus lanceolatus Hook.f.	Malpighiales	Syntype	AK100240	Flagstaff Hill
Melicytus lanceolatus var. *latior* G.Simpson & J.S.Thomson	Malpighiales	Holotype	CHR 75719	Pine Hill, Dunedin
Pimelea aridula Cheeseman subsp. *aridula*	Malvales	Isotype	CHR 6344	Akatore
Pimelea aridula Cheeseman subsp. *aridula*	Malvales	Lectotype	AK101181	Clyde Hospital Grounds
Pimelea notia C.J.Burrows & Thorsen	Malvales	Holotype	1E+08	Remarkables
Pimelea oreophila subsp. *lepta* C.J.Burrows	Malvales	Holotype	1E+08	Taieri Ridge
Pimelea poppelwellii Petrie	Malvales	Syntype	SP044228	Symmetry Peaks, Eyre Mountains
Pimelea prostrata (J.R.Forst. & G.Forst.) Willd. subsp. *prostrata*	Malvales	Syntype	AK5410	Mount Earnslaw Creek / Earnslaw Burn
Pimelea prostrata (J.R.Forst. & G.Forst.) Willd. subsp. *prostrata*	Malvales	Lectotype	CHR 73187	Rough Peaks
Pimelea sericeovillosa subsp. *alta* C.J.Burrows	Malvales	Holotype	CHR 669170	Rough Peaks
Metzgeria furcata (L.) Corda 1829	Metzgeriales	Holotype	4000427	Morrison Creek, Leith Valley, west of Dunedin
Epilobium parviflorum Schreb.	Myrtales	Holotype	CHR 72749	Flats at the Matukituki River, Wānaka, near the forks to East and West
Epilobium pictum Petrie	Myrtales	Lectotype	SP041030	Near Cromwell, Lowburn Creek
Epilobium porphyrium G.Simpson	Myrtales	Holotype	CHR 90790	Garvie Mountains
Epilobium porphyrium G.Simpson	Myrtales	Isotype	AK22888	Hectors Col
Epilobium hectorii Hausskn.	Myrtales	Holotype	CHR 76098	Two mile Valley, Tūpuae-O-Uenuku / Hector Mountains
Orthotrichum cyathiforme R.Br.bis	Orthotrichales	Type	CHR 537638	Roxburgh Golf Course
Orthotrichum cyathiforme R.Br.bis	Orthotrichales	Isotype	CHR 633244	Roxburgh Golf Course
Orthotrichum rupestre Schwägr.	Orthotrichales	Isolectotype	CHR 540492	Great Moss Swamp
Orthotrichum rupestre Schwägr.	Orthotrichales	Type	CHR 635982	Poolburn Reservoir, near fishing huts
Orthotrichum sainsburyi Allison	Orthotrichales	Holotype	CHR 540488	Conical Hill
Orthotrichum sainsburyi Allison	Orthotrichales	Part of type	CHR 540495	Otago Peninsula
Orthotrichum sainsburyi Allison	Orthotrichales	Isotype	CHR 540495	Wye Creek, Remarkables

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Scientific name and authority	Order	Type	Catalogue number	Locality
Orthotrichum sainsburyi Allison	Orthotrichales	Type	CHR 540488	Lauder Creek, Dunstan Mountains
Orthotrichum sainsburyi Allison	Orthotrichales	Isotype	M004727	Near Milton
Orthotrichum sainsburyi Allison	Orthotrichales	Isotype	M004728	Near Milton
Ulota lutea (Mitt. in Wilson) Mitt.	Orthotrichales	Syntype	http://id.luomus.fi/HA.H3305776	Mount Maungatua
Ulota lutea (Mitt. in Wilson) Mitt.	Orthotrichales	Holotype	http://id.luomus.fi/HA.H3305768	Lake Harris
Ulota viridis Venturi	Orthotrichales	Lectotype	http://id.luomus.fi/HA.H3305785	Mount Bonpland
Ulota viridis Venturi	Orthotrichales	Type	http://id.luomus.fi/HA.H3305772	Mount Earnslaw
Ulota viridis Venturi	Orthotrichales	Syntype	CHR 570721	Mouth of Akotore Stream
Ulota viridis Venturi	Orthotrichales	Syntype	CHR 570722	Carrick Range
Zygodon menziesii (Schwägr.) Arn.	Orthotrichales	Type	CHR 335583	Mount Maungatua
Aristotelia fruticosa Hook.f.	Oxalidales	Syntype	AK22914	Flagstaff Hill
Aristotelia fruticosa Hook.f.	Oxalidales	Syntype	AK22915	Flagstaff Hill
Aristotelia fruticosa Hook.f.	Oxalidales	Syntype	AK22916	Flagstaff Hill
Aristotelia fruticosa Hook.f.	Oxalidales	Syntype	AK22917	Flagstaff Hill
Aristotelia fruticosa Hook.f..	Oxalidales	Syntype	AK22918	Flagstaff Hill
Aristotelia fruticosa Hook.f.	Oxalidales	Syntype	AK22919	Flagstaff Hill
Aristotelia fruticosa Hook.f.	Oxalidales	Syntype	AK22920	Flagstaff Hill
Aristotelia fruticosa Hook.f.	Oxalidales	Holotype	CHR 75704	Saddle Hill
Aristotelia fruticosa Hook.f.	Oxalidales	Isotype	US 2038699	Flagstaff Hill
Achnatherum petriei (Buchanan) S.W.L.Jacobs & J.Everett	Poales	Isotype	US 2044070	Cromwell
Agrostis imbecilla Zotov	Poales	Isotype	AK1434	Macraes
Agrostis muscosa Kirk	Poales	Isolectotype	SP069295	Lake Wānaka
Agrostis muscosa Kirk	Poales	Lectotype	SP069300	Lake Wānaka
Agrostis petriei Hack.	Poales	Isotype	CHR 25061	Milton
Agrostis petriei Hack.	Poales	Type	1916-0036494	Nevis Valley
Agrostis petriei Hack.	Poales	Isotype	SP068876	Nevis Valley

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Agrostis petriei Hack.	Poales	Isotype	AK1425	Cromwell
Agrostis petriei Hack.	Poales	Isotype	AK223523	Cromwell
Anthosachne aprica (Á.Löve & Connor) C.Yen & J.L.Yang	Poales	Holotype	CHR 370822	Clyde
Anthoxanthum equisetum (Zotov) de Lange & C.J.James	Poales	Holotype	CHR 9679	Mount Cardrona
Carex allanii Hamlin	Poales	Isotype	CHR 308008	Flagstaff Hill
Carex allanii Hamlin	Poales	Isotype	CHR 599371	Flagstaff Hill
Carex allanii Hamlin	Poales	Isotype	AK2476	Old Man Range
Carex allanii Hamlin	Poales	Isotype	AK358365	Old Man Range
Carex allanii Hamlin	Poales	Holotype	SP005135	Old Man Range
Carex allanii Hamlin	Poales	Isotype	SP005135	Old Man Range
Carex applanata Thorsen & de Lange	Poales	Holotype	AK302066	Old Woman Range
Puccinellia stricta (Hook.f.) C.H.Blom	Poales	Isotype	CHR 1587	Green Island Bush
Puccinellia stricta (Hook.f.) C.H.Blom	Poales	Type fragment	CHR 42730	Mount Maungatua
Pentapogon youngii (Hook.f.) de Lange & L.M.H.Schmid	Poales	Isotype	CHR 333273	Dunedin
Pentapogon youngii (Hook.f.) de Lange & L.M.H.Schmid	Poales	Isotype	CHR 333327	Dunedin
Pentapogon youngii (Hook.f.) de Lange & L.M.H.Schmid	Poales	Isotype	CHR 333355	Dunedin
Pentapogon youngii (Hook.f.) de Lange & L.M.H.Schmid	Poales	Isotype	CHR 2785	Abbotts Hill
Rytidosperma pumilum (Kirk) Connor & Edgar	Poales	Type fragment	CHR 236573	Saint Clair
Rytidosperma pumilum (Kirk) Connor & Edgar	Poales	Isolectotype	CHR 4152	Green Island Bush
Carex berggrenii Petrie	Poales	Isolectotype	AK199699	Mount Pisa
Carex berggrenii Petrie	Poales	Isolectotype	AK2693	Mount Pisa
Carex berggrenii Petrie	Poales	Isolectotype (possible)	SP011949	Mount Pisa
Carex berggrenii Petrie	Poales	Isolectotype	SP011952	Mount Pisa
Carex berggrenii Petrie	Poales	Lectotype	SP011974	Mount Pisa
Carex berggrenii Petrie	Poales	Isolectotype (possible)	SP011978	Mount Pisa
Carex colensoi Boott	Poales	Isotype	CHR 607773	Flagstaff Hill
Carex comans Berggr.	Poales	Lectotype	AK223510	Naseby
Carex comans Berggr.	Poales	Lectotype	AK2731	Naseby

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Carex drucei (Hamlin) K.A.Ford	Poales	Holotype	CHR 672964	Flagstaff Hill
Carex edgariae Hamlin	Poales	Holotype	SP002007	Nevis Valley
Carex edura K.A.Ford 2015	Poales	Isolectotype	AK2339	Eweburn
Carex hectorii Petrie	Poales	Isotype	CHR 288717	Flagstaff Hill
Carex hectorii Petrie	Poales	Isolectotype	AK223516	Old Man Range
Carex hectorii Petrie	Poales	Isolectotype	AK2695	Old Man Range
Carex hectorii Petrie	Poales	Lectotype	SP021726	Carrick Range
Carex kirkii Petrie	Poales	Type (possible)	SP105929	Luggate Creek
Carex lachenalii subsp. *parkeri* (Petrie) Toivonen	Poales	Neotype	AK223517	head of Lake Wakatipu
Carex lachenalii subsp. *parkeri* (Petrie) Toivonen	Poales	Neotype	AK223518	head of Lake Wakatipu
Carex lachenalii subsp. *parkeri* (Petrie) Toivonen	Poales	Neotype	AK2564	head of Lake Wakatipu
Carex longifructus (Kük.) K.A.Ford	Poales	Isolectotype	AK2328	Route burn
Carex muelleri Petrie	Poales	Lectotype	SP021679	Nevis Valley
Carex purpurata (Petrie) K.A.Ford	Poales	Isotype	CHR 294811	Lee Stream Valley, south of Dunedin, 2 km north of Lee Stream school
Carex purpurata (Petrie) K.A.Ford	Poales	Isolectotype	AK2353	Near Dunedin
Carex pterocarpa Petrie	Poales	(possible) lectotype	SP021488	Mount Pisa
Carex pterocarpa Petrie	Poales	Isolectotype	CHR 73159	Flagstaff Hill
Carex subtilis K.A.Ford	Poales	Isotype (possible)	SP001758	Black's, Ophir, Manuherikia Valley
Carex wakatipu Petrie	Poales	Syntype	AK2659	Ben Lomond
Carex wakatipu Petrie	Poales	Syntype	SP011894	Ben Lomond
Carex wakatipu Petrie	Poales	Syntype	SP011895	Ben Lomond
Chionochloa crassiuscula subsp. *torta* Connor	Poales	Holotype	CHR 9613	Waipori River, above Lake Mahinerangi
Chionochloa rubra subsp. *cuprea* Connor	Poales	Holotype	CHR 132481	Deep Stream, Lammermoor Range to Taieri River
Deschampsia chapmanii Petrie	Poales	Isolectotype	CHR 2808	Rock and Pillar Range
Deschampsia pusilla Petrie	Poales	Isolectotype	CHR 333257	Rock and Pillar Range
Deschampsia pusilla Petrie	Poales	Isolectotype	1916-0027926	Hector Mountains
Deschampsia pusilla Petrie	Poales	Isolectotype	1916-0027927	Hector Mountains

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Type localities in Otago

Plants continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Deschampsia pusilla Petrie	Poales	Lectotype	SP069433	Hector Mountains
Deschampsia tenella Petrie	Poales	Isolectotype	1904-0007908	Catlins River
Deschampsia tenella Petrie	Poales	Paralectotype	AK1549	Catlins River
Deschampsia tenella Petrie	Poales	Paralectotype	AK1550	Catlins River
Deschampsia tenella Petrie	Poales	Paralectotype	AK223534	Catlins River
Deschampsia tenella Petrie	Poales	Lectotype	SP069304/A	Catlins River
Festuca matthewsii (Hack.) Cheeseman	Poales	Isolectotype	AK1990	Mount Bonpland
Festuca matthewsii (Hack.) Cheeseman	Poales	Isolectotype	AK212981	Mount Bonpland
Festuca matthewsii (Hack.) Cheeseman	Poales	Lectotype	1916-0008151	Mount Bonpland
Festuca matthewsii (Hack.) Cheeseman	Poales	Isotype	SP068650	Mount Bonpland
Festuca matthewsii (Hack.) Cheeseman	Poales	Isolectotype	SP068666	Mount Bonpland
Festuca matthewsii (Hack.) Cheeseman	Poales	Isolectotype	CHR 1537	Cecil Peak
Festuca matthewsii (Hack.) Cheeseman	Poales	Isolectotype	CHR 2870	Cecil Peak
Festuca matthewsii (Hack.) Cheeseman.	Poales	Isosyntype	US 91401	Mount Bonpland
Festuca matthewsii subsp. *latifundii* Connor	Poales	Holotype	CHR 98244	Two mile Valley, Tūpuae-O-Uenuku / Hector Mountains
Festuca matthewsii subsp. *latifundii* Connor	Poales	Holotype	CHR 74046	Two mile Valley, Tūpuae-O-Uenuku / Hector Mountains
Lachnagrostis tenuis (Cheeseman) Edgar	Poales	Isotype	CHR 2799	Rock and Pillar Range
Lachnagrostis tenuis (Cheeseman) Edgar	Poales	Isotype	CHR 2985	Rock and Pillar Range
Lachnagrostis tenuis (Cheeseman) Edgar	Poales	Holotype	SP077014	Catlins River, on coast
Lachnagrostis tenuis (Cheeseman) Edgar	Poales	Isotype	1916-0027252	Catlins River, on coast
Luzula banksiana var. *rhadina* (Buchenau) Edgar	Poales	Type	CHR 491823	Macraes
Luzula crenulata Buchenau	Poales	Holotype	SP012358	Old Man Range
Luzula crinita var. *petrieana* (Buchenau) Edgar	Poales	Syntype	1906-0009613	Mount Saint Bathans
Luzula leptophylla Buchenau & Petrie	Poales	Type	CHR 491870	Oamaru
Luzula leptophylla Buchenau & Petrie	Poales	Holotype	SP012654	Mount Kyeburn
Luzula leptophylla Buchenau & Petrie	Poales	Isotype	AK223509	Mount Kyeburn
Luzula leptophylla Buchenau & Petrie	Poales	Isotype	AK3068	Mount Kyeburn

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Plants continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Luzula pumila Hook.f.	Poales	Type	CHR 491679	
Luzula pumila Hook.f.	Poales	Isotype	CHR 491678	Oamaru
Luzula pumila Hook.f.	Poales	Holotype	AK105078	Mount Cardrona
Luzula traversii var. *tenuis* Edgar	Poales	Holotype	CHR 113666	Dunback-Kyeburn Road, near Kyeburn
Luzula traversii var. *tenuis* Edgar	Poales	Isotype	V-232641	Cromwell Gorge
Luzula traversii var. *tenuis* Edgar	Poales	Isotype	V-232642	Cromwell Gorge
Pentapogon avenoides (Hook.f.) P.M. Peterson, Romasch. & Soreng	Poales	Syntype	1916-0037902	Dunedin
Pentapogon avenoides (Hook.f.) P.M. Peterson, Romasch. & Soreng	Poales	Syntype	1916-0037903	Dunedin
Pentapogon youngii (Hook.f.) de Lange & L.M.H.Schmid	Poales	Holotype	1916-0029192	Swampy Summit
Pentapogon youngii (Hook.f.) de Lange & L.M.H.Schmid	Poales	Isotype	SP069693	Swampy Summit
Pentapogon youngii (Hook.f.) de Lange & L.M.H.Schmid	Poales	Isotype	SP069694	Swampy Summit
Pentapogon youngii (Hook.f.) de Lange & L.M.H.Schmid	Poales	Isotype	SP069696	Swampy Summit
Pentapogon youngii (Hook.f.) de Lange & L.M.H.Schmid	Poales	Isotype	AK1508	Mount Pisa
Poa astonii Petrie	Poales	Lectotype	SP066186	Brighton, near Dunedin
Poa imbecilla Spreng.	Poales	Isolectotype	1916-0014356	Manuherikia
Poa maniototo Petrie	Poales	Isolectotype	SP066145	Maniototo Plain
Poa maniototo Petrie	Poales	Isolectotype	SP076707	Maniototo Plain
Poa maniototo Petrie	Poales	Lectotype	AK1940	Maniototo Plain
Poa matthewsii Petrie	Poales	Isolectotype	CHR 6768	Above Lake Harris
Poa matthewsii Petrie	Poales	Lectotype	1916-0014358	Catlins River
Poa matthewsii Petrie	Poales	Syntype	1916-0014357	Waipahi
Poa matthewsii Petrie	Poales	Lectotype	SP066983	Waipahi
Poa matthewsii Petrie	Poales	Isolectotype	SP066990	Waipahi
Poa pygmaea Buchanan	Poales	Isotype	SP066744	Mount Pisa
Poa pygmaea Buchanan	Poales	Isotype	SP066745	Mount Pisa
Poa pygmaea Buchanan	Poales	Isotype	SP066747	Mount Pisa
Poa pygmaea Buchanan	Poales	Isotype	AK1902	Mount Pisa

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Plants continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Poa pygmaea Buchanan	Poales	Isotype	AK223876	Mount Pisa
Poa pygmaea Buchanan	Poales	Isotype	AK223877	Mount Pisa
Poa pygmaea Buchanan	Poales	Type	1904-0007883	Mount Pisa
Poa pygmaea Buchanan	Poales	Type	1916-0011640	Mount Pisa
Poa pygmaea Buchanan	Poales	Isotype	SP066748	Mount Pisa
Poa pygmaea Buchanan	Poales	Isotype	SP015854	Mount Pisa
Poa pygmaea Buchanan	Poales	Holotype	SP059606	Mount Pisa
Poa pygmaea Buchanan	Poales	Isotype	SP066746	Mount Pisa
Poa schistacea Edgar & Connor	Poales	Holotype	CHR 395536 A	Green Island
Poa schistacea Edgar & Connor	Poales	Isotype	CHR 395538	Lammermoor Mountains
Poa schistacea Edgar & Connor	Poales	Isotype	CHR 395536 B	Kinloch
Poa schistacea Edgar & Connor	Poales	Isotype	CHR 395537	Diamond Lake
Poa senex Edgar	Poales	Isotype	CHR 133881	Summit of Waikaia-Heriot Road
Poa senex Edgar	Poales	Isotype	CHR 133877	Cliffs on south side of Mount Cargill, just below summit
Poa senex Edgar	Poales	Isotype	CHR 133879	Pigroot, 16 miles from Ranfurly
Poa senex Edgar	Poales	Isotype	CHR 133880	Cardrona River
Poa senex Edgar	Poales	Holotype	CHR 133878	Lake Harris
Poa spania Edgar & Molloy	Poales	Holotype	CHR 511252	Upper Waipori, Lake Mahinerangi
Poa spania Edgar & Molloy	Poales	Isotype	CHR 511252 B	Swampy Summit
Poa tonsa Edgar	Poales	Holotype	CHR 175630	Mount Cargill, roadside west of summit road
Puccinellia fasciculata (Torr.) E.P.Bicknell	Poales	Isolectotype	CHR 17130	Swineburn Valley, near Kyeburn
Puccinellia fasciculata (Torr.) E.P.Bicknell	Poales	Lectotype	CHR 17120	Upper Routeburn Valley
Puccinellia raroflorens Edgar	Poales	Holotype	CHR 402693	Mount Pisa
Puccinellia stricta (Hook.f.) Blom	Poales	Isotype	AK1972	Near Oamaru
Puccinellia stricta (Hook.f.) Blom	Poales	Holotype	1916-0010913	Oamaru
Rytidosperma australe (Petrie) Connor & Edgar	Poales	Type fragment	CHR 4091	Near Lake Wakatipu
Rytidosperma australe (Petrie) Connor & Edgar	Poales	Isotype	SP039845	Mount Ida

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Type localities in Otago

Plants continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Rytidosperma australe (Petrie) Connor & Edgar	Poales	Holotype	SP040330	Mount Ida
Rytidosperma australe (Petrie) Connor & Edgar	Poales	Syntype	1904-0007888	Mount Ida
Rytidosperma australe (Petrie) Connor & Edgar	Poales	Isotype	CHR 20141	Mount Charles
Rytidosperma horrens Connor & Molloy	Poales	Isotype	CHR 569770	Queenstown Hill
Rytidosperma maculatum (Zotov) Connor & Edgar	Poales	Holotype	CHR 3660	Black Head
Rytidosperma pumilum (Kirk) Connor & Edgar	Poales	Paralectotype	AK1717	Upper Waipori
Rytidosperma pumilum (Kirk) Connor & Edgar	Poales	Isolectotype	SP039871	Macraes
Rytidosperma pumilum (Kirk) Connor & Edgar	Poales	Lectotype	SP039891	Macraes
Rytidosperma pumilum (Kirk) Connor & Edgar	Poales	Isolectotype	SP039907	Macraes
Rytidosperma pumilum (Kirk) Connor & Edgar	Poales	Paralectotype	AK1715	Otago
Rytidosperma pumilum (Kirk) Connor & Edgar	Poales	Paralectotype	AK1716	Macraes, Steppe Shag Valley
Rytidosperma tenue (Petrie) Connor & Edgar	Poales	Isotype	CHR 2901	Rock and Pillar Range
Rytidosperma tenue (Petrie) Connor & Edgar	Poales	Lectotype	SP039920	Upper Waipori
Rytidosperma tenue (Petrie) Connor & Edgar	Poales	Isolectotype	AK220679	Waipori
Rytidosperma thomsonii (Buchanan) Connor & Edgar	Poales	Isotype (possible)	SP068111	Otago
Rytidosperma thomsonii (Buchanan) Connor & Edgar	Poales	Paratype	AK1720	Mount Saint Bathans
Simplicia laxa Kirk	Poales	ISOSyntype	SP043019	Rock and Pillar Road, Old Dunstan Road, near Deep Stream Hotel, not far from roadside
Simplicia laxa Kirk	Poales	Isolectotype	US 2044071	Waikouaiti
Simplicia laxa Kirk	Poales	Lectotype	SP043017	Waikouaiti
Simplicia laxa Kirk	Poales	Isolectotype	SP043021	Waikouaiti
Stenostachys laevis (Petrie) Connor	Poales	Syntype	SP068386	Catlins River
Stenostachys laevis (Petrie) Connor	Poales	Lectotype	SP068353	Matukituki Valley
Stenostachys laevis (Petrie) Connor	Poales	Isolectotype	AK2038	Matukituki Valley
Stenostachys laevis (Petrie) Connor	Poales	Isolectotype	AK223527	Matukituki Valley
Stenostachys laevis (Petrie) Connor	Poales	Isolectotype	AK223528	Matukituki Valley
Stenostachys laevis (Petrie) Connor	Poales	Syntype	1916-0008251	Lake Wānaka

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Plants continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Asplenium lyallii (Hook.f.) T.Moore	Polypodiales	Lectotype		
Atrichopsis bellii (Broth.) N.E.Bell & Hyvönen	Polytrichales	Syntype	M019440	Mount Cargill
Atrichopsis bellii (Broth.) N.E.Bell & Hyvönen	Polytrichales	Syntype	M019441	Mount Cargill
Atrichopsis bellii (Broth.) N.E.Bell & Hyvönen	Polytrichales	Syntype	CHR 632084	Swineburn Valley, near Kyeburn
Atrichopsis bellii (Broth.) N.E.Bell & Hyvönen	Polytrichales	Syntype	CHR 632085	Swineburn Valley, near Kyeburn
Atrichopsis bellii (Broth.) N.E.Bell & Hyvönen	Polytrichales	Type	barcode-00783554	Mount Cargill
Anoectangium aestivum (Hedw.) Mitt	Pottiales	Type	CHR 566203	Saddle Hill
Anoectangium aestivum (Hedw.) Mitt	Pottiales	Type	CHR 570790	Saddle Hill
Anoectangium aestivum (Hedw.) Mitt	Pottiales	Isolectotype	90001796	Mount Ida
Anoectangium aestivum (Hedw.) Mitt	Pottiales	Isotype		Mount Ida
Hennediella macrophylla (R.Br.bis) Paris	Pottiales	Type	CHR 570774	Mount Cardrona
Syntrichia phaea (Hook.f. & Wilson) R.H.Zander	Pottiales	Syntype	http://id.luomus.fi/HA.H3302032	Andersons Bay
Syntrichia phaea (Hook.f. & Wilson) R.H.Zander	Pottiales	Type	CHR 570782	Waikouaiti
Syntrichia rubella (Hoo.f. & Wilson) R.H.Zander	Pottiales	Holotype	http://id.luomus.fi/HA.H3302037	Lake Wakatipu
Tetracoscinodon irroratus (Mitt.) R.H.Zander	Pottiales	Type	CHR 335701	Pine Hill
Tridontium tasmanicum Hook.f.	Pottiales	Type	BM001006465	Kaitangata
Tridontium tasmanicum Hook.f.	Pottiales	Type	45716	Wānaka
Chrysoblastella chilensis (Mont.) Reimers	Pseudoditrichales	Type	90207016	Blue Mountains
Psychrophila obtusa (Cheeseman) W.A.Weber	Ranunculales	Syntype	AK4363	Black Peak hills
Ranunculus acraeus Heenan & P.J.Lockh.	Ranunculales	Holotype	CHR 536281	Upper Lauder Creek
Ranunculus buchananii Hook.f.	Ranunculales	Holotype	CHR 5338 B	Lake Waihola
Ranunculus buchananii Hook.f.	Ranunculales	Holotype	CHR 5338 A	Trotters Gorge Scenic Reserve
Ranunculus enysii Kirk	Ranunculales	Isolectotype	AK4242	Carrick Range
Ranunculus gracilipes Hook.f.	Ranunculales	Neotype	CHR 334052	Deep Stream
Ranunculus maculatus Cockayne & Allan	Ranunculales	Neotype	CHR 199637	Dunedin
Ranunculus pilifera (F.J.F.Fisher) Heenan & P.J.Lockh.	Ranunculales	Lectotype	CHR 158126 C	Rock and Pillar Range

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Plants continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Ranunculus royi G.Simpson	Ranunculales	Holotype	CHR 75712	Head of Estuary Burn, Lake Wānaka
Ranunculus sericophyllus Hook.f.	Ranunculales	Neotype	CHR 76532	Mount French near Hector's Col, West Matukituki Valley
Gloiodermatopsis setchellii Lindauer	Rhodymeniales	Isotype		Long Beach
Acaena buchananii Hook.f.	Rosales	Syntype	CHR 330983	Tautuku Bush
Acaena buchananii Hook.f.	Rosales	Syntype	CHR 330984	Tautuku Bush
Acaena buchananii Hook.f. f. *erubescens* Bitter	Rosales	Holotype	CHR 9358	Tautuku Bush
Acaena juvenca B.H.Macmill.	Rosales	Holotype	CHR 316173 A	Tautuku Bush
Acaena juvenca B.H.Macmill.	Rosales	Holotype	CHR 316173 B	False Islet
Acaena juvenca B.H.Macmill.	Rosales	Isotype	CHR 554414	False Islet
Acaena juvenca B.H.Macmill.	Rosales	Isotype	AK176854	South of Willsher Bay Reserve, above Karoro Creek
Acaena juvenca B.H.Macmill.	Rosales	Isotype	SP078439	Above Karoro Creek, south of Willsher Bay Reserve
Acaena microphylla f. *longiscapa* Bitter	Rosales	Holotype	CHR 6369	False Islet
Acaena microphylla Hook.f. var. *microphylla* (Hook.f.) Kirk f. *breviscapa*	Rosales	Holotype	CHR 9356	Catlins River Valley
Acaena tesca B.H.Macmill.	Rosales	Holotype	CHR 391420	Catlins River Valley
Acaena tesca B.H.Macmill.	Rosales	Isotype	SP078896	Old Man Range, east slope
Urtica aspera Petrie	Rosales	Syntype	AK210752	Maniototo Plains
Urtica aspera Petrie	Rosales	Syntype	AK3785	Maniototo Plains
Urtica aspera Petrie	Rosales	Syntype	AK210751	Near Cromwell, Firewood Creek
Urtica aspera Petrie	Rosales	Syntype	AK3784	Near Cromwell, Firewood Creek
Urtica sykesii Grosse-Veldm. & Weigend	Rosales	Holotype	CHR 546587 B	Richardson Range, Lake County, near Minor Peak
Crassula sinclairii (Hook.f.) A.P.Druce & Given	Saxifragales	Syntype	AK4552	
Gonocarpus aggregatus (Buchanan) Orchard	Saxifragales	Isolectotype	AK209568	Lake Hawea
Gonocarpus aggregatus (Buchanan) Orchard	Saxifragales	Isolectotype	AK5939	Hunter River, Lake Hawea
Gonocarpus aggregatus (Buchanan) Orchard	Saxifragales	Type		Lake Hawea
Chaetomorpha aureola V.J.Chapm	Siphonocladales	Holotype	CHR 69206	Long Beach, Pūrākaunui

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Type localities in Otago

Plants continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Dichondra brevifolia Buchanan	Solanales	Isotype		Popotunoa
Eugomontia stelligera R.Nielsen	Ulotrichales	Syntype	CHR 219311	Two mile Valley, Tūpuae-O-Uenuku / Hector Mountains
Lobata foliosa V.J.Chapm.	Ulvales	Holotype	CHR 69149	Pine Hill, Dunedin

Appendix 3: Fungi and lichen with type localities in Otago

Scientific name and authority	Order	Type	Catalogue number	Locality
Conocybe novae-zelandiae	Agaricales	Holotype	PDD 84046	Maude Street, Oamaru
Cortinarius armiae	Agaricales	Paratype	PDD 94055	Waipori Falls River
Cortinarius armiae	Agaricales	Holotype	PDD 94057	Waipori Falls River
Cortinarius aurantioferreus	Agaricales	Holotype	PDD 71002	Tawanui
Cortinarius calaisopus	Agaricales	Holotype	PDD 94050	Whare Flat, Waiora Scout Camp
Cortinarius citribasalis	Agaricales	Holotype	PDD 101845	Waipori Falls
Cortinarius cremeorufus	Agaricales	Holotype	PDD 94056	Waipori Falls River
Cortinarius cypripedii	Agaricales	Holotype	PDD 107723	Cameron Creek, Haast Pass
Cortinarius malosinae	Agaricales	Holotype	PDD 88279	Blue Pools, Haast Pass
Cortinarius minoscaurus	Agaricales	Holotype	PDD 71005	Waipori Park
Cortinarius mysoides	Agaricales	Holotype	PDD 94027	Bridle Track, Haast Pass
Cortinarius palissandrinus	Agaricales	Paratype	PDD 94025	Blue Pool Track, Haast Pass
Cortinarius paraoniti	Agaricales	Holotype	PDD 88268	Davis Flat, Haast Pass
Cortinarius pectochelis	Agaricales	Holotype	PDD 88278	Blue Pools, Haast Pass
Cortinarius pholiotellus	Agaricales	Holotype	PDD 68470	Waipori Falls
Cortinarius promethenus	Agaricales	Holotype	PDD 94059	Waipori Falls River
Cortinarius turcopes	Agaricales	Paratype	PDD 94058	Waipori Falls River
Cortinarius turcopes	Agaricales	Holotype	PDD 94051	Woodside Glen, near Outram
Cortinarius wallacei	Agaricales	Paratype	PDD 97528	Cameron Flat, Haast Pass
Crepidotus isabellinus	Agaricales	Holotype	PDD 71274	Davis Flat, Haast Pass
Crepidotus isabellinus	Agaricales	Isotype	PDD 98269	Davis Flat, Haast Pass
Dendrothele novae-zelandiae	Agaricales	Holotype	PDD 99983	Catlins Forest Park, Cairn Road summit
Gymnopus ceraceicola	Agaricales	Paratype	PDD 87661	Government Track, Waipori Falls Road
Gymnopus ceraceicola	Agaricales	Paratype	PDD 87661	Government Track, Waipori Falls Road
Gymnopus imbricatus	Agaricales	Paratype	PDD 87660	Racemans Track, Silverstream Valley
Gymnopus imbricatus	Agaricales	Paratype	PDD 87659	Evansdale Glen
Inocybe microsperma	Agaricales	Holotype	PDD 89335	Stewart Falls, Haast Pass

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Type localities in Otago

Fungi and lichens continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Nivatogastrium baylisianum	Agaricales	Holotype	PDD 27005	Rock and Pillar Range
Nivatogastrium lignicola	Agaricales	Holotype	PDD 27003	Filter Station
Psilocybe makarorae	Agaricales	Holotype	PDD 57396	Blue Pools Track, Haast Pass
Thaxterogaster viola	Agaricales	Holotype	PDD 71001	Cameron Flat, Haast Pass
Lecanora perrugosa var. *brevilobata*	Agyriales	Isotype	CHR 347956	Pisa Range
Lecidea congregans	Agyriales	Isolectotype	CHR 347019	Earnslaw Burn
Placopsis fusciduloides	Agyriales	Isotype	CHR 528307	Eyre Mountains
Lecanactis pallens	Arthoniales	Lectotype	CHR 378574	Bold Peak, Humboldt Mountains
Lecanactis subfarinosa (C.Knight) Hellb.	Arthoniales	Isotype	CANB 808972.1	Mt Cargill
Opegrapha agelaeoides Nyl.	Arthoniales	Type	http://id.luomus.fi/HA.H9507813	
Septobasidium album Burt	Atractiellales	Holotype	PDD 542	Queenstown
Septobasidium album Burt	Atractiellales	Isotype	NCU-F-0031547	Queenstown
Lecidea coarctata (Turner) Nyl.	Baeomycetales	Type	http://id.luomus.fi/HA.H9508113	
Porphyrellus nothofagi	Boletales	Holotype	PDD 25184	Puketiro Reserve, Catlins
Xerocomus aurantiacus	Boletales	Holotype	PDD 25175	Black Gully, Tapanui,
Xerocomus nothofagi	Boletales	Holotype	PDD 25168	Puketiro Reserve, Catlins
Amandinea otagensis (Zahlbr.) Blaha, Elix & H.Mayrhofer	Caliciales	Isotype	CANB 813276.1	Otago Heads
Amandinea pelidna (Ach.) Fryday & Arcadia	Caliciales	Isotype	CANB 813277.1	Fool Island, near Dunedin
Buellia maungatuensis Elix & H.Mayrhofer	Caliciales	Isotype	4687519	Mount Maungatua, c. 500 m west of the summit
Buellia maungatuensis Elix & H.Mayrhofer	Caliciales	Isotype	338092	Mount Maungatua, c. 500 m west of the summit
Buellia maungatuensis Elix & H.Mayrhofer	Caliciales	Isotype	338034	Mount Maungatua, c. 500 m west of the summit
Buellia maungatuensis Elix & H.Mayrhofer	Caliciales	Holotype	338009	Mount Maungatua, c. 500 m west of the summit
Buellia maungatuensis Elix & H.Mayrhofer	Caliciales	Isotype	M-0312322 / 1028483 / 558083	Mount Maungatua, c. 500 m west of the summit

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Type localities in Otago

Fungi and lichens continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Rinodina gallowayi H.Mayrhofer, 1983	Caliciales	Holotype	292674	Lake Hayes
Rinodina herteliana Kaschik	Caliciales	Holotype	286074	Pulpit Rock, Summit of Silver Peak
Rinodina herteliana Kaschik	Caliciales	paratype	286075	Mitchell Cottage, bottom of Old Man Range
Rinodina jamesii H.Mayrhofer	Caliciales	Isotype	338087	Lee Stream Bridge, ca. 320 m, Lee Stream Valley
Rinodina jamesii H.Mayrhofer	Caliciales	Holotype	294913	Lee Stream Bridge, ca. 320 m, Lee Stream Valley
Rinodina murrayi H.Mayrhofer	Caliciales	Isotype	292676	2 km from Lee Stream School, Lee Stream Valley
Rinodina murrayi H.Mayrhofer	Caliciales	Isotype	292678	2 km from Lee Stream School, Lee Stream Valley
Rinodina murrayi H.Mayrhofer	Caliciales	Isotype	292677	2 km from Lee Stream School, Lee Stream Valley
Rinodina murrayi H.Mayrhofer	Caliciales	Holotype	292675	2 km from Lee Stream School, Lee Stream Valley
Rinodina peloleuca (Nyl.) Müll.Arg.	Caliciales	Lectotype	http://id.luomus.fi/HA.H9506689	
Rinodina peloleuca (Nyl.) Müll.Arg.	Caliciales	Isolectotype	http://id.luomus.fi/HA.H9506690	
Rinodina peloleuca (Nyl.) Müll.Arg.	Caliciales	Type	http://id.luomus.fi/HA.H9506475	
Chloridium novae-zelandiae	Chaetosphaeriales	Holotype	PDD 120400	Haast, Cameron Creek Track
Echinosphaeria medusa	Chaetosphaeriales	Holotype	PDD 94222	nr. Outram, Woodside Glen
Phialoturbella calva	Chaetosphaeriales	Holotype	PDD 119190	Tautuku Nature Walk
Phialoturbella calva	Chaetosphaeriales	Holotype	ICMP 23826	
Stilbochaeta brevisetula	Chaetosphaeriales	Epitype	PDD 119677	Mount Aspiring National Park, Makarora, Mt. Shrimpton Track
Zanclospora xylophila	Chaetosphaeriales	Holotype	ICMP 22737	
Synchytrium limosellae	Chytridiales	Holotype	PDD 25212	Ranfurly
Gigaspora aurigloba	Diversisporales	Paratype	PDD 34856	Leith Saddle
Gigaspora aurigloba	Diversisporales	Holotype	PDD 34859	Leith Saddle
Gigaspora aurigloba	Diversisporales	Paratype	PDD 35157	Leith Saddle
Glomus infrequens	Diversisporales	Holotype	PDD 34858	Waikouaiti, Leith Saddle
Entorrhiza citriformis	Entorrhizales	Holotype	PDD 70949	Wānaka, Diamond Lake
Cryptococcus terreus Di Menna	Filobasidiales	Type		Dunedin
Glomus invermaium	Glomerales	Holotype	PDD 34857	Invermay Farm, Paddock 37
Glomus magnicaule	Glomerales	Holotype	PDD 34855	Leith Saddle

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Fungi and lichens continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Glomus pallidum	Glomerales	Holotype	PDD 34854	Tautuku Beach
Glomus pallidum	Glomerales	Paratype	PDD 35025	Tautuku Beach
Catillaria perpulchra	Gyalectales	Isotype	CHR 241736 A	Saddle between Leith and Waitati Valleys, North Dunedin
Catillaria perpulchra	Gyalectales	Isotype	CHR 241736 B	Swampy Summit
Chlorociboria halonata	Helotiales	Holotype	PDD 64635	Catlins, 5 km north of Papatowai, Table Hill Reserve
Helotium novae-zelandiae	Helotiales	Isotype	PDD 19039	Tapanui, Black Gully
Orbiliopsis callistea	Helotiales	Holotype	PDD 996	Lake Harris Track
Bionectria aureofulvella	Hypocreales	Holotype	PDD 50044	Lake Wilkie, Catlins
Nectria grammicosporopsis	Hypocreales	Holotype	PDD 50042	Lake Wilkie, Catlins
Bacidia albozonata	Lecanorales	Lectotype	CHR 373609	Mount Maungatua
Bacidia subcerina	Lecanorales	Lectotype	CHR 373613	Mount Maungatua
Bacidia thalassina	Lecanorales	Lectotype	CHR 373614	Mount Maungatua
Buellia dunedina	Lecanorales	Lectotype	CHR 379750	Abbotts Hill
Buellia fuscoatratula	Lecanorales	Isotype	CHR 374336	Abbotts Hill
Buellia litoralis	Lecanorales	Isotype	CHR 374337	Abbotts Hill
Buellia macularis	Lecanorales	Lectotype	CHR 374335	Abbotts Hill
Buellia nitrophila	Lecanorales	Isotype	CHR 374331	Abbotts Hill
Buellia nitrophila	Lecanorales	Lectotype	CHR 374331	Abbotts Hill
Buellia otagensis	Lecanorales	Isotype	CHR 374334	Abbotts Hill
Bunodophoron notatum (Tibell) Wedin	Lecanorales	Isotype	399919	Camerson Flat Campsite, Haast Pass
Catillaria intermixta var. *pallescens*	Lecanorales	Isotype	CHR 373806	Saddle between Leith and Waitati Valleys, Dunedin
Catillaria melanotropa (Nyl.) Zahlbr.	Lecanorales	Type	http://id.luomus.fi/HA.H9510536	
Catillaria melanotropa (Nyl.) Zahlbr.	Lecanorales	Lectotype	http://id.luomus.fi/HA.H9510686	
Catillaria melanotropa (Nyl.) Zahlbr.	Lecanorales	Type	http://id.luomus.fi/HA.H9510687	
Catillaria weinmanniae	Lecanorales	Isotype	CHR 373895	Swampy Summit

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Fungi and lichens continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Chondropsis sorediata	Lecanorales	Holotype	CHR 565025	Lamb Hill, Hindon
Cladonia arbuscula subsp. *stictica*	Lecanorales	Isotype	CHR 425279	Lamb Hill, Hindon
Cladonia arbuscula subsp. *stictica*	Lecanorales	Isotype	CHR 425280	Matanaka, coast near Waikouaiti
Cladonia arbuscula subsp. *stictica*	Lecanorales	Isotype	CHR 425281	Matanaka, coast near Waikouaiti
Cladonia arbuscula subsp. *stictica*	Lecanorales	Isotype	CHR 425283	Matanaka, coast near Waikouaiti
Cladonia arbuscula subsp. *stictica*	Lecanorales	Holotype	CHR 425285	Matanaka, coast near Waikouaiti
Cladonia arbuscula subsp. *stictica*	Lecanorales	Isotype	http://id.luomus.fi/HA.H9509143	
Cyphelium polycarpum	Lecanorales	Type	CHR 378543	Hyde
Haematomma hilare	Lecanorales	Isotype	CHR 241752	Lake Hayes
Lecanora albidorufa	Lecanorales	Lectotype	CHR 345830	Bold Peak, Humboldt Mountains
Lecanora blanda f. *crustosa*	Lecanorales	Syntype	CHR 345852	Bold Peak, Humboldt Mountains
Lecanora blanda f. *crustosa*	Lecanorales	Isolectotype	CHR 345854	Bold Peak, Humboldt Mountains
Lecanora dasycarpa	Lecanorales	Isotype	CHR 160286	Mount Bonpland, Humboldt Mountains
Lecanora dasycarpa	Lecanorales	Isotype	CHR 620824	Mount Bonpland, Humboldt Mountains
Lecanora fertilissima	Lecanorales	Lectotype	CHR 345883	Mount Bonpland, Humboldt Mountains
Lecanora limosescens	Lecanorales	Isolectotype	CHR 241776	Mount Bonpland, Humboldt Mountains
Lecanora limosescens	Lecanorales	Isotype	CHR 241776	Mount Bonpland, Humboldt Mountains
Lecanora ochrotropa	Lecanorales	Lectotype	CHR 345884	Mount Bonpland, Humboldt Mountains
Lecanora ochrotropa	Lecanorales	Isotype	CHR 345884	Mount Bonpland, Humboldt Mountains
Lecanora platylepis	Lecanorales	Lectotype	CHR 345808	Luggate, Central Otago
Lecanora subglaucodea var. *cinerascens*	Lecanorales	Type	CHR 160830	Upper Route Burn Valley
Lecanora subglaucodea var. *cinerascens*	Lecanorales	Isotype	CHR 160830	Luggate, Central Otago
Lecidea confoederata	Lecanorales	Lectotype	CHR 160437	Wānaka
Lecidea confoederata	Lecanorales	Isolectotype	CHR 160437	Roys Peak, Lake Wānaka

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Fungi and lichens continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Lecidea dunedina	Lecanorales	Isolectotype	CHR 347043	Humboldt Mountains,
Lecidea dunedina	Lecanorales	Type	CHR 347042	Mount Nox, Humboldt Mountains
Lecidea eucheila	Lecanorales	Lectotype	CHR 347044	Lake Nerine, Humboldt Mountains
Lecidea friabilis	Lecanorales	Isotype	CHR 347045	Mount Earnslaw / Pikirakatahi
Lecidea irrubens	Lecanorales	Isotype	CHR 347054	Mount Alta
Lecidea irrubens var. *albidior*	Lecanorales	Isolectotype	CHR 160500	Mount Alta
Lecidea irrubens var. *albidior*	Lecanorales	Isotype	CHR 160500	French Ridge, Matukituki River West Branch,
Lecidea myoplaca	Lecanorales	Isotype	CHR 545169	French Ridge, Matukituki River West Branch
Lecidea otagensis	Lecanorales	Type	http://id.luomus.fi/HA.H9510542	
Lecidea otagensis	Lecanorales	Lectotype	CHR 347200	French Ridge, Matukituki River West Branch
Lecidea schistiseda	Lecanorales	Lectotype	CHR 347058	French Ridge, Matukituki River West Branch
Lecidea subdacrydii	Lecanorales	Lectotype	CHR 347065	Wilkin River North Branch, Mount Aspiring National Park
Lecidea tararuensis	Lecanorales	Isolectotype	CHR 347069	Mount Heim
Lecidea trachona (Ach.) Nyl.	Lecanorales	Type	http://id.luomus.fi/HA.H9510779	
Lecidea vexillaris	Lecanorales	Lectotype	CHR 347073	Tarras and Luggate
Megalaria orokonuiana Fryday & A.Knight	Lecanorales	Isotype	CANB 897750.1	Orokonui Ecosanctuary
Megalaria orokonuiana Fryday & A.Knight	Lecanorales	Isotype	127624	Orokonui Ecosanctuary
Megalospora atrorubicans subsp. *australis*	Lecanorales	Holotype	CHR 374739	Kelso
Megalospora atrorubicans subsp. *australis*	Lecanorales	Type	CHR 374739	Mount Alfred
Micarea erratica	Lecanorales	Type	http://id.luomus.fi/HA.H9509199	
Neuropogon subcapillaris	Lecanorales	Holotype	CHR 343756	Black Head, Dunedin
Parmelia adpicta	Lecanorales	Syntype	CHR 162938	Fairfax Spur, near Leaning Rock, Dunstan Mountains
Parmelia epheboides	Lecanorales	Isolectotype	CHR 238701	Old Man Range
Parmelia epheboides	Lecanorales	Isotype	CHR 238701	Old Man Range
Parmelia lugubris f. *compactior*	Lecanorales	Isotype	CHR 357978	Mount Pisa

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Fungi and lichens continued

Scientific name and authority	**Order**	**Type**	**Catalogue number**	**Locality**
Parmelia lugubris f. *compactior*	Lecanorales	Isolectotype	CHR 357978	Wilkin River North Branch, Mount Perseus, Plot AA143
Parmelia martinii	Lecanorales	Isotype	CHR 162938	Alexandra
Parmelia otagensis	Lecanorales	Holotype	CHR 238697	Near Alexandra
Parmelia subteres var. *pulverulenta*	Lecanorales	Isotype	CHR 376078	Creek margins, Makarora, Lake Wānaka
Parmelia tenuirima var. *labrosa*	Lecanorales	Lectotype	CHR 160201	Creek margins, Makarora, Lake Wānaka
Parmelia tenuirima var. *labrosa*	Lecanorales	Type	CHR 160201	Creek margins, Makarora, Lake Wānaka
Parmelia tenuirima var. *platyna*	Lecanorales	Isotype	CHR 160205	
Parmelia tenuirima var. *platyna*	Lecanorales	Isotype	CHR 621696	
Parmelia tenuirima var. *platyna*	Lecanorales	Isotype	CHR 621697	
Parmelia waiporiensis	Lecanorales	Isotype	CHR 162937	
Parmelia waiporiensis	Lecanorales	Isolectotype	CHR 162937	Makarora, Lake Wānaka
Protoparmelia petraeoides (Nyl. ex C.Bab. & Mitt.) Hertel	Lecanorales	Type	http://id.luomus.fi/HA.H9509463	
Ramalina erumpens var. *norstictica*	Lecanorales	Holotype	CHR 429592	Hector Col
Ramalina leiodea var. *condensata*	Lecanorales	Lectotype	CHR 378200	Lindis Pass
Rhizocarpon lunulatum	Lecanorales	Isotype	CHR 347984	
Rinodina murrayi	Lecanorales	Isotype	CHR 528672	Pine Hill
Sphaerophorus notatus Tibell	Lecanorales	Isotype	BC-Lichen-Caliciales-912291	Cameron Flat Campsite, Haast Pass
Sphaerophorus notatus Tibell	Lecanorales	Isotype	63117	Cameron Flat Campsite, Haast Pass
Sphaerophorus notatus Tibell	Lecanorales	Isotype	CANL 82051	Cameron Flat Campsite, Haast Pass
Sphaerophorus notatus Tibell	Lecanorales	Isotype	1039146	Cameron Flat Campsite, Haast Pass
Stereocaulon caespitosum	Lecanorales	Syntype	CHR 559060	Long Burn, Eyre Mountains
Stereocaulon caespitosum	Lecanorales	Isolectotype	CHR 559060	Pisa Flat, Clutha River
Stereocaulon caespitosum	Lecanorales	Syntype	CHR 559059	South Island. Westland Prov.: Mt. Aspiring Natl. Park, below and W. of Mt. Armstrong, SSW of Mt. Bewster
Stereocaulon corticatulum Nyl.	Lecanorales	Isotype	G-G-235882/1	Taieri Mouth
Stereocaulon corticatulum Nyl.	Lecanorales	Type	http://id.luomus.fi/HA.H9503925	
Stereocaulon corticulatum Nyl.	Lecanorales	Isotype	M-0034615 / 553819 / 233069	Taieri Mouth

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Fungi and lichens continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Stereocaulon gregarium	Lecanorales	Isotype	CHR 559058 C	Pine Hill, Dunedin
Stereocaulon gregarium	Lecanorales	Isotype	CHR 559058 B	The Remarkables
Stereocaulon gregarium	Lecanorales	Syntype	CHR 559058 A	Mount Kyeburn
Stereocaulon gregarium	Lecanorales	Syntype	CHR 559058 B	Mount Alfred
Stereocaulon gregarium	Lecanorales	Isotype	CHR 559058 A	Young Range, Hunter River valley, Long Flat Creek
Stereocaulon loricatum	Lecanorales	Isotype	CHR 240480	Pine Hill, Dunedin
Stereocaulon loricatum	Lecanorales	Isotype	CHR 621820	Waipori, Lake Mahinerangi
Stereocaulon pulvinare	Lecanorales	Type	CHR 557708	Black Head, Dunedin
Stereocaulon pulvinare	Lecanorales	Isotype	CHR 557708	Waipori, Lake Mahinerangi
Stereocaulon ramulosum f. *crebratum*	Lecanorales	Holotype	CHR 557709	Silver Peaks
Stereocaulon ramulosum f. *crebratum*	Lecanorales	Type	CHR 557709	Silver Peaks
Toniniopsis aromatica (Sm.) Kistenich, Timdal, Bendiksby & S.Ekman	Lecanorales	Holotype	http://id.luomus.fi/HA.H9510356	
Usnea capillacea	Lecanorales	Isotype	CHR 343971	
Usnea ciliata var. *subcapillaris*	Lecanorales	Holotype	CHR 343756	Deep Stream, (hotel, Old Duntroon Road)
Usnea ciliata var. *subcapillaris*	Lecanorales	Isotype	CHR 343756 B	Near Herbert
Usnea ciliata var. subcapillaris	Lecanorales	Isotype	CHR 343756 A	Central Hawea River. near Horseshoe Bend
Usnea contexta	Lecanorales	Isotype	CHR 343973 B	Kinloch, Lake Wakatipu
Xanthoparmelia alexandrensis	Lecanorales	Holotype	CHR 421558	Alexandra, Central Otago
Xanthoparmelia brattii (Essl.) O.Blanco, A.Crespo, Elix, D.Hawksw. & Lumbsch	Lecanorales	Isotype	HO 61283	Mount Roy
Xanthoparmelia concomitans	Lecanorales	Holotype	CHR 343817	Little Valley Road, Lookout, Alexandra
Xanthoparmelia scabrosa (Taylor) Hale	Lecanorales	Holotype	http://id.luomus.fi/HA.H9505484	
Lecidea fuscoatrula Nyl.	Lecideales	Type	http://id.luomus.fi/HA.H9509225	Kaikorai Hill
Chaenothecopsis sagenidii Tibell	Mycocaliciales	Isotype	267	15 km WNW of Owaka, Catlins Forest, along Catlins river, S of the junction with Chloris stream

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Fungi and lichens continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Chaenothecopsis sagenidii Tibell	Mycocaliciales	Isotype	CANL 99795	15 km WNW of Owaka, Catlins Forest, along Catlins river, S of the junction with Chloris stream.
Chaenothecopsis sagenidii Tibell	Mycocaliciales	Isotype	NA	15 km WNW of Owaka, Catlins Forest, along Catlins River, S of junction with Chloris Stream.
Chaenothecopsis sagenidii Tibell	Mycocaliciales	Isotype	62633	15 km WNW of Owaka, Catlins Forest, along Catlins River, S of the junction with Chloris Stream
Chaenothecopsis sagenidii Tibell	Mycocaliciales	Isotype	289095	15 km WNW of Owaka, Catlins Forest, along Catlins river, S of the junction with Chloris stream
Chaenothecopsis sagenidii Tibell	Mycocaliciales	Isotype	1055548	
Chaenothecopsis sagenidii Tibell	Mycocaliciales	Isotype	M-0103234 / 553827 / 233077	15 km WNW of Okawa, Catlins Forest, along catlins river, S of the junction with Chloris stream, 46ï¿½25'S, 169ï¿½27'E. Alt. 150 m. On still corticated parts of decaying stump of Nothofagus menziesii in N. menziesii-forest along river.
Chaenothecopsis sagenidii Tibell	Mycocaliciales	Isotype	MEL 1053154A	15 km WNW of Owaka, Catlins Forest, along Catlins River, S of the junction with Chloris stream.
Rhizophagus tenuis	NULL	Holotype	PDD 21626	Dunedin
Strigula johnsonii	NULL	Holotype	CHR 494632	Silver Peaks
Umbilicaria durietzii	NULL	Isotype	CHR 160025	Mount Roy, Lake Wānaka
Umbilicaria murihikuana	NULL	Holotype	CHR 378718	Lee Stream Valley SW Dunedin, Lee Stream Bridge
Diploschistes cervinus	Ostropales	Lectotype	CHR 106157	Old Man Range/Kopuwai
Diploschistes cervinus	Ostropales	Type	CHR 106157	Old Man Range/Kopuwai
Diploschistes sanguinescens	Ostropales	Type	CHR 376997	Conroys Road, Alexandra
Lobaria adscripta	Peltigerales	Syntype	http://id.luomus.fi/HA.H9506030	Saddle Hill
Nephroma cellulosum var. *isidioferum*	Peltigerales	Holotype	CHR 375590	Lammermoor Range, ca. 6 km NE of Ailsa Craig, via vehicle track
Nephroma cellulosum var. *isidioferum*	Peltigerales	Type	CHR 375590	Summit Rock, Rock and Pillar Range
Pannaria immixta Nyl	Peltigerales	Holotype	http://id.luomus.fi/HA.H9506227	
Pannaria minutiphylla Elvebakk	Peltigerales	paratype	L002764	Catlins State Forest Park, track at northern end of Backstream Road
Pannaria minutiphylla Elvebakk	Peltigerales	paratype	L006060	Morrisons Burn
Pannaria minutiphylla Elvebakk	Peltigerales	paratype	42414/1	Orokonui Ecosanctuary.

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Fungi and lichens continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Pannaria minutiphylla Elvebakk	Peltigerales	paratype	42420/1	Orokonui Ecosanctuary.
Parmeliella gymnocheila (Nyl.) Müll.Arg.	Peltigerales	Type	http://id.luomus.fi/HA.H9506260	
Pseudocyphellaria coriacea (Hook. & Taylor) D.Galloway & James	Peltigerales	Holotype	http://id.luomus.fi/HA.H9505978	Saddle Hill
Pseudocyphellaria episticta (Nyl.) Vainio	Peltigerales	Holotype	http://id.luomus.fi/HA.H9506004	Saddle Hill
Pseudocyphellaria rufovirescens (Church.Bab.) D.Galloway	Peltigerales	Holotype	http://id.luomus.fi/HA.H9506017	
Psoroma melanizum Zahlbr.	Peltigerales	Isolectotype	44775/1	Otago Land District, Boyd's Bush, near Dunedin.
Psoroma pholidotoides (Nyl.) Trevis.	Peltigerales	Lectotype	http://id.luomus.fi/HA.H9504395	
Sticta subcaperata (Nyl.) Nyl., 1888	Peltigerales	Lectotype	http://id.luomus.fi/HA.H9505967	
Pertusaria basaltica	Pertusariales	Isotype	CHR 374717	Makarora, Lake Wānaka
Pertusaria dunedina	Pertusariales	Isotype	CHR 374718	
Pertusaria erubescens (Hook.f. & Taylor) Nyl.	Pertusariales	Type	http://id.luomus.fi/HA.H9508501	
Pertusaria leioplaca (Ach.) DC.	Pertusariales	Type	http://id.luomus.fi/HA.H9508502	
Pertusaria nothofagi	Pertusariales	Isolectotype	CHR 374716	Sandstone at the foot of M. St. Mary near Duntroon, Waitaki Valley, N. Otago
Pertusaria nothofagi	Pertusariales	Syntype	CHR 361449	
Pertusaria otagoana	Pertusariales	Isotype	CHR 374711	Flats at the Matukituki River, Wānaka, near the forks to East and West
Pertusaria simulans	Pertusariales	Isotype	CHR 374711	From flats at the Matukituki River, Wānaka, near the forks to East and West
Pertusaria superba	Pertusariales	Isolectotype	CHR 374720	Niger Hut. Fork of Matukituki R. east and west
Protubera parvispora	Phallales	Paratype	PDD 8312	Maclennan
Linochora aberrans	Phyllachorales	Holotype	PDD 1046	Dunedin Botanic Garden
Trabutia nothofagi	Phyllachorales	Holotype	PDD 987	Rere Lake
Leptosphaeria reidiana	Pleosporales	Holotype	PDD 1019	Mount Judah
Parasphaeria contraria	Pleosporales	Holotype	PDD 1058	Lake Harris Track

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Type localities in Otago

Fungi and lichens continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Merulius corium	Polyporales	Type	BPI 323416	Caversham
Merulius nothofagi	Polyporales	Holotype	PDD 6849	Routeburn Valley
Poria otakou	Polyporales	Holotype	PDD 4182	Kinloch
Aecidium celmisiae-discoloris	Pucciniales	Holotype	PDD 384	Tooth Peaks
Aecidium celmisiae-petriei	Pucciniales	Holotype	PDD 38526	Lake Harris Track
Melampsora novae-zelandiae	Pucciniales	Holotype	PDD 3386	Brighton, Seal Rock
Phragmidium constrictosporum	Pucciniales	Isotype	PDD 1482	Lake Wakatipu, Table Bay
Phragmidium constrictosporum	Pucciniales	Holotype	PDD 770	Lake Wakatipu, Table Bay
Phragmidium novae-zelandiae	Pucciniales	Holotype	PDD 766	Queenstown
Phragmidium subsimile	Pucciniales	Holotype	PDD 768	Queenstown
Puccinia alboclava	Pucciniales	Holotype	PDD 12683	Mount Maungatua
Puccinia anisotomes	Pucciniales	Holotype	PDD 9116	Lake Harris
Puccinia austropunctata	Pucciniales	Holotype	PDD 7600	Glenorchy
Puccinia cockaynei	Pucciniales	Holotype	PDD 1362	Queenstown
Puccinia cockaynei	Pucciniales	paratype	CUP-012755	Rock and Pillar Range
Puccinia contegens	Pucciniales	Holotype	PDD 284	Macraes
Puccinia fodiens	Pucciniales	Holotype	PDD 376	Botanic Gardens, Queenstown
Puccinia inornata	Pucciniales	Holotype	PDD 444	Macraes
Puccinia kopoti	Pucciniales	Holotype	PDD 377	Lake Harris
Puccinia pounamu	Pucciniales	Holotype	PDD 426	Greenstone Valley
Puccinia rautahi	Pucciniales	Holotype	PDD 492	Mount Judah
Puccinia reidii	Pucciniales	Holotype	PDD 378	Walter Peak
Puccinia reidii	Pucciniales	Isotype	PDD 9524	Walter Peak
Puccinia whakatipu	Pucciniales	Holotype	PDD 742	Table Bay
Uredo puawhananga	Pucciniales	Holotype	PDD 12908	Swampy Spur, Dunedin
Uromyces discariae	Pucciniales	Holotype	PDD 1344	Queenstown
Uromyces edwardsiae	Pucciniales	Holotype	PDD 1234	Catlins, Tahakopa
Uromyces otakou	Pucciniales	Holotype	PDD 1323	Routeburn Valley

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Type localities in Otago

Fungi and lichens continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Melanotheca irregularis	Pyrenulales	Lectotype	CHR 378613	Kinloch, Lake Wakatipu
Pyrenula cinereoglauca	Pyrenulales	Syntype	CHR 604774	Black Head, Dunedin
Pyrenula cinereoglauca	Pyrenulales	Isotype	CHR 379755	Kakanui
Pyrenula cinereoglauca	Pyrenulales	Lectotype	CHR 379755	Shag Point, near Palmerston
Pyrenula cinereoglauca	Pyrenulales	Syntype	CHR 678052	Tapuae-o-Uenuku / Hector Mountains
Pyrenula consociata	Pyrenulales	Lectotype	CHR 379999	Tapuae-o-Uenuku / Hector Mountains
Pyrenula consociata	Pyrenulales	Isotype	CHR 379999	Otago Prov. [Province]: Mt. Aspiring Nat. [National] Park, below and W. [west] of Mount Shrimpton
Pyrenula nitidula	Pyrenulales	Type	CHR 674170	Mount Cargill
Pyrenula straminescens	Pyrenulales	Lectotype	CHR 380000	Tahakopa Bay Scenic Reserve
Pyrenula straminescens	Pyrenulales	Isotype	CHR 380000	Lake Harris
Coccomyces clavatus	Rhytismatales	Holotype	PDD 45286	Mount Cargill
Coccomyces libocedri	Rhytismatales	Holotype	PDD 45275	Mount Cargill
Lophodermium rectangulare	Rhytismatales	Holotype	PDD 49322	Mount Cargill
Russula australis	Russulales	Paratype	PDD 26924	Puketiro Reserve, Catlins
Russula griseoviolacea	Russulales	Paratype	PDD 26933	Puketiro Reserve, Catlins
Stereum pannosum Cooke	Russulales	Syntype	BPI 274132	Dunedin
Dactylospora australis Triebel & Hertel	Sclerococcales	Holotype	M-0041412 / 16084 / 10233	Around Lake Alta, The Remarkables:
Bacidia cargillensis	Teloschistales	Lectotype	CHR 373610	Mount Maungatua
Caloplaca circumlutosa	Teloschistales	Lectotype	CHR 373792	Dunedin
Caloplaca erecta Arup & H.Mayrhofer	Teloschistales	Holotype	292049	Mount Maungatua
Caloplaca erecta Arup & H.Mayrhofer	Teloschistales	Isotype	1099985	Mount Maungatua
Caloplaca erecta Arup & H.Mayrhofer	Teloschistales	Isotype	1088337	Mount Maungatua
Caloplaca murrayi	Teloschistales	Holotype	CHR 534104	Dunedin
Caloplaca murrayi	Teloschistales	Isotype	CHR 534105	Dunedin
Caloplaca papanui	Teloschistales	Holotype	CHR 523671	Signal Hil

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Type localities in Otago

Fungi and lichens continued

Scientific name and authority	Order	Type	Catalogue number	Locality
Caloplaca schisticola	Teloschistales	Holotype	CHR 533612	North East Valley
Megaloblastenia flavidoatra (Nyl.) Sipman	Teloschistales	Isotype	M-0024158 / 553814 / 233064	Dobbins Creek, Fairfield
Megaloblastenia flavidoatra (Nyl.) Sipman	Teloschistales	Type	http://id.luomus.fi/HA.H9510476	
Teloschistes fasciculatus	Teloschistales	Isolectotype	CHR 166123	South Waipahi, on river bank
Umbilicaria durietzii Frey	Umbilicariales	Type	G-G-165866/1	Mount Pisgah
Anthracoidea wakatipu	Ustilaginales	Holotype	PDD 23213	Cardrona Valley
Dermatocarpon insigne	Verrucariales	Type	CHR 376989	Rock and Pillar Range
Verrucaria austroschisticola	Verrucariales	Holotype	CHR 494627	
Verrucaria austroschisticola	Verrucariales	Isotype	CHR 494627 B	Summit Rock, Rock and Pillar Range
Verrucaria lacrimans	Verrucariales	Isotype	CHR 373509	
Verrucaria otagensis	Verrucariales	Isotype	CHR 373523	
Verrucaria otagensis	Verrucariales	Isotype	CHR 373525	Old Man Range, near Prophets Rock
Verrucaria otagensis	Verrucariales	Isotype	CHR 373524	Deep Stream
Verrucaria otagensis	Verrucariales	Part of type	CHR 373524	Head of Estuary Burn, Lake Wānaka
Rosellinia nothofagi	Xylariales	Holotype	PDD 74976	Blue Mountains, Tapanui

Appendix 5: Bird species with type localities in Otago

Scientific name and authority	Common name	Order	Māori name from New Zealand Threat Classificaiton System*	Locality
EXTANT				
Eudyptes pachyrhynchus G.R. Gray, 1845	Fiordland crested penguin	Sphenisciformes	tawaki	Waikouaiti
Leucocarbo chalconotus G.R. Gray, 1845	Otago shag	Suliformes	matapo	Ōamaru
Podiceps cristatus australis Gould, 1844	Australasian crested grebe	Podicipediformes	pūteketeke	Lake Wakatipu/Whakatipu Waimāori
Pachyptila turtur (Kuhl, 1820	fairy prion	Procellariiformes	tītī wainui	Accession number: LB11856
EXTINCT				
Aptornis defossor Owen, 1871	South Island adzebill	Gruiformes	ngutu hahau	Ōamaru
Biziura delautouri Forbes, 1892	New Zealand musk dusk	Anseriformes		Enfiled Swamp
Chenonetta finschi (Van Beneden, 1875)	Finsch's duck	Anseriformes	manutahora*	Earnscleugh Cave
Dinornis robustus Owen, 1846	South Island giant moa	Dinornithiformes	moa nunui	Waikouaiti
Emeus crassus Owen, 1846	eastern moa	Dinornithiformes	moa mōmona	Waikouaiti
Ixobrychus novaezelandiae (Purdie, 1871)	New Zealand little bittern	Pelecaniformes	kaoriki	Lake Wakatipu/ Whakatipu Waimāori
Megalapteryx didinus Owen 1883	upland moa	Dinornithiformes	moa pukepuke	Tāhuna/Queenstown
Pachyornis elephatopus (Owen, 1856)	heavy-footed moa	Dinornithiformes	moa waewae taumaha	Awamoa
Sceloglaus albifacies albifacies G.R. Gray, 1844	South Island laughing owl	Strigiformes	Whēkau*	Waikouaiti

*Most common te reo Māori name used in the Notornis scientific journal as cited in the Checklist Committee (2022). Alternative names provided in Appendix 3 of the checklist.
NB. All bird type localities are holotypes.

Appendix 6. Reptiles with type localities in Otago

Scientific name and authority	Common name	Order	Locality
Oligosoma toka Chapple et al., 2011	Nevis skink	Squamata	Nevis Valley
Oligosoma repens Chapple et al., 2011	Eyres skink	Squamata	Eyre Mountains, ~200 m from the Southland-Otago Regional boundary
Oligosoma otagense (McCann, 1955)	Otago skink	Squamata	Otago
Oligosoma maccanni (Patterson & Daugherty, 1990)	McCann's skink	Squamata	Near Ranfurly
Oligosoma inconspicuum (Patterson & Daugherty, 1990)	cryptic skink	Squamata	Tree Island, Lake Wakitipu
Oligosoma grande (Gray, 1845)	grand skink	Squamata	Otago
Oligosoma eludens (Knox, Chapple & Bell, 2024)	rockhopper skink	Squamata	Hawkdun Range
Oligosoma burganae Chapple et al., 2011	Burgan skink	Squamata	Rock and Pillar Range
Mokopirirakau galaxias Knox et al., 2021	hura te ao gecko	Squamata	Oteake Conservation Park

NB: all reptile type localities are holotypes

Appendix 7. Freshwater fishes with type localities in Otago

Scientific name and authority	Common name	Order	Locality
Galaxias anomalus Stokell 1959	central Otago roundhead galaxias	Galaxiiformes	Ophir Hotel, Central Otago
Galaxias cobitinis McDowall & Waters 2002	lowland longjaw galaxias (Kakanui River)	Galaxiiformes	Kauru River, North Otago
Galaxias depressiceps McDowall & Wallis 1996	Taieri flathead galaxias	Galaxiiformes	Healy Creek, Kye Burn, Central Otago
Galaxias eldoni McDowall 1997	Eldon's galaxias	Galaxiiformes	Smugglers Creek, Traquair Burn, Taieri River
Galaxias pullus McDowall 1997	dusky galaxias	Galaxiiformes	Munro Dam, Waipori River, Taieri River

NB: all freshwater fishes type localities are holotypes

Appendix 8. Onchyphora with type localities in Otago

Scientific name and authority	Common name	Te reo Māori name	Phlyum	Locality
Peripatoides otepoti (Trewick et al., 2024)	peripatus	ngaokeoke	Onchyphora	Nichols Creek, Dunedin

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www.orc.govt.nz/environment/biodiversity/

Otago Regional Council

9.7. Regionally Endemic Species in Otago

Prepared for: Science and Resilience Committee

Report No. GOV2535

Activity: Governance Report

Author: Scott Jarvie, Senior Scientist Biodiversity

Endorsed by: Tom Dyer, General Manager Science and Resilience

Date: 4 June 2025

PURPOSE

[1] This paper provides an overview of regionally endemic species in the Otago Region, meaning they do not occur naturally anywhere else on Earth.

EXECUTIVE SUMMARY

[2] A species is endemic when its geographic range is confined to a single given area.

[3] In the Otago Region a total of 360 species were identified as endemic.

[4] Eighty-five percent of Otago's endemic species are nationally assessed with heightened risks of extinction.

[5] This report will support council staff, iwi partners, territorial authorities in the Region, stakeholders, landowners, and community groups with an evidence base on regionally endemic species to inform biodiversity management in the Region.

RECOMMENDATION

That the Committee:

1) ***Notes*** *this report.*
2) ***Notes*** *this work is part of a broader programme to inform management of biodiversity in the Otago Region.*

BACKGROUND

[6] A species is considered endemic if it is native to and only found in a specific geographic location, and nowhere else in the world.

[7] Endemic species often have specialised adaptations that allow them to survive only in unique habitats. Such specialisations often make them susceptible to the effects of environmental disturbances.

[8] Aotearoa New Zealand has a high proportion of endemic species.

[9] A species is a regional endemic if it is native to and found only within a particular region, which is a smaller area within a larger landmass (like a region within Aotearoa New Zealand).

[10] The Department of Conservation – Te Papa Atawhai manages indigenous species nationally under the Wildlife Act (1953), but district and regional councils have statutory

obligations to maintain indigenous biodiversity under the Resource Management Act 1991 (RMA), including habitats for threatened species.

[11] This report provides a list of species that are regional endemics to Otago.

DISCUSSION

[12] A total of 360 species were identified as endemic to Otago.

[13] Invertebrates were the most numerous species group of regional endemics with 302 species, followed by indigenous vascular plants with 40 species, freshwater fish with nine species, reptiles with six species, bryophytes (mosses and liverworts) with two species, and birds with a single species.

[14] Well-known regional endemics to Otago include the flightless Cromwell chafer beetle, the large-bodied and spectacularly coloured Otago skink, the nine non-migratory galaxiids, and the recently described Otago shag.

Figure 1. Four regionally endemic species found only in the Otago Region. The Cromwell Chafer beetle, photographed by Danilo Hegg; Otago skink, photographed by Carey Knox; Otago shag, photographed by Oscar Thomas; Taieri flathead, photographed by James Tweed

[15] Of the regional endemics, 194 species have had their conservation status assessed nationally in the New Zealand Threat Classification System (NZTCS)[1]. This means only ~54 percent of the regionally endemic species in Otago have been assessed nationally.

[16] Conservation statuses show many species are threatened (n = 47: Nationally Critical = 25; Nationally Endangered = 15; Nationally Vulnerable = 6; Nationally Increasing = 1) or

[1] NZTCS

at risk (n = 56; Declining = 2; Naturally Uncommon = 52; Relict = 2) with extinction. The largest conservation status species were assessed is data deficient (n = 66), meaning there is insufficient data to assign a conservation status. The remaining species were not threatened (n = 25).

[17] Knowledge of the species that are regional endemic to Otago should inform biodiversity management in the Region.

OPTIONS

[18] This report is for noting only.

CONSIDERATIONS

Strategic Framework and Policy Considerations

[19] The terrestrial ecology programme contributes towards the Healthy water, soil and coast, and Healthy diverse ecosystems strategic priorities.

[20] The work outlined in this paper aligns with visions in ORC's Biodiversity Strategy Plan: Our Living Treasure | Tō tatou Koiora Taoka and with visions and outcomes in the Biodiversity Action Plan | Te Mahi hei Tiaki i te Koiora.

Financial Considerations

[21] The work is funded and was part of the planned work programme.

Significance and Engagement

[22] Engagement is ongoing with mana whenua, government agencies, stakeholders, and landowners who work in biodiversity management. This report provides an overview of the regionally endemic species and can inform future policy and strategy development.

Legislative and Risk Considerations

[23] ORC has statutory obligations to maintain indigenous biodiversity. This report provides an evidence base to inform the management of biodiversity in the Region.

Climate Change Considerations

[24] Due to endemic species often being found in isolated areas and often having specialised adaptations, they can be susceptible to the effects of environmental disturbances. Future work will compare the listed regionally endemic to a recently completed Climate Change Vulnerability Assessment for terrestrial taxa.

Communications Considerations

[25] The report and accompanying spreadsheet to be released to the public. This includes the documents being available on the ORC webpage in its Biodiversity section.

[26] The report and accompanying spreadsheet will be provided to members of the Otago Biodiversity Forum, whose memberships include mana whenua, territorial authorities, and other agencies.

NEXT STEPS

[27] The report and accompanying spreadsheet will be provided to Strategy for consideration on how can inform biodiversity management in the Region.

[28] Incorporation of Climate Change Vulnerability Assessments for the endemic threatened species.

[29] Further work to compile regional endemic lists for species from lesser-known taxonomic groups, particularly in the freshwater species.

ATTACHMENTS

1. Regionally Endemic Species [**9.7.1** - 39 pages]

Regionally Endemic Species in Otago

Scott Jarvie

April 2025

Otago Biodiversity Series Volume 1

Otago Regional Council

orc.govt.nz

Regionally Endemic Species in Otago

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Salt pan cress, *Lepidium kirkii* Petrie. A regionally endemic vascular plant only known to occur on patches of saline/sodic soils (sometimes referred to as salt pans) in the semi-arid region of Central Otago. Photograph by John Barkla on the front and back covers.

Burgan skink, *Oligosoma burganae* Chapple et al. 2011. A regionally endemic skink species restricted to the Rock and Pillar and Lammermoor Ranges in Otago. Photograph by Carey Knox on the frontispiece.

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Executive Summary

This report provides an overview of regionally endemic species in the Otago Region, meaning they are not found elsewhere on Earth. A total of 360 species were identified as regionally endemic to Otago, with the species group mainly focused on being those found in the terrestrial realm. This includes birds, bryophytes, reptiles, select invertebrate groups, vascular plants, although freshwater fish and some freshwater invertebrates are included. Of the species assessed, 194 had been assessed nationally for their threat status, with 170 (88 percent) having elevated extinction risk (Threatened, At Risk, or Data Deficient). Other species groups should have their regional endemics identified. The report will support the Otago Regional Council, our iwi partners, territorial authorities in the region, stakeholders, landowners, and community groups to provide an evidence base to inform biodiversity management across the region. This includes highlighting the biota (flora, fauna, and fungi) in Otago that are regionally endemic, including those that are at risk or threatened with extinction, which the Council has statutory obligations to protect.

Table of Contents

Introduction

This report provides an overview of species that are regionally endemic to Otago, meaning they are found nowhere else on Earth. A summary is provided of the number of regionally endemic species for select taxonomic groups, including birds, bryophytes (mosses, hornworts and liverworts), select invertebrates groups, reptiles, and vascular plants. The report will support the Otago Regional Council, iwi partners, territorial authorities in the region, stakeholders, landowners, and community groups to provide an evidence base to inform biodiversity management across the region. This includes highlighting the flora, fauna, and fungi in Otago that are regionally endemic and at risk or threatened with extinction, which the Council has statutory obligations to protect.

Background

An endemic species is a species (or taxon) whose geographic range or distribution is confined to a single given area. Although the species may inhabit a small area, such as a single lake, or its range may extend across an entire region, it is considered endemic if it not found natively anywhere else in the world. Endemic species are often found in isolated areas, such as on island or on a mountain within a mountain range, and they often have specialised adaptations that allow them to survive only in unique habitats. Such specialisations often make them susceptible to the effects of environmental disturbances.

Our indigenous biodiversity in Aotearoa New Zealand makes a significant contribution to overall global diversity, with an estimated 80,000 species of native animals, plants and fungi. Our high level of endemism among these native species and large proportion of threatened species makes Aotearoa New Zealand an internationally recognised world ‘hotspot’ for biodiversity (Myers et al. 2000). The high endemism is largely the result of our long isolation from other land masses and diverse geography and climate, allowing unique flora, fauna and fungi to develop. For example, Aotearoa New Zealand’s endemic species include all our native frogs and reptiles, more than 90% of our insects, approximately 80% of vascular plants and a quarter of bird species. At regional scales in Aotearoa New Zealand, an area that has long been recognised to have extraordinary regional endemism is Otago.

In Aotearoa New Zealand the Department of Conservation – Te Papa Atawhai manages indigenous species nationally under the Wildlife Act (1953), but regional and district councils have statutory obligations to maintain indigenous biodiversity under the Resource Management Act 1991 (RMA), including to manage the habitats of threatened species. This report provides a preliminary list of regionally endemic, largely terrestrial taxonomic species found in Otago (see Appendix 1 for a map of the Region).

Methods

Data sources

1. Compilation of information from regional conservation statuses and species lists

To compile information on regionally endemic species in Otago, initially sources were:

A. Recently completed regional conservation status reports for six taxonomic groups (bats, 2023b; indigenous vascular plants, 2024a; birds, 2024b; reptiles, Jarvie et al. 2024c; mushroom fungi, i.e., selected species of non-lichenised agarics, boletes and russuloid fungi, Jarvie and Cooper 2024; amphibians, Jarvie 2024; see website link for more information: www.orc.govt.nz/environment/biodiversity/regional-threat-assessments/).
B. Recently completed compilations of species lists for two groups (lichen and non-lichenised fungi; fungi from 2005 report by Hitchmough et al., excluding those taxa included in the de Lange et al. 2018 report).
C. Recently completed spreadsheets for five groups (hornworts and liverworts, Pritchard 2025a; mosses, Pritchard 2025b; freshwater fish, Campbell 2025; marine mammals, Jarvie 2024b; parasitic mites and ticks, Jarvie 2024c; Onychophora, Jarvie 2024d; see pages of the following website link for more information: www.orc.govt.nz/environment/biodiversity/otago-species/).
D. Recently completed species lists for four taxonomic groups in Aotearoa by region (amphibians, Dale et al. 2025; bats, Pryde et al. 2025; birds, Thomas 2025; reptiles, Knox and Hitchmough 2025; Jarvie and Monks, 2025).

2. Collation of information from the Global Biodiversity Information Facility

The Global Biodiversity Information Facility (GBIF, www.gbif.org/) was used as a secondary source, because it captures data from many institutions with standardised terminology. GBIF has become the 'go-to' aggregator for such information and has directly enabled a steady increase in scientific publications[1] and a 1:12 societal benefit[2]. To get data not available on GBIF, contact was made with the curators of Tūhura Otago Museum (OMNZ), Canterbury Museum (CMNZ), the Te Papa – Museum of New Zealand (MONZ) and Lincoln University (LUNZ), as these collections either don't publish, or have limited records, on GBIF. Responses were received from every institution. A geographical filter was then applied using the GIS layer for the Otago Regional Council's administrative boundary (https://datafinder.stats.govt.nz/layer/120946-regional-council-2025/).

To validate the preliminary list the following was also completed:

[1] More than 10,000 scientific papers enabled by GBIF-mediated data
[2] Report reveals return on investments in GBIF

A. Each species was checked to see if specimens were from outside Otago.
B. Online searches were conducted for any indication that the species was not only from Otago. The taxonomic name was used in the search, and any information returned was typically a text-based description (e.g., 'species x is often in the Waikato and Auckland regions …'). Online sources included Wikipedia, Wikispecies, iNaturalist, specialist taxonomic portals (World Spider Catalogue (https://wsc.nmbe.ch/), Scalenet (García Morales et al. 2016), Thysanoptera Aotearoa (Thrips of New Zealand) [Mound et al. 2017]), and published literature.

3. *Additional sources of information*

To ensure backward and forward compatibility with changes in taxonomic nomenclatures to future proof the compilation, the New Zealand Organisms Register (NZOR, www.nzor.org.nz) 'matching' function was used to match the names of type species and return an NZOR identification number. NZOR is an actively maintained compilation of all organism names relevant to Aotearoa New Zealand: indigenous, endemic or exotic species or species not present in Aotearoa New Zealand but of national interest to our conservation and biosecurity agencies. NZOR is digitally and automatically assembled on a regular basis from several taxonomic data providers. It provides a consensus opinion on the preferred name for an organism, any alternative scientific names (synonyms), common and Māori names, relevant literature, and the data provider's view on the documented presence/absence in New Zealand.

Next, the database of the New Zealand Threat Classification System (NZTCS, https://nztcs.org.nz/) was used to match the names of type species with their conservation status (if it had been assessed) by 'marrying' with the Species ID. For each taxonomic group, the latest threat assessment information is provided: i.e., amphibians (Burns et al. 2025), indigenous vascular plants (de Lange et al. 2024), rhytididae (carnivorous snails; Walker et al. 2024), bats (O'Donnell et al. 2023), mushroom fungi (selected species of Agaricales, Boletales, Russulales; Cooper et al. 2022), Orthoptera (wēta, crickets and grasshoppers; Trewick et al. 2022), parasitic mites and ticks (Acari; Heath et al. 2022), birds (Robertson et al. 2021), reptiles (Hitchmough et al. 2021), spiders (Sirvid et al. 2021), leaf-veined slugs and amber snails (Barker et al. 2021), pūpūharakeke/flax snails (Walker et al. 2021), hornworts and liverworts (de Lange et al. 2020), marine macroalgae (Nelson et al. 2019), marine mammals (Baker et al. 2019), chimaeras, sharks and rays (Duffy et al. 2018), freshwater fishes (Dunn et al 2018), lichens (de Lange et al. 2018), Onychophora (Trewick et al. 2018), hymenoptera (Ward et al. 2017), lepidoptera (Hoare et al. 2017), mosses (Rolfe et al. 2016), stick insects (Buckley et al. 2016), earthworms (Buckley et al. 2015), fleas (Heath et al. 2015), aphids (Stringer et al. 2012), coleoptera (Leschen et al. 2012), diptera (Andrew et al. 2012), hemiptera (Stringer et al. 2012), small or less well-known terrestrial invertebrates

(Buckley et al. 2012), nematodes (Yeates et al. 2012), micro-snails (Mahlfeld et al. 2012), and fungi excluding selected species of Agaricales, Boletales and Russulales (Hitchmough et al. 2007; other taxa were re-assessed by Cooper et al. 2022).

Results

A total of 360 species are recorded as endemic to or occurring only in Otago (Table 1). The most speciose group was invertebrates with 302 taxa, followed by indigenous vascular plants with 40 taxa, freshwater fish with nine taxa, reptiles with six taxa, bryophytes (mosses and liverworts) with two taxa, and birds with one taxon.

Table 1. The number of species that are endemic to Otago from different functional groups with different orders (listed initially by functional groups then the order with the most species)

Functional group	Order name	Common name	Number of species
Invertebrates (n = 302)			
	Araneae	Spiders	73
	Diptera	Flies	64
	Coleoptera	Beetles	46
	Lepidoptera	Moths	32
	Sarcoptiformes	Mites (feather, skin)	20
	Hymenoptera	Wasps, bees, ants	17
	Hemiptera	True bugs	15
	Plecoptera	Stoneflies	8
	Trichoptera	Caddisflies	6
	Orthoptera	Weta, grasshoppers	5
	Opilliones	Harvestmen	5
	Trombidiformes	Chiggers (mites)	5
	Entomobryomorpha	Springtails	1
	Diplostracha	Water fleas	1
	Dorylaimida	Roundworms (dorylaims)	1
	Isopoda	Crustaceans (pill bugs, woodlice, slaters, or sowbugs)	1
	Pseudoscorpiones	False scorpions	1
	Stylommatophora	Land snail, slugs	1
Vascular plants (n = 40)			
	Asterales	Daisies, sunflowers	11
	Boraginales	Borages, for-me-nots	7
	Poales	Grasses	7
	Capparales	Brassicales – mustard, capers	3
	Araliales	Ivy family	2
	Rosales	Roses	2
	Thymelaeales	Daphne	2
	Apiales	Umbellifers (celery, carrot or parsley)	1
	Caryophyllales	Inks, carnations	1
	Fabales	Legumes, peas, beans	1
	Oxalidales	Wood sorrel	1
	Ranunculales	Buttercups	1
	Violales	Violets	1
Freshwater fishes (n = 9)			
	Galaxiiformes	Galaxiids	8
Reptiles (n = 6)			
	Squamata	Lizards and snakes*	6
Bryophytes (n = 2)			
	Bartramiales	Mosses	1
	Jungermanniales	Liverworts	1
Birds (n = 1)			
	Suliformes	Gannets, cormorants, and allies	1

*Note that terrestrial snakes are not resident indigenous species in Aotearoa New Zealand

Of the regional endemics, 194 taxa had their conservation status assessed nationally in the NZTCS (Table 2). This means only ~54 percent of regionally endemic taxa in the Region had been assessed nationally. Conservation statuses for these species from the NZTCS are as follows: 47 taxa in the Threatened category (Nationally Critical = 25; Nationally Endangered = 15; Nationally Vulnerable = 6; Nationally Increasing = 1), 56 taxa in the At Risk category (Declining = 2; Naturally Uncommon = 52; Relict = 2) and 25 taxa in the Not Threatened category. Sixty-six taxa were assessed as Data Deficient, meaning there was insufficient data to assign a conservation status, while 165 taxa have not been assessed yet.

Table 2. Number of regionally endemic species in Otago assessed in the New Zealand Threat Classification System (NZTCS), with their threat category and status.

NZTCS category	NZTCS status	Taxon count
Threatened (n = 47)		
	Nationally Critical	25
	Nationally Endangered	15
	Nationally Vulnerable	6
	Nationally Increasing	1
At Risk (n = 56)		
	Declining	2
	Naturally Uncommon	52
	Relict	2
Not Threatened (n = 25)	Not Threatened	25
Data Deficient (n = 66)	Data Deficient	66
Total		194

In the Otago region the invertebrate species had the most regional endemics (Table 3). Of these, the orders with more than ten regional endemic taxa are Araneae, Diptera, Coleoptera, Lepidoptera, Sarcoptiformes, Hymenoptera and Hemiptera. Whereas the following taxonomic groups have eight taxa or less in their orders: Plecoptera, Orthoptera, Trombidiformes, Trichoptera, Opiliones, Dorylaimida, Entomobryomorpha, Isopoda, Pseudoscorpiones and Stylommatophora.

Many regionally endemic invertebrates have not had their conservation status assessed nationally (Table 3; 159 out of 302 or ~53 percent). Of the taxa that have a national conservation status, 18 were Threatened (Nationally Critical = 11; Nationally Endangered = 5; Nationally Vulnerable = 3), 37 were At Risk (Naturally Uncommon = 35; Relict = 2), 23 were Not Threatened, and 64 were Data Deficient.

Table 3. Regionally endemic invertebrate species in Otago. The New Zealand Threat Classification System (NZTCS) categories and statuses are provided. The NZTCS reports are Andrew et al. 2012, Grainger et al. 2018, Hoare et al. 2017, Leschen et al. 2012, Marlfeld et al. 2012, Sirvid et al. 2021, Stringer et al. 2012, Trewick et al. 2022, Ward et al. 2016, and Yeates et al. 2012.

Name and authority	Order	Family	NZTCS category	NZTCS status	Report name
Akatorea otagoensis Forster & Wilton, 1973	Araneae	Desidae	Not Threatened	Not Threatened	Spiders 2020 (Sirvid et al. 2021)
Alistra centralis (Forster, 1970)	Araneae	Hahniidae	At Risk	Naturally Uncommon	Spiders 2020 (Sirvid et al. 2021)
Amaurobioides maritima O. Pickard-Cambridge, 1883	Araneae	Anyphaenidae	At Risk	Naturally Uncommon	Spiders 2020 (Sirvid et al. 2021)
Anoteropsis flavescens L. Koch, 1878	Araneae	Lycosidae	Not Threatened	Not Threatened	Spiders 2020 (Sirvid et al. 2021)
Anoteropsis urquharti (Simon, 1898)	Araneae	Lycosidae	Not Threatened	Not Threatened	Spiders 2020 (Sirvid et al. 2021)
Aorangia poppelwelli Forster & Wilton, 1973	Araneae	Stiphidiidae	At Risk	Naturally Uncommon	Spiders 2020 (Sirvid et al. 2021)
Ascuta leith Forster & Platnick, 1985	Araneae	Orsolobidae	At Risk	Naturally Uncommon	Spiders 2020 (Sirvid et al. 2021)
Cambridgea arboricola (Urquhart, 1891)	Araneae	Desidae	Not Threatened	Not Threatened	Spiders 2020 (Sirvid et al. 2021)
Cambridgea secunda Forster & Wilton, 1973	Araneae	Desidae	Not Threatened	Not Threatened	Spiders 2020 (Sirvid et al. 2021)
Cantuaria aperta Forster, 1968	Araneae	Idiopidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Cantuaria apica Forster, 1968	Araneae	Idiopidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Cantuaria assimilis Forster, 1968	Araneae	Idiopidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Cantuaria catlinensis Forster, 1968	Araneae	Idiopidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Cantuaria depressa Forster, 1968	Araneae	Idiopidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Cantuaria dunedinensis Forster, 1968	Araneae	Idiopidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Cantuaria kakanuiensis Forster, 1968	Araneae	Idiopidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Cantuaria lomasi Forster, 1968	Araneae	Idiopidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Cantuaria maxima Forster, 1968	Araneae	Idiopidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Cantuaria napua Forster, 1968	Araneae	Idiopidae	At Risk	Naturally Uncommon	Spiders 2020 (Sirvid et al. 2021)
Cantuaria pilama Forster, 1968	Araneae	Idiopidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Cantuaria toddae Forster, 1968	Araneae	Idiopidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Cantuaria vellosa Forster, 1968	Araneae	Idiopidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Cycloctenus fugax Goyen, 1890	Araneae	Cycloctenidae	Not Threatened	Not Threatened	Spiders 2020 (Sirvid et al. 2021)
Dunedinia pullata Millidge, 1988	Araneae	Linyphiidae	Not Threatened	Not Threatened	Spiders 2020 (Sirvid et al. 2021)
Dunstanoides kochi (Forster & Wilton, 1973)	Araneae	Desidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Duripelta otara Forster & Platnick, 1985	Araneae	Orsolobidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Gasparia montana Forster, 1970	Araneae	Desidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Gasparia nava Forster, 1970	Araneae	Desidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Gohia parisolata Forster, 1970	Araneae	Desidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Goyenia multidentata Forster, 1970	Araneae	Desidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)

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Haplinis dunstani (Blest, 1979)	Araneae	Linyphiidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Haplinis marplesi Blest & Vink, 2003	Araneae	Linyphiidae	At Risk	Naturally Uncommon	Spiders 2020 (Sirvid et al. 2021)
Hapona otagoa (Forster, 1964)	Araneae	Desidae	Not Threatened	Not Threatened	Spiders 2020 (Sirvid et al. 2021)
Hexathele waipa Forster, 1968	Araneae	Hexathelidae	Not Threatened	Not Threatened	Spiders 2020 (Sirvid et al. 2021)
Huttonia palpimanoides O. Pickard-Cambridge, 1880	Araneae	Huttoniidae	At Risk	Naturally Uncommon	Spiders 2020 (Sirvid et al. 2021)
Laestrygones otagoensis Forster, 1970	Araneae	Desidae	Not Threatened	Not Threatened	Spiders 2020 (Sirvid et al. 2021)
Lamina minor Forster, 1970	Araneae	Toxopidae	At Risk	Naturally Uncommon	Spiders 2020 (Sirvid et al. 2021)
Makora mimica Forster & Wilton, 1973	Araneae	Desidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Mamoea rufa (Berland, 1931)	Araneae	Desidae	Not Threatened	Not Threatened	Spiders 2020 (Sirvid et al. 2021)
Mangareia maculata Forster, 1970	Araneae	Desidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Maniho centralis Forster & Wilton, 1973	Araneae	Desidae	Threatened	Nationally Endangered	Spiders 2020 (Sirvid et al. 2021)
Meringa leith Forster, 1990	Araneae	Physoglenidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Meringa otago Forster, 1990	Araneae	Physoglenidae	Not Threatened	Not Threatened	Spiders 2020 (Sirvid et al. 2021)
Migas linburnensis Wilton, 1968	Araneae	Migidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Migas lomasi Wilton, 1968	Araneae	Migidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Migas taierii Todd, 1945	Araneae	Migidae	Threatened	Nationally Endangered	Spiders 2020 (Sirvid et al. 2021)
Migas toddae Wilton, 1968	Araneae	Migidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Neoramia alta Forster & Wilton, 1973	Araneae	Stiphidiidae	At Risk	Naturally Uncommon	Spiders 2020 (Sirvid et al. 2021)
Neoramia matua Forster & Wilton, 1973	Araneae	Stiphidiidae	Not Threatened	Not Threatened	Spiders 2020 (Sirvid et al. 2021)
Neoramia nana Forster & Wilton, 1973	Araneae	Stiphidiidae	At Risk	Naturally Uncommon	Spiders 2020 (Sirvid et al. 2021)
Neoramia otagoa Forster & Wilton, 1973	Araneae	Stiphidiidae	At Risk	Naturally Uncommon	Spiders 2020 (Sirvid et al. 2021)
Otagoa wiltoni Forster, 1970	Araneae	Desidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Oramia littoralis Forster & Wilton, 1973	Araneae	Agelenidae	At Risk	Naturally Uncommon	Spiders 2020 (Sirvid et al. 2021)
Pakeha protecta Forster & Wilton, 1973	Araneae	Cycloctenidae	Not Threatened	Not Threatened	Spiders 2020 (Sirvid et al. 2021)
Pakeha subtecta Forster & Wilton, 1973	Araneae	Cycloctenidae	Not Threatened	Not Threatened	Spiders 2020 (Sirvid et al. 2021)
Panoa tapanuiensis Forster, 1970	Araneae	Desidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Parafroneta monticola Blest, 1979	Araneae	Linyphiidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Paravoca otagoensis Forster & Wilton, 1973	Araneae	Cycloctenidae	Not Threatened	Not Threatened	Spiders 2020 (Sirvid et al. 2021)
Protoerigone otagoa Blest, 1979	Araneae	Linyphiidae	Not Threatened	Not Threatened	Spiders 2020 (Sirvid et al. 2021)
Rayforstia antipoda (Forster, 1959)	Araneae	Anapidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Rinawa otagoensis Forster, 1970	Araneae	Hahniidae	Not Threatened	Not Threatened	Spiders 2020 (Sirvid et al. 2021)
Subantarctia centralis Forster & Platnick, 1985	Araneae	Orsolobidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)

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Subantarctia trina Forster & Platnick, 1985	Araneae	Orsolobidae	At Risk	Naturally Uncommon	Spiders 2020 (Sirvid et al. 2021)
Tangata otago Forster & Platnick, 1985	Araneae	Orsolobidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Tangata tautuku Forster & Platnick, 1985	Araneae	Orsolobidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Tautukua isolata Forster & Platnick, 1985	Araneae	Orsolobidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Viridictyna kikkawai Forster, 1970	Araneae	Dictynidae	At Risk	Naturally Uncommon	Spiders 2020 (Sirvid et al. 2021)
Waiporia hawea Forster & Platnick, 1985	Araneae	Orsolobidae	At Risk	Relict	Spiders 2020 (Sirvid et al. 2021)
Waiporia wiltoni Forster & Platnick, 1985	Araneae	Orsolobidae	At Risk	Naturally Uncommon	Spiders 2020 (Sirvid et al. 2021)
Wiltonia graminicola Forster & Platnick, 1985	Araneae	Orsolobidae	At Risk	Naturally Uncommon	Spiders 2020 (Sirvid et al. 2021)
Wiltonia porina Forster & Platnick, 1985	Araneae	Orsolobidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Zealanapis otago Platnick & Forster, 1989	Araneae	Anapidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Zealoctenus cardronaensis Forster & Wilton, 1973	Araneae	Miturgidae	Data Deficient	Data Deficient	Spiders 2020 (Sirvid et al. 2021)
Asilis annulicornis Wittmer, 1979	Coleoptera	Cantharidae			
Catoptes robustus (Sharp, 1886)	Coleoptera	Curculionidae			
Chalcolampra apicula Wardhaugha & Leschen, 2021	Coleoptera	Chrysomelidae			
Chalepistes curvus (Barratt & Kuschel, 1996)	Coleoptera	Curculionidae			
Chalepistes dugdalei (Chalepistes dugdalei, 1996)	Coleoptera	Curculionidae			
Chalepistes patricki (Barratt & Kuschel, 1996)	Coleoptera	Curculionidae			
Duvaliomimus (Duvaliomimus) *taieriensis* Townsend, 2010	Coleoptera	Carabidae	At Risk	Naturally Uncommon	Coleoptera 2010 (Leschen et al. 2012)
Eugnomus alternans Broun, 1917	Coleoptera	Curculionidae			
Inophloeus inuus Pascoe, 1875	Coleoptera	Curculionidae			
Inophloeus praelatus Broun, 1886	Coleoptera	Curculionidae			
Irenimus minimus Brown, 2017	Coleoptera	Curculionidae			
Lithocia stictica Broun, 1923	Coleoptera	Curculionidae			
Lyperobius cupiendus Broun, 1886	Coleoptera	Curculionidae			
Maoritrechus nunni Townsend, 2010	Coleoptera	Carabidae	At Risk	Naturally Uncommon	Coleoptera 2010 (Leschen et al. 2012)
Mecodema laeviceps Broun, 1904	Coleoptera	Carabidae	Threatened	Nationally Critical	Coleoptera 2010 (Leschen et al. 2012)
Mecyclothorax otagoensis Liebherr & Marris, 2009	Coleoptera	Carabidae			
Megadromus fultoni Broun, 1882	Coleoptera	Carabidae	At Risk	Naturally Uncommon	Coleoptera 2010 (Leschen et al. 2012)
Megadromus sp. 8 "Omeo Hut" (Omeo Hut, Otago, CMNZmega08)	Coleoptera	Carabidae	Threatened	Nationally Critical	Coleoptera 2010 (Leschen et al. 2012)

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Metacorneolabium zanotium	Coleoptera	Staphylinidae			
Mimopeus lewisianus (Sharp, 1903)	Coleoptera	Tenebrionidae			
Mimopeus rugosus Bates, 1873	Coleoptera	Tenebrionidae	At Risk	Naturally Uncommon	Coleoptera 2010 (Leschen et al. 2012)
Nicaeana fraudator (Marshall, 1931)	Coleoptera	Curculionidae			
Oopterus monticola Larochelle & Larivière, 2017	Coleoptera	Carabidae			
Orchymontia otagensis Ordish, 1984	Coleoptera	Hydraenidae	Data Deficient	Data Deficient	Freshwater invertebrates 2018 (Grainger et al. 2018)
Oregus inaequalis (Laporte de Castelnau, 1867)	Coleoptera	Carabidae	At Risk	Naturally Uncommon	Coleoptera 2010 (Leschen et al. 2012)
Pedalopia novaezelandiae Laporte de Castelnau, 1867	Coleoptera	Carabidae			
Pentarthrum fultoni Broun, 1893	Coleoptera	Curculionidae			
Pentarthrum subsericatum Wollaston, 1873	Coleoptera	Curculionidae			
Prodontria capito (Broun, 1909)	Coleoptera	Scarabaeidae			
Prodontria jenniferae Emerson, 1997	Coleoptera	Scarabaeidae	At Risk	Naturally Uncommon	Coleoptera 2010 (Leschen et al. 2012)
Prodontria lewisii Broun, 1904	Coleoptera	Scarabaeidae	Threatened	Nationally Endangered	Coleoptera 2010 (Leschen et al. 2012)
Prodontria modesta (Broun, 1909)	Coleoptera	Scarabaeidae	At Risk	Naturally Uncommon	Coleoptera 2010 (Leschen et al. 2012)
Prodontria montis Emerson, 1997	Coleoptera	Scarabaeidae			
Prodontria patricki Emerson, 1997	Coleoptera	Scarabaeidae	Data Deficient	Data Deficient	Coleoptera 2010 (Leschen et al. 2012)
Prodontria pinguis Given, 1952	Coleoptera	Scarabaeidae	At Risk	Naturally Uncommon	Coleoptera 2010 (Leschen et al. 2012)
Prodontria regalis Emerson, 1997	Coleoptera	Scarabaeidae	At Risk	Naturally Uncommon	Coleoptera 2010 (Leschen et al. 2012)
Rygmodus opimus Broun, 1880	Coleoptera	Hydrophilidae			
Sciacharis (Sciacharis) *t autukuensis* Franz, 1986	Coleoptera	Staphylinidae			
Scopodes basalis Broun, 1893	Coleoptera	Carabidae			
Syrphetodes cirrhopogon Leschen & Buckley, 2015	Coleoptera	Ulodidae			
Taenarthrus capito (Jeannel, 1938)	Coleoptera	Carabidae			
Trichopsida popei Larochelle & Larivière, 2013	Coleoptera	Carabidae			
Trichopsida propinqua (Broun, 1917)	Coleoptera	Carabidae			
Waitatia bellicosa Bordoni, 2005	Coleoptera	Staphylinidae			
Zeadelium senile Watt, 1992	Coleoptera	Tenebrionidae	At Risk	Naturally Uncommon	Coleoptera 2010 (Leschen et al. 2012)
Zeolymma brachypterum Steel, 1950	Coleoptera	Staphylinidae			

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Eulimnadia marplesi Timms & McLay, 2005	Diplostracha	Limnadiidae	Threatened	Nationally Critical	Freshwater invertebrates 2018 (Grainger et al. 2018)
Amphineurus operculatus Alexander, 1924	Diptera	Limoniidae			
Amphineurus perarmatus Alexander, 1924	Diptera	Limoniidae			
Amphineurus senex Alexander, 1922	Diptera	Limoniidae			
Anabarhynchus castaneus Hutton, 1901	Diptera	Therevidae			
Anabarhynchus fuscofemoratus Lyneborg, 1992	Diptera	Therevidae	Data Deficient	Data Deficient	Diptera 2010 (Andrew et al. 2012)
Anabarhynchus indistinctus Lyneborg, 1992	Diptera	Therevidae	Data Deficient	Data Deficient	Diptera 2010 (Andrew et al. 2012)
Anabarhynchus spiniger Lyneborg, 1992	Diptera	Therevidae			
Anabarhynchus triangularis Lyneborg, 1992	Diptera	Therevidae	At Risk	Naturally Uncommon	Diptera 2010 (Andrew et al. 2012)
Anabarhynchus tricoloratus Lyneborg, 1992	Diptera	Therevidae			
Anabarhynchus wisei Lyneborg, 1992	Diptera	Therevidae	Data Deficient	Data Deficient	Diptera 2010 (Andrew et al. 2012)
Ceratomerus earlyi Plant, 1991	Diptera	Therevidae			
Culiseta novaezealandiae Pillai, 1966	Diptera	Culicidae			
Dicranomyia acanthophallus Alexander, 1924	Diptera	Limoniidae			
Dicranomyia allani Alexander, 1959	Diptera	Limoniidae			
Dicranomyia circularis Alexander, 1924	Diptera	Limoniidae			
Dicranomyia huttoni Edwards, 1923	Diptera	Limoniidae			
Dicranomyia megastigmosa Alexander, 1922	Diptera	Limoniidae			
Dicranomyia otagensis Alexander, 1924	Diptera	Limoniidae			
Dicranomyia primaeva Alexander, 1924	Diptera	Limoniidae			
Discobola haetara Johns, 2007	Diptera	Limoniidae	Data Deficient	Data Deficient	Diptera 2010 (Andrew et al. 2012)
Dolichopeza howesi Alexander, 1922	Diptera	Tipulidae			
Gonomyia oliveri Alexander, 1924	Diptera	Limoniidae			
Gynoplistia aculeata Alexander, 1924	Diptera	Limoniidae			
Gynoplistia aurantiopyga Alexander, 1922	Diptera	Limoniidae			
Gynoplistia hirsuticauda Alexander, 1923	Diptera	Limoniidae			
Gynoplistia (Cerozodia)*l aticosta* Alexander, 1930	Diptera	Limoniidae			

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Heteria flavibasis Malloch, 1930	Diptera	Tachinidae			
Hilara anisonychia Collin, 1928	Diptera	Empididae			
Hilara philpotti Miller, 1913	Diptera	Empididae			
Hilara vector Miller, 1923	Diptera	Empididae			
Hilarempis kaiteriensis (Miller, 1913)	Diptera	Empididae			
Libnotes falcata Alexander, 1935	Diptera	Limoniidae			
Limnophila oliveri Alexander, 1923	Diptera	Limoniidae			
Liriomyza vicina Spencer, 1976	Diptera	Agromyzidae	Data Deficient	Data Deficient	Diptera 2010 (Andrew et al. 2012)
Metalimnophila penicillata (Alexander, 1922)	Diptera	Limoniidae			
Metalimnophila simplicis (Alexander, 1922)	Diptera	Limoniidae			
Molophilus analis Alexander, 1923	Diptera	Limoniidae			
Molophilus pictipleura Alexander, 1922	Diptera	Limoniidae			
Neolimnia ura Barnes, 1979	Diptera	Sciomyzidae	At Risk	Naturally Uncommon	Diptera 2010 (Andrew et al. 2012)
Neolimnia vittata Harrison, 1959	Diptera	Sciomyzidae			
Nothodixa otagensis (Alexander, 1922)	Diptera	Dixidae			
Oropezella nigra Miller, 1923	Diptera	Hybotidae	Data Deficient	Data Deficient	Diptera 2010 (Andrew et al. 2012)
Pales exitiosa (Hutton, 1904)	Diptera	Tachinidae			
Paracladura lyrifera Alexander, 1923	Diptera	Trichoceridae			
Parahyadina angusta Mathis and Zatwarnicki, 2019	Diptera	Ephydridae			
Parentia defecta Bickel, 1991	Diptera	Dolichopodidae	Data Deficient	Data Deficient	Diptera 2010 (Andrew et al. 2012)
Pericoma barbata Satchell, 1950	Diptera	Psychodidae			
Pollenia hispida Dear, 1986	Diptera	Polleniidae			
Pollenia immanis Dear, 1986	Diptera	Polleniidae			
Pollenia uniseta Dear, 1986	Diptera	Polleniidae			
Pseudolycoriella hauta Köhler, 2019	Diptera	Sciaridae			
Pseudolycoriella plicitegmenta Köhler, 2019	Diptera	Sciaridae			
Pseudolycoriella porehu Köhler, 2019	Diptera	Sciaridae			
Psychodocha pulchrima (Satchell, 1954)	Diptera	Psychodidae			
Psychodocha tridens (Satchell, 1954)	Diptera	Psychodidae			

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Rhabdomastix neozelandiae Alexander, 1922	Diptera	Limoniidae			
Scatella subvittata Tonnoir & Malloch, 1926	Diptera	Ephydridae			
'Spilogona' argentifrons Malloch, 1931	Diptera	Muscidae			
Spilogona dolosa (Hutton, 1901)	Diptera	Muscidae			
Tasiocera bituberculata Alexander, 1924	Diptera	Limoniidae			
Tephritis marginata Malloch, 1931	Diptera	Tephritidae			
Thinempis otakouensis (Miller, 1910)	Diptera	Empididae			
Tricimba dugdalei Spencer, 1977	Diptera	Chloropidae	At Risk	Naturally Uncommon	Diptera 2010 (Andrew et al. 2012)
Zelandomyia otagensis (Alexander, 1923)	Diptera	Limoniidae			
Longidorus waikouaitii Yeates, Boag & Brown, 1997	Dorylaimida	Longidoridae	Threatened	Nationally Critical	Nematodes 2010 (Yeates et al. 2012)
Entomobrya promontorium Jordana and Greenslade, 2020	Entomobryomorpha	Entomobryidae			
Aneurus (Aneurodellus) brevipennis Heiss, 1998	Hemiptera	Aradidae			
Anzygina barrattae Fletcher & Larivière, 2009	Hemiptera	Cicadellidae	Data Deficient	Data Deficient	Hemiptera 2010 (Stringer et al. 2012)
Chinamiris zygotus Eyles & Carvalho, 1991	Hemiptera	Miridae	At Risk	Naturally Uncommon	Hemiptera 2010 (Stringer et al. 2012)
Eriococcus argentifagi Hoy, 1962	Hemiptera	Eriococcidae			
Eriococcus crenilobatus Hoy, 1962	Hemiptera	Eriococcidae			
Eriococcus latilobatus Hoy, 1962	Hemiptera	Eriococcidae			
Forsterocoris salmoni Woodward, 1953	Hemiptera	Rhyparochromidae	Data Deficient	Data Deficient	Hemiptera 2010 (Stringer et al. 2012)
Hypsithocus hudsonae Bergroth, 1927	Hemiptera	Pentatomidae	At Risk	Naturally Uncommon	Hemiptera 2010 (Stringer et al. 2012)
Kiwisaldula laelaps (White, 1878)	Hemiptera	Saldidae	Threatened	Nationally Endangered	Freshwater invertebrates 2018 (Grainger et al. 2018)
Kiwisaldula yangae Larivière and Larochelle, 2018	Hemiptera	Saldidae			
Montanococcus thriaticus Henderson, 2007	Hemiptera	Eriococcidae			
Paradorydium sertum Knight, 1973	Hemiptera	Cicadellidae			
Romna oculata Eyles & Carvalho, 1988	Hemiptera	Miridae	Not Threatened	Not Threatened	Hemiptera 2010 (Stringer et al. 2012)
Trioza gourlayi Tuthill, 1952	Hemiptera	Triozidae			
Ventrispina dugdalei Cox, 1987	Hemiptera	Pseudococcidae			
Adelencyrtoides tridens Noyes, 1988	Hymenoptera	Encyrtidae	Data Deficient	Data Deficient	Hymenoptera 2014 (Ward et al. 2017)
Amblyaspis breviscutellaris Buhl, 2011	Hymenoptera	Platygastridae	Data Deficient	Data Deficient	Hymenoptera 2014 (Ward et al. 2017)
Ceratanaphes monticola Noyes & Valentine, 1989	Hymenoptera	Mymaridae			

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Chorebus paranigricapitis Berry, 2007	Hymenoptera	Braconidae	Data Deficient	Data Deficient	Hymenoptera 2014 (Ward et al. 2017)
Leptacis arcuata Buhl, 2011	Hymenoptera	Platygastridae	Data Deficient	Data Deficient	Hymenoptera 2014 (Ward et al. 2017)
Leptacis fuscalata Buhl, 2011	Hymenoptera	Platygastridae	Data Deficient	Data Deficient	Hymenoptera 2014 (Ward et al. 2017)
Platygaster novaezealandiae Buhl, 2011	Hymenoptera	Platygastridae	Data Deficient	Data Deficient	Hymenoptera 2014 (Ward et al. 2017)
Prosynopeas notaulicum Buhl, 2017	Hymenoptera	Platygastridae			
Shireplitis frodoi Fernandez-Triana and Ward, 2013	Hymenoptera	Braconidae	Data Deficient	Data Deficient	Hymenoptera 2014 (Ward et al. 2017)
Shireplitis tolkieni Fernandez-Triana and Ward, 2013	Hymenoptera	Braconidae	Data Deficient	Data Deficient	Hymenoptera 2014 (Ward et al. 2017)
Woldstedtius gauldius Ward, 2013	Hymenoptera	Ichneumonidae	Not Threatened	Not Threatened	Hymenoptera 2014 (Ward et al. 2017)
Zelandonota rufiscutum Buhl, 2011	Hymenoptera	Platygastridae	Data Deficient	Data Deficient	Hymenoptera 2014 (Ward et al. 2017)
Zelostemma longipedicellatum Buhl, 2017	Hymenoptera	Platygastridae			
Zelostemma medionitens Buhl, 2017	Hymenoptera	Platygastridae			
Zelostemma brevistriatum Buhl, 2017	Hymenoptera	Platygastridae			
Zelostemma laevicornu Buhl, 2017	Hymenoptera	Platygastridae			
Zelostemma popovicii Buhl, 2017	Hymenoptera	Platygastridae			
Austridotea benhami Nicholls, 1938	Isopoda	Idoteidae	At Risk	Naturally Uncommon	Freshwater invertebrates 2018 (Grainger et al. 2018)
Aoraia oreobolae Dugdale, 1994	Lepidoptera	Hepialidae	At Risk	Naturally Uncommon	Freshwater invertebrates 2018 (Grainger et al. 2018)
Aoraia orientalis Dugdale, 1994	Lepidoptera	Hepialidae			
Archyala culta Philpott, 1931	Lepidoptera	Tineidae	Data Deficient	Data Deficient	Lepidoptera 2015 (Hoare et al. 2017)
Arctesthes siris (Hudson, 1908)	Lepidoptera	Geometridae			
Arctesthes titanica B.H. Patrick, H.J.H. Patrick, R.J.B. Hoare, 2019	Lepidoptera	Geometridae	Threatened	Nationally Vulnerable	Lepidoptera 2015 (Hoare et al. 2017)
Atomotricha lewisi Philpott, 1927	Lepidoptera	Oecophoridae			
Dichromodes gypsotis Meyrick, 1888	Lepidoptera	Geometridae			
Dichromodes ida Hudson, 1905	Lepidoptera	Geometridae			
Dichromodes simulans Hudson, 1908	Lepidoptera	Geometridae			
Epichorista tenebrosa Philpott, 1917	Lepidoptera	Tortricidae			
Gelophaula palliata (Philpott, 1914)	Lepidoptera	Tortricidae			
Hierodoris gerontion Hoare, 2005	Lepidoptera	Oecophoridae			
Hierodoris polita Hoare, 2005	Lepidoptera	Xyloryctidae	At Risk	Naturally Uncommon	Lepidoptera 2015 (Hoare et al. 2017)

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Hydriomena clarkei (Howes, 1917)	Lepidoptera	Geometridae			
Lycaena sp. "Chrystalls Beach boulder"	Lepidoptera	Lycaenidae	Threatened	Nationally Critical	Lepidoptera 2015 (Hoare et al. 2017)
Loxostege sp. “salt pan”	Lepidoptera	Crambidae	At Risk	Relict	Lepidoptera 2015 (Hoare et al. 2017)
Mallobathra cataclysma Clarke, 1934	Lepidoptera	Psychidae			
Mallobathra memotuina Clarke, 1934	Lepidoptera	Psychidae			
Mallobathra perisseuta Meyrick, 1920	Lepidoptera	Psychidae			
Notoreas "South Shag River"	Lepidoptera	Geometridae			
Orocrambus cultus Philpott, 1917	Lepidoptera	Crambidae			
Orocrambus geminus Patrick, 1991	Lepidoptera	Crambidae			
Orocrambus lindsayi Gaskin, 1975	Lepidoptera	Crambidae			
Orocrambus punctellus (Hudson, 1950)	Lepidoptera	Crambidae	Data Deficient	Data Deficient	Lepidoptera 2015 (Hoare et al. 2017)
Phylacodes cauta Meyrick, 1905	Lepidoptera	Plutellidae			
Pyrgotis humilis Philpott, 1930	Lepidoptera	Tortricidae			
Scoparia caliginosa Philpott, 1918	Lepidoptera	Crambidae			
Scoparia pascoella Philpott, 1920	Lepidoptera	Crambidae			
Scoparia tuicana Clarke, 1926	Lepidoptera	Crambidae			
Scoriodyta suttonensis Hattenschwiler, 1989	Lepidoptera	Psychidae			
Tinea furcillata Philpott, 1930	Lepidoptera	Tineidae			
Tingena terrena (Philpott, 1926)	Lepidoptera	Oecophoridae			
Americovibone remota Taylor, 2016	Opiliones	Neopilionidae			
Cenefia sorenseni hawea Forster, 1954	Opiliones	Triaenonychidae			
Nuncia (Corinuncia) *sublaevis* (Pocock, 1903)	Opiliones	Triaenonychidae			
Rakaia macra Boyer & Giribet, 2003	Opiliones	Pettalidae			
Prasma sorenseni regalia Forster, 1954	Opiliones	Triaenonychidae			
Pharmacus notabilis Hegg, Morgan-Richards and Trewick, 2022	Orthoptera	Rhaphidophoridae	Not Threatened	Not Threatened	Orthoptera 2022 (Trewick et al. 2022)
Pharmacus senex Hegg, Morgan-Richards and Trewick, 2022	Orthoptera	Rhaphidophoridae	Not Threatened	Not Threatened	Orthoptera 2022 (Trewick et al. 2022)
Pharmacus vallestris Hegg, Morgan-Richards and Trewick, 2022	Orthoptera	Rhaphidophoridae	Data Deficient	Data Deficient	Orthoptera 2022 (Trewick et al. 2022)
Isoplectron pallidum (Richards, 1972)	Orthoptera	Rhaphidophoridae	Not Threatened	Not Threatened	Orthoptera 2022 (Trewick et al. 2022)
Sigaus childi Jamieson, 1999	Orthoptera	Acrididae	Threatened	Nationally Vulnerable	Orthoptera 2022 (Trewick et al. 2022)
Nesoperla patricki McLellan, 2003	Plecoptera	Gripopterygidae	Threatened	Nationally Critical	Freshwater invertebrates 2018 (Grainger et al. 2018)

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Regionally endemic species in Otago

Endemic invertebrates

Name and authority	Order	Family	NZTCS category	NZTCS status	Report name
Zelandobius auratus McLellan, 1993	Plecoptera	Gripopterygidae	Data Deficient	Data Deficient	Freshwater invertebrates 2018 (Grainger et al. 2018)
Zelandobius crawfordi McLellan, 2008	Plecoptera	Gripopterygidae	Threatened	Nationally Critical	Freshwater invertebrates 2018 (Grainger et al. 2018)
Zelandobius edwardsi McLellan, 2008	Plecoptera	Gripopterygidae	Threatened	Nationally Critical	Freshwater invertebrates 2018 (Grainger et al. 2018)
Zelandobius inversus McLellan, 1993	Plecoptera	Gripopterygidae	Data Deficient	Data Deficient	Freshwater invertebrates 2018 (Grainger et al. 2018)
Zelandobius mariae McLellan, 1993	Plecoptera	Gripopterygidae	Threatened	Nationally Critical	Freshwater invertebrates 2018 (Grainger et al. 2018)
Zelandobius montanus McLellan, 1993	Plecoptera	Gripopterygidae	Data Deficient	Data Deficient	Freshwater invertebrates 2018 (Grainger et al. 2018)
Zelandoperla maungatuaensis Foster, McCulloch & Waters, 2019	Plecoptera	Gripopterygidae			
Synsphyronus lineatus Beier, 1966	Pseudoscorpiones	Garypidae			
Austrachipteria novazealandica Ermilov & Minor, 2015	Sarcoptiformes	Achipteriidae			
Cultroribula otagoensis Ermilov & Minor, 2015	Sarcoptiformes	Astegistidae			
Dicrotegaeus incurvus Ermilov & Minor, 2015	Sarcoptiformes	Cerocepheidae			
Dicrotegaeus mariehammerae Ermilov & Minor, 2015	Sarcoptiformes	Cerocepheidae			
Lanceoppia (Baioppia) *trapezoides* Ermilov & Minor, 2015	Sarcoptiformes	Oppiidae			
Macrogena abbreviata Ermilov & Minor, 2015	Sarcoptiformes	Ceratozetidae			
Macrogena brevisensilla Ermilov & Minor, 2015	Sarcoptiformes	Ceratozetidae			
Macrogena hexasetosa Ermilov & Minor, 2016	Sarcoptiformes	Ceratozetidae			
Magellozetes crassisetosus Ermilov & Minor, 2015	Sarcoptiformes	Ceratozetidae			
Microlamellarea minuta Ermilov & Minor, 2015	Sarcoptiformes	Lamellareidae			
Pedunculozetes ovatum Ermilov & Minor, 2015	Sarcoptiformes	Chamobatidae			
Porallozetes badamdorji Ermilov & Minor, 2016	Sarcoptiformes	Punctoribatidae			
Pterochthonius roynortoni Ermilov & Minor, 2015	Sarcoptiformes	Atopochthoniidae			
Safrobates gerdi Ermilov & Minor, 2016	Sarcoptiformes	Oribatellidae			
Safrobates insignis Ermilov, Behan-Pelletier & Minor, 2016	Sarcoptiformes	Oribatellidae			

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Endemic invertebrates

Name and authority	Order	Family	NZTCS category	NZTCS status	Report name
Scapheremaeus gibbus Ermilov & Minor, 2015	Sarcoptiformes	Cymbaeremaeidae			
Scapheremaeus luxtoni Ermilov & Minor, 2015	Sarcoptiformes	Cymbaeremaeidae			
Tripiloppia alpina Ermilov & Minor, 2015	Sarcoptiformes	Oppiidae			
Tripiloppia frigida Ermilov & Minor, 2015	Sarcoptiformes	Oppiidae			
Zealandozetes southensis Ermilov, Minor & Behan-Pelletier, 2015	Sarcoptiformes	Maudheimiidae			
Alsolemia cresswelli Climo, 1978	Stylommatophora	Charopidae	Threatened	Nationally Critical	Land Snails 2010: (Mahlfeld et al. 2012)
Costachorema hebdomon McFarlane, 1981	Trichoptera	Hydrobiosidae	At Risk	Naturally Uncommon	Freshwater invertebrates 2018 (Grainger et al. 2018)
Oeconesus angustus Ward, 1997	Trichoptera	Oeconesidae	Threatened	Nationally Critical	Freshwater invertebrates 2018 (Grainger et al. 2018)
Olinga christinae Ward & McKenzie, 1998	Trichoptera	Conoesucidae	Data Deficient	Data Deficient	Freshwater invertebrates 2018 (Grainger et al. 2018)
Philorheithrus harunae Henderson & Ward, 2006	Trichoptera	Philorheithridae	At Risk	Naturally Uncommon	Freshwater invertebrates 2018 (Grainger et al. 2018)
Pseudoeconesus paludis Ward, 1997	Trichoptera	Oeconesidae	Threatened	Nationally Endangered	Freshwater invertebrates 2018 (Grainger et al. 2018)
Tiphobiosis quadrifurca Ward, 1997	Trichoptera	Hydrobiosidae	Data Deficient	Data Deficient	Freshwater invertebrates 2018 (Grainger et al. 2018)
Aceria microphyllae Manson, 1984	Trombidiformes	Eriophyidae			
Diversipes laticaudatus Khaustov and Minor, 2018	Trombidiformes	Scutacaridae			
Pedaculops propinquae Manson, 1984	Trombidiformes	Eriophyidae			
Scutacarus cornutus Khaustov and Minor, 2018	Trombidiformes	Scutacaridae			
Scutacarus incisus Khaustov and Minor, 2018	Trombidiformes	Scutacaridae			

Forty vascular plant taxa are endemic to Otago (Table 4). The most speciose order was Asterales with 11 taxa, then Boraginales and Poales with seven taxa, Capparales with three taxa, Araliales, Rosales, and Thymelaeales with two taxa, and Apiales, Caryophyllales, Fabales, Oxalidales, Ranunculales and Violales all with one taxon.

Thirty-four regionally endemic vascular plants have had their conservation status assessed nationally (Table 4; de Lange et al. 2024), while all 40 taxa had their conservation status assessed regionally (Table 4; Jarvie et al. 2025). In the recent regional threatened classification 20 species were assessed as Regionally Threatened (Regionally Critical = 13; Regionally Endangered = 4; Regionally Vulnerable = 3), 16 species were Regionally At Risk (Regionally Declining = 3; Regionally Naturally Uncommon = 13) and four taxa were Regionally Data Deficient.

Table 4. Regionally endemic vascular plants species in Otago. The New Zealand Threat Classification System (NZTCS) and Regional Threat Classification System (RTCS) categories and statuses are provided from de Lange et al. 2024 and Jarvie et al. 2025, respectively.

Name and authority	Common name	Order	Family	NZTCS category	NZTCS status	RTCS category	RTCS status
Abrotanella patearoa Heads		Asterales	Asteraceae	At Risk	Naturally Uncommon	Regionally At Risk	Regionally Naturally Uncommon
Acaena aff. *rorida* (OTA 59561; Pool Burn)	bidibidi	Rosales	Rosaceae	Threatened	Nationally Critical	Regionally Threatened	Regionally Critical
Acaena tesca B.H.Macmill.	bidibidi	Rosales	Rosaceae	Not Threatened	Not Threatened	Regionally At Risk	Regionally Naturally Uncommon
Anisotome (b) (CHR 511716); "Otago bog")		Araliales	Apiaceae	At Risk	Naturally Uncommon	Regionally At Risk	Regionally Naturally Uncommon
Anthosachne aprica (Á.Löve & Connor) C.Yen & J.L.Yang	blue wheat grass	Poales	Poaceae	At Risk	Naturally Uncommon	Regionally Threatened	Regionally Vulnerable
Apium "inland saline"		Apiales	Apiaceae			Regionally Threatened	Regionally Critical
Brachyscome humilis G.Simpson & J.S.Thomson	daisy	Asterales	Asteraceae	At Risk	Naturally Uncommon	Regionally At Risk	Regionally Naturally Uncommon
Brachyscome "Taiari"		Asterales	Asteraceae			Regionally Threatened	Regionally Critical
Cardamine sciaphila Heenan	cress	Capparales	Brassicaceae	Threatened	Nationally Critical	Regionally Threatened	Regionally Critical
Carex applanata Thorsen & de Lange		Poales	Cyperaceae	At Risk	Naturally Uncommon	Regionally Threatened	Regionally Endangered
Carex aff. *aucklandica* "Dunstan"		Poales	Cyperaceae			Regionally Data Deficient	Regionally Data Deficient
Carex aff. *wakatipu* (e) (CHR 472041; Bendigo)		Poales	Cyperaceae			Regionally Data Deficient	Regionally Data Deficient
Carmichaelia compacta Petrie	Cromwell broom	Fabales	Fabaceae	At Risk	Naturally Uncommon	Regionally At Risk	Regionally Declining
Celmisia haastii var. *tomentosa* G.Simpson & J.S.Thomson	daisy	Asterales	Asteraceae	At Risk	Naturally Uncommon	Regionally At Risk	Regionally Naturally Uncommon
Celmisia lindsayi Hook.f.	Lindsay's daisy	Asterales	Asteraceae	At Risk	Naturally Uncommon	Regionally At Risk	Regionally Naturally Uncommon
Craspedia argentea Breitw. & K.A.Ford, sp. nov.		Asterales	Asteraceae	Threatened	Nationally Critical	Regionally Threatened	Regionally Critical
Craspedia (ll) (CHR 629757; Otago)		Asterales	Asteraceae	Not Threatened	Not Threatened	Regionally Data Deficient	Regionally Data Deficient
Craspedia (y) (CHR 516260; Cape Saunders)		Asterales	Asteraceae	Threatened	Nationally Critical	Regionally Threatened	Regionally Critical
Festuca matthewsii subsp. *pisamontis* Connor		Poales	Poaceae	At Risk	Naturally Uncommon	Regionally At Risk	Regionally Naturally Uncommon
Gingidia grisea Heenan		Araliales	Apiaceae	At Risk	Naturally Uncommon	Regionally At Risk	Regionally Declining
Helichrysum simpsonii subsp. tumidum (Cheeseman) de Lange & Blanchon		Asterales	Asteraceae	Threatened	Nationally Vulnerable	Regionally Threatened	Regionally Vulnerable
Kelleria villosa var. *barbata* Heads		Thymelaeales	Thymelaeaceae	At Risk	Naturally Uncommon	Regionally At Risk	Regionally Naturally Uncommon
Leptinella aff. *pectinata* (a) (CHR 580894; Nevis)		Asterales	Asteraceae	Threatened	Nationally Vulnerable	Regionally Threatened	Regionally Vulnerable
Lepidium crassum Heenan & de Lange	thick-leaved scurvy grass	Capparales	Brassicaceae	Threatened	Nationally Endangered	Regionally Threatened	Regionally Endangered
Lepidium kirkii Petrie	salt-pan cress	Capparales	Brassicaceae	Threatened	Nationally Critical	Regionally Threatened	Regionally Critical
Luzula traversii var. *tenuis* Edgar	wood-rush	Poales	Juncaceae	At Risk	Naturally Uncommon	Regionally Threatened	Regionally Endangered
Melicytus aff. *crassifolius* (b) (CHR 616706; Cape Saunders)		Violales	Violaceae	Threatened	Nationally Critical	Regionally Threatened	Regionally Critical
Montia aff. *fontana* (CHR 681612; "Otago alpine flush")		Caryophyllales	Montiaceae			Regionally At Risk	Regionally Naturally Uncommon
Myosotis albosericea Hook.f.		Boraginales	Boraginaceae	Threatened	Nationally Critical	Regionally Threatened	Regionally Critical
Myosotis bryonoma Meudt, Prebble & Thorsen	forget-me-not	Boraginales	Boraginaceae	At Risk	Naturally Uncommon	Regionally At Risk	Regionally Naturally Uncommon

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Regionally endemic species in Otago

Endemic vascular plants

Name and authority	Common name	Order	Family	NZTCS category	NZTCS status	RTCS category	RTCS status
Myosotis goyenii Petrie subsp. *goyenii*		Boraginales	Boraginaceae	At Risk	Naturally Uncommon	Regionally At Risk	Regionally Declining
Myosotis hikuwai Meudt et al. 2022.		Boraginales	Boraginaceae	Threatened	Nationally Endangered	Regionally Threatened	Regionally Endangered
Myosotis oreophila Petrie		Boraginales	Boraginaceae	Threatened	Nationally Critical	Regionally Threatened	Regionally Critical
Myosotis umbrosa Meudt, Prebble & Thorsen		Boraginales	Boraginaceae	Threatened	Nationally Critical	Regionally Threatened	Regionally Critical
Oxalis aff. *magellanica* (CHR 472028: "Otago alpine flush")		Oxalidales	Oxalidaceae			Regionally At Risk	Regionally Naturally Uncommon
Pimelea sericeovillosa subsp. *alta* C.J.Burrows		Thymelaeales	Thymelaeaceae	At Risk	Naturally Uncommon	Regionally At Risk	Regionally Naturally Uncommon
Poa pygmaea Buchanan		Poales	Poaceae	At Risk	Naturally Uncommon	Regionally At Risk	Regionally Naturally Uncommon
Solenogyne christensenii (Petrie) de Lange, Jian Wang ter & Barkla, comb. nov.		Asterales	Asteraceae	Threatened	Nationally Critical	Regionally Threatened	Regionally Critical
Ranunculus (c) (CHR 472008; Garvie Range)		Ranunculales	Ranunculaceae	Data Deficient	Data Deficient	Regionally At Risk	Regionally Naturally Uncommon

In Otago six lizard species are regional endemics (Table 5). Of these six, three are skinks and three are geckos. Two of the largest, most colourful species of skinks in Aotearoa New Zealand are the regionally endemic Otago skink (*O. otagense*) and grand skink (*O. grande*). Shiny black with bold blotches of gold, the Otago skink can reach 30 cm in length on a heavy-set body and is a true giant among the country's endemic skinks. The grand skink is a little smaller and more svelte than the Otago skink, and its black skin is peppered with tiny golden flecks. A small alpine skink is the third regionally endemic skink and is restricted to two populations in inland Otago; it is known as the Burgan skink (*O. burganae*). The three gecko species that are endemic to Otago belong to the *Woodworthia* species complex: Raggedy Range gecko (*W.* "Raggedy"), schist gecko (*W.* "Central Otago"), and the Kawarau gecko (*W.* "Cromwell"). These three gecko species are medium-sized, with diurno-noctural activity patterns, and typically occur in rocky habitats. All six regionally endemic lizards are at risk or threatened with extinction as assessed in the national and regional threat classifications (Hitchmough et al. 2021; Jarvie et al. 2024).

Table 5. Regionally endemic reptile species in Otago. The New Zealand Threat Classification System (NZTCS) and Regional Threat Classification System (RTCS) categories and statuses are provided from Hitchmough et al. 2021 and Jarvie et al. 2024, respectively.

Name and authority	Common name	NZTCS category	NZTCS status	RTCS category	RTCS status
Oligosoma burganae Chapple et al., 2011	Burgan skink	Threatened	Nationally Endangered	Regionally Threatened	Regionally Vulnerable
Oligosoma grande (Gray, 1845)	grand skink	Threatened	Nationally Endangered	Regionally Threatened	Regionally Endangered
Oligosoma otagense (McCann, 1955)	Otago skink	Threatened	Nationally Endangered	Regionally Threatened	Regionally Endangered
Woodworthia "Central Otago"	schist gecko	At Risk	Declining	Regionally At Risk	Regionally Declining
Woodworthia "Cromwell"	Kawarau gecko	At Risk	Declining	Regionally At Risk	Regionally Declining
Woodworthia "Raggedy"	Raggedy Range gecko	Threatened	Nationally Vulnerable	Regionally Threatened	Regionally Vulnerable

In Otago two bryophytes are regionally endemic (Table 6). One of these species is a liverwort (*Neolepidozia patentissima* var. *ampliata*, with a national threat assessment of Data Deficient), while the other is a moss (*Conostomum pusillum* var. *otagoensis*, whose threat status has not yet been nationally assessed).

Table 6. Regionally endemic bryophyte species in Otago. The New Zealand Threat Classification System (NZTCS) category and status for the liverwort is from de Lange et al. 2020.

Name and authority	Order	NZTCS category	NZTCS status	Functional group
Neolepidozia patentissima var. *ampliata* (J.J. Engel & G.L.Sm.) E.D. Cooper	Jungermanniales	Data Deficient	Data Deficient	liverwort
Conostomum pusillum var. *otagoensis* Fife	Bartramiales			moss

The only regionally endemic bird species is the Otago shag/matapo, i.e., known to currently exclusively breed in the region (Table 7). Although a Holocene fossil and archaeological midden assemblages indicate a former wider distribution across the eastern Te Waipounamu/South Island, following human arrival the species became restricted to rocky cliffs and islands off Otago. The Otago shag has recently extended their range northwards and southwards, and now occur from the southern Catlins north towards the Waitaki River. Using updated information released since national assessment, research suggests the species is not having a population increase > 10% but would have a stable count of ±10 % between 2007 and 2021 (Parker & Rexer-Huber 2022). This is why there is a difference between the national status and the regional status.

Table 7. Regionally endemic bird species in Otago. The New Zealand Threat Classification System (NZTCS) category and status is from Robertson et al. 2021 and the Regional Threat Classification (RTCS) category and status is from Jarvie et al. 2025.

Name and authority	Common name	Māori name	NZTCS category	NZTCS status	RTCS category	NZTCS status
Leucocarbo chalconotus G.R. Gray, 1845	Otago shag	matapo	Threatened	Nationally Increasing	Regionally Threatened	Regionally Vulnerable

Nine freshwater fishes are endemic to the Otago region, all of which are Galaxiid species (Table 8). There are two slim and slender species from the pencil galaxias group – lowland longjaw galaxias (*Galaxias cobitinis*) and alpine galaxias (Manuherikia River) (*G.* aff. *paucispondylus* “Manuherikia”), and seven belong to the cigar-shaped *Galaxias vulgaris* species complex: central Otago roundhead galaxias (*G. anomalus*), Taieri flathead galaxias (*G. depressiceps*), Eldon’s galaxias (*G. eldoni*), dusky galaxias (*G. pullus*), Teviot flathead galaxias (*G.* “Teviot”), Clutha flathead galaxias (*G.* “species D”), and Nevis galaxias (*G.* “Nevis”). All of Otago’s endemic freshwater fishes are threatened with extinction (Dunn et al. 2018).

Table 8. Regionally endemic freshwater fishes in Otago. The New Zealand Threat Classification System (NZTCS) categories and statuses are provided from Dunn et al. 2018.

Name and authority	Common name	NZTCS category	NZTCS status
Galaxias anomalus Stokell, 1959	central Otago roundhead galaxias	Threatened	Nationally Endangered
Galaxias cobitinis McDowall & Waters, 2002	lowland longjaw galaxias (Kakanui River)	Threatened	Nationally Critical
Galaxias depressiceps McDowall & Wallis, 1996	Taieri flathead galaxias	Threatened	Nationally Vulnerable
Galaxias eldoni McDowall, 1997	Eldon’s galaxias	Threatened	Nationally Endangered
Galaxias pullus McDowall, 1997	dusky galaxias	Threatened	Nationally Endangered
Galaxias "Teviot"	Teviot flathead galaxias (Teviot River)	Threatened	Nationally Critical
Galaxias aff. *paucispondylus* "Manuherikia"	alpine galaxias (Manuherikia River)	Threatened	Nationally Endangered
Galaxias "Nevis"	Nevis galaxias (Nevis River)	Threatened	Nationally Endangered
Galaxias “species D”	Clutha flathead galaxias	Threatened	Nationally Critical

Summary and conclusions

The Otago Region has a diverse biota (fauna, flora and fungi) reflecting the region's contemporary landscapes, geological past and climatic history. Alpine areas, river valleys, dryland ecosystems and coastal landscapes are among the many ecosystems that contribute to this biodiversity.

For most taxonomic groups, the process of obtaining data and verifying regional endemics within the Otago region worked well, particularly with the data-driven approach trialled. However, it would be highly valuable to have all institutions in Aotearoa New Zealand provide data to GBIF as a central aggregator of biodiversity information. This would enhance access to data and provide better taxonomic and geographical coverage.

Endemic species

A total of 360 species were identified as regionally endemic to Otago. Although it is often difficult to create lists of endemic species for a region, with the traditional approach being to create a list by sifting through published literature, examining specimens in collections, and/or conducting new sampling. However, these are time consuming tasks, typically done by a researcher with a restricted taxonomic focus. The combination of the data-driven and traditional approaches has made regionally endemic lists of species feasible.

Because of the increasing number of digital records now makes such a task much easier and taxonomically more comprehensive, the data-driven approach used in this report to generate a preliminary regional list of endemic species worked well. For example, it returned several well-known endemic species, such as the Cromwell chafer beetle (*Prodontria lewisi*), speargrass weevil (*Lyperobius cupiendus*), Maungatua stonefly (*Zelandoperla maungatuaensis*), salt pan cress (*Lepidium kirkii*), Cromwell broom (*Carmichaelia compacta*), Otago skink (*Oligsoma otagense*), grand skink (*O. grande*), among many others.

Despite this, the endemic list should be considered preliminary. The biggest issue is that the list has been created with incomplete digital information about almost all the species. Consequently, the extent of the geographical distribution is also likely to be incomplete (although there are some exceptions; for example, the Cromwell chafer beetle, the Maungatua stonefly, salt pan cress and the grand skink).

Greater confidence could be obtained by:

A. Digitising all specimens that already exist in taxonomic collections
B. Undertaking new field surveys to better delimit a species distribution (e.g., it is likely that some of the regionally endemic species listed in this report will also be present in the Southland and Canterbury regions).

Taxa that are potentially regionally endemic that do not appear in this report should be reported to the Otago Regional Council for future assessment and inclusion in subsequent reports. Future reports intend to also focus on regional endemic lists for species from lesser-known taxonomic groups, e.g., fungi, freshwater invertebrates, spiders.

Recommendations

- Complete compilation of regional endemic lists for species from lesser-known taxonomic groups.
- Support initiatives to digitise all specimens and samples of endemic species in the Otago Region. This will give important information on their geographical distributions.
- Encourage institutions to become data providers to GBIF as a central aggregator of biodiversity information. This will enhance access to data and provide better taxonomic and geographical coverage.
- Encourage and support national initiatives on the digitisation of specimens and the georeferencing of locality information.

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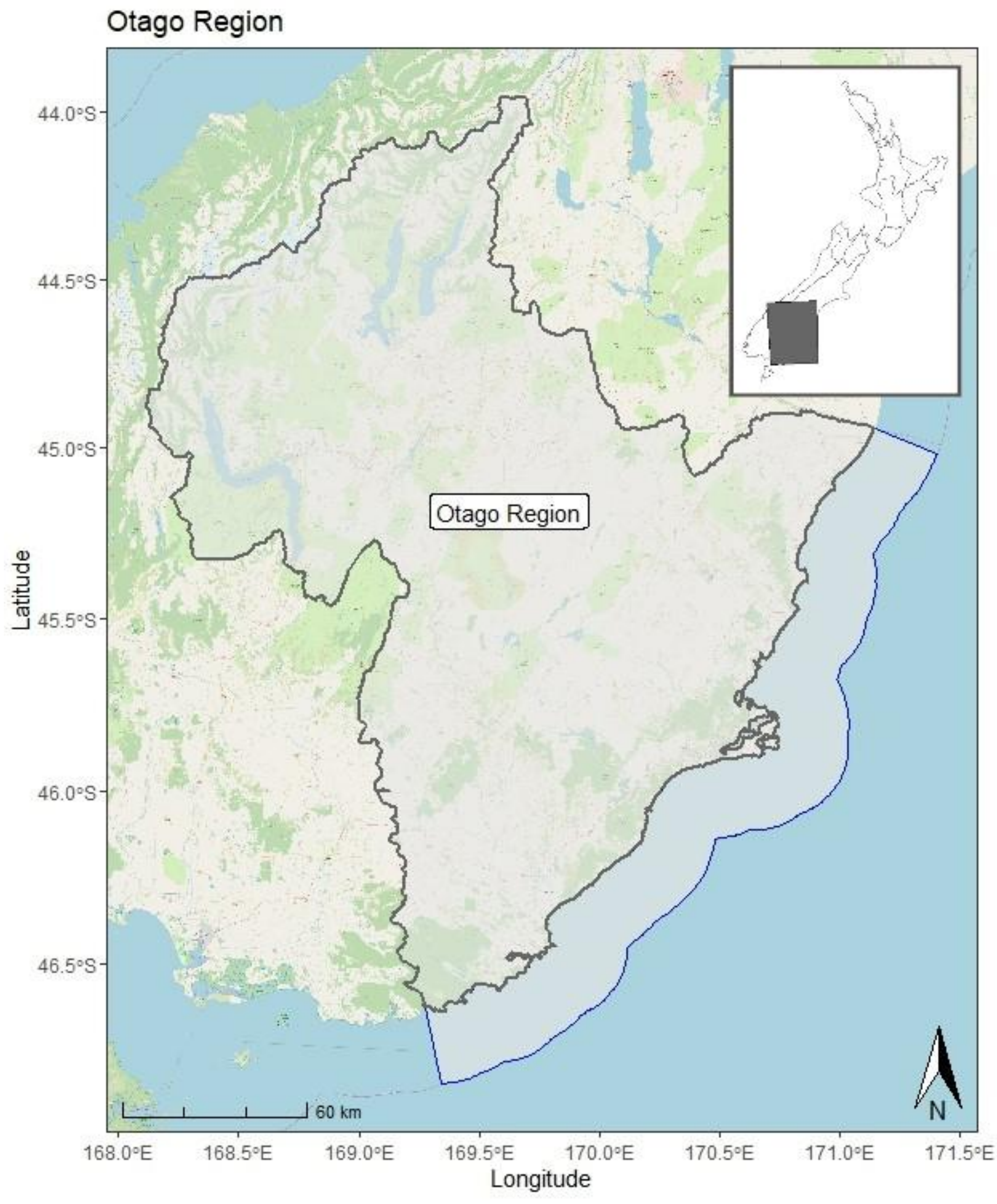
Appendices



Appendix 1: Map of the Otago Region, showing the coastal marine area. Inset map shows Otago in relation to the remainder of Aotearoa New Zealand

Find out more:
www.orc.govt.nz/environment/biodiversity/

Otago Regional Council

9.8. Recreational Water Quality Annual Report

Prepared for:	Science and Resilience Committee
Report No.	GOV2562
Activity:	Governance Report
Author:	Helen Trotter, Scientist - Water Quality
Endorsed by:	Tom Dyer, General Manager Science and Resilience
Date:	4 June 2025

PURPOSE

[1] The contact recreation programme monitors faecal indicator bacteria and potentially toxic cyanobacteria across 16 freshwater and 16 coastal sites in the Otago Region to assess risks to human health during the summer bathing period.

[2] This report provides an overview of the programme and accompanies the attached report card summarising the results of weekly monitoring undertaken during the 2024-25 season.

EXECUTIVE SUMMARY

[3] The contact recreation monitoring programme assesses recreational water quality at primary contact sites weekly between December and March each year. Faecal indicator bacteria *Escherichia coli* (freshwater) and enterococci (coastal/saltwater) are measured as a proxy for the presence of pathogens that may cause illness when ingested.

[4] Cyanobacteria (toxic algae) can form nuisance blooms and produce harmful cyanotoxins. In rivers they bloom as dense mats on the stream bed (benthic cyanobacteria), and in lakes they typically float in the water column (planktonic cyanobacteria).

[5] Microbial water quality and cyanobacteria results are assessed against national guidelines and reported on the Land Air Water Aotearoa (LAWA) website. Otago Regional Council (ORC) notifies Health New Zealand - Te Whatu Ora of results that exceed the guidelines, and health warnings are issued according to the programme protocols.

[6] In the 2024-25 season, 509 routine samples from 32 primary contact sites were analysed for faecal indicator bacteria. Ninety-three percent of samples indicated water quality was ‘suitable for swimming’ at the time of sampling.

[7] For 14 samples (3%) across 12 sites, bacteria concentrations indicated the site was ‘unsuitable for swimming’ at the time of sampling and a health warning was issued. A further 17 results (3%) across seven sites, met the ‘caution advised’ guideline due to slightly elevated bacteria concentrations.

[8] ORC sampled weekly for cyanobacteria at six lake sites and five river sites. Planktonic cyanobacteria blooms were identified at three lakes (Butchers Dam, Lake Waihola and Upper Tomahawk Lagoon), and levels triggered the ‘action’ (red mode) guideline and requiring public health warnings. Benthic cyanobacteria cover did not exceed the ‘surveillance’ (green mode) guideline at the monitored river sites.

[9] Long-term *E. coli* grades for freshwater sites show that 67% of freshwater primary contact sites are 'excellent' or 'good'. Four sites (35%) are graded 'poor': Taieri River at Waipiata, Taieri River at Outram, Waikouaiti River at Bucklands, and Manuherekia River at Shaky Bridge. For coastal sites, 88% of sites are graded 'excellent/very good' or 'good' and just one site, Otokia Creek at Brighton, is graded 'poor'.

RECOMMENDATION

That the Committee:

1) ***Notes** this report.*

BACKGROUND

[10] The ORC recreational water quality monitoring programme and response protocols are implemented annually, in accordance with the National Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (MfE and MoH, 2003), the New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters: Interim Guidelines (MfE and MoH, 2009) and the National Policy Statement – Freshwater Management 2020 (NPS-FM).

[11] Human contact (for recreation) is a compulsory value of freshwater under the NPS-FM relating to how people connect with the water through recreational activities such as swimming, boating, and fishing. This value has three compulsory attributes.

[12] The 'E. coli (primary contact sites)' attribute, described in the NPS-FM (Appendix 2B, Table 22), assesses the condition of primary contact sites based on five years of weekly monitoring during the bathing season only.

[13] Two further attributes, 'Escherichia coli (E. coli)' and 'Cyanobacteria (planktonic)', are assessed on long-term, year-round data collected at State of the Environment sites. ORC reports these data in State of the Environment water quality reports (at least five-yearly).

[14] Long-term performance for coastal sites is assessed according to Microbiological Assessment Categories (MACs) outlined by the national guidelines (MfE and MoH, 2003).

[15] The annual report card presents a summary of the results for 2024-25 monitoring period and long-term grades for freshwater and coastal sites for the last five summers (2020-21 to 2024-25).

DISCUSSION

[16] Bacteria concentration exceedances in the 2024-25 season were most often associated with moderate to heavy rainfall in the preceding 72 hrs. Increased run-off from urban and rural land carries contaminants to waterways and is associated with elevated bacteria concentrations. ORC's communications about contact recreation emphasise the risk of elevated bacteria concentrations following rainfall (e.g. see page 4 of attached report card).

[17] Exceedances of the guidelines were notified to the Health New Zealand – Te Whatu Ora and territorial authorities and were shared with the community in accordance with the programme communications plan.

[18] Over 100 customer enquiries and media requests relating to the programme were received during the monitoring period. In response to reports from the public a number of additional site visits were made, typically to assess the presence of suspected algae blooms. Two instances (Lake Johnson and Aronui Dam) samples found cyanobacteria biovolumes at 'action' levels and health warnings were issued.

[19] Science staff have been proactive with communities where there are frequent exceedances to provide context and further information about the results.

[20] There are four freshwater sites with 'poor' long-term grades. These are in catchments affected by run-off from agricultural land-use (Taieri River at Waipiata, Taieri River at Outram, Waikouaiti River at Bucklands, and Manuherekia River at Shaky Bridge). Previous faecal source tracking (FST) analyses have identified ruminant sources at Manuherekia River at Shaky Bridge, Waikouaiti River at Bucklands and Taieri River at Waipiata, and avian sources at Taieri River at Outram and Manuherekia River at Shaky Bridge.

[21] One coastal site has a 'poor/D' long-term grade – Otokia Creek at Brighton. This coastal creek is prone to elevated bacteria levels particularly after heavy rainfall and when the creek mouth is closed (i.e. reduced flushing of water). Previous FST investigations have identified avian sources at the site.

[22] The long-term grade changed for one site following the 2024-25 season:

- Pacific Ocean at Tomahawk Beach West: 'fair' to 'good'
  This site is monitored by the Dunedin City Council as part of the consent requirements for the Tahuna Wastewater Treatment Plant. The grade change can be attributed to several elevated results in the 2019-20 season not being included in the latest five-year period, and two years with no exceedances in the current period.

[23] Long-term grades are determined based on 95th-percentile results so a small number of high results can influence the grade. A site with ongoing faecal contamination and one with just one or two exceedances following high rainfall might both be classified as 'poor'. It is, therefore, useful to consider the percentage of samples exceeding the guidelines over the five-year period, alongside the long-term grade to understand the overall suitability of a site for recreation (see Appendix 2 of the attached annual report card).

[24] Programme changes in the 2024-25 season included removal of Waianakaurua River at Graves Dam from the site schedule. This site was sampled for two seasons (2022-23 and 2023-24) and was found to have very frequent exceedances associated with upstream gull colonies (as identified by FST investigations). A permanent advisory sign was erected at the site. This scenario is similar that previously identified at Kakanui River at Clifton Falls which is also affected by avian sources.

[25] This determination is in line with national guidance (MoE and MoH, 2003) which recommends that for sites with very poor grades, where exceedances of the guidelines are very frequent and where significant sources of faecal contamination have been identified (including for example dense bird populations), weekly monitoring is not justified unless significant change in the catchment characteristics has occurred.

[26] Routine duplicate sampling for FST at all sites was discontinued this season. As a result of previous analyses over several years the key contamination sources at the sites which most frequently exceed the guidelines have been adequately identified. To improve efficiency future application of FST will be directed to targeted, site specific investigations.

[27] A trial of a new continuous sensor for E. coli was to be undertaken at Manuherekia River at Shaky Bridge. After a delayed delivery from the supplier the sensor was installed in March, however soon thereafter experienced a fault. The sensor has been returned to the supplier and the trial is expected to recommence in the next monitoring period (summer 2025-26).

CONSIDERATIONS

Strategic Framework and Policy Considerations

[28] This programme supports the enhancing environmental management and healthy water strategic priorities:

- Enhancing access to and communication of data and knowledge
- Monitoring and investigating the health of Otago's fresh and coastal water
- Providing the best available information on Otago's water resources

Financial Considerations

[29] This work is planned and funded through the annual work programme.

Significance and Engagement

[30] During the bathing season (December to March), and in preparation for the season, engagement is ongoing between stakeholders e.g., territorial authorities and Health New Zealand - Te Whatu Ora according to ORC contact recreation monitoring programme and response protocols.

Legislative and Risk Considerations

[31] This report and programme comply with the relevant statutory obligations of ORC, including but not restricted to, the Resource Management Act 1991 and NPS-FM 2020.

[32] The NPS-FM requires councils to develop action plans aimed at improving water quality at sites below the 'national bottom line' (graded 'poor'). This monitoring assists with identifying where action plans are required.

Climate Change Considerations

[33] Programme amendments (to sites, monitoring periods or methods) to consider the effects of climate change will be addressed during the ongoing annual review of the programme.

Communications Considerations

[34] The ORC Communications Team implements the programme communications plan prior to and throughout the contact recreation that includes targeted public awareness messaging and communication of health warnings to the community.

[35] Ongoing public awareness and education about recreational water quality (both microbial and cyanobacteria risks) is required to enable the public to make informed choices about where and when they choose to recreate.

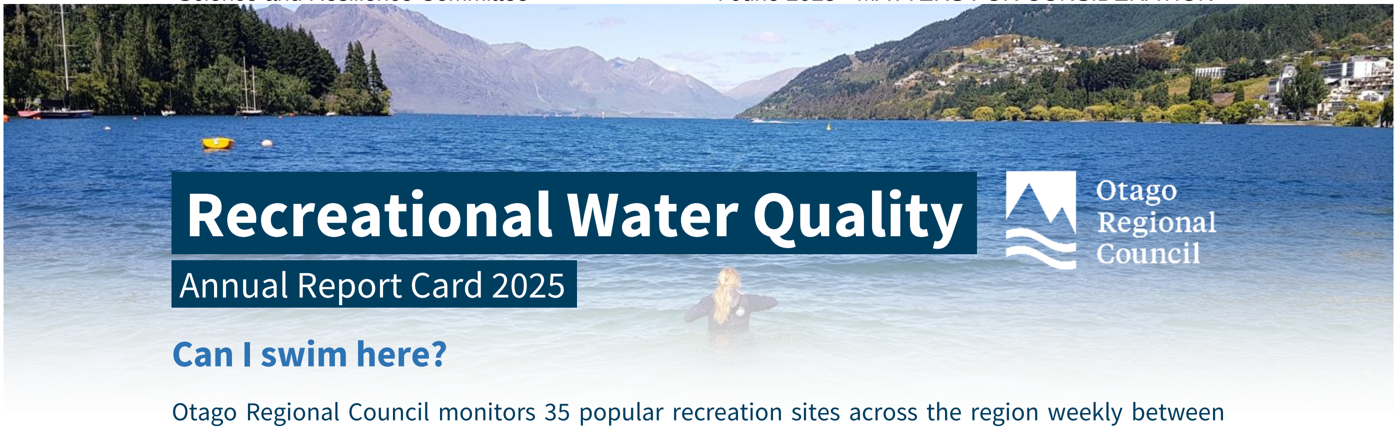
NEXT STEPS

[36] The 2025-26 contact recreation monitoring period will commence in December 2025.

[37] Future work directions include trailing real-time monitoring to improve reporting efficiency, targeted sampling programmes for sites with frequent exceedances to investigate potential contaminant sources and reviewing sites and procedures ahead of each season to ensure the programme maintains appropriate coverage across the region.

ATTACHMENTS

1. Recreational Water Quality annual report card 2025 [**9.8.1** - 6 pages]



Recreational Water Quality

Annual Report Card 2025

Otago Regional Council

Can I swim here?

Otago Regional Council monitors 35 popular recreation sites across the region weekly between December and March.

Samples are tested for *Escherichia coli* (*E. coli*) at 16 freshwater sites and enterococci at 16 coastal sites. These bacteria are indicators of faecal contamination and risk of illness from disease-causing pathogens.

Cyanobacteria or toxic algae risk is also monitored at some of these sites (three lakes and five rivers), as well as a further three lakes sites monitored for cyanobacteria only. Naturally occurring toxic algae can produce cyanotoxins which pose a risk to human and animal health.

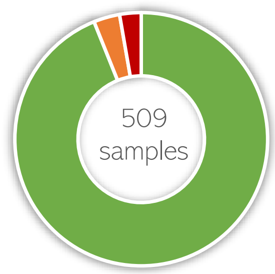
National Microbiological[1] and Cyanobacteria Guidelines[2] are used to assess the results and determine whether the water quality is safe for swimming.

SUITABLE FOR SWIMMING	CAUTION ADVISED	UNSUITABLE FOR SWIMMING
The monitoring result met the national water quality guidelines at the time of testing - safe to swim!	Slightly elevated result at the time of testing. Water quality generally suitable for swimming	High bacterial or algal count exceeding national guidelines at the time of testing

Results are reported on LAWA using a traffic light system and are notified to Te Whatu Ora – Health NZ and district councils when public health warnings are required.

Summer 2024-25 results

Microbial water quality (*E. coli* and enterococci)

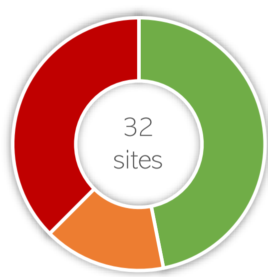


► 509 water samples were collected over the summer monitoring period

► 94 % of samples found water quality was suitable for swimming at the time of sampling

► 3 % of samples exceeded the caution advised guideline due to slightly elevated bacteria levels

► 3 % of samples found water quality was unsuitable for swimming and a health warning was issued to the public



► At 15 sites all samples met the suitable for swimming guidelines. A further five sites were generally safe for swimming but had at least one result with slightly elevated bacteria levels (caution advised).

► Water quality was unsuitable for swimming for at least one sample at 12 sites – for most of these sites this meant single high bacteria result typically following rainfall in the catchment.

Results for each site are presented in **Appendix 1.**

Cyanobacteria (toxic algae)

Toxic algal blooms were observed in three of the six monitored lakes (e.g. Figure 1) and health warnings were issued for these sites. A permanent warning sign was installed at Butchers Dam as in recent years this site has been prone to persistent toxic algal blooms throughout the summer months (Figure 2). Toxic algae did not exceed the % coverage guidelines at any of the five river sites monitored for recreational water quality.

Warnings were issued for an additional three river sites and one lake site where high levels of toxic algae were identified during other routine monitoring activities:

▶ **Lakes**	Butchers Dam, Lake Waihola, Upper Tomahawk Lagoon, Lake Johnson, Aronui Dam
▶ **Rivers**	Manuherekia River (multiple sites), Dunstan Creek, Cardrona River

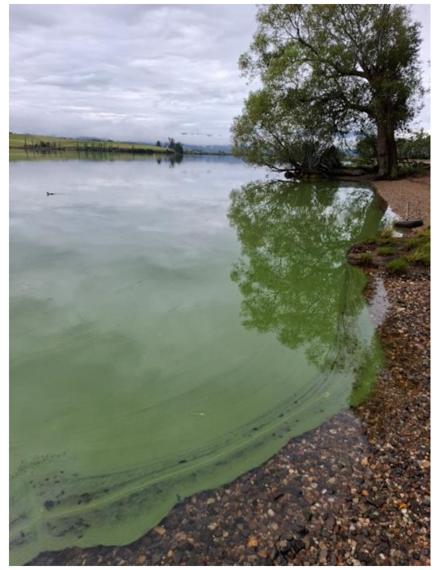


Figure 1. Cyanobacteria (toxic algae) bloom at Lake Waihola, December 2024

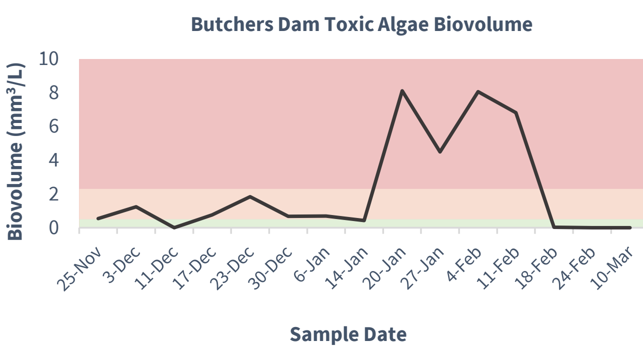


Figure 2. Biovolume (mm^3/L) of toxic algae from weekly samples at Butchers Dam (near Alexandra) during the 2024-25 summer monitoring period. Action, Alert and Surveillance alert level thresholds are shown by the coloured bands.

What causes high bacteria levels?

Faecal indicator bacteria like *E. coli* live in the gut of warm-blooded animals and are introduced to the environment through animal droppings, effluent, wastewater discharges and stormwater run-off. When it rains contaminants from rural and urban land are carried to our waterways in run-off and stormwater. This means that even sites with good water quality can have high bacteria levels at times, following heavy rainfall. For some sites other factors can contribute to more frequent exceedances of bacteria guidelines. These may be both natural sources e.g. gull colonies, and as a result of human activities e.g. wastewater discharges or animal agriculture.

Most instances where high bacteria were recorded was associated with rainfall in the 72 hrs prior to sampling (Table 1). There was limited rainfall in the 72 hrs preceding the high bacteria result at Taieri River at Outram (January 6) however the rainfall data shows over 10 mm just outside this window (within 79 hrs).

Exceedances at Tomahawk Beach on January 13 and Waikouaiti River at Bucklands on January 20 were not associated with rainfall. High bacteria levels are relatively uncommon at these sites (i.e. ≤5 % samples in the last five years). Faecal source tracking has previously identified ruminant sources of *E. coli* for the Waikouaiti River. Tomahawk Beach is monitored as part of the consent requirements for the Tahuna Wastewater Treatment Plant.

Table 1. Microbial water quality results exceeding the 'action/unsuitable for swimming' guideline (E. coli (freshwater) 540 MPN/100 mL; Enterococci (coastal) 280 MPN/100 mL) and preceding rainfall (up to 72 hrs) for monitored primary contact sites in the 2024-25 bathing period.

Date	Site	Count (MPN/100 mL)		Rainfall (mm)		
		E. coli	Enterococci	00-24 hr	25-48 hr	49-72 hr
9/12/2024	Otago Harbour at Macandrew Bay		594	0.2	4	1.2
16/12/2024	Lawyers Head Beach		580	0.6	8.6	0.2
23/12/2024	Otokia Creek at Bright Rd Bridge		2380	1	7.4	19.2
30/12/2024	Lake Hawea at Swimming Embayment	980		4	0.5	0
30/12/2024	Otokia Creek at Brighton Rd Bridge		1872	14	0	0
6/01/2025	Taieri River at Outram	1300		0	1.5	1.5
13/01/2025	Tomahawk Beach (East)		360	0	0	2
13/01/2025	Tomahawk Beach (West)		600	0	0	2
20/01/2025	Waikouaiti River at Bucklands	613		0	0	0
27/01/2025	Otokia Creek at Brighton		295	5.8	0.8	0
27/01/2025	Taieri River at Waipiata	980		13.8	0	0
27/01/2025	Clutha River at Dunorling St	649		13	0	0
27/01/2025	Manuherekia River at Shaky Bridge	1300		13	0	0
3/03/2025	Kakanui Estuary		650	3.2	0	0

Long-term Grades

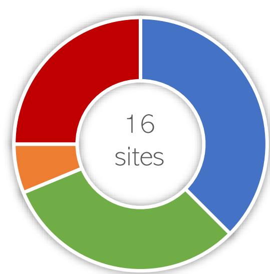
Freshwater Sites: National Policy Statement-Freshwater Management (NPS-FM)

Under the NPS-FM (2020)[3] regional councils are required to assess primary contact sites using the 95th percentile from five years of bathing season monitoring data to categorise sites into four bands or grades (Excellent, Good, Fair and Poor). For the 2020-2025 period:

► Most sites (67 %) are graded Excellent or Good

► Four sites of sites are graded Poor (below the national bottom line)

► For three of the 15 freshwater recreational water quality sites grades are considered interim because the data record is < 5 years.

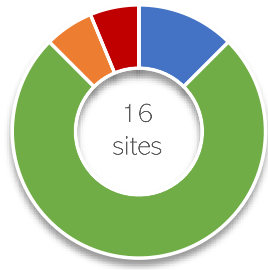


Recreational Water Quality Annual Report Card 2025

Otago Regional Council

Coastal Sites: Microbiological Assessment Categories (MACs)

For coastal sites MAC grades are similarly calculated based on five years of monitoring data to give an indication of general water quality over an extended period. For the 2020-2025 period:



► Most sites (88 %) are graded Excellent or Good

► One site is graded Fair and one site is graded Poor

Long-term grades and the percentage of samples exceeding guidelines are presented in **Appendix 2**.

Want to learn more?

Find factsheets, weekly monitoring results, long-term grades & health warnings for routinely monitored sites at **LAWA www.lawa.org.nz**

Additional toxic algae warnings are listed on the Toxic Algae Notifications page on our website **www.orc.govt.nz/toxic algae**

For information about water quality monitoring in Otago and to access previous reports see our website **www.orc.govt.nz** [Reports and publications – water quality]

References

[1] Ministry for the Environment and Ministry of Health (2003). Microbiological water quality guidelines for marine and freshwater recreational areas. Ministry for the Environment, Wellington.

[2] Ministry for the Environment and Ministry of Health (2009). New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters – Interim Guidelines. Prepared for the Ministry for the Environment and the Ministry of Health by SA Wood, DP Hamilton, WJ Paul, KA Safi and WM Williamson. Wellington: Ministry for the Environment

[3] Ministry for the Environment (2017). National Policy Statement for Freshwater Management 2020 (amended January 2024). Ministry for the Environment, Wellington

Appendix 1 –Recreational water quality 2024-25 monitoring results for primary contact sites in Otago by Freshwater Management Unit (FMU)

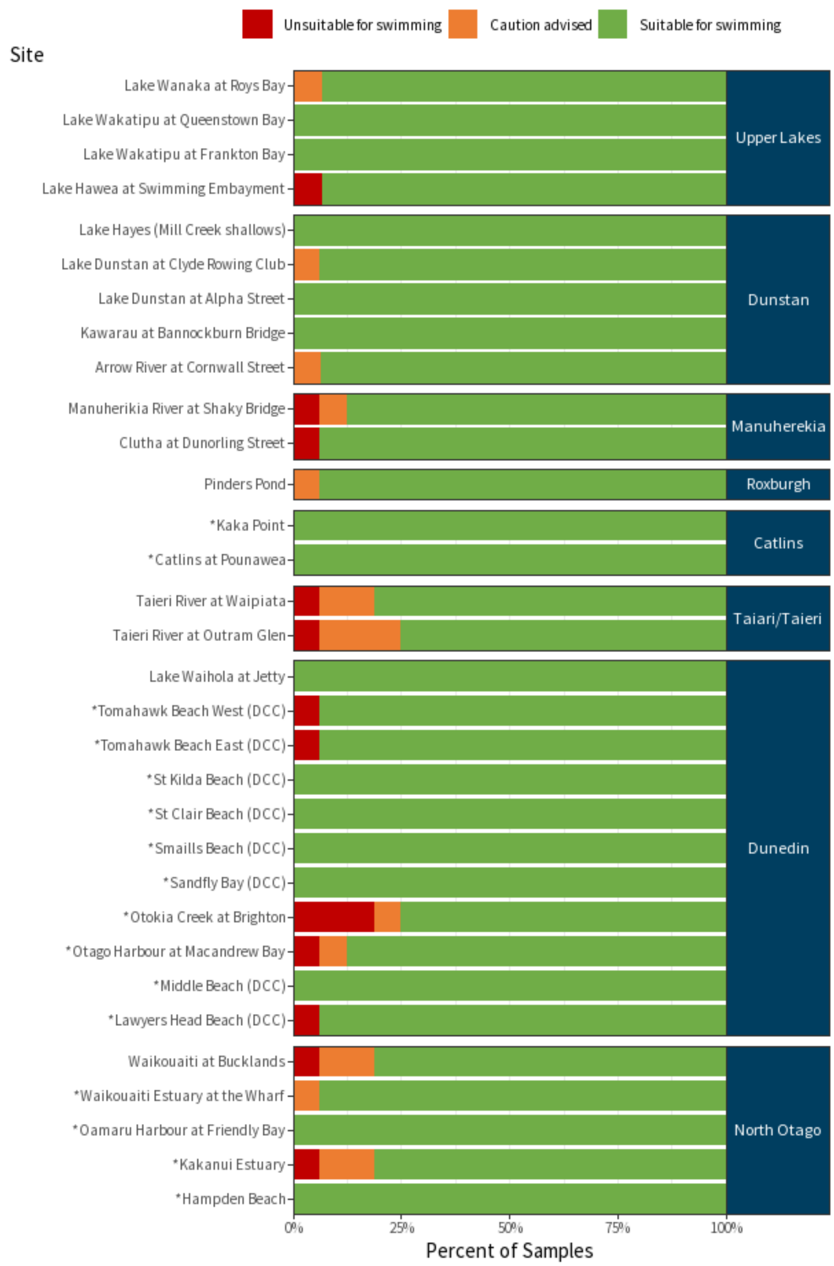


*Figure 3 Percentage of samples (n=16 per site) which met surveillance (suitable for swimming), alert (caution advised) and action (unsuitable for swimming) guidelines for primary contact sites monitored weekly across Otago (grouped by Freshwater Management Unit FMU/Rohe) in the 2024-2025 bathing season. For freshwater sites E. coli concentrations were assessed; for coastal sites (marked *) Enterococci concentrations were assessed.*

Appendix 2 – Long-term (five-year) recreational water quality monitoring results for primary contact sites in Otago

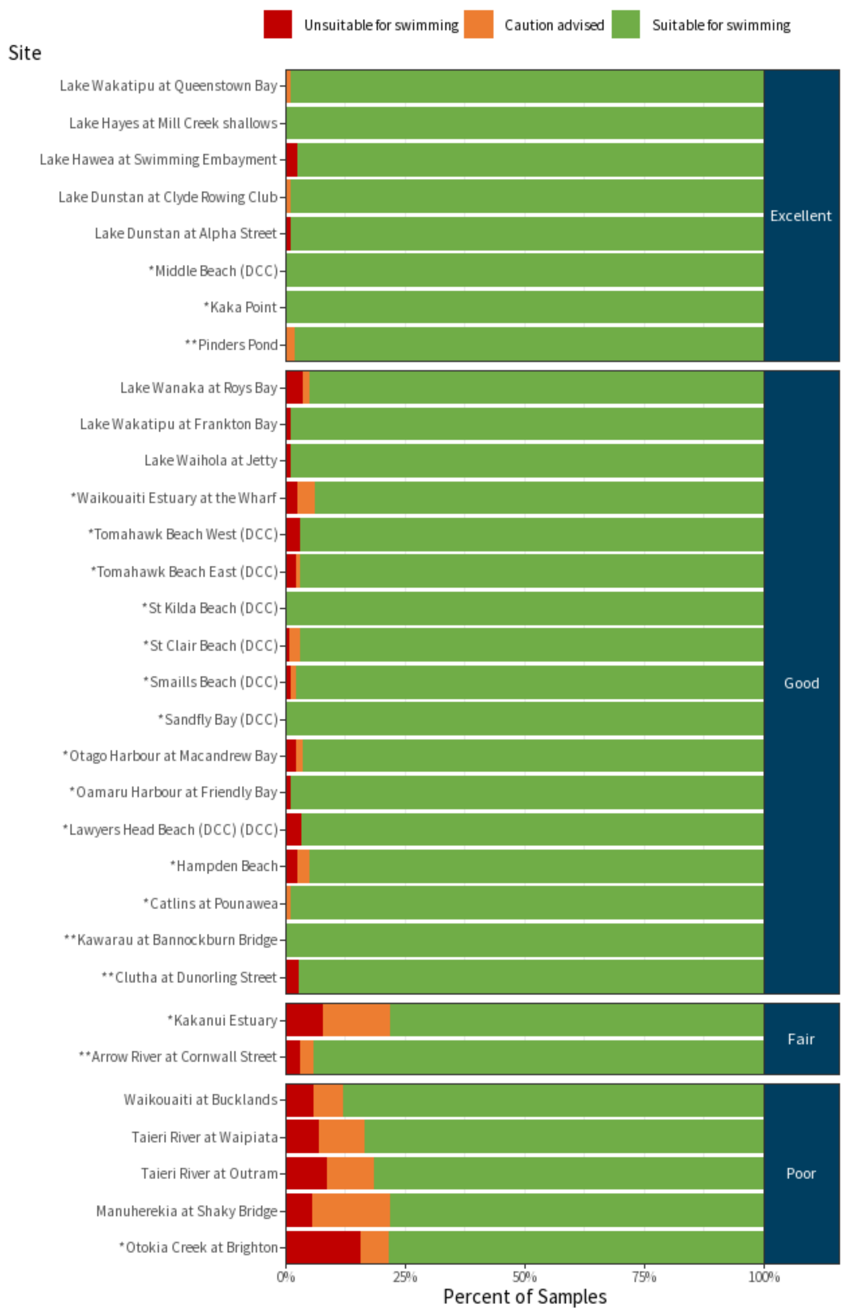


*Figure 4 Percentage of samples over the past five years which met surveillance (suitable for swimming), alert (caution advised) and action (unsuitable for swimming) guidelines for primary contact sites monitored weekly across Otago, grouped by the associated long-term grades (blue panels). Long-term grades are based on hazen 95th percentile results from five seasons of data (2020-21 to 2024-25). For freshwater sites E. coli concentrations were assessed; for coastal sites (marked *) Enterococci concentrations were assessed. Grades are interim for sites monitored for less than five years (**)*

9.9. CDEM Partnership Report

Prepared for:	Science and Resilience Committee
Report No.	OPS2504
Activity:	Governance Report
Author:	Tom Dyer, General Manager Science and Resilience
Endorsed by:	Tom Dyer, General Manager Science and Resilience
Date:	4 June 2025

PURPOSE

[1] To report on Otago Regional Council's (ORC) delivery of its responsibilities under the Otago Civil Defence and Emergency Management Agreement, for the second half of 2024/25.

EXECUTIVE SUMMARY

[2] ORC and the five Otago territorial authorities have responsibilities under the Civil Defence and Emergency Management Act 2002 within the Otago Civil Defence and Emergency Management Group area. Those responsibilities are delivered through Emergency Management Otago with support from each local authority, including ORC. The responsibilities of ORC and four of the five territorial authorities are recorded in the Otago Civil Defence and Emergency Management Agreement (June 2022). ORC's achievement in relation to its functions and responsibilities specified in the Agreement, for the first six months of 2024/25, is summarised as follows:

53 – Achieved
5 – Partially Achieved
1 – Not Achieved
0 – Not Applicable.

RECOMMENDATION

That the Committee

1) ***Notes*** *this report.*

BACKGROUND

[3] ORC and the five Otago territorial authorities have responsibilities under the Civil Defence and Emergency Management Act 2002 within the Otago Civil Defence and Emergency Management Group area. The Group area includes the whole of Waitaki District.

[4] Whilst the Act prescribes governance and oversight arrangements for the Civil Defence and Emergency Management (CDEM) functions undertaken by local authorities, it is silent on the operational arrangements and how they should be structured. This gives the Groups discretion on how they choose to deliver the responsibilities and the associated delivery structure. For the Otago CDEM Group those responsibilities are delivered through Emergency Management Otago with support from each local authority, including ORC (Figure 1). The responsibilities of ORC and four of the five

territorial authorities are recorded in the Otago Civil Defence and Emergency Management Agreement (June 2022)[1].

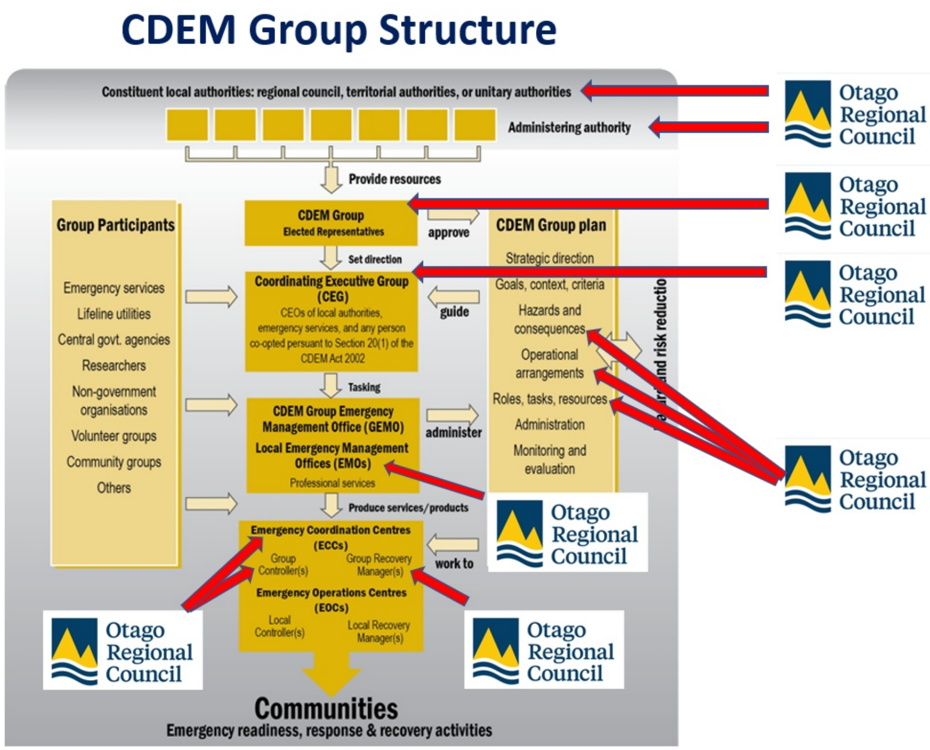


Figure 1: ORC's participation in the Otago CDEM Group.

[5] This report describes ORC's achievements in relation to each of its responsibilities set out in the Agreement. It also provides detail and context for reporting against the 2024/25 Annual Plan measures and targets. Those measures and targets are presented in Figure 2, for reference.

[1] *Emergency Management Otago Partnership Agreement*, Report OPS2104, Report to 25 May 2022 Council.

Level of Service Statements, Measures and Targets

The service statements (LoS), measures and targets for this activity are defined in the table(s) below.

Level of Service: Support the Otago CDEM Group in improving the resilience of Otago to civil defence emergencies.	
Performance measure	**Target**
Support is provided to the Otago CDEM Group as per the CDEM Act and Otago CDEM Partnership Agreement.	Fulfil all requirements as the administering authority

Level of Service: Provide resources to coordinate an efficient and effective region-wide response to a civil defence emergency.	
Performance measures	**Targets**
An adequate Emergency Coordination Centre (ECC) facility and staffing are available.	Adequate staff who are trained and available for any activation of the ECC
	An appropriate facility is available for activation at all times
Maintain response functionality to enable operational situational awareness when ECC activated.	Response solutions are checked as scheduled and any issues remedied

Figure 2: ORC Annual Plan 2023/24 targets for civil defence and emergency management.

DISCUSSION

[6] The functions and responsibilities of ORC under the Agreement are listed in Attachment 1. Achievement against each of those responsibilities for the first half of 2024/25 is noted, with commentary. This is summarised as follows:

53 – Achieved
5 – Partially Achieved
1 – Not Achieved
0 – Not Applicable.

[7] One group declaration was initiated in support of Dunedin City and Clutha Emergency Operations Centres during Heavy Rain event 3-4 October 2024.

[8] ORC staff have been providing technical support to Emergency Management Otago for risk assessment and response planning for the Phoenix Dam near Lawrence. Emergency Management Otago established a D4H[2] channel specifically to facilitate information sharing between stakeholders in monitoring the dam, including developing a dam inspection reporting module to replace a paper-based reporting system.

[9] Works to remediate the dam and reduce the risk downstream communities were completed in the first quarter of 2024/25.

[10] An effective CDEM response is critically dependent on staff capability and capacity. EMO has a core complement of professionally trained staff with a wider pool of trained staff available from ORC. ECC staff capability from 2022 to the end of December 2024 is shown in Figure 3 (available, trained staff) along with target levels recommended by Emergency Management Otago and approved by the Coordinating Executive Group

[2] D4H is the proprietary system used by Emergency Management Otago and its partners to maintain a common operating picture, to manage workflows and to provide ready-access to Standard Operating Procedures.

(CEG)[3]. There is a shortfall of 11 trained staff across the three role-types (Function Team, Function Lead, Controller).

[11] A larger number of ORC staff are potentially available to support ECC operations but not all are trained to the minimum standard. The Function Team staff numbers are the combined totals across all seven Coordinated Incident Management System (CIMS) functions. As a generalisation, ORC staff that are directly involved in responding to flood events (principally from the Engineering, Environmental Monitoring and Natural Hazards teams) are not part of the ECC and are not counted in Figure 3.

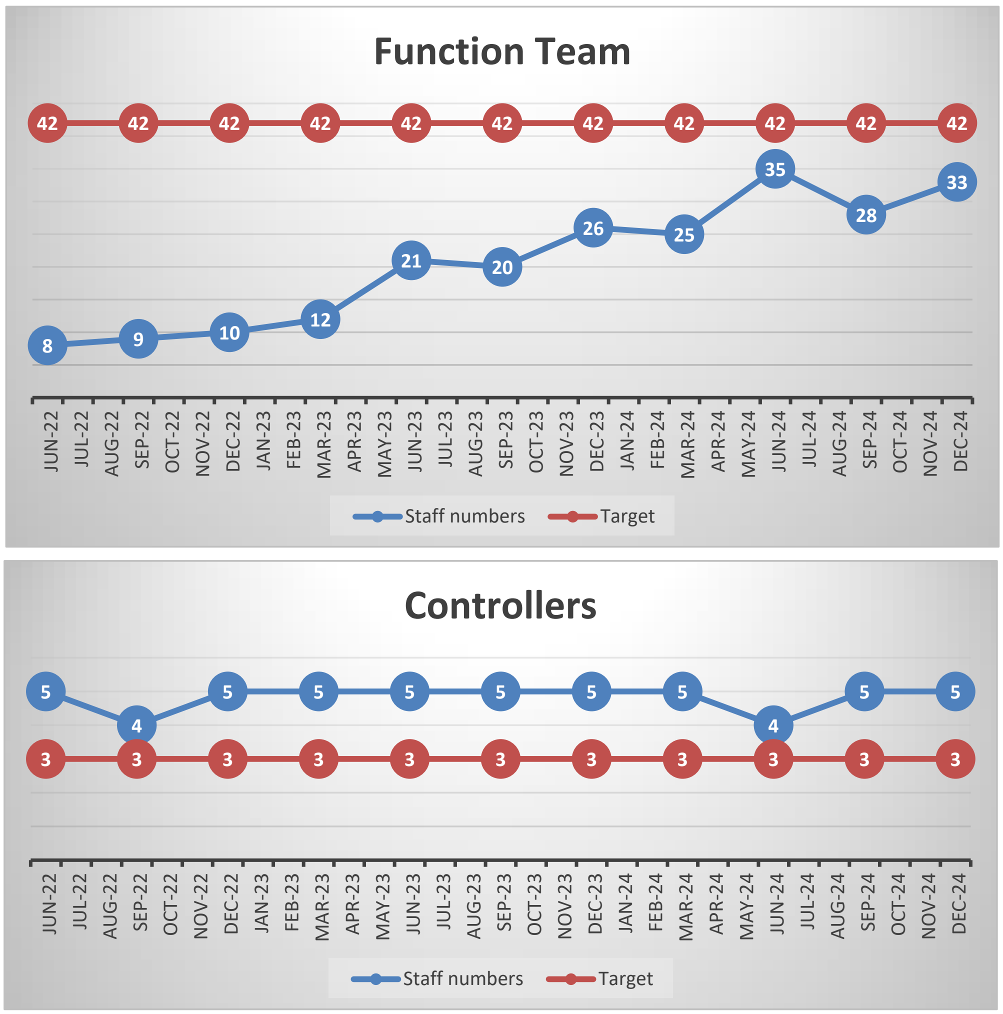


Figure 3: ECC staff capacity and capability (trained staff) during 2022/2023/2024 and the first three months of 2025.

[3] A Function Lead leads one of the following functions as defined in the Coordinated Incident Management System (CIMS) model: Intelligence, Logistics, Operations, Planning, Public Information Management (PIM), Safety, Welfare.

[12] Steps taken to attain and maintain the target levels for staff trained to (or better than) the minimum standard include:

a. Pro-active recruitment within ORC of staff for the ECC.
b. Monthly reporting of ECC staffing levels to the Executive Leadership Team so that levels are actively monitored and managed by ELT.
c. Setting the expectation that ECC responsibilities will be incorporated into performance plans, for staff that fulfil ECC roles.
d. Regular (quarterly) training opportunities for staff that fulfil Function and Function Lead roles, to provide flexibility and allow training to be fitted around other work.
e. Clarity around the budgeting for staff training and exercises, and (from 1 July 2024) centralisation of the budget.

[13] Despite these steps, and the relatively low demand on ORC (less than 20% of total ORC staff), it continues to be difficult to maintain the target levels for staff trained to the minimum standard. Additional actions to recruit staff to resource the ECC will be considered and implemented throughout 2025.

CONSIDERATIONS

Strategic Framework and Policy Considerations

[14] The partnership is aligned with Council's Strategic Directions where the vision states: *communities that are resilient in the face of natural hazards, climate change and other risks*.

Financial Considerations

[15] Financial reporting is part of the Annual Report for 2023/24, and quarterly reporting throughout the 2024/25 year.

Significance and Engagement Considerations

[16] Not relevant.

Legislative and Risk Considerations

[17] There is no legislative requirement for ORC and the rest of the Otago CDEM Group to have a written agreement however an agreement is good practice and reduces risk for all parties by ensuring respective responsibilities are clear.

[18] As noted in the report, it continues to be difficult to maintain the target levels for ORC staff trained to the minimum standard for the ECC.

Climate Change Considerations

[19] Robust and effective CDEM arrangements assist ORC in delivering its climate change adaptation programme of work.

Communications Considerations

[20] Not relevant.

NEXT STEPS

[21] To provide an update to the Safety and Resilience Committee in late 2025 on progress with achievement of the Partnership Agreement responsibilities, for the remainder of 2024/25.

ATTACHMENTS

1. Otago Civil Defence Emergency Management Agreement 2022 Table [**9.9.1** - 11 pages]

Attachment 1 - Otago Civil Defence and Emergency Management Agreement June 2022

🟢 Achieved
🟡 Partially Achieved
🔴 Not Achieved
⚫ Not Applicable

Function	ORC Responsibility	Achievement 2024/25	Achievement 2023/24	Explanation
Business Continuity Management Disruptions are an expected part of business, so it's important to be prepared for when they occur. Disruptions can be internal events that impact on organisation alone (e.g: IT system failure), or external events that could impact across several organisations and locations (e.g., earthquake).	Undertake business continuity planning for Otago Regional Council to be capable of delivering essential services and a functioning Group Emergency Coordination Centre (GECC) during a crisis/ emergency event and through the recovery.	🟡	🟡	Arrangements for the ORC flood team to operate remotely were established and tested during the 2020 pandemic lockdown. ORC does not have a Business Continuity Plan. A Business Continuity Plan is being scoped.
Capability Development, Training and Exercises Training and exercising progressively enhances individuals, local authorities and the Otago CDEM Group's capability to prepare for and manage emergencies and resources, using lessons learnt. The CDEM Group and each member of the Group are to take all steps necessary on an ongoing basis to maintain and provide, or to arrange the provision of, or to otherwise make available suitably trained and	Agree sufficient access to all ORC staff identified in CDEM roles with supervisors to ensure they're available for, attend and complete all competencies associated with training and exercises in accordance with the agreed training schedule.	🟡	🟡	BAU work pressure for ORC has continued to prove a barrier to attendance at training. Sufficient staff have been identified to fill operational roles. The rating reflects the number of trained and capable staff available.

Attachment 1 - Otago Civil Defence and Emergency Management Agreement June 2022

Function	ORC Responsibility	Achievement 2024/25	Achievement 2023/24	Explanation
competent personnel, including volunteers, and an appropriate organisational structure for those personnel, for effective civil defence emergency management.				
Community Resilience and Partnership Community resilience in the Civil Defence and Emergency Management context, can best be described as the community's ability to cope with, bounce back and learn from adversity encountered during and after disasters. There are activities to support in building community resilience. These activities are community engagement, community planning, public education, monitoring and evaluation to measure community resilience. The integration and inclusion of iwi in community resilience activities cements the Otago CDEM principles of Māori partnership.	Support Emergency Management Otago (EMO) and local level Community Resilience activities by commitment of staff resources and technical information to assist in local Community Resilience activities (hazard specific) as required.	●	●	
	Ensure whole-of-council approach to Regional Council Community Resilience activities.	●	●	
Equipment Includes all equipment to support readiness, response and recovery activities.	Fit out and provide associated Information Technology (IT) equipment and infrastructure for EMO staff and GECC facilities (and alternate sites).	●	●	

Attachment 1 - Otago Civil Defence and Emergency Management Agreement June 2022

Function	ORC Responsibility	Achievement 2024/25	Achievement 2023/24	Explanation
	Implement minimum equipment standards required for GECC in line with CDEM Group policy.			
	Own equipment and associated infrastructure, to cover costs to maintain it to an operational standard and to manage and conduct maintenance programme.			
	Provide EMO with furniture and equipment for staff located at Otago Regional Council offices.			
	Undertake fleet management of all Emergency Management Otago vehicles.			
	Procure any priority equipment required by the activated GECC to ensure effective operational capability of the GECC.			Starlink satellite has now been purchased for the ECC facility to increase communication capability.
Facilities Includes any facility to support readiness, response and recovery activities.	Provide and maintain GECC facilities (and alternate facilities) for operational response.			The Philip Laing House Council Chamber has been tested as an alternative ECC during an exercise and shown to have limited functionality. The specifications developed for the ECC in the new Head Office will be used to identify suitable alternative ECC Facilities.
	Provide EMO with fit for purpose office space.			

Attachment 1 - Otago Civil Defence and Emergency Management Agreement June 2022

Function	ORC Responsibility	Achievement 2024/25	Achievement 2023/24	Explanation
	Support the activation of the GECC facility if required for response if requested by the Group Controller.	●	●	
Financial Management The CDEM Group is to ensure allocation of financial budget to ensure effective delivery of the of CDEM services as outlined in the Group Plan.	Provide financial management and accounting services for CDEM Group budget.	●	●	
	Manage, administer and submit reporting to the CDEM Group of Regional Council budgets for regional CDEM delivery.	●	●	
	Provide staff time and travel and accommodation costs associated with attendance at training and exercises.	●	●	
Governance and Management	**Joint Committee**			
	Active participation through appointed designates.	●	●	
	As Administrating Authority provide governance and secretarial support to the Joint Committee.	●	●	
	Provide reports and recommendations on Regional Council matters to the Joint Committee.	●	●	
	Provide reports, decisions and recommendations back to Regional Council on CDEM Group matters	●	●	

Attachment 1 - Otago Civil Defence and Emergency Management Agreement June 2022

Function	ORC Responsibility	Achievement 2024/25	Achievement 2023/24	Explanation
	Coordinating Executive Group (CEG)			
	Active participation through appointed designates and provide support as agreed to lead delivery of the regional CDEM work programme.	●	●	
	Develop and implement specific Regional Council Annual Plan tasking in a Regional Council CDEM work programme with alignment to CDEM Group Annual Plan.	●	●	
	CEG Operations Sub-committee			
	Active participation through appointed designates and support the CEG Sub-committees.	●	●	
	Ensure the alignment of CDEM Group Annual Plan and Regional CDEM work programmes.	●	●	
Hazard and Risk Management In relation to relevant hazards and risks: identify, assess, and manage those hazards and risks; consult and communicate about risks; identify and implement cost-effective risk reduction. Identification of the hazards and risks in a Group area that may result in an emergency that requires national-level support and co-ordination.	Lead identification of hazards (as required) in accordance with the hazard scape outlined in the CDEM Group Plan at the regional level.	●	●	
	Own and manage the hazards (as required) and risk within the appropriate area of responsibility as mandated through the Regional Policy Statement in alignment with the hazardscape detailed in the Otago CDEM Group Plan.	●	●	

Attachment 1 - Otago Civil Defence and Emergency Management Agreement June 2022

Function	ORC Responsibility	Achievement 2024/25	Achievement 2023/24	Explanation
	Fund and manage hazard investigation within the appropriate area of responsibility as mandated through the Regional Policy Statement in alignment with the hazardscape detailed in the Otago CDEM Group Plan	●	●	
	Support effective planning for response through collaboration on hazard risk management for hazards with cross regional and national impacts.	●	●	
Lifeline Utilities Lifeline's failures can disrupt and endanger the wellbeing of local and regional communities. Effective relationships, priority of response protocols and lead agency role definition can reduce the risk such failures may pose. Lifeline utility means an entity named or described in the CDEM Act 2002 in Part A of Schedule 1, or that carries on a business described in the CDEM Act, Part B of Schedule 1.	Lead hazard risk assessment and planning for hazard risk reduction and response activities on key Regional Council services and infrastructure.	●	●	
	Support lifelines projects and activities.	●	●	GIS support has been provided to support the creation of a critical infrastructure viewer within Arc GIS online.
Planning Fundamental to any successful undertaking is attention to planning and preparation. Whilst we pay attention to the plans that are produced, the process of planning is	**Otago CDEM Group Plan**			
	Support, the development, implementation, maintenance, monitoring and evaluation of the Otago CDEM Group Plan.	●	●	

Attachment 1 - Otago Civil Defence and Emergency Management Agreement June 2022

Function	ORC Responsibility	Achievement 2024/25	Achievement 2023/24	Explanation
important to ensure that the plans developed meet the needs of the people affected.	Ensure alignment between the Otago CDEM Group Plan and Regional Council Long Term Plans.	🟢	🟢	
CDEM Groups and agencies are expected to routinely incorporate CDEM arrangements into their business planning and risk management processes, and to regularly monitor and report on their progress as appropriate. This is an important role to play in making progress towards the vision of a 'Resilient New Zealand'.	**Pre-event response action planning**			
	Support development, implementation, maintenance of CDEM response planning for Regional Council.	🟢	🟢	
	Standard Operating Procedures			
	Support the development, implementation, maintenance of CDEM Standard Operating Procedures as required	🟢	🟢	
	Recovery planning			
	Support the development, implementation, maintenance of Regional Council Recovery Plan for key council infrastructure and assets.	🔴	🔴	There is no Regional Council Recovery Plan. Event-specific recovery plans have been prepared for damage to flood protection infrastructure and assets as required. A Plan will be prepared based on learnings from the North Island weather events.
	Financial planning			
	Support the development, implementation, maintenance of CDEM Group policy on the management of response and management of response and recovery claims.	🟢	🟢	

Attachment 1 - Otago Civil Defence and Emergency Management Agreement June 2022

Function	ORC Responsibility	Achievement 2024/25	Achievement 2023/24	Explanation
Public Information Management Public information management (PIM) enables people affected by an emergency to understand what is happening and take the appropriate actions to protect themselves. This is achieved by making sure that timely, accurate, and clear information is shared with the public in an emergency. Strategic communications is a core component of Public Information Management activities.	**Public Information Management staff**			
	Alternate Group Public Information Managers provided by Regional Council.	●	●	
	Provide staff to support a 24/7 duty Group PIM function.	●	●	
	Provide communications/ media staff to receive training and support the Group and local PIM functions, including strategic communications	●	●	
	Public Information Management planning			
	Support all CDEM Communications and Social Media activities at the Group and local level as required.	●	●	
	Support consistent CDEM messaging across all Regional Council social media platforms and websites.	●	●	
	Provide communications/ media staff to support the Group and Local PIM function during response and recovery if required.	●	●	
Reporting, Monitoring and Evaluation All members of the CDEM Group must provide reports that may be required by the Group. Monitoring and evaluation provide a method for learning from experience,	**Reporting**			
	Ensure Elected Officials and Leadership Team are informed of Joint Committee and CEG resolutions, directions and decisions.	●	●	Information is made available to Elected Officials via ORC's website and, as required, through Chairperson's reports to Council. CDEM matters are included in ELT Management reports as appropriate.

Attachment 1 - Otago Civil Defence and Emergency Management Agreement June 2022

Function	ORC Responsibility	Achievement 2024/25	Achievement 2023/24	Explanation
analysing capability, planning and allocating resources, and demonstrating results as part of accountability to stakeholders.	Provide reporting to Joint Committee, CEG and CEG Sub-Committee on specific Regional Council Annual Plan tasks related to CDEM.	●	●	
	Monitoring and Evaluation			
	Support, contribute and implement a lessons learned/ knowledge management process for CDEM Group.	●	●	
	Support Monitoring and Evaluation process for CDEM Group.	●	●	
Staff All staff with CDEM responsibilities including CDEM career staff, CDEM appointed staff, Regional Council and Territorial Authority staff fulfilling CIMS functions as part of an Emergency Coordination Centre (ECC) or Emergency Operations Centre (EOC) and any CDEM volunteers providing support to any CDEM function. The CDEM Group and each member of the Group are to take all steps necessary on an ongoing basis to maintain and provide, or to arrange the provision of, or to otherwise make available suitably trained and	**CEG Operations Sub-committee**			
	Appoint a Senior Manager as CDEM designate to represent Regional Council.	●	●	
	CDEM career staff			
	The Otago Regional Council is the employer of CDEM career staff (EMO) to deliver CDEM outlined in the CDEM Group Plan and this Agreement.	●	●	
	24/7 Duty staff			
	Provide staff to support a 24/7 duty Group Controller capability.	●	●	
	Staff for CIMS functions			
	Group Emergency Coordination Centre Incident Management Team and alternates provided by Regional Council.	●	●	

Attachment 1 - Otago Civil Defence and Emergency Management Agreement June 2022

Function	ORC Responsibility	Achievement 2024/25	Achievement 2023/24	Explanation
competent personnel, including volunteers; and an appropriate organisational structure for those personnel, for effective civil defence emergency management.	Provide staff to Coordinated Incident Management System (CIMS) functions within the GECC.	🟡	🟡	Staff are provided to these functions but target levels have not been met for Function Leads and Function Teams.
	Consult with EMO on appointments of staff to Coordinated Incident Management System (CIMS) functions for the GECC.	🟢	🟢	
	Ensure all CDEM GECC staff have respective CDEM role included in Job Description, KPI in annual performance plan, required training and exercising in annual professional development plan and be allocated the time for active participation.	🟡	🟡	Further work is required to include KPIs in performance plans. This is now largely redundant with new rostering and availability allowances available.
	Activation in response/ recovery			
	Ensure availability and prioritisation of staff to conduct GECC operations and deliver 24/7 response.	🟢	🟢	
	Support the provision and deployments of surge regional council CDEM staffing to support Group and Local level response and recovery within the Otago or across New Zealand.	🟢	⚫	Surge support was provided in the October 2024 weather event.
Warning Systems When there is an imminent threat to life, health or property from	Ensure an effective flood event monitoring and information system.	🟢	🟢	

Attachment 1 - Otago Civil Defence and Emergency Management Agreement June 2022

Function	ORC Responsibility	Achievement 2024/25	Achievement 2023/24	Explanation
hazard events the issue of official warnings is the responsibility of CDEM agencies.	Promote the flood warning system to partners, emergency services and communities.			
	Support the dissemination of warnings from the CDEM Group to communities.			
Welfare Management Management of welfare across all welfare services and clusters: Registration, Needs Assessment, Inquiry, care and protection services for children and young people, Psychosocial support, Household goods and services, Shelter and accommodation, Financial Assistance and Animal welfare. The objective of the welfare services function is to carry out activities across the 4Rs to provide for the needs of people affected by an emergency and to minimise the consequences of the emergency for individuals, families and whanau, and communities.	Support Group (GECC) and local (EOC) welfare activities in response.			Support provided during the October 2024 weather event

9.10. Otago Region Natural Hazards Exposure

Prepared for:	Science and Resilience Committee
Report No.	HAZ2503
Activity:	Governance Report
Author:	Tim van Woerden, Senior Natural Hazards Analyst Andrew Welsh, Spatial Analyst Jean-Luc Payan, Manager Natural Hazards
Endorsed by:	Tom Dyer, General Manager Science and Resilience
Date:	4 June 2025

PURPOSE

[1] To inform the Committee of the work on a region-wide natural hazards assessment programme, including presenting a report analysing natural hazards exposure within the Otago region.

EXECUTIVE SUMMARY

[2] The Otago Regional Council (ORC) Natural Hazards team have been progressing work on a regional-scale natural hazards assessment programme. The programme is aiming to work towards a comprehensive, regional-scale, spatial understanding of Otago's natural hazards and risks.

[3] This paper presents a recently completed natural hazards exposure analysis for the region, which is ORC's first iteration of analysis to quantify and map natural hazards exposure in Otago at a regional scale.

[4] The natural hazards exposure information will be an important input towards the ORC Natural Hazard team's region-wide natural hazards prioritisation process, which is planned to commence in 2025/2026, and the exposure analysis results are expected to also be of interest to other organisations in the region, for example Emergency Management Otago and territorial authorities.

RECOMMENDATION

That the Committee:

1) ***Notes*** *this report.*
2) ***Endorses*** *the report Otago Region Natural Hazards Exposure Analysis.*
3) ***Notes*** *the next steps in the work programme, including commencement of the natural hazards prioritisation workstream.*

BACKGROUND

[5] Since the 2021/22 financial year, the ORC Natural Hazards team have been progressing work on a regional-scale natural hazards assessment programme. The programme is aiming to work towards a comprehensive, regional-scale, spatial understanding of Otago's natural hazards and risks. The background to the work programme is outlined in a paper presented to the ORC Safety and Resilience committee in May 2023.[1]

[1] van Woerden T, 2023. Otago Region Natural Hazards Risk Assessment. Report to the Otago Regional Council Safety and Resilience Committee, 10 May 2023.

[6] Figure 1 outlines the key activities and programme sequencing in the natural hazards assessment and prioritisation programme.

[7] This paper presents the recently completed natural hazards exposure analysis, which builds on ORC's existing hazards datasets to provide further insights into the region's natural hazards setting. To introduce the exposure analysis report, this paper first provides a brief overview of the natural hazards information held by ORC.

[8] A natural hazards prioritisation approach for the region has been developed and was presented to the ORC Safety and Resilience Committee in a May 2024 workshop[1] and a November 2024 paper.[2]

[1] Otago Region Natural Hazards Exposure and Risk Analysis. Otago Regional Council Safety and Resilience Committee workshop, 9 May 2024.
[2] van Woerden T Welsh A and Payan J, 2024. Otago Region Natural Hazards Prioritisation. Report to the Otago Regional Council Safety and Resilience Committee, 7 November 2024.

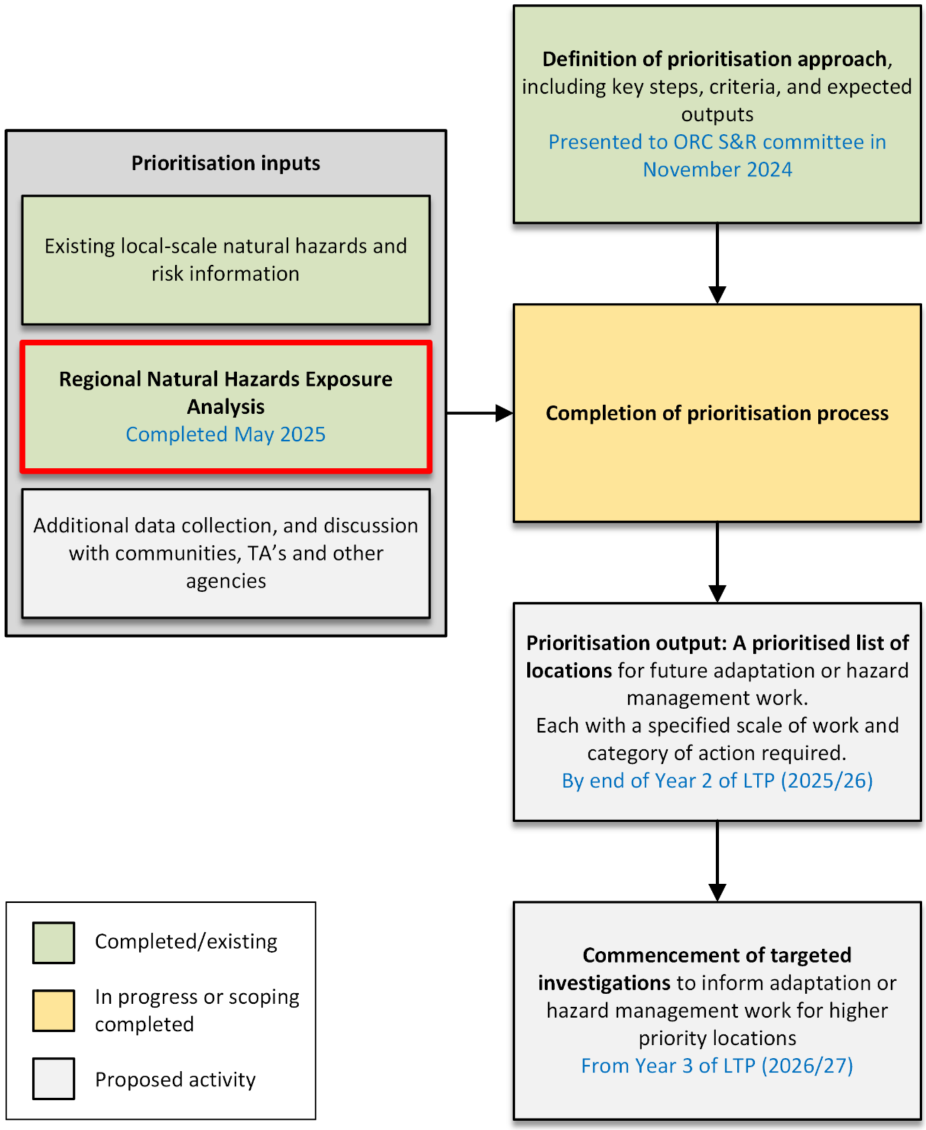


Figure 1: Flow chart showing key activities and programme sequencing in the natural hazards assessment and prioritisation programme. The regional natural hazards exposure analysis report presented in this paper is highlighted red.

LEGISLATIVE REQUIREMENTS

[9] The natural hazard information held by ORC enables the understanding and management of the risks associated with natural hazards in the region, required by legislation such as the Civil Defence Emergency Management Act (CDEMA) and the Resource Management Act (RMA).

[10] The RMA specifies that councils must, as a matter of national importance, recognise and provide for the management of significant risks,[1] and regional councils have specified

[1] Resource Management Act, 1991. Section 6(h).

functions[1] including the control of land for the purpose of the avoidance or mitigation of natural hazards.

[11] The CDEMA[2] states that a function of a Civil Defence membership group is to identify, assess, and manage natural hazards and risks.

[12] ORC is required to investigate and map potential natural hazards to meet the requirements of these legislations. The legislation does not provide any guidance on the precise approach or level of detail to be used in hazards investigation or mapping, this is developed based on ORC's requirements, industry good practice and with reference to national guidelines[3] where available.

ORC NATURAL HAZARDS INFORMATION

[13] ORC carries out investigations of natural hazards and their risks and holds a large amount of natural hazards information compiled over decades to identify, map and characterise natural hazards in the Otago region. Natural hazards information ranges from region-wide mapping datasets to targeted local-scale studies, and includes mapping or modelling datasets, technical reports, surveys and photographs.

[14] Much of ORC's natural hazards information is publicly available on the ORC Natural Hazards Portal, and other information can be provided on request. Data such as technical reports and hazards mapping are provided to key internal/external stakeholders for their reference and use, for example:

- For ORC Engineering team (e.g. for management of flood protection schemes).
- For Otago's territorial authorities (district and city councils) for use in landuse planning (District Plans, Spatial Plans) and for inclusion on Land Information Memorandum (LIM).
- For Emergency Management Otago for use in civil defence response planning.
- For infrastructure managers (e.g. lifelines organisations).

[15] The ORC Natural Hazards team regularly responds to public enquiries[4] for natural hazards information (approximately 100 enquiries per year).[5] For example, enquiries from a prospective purchaser of a property enquiring about what natural hazards information ORC holds for that location.

[16] The regional or district-scale natural hazards mapping datasets held by ORC cover all of the main types of natural hazards which may impact the region, including slope stability, flooding, coastal and seismic hazard types (Appendix 1).

[17] These regional mapping layers are often based largely on interpretation from aerial imagery and topographic information, supplemented by on-ground observations (e.g. flooding, landslides, alluvial fans, active fault mapping) or based on modelling approaches (e.g. storm surge and tsunami).

[1] Resource Management Act, 1991. Section 30(1)(c)(iv)
[2] CDEM Act, 2002. Section 17.
[3] e.g. the GNS Science landslide planning guidance (2024), and the MfE/MBIE guidance for potentially liquefaction-prone land (2017).
[4] NaturalHazards.Enquiries@orc.govt.nz
[5] 90 enquiries in the 2023/24 financial year, and 120 enquiries in the 2024/25 financial year (as of 9th May 2025).

[18] This ORC natural hazards mapping provides a regional overview and a general indication of locations where that hazard may be an issue or require further assessment but are not designed to be used at a more detailed project or property-specific scale. For mapping layers compiled through topographic interpretation, the accuracy is generally considered to be in the order of about ±100 metres at best.

[19] In addition to these broad-scale hazards datasets, ORC also holds a variety of other supporting data which enables natural hazards analysis, e.g. LiDAR[1] and other survey data, aerial imagery, environmental monitoring datasets such as lake level, river flow or rainfall records, and hazards photographs including historical images from the Otago Catchment Board archives.

[20] Many national-scale natural hazards datasets and information sources are also available, and which complement the regional or local-scale data held by ORC. These include:

- Spatial datasets of mapping or modelled natural hazards data, e.g., coastal inundation mapping,[2] location-specific sea-level rise projections,[3] and the National Seismic Hazard Model.[4]
- Information sharing platforms holding compilations of natural hazards of geotechnical data, e.g., the New Zealand Geotechnical Database for publicly available geotechnical information,[5] Natural Hazards Commission compilation of previous natural hazard damage claims.[6]

Local-scale targeted hazard and risk studies

[21] Local-scale targeted investigations are often carried out to add detail and spatial resolution beyond that available in regional or district-scale information. These targeted studies will generally be completed for a specific natural hazards issue in a defined geographic location, and for a specific purpose. Investigation purpose could be to inform decision-making (e.g. for the ORC Engineering team, or for an adaptation programme), or to inform landuse planning decision-making (e.g. supporting a territorial authority in District Plan review or spatial planning). Investigations may be reactive, in response to the occurrence of a natural hazards event, while others are undertaken proactively in response to identification of a potential hazard impact which requires further assessment.

[22] Local-scale investigations can be designed as either a natural hazard assessment or a risk assessment:

- A natural hazard assessment aims to understand the physical characteristics of the potential natural hazard event, such as the possible extent, behaviour, likelihood or severity of the event (e.g. a flood hazard or debris flow modelling study, or a geotechnical study for landslide or liquefaction susceptibility).
- A natural hazard risk assessment aims to understand and explain the event's impacts and consequences (i.e. possible harm), building on the available natural hazards information, but also information about the vulnerability of the people/community or assets exposed to the hazard (e.g. risk assessments recently

[1] Light Detection and Ranging, a remote sensing technique for capturing high-resolution topographic information.
[2] NIWA, Extreme coastal flood maps for Aotearoa New Zealand (https://niwa.co.nz/hazards/coastal-hazards/extreme-coastal-flood-maps-aotearoa-new-zealand).
[3] NZ SeaRise (https://www.searise.nz/).
[4] GNS Science (https://www.gns.cri.nz/research-projects/national-seismic-hazard-model/).
[5] NZGD (nzgd.org.nz).
[6] NHC Natural Hazards Portal (https://www.naturalhazardsportal.govt.nz).

completed for South Dunedin[1] and Glenorchy,[2] and in progress for debris flow hazard in the Roxburgh area [3]).

[23] Compared to the regional-scale natural hazards information described in paragraphs 16-20, these more targeted studies will typically involve more detailed data collection, analysis or hazards modelling. Although studies of this type may be completed at a relatively finer spatial resolution, they are generally not intended for use at an individual property-level.

OTAGO REGION NATURAL HAZARDS EXPOSURE ANALYSIS

Introduction

[24] In order to provide further insights into the region's natural hazards context, ORC has completed an analysis of natural hazard exposure for the region, which utilises information from the existing regional-scale natural hazards mapping datasets.

[25] "Exposure" is the people, infrastructure, buildings, the economy, and other assets that are exposed to a hazard.

[26] This is ORC's first systematic analysis of natural hazard exposure for Otago – the existing hazards mapping datasets have not previously been used for further analysis to understand or characterise natural hazards exposure in the region. The report provides a stocktake and baseline of the current understanding of natural hazard exposure for the region, and is a first iteration of analysis to quantify and map natural hazards exposure in Otago at a regional scale.

[27] Reporting and analysis were completed by the ORC Natural Hazards team, and externally reviewed by NIWA and GNS Science.

[28] The technical report is included as Appendix 2, and results are also available through an online data viewer at orc.govt.nz/naturalhazardexposure.

Methods

[29] Exposure analysis was completed for nine natural hazard types where region or district-wide hazard mapping coverage was available, aiming to give a region-wide understanding and broad-focus view, enabling a comparison across the region and between natural hazard types.

[30] The analysis methodology and input datasets used are more fully detailed in the appended technical report (Appendix 2).

[31] The analysis assesses the exposure of three elements at risk: population, buildings and 'critical community facilities' defined as facilities which have a post-disaster function (Saunders et al, 2013). These three elements are identified based on the approach to assessing hazard consequences in the proposed Otago Regional Policy Statement 2021

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[1] South Dunedin Future risk assessment report, March 2025 (https://www.dunedin.govt.nz/__data/assets/pdf_file/0007/1124179/south-dunedin-risk-assessment.pdf).

[2] Glenorchy and Kinloch natural hazards risk analysis report. Beca Ltd, August 2024 (https://www.orc.govt.nz/media/hnlim52b/glenorchy-and-natural-hazards-risk-analysis-report_final-report-26aug2024-compres.pdf)

[3] Roxburgh natural hazards management. ORC committee paper, November 2024 (https://www.orc.govt.nz/media/ffqpudud/20241107-sr-agenda.pdf).

(pORPS, ORC 2021b). The elements at risk considered are representative of socio-economic elements at risk to natural hazard impacts, and provide an indication of the magnitude of potential natural hazards exposure.

[32] Natural hazard exposure analysis was completed using RiskScape software,[1] with analysis completed for over the full Otago region for 351 distinct geographic units, termed 'community areas', based on Statistical Areas (SA's) defined by Statistics NZ.[2]

[33] The analysis approach is summarised in Figure 2. The natural hazard mapping and elements at risk information used in analysis is listed in Table 1.

[34] Exposure statistics are estimated for each element at risk within each community area, and aggregated by urban area/settlement, district, and over the full region. An exposure level classification is also developed for each community area, for each hazard type.

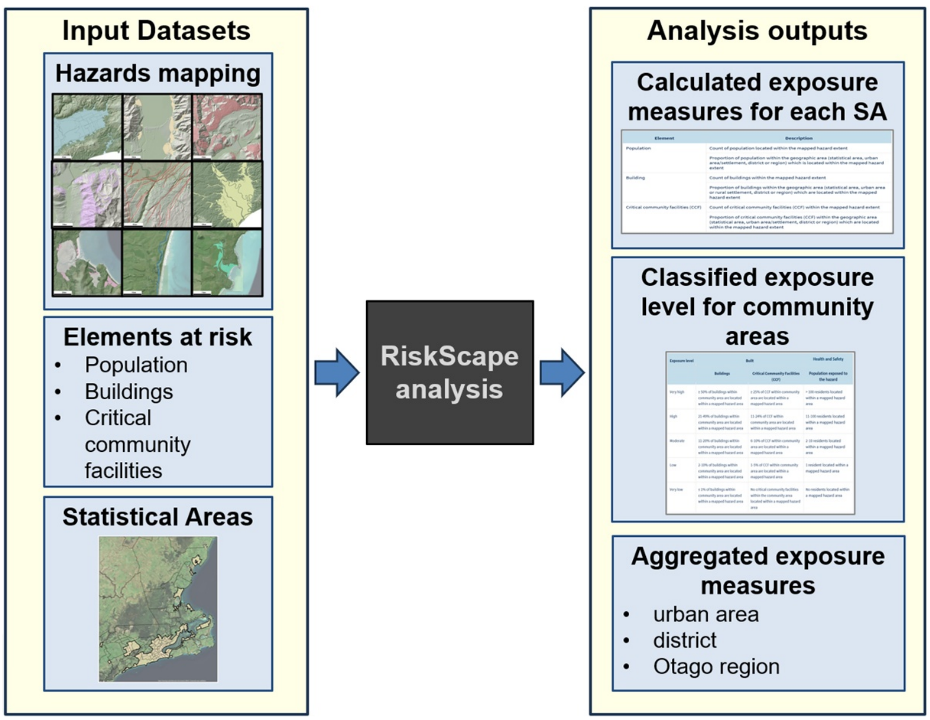

Figure 2: Schematic illustration of the process used for natural hazards exposure analysis. A more detailed illustration of the analysis process is included in the technical report as Figure 4.1.

Table 1: Natural hazards mapping and elements at risk information used in natural hazards exposure analysis

[1] RiskScape is an open-source software designed for multi-hazard risk analysis, developed by GNS Science, NIWA and the Natural Hazards Commission Toka Tū Ake (https://riskscape.org.nz/). RiskScape is widely used for natural hazards analysis, and provides a robust, replicable analysis framework.

[2] Rural community areas are defined by SA1 (100-200 residents), while urban community areas are defined by SA2 (1000-4000 residents) and rural settlements by SA1 (100-200 residents).

Natural hazards mapping
ORC region or district-wide hazards mapping layers

Flooding
- River, alluvial fan and lake flooding

Seismic
- Active faults
- Liquefaction susceptibility

Slope stability
- Landslide
- Rockfall
- Alluvial fan

Coastal
- Coastal inundation (storm surge)
- Coastal erosion (data for Waitaki district only)
- Tsunami

Elements at risk
1. Usually resident population
2. Buildings
3. Critical community facilities
    - Medical facilities (hospitals or ambulance stations)
    - Emergency service facilities (fire and police stations).
    - Emergency Coordination Centre (ECC) and Emergency Operations Centres (EOC)

Limitations

[35] The most significant constraint on completion of a regional-scale natural hazards exposure assessment is the availability and consistency of data for natural hazards and elements at risk. A selection of key limitations in exposure analysis are summarised in paragraphs 36-37, the analysis limitations are explained more fully in the technical report (Appendix 2).

[36] The natural hazards mapping data used in this analysis is the best natural hazards information with region-wide coverage currently available, however a number of key limitations are identified, including:

- Only ORC's regional or district-scale hazards mapping datasets were used in analysis. More detailed natural hazard information is available in many locations (e.g. local-scale flood hazard modelling or geotechnical investigations) but was not used for this initial analysis to maintain consistency of data resolution across the full region.
- Some datasets include consideration of climate change or sea level rise (e.g. coastal inundation, tsunami and coastal erosion), but climate change effects are not accounted for in other datasets such as flood hazard mapping or landslides.
- Several hazard mapping datasets (e.g. flooding, landslides) have been compiled from a range of composite sources or using differing methodologies, leading to variation in the precision and quality of information within a specific mapping dataset.

[37] The key limitations of the elements at risk are associated with the development of the population and building datasets used in analysis. For example:

- The spatial distribution of the population was estimated by modelling population allocation into building types likely to represent dwellings, and is therefore an approximation.

Results

[38] Natural hazards exposure analysis results are presented in tabular form in the technical report (Appendix 2), and can be viewed spatially through a digital data portal (accessible at orc.govt.nz/naturalhazardexposure). Two high-level results tables are reproduced in this paper:

- Table 2 is a summary of natural hazard exposure in the region for each hazard type considered.
- Table 3 identifies the 'Top 10' urban areas or rural settlements with highest exposure (by population count) for each hazard type.

[39] Selected findings from this natural hazard exposure analysis for the Otago region are summarised in paragraphs 40-44.

[40] The highest exposure for the natural hazard types considered is for river and lake flooding, and liquefaction. Totals of greater than 30,000 people and buildings, including >10,000 residential dwellings, within the Otago region are located in areas identified as potentially subject to each of these hazards. There is also a notable spatial overlap between the geographic extents of flooding and liquefaction hazards exposure, because flood-prone areas typically comprise geologically-recent sediment deposits which may also be susceptible to liquefaction.

[41] The majority of exposure to flooding hazards in the region is located within the Dunedin City district, including the floodplains receiving flood mitigation from ORC's Leith and Lower Taieri flood protection schemes. Population and buildings located within the 'protected' areas of ORC's flood protection schemes are considered to be potentially exposed to the hazard, as these areas could still be exposed to flooding in the case of a super-design flood event or a failure of flood protection infrastructure.[1]

[42] The majority of exposure to slope stability hazards (landslide, rockfall and alluvial fan hazard) is located within the Queenstown Lakes and Dunedin City districts, with much of the exposure to these hazard types within the urban areas of Queenstown, Dunedin city and Wanaka.

[43] The majority of exposure to seismic hazards (active faulting and liquefaction) is located within the Dunedin City district, where the highest exposure is for the urban areas of Dunedin and Mosgiel.

[44] The exposure to coastal hazards (storm surge, tsunami, and coastal erosion) is much less relative to the other hazard types considered, with exposure of up to ~500 people and ~1100 buildings for each of storm surge and tsunami.

[1] i.e. there is an exposure to residual risk, where residual risk is the risk that remains after risk treatment (e.g. flood protection works) has been applied to reduce the potential consequences.

Table 2: Natural hazards exposure summary for the Otago Region, showing the estimated count and percentage of those elements within Otago potentially exposed to impact from the named natural hazard types.

Hazard type	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in region
	Count	Percent of population in region	Count (all buildings)	Percent of total buildings in region	Count (Dwellings)	Percent of total dwellings in region	Count	Percent of total CCF in region	Very Low	Low	Moderate	High	Very High	
River and lake flooding	38,778	16.1	33,898	16.1	12,776	14.4	23	25.6	121	26	45	99	60	351
Liquefaction	46,047	19.1	43,029	20.4	17,459	19.7	37	41.1	142	18	45	68	78	351
Active Faults	21,949	9.1	20,096	9.5	8,371	9.4	10	11.1	203	19	21	68	40	351
Landslide	8,038	3.3	6,592	3.1	2,844	3.2	3	3.3	225	14	51	41	20	351
Alluvial fan	5,473	2.3	5,904	2.8	1,996	2.3	3	3.3	272	10	18	38	13	351
Rockfall	1,234	0.5	1,056	0.5	377	0.4	0	0	290	14	29	14	4	351
Tsunami	504	0.2	1,130	0.5	266	0.3	0	0	327	4	7	12	1	351
Storm surge	504	0.2	1,122	0.5	230	0.3	0	0	325	7	8	10	1	351
Coastal Erosion (Waitaki)	37	0	111	0.1	19	0.0	0	0	346	1	3	1	0	351

Table 3: Natural hazards exposure summary for the Otago Region, showing the 'Top 10' urban areas or rural settlements with highest exposure for each hazard type, identified and ordered by the estimated population exposed to the hazard within that urban area/settlement. The population exposed within each urban area/settlement is indicated by the cell shading (see legend). Coastal erosion hazard is not included in the table, as there is insufficient data to provide a region-wide comparison across the full Otago coastline.

Hazard type							
River and lake flooding	*Liquefaction*	*Active Faults*	*Landslide*	*Alluvial fan*	*Rockfall*	*Tsunami*	*Storm surge*
Mosgiel	Dunedin	Dunedin	Dunedin	Queenstown	Queenstown	Pounawea	Dunedin
Dunedin	Mosgiel	Mosgiel	Wanaka	Dunedin	Dunedin	Taieri Mouth	Waikouaiti
Oamaru	Wanaka	Alexandra	Warrington	Wanaka	Arrowtown	Purakaunui	Purakaunui
Queenstown	Queenstown	Wanaka	Queenstown	Roxburgh	Wanaka	Brighton	Pounawea
Balclutha	Milton	Lake Hawea	Mosgiel	Palmerston	Roxburgh	Waikouaiti	Taieri Mouth
Outram	Balclutha	Roxburgh	Moeraki	Waikouaiti	Aramoana	Karitane	Waitati-Doctors Point
Milton	Outram	Kaitangata	Roxburgh	Glenorchy	Purakaunui	Waitati-Doctors Point	Brighton
Luggate	Kingston	Waihola	Brighton	Arrowtown	Lake Roxburgh	Kaka Point	Karitane
Glenorchy	Glenorchy	Allanton	Karitane	Kingston	Oamaru	Kaitangata	Kakanui
Waihola	Brighton	Queenstown	Waitati-Doctors Point	Harington Point	Moeraki	Kakanui	Moeraki

Legend
Population exposed
>5,000
1000-5000
500-1000
100-500
20-100
≤20

DISCUSSION

[45] The natural hazards exposure analysis presented in this report is ORC's first iteration of analysis to quantify and map natural hazards exposure in Otago at a regional scale. The analysis enables comparison of natural hazards exposure between natural hazard types, and between geographic locations.

[46] The natural hazards information used as the basis for analysis has been available for many years, but this new analysis of hazard exposure provides significant added value beyond the existing mapping, to improve understanding of the potential scale of impact of those natural hazard events.

[47] Although the analysis is generally based on relatively broad-scale hazards mapping information, the findings are useful to identify where more detailed hazards or risk assessment may be required, or as a prompt to check if more detailed information is available.

[48] Many of the locations identified as being of relatively higher exposure have been the previous focus of detailed hazard/risk investigations, adaptation work programmes or hazard mitigation works (e.g. engineered flood protection). This exposure analysis therefore confirms the justification for targeting of those work programmes.

[49] For the ORC Natural Hazards team, the exposure information will inform the region-wide natural hazards prioritisation process which is planned to commence in 2025/2026.

[50] The exposure analysis is expected to also be of interest to other organisations in the region, for example Emergency Management Otago and territorial authorities, both of whom have already been briefed on the work programme purpose and approach in February-March 2025. The full natural hazards exposure dataset will be publicly available, so can be interrogated by others based on interest and perspective.

CONSIDERATIONS

Strategic Framework and Policy Considerations

[51] The information in the natural hazards exposure analysis report aligns with Council's Strategic Directions, where the 'Resilience' focus area has the aspiration that "*Otago builds resilience in a way that contributes to community and environmental wellbeing through planned and well-managed responses to shocks and stresses, including natural hazards*".

[52] The proposed Otago Regional Policy Statement June 2021, notified in late March 2024, states that ORC specifically is responsible for "identifying areas in the region subject to hazards and describing their characteristics" and including hazard maps on a natural hazard register or database.[22]

Financial Considerations

[53] The forward work programme is included in the 2024-34 Long-Term Plan budget, with a total proposed budget for the 2024/25, 2025/26 and 2026/27 financial years of $150,000.

[22] HAZ-NH-M1 (2b)

[54] The work programme includes completion of the regional natural hazards prioritisation, revision/updating of natural hazards exposure analysis (if required), and targeted investigations for higher priority locations (see Figures 1, 3).

Significance and Engagement

[55] Initial engagement has been undertaken with territorial authorities and Emergency Management Otago to ensure they are aware of this natural hazards exposure analysis and the wider work programme.

[56] We will also discuss this work programme and exposure analysis with others such as the Insurance Council of New Zealand (ICNZ) and the Natural Hazards Commission.

[57] Engagement with territorial authorities, communities, and other stakeholders will form a key component of the prioritisation process, to be completed over the financial next year.

Legislative and Risk Considerations

[58] The work described in this paper helps ORC fulfil its responsibilities under sections 30 and 35 of the RMA.

[59] As part of the Government's Resource Management Act reform programme, a national direction on managing natural hazard risk is being developed. Targeted changes to this national direction will be consulted on from mid-2025.

Climate Change Considerations

[60] Climate change and sea level rise effects are considered in the coastal hazards data (tsunami, storm surge and coastal erosion) used in natural hazard exposure analysis.

[61] For some other hazards which may be exacerbated by climate change (e.g. flooding), the regional-scale hazard mapping used in exposure analysis reflects only the present-day hazards extent, however this present-day regional exposure is useful to highlight areas of possible future impacts. Climate change effects are considered in local-scale targeted natural hazard and risk assessments, such as those for river flooding or coastal hazards.

Communications Considerations

[62] A digital data viewer has been developed which presents the spatial data outputs from the natural hazards exposure analysis. This viewer can be accessed at orc.govt.nz/naturalhazardexposure.

[63] This data viewer will be linked or embedded in a web page on the ORC website, which also includes plain language summary information explaining the project purpose and approach, and a link to the supporting technical report.

[64] A media release providing an outline of the project has been prepared, to be distributed at the time this meeting agenda is made public. This may be supplemented by other communications methods such as social media posts or news updates on the ORC website.

NEXT STEPS

[65] The completion and publication of this exposure report is not the end-point for ORC's regional natural hazards analysis, rather a useful information source which will then feed into further analysis such as natural hazards prioritisation.

[66] Following completion of this regional natural hazards exposure analysis, there are two main next steps in ORC's region-wide natural hazards risk programme:

a. Natural hazards prioritisation for the Otago region.

b. Review and possible revision of this region-wide natural hazards exposure analysis.

[67] Natural hazards prioritisation will be completed using the approach presented to the committee in November 2024, and is intended to enable a systematic identification and definition of key projects and allocation of work within the Natural Hazards work programme. Figure 3 is a schematic timeline of the work programme, showing the natural hazards prioritisation scheduled for completion in mid-2026 (by end of Year 3 of the LTP, 2025/26).

[68] Review and revision of this region-wide natural hazards exposure analysis will be completed as required. The exposure analysis approach and RiskScape workflow are now well-established, and it is now possible to re-run the analysis to include additional elements at risk data, or new/revised natural hazards information as it becomes available.

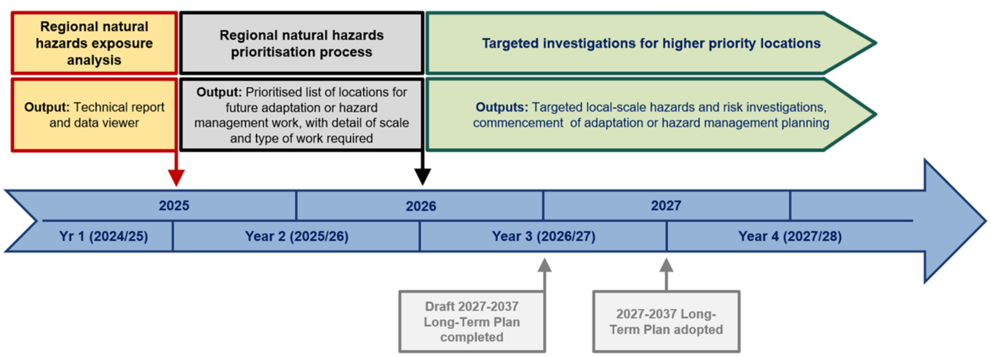

Figure 3: Schematic timeline of the work programme work, showing the completion of the regional natural hazards analysis, and the proposed work to follow. The timing for development of the 2027-2037 Long-Term Plan is also shown, to illustrate that the outcomes of the prioritisation process can be used to inform plan preparation.

ATTACHMENTS

1. Otago regional or district-scale natural hazards mapping datasets [**9.10.1** - 5 pages]
2. Otago Region Natural Hazards Exposure Analysis [**9.10.2** - 107 pages]

Appendix 1: Otago regional or district-scale natural hazards mapping datasets.

Hazard Type	Hazard Mapping Dataset	Data coverage	Description	Reference for mapping dataset	Considers climate change or sea level rise
Flooding	River and lake flooding	Otago region	A dataset representing flood-prone areas. Most mapping is based on observations of historical flooding, and interpretation from aerial imagery and topographic datasets (e.g. LINZ Topo50 mapping or LiDAR). This mapping dataset does not include pluvial flooding (surface flooding from rainfall runoff where stormwater systems are overwhelmed). Note that mapping of 'floodwater- dominated' alluvial fan surfaces is included within the alluvial fan dataset (Grindley et al, 2009)	ORC (1999a, b, c; 2002; 2025).	No
Seismic	Active faults	Otago region	Mapped active faults, generally based on regional geologic mapping and air photo interpretation. 'Active' faults are those which have undergone at least one ground-deforming rupture within the last 125,000 years, or at least two ground-deforming ruptures within the last 500,000 years (Barrell, 2021).	Barrell (2016, 2019b, 2021)	n/a
	Liquefaction susceptibility	Otago region	Mapping of areas which are potentially subject to liquefaction hazards, based on regional-scale geologic mapping (QMAP), and interpretation from aerial imagery, LiDAR topography, and borehole information. Equivalent to a basic desktop assessment as defined in the MBIE/MfE (2017) guidance.	Barrell *et al* (2014), Barrell (2019a)	n/a

Hazard Type	Hazard Mapping Dataset	Data coverage	Description	Reference for mapping dataset	Considers climate change or sea level rise
	Ground shaking	Otago region	Spatial distribution of earthquake ground shaking hazard (in Modified Mercalli Intensity, MMI) expected to be exceeded, on average, once within a specified timeframe (100, 2500 years), and as isoseismals (contours of equal shaking intensity) for selected active faults (Akatore, Alpine, Dunstan North, Dunstan South)	Murashev and Davey (2004)	n/a
Slope Stability	Landslide	Otago region	Mapping of interpreted locations of past landslide movements, generally based on interpretation from aerial imagery. This dataset does not represent landslide susceptibility (i.e. slopes which may fail in future), or areas which may be impacted by the runout of landslide debris.	Compiled from various sources, including; Barrell *et al* (2017), Forsyth (2001), Turnbull (2000), Turnbull and Allibone (2003)	No
	Rockfall	Otago region (excludes catchments devoid of buildings or roads, or with only very sparsely distributed buildings).	Rockfall 'awareness areas' which may be susceptible to rockfall. Developed based on RAMMS modelling from source areas defined by slope-angle analysis.	Easterbrook-Clarke *et al* (2022)	No
	Alluvial fan	Otago region	Mapped alluvial fan surfaces which have been classed by activity (i.e. active, inactive) and dominant depositional process (floodwater-dominated, debris-dominated, or composite).	Grindley *et al* (2009)	No

Hazard Type	Hazard Mapping Dataset	Data coverage	Description	Reference for mapping dataset	Considers climate change or sea level rise
Coastal	Coastal inundation (storm surge) and sea level impacts	Otago region	Modelled extents of potential inundation due to extreme sea level events (storm surge) with return periods of up to 500-year ARI.	Lane *et al* (2008)	Yes. Sea level rise scenarios of 0.3 and 0.5 m considered. These scenarios could be reached in approximately 2065 and 2095 under SSP2-4.5 (MfE, 2022).
	Coastal inundation (storm surge) and sea level impacts	Waitaki District (for the populated coastal areas of Moeraki, Hampden, Kakanui and Oamaru)	Modelled extents of potential inundation due to extreme sea level events (storm surge) with return periods of up to 500-year ARI.	Bosserelle *et al* (2019)	Yes, up to an upper bound of 1.3 m sea level rise by 2115.
	Coastal erosion	Waitaki District	Modelled future shoreline position for a range of outlook timeframes (50, 100 years) and risk levels (5%, 50% probability of erosion extending up to or landward of this line over the relevant outlook period).	Bosserelle *et al* (2019)	Yes, up to an upper bound of 1.3 m sea level rise by 2115.
	Tsunami	Otago region	Numerical modelling findings showing the maximum area affected by a modelled tsunami from near and far-field sources, for events up to a 500-year ARI.	Lane *et al* (2007)	Yes. Sea level rise scenarios of 0.3 and 0.5 m considered. These scenarios could be reached in approximately 2065 and 2095 under SSP2-4.5 (MfE, 2022).

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Otago Regional Council

Otago Region Natural Hazards Exposure Analysis

Report title

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Contents

1 Executive Summary

This report presents findings of Otago Regional Council's (ORC's) first systematic analysis of natural hazard exposure for Otago. The report provides a 'stocktake' and baseline of the current understanding of natural hazard exposure for the region, and is a first iteration of analysis to quantify and map natural hazards exposure in Otago at a regional scale.

ORC's existing regional or district-scale natural hazards mapping datasets were used to identify populations and assets located in areas potentially exposed to natural hazards impact. Nine natural hazards were analysed; river and lake flooding, seismic hazards (fault rupture, liquefaction), slope stability hazards (landslide, rockfall, alluvial fans/debris inundation), and coastal hazards (storm surge inundation, tsunami and coastal erosion).

This report enumerates the exposure of three elements at risk: population, buildings and 'critical community facilities' defined as facilities which have a post-disaster function (ORC, 2021).[1] These three elements are identified based on the approach to assessing hazard consequences in the proposed Otago Regional Policy Statement 2021 (pORPS, ORC 2021). The elements at risk considered are representative of socio-economic elements at risk to natural hazard impacts, and provide an indication of the magnitude of potential natural hazards exposure.

Natural hazard exposure analysis was completed using RiskScape software, with analysis completed for the full Otago region encompassing 351 distinct geographic units, termed 'community areas', based on Statistical Areas (SA's) defined by Statistics NZ. Exposure statistics are estimated for each 'community area' and aggregated by urban area/settlement, district, and over the full region.

Key findings from this natural hazard exposure analysis for the Otago region include:

- The highest exposure for the natural hazard types considered is for river and lake flooding and liquefaction. Totals of greater than 30,000 people and buildings, including >10,000 dwellings, within the Otago region are located in areas identified as potentially subject to each of these hazards. There is also a notable spatial overlap between the geographic extents of flooding and liquefaction hazards exposure, because flood-prone areas typically comprise geologically-recent sediment deposits which may also be susceptible to liquefaction.

- The majority of exposure to river and lake flooding hazards in the region is located within the Dunedin City district, where 39 (of 117) community areas are classed having a 'high exposure'. This includes the floodplains receiving flood mitigation from ORC's Leith and Lower Taieri flood protection schemes. Population and buildings located within the 'protected' areas of ORC's flood protection schemes are considered to be potentially exposed to the hazard, as these areas could still be exposed to flooding in the case of a super-design flood event or a failure of flood protection infrastructure.

- Landslide and alluvial fan hazards each have exposure totals of greater than 5,000 people and buildings, including around 2,000 dwellings. The majority of exposure to slope stability hazards (landslide, rockfall and alluvial fan hazard) is located within the Queenstown Lakes and Dunedin City districts, with much of the exposure to these hazard types within the urban

[1] e.g. medical facilities, emergency services (police and fire), and emergency coordination/operations centres.

areas of Queenstown, Dunedin city and Wanaka. All of the community areas classed as having a ‘high exposure’ are located in either the Queenstown Lakes or Dunedin City districts.

- The majority of exposure to seismic hazards (active faulting and liquefaction) is located within the Dunedin City district, where the highest exposure is for the urban areas of Dunedin and Mosgiel. Totals of greater than 20,000 people and buildings in the region, including around 8,000 dwellings are located in near proximity (within 250 metres) of mapped active faults, and 40 of the community areas in the region (n = 351) are classed as having ‘high exposure’. Totals of greater than 40,000 people and buildings in the region, including around 17,000 dwellings are located in locations where liquefaction is considered possible, and 78 of the community areas in the region (n = 351) are classed as having ‘high exposure’ to this hazard type.

- The exposure to coastal hazards (storm surge, tsunami, and coastal erosion) is much less relative to the other hazard types considered, with exposure of up to ~500 people and ~1100 buildings for each of storm surge and tsunami. Coastal erosion exposure has been analysed only for the Waitaki district, where exposure is around 100 buildings and ~40 people.

- The exposure of 90 critical community facilities in the region has been assessed for each hazard type. The greatest exposure of these facilities is to river and lake flooding (23 facilities exposed to the hazard) and liquefaction (35 facilities exposed), with some exposure also for active fault, landslide and alluvial fan hazard types.

Following completion of this regional natural hazards exposure analysis, there are two main next steps in ORC’s region-wide natural hazards risk programme:

1. Natural hazards prioritisation for the Otago region, to enable a systematic identification and definition of key projects and allocation of work within the ORC Natural Hazards work programme
2. Review and possible revision of this region-wide natural hazards exposure analysis to incorporate additional or updated natural hazards mapping or elements at risk datasets. These may include incorporation of local-scale natural hazards information, use of national hazards datasets, or data for additional types of elements at risk.

2 Introduction

The Otago region is exposed to a diverse range of potential natural hazard events that may impact on people, property, infrastructure, and the wider environment; including flooding, slope stability, seismic hazards, coastal erosion, or coastal inundation due to tsunami or storm surge.

This report presents findings of Otago Regional Council's (ORC's) first systematic analysis of natural hazard exposure for Otago. The report provides a stocktake and baseline review of the natural hazard exposure for the region. The natural hazards analysis was completed as part of an ORC programme to work towards a regional-scale, spatial understanding of Otago's exposure to natural hazards.

This exposure analysis builds on the extensive natural hazard mapping and hazard assessments completed by ORC over the last 25+ years, to inform compilation of datasets with regional or district-wide coverage which provide an overview of the extents and characteristics of natural hazards. ORC's natural hazards mapping is publicly available on the ORC Natural Hazards Portal,[2] which also includes supporting information such as technical reports and photographs from previous natural hazards events. The Natural Hazards Portal provides a spatial representation of mapped natural hazards extents, which enables analysis of elements potentially exposed to those hazards to be undertaken

2.1 Purpose

The primary usage intended for this analysis and reporting is as a tool to explore the magnitude and spatial distribution of relative hazards exposure across the Otago region.

The findings from this analysis will be one source of information which will inform a regional approach developed for prioritising natural hazards adaptation. This prioritisation approach is outlined in van Woerden *et al* (2024) and will be used as a project planning tool for the ORC Natural Hazards team, to assist with enabling ORC to systematically identify and define key projects and allocation of work within the overall Natural Hazards work programme.

This natural hazard exposure analysis aligns with ORC's Strategic Directions, and plays an important role to support ORC's 2024-2034 strategic direction and vision for Otago that, "*Otago builds resilience in a way that contributes to the wellbeing of our communities and environment through planned and well- managed responses to shocks and stresses, including natural hazards.*" (ORC, 2024). More specifically, it will inform requirements of the proposed Otago Regional Policy Statement (pORPS 2021), where local authorities must "*assess the level of natural hazard risk in their region or district*" and "*continue to undertake research on the identification of natural hazard risk and amend natural hazard registers, databases, regional and/or district plans as required*." (ORC, 2021).

[2] http://hazards.orc.govt.nz

3 Methods

3.1 Natural Hazards Exposure Analysis

3.1.1 Introduction

In the context of this analysis, natural hazards exposure is the spatial overlay of the three selected community elements at risk (population, buildings, critical community facilities) with the mapped extent of potential hazard impact.

For each community area assessed in the region (n = 351), eight exposure outputs have been calculated, as summarised in Table 3.1. Natural hazard exposure is also aggregated and reported for each urban area or rural settlement, district, and the full Otago region.

These exposure values assist in understanding the scale and proportion of the element which may be directly impacted by each natural hazard.

Table 3.1: Description of exposure analysis outputs.

Element	***Description***
Population	Count of population located within the mapped hazard extent
	Proportion of population within the geographic area (statistical area, urban area/settlement, district or region) which is located within the mapped hazard extent
Buildings	Count of buildings within the mapped hazard extent (all buildings)
	Proportion of buildings within the geographic area (statistical area, urban area or rural settlement, district or region) which are located within the mapped hazard extent
	Count of buildings categorized as dwellings, within the mapped hazard extent
	Proportion of buildings categorized as dwellings within the geographic area (statistical area, urban area or rural settlement, district or region) which are located within the mapped hazard extent
Critical community facilities (CCF)	Count of critical community facilities (CCF) within the mapped hazard extent
	Proportion of critical community facilities (CCF) within the geographic area (statistical area, urban area/settlement, district or region) which are located within the mapped hazard extent

3.1.2 Exposure Classification

An exposure classification has been developed as an indicator of the overall natural hazards exposure for the three elements considered (population, buildings and critical community facilities) (Table 3.2). This table is based on the approach to assessing consequences in the proposed Otago Regional Policy Statement 2021 (pORPS, ORC 2021).

An exposure classification level has been identified for each of the 351 'community areas' in the region used for this analysis. When assessing overall natural hazards exposure level within this matrix, the exposure level class is selected on the first-past-the-post principle, in that the element with the highest exposure level sets the exposure level for that community area.

Table 3.2: Exposure level classification.

Exposure level	***Built***		***Health and Safety***
	Buildings	***Critical Community Facilities (CCF)***	***Population exposed to the hazard***
Very high	≥ 50% of buildings within community area are located within a mapped hazard area	≥ 25% of CCF within community area are located within a mapped hazard area	> 100 residents located within a mapped hazard area
High	21-49% of buildings within community area are located within a mapped hazard area	11-24% of CCF within community area are located within a mapped hazard area	11-100 residents located within a mapped hazard area
Moderate	11-20% of buildings within community area are located within a mapped hazard area	6-10% of CCF within community area are located within a mapped hazard area	2-10 residents located within a mapped hazard area
Low	2-10% of buildings within community area are located within a mapped hazard area	1-5% of CCF within community area are located within a mapped hazard area	1 resident located within a mapped hazard area
Very low	≤ 1% of buildings within community area are located within a mapped hazard area	No critical community facilities within the community area located within a mapped hazard area	No residents located within a mapped hazard area

3.1.3 RiskScape Analysis for Natural Hazard Exposure

Exposure analysis was completed using RiskScape, an open-source software with a flexible modelling engine for multi-hazard risk analysis (Paulik *et al*, 2022). RiskScape has a modular structure, integrating hazard, exposure (i.e., elements-at-risk), and consequence data in a workflow to quantify exposure, impact or risk from natural hazards.

RiskScape software (Version 1.8.0) was configured to identify *elements-at-risk* within the mapped hazard extent areas, then apply a binary exposure function (i.e., 1 = exposed to natural hazard; 0 = not exposed to natural hazard) to enumerate their exposure to natural hazards. The process to analyse and report natural hazard exposure in Otago is conceptually represented in Equation 3.1.

$$\mathbf{H_{exp}} = \begin{cases} \mathbf{1}, & \boldsymbol{Hazard\ Present} \\ \mathbf{0}, & \boldsymbol{Hazard\ Not\ Present} \end{cases} \tag{1}$$

The analysis process is summarised in Figure 3.1, and detailed in Appendix E which includes commentary on the natural hazards, statistical area and elements at risk input data, RiskScape model development, and analysis and reporting workflows.

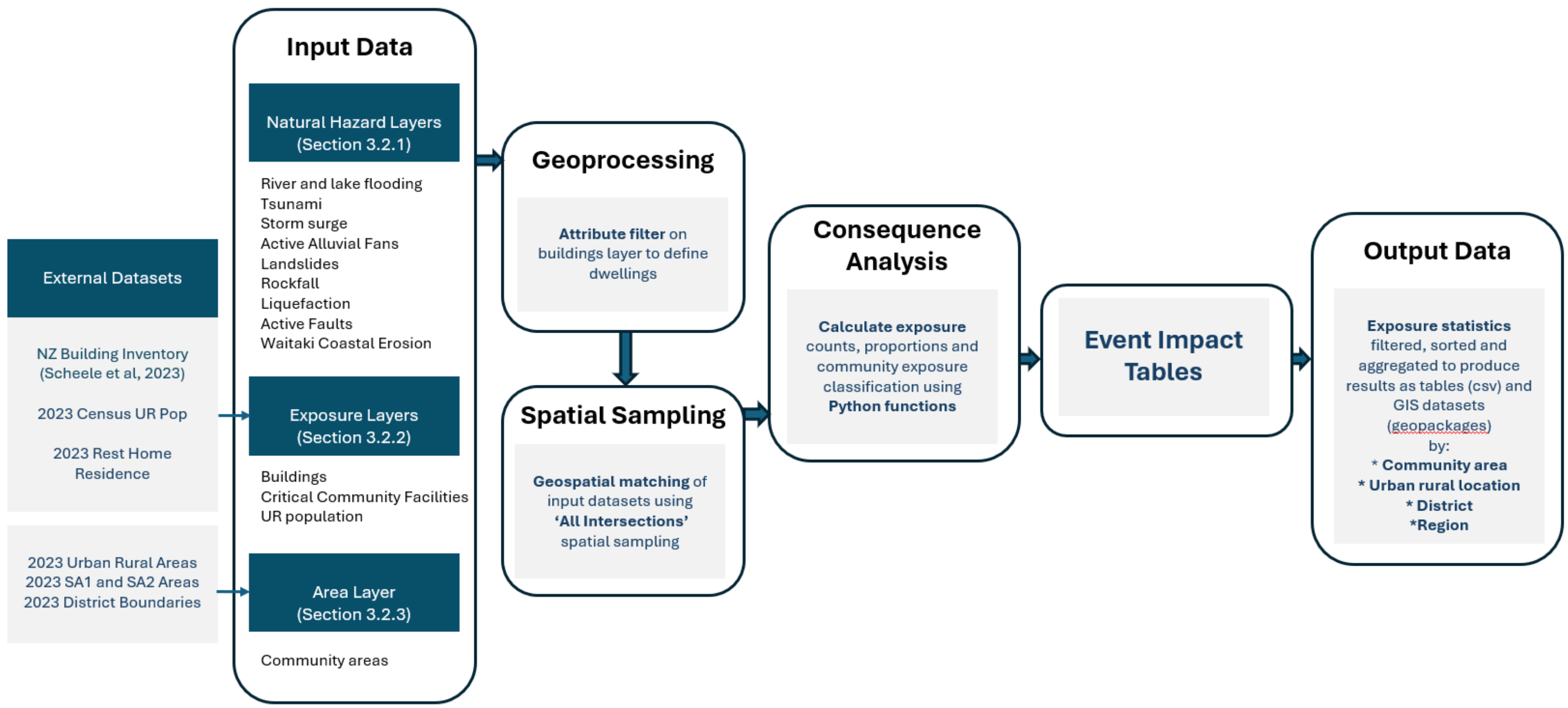

Figure 3.1: Generalised RiskScape model pipeline for the exposure analysis.

3.1.4 Aggregation and Reporting

Calculated exposure metrics for individual 'community areas' are then aggregated to give totals for each urban area and settlement, district, and the region as a whole. Table 3.3 summarises the exposure outputs reported for each geographic scale.

Where natural hazard exposure findings are not included in this technical report (e.g. exposure measures for individual community areas), these can be viewed through the online data viewer accessible at orc.govt.nz/naturalhazardexposure.

Table 3.3: Summary of exposure reporting outputs for each hazard type, where cells coloured green are outputs generated from this study.

Exposure reporting output	*Geographic area*			
	Community area (n= 351)	*Urban area or rural settlement (n = 54)*	*District*	*Region*
Exposure measures for usually resident population, buildings, dwellings and critical community facilities in each community area (measures listed in Table 3.1)	Online data viewer			
Aggregated exposure measures for usually resident population, buildings, dwellings and critical community facilities		Section 5 (e.g. Table 5.5)	Appendix D, Tables 9.4-9.8	Table 5.1
Exposure level classification for each community area (using the classification scheme in Table 3.2)	Online data viewer			
Numerical breakdown of the exposure level classifications for the community areas within a larger area		Section 5 (e.g. Table 5.5)	Appendix D, Tables 9.4-9.8	Table 5.1
A 'Top 10' table of community areas, ordered by population exposure	Table 5.2			
A 'Top 10' table of urban areas or rural settlements, ordered by population exposure		Section 5 (e.g. Table 5.5)		

3.2 Input Data

3.2.1 Natural Hazard Mapping

The natural hazards considered in this exposure analysis are those where ORC holds existing spatial mapping datasets with regional or district-wide coverage. The mapped natural hazard extents can be considered as an overlay or mask indicating locations which may be exposed to those natural hazards processes.

The natural hazard mapping layers used in this analysis are listed and described in Table 3.4. Mapping for each of these hazard types are shown in Appendix A as Figures 9.1-9.9.

The key limitations associated with the use of these natural hazards datasets for exposure analysis are summarised in Section 4.

Table 3.4: Natural hazards mapping layers used in this natural hazards exposure and risk analysis.

Hazard Type	Hazard Mapping Dataset	Data coverage	Description	Reference for mapping dataset	Considers climate change or sea level rise
Flooding	River, alluvial fan and lake flooding	Otago region	A dataset representing flood-prone areas, compiled for this study by merging a number of existing flood hazard mapping datasets (e.g. river floodplain, active floodwater-dominated alluvial fan streams, coastal streams). Most mapping is based on observations of historical flooding, and interpretation from aerial imagery and topographic datasets (e.g. LINZ Topo50 mapping or LiDAR). This mapping dataset does not include pluvial flooding (surface flooding from rainfall runoff where stormwater systems are overwhelmed).	Compilation of data from various sources (e.g. those described in ORC (1999a, b, c, 2002, 2014) and Grindley *et al* (2009)	No
Seismic	Active faults	Otago region	Mapped active faults, generally based on regional geologic mapping and air photo interpretation. For this study, active fault traces have been buffered by ±250m to create polygon features representing the area in near proximity to an active fault structure. 'Active' faults are those which have undergone at least one ground-deforming rupture within the last 125,000 years, or at least two ground-deforming ruptures within the last 500,000 years (Barrell, 2021).	Barrell (2016, 2019, 2021)	n/a
	Liquefaction susceptibility	Otago region	Mapping of areas which are potentially subject to liquefaction hazards, based on regional-scale geologic mapping (QMAP), and interpretation from aerial imagery, LiDAR topography, and borehole information. Equivalent to a basic desktop assessment as defined in the MBIE/MfE (2017) guidance.	Barrell *et al* (2014), Barrell (2019)	n/a

Hazard Type	***Hazard Mapping Dataset***	***Data coverage***	***Description***	***Reference for mapping dataset***	***Considers climate change or sea level rise***
Slope Stability	Landslide	Otago region	Mapping of interpreted locations of past landslide movements, generally based on interpretation from aerial imagery. This dataset does not represent landslide susceptibility (i.e. slopes which may fail in future), or areas which may be impacted by the runout of landslide debris, and predates the national landslide planning guidance (de Vilder *et al*, 2024).	Compiled from various sources, including; Barrell *et al* (2017), Forsyth (2001), Turnbull (2000), Turnbull and Allibone (2003)	No
	Rockfall	Otago region (excludes catchments devoid of buildings or roads, or with only very sparsely distributed buildings).	Rockfall 'awareness areas' which may be susceptible to rockfall. Developed based on RAMMS modelling from source areas defined by slope-angle analysis.	Easterbrook-Clarke *et al* (2022)	No
	Alluvial fan (debris inundation)	Otago region	Mapped alluvial fan surfaces which have been classed as 'active', and as either 'debris-dominated' or 'composite' (fans may be subject to a combination of both debris flow and floodwater flow processes). Active 'floodwater-dominated' alluvial fans were mapped and included in the original mapping dataset (Grindley *et al*, 2009), these have been included within the flood hazard layer compiled for this study.	Grindley *et al* (2009)	No

Hazard Type	*Hazard Mapping Dataset*	*Data coverage*	*Description*	*Reference for mapping dataset*	*Considers climate change or sea level rise*
Coastal	Coastal inundation and sea level impacts	Otago region	Modelled extents of potential inundation due to extreme sea level events with return periods of up to 500-year ARI.	Lane *et al* (2008)	Yes. Sea level rise scenarios of 0.3 and 0.5 m considered. These scenarios could be reached in approximately 2065 and 2095 under SSP2-4.5 (MfE, 2022).
	Coastal erosion	Waitaki District	Modelled future shoreline position with a 5% probability of erosion extending up to or landward of this line over the 100-year outlook period. Data converted to a polygon feature by buffering coastwards from the mapped coastal hazard zone (CHZ) line feature.	Bosserelle *et al* (2019)	Yes, up to an upper bound of 1.3 m sea level rise by 2115.
	Tsunami	Otago region	Numerical modelling findings showing the maximum area affected by a modelled tsunami from near and far-field sources, for events up to a 500-year ARI. There is no data available for lake tsunami or seiche.	Lane *et al* (2007)	Yes. Sea level rise scenarios of 0.3 and 0.5 m considered. These scenarios could be reached in approximately 2065 and 2095 under SSP2-4.5 (MfE, 2022).

3.2.2 Elements at Risk

Elements at risk are those which are exposed to the potential impacts of natural hazards events. The three "elements at risk" datasets used in this analysis represent aspects of the 'human' and 'built environment' domains defined by MfE (2020);

- Population
- Buildings
- Critical community facilities (CCF).

The development of these datasets is summarised below and further detailed in Appendix E. These elements align with the approach to assessing hazard consequences in the proposed Otago Regional Policy Statement 2021 (pORPS, ORC 2021), and were selected for use in this analysis because they are repeatable measures which can be used to provide an indication of the magnitude of exposure, and therefore of the relative impact of potential natural hazard events.

The three elements at risk selected for this analysis are considered sufficient to provide a broad regional overview, at a screening level, to identify the population, assets and locations exposed to natural hazards.

The proposed Otago Regional Policy Statement 2021 also includes lifelines infrastructure and social/cultural buildings in the approach to assessing hazard consequences, however these are not considered in this iteration of exposure analysis. Lifelines infrastructure (e.g. transport, communications and energy networks) are not included to avoid overlap or duplication with Emergency Management Otago's lifelines projects (e.g. Toa Consulting, 2024), and instead to complement any existing or future CDEM work in this area. The social/cultural buildings element is also not considered in the assessment, as at the time of writing no consistent and comprehensive dataset compiling all social/cultural buildings in Otago was available.

3.2.2.1 POPULATION

The usually resident population estimated to be exposed to a hazard is a primary indicator of social/community disruption in the event of hazard occurrence. NZ census 2023 usually resident population count data for all SA1 and SA2 units in the region was acquired from Statistics NZ (Stats NZ, 2025).

In order to provide an estimate of the spatial distribution of population in each statistical area, a population model was developed to estimate the distribution of residents within the buildings present. This is a refinement over simpler approaches such as assuming the population is evenly distributed within all buildings present within the statistical area, i.e. estimation based on a 'mean population per building' rate.

The model was based on the usually resident population count data for all SA1 and SA2 units, and identification of building types likely to represent dwellings. Model refinements were required to address limitations in accurately representing populations present in rest home dwellings, which contain a large population residing in one facility, and would not be well-represented in estimates based only on a 'population per dwelling' approach.

Information on rest home bed counts and occupancy is available for facilities in Otago via the Ministry of Health (Manatū Hauora) and Aged Residential Care websites (MoH, 2023; ARC, 2024). This information has been used to identify the spatial location for rest homes in Otago and make an estimate of their occupancy, which is then integrated with estimates for population within all other dwelling types. This estimation process is detailed in Appendix E.

3.2.2.2 BUILDINGS

The building inventory dataset (polygon geometry) was provided by GNS Science (Scheele *et al*, 2023). The dataset was developed using the latest (2024) LINZ NZ Building Outline and Primary Parcels datasets, in combination with property data acquired from Corelogic.

The dataset maps the outlines of all buildings larger than or equal to 10 square metres in size. The dataset will not include any buildings constructed since the date of its compilation in 2024, however this is not expected to cause any significant changes to the analysis findings.

In addition to dwellings, the dataset also includes other structures such as commercial buildings, garages, sheds and farm outbuildings. The building inventory layer was used to identify building types which represent a main place of residence for the usually resident population (i.e. where they sleep and generally live); buildings with a 'use category' field attribute of 'residential dwelling', 'lifestyle' and 'rest home' categories are chosen to represent dwellings.

Further building categorisation was undertaken for rural locations, where many buildings likely to be dwellings were initially assigned an 'unknown' use category attribute within the building inventory. A manual analysis process was carried out to identify and refine building use categorization for those buildings based on specific criteria developed to distinguish general rural farm type buildings (sheds, barns, garages, storage etc.) from those that could be considered dwellings. A new use category attribute ('farm/rural dwelling') was then created to identify those dwellings. This categorization process is detailed in Appendix E.

3.2.2.3 CRITICAL COMMUNITY FACILITIES

Critical Community Facilities (CCF) provide a direct measure of medical and emergency services, and disaster coordination/operations centres exposed to a hazard. They are an important indicator of social/community disruption in case of a hazard event where CCF and associated services are significantly affected or not available.

Critical community facilities (CCF) are defined as facilities which have a post-disaster function (ORC, 2021). There are a total of 90 critical community facilities identified in the region and used in this analysis (listed in Appendix C), these are;

- Medical facilities (hospitals or ambulance stations).
- Emergency service facilities (fire and police stations).
- Emergency Coordination Centre (ECC) and Emergency Operations Centres (EOC).

The Critical Community Facilities dataset (dated 2022) was acquired from Emergency Management Otago as a point geometry GIS feature layer with locations identified as points on or close to the relevant site of interest. To ensure all CCF building locations were included partly or fully within polygon boundaries for location units and natural hazard mapped layer extents, the point dataset was converted into polygon geometry. This was done by cross referencing the provided point locations with the latest available imagery (e.g. Google Earth and Google Street View), and then using the NZ Building Inventory dataset (set out in Section 3.2.2) to determine the outline extents of those building locations.

Emergency Coordination Centre (ECC) and Emergency Operations Centres (EOC) were not identified in the original point dataset of Critical Community Facilities, these were subsequently included based on location information provided by Emergency Management Otago.

As some facilities are made up of multiple buildings, the dataset attributes were modified to represent all buildings within a single facility as a single occurrence, to ensure all facilities are equally weighted in analysis.

3.2.3 Geographic Units

3.2.3.1 STATISTICAL AREAS

Statistical Area 1 (SA1) and Statistical Area 2 (SA2) geographic areas classified by Statistics New Zealand are used to give a consistent spatial division over the region for this natural hazards exposure analysis. The use of defined geographic units provides a systematic approach to dividing the region into smaller sub-areas with comparable population sizes.

The geographic resolution of this exposure analysis is a ‘community area’, defined using statistical units defined by Statistics New Zealand. These are intended to represent “a ‘community of place’ where people interact together socially and economically” (Stats NZ, 2022).

The hierarchy of statistical units developed by Statistics New Zealand (Stats NZ, 2022) is described in Appendix B. The boundaries of these units align and can be aggregated into larger contiguous units. For example, SA1’s are aggregated into SA2’s, and SA2’s aggregate to align with urban area/settlement, territorial authority and regional council boundaries.

For this analysis, the region is assessed as a series of 351 geographic units (Appendix B). These geographic units are SA2’s for urban areas where they are equivalent to suburbs, for rural settlements are either SA1 or SA2’s, and for areas outside of urban areas and rural settlements are SA1’s. For this analysis, these geographic units are referred to as ‘community areas’ and are the relevant spatial scale to describe a ‘community’. The finer spatial resolution represented by Stats NZ meshblock units is not used in this analysis.

3.2.3.2 URBAN RURAL GEOGRAPHY

Statistics NZ define the boundaries of urban areas and rural settlements in the region as distinct geographical units, which form the 'urban rural' (UR) geography dataset (Stats NZ, 2022). A total of 54 localities in the Otago region are identified as being either an urban area or rural settlement (Appendix B). The urban area and rural settlement geographies are formed by one or more SA1 or SA2 areas.

There are 14 localities in the region identified as urban areas with a population of ≥1,000, and an additional 40 rural settlements (Appendix B). Within these urban areas and rural settlements, SA2s have been used to provide a subdivision into smaller community-scale units. Rural areas outside of urban areas and rural settlements are classed as 'rural other' in the urban rural (UR) dataset. For these areas, SA1's have been used to provide a sub-division into smaller geographic units.

4 Limitations

The most significant constraint on completion of a regional-scale natural hazards exposure assessment is the availability and consistency of data for natural hazards and elements at risk. This section presents and discusses the key limitations in this natural hazards exposure analysis.

Despite these limitations, the analysis is sufficient to provide a first-pass measure of the order of magnitude of potential natural hazards exposure across the Otago region.

4.1 Input Data

4.1.1 Natural Hazards Mapping

The natural hazards mapping data used in this analysis is the best natural hazards information with region-wide coverage currently available, however some inconsistencies are identified and a number of key limitations are noted, for example;

- Some data is derived from modelling and represents a specific likelihood event (e.g. coastal inundation and tsunami hazard (Lane *et al* 2007, 2008) but others are developed based on observation of historical events and/or geomorphic interpretation and do not have an associated likelihood (e.g. river and lake flooding, alluvial fan (Grindley *et al*, 2009), or landslide hazards (e.g. Barrell *et al*, 2017).

- Some datasets include consideration of climate change or sea level rise (e.g. coastal inundation, tsunami and coastal erosion (Lane *et al* 2007, 2008; Bosserelle *et al*, 2019), but climate change effects are not accounted for in other datasets such as flood hazard mapping or landslides (e.g. Barrell *et al*, 2017).

- This exposure analysis has used only ORC's regional or district-scale hazards mapping datasets. More detailed natural hazard information is available in many locations (e.g. local-scale flood hazard modelling or geotechnical investigations) but was not used for this initial analysis to maintain consistency of data resolution across the full region.

- Most of the hazards mapping datasets identify mapped areas susceptible to potential future impact from that hazard type, but a key exception is the landslide dataset (e.g. Barrell *et al*, 2017; Turnbull, 2000) which represents only mapping of existing landslide features, but not areas of potential future landslide susceptibility (i.e. slopes which have not yet failed), or areas which may be impacted by the runout of landslide debris. Additionally, some of the mapped landslide features included in the analysis are currently inactive (i.e. not active since prehistoric times) and therefore not necessarily posing a high threat.

- The rockfall awareness areas used in exposure analysis (Easterbrook-Clarke *et al*, 2022) were developed for a domain which excluded hydrologic catchments with no roads present and where buildings were absent or only sparsely distributed, largely in the mountainous parts of the Queenstown Lakes District (see Figure 9.6, Appendix A). The rockfall hazard mapping coverage therefore does not have complete region-wide coverage, but the mapping dataset will include the large majority of the elements at risk (population and buildings) considered in this exposure analysis.

- The active faults used in analysis should be regarded as a minimum representation of the active faults of the region, as earthquake rupture can also occur on as-yet undetected active faults (Barrell, 2021). The mapped active fault traces are generalised and their locations are therefore subject to uncertainty. Barrell (2021) notes that mapped locations are located within ±100 metres at best, and ±250 metres as a general rule.

- Several hazard mapping datasets have been compiled from a range of composite sources or using differing methodologies, leading to variation in the precision and quality of information within a specific mapping dataset;
  - The composite flood hazard layer used in this analysis includes both mapping of flood prone areas (based in part on flood event observations (e.g. ORC, 2025)) and mapping of floodwater-dominated alluvial fans (based on desktop analysis from aerial imagery and topographic interpretation (Grindley *et al*, 2009)). This flood hazard dataset does not include pluvial flooding,[3] meaning that some known flood-prone areas such as the South Dunedin plain are not identified as exposed to flooding hazard in this analysis. For flood hazards in areas of the ORC's flood protection schemes, the population and buildings located within the 'protected' areas are considered to be potentially exposed to the hazard and are included within exposure analysis. This is because these areas could still be exposed to flooding in the case of a super-design flood event or failure of flood protection infrastructure.

  - The landslide dataset used in this analysis is based on regional-scale mapping of landslide features (e.g. QMAP 1:2,500,000 series landslide layers compiled at a 1:50,000 scale), but for the coastal sector of the Dunedin City District the dataset includes higher resolution mapping compiled at a scale of 1:10,000 or better (Barrell *et al*, 2017).

  - The active fault traces included in analysis range in certainty from 'definite' to 'potentially active', and these include features where it is not possible to rule out other origins (e.g. formation due to erosion), or faults which require further positive information be treated as active faults (Barrell, 2021).

4.1.2 Elements at Risk

The key limitations of the elements at risk are associated with the development of the population and building datasets used in analysis

4.1.2.1 POPULATION

- "Usually resident" population is based on values from the 2023 census, so will not account for any changes in population since that time.

- The spatial distribution of the population was estimated by modelling population allocation into building types likely to represent dwellings. This is therefore an approximation rather than a measurement of population in each dwelling, and influenced by uncertainties in the building categorization dataset.

- The use of 'usually resident' population census values does not represent the spatial or temporal distribution of other populations such as transient tourist or seasonal worker

[3] A flood event caused by rainfall where the rainfall exceeds the capacity of the ground, drainage systems, or swales to absorb or drain the rainfall. This can be independent of an overflowing water body from rivers.

populations, so these are not included in estimates of population exposure. Similarly, a significant daytime population could be present in workplace locations during working hours, but is not included in estimates of population exposure based on usually resident population.

4.1.2.2 BUILDINGS

- In rural areas of Otago, the classification of building use category was less comprehensive than in urban areas, and further classification was required to identify and categorise rural dwellings (Scheele *et al*, 2023). Although an improvement to the dataset, this further classification is still only an approximation, and uncertainties also have a flow-on effect as this building categorisation is then used as an input in estimation of population.

- The building outline dataset used in analysis was compiled in 2024, so will not account for any buildings constructed (or removed) since that time. However, this is not expected to cause any significant drawback to the analysis as the rate of new building construction over this time is not considered to be significant compared to the relative quantity of pre-2024 buildings in the dataset.

4.2 Methodological Limitations

4.2.1 Exposure Analysis

- A key limitation in exposure analysis is the assumption that all buildings and population exposed within a mapped hazards extent may come into contact with the natural hazard process, which could then cause an adverse impact to those elements. This is an approximation only, and a conservative approach as not every resident or building may be significantly affected, for example in the case of minor 'nuisance' flooding which does not reach the floor level of a building.

- The 'exposure level' classification for community areas (Table 3.2) uses a first-past-the-post approach rather than a weighted scoring across the three elements at risk. In some cases, the proportion-based classification criteria (buildings and critical community facilities) identify a high proportion of the element but of a relatively low total count. For example, one community area[4] in a remote area has a usually resident population of four residents and only 10 buildings present, but is classed as having 'high' exposure because >50% of those buildings are located in the mapped alluvial fan hazard area. The 'exposure level' classification is therefore considered a useful indicator of overall exposure level, but consideration of the individual exposure components will provide a fuller understanding of the exposure levels and their drivers.

[4] The 'Hunter River' community area at the head of Lake Hawea.

5 Results

5.1 Natural Hazard Exposure

5.1.1 Introduction

Natural hazards exposure analysis results are presented in tabular form in this report section and can be viewed spatially through a digital data portal which complements this technical report. The viewer presents hazards mapping layers, elements at risk information, and all natural hazards exposure outputs. The exposure data portal can be accessed at orc.govt.nz/naturalhazardexposure and copies of output datasets in spreadsheet or GIS format can be provided on request.

At a regional level, Table 5.1 presents a summary of natural hazards exposure, showing aggregated totals for each hazard type. Similar results tables with these exposure outputs tabulated for each district are included as Tables 9.4-9.8 in Appendix D. Tables 5.2 and 5.3 provide a summary of the top 10 urban areas/settlements and community areas in the region exposed to each hazard type.

For each hazard type, exposure analysis results are summarised in a series of two tables;

- A summary table showing the estimated count and percentage of those elements within each district potentially exposed to impact from the hazard (e.g. Table 5.4).
- A 'Top 10' table listing the urban areas and settlements with the greatest hazard exposure, ranked by the usual resident population exposed to the hazard, and presents the exposure totals aggregated for the urban areas or settlement (e.g. Table 5.5).

The count of critical community facilities exposed to each hazard type are included in Tables 5.4-5.21, these exposed facilities are identified in Table 9.9, Appendix D.

For any urban area/settlement or community area, where exposure analysis results are not presented within this technical report, they can be viewed through the exposure data portal.

5.1.2 Regional and District Summary

Regional-level natural hazards exposure outputs are summarised in Table 16, which shows a comparison between the elements exposed to the range of natural hazard types assessed.

Exposure analysis demonstrates that the two hazard types in the Otago region with the greatest populations and buildings located within hazard-prone areas are river and lake flooding and liquefaction (Table 16). There is also a notable spatial overlap between the geographic extents of these two hazard types, because flood-prone floodplain areas typically comprise geologically-recent sediment deposits which may also be susceptible to liquefaction. Although liquefaction hazard has the highest exposure in terms of population, this hazard does not necessarily pose the highest risk to the region as the likelihood of occurrence for a major earthquake triggering liquefaction is lower than other hazard types such as flooding.

In comparison, hazard types with a more localised spatial occurrence, or in locations less appealing for residential development, have a significantly lower exposure level. For example, potential coastal inundation impacts are limited to the immediate coastal margins, and rockfall impacts are limited to the immediate downslope extents below steep source areas.

Table 5.1: Natural hazards exposure summary for the Otago Region, showing the estimated count and percentage of those elements within Otago potentially exposed to impact from the named natural hazard types.

Hazard type	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in region
	Count	Percent of population in region	Count (all buildings)	Percent of total buildings in region	Count (Dwellings)	Percent of total dwellings in region	Count	Percent of total CCF in region	Very Low	Low	Moderate	High	Very High	
River and lake flooding	38,778	16.1	33,898	16.1	12,776	14.4	23	25.6	121	26	45	99	60	351
Liquefaction	46,047	19.1	43,029	20.4	17,459	19.7	37	41.1	142	18	45	68	78	351
Active Faults	21,949	9.1	20,096	9.5	8,371	9.4	10	11.1	203	19	21	68	40	351
Landslide	8,038	3.3	6,592	3.1	2,844	3.2	3	3.3	225	14	51	41	20	351
Alluvial fan	5,473	2.3	5,904	2.8	1,996	2.3	3	3.3	272	10	18	38	13	351
Rockfall	1,234	0.5	1,056	0.5	377	0.4	0	0	290	14	29	14	4	351
Tsunami	504	0.2	1,130	0.5	266	0.3	0	0	327	4	7	12	1	351
Storm surge	504	0.2	1,122	0.5	230	0.3	0	0	325	7	8	10	1	351
Coastal Erosion (Waitaki)	37	0	111	0.1	19	0.0	0	0	346	1	3	1	0	351

Table 5.2: Natural hazards exposure summary for the Otago Region, showing the 'Top 10' urban areas or rural settlements with highest exposure for each hazard type, identified and ordered by the estimated population exposed to the hazard within that urban area/settlement. The population exposed within each urban area/settlement is indicated by the cell shading (see legend). Coastal erosion hazard is not included in the table, as there is insufficient data to provide a region-wide comparison across the full Otago coastline.

Hazard type							
River and lake flooding	**Liquefaction**	**Active Faults**	**Landslide**	**Alluvial fan**	**Rockfall**	**Tsunami**	**Storm surge**
Mosgiel	Dunedin	Dunedin	Dunedin	Queenstown	Queenstown	Pounawea	Dunedin
Dunedin	Mosgiel	Mosgiel	Wanaka	Dunedin	Dunedin	Taieri Mouth	Waikouaiti
Oamaru	Wanaka	Alexandra	Warrington	Wanaka	Arrowtown	Purakaunui	Purakaunui
Queenstown	Queenstown	Wanaka	Queenstown	Roxburgh	Wanaka	Brighton	Pounawea
Balclutha	Milton	Lake Hawea	Mosgiel	Palmerston	Roxburgh	Waikouaiti	Taieri Mouth
Outram	Balclutha	Roxburgh	Moeraki	Waikouaiti	Aramoana	Karitane	Waitati-Doctors Point
Milton	Outram	Kaitangata	Roxburgh	Glenorchy	Purakaunui	Waitati-Doctors Point	Brighton
Luggate	Kingston	Waihola	Brighton	Arrowtown	Lake Roxburgh	Kaka Point	Karitane
Glenorchy	Glenorchy	Allanton	Karitane	Kingston	Oamaru	Kaitangata	Kakanui
Waihola	Brighton	Queenstown	Waitati-Doctors Point	Harington Point	Moeraki	Kakanui	Moeraki

Legend
Population exposed
>5,000
1000-5000
500-1000
100-500
20-100
≤20

Table 5.3: Natural hazards exposure summary for the Otago Region, showing the 'Top 10' community areas with highest exposure for each hazard type, identified and ordered by the estimated population exposed to the hazard within that community area. Where a community area forms part of a larger urban area/settlements, that larger area is named within parentheses. Community areas outside of urban area/settlements are noted as 'rural'. The population exposed and the exposure level classification for each community area are indicated by the cell shading and text formatting, respectively (see legend). Coastal erosion hazard is not included in the table, as there is insufficient data to provide a region-wide comparison across the full Otago coastline.

Hazard type							
River and lake flooding	***Liquefaction***	***Active Faults***	***Landslide***	***Alluvial fan***	***Rockfall***	***Tsunami***	***Storm surge***
Mosgiel East (Mosgiel)	St Kilda South (Dunedin)	East Taieri (Mosgiel)	Fernhill (Dunedin)	Warren Park (Queenstown)	Warren Park (Queenstown)	Pounawea	*Waikouaiti*
Gardens (Dunedin)	Mosgiel Central (Mosgiel)	Green Island (Dunedin)	Abbotsford (Dunedin)	Roseneath-Sawyers Bay (Dunedin)	Sunshine Bay-Fernhill (Queenstown)	*Taieri Mouth*	*Pūrākaunui*
Seddon Park (Mosgiel)	Seddon Park (Mosgiel)	Caversham (Dunedin)	Dunedin Central (Dunedin)	Wānaka West (Wanaka)	Arthurs Point (Queenstown)	*Pūrākaunui*	Pounawea
Mosgiel Central (Mosgiel)	St Kilda North (Dunedin)	Wakari (Dunedin)	Roslyn (Dunedin)	Frankton (Queenstown)	*Arrowtown*	*Brighton*	*Andersons Bay (Dunedin)*
Bush Road (Mosgiel)	South Dunedin (Dunedin)	Seddon Park (Mosgiel)	Warrington	Roxburgh	*Glenleith (Dunedin)*	*Owaka Valley East (Clutha rural)*	*Taieri Mouth*
Campus South (Dunedin)	Bush Road (Mosgiel)	Albert Town (Wanaka)	Brockville (Dunedin)	Sunshine Bay-Fernhill (Queenstown)	*Maori Hill (Dunedin)*	*Glenledi-Toko Mouth (Clutha rural)*	*Waverley (Dunedin)*
Oamaru North Milner Park (Oamaru)	Milton	Alexandra South (Alexandra)	Wānaka Central (Wanaka)	Palmerston	*Gibbston (Queenstown rural)*	*Waikouaiti*	*Waitati-Doctors Point*
Jacks Point (Queenstown)	Campus South (Dunedin)	Roslyn (Dunedin)	Albert Town (Wanaka)	Queenstown Central (Queenstown)	*Frankton (Queenstown)*	*Purakaunui (Clutha rural)*	*Glenledi-Toko Mouth (Clutha rural)*
Balclutha South (Balclutha)	Albert Town (Wanaka)	Wingatui (Mosgiel)	Wānaka West (Wanaka)	Broad Bay-Portobello (Dunedin)	*Otago Harbour Deborah Bay To Aramoana (Dunedin rural)*	*Karitāne*	*Brighton*
Campus North (Dunedin)	Jacks Point (Queenstown)	Lake Hāwea	Kaikorai-Bradford (Dunedin)	Waverley (Dunedin)	*St Clair (Dunedin)*	*Waitati-Doctors Point*	*Karitāne*

Legend	
Population exposed	***Exposure Class***
>2,500	Very High (regular)
1000-2500	*High (italics)*
500-1000	
100-500	
20-100	
≤20	

5.1.3 River and Lake Flood Hazard

There are a total of approximately 38,000 people and 34,000 buildings, including >12,000 dwellings, within the Otago region located in areas identified as potentially prone to river or lake flooding (Table 5.4). The majority of the population (72%) and buildings (58%) exposed are those located within the Dunedin City district, however all districts include a total of ≥1400 people and >500 dwellings exposed to the hazard.

A total of 23 critical community facilities in the region are located in flood-prone areas, this includes 11 fire stations, 6 police stations, 4 ambulance facilities and 1 hospital complex, and one Emergency Operations Centre (Table 9.9).

A 'top-10' list of the urban areas or rural settlements most exposed to flooding hazards (in terms of estimated population numbers) are shown in Table 5.5. This table shows the ten urban areas or rural settlements in the region assessed as having the greatest population exposed to flooding hazards.

In general, the flood hazard areas with the highest exposure are those which have been the focus of more detailed flood hazard assessments or the construction of engineered flood protection infrastructure (i.e. the ORC's Leith, Lower Taieri and Lower Clutha Flood Protection Schemes). For example, urban areas or rural settlements in the top-10 flooding exposure list (Table 5.5) include Dunedin City, the settlements of the Taieri Plain (Mosgiel, Outram, Waihola), Balclutha, Milton, Queenstown and Glenorchy.

Flood hazard exposure for each 'community area' has been classed using the criteria in Table 3.2, with about 159 (45%) of the 351 community areas in the region classified with a 'high' or 'very high' exposure to flood hazards (Table 5.4).

Table 5.4: Flood hazard exposure summary for the Otago region, showing the estimated count and percentage of those elements within each district potentially exposed to impact from flooding events.

District	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in district
	Count	Percent of population in district	Count (all buildings)	Percent of total buildings in district	Count (Dwellings)	Percent of total dwellings in district	Count	Percent of total CCF in district	Very Low	Low	Mod.	High	Very High	
Dunedin City	27,969	21.7	19,683	21.9	8,666	19.2	10	33.3	47	1	7	23	39	117
Clutha	3,754	20.5	5,593	18.7	1,276	21.2	10	45.5	18	8	5	23	10	64
Queenstown-Lakes	2,883	6	3,161	8.7	1,387	7.2	1	7.7	29	8	14	14	4	69
Waitaki	2,707	12.5	2,870	11.2	924	11.3	0	0.0	21	5	9	10	4	49
Central Otago	1,466	6	2,591	9	523	5.2	2	11.8	6	4	10	29	3	52
Otago Total	38,778		33,898		12,776		23		121	26	45	99	60	351

Table 5.5: Flood hazard exposure summary for the Top 10 urban areas or rural settlements in the Otago region, identified and ordered by the estimated population exposed to the hazard within that urban area/settlement.

Location	District	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in location
		Count	Percent of population in location	Count (all buildings)	Percent of total buildings in location	Count (Dwellings)	Percent of total dwellings in location	Count	Percent of total CCF in location	Very Low	Low	Mod.	High	Very High	
Mosgiel	Dunedin City	12,530	85.9	8,765	87.1	4,993	86.6	3	100.0	0	0	0	0	6	6
Dunedin	Dunedin City	12,078	12.0	5,560	9.4	2,635	7.7	5	25.0	22	0	1	11	17	51
Oamaru	Waitaki	1,989	14.5	1,466	13.9	784	14.0	0	0.0	6	0	0	0	2	8
Queenstown	Queenstown-Lakes	1,546	6.2	1,027	8.2	819	10.0	0	0.0	7	1	3	1	1	13
Balclutha	Clutha	1,105	25.4	1,104	34.5	421	24.5	3	75.0	0	0	0	1	1	2
Outram	Dunedin City	912	100.0	734	100.0	356	100.0	1	100.0	0	0	0	0	1	1
Milton	Clutha	839	39.6	827	41.1	358	40.2	2	66.7	0	0	0	0	1	1
Luggate	Queenstown-Lakes	461	73.5	365	76.2	175	73.5	1	100.0	0	0	0	0	1	1
Glenorchy	Queenstown-Lakes	351	96.6	467	86.8	171	96.6	0	0.0	0	0	0	0	1	1
Waihola	Clutha	324	63.1	346	65.0	130	63.1	0	0.0	0	0	0	0	1	1

5.1.4 Alluvial Fan Hazard

There are a total of 5,400 people and 5,900 buildings, including about 2000 dwellings, within the Otago region located in areas identified as being prone to inundation or debris hazards from active alluvial fans (Table 5.6). This analysis includes active alluvial fan surfaces mapped as being 'debris-dominated' or 'composite' but excludes those solely characterised as 'floodwater-dominated' (these are included within analysis of flooding hazards). Composite fans are those where debris and floodwater processes are unable to be separated at the scale of mapping, or the fans may be subject to both processes.

A majority of the population (81%) and buildings (72%) exposed to these alluvial fan hazards are those located within either the Queenstown Lakes or Dunedin City districts, with lesser exposure in the Central Otago, Waitaki and Clutha districts.

A total of 3 critical community facilities in the region are located in active alluvial fan hazard areas; 2 police stations and 1 fire station (Table 9.9).

A top-10 list of the urban areas or rural settlements exposed to active alluvial fan hazards are shown in Table 5.7. This table shows the ten urban areas or rural settlements in the region assessed as having the greatest population exposed to active alluvial fan hazards.

Many of these alluvial fan locations have been the focus of previous alluvial fan hazards investigations by ORC or territorial authorities, in particular those at Queenstown (Brewery Creek and Reavers Lane), Wanaka (Stoney Creek and Waterfall Creek), Roxburgh (Reservoir Creek and other nearby catchments) and Glenorchy (Buckler Burn). The majority of the Buckler Burn alluvial fan is mapped as 'floodwater-dominated' so is included only within the flooding hazard analysis, the values for Glenorchy in Table 5.7 refer only to the portion of the Buckler Burn fan mapped as 'debris dominated'.

For Dunedin city, the relatively high exposure is due to the number of 'debris-dominated' active alluvial fans located on the Otago Peninsula, such as those at Broad Bay, Portobello and Challis. For Waikouaiti, exposure is due to Post Office Creek and several other urban stream areas which are classed as 'composite' alluvial fans.

Active alluvial fan hazard exposure for each 'community area' has been classed using the criteria in Table 3.2, with 51 (~15%) of the 351 community areas in the region classified with a 'high' or 'very high' exposure to alluvial fan hazards (Table 5.6).

Table 5.6: Alluvial fan hazard exposure summary for the Otago region, showing the estimated count and percentage of those elements within each district potentially exposed to debris inundation impact.

District	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in district
	Count	Percent of population in district	Count (all buildings)	Percent of total buildings in district	Count (Dwellings)	Percent of total dwellings in district	Count	Percent of total CCF in district	Very Low	Low	Mod.	High	Very High	
Queenstown-Lakes	3,189	6.7	2,862	7.9	1,104	5.7	1	7.7	29	3	6	24	7	69
Dunedin City	1,294	1.0	1,436	1.6	530	1.2	1	3.3	103	3	4	3	4	117
Central Otago	734	3.0	1,063	3.7	256	2.6	0	0.0	34	3	3	11	1	52
Waitaki	238	1.1	451	1.8	102	1.3	1	12.5	46	0	2	0	1	49
Clutha	17	0.1	92	0.3	4	0.1	0	0.0	60	1	3	0	0	64
Otago Total	5,473		5,904		1,996		3		272	10	18	38	13	351

Table 5.7: Alluvial fan hazard exposure summary for the Top 10 urban areas or rural settlements in the Otago region, identified and ordered by the estimated population exposed to the hazard within that urban area/settlement.

Location	District	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in location
		Count	Percent of population in location	Count (all buildings)	Percent of total buildings in location	Count (Dwellings)	Percent of total dwellings in location	Count	Percent of total CCF in location	Very Low	Low	Mod.	High	Very High	
Queenstown	Queenstown-Lakes	2,085	8.3	1,214	9.7	521	6.4	1	16.7	5	0	1	2	5	13
Dunedin	Dunedin City	1,172	1.2	1,084	1.8	484	1.4	1	5.0	47	0	0	0	4	51
Wanaka	Queenstown-Lakes	624	5.2	559	5.6	392	6.3	0	0.0	5	0	0	0	1	6
Roxburgh	Central Otago	279	44.1	235	32.8	149	45.0	0	0.0	0	0	0	0	1	1
Palmerston	Waitaki	221	20.9	306	25.6	98	21.3	1	50.0	0	0	0	0	1	1
Waikouaiti	Dunedin City	51	4.0	85	6.1	25	4.0	0	0.0	0	0	0	1	0	1
Glenorchy	Queenstown-Lakes	25	6.8	37	6.9	12	6.8	0	0.0	0	0	0	1	0	1
Arrowtown	Queenstown-Lakes	19	0.7	17	0.8	9	0.7	0	0.0	0	0	0	1	0	1
Kingston	Queenstown-Lakes	15	3.7	16	3.3	8	3.7	0	0.0	0	0	0	1	0	1
Harington Point	Dunedin City	10	5.3	34	6.7	4	5.3	0	0.0	0	0	1	0	0	1

5.1.5 Active Fault Hazards

There are a total of about 22,000 people and 20,000 buildings, including 8,000 dwellings, within the Otago region located in areas identified as being located in proximity (within 250 metres) of active faults (Table 5.8). The majority of the population (63%) and buildings (51%) exposed to active fault hazards are those located within the Dunedin City district, with lesser exposure in the remaining districts.

A total of ten critical community facilities in the region are located in proximity to active faults; 3 police stations, 6 fire stations, and one Emergency Operations Centre (Table 9.9).

A top-10 list of the urban areas or rural settlements exposed to active fault hazards are shown in Table 5.9. This table shows the ten urban areas or rural settlements in the region assessed as having the greatest population located in near proximity to active faults.

The relatively high exposure in the Dunedin City district is due to the presence of the Kaikorai and Titri Faults, which run through Dunedin city and Mosgiel, respectively. Alexandra is intersected by several strands of the Galloway Fault zone, and both Wanaka and Lake Hawea by the Cardrona-Hawea Fault.

The locations of highest exposure are not necessarily at the highest risk for fault rupture hazards, as the exposure analysis does not account for the variation in ground-surface rupture recurrence interval for each fault, which ranges from <2000 years for the Akatore and Settlement Faults, to ≥50,000 years for others.

Active fault hazard exposure for each ‘community area’ has been classed using the criteria in Table 3.2, with 108 (~31%) of the 351 community areas in the region classified with a ‘high’ or ‘very high’ exposure to alluvial fan hazards (Table 5.8).

Table 5.8: Active fault hazard exposure summary for the Otago region, showing the estimated count and percentage of those elements within each district potentially exposed to impact from fault rupture.

District	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in district
	Count	Percent of population in district	Count (all buildings)	Percent of total buildings in district	Count (Dwellings)	Percent of total dwellings in district	Count	Percent of total CCF in district	Very Low	Low	Mod.	High	Very High	
Dunedin City	13,748	10.7	10,158	11.3	5,273	11.7	3	10.0	73	7	4	11	22	117
Central Otago	3,758	15.5	4,694	16.3	1,517	15.2	5	29.4	11	2	5	26	8	52
Queenstown-Lakes	2,172	4.5	1,891	5.2	899	4.7	1	7.7	51	3	4	8	3	69
Clutha	1,774	10.0	2,624	8.8	581	9.7	1	4.5	33	6	3	17	5	64
Waitaki	497	2.3	729	2.8	101	1.2	0	0.0	35	1	5	6	2	49
Otago Total	21,949		20,096		8,371		10	11.1	203	19	21	68	40	351

Table 5.9: Active fault hazard exposure summary for the Top 10 urban areas or rural settlements in the Otago region, identified and ordered by the estimated population exposed to the hazard within that urban area/settlement.

Location	District	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in location
		Count	Percent of population in location	Count (all buildings)	Percent of total buildings in location	Count (Dwellings)	Percent of total dwellings in location	Count	Percent of total CCF in location	Very Low	Low	Moderate	High	Very High	
Dunedin	Dunedin City	8,293	8.2	5,895	10.0	3,269	9.5	3	15.0	35	1	0	3	12	51
Mosgiel	Dunedin City	4,374	30.0	2,823	28.0	1,657	28.7	0	0.0	1	0	0	0	5	6
Alexandra	Central Otago	1,617	28.9	1,300	30.4	721	29.5	2	50.0	0	0	0	0	2	2
Wanaka	Queenstown-Lakes	1,042	8.7	828	8.3	426	6.8	0	0.0	3	0	0	2	1	6
Lake Hawea	Queenstown-Lakes	727	36.3	544	35.4	335	36.3	1	100.0	0	0	0	0	1	1
Roxburgh	Central Otago	586	92.6	628	87.7	307	92.7	2	100.0	0	0	0	0	1	1
Kaitangata	Clutha	573	69.0	574	63.6	238	69.0	0	0.0	0	0	0	0	1	1
Waihola	Clutha	329	64.1	370	69.5	132	64.1	0	0.0	0	0	0	0	1	1
Allanton	Dunedin City	235	68.2	220	70.7	90	68.2	0	0.0	0	0	0	0	1	1
Queenstown	Queenstown-Lakes	130	0.5	94	0.7	44	0.5	0	0.0	12	0	0	0	1	13

5.1.6 Liquefaction Hazard

There are a total of 46,000 people and 43,000 buildings, including >17,000 dwellings, within the Otago region located in areas identified as being potentially susceptible to liquefaction (Table 5.10). This analysis includes all areas mapped as having either a 'low to moderate' or 'moderate to high' susceptibility to liquefaction, as mapped in studies by Barrell *et al* (2014) and Barrell (2019). In the terminology of the MBIE/MfE guidance (2017), these are collectively classed as being locations where 'Liquefaction damage is possible'.

The majority of the population (66%) and buildings (56%) which are exposed to potential liquefaction hazard are those located within the Dunedin City District, however all districts include a total of >500 people and >1000 buildings exposed to liquefaction hazards.

A total of 35 critical community facilities in the region are located in liquefaction-prone areas, this includes 18 fire stations, 12 police stations, 4 ambulance stations and 1 hospital complex (Table 9.9).

A top-10 list of the urban areas or rural settlements exposed to liquefaction hazards are shown in Table 5.11. This table shows the ten urban areas or rural settlements in the region assessed as having the greatest population exposed to liquefaction hazards. About 50% of the population identified as being potentially susceptible to liquefaction are in either the Dunedin City urban area or Mosgiel, with sizeable (>1000) populations also exposed in Wanaka, Queenstown, Milton and Balclutha.

Liquefaction hazard exposure for each 'community area' has been classed using the criteria in Table 3.2, with about 42% (146) of the 351 community areas in the region classified with a 'high' or 'very high' exposure to liquefaction hazard (Table 5.10).

The assessment of liquefaction hazard exposure only demonstrates the locations where geological and groundwater conditions are such that liquefaction may occur, given sufficient earthquake shaking as a trigger event. Exposure analysis does not account for the spatial variability in the likelihood of a major earthquake shaking capable of triggering liquefaction, which is more likely to occur in the western parts of the region (Murashev and Davey, 2004).

Table 5.10: Liquefaction hazard exposure summary for the Otago region, showing the estimated count and percentage of those elements within each district potentially exposed to impact from liquefaction events.

District	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in district
	Count	Percent of population in district	Count (all buildings)	Percent of total buildings in district	Count (Dwellings)	Percent of total dwellings in district	Count	Percent of total CCF in district	Very Low	Low	Mod.	High	Very High	
Dunedin City	30,128	23.4	23,924	26.7	10,673	23.7	14	46.7	48	1	11	16	41	117
Queenstown-Lakes	8,870	18.6	8,059	22.2	4,350	22.5	4	30.8	25	6	8	17	13	69
Clutha	5,184	28.3	7,442	24.8	1,901	31.6	14	63.6	15	7	8	18	16	64
Waitaki	992	4.6	1,967	7.7	268	3.3	3	37.5	17	2	15	10	5	49
Central Otago	872	3.6	1,637	5.7	267	2.7	2	11.8	37	2	3	7	3	52
Otago Total	46,047		43,029		17,459		37		142	18	45	68	78	351

Table 5.11: Liquefaction hazard exposure summary for the Top 10 urban areas or rural settlements in the Otago region, identified and ordered by the estimated population exposed to the hazard within that urban area/settlement.

Location	District	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in location
		Count	Percent of population in location	Count (all buildings)	Percent of total buildings in location	Count (Dwellings)	Percent of total dwellings in location	Count	Percent of total CCF in location	Very Low	Low	Mod.	High	Very High	
Dunedin	Dunedin City	18,082	17.9	12,061	20.4	5,945	17.3	9	45	23	0	3	5	20	51
Mosgiel	Dunedin City	8,333	57.1	6,098	60.6	3,411	59.2	3	100	1	0	0	1	4	6
Wanaka	Queenstown-Lakes	4,357	36.6	3,879	39.1	2,291	36.8	2	67	1	0	1	0	4	6
Queenstown	Queenstown-Lakes	3,206	12.8	2,137	17.0	1,429	17.5	2	33	3	0	1	4	5	13
Milton	Clutha	1,994	94.0	1,854	92.2	837	94.0	3	100	0	0	0	0	1	1
Balclutha	Clutha	1,071	24.6	1,072	33.5	408	23.7	3	75	0	0	0	1	1	2
Outram	Dunedin City	909	99.7	733	99.9	355	99.7	1	100	0	0	0	0	1	1
Kingston	Queenstown-Lakes	393	100.0	479	99.8	216	100.0	0	0	0	0	0	0	1	1
Glenorchy	Queenstown-Lakes	363	100.0	502	93.3	177	100.0	0	0	0	0	0	0	1	1
Brighton	Dunedin City	317	22.0	311	22.8	135	22.0	0	0	0	0	0	0	1	1

5.1.7 Landslide Hazard

There are a total of 8,000 people and 6,500 buildings, including nearly 3,000 dwellings, within the Otago region located in areas identified as being located within mapped landslide features (Table 5.12). A large majority of the population (97%) and buildings (90%) exposed are those located within the Dunedin City or Queenstown Lakes districts.

A total of 2 critical community facilities in the region are located in mapped landslide features, this includes 1 fire station and 1 police station.

A top-10 list of the urban areas or rural settlements exposed to landslide hazards are shown in Table 5.13. This table shows the ten urban areas or rural settlements in the region assessed as having the greatest population being located within mapped landslide features.

Landslide feature exposure for each 'community area' has been classed using the criteria in Table 3.2, with 61 (~17%) of the 351 community areas in the region classified with a 'high' or 'very high' exposure to landslide features (Table 5.12).

It is important to note that this analysis is based only on mapping of existing landslide features, but does not include areas of potential future landslide susceptibility (i.e. slopes which have not yet failed), or areas which may be impacted by the runout of landslide debris. Additionally, the mapped landslide features may be currently inactive (i.e. not active since prehistoric times) and therefore not necessarily posing a high threat.

However, the spatial distribution of exposure to existing landslide features would be expected to have a reasonable correlation to exposure to areas of potential future landslide occurrence, as the presence of numerous existing landslide features likely indicates geological conditions are such that future landsliding is possible in the vicinity.

Table 5.12: Landslide hazard exposure summary for the Otago region, showing the estimated count and percentage of those elements within each district within the extent of mapped landslide features.

District	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in district
	Count	Percent of population in district	Count (all buildings)	Percent of total buildings in district	Count (Dwellings)	Percent of total dwellings in district	Count	Percent of total CCF in district	Very Low	Low	Mod.	High	Very High	
Dunedin City	6,160	4.8	4,380	4.9	1,981	4.4	1	3.3	52	3	24	25	13	117
Queenstown-Lakes	1,663	3.5	1,531	4.2	761	3.9	2	15.4	32	7	12	11	7	69
Central Otago	116	0.5	411	1.4	40	0.4	0	0.0	38	3	7	4	0	52
Waitaki	92	0.4	243	0.9	60	0.7	0	0.0	40	1	7	1	0	49
Clutha	8	0.0	27	0.1	2	0.0	0	0.0	63	0	1	0	0	64
Otago Total	8,038		6,592		2,844		3		225	14	51	41	20	351

Table 5.13: Landslide hazard exposure summary for the Top 10 urban areas or rural settlements in the Otago region, identified and ordered by the estimated population exposed to the hazard within that urban area/settlement.

Location	District	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in location
		Count	Percent of population in location	Count (all buildings)	Percent of total buildings in location	Count (Dwellings)	Percent of total dwellings in location	Count	Percent of total CCF in location	Very Low	Low	Mod.	High	Very High	
Dunedin	Dunedin City	5,025	5.0	2,673	4.5	1,561	4.5	1	5	24	0	9	7	11	51
Wanaka	Queenstown-Lakes	1,064	8.9	965	9.7	560	9.0	2	67	2	0	0	1	3	6
Warrington	Dunedin City	530	96.6	612	93.7	225	96.6	0	0	0	0	0	0	1	1
Queenstown	Queenstown-Lakes	494	2.0	273	2.2	158	1.9	0	0	3	0	5	2	3	13
Mosgiel	Dunedin City	64	0.4	43	0.4	24	0.4	0	0	4	0	0	2	0	6
Moeraki	Waitaki	49	31.1	130	27.4	51	31.1	0	0	0	0	0	1	0	1
Roxburgh	Central Otago	47	7.4	43	6.0	25	7.6	0	0	0	0	0	1	0	1
Brighton	Dunedin City	12	0.8	9	0.7	5	0.8	0	0	0	0	0	1	0	1
Karitane	Dunedin City	11	2.6	10	1.3	8	2.6	0	0	0	0	0	1	0	1
Waitati-Doctors Point	Dunedin City	3	0.4	1	0.2	1	0.4	0	0	0	0	1	0	0	1

5.1.8 Rockfall Hazard

There are a total of 1,200 people and 1,000 buildings, including nearly 400 dwellings, within the Otago region located in areas identified as being in areas exposed to potential rockfall hazard (Table 5.14). This analysis is based on mapping of 'rockfall awareness areas' by Easterbrook-Clarke *et al* (2022) which include the extent of modelled rockfall trajectories and a buffer to account for modelling uncertainties. No critical community facilities in the region are located in rockfall hazard areas.

A large majority of the population (84%) and buildings (76%) exposed to potential rockfall hazards are located within the Queenstown Lakes district.

A top-10 list of the urban areas or rural settlements exposed to rockfall hazards are shown in Table 5.15. This table shows the ten urban areas or rural settlements in the region assessed as having the greatest population being located within mapped rockfall awareness areas.

Rockfall hazard exposure for each 'community area' has been classed using the criteria in Table 3.2, with 18 (~5%) of the 351 community areas in the region classified with a 'high' or 'very high' exposure to rockfall hazard (Table 5.14).

Table 5.14: Rockfall hazard exposure summary for the Otago region, showing the estimated count and percentage of those elements within each district within the extent of rockfall awareness areas and potentially exposed to rockfall impact.

District	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in district
	Count	Percent of population in district	Count (all buildings)	Percent of total buildings in district	Count (Dwellings)	Percent of total dwellings in district	Count	Percent of total CCF in district	Very Low	Low	Mod.	High	Very High	
Queenstown-Lakes	1,040	2.2	810	2.2	303	1.6	0	0.0	32	9	15	9	4	69
Dunedin City	165	0.1	152	0.2	64	0.1	0	0.0	102	1	10	4	0	117
Central Otago	29	0.1	57	0.2	10	0.1	0	0.0	44	3	4	1	0	52
Clutha	0	0.0	21	0.1	0	0.0	0	0.0	63	1	0	0	0	64
Waitaki	0	0.0	16	0.1	0	0.0	0	0.0	49	0	0	0	0	49
Otago Total	1,234		1,056		377		0		290	14	29	14	4	351

Table 5.15: Rockfall hazard exposure summary for the Top 10 urban areas or rural settlements in the Otago region, identified and ordered by the estimated population exposed to the hazard within that urban area/settlement.

Location	District	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in location
		Count	Percent of population in location	Count (all buildings)	Percent of total buildings in location	Count (Dwellings)	Percent of total dwellings in location	Count	Percent of total CCF in location	Very Low	Low	Mod.	High	Very High	
Queenstown	Queenstown-Lakes	887	3.5	514	4.1	237	2.9	0	0	4	1	3	2	3	13
Dunedin	Dunedin City	125	0.1	80	0.1	48	0.1	0	0	42	0	6	3	0	51
Arrowtown	Queenstown-Lakes	60	2.1	48	2.1	29	2.1	0	0	0	0	0	1	0	1
Wanaka	Queenstown-Lakes	14	0.1	22	0.2	6	0.1	0	0	4	1	0	1	0	6
Roxburgh	Central Otago	8	1.2	10	1.4	4	1.2	0	0	0	0	1	0	0	1
Aramoana	Dunedin City	4	2.9	10	3.8	2	2.9	0	0	0	0	1	0	0	1
Purakaunui	Dunedin City	3	1.5	11	2.3	2	1.5	0	0	0	0	1	0	0	1
Lake Roxburgh	Central Otago	0	0.0	5	3.5	0	0.0	0	0	0	1	0	0	0	1
Oamaru	Waitaki	0	0.0	4	0.0	0	0.0	0	0	8	0	0	0	0	8
Moeraki	Waitaki	0	0.0	1	0.2	0	0.0	0	0	1	0	0	0	0	1

5.1.9 Storm Surge Inundation Hazard

There are a total of 500 people and 1,100 buildings, including 200 dwellings, within the Otago region located in areas identified as being prone to coastal inundation from storm surge (Table 5.16). This analysis is based on the data layer 'storm surge affected areas – all scenarios' which includes scenarios of up to 500-year ARI events and a sea level rise scenarios of up to 50 cm above mean sea level. No critical community facilities in the region are located in areas exposed to this hazard.

A majority of the population (67%) and buildings (59%) exposed to storm surge inundation hazard are those located within the Dunedin City district, with lesser numbers in the Clutha district (33%, 39%) and minor exposure in the Waitaki district.

A top-10 list of the urban areas or rural settlements exposed to storm surge hazards are shown in Table 5.17. This table shows the ten urban areas or rural settlements in the region assessed as having the greatest population being located within mapped storm surge inundation areas.

Storm surge inundation hazard exposure for each 'community area' has been classed using the criteria in Table 3.2, with 11 (~5%) of the 230 community areas in the three coastal districts (Waitaki, Dunedin City, Clutha) classified with a 'high' or 'very high' exposure to storm surge hazard (Table 5.16).

Table 5.16: *Storm surge inundation hazard exposure summary for the Otago region, showing the estimated count and percentage of those elements within each district potentially exposed to storm surge impact.*

District	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in district
	Count	Percent of population in district	Count (all buildings)	Percent of total buildings in district	Count (Dwellings)	Percent of total dwellings in district	Count	Percent of total CCF in district	Very Low	Low	Mod.	High	Very High	
Dunedin City	336	0.3	664	0.7	136	0.3	0	0.0	102	2	5	8	0	117
Clutha	164	0.9	440	1.5	90	1.5	0	0.0	55	4	2	2	1	64
Waitaki	4	0.0	18	0.1	3	0.0	0	0.0	47	1	1	0	0	49
Central Otago	*Hazard not present*													52
Queenstown-Lakes	*Hazard not present*													69
Otago Total	504		1,122		229		0		325	7	8	10	1	351

Table 5.17: Storm surge inundation hazard exposure summary for the Top 10 urban areas or rural settlements in the Otago region, identified and ordered by the estimated population exposed to the hazard within that urban area/settlement.

Location	District	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in location
		Count	Percent of population in location	Count (all buildings)	Percent of total buildings in location	Count (Dwellings)	Percent of total dwellings in location	Count	Percent of total CCF in location	Very Low	Low	Mod.	High	Very High	
Dunedin	Dunedin City	111	0.1	195	0.3	23	0.1	0	0	45	1	3	2	0	51
Waikouaiti	Dunedin City	73	5.8	81	5.8	36	5.8	0	0	0	0	0	1	0	1
Purakaunui	Dunedin City	72	34.4	230	48.3	45	34.4	0	0	0	0	0	1	0	1
Pounawea	Clutha District	65	60.0	112	57.7	42	60.0	0	0	0	0	0	0	1	1
Taieri Mouth	Clutha District	52	15.7	103	18.3	29	15.7	0	0	0	0	0	1	0	1
Waitati-Doctors Point	Dunedin City	28	4.7	37	5.6	11	4.7	0	0	0	0	0	1	0	1
Brighton	Dunedin City	19	1.3	30	2.2	8	1.3	0	0	0	0	0	1	0	1
Karitane	Dunedin City	14	3.3	45	5.8	10	3.3	0	0	0	0	0	1	0	1
Kakanui	Waitaki	3	0.8	10	1.4	2	0.8	0	0	0	0	1	0	0	1
Moeraki	Waitaki	1	0.6	3	0.6	1	0.6	0	0	0	1	0	0	0	1

5.1.10 Tsunami Hazard

There are a total of 500 people and 1,100 buildings, including >250 dwellings, within the Otago region located in areas identified as being prone to tsunami impact (Table 5.18). This analysis is based on the data layer which combines modelled tsunami extents for three scenarios (Puysegur, and South America 100 and 500-year ARI), and includes a sea level rise scenario of up to 50 cm above mean sea level. No critical community facilities in the region are located in areas mapped as being

A majority of the population (60%) and buildings (61%) exposed to tsunami inundation hazard are those located within the Clutha district, with lesser numbers in the Dunedin City district (38%, 33%) and minor exposure in the Waitaki district.

A top-10 list of the urban areas or rural settlements exposed to tsunami hazards are shown in Table 5.19. This table shows the ten urban areas or rural settlements in the region assessed as having the greatest population being located within mapped tsunami inundation areas.

Tsunami inundation hazard exposure for each 'community area' has been classed using the criteria in Table 3.2, with 13 (~6%) of the 230 community areas in the three coastal districts (Waitaki, Dunedin City, Clutha) classified with a 'high' or 'very high' exposure to tsunami hazard (Table 5.18).

Table 5.18: Tsunami hazard exposure summary for the Otago region, showing the estimated count and percentage of those elements within each district potentially exposed to tsunami impact.

District	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in district
	Count	Percent of population in district	Count (all buildings)	Percent of total buildings in district	Count (Dwellings)	Percent of total dwellings in district	Count	Percent of total CCF in district	Very Low	Low	Mod.	High	Very High	
Clutha	303	1.7	697	2.3	164	2.7	0	0.0	52	2	2	7	1	64
Dunedin City	191	0.1	378	0.4	95	0.2	0	0.0	108	0	4	5	0	117
Waitaki	11	0.0	55	0.2	7	0.1	0	0.0	46	2	1	0	0	49
Central Otago	*Hazard not present*													52
Queenstown-Lakes	*Hazard not present*													69
Otago Total	504		1,130		266		0		327	4	7	12	1	351

Table 5.19: Tsunami hazard exposure summary for the Top 10 urban areas or rural settlements in the Otago region, identified and ordered by the estimated population exposed to the hazard within that urban area/settlement.

Location	District	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in location
		Count	Percent of population in location	Count (all buildings)	Percent of total buildings in location	Count (Dwellings)	Percent of total dwellings in location	Count	Percent of total CCF in location	Very Low	Low	Mod.	High	Very High	
Pounawea	Clutha District	103	95.7	186	95.9	67	95.7	0	0	0	0	0	0	1	1
Taieri Mouth	Clutha District	68	20.5	144	25.5	38	20.5	0	0	0	0	0	1	0	1
Purakaunui	Dunedin City	55	26.0	164	34.5	34	26.0	0	0	0	0	0	1	0	1
Brighton	Dunedin City	52	3.6	59	4.3	22	3.6	0	0	0	0	0	1	0	1
Waikouaiti	Dunedin City	24	1.9	20	1.4	15	2.4	0	0	0	0	0	1	0	1
KaritÄ• ne	Dunedin City	21	5.0	50	6.5	12	4.0	0	0	0	0	0	1	0	1
Waitati-Doctors Point	Dunedin City	21	3.4	22	3.3	12	5.2	0	0	0	0	0	1	0	1
Kaka Point	Clutha District	15	6.4	26	6.4	8	4.3	0	0	0	0	0	1	0	1
Kaitangata	Clutha District	12	1.4	9	1.0	6	1.7	0	0	0	0	0	1	0	1
Kakanui	Waitaki	10	2.3	28	3.9	5	1.9	0	0	0	0	1	0	0	1

5.1.11 Coastal Erosion Hazard

There are a total of around 40 people and 110 buildings, including about 20 dwellings, within the Waitaki District located in areas identified as being prone to coastal erosion impact (Table 5.20). This analysis is based on a modelled future shoreline position where there is a 5% probability of erosion extending up to or landward of this position over the 100-year outlook period.

Exposure analysis was not carried out for the Dunedin City or Clutha districts as this type of coastal erosion modelling dataset is not currently available.

No critical community facilities in the Waitaki District are located in areas mapped as being prone to coastal erosion inundation.

A list of the urban areas or rural settlements in the Waitaki District exposed to coastal erosion hazard are shown in Table 5.21. This table shows four urban areas or rural settlements in the district assessed as having some population or buildings being located within mapped coastal erosion areas. A significant portion (50%) of the population and buildings (29%) exposed to potential coastal erosion are those located in rural areas outside of these urban boundaries.

Coastal erosion hazard exposure for each ‘community area’ has been classed using the criteria in Table 3.2, with only ~2% of the 49 community areas in the Waitaki district classified with a ‘high’ or ‘very high’ exposure to coastal erosion hazard (Table 5.20).

Table 5.20: Coastal erosion hazard exposure summary for the Otago region, showing the estimated count and percentage of those elements within the Waitaki district potentially exposed to coastal erosion impact

District	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in district
	Count	Percent of population in district	Count (all buildings)	Percent of total buildings in district	Count (Dwellings)	Percent of total dwellings in district	Count	Percent of total CCF in district	Very Low	Low	Mod.	High	Very High	
Waitaki	37	0.2	111	0.4	18	0.2	0	0.0	44	1	3	1	0	49
Dunedin City	*Data not available*													117
Clutha	*Data not available*													64
Central Otago	*Hazard not present*													52
Queenstown-Lakes	*Hazard not present*													69
Otago Total														351

Table 5.21: Coastal erosion hazard exposure summary for the four urban areas or rural settlements exposed in the Waitaki District, identified and ordered by the estimated population exposed to the hazard within that urban area/settlement.

Location	District	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in location
		Count	Percent of population in location	Count (all buildings)	Percent of total buildings in location	Count (Dwellings)	Percent of total dwellings in location	Count	Percent of total CCF in location	Very Low	Low	Mod.	High	Very High	
Oamaru	Waitaki	10	0.1	27	0.3	4	0.1	0	0	0	0	2	0	6	8
Moeraki	Waitaki	7	4.3	38	8.0	7	4.3	0	0	0	0	1	0	0	1
Kakanui	Waitaki	2	0.4	10	1.4	1	0.4	0	0	0	0	0	1	0	1
Hampden	Waitaki	0	0.0	4	0.6	0	0.0	0	0	0	0	0	0	1	1

6 Summary and Next Steps

6.1 Summary

This report presents findings of Otago Regional Council's (ORC's) first systematic analysis of natural hazard exposure for Otago. The report provides a 'stocktake' and baseline of the current understanding of natural hazard exposure for the region, and is a first iteration of analysis to quantify and map natural hazards exposure in Otago at a regional scale.

This report enumerates the exposure of three elements at risk: population, buildings and 'critical community facilities' to nine natural hazard types, and classifies natural hazard exposure levels for each hazard, for each of 351 community areas in the region. Together the exposure classification and enumeration enables a spatial mapping of natural hazards exposure in the region, and comparison of natural hazards exposure between hazard types, and between districts or urban areas.

6.2 Next Steps

Following completion of this regional natural hazards exposure analysis, there are two main next steps in ORC's region-wide natural hazards risk programme;

1. Natural hazards prioritisation for the Otago region, and
2. Review and possible revision of this region-wide natural hazards exposure analysis.

6.2.1 Natural Hazards Prioritisation

ORC has developed a natural hazards prioritisation approach, which will enable a systematic identification and definition of key projects and allocation of work within the Natural Hazards work programme (van Woerden *et al*, 2024). The outputs from implementation of the prioritisation approach will be a key factor in the development of ORC's Natural Hazards work programme through the Long-term Plan (LTP) process, through providing a guide to the relative priority and scale of the possible projects considered for inclusion. This prioritisation approach includes development of a preliminary risk analysis for each long-listed geographic location.

The findings of the exposure analysis presented in this report will be one source of information which will inform the prioritisation approach, which will also include reference to a much wider range of other information available (Figure 6.1). The prioritisation process is intended to be completed by mid-2026.

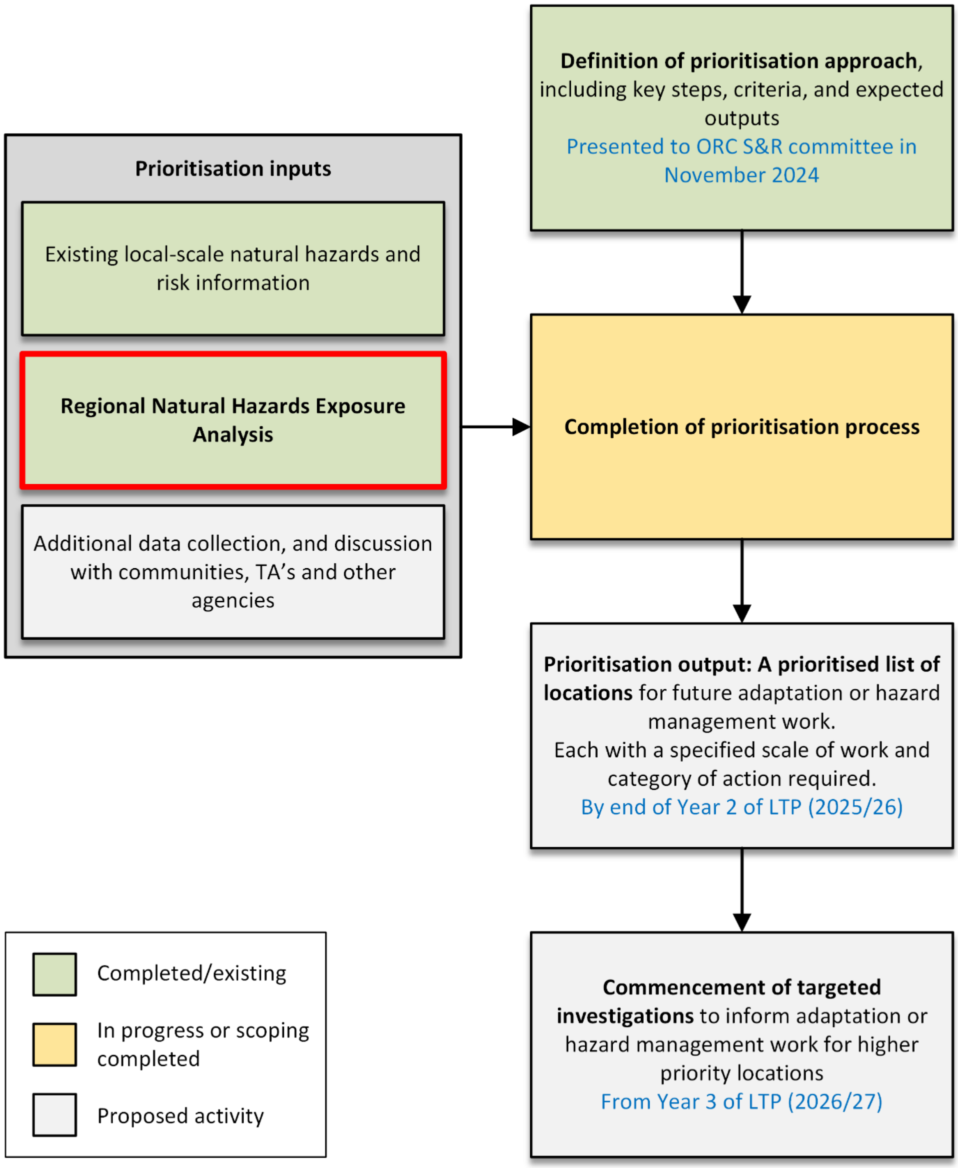

Figure 6.1: Flow chart showing key activities and programme sequencing in the natural hazards risk assessment and prioritisation programme. The exposure analysis presented in this report is highlighted red.

6.2.2 Review and revision of region-wide exposure analysis

Revision of natural hazards exposure analysis and reporting will be undertaken periodically (no longer than 6-yearly) as substantive new or updated natural hazards mapping or elements at risk datasets become available. Additional datasets which could be included in future iterations of this exposure analysis include;

6.2.2.1 NATURAL HAZARDS MAPPING DATA

- Incorporation of higher-resolution project-scale natural hazards information for locations where this is available. For example, locations where more detailed local-scale flooding or debris flow hazard modelling have been completed, or where data held by territorial authorities may be suitable for inclusion.

- Incorporation of national-scale natural hazards datasets such as several studies currently in progress or recently completed, for example;
  - GNS Science's national-scale landslide susceptibility modelling (Sliding Lands Hōretireti Whenua)
  - NIWA's national-scale fluvial-pluvial flood mapping project (Mā te haumaru ō te wai) which aims to develop consistent nationwide flood hazard maps and also to consider the effects of climate change.
  - NIWA's coastal flood mapping, which provides modelled representation for a 1% annual exceedance probability (AEP) extreme sea level flooding under current climatic sea conditions, plus relative sea level rise up to 2m above present-day mean sea level (Stephens and Paulik, 2023).
  - Tonkin + Taylor Ltd are developing a national liquefaction model, which will provide a nationally consistent way to describe and measure liquefaction risk.

- Several existing ORC natural hazard mapping datasets (e.g. alluvial fan mapping) are based on geomorphic interpretation but were compiled prior to the widespread availability of high-resolution topographic data (i.e. LiDAR). ORC can consider refinement of those mapping layers when there is more comprehensive LiDAR coverage available in the region, and revised hazards datasets can be incorporated into future iterations of analysis.

- The Natural Hazards Commission Toka Tū Ake (formerly EQC) holds a dataset of ~5,000 settled damage claims for the Otago region (dated 1997-present), each classified by hazard type and linked to a specific address. Analysis of this dataset would identify locations of known natural hazards impact, complementing analysis based on mapped natural hazards extents.

6.2.2.2 ELEMENTS AT RISK DATA

- Revision and updating of elements at risk information such as updating with future census data, and refinement of population estimation and building classification approaches.

- Possible inclusion of additional types of elements or data such as demographic information (e.g. age), social or cultural assets (e.g. schools, marae), lifelines infrastructure (EMO, 2018; Toa Consulting, 2024), social vulnerability indicators (e.g. EHINZ, 2024), or monetary values (e.g. building value).

7 List of Abbreviations

7.1 Abbreviations

Abbreviation	*Explanation*
AEP	Annual exceedance probability
ARI	Average recurrence interval
EMO	Emergency Management Otago
EQC	EQC Toka Tū Ake, Earthquake Commission (renamed the Natural Hazards Commission, NHC from 1 July 2024)
GIS	Geographic Information System
GNS	GNS Science, a Crown Research Institute
LiDAR	Light Detection and Ranging, a remote sensing method for topographic survey
LINZ	Land Information New Zealand
NIWA	National Institute of Water & Atmospheric research
NSHM	National Seismic Hazard Model
ORC	Otago Regional Council
pORPS/RPS	Proposed Otago Regional Policy Statement
SA	Statistical Area
SSP	Shared socio-economic pathways, scenarios for a range of plausible societal and climatic futures

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9 Appendices

9.1 Appendix A. Natural Hazard Mapping

Summary images to show approximate location and extent of mapping coverage for each hazard type used in exposure analysis. Note that the images for tsunami, storm surge and coastal erosion have a buffer added to the hazard polygon to enable visibility at this scale of map display.

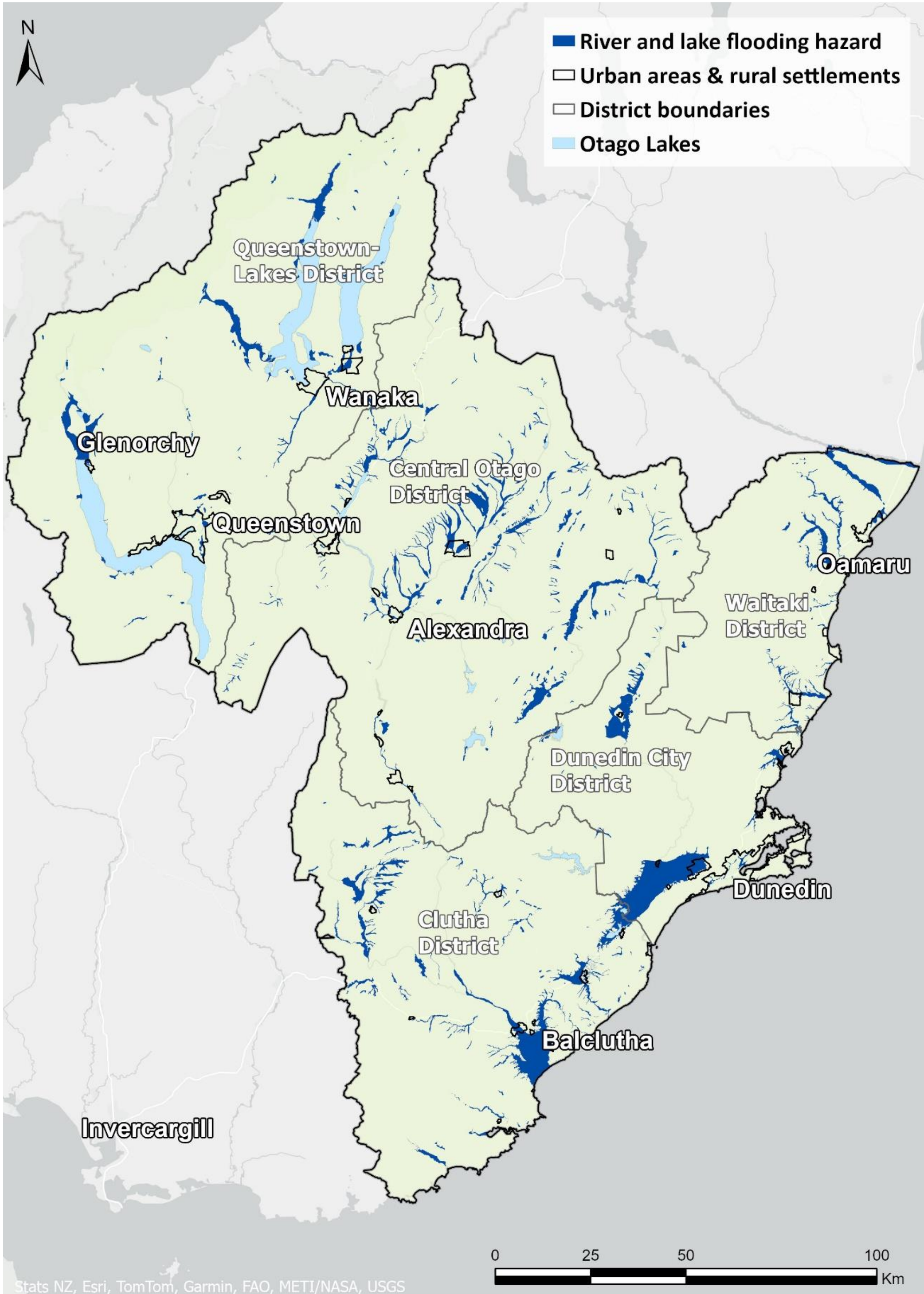

Figure 9.1: River and lake flooding mapping dataset used in Otago natural hazard exposure analysis.

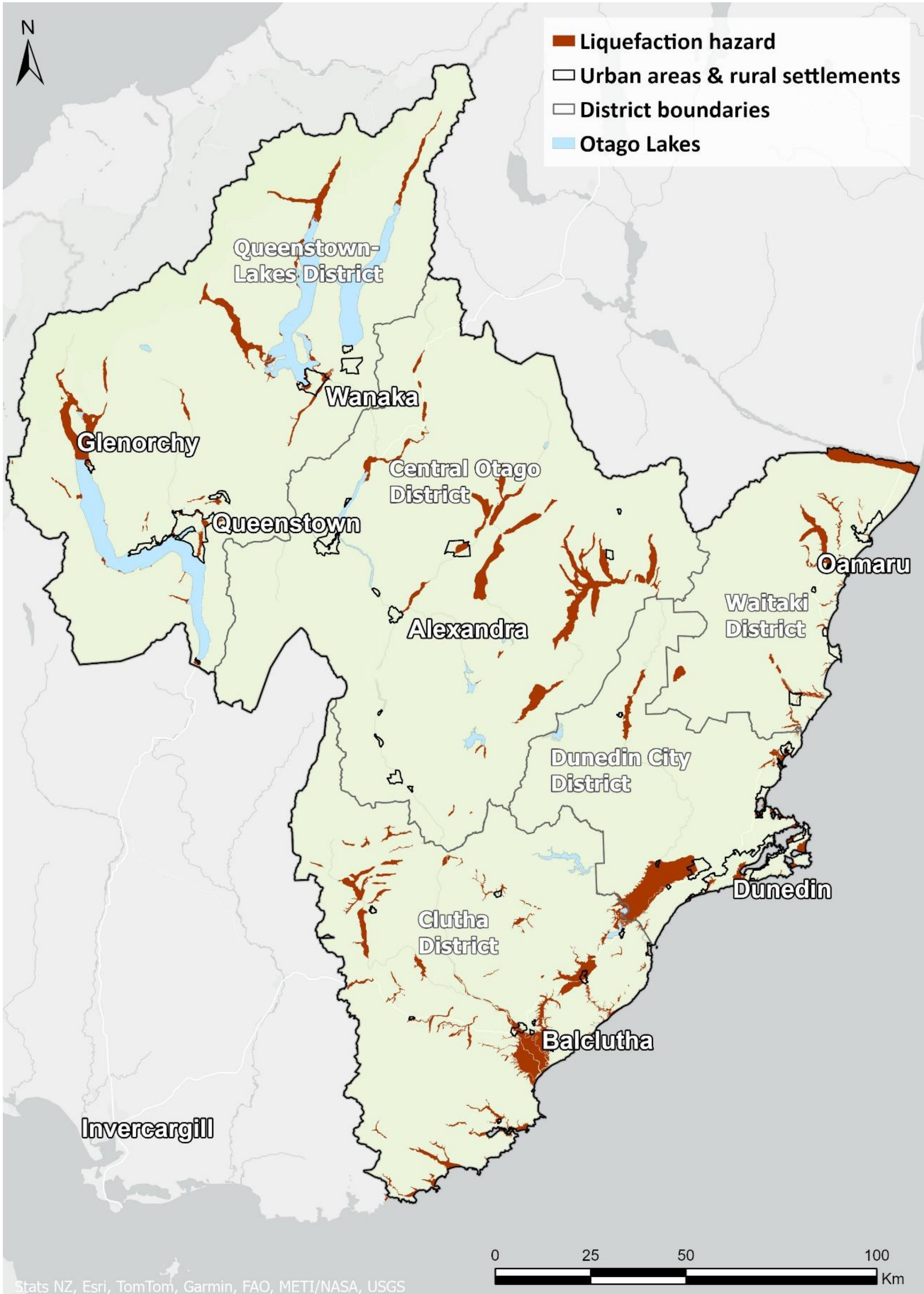

Figure 9.2: Liquefaction susceptibility mapping dataset used in Otago natural hazard exposure analysis.

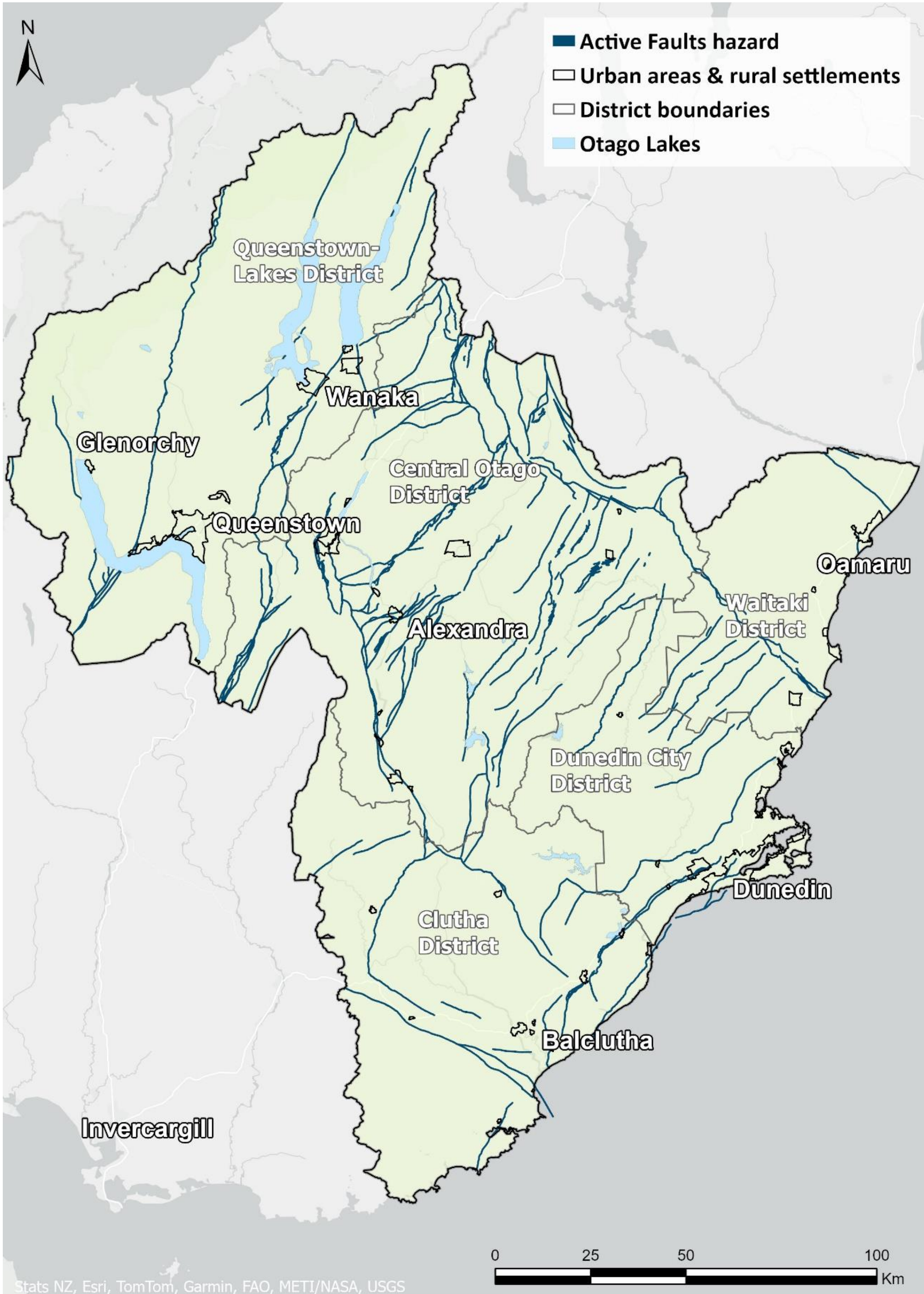

Figure 9.3: Active fault mapping dataset used in Otago natural hazard exposure analysis.

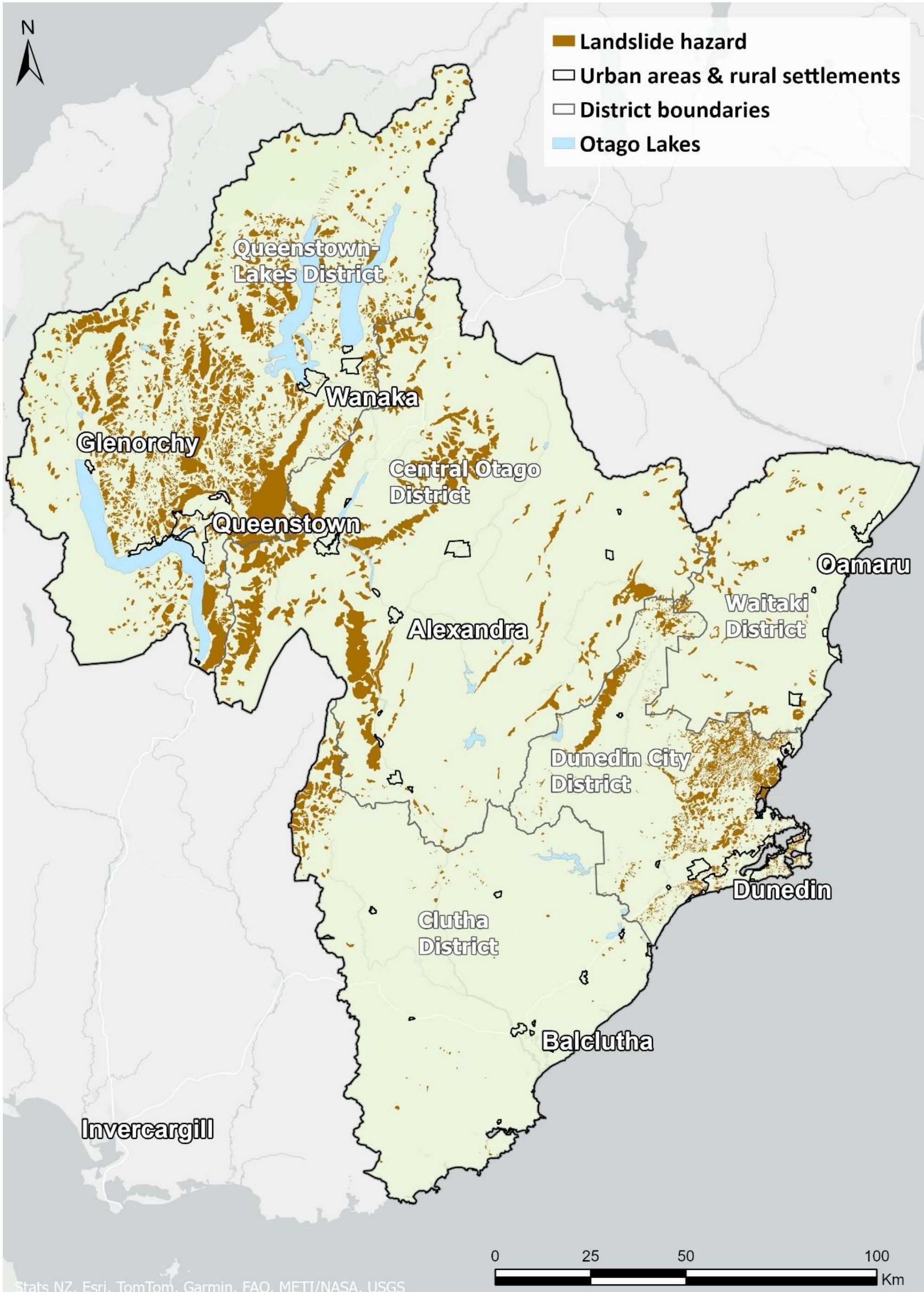

Figure 9.4: Landslide features mapping dataset used in Otago natural hazard exposure analysis.

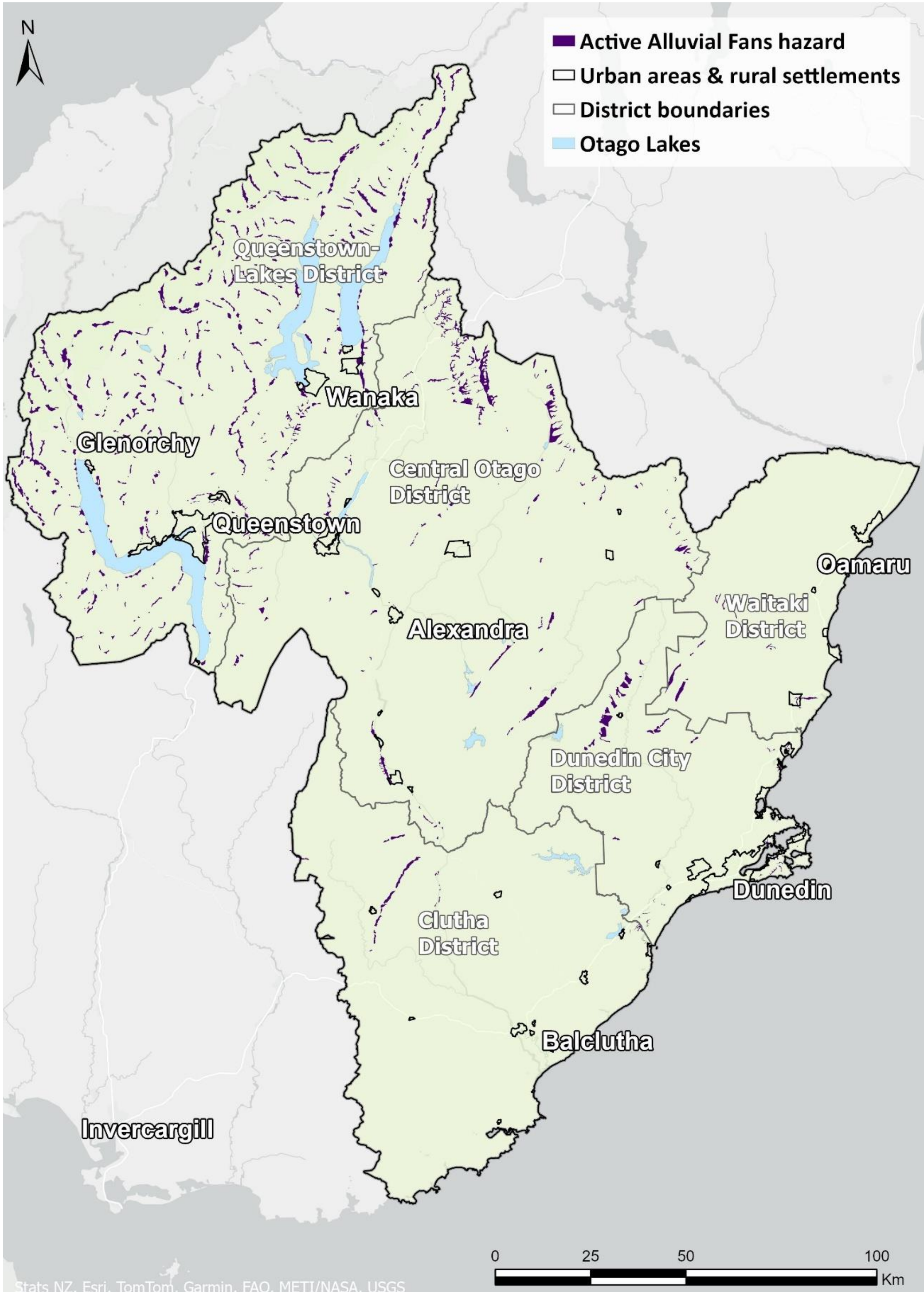

Figure 9.5: Active alluvial fan mapping dataset used in Otago natural hazard exposure analysis, showing 'debris-dominated' or 'composite' fan surfaces, but excluding those solely characterised as 'floodwater-dominated' which have been included within analysis of flooding hazards.

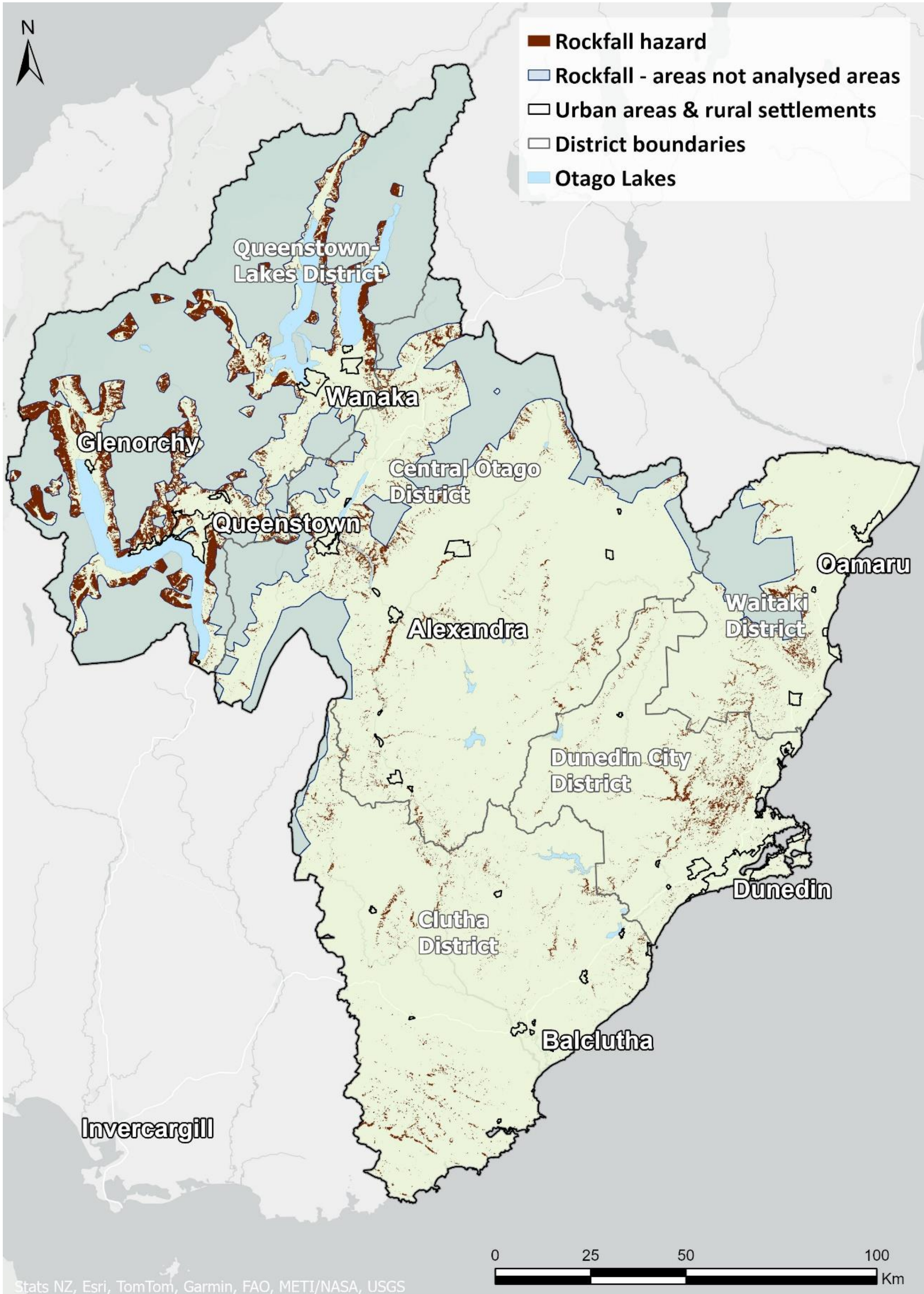

Figure 9.6: Rockfall awareness areas mapping dataset used in Otago natural hazard exposure analysis. Note that mapping coverage excludes catchments devoid of buildings or roads, or with only very sparsely distributed buildings.

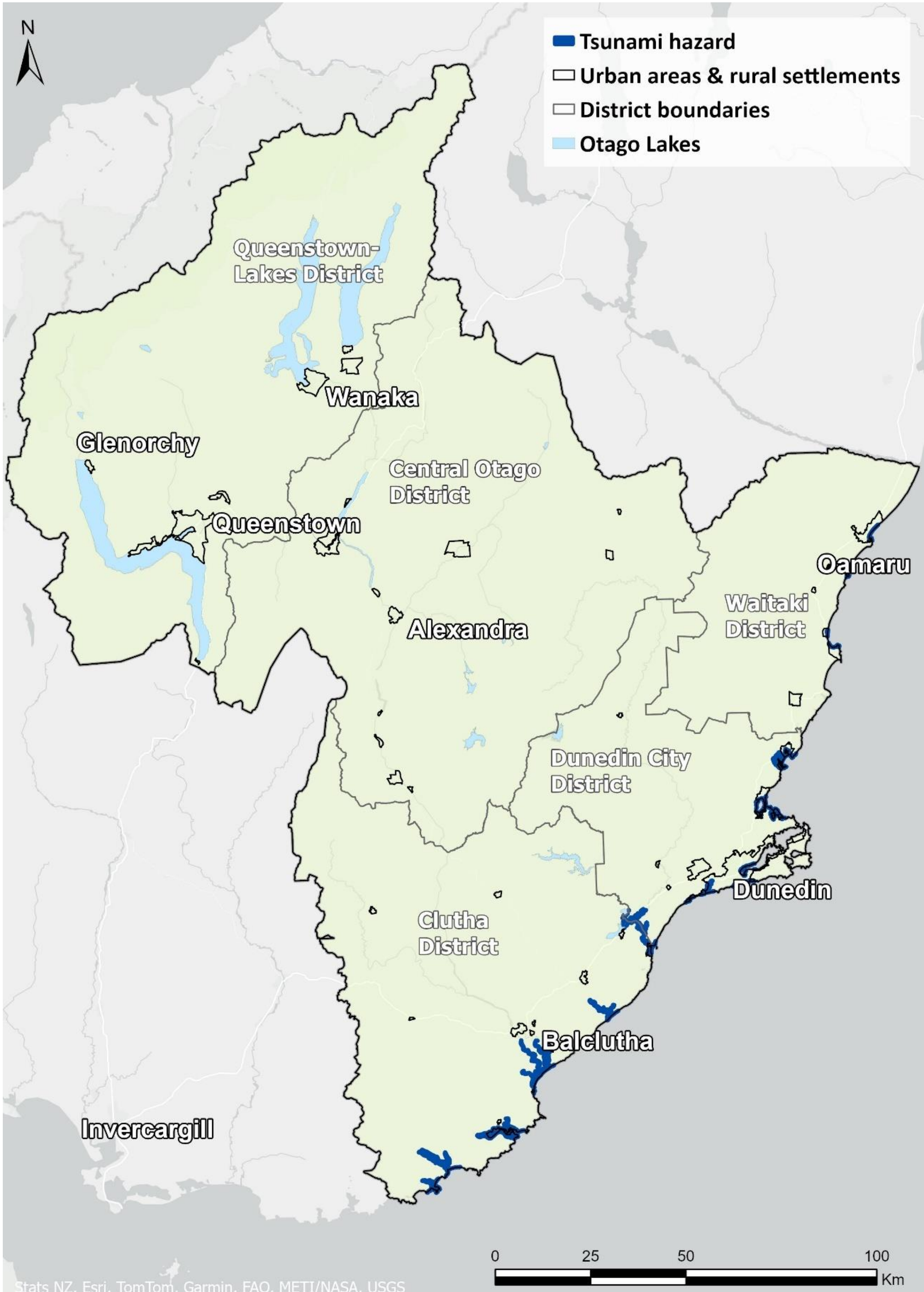

Figure 9.7: Tsunami hazard mapping dataset used in Otago natural hazard exposure analysis. A buffer has been added to the hazard polygon to enable visibility at this scale of map display.

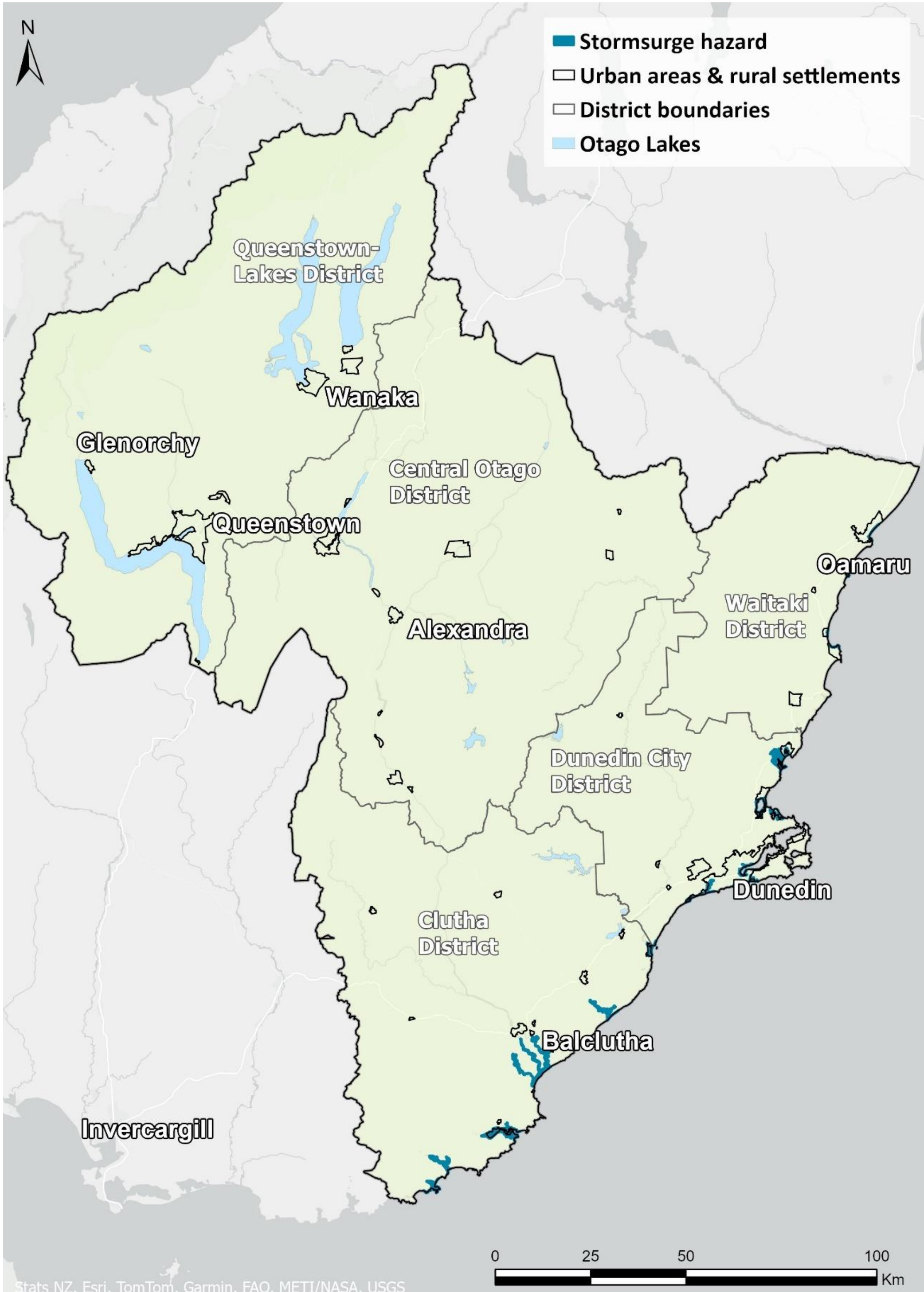

Figure 9.8: Storm surge inundation hazard mapping dataset used in Otago natural hazard exposure analysis. A buffer has been added to the hazard polygon to enable visibility at this scale of map display.

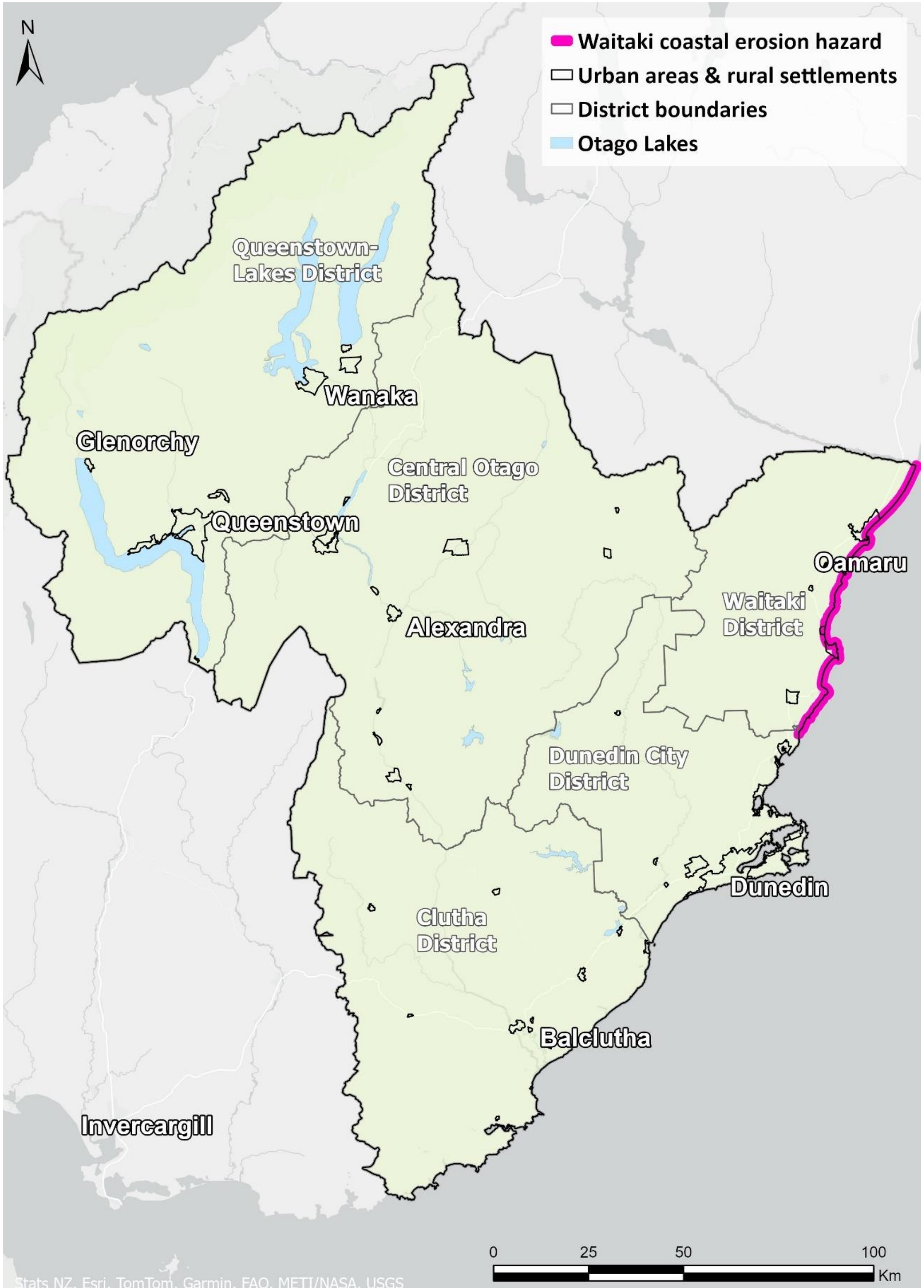

Figure 9.9: Coastal erosion hazard mapping dataset for the Waitaki District used in Otago natural hazard exposure analysis. A buffer has been added to the hazard polygon to enable visibility at this scale of map display.

9.2 Appendix B. Geographic Units

9.2.1 Description of Statistical Units

Table 9.1: Description of the Stats NZ statistical units.

Unit	Description
Meshblock	The smallest geographic unit for which statistical data is collected and processed by Stats NZ, varying in size from part of a city block to a large area of rural land. Meshblock units are not used in this current natural hazards analysis.
Statistical Area 1 (SA1)	SA1 is a geographic area built by joining meshblocks. SA1s have an ideal size range of 100-200 residents, and a maximum population of about 500. There are 1641 SA1 areas within the Otago region, of which 214 are located outside of urban areas or rural settlements.
Statistical Area 2 (SA2)	SA2 is a geographic area which aggregates SA1s, and is designed to represent a 'community of place' where people interact together socially and economically. SA2s in city council areas generally have a population of 2,000–4,000 residents while SA2s in district council areas generally have a population of 1,000–3,000 residents. There are 132 SA2 areas within the Otago region, of which 119 are within urban areas or rural settlements.
Urban / Rural	A geography which identifies urban-rural boundaries. • Urban areas (small, medium, large, major) • Rural settlement • Other rural

9.2.2 Urban areas and rural settlements and rural Otago community units

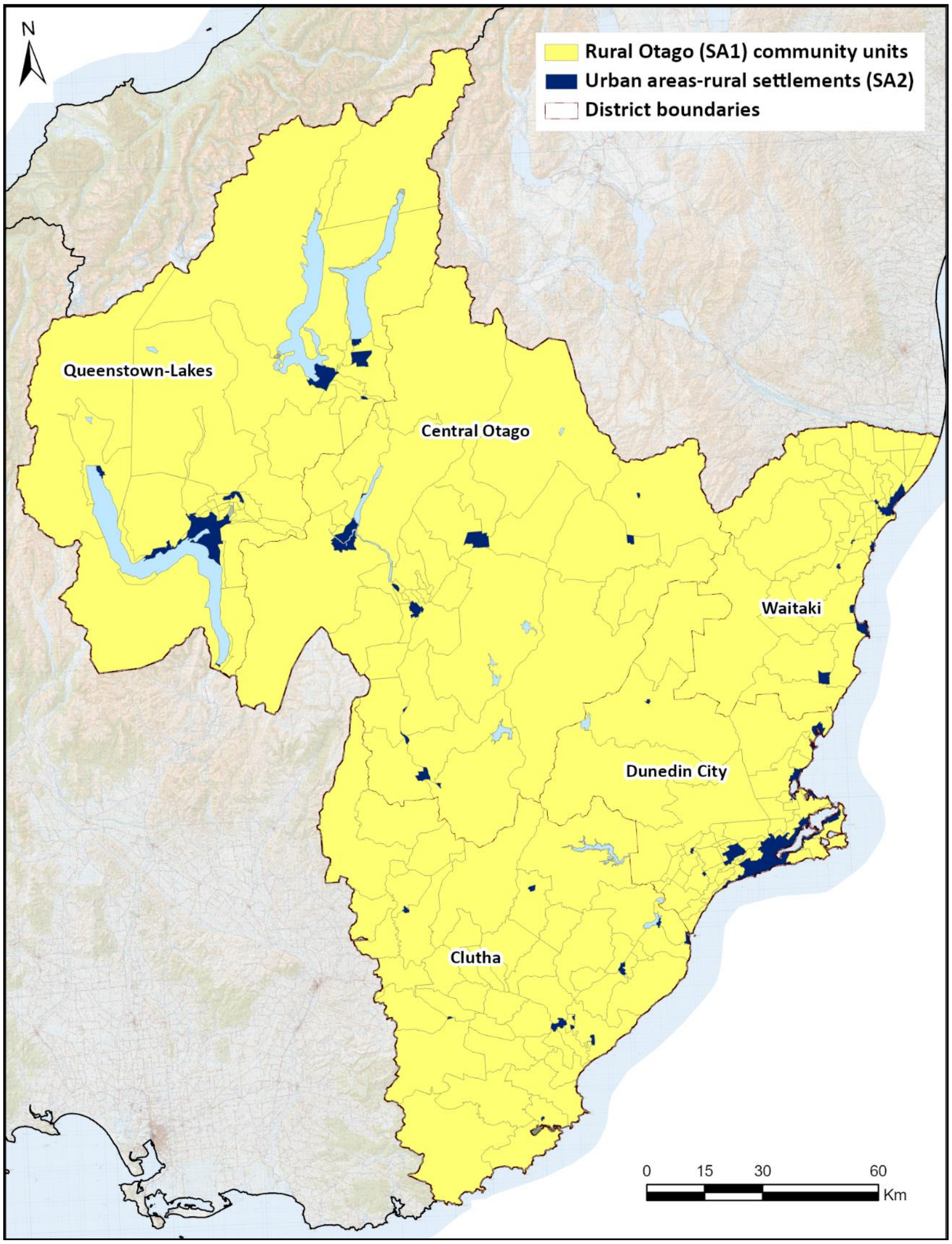

Figure 9.10: Illustration of the urban areas and rural settlement boundaries (blue) and rural Otago community areas (yellow) used in Otago natural hazard exposure analysis.

9.2.3 Otago urban areas and rural settlements

Table 9.2: List of Otago urban areas and rural settlements used in used in Otago natural hazard exposure analysis (Stats NZ, 2022).

Geography	Count	Locations	
Major Urban Area (>100,000 residents)	1	Dunedin	
Large Urban Area (30,000-99,999 residents)	0	None within Otago	
Medium Urban Area (10,000-29,999 residents)	4	Mosgiel Oamaru	Queenstown Wanaka
Small Urban Area (1,000-9,999 residents)	9	Alexandra Arrowtown Balclutha Brighton Clyde	Cromwell Lake Hawea Milton Waikouaiti
Rural Settlement	40	Allanton Aramoana Bannockburn Benhar Clinton Ettrick Glenorchy Hampden Harwood Hawea Flat Herbert Kaitangata Kaka Point Kakanui Karitane Kingston Lake Roxburgh Village Lawrence Luggate Maheno	Middlemarch Millbrook Millers Flat Moeraki Naseby Omakau Outram Owaka Palmerston Pisa Moorings Pounawea Purakaunui Ranfurly Roxburgh Stirling Taieri Mouth Tapanui Waihola Waitati-Doctors Point Warrington

9.3 Appendix C. Critical Community Facilities

Table 9.3: List of the 90 critical community facilities (CCF) used in Otago natural hazard exposure analysis.

Police Station (26)	***Fire Station (44)***	***Hospital (4)***	***Ambulance Station (10)***	***ECC and EOC (6)***
Alexandra Arrowtown Balclutha Clinton Cromwell Dunedin Central & Southern Police District HQ Dunedin North Dunedin South Hampden Kaikorai Lawrence Middlemarch Milton Mosgiel Oamaru Omakau Owaka Palmerston Port Chalmers Portobello Queenstown Ranfurly Roxburgh Tapanui Waikouaiti Wanaka	Alexandra Arrowtown Balclutha Brighton Clinton Clutha Valley Clyde Cromwell Dunedin Central Frankton Heriot Kaitangata Kaka Point Lake Hawea Lawrence Lookout Point Luggate Middlemarch Millers Flat Milton Mosgiel Naseby Oamaru Naseby Oamaru Omakau Outram Owaka Palmerston Port Chalmers Portobello Queenstown Ranfurly Ravensbourne Roslyn Roxburgh St Kilda Tapanui Waikouaiti Waitahuna Waitati Wakari Rural Waiwera South Wanaka Weston Willowbank	Dunedin Hospital Dunstan Hospital Lakes District Hospital Wakari Hospital	Alexandra Balclutha Cromwell Dunedin Central Frankton Lawrence Milton Mosgiel Oamaru Wanaka	ECC (Dunedin) EOC (Waitaki) EOC (Dunedin city) EOC (Clutha) EOC (Central Otago) EOC (Queenstown Lakes)

9.4 Appendix D. Additional Natural Hazards Exposure Results

9.4.1 Natural Hazards Exposure Summary per District

Table 9.4: Natural hazards exposure summary for the Waitaki District, showing the estimated count and percentage of those elements within the district potentially exposed to impact from the named natural hazard types.

Hazard type	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in district
	Count	Percent of population in district	Count (all buildings)	Percent of total buildings in district	Count (Dwellings)	Percent of total dwellings in district	Count	Percent of total CCF in district	Very Low	Low	Moderate	High	Very High	
River and lake flooding	2,707	12.5	2,870	11.2	924	11.3	0	0.0	21	5	9	10	4	49
Liquefaction	992	4.6	1,967	7.7	268	3.3	3	37.5	17	2	15	10	5	49
Active Faults	497	2.3	729	2.8	101	1.2	0	0.0	35	1	5	6	2	49
Landslide	92	0.4	243	0.9	60	0.7	0	0.0	40	1	7	1	0	49
Alluvial fan	238	1.1	451	1.8	102	1.3	1	12.5	46	0	2	0	1	49
Rockfall	0	0.0	16	0.1	0	0.0	0	0	49	0	0	0	0	49
Tsunami	11	0.0	55	0.2	7	0.1	0	0	46	2	1	0	0	49
Storm surge	4	0.0	18	0.1	3	0.0	0	0	47	1	1	0	0	49
Coastal erosion	37	0.2	111	0.4	18	0.2	0	0	44	1	3	1	0	49

Table 9.5: Natural hazards exposure summary for the Dunedin City District, showing the estimated count and percentage of those elements within the district potentially exposed to impact from the named natural hazard types.

Hazard type	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in district
	Count	Percent of population in district	Count (all buildings)	Percent of total buildings in district	Count (Dwellings)	Percent of total dwellings in district	Count	Percent of total CCF in district	Very Low	Low	Moderate	High	Very High	
River and lake flooding	27,969	21.7	19,683	21.9	8,666	19.2	10	33.3	47	1	7	23	39	117
Liquefaction	30,128	23.4	23,924	26.7	10,673	23.7	14	46.7	48	1	11	16	41	117
Active Faults	13,748	10.7	10,158	11.3	5,273	11.7	3	10.0	73	7	4	11	22	117
Landslide	6,160	4.8	4,380	4.9	1,981	4.4	1	3.3	52	3	24	25	13	117
Alluvial fan	1,294	1.0	1,436	1.6	530	1.2	1	3.3	103	3	4	3	4	117
Rockfall	165	0.1	152	0.2	64	0.1	0	0.0	102	1	10	4	0	117
Tsunami	191	0.1	378	0.4	95	0.2	0	0	108	0	4	5		117
Storm surge	336	0.3	664	0.7	136	0.3	0	0	102	2	5	8	0	117

Table 9.6: Natural hazards exposure summary for the Central Otago District, showing the estimated count and percentage of those elements within the district potentially exposed to impact from the named natural hazard types.

Hazard type	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in district
	Count	Percent of population in district	Count (all buildings)	Percent of total buildings in district	Count (Dwellings)	Percent of total dwellings in district	Count	Percent of total CCF in district	Very Low	Low	Moderate	High	Very High	
River and lake flooding	1,466	6	2,591	9	523	5.2	2	11.8	6	4	10	29	3	52
Liquefaction	872	3.6	1,637	5.7	267	2.7	2	11.8	37	2	3	7	3	52
Active Faults	3,758	15.5	4,694	16.3	1,517	15.2	5	29.4	11	2	5	26	8	52
Landslide	116	0.5	411	1.4	40	0.4	0	0.0	38	3	7	4	0	52
Alluvial fan	734	3.0	1,063	3.7	256	2.6	0	0.0	34	3	3	11	1	52
Rockfall	29	0.1	57	0.2	10	0.1	0	0	44	3	4	1	0	52

Table 9.7: Natural hazards exposure summary for the Queenstown Lakes District, showing the estimated count and percentage of those elements within the district potentially exposed to impact from the named natural hazard types.

Hazard type	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count commu areas distri
	Count	Percent of population in district	Count (all buildings)	Percent of total buildings in district	Count (Dwellings)	Percent of total dwellings in district	Count	Percent of total CCF in district	Very Low	Low	Moderate	High	Very High	
River and lake flooding	2,883	6	3,161	8.7	1,387	7.2	1	7.7	29	8	14	14	4	69
Liquefaction	8,870	18.6	8,059	22.2	4,350	22.5	4	30.8	25	6	8	17	13	69
Active Faults	2,172	4.5	1,891	5.2	899	4.7	1	7.7	51	3	4	8	3	69
Landslide	1,663	3.5	1,531	4.2	761	3.9	2	15.4	32	7	12	11	7	69
Alluvial fan	3,189	6.7	2,862	7.9	1,104	5.7	1	7.7	29	3	6	24	7	69
Rockfall	1,040	2.2	810	2.2	303	1.6	0	0	32	9	15	9	4	69

Table 9.8: Natural hazards exposure summary for the Clutha District, showing the estimated count and percentage of those elements within the district potentially exposed to impact from the named natural hazard types.

Hazard type	Population exposed		Buildings exposed				Critical Community Facilities (CCF)		Count of community areas in each exposure class					Count of community areas in district
	Count	Percent of population in district	Count (all buildings)	Percent of total buildings in district	Count (Dwellings)	Percent of total dwellings in district	Count	Percent of total CCF in district	Very Low	Low	Moderate	High	Very High	
River and lake flooding	3,754	20.5	5,593	18.7	1,276	21.2	10	45.5	18	8	5	23	10	64
Liquefaction	5,184	28.3	7,442	24.8	1,901	31.6	14	63.6	15	7	8	18	16	64
Active Faults	1,774	10.0	2,624	8.8	581	9.7	1	4.5	33	6	3	17	5	64
Landslide	8	0.0	27	0.1	2	0.0	0	0.0	63	0	1	0	0	64
Alluvial fan	17	0.1	92	0.3	4	0.1	0	0.0	60	1	3	0	0	64
Rockfall	0	0.0	21	0.1	0	0.0	0	0	63	1	0	0	0	64
Tsunami	303	1.7	697	2.3	164	2.7	0	0	52	2	2	7	1	64
Storm surge	164	0.9	440	1.5	90	1.5	0	0	55	4	2	2	1	64

9.4.2 Exposure of Critical Community Facilities (CCF)

Table 9.9: Summary of critical community facilities (CCF) in the Otago region which are exposed to potential natural hazards within each district. The facilities listed are coloured by type; Medical (hospital or ambulance, in red), Police (blue), Fire (orange), or Emergency Coordination/Operations Centres (ECC or EOC, green). There are no critical community facilities identified in this study as being exposed to rockfall, tsunami, storm surge or coastal erosion hazards.

	Hazard type				
District	**River and lake flooding**	**Liquefaction**	**Active Faults**	**Landslide**	**Alluvial fan**
Dunedin City	St John Ambulance Mosgiel	Dunedin Hospital	Lookout Point Fire Station	GECC Group Emergency Coordination Centre	Portobello Fire Station
	Dunedin Hospital	St John Ambulance Mosgiel	Roslyn Fire Station		
	Willowbank Fire Station	Mosgiel Fire Station	Kaikorai Police Station		
	Mosgiel Fire Station	Wakari Rural Fire Station			
	Waitati Fire Station	Dunedin Central Fire Station			
	Dunedin Central Fire Station	Outram Fire Station			
	Outram Fire Station	Port Chalmers Fire Station			
	Dunedin Central Police Station & Southern Police District HQ	St Kilda Fire Station			
	Dunedin North Police Station	Waitati Fire Station			
	Mosgiel Police Station	Ravensbourne Fire Station			
		Dunedin Central Police Station & Southern Police District HQ			
		Dunedin South Police Station			
		Mosgiel Police Station			
Queenstown Lakes	Luggate Fire Station	Wanaka Fire Station	Lake Hawea Fire Station	Wanaka Fire Station	Queenstown Police Station
		Queenstown Fire Station		Wanaka Police Station	
		Queenstown Police Station			
		Wanaka Police Station			

	Hazard type				
District	**River and lake flooding**	**Liquefaction**	**Active Faults**	**Landslide**	**Alluvial fan**
Central Otago	Alexandra Police Station	Omakau Fire Station	Roxburgh Fire Station		
	CODC Central Otago District EOC	Omakau Police Station	Clyde Fire Station		
			Roxburgh Police Station		
			Alexandra Police Station		
			CODC Central Otago District EOC		
Clutha	St John Ambulance Lawrence	St John Ambulance Lawrence	Waitahuna Fire Station		
	St John Ambulance Balclutha	St John Ambulance Balclutha			
	St John Ambulance Milton	St John Ambulance Milton			
	Milton Fire Station	Heriot Fire Station			
	Balclutha Fire Station	Milton Fire Station			
	Lawrence Fire Station	Kaitangata Fire Station			
	Kaitangata Fire Station	Waitahuna Fire Station			
	Waitahuna Fire Station	Owaka Fire Station			
	Lawrence Police Station	Balclutha Fire Station			
	Balclutha Police Station	Lawrence Fire Station			
		Lawrence Police Station			
		Milton Police Station			
		Owaka Police Station			
		Balclutha Police Station			
Waitaki		Palmerston Police Station			Palmerston Police Station
		Oamaru Police Station			
		WDC EOC			

9.5 Appendix E. Natural Hazards Exposure Assessment Methodology

MEMORANDUM

To:	**Tim van Woerden and Natural Hazards Team**
From:	**Andrew Welsh**
Date:	**14/03/2025**
Re:	**Otago Natural Hazards Exposure Assessment – Exposure assessment methodology**

1.0 Background

The ORC is undertaking a natural hazard exposure and risk assessment work programme, designed as a review and high-level assessment of natural hazard exposure and risks for mapped natural hazards in the Otago region. The purpose of the natural hazards exposure and risk assessment (NHERA) is to work towards a comprehensive, regional-scale, spatial understanding of Otago's natural hazards exposure and risks.

The proposed natural hazard exposure assessment programme is listed in the 2024-2034 ORC Long-term Plan (LTP) as work to "Develop comprehensive risk mapping of natural hazards across Otago" and specifies the performance measure: "Complete regional natural hazards risk assessment (NHERA) and develop a regional approach for prioritising adaptation to inform adaptation planning and implementation" (ORC, 2024). In addition, the work programme aims to support the ORC community outcome "Communities that are resilient in the face of natural hazards & climate change and other risks." Further detail on the programme background is outlined in an ORC committee paper by van Woerden *et al* (2023).

The work will look at all regionally mapped natural hazards datasets for the full Otago region and hence will not include those from more detailed, site-specific studies (e.g. Glenorchy liquefaction vulnerability mapping).

This memorandum will cover the general methodology used in the exposure analysis phase of the Otago Natural Hazards Exposure and Risk Assessment. Please refer to the technical report van Woerden and Welsh (2025) for a full description and overview of the Otago Natural Hazards Exposure and Risk Assessment.

2.0 Approach

2.1 Proposed Otago RPS (2021) and NHRA framework

The proposed Otago Regional Policy Statement 2021 (pORPS) has been used as the basis for the NHERA exposure analysis framework (ORC, 2021). The pORPS event consequence table (Table 1) incorporates five different risk elements, these being 1) social/culturally significant buildings, 2) buildings, 3) critical facility buildings, 4) lifelines infrastructure (undifferentiated) and 5) health and safety (people injured or dead).

Table E1: Proposed Otago Regional Policy Statement (pORPS) event 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 zone have functionality compromised	≥50% of affected *buildings* within hazard zone have functionality compromised	≥25% of critical facilities within hazard zone 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)	> 101 dead and/or > 1001 injured
Major (IV)	11-24% of *buildings* of social/cultural significance within hazard zone have functionality compromised	21-49% of *buildings* within hazard zone have functionality compromised	11-24% of *buildings* within hazard zone 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)	11 – 100 dead and/or 101 – 1000 injured
Moderate (III)	6-10% of *buildings* of social/cultural significance within hazard zone have functionality compromised	11-20% of *buildings* within hazard zone have functionality compromised	6-10% of *buildings* within hazard zone 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)	2 – 20 dead and/or 11 – 100 injured
Minor (II)	1-5% of *buildings* of social/cultural significance within hazard zone have functionality compromised	2-10% of *buildings* within hazard zone have functionality compromised	1-5% of *buildings* within hazard zone 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	1 dead and/or 1 – 10 injured
Insignificant (I)	No *buildings* of social/cultural significance within hazard zone have functionality compromised	< 1% of affected *buildings* within hazard zone have functionality compromised	No damage within hazard zone, 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.

When this assessment is being undertaken in accordance with HAZ-NH-M3(7)(a) or HAZ-NH-M4(7)(a) the text within Step 2 shall guide the assessment of *natural hazard* consequence.

The NHERA focuses on 3 of these (buildings, critical facilities and health and safety, Table 2).

Buildings provide a direct measure of building infrastructure exposed to a hazard. They can also be used to estimate usual resident population affected where building type information is available separating dwellings from other types of buildings.

Critical Community Facilities (CCF) provide a direct measure of emergency services and disaster operation/coordination centres exposed to a hazard. They are an important indicator of social/community disruption in a hazard event in the case where critical facilities and associated services are significantly affected and/or not available due to hazard occurrence.

The **health and safety** element provides a measure of the ***usual resident population*** estimated to be exposed to a hazard. This is a primary indicator of social/community disruption in the event of hazard occurrence.

Table E2: oRPS principles-based **exposure** table

Exposure level	Built		Health and Safety
	Buildings	Critical Community Facilities (CCF)	Usual resident population
Very high (V)	≥ 50% of buildings within **community area** are located within a mapped hazard area	≥ 25% of CCF buildings within **community area** are located within a mapped hazard area	> 100 within **community area** are located within a mapped hazard area
High (IV)	21-49% of buildings within **community area** are located within a mapped hazard area	11-24% of CCF buildings within **community area** are located within a mapped hazard area	11-100 within **community area** are located within a mapped hazard area
Moderate (III)	11-20% of buildings within **community area** are located within a mapped hazard area	6-10% of CCF buildings within **community area** are located within a mapped hazard area	2-10 within **community area** are located within a mapped hazard area
Low (II)	2-10% of buildings within **community area** are located within a mapped hazard area	1-5% of CCF buildings within **community area** are located within a mapped hazard area	1 within **community area** are located within a mapped hazard area
Very low (I)	≤ 1% of buildings within **community area** are located within a mapped hazard area	No CCF buildings within the **community area** located within a mapped hazard area	None within **community area** are located within a mapped hazard area

Lifelines infrastructure is not considered in the NHRA. This is to avoid overlap and/or any duplication of CDEM lifelines work; and instead to complement any existing or future CDEM work in this area. The social/cultural buildings element is also not considered in the assessment. At the time of writing, no consistent and comprehensive dataset compiling all social/cultural buildings in Otago is available.

The three elements chosen (buildings, critical facilities, health and safety (estimated usual resident population) are considered more appropriate for the NHERA as together they provide a holistic overview of hazard consequences and social impact at community scale. Further, the lifelines infrastructure and social/culturally significant buildings elements would likely add more value and be more appropriate for analysis at a more detailed scale than that chosen for this phase of the NHERA (i.e. as part of the subsequent risk assessment and prioritisation phase of the natural hazards exposure and risk assessment).

2.2 Exposure

Mapped natural hazard extent is consistent across datasets used in the analysis and hence this is the primary means to calculate exposure (Table 2).

The level of exposure for a community area is assessed on the 'first past the post' principle, in that the highest level of exposure across the three categories applies. For example, if a natural hazard event resulted in moderate exposure level across all the categories for a community area, with the exception of critical facility buildings which is classed as 'high', that community area will be classed with a high exposure level. If a natural hazard event resulted in all of the measures being at the same level (for example, all of the elements are classed moderate), then the level of exposure will be classed as moderate.

3.0 Modelling platform, data sources and datasets

Exposure analysis was completed using the RiskScape modeling platform, an open-source software with a flexible modelling engine for multi-hazard risk analysis (Paulik *et al*, 2022). Riskscape provides a highly customizable and efficient modelling environment, allowing the user to tailor the input data and run an automated series of linked processes to produce results and reporting outputs quickly (Riskscape, 2025). A detailed description of the data sources and datasets used in the analysis is provided below.

3.1 Natural hazard datasets

The natural hazard datasets used in the NHERA analysis are listed in Table 3 below. These are all 5m cell size spatial resolution raster datasets. These datasets were originally represented as polygon features. To enhance the efficiency of the riskscape modelling process, the polygon datasets were converted to raster data structures and a 5m cell size was chosen as the best compromise between mapped feature accuracy and riskscape model efficiency.

Natural hazard exposure analysis was completed for those datasets with mapping coverage across the full Otago region. Exposure analysis was also completed for coastal erosion in the Waitaki district as this information was available for the whole coastline in the district (Bosserelle et al, 2019), but not for other areas along the Otago coast due to incomplete coverage. Seismic ground shaking (potentially outdated information) datasets were not included in this phase of the analysis.

Table E3: Natural hazard datasets used in the exposure analysis

Hazard Type	Hazard Mapping Dataset
River and Lake Flooding	River and lake flooding
	Active alluvial fans (stream flood-dominated)
Seismic	Active Faults
	Liquefaction
Slope Stability	Landslide
	Rockfall
	Active alluvial fans (debris & composite)
Coastal Erosion and Inundation	Storm surge inundation
	Coastal erosion (Waitaki only)
	Tsunami inundation

3.2 Dataset refinements

Some refinements and adjustments were made to datasets for the analysis. Features in the ORC Alluvial Fans Otago regional dataset were restricted to just those recorded as 'active' in the fan activity field within the layers metadata. For the analysis, active alluvial fans are argued to pose a more significant natural hazard threat compared to those recorded as inactive, because fan forming processes are interpreted to be ongoing and/or there is potential for significant reactivation during extreme events (e.g. heavy rainfall, earthquake) (Barrell, 2015).

In addition, alluvial fans classified as 'active floodwater-dominated' were added to the regional Otago flood hazard dataset to create a new version of the Otago Flood Hazard dataset. This was done because 1) in some cases these features were already represented in this layer and 2) they represent the flood hazard component from small tributaries and steep streams on alluvial fans, being in essence a flood water hazard extent.

A new version of the alluvial fan dataset was then created comprising active alluvial fans with a debris component or a combination of processes. In particular, the remaining alluvial fan hazard extents represent the other predominant hazards - debris dominated and composite (combination of concurrent processes) phenomena. The likelihood for significant hazard occurrences is generally understood to be in the vicinity of hundreds of years, in contrast to flood water events which are expected to be more frequent (tens to hundreds of years recurrence) (Barrell, 2015). Hence the flood water hazard on alluvial fans is grouped with the Otago Flood Hazard layer as it interpreted to be better represented in this dataset for the current analysis.

In addition, the river flooding layer from the general coastal hazard mapping dataset (ORC, 2014-2), refined mapping for Dunedin's Urban Streams (ORC, 2014-1) and mapping of the flood hazard for the Milton urban area (ORC, 2012) were also added to the Otago Flood Hazard dataset to ensure full coverage of mapped river and lake flood hazard extents for the region.

To determine exposure of elements to Active faults in the region, buffer polygons were produced for each trace. A 250m buffer distance was chosen for each fault trace (line feature) representing the margin of uncertainty around the mapping of active fault traces (Barrell, 2016, Barrell, 2019, Barrell, 2021).

Buffer polygons were also created for the line features in the Waitaki Coastal Erosion dataset. A 400m distance was chosen, extending coastwards from each mapped coastal hazard zone (CHZ) line feature. This ensured all land between the mapped CHZ lines and the coastal margin (LINZ, 2023) was captured for the exposure analysis.

3.3 Location unit, building and critical facility datasets.

A number of geographic location unit polygon datasets were acquired from Statistics New Zealand (Stats NZ, 2023) for the exposure analysis (Table 4). These were used to establish a consistent geographic framework of location units at appropriate scales (community, district, regional) for the analysis. The urban-rural boundaries dataset allows distinction between built up areas (urban areas - rural settlements) and the rural areas outside these population centres (Figure 1).

Statistical Area 1 and 2 datasets were used to define community boundaries for urban areas and rural settlements, and the remaining rural areas outside of the urban area-rural settlement boundaries. Statistical area 2 (SA2) is designed to represent communities that interact socially and economically (Stats NZ, 2023). In urban areas, they are equivalent to suburbs. Statistical area 1's (SA1) are subsets of these SA2 areas and represent smaller community units that make up the wider SA2 community.

Urban areas and rural settlements in the region are generally defined by SA2's, with some smaller settlements defined by SA1. Rural Otago areas outside of these settlements are defined by SA1's. This ensures the rural units are 1) an appropriate size and scale for analysis in comparison to the urban area rural settlement units, and 2) are more appropriate for the proposed community prioritisation framework (please refer to Woerden et al, 2023 for more information on the proposed community prioritisation framework).

Figure E1: Spatial location of urban areas and rural settlements (blue) and rural Otago community units (yellow).

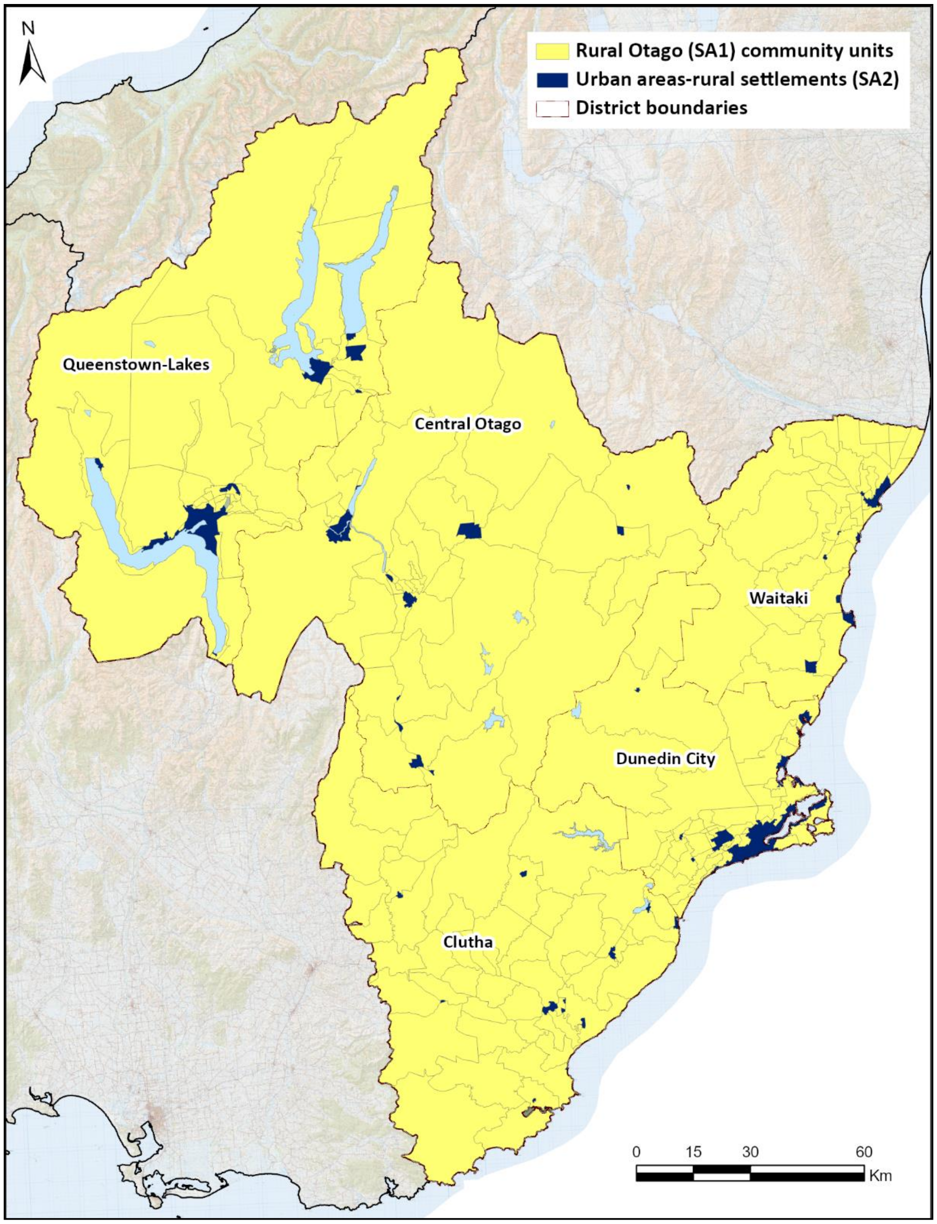

Table E4: Location unit, building and critical facility datasets

Datasets used:	**Source:**
2023 Statistical Area 1 boundaries (SA1)	Statistics NZ: Data Finder website
2023 Statistical Area 2 boundaries (SA2)	Statistics NZ: Data Finder website
2023 Urban Rural classification boundaries	Statistics NZ: Data Finder website
2023 Census Usual Resident Population counts	Statistics NZ: 2023 census-statsnz hub website
2023 District and Regional Council Boundaries	Statistics NZ: Data Finder website
2024 NZ Building Inventory dataset	GNS Science – Finn Scheele
2023 Critical Community facilities	Otago Civil Defence and Emergency Management (OCDEM), modified and updated by ORC Natural Hazards

NZ census 2023 usual resident population count data for all SA1 and SA2 units in the region was acquired from the Statistics NZ: 2023 census-statsnz hub website (Stats NZ, 2025-2). District and regional council boundaries were also acquired from Statistics NZ (Stats NZ, 2025-1). These were used to calculate statistics at district and regional scale and compliment the information at SA1 and SA2 community level, allowing a holistic overview of natural hazard exposure at different scales in Otago.

The GNS NZ Building Inventory and Critical Community Facility datasets comprised the source data to represent 'elements at risk' for the exposure analysis. The GNS NZ Building Inventory dataset (polygon geometry) was developed using the latest (2024) LINZ NZ Building Outline and LINZ Primary Parcels datasets, available from the LINZ Data Service, in combination with property data acquired from Corelogic (Scheele et al, 2023).

The Critical Community Facilities (CCF) layer was originally acquired from Otago CDEM as a point location dataset. This layer was then converted to a polygon building location outline dataset to ensure it was up to date and facilitate the analysis. It comprises all emergency services and disaster operation/coordination centres across the region.

4.0 Workflows

Exposure analyses for the Otago Natural Hazards Exposure Assessment were carried out using the latest version of NIWA Riskscape software 1.8.0.

ESRI ArcGIS Pro 3.3.1 (2025) software, imagery datasets (ESRI 2023 basemaps, google earth, street view imagery) were also used to cross reference and visualise map information. A description of the workflows undertaken to determine exposure statistics and mapping outputs is presented below.

4.1 Initial base data workflow:

The **Critical Community Facilities** dataset acquired from Otago CDEM (2022) is a point geometry feature layer (called Critical Community Sites) with locations identified as points on or close to the relevant site of interest. To ensure all critical site building locations were included partly or fully within polygon boundaries for location units and natural hazard mapped layer extents, the point dataset was converted into polygon geometry. This was done by cross referencing point locations with the latest google earth and street view imagery, and then using the GNS NZ Building Inventory dataset to determine the outline extents of those building locations. Disaster operation/coordination centre locations were also located and added to the dataset at this stage. Polygon features were then created for all point locations using the NZ Building Inventory outline features for each location of interest.

The Critical Community Sites polygon layer displays all building site locations (emergency response facilities and coordination centres) across Otago. In this case, some facilities (e.g. Dunedin Wakari Hospital) are made up of multiple buildings. To ensure critical community sites were grouped by facility, two new fields (Site count and Facility) were added to the

Critical Community Sites polygon layer. The feature layer was then renamed Critical Community Facilities and the facility count used in the analysis to reduce skew in the resulting outputs (i.e. normalise across the dataset to ensure e.g. Wakari Hospital (30 buildings) is not over-represented in the results when comparing with other sites across the region, which may only have 1 building but are considered equally as critical to the community they service during an event).

2023 **Statistical Area 1** (SA1) and **Statistical Area 2** (SA2) polygon datasets and the **Urban Rural** Classification boundaries dataset were acquired from the Stats NZ data finder website. The Urban-Rural boundaries dataset was then used to identify 1) all SA's classified as either urban area or rural settlement, and 2) all SA1's outside out the urban area-rural settlement boundaries (Figure 1).

Two new polygon feature class datasets were then established for the analysis:

- ***Urban areas and rural settlements***; and
- ***Rural areas outside of urban area-rural settlements***

For the two new base datasets, a field for total usual resident population count was added and populated with official 2023 usual resident population count census data acquired from Stats NZ (Stats NZ, 2025-2).

These were then combined into one polygon dataset comprising all SA features:

- **SetRural**

In addition, resident information for rest homes in Otago was acquired from the Ministry of Health website (MoH, 2023). The NZ Building Inventory was updated with this information and subsequently used to calculate an adjusted UR population stat (essentially UR population excluding those who live in rest homes – please refer to section 4.2.4 for a detailed explanation of this process). This information is stored in a new attribute field created in the SetRural layer called 'Adjusted UR Population'. This completed preparation of the area layer dataset input for the riskscape model.

4.2 Riskscape Exposure Model

A model was built in Riskscape to classify all community areas (defined by Statistical Areas (SAs)) within the region by level of exposure associated with the mapped natural hazards chosen for the analysis (Table 3). The Riskscape model pipeline (series of data-processing steps) is shown in Figure 2 below (next page) and is followed by a detailed breakdown of each processing phase in the model.

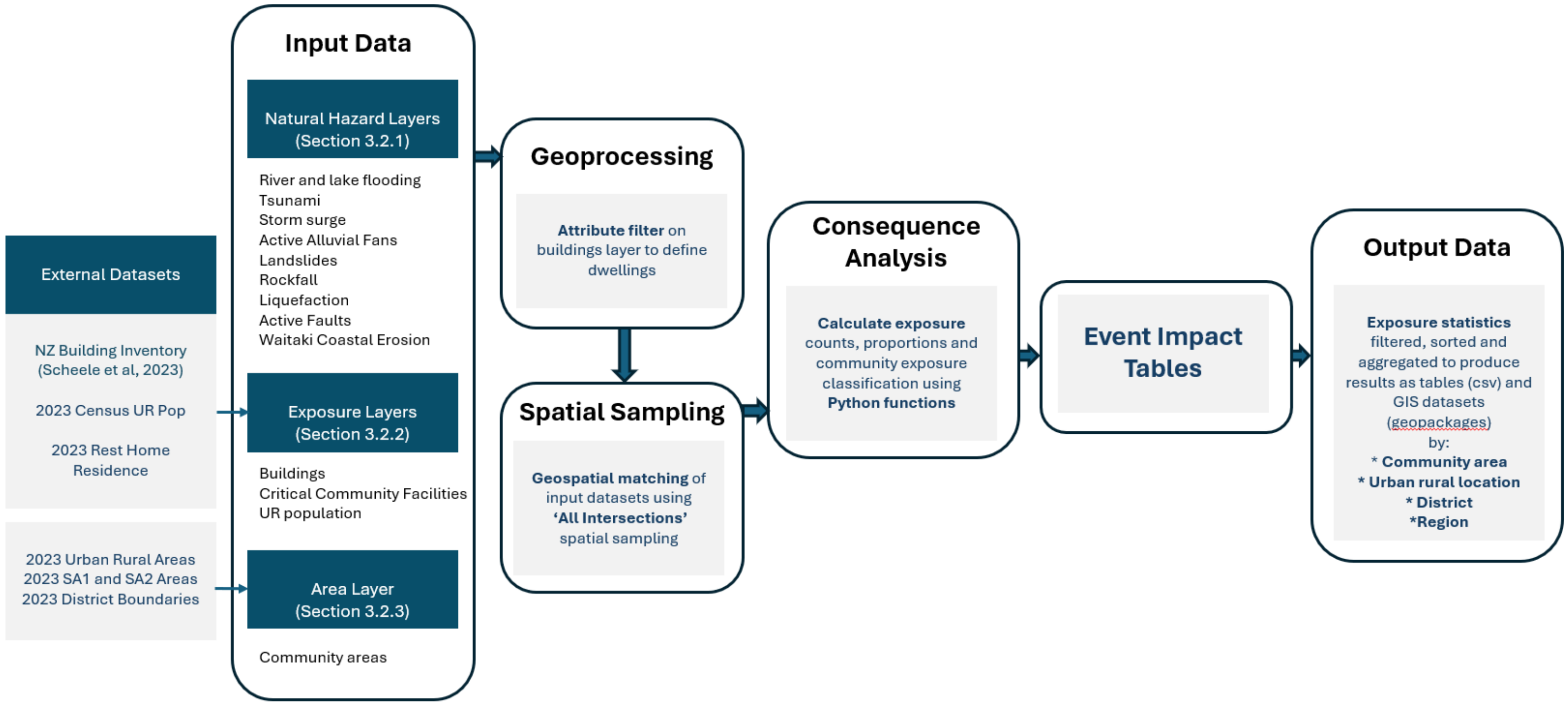

Figure E2: Generalised Riskscape model pipeline for the exposure analysis

4.2.1. Input data

The main data inputs to the model are listed below:

Exposure data (elements at risk source datasets):

- The GNS NZ Building Inventory (building outlines polygon dataset).
- Critical Community Facilities (building outlines polygon dataset).
- Usual resident (UR) population (census 2023 by statistical area), incorporated into the area data layer used for the analysis.
- Rest home residence – facility total bed counts and average occupancy (MoH, 2023).

Hazard data:

- Raster layer datasets with a 5m cell size spatial resolution:
  - River and lake flooding
  - Active Alluvial Fans
  - Landslides
  - Rockfall
  - Active Faults
  - Liquefaction awareness areas
  - Storm surge
  - Tsunami
  - Waitaki Coastal Erosion:
    - CHZ 50, 50 year outlook
    - CHZ 50, 100 year outlook
    - CHZ 95, 50 year outlook
    - CHZ 95, 100 year outlook

Area data:

- 'SetRural' layer - Polygon dataset for statistical area-defined community areas in Otago, combining urban areas and rural settlements, and rural areas outside of these (Rural Otago). These areas aggregate to form district boundaries, allowing analysis at community, urban-rural location, district and regional scales.

4.2.2. Geoprocessing (pre-processing).

This phase is skipped for the calculation of buildings and Critical Community Facilities exposed i.e. no additional pre-processing to filter or transform the input geometry is undertaken on the input datasets.

For the calculation of UR population exposed, an attribute filter is used to select specific building types in the NZ Building Inventory dataset to approximate the spatial distribution of UR population in the region. This is described in detail in section 4.2.4.

4.2.3. Spatial sampling phase

To begin, join steps are run to combine input datasets and prepare the output for spatial sampling. Fields from the building and CCF datasets are joined to the area layer data.

The next stage involves geometry-based lookup sampling, whereby coverages (grid-based GeoTiff raster files) are created for the spatial matching of the input exposure and hazard datasets.

Riskscape geospatially matches the building and CCF building footprint locations with each hazard-layer coverage, returning a hazard intensity measure for that building, in this case whether it intersects the hazard layer or otherwise.

In particular, the 'is-exposed' in built Riskscape Function is run to count the building and CCF features that are exposed to the hazard within each community area, based on 'all intersections' spatial sampling i.e. if any of the building footprint is exposed it will be counted as exposed. The outputs are counts for all buildings and CCFs that intersect natural hazard areas in each community area. The results of the analysis are then saved as building impact tables (csv format) for each of the building and CCF risk elements.

4.2.4. Consequence analysis

The counts of building and CCF features determined to be exposed to the hazard are then calculated as a percentage of the total building and CCF features within that community area.

The calculated proportions are classified in accordance with the exposure table (Table 2) and every community unit is assigned a number corresponding to the level of exposure from (V) Very High to (I) Very Low) to each natural hazard.

Three separate python functions were developed to reflect the categories in the exposure table (Table 2) and used in the Riskscape model to classify community area units by exposure level:

- blbbuckets – calculates **building exposure** level for each community area
- ccfbuckets – calculates **critical community facility exposure** level for each community area

- popbuckets – calculates estimated **usual resident population exposure** level for each community area

Usual resident (UR) population exposed estimate

To determine an estimate for the usual resident population exposed, 3 main datasets are used as inputs:

- the NZ Building Inventory dataset;
- Resident information for all rest homes in Otago acquired from the MoH (2023) website; and
- 2023 NZ Census usual resident (UR) counts for each community area, within the SetRural dataset

The NZ Building Inventory includes the field attribute 'use category' which classifies buildings by their type of use. This field attribute is used in the analysis to define the building types which represent a main place of residence for the UR population (i.e. where they sleep and generally live). In particular, the 'residential dwelling', 'lifestyle' and 'rest home' categories are chosen to represent dwellings, and hence approximate the spatial distribution of UR population for community areas in Otago.

In addition, a third category was created in the building inventory 'farm/rural dwelling' to represent dwellings in rural areas. The process for this is described below and shown graphically in Figure 3.

Addition of Farm/rural dwelling use category attribute

In many rural locations, building features have been assigned an 'unknown' use category attribute within the building inventory. It is expected a certain number of these will be dwellings (primary place of residence). Overall, buildings likely to be dwellings are not well defined in rural areas due to incomplete or absent property information in the source Corelogic dataset used to build the building inventory (Scheele et al, 2023).

To improve the classification of dwellings in rural areas, those locations containing a large number of buildings with an 'unknown' use category (e.g. rural Waitaki District) were examined manually using the latest aerial and satellite imagery available through ESRI, along with supplementary data sources such as existing photographs and google street view (where available). Following visual on-screen inspection of rural buildings in the dataset, some specific criteria (Table 5) were developed to distinguish general rural farm type buildings (sheds, barns, garages, storage etc.) from those that could be considered dwellings: Buildings >65m2 in close proximity to a main drive-way (within approx. 5m), with more complex roof and footprint characteristics (e.g. multiple pitched roof parts (more than 2), chimney structures, adjoining decks) and/or with other evidence consistent with a dwelling (e.g. vehicles parked next to them, visible bikes, trampolines close by). Those meeting the four primary indicators shown in Table 5, were interpreted to be farm/rural type dwellings.

A new use category attribute (farm/rural dwelling) was then created in the NZ building inventory and assigned to those buildings interpreted to be dwellings, with the aim of better approximating the spatial distribution of UR population in rural areas, and hence reducing the potential of an undercount of UR population exposed to hazards for these areas.

Table E5: Criteria used to identify dwellings in rural areas of Otago

Rural/Farm Dwellings: Primary indicators	**Rural Farm Dwellings: Secondary indicators**	**Non-dwelling buildings**
Building footprint >65m2	Vehicles parked beside house	Building footprint <65m2
Drive way next to house (<=5m away)	Other evidence of residence (bikes, trampolines nearby)	No drive way next to house; > 5m away
Complex roof characteristics (multiple (>2) pitched roof segments); lower reflective properties (e.g. colours other than white, cream)		Basic roof structure (<= 1 pitch segments); Higher reflective properties (e.g. white, cream spectral signature
Other distinctive building characteristics (Chimney structures, adjoining decks)		No chimney, and/or adjoining deck structures

Dwellings in the analysis

Following the addition of the 'farm/rural dwelling' use category to the NZ Building Inventory dataset, 4 building use category types are confirmed to represent dwellings in the analysis:

- Residential dwelling,
- Lifestyle
- Farm/rural dwelling, and
- Rest home

Only buildings with a floor area greater than or equal to 65m^2 are selected. This is based on the assumption that buildings with a floor area smaller than 65m^2 are more likely to be sheds, garages or other farm type buildings rather than dwellings which house the UR population.

Of the 4 building use category types above, residential dwelling, lifestyle and farm/rural dwelling are used to represent ‘standard’ dwellings, while rest homes are considered separately (please see rest home use category below). A total count of ‘standard’ dwellings is then calculated for each community area.

Rest home use category

Rest home dwellings (RH) are considered separately from the other dwelling types for the estimate of population as they often contain a large amount of people residing in one location. Information on rest home bed counts and occupancy is readily available for facilities in Otago via the Ministry of Health and Aged Residential Care websites (MoH, 2023; ARC, 2024). Using these resources, the spatial location for all rest homes in Otago was determined, and total bed counts (which indicate maximum available occupancy) were acquired for each facility (MoH, 2023). The NZ Building Inventory source dataset was then updated to include 3 new attribute fields incorporating this information:

- RH facility total bed count (acquired from MoH, 2023)
- RH facility building count (footprint determined by cross referencing building inventory with imagery)
- RH facility average beds per building (calculated as below)

RH facility average beds per building:

For rest home facilities that have more than one building, the acquired bed count is divided amongst the number of buildings for that facility to give an **average bed count per building.**
e.g. Bed count 108 and 10 buildings = average bed count of 10.8 beds per building.

This is done to ensure an approximate bed count is available per building for each rest home facility.

RH beds aggregate per community area:

This is then aggregated (sum) for each community area to give the total number of **RH beds per community area.**

Convert to estimate of population:

Next, an estimate for the UR population in rest homes is calculated using the RH facility bed count information and average occupancy of rest homes in Otago (2023) acquired from the Aged Residential Care Sector Report (ARC, 2024) as primary inputs. According to ARC (2024), the average occupancy of rest homes in Otago in 2023 was 87%.

This figure (87%) is used to convert the **RH beds per community area** result into an estimate of population residing in rest homes for that community area:

RH Beds per community area * 0.87 =

Estimate for **total UR Population residing in rest homes** per community area.

Calculation of UR population residing in 'standard' dwellings

Buildings with use categories: residential dwelling, lifestyle and farm/rural dwelling are used to define 'standard' dwellings i.e. those other than rest homes.

For each community area, the count for total **UR population residing in rest homes** is subtracted from the total **UR population census count** to produce a stat called 'Adjusted UR population':

Total UR population residing in rest homes –

Total UR population census count

= **Adjusted UR population count.**

The 'adjusted UR population' count represents the UR population in the area excluding those who live in rest homes.

The total UR population census count is hence partitioned into 2 parts for the analysis which together make up the total UR population census count for that community area:

Total UR population in rest homes +

Adjusted UR population count

= **Total UR population census count**

The adjusted UR population count for each community area is then divided over the total 'standard' dwelling count for that community area to give an **average UR population per 'standard' dwelling** metric:

Adjusted UR population census count / total 'standard' dwelling count

= Average UR population per 'standard' dwelling

Total UR population exposed for community areas

To determine the total number of UR population exposed to natural hazards for all community areas in Otago, processes are run in Riskscape to determine the total number of 1) dwellings and 2) rest home beds located **within natural hazard extents.**

First, a count of all standard dwellings located within the natural hazard area is determined. This is then multiplied by the average UR population per 'standard' dwelling stat to give the 'total number of UR population exposed to the hazard for **'standard dwellings.'**

In addition, a count of all rest home beds within the hazard extent is determined (using the RH beds per building stat within the NZ Building Inventory). This number is then multiplied by 0.87 to give an estimate of the 'total number of UR population **exposed in RHs'** for each community area.

These two are added together to give the **total number of UR population exposed** to the hazard for each community area:

Total UR pop exposed in RH +

Total UR pop exposed in 'standard' dwellings

= **Total UR population exposed to the hazard** for a community area

Essentially the sum of population exposed in rest homes and the sum of population exposed in all other dwellings ('standard' dwellings) are added together to find the total population exposed to a natural hazard for each community area.

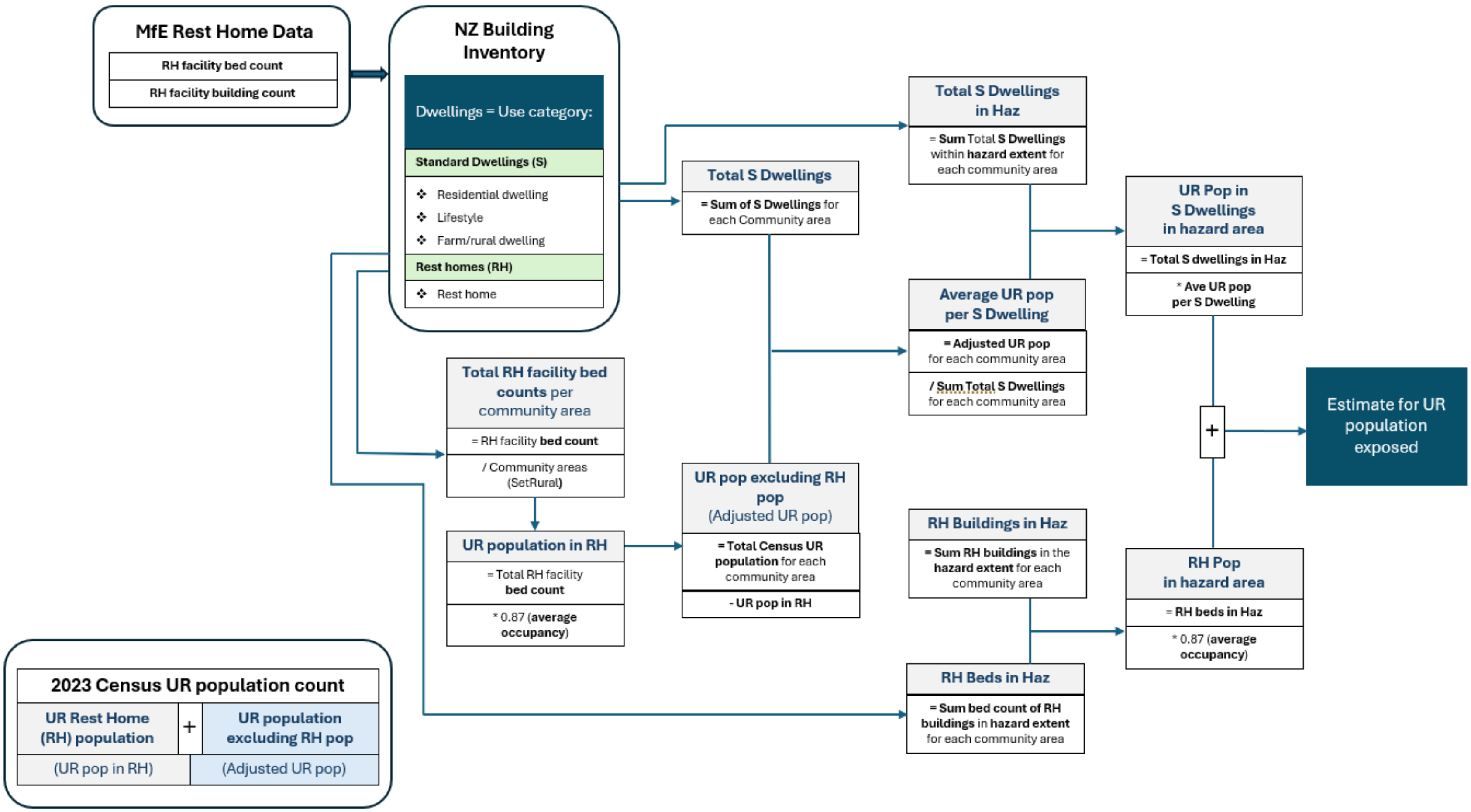

Figure E3: Overview of the process for the UR population exposed estimate.

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4.2.5. Reporting

Event impact tables are produced during the consequence analysis phase displaying exposure statistics at community area level, including the exposure level classification for each community area, counts of communities for each exposure level, and regional statistics for the counts and proportions of elements-at-risk. These results are then filtered, aggregated and sorted before being saved to file as Microsoft exel csv's, and/or geopackages.

District exposure outputs

For all community areas, exposure statistics are aggregated by district. The filter function is used save individual tables for each natural hazard and the sort function is used to sort alphabetically by district. The resulting tables are saved as Microsoft Excel csv spreadsheets.

Urban area or rural settlement outputs

Exposure statistics are aggregated for each urban area or rural settlement location. The filter function is used to screen for urban areas and rural settlements only and then save individual tables for each natural hazard. The sort function is used to sort by population count. The resulting tables are saved as Microsoft Excel csv spreadsheets.

Rural Otago areas outputs

Exposure statistics for rural Otago areas are aggregated by district for each rural community area. The filter function is used to screen for rural Otago areas only and then save individual tables for each natural hazard. The sort function is used to sort by population count. The resulting tables are saved as Microsoft Excel csv spreadsheets.

Full exposure analysis results are saved for each natural hazard and the source area layer (SetRural, which contains fields for all interim calculated counts and proportions) in geopackage file format.

Additional specific outputs e.g. Top 10 communities exposed for each hazard at each scale (community, urban area or rural settlement, district, region etc) are determined by running filtering options on the full exposure results in Microsoft Excel. A list of some of the main outputs from the model is shown below:

Main model outputs:

- Exposure table compiling the event impact exposure information for all hazards by **district**; and
    - Separate individual exposure tables for each hazard by **district** (csv format).

- Exposure table compiling the event impact exposure information for all hazards by **urban area or rural settlement**; and
  - Separate individual exposure tables for each hazard by **urban area or rural settlement location** (csv format).
- Exposure table compiling the event impact exposure information for all hazards by **district** for **rural Otago areas**; and
  - Separate individual exposure tables for each hazard by district for **rural Otago areas** (csv format).
- Exposure table showing counts and proportions of exposure elements and community area sum total counts **for each natural hazard type** in the **region** (csv format).
- SetRural area layer feature class (geopackage format).
- Exposure table output for all hazards; and individual exposure table outputs for each hazard (geopackage format).

5.0 Example Outputs

Selected examples of the exposure results generated in the analysis are displayed as tables from the next page below. Further table output examples for the analysis are presented in the van Woerden and Welsh (2025) technical report.

5.1 Exposure table examples

Table E6: Exposure by **natural hazard type** for Otago, with total counts and proportions for population, buildings and critical facilities, and count of communities classified with high or very high exposure.

Hazard Type	Population (count)	Population (%)	Buildings (count)	Buildings (%)	Critical Community Facilities (CCF)	CCF (%)	Communities with high or very high exposure
River and lake flooding	38778	16.1	33,898	16.1	23	25.6	159
Liquefaction	45,047	19.1	43,029	20.4	37	41.1	146
Active Faults - Otago	21,949	9.1	20,096	9.5	10	11.1	108
Landslide	8,038	3.3	6,592	3.1	3	3.3	61
Alluvial fan (debris inundation)	5,473	2.3	5,904	2.8	3	3.3	51
Rockfall	1,234	0.5	1,056	0.5	0	0.0	18
Coastal inundation - Tsunami	504	0.2	1,130	0.5	0	0.0	13
Coastal inundation – Storm surge	504	0.2	1,122	0.5	0	0.0	11
Waitaki Coastal Erosion - CHZ 95, 100 yr outlook	37	0.0	111	0.1	0	0.0	1
Waitaki Coastal Erosion - CHZ 95, 50 yr outlook	24	0.0	69	0.0	0	0.0	1
Waitaki Coastal Erosion - CHZ 50, 100 yr outlook	19	0.0	57	0.0	0	0.0	0
Waitaki Coastal Erosion - CHZ 50, 50 yr outlook	5	0.0	36	0.0	0	0.0	0

Table E7: River and lake flood hazard exposure at **district scale**, ordered by population count and listing total count of communities with a high to very high exposure.

District	Communities with high or very high exposure	Population (count)	Population (% of District)	Buildings (count)	Buildings (% of District)	Critical Community Facilities (CCF)
Dunedin City	62	27,969	21.7	19,683	21.9	10
Clutha District	33	3,754	20.2	5,593	18.7	10
Queenstown-Lakes	18	2,883	6	3,161	8.7	1
Waitaki	14	2,707	12.5	2,870	11.2	0
Central Otago	32	1,466	6	2,591	9	2
Otago Total	**159**	**38,778**	**16.1**	**33,898**	**16.1**	**23**

Table E8: Flood hazard exposure for **urban areas - rural settlements** and the communities within them: **Top 10** urban area- rural settlements ordered by population count.

Location	District	Communities with high or very high exposure	Population (count)	Population (% of location)	Buildings (count)	Buildings (% of location)	Critical Community Facilities (CCF)
Mosgiel	Dunedin City	6	12,530	85.9	8,765	87.1	3 (1P, 1F, 1A)
Dunedin	Dunedin City	28	12,078	12.0	5,560	9.4	5 (2P, 2F, 1H)
Oamaru	Waitaki	2	1,989	14.5	1,466	13.9	0
Queenstown	Queenstown-Lakes	2	1,546	6.2	1,027	8.2	0
Balclutha	Clutha District	2	1,105	25.4	1104	34.5	3 (1P, 1F, 1A)
Outram	Dunedin City	1	912	100.0	734	100.0	1 (1F)
Milton	Clutha District	1	839	39.6	827	41.1	2 (1F, 1A)
Luggate	Queenstown-Lakes	1	461	73.5	365	76.2	1 (1F)
Glenorchy	Queenstown-Lakes	1	351	96.6	467	86.8	0
Waihola	Clutha District	1	324	63.1	346	65.0	0

Table E9: Flood hazard exposure **for rural areas** outside of urban areas – rural settlements by **district** ordered by population count.

Location	District	Communities with high or very high exposure	Population (count)	Population (% of location)	Buildings (count)	Buildings (% of location)	Critical Community Facilities (CCF)
Rural	Dunedin City	23	2071	29.8	4129	32.7	0
Rural	Clutha District	24	1150	16.4	2176	15.9	0
Rural	Central Otago	25	1081	14.4	2734	14.1	1
Rural	Waitaki	12	712	12.6	1379	11.8	0
Rural	Queenstown-Lakes	11	383	9.9	1025	14.0	0
Otago rural	**Total**	**95**	**5398**	**17.4**	**11443**	**17.7**	**1**

6.0 Limitations overview

6.1 Population datasets

Transient population counts (e.g. tourists, short term visitors) are not included in the analysis. This is because 1) appropriate statistics on transient population counts are not available at the community unit scale, and 2) the transient population fluctuates over comparatively shorter time frames (days-weeks) to that of the usual resident population (months-years), rendering it inappropriate for the temporal scale of the analysis (in alignment with official census counts, approx. 4-yearly).

6.2 NZ Building Inventory

The NZ Building Inventory dataset reflects building outlines and property information as of June 2024, hence changes after this date are not reflected in the dataset used for the analysis. This is not expected to cause any significant changes to the analysis findings however (i.e., rate of new building construction over this time is not considered to be significant compared to rest of the dataset). The source dataset is updated in line with aerial and satellite imagery availability (every few years) and can be used to re-run the analysis where updates are available.

As touched upon in Scheele et al (2023), significant gaps exist in building attribute information for rural areas in the dataset, including the building use category classification. This holds true for rural areas of Otago where many buildings do not have a use category assigned. Upon examination of the dataset using aerial and satellite imagery, open street map, google street view (where available) and available property datasets (e.g. LINZ parcels, ORC property information, Otago district rates information etc.), an approach is developed to distinguish farm/rural dwellings from general farm type buildings in the dataset (section 4.2.4) for buildings without an assigned use category. This approach develops criteria interpreted to be specific to dwellings (e.g. roof characteristics, building footprint size, evidence for family residence etc.) to improve building classification and support the UR population exposed calculation (section 4.2.4). Further work is suggested to calibrate this approach in more detail to confirm building use categorisation (e.g. site visits where street view is not available).

In the current analysis, only a very small number of buildings (<100) have been classified using this approach, hence it is unlikely to have any major impact on the UR population exposed results for rural areas in the region. Nonetheless further work is recommended to improve the classification of use category for buildings in rural areas of the NZ Building Inventory dataset and hence improve the identification and classification of dwellings for future iterations of the exposure analysis.

6.3 Proposed ORPS exposure table and elements at risk

Elements at risk used in the analysis

Lifelines infrastructure and the social/cultural buildings elements are not considered in this phase of the analysis. Please see section 2.1 for a description on the rationale for this.

6.4 Natural hazards dataset mapping

Accuracy of mapped extents

This analysis maps the location of buildings within the mapped extents of natural hazards. The features mapped for some of the datasets (e.g. landslides, alluvial fans, Tsunami etc.) have a boundary extent accuracy of +/- 100 m, hence more or less buildings may be counted when determining those affected by the occurrence of the natural hazard.

Mapped natural hazard extent and elements exposed

The mapped natural hazard areas used in this analysis represent the full known extent of natural hazard occurrence based on current knowledge. i.e. a worst-case scenario based on current knowledge (past events, modelling etc).

In this case, all elements at risk located within the mapped extents are counted as exposed. This assumption is on the conservative side but is considered appropriate given the limitations of the source datasets and scale of the analysis (community to district-regional). In practice however, potentially less elements maybe counted as exposed in smaller magnitude events where less ground area is affected and hence the mapped extent is smaller.

Landslide mapping

Mapping of the lower boundaries of landslides may not cover the full extent of runout, particularly in areas outside the Dunedin coastal area. The Dunedin coastal area has been mapped more recently (Barrell et al, 2017) using more up to date technology (e.g. lidar) and thus boundaries are expected to be more accurate for these features, including interpreted runout zones, than for the comparatively older information mapped elsewhere in the region.

6.5 Overall exposure analysis

UR population exposed estimate

The use categories used to define dwellings in the analysis are argued to best reflect place of residence of the usual resident population in Otago. Despite this, some other use categories may include dwellings e.g. buildings classified as appurtenant, mixed residential/non-residential, farm in rural areas etc. This may in turn result in an undercount of the UR population exposed as the average UR population per dwelling statistic is used in the calculation of UR population exposed where a dwelling intersects a mapped hazard extent. In urban areas, this is not expected to be significant as the classification of building type is relatively comprehensive. In rural areas, the classification of use category is less well defined as described in Scheele et al (2023). Future iterations of the NZ Building Inventory could make use of image classification techniques based on spectral and optical characteristics of building features (as per Table 5) to improve the classification of buildings in these areas, and hence improve the overall estimate of UR population exposed.

In order to calculate an estimate for UR population residing in rest homes, the total bed count for each facility is multiplied by the average occupancy statistic (87%) for rest homes in Otago (see section 4.2.4). This is an average metric of resident occupancy for all rest home facilities across the region. In practice, occupancy may vary between facilities. Despite this, the average occupancy statistic is considered scale appropriate for the analysis (community and district level), enabling a good estimate on UR population residing in rest homes across the region.

Mapped vs unmapped areas

The exposure analysis has only been carried out for areas where mapped natural hazard information is available. This means that some areas where a natural hazard is a known significant threat, but where mapping is not yet available, will not be included in the results. South Dunedin is a primary example of this where large areas are subject to pluvial flood hazard, as demonstrated in recent events (e.g. June 2015, October 2024), but where adequate mapping for this type of hazard has not yet been carried out.

For further details on the limitations of the source datasets used in the analysis and the Otago Natural Hazards Risk Assessment in general, please refer to the exposure technical analysis report (van Woerden and Welsh, 2025).

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