Vulnerable: the quantum of local government infrastructure exposed to sea level rise

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Survey and support by Tonkin & Taylor Ltd

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CLIMATE CHANGE

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Foreword

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This report and its recommendations are of deep personal interest to me. As Mayor of Dunedin, I have seen first-hand the risks that rising sea levels pose to our low lying urban neighbourhoods. I also know how difficult it can be to develop long-term plans to adapt to this challenge in a fair and equitable way.

This report and its recommendations are of deep personal interest to me. As Mayor of Dunedin, I have seen first-hand the risks that rising sea levels pose to our low lying urban neighbourhoods. I also know how difficult it can be to develop long-term plans to adapt to this challenge in a fair and equitable way. Yet it is a challenge we must take up if we are to limit the impact that climate change has on our country – particularly sea level rise. As this study highlights, roughly 65 per cent of New Zealanders live within five kilometres of the ocean, and an increasing number of councils will face significant policy and financial challenges as the sea continues to encroach on them.

The focus in this report is on council owned infrastructure, particularly roading, three waters networks and buildings/facilities. These are vital building assets which underpin the viability of our communities, and as they come under strain, so too will the fabric that binds our communities together. Addressing sea level rise will require a data-driven understanding of the problem so that our communities and stakeholders can put in place plans and other measures to bolster resilience for this uncertain future. This report is a first step in that direction.

We acknowledge that the costs of responding to and preparing for sea level rise (and other, compounding changes to the climate) will be significant, but recognise that the costs of doing nothing are even greater. Our communities must begin to build resilient infrastructure and, most importantly, prepare for change. The analysis provides an indication of the very minimum level of investment that is likely to be required.

More specifically, this analysis fills a gap in understanding of the type, amount and replacement value of core local government owned infrastructure that is exposed to sea level rise. Further, it proposes recommendations to address those impending impacts and associated costs. In doing so, it intends to help our community leaders prime and test council staff, constituents and stakeholders to engage in the most effective long-term planning, disaster risk reduction, and rebuilding of core infrastructure to effectively manage exposed investments. While climate change is a global phenomenon, it is at the local level where its impacts are most acutely felt.

Importantly, this report intends to assist in shaping our vision of how to address the challenge of sea level rise for the next 50 to 150 years, using actual quantity and replacement value data. Additionally, it is important to note that this is the first time a national survey measuring the value of owned infrastructure exposed to the effects of sea level rise has been completed by a local government organisation. It shows just how serious New Zealand's local government is about addressing the effects of climate change.

LGNZ looks forward to your input and continued dialogue on this important issue.

Dave Cull
President
LGNZ

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Introduction

Introduction

Background – LGNZ's Climate Change project

Councils are already experiencing the impacts of climate change, which have bearing on the prosperity, vibrancy and long-term viability of our communities. Climate change will affect all of us during our lifetimes, and councils are increasingly recognising that resilience to climate change depends in large part on what is being done to adapt to it.

This report forms part of LGNZ's wider flagship Climate Change project. The project is focused on supporting councils with their adaptation and mitigation responsibilities, and involves ongoing advocacy to the Government on the tools and resources that councils and their communities need to address climate change.

In 2017, LGNZ published a position statement on climate change. The document explicitly states:

"Responsive leadership and a holistic approach to climate change is urgent. We must act now to avoid future risk and, at the same time, agree how to manage safety, existing risks, limitations and liabilities to underpin effective mitigation and adaptation."

However, until now, we have not had a good understanding of the type, amount and replacement value of local government owned infrastructure that is exposed to sea level rise. Although other agencies and organisations have performed similar research and data analysis, their outputs have not been readily transferable to local government asset owners or stakeholders. This report is designed to address that gap in knowledge, and build understanding of the replacement value of exposed local government infrastructure.

As LGNZ's advocacy and policy positioning is data driven, we intend to use the information from this research programme across multiple projects and to inform future policy positions. We encourage local government, central government and other key stakeholders to do the same.

Purpose of this study

This project has two intended outputs. The first is to research the current quantity and value of infrastructure exposed to sea level rise at four increments; 0.5, 1.0, 1.5 and 3.0 metres, and to quantify replacement value. The scope of this research project primarily includes roads, three waters infrastructure and buildings. Data was also collected on other types of infrastructure, including greenspace, jetties and airports.

The second and more important output of this research is to provide responses to rising sea levels. This study intentionally avoids specific and local costs, and targets discussion at a regional and national level in order to highlight trends and general areas of high and low priority. It raises questions about how to improve procurement, appropriately share management of risk, and communicate with stakeholders about priorities.

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Impacts resulting from sea level rise will be far reaching, and will demand that central and local government, communities, iwi, businesses and property owners coordinate investments to adapt and build community resilience. For too long in the local government setting, dialogue has focused on response to an opaque impact; unquantified replacement values and costs have led to indecision in planning and investment, and vague objectives. Until this time, there has been no cohesive body of data to ground a discussion and develop reasonable outcomes with a national and regional focus.

Action on climate change demands, and will continue to require, proactive collaboration between stakeholders. Without continued research and dialogue to establish positions for directing local government resources, our communities will be ill prepared for the inevitable impacts.

Planned outcomes

The primary outcome of the research is to increase the priority of importance of this issue amongst all stakeholders. The replacement value of exposed infrastructure is a best estimate based on information received from surveyed councils. Our view is that this will be a small fraction of what New Zealand stakeholders will have to manage in the next 150 years, given that there will be impacts not only to local public infrastructure, but also on central government

and private property and infrastructure. The research clearly demonstrates that this is an intergenerational issue requiring action by decision-makers now if the impacts are to be efficiently and equitably managed, and communities are to adapt.

Further, the research intends to provide a context to begin discussions between stakeholders. The impacts of sea level rise on local government owned infrastructure, and costs associated with these impacts will directly and indirectly impact levels of service and costs for all stakeholders. Consequently, an issue to consider is who bears the costs of both replacing the infrastructure that is impacted, and of building the resilience of that infrastructure before seas rise further. Real success will be attained when stakeholders align efforts to ensure a future with prioritised affordable and effective responses to the demands of a changing climate.

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The regional approach to this data analysis is designed to encourage local government to explore solutions at a regional, and in some cases national, level. Although solutions will be executed through local engagement, local government must approach this challenge with a focus that is both broad and deep. Solutions must not be constrained by man-made lines on a map, but rather need to be underpinned by a vision for national benefit.

In addition to raising the priority of this issue and the outcomes that need to be achieved, the report is intended is to reiterate the increasing pace at which change is occurring. Effective advanced planning requires good communication, strong issue literacy, and full consideration of the variables that affect outcomes. Given that sea level rise and its impacts will manifest relatively slowly, New Zealand does have a small window of time to begin conversations with communities about how to respond, and ensure a time-sensitive approach for sustainable and equitable management of expensive resources. However, this time is limited and it must be used wisely.

Research programme methodology

The survey, jointly developed by LGNZ and Tonkin & Taylor, was issued to 62 councils on 2 February 2018. In producing the survey, LGNZ coordinated with NIWA to source regional GIS polygons relating to a range of sea level rise elevations in coastal areas. The supplied polygon information was intended to be overlaid with council GIS information to quantify exposed infrastructure, and to understand its depreciated and replacement value. Councils were provided with Excel survey templates to complete.

The NIWA GIS information shared with councils included data at various levels based on Light Detection and Ranging (LiDAR) data for some New Zealand regions, and a single New Zealand-wide GIS data set (based on a 3.0 metre national digital elevation model (DEM)) to be used for the remaining areas without LiDAR. In some cases, councils had to use a mixture of LiDAR and the national DEM data. For clarity on what council data was available and where, please refer to Appendix A.

Included in the correspondence to councils were two templates; for the LiDAR area and for the DEM area. For the LiDAR areas, four elevation scenarios were requested; 0.5m, 1.0m, 1.5m and 3.0m. For the DEM areas, only the single three metre scenario was required. The elevation scenarios were chosen for clarity of impact at increments measurable in both the short and long-term, with the understanding that scenarios identified in the short-term (0-100 years) would be of greater interest than those posed in the long term (100+ years). Further, those short term increments were set based on general, sustained exposure with the understanding that variability of conditions, e.g. king tide with a storm event, could make the smaller available measurement increments irrelevant.

Finally, in addition to the scenarios requested, total council quantities and replacement values for the relevant assets were requested to enable an analysis of percentages impacted. All data received via survey responses was compiled into a database, which was finalised on 20 October 2018.

The survey response rate was 97 per cent. Two councils chose not to participate in the survey. Of those surveys returned, six councils reported no assets exposed, and therefore no information was input into the database for these councils. For a full list of disclosures, see Appendix B.

For clarity, the definition of exposed infrastructure is that physical assets that are located within the inundation area used for the analysis, and therefore potentially susceptible to the impacts of sea level rise. We note that asset exposure does not necessarily mean there will be "damage" or impact, or that replacement will be required.

This report has a primary focus on sea level rise, noting that it is one of several "general" underpinning factors that impact or cause coastal flooding. Other variables include storm events, high tides

and land subsidence. Reporting in this way attempts to avoid conflating "weather" events with the constant variable of sea level rise. Importantly, the frequency of impacts related to rising sea levels will increase in coming decades. Sea level rise is a foundational issue requiring a long-term, sustainable and permanent response.

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Further, this analysis identifies and measures only replacement value. The analysis does not take into account costs for other activities, such as temporary or permanent adaptation measures, planning activities and purchasing additional resources to ensure an acceptable level of service, e.g. right-of-way for a road realignment. For a list of full disclosures, see Appendix B.

At Risk Infrastructure Working Group

To support this study, LGNZ formed an At Risk Infrastructure Working Group. The group included representatives from 12 councils and supporting participation from other organisations, including NIWA. The group has advised on the approach of the research, the formulation of the methodology for gathering information from councils, and implications of the data gathered for the local government sector. It has also provided input into this final report. In doing all of this, the Working Group drew on multiple sources of existing research and analysis, including the 2015 NIWA report "National and regional risk exposure in low-lying coastal areas".

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Survey observations

Survey observations

Council Challenges

LGNZ has identified key local government challenges as a result of this study and from consultation with the At Risk Infrastructure Working Group. The considerable amount of local government owned infrastructure that this survey reveals is exposed demonstrates that there is an urgent need to prepare for and address the challenges that this exposure will ultimately create. So that councils and their communities are equipped to address this challenge, there are a number of fundamental areas for improvement, including:

Intra-council coordination

Councils need to improve internal coordination. From the survey, it was clear that for many councils department staff held fluency in their area of expertise, but there was a need for coordination of council finance, geospatial information systems and asset management. Completion of the survey identified gaps and inefficiencies in work across departments. Councils need to build their capacity and better coordinate to manage projects and data, and need clearer reporting for planning and improved internal coordination.

Inter-council coordination

Greater coordination across regionally aligned councils is needed to execute long-term planning, resource planning, procurement of capital infrastructure, operations, maintenance activities and community engagement to prepare for and adapt to the impacts of sea level rise. Clearer and more coordinated planning will help ensure reduction of competition for resources and engagement with the public.

A number of councils have begun taking a regionally coordinated and collaborative approach to the way in which they address climate change. More must be done to maximise opportunities for such collaboration.

External coordination

Greater collaboration by central and local government is needed to plan for sea level rise, and climate change more generally. Given that adaptation to climate change happens at the local level, local government needs to be closely engaged by central government on all decisions that it makes about existing and future climate change challenges and responses.

Central government needs to work with local government to overcome the challenges that councils have identified as precluding them from doing more to address climate change, including challenges relating to funding, and capacity and capability to undertake risk assessments.

Integrated adaptation and mitigation planning

Councils should consider how their planning and decisions could address both adaptation and mitigation when making decisions about infrastructure. An integrated approach to both adapting to and mitigating the impacts of climate change provides an opportunity for local government to create synergies, deliver a range of co-benefits and potentially increase cost effectiveness.

The most recent Intergovernmental Panel on Climate Change (IPCC) reported that a systemic, transformative change is needed to limit global warming to 1.5°C, and that efforts need to be linked to complementary adaptation action. It identifies that a mix of mitigation and adaptation options implemented in a participatory and integrated manner can enable rapid and systemic transitions in urban and rural areas.

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Summary analysis

Summary analysis

Never before have local governments combined to create a national review of their infrastructure exposed to sea level rise with a quantified estimate of replacement value. New Zealand is now leading the charge to create clarity around potential impact and associated cost due to climate change, and intends to share evidence and lessons learned internationally.

In initial review, the quantity and value of infrastructure exposed is not extraordinary, nor perhaps unanticipated. However, noted quantities and values are a baseline for "exposed" infrastructure only. No other variables, such as timing of sea level rise and the various ways in which councils can respond, are considered due to research time and cost constraints.

This report addresses only local government owned infrastructure that is exposed to sea level rise. Central government, businesses, and other stakeholders also have investments, both in infrastructure and other resources, that may be indirectly impacted if local government owned infrastructure is impacted by rising seas. The full quantum of impact is not yet fully understood, but key to New Zealand's success in addressing the resilience of its "system" of assets is to communicate where and how intended responses to sea level rise need to take place and why.

Quantity of Impacts

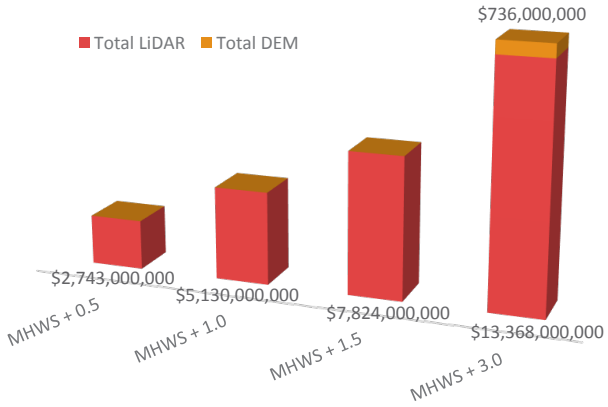
All local government owned infrastructure exposed to sea level rise has been quantified nationally at noted increments. Exposure varies in quantity and value based on region and sea level rise increment.

Three waters infrastructure has the greatest exposure. For example, at the 1.5 metre increment more than 6,000 kilometres of pipe is exposed, roughly equivalent to the distance of a return trip from Melbourne to Darwin. The quantum of exposed roading at 1.5 metres is more than 2,000 kilometres (roughly the distance from Stockholm to Rome). Additionally, almost 2,000 buildings/facilities are exposed nationally.

Replacement values

The total replacement value of all exposed infrastructure (three waters, roading, buildings/facilities, green space and landfills) at the 1.5 metre increment is estimated at approximately $8 billion. Importantly, at each noted increase of sea level rise between 0.5 and 3.0 metres, the incremental increase in value is between 50 and 90 per cent. Notably, between 1.5 and 3.0 metres, the increase is an approximate doubling of value exposed creating a total estimated value greater than $13 billion.

Figure 1: Total replacement value of exposed infrastructure



Note:

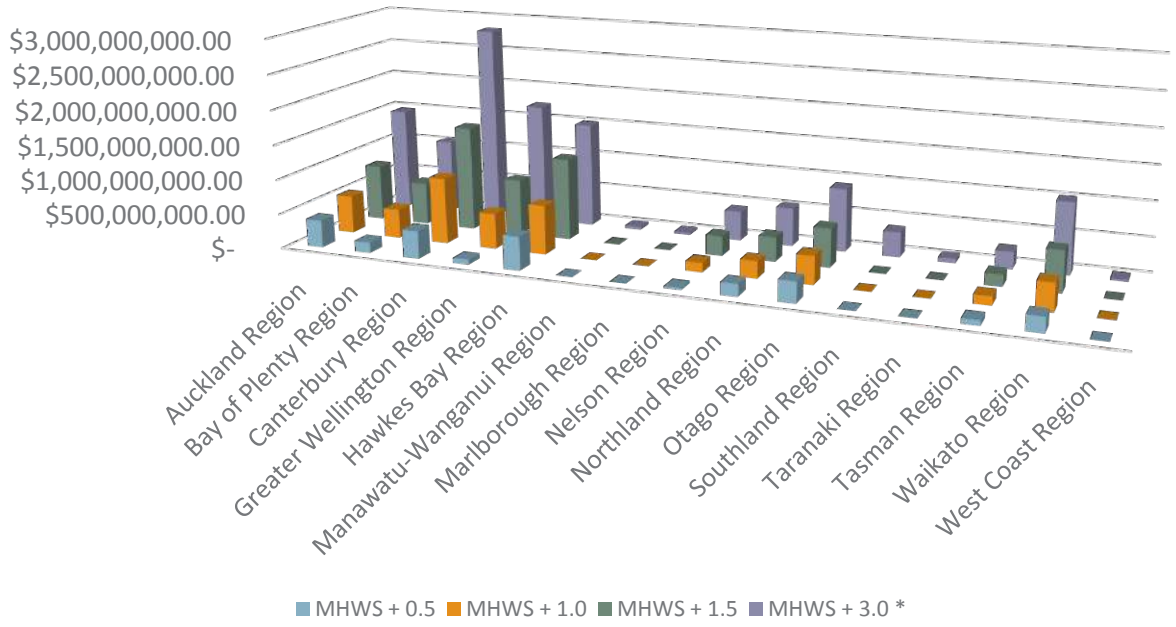
1 Data includes, three waters, buildings/facilities, transport, landfills and green spaces.

2 National DEM data was only available at the MHWS + 3.0m elevation. It is important to note that while the DEM data is much coarser it only represents a small proportion of councils, and the related quantity/value of assets exposed. For completeness, it is included within the overall data set within the MHWS + 3.0m category. Consequently, the 3.0m category has a greater number of councils represented. There will also be a small proportion of 'DEM' assets exposed at the lower elevation bands for those councils that are not included within the totals.

3 Please refer to Appendix B for all assumptions and limitations, including those councils which are DEM and LiDAR.

The greatest value of exposed local government owned infrastructure is different at varying increments. Generally, at the 1.5 metre increment, Canterbury's exposure is the greatest, followed by the Hawke's Bay and by Auckland. Additional noted areas include Greater Wellington, Bay of Plenty, Otago, and Waikato.

Figure 2: Total replacement value for three waters, roading and buildings/facilities, per region



Note:

1 Data includes, three waters, buildings/facilities, transport, landfills and green spaces.

2 National DEM data was only available at the MHWS + 3.0m elevation. Those councils with DEM only data are those shown with only a single bar at MHWS + 3.0m. Note that Northland, Bay of Plenty and Waikato both have a small proportion of DEM data included within their MHWS+3.0m totals.

3 Please refer to Appendix B for all assumptions and limitations, including those councils which are DEM and LiDAR.

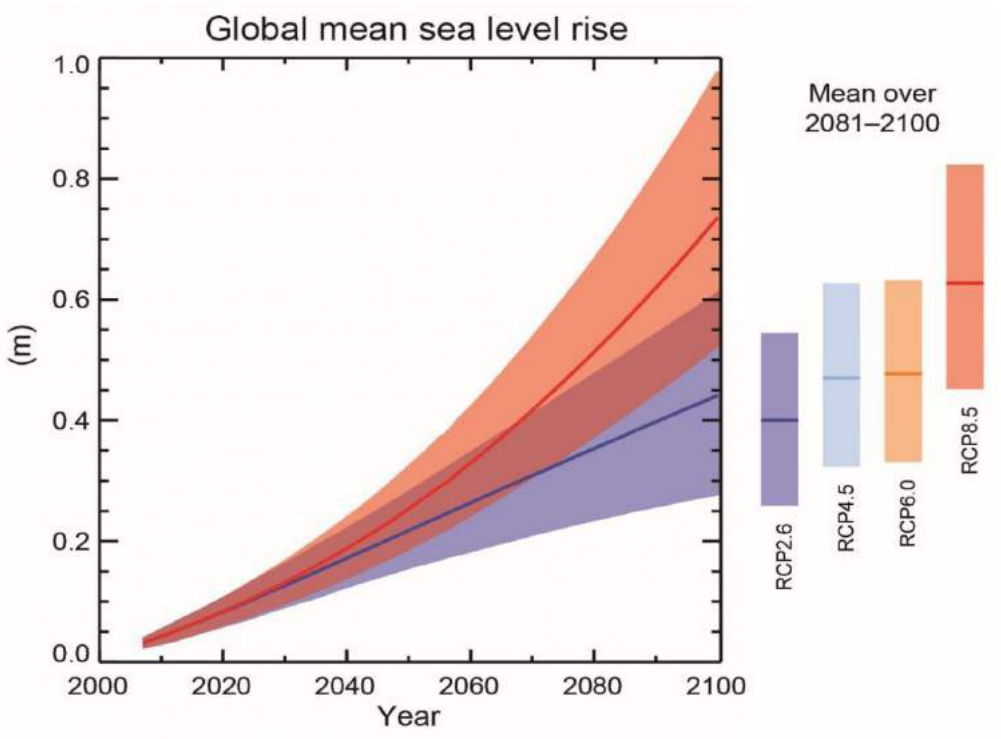
Time

Time may be the most critical variable of this analysis. From research, it is clear that the rate of sea level rise will accelerate with time, due in great part to increasing melt in Antarctica and Greenland. Predictions vary considerably depending on source, although NASA scientists predict between a 30 centimetre and 1.3 metre increase by 2100. NIWA is more conservative in its estimates, with between 40 centimetres and roughly one metre.

Timing impacts how councils respond to impacts on essential infrastructure. Council administration, research, planning, new procurement and community engagement will be required to respond to numerous associated threats and outcomes. For example, salinity in coastal aquifers and prolonged inundation of water pipes will compound the issue of sea level rise, along with pressures from population growth and decline.

Central to the issue of timing is that once the impacts of sea level rise are fully recognised and stakeholders are forced to respond, it will be too late to comprehensively plan for future impacts. Optimally, providers of infrastructure should not be in the "chase" with infrastructure planning and development. Realistic expectations for levels of service for roads, water and other infrastructure must be planned, managed and communicated with the public now in order to effectively and sustainably meet expectations. This will require a lead-time with strong communication and collaboration across all owners and stakeholders of critical infrastructure.

Figure 3 Global mean sea level rise



https://www.niwa.co.nz/natural-hazards/hazards/sea-levels-and-sea-level-rise

RCPs are "representative concentration pathways", which characterise atmospheric concentrations of greenhouse gases and aerosols. Climate modelling and research modelling is based on different climate futures, all of which are considered possible, depending on how much greenhouse gas is emitted in the years to come. The four RCPs are labelled after a possible range of radiative forcing values in the year 2100 relative to pre-industrial values.

Proposed actions

In light of the issues and challenges identified in this study, we have developed a very broad, but targeted, set of proposed actions. They are:

1. Local government leads a national conversation about levels of service currently provided and what can be anticipated in the short (1 – 10 years), medium (10 – 30 years) and long-term (30+ years). This should include comprehensive and targeted communication and engagement by local government with residents and businesses exposed to rising sea levels.

2. Central and local government coordinate to establish a National Climate Change Adaptation Fund to improve stakeholder participation in responding to climate change to ensure equitable outcomes.

3. Complete the approval process to create a Local Government Risk Agency, to assist and guide consistent and expedited planning, decision-making and procurement, and build local government capability and capacity to identify, quantify and understand risk.

4. Local government coordinates with stakeholders that have exposed infrastructure to create a National Master Plan, prioritising options and opportunities in responding to sea level rise.

5
Three waters

Three Waters

Summary

The national total replacement value of exposed council owned three waters infrastructure exceeds the combined national total replacement value of exposed roading and buildings. At 0.5 metres, a conservative estimate of replacement value is roughly $1.4 billion. The infrastructure surveyed for this analysis consists of drinking, storm and wastewater assets including:

- Pipes;
- Pump stations;
- Manholes; and
- Treatment plants.

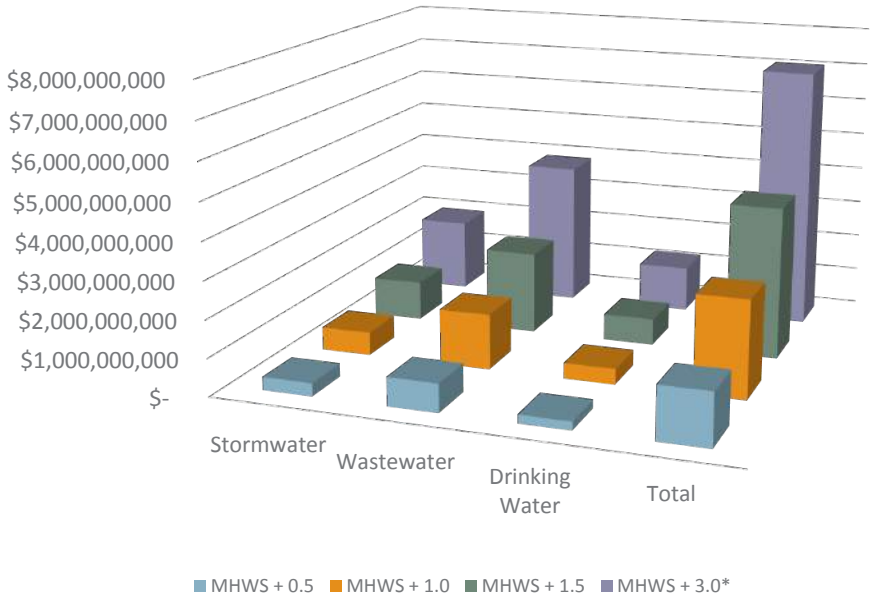
Irrigation and flood control assets are excluded (refer to section "Other Infrastructure").

It is noted that some councils did not provide replacement values for all assets, as either they were not available or the council chose not to provide the information.

At 1.0 metre, the estimated total replacement value of water infrastructure is approximately $2.6 billion and at 1.5 metre elevation, the estimated replacement value is $4 billion. At the 3.0 metre elevation, the overall estimated replacement value is over $7 billion. These impacts are broken down into drinking water, stormwater and wastewater.

The survey assessed the replacement value of exposed infrastructure, and does not cover other variables which may have a bearing on the impact of sea level rise, such as salt water intrusion into aquifer systems and investment to move further up freshwater channels (e.g. rivers and streams) to draw drinking water without salt intrusion. As with the data collected for transport and buildings/facilities, the baseline data only applies to the infrastructure exposed to sea level

Figure 4: Total national replacement value for three waters infrastructure - national



**Note MHWS + 3.0m includes data from councils with both LiDAR and DEM contour information. For MHWS + 0.5, 1.0 and 1.5m only councils with LiDAR contour information are presented in the totals. DEM data was only available at the MHWS + 3.0m elevation. It is important to note that while the DEM data is much coarser, it only represents a small proportion of councils, and the related quantity/value of assets exposed. For completeness, it is included within the overall data set within the MHWS + 3.0m category. Consequently, the 3.0m category has a greater number of councils represented. There will also be a small proportion of 'DEM' assets exposed at the lower elevation bands for those councils that are not included within the totals.*

Please refer to Appendix B for all assumptions and limitations.

rise, not ongoing adjustments to systems, adaptation planning and measures or any other related activity.

As reflected in Figure 4, it was found that the costs to replace exposed wastewater infrastructure are significantly higher than those for drinking and stormwater and, in some cases, exceed the combined drinking and storm water infrastructure replacement costs.

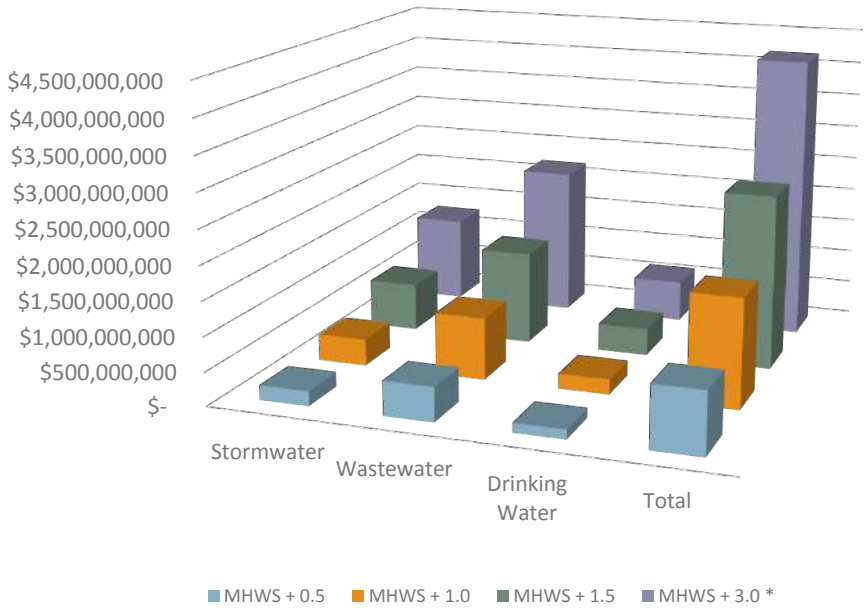
North Island

The North Island has a total value of exposed water infrastructure of $1.5 billion at the 1.0 metre increment. This is comprised of $400 million for stormwater, $920 million for wastewater and $230 million for drinking water. It is noted that the total is roughly 50 per cent higher than the South Island. Again, there is a trend of wastewater replacement value exceeding the replacement value of other water infrastructure.

Further, based on current estimates the asset count doubles at each measured increment of sea level rise. For example, at the 1.0 metre elevation, the number of exposed pump stations is approximately 150. This increases to 370 at the 1.5 metre increment, then to more than 840 at 3.0 metres.

Exposed wastewater and stormwater pipes represent the greatest potential costs. The total amount of exposed three waters pipelines at 1.0 metre includes more than 2,700 kilometres of stormwater, wastewater and potable water pipes, 20 treatment plants, more than 9,000 manholes and over 200 pump stations.

Figure 5: Total replacement value for three waters infrastructure – North Island



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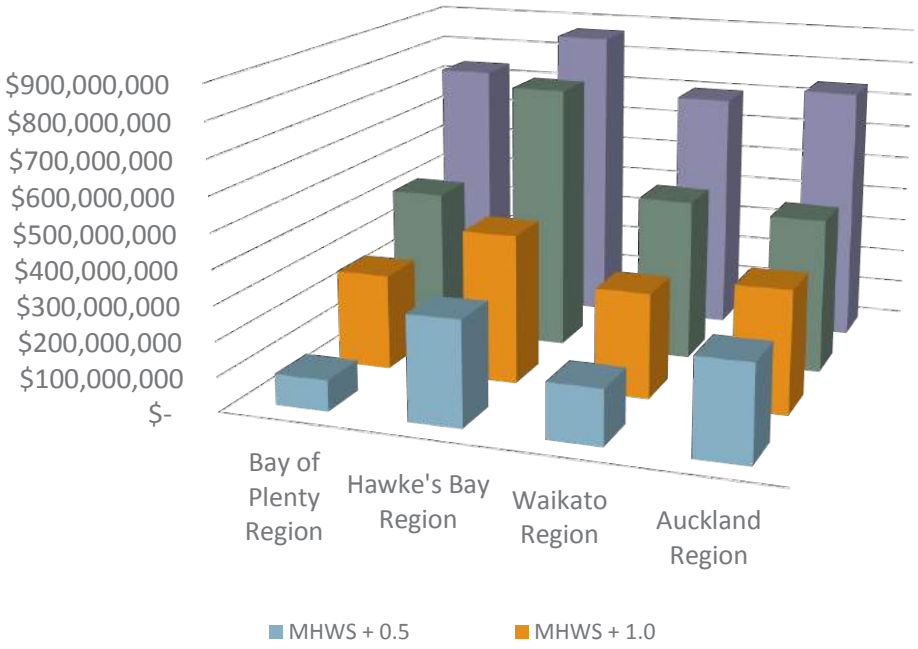
Please refer to Appendix B for all assumptions and limitations.

Figure 6: Total three waters replacement value – North Island priority areas



Notes:

1. *All of the above regions had LiDAR contour information available.*
2. *Please refer to Appendix B for all assumptions and limitations.*
3. *Auckland values do not include treatment plants.*

Priority regions – North Island

North Island priority regions have the largest total exposed assets combined with the highest replacement value. These regions include Hawke's Bay, Bay of Plenty, Waikato and Auckland. Specifically, three waters infrastructure at the 1.0 metre increment for these areas has a total replacement value of $1.4 billion, at the 1.5 metre increment it is valued at $2.1 billion, and at the 3.0 metre increment, it is $3 billion. The values increase by roughly 50 to 75 per cent at each increment. Wastewater infrastructure, again, is the most exposed of the three waters infrastructure, having double the value of stormwater. Exposed stormwater infrastructure is often significantly higher than the value of drinking water.

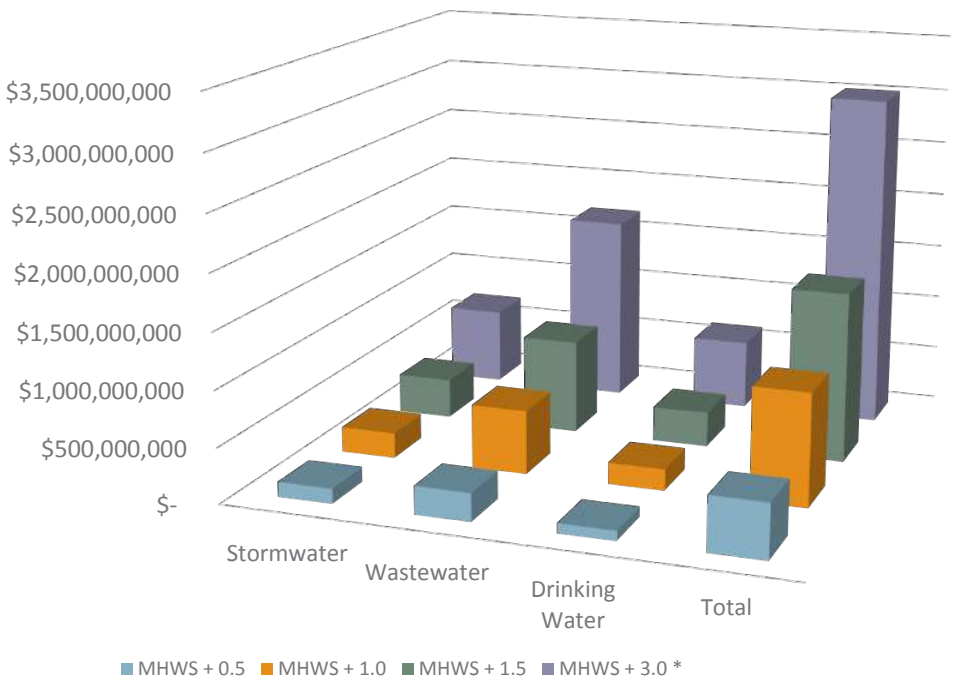
As shown in Figure 6, the Hawke's Bay region shows the greatest exposure of water infrastructure at all increments of sea level rise. For comparison, at the 1.0 metre increment, the Hawke's Bay region has approximately $430 million exposed, the Auckland Region indicates $350 million, the Waikato region has $300 million, and the Bay of Plenty region $280 million. It is noted that Auckland's values do not include treatment plants.

South Island

The South Island's total replacement value of exposed water infrastructure is $1 billion at the 1.0 metre increment. This is made up of $230 million for stormwater, $580 million for wastewater and $200 million for drinking water. Given that the South Island has roughly 25 per cent of New Zealand's population, this means local councils in the South Island will likely face higher replacement costs per capita.

In total, the amount of exposed water infrastructure at 1.0 metre includes approximately 1,400 kilometres of stormwater, wastewater and potable water pipes, one treatment plant, more than 4,700 manholes and over 180 pump stations. Wastewater pipes and storm water pipes represent the greatest proportion of potential value exposed.

Figure 7: Total replacement value for three waters infrastructure – South Island



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Please refer to Appendix B for all assumptions and limitations.

Priority regions – South Island

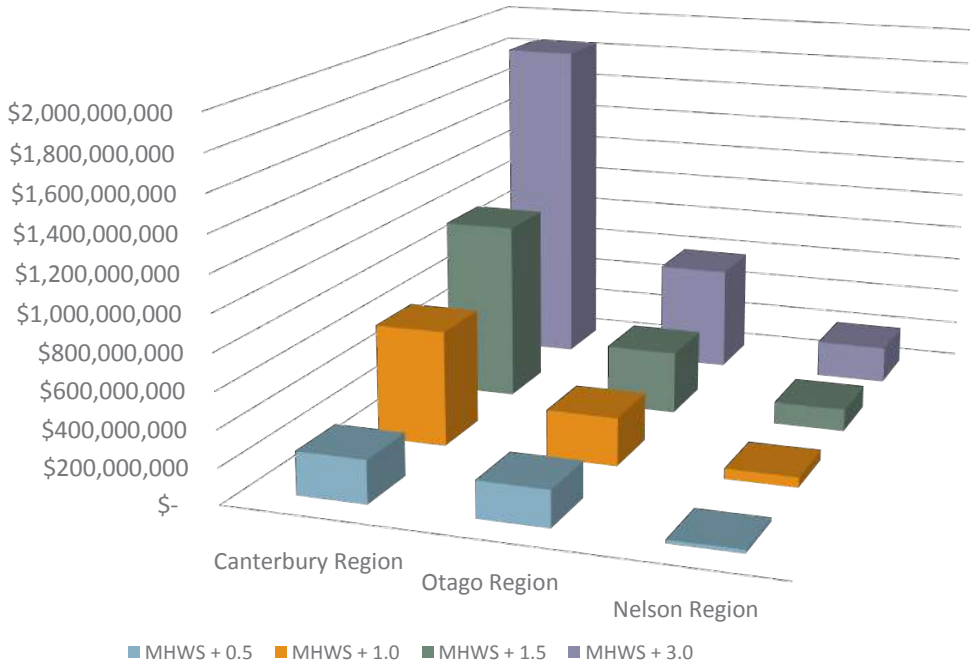
The priority regions for the South Island represent the three regions that have the largest total of exposed assets combined with the highest replacement value. These regions include Canterbury, Otago and Nelson, with Canterbury having the most exposed assets. Specifically, three waters infrastructure at the 0.5 metre increment for these areas has a total replacement value of $470 million, at 1.0 metre it is $970 million, at the 1.5 metre increment it is $1.5 billion, and at the 3.0 metre increment it is $2.6 billion. As in the North Island, wastewater infrastructure is by far the most exposed of the three waters.

At the 1.0 metre increment, the Canterbury region has exposed water infrastructure valued at more than $630 million. This includes 650 kilometres of water pipes and over 120 pump stations. Regarding pump stations in Canterbury, the number exposed at the 3.0 metre elevation jumps to approximately 230 at a current value of more than $210 million.

The Otago region shows $270 million of exposed three waters infrastructure at the 1.0 metre increment, which increases significantly with inundation depth. For example, at 0.5 metres of sea level rise, five pump stations are exposed, at 1.5 metres, 30 are exposed and at 3.0 metres, 55 are exposed.

Further, at 0.5 metres, approximately 408 kilometres of storm water, wastewater and water supply pipes are exposed, and at 1.5 metres approximately 607 kilometres are exposed. Uniquely, no treatment plants are exposed at 0.5 metres, but six are at 3.0 metres of sea level rise.

Figure 8: Total three waters replacement value – South Island priority areas



Notes:

1. *ll of the above regions had LiDAR contour information available.*
2. *Please refer to Appendix B for all assumptions and limitations.*

Proposed actions

As this analysis has clarified challenges associated with forecasted risks and replacement value of exposed infrastructure, we can begin to formulate and address practical recommendations to turn them into opportunities.

To adequately plan for and address the potential impacts on exposed water infrastructure, councils need to undertake analysis and reporting of the impacts of sea level rise on local three waters networks. For example, we estimate that the minimum value of exposed water infrastructure at 1.0 metre is more than $540 per person nationally (in today's costs).

- Primary recommendations that include both council-led initiatives and joint stakeholder/owner coordination include:
- Coordinate with stakeholders on a list of prioritised research activities that evaluates compounding events and circumstances accelerating the impacts of sea level rise;
- Agree to land use planning and consenting processes that ensure sea level rise and associated impacts on existing and future water infrastructure resources are evaluated;
- Explore options for a legislative amendment to address the LGA's current limitations allowing councils to cease providing water services; and
- Commitment by councils to plan for resilience by avoiding areas exposed to sea level rise.

6

Roading

Roading

Summary

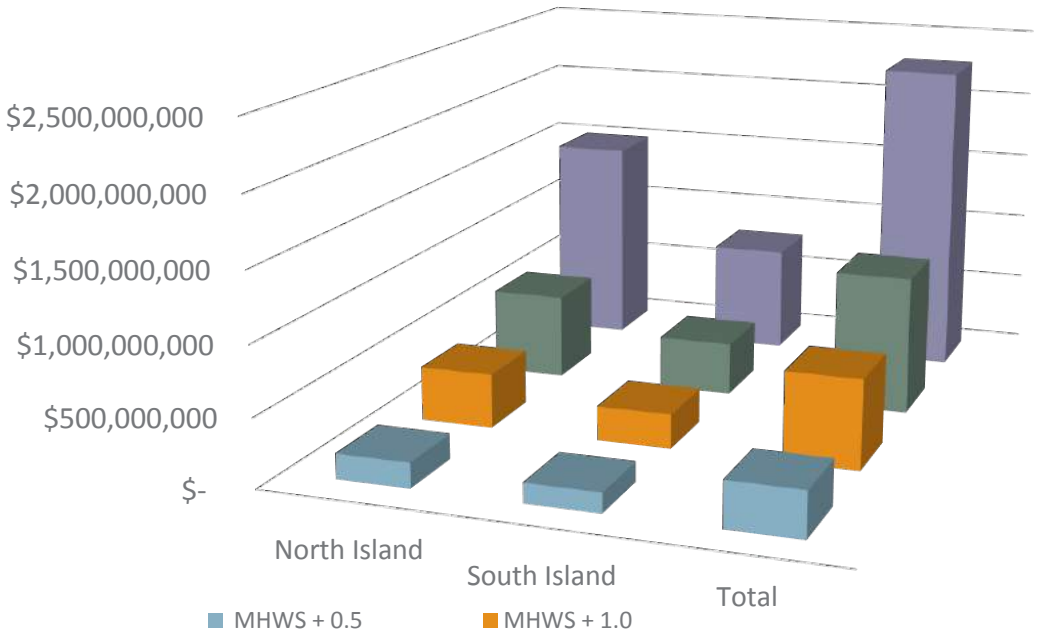
The 2015 NIWA report, "National and regional risk exposure in low-lying coastal areas" noted that at up to 1.5 metres of sea level rise 1,930 kilometres of local roads would be exposed, and 3,556 kilometres at the 3.0 metre level. LGNZ's analysis shows an increase over the quantities represented in the NIWA study. LGNZ's study indicates approximately 2,100 kilometres of roads exposed up to the 1.5 metre increment, with a replacement value of $1.0 billion. For roads exposed to 3.0 metres of sea level rise, LGNZ's analysis reflects an additional 1,003 kilometres of exposure compared to the NIWA study, with 4,559 kilometres of road exposed, at a replacement value of $2.3 billion. Our analysis accounts for both sealed and unsealed roads, but does not include bridges.

North Island

The North Island has a total value of exposed roading infrastructure of approximately $400 million at the 1.0 metre increment, equating to approximately 800 kilometres of road. Generally, the North Island has higher levels of exposure for roading infrastructure than the South Island.

As shown, the length of exposed road increases significantly at each measured increment of sea level rise. For example, at the 0.5 metre elevation there is approximately 380 kilometres of road exposed. This increases to 800 kilometres at the 1.0 metre increment and 1,200 kilometres at the 1.5 metre elevation (roughly, the distance from Invercargill to Auckland). At the 3.0 metre elevation, approximately 2,860 kilometres is exposed.

Figure 9: Total replacement value for roading - National



**Note MHWS + 3.0m includes data from councils with both LiDAR and DEM contour information. For MHWS + 0.5, 1.0 and 1.5m only councils with LiDAR contour information are presented in the totals. DEM data was only available at the MHWS + 3.0m elevation. It is important to note that while the DEM data is much coarser, it only represents a small proportion of councils, and the related quantity / value of assets exposed. For completeness, it is included within the overall data set within the MHWS + 3.0m category. Consequently, the 3.0m category has a greater number of councils represented. There will also be a small proportion of 'DEM' assets exposed at the lower elevation bands for those councils which are not included within the totals.*

Please refer to Appendix B for all assumptions and limitations.

Priority Regions – North Island

Roading infrastructure exposed to sea level rise varies around the country. In the North Island, Auckland, the Hawke's Bay, and Bay of Plenty show the greatest length and value of roads exposed to sea level rise in the short term. The following figure illustrates the value exposed, ranging from 0.5 to 3.0 metres for the four elevation increments.

Value Exposed

Hawke's Bay has the greatest potential exposed value up to 1.5 metres above MHWS. Auckland exceeds Hawke's Bay only for the 3.0 metre increment. More specifically, the estimated value of exposed infrastructure in the Hawke's Bay at the 1.0 metre increment is $126 million, which is 60 per cent higher than Auckland's. The total value for exposed roading infrastructure for the priority regions at the 1.0 metre increment is approximately $250 million.

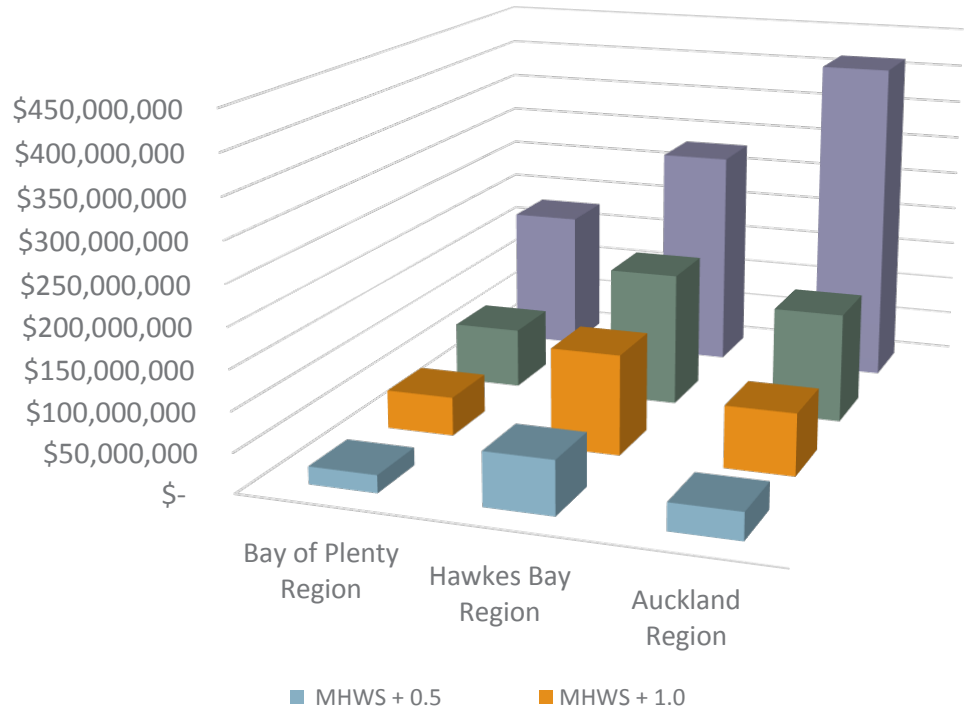
Quantity Exposed

Figure 11 highlights that the Bay of Plenty, Hawke's Bay and Auckland regions have the greatest length of roads exposed for all increments of sea level rise. For example at 0.5 metres, 170 kilometres is exposed across all three regions.

In general, lengths of roads exposed increase relatively consistently with increases in sea level rise. These three priority regions account for around 60 per cent of the total estimated value of exposed roading on the North Island at the 1.0 metre increment.

Hawke's Bay has the highest quantity of roading exposed across all elevation increments. The Bay of Plenty follows, with Auckland closely behind. At the 1.0 metre elevation, Hawke's Bay has 160 kilometres exposed, Bay of Plenty has 115 kilometres, and Auckland has 95 kilometres, for a combined total of 370 kilometres. These priority regions account for roughly 45 per cent of total length of exposed roading within the North Island.

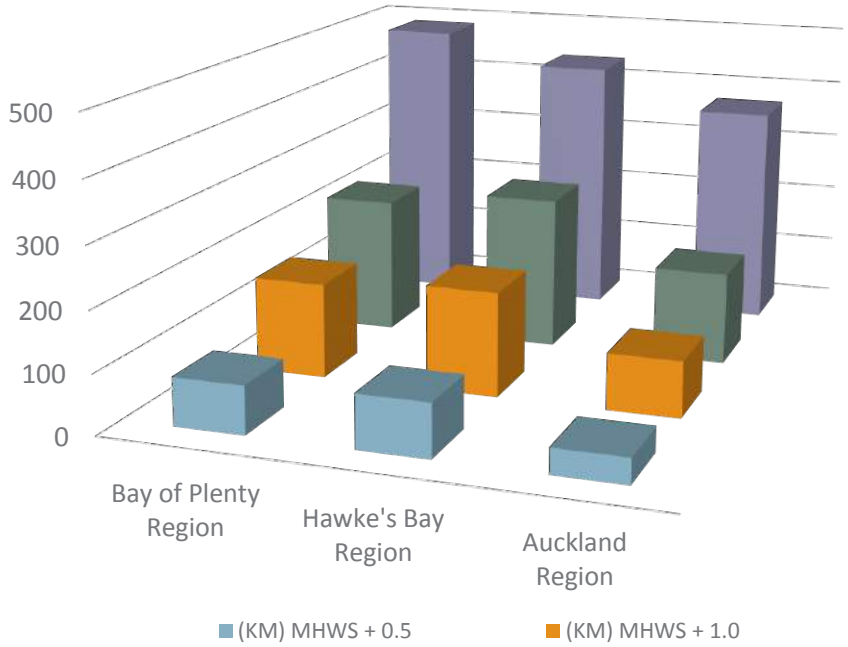
Figure 10: Replacement value of exposed roading – North Island priority regions



Notes:

1. *All of the above regions had LiDAR contour information available.*
2. *Please refer to Appendix B for all assumptions and limitations.*

Figure 11: Length of exposed road – North Island priority regions



Notes:

1. *All of the above regions had LiDAR contour information available.*
2. *Please refer to Appendix B for all assumptions and limitations.*

South Island

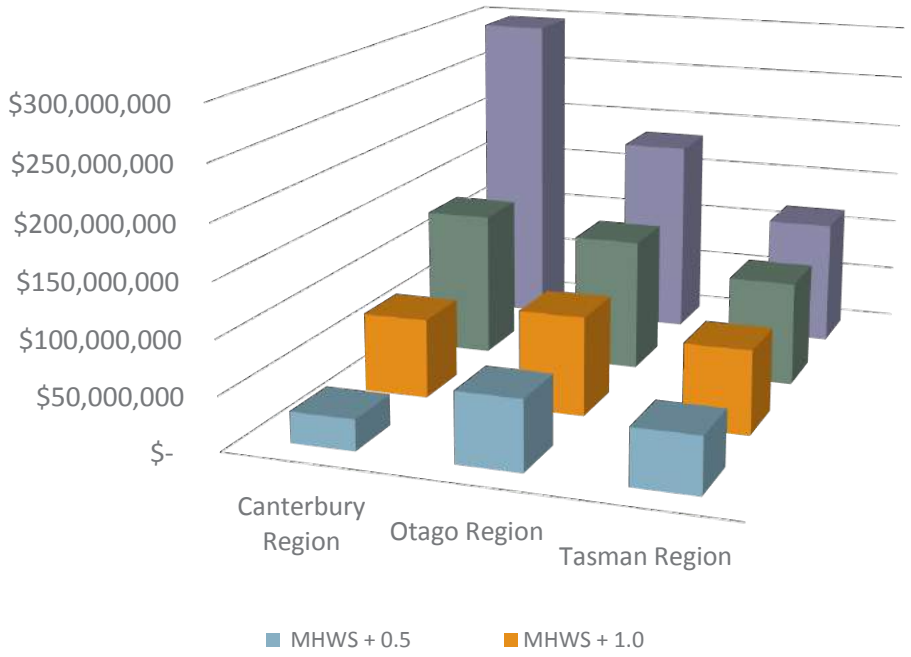
The South Island has a total value of exposed roading infrastructure of approximately $260 million at the 1.0 metre increment, equating to around 590 kilometres of road. As in the North Island, roading exposed to sea level rise is not equally distributed. Further, it is noted that in every elevation increment, the South Island has fewer kilometres of exposed infrastructure and a lesser replacement value due to sea level rise than the North Island.

Canterbury, Otago and Tasman record the highest estimated value of exposed roading infrastructure. This is discussed further below.

Priority Regions – South Island

Current estimates show that Otago has the highest value exposed for the 0.5 metre and 1.0 metre scenarios, with Canterbury then showing the highest exposure for the 1.5 metre and 3.0 metre scenarios. The Tasman region's exposed length of road falls in between these two.

Figure 12: Value of exposed roading – South Island priority regions



Notes:

1. *All of the above regions had LiDAR contour information available.*
2. *Please refer to Appendix B for all assumptions and limitations.*

Value exposed

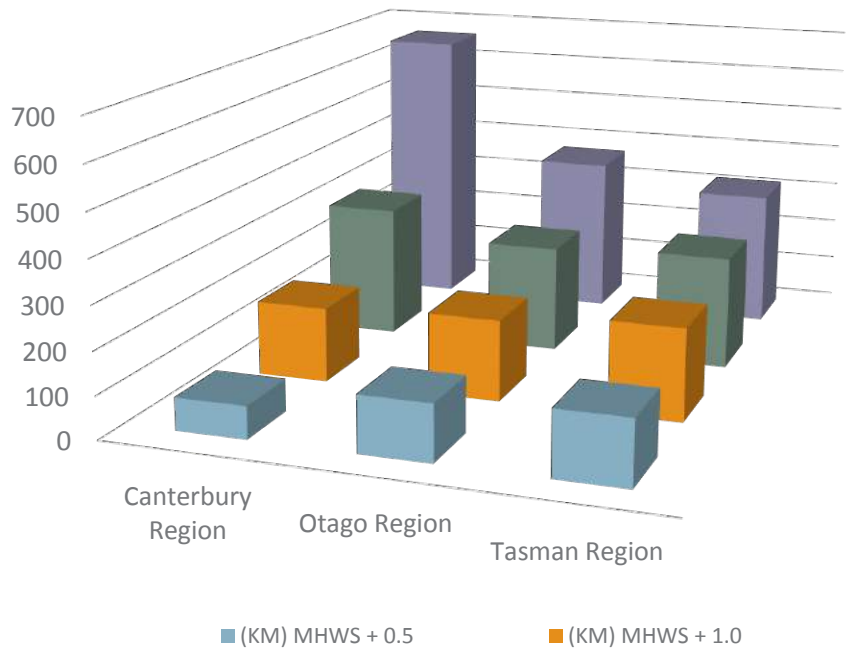
In the 0.5 metre and 1.0 metre scenarios, the values exposed are roughly similar for the three priority regions, with Otago being slightly higher. Interestingly, Canterbury's estimated exposed length of road, at the 1.0 metre increment, is 80 per cent of that for Tasman, although exposed value is roughly equal. This anomaly has not been investigated, however may be the result of differences in procurement, valuation approaches, or perhaps may be due to the complexity of the roads and associated infrastructure, e.g. retaining walls, within Canterbury. With regard to all three priority regions, at the 1.0 metre increment, exposed roading holds a value of more than $240 million, and at the 1.5 metre increment the replacement value is $360 million. Importantly, at the 0.5 metre and 1.0 metre elevations, these priority regions comprise almost the entirety of the total South Island's value exposure.

Quantity exposed

In total, the number of kilometres exposed to sea level rise increases by more than 60 per cent between 0.5 metres and 1.5 metres in the South Island. At the 3.0 metre increment, Canterbury records 664 kilometres of exposed roading; similar in total to Otago and Tasman combined.

For context, Canterbury has more impacted road kilometres at the 3.0 metre increment than required to drive between Wellington and Auckland on State Highway 1 (646 kilometres). At the 1.0 metre elevation, priority regions comprise 71 per cent of the total of the South Island's exposed roading network.

Figure 13: Length of exposed road – South Island priority regions



Notes:

1. *All of the above regions had LiDAR contour information available.*
2. *Please refer to Appendix B for all assumptions and limitations.*

Proposed actions

Although South Island roading assets reflect less exposure than the North Island, there is a significantly smaller population in the South Island (roughly 25 per cent of the NZ population). Consequently, the South Island has a greater burden per capita to pay for potential adaptation measures. The difference in impacts and costs will be dramatic for South Island councils in the near term. Further, critical coastal infrastructure drawing tourism will be deeply impacted, potentially affecting local economic productivity and business development. As noted in the broadly proposed actions for this report, the creation of a Local Government Risk Agency (LGRA) and a National Adaptation Fund could be used to assist councils balance the cost of planning for and addressing impacts.

There are steps to begin preparation for a resilient roading network and to enable councils to begin preparing for imminent impacts. Detailed analysis and reporting of the impacts of sea level rise on local road networks is needed by each council. Impacts and understanding by council members about changing conditions will provide context and highlight decisions for long-term planning (both 10 year Long Term Plans and 30 year Infrastructure Plans).

Community engagement and literacy through planning protocols are needed to bring the public into the dialogue about options to address changes, including adaptation and retreat. Prioritisation against all of a council's other issues can then be addressed with the context of priority and cost.

Primary recommendations of this research include:

- Highlight exposed infrastructure for council members and public consideration;
- Improve coordination with stakeholders to prioritise "lifeline" roads and associated infrastructure;
- Perform research and analysis to determine options for priority roads;
- Engage with both central government and private businesses to address alternatives and costs; and
- Ensure planned levels of service and suitability of location are included in long-term planning.

7

Buildings and facilities

Buildings and facilities

Summary

The survey collected information on many types of local government owned infrastructure. Within the category of 'buildings and facilities' data was collected relating to community facilities, council housing (flats and sites), council offices, playgrounds and significant other buildings/facilities.

Nationally, with a 0.5 metre sea level rise, approximately 740 council owned buildings/facilities will be exposed, with an estimated replacement value of around $190 million.

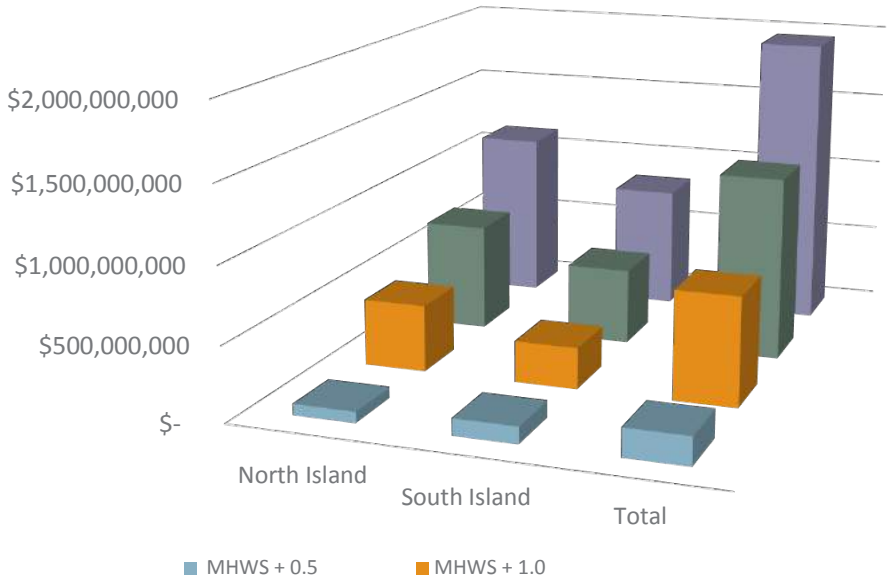
At the 1.0 metre elevation, the number of buildings/facilities exposed increases to approximately 1,300 with an estimated replacement value of more than $730 million. Further, at the 1.5 and 3.0 metre increments approximately 1,980 and 3,270 buildings/facilities will be exposed, with replacement values of roughly $1.2 and $1.9 billion respectively.

North Island

As with roading, buildings/facilities exposed to the impacts of sea level rise are not equally distributed around the country. Generally, where the population is larger, there will be greater exposure. In most locations, exposed buildings/facilities represent only a small proportion of the total supply, but in some cases the types of buildings/facilities vary considerably, from community centres to council housing.

At the 0.5 metre increment, approximately 180 council owned buildings/facilities are exposed in the North Island, with a replacement value of $76 million. At 1.0 and 1.5 metres, 470 and 980 are exposed, with replacement values of $450 and $720 million respectively. At 3.0 metres, over 1,500 buildings/facilities are exposed with a total value of $1.1 billion. The number of buildings/facilities exposed at all increments in the North Island is smaller than what is exposed in the South Island. In most cases exposed buildings/facilities in the North Island have a higher replacement value.

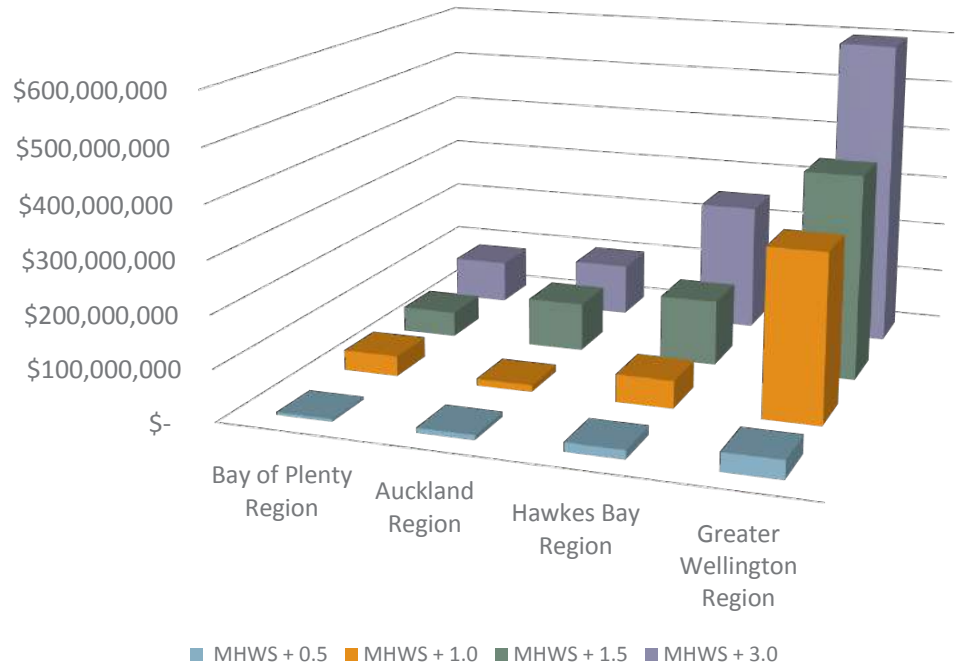
Figure 14: Total replacement value for buildings / facilities



**Note MHWS + 3.0m includes data from councils with both LiDAR and DEM contour information. For MHWS + 0.5, 1.0 and 1.5m only councils with LiDAR contour information are presented in the totals. DEM data was only available at the MHWS + 3.0m elevation. It is important to note that while the DEM data is much coarser, it only represents a small proportion of councils, and the related quantity / value of assets exposed. For completeness, it is included within the overall data set within the MHWS + 3.0m category. Consequently, the 3.0m category has a greater number of councils represented. There will also be a small proportion of 'DEM' assets exposed at the lower elevation bands for those councils that are not included within the totals.*

Please refer to Appendix B for all assumptions and limitations.

Figure 15: Total replacement value for buildings/facilities – North Island priority regions



Notes:

1. *All of the above regions had LiDAR contour information available.*
2. *Please refer to Appendix B for all assumptions and limitations.*

Priority Regions

Although the total replacement value of exposed buildings/facilities is not as significant as that of water and/or roading infrastructure, it is pertinent to note that there are priority areas in the North and South Island. In both islands, the identified areas are predictably similar to those of three waters, with the exception of the North Island, where Greater Wellington becomes a priority area alongside Auckland, Hawke's Bay, and the Bay of Plenty.

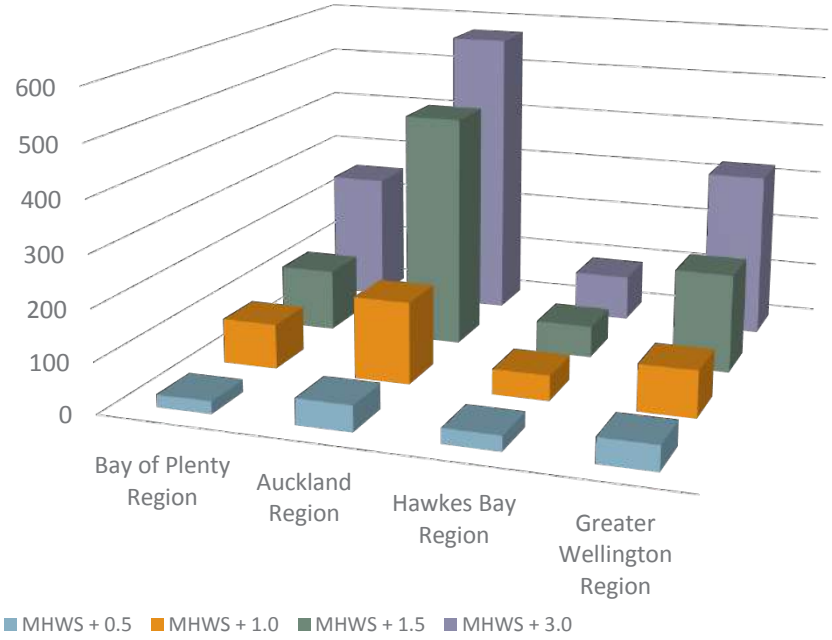
Value of exposed buildings/facilities

The North Island's priority areas are Greater Wellington, Hawke's Bay, Bay of Plenty and Auckland. Interestingly, there are some large jumps in value across elevation increments. This is especially noticeable for Greater Wellington, which has roughly a nine fold increase between the 0.5 and 1.0 metre increments, with the value increasing from $36 million to $320 million. At the 3.0 metre increment, the total replacement value for these four regions is estimated to be around $1 billion in total.

Quantity of exposed buildings / facilities

Regarding quantity of buildings and facilities in the North Island, the Auckland region appears to have the greatest number of buildings and facilities exposed. In total, at the 0.5 metre increment, the combined priority regions show approximately 155 buildings exposed. At the 1.0 and 1.5 metre increments, the quantum is roughly 390 and 840 respectively. At the 3.0 metre increment, roughly 1240 council buildings/facilities are exposed. At the 1.0 metre elevation, priority regions comprise approximately 80 per cent of the total number of buildings exposed to sea level rise for the North Island.

Figure 16: Quantity of exposed buildings / facilities – North Island priority regions



Notes:

1. *All of the above regions had LiDAR contour information available.*
2. *Please refer to Appendix B for all assumptions and limitations.*

South Island

In the South Island, at the 0.5 metre increment, approximately 570 council owned buildings/facilities are exposed, with a replacement value of $115 million. At 1.0 and 1.5 metres, approximately 820 and 1000 buildings/facilities are exposed, with replacement values of roughly $280 and $510 million respectively. At 3.0 metres, approximately 1,700 buildings/facilities are exposed, with a total replacement value of roughly $820 million.

Priority Regions

As with three waters, Nelson, Otago and Canterbury are the priority regions in the South Island for buildings/facilities with the greatest exposure to sea level rise. For the lower elevation increments, Otago has a greater number of buildings/facilities exposed. However, as increments increase, Canterbury exceeds the others, and at the 3.0 metre increment, the number of council owned buildings and facilities within Canterbury exceeds the other two priority regions by 215 buildings/facilities.

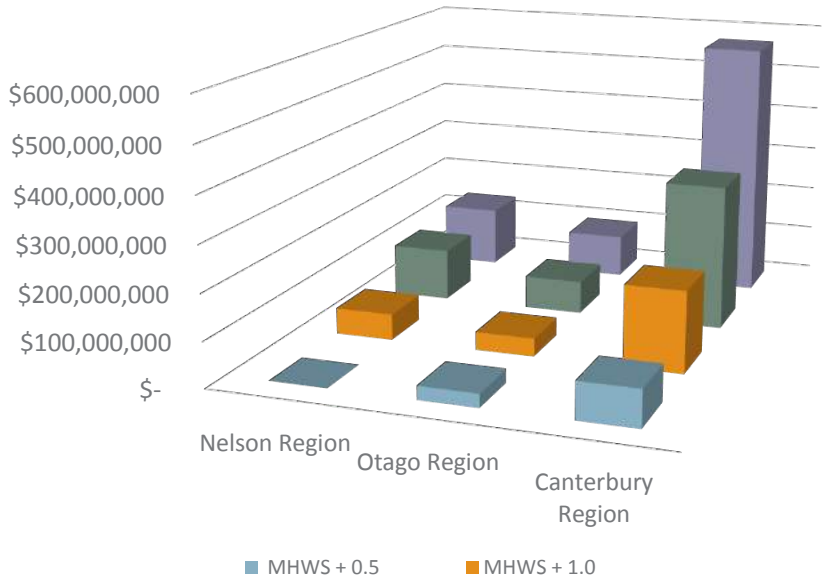
Value of exposed buildings / facilities

Canterbury has the highest replacement value associated with council owned exposed buildings/ facilities. In most increments, it more than doubles the combined total potential value for Nelson and Otago. At the 0.5 metre increment, the combined total for the priority regions is more than $110 million, with Canterbury recording more than $80 million (or 73 per cent of the total). At the 3.0 metre increment, the combined total of council owned exposed buildings/ facilities totals $800 million, and Canterbury records $570 million, or 71 per cent. Priority regions comprise nearly 100 per cent of the total exposed value of South Island buildings/facilities.

Quantity of exposed buildings/facilities

Surprisingly, at the 0.5 metre and 1.0 metre elevations, Otago has more buildings/facilities exposed than Canterbury; for example at the 1.0 metre elevation Otago has 400 buildings/facilities exposed whereas Canterbury has nearly 380. However, Canterbury exceeds the other priority regions for the remaining increments, and at the 3.0 metre elevation holds nearly 910 of the roughly 1,610 exposed buildings/facilities (57 per cent). At the 1.0 metre elevation, priority regions comprise almost all of the total quantity of exposed buildings/facilities in the South Island.

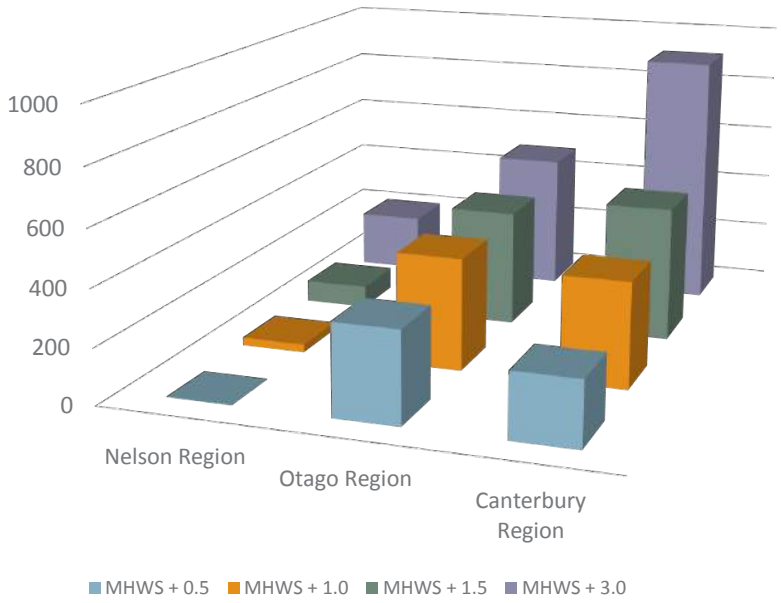
Figure 17: Replacement value for buildings/facilities – South Island priority regions



Notes:

1. *All of the above regions had LiDAR contour information available.*
2. *Please refer to Appendix B for all assumptions and limitations.*

Figure 18: Quantity of buildings / facilities – South Island priority regions



Notes:

1. *All of the above regions had LiDAR contour information available.*
2. *Please refer to Appendix B for all assumptions and limitations.*

Proposed actions

In the wider context of this analysis, exposed buildings/facilities represent a small proportion of the national total value of exposed council owned infrastructure and assets (approximately 15 per cent of the total exposed infrastructure) at the 1.0 metre increment. Regardless, 1,400 buildings are exposed at the 1.0 metre elevation across the country, with a total replacement value of $780 million.

As with other council owned assets, engagement is needed to ensure impacts are understood, and that there is understanding by council members about changing conditions to provide context and highlight decisions for long-term planning. Priority should be given to increasing the resilience of buildings and facilities.

As with water and roading, greater detail in analysis and reporting of the impacts of sea level rise is needed by each council. Land use planning for future development must ensure sea level rise is part of a matrix of evaluation to continued building/facility development and management, and, where appropriate, planning should account for a limited building life. Engagement with the public should include a focus on managing expectations around the use of buildings and facilities, which may require transition to other uses and/or a transfer of activity to other buildings/facilities. This may also include consideration toward multiple land uses as the impact of sea level rise impacts community activity and function.

In the longer term, focus on repurposing lands, including for drainage or nature preservation, should be considered with the public. Additionally, targeted approaches by councils should be encouraged to ensure properties and facilities are converted to their highest and best use. Additionally, consideration should be made by councils as to when to terminate depreciation and plan for adapted use or abandonment of its at risk buildings and facilities.

Again, community engagement and literacy will be required to bring the public into the conversation regarding options to address needed changes, including demolition, adaptation or retreat. The primary recommendations of this research include:

- Ensure sea level rise is part of a national matrix of evaluation in continued asset ownership and management;
- Plan and design buildings, where necessary, with consideration toward life expectancy provided impacts of sea level rise;
- Create a national management retreat programme for buildings/facilities that is predictable, clear and planned; and
- Outline acceptable alternatives in repurposing lands to ensure buildings/facilities have optimised use and resilience.

8

Other infrastructure

Other infrastructure

Summary

Data was obtained on a range of specific infrastructure categories that are either not included specifically in the above sections, or merit additional discussion, e.g. treatment plants. These categories contribute to a fuller understanding of the exposure of local government owned assets to sea level rise.

In particular, these are :

- Bridges;
- Marine facilities;
- Open and closed landfills;
- Green space;
- Airports;
- Flood control/irrigation;
- Treatment plants (wastewater); and
- Treatment plants (water supply).

These categories were not presented in the above sections as the survey data obtained for these categories was far more variable, and in some cases was not provided by councils.

The following sections indicate asset quantities only and not replacement values. Quantities are provided both nationally and within priority areas for both islands. In some cases the three priority areas are the only areas that provided information via the survey. This also applies in some cases where there are only one or two priority areas. The related replacement values are included within the grand total (Figure 1).

The following analysis is based on the data, which is considered largely incomplete. Therefore, the numbers presented are likely to be a significant under-estimation of exposure at an aggregate level. The analysis does, however, provide some insight into particular regions.

The tables below provide quantities of assets exposed. The tags 'P1', 'P2', 'P3' indicate priority areas.

Bridges

As shown in Table 1, based on the data received Waikato and Northland show the highest number of bridges exposed at 0.5 and 1.0 metres above MHWS. Canterbury becomes the highest at 1.5 and 3.0 metres.

Table 1: Bridges exposed within various increments of sea level rise

Bridges	Quantity 0.5	Quantity 1.0	Quantity 1.5	Quantity 3.0
National	***185***	***281***	***359***	***68***
North Island Total	**130**	**186**	**222**	**380**
P1- Waikato Region	47	58	67	104
P2- Northland Region	37	53	62	106
P3- Bay of Plenty Region	31	46	52	90
South Island Total	**55**	**95**	**137**	**302**
P1- Canterbury Region	25	48	68	136
P2- Otago Region	20	27	39	65
P3- Nelson Region	5	12	18	34

Please refer to Appendix B for assumptions and limitations.

Note: Not all councils provided data on marine facilities as some were owned or partly owned by private entities. While parts of port facilities may be exposed, others may not due to large geographical areas of port sites. Marine facilities in general may be able to continue to function despite higher water elevations – therefore there is some difficulty in determining 'exposure'. Further detailed work is needed be required to better understand exposure, and potential impact for marine facilities and ports.

Marine Facilities

The following summarises data received in relation to ports, marinas, jetties/wharves and boat ramps.

In summary, more detailed work would be required to better understand exposure and potential impact for marine facilities and ports. As shown in Table 2, based on the data received there are significant numbers of jetties, wharves and boat ramps exposed. A number of regions report ports and marinas exposed, including Northland and Tasman, which each have two exposed at 0.5 metres.

It is important to note that it is difficult to interpret to what degree operation of these marine facilities would be affected without undertaking additional work.

Table 2: Marine facilities exposed within various increments of sea level rise

Facilities - Marine	Quantity 0.5	Quantity 1.0	Quantity 1.5	Quantity 3.0
Ports				
National	***4***	***4***	***5***	***6***
North Island Total	**4**	**4**	**5**	**5**
P1- Northland Region	2	2	2	2
P2- Hawke's Bay Region	1	1	1	1
P3- Waikato Region	1	1	1	1
South Island Total	**0**	**0**	**0**	**1**
P1- Canterbury Region	0	0	0	1
Marinas				
National	***1***	***11***	***11***	***12***
North Island Total	**10**	**10**	**10**	**11**
P1- Auckland Region	6	6	6	6
P2- Northland Region	3	3	3	3
P3- Taranaki Region	0	0	0	1
South Island Total	**1**	**1**	**1**	**1**
P1- Canterbury Region	1	1	1	1
Jetties/Wharfs				
National	***1***	***140***	***142***	***176***
North Island Total	**65**	**71**	**73**	**83**
P1- Northland Region	34	35	37	39
P2- Bay of Plenty Region	11	16	16	17
P3- Hawke's Bay Region	15	15	15	15
South Island Total	**69**	**69**	**69**	**93**
P1- Canterbury Region	36	36	36	40
P2- Nelson Region	32	32	32	32
P3- Marlborough Region	0	0	0	14

Facilities - Marine	Quantity 0.5	Quantity 1.0	Quantity 1.5	Quantity 3.0
Boat Ramps				
National	***2***	***270***	***276***	***293***
North Island Total	**219**	**219**	**225**	**241**
P1- Auckland Region	142	152	156	161
P2- Northland Region	49	53	54	55
P3- Bay of Plenty Region	26	11	11	13
South Island Total	**51**	**51**	**51**	**52**
P1- Canterbury Region	40	40	40	40
P2- Nelson Region	6	6	6	6
P3- Otago Region	5	5	5	5

Please refer to Appendix B for all assumptions and limitations.

Open and closed landfills

Data was provided for both closed landfills and active landfills for some councils. Auckland, in particular, dominates the data with a significant number of closed landfills (88 in total) at the 0.5 metre increment and this increases to 94 at the 1.5 metre increment. In terms of active landfills, Canterbury and Otago each have one exposed at the 0.5 metre increment.

Table 3: Landfills exposed within various increments of sea level rise

Closed Landfill	Quantity 0.5	Quantity 1.0	Quantity 1.5	Quantity 3.0
National	***110***	***129***	***139***	***163***
North Island Total	**92**	**95**	**103**	**114**
P1- Auckland Region	88	89	94	99
P2- Hawke's Bay Region	2	4	6	6
P3- Waikato Region	1	1	2	3
South Island Total	**18**	**34**	**36**	**49**
P1- Nelson Region	5	18	19	19
P2- Otago Region	9	11	12	18
P3- Canterbury Region	4	5	5	7
Active Landfill	**Quantity 0.5**	**Quantity 1.0**	**Quantity 1.5**	**Quantity 3.0**
National	***2***	***2***	***2***	***3***
North Island Total	**0**	**0**	**0**	**1**
P1- Auckland Region	0	0	0	1
South Island Total	**2**	**2**	**2**	**2**
P1- Canterbury Region	1	1	1	1
P2- Otago Region	1	1	1	1

Please refer to Appendix B for all assumptions and limitations.

Green space

Data was provided by some councils for areas of exposed green space. This primarily included parks/reserves and sports fields. In the North Island, Auckland has by far the largest exposure for parks/reserves, with around 880 hectares exposed at 0.5 metres, which increases to around 1860 hectares at 1.5 metres. In the South Island, Canterbury has around 580ha of parks/reserves exposed at the 0.5 metre increment and 1100 at the 1.5 metre increment.

Sports fields in the Hawke's Bay Region represent the largest exposure in the North Island, with Canterbury again leading in the South Island.

Table 4: Areas of green space exposed within various increments of sea level rise

Parks/Reserves and Sport Fields	Area (ha) 0.5	Area (ha) 1.0	Area (ha) 1.5	Area (ha) 3.0
Parks/ Reserves				
National	***1972***	***3275***	***471***	***1180***
North Island Total	**1170**	**202**	**3091**	**5662**
P1- Auckland Region	88	136	1857	324
P2- Bay of Plenty Region	169	27	343	64
P3- Greater Wellington Region	59	22	316	60
South Island Total	**80**	**1251**	**1620**	**6146**
P1- Canterbury Region	582	85	1060	248
P2- Tasman Region	84	158	211	336
P3- Otago Region	4	121	186	379
Sport Fields				
National	***133***	***32***	***475***	***777***
North Island Total	**7**	**19**	**252**	**36**
P1- Hawke's Bay Region	15	10	125	128
P2- Bay of Plenty Region	23	34	48	82
P3- Auckland Region	7	18	36	90
South Island Total	**6**	**128**	**22**	**414**
P1- Canterbury Region	43	97	16	30
P2- Otago Region	10	1	25	45
P3- Nelson Region	0	10	23	48

Please refer to Appendix B for all assumptions and limitations.

**Note: definitions of 'sports fields' vary across councils.*

Airports

Some data was provided in relation to exposure of council owned airports, as shown within the table below.

In summary, more detailed work would be required to better understand exposure and potential impact for airports.

The Hawke's Bay, Auckland, Northland and West Coast indicated that a single airport within their region has some exposure.

Table 5: Airports exposed within various increments of sea level rise.

Airports	Quantity 0.5	Quantity 1.0	Quantity 1.5	Quantity 3.0
National	***3***	***3***	***3***	***5***
North Island Total	**3**	**3**	**3**	**4**
P1- Hawke's Bay Region	1	1	1	1
P2 – Auckland Region	1	1	1	1
P3- Northland Region	1	1	1	1
South Island Total	**1**	**1**	**1**	**1**
P1- West Coast Region	0	0	0	1

Please refer to Appendix B for all assumptions and limitations.

Note: Not all councils provided data on airport facilities as some were owned or partly owned by private entities, and while parts of airport facilities may be exposed, others may not due to large geographical areas of port sites. More detailed work is needed to better understand exposure, and potential impact for airports.

Flood Control / Irrigation

Data was received on irrigation/flood control infrastructure that primarily included pump stations. As shown below, the Waikato and Bay of Plenty regions have the largest number of exposed flood control pump stations in the North Island, with the Canterbury region having the highest exposure in the South Island.

A small number of councils provided information on stop banks and floodgates, however this has not been presented.

Table 6:

Irrigation	Quantity 0.5	Quantity 1.0	Quantity 1.5	Quantity 3.0
National	***78***	***119***	***145***	***207***
North Island Total	**59**	**91**	**113**	**166**
P1- Waikato Region	38	41	47	58
P2- Bay of Plenty Region	14	37	48	78
P3- Hawke's Bay Region	7	10	12	15
South Island Total	**19**	**28**	**32**	**41**
P1- Canterbury Region	16	23	25	30
P2- Otago Region	3	5	6	8
P3- Nelson Region	0	0	1	2

Treatment Plants (Wastewater)

Council data indicates that, in total, there are 11 North Island wastewater treatment plants exposed at 0.5 metres of exposure. This more than doubles at 1.5 metres of exposure. The Waikato Region has a relatively large number exposed with five and 12 exposed at 0.5 metres and 1.5 metres respectively. The South Island has few plants reported as exposed.

Table 7: Wastewater treatment plants exposed at various increments of sea level rise.

Treatment Plants (Wastewater)	Quantity 0.5	Quantity 1.0	Quantity 1.5	Quantity 3.0
National	***11***	***21***	***30***	***67***
North Island Total	**11**	**20**	**24**	**48**
P1- Waikato Region	5	9	12	24
P2- Northland Region	3	4	4	8
P3- Bay of Plenty Region	0	3	4	10
South Island Total	**0**	**1**	**6**	**19**
P1- Canterbury Region	0	1	4	9
P2- Otago Region	0	0	1	5
P3- Nelson Region	0	0	1	1

Please refer to Appendix B for all assumptions and limitations.

Treatment plants (drinking water)

Very few water supply treatment plants are exposed. This is to be expected as more often these are located on higher ground. An exception is the Bay of Plenty, which reports one plant exposed at 1.5 metres.

Table 7. Water supply treatment plants exposed at various increments of sea level rise

Treatment Plant (Drinking Water)	Quantity 0.5	Quantity 1.0	Quantity 1.5	Quantity 3.0
National	***0***	***0***	***1***	***10***
North Island Total	**0**	**0**	**1**	**7**
P1- Bay of Plenty Region	0	0	1	1
P2- Hawke's Bay Region	0	0	0	2
P3- Waikato Region	0	0	0	2
South Island Total	**0**	**0**	**0**	**3**
P1- Southland Region	0	0	0	1
P2- Otago Region	0	0	0	1
P3- Tasman Region	0	0	0	1

Please refer to Appendix B for all assumptions and limitations.

Proposed actions

The variability of the value of some assets will not change with time. Replacement value of green space or boat ramps may always be different depending on location. Regardless, a better understanding of what is exposed, and its value, is essential to completing the picture that local government is creating to lead this discussion. As a baseline, there are a few recommendations to assist in creating a strong foundation for futureproofing locally owned assets:

- Determine and prioritise essential infrastructure and ensure proper valuation for long-term planning;
- Communicate to stakeholders potential action for replacement or abandonment of essential infrastructure; and
- Determine when to end depreciating costs, and when to initiate replacement costs.

9 Conclusion

Conclusion

Although the data reported may appear daunting in itself, it is important to highlight three critical factors; local government is one of several major asset owners in New Zealand; in addition to sea level rise, climate change will impact not only sea levels, but the intensity of drought and flooding; and value of infrastructure represents only direct replacement of assets and not associated costs of adaptation. As such, it is imperative to recognise that New Zealand is at a unique place in time. It can leverage tremendous quantities of accurate scientific, social and economic data with unprecedented media and communication to coordinate a positive response to the effects of sea level rise. But, the real challenge is much larger than quantifying, planning and executing to adapt; it is for our leadership and our communities to accept that multi-generational investment for sustainable future outcomes is needed now.

This study highlights that in the next 50 to 75 years, impacts to local government infrastructure related to sea level rise alone could reach $8 billion. But, costs will likely go far beyond tangible measures; not only will infrastructure be exposed, so will potential economic development and growth, community health and safety, and social support systems.

Further, divisibility is not an option for New Zealand; this report intentionally focuses on regional and national outcomes as impacts will not be felt equally around the country, but the challenge is national with a base population of five million. As such, to successfully mitigate existing and future unknowns, local government must:

- Create social license through leading community engagement with modelling, scenario planning and evidence as it becomes available;
- Manage with a national focus;
- Plan and deliver early to save costs; and
- Focus to equitably balance all well-beings.

Proposed actions from this reporting include determining roles and responsibilities to invest in opportunities where local government and stakeholders can plan for results that benefit all. Assignment requires alignment on agreed outcomes, processes and schedules, and reasonable objectives. Critical to this process is engagement with the public and stakeholders. Outcomes focused engagement with clear understanding of what the future will look like with rising seas is essential to ensure community approval.

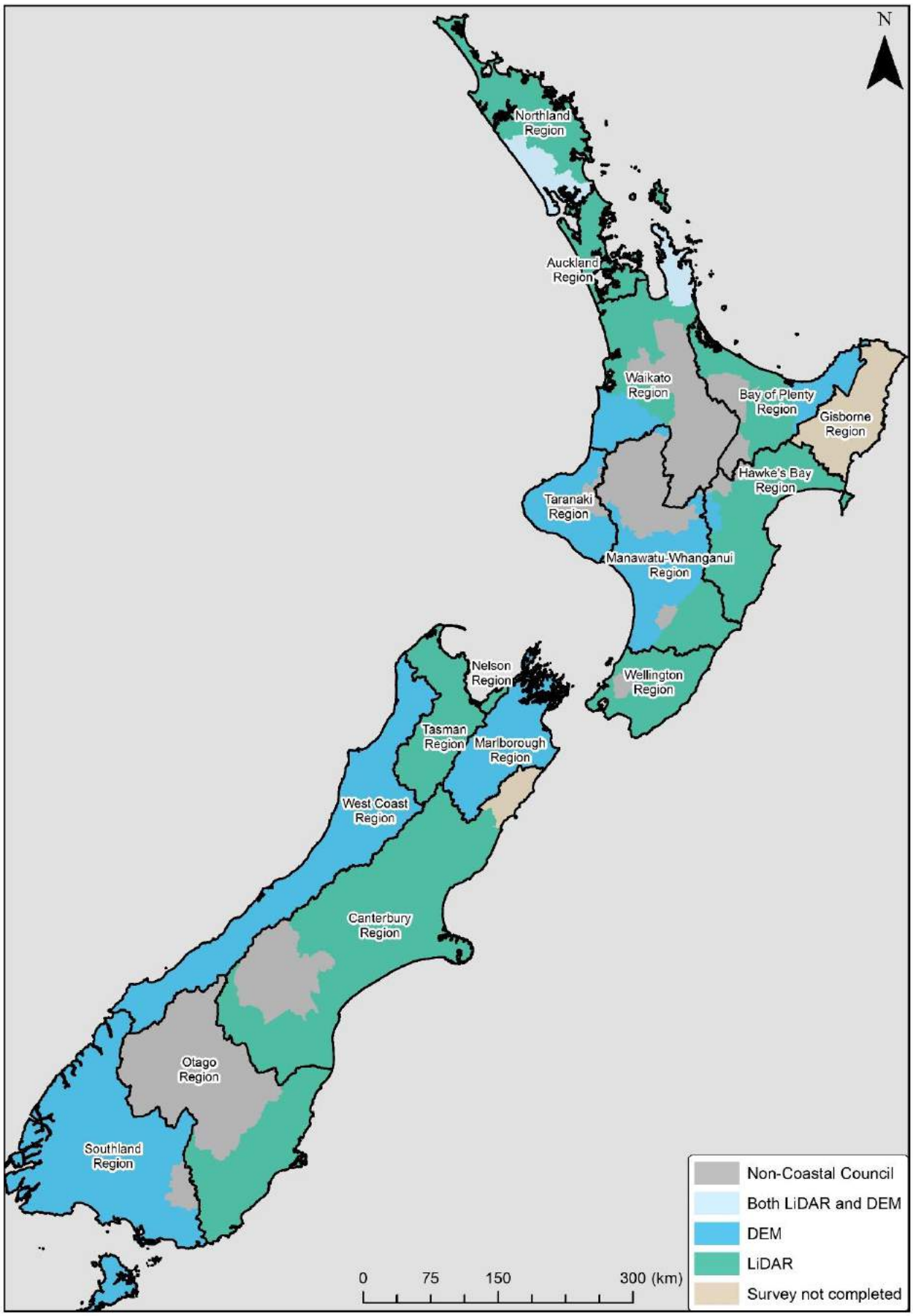
Orchestrated planning and communication with the public must be fulsome, clear and continuous. Interests, media type and different forms of communication will evolve, and in order to capture and ensure understanding, government and private stakeholders must be across all forms of delivery to ensure the greatest amount of literacy.

This moment will not come again. As noted in Figure 2, we may estimate a window of roughly 25 years before government starts parking its ambulance at the bottom of a metaphorical hill. This analysis and included recommendations, for the first time in New Zealand, quantifies and values local government infrastructure exposed to sea level rise. It is only the beginning of the story. Real questions exist around how local councils will collaborate with other stakeholders to avoid disaster through coordination, efficiencies in procurement, and focus on sustainable outcomes that evaluate tangible and non-tangible outcomes.

10

Appendix

Appendix A - Data source type



Appendix B – Table data Disclosure

As with all reporting based on survey responses, there are anomalies in the information gathered. Across surveyed local governments, interpretation, coordination, technological and human capabilities differ. Further, two councils have chosen not to participate. The following considerations are noted for full disclosure of information and data gathered.

The tick in the "All Data" column represents those councils that provided us with all of the data required for the assets that they own. In some cases, particularly for regional councils, it has been noted which assets the councils owned and provided information for; this was generally limited to a few.

Council Name	Region	Survey Sent	Survey received	Zero Asset Exposure	DEM/ LiDAR	Incomplete sections	Assumptions/ Information/Comments
Ashburton District Council	Canterbury	✓	✓	✓	LiDAR		
Auckland Council	Auckland	✓	✓		LiDAR	**Three waters;** No quantity data provided for stormwater from Auckland Transport. **Transport;** No quantities provided for bridges at each increment of sea level rise. No bus terminal data provided. No boat ramp value data provided. Valuation for roading includes carriageway, stormwater assets associated with the road, footpaths & cycleways, streetlights and traffic signals. Valuation figures for bridges include bridges, retaining walls and railings. Ports of Auckland was considered out of scope since it is not council owned. **Buildings/facilities;** No valuation data provided for playgrounds and council housing. Data may not include buildings/facilities owned by CCOs.	**Three waters;** Aggregated WS and WW (pipes/MHs/PS) replacement values were provided for 0.5m and 3.0m levels. Interpolated values were generated by Tonkin & Taylor for 1.0m and 1.5m. No valuations were provided for treatment plants, as Watercare considered these would be defended over time. Green space; Sports fields defined as soil fields, soil field surround, sand carpet fields, and sand carpet field surrounds (in the absence of a specific definition of sports field in the survey). **Buildings / Facilities;** Data provided in different categories to those within the survey, however aggregate totals were used.
Bay of Plenty Regional Council	Bay of Plenty	✓	✓		LiDAR		

Council Name	Region	Survey Sent	Survey received	Zero Asset Exposure	DEM/ LiDAR	Incomplete sections	Assumptions/ Information/Comments
Buller District Council	West Coast	✓	✓		DEM		
Carterton District Council	Greater Wellington	✓	✓	✓	LiDAR		
Central Hawke's Bay District Council	Hawke's Bay	✓	✓		LiDAR		
Christchurch City Council	Canterbury	✓	✓		LiDAR	**Transport;** Lyttleton Port is excluded as it is owned by Christchurch City Holding Ltd (private CCC company), but would be affected by sea level rise.	
Clutha District Council	Otago	✓	✓		LiDAR		
Dunedin City Council	Otago	✓	✓		LiDAR		**Transport;** Road data does not include other asset types including sea walls, lights, footpaths and drainage assets. **Landfills;** Remaining landfill value is the value of available void space, so no depreciated value. There is no value for closed landfills.
Environment Canterbury Regional Council	Canterbury	✓	✓		DEM		
Far North District Council	Northland	✓	✓		LiDAR		
Gisborne District Council	Gisborne	✓	✓		û	NO DATA	NO DATA
Greater Wellington Regional Council	Greater Wellington	✓	✓		LiDAR		
Grey District Council	West Coast	✓	✓		DEM	No buildings/facilities, transport, green space or landfills	

Council Name	Region	Survey Sent	Survey received	Zero Asset Exposure	DEM/ LiDAR	Incomplete sections	Assumptions/ Information/Comments
Hastings District Council	Hawke's Bay	✓	✓		LiDAR		**Green space;** Sports fields area and valuation is captured within parks.
Hauraki District Council	Waikato	✓	✓		LiDAR	**Three Waters;** No replacement values provided for Water Supply pump stations. No buildings/facilities, green space or landfills data due to data not in GIS.	Note: Majority of the Hauraki Plains is already below sea level on every high tide. Therefore, stop banks, floodgates and pump stations manage this. The only way for the Plains to be inundated by sea level would be by stop bank failure or tsunami.
Hawke's Bay Regional Council	Hawke's Bay	✓	✓		LiDAR		
Horowhenua District Council	Manawatu-Wanganui	✓	✓		DEM		
Hurunui District Council	Canterbury	✓	✓		LiDAR		
Hutt City Council	Greater Wellington	✓	✓		LiDAR		
Invercargill City Council	Southland	✓	✓		DEM		
Kaikōura District Council	Canterbury	✓	✓		û	NO DATA	NO DATA
Kaipara District Council	Northland	✓	✓		LiDAR / DEM		DEM and LiDAR combined for 3.0m increment
Kāpiti Coast District Council	Greater Wellington	✓	✓		LiDAR		
Manawatu District Council	Manawatu-Wanganui	✓	✓		DEM		
Manawatu-Wanganui Region (Horizons)	Manawatu-Wanganui	✓	✓	✓	DEM		
Marlborough District Council	Marlborough	✓	✓		DEM		

Council Name	Region	Survey Sent	Survey received	Zero Asset Exposure	DEM/ LiDAR	Incomplete sections	Assumptions/ Information/Comments
Masterton District Council	Greater Wellington	✓	✓		LiDAR		
Napier City Council	Hawke's Bay	✓	✓		LiDAR	**Landfills;** No replacement values provided for closed landfills.	**Three waters;** Due to limitations with the way assets and valuations have been set up, wastewater, water supply or stormwater pump station assets are not itemised.
Nelson City Council	Nelson	✓	✓		LiDAR	**Three waters;** Replacement values missing for Water supply wells/bores. **Transport;** Replacement values not provided for bridges and bus terminals. **Buildings/facilities;** Replacement values not provided for playgrounds. **Green space;** No replacement values provided. **Landfills;** No replacement values provided for closed landfills.	
New Plymouth District Council	Taranaki	✓	✓		DEM		
Northland Regional Council	Northland	✓	✓		LiDAR		
Ōpōtiki District Council	Bay of Plenty	✓	✓		DEM		
Otago Regional Council	Otago	✓	✓		LiDAR		
Otorohanga District Council	Waikato	✓	✓		LiDAR		
Porirua City Council	Greater Wellington	✓	✓		LiDAR	**Green space;** No areas were given for exposed green spaces, only replacement values. **Buildings/facilities;** Only some replacement values were provided.	The missing replacement values for buildings/facilities were populated by applying an approximate ratio between replacement/ depreciated values (for those values provided). A ratio of three was calculated and applied.

Council Name	Region	Survey Sent	Survey received	Zero Asset Exposure	DEM/ LiDAR	Incomplete sections	Assumptions/ Information/Comments
Rangitikei District Council	Manawatu-Wanganui	✓	✓		DEM	**Green space;** No replacement values provided for parks/reserves.	
Selwyn District Council	Canterbury	✓	✓		LiDAR		
South Taranaki District Council	Taranaki	✓	✓		DEM		
South Wairarapa District Council	Greater Wellington	✓	✓		LiDAR		Were unable to give a breakdown between sealed and unsealed roads.
Southland District Council	Southland	✓	✓		DEM		**Landfills;** No replacement costs provided for closed landfills because they are liability only.
Southland Regional Council	Southland	✓	✓		DEM		
Taranaki Regional Council	Taranaki	✓	✓	✓	LiDAR		
Tararua District Council	Manawatu-Wanganui	✓	✓		LiDAR		
Tasman District Council	Tasman	✓	✓		LiDAR		
Tauranga City Council	Bay of Plenty	✓	✓		LiDAR		
Thames - Coromandel DC	Waikato	✓	✓		LiDAR / DEM		DEM and LiDAR combined for 3.0m increment.
Timaru District Council	Canterbury	✓	✓		LiDAR		
Waikato District Council	Waikato	✓	✓		LiDAR	**Three waters;** No replacement values provided for wastewater treatment plants. **Transport;** No replacement values provided for road data.	

Council Name	Region	Survey Sent	Survey received	Zero Asset Exposure	DEM/ LiDAR	Incomplete sections	Assumptions/ Information/Comments
Waikato Regional Council	Waikato	✓	✓		LiDAR		
Waimakariri District Council	Canterbury	✓	✓		LiDAR		
Waimate District Council	Canterbury	✓	✓	✓	LiDAR		
Wairoa District Council	Hawke's Bay	✓	✓		LiDAR		
Waitaki District Council	Otago (Coastal Area)	✓	✓		LiDAR		
Waitomo District Council	Waikato	✓	✓		DEM		
Wellington City Council	Greater Wellington	✓	✓		LiDAR	**Buildings/facilities;** No replacement values provided for playgrounds.	
West Coast Regional Council	West Coast	✓	✓	✓	LiDAR		
Western Bay of Plenty District Council	Bay of Plenty	✓	✓		LiDAR		
Westland District Council	West Coast	✓	✓	✓	DEM		
Whakatāne District Council	Bay of Plenty	✓	✓		LiDAR		
Whanganui District Council	Manawatu-Wanganui	✓	✓		DEM		
Whangarei District Council	Northland	✓	✓		LiDAR		

Note: In instances where no data was provided (blank entry) with no explanation, it is unclear whether this is due to a) no assets being exposed; b) exposure exists, however assets are not owned by council or c) incomplete survey data was provided.

In these circumstances it was assumed that no assets were exposed (i.e. as per (a) above).

We are. LGNZ.

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Grey.
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Hauraki.
Hawke's Bay Region.
Horizons.
Horowhenua.
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