NATIONAL RESILIENCE PROGRAMME BUSINESS CASE

TONKIN + TAYLOR AND TREGASKIS BROWN FOR
WAKA KOTAHI NZ TRANSPORT AGENCY

1 JUNE 2020

VERSION 2.7

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Published June 2020

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APPROVAL

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DOCUMENT VERSION

REVISION NUMBER	IMPLEMENTATION DATE	SUMMARY OF REVISION
0.1	14 October 2019	First draft for review by Tonkin + Taylor and Tregaskis Brown
1.0	28 January 2020	First draft for review by NZ Transport Agency
2.0	3 February 2020	Final draft for NZ Transport Agency formal IQA review
2.2	20 February 2020	Updated draft (Management Case) for IQA Review
2.5	1 April 2020	Submitted to NZTA Board for approval
2.6	May 2020	Board Approved version.
2.7	June 2020	Final issue

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SUPPORTING DOCUMENTS

ORGANISATION	DOCUMENT TITLE	PUBLICATION DATE
Tonkin + Taylor	Risk Assessment Methodology	March 2020
Tonkin + Taylor	Portfolio Risk Assessment Summary	March 2020

GLOSSARY OF KEY TERMS

Key to any discussion, study or project is a common understanding of taxonomy. Below are established definitions based on existing literature across the resilience, climate change and natural hazard risk space:

TERM	DEFINITION
Access	People's ability to connect with people, goods, services and opportunities and thereby engage in economic and social activity.
Adaptive capacity	The extent that systems, institutions, humans and other organisms can adjust to potential damage, to take advantage of opportunities, or to respond to consequences.
Asset	The physical hardware (e.g. pipes, wires), software and systems to own, operate and manage utilities such as energy, transport, telecommunications, water.
Autonomous vehicle	A vehicle capable of travelling without the need for human input, by using a combination of sensors and software to control, navigate and drive the vehicle.
Base Levels of Service	The essential benefits that the land transport system provides to customers, including safety, resilience, reliability and access across land transport modes. The appropriate base level of service varies in different corridors according to the nature and level of demand on each corridor. Base levels of service are maintained through the interventions we make to plan, maintain, manage, operate and regulate use of the land transport system. Levels of service for different types of corridor are defined in the One Network Road Classification. Work is underway to update this classification to better reflect urban settings and define levels of service for modes other than roads.
Climate change	A change in the state of the climate that can be identified by changes in the mean variability of its properties, and that persists for an extended period (IPCC 2013).
Climate change adaptation	Anticipating the adverse effects of climate change and taking appropriate action to prevent or minimise the damage they can cause, or taking advantage of opportunities that may arise (European Commission, undated).

TERM	DEFINITION
Corridor	A linear transport connection that enables the movement of people and goods, using one or more modes.
Criticality	Informed (defined) by the consequence of the asset failing. That is if there is an unacceptable consequence should a particular asset fail, then that asset would be classed as highly critical.
Exposure	The location of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.
Hazard	The potential occurrence of a natural or human-induced physical event that may cause harm. Harm can be both physical and non-physical, such as economic, social and/ or cultural.
Mitigation (of climate change)	A human intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC, 2014).
Mode neutrality	Considering all transport modes when planning and investing and basing decisions on the merits of each mode to deliver positive social, economic, and environmental outcomes.
Place-based	A general approach to urban and transport planning that focuses on place. It emphasises the look and feel of places and their form and character as a fundamental starting point for planning and development.
Resilience	The transport system's ability to enable communities to withstand and absorb impacts of unplanned disruptive events, perform effectively during disruptions, and respond and recover functionality quickly. It requires minimising and managing the likelihood and consequences of small-scale and large-scale, frequent and infrequent, sudden and slow-onset disruptive events, caused by natural or man-made disasters[1].
Risk	Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur.
Sensitivity	The degree to which a system or species is affected or changes in response to a change in an influencing factor, either adversely or beneficially, by climate variability or change.
Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including susceptibility to harm and lack of capacity to cope and adapt.

[1] Derived and aligned with resilience definitions from the Sendai Framework for Disaster Risk Reduction, draft National Resilience Strategy (MCDEM, Nov 2017) and NZTA's Four Year Excellence Horizon.

KEY ACRONYMS

ACRONYMS	MEANING
ASOI	Amended Statement of Intent (NZ Transport Agency)
AMP	Asset Management Plan
CAN	Cycling Action Network
DOC	Department of Conservation
EAST	Early Assessment Sifting tool
EQC	Earthquake Commission
GDP	Gross Domestic Product
GHG	Greenhouse gas
GIS	Geographical information system
GNS	Geological and Nuclear Sciences
GPS	Government Policy Statement
HPMV	High productivity motor vehicle
IDMF	Investment Decision Making Framework (NZ Transport Agency)
ILM	Investment Logic Map
IPCC	Intergovernmental Panel on Climate Change
KPI	Key performance indicator
LGNZ	Local Government New Zealand
LINZ	Land Information New Zealand
LSF	Living Standards Framework
LTMA	Land Transport Management Act
MBIE	Ministry of Business, Innovation and Employment
MCDEM	Ministry of Civil Defence and Emergency Management
MoT	Ministry of Transport
NCCRA	National Climate Change Risk Assessment
NDRS	National Disaster Resilience Strategy
NEMA	National Emergency Management Agency
NIP	National Infrastructure Plan

ACRONYMS	MEANING
NIWA	National Institute of Water and Atmospheric Research
NLTF	National Land Transport Fund
NLTP	National Land Transport Programme
NOC	Network Outcome Contract (holders)
NRPBC	National Resilience Programme Business Case
NRSC	National Resilience Strategic Case
NZ	New Zealand
NZTA	Waka Kotahi NZ Transport Agency
OECD	Organisation for Economic Co-operation and Development
ONRC	One Network Road Classification
PBC	Programme Business Case
RCP	Representative Concentration Pathways
RLTP	Regional Land Transport Plan
RMA	Resource Management Act
RTC	Regional Transport Committee
SDG's	Sustainable Development Goals
SH	State Highway
SUV	Sport utility vehicle
TAIP	Transport Agency Investment Proposal
Transport Agency	Waka Kotahi NZ Transport Agency
UN	United Nations

EXECUTIVE SUMMARY

RECOMMENDATIONS

The decision this National Resilience Programme Business Case (NRPBC) is seeking from the Waka Kotahi NZ Transport Agency (Transport Agency) Board is for the Board to:

1. **Support** the National Resilience Programme Business Case which prioritises major and extreme natural hazard (including climate change related) risks in the New Zealand land transport system and recommends an integrated suite of system responses.
2. **Note** that responses to the highest priority risks and sites will be submitted for consideration into the 2021-24 National Land Transport Programme;
3. **Note** that the evidence base, risk prioritisation methodology and decision-making framework will be made available to our partner organisations.

PURPOSE

This National Resilience Programme Business Case was commissioned to:

- Provide an evidence base of the nationally extreme and major risks posed to the New Zealand land transport system from a natural hazards perspective;
- Deliver an associated agreed, preferred and integrated suite of system responses that the Transport Agency and its investment partners could implement to address the identified risks and best achieve the benefits and outcomes defined by this case. These responses represent the high-level strategic interventions (especially focussed on the NLTP) or initiatives across the Agency's Resilience Programme to address the resilience risks, issues, deficiencies and opportunities in or affecting the land transport system, including those geographical sites identified in the evidence base; and
- Reflect the significance of resilience issues affecting the land transport system and associated infrastructure.

This case also identifies potential actions for the Transport Agency Business Plan and for Regional Land Transport Plans.

BACKGROUND

The Transport Agency commissioned the development of a National Resilience Programme Business Case following on from the work commenced by the National Resilience Strategic Case (NRSC).

This case is the latest in a series of studies and cases that seek to improve how the Agency appropriately embeds resilience into its business and investment planning. The National Strategic Resilience Strategic Case that was approved in January 2019 included the agreed objectives that it would:

- Improve the ability for communities to make informed decisions about resilience and prepare for, withstand, absorb, continue functioning after and recover quickly from adverse events;
- Prioritise planning and investment in improving transport system resilience that meets user and community tolerances and risk appetite;

- Position the Transport Agency in a leadership role as a strong influencer for the whole of the transport system and the communities to which it provides access; and
- Enhance New Zealand's capacity to cope with unplanned disruptive events thereby supporting the wellbeing and prosperity of all New Zealanders.

The original NRSC was largely undertaken as an internal exercise. This NRPBC has tested the issues raised by that case with a range of national-level stakeholders to validate the challenges and problems identified and identify potential system and strategic responses. Many of the issues and potential responses have been covered in parallel activity including the development of Arataki and the Investment Decision Making Framework Review.

In parallel, a desktop evaluation of resilience related risks based on hazard and asset data was conducted to generate a preliminary view of priority risks for the land transport system. Testing of this preliminary analysis was undertaken with stakeholders through a series of regional workshops throughout New Zealand and ground truthed against existing climate change research.

The risk assessment aimed to identify extreme and major risks across the land transport system with regards to natural hazards: 'shock' events, as well as slow onset and climate change induced hazards.

STRATEGIC RELEVANCE

Resilience of New Zealand's land transport system, including in the face of a changing natural hazard context is a matter that has been investigated extensively. Resilience and the impacts of a changing climate have been canvassed through the GPS (2018), the Ministry of Transport's Resilience and Security Strategic Framework, and the Transport Agency's own Statement of Intent, Resilience Framework and Arataki: Our (Transport Agency) plan for the land transport system.

Improving how resilience is incorporated into investment and decision-making thinking is likely to lead to changes in how the Agency considers and prioritises investments. This is also reflected in the draft GPS (2021) which was released in March 2020 for consultation. This NRPBC therefore represents another milestone on the journey to continually update and improve how we best deliver land transport resilience. In March 2020 New Zealand was impacted by the global COVID 19 pandemic. At the time of writing the medium and long term implications of the pandemic are unclear, but it is likely that that priorities across NZ are likely to change. However, resilience aspects remain relevant and there is an opportunity to progress / integrate resilience planning as part of the infrastructure projects that are anticipated as part of the economic stimulus package announced in response to the pandemic.

KEY ISSUES

Key problems identified with stakeholders are set out in Figure 1.

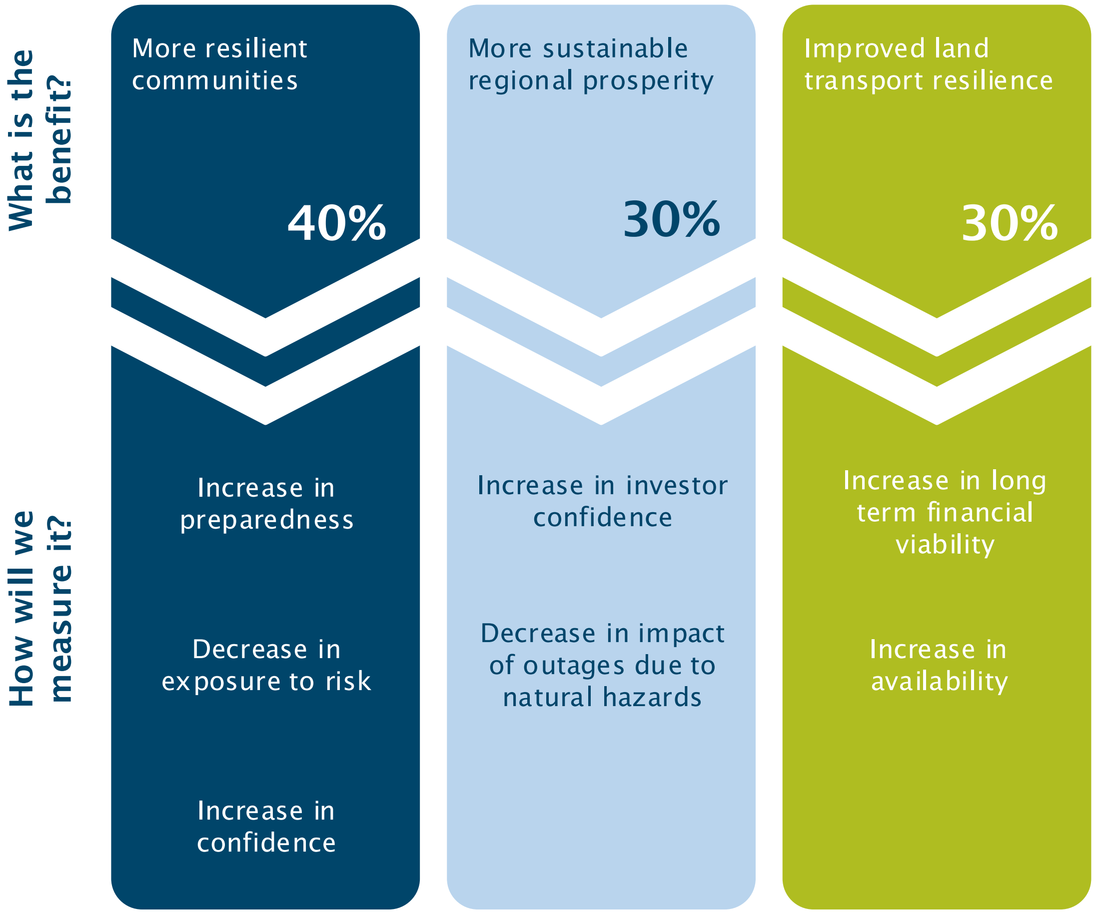
Figure 1: NRPBC problem overview

Causes	Key problem
• More frequent and more severe natural hazard events as a result of climate change • Increasing susceptibility of our road and rail networks • The severe impacts of low frequency high impact events • Changing transportation patterns • Changing societal expectations and needs	Increasing risks from natural hazards in an increasingly transport-dependent society is leaving communities and business susceptible to isolation, hardship and economic loss **40%**
• Absence of planning framework at a national level (spatial and transport) • Lack of integration across modes • Poor information / evidence base • Limited understanding of business need • Thinking is still developing, and resilience not yet factored into decision-making • Low frequency events are difficult to plan for and fund • Current economic assessment model does not afford priority to resilience • Different transport infrastructure is owned and managed by different entities • KiwiRail funding mechanisms • Current system swamped by need to respond to crisis	Disjointed and reactive decision-making has led to sub-optimal and inefficient investment choices and is hampering our ability to adapt **40%**
• Business practice is slow to change • Uncertainty creates inertia • Perverse signals	Failure to account for changing hazard risk is leading to rising costs of unplanned urgent repairs and emergency works **20%**

KEY BENEFITS

The key benefits we could expect to see from resolving the identified problems are set out in Figure 2 and discussed below.

Figure 2: Benefits and KPI's



More resilient communities

Our communities would be better protected from impacts and outages in the land transport system as a result of natural hazards and would be more resilient when events do occur. Because extreme events will occur, and will happen more frequently, it is essential that communities are better prepared to manage the effects of these events when they do occur.

If we have good information on the level of risk communities are exposed to, and have taken steps to avoid, minimise, or manage those risks, the residual risk that communities are exposed to would be increasingly acceptable.

People would therefore have increasing confidence that the risks posed to their health, safety and lifestyle are within acceptable tolerances.

More sustainable regional prosperity

Investor confidence is important if regions are to prosper. Investors need reasonable assurance that the level of risk posed by natural hazards to critical business linkages is minimised or managed appropriately to avoid and minimise reasonably foreseeable disruptions on critical routes.

The two KPI measures proposed would assess the contribution that resilience in the land transport system would make to enabling regional prosperity and stability.

Improved land transport resilience

Long term resilience of our land transport system means we would have both understood and factored in the whole-of-life costs – including repairs and maintenance – when making investment decisions.

Shifting to a model that requires us to consider the levels of service desired and driven by the Living Standards Framework against that backdrop of both long-term physical asset resilience and financial impacts may require us to reassess aspects of our land transport system and make decisions that could be quite different to aspects of the system we have today.

KEY OUTPUTS

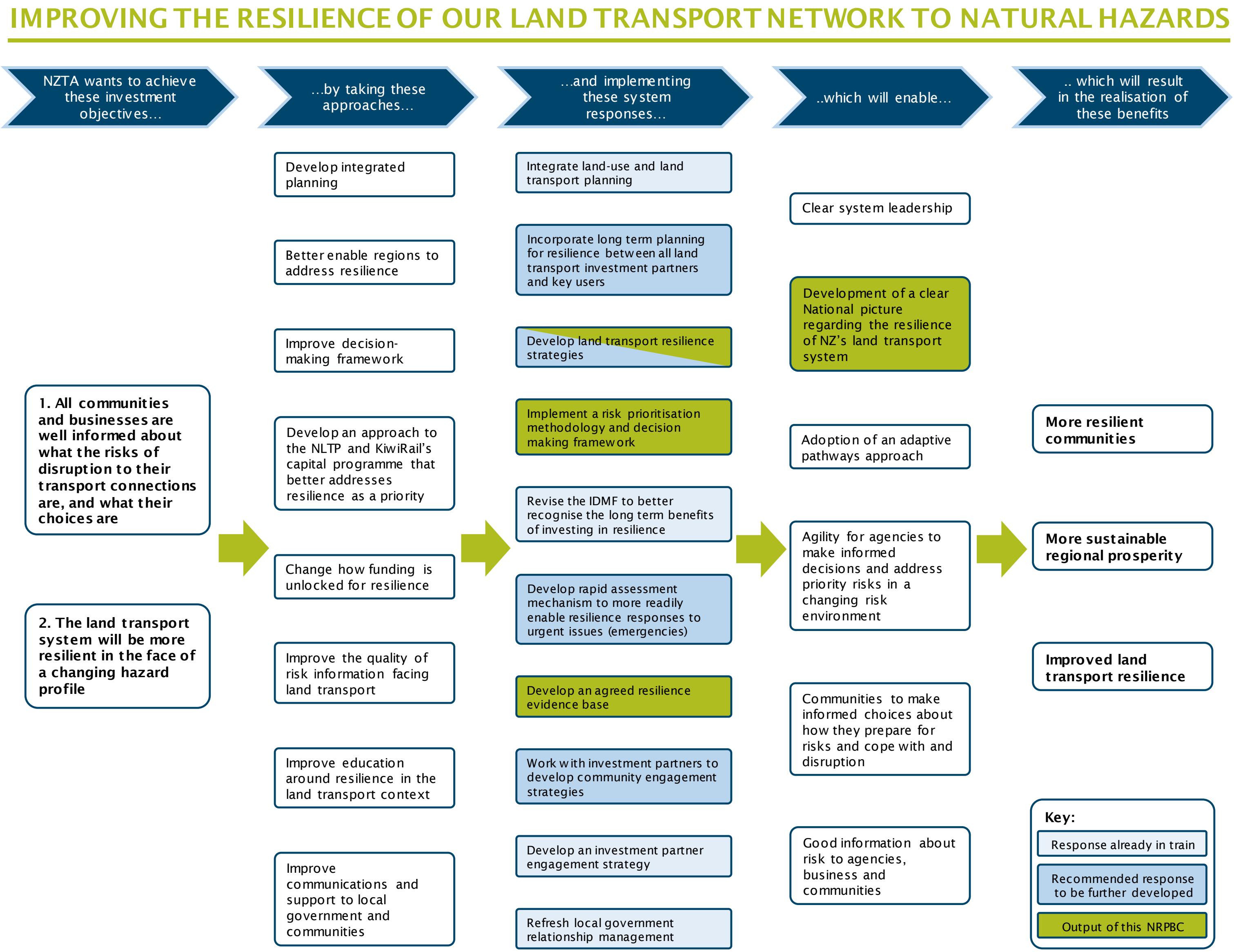
System responses

High-level approaches were tested with stakeholders and a suite of system level responses was derived. These responses were then refined with Transport Agency staff in a workshop in December 2019 and tested in one-on-one meetings with national level stakeholders. A set of approaches and a preferred programme have been derived through an economic assessment. An Outcomes Framework was prepared to identify how the identified approaches and system responses would deliver the objectives and benefits sought by the Transport Agency from this work. This is set out in Figure 3.

Several of the responses are already in train - through Arataki and through the Investment Decision Making Framework Review. The Key Issues and Key Benefits identified in the preparation of this case support the activity completed or underway through these projects including integrating land use, spatial planning and transport planning, collaboration with investment partners and ensuring investment decisions recognise the benefits of improved resilience taking an integrated view of the land transport system.

Identifying prioritised risks is an important response when considered alone. Successfully addressing the risks relies on the effective implementation of the other responses identified in the programme requiring an integrated approach. For example, business cases for a resilience focussed intervention may not secure funding unless the Investment Decision Making Framework (IDMF) review elevates the influence of resilience in prioritising investment across the NLTP, or may not consider alternative options to ‘building our way out’.

Figure 3: Outcomes Framework for the preferred package of system responses



Programme options

Four broad approaches have been derived by grouping the system responses. Each option below builds on the prior option. So, Option 3 (integrated investment model) builds on Option 2 (Do Minimum). These options were derived and tested with key stakeholders through one on one meetings.

Table 1: Programme options

OPTION	DESCRIPTION	INCLUDES THESE STRATEGIC RESPONSES	ADVANTAGES	DISADVANTAGES	COMMENT
Option 1	**Current state (status quo):** This option reflects current state plus initiatives that are already in train either to improve resilience, or that would provide resilience benefits.	• Integrate land-use and land transport planning; • Revise the IDMF to better recognise the long-term benefits of investing in resilience; • Develop an investment partner engagement strategy; • Refresh local government relationship management.	• Continues current models with evolutionary changes that do not require significant additional change effort at regional level.	• Investment decisions would continue to be tactical and resilience considerations susceptible to being traded off against more urgent priorities; • Risks that sub-optimal investment decisions are made for emergency repairs and low-cost investments, further locking in non-resilient investments; • Communities would continue to make decisions on the current state of infrastructure, not factoring opportunities or future changes; • No national picture of resilience challenges facing NZ, nor understanding of the magnitude of risk is developed; • Would not fulfil requirements for adaptation planning under the *Climate Change Response (Zero Carbon) Amendment Act*; • Would not achieve step-change identified in Arataki.	Levels of service would continue to decline across the system in the medium to longer term, costs of repairs would continue to rise and communities would be increasingly disrupted.
Option 2	**Resilience issues, and approaches for risk management are identified:** This package creates a national picture of issues and provides mechanisms for identifying how they might best be addressed.	• Option 1 responses plus; • Implement risk prioritisation methodology and decision-making framework; • Develop a rapid assessment mechanism to more readily enable resilience responses to urgent issues (emergencies); • Develop an agreed resilience evidence base.	• Better national picture of the resilience risks facing NZ; • Availability of tools to assist regional decision-making and ensure that more resilient options are factored into RLTPs; • More effective response to urgent issues (emergencies).	• Decision-making can still be ad hoc and tactical, locking in sub-optimal options; • Communities would continue to make decisions on the current state of infrastructure, not factoring opportunities or future changes; • Unlikely to achieve step-change identified in Arataki.	Levels of service are likely to continue to decline, but better information available about risks and disruption may be better managed.

OPTION	DESCRIPTION	INCLUDES THESE STRATEGIC RESPONSES	ADVANTAGES	DISADVANTAGES	COMMENT
Option 3	**Integrated investment model:** This option builds on the previous option and establishes long term resilience planning in the form of resilience strategies, that are used to inform long term planning and investment and provide a resilience blueprint to guide short term and emergency works. The community is engaged in the process and are aware of the challenges, and how those can be resolved, including the use of non-infrastructural options.	• Option 2 responses plus; • Incorporate long term planning for resilience between all land transport investment partners and key users; • Develop land transport resilience strategies; • Work with investment partners to develop community engagement strategies.	• Transparency of trade-offs made to ensure that long term investments are in the best interests of the community and systems; • Co-benefits streams from integrated investment such as safety, connectivity can be realised, resulting in better value for money; • Clear path for resilience decision-making in short-term and emergency repair considerations; • Community is clear what the risks of natural hazards are to community and business interests, and can plan for known disruption; • Greater buy-in from all parties; • Should deliver on adaptation aspects of *Climate Change Response (Zero Carbon) Amendment Act* requirements; • Delivers on Arataki step change.	• Clear knowledge about decisions that need to be taken for resilient outcomes, yet trade-offs against other more urgent or shorter-term outcomes are still possible.	This option is most likely to enable the current level of service across the land transport system to be maintained, by identifying and enabling more sustainable choices to be made, including retreat. It also delivers aspirations of Arataki's step change.
Option 4	**Invest for resilience:** This option further develops the integrated investment model. Resilience is made a priority at a national level, and a protected fund is established to ensure continual progress.	• Option 3 responses plus; • Develop funding model for non-transport infrastructure solutions; • Establish a targeted resilience fund.	• Resilience investment decisions are protected against ad hoc re-prioritisation decisions; • Supports regional development; • The overall resilience of the land transport system improves over time.	• Risk of over-investment in resilience in comparison for the benefits received; • Prioritisation of resilience compromises investments targeted at other benefit streams; • Potential lost opportunity for multi-outcomes solutions.	This option would enable NZ to get ahead of the challenges and make strategic investments that support system and community resilience and get beyond transport solutions.

Programme options analysis

Table 2 sets out how the options respond to investment objectives and critical success factors.

Table 2: Programme options analysis (completed in December 2019 i.e. pre COVID-19)

			1. Status Quo	2. Improved decision-making	3. Integrated investment model	4. Invest for resilience
Description			Includes integrate land-use and land transport planning, revise the IDMF, investment partner engagement strategy and refresh local government relationship	Status Quo responses plus risk prioritisation methodology and decision making framework, rapid assessment mechanism and evidence base	Do Minimum responses plus long terms resilience planning between investment partners, regional resilience strategies, and community engagement strategies	Preferred responses plus funding model for non-infrastructure solutions targeted resilience programme.
Investment Objectives		All communities and businesses are well informed about what the risks of disruption to their transport connections are, and what their choices are	No	Partial	Partial	Yes
Investment Objectives		The land transport system will be more resilient in the face of a changing hazard profile	Partial	Partial	Yes	Yes
Critical Success Factors	Strategic Fit	Aligned to GPS, MoT Transport Outcomes Framework, NZTA Resilience Framework	No	Partial	Yes	Yes
Critical Success Factors	V for M	Must demonstrate good benefits for the expenditure required	Yes	Yes	Yes	Partial
Critical Success Factors	Afford	Can be done within existing budgets	Yes	Partial	Partial	No
Critical Success Factors	Achieve	Agencies have the capability and capacity to deliver	Yes	Yes	Yes	Yes
Critical Success Factors	Feasibility	Possible to deliver in current environment	Yes	Yes	Yes	No
Summary			Makes some progress towards resilience, but investment decisions likely to be tactical rather than strategic	Establishes a methodology for prioritising resilience risks, and a national view of the challenges, and provides mechanisms that enable repair work to take resilience into account, but remains tactical	Provides a strategic view of risks and preferred approaches that guides and informs investment planning in the long term, short term and for emergency works. Increases community engagement to ensure that communities are well informed.	Provides a strategic view of risks and preferred approaches, and creates a protected funding mechanism to ensure that resilience investments do not get crowded out by other priorities.
Comment			Status quo option	Do minimum option	Preferred option	Ideal option

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Recommended programme at system level

A number of these responses (see Figure 3) are either being canvassed through other programmes of work or have already been agreed. Responses therefore fall under three categories:

- Responses that are already underway (but not implemented) or are part of another programme of work (coloured light blue in Figure 3). Achieving the outcomes of this programme are dependent on these initiatives being completed as set out in these other programmes. These are:
  - Integrate land-use and land transport planning;
  - Revise the Investment Decision-Making Framework to better recognise the long-term benefits of investing in resilience;
  - Develop an investment partner engagement strategy; and
  - Refresh local government relationship management.

The detail of these other programmes is set out in Appendix I.

- Responses that require further consideration but are outside the scope of this case (coloured dark blue in Figure 3). These responses have been developed to a strategic level and form part of the programme to be implemented under this business case. There would be a number of ways in which the intent of these options can be realised. This is not addressed in this case, but at a headline level are:
  - Incorporate long term planning for resilience between all land transport investment partners and key users;
  - Develop rapid assessment mechanisms to more readily enable resilience responses to urgent issues (emergencies);
  - Work with investment partners to develop community engagement strategies; and
  - Develop land transport resilience strategies - to address priority risks. This is discussed further below.

- Deliverables from this case (coloured in green in Figure 3).
  - Develop an agreed evidence base – for evaluating resilience related risks; and
  - Implement a risk prioritisation methodology and decision-making framework which would provide:
    - A standard approach to assessing and prioritising resilience related risks and developing appropriate solutions; and
    - A preliminary list of prioritised risks developed using the evidence base and standard approach.

As the key outputs of this case, these responses have been developed to a much more granular level of detail as part of this case. Building on these responses and with support from other team members, next steps would include activity to:

- establish a process to ensure that this evidence base is periodically updated, maintained, promoted, and linked to other related data-bases;
- support the use of the agreed evidence base and risk prioritisation methodology in investment decision making including using the IDMF;
- ensure projects supporting the agreed risk treatments are prioritised for incorporation into the NLTP (or RLTP) and deliver a response to the risk; and
- where feasible, utilise existing spatial planning exercises, capital improvement projects, business cases, and maintenance programmes to resolve resilience issues.

Other responses raised through the regional workshops not included in the preferred programme to be implemented under this business case due to scope include:

- Providing a funding model that allows for consideration of investments in non-transport infrastructure solutions to address resilience related risks where these interventions may be more appropriate than a traditional infrastructure solution;
- Establishing a resilience fund which would be specifically made available for investments in existing or new transport infrastructure that specifically address resilience risks, as a means of transitioning to a more resilient future land transport system (e.g. specifically address impacts of sea level rise in the near to medium term).

While these could address issues raised in the workshops they were excluded because they require significant additional investment but are not anticipated to deliver additional benefits in a similar proportion.

Changing funding models for key transport system investors to explicitly allow for supporting non transport related activities would require a change to the existing statutory framework. This would require supporting analysis, developing a detailed proposal, appropriate consultation and formal adoption of the amended framework.

Establishing a resilience fund would provide funding for addressing resilience issues where there are no other drivers for change at a specific location. Many resilience related issues for the transport system occur in parts of the system where there are other reasons for investing in change, for example to improve efficiency or to address safety issues. This means a dedicated resilience fund would address the remaining risks that are not prioritised through the use of the appropriate investment decision making framework.

Prioritised Risks

The prioritised geographic risks are those that have both a high likelihood of occurring and will result in significant consequence if they do occur. The analysis of geographic risks considers current and future hazards, the vulnerability of transport systems to these risks and the criticality of the system. Key data sets used included existing natural hazards data, network asset information and the One Network Road Classification (ONRC) system. The risks implied by the datasets was discussed and validated with transport system managers in each region.

A summary of the extreme and major-risk sites from the prioritised list is included in Appendix F. Given the transient nature of some natural hazards (e.g. landslides) new information becoming available and progress being made through improvements and interventions, this list is likely to change over time. The focus has been on those areas that are not currently addressed through existing investment plans. This programme takes a long-term view of 70 years to reflect changing hazards due to climate change.

Appendix F of this case provides a summary of the extreme and major risks identified through the preliminary analysis and Regional Workshops. For each risk identified consideration has been given to both the approach to develop a response and options for responding, referencing ISO 14090 "*Adaptation to climate change — Principles, requirements and guidelines*". Action to address these risks would take a variety of forms. Timing would vary and include addressing some risks immediately, developing concept solutions that can be implemented if there is a need to restore transport connections and / or scheduling medium to long-term implementation of solutions for risks that are forecast to emerge or evolve.

It is important that a range of responses are considered for priority risks rather than assuming that infrastructure would be maintained or upgraded to mitigate risk. Types of options for responding can be grouped as:

- **Defend** - develop solutions to mitigate the risk of disruption, for example flood protection or slope stabilisation;
- **Accommodate** - plan for periodic disruption, for example providing for rapid reinstatement, detour routes and/or timely information; and
- **Retreat** - re-route journeys away from the impacted corridor.

The risks have been grouped by region with preliminary development to address priority risks drawing on the timing and response options noted above. The risks have been grouped on a regional basis but could also be put together using a corridor or journey view. This is enabled by identifying and prioritising individual risks on a location basis across the country to develop a national dataset that can be filtered in multiple ways.

Responses would consider individual risks, but more importantly should look at combined risk on a regional, corridor or journey basis. The response projects would:

- Make use of the risk prioritisation approach;
- Sit within a framework including the updated Investment Decision Making Framework, future versions of Arataki and enhanced strategic land use planning and evolving operational processes/methods to address both immediate and future risks;
- Identify where business cases are required e.g. for responses to address extreme and major risks;
- Provide concepts or example designs to enable emergency response activities to deliver improved resilience; and
- Be reflected in Corridor Management Plans, Emergency Response Plans and future versions of Arataki (regional summaries).
- Provide an integrated, long term view on activities required to improve the resilience of the land transport system on a regional, corridor or journey basis.

PART A – STRATEGIC CASE

STRUCTURE OF THIS DOCUMENT

Part A of this case sets out the strategic context for resilience and the problems this case seeks to address.

Part B outlines the range of options, assesses those options and identifies a preferred package of system responses. This includes an overview of the geographic issues and approaches.

Part C outlines next steps to be undertaken if this case is to be implemented.

INTRODUCTION

The decision this National Resilience Programme Business Case is seeking from the Waka Kotahi NZ Transport Agency (Transport Agency) Board is for the Board to:

1. **Support** the National Resilience Programme Business Case (NRPBC) for the prioritisation of extreme and major risks in the New Zealand land transport system;
2. **Note** the recommendations for further work made within this business case;
3. **Note** that the highest priority risks and sites would be discussed with the affected local RTC's and where appropriate submitted for inclusion in the TAIP and the relevant 2021/24 Regional Land Transport Plans; and
4. **Note** that the NRPBC including the evidence base, risk prioritisation methodology and decision-making framework would be made available to our partner organisations.

Why have we prepared this programme business case?

This NRPBC has been commissioned by the Transport Agency as a key response to the increased focus on resilience in the Government Policy Statement on Land Transport 2018/19 – 2027/28 (GPS 2018). It also refreshes the 2019 National Resilience Strategic Case which set the scene for this case. It has been developed in parallel with Arataki (Version 1) which was adopted by the Transport Agency and released for engagement in December 2019. Arataki is the Transport Agency's 10-year view of what is needed to deliver on the government's current priorities and long-term objectives for the land transport system.

Developed in collaboration with the Transport Agency's land transport co-investment partners, the purpose of this NRPBC is to:

- Develop a robust national evidence base that outlines the key geographical sites (within the national land transport system) where the resilience of the system is currently threatened by the risk of natural hazards;
- Establish a risk prioritisation methodology and decision-making framework which:
  a) provides a methodology to effectively prioritise between different resilience risks to identify the nationally extreme and major risks posed to the land transport system from a natural hazards perspective. This is to support decision makers direct investment / intervention in the land transport system where it would have the greatest benefit and;
  b) provides a framework that supports decision makers to determine which intervention is most appropriate to mitigate the respective risk;

- Identify improvements already in train that would contribute to improving the resilience of the land transport system;
- Utilise all this information to deliver an associated agreed, preferred and integrated suite of system responses that the Transport Agency and its investment partners could implement to address the identified risks and best achieve the benefits and outcomes defined by this case. These responses represent the high-level strategic interventions (especially focussed on the National Land Transport Programme) or initiatives across the Transport Agency's Resilience Programme required to address the resilience risks, issues, deficiencies and opportunities in or affecting the land transport system, including those geographical sites identified in the evidence base; and
- Reflect the significance of resilience issues affecting the land transport system and associated infrastructure.

As this NRPBC is a stepping-stone in a wider resilience improvement process, it is high-level and does not seek to determine final solutions. This case identifies potential actions for the Transport Agency Business Plan and for contributions to Regional Land Transport Plans which when implemented would better enable the Transport Agency and other land transport investment partners to improve the resilience of the land transport system. Many of the issues and potential responses have been covered in parallel activity including the development of Arataki and the Investment Decision Making Framework Review.

This NRPBC is not intended to replace or obviate any later place-based resilience Programme Business Cases. Rather it is to be used to provide context, initial evidence, coordination and direction for these subsequent Programme Business Cases, which would seek to address the resilience of the prioritised geographical sites or routes identified by this case. It is important that a range of responses are considered for priority risks rather than assuming that infrastructure would be maintained or upgraded to mitigate risk. Other options including enhanced planning for the management of disruption and considering 'retreating' from sections of the land transport system where they are costly or complex to retain.

Why is the land transport system important to New Zealand?

A safe, well connected and accessible land transport system is critical for the health and wellbeing of all New Zealanders and underpins our economy. Comprising of a nationwide network of road, rail and cycle infrastructure, the land transport system plays a major role in our society and economy by:

Connecting our communities, businesses and overseas visitors to one another, strengthening our social and cultural bonds, unlocking productivity and promoting business growth;

Supporting the movement of freight and the flow of international trade by providing key linkages between the regions and to and from other modes of transport such as maritime and air. This enables the efficient movement of goods and connects producers with consumers;

Providing critical access during emergency events allowing responders to perform more effectively when disruptions occur.

New Zealanders on average spend just under an hour a day travelling using the land transport system to access work, education, recreation, health, essential services and for visiting family and friends.

Roads currently make up the backbone of the system, supporting travel through many different modes such as cycling, private vehicles and public transport. The roading network plays an important role for household travel, given that 93% of the total distance travelled by households and 78% of all trips are made either as a car driver or as a passenger (Ministry of Transport, 2017). Roads are also New Zealand's most dominant mode of transport for moving freight, accounting for 93% of the total tonnes transported in 2017/18 and 75% of the total tonne-kilometres (load carried measured by tonne x distance covered in kilometre) (Richard Paling Consulting et al., 2019).

By comparison, most of New Zealand's rail network is used for the movement of freight given its effectiveness at moving heavier loads over longer distances. In 2017/18 rail accounted for 6% of the total tonnes transported and 12% of the total tonne-kilometres (Richard Paling Consulting et al., 2019). However, in recent years rail has also played an increasing role as a public transport service, particularly in some of our major urban areas. In 2016 a total of 18.1 million passenger boardings were recorded on commuter services in Auckland and a further 13.1 million passenger boardings were recorded in Wellington. The importance of the role rail plays as a public transport service is also set to increase with new services currently being planned from Hamilton to Auckland (Ministry of Transport, 2017).

Why is resilience important to New Zealand?

Providing and enabling reliable access is the basis of a well-functioning land transport system. However, the availability of our land transport system can sometimes be disrupted by the impacts of natural hazards. These impacts can be caused by shock events such as earthquakes which are low frequency, but high impact, or by more gradual and certain changes such as sea level rise as a result of climate change.

The Transport Agency recognises that their customers, investment partners and Central Government expect a land transport system that is resilient, robust, reliable, able to adapt to adverse events and that protects them from harm. This includes the expectation that the Transport Agency maintain or quickly restore reasonable levels of service when disruptive events occur.

With growing demands on the land transport system and an increasing risk posed by climate change, (including an increasing incidence of extreme weather events) improving resilience is becoming increasingly important as both a network asset and an organisational characteristic.

Resilience, in the land transport context, is defined by the Transport Agency in the 2018 Resilience Framework[2] as:

> *The transport system's ability to enable communities to withstand and absorb impacts of unplanned disruptive events, perform effectively during disruptions, and respond and recover functionality quickly.*

The framework goes on to note that

> *[Resilience] requires minimising and managing the consequences of small-scale and large-scale, frequent and infrequent, sudden and slow-onset disruptive events, caused by natural and manmade hazards.*

A transport system that lacks resilience would become unavailable in a major disruption, hindering

[2] Derived from and aligned with resilience definitions from the Sendai Framework for Disaster Risk Reduction, draft National Disaster Resilience Strategy (MCDEM, Nov 2017) and NZTA's Four Year Excellence Horizon.

emergency responses, recovery, impacting lives, livelihoods, communities and businesses. Studies[3] show that if any of our urban centres, are significantly impacted there is potential for severe damage to both the national economy and the social wellbeing of our communities.

Case study: The importance of resilience

Since the mid 1990's Orion, (a New Zealand electricity distribution company) has actively sought to improve the resilience of its network, in order to minimise the potential economic impact that outages can cause, including those outages caused by earthquakes. From 1996, Orion spent a total of $6 million in an ongoing seismic strengthening programme, an investment which is estimated to have saved the company $30 - $50 million in direct asset replacement costs following the 2010 and 2011 Christchurch earthquakes. The balance between the costs and benefits of this investment is even more pronounced when you take into account the societal benefits achieved from the enhanced resilience of the assets. After the 2010 earthquake, all of the facilities that were upgraded by Orion's seismic strengthening programme remained serviceable and only a few were left non-serviceable after the 2011 earthquake. This contributed to Orion's ability to restore power to 90% of consumers within 24 hours following the 2010 earthquake and within approximately 10 days following the more severe, 2011 earthquake.

Although this example is not directly transport related it does show the significance and breadth of the benefits that can be achieved through investing in resilience.

Image: Orion Asset Management Plan

Case study: Kestrel Group Ltd. (2011). *Resilience Lessons: Orion's 2010 and 2011 Earthquake Experience.* Independent Report. Wellington, New Zealand: Kestrel Group Ltd. Retrieved from https://www.oriongroup.co.nz/assets/Customers/Kestrel-report-resilience-lessons.pdf

BACKGROUND

NZ Transport Agency 2018 – 2021 Business Plan

The Transport Agency's 2018-21 Business Plan outlines their 3-year internal work programme. The plan consists of 24 critical programmes, one of which (Programme 7) is the National resilience framework programme. This programme is intended to put in place a national resilience framework to enable regional economies and deliver better employment, health and social outcomes in the face of natural hazards.

[3] For example, Wellington – essential to NZ's Top Tier: Its resilience is a national issue BERL, December 2015.

NZ Transport Agency 2018 Resilience Framework

As the key output of the National resilience framework programme, the Resilience Framework was adopted by the Transport Agency Board in April 2018. It responds to the increased focus on improving access in the Government Policy Statement on Land Transport 2018/2019- 2028/2028.

The purpose of the framework is:

- To promote a clear expression of the Transport Agency's strategic approach to resilience; and
- To develop, enable, prioritise, guide, deliver, monitor and coordinate the Transport Agency's ongoing activity and strategic partnerships related to addressing the current and future resilience risks to the land transport system.

The outcomes sought are that:

- Through collaboration with key partners, we have a shared understanding of communities' acceptance of risk and tolerance of system disruptions;
- Communities are less exposed, and better prepared to deal with, the economic, physical, social, cultural and environmental impacts of risks and shocks from natural hazards and other disruptive events.

The Resilience Framework also defines its strategic work programme which is broken down across four interrelated workstreams. This NRPBC sits under the planning and decision making workstream, which is designed to strengthen and support improved planning and decision-making processes and guidance for projects and land use to deal with resilience risks to the transport system. It would achieve this by:

- Aligning resilience with Arataki and utilising the levers set out in Arataki;
- Producing a NRPBC – which would create a nationally consistent assessment method and a high-level programme of action (noting the role of co-investment partners and KiwiRail).

National Resilience Strategic Case

The National Resilience Strategic Case (NRSC) was approved in January 2019. The NRSC refreshed the National Strategic Assessment for Resilience in the State Highway Network (NZ Transport Agency, 2013), by widening the scope to consider the resilience of the whole land transport system beyond State Highways. Other key differences include a more in-depth consideration of the impacts of climate change and low frequency high impact events.

The NRSC created the frame for this NRPBC. The agreed objectives of this case as set out in the NRSC are that it would:

- Improve the ability for communities to make informed decisions about resilience and prepare for, withstand, absorb, continue functioning during/after and recover quickly from adverse events;
- Prioritise planning and investment in improving transport system resilience that meets user and community tolerances and risk appetite;
- Position the Transport Agency in a leadership role as a strong influencer for the whole of the transport system and the communities to which it provides access; and
- Enhance New Zealand's capacity to cope with unplanned disruptive events thereby supporting the wellbeing and prosperity of all New Zealanders.

The NRSC also identified three strategic problems:

- **Disruptive events:** Changing social and economic dynamics and more frequent natural hazard events, increase communities' vulnerability to unplanned transport system disruptions, adversely impacting communities and the economy;
- **Prioritisation:** Planning and investment decision-making processes and practices do not fully capture the long-term resilience costs and benefits, which lead to increased economic and social risks and impacts; and
- **Inter-organisation coordination and resourcing:** Inter-organisational capital, capability and capacity constraints hinder the ability to build resilience into the transport system's improvement and operational activities[4] where they are most needed.

The NRSC also identified that the benefits from investment in addressing these problems and improving the resilience of the transport system are:

- An improved ability for communities to make informed decisions about resilience and prepare for, absorb and recover quickly from adverse events;
- A resilient, affordable transport system that meets user and community tolerances and risk appetite;
- Resilience is considered as part of all planning and investment decisions to influence activities that increase vulnerability; and
- There is an integrated, transparent and 'system-wide' approach to prioritising responses and optimising resource allocation.

Other previous resilience projects and business cases

Since 2013, the Transport Agency has undertaken a number of projects and business cases to address the resilience of the State Highway network. Although these previous undertakings have taken a much narrower lens than this case, they provide many useful insights that can be draw upon. As part of the development of this case a review of a number of other relevant resilience projects was undertaken. A full summary of this review is provided in Appendix A.

Key relevant points from the review include:

- There is a need to match major hazards with critical infrastructure;
- Key success factors in successfully addressing resilience include:
    - Investment decision making;
    - Collaboration.
- There is a range of approaches to evaluating risk to the land transport system; and
- Addressing resilience issues across the land transport system should involve a range of approaches including investment in upgraded or changed infrastructure, asset management planning and emergency preparedness.

[4] Includes reduction, readiness, response and recovery activities

STRATEGIC ALIGNMENT

Alignment to New Zealand legislation

Climate Change Response (Zero Carbon) Amendment Act (2019)

This Climate Change Response (Zero Carbon) Amendment Act (2019) ("the Act") amends the original Climate Change Response Act 2002 to introduce climate change adaptation requirements. Amongst other things, the Act introduced an obligation to a national climate change risk assessment that identifies:

"the most significant risks to New Zealand, based on the nature of the risks, their severity, and the need for co-ordinated steps to respond to those risks in the next 6-year period." (S5ZM clause (b))

This assessment must be done within one year of the commencement of the Act. Further, a national adaptation plan must be prepared that considers the effect of climate change across society, taking into account the ability of communities (amongst others) to undertake adaptation action, and taking particular account of scientific and technical advice.

In addition, the Act empowers the Minister or Climate Commission to request information on climate change adaptation from *reporting organisations* including crown entities.

Section 5ZW of the Amendment Act sets out what may be requested:

(a) a description of the organisation's governance in relation to the risks of, and opportunities arising from, climate change:

(b) a description of the actual and potential effects of the risks and opportunities on the organisation's business, strategy, and financial planning:

(c) a description of the processes that the organisation uses to identify, assess, and manage the risks:

(d) a description of the metrics and targets used to assess and manage the risks and opportunities, including, if relevant, time frames and progress:

(e) any matters specified in regulations.

This NRPBC would form part of the evidence base for climate change adaptation planning for the transport sector.

Alignment to the New Zealand government's priorities for land transport

Government Policy Statement on Land Transport 2018/19 – 2027/28

The Government Policy Statement on Land Transport 2018/19 – 2027/28 (GPS 2018) sets out the government's strategic priorities for the land transport system and provides guidance for allocation of the National Land Transport Fund (NLTF) to different types of investments known as activity classes. It provides strategic direction for the development of the National Land Transport Programme, (NLTP) and associated Regional Land Transport Plans (RLTP's) and guides investment in activities that best achieve the results government wants for the land transport system.

One of the government's strategic priorities outlined in the GPS 2018 is to improve access. Access is defined as people's ability to connect with people, goods, services and opportunities and thereby engage in economic and social activity. To improve access, the GPS 2018 specifies three key objectives which should be met. One of these is 'A land transport system that is resilient'. In meeting this objective, the result that the government wants to achieve is 'improved network resilience for the most critical connections.' The successful delivery of this NRPBC is therefore a significant milestone in achieving this objective.

Figure 4 outlines how the strategic priority of improving access and its associated objectives work together to contribute to the delivery of the land transport system that the government is striving for.

Figure 4: Strategic direction of the Government Policy Statement 2018/19 – 2027/28

The GPS 2018 prioritises investment that improves resilience on routes where disruptions pose the highest economic and social costs. This includes investments to improve the resilience of the land transport system to gradual changes (for example sea level rise and resulting erosion) and high impact events of low and medium probability events (for example earthquakes). It also promotes the development and implementation of regional plans to improve targeting of resilience risk and vulnerabilities in an integrated system-wide approach. This approach can also improve recognition of interdependencies.

The GPS 2018 also supports investment for the best solutions on the most critical transport routes in regions that have only one viable route in and out. Examples given include the recovery of land transport system into and across North Canterbury and for urban areas such as Auckland, Wellington and Christchurch. In all cases these are vulnerable to high impact low probability natural events.

The GPS recognises that it often takes a whole-of-system approach to achieve the best results when improving network resilience. On this basis a regional and local system approach is encouraged. The GPS recommends that all parts of the transport system and non-transport systems relevant to the resilience of the land transport system be considered (e.g. flood mitigation infrastructure). Taking a whole-of-system approach also advances one of the government's supporting strategic priorities; value for money, by encouraging resilience investments that deliver the right infrastructure and services to the right level at the best cost (Ministry of Transport, 2018a).

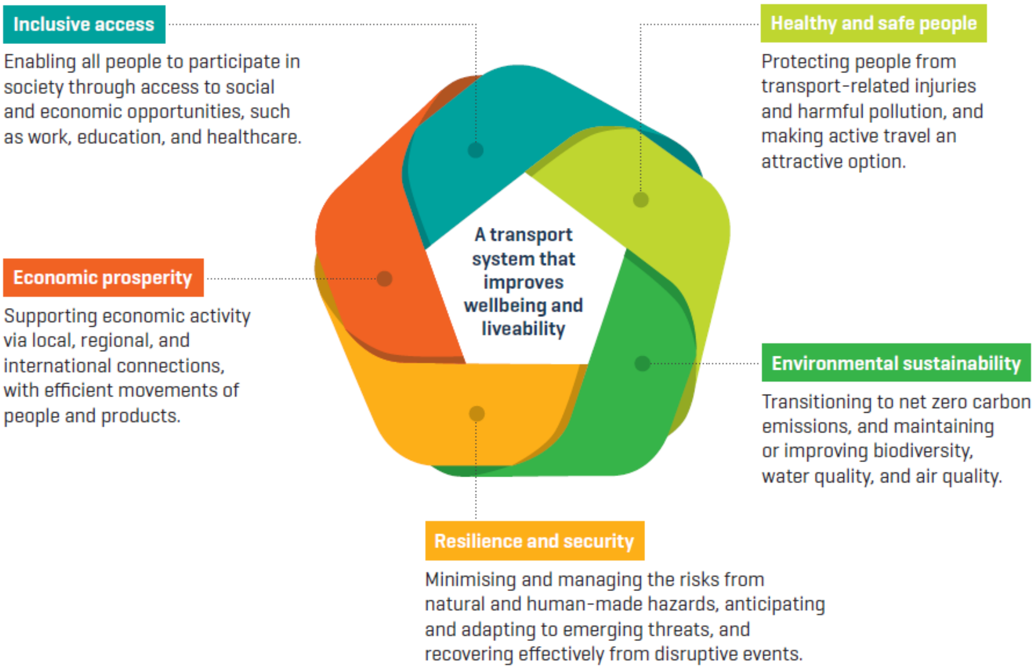
In March 2020, the Ministry of Transport released the draft Government Policy Statement on land transport 2021/22–2030/31 (the draft GPS 2021) for public feedback. The draft GPS 2021 builds on the strategic direction of GPS 2018 by maintaining the priorities but updating them to align with recent policy work and simplifying them. The Government is proposing to prioritise safety, better transport options, improving freight connections, and climate change.

Transport Outcomes Framework 2018

In June 2018 the MoT launched "A framework for shaping our transport system: Transport outcomes and mode neutrality". The framework is intended to be enduring (across Governments) while recognising that each Government would have its own priorities.

This framework defines five long-term strategic outcomes for the transport system. These outcomes are interrelated and need to be achieved together to improve intergenerational wellbeing and the quality of life in New Zealand's cities, towns and provinces. The five outcomes are summarised in Figure 5.

Figure 5: Ministry of Transport's Transport Outcomes



One of the core outcomes defined by the framework is resilience and security. The Ministry indicates this can be addressed by:

- Minimising and managing the risks from ongoing natural and man-made hazards that cause damage to infrastructure and communities;
- Anticipating and adapting to emerging and increasing risks so that the transport system is prepared – particularly for the impacts of climate change; and
- Ensuring the land transport system is resilient and ready to withstand, recover and respond to disruptive events. A well-functioning transport system is vital for restoring communities and business activity after an emergency (Ministry of Transport, 2018).

The Draft Transport Resilience and Security Strategic Framework

Also being developed by the Ministry of Transport, the Draft Transport Resilience and Security Strategic Framework provides more specific direction about how all transport investment partners can achieve resilience and security through the national transport system. The overall outcome sought by this framework is that the transport system minimises and manages the risks from natural and human-made threats and recovers effectively from disruptive events.

The framework defines 4 key objectives which outline what a resilient transport system looks like and how it behaves. This NRPBC contributes to objective one 'Reduce', which the framework outlines would be achieved when; risks are understood, and conscious decisions are made to reduce their likelihood and/or consequence. The framework also defines four key enablers, which inform government how best to utilise the levers to achieve resilience and security through the land transport system. This NRPBC delivers a component of the data, analytics / modelling and intelligence enabler, given an output of this case is to provide an evidence base of the geographical risks exposed to natural hazard risk within the land transport system and provides a supporting risk prioritisation methodology and decision-making framework.

The New Zealand Transport Agency Amended Statement of Intent

The Transport Agency's Amended Statement of Intent 2018-22 (ASOI) outlines a series of commitments that the Agency needs to make in order to support a land transport system that keeps people safe, is connected and can be accessed by everyone. This reflects how the Transport Agency will contribute to improving the wellbeing of all New Zealanders.

A key component of the ASOI is the eight position statements that were adopted by the Board in July 2019. These statements address how the Transport Agency will respond to the significant challenges that lie ahead for them and the overall land transport sector over the next four years. One these position statements is directly related to resilience with the Transport Agency's stating its position as:

> *The resilience of the land transport system is increased by managing risk and long-term resilience challenges and helping communities recover quickly from disruptions.*

The ASOI also sets out two key resilience targets that the Transport Agency is aiming for by 30 June 2021. These are:

- A system that is recognised as appropriately adapting to climate change; and
- The reputation as highly responsive to significant disruption.

The ASOI notes that to address resilience and achieve the targets they have set would require a cross-government partnership approach, including:

- An increased understanding of hazard risk, system vulnerability, best-practice response and community tolerance;
- Working together to reduce the impact of disruptive events; and
- A decision-making framework that appropriately values the wider benefits of a resilient system (NZ Transport Agency, 2019).

Interface with the Transport Agency's priorities for land transport

Sustaining a resilient land transport system also underpins other key parts of the Transport Agency's current work programme. This includes:

- Arataki: Our Plan for the Land Transport System;
- Quick Wins project; and

- Toitū Te Taiao: Our Sustainability Action Plan.

Other workstreams are identified in Dependencies (on Page 63) and described in Appendix I.

Arataki: Our Plan for the Land Transport System

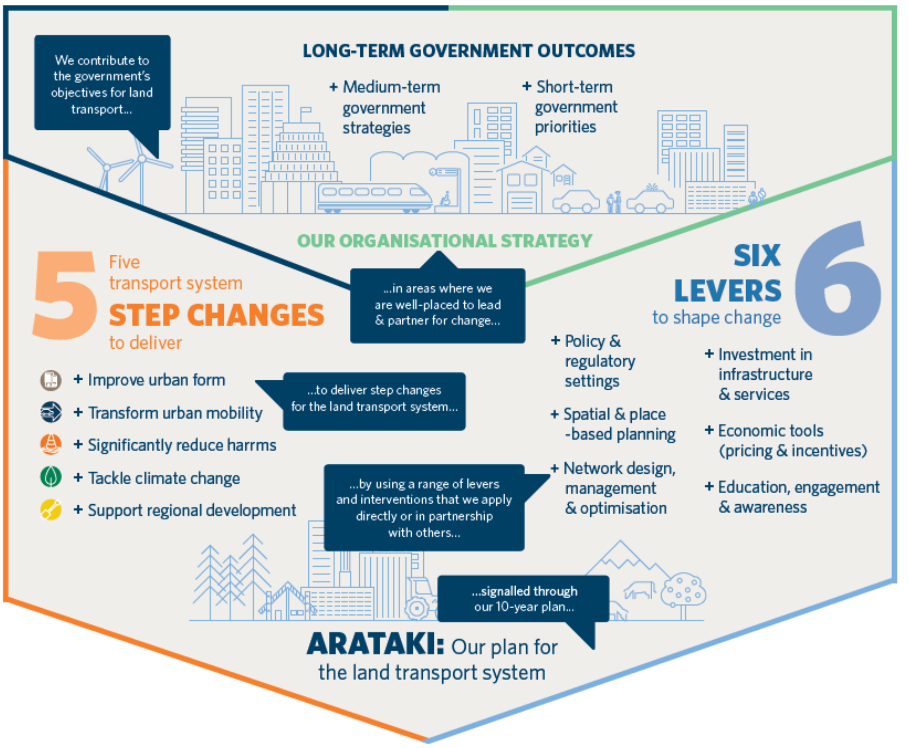
What is Arataki?

Arataki presents the Transport Agency's 10-year view for what is needed to deliver on the New Zealand government's current short-term priorities and long-term outcomes for the land transport system. It provides a series of place-based summaries which provide a national story, three pan-regional summaries (upper North Island, lower North Island, South Island) and 14 regional summaries, which are framed by:

- Five step changes where the Transport Agency sees there is a need for significant change (over and above maintaining base levels of service);
- These step changes respond to six key drivers that influence the future of the land transport system and inform what the Transport Agency and its co-investment partners need to do across;
- Six key levers that deliver the government's objectives for the land transport system.

The strategic approach taken by the Transport Agency to develop Arataki and the specific step changes and key levers is shown in Figure 6.

Figure 6: Transport Agency Strategic Approach to Arataki



Arataki provides the Transport Agency and its co-investment partners:

- A shared evidence base to support better and more aligned decision making;
- A system view across a range of levers;
- A place-based focus that translates government objectives into a better planned and staged approaches for regions, cities, towns and transport corridors;
- A focus so that all land transport investment partners can target effort where it is most needed;
- Clarity of roles around how the Transport Agency would partner for change;
- A better sector capability that land transport investment partners can best respond to changing needs (NZ Transport Agency, 2019a) and;
- Potential national and regional responses and priorities.

Interface with this NRPBC

Arataki Version 1 was adopted by the Transport Agency and released for engagement in December 2019. Version 1 of Arataki has been produced in parallel with this case. Resilience cuts across Arataki's step changes, but two that are particularly relevant are:

- Improved urban form to optimise transport's role to improve connections between people, products and places. This would be achieved by integrated land-use and transport system planning; and
- Tackling climate change by enhancing community's long-term resilience to the impacts of climate change. This would be achieved through adaptation which would ensure the system and communities are better prepared for, and resilient to, climate change impacts such as increasingly severe storms and sea level rise.

Arataki encompasses a broader mandate, compared with this NRPBC, as it seeks to addresses resilience amongst other co-benefit streams such as safety. The regional summaries in Arataki set out the natural hazard issues affecting different regions including those caused by and exacerbated by climate change (such as sea level rise and flood risk) and low-frequency high impact events (such as earthquakes). Arataki provides a 10-year view for addressing medium term issues (30-years), whereas this case takes a longer view of the changes and impacts caused by natural hazards, viewing risk over a 70-year period.

This PBC would form part of the evidence basefor future versions of Arataki. This NRPBC provides a more in-depth analysis of natural hazard risks and may inform additional priority sites that would need to be addressed in the short term by Arataki.

Quick Wins project

The Transport Agency is currently undertaking this project to identify risks to the land transport system which can form projects for delivery in the next National Land Transport Programme. The project is expected to identify actual points on the network where the risk warrants either a Low-Cost / Low-Risk project or more detailed investigation. There are clear linkages and potential overlap between the Quick Wins project and this case, so it is critical that both pieces of work inform each other to avoid double effort.

Toitū Te Taiao: Our Sustainability Action Plan

The Transport Agency has developed *Toitū Te Taiao: Our Sustainability Action Plan*, an internal Plan to provide further direction on (amongst other things) climate change mitigation and how to reduce emissions from the land transport system. Toitū responds to four challenges: Reducing GHG emissions; improving public health; reducing environmental harm; and reducing the Transport Agency's emissions. This case focuses on climate change adaptation and other natural hazards, which are not included in Toitū.

Relationship of this case to other resilience work

Appendix B provides further detail on how this NRPBC aligns with international, national and regional strategies and priorities.

THE NEED FOR INVESTMENT

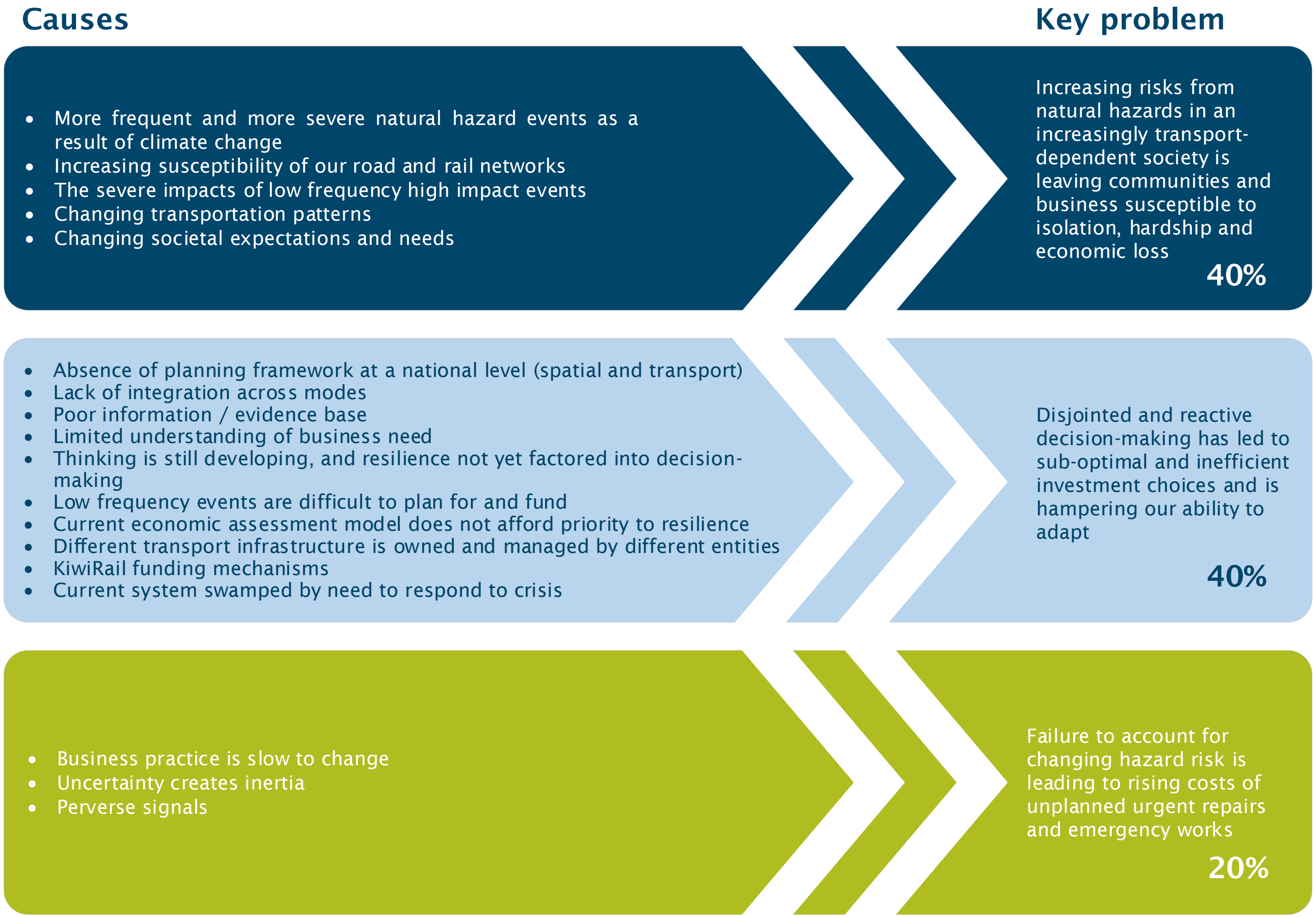
This section sets out the challenges that this programme seeks to address.

Defining the problem

A workshop was held on 7 November 2019 attended by representatives of the Transport Agency, the Northern Transport Alliance and Tauranga City Council to review and update the problem statements and associated benefits of the NRSC (January 2019). These have been further tested with stakeholders from GNS, NIWA and the Horizons Regional Council (Manawatu-Wanganui Regional Council). The direction set by the problem statements from the NRSC remains largely unchanged but have been refined and clarified with stakeholders to create these refreshed statements.

An overview of the key problems and root causes is shown in Figure 7.

Figure 7: NRPBC problem overview



The Investment Logic Map is attached as Appendix C.

Problem 1

Increasing risks from natural hazards in an increasingly transport-dependent society is leaving communities and business susceptible to isolation, hardship and economic loss.

This is the immediate challenge to hand. The root causes of this problem are set out below.

More frequent and more severe natural hazard events as a result of climate change

The Ministry for the Environment (2016) summarises that the main consequences of climate change for New Zealand are; higher seas levels and higher storm surges affecting all coastal areas; more extreme high temperatures and fewer extreme low temperatures; less rainfall on the east coast and more rainfall to the west; snow and glaciers retreating to higher altitudes; and more intense rain and wind events. However, there remains a level of uncertainty around the magnitude, timing and spatial allocation of these consequences, given variances between models.

Gardiner et al. (2009) state that New Zealand's transport infrastructure is most exposed to risks that arise due to:

- Coastal inundation from sea-level rise and storm surge;
- Inland flooding;
- High intensity rainfall, associated flooding and inland erosion;
- Prolonged high temperatures and;
- To a lesser extent winds, fires, lightning, structural damage from humidity and saltwater, and heat and freeze-thaw episodes damaging road surfaces.

Changes in both the mean climate condition and in the variability around the mean climate condition can alter the probability of extreme weather events as seen in Figure 8 to the right (Benson et al., 2011). For example, sea-level rise would profoundly increase the incidence of surge tides - a 30cm rise in sea level is expected to increase the frequency of extreme sea-level events that currently occur once every hundred years to once every year in Wellington and Christchurch, every two years in Dunedin, and every four years in Auckland (Ministry for the Environment, 2017).

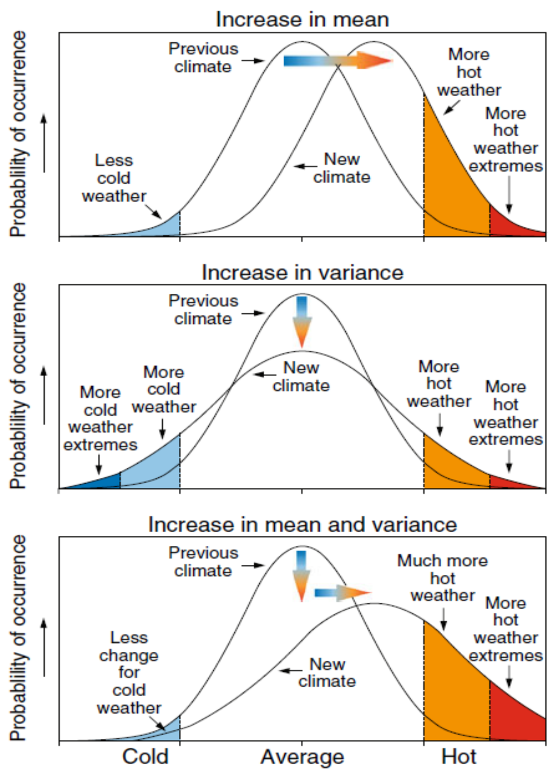


Figure 8: Changes in the frequency of extreme weather events if the mean weather condition increases, (top graph) the variance in the mean weather condition changes (middle graph) or if both increase (bottom graph).

Climate change affects the land transport system itself by causing damage, accidents and disruptions to transport flows. These impacts can result in wider effects on communities and the economy (Koetse & Rietveld, 2009). The Ministry of Transport (2015) advises that there is already strong evidence that more frequent extreme weather events are already causing significant costs and disruptions to the land transport system, including loss of mobility and access to services.

Case study: Supply-side impacts of climate change

In June 2013, a storm severely impacted Wellington's wider transport system, causing both immediate and flow-on consequences for many commuters throughout the region. The storm caused significant damage to the Hutt Valley rail line, leading to disruptions in passenger rail services for six days following the storm.

After the event, the Ministry of Transport, in partnership with the Waka Kotahi NZ Transport Agency, KiwiRail and Greater Wellington Regional Council undertook a research project which estimated that the economic impacts of disruption caused by the storm was between $12 million and $43 million. This included $5.3 million in infrastructure repairs and remediation, $5.3 million in extra travel costs for commuters and $2 – 32 million in lost output. These figures shed light on the scale and types of costs which can be incurred and is analogous to those which are caused or exacerbated by climate change.

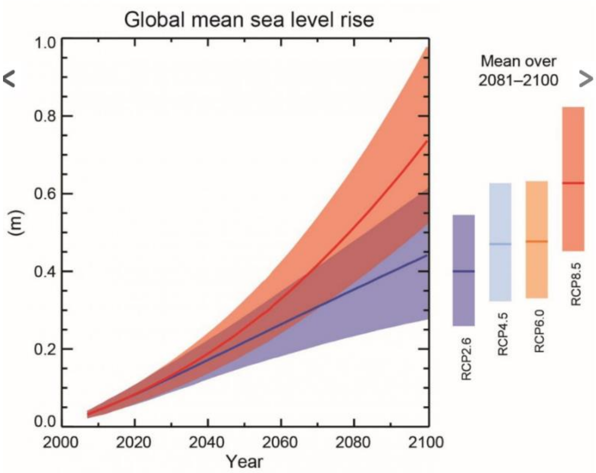
Case study: Ministry of Transport, NZ Transport Agency, KiwiRail and the Greater Wellington Regional Council. (2013). *The transport impacts of the 20 June 2013 storm: The effects of closing the Hutt Valley rail line between Petone and Wellington for multiple days*. Retrieved from https://www.transport.govt.nz/assets/Uploads/News/Documents/Transport-impacts-in-Wellington-storm-June-2013.pdf

Sea level rise and storm surges

The Intergovernmental Panel on Climate Change (IPCC) (2013a) states that global average sea-level rise will continue to rise during the 21st Century and estimates (see Figure 9) that by 2100 global average sea level rise (relative to 1986 -2005) is likely to be within the ranges of:

- 0.28 - 0.61 metres for RCP2.6 (scenario where greenhouse gas emissions are substantially reduced over time) or;
- 0.52 – 0.98 metres for RCP 8.5(scenario where greenhouse gas emissions continue to increase over time).

Figure 9: Projections of global mean sea level rise over the 21st century relative to 1986 – 2005.



Over the last century the average coastal sea levels in New Zealand have rose by 0.17 metres (Hannah & Bell, 2012). The Royal Society of New Zealand (2016) states that New Zealand would generally follow global changes caused as a result of climate change but with some differences. In the case of sea level rise the average for New Zealand is likely to be about 10% more than the global average. Based on this, projections to 2100 show that New Zealand average sea level rise is expected to be within the ranges of:

- 0.3 – 0.6 metres for RCP2.6
- 0.6 – 1.1 metres for RCP 8.5.

It is also expected that sea level rise will continue past 2100, even if global temperatures stabilise, as land-based ice would continue to melt, and the oceans would continue to get warmer as they adjust to a warmer atmosphere.

The Ministry of Environment (2017a) too expects sea level to rise by an average of 0.2 – 0.3 metres by 2040. As sea levels rise, communities and land transport infrastructure occupying coastal land would be increasingly exposed to flood inundation arising from combinations of storm-tide, elevated groundwater, high river flows and intense rainfall super-imposed above a higher sea-level (Paulik et al. 2019a). Sea level rise would also increase the rate of coastal erosion (Royal Society of New Zealand, 2016) and the frequency of coastal flooding events (Stephens, 2015).

Heavy rainfall and landslides

Climate change increases the frequency and intensity of heavy rainfall events. Carey-Smith et al. (2018) estimate that for a rainfall event that occurs once every century there would be:

- A 14% increase in rainfall depth per degree of warming for a one hour-long rainfall event; and
- A 9% increase in rainfall depth per degree of warming for a 24-hour-long rainfall event.

Heavier rainfall events threaten more severe riverine floods, pluvial floods and landslides[5]. These events cause disruptions to land transport infrastructure with close proximity. These disruptions can be caused for example by, blocking roads and rail bridges.

[5] Landslides are already a high risk in many parts of New Zealand due to heavy rainfall and earthquakes.

Heat extremes

The Ministry for the Environment (2016) forecast that New Zealand's mean temperature would increase by 0.2 – 1.7°C by 2040 and 0.1 – 4.6°C by 2090, relative to 1995 temperatures. This increase in mean temperatures is combined with an amplification of heat extremes. Both natural hazards threaten the land transport system through road and rail buckling which damages infrastructure and results in more frequent closures. Similar impacts may also occur due to wildfires.

Damaged infrastructure results in subsequent repair costs and road closures cause disruptions which have flow on effects, to the communities and businesses who rely on the affected sections of the land transport system (Blakeley et al., 2019).

Increasing susceptibility of our road and rail networks

Most New Zealanders live within a few kilometres of the coast (NZ Transport Agency, 2019 b). Work undertaken by NIWA has indicated that significant lengths of the land transport system are susceptible to impacts from changing sea level rise. While approximately 90% of these are local roads, significant lengths of collector and arterial routes are likely to be impacted within a relatively low level of sea level rise. The areas with the greatest exposure for roads are in Waikato / Coromandel, Canterbury, Bay of Plenty and the greatest exposure for rail is in Otago. NIWA estimates that nationwide a total of 2,121 kilometres of road and 46km of rail are exposed to a 1.5 metre sea level rise, with the implication that adaptation work needs to occur sooner rather than later (Bell et al., 2015).

Another report also undertaken by NIWA observed what would happen when rivers are flooded by heavy rain and storms and found that nationwide a total of 19,098 kilometres of road and 1,577 kilometres of rail are exposed to river flooding in the event of extreme weather events (Paulik et al., 2019).

The severe impacts of low frequency high impact events

New Zealand is familiar with the severity and consequences of low frequency high impact events such as earthquakes on its land transport system and the communities it serves.

In 2017, the Minister of Economic Development and Transport released a report which assessed the economic impact of the 2016 Kaikoura Earthquake. This focussed on the economic impacts of damage and loss of connectivity. The loss of connectivity also has social, cultural and environmental impacts at the location of any disruption and also on alternative routes. This was demonstrated through the extend diversion of SH1 traffic via SH6, SH63, SH65 and SH7 and localised impacts around Kaikoura.

The report projected both the direct impacts (changes in expenditure, business operability and employment) and flow-on impacts caused by these direct impacts. The report projected the total cost of the rebuild of all transport related infrastructure to be between $2 billion - $3 billion (in 2016 dollars) and would take anywhere between 9 and 24 months to complete.

It determined that the total estimated loss to the New Zealand economy over the first 24 months following the earthquake was between $465 million - $513 million of GDP. $117 million - $137 million of this total loss was in Canterbury while the remaining $348 million - $376 million was across the rest of New Zealand including significant impacts in Wellington. The report also found that approximately 45-51% of the total impact on GDP over the 2 years is attributed to increases in transportation costs (freight). This is because increased transportation costs mean New Zealand consumers can afford to spend less on other goods and goods in New Zealand become less competitive with overseas goods. Lost business operability is also attributed in the report as having a significant impact on GDP. A significant contributor to lost business operability was travel disruptions caused by road closures and damaged transport infrastructure among other factors (Market Economics, 2017).

As the assessment focussed on economic costs, it does not reflect the full scale of the economic and social impacts on New Zealand arising from the 2016 Kaikoura earthquake.

Changing transportation patterns

Population growth, demographic changes and increased economic activity have evolved the patterns of transport usage. These changes result in increased freight movement and a greater number of trips to access employment, services, education and recreation. Patterns of use are also shifting with changing expectations around the movement of goods and use of public transport modes. Collectively these changes put pressure on the land transport system.

Increased use of all transport modes increasing demand for the land transport system

The use of all land transport modes including: private vehicles, vehicle sharing, public transport, (trains and buses) active modes (walking and cycling) and other modes (e.g. mobility scooter) has increased year on year. Most of this increase is in private vehicle use and freight. This increased usage creates greater demand on the land transport system, which increases the potential impact that a disruption due to a natural hazard could cause. The Ministry of Transport (2017a) also projects that the use of these modes is would continue to grow, with the total number of trips increasing by 30% to more than 7.6 billion trips by 2043, compared to 5.9 billion in 2012/13.

More cars and more car use

New Zealand is considered among the top ten countries in terms of vehicle ownership per capita with 657 light passenger vehicles for every 1,000 people in New Zealand. The OECD (2017) attributes this to New Zealand's dispersed population, a history of low-density urban development and the associated challenges in expanding alternative transport modes (notably public transport).

The Ministry of Transport's Transport Outlook Current State 2016 ((Ministry of Transport 2017) provides some useful statistics. The increasing dependency noted by the OECD can be evidenced by the increasing number of light passenger vehicles on New Zealand roads. In 2015 New Zealand's vehicle fleet was made up of a total of 3.9 million vehicles in New Zealand, 78% of which were cars and SUV's. This figure had increased by 20% over 10 years and 44% over 15 years, with light passenger vehicles accounting for around three quarters of this growth.

New Zealand households mostly travel by car. 78% of trip legs and 93% of the total distance travelled by households is done either as a driver or passenger. This dominant share has increased over time. New Zealanders also spend the majority of their daily travel time travelling in a car. On average New Zealanders spend just under an hour travelling per day, and 36 minutes of this time is spent in a car either as a driver (30 minutes per day) or as a passenger (6 minutes a day). This amount has increased from 28 minutes per day in 1989/90.

In terms of the total distance travelled by all vehicles for all purposes (beyond household travel and excluding walking and cycling), cars and SUV's account for 76% of the total distance travelled in 2015. The remaining 24% is made up by light commercial vehicles, buses and heavy trucks (Ministry of Transport 2017).

Increased freight demand

Growing demand for freight has seen many more trucks on the roads and pressure for larger and longer vehicles to increase efficiency of transport. The National Freight Demand Study 2017/18 estimated that total freight tonnage by road and rail increased by 18.3% from 232 million tonnes in 2012 to 274 million tonnes in 2017/18. Total freight tonnage by road transport increased by 19.9% from 215.6 million tonnes in 2012 to 258.5 million tonnes in 2017/18 (Richard Paling Consulting, 2019). Projections of travel demand also indicate that freight tonnage by road and rail would continue to increase with estimations over the next 25 years predicting a 55% increase from 232 million tonnes in 2012/13 to 360 million tonnes in 2042/43.

Worldwide trends towards larger container vessels which visit fewer ports could also increase the dependency that national freight transport places on the road and rail systems that access port facilities, therefore increasing the criticality of these nodes (Ministry of Transport, 2017a).

Heavier vehicles (High productivity motor vehicles, HPMV)

There are significant efficiency gains to be made with the use of longer and heavier vehicles that transport more goods in a single vehicle. Since 2010, law changes have allowed increasingly longer and heavier trucks on the New Zealand State Highway network that can now carry more than 50-tonnes in comparison to the previous 44-tonne limit. In 2012 slightly more than 10% of New Zealand's freight was carried by these larger trucks, but by 2017 this had tripled to more than a third.

Allowing HPMV's to access more roads in New Zealand is one of the five key priorities of investment over the next two years as outlined in the Transport Agency's 2018-19 annual report. The proportion of highway available to HPMV's has increased from 45% of all highways in 2016, to 71% in 2019 (Pennington, 2019).

There are still large portions of the land transport system which are unsuitable for HPMV's to operate on. This is particularly the case for local roads which often serve as alternate routes to the State Highway network when disruptions occur. With an increasing trend towards the use of HPMV's to move freight, communities and freight companies are becoming increasingly dependent on the availability of those sections of the State Highway network available to these trucks. This growing dependency exposes both the communities serviced by HPMV's and freight companies that use them to a greater level of risk and increases the potential impact that a disruption due to a natural hazard could cause.

Changing societal expectations and needs

Population changes

New Zealand, like most countries, is becoming increasingly urbanised. Currently more than 70% of New Zealanders live in urban areas (Statistics NZ, undated). By 2043, we expect another 1.5 million people to live in New Zealand, with most of this growth being concentrated being in the 'golden triangle' (Auckland, Waikato and Bay of Plenty). Auckland alone would account for more than 50% of this population growth (Statistics NZ, 2016). As the population continues to rise in these areas additional pressure would be put on the land transport system for the movement of people and freight to and from the ports at Tauranga and Auckland.

In contrast to the golden triangle and other growing urban areas, some parts of New Zealand are forecast to experience slow growth or even decline in the case of the West Coast. By 2043, 16 of New Zealand's 67 territorial authorities are projected to have fewer residents than they did in 2013 (Stats NZ, 2016). Regions projecting decreases are primarily rural areas that tend to have a greater reliance on roads to access service centres but struggle to maintain their networks to satisfactory levels. In addition, some of these areas have also seen rises in visitor numbers, putting pressure on often already under-maintained or under-capacity infrastructure.

Continued growth has also impacted how urban areas are developed. Past approaches to urban development have generally resulted in low-density, car-based development with insufficient consideration of optimising where people live, work, study and play (NZ Transport Agency, 2019c).

Technology changes

Changes in technology are also changing the way people interact with land transport systems. To date changes have largely been about how people receive information and make journey decisions, but in future may change the shape of how the system is used (e.g. autonomous vehicles, vehicle sharing) if not the system itself.

A thriving tourism sector

Tourism is New Zealand’s largest service export (NZ Transport Agency, 2019d) and the industry is continuing to grow with more and more international visitors coming every year. In 2016 alone, there was a total of 3.5 million overseas visitors, which was up 12 % from 2015 and 45% since 2006. This number is also forecast to increase with visitor numbers swelling to an estimated 5.1 million by 2025 (Ministry of Business, Innovation and Employment, 2019).

The tourism sector is highly dependent on the land transport system for the movement of tourists to and from key entry points into the country and between major visitors’ centres and attractions. Growth in tourism creates increased demand on the land transport system with greater use of cars, camper vans and tourist coaches within and between main tourist centres such as Queenstown and Rotorua and the key overseas entry points of Auckland and Christchurch (NZ Transport Agency, 2019b). The tourism sector puts increasing pressure on susceptible routes such as SH6 on the West Coast of the South Island. It also relies on the system to support the delivery of extra goods such as food to tourism hotspots. Growth in tourism therefore increases the dependency that the industry has in the land transport system (Ministry of Transport, 2017) but is also subject to global markets and conditions.

At April 2020 the impacts of the COVID-19 pandemic are unclear but seems likely that there will be an extended period of little or no international travel. This implies that that a recovery to 2019 tourism numbers and associated impacts on the land transport system may not occur and will certainly take a long time.

Increasingly centralisation of services

Services have increasingly been centralised over the past few decades as the sophistication and costs of services such as health have increased. Recent examples include closure of maternity facilities in place such as Te Anau, and small hospitals in rural towns, and closures of small rural schools. This has resulted in people having to travel further to receive support and services, and increased the dependence on travel and private vehicles.

Just-in-time and last mile delivery systems

New Zealand’s demands on the services that the land transport system provides has increased and expectations of the levels of service provided are changing. For example:

- Businesses are shifting towards ‘just in time’ logistics chains to generate cost savings on storage facilities, as goods are moved from larger transport hubs; and
- Consumers are increasingly shopping online and relying on ‘last mile delivery’ systems to deliver the goods they want and need to their doorstep.

Both trends assume and rely upon a very high level of availability for the land transport system. Expectations of availability however are often far greater than the level at which the transport system is designed and maintained. This can mean that communities have much lower resilience if they are relying on the supply of non-local goods such as food. It has been estimated in a previous case that Wellington for example has about 3 days of food supply in the city at any one point in time, which suggests the city is exposed to significant risk of supply shortages should a natural hazard occur.

Case study: Just in-time delivery systems

In July 2014, an extreme storm event lasting four days caused severe flooding and landslips that closed State Highways 1, 12 and what is now State Highway 15 in Northland. The road closures isolated many communities in the Far North and led to brief shortages in food and fuel as road access was cut off for many trucks and tankers making freight deliveries from Auckland. Even when access was re-established, it was very limited, and the diversion routes required truck drivers to travel longer distances, further delaying the supply of food and fuel. There were also reports that some trucks had tipped over trying to access alternative routes.

Despite the fact this extreme weather event only caused brief shortages in food and fuel supplies, it did demonstrate how communities have a much lower resilience when they rely on non-local food supplies. Communities in Northland, like many other parts of the country have become increasingly dependent on the land transport system for the supply of goods, fuel and food. Almost all of these supplies are now delivered to these communities by road, increasing the potential impact that a disruption due to a natural hazard can cause. Northland also has a lack of suitable alternative transport routes, should State Highway access be cut off, further exposing communities to a greater risk of isolation.

Left: State Highway 1 at Maromaku, south of Kawakawa, remains closed due to storm damage.

Image: Radio NZ

Case study: Northland Regional Council, NZ Transport Agency, Far North District Council, Kaipara District Council & Whangarei District Council. (2018). Regional Land Transport Plan: 2105 – 2021 Three Year Review. New Zealand. Retrieved from https://www.nrc.govt.nz/media/10642/finalrltp20152021reviewfor20182021.pdf

Existing development in areas subject to escalating risk

Many of New Zealand's communities have established near rivers and coastlines. There are extreme examples where communities have had to be relocated due to risks such as flood hazard risk (Nightcaps in Southland, parts of Franz Josef south of the Waiho River, on the West Coast of the South Island) or elevated (Kaeo in Northland). Many areas are subject to frequent inundation or loss of access through inundation (e.g. Monaco Peninsula, Nelson, Thames) and many more would be at risk as sea levels rise. All these communities are serviced by land transport and would face deteriorating service levels or increases in costs for maintaining access.

Problem 2

Disjointed and reactive decision-making has led to sub-optimal and inefficient investment choices and is hampering our ability to adapt.

This is a problem affecting the planning system as a whole, not just the land transport system. Network decisions are rarely taken at a system level, but at an individual network level. The majority of place-based decisions are made within geographic limits, and while impacts on networks that transcend those geographic limits are considered at the transactional level, it is more challenging for local government entities to make trade-offs at the strategic or system level.

The Transport Agency has recognised this challenge and encouraged pan-regional considerations in RLTPs. This challenge is also recognised in Arataki, and so some extent in the drive for more integrated spatial planning through recent Resource Management Act proposals.

Our current development investment and decision-making system has evolved over time and has established processes that have resulted in decisions that do not necessarily serve NZ best over the long term. Lock-in of these investment decision processes has meant that other options have not been necessarily identified, considered or protected, or are very difficult to progress due to impacts on the communities they serve, and cost. An example of this is allowing ongoing development in areas that are challenging to service with reliable land transport connections (remote coastal communities, lifestyle blocks in areas subject to landslides). Decisions do not take a systems approach and often rely on infrastructure solutions to ‘build our way out’ of problems.

Absence of planning framework at a national level (spatial and transport)

Local government entities have responsibility for development patterns in their own jurisdictions. They are inherently limited by their geographic boundaries, and by requirements under the Local Government Act 2002. While triennial agreements create the mechanism for a degree of cooperation and rationalisation within regions, no such mechanism currently exists outside or between regions. Further, local authorities are bound to make financial decisions in a manner that benefits its community. This creates a high bar for any entity to make decisions that might favour a broader community of interests (i.e. in the national interest) (Ministry for the Environment, 2019).

The Transport Agency as a network utility provider (alongside other network utilities) has no status other than as a requiring authority under the Resource Management Act 1991. This enables it to utilise powers to protect existing and planned investments (including recourse to the Public Works Act for land acquisition). It has no greater ability to influence land use planning decisions than any other entity. This means areas may be developed with limited regard to the implications for developing or maintaining connectivity considering current and projected future hazards.

The Transport Agency relies on mechanisms within the Land Transport Management Act 2003. This includes the National Land Transport Programme, which is built up from Regional Land Transport Plans, to identify priorities and allocate funding across a range of activity classes. There is an ability for the Transport Agency to influence local authority decisions on land transport infrastructure through these processes, particularly through funding allocations. It is however largely a top-down policy process combined with a bottom-up prioritisation process.

A consequence of this fragmentation is that each jurisdiction has undertaken its own land use planning, with cooperation often not going beyond managing boundary effects. In some areas, competition for growth between local authorities has led to developments in less than optimal locations that not only fail to maximise the broader benefits to the nation, but in some cases, expose communities to risk (such as in low lying areas) or in areas that are difficult or expensive to service from a transport connectivity perspective.

The National Policy Statement on Urban Capacity sets out expectations for certain localities to complete a future development strategy and set minimum targets for development capacity for housing; a number of councils are now developing spatial plans as part of this and NZTA is a key partner involved in this planning to ensure spatial and land transport planning are integrated in major urban centres.

Lack of integration across modes

Road and rail planning have been disconnected for more than 30 years. There are now moves to bring systems into alignment in order to achieve more mode neutrality, but this would take time. Management of natural hazards and hazard events at specific locations is one area where collaboration is beginning to occur; but information systems and approaches are disconnected.

Poor information / evidence base

Natural hazards information is by nature uncertain with projections for the frequency and severity of future events based on our current understanding. For predictions incorporating the impacts of climate change multiple scenarios can make it difficult to select the most appropriate future projections to use for a given purpose. The adoption of the precautionary principle where there is uncertainty is good practice, this reflected in the climate change projections generally used for policy and decision making in New Zealand.

Environmental reporting, including natural hazards such as flooding often draws on information from a range of disparate sources (Parliamentary Commissioner for the Environment, 2019). There is an increasing demand for better, more widespread use of data across New Zealand. Improving the quality of, or access to, natural hazards, transport and related data would lead to a better evidence base on which decisions can be made about addressing risks to the land transport system.

Limited understanding of business need

As noted above the NLTP is built up from RLTPs and relies on the RLTP process to identify needs of each region. This means that there is not necessarily a national picture of what the consequences of any particular outage are for road transport other than at a high level. This is an issue that is addressed at the regional level, and increasingly through Customer Insights work at the Transport Agency. Arataki also provides some level of consistency and regional councils can use it to inform the development of their RLTPs.

KiwiRail has a strong understanding of the business needs of its customers as a result of their commercial model. KiwiRail both provide and use the rail infrastructure with their customers being passengers or freight forwarders.

Thinking is still developing, and resilience not yet factored into decision-making

The previous NRSC identified that while the language of resilience had been incorporated into core policy documents and plans, many processes and practices still exist that do not support implementation. Examples identified in the previous case included that design requirements do not adequately take onto consideration long-term sea-level rise or other climate-change related scenarios. In some areas thinking is rapidly evolving, and Arataki identifies the step changes required to address these matters. It would take time however for these changes to be implemented through the system and embedded through reviews to core planning and accountability documents such as Asset Management Plans. Arataki can be used to inform the evidence base for Regional Land Transport Plans which would start to drive the step changes.

Low frequency events are difficult to plan for and fund

While the likelihood of hazards occurring are known (e.g. risk of landslide) they are often deprioritised in favour of more immediate issues. It is difficult for a local authority to prioritise an investment to protect against an event that might happen at some stage in the future in the face of community pressure to fund something else, or to keep rates down. The consequence of this is that when an event does occur, preventative or mitigating measures are not in place, and yet more pressure is put on emergency funding.

Current economic assessment model does not afford priority to resilience

This is a widely recognised issue for land transport investment partners when addressing resilience. National Emergency Management Agency (NEMA - formerly Ministry of Civil Defence and Emergency Management) recognises the difficulty in making an investment case for resilience revolves around the traditional methods of appraising investments in disaster risk management. NEMA states that these traditional methods undervalue the benefits associated with resilience and that this is linked to the perception that investing in disaster resilience would only yield benefits once disaster strikes. NEMA also recognises that one of the main barriers limiting our pursuit of resilience is that the full costs of disasters due to natural hazards are often not completely visible (particularly the cost of indirect and intangible impacts including the wider environment, social and cultural impacts). This lack of visibility often means these costs are not factored into the investment decision makers process undervaluing the benefits of investing for resilience (Ministry for Civil Defence and Emergency Management, 2019).

The Transport Agency 2018 Resilience Framework also recognises this issue noting two challenges which limit the wider land transport sectors efforts to improve system resilience as:

- Limited understanding, evidence and metrics of how disruption in different locations impacts on customers and communities' well-beings and their tolerance and acceptance of risk; and,
- Assessment frameworks and discount rates serve to undermine investment in low frequency events and effective trade-offs across programme outcomes (e.g. safety vs resilience vs reliability) (NZ Transport Agency, 2018a).

Different transport infrastructure is owned and managed by different entities

New Zealand's land transport infrastructure consists of many long-lived assets which are owned and managed by different investment partners. This decentralised ownership structure and lack of integration between all investment partners makes it difficult to coordinate decisions about how to address the resilience of the system and adapt to climate change. This can increase the ambiguity surrounding who should pay for such effort or can lead to double effort, with entities addressing the same issue in isolation of each other.

Another complexity created from the decentralised ownership structure, is different investment partners have different timeframes to make intervention or adaptation decisions. This is because:

- Different parts of the system are exposed to different types of resilience related risks (particularly the case for climate change risks);
- Different land transport assets have different effective lifetimes; and
- Different funding mechanisms affect when and how funding can be accessed. For example, the Future of Rail Review found that KiwiRail's current planning and funding framework isolated road and rail infrastructure decisions from each other, making it difficult to deliver a coordinated land transport investment programme (Ministry of Transport, 2019a)[6].

Participants of the Motu note #40 (Blakeley et al., 2019) agreed that it was unclear whether land transport investment partners had institutional arrangements that would align these timeframe differences, demonstrating an inability to facilitate coordinated decisions to address the resilience of the land transport system.

KiwiRail funding mechanisms

KiwiRail faces many of its own resilience challenges which other investment partners do not. The *Future of Rail Review* found that the current planning and funding framework for the rail network involves short-term funding decisions which are inadequate for long lived assets. This has hampered KiwiRail's ability to invest in creating a resilient and reliable rail network. Although there has been past investment in both freight rail and passenger networks, it has not been consistent or sustainable. KiwiRail has been unable to fully fund the level of investment needed to complete the required maintenance for the national freight network. The Draft New Zealand Rail Plan notes that the lack of long-term investment:

> '*Has resulted in a backlog of deferred maintenance and renewals, with significant parts of the national freight rail network facing a state of managed decline.'*

The Draft Plan seeks to better integrate the rail network into the land transport system, ensuring it is planned, funded and maintained as part of this system (Ministry of Transport, 2019a).

Note: Central Governments also announced a $12 billion infrastructure investment during the development of this PBC which includes some investment in rail.

[6] At a practical level, KiwiRail are often able to move from concept through to implementation quickly, reflecting a historic need to respond quickly when funding is available. NZTA have a longer project development and approval process, reflecting a different (public) funding model.

Current system swamped by need to respond to crisis

An ongoing challenge in recent years has been the need to respond to crisis as New Zealand has been hit by a series of natural disasters, such as earthquakes and cyclones and the global COVID-19 pandemic, that have diverted funds into recovery operations at the expense of long-term resilience planning. This particularly affects local government, where the need to respond to near term events can crowd out long term planning and investment.

NEMA recognises that one of the barriers limiting New Zealand's pursuit of resilience is the fact emergency management issues often require immediate corrective action. The NDRS acknowledges that this action is understandable and needed but taking this approach means that land transport investment partners often focus on fixing the problems of the day and address the issues from the previous event as opposed to forecasting and considering future risks and taking action for the long-term (Ministry of Civil Defence and Emergency Management, 2019).

While progress is being made to better understand future risks through the development of Arataki, (which has a particular focus on the risks posed by climate change) this still remains a challenge at a system level.

Problem 3

Failure to account for changing hazard risk is leading to rising costs of unplanned urgent repairs and emergency works.

This challenge recognises that increasingly New Zealand is locked into networks and systems with components that would become unsustainable over time (the emerging future problem). This largely impacts on the operational budgets of land transport investment partners. There is limited consideration of options that do not involve repairs and maintenance focussed on maintaining the current land transport system. Taking an adaptive management approach may be appropriate including consideration of managing (rather than removing) risk or retreating from heavily impacted areas.

A press release in November 2019 using Transport Agency figures showed emergency works spending had increased from about approximately $30M in 2014/15 to almost $79M in 2017/18 and just over $72M in 2018-19 with more costs to come (Sivignon, 2019).

Business practice is slow to change

Regional land transport plans (RLTPs) are six-year plans that document the regions' land transport objectives, policies, and measures as well as providing a statement of transport priorities for the region. They must be reviewed every three years and must align to the GPS. This means that there can be a lag between changes to GPS and implementation in practice. The lag time is potentially even longer with decisions on maintenance.

Unless there is compelling information as to why practice should change, or a different approach considered, the likelihood is that current practice would remain. Examples include:

- Not taking opportunities to upgrade culvert sizes to cope with higher flood flow events (see Takaka Hill case study on Page 51**Error! No bookmark name given.**);
- Prioritising activities that deliver immediate or more easily quantifiable benefits rather than investment that increases resilience, particularly when changing hazard risk or considering low frequency, high impact events or future risks; and

- Focussing on maintaining existing assets without consideration of alternative approaches.

Uncertainty that creates inertia

Planning for climate change has been hampered by a lack of guidance about what design criteria to plan for and over what timescale. Guidance has recently been released for local government (Ministry for the Environment, 2018), and significant effort is going in via the Resilience to Nature's Challenges Science Challenge. In many areas there is still a significant amount of work to do to ascertain what the likely impacts would be, and then in factoring this into planning. In the absence of good information councils have found themselves challenged by their own communities, setting back efforts.

Certainty and guidance are important, as councils and the Transport Agency can be reluctant to invest up front because of impacts on funding models and rates, particularly when the benefits of that investment may be experienced many years down the track, and by a different generation of ratepayers. Unless Councils fund these programmes over the life of the asset (i.e. debt-funding) the costs are borne by today's ratepayers. Neither option tends to be particularly palatable to ratepayers.

Perverse outcomes

NEMA recognises perverse outcomes as a barrier to addressing resilience. They state that too often, Agencies aim for the minimum acceptable standard at the lowest capital cost. This is because it is expressed as value for money. There is a risk that timeliness is at the expense of delivering a solution which would best address the resilience risk from a long-term perspective, where this doesn't fit a minimum acceptable threshold (Ministry of Civil Defence and Emergency Management, 2019).

Even where agencies and local authorities can clearly see that replacing like-for-like assets such as bridges and culverts, or even entire parts of a route, represent a poor investment due to the changing risk profile, improvements are often not sought – rather the effort goes into reinstatement or replacement with similar assets. This can be due to:

- Timing - pressure to restore connections;
- Funding - emergency works funding is focussed on reinstatement rather than addressing future risks or current shortcomings or maintaining a level of service. There is provision to incorporate improvements in emergency works activity, but design and approvals requirements, funding and timelines can make this difficult in practice; and
- Hard infrastructure focus – alternative options including green infrastructure may be overlooked.

Significant pressure is often placed on infrastructure providers to reinstate infrastructure as quickly as possible, to minimise recovery time and avoid community and business harm.

Case study: SH60 culvert replacement on Takaka Hill

Ex-tropical storm Cyclone Gita caused significant damage to multiple sections of the Takaka Hill Road (SH60) in February 2018. Part of the damage was to a section of road that was overtopped when a box culvert at the base of the hill was overwhelmed by storm debris. This culvert was known to be non-compliant with the Transport Agency's standards. There was damage to an adjacent property as a result of this overtopping. SH60 is a primary collector road (as per One Network Road Classification) and the only road link to Golden Bay.

Following initial road clearances and repairs, funding was sought for investigations into options to bring this section of road up to standard. A number of options were proposed, including upgrading the culvert to the Transport Agency's standards by increasing culvert capacity and alignment, and a non-infrastructure solution. This involved realigning a stream, and installing debris control structures on adjacent land that would have alleviated pressure on the culvert. Emergency funding was declined as that was only available to provide immediate road reinstatement, despite around $20M being spent to repair the route. It was noted that works on private property to alleviate the problem could also not be funded.

The result of this is that a known weakness in the SH network is allowed to persist, even though repair and improvement works were being planned and undertaken at the same time to several other parts of the route in close proximity. With the increasing frequency of high intensity storms expected as a result of climate change, and as a result of catchment damage from ex-tropical storm Cyclone Gita, it is likely that damage and resultant closures will be experienced in this location again in the foreseeable future.

Image: Significant debris, gravel and silts blocked the existing culvert and overtopped State Highway 60, damaging downstream property. Retrieved from NZTA minor resilience application form completed for this project.

Case study:
Retrieved from Andrew James: NZTA System Management – Top of the South

Why do we need to address it now?

Land use planning and land transport infrastructure investments are long term

Land transport investments have long lead times, high costs and leave long legacies (Ministry of Transport, 2018a). If we are to make changes to how we select and prioritise investments, these changes need to be embedded in the system early if we are to see benefits even in the medium term. Land use planning responses to resilience also vary across the regions and have long term implications where development occurs in hazard prone areas. If we do not start putting measures in place to address resilience now, New Zealand would suffer the increased consequences over time and delay the re-balancing of proactive/reactive responses.

Improved understanding of risks

As we further develop our understanding of natural hazards, we need to keep evaluating the risks our vital transport connections are prone to. Recent earthquakes and ex-tropical cyclones have highlighted risks and impacts on the transport system. For example, the Christchurch earthquakes in 2010 and 2011 resulted in major road closures (with 45% of roads damaged), and rail freight disruption. Even more concerning is that we know greater disruptions are on the horizon, such as an Alpine Fault earthquake[7] with significant aftershocks potentially lasting many years, more intense and frequent rainfall events and sea level rise. All information related to these hazards has a degree of uncertainty and unknown. These events and improving information have highlighted the need to better understand and plan for these risks.

The Resilience to Nature's Challenges National Science Challenge[8] was established in 2015 to enhance New Zealand's ability to anticipate, adapt and thrive in the face of ever-changing natural hazards. Information deriving from this work has highlighted the severity of consequences, in particular from low frequency but high impact events, and from slow onset events such as sea level rise.

Recent advances in knowledge regarding the low frequency, high impact events have included modelling for how severe earthquakes and associated hazards (such as movement on the Alpine Fault or tsunami resulting from earthquakes in the Hikurangi Trench) would impact on our towns, cities, and transport connections.

Planning for the impacts of climate change

Like many other countries New Zealand is also beginning to better understand the impact of changes in the global climate and recognise these changes would continue to occur. In New Zealand, we would experience increased frequency and intensity of extreme events such as higher temperatures, storms, flooding, droughts and wildfires, sea-level rise, and warmer and more acidic oceans. We are already seeing evidence of this.

The government has recognised these changing risks and is now placing a greater emphasis on promoting resilience and climate change adaptation via documents such as the Government Policy Statement on Land Transport 2018/19 – 2027/28 (Ministry of Transport, 2018a), its passing of the Climate Change Response (Zero Carbon) Amendment Act 2019[9], and release of guidance for local authorities on preparing for the impacts of climate change[10].

In combination, these elements mean that it is increasingly important that NZ takes an early and thoughtful view of its long-term investments. This provides the opportunity to invest in options that would be cheaper in the long term. Investment needs to recognise risk and uncertainty, for example through the use of the adaptive pathways approach.

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[7] Ground Transport AF8+ earthquake scenario workshop report https://infohub.nzta.govt.nz/otcs/cs.dll/link/33688940
[8] Refer https://resiliencechallenge.nz/
[9] Refer https://www.mfe.govt.nz/climate-change/zero-carbon-amendment-act
[10] Refer https://www.mfe.govt.nz/climate-change/climate-change-guidance/local-government-preparing-climate-change

What happens if we do nothing?

Failure to address resilience, particularly in the face of a changing hazard profile means more New Zealander's would be exposed to more frequent and more severe disruption. This translates to a decreasing level of service from existing assets i.e. reduced availability of the land transport system. At a practical level this means that some communities would be isolated more often, and the impacts on social and economic wellbeing would increase, contrary to the aspirations of the Living Standards Framework.

We would continue to make decisions that locate people and assets in areas that would be at risk, adding to the profile of cost as we seek to maintain and repair transport assets that are at increasing risk from hazards such as sea level rise. We would continue to screen out low frequency events with severe consequences, and so continue to get surprises, with significant consequences to the economy and our reputation. Our approach would be largely reactive via emergency response rather than addressing risks before they occur. Investment in reducing risk would be ad hoc and poorly targeted, based on incomplete information and inconsistent risk assessment and prioritization approaches.

We risk losing major components of our current income if New Zealand is seen as a risky place to visit. Severe disruption through for example major flood events or earthquake on the West Coast of the South Island could result in a major loss of tourism to the coast, affecting tourism in New Zealand generally.

Resilience is a journey, but slow-creep hazards would not wait

The resilience focus is not new. A range of agencies have invested significant effort in understanding and planning for resilience, yet a consistent approach to responding to resilience risks is not yet embedded. The Transport Agency has previously set aside funds for resilience programmes, but in some instances these were not well accessed.

The issue is that the longer we leave it (or fail to adjust our approach sufficiently), the greater the consequences and impacts on our communities where resilience related disruptions occur. Maladaptive decisions are still being taken that lock in investments that are insufficient to cope with coming changes and may lead to more damage in the future as other priorities (such as timeliness and cost) overwhelm resilient considerations.

PARTNERS AND KEY STAKEHOLDERS

New Zealand's land transport system includes many long-lived assets that are owned and managed by multiple entities all of whom have roles to play to ensure the system functions and delivers the services that the community needs.

Achieving a land transport system that is resilient requires a collaborative approach. The system is an enabler of the things that people need and want to do, and does not exist for its own sake, or in a vacuum. It is therefore vital that we have a strong understanding of what people need from it.

Investment partners

This section specifies the principal planning and investment partners to the New Zealand land transport system, who have a responsibility for addressing both the barriers to investing in resilience and the geographical sites where community resilience is exposed to risk related to natural hazards.

New Zealand Transport Agency

The Transport Agency is responsible for managing, operating, maintaining, planning for and improving the State Highway network. They are responsible for giving effect to the GPS, through the National Land Transport Programme, (NLTP) by deciding which projects from the Regional Land Transport Plans (RLTP's) would receive funding from National Land Transport Fund (NLTF). The Transport Agency allocates NLTF funding to both State Highway and local road expenditure. Local rates are used to supplement funding for local roads in an approximate 50/50 split with the Transport Agency.

Investment in the land transport system is essential to solving the problems identified in this case and to fully realise the benefits of investing in resilience.

Local government

Regional council responsibilities

Regional Councils have the responsibility of appointing members of Regional Transport Committees, (RTC's) or in Auckland's case, Auckland Transport. RTC's have the responsibility of developing RLTP's which list all the transport activities that a region intends to progress over at least 10 years and are used to prioritise applications for government funding through the NLTP. RLTP's must be issued every six years and reviewed every three years and they must be consistent with the GPS on land transport.

Regional Councils have tended to play a limited role in strategic planning when it comes to land use and development planning. Future Proof Waikato[11] and Greater Christchurch Urban Development Strategy[12] are two initiatives that have been taken at a regional level to take a strategic approach to growth in part of both regions. Regional Policy Statements also set out the broad land use objectives for each region.

District and City councils

Each City and District council owns and is therefore responsible for managing the local road, walking and cycling networks that, together with State Highways, provide connectivity within and between local council areas. Most of the land transport system in New Zealand is managed by local authorities.

The National Policy Statement on Urban Development Capacity (NPS-UDC) directs local authorities to provide development capacity in their resource management plans to meet demand for housing and business space. The Government consulted on a proposal for a new National Policy Statement on Urban Development (NPS-UD) in late 2019. The NPS-UD will provide clear direction to local government about how to enable opportunities for development in New Zealand's urban areas in a way that delivers quality urban environments for people, now and in the future.

[11] Refer http://futureproof.org.nz/the-strategy/read-the-strategy/
[12] Refer https://greaterchristchurch.org.nz/projects/strategy

KiwiRail

KiwiRail is a state-owned enterprise that owns and maintains nationwide rail infrastructure. KiwiRail also owns and operates the Inter-islander ferries between Wellington and Picton, with one of the ferries, Aratere, being able to accommodate rail wagons, thereby providing a link between the North and South Island sections of the national rail network.

Department of Conservation

The Department of Conservation provides co-funding for activities under the Regional Land Transport Plans and owns and manages roads on the conservation estate (e.g. national parks).

New Zealand Lifelines Groups

New Zealand Lifelines Groups co-ordinate the raising of awareness of resilience issues and co-ordinate assessments by national utility and transport service providers.

Ports and Airports

Air and seaports are generally owned by local councils, either outright or in partnership with local corporates.

Central Government

Central Government may sometimes allocate additional funding through the Crown appropriations process for other projects. These may include accelerating the construction of regional roads or funding major repairs following natural hazard events such the 2016 Kaikoura Earthquake.

Key stakeholders

In addition to the investment partners outlined above, there are a number of stakeholders who have an interest or level of influence over national resilience investment proposals. These stakeholders include:

- Ministry of Transport
- EQC
- Users of the land transport system such as communities and businesses;
- Road Transport Forum NZ;
- Automobile Association (AA);
- CAN / Living Streets
- Port and airport operators;
- Network Outcome Contract holders such as Downer or Fulton Hogan;
- Ministry for the Environment; and,
- National Emergency Management Agency (NEMA - formerly Ministry of Civil Defence and Emergency Management) and regional Emergency Management Offices such as Wellington Regional Emergency Management Office (WREMO)
- The Treasury
- New Zealand Infrastructure Commission - Te Waihanga.
- Climate Change Commission

The specific stakeholders that were engaged in the development of this NRPBC are listed in Appendix D. Participation has been limited due to a range of factors including timing. Efforts were made to capture input through skype and one on one meetings where possible, but the risk remains that only a limited perspective has been captured.

WHAT DO WE WANT TO ACHIEVE THROUGH THIS INVESTMENT?

Investment objectives, existing arrangements and system needs

The NRSC identified a set of benefits that would be derived from undertaking a full Programme Business Case as follows:

- An improved ability for communities to make informed decisions about resilience, prepare for, absorb, and recover quickly from adverse events;
- A resilient, affordable transport system that meets user and community tolerances and risk appetite;
- Resilience is considered as part of all planning and investment decisions to influence activities that increase vulnerability; and,
- There is an integrated, transparent and 'system-wide' approach to prioritising responses and optimising resource allocation.

Key outcomes were identified at a workshop on 11 October 2019 with national level stakeholders. These outcomes are framed up in the following statements:

> "*We would know we are successful when communities have appropriate and agreed levels of resilience in services provided by transport. Communities would be sufficiently resilient to cope through the duration of disruption without undue economic and social hardship as a result of transport service failures.*
>
> *This would be achieved through a reduction in risk, access to alternate service options, and appropriate preparedness.*
>
> *To achieve this, we would have incorporated resilience throughout our thinking. This means we have taken resilience into account when designing, providing, operating and maintaining services. We would have communicated with our communities about their challenges and options, and they would be both aware of and prepared for any likely disruptions to transport services caused by hazard events.*"

These outcomes confirm the benefits identified in the original NRSC.

We have derived the following investment objectives from these inputs:

- All communities and businesses are well informed about what the risks of disruption to their transport connections are, and what their choices are; and
- The land transport system would be more resilient in the face of a changing hazard profile.

Table 3: Summary of the existing arrangements and business needs

INVESTMENT OBJECTIVE ONE	**All communities and businesses are well informed about what the risks of disruption to their transport connections are, and what their choices are**
Existing arrangements	There is limited consistent analysis and communication of resilience related risks to the connectivity provided by the land transport system. This means that communities and businesses have variable understanding of the potential for disruption and the likely impacts of that disruption. Options for addressing risk are not well understood and discussion often focusses on defending existing assets and connections. For some corridors defending assets involves significant investment making it difficult to progress under existing investment decision making approaches.
System needs	Communities and businesses are provided with relevant and up-to-date information about the risks posed to transport connections by natural hazards. Options for addressing or reducing risk are also well articulated including consideration of defend, accommodate and/or retreat for assets and corridors. In light of finite funding to invest in the land transport system communities and businesses understand the prioritisation of investment to address resilience related risks of disruption. Through appropriate information and communications communities and businesses are enabled to prepare for and respond appropriately to disruptions that do occur.

INVESTMENT OBJECTIVE TWO	**The land transport system would be more resilient in the face of a changing hazard profile**
Existing arrangements	The approach to addressing resilience related risks is largely reactive via emergency response rather than addressing or reducing risk before events occur. Proactive investment in reducing risk is ad hoc, based on incomplete information and / or inconsistent risk assessment and prioritisation approaches. With limited links between land use and transport planning people and assets are sometimes located or remain in areas that would be at risk. This adds to costs for maintenance and repair of transport assets. The investment decision making approach effectively screens out solutions for low frequency events with severe consequences with consequences to the economy and our reputation when these events do occur.

INVESTMENT OBJECTIVE TWO	The land transport system would be more resilient in the face of a changing hazard profile
System needs (usually business needs)	Decisions on improvements or alternatives to assets where they are at risk of natural hazard events would be taken in line with the level of risk posed to the communities affected. There would be an aligned and integrated approach to resilience across partner agencies, and the full range of options, including retreat, would be considered. Decision-makers would have good access to information and be able to make robust decisions in the face of current and likely future natural hazard risks and events. Agencies would be aligned in responses and would have the capability and capacity in the right places to be able to take appropriate actions. Resilience thinking would be factored into investment and maintenance decisions, and decisions taken that ensure the long-term resilience of our land transport system. System leadership would be clear, and we would have an appropriate level of governance across the system to guide thinking, investment and response.

PROGRAMME SCOPE

Communities

All communities including the general public, businesses and freight companies, are reliant on the New Zealand land transport system for prosperity and wellbeing. This includes future communities.

The focus of this case is around:

- People and the services they need, as opposed to infrastructure. This is in line with the Transport Agency's Resilience Framework; and
- Consequence management (ties into the Treasury Living Standards Framework): look at the consequence of infrastructure failure as opposed to just the infrastructure condition.

Geographic service scope

All geographical areas within New Zealand, where communities are reliant on the land transport system for prosperity and wellbeing. There would be a focus on primary land transport links (i.e. the State Highway network and rail network) and the wider land transport system including other publicly available linkages insofar as they provide alternate services which include:

- Access to a critical interdependency;
- Where they provide a detour or evacuation route (if known); 0r
- They enable community to effectively function.

The programme is agnostic about ownership.

The project steering committee for this NRPBC agreed that some Department of Conservation (DOC) owned roads are considered relevant when assessing the current resilience risks that face the New Zealand land transport system. This is because some of these roads provide key access and alternate services for various communities.

Transport modes

All land-based modes of transport that move people and products (e.g. cars, trucks, trains and bicycles). This includes mobility services (e.g. public transport).

Transport assets

All physical land transport infrastructure for both road and rail land transport including:

- State Highways;
- Some local roads;
- Bridges and tunnels;
- Operation centres; and
- KiwiRail owned rail track, (both electrified and non) bridges, and other utility infrastructure (e.g. passenger stopping points within transport corridors or overhead power supply).

Access to nodes with other forms of transport (e.g. airports and ports) are included within scope. However, the actual facilities relating to these other forms of transport are not in scope. This is except for the Cook Strait ferry route between Wellington and Picton, which is in scope, because this route is recognised by the Transport Agency as a State Highway. Ferry facilities at CentrePort (Wellington) and Picton Port are therefore also included within scope.

Access to utility infrastructure for fuel, gas, and electricity services which is served by the land transport system is also considered in scope. This is to inform and develop understanding of the interdependencies within the land transport system and supplements the criticality assessment.

Hazards

Unplanned disruptions and damage occur to the land transport system for a number of reasons. However, the scope of this NRPBC focuses on disruptions caused by natural hazards, that impact on connectivity and provision of land transport services. This includes any disruption or damage which comes as a result of low frequency high impact events (e.g. earthquake) and climate change. Climate change causes impacts of its own (e.g. sea level rise) and acts as an exacerbating factor for other hazards (e.g. amplifies the magnitude and frequency of storms or erosion).

The natural hazards considered by this case include:

- Seismic events
  - Surface rupture
  - Shaking
  - Liquefaction
  - Associated land movement and landslides
- Tsunami

- Volcanic (Note: GNS specifies that there are 8 different Volcanic hazards, however only 4 of these relate to land transport resilience)
    - Pyroclastic flows
    - Ashfall
    - Ballistics
    - Lahar
- Land instability
    - Landslides
    - Debris flows
    - Coastal and other erosion
- Weather / climatic events / impacts of climate change
    - Storm / high wind / lightning
    - Flooding and inundation
    - Snow and ice
    - Associated landslides, debris flows and river / stream erosion
    - Drought and heat
- Wildfire.

Time horizon

This case takes a focus on investment planning for projects over the next 10 years (to align with the National Land Transport Programme). A 30-year view has been taken as a strategic horizon to ensure that a pipeline of future investments is kept in the picture. A 70-year view has been adopted to ensure that future hazards and risks are taken into account over the full lifecycle for most infrastructure.

What's not in scope

Hazards that cause unplanned disruptions and damage to occur on the land transport system which are considered out of scope as they are being covered separately to this Business Case include:

- Human-made or human-induced events, such as crashes, community events, protest, terrorism;
- System failures such as supply chain disruptions e.g. fuel, electricity and road construction that are not caused by natural hazards; and
- Failing, or ageing infrastructure that is becoming less robust overtime.

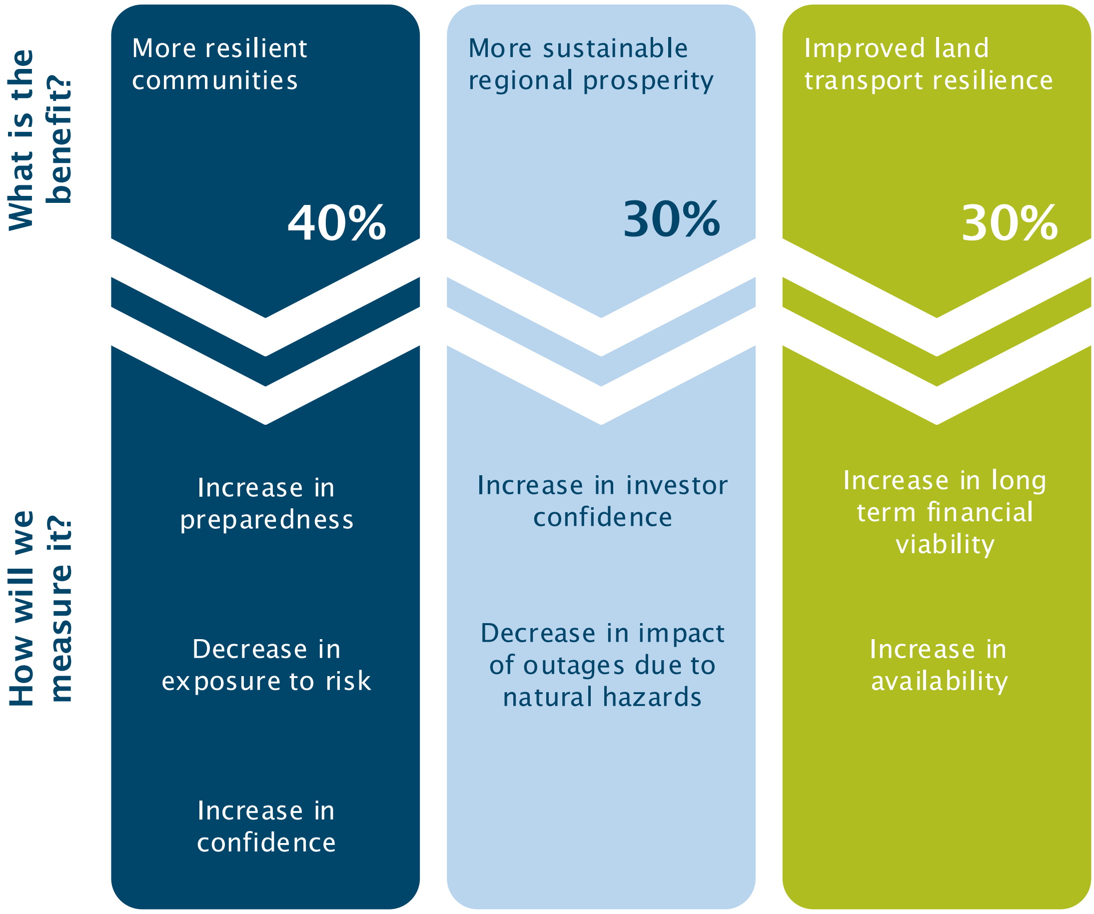
Other elements considered out of scope of this NRPBC include:

- Digital infrastructure (such as navigation aids, travels apps);
- Personal safety and health;
- Environmental resilience i.e. impacts on the environment;
- Air and water travel modes and routes. This is apart from the Cook Strait Ferries and route;
- The facilities relating to other forms of transport. This mainly pertains to airports and ports; and
- Department of Conservation owned roads would not be in scope of the risk analysis component of this case.

WHAT ARE THE MAIN BENEFITS THIS INVESTMENT WOULD DELIVER?

The key benefits we could expect to see from resolving the identified problems are set out in Figure 10.

Figure 10: Benefits and KPI's



More resilient communities

Our communities would be better protected from impacts and outages in the land transport systems as a result of natural hazards and would be more resilient when disruptions do occur. Because extreme events would occur, and would happen more frequently, it would be essential that communities are better prepared to manage the effects of these events when they do occur.

If we have good information on the level of risk communities are exposed to, and have taken steps to avoid, minimise, or manage those risks, the residual risk that communities are exposed to would be increasingly acceptable.

People would therefore have increasing confidence that the risks posed to their health, safety and lifestyle are within acceptable tolerances.

More sustainable regional prosperity

Investor confidence is important if regions are to grow and prosper. Investors need reasonable assurance that the level of risk posed by natural hazards to critical business linkages is minimised or managed appropriately to avoid and minimise reasonably foreseeable disruptions on critical routes.

The two KPI measures proposed would assess the contribution that resilience in the land transport system would make to enabling regional prosperity and stability.

Improved land transport resilience

Long term resilience of our land transport system means we would have both understood and factored in the whole-of-life costs – including repairs and maintenance – when making investment decisions.

Shifting to a model that requires us to consider the levels of service desired and driven by the Living Standards Framework against that backdrop of both long-term physical asset resilience and financial impacts may require us to reassess aspects of our land transport system and make decisions that could be quite different to aspects of the system we have today.

WHAT ARE THE MAIN RISKS, CONSTRAINTS AND DEPENDENCIES?

Risks

Table 4: NRPBC risks

RISK	MITIGATION
The methodology may identify new priorities that are not currently on the radar for the National Land Transport Fund, the Transport Agency's Business Plan and Council Long Term Plans which could lead to insufficient funding to address the suite of necessary resilience interventions.	Ensure a focus on reprioritisation where issues are critical, delivering long term value, and changes in approach that do not necessarily change costs.
	Ensure a whole-of-life approach is taken to ensure that resilience is appropriately prioritised and factored in appropriately.
Lack of engagement of investment partners means that either insufficient information is input into this NRPBC, or partners do not accept the findings of this case.	Ensure that communication channels are in place for partners, and information is pushed, even if they are not actively engaged.
	Ensure risk prioritisation approach allows for inclusion of additional information as it becomes available.
This NRPBC becomes misaligned with or duplicative of other programmes of work – both within the Transport Agency and between agencies.	Ensure that as far as possible linkages and communications between programmes are established and maintained.

Constraints

Data

The risk analysis is limited to the asset and hazard data supplied/sourced. No new data or attributes would be generated. This means this NRPBC is limited to current available data.

Scope of hazards

There are other hazards to the land transport system that may interact with natural hazards to raise the overall risk of any route or node. These additional hazards may not be assessed within this programme (for example key nodes that are susceptible to interference by disruptive actors).

Dependencies

In developing this case it became apparent that there is a significant amount of work being undertaken by the New Zealand Government that revolves around the theme of resilience. Some of this work has strong interdependencies with this NRPBC and it is important that the work of this case is not seen in isolation. In some cases, the problem statements developed for this NRPBC would be addressed by work already underway.

Although we have sought to best capture all the dependencies that exist with this NRPBC, there would inevitably be other pieces of work which we have not captured in this list, given the fact resilience is a constantly developing field of interest for many organisations throughout New Zealand.

Table 5: Selected NRPBC dependencies

ORGANISATION	DEPENDENCY	KEY DATES
Department of Internal Affairs	Resilient communities programme (includes framework to guide the role of central government in strengthening community resilience)	Report-back due mid-2020. Key relevant elements to be aligned to delivery of National Climate Change Risk Assessment
New Zealand Infrastructure Commission	30-year infrastructure strategy to replace the government's current strategy	Ongoing
Ministry for the Environment	Development of planning guidance/ possible RMA reform. Includes improved integration between RMA and LTMA, improved spatial planning	Guidance linked to National Adaptation Plan. Possible changes to RMA through reform programme (at Issues and Options stage)
	Research and guidance on climate change information to central and local government being maintained and up to date	Ongoing

ORGANISATION	DEPENDENCY	KEY DATES
	National Climate Change Risk Assessment	National Assessment due mid-2020, National Adaptation Plan mid 2022
Ministry for Transport	Government Policy Statement on Land Transport 2021	Draft released March 2020
	Future of Rail – changes to the planning and funding framework	Due 2021
	Road to Zero: A New Road Safety Strategy for NZ NZ's road safety strategy 2020-2030.	2020-22 Action Plan published Dec 2019
NIWA/GNS/RNS/Quake Core	Research into various resilience areas including earthquake effects, cascade and secondary effects, interdependencies and climate change mitigation and adaptation	Ongoing
The New Zealand Transport Agency	Arataki (Version 1.1)	April 2020
	Road safety and harm reduction	Ongoing
	Safe network programme	Ongoing
	Keeping cities moving – a plan for mode shift, September 2019	Five of 6 urban mode shift plans to be delivered in mid-2020
	Optimisation programme	Ongoing
	Future transport technology national programme	
	Resilience Framework - four key workstream	Ongoing to 2021
	Review of the Investment Decision Making Framework	July 2020

PART B – ADDRESSING RESILIENCE RISKS, ISSUES, DEFICIENCIES AND OPPORTUNITIES

The costs of repairs (even removing extreme events such as earthquake) are rising as a result of increasing pressure on the system combined with increased risks through a changing natural hazard profile. The broad options to manage this are to manage demand on the transport system (e.g. by mode shift or changes to behaviour), increase supply (e.g. improve the state) and/or to increase efficiency (e.g. improve how we use current investment, response and recovery processes).

This programme has a dominant focus on the latter options. Increasing supply through increasing funding is an option, but in the context of resilience has the potential to require extensive capital investment making efficiency improvements an equally important approach. Demand management is out of scope of this business case but is considered an interdependency.

This next section is focused on the system level process and organisational changes needed and identifies a preferred programme of work to address resilience. Specific responses, which are the focus of this case, are then further developed with an example of how they might be developed.

HOW MIGHT WE ADDRESS RESILIENCE?

By its nature resilience is not a matter that can or should be considered in isolation, otherwise it may be traded off against more urgent, or short-term, or demanding priorities. For that reason, a broad approach to addressing resilience is taken that enables considering responses that go beyond transport engineering or planning and can consider a range and combination of hazards over a longer time frame. The approach also considers both immediate risks and those that are likely to emerge over time due to changing use of the land transport system and/or changes in the nature and severity of natural hazards.

Similarly, resilience is not a matter that can be managed by one agency alone. Responses require a collaborative approach between the Transport Agency and investment partners to ensure successful implementation.

A suite of strategic approaches was derived in response to issues raised both through the ILM process and during workshops with regional stakeholders across New Zealand. These approaches identified high level thematic changes or strategic interventions that are required at the system level if resilience issues are to be addressed.

LONG-LIST OF SYSTEM RESPONSES

The high-level approaches were tested with stakeholders and a suite of system level responses was derived. These responses were then refined with Transport Agency staff in a workshop in December 2019 and tested in one-on-one meetings with national level stakeholders. An Outcomes Framework was prepared to identify how the identified approaches and system responses would deliver the objectives and benefits sought by the Transport Agency from this work. This is set out in Figure 11. Intermediate benefits are set out in the framework as enablers. Most of the matters identified as benefits in the NRSC have been captured as intermediate benefits.

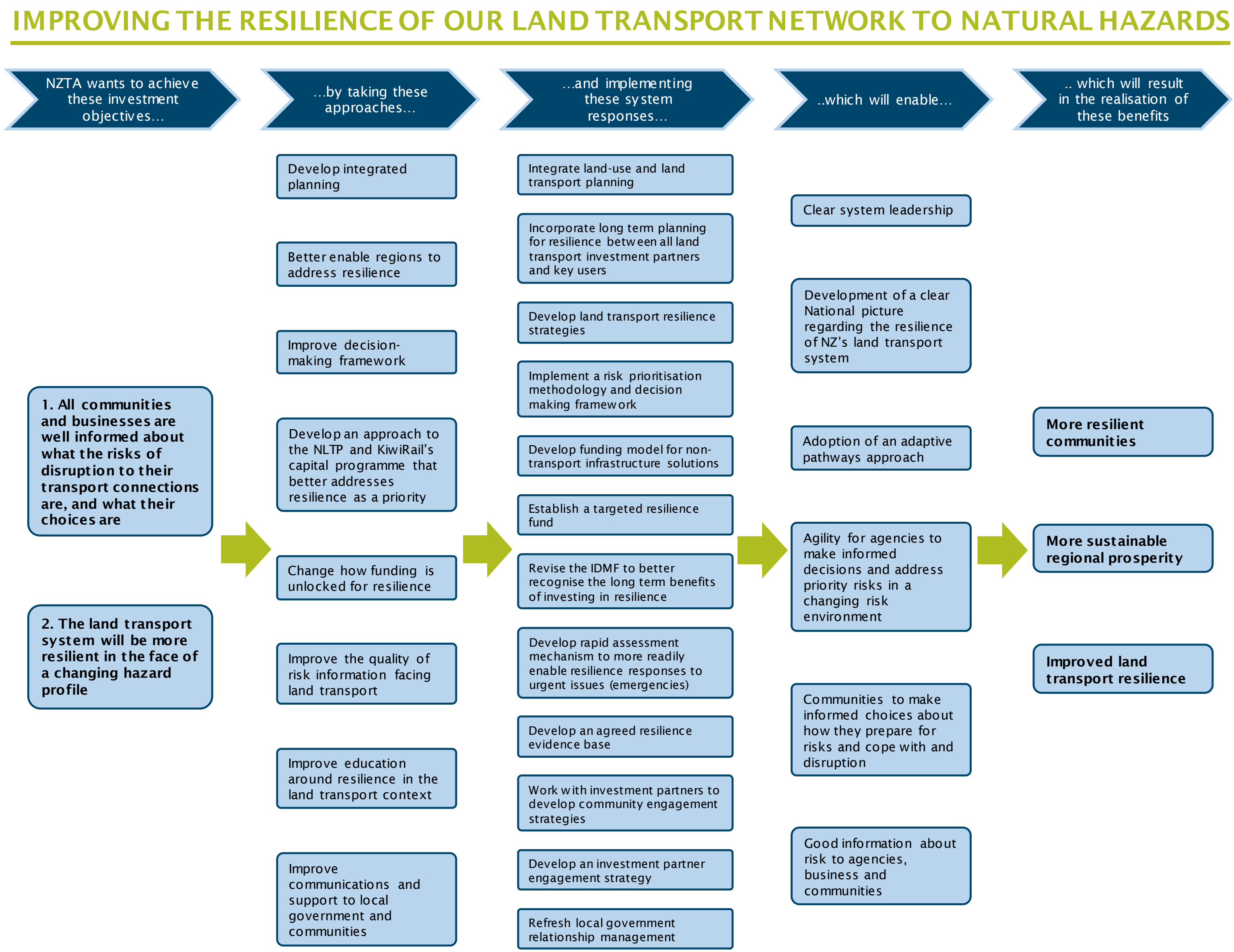
The responses include two categories of system responses. One set identifies priority geographic risks (Response 4) and developing approaches to addressing each risk (Responses 3 and 7). The remaining responses set the framework for responding to individual geographic risks.

In some cases the preferred approach may be to accept the risk and manage impacts should disruption occur. It may also be appropriate to implement changes or upgrades to physical infrastructure alongside planning for disruption in some scenarios. All options should be explored in the context of a business case process to consider resilience risks, other risks and potential benefits.

This range of potential approaches to address geographical risks means that the implementation of system responses alongside addressing priority location based risks would reduce, but not eliminate, risk. The residual risk is dependent on the solutions adopted. A higher residual risk may be preferable where the cost (financial or otherwise) of reducing residual risk is inordinately high.

A full list of the issues raised in the regional workshops and how they link to these responses is provided in Appendix E.

Figure 11: Outcomes Framework for the long list of system responses



Long-list descriptions

A brief description of each system response and the high-level advantages, disadvantages, benefits gained or supported, and constraints and dependencies is set out in Table 6.

Table 6: System response descriptions

1. Integrate land-use and land transport planning	**Spatial planning and transport planning are integrated at a national and regional level so that place-based decisions take account of the ability to provide resilient transport connections. Land use planning takes into account any resilience risks, issues, deficiencies and opportunities in, or affecting, the land transport system. This is particularly important for risks posed by climate change given the impacts of these risks are not so immediate. This would ensure that new and existing land transport infrastructure is resilient and access to various communities (including new communities) is reliable, enabling communities to thrive.**
Advantages	The main advantages of this response are: • Future land use and settlement pattern decisions are not taken in isolation of the ability to efficiently service those locations in the long term; • Resilience can be built in, minimising unplanned disruption; and • Land and / or transport system developments are not taken that are at odds with each other, or impose expectations on the other. For example, enabling land development in a location that requires upgrades to existing transport infrastructure to function effectively.
Disadvantages	The main disadvantages of this response are: • Both land use planning and transport planning are complex in their own right, often involving multiple stakeholders. Integrating decision making requires alignment of stakeholders and timeframes; and • The complexity and time taken to integrate land-use and land transport planning, particularly when many of New Zealand's major urban areas are growing at an accelerated rate and require more immediate development.
Benefits	This response would enable more resilient communities, more sustainable regional prosperity and improved land transport resilience.
Constraints and dependencies	This response is currently constrained by the current mandate of agencies (the Transport Agency and local government). While integrated spatial planning is a priority in major urban growth areas, and some pan-regional planning has been undertaken, this is not yet mandated nationally i.e. across the land transport system. RMA reform may address this. This response is dependent on the Arataki programme as *spatial and place-based planning* is one of the key levers defined Arataki. Arataki states this lever would deliver step change through long-term integrated growth and infrastructure plans, and land-use decision-making. The Transport Agency is currently developing their *Good Practice Guide for integrating Land Use with the Transport System* which sets out principles for integrated transport and land-use planning.

Comment	This response is essential if resilience is to be integrated into design and approaches with long term (70 years) implications. At a strategic level this response requires coordination across multiple national and local government organisations. Better integration across the RMA and LTMA has been identified as a possible area of reform in the broader RMA reform programme.

2. Incorporate long-term planning for resilience between all land transport investment partners and key users	**Resilience of any network or option is explicitly factored into planning tools including but not limited to Regional Land Transport Plan development, corridor management plans, asset management plans and district plans. All investment partners and key users are engaged in plan development. Many of these tools inform NLTP and TAIP development. This relies on a common understanding of risk (hazards, likelihood, consequence), short term and long (70 years) and approach to prioritising (refer Response 4). This also links to the Investment Decision Making Framework review process.**
Advantages	The main advantages of this response are: • Transparency of the trade-offs informing decisions (cost, maintain level of service, land requirements); • Better understanding within key parties as to the rationale for option selection, and therefore improved preparedness for short and long-term issues that arise; • Coordinated approach to resilience decisions including consideration of reducing exposure to hazards (Defend) planning to manage outages (Accommodate) and/or finding different route to provide connectivity (Retreat). • Better integration, planning and staging; and • Improved certainty for partners and communities
Disadvantages	The main disadvantages of this response are: • Complexities in involving multiple parties (the Transport Agency, local government, KiwiRail) in the planning process; • Resilience may not be an equal priority amongst all investment partners; and • Resilience considerations may be an additional complexity, slowing up an already complex process.
Benefits	This response would enable more resilient communities.
Constraints and dependencies	This response is constrained to a degree by the mandate, particularly regarding RLTP / NLTP development, and KiwiRail's long term planning. While this response is possible without mandate, it is still susceptible to being traded off as individual business case processes prevail. This response is dependent on the development of the resilience strategies, particularly if they are corridor, route or journey based.

Comment	This response remains to be developed but is outside of the scope of this programme business case. It is noted that better linkages between transport modes (i.e. road and rail) have been established at a tactical and individual locality level, and in some regions, but this is still ad hoc rather than systematised. In addition to delivering benefits set out in the ILM, this response would provide a platform for better integrated and staged programmes and provide certainty for the community and investors in the land transport system.

3. Develop land transport resilience strategies	**Land transport resilience strategies developed to present a long-term view (70 years) of aspects of the system (whether geographic, route / journey or thematic) so that a long-term picture of the resilience needs of the system can be developed as a basis to guide investment decisions. These strategies would identify preferred solutions or approaches (defend, accommodate, retreat), that can inform the selected response.** **These strategies provide the framework for identifying solutions for the identified priority risks using the outputs from response 4. (risk prioritisation methodology and decision-making framework). Solutions can then be developed through existing projects or new business cases and may include new or upgraded system components, enhanced management of existing system components, enhanced risk communication and/or enhanced planning for disruption.** **The community and stakeholders would be engaged as part of the development of those strategies so that the community understands or contributes input into options and level of service and is well informed about the short and long term risks faced.**
Advantages	The main advantages of this response are: • A focus on long-term risks alongside immediate risks; • Reflecting a wider shift to a focus on connectivity, community impacts and long-term planning rather than State Highway and local road infrastructure; • Better alignment of asset management plans, natural hazard planning management and transport planning, including an explicit link to any national adaptation plan in the longer term; • A clear view of where investment can be targeted to best deliver a land transport corridor that is resilient; • An improved ability to build a national picture of the resilience of NZ's land transport system; • Creates a blueprint that can be drawn on for short term investment planning (RLTP), long term investment planning and emergency response; and • Improved certainty for all parties about likely responses to natural hazard events. • Individual priority risks are addressed in the context of regional and/or corridor priorities.
Disadvantages	The main disadvantages of this response are: • Effort, cost and time required to develop resilience strategies; • Risks of single focus with potential loss of efficiency of integrating other issues; and • Not legally binding.

Benefits	This response would enable more resilient communities, more sustainable regional prosperity and improved land transport resilience.
Constraints and dependencies	This response is currently constrained by mandate. While there is no legal barrier to developing strategies without a formal requirement, proceeding without one is likely to lead to patchy take-up and trade-offs with other priorities, as more urgent matters are dealt with. This response is dependent on having an agreed evidence base and a consistent approach to prioritising risk and identifying and deciding on options for addressing risk (Response 4). These components have been addressed the preparation of this Business Case.
Comment	This response is a keystone solution. It remains to be developed but is outside of the scope of this programme business case. Arataki provides one potential example of integrating resilience in the regional, pan-regional and national summaries of the Transport Agency's 10-year plans. The Wellington Regional Land Transport Resilience Programme Business Case or the Twin Coast Discovery Routes business cases could also serve as an initial template of a resilience strategy. These strategies should inform resilience aspect of Corridor Management Plans and Emergency Response Plans. This avoids a discrete resilience-only focused document. Work completed in the preparation of this business case has included developing and applying a risk prioritisation methodology (Response 4). The methodology is presented in Appendix G. The priority risks identified through application of the methodology are presented in Appendix F. This provides a starting point for the development of resilience strategies.

4. Implement a risk prioritisation methodology and decision-making framework	**A risk prioritisation methodology and decision-making framework is developed and implemented that:** **a) provides a methodology to effectively prioritise between different resilience risks to identify the nationally extreme and major risks posed to the land transport system from a natural hazards perspective. This is to support decision makers direct investment / intervention in the land transport system where it would have the greatest benefit and;** **b) provides a framework that supports decision makers determine which intervention is most appropriate to mitigate the respective risk and ensure the benefits of investment are best realised.**
Advantages	The main advantages of this response are: • Investment / intervention is directed to those resilience risks which when addressed would deliver the greatest benefit; • Investment / intervention is prioritised to address the most extreme and immediate risks; • Emerging risks are identified with appropriate responses programmed i.e. future risks are acknowledged rather then left for later consideration; • The decision-making approach ensures all options (defend existing infrastructure, accommodate disruptions and/or retreat from existing locations) and staging are considered when seeking the best value for money option to address priority risks; • Regions have access to nationally consistent tools to assist their decision making which ensures that RLTP's deliver a more resilient land transport system; and • May assist with meeting requirements under section 5ZM of the Climate Change Response (Zero Carbon) Amendment Act, 2019.
Disadvantages	The main disadvantages of this response are: • The prioritisation methodology is stretched when applied at a national level, as there are different variables that inform both criticality and the scale of the natural hazard for each region; and • Slowly developing hazards that are exacerbated by climate change also difficult to plan for.
Benefits	This response would deliver information and a methodology that would support improved land transport resilience.
Constraints and dependencies	This response is dependent on users taking a strategic approach and considering transport linkages at a system rather than a unit level if it is to be of value. As such it is most effective through the development of integrated resilience strategies.
Comment	A risk prioritisation methodology and decision-making approach has been developed as part of this Case. The approach is described in detail in <u>Appendix G.</u> While the approach has been adopted considering previous work and the current National Climate Change Risk Assessment approach it is less comprehensive. This means that there is a risk that the priorities identified using this approach are different to those taking account of social, cultural and broader environmental impacts alongside the system disruption and connectivity aspects that are the focus here.

5. Develop funding model for non-transport infrastructure solutions	Providing a funding model that allows for consideration of investments in non-transport infrastructure solutions to address resilience related risks where these interventions may be more appropriate than a traditional infrastructure solution. These could range from discrete improvements that protect land transport systems, through to alternatives to a continuous land transport level of service (e.g. electronic connectivity, food storage facilities).
Advantages	The main advantages of this response are: • Communities can be supported to be resilient using mechanisms other than transport infrastructure changes; and • Potential for significant costs savings as non-transport infrastructure investments have the potential to be significantly cheaper than infrastructure solutions. • Builds on collaborative approach and levers set out in Arataki; and • Supports integrated land and transport planning
Disadvantages	The main disadvantages of this response are: • Potentially complex assessment process needed; • Implementation of this option poses some challenges with managing long term expectations of the community and may require explicit and ongoing communications; and • The current statutory framework limits the Transport Agency and National Land Transport Fund investment to transport infrastructure.
Benefits	This response would enable more resilient communities.
Constraints and dependencies	This response is currently constrained by a required legislation change to give a mandate to invest in non-transport solutions and / or a change to the investment options for the National Land Transport Fund. As well as a legislative change this response is dependent on the Transport Agency's Investment Decision Making Framework Review outputs.
Comment	This response remains to be developed but is outside of the scope of this programme business case. Explicitly providing for a whole of system view when considering the most appropriate response to risks to the land transport system enables a wider range of responses to be considered and is anticipated to result in better value for money interventions in some cases. However, it may require inclusion of non-traditional investment partners.

6. Establish a targeted resilience fund	**The Transport Agency sets aside a ring-fenced resilience fund (possibly within an existing activity class) which would be specifically made available for investments in existing or new transport infrastructure that directly address resilience risks, issues, deficiencies and opportunities in or affecting geographical sites within the land transport system.**
Advantages	The main advantages of this response are: • A more targeted programme of resilience investment which shifts the current focus away from reactive maintenance or emergency response to natural hazard risks, to long term prevention; and • In the context of the resilience fund, investment decisions avoid competition between resilience and other project outcomes (safety, freight efficiency).
Disadvantages	The main disadvantages of this response are: • Risk of over-investment in resilience in comparison to the other near-term benefits (e.g. safety); • Prioritisation of resilience compromises investments targeting at other benefit streams; • Cost and; • Potential disincentive to achieve multi-outcome solutions.
Benefits	This response would deliver improved land transport resilience.
Constraints and dependencies	This response is dependent on the development of broader transport resilience strategies if it is to take more than a tactical approach to resilience. It would also depend on an agreed approach to prioritising resilience related risks to ensure that investment provides the best net risk reduction at a system wide level. Changes to the IDMF could mean that the drivers for this option are reduced (i.e. long-term benefits are more directly addressed).
Comment	This response has not been developed and is outside of the scope of this programme business case. The risk prioritisation approach and resilience strategies could inform the allocation of funds to maximise the net reduction in risk at a system level. This response could also create a step-change in how NZ achieves a more resilient system. The National Adaptation Plan, to be developed in response to the National Climate Change Risk Assessment, may direct agencies to take action. This could include funding or implementing activities to enable New Zealand to adapt to the impact of climate change.

7. Revise the IDMF to better recognise the long-term benefits of investing in resilience	**The Investment Decision Making Framework is configured to better recognise the value of the outcomes and benefits sought from long term strategic investments that improve the resilience of the land transport system. Economic evaluations now consider resilience alongside other benefits such as safety and efficiency, reducing the current difficulty investment partners have in accessing funding for resilience interventions.** **Under the current review proposed changes include reducing the discount rate used in cost benefit analysis from 6% to 4%, and increasing the analysis period to 60 years, from the current 40-year time period. This has the effect of increasing the assessed value of future benefits compared to benefits accruing in the short term.** **The risk prioritisation methodology and decision-making framework (Response 4) provides a consistent approach to evaluating resilience related risks in the context of implementing the IDMF.**
Advantages	The main advantages of this response are: • Long-term impacts such as those caused by climate change would be given more weight; • The value of improved resilience is increased compared to other, more immediate benefits such as safety in regard in the economic evaluation process; • Investment partners are provided additional guidance on how to recognise the wider economic costs and benefits of investing in resilience i.e. for tourism-related impacts; and • May capture indirect and intangible benefits often overlooked in analysis.
Disadvantages	This may change existing rankings of planned programmes, increasing uncertainty for some programmes and affected communities of interest
Benefits	This response supports improved land transport resilience.
Constraints and dependencies	This response is dependent on a consistent and agreed approach to assessing resilience related risks (Response 4).
Comment	This response is being considered as part of the Transport Agency's Investment Decision Making Framework Review with many of the proposed changes scheduled to come into force in mid-2020. Examples include: • The revised discount rate; • Early Assessment Sifting Tool (EAST); and • Updated Multi-Criteria Analysis decision support tool. The evidence base adopted in the preparation of this business case provides the basis for considering resilience aspects in applying the IDMF. This is related to: • Considering Strategic Alignment • Considering resilience priorities in broader prioritisation processes • Using the evidence base and risk assessment methodology to consider resilience in multi-criteria assessments. • Using the evidence base and risk assessment methodology and outputs in the consideration of wider economic benefits in the economic evaluation process.

8. Develop rapid assessment mechanism to more readily enable resilience responses to urgent issues (emergencies)	**The rapid assessment mechanism allows network managers to quickly identify options to improve the resilience of the land transport system when reinstating transport connections following disruption from natural hazard events. Land transport investment partners would utilise resilience strategies to identify areas where any replacement or reinstatement should incorporate new or enhanced design. There may be either pre-determined solutions identified, for example upgraded culverts, whereas for larger issues there may be concept level designs prepared (through a conventional business case process) with provision for a rapid detailed business case. The process adopted for the Kaikoura rebuild provides lessons in designing this approach for major projects.**
Advantages	The main advantages of this response are: • Enables responders to ensure that appropriate levels of service are provided for or maintained while also completing required design and construction work in a timely manner; and • Reduced time for improvements to be agreed and implemented, increasing the likelihood that these can be undertaken within the repair timeframes and not require revisiting previous temporary repairs or replacements. • Reduced likelihood of wasted repair costs by considering long term solution throughout.
Disadvantages	The main disadvantages of this response are: • Risks that sub-optimal or inappropriate improvements are made as a result of lack of full assessment; and • Investment in designs (for small projects) and preliminary business case/concept design (for major projects) may be wasted if they are ultimately not used.
Benefits	This response supports improved land transport resilience.
Constraints and dependencies	This response is dependent on the development of resilience strategies and appropriate processes that allow for rapid assessment to be developed, in order to avoid “on the fly” decisions that may not be consistent with long term system resilience or desired community resilience outcomes.
Comment	This response remains to be developed but is outside of the scope of this programme business case.

9. Develop an agreed resilience evidence base	**A robust evidence base that outlines the key geographical sites (within the national land transport system) where the resilience of the system is currently threatened by the risk of natural hazards.** **This links to the approach to identifying and prioritising resilience related risks - that relies on an agreed evidence base. It is important to note that new information on natural hazards would continue to become available. The approach to identifying and prioritising risks is designed to easily incorporate new information.**
Advantages	The main advantages of this response are: • An agreed national picture of the resilience risks facing the land transport system that all land transport investment partners and key stakeholders can refer to; and • A single consolidated view of the resilience risks in or affecting geographical sites where road and rail exists together within the land transport system. This allows for joint resilience planning, reducing the risk that KiwiRail, the Transport Agency and/or local roading authorities complete work in isolation.
Disadvantages	The main disadvantages of this response are: • If the evidence base is static, it immediately becomes outdated, unless an organisation assumes the responsibility of maintaining and updating the evidence base; and • In focusing on high priority risks, the evidence base may not present the resilience risks facing the entirety of each regions local roading system - only those considered of national importance.
Benefits	This response supports improved land transport resilience.
Constraints and dependencies	The information on natural hazards and their likely impacts on the land transport system is continuing to develop. This response is therefore dependent on continued investment in data collection and analysis. The evidence base also needs to be accessible and usable for decision makers.
Comment	This response is being delivered as an output of this NRPBC. The evidence regarding natural hazards is constantly developing in light of ongoing research and insights from recent events. This means that the evidence base would not remain static. This response is closely related to the risk prioritisation process (Response 4). The evidence used in identifying priority risks is described in detail in Appendix G.

10. Work with investment partners to develop community engagement strategies	**This process would seek to engage NZ communities with the resilience strategies to raise awareness, help find solutions that would work for the communities affected by natural hazards and improve community preparedness to natural hazard events. This would include providing education and improved information to support communities to making better decisions.**
Advantages	The main advantages of this response are: • Develops options that are appropriate to the communities' needs; • Communities are clear what natural hazard risks threaten the resilience of their respective land transport corridors. This reduces community uncertainty and allows them to plan for disruptions due to natural hazards; and • Transparency of trade-offs made to ensure that long-term investments are in the best interests of the community.
Disadvantages	The main disadvantages of this response are: • Need to stage as a big resource requirement with significant complexity and expectation management needed; and • Pressure on the national land transport system to provide local solutions that are non-standardised, potentially raising costs and increasing time needed to assess locally appropriate solutions.
Benefits	This response would support the delivery of more resilient communities.
Constraints and dependencies	These processes are dependent on linkages to other programmes that support community resilience – which could include non-infrastructure resilience, or funds and approaches drawn from other mechanisms (such as land use and spatial planning).
Comment	This response remains to be developed but is outside of the scope of this programme business case.

11. Develop an investment partner engagement strategy	Strategy to incorporate and engage all investment partners in land transport planning. This option enables integrated planning.
Advantages	The main advantages of this response are: • Creates a mechanism for involving all relevant parties in resilience thinking and planning; and • Makes the process overt and minimised the risk of trade-offs being made unilaterally.
Disadvantages	None.
Benefits	This response would enable more resilient communities, more sustainable regional prosperity and improved land transport resilience.
Constraints and dependencies	Investment partners would need to see the benefits of engaging and buying in to the process. It may require different approaches to be adopted (e.g. aligning timing of processes) and may require greater resourcing. Arataki is the current Transport Agency vehicle for this and would inform the development of RLTPs. There is also a dependency with changes to KiwiRail that bring the investment process into alignment with other partner agencies.
Comment	This response is already being implemented by the Transport Agency's Arataki Programme and to varying degrees through RTC's.

12. Refresh local government relationship management	Refresh the Transport Agency’s approach to engaging with local government to ensure that local government is adequately supported in pursuing activity that delivers a resilient future land transport system. This involves better supporting local government to develop their RLTPs, providing clear and consistent advice on how best to construct investment proposals and connecting with local government to better facilitate information sharing.
Advantages	The main advantages of this response are: • Local and regional councils receive clear and consistent communication, and support from the Transport Agency (including navigation of the Transport Agency’s IDMF); • The Transport Agency is better connected with local government, facilitating better information sharing between the two bodies i.e. the Transport Agency can draw upon the extensive knowledge that the regions have about natural hazard risks facing their respective parts of the land transport system; • The Transport Agency is supported to partner more effectively with local government to achieve better resilience outcomes for the New Zealand land transport system; • Smaller local councils who may not have sufficient capability and capacity can be better supported by the Transport Agency to effectively plan for resilience; and • Further supports integrated land use and land transport planning.
Disadvantages	The main disadvantages of this response are: • None.
Benefits	This response would enable more resilient communities, more sustainable regional prosperity and improved land transport resilience.
Constraints and dependencies	None.
Comment	This response is already being implemented by the Transport Agency.

DEVELOPMENT OF PROGRAMME OPTIONS

Four broad approaches have been derived by grouping the system responses. Each option below builds on the prior option. So, Option 3 (integrated investment model) builds on Option 2 (Do Minimum). These options were derived and tested with key stakeholders through one on one meetings.

Table 7: Programme options

OPTION	DESCRIPTION	INCLUDES THESE STRATEGIC RESPONSES	ADVANTAGES	DISADVANTAGES	COMMENT
Option 1	**Current state (status quo):** This option reflects current state plus initiatives that are already in train either to improve resilience, or that would provide resilience benefits.	• Integrate land-use and land transport planning; • Revise the IDMF to better recognise the long-term benefits of investing in resilience; • Develop an investment partner engagement strategy; • Refresh local government relationship management.	• Continues current models with evolutionary changes that do not require significant additional change effort at regional level.	• Investment decisions would continue to be tactical and resilience considerations susceptible to being traded off against more urgent priorities; • Risks that sub-optimal investment decisions are made for emergency repairs and low-cost investments, further locking in non-resilient investments; • Communities would continue to make decisions on the current state of infrastructure, not factoring opportunities or future changes; • No national picture of resilience challenges facing NZ, nor understanding of the magnitude of risk is developed; • Would not fulfil requirements for adaptation planning under the *Climate Change Response (Zero Carbon) Amendment Act*; • Would not achieve step-change identified in Arataki.	Levels of service would continue to decline across the system in the medium to longer term, costs of repairs would continue to rise and communities would be increasingly disrupted.
Option 2	**Resilience issues, and approaches for risk management are identified:** This package creates a national picture of issues and provides mechanisms for identifying how they might best be addressed.	• Option 1 responses plus; • Implement risk prioritisation methodology and decision-making framework; • Develop a rapid assessment mechanism to more readily enable resilience responses to urgent issues (emergencies); • Develop an agreed resilience evidence base.	• Better national picture of the resilience risks facing NZ; • Availability of tools to assist regional decision-making and ensure that more resilient options are factored into RLTPs; • More effective response to urgent issues (emergencies).	• Decision-making can still be ad hoc and tactical, locking in sub-optimal options; • Communities would continue to make decisions on the current state of infrastructure, not factoring opportunities or future changes; • Unlikely to achieve step-change identified in Arataki.	Levels of service are likely to continue to decline, but better information available about risks and disruption may be better managed.

OPTION	DESCRIPTION	INCLUDES THESE STRATEGIC RESPONSES	ADVANTAGES	DISADVANTAGES	COMMENT
Option 3	**Integrated investment model:** This option builds on the previous option and establishes long term resilience planning in the form of resilience strategies, that are used to inform long term planning and investment and provide a resilience blueprint to guide short term and emergency works. The community is engaged in the process and are aware of the challenges, and how those can be resolved, including the use of non-infrastructural options.	• Option 2 responses plus; • Incorporate long term planning for resilience between all land transport investment partners and key users; • Develop land transport resilience strategies; • Work with investment partners to develop community engagement strategies.	• Transparency of trade-offs made to ensure that long term investments are in the best interests of the community and systems; • Co-benefits streams from integrated investment such as safety, connectivity can be realised, resulting in better value for money; • Clear path for resilience decision-making in short-term and emergency repair considerations; • Community is clear what the risks of natural hazards are to community and business interests, and can plan for known disruption; • Greater buy-in from all parties; • Should deliver on *Climate Change Response (Zero Carbon) Amendment Act* requirements; • Delivers on Arataki step change.	• Clear knowledge about decisions that need to be taken for resilient outcomes, yet trade-offs against other more urgent or shorter-term outcomes are still possible.	This option is most likely to enable the current level of service across the land transport system to be maintained, by identifying and enabling more sustainable choices to be made, including retreat. It also delivers aspirations of Arataki's step change.
Option 4	**Invest for resilience:** This option further develops the integrated investment model. Resilience is made a priority at a national level, and a protected fund is established to ensure continual progress.	• Option 3 responses plus; • Develop funding model for non-transport infrastructure solutions; • Establish a targeted resilience fund.	• Resilience investment decisions are protected against ad hoc re-prioritisation decisions; • Supports regional development; • The overall resilience of the land transport system improves over time.	• Risk of over-investment in resilience in comparison for the benefits received; • Prioritisation of resilience compromises investments targeted at other benefit streams; • Potential lost opportunity for multi-outcomes solutions.	This option would enable NZ to get ahead of the challenges, and make strategic investments that support system and community resilience and get beyond transport solutions.

PROGRAMME OPTIONS ANALYSIS

Table 8 sets out how the options respond to investment objectives and critical success factors

Table 8: Programme options analysis (completed in December 2019 i.e. pre COVID-19)

			1. Status Quo	2. Improved decision-making	3. Integrated investment model	4. Invest for resilience
Description			Includes integrate land-use and land transport planning, revise the IDMF, investment partner engagement strategy and refresh local government relationship	Status Quo responses plus risk prioritisation methodology and decision making framework, rapid assessment mechanism and evidence base	Do Minimum responses plus long terms resilience planning between investment partners, regional resilience strategies, and community engagement strategies	Preferred responses plus funding model for non-infrastructure solutions targeted resilience programme.
Investment Objectives		All communities and businesses are well informed about what the risks of disruption to their transport connections are, and what their choices are	No	Partial	Partial	Yes
Investment Objectives		The land transport system will be more resilient in the face of a changing hazard profile	Partial	Partial	Yes	Yes
Critical Success Factors	Strategic Fit	Aligned to GPS, MoT Transport Outcomes Framework, NZTA Resilience Framework	No	Partial	Yes	Yes
Critical Success Factors	V for M	Must demonstrate good benefits for the expenditure required	Yes	Yes	Yes	Partial
Critical Success Factors	Afford	Can be done within existing budgets	Yes	Partial	Partial	No
Critical Success Factors	Achieve	Agencies have the capability and capacity to deliver	Yes	Yes	Yes	Yes
Critical Success Factors	Feasibility	Possible to deliver in current environment	Yes	Yes	Yes	No
Summary			Makes some progress towards resilience, but investment decisions likely to be tactical rather than strategic	Establishes a methodology for prioritising resilience risks, and a national view of the challenges, and provides mechanisms that enable repair work to take resilience into account, but remains tactical	Provides a strategic view of risks and preferred approaches that guides and informs investment planning in the long term, short term and for emergency works. Increases community engagement to ensure that communities are well informed.	Provides a strategic view of risks and preferred approaches, and creates a protected funding mechanism to ensure that resilience investments do not get crowded out by other priorities.
Comment			Status quo option	Do minimum option	Preferred option	Ideal option

For more detail on how this assessment was derived please see Appendix H.

Programme options assessment

The analysis presented in Table 8 and outlined below is qualitative in nature and reflects the comments from the participants in the process. The options have not been fully tested through a robust economic evaluation.

The costs of unplanned urgent repairs and emergency works are rising due to the increasing frequency of natural hazard events (see Page 49). This is also a result of increasing pressure on the land transport system, and increased risks posed by a changing natural hazard profile.

A focus on resilience would increase viability and sustainability over the long term – the degree of difference it would make depends on the extent and type of intervention made and how integrated land transport investment partners are in their responses.

The status quo option

This option reflects current state, including recent changes that have been made as a result of other programmes (e.g. Arataki V1) changes that have been accepted but are yet to be implemented, and changes that are still in the engagement phase (e.g. IDMF review).

This option would make some progress to recognising and investing in resilience however, at best investment decisions would continue to be ad-hoc, given there is no national or system wide view of the geographic risks. Many of the barriers to resilience would remain un-addressed, risking further lock-in of investments that may not be resilient or optimally so.

It is likely that the issues that gave rise to this case – prioritisation of nearer term benefits, and in particular a focus on safety and congestion management as major drivers – could persist at the expense of improvements primarily with resilience benefits.

This means that New Zealand would make very little progress towards achieving a land transport system that is resilient, rather New Zealand would continue to lose ground overall as climate change factors in particular increasingly affect the land transport system, resulting in increasing need for investment in emergency repairs, and more frequent disruptions to communities as risk profiles change.

This option may not fulfil Ministerial (or the Commission) requests to reporting organisations to provide information (as set out under S.5ZW of the Climate Change Response (Zero Carbon) Amendment Act 2019).

The improved decision-making option (do minimum)

This option includes the core deliverables that form the outputs of this case, plus a recommendation that the Transport Agency develops a rapid assessment mechanism. The outputs of the case include an evidence base that sets out geographical sites where the resilience of the land transport system is currently threatened by extreme or major risk of natural hazards. This would be grouped on a region by region basis. A summary of a preliminary evaluation of extreme and major risks is set out in Appendix F. A risk prioritisation methodology that would assist decision-making is also provided in Appendix G. Further, this case recommends a rapid assessment mechanism that enables resilience improvements to be made when undertaking emergency repairs.

Overall, this option delivers better information about risks, and better mechanisms to address these geographical sites exposed to extreme and major risk, particularly during emergency response. The approaches remain tactical however, and addresses issues hazard by hazard rather than at a strategic or system level.

If this approach is taken, New Zealand would have better information to drive the decision-making processes, a more granular approach to decision-making and guidance of choices, and an improved ability to bring land transport links up to standard on an opportunistic and ad hoc basis. This means that incorporation of resilience benefits is more likely in design and investment decisions. Many of the issues set out for the Status Quo option would persist. Other priorities would continue to crowd out resilience investments, and decisions would be taken on an ad hoc and locational basis (albeit with better information). This option would however make progress above the Status Quo option and would ensure a better understanding of the issues we are facing.

It is likely that the Transport Agency would continue to face rising costs as we tactically upgrade and repair routes that may prove suboptimal in the long term.

The Integrated investment option (preferred)

The main difference with this option is it proposes that a strategic approach be taken that enables full value to be extracted from the evidence base, methodology and decision-making framework. The key mechanism is the development of long-term resilience "strategies" (for regions, sub-regions, corridors, etc.). These strategies should be integrated into other decision-making, and in particular spatial planning, road safety initiatives and economic development strategies and ensure consistency with future direction under the National Adaptation Plan.

This option provides for consideration of a range of responses to individual, corridor and system wide risks. This means that planning to accommodate risks (for example through enhanced emergency response) and considering retreat from certain parts of the transport system are explicitly considered alongside ongoing investment in maintenance and upgrades.

Land transport resilience strategies would identify the immediate and long-term risks that threaten the land transport system. This would enable agencies to clearly identify, prioritise, and appropriately plan for the different categories of natural hazard risk – ranging from the low-frequency – high impact events (such as earthquakes) through more certain high to medium-frequency risks (such as landslide and flooding) to the certain but medium-term issues such as sea level rise. These interventions could range from localised improvements undertaken in either a programmed way or responding to local natural hazard events; through to completely reviewing and re-planning major routes.

This option does pose an additional burden on agencies – however local authorities and KiwiRail already undertake varying forms of long-term planning, and in addition, are also likely to be required to align to the future national adaptation plan. Resilience strategies would inform and be informed by asset management plans, corridor plans, and day-to-day regional response plans and underpin specific business cases for future investment. They would also be reflected in the programme of activity laid out in the NLTP.

This option creates the scenario where New Zealand is maintaining the current level of service, avoiding a reduction in resilience that is anticipated with the Status Quo and Do Minimum options. It is likely that there would be transition costs in maintaining current levels of resilience. These cannot be accurately costed without strategies being developed. It also creates visibility for where the issues lie, so that resilience can be incorporated when decisions are being taken primarily for other benefits (e.g. road safety).

This option would also support the outcomes sought by Arataki.

It is only once this level of change is implemented that the Transport Agency is likely to be able to align to and satisfy likely requirements of reporting organisations under the Climate Change Response (Zero Carbon) Amendment Act 2019.

The invest for resilience option (ideal)

This option introduces the concept of a targeted resilience fund and enables investment into non-infrastructural solutions. Examples of non-infrastructural solutions could include:

- Improving other forms of connectivity (e.g. communications);
- Assisting communities to cope with lower levels of service and outage;
- Providing communities with the means to maintain social and business continuity in the absence of a reliable land transport link at one end of the spectrum; and
- Improving resilience through activities that do not involve the system.

This option is likely to be more expensive than the others but would enable NZ to transition to a more resilient future. It aligns more closely to the expectations set out in the GPS 2018 and signalled in the draft GPS 2021, but is restricted by the current statutory framework. Specifically, current legislation does not allow for National Land Transport Fund funding to be used for non-infrastructure solutions. This means that this option would require changes to the statutory framework.

A disadvantage of this option is that it separates resilience from other benefits. This potentially misses opportunities to deliver resilience benefits while investing in other outcomes, for example safety or optimisation. However, with careful management it could be a useful transition measure to help New Zealand to move towards a more sustainable future, particularly in the face of sea level change and a changing climate. As indicated in previous sections of this PBC, a significant portion of New Zealand's roading network is susceptible to relatively small rises in sea level – i.e. the issues are near term. There could be significant benefits in developing a mechanism that lifts the system's resilience in some specific targeted areas where there are no other compelling reasons to invest. This may involve investment in physical transport infrastructure but may also involve planning for periodic disruption or exploring ways to avoid impacting sections of the network.

Recommended programme at system level

The overall recommended programme and how it links to the objectives and benefits sought is set out in Figure 12 (Outcomes Framework).

It became clear through this process that a number of these responses are either being canvassed through other programmes of work or have already been agreed. Responses therefore fall under three categories (see Figure 12):

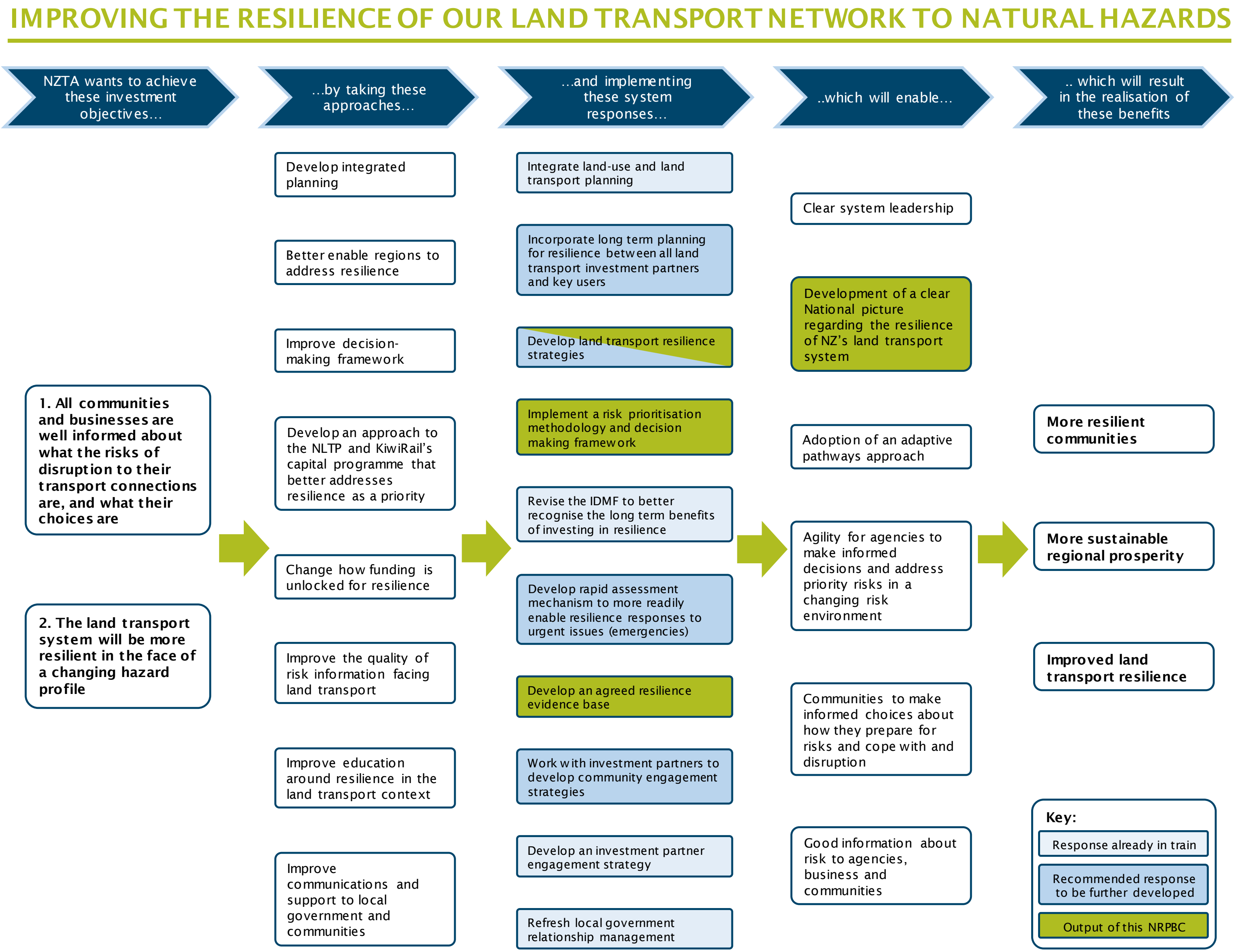
- Responses that are already agreed (but not implemented) or are part of another Transport Agency programme of work (coloured light blue in Figure 12). Achieving the outcomes of this programme are dependent on these initiatives being completed as set out in these other programmes. These other programmes are set out in Appendix I;
- Responses that require further consideration but are outside the scope of this case (coloured dark blue in Figure 12). These responses have been developed to a strategic level and form part of the programme to be implemented under this business case. There would be a number of ways in which the intent of these options can be realised. This is not addressed in this case;

- Deliverables from this case (coloured green in Figure 12). As the key outputs of this case, these responses have been developed to a much more granular level of detail in the next section (Appendix F and G).

Responses raised through the regional workshops worthy of further consideration but not included in the preferred programme to be implemented under this business case due to scope include:

- Providing a funding model that allows for consideration of investments in non-transport infrastructure solutions to address resilience related risks where these interventions may be more appropriate than a traditional infrastructure solution;
- Establishing a resilience fund which would be specifically made available for investments in existing or new transport infrastructure that specifically address resilience risks, as a means or transitioning to a more resilient future land transport system (e.g. specifically address impacts of sea level rise in the near to medium term).

Figure 12: Outcomes Framework for the preferred package of system responses



PRIORITY RISKS

This next sub-section sets out how priority risks have been identified including the datasets used, approach to evaluating risk and developing options for addressing each priority risk. As noted in the discussion on system responses the identified priority risks are relevant for a number of the system responses. This includes developing resilience strategies, applying a revised IDMF, rapid assessment mechanism for emergency response and community engagement strategies.

Natural hazard and asset data

Appendix G (Methodology) presents an overview of the natural hazard and asset data collected and reviewed. Asset data includes available land transport system information as well as key utility locations to inform understanding of interdependencies and criticality. Hazard and risk information has been collected for both natural and technological hazards. For the purpose of this project technological hazards are defined as those hazards resulting from a failure of technology (failed traffic lights, operation centre outage, etc).

When identifying **hazards** of interest, the following were considered.

- The full range of natural hazard events that occur within each region;
- Human-made hazards (technological and socio/political) where relevant; and
- Exacerbating factors – factors that could amplify or exacerbate hazard magnitudes and frequencies should be considered. These include climate change effects, as well as other human-induced causes such as crashes.

Transport **system / networks / asset data** has been collected from the Transport Agency and publicly available data sources such as LINZ. This data primarily focuses on land transport infrastructure e.g. roads and rail, as well as critical infrastructure locations such as ports, bridges, airports, vehicle charging infrastructure and other utility infrastructure served by transport corridors.

Data has been gathered on key interdependencies, such as electricity, primarily within different elements of the transport system. Systems / networks / assets have been considered both individually by sector (e.g. road, rail, port) and in the context of a 'route' which may serve a community either in a business-as-usual or disaster situation, and considering multiple modes serving the same transport purpose.

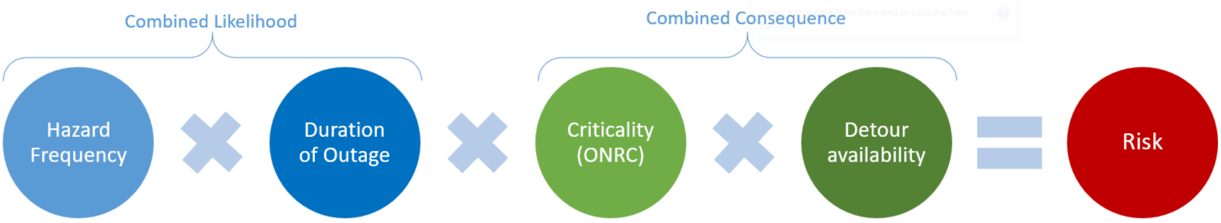
Risk assessment approach

The risk assessment methodology adopted a *Likelihood* and *Consequence* approach to assess risk. This is consistent with ISO31000 Risk Management Principles and Guidelines. This approach is considered good practice, is simple to understand and aligns with The Transport Agency's Risk Management Practice Guide (Z/44). The risk assessment aimed to identify extreme and major risks across the land transport system with regards to natural hazards: 'shock' events, as well as slow onset and climate change induced hazards.

Current natural hazards

The approach incorporates combined likelihood and consequence parameters that influence the level of risk (refer Figure 13). The likelihood is addressed by combining the hazard frequency and the duration of outage which is indicative of the level of potential damage to the asset from its exposure to the hazard (i.e. the greater the damage the greater the duration of outage). The consequence is addressed by combining the criticality of the road and the availability of a viable alternatives such as detours. Criticality is informed by the ONRC rating with provision to adjust the rating to reflect location specification factors such as importance to specific users or access to key utilities infrastructure.

Figure 13: Risk assessment methodology/framework



Consequence is linked directly to the *criticality* of the road network which has been based on the Transport Agency's One Network Road Classification (ONRC). Criticality also considers the road interdependencies with essential services and lifeline utilities. Where the ONRC was viewed (by regional stakeholders) to not reflect the actual use of the road and its importance to the region / nation, the ONRC rating was able to be increased (for these purposes) to reflect the appropriate risk to the land transport system.

The availability of one or more viable alternative routes is a key factor in managing the consequence of a hazard. For example, a national road that has a high criticality rating would have a lower risk if there is a short detour available for all vehicles (therefore the disruption to the system is minimal) compared to a regional road with a poor quality or no alternative for the same combined likelihood.

The risk assessment process used available datasets to form a preliminary view on resilience risks at locations across the land transport systems. The risks identified through this process were then discussed with stakeholders in a workshop format. Adjustments arising from the workshops included:

- Adding or removing existing hazards based on local knowledge.
- Adjusting the criticality of components of the land transport network based on local understanding of the transport system functions.

Approach for climate hazards / stressors (time bound)

A slightly modified methodology was adopted for climate related hazards (coastal inundation, coastal erosion and groundwater rise) as the risk generally increases over time. Hazards already affecting the land transport system were identified and worked through the same process as outlined above for the current climate. These were also given a risk rating for the expected future likelihood and consequence based on the current projections under Representative Concentration Pathway (RCP) 8.5 for New Zealand - considered a reasonable worst case and corresponds to the current warming trajectory with insufficient reduction in GHG emissions. Typically, this meant increasing the hazard likelihood / frequency and / or the duration of outage to increase the climate risk over time.

A high-level exposure assessment was carried out to identify areas of potential future risk to climate change induced hazards for the hazards / risks that are not currently affecting the land transport system. The exposure assessment was a desk-top based assessment which utilises geospatial information systems and available hazard and asset datasets to identify areas where the asset intersects or is exposed to the relevant hazards.

When identifying the extreme and major risk areas, stakeholders were also asked to determine the approximate cost of physical works needed to minimise or eliminate the risk. Where physical works were not viable, responses were considered as either BAU / Ongoing maintenance / Reactive works, or Enhanced preventative maintenance through the NOC contracts. Where no options were deemed possible risks were classified as unsolvable.

Priority risks - preliminary assessment

Identified priority risks

A summary of the extreme and major-risk sites is included in the summary of the outcome of the risk prioritisation process (Appendix F). Given the transient nature of natural hazards, the developing state of knowledge and progress being made through improvements and interventions, this list is likely to change over time. The focus has been on those areas that are not currently addressed through existing investment plans. This list identifies both immediate risks not addressed elsewhere and takes a longer view (50 - 70 years).

The existing risks and potential solutions were developed in discussion with network managers at a regional level. This provided a deep understanding of existing hazards and criticality at a local level. The potential solutions identified tend to be focussed on building solutions.

A map of the extreme and major risks identified in Northland through the preliminary analysis and Regional Workshop is provided as Figure 14, as an example. The colour coding of the State Highway network relates to the desktop analysis of the level of risk. For the corridor orange and red indicating extreme and major risk respectively. The points are derived from workshop discussion with each hazard type represented by a different coloured point on the map.

Figure 14: Mapping extreme and major geographic risks – Northland

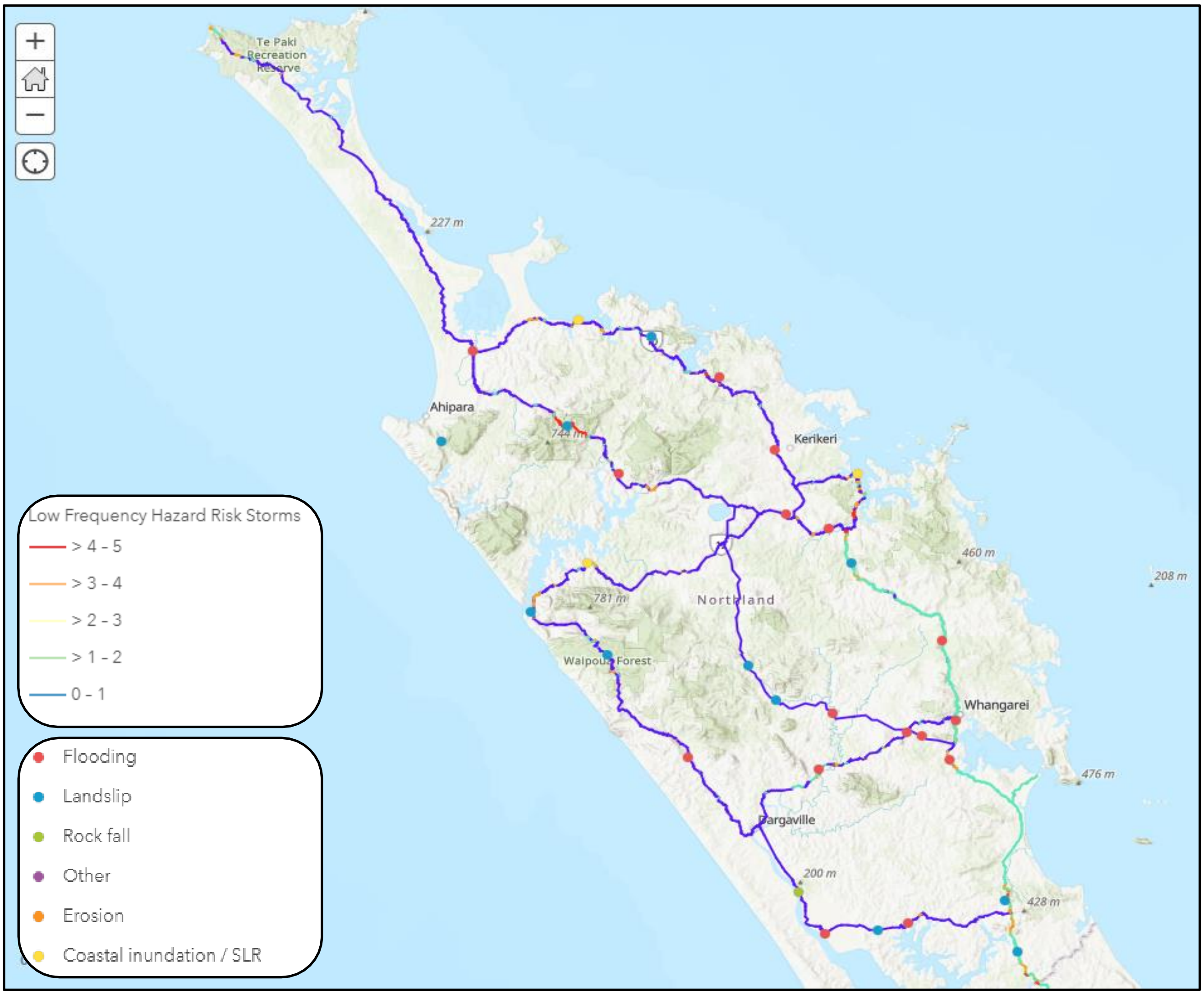
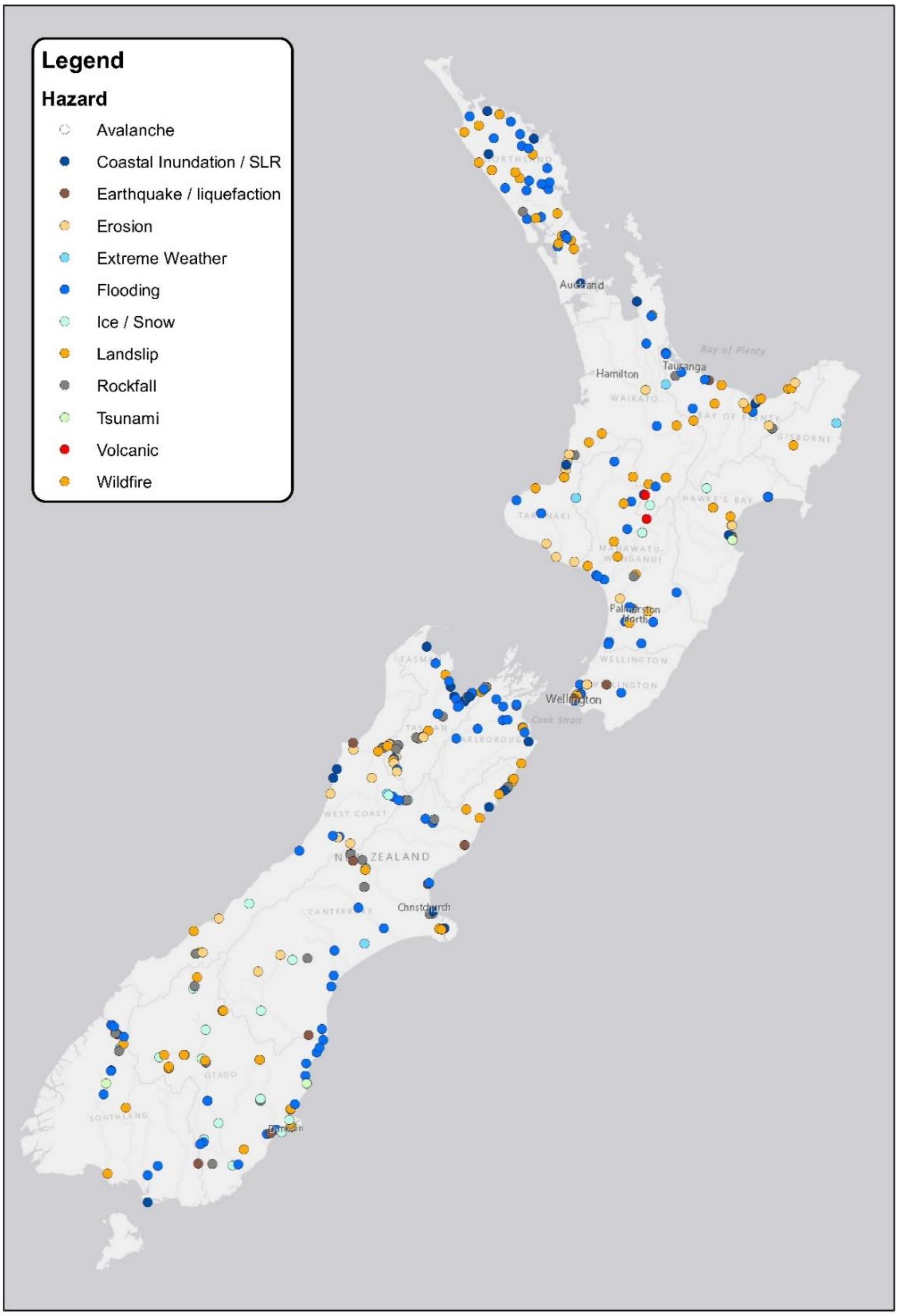


Figure 15 provides a national overview of the locations of extreme and major risks across New Zealand. As shown, Top of the South (Marlborough, Nelson and Tasman Districts), Otago and Canterbury have the highest numbers of identified risks, with Auckland and Gisborne[13] identifying the lowest number.

[13] The Waioeka Gorge is noted as 5VL (extreme risk) due to rockfall with impacts related to connectivity for Gisborne. The location of the risk is in the Bay of Plenty Region so the risk is recorded under Bay of Plenty rather than Gisborne.

Figure 15: Mapping extreme and major geographic risks - Northland



Approaches and options for improving resilience

Action to address priority risks could take a variety of forms. Timing would vary and include addressing risks immediately, developing concept solutions that can be implemented if there is a need to restore transport connections and / or scheduling medium to long-term implementation of solutions for risks that are forecast to emerge or evolve. Intervention may include solutions that maintain current connections, approaches to improve our ability to respond to disruption to the land transport system and / or accepting that some transport connections cannot be maintained.

The potential approaches to developing a response include:

- The risk is current and requires a response now;
  In this case options for addressing the risk should be considered in a formal business case process or incorporated into existing project evaluation and planning
- The risk is current but can be addressed as the opportunity arises e.g. during projects undertaken for other purposes (safety, efficiency) or as part of emergency response and recovery; and
- The risk would emerge in future so a response can designed and implemented at a later time. Early work may be justified, for example to protect alternative routes or have concept designs available in the event of catastrophic failure.

The options for responding that should be considered in all cases include:

- **Defend** - develop solutions to mitigate the risk of disruption, for example flood protection or slope stabilisation;
- **Accommodate** - plan for periodic disruption, for example providing for rapid reinstatement, detour routes and/or timely information; and
- **Retreat** - re-route journeys away from the impacted corridor.

Responding to priority risks

The risks have been grouped by region with potential solutions identified by stakeholders noted where relevant. The risks have been presented on a regional basis but can also be considered taking a corridor or journey view.

Through the regional stakeholder workshops, a range of suggested response options (grouped in wider response categories) were identified. The discussions within the workshops focussed primarily on direct Transport Agency interventions, such as physical works, maintenance or emergency management responses.

As noted elsewhere, the majority of identified risks will require further investigation and development of specific business cases. During these processes a broader suite of response categories should be considered. These could include:

- Physical works (NZTA)
- Physical works (third party – e.g. local road detour improvements, stop banks)
- BAU maintenance, monitoring and/or emergency response planning
- Enhanced maintenance and/or monitoring
- Enhanced emergency response plans and/or preparedness
- Land use and/or development controls
- Real time info, community emergency information systems and/or education.

For all major and extreme risks identified, two categories of 'next steps' have been recommended which indicate next steps in the process rather than the proposed solution. The process should identify the most appropriate solution considering an entire suite of potential response categories (as listed above), along with the suggested solution from the regional stakeholder workshop. As such, the two next step categories are:

- *Business Case funded or underway*: The next step is to proceed with the current business case development ensuring that an appropriate suite of response options is considered.
- *Business Case required*: The next step is development of a 'right sized' business case to address the identified risk, considering an appropriate suite of response options. The

business case point of entry will determine the level of effort required.

Responses would consider individual risks, but more importantly can look at combined risk on a regional, corridor or journey basis (e.g. via the development of a regionally focussed resilience 'strategy'). The response projects would:

- Make use of the risk prioritisation approach;
- Sit within a framework including the updated Investment Decision Making Framework and enhanced strategic land use planning and evolving operational processes/methods to address both immediate and future risks;
- Support the step change set out in Arataki
- Identify where business cases are required e.g. for responses to address extreme and major risks;
- Provide concepts or example designs to enable emergency response activities to deliver improved resilience; and
- Be reflected in Corridor Management Plans, Emergency Response Plans and the Arataki regional summaries.

Conceptually, a resilience strategy considers priority risks grouped on a regional, corridor, journey or other basis. Actions are developed to address individual risks testing the impact of the overall package. This means that activity may address lower priority risks first to mitigate combined risk for a region, corridor or journey.

Considering risks in isolation has the potential to result in focus on individually extreme risks but avoid regional, corridor or journey level impacts from a combination of risks. For the purposes of this NRPBC risks have been captured and presented at a regional level. This illustrates how the prioritised risks can be compiled to provide a resilience strategy with a regional, corridor, journey or other focus.

Resilience strategies provide a mechanism for considering resilience in a holistic manner. This includes considering the impact of multiple hazards, in multiple locations. Depending on the approach selected a strategy could take a regional, corridor or journey view of priority risks' potential solutions.

There is a risk that resilience-focused activity does not link with other initiatives on a regional, corridor or journey basis. For this reason, it is likely that the activities identified in a resilience strategy are best reflected in Corridor Management Plans. Background information and analysis of priority risks should be reflected in the Resilience section of 'Understanding customer levels of service on the corridor'. Priority actions should be addressed in the Investing in access and resilience section of 'Investing in the corridor'. In some cases, actions would need to be informed by detailed evaluation of options (defend, accommodate, retreat), businesses cases and/or concept design work.

Another integrated view of activity on the transport system is provided by Arataki. The regional summaries in Arataki provide current areas of focus and a description of potential interventions for the following decade (2021 - 2031), which will likely be amended under subsequent versions. Arataki provides the strategic overview of activities implemented through Corridor Management Plans, Regional and National Land Transport Programmes and individual projects.

NZTA INVESTMENT ASSESSMENT FRAMEWORK

Anticipated strategic fit and effectiveness

An assessment of the anticipated results alignment has been undertaken in accordance with the Investment Assessment Framework for the 2018-21 National Land Transport Programme. The assessment determines that the anticipated profile is classified High, under the Investment Management activity class. This is because this Programme case provides:

"Access to opportunities, enables transport choice and access and is resilient – thriving regions and liveable cities" and:

- Considers approaches to addressing a significant resilience gap in nationally important social and economic connections; and
- Considers approaches to addressing an unplanned loss of an existing significant connection from the impact of significant natural events.

In this instance, significance relates to the national scale of this NRPBC.

This case makes recommendations for the Transport Agency and its investment partner agencies to implement changes which could improve their approaches so that resilience is better integrated into decision-making. It does not make specific recommendations for funding any particular investment and no further analysis has therefore been undertaken.

Regarding the expected customer levels of service for the land transport system, there are some clearly state expectations under the One Network Road Classification system. For a National Route, the expectation is:

Route is always available during major weather or emergency events and viable alternatives exist. Rapid clearance of incidents affecting road users. Road users are generally advised in advance of issues and incidents.

However, when considering the current risks for the NZ transport system as a whole, it is clear that it may be difficult to meet this expectation in a major event on many highly significant routes. Further, the risk of concurrent disruption to many secondary or alternative routes is such that some of the National class routes are likely to not have a suitable alternative after a significant hazard event.

RECOMMENDATIONS

The decision this National Resilience Programme Business Case (NRPBC) is seeking from the Waka Kotahi NZ Transport Agency (Transport Agency) Board is for the Board to:

1. **Support** the National Resilience Programme Business Case which prioritises major and extreme natural hazard (including climate change related) risks in the New Zealand land transport system and recommends an integrated suite of system responses.
2. **Note** that responses to the highest priority risks and sites will be submitted for consideration into the 2021-24 National Land Transport Programme;
3. **Note** that the evidence base, risk prioritisation methodology and decision-making framework will be made available to our partner organisations.

PART C – DELIVERING THE PROGRAMME

MANAGEMENT CASE

A Programme Management Plan shall be developed to define how the proposed responses in this Business Case shall be executed, monitored, and controlled. At a high level, this plan consists of:

- Programme roles and responsibilities
- Management strategies
- Cost management
- Stakeholder management
- Reporting

Programme roles and responsibilities

The delivery of the responses set out in this programme business case will be incorporated into the Resilience Programme, drawing on the existing roles and responsibilities. The roles and responsibilities for the ongoing programme governance, delivery and management of this PBC through the Resilience Programme are as outlined below.

Table 9: Programme roles and responsibilities

Role	Name	Responsibilities
Governance Group	ELT representatives Programme Sponsor Programme Manager Senior representatives from other programmes	To hold the vision of the project, ensure project delivers on the project objectives, oversee and direct risk management, integrate with other Transport Agency initiatives and collaborate appropriately with partners
Programme Management Team	Programme Manager Work-Stream Leads Comms Lead Change Manager Project Manager	To design, shape and deliver the work-stream objectives and outputs within agreed timeframes and budgets. It is anticipated that many of the activities in this programme will be incorporated into the existing Resilience Programme and managed by the relevant Work Stream Leads. Members should lead work-streams, or have key roles within the programme delivery Provide Programme Status Reports to the Governance Group, with a current view of the programme status considering

		• Overall Programme Health • Key Programme Metrics • Programme Progress • Road Blocks / Issues • Programme Change
Supporting Team	Interface Managers with other initiatives, such as Arataki, IDMF, GPS, and TAIP etc. Technical Specialists from OPPP, Procurement, and Corporate Support etc.	To manage interdependencies with other Transport Agency programmes and provide subject matter expertise
Community of Interest	2-3 reps from each Agency Group/ Directorate	To develop, assist & co-ordinate activities, and share/ champion info and issues across Agency

Management strategies

This section describes how the Resilience Programme will manage the responses proposed in this Programme Business Case, including:

- Responses that have been further developed within this PBC
- Responses implemented/considered by other programmes of work
- Recommendations for new responses to be developed

It should be noted these elements are all inter-related and are necessary if the benefits are to be achieved. It is important to note that compiling a prioritised list of risks does not in itself bring about change. Successfully addressing the risks depends on the effective implementation of all responses identified in the programme and/or integration in a range of existing processes and organisational structures.

<u>Responses that have been further developed within this Programme Business Case;</u>

This category includes responses such as:

- Develop an agreed natural hazard resilience risk evidence base; and
- Implement a risk prioritisation methodology and decision-making framework to provide a list of priority risks.

The latter are identified in Appendix G which sets out methodology including a summary of the evidence base and Appendix F that identifies extreme and major risks for the New Zealand transport system.

Building on these responses and with support from other team members, it is the Programme

Manager's responsibility to:

- establish a process to ensure that this evidence base is periodically updated, maintained and, promoted and linked to other related data-bases;
- support the use of the agreed evidence base and risk prioritisation methodology in investment decision making including using the IDMF;
- ensure projects supporting the agreed risk treatments are prioritised for incorporation into the NLTP (or RLTP) and managed properly; and
- where feasible, utilise existing capital improvement projects, business cases, and maintenance programmes to resolve resilience issues.

<u>Responses implemented/considered by other programmes of work</u>

This category includes responses such as:

  - Integrate land use and land transport planning (part of an integrated set of step changes in Arataki);
  - Revise the IDMF to better recognise the long-term, indirect and intangible benefits of investing in resilience;
  - Develop an investment partner engagement strategy; and
  - Refresh local government relationship management;

The Programme Manager and relevant Work-Stream Leads will include actions and targets in the Resilience Programme work plan to collaborate with Interface Managers in the supporting team to manage interdependencies and make sure any new activities/projects are properly scoped, i.e. no overlapping or gap from other programmes of work.

Where necessary, there are senior representatives from the Governance Group available to ensure all issues are escalated to the right level so that the programme is owned and championed.

<u>Recommendations for new responses to be developed</u>

This category includes responses such as:

- Incorporate long term planning for resilience into the management of the land transport system involving all land transport partners and key users. This will include;
  - Developing integrated land transport resilience strategies, to be incorporated into land transport system management tools such as Corridor Management Plans and the State Highway Activity Management Plan.;
  - Developing a rapid assessment mechanism to more readily enable more holistic resilience responses to urgent issues(emergencies), to be reflected in emergency response tools such as Emergency Preparedness and Procedures Plans and Emergency Response Plans at a Business Unit and National Level; and
  - Work with investment partners to develop community engagement strategies;

These responses will be integrated in the Resilience Programme work plan and managed by relevant Work-Stream Leads. Should a new project need to be initiated, it is the Programme Manager's responsibility to ensure the project is appropriately scoped and resourced.

The responses noted above are summarised in the table overleaf. This notes the issue as highlighted in the Strategic Case, the response developed in the Economic Case, proposed activities and indicative resourcing.

Table 10: Responses, recommendations and activities

Issue	Recommendation	Activities	Indicative budget	
Responses implemented/considered by other programmes of work				
Land use planning decisions are made without reference to the resilience-related impacts on the land transport network	Integrate land use and land transport planning - step change in Arataki	To be address through the levers set out in Arataki and wider Agency engagement in spatial planning and urban development with partners	Included in currently budgeted activities	
Investment decision making doesn't recognise the long term indirect and intangible costs and benefits of addressing resilience related risks.	Revise the IDMF to better recognise the long-term, indirect and intangible benefits of investing in resilience	To be addressed through the IDMF Review	Included in currently budgeted activities	
Investment decisions are not well coordinated between investors in the land transport system - NZTA, Kiwirail, local authorities.	Develop an investment partner engagement strategy Refresh local government relationship management	To be address in various workstreams Partly address via Arataki and lead by LSP's in the Agency with engagement in spatial planning exercises	Included in currently budgeted activities Included in currently budgeted activities	
Response developed as part of this business case				
There is no agreed evidence base or identification of priority risks for the national land transport network.	Develop an agreed resilience evidence base; and Implement a risk prioritisation methodology and decision-making framework.	• Addressed in the development of this Programme Business Case. • Refer to recommendations below for ongoing maintenance of the evidence base and application of the risk prioritisation process.	Completed as part of the development of this PBC	

Issue	Recommendation	Activities	Indicative budget	
Recommendations for new responses to be developed				
There is no agreed evidence base or identification of priority risks for the national land transport network.	Maintain an agreed resilience evidence base.	• Establish a process to ensure that the evidence base is periodically updated, maintained and, promoted and linked to other related data-bases.	Internal resource Allowance for developing/ updating data over time	Resilience team 0.1 FTE Geospatial 0.25 FTE
There is a lack of long term planning for resilience in the land transport system	Developing integrated land transport resilience strategies, documented in Corridor Management Plans, Activity Management Plans or similar planning documents.	• Build on the priority risk work with input from NZTA network managers and other transport system managers (Kiwirail, local authorities) • Identify risks to be addressed, develop and evaluate appropriate treatments for priority risks through existing projects (where possible) and new projects.	Resilience team	2020/21 Resilience team 0.5 FTE Ongoing Resilience team 0.5 FTE
Investment decisions are not well coordinated between investors in the land transport system - NZTA, Kiwirail, local authorities.	Develop a rapid assessment mechanism to identify appropriate responses to emergency issues.	• Develop, pilot and implement a rapid assessment mechanism including consideration of desired long term Level of Service of the impacted network (drawing on priority risk work) for use with emergency works response reinstatements.	Resilience team Consultant to develop emergency response approach Engage with regions and partners (part of priority risk work)	2020/21 Resilience team 0.3 FTE Consultant 100K+ Ongoing Resilience team 0.3 FTE

Issue	Recommendation	Activities	Indicative budget	
Land transport system users don’t understand or recognise resilience risks or their options to mitigate them.	Work with investment partners to develop community engagement strategies	• Develop community focussed information on priority risks. • Identify communication pathways - road user information, NZTA communication channels, partner communications.	NZTA Communication with Resilience Team.	2020/21 Resilience team 0.2 FTE NZTA Comms 0.25 FTE Consultant 100 K + Ongoing Resilience team 0.2 FTE NZTA Comms 0.2 FTE

Cost Management

The cost required to deliver these responses would be secured on an annual basis through the Business Planning (Resilience Programme activities) and through the NLTP National Programmes (addressing priority risks) for appropriate elements.

The individual project manager is responsible for tracking actual spending and reporting through Work Stream Leads to the Programme Manager on a monthly basis.

Stakeholder Management

Stakeholder engagement with the key stakeholders both at a national level and at the regional level, (as set out in Appendix D) is vital to ensure that progress towards implementation is maintained. The development of resilience strategies (delivered by other teams, likely in System Design) provides a good ‘reason’ to discuss resilience issues and specific risks with relevant stakeholders.

A Stakeholder Management Plan will be developed to ensure that parties are connected in, and that the importance of the resilience work is clear.

Special focus shall be put into the Stakeholder Management Plan on engaging investment partners such as local authorities, Regional Transport Committees and KiwiRail. Engaging these parties is vital if genuine progress towards a resilient land transport system is to be made.

Reporting

The Programme Manager is responsible for agreeing with the Programme Sponsor and the Governance Group in terms of reporting requirements, including frequency of Governance Group meeting and content of monthly and quarterly reports. It is anticipated that report on the implementation of the activities set out in this Programme Business Case will be incorporated into reporting on the Resilience Programme.

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APPENDIX A – SUMMARY OF PREVIOUS RISK / RESILIENCE PROJECTS

1. Resilience of State Highways: Lessons from the 2016 Kaikoura Earthquake, OPUS, 2017

Overview

This project aimed to assess the resilience of the state highway network at a broad national level and develop a methodology for implementation at a regional level. The Kaikoura EQ then provided an opportunity to calibrate the resilience studies against observations from this earthquake and bring together key learnings for future resilience studies. Resilience of roads has been defined as being dependent on the loss of quality or serviceability, and the time taken to bring the road back into its original usage state:

Resilience State	Description of State
Availability state	Availability State indicates whether the road section would be able to be used either at full level, at various reduced levels or not at all. This gives an indication of the degree of access on a link after an event.
Outage state	Outage State indicates the duration over which the road will be in the Availability State above. This gives an indication of the duration of loss or reduced access in links along the road network.

Methodology included:

1. Characterisation of the 14 November 2016 Kaikoura earthquake;
2. Review of previous work;
3. Gathering of earthquake damage data;
4. Mapping of the availability state of the Kaikoura section of State Highway 1 after the earthquake;
5. Gap analyses by reviewing and comparing the previous resilience assessments with the observed post-earthquake resilience of SH1 in the Kaikoura earthquake, subsequent after-shocks and storm events;
6. Preparation of a report with observations and recommendations for future resilience assessments.

In 2001, a more detailed corridor level resilience study was carried out. This was also calibrated against the observations of resilience after the Kaikoura earthquake. It allowed comparison between the expected performance and the actual damage from the Kaikoura earthquake in discrete sections. Overall, the national resilience study predicted the outcome of a large earthquake to close the highway both north and south of Kaikoura and the 2016 Kaikoura earthquake has validated this. Overall, the route was closed over most of the coastal sections of the highway, as predicted in the 2001 resilience study as well as the 2016 national state highway resilience study.

A key observation by Brabhaharan et al. (2006) that was reinforced following the Kaikoura earthquake was that the restoration of access following an event occurs in stages rather than as a linear process from loss of service to full. In many instances particularly following a large event, access may be restored to restricted access, single lane and full access in a number of stages.

The project also recognised that safety hazards such as potential for rock fall could compromise availability of the route, even when the route is not closed. Until the source areas for rock fall can be made safe, by scaling, sluicing or rock anchoring. This needs to be considered in response planning.

2. NZ Lifelines Infrastructure Vulnerability Assessment, NZ Lifelines Council, 2017

Overview

This report was a first pass at collating and summarising key findings from regional lifelines studies and other major national hazard studies such as DeVoRA, AF8 and WENIRP1. It aimed to provide insights on New Zealand's critical lifelines infrastructure and its resilience (and conversely its vulnerability) to major hazards and identify a number of knowledge gaps in our understanding and mitigation of New Zealand's critical infrastructure vulnerabilities.

The longer-term goal, (to be delivered through Stages 2 and 3 of the project) is to provide the government and industry with a strategic understanding of nationally significant infrastructure, its vulnerability and resilience to hazards, and strategies to mitigate risks to a nationally agreed 'acceptable' level.

The report found that recent lifelines projects had followed a criticality assessment approach, which identified lifelines infrastructure within the region as nationally, regionally or locally significant. Nationally significant infrastructure assets are often where there are 'pinch points' in the supply chain – sometimes these are single sites which would cause a significant loss of national service.

Along with key sector pinch points such as those described above, many regional lifelines projects were found to look at risks associated with infrastructure 'hotspots' where critical assets from a number of sectors converge with a high consequence of failure associated with cumulative loss of services at that site.

The aim of this Stage 1 assessment was to provide a national view of critical infrastructure and vulnerabilities. It was intended to inform a range of activities, including:

- Regional lifelines projects, to provide an understanding of the cross-boundary issues that need to be considered in regional vulnerability assessments (impacts within the region impacting outside the region and vice versa);
- Lifeline utility resilience planning (e.g. support prioritisation of resilience projects with consideration of wider infrastructure impacts);
- National policy and strategy setting, such as the National Disaster Resilience Strategy and future review of the National Infrastructure Plan and;
- Future infrastructure and hazard research priorities

A number of knowledge gaps were identified and suggested projects to support ongoing resilience improvements were presented in the report. Coming out of work in the 'lifelines' sector, these projects were focussed on aspects such as improving understanding of critical infrastructure, major hazards and the intersection between the two. The report also identified further work is required to understand the dependence of critical community sectors (health, emergency services, Fast Moving Consumer Goods, etc) on lifelines services and backup arrangements if those services fail.

3. Resilience Business Improvement Project 2014-17, NZTA, 2017

Overview

Initiated by the 2013 State Highway Network Resilience National Strategic Case, the Resilience Business Improvement Project 2014-17 focussed on three work streams: business continuity plans; emergency response plans; and the business case process.

The project was completed in 2017 and the associated close out report[14] identifies achievements and outstanding issues and recommendations.

Some of the outstanding issues, such as improving clarity and guidance around investment decision making, improving collaboration with partner agencies, such as National Lifelines, CDEM groups, KiwiRail, Transport etc.), and management and refinement of the MERIT tool (a methodology for assessing the economic impact of major network disruption) support the problems raised throughout the National Resilience Strategic Case (January 2019).

[14] Refer https://infohub.nzta.govt.nz/otcs/cs.dll/Overview/25986066

4. Resilience of State Highways: Recommended Regional Assessment Methodology for Low Frequency Hazard Exposure, NZTA, 2016

Overview

This report presented the methodology developed for the regional level assessment of the resilience exposure of the state highway network for low frequency, high impact natural hazards. The framework is consistent with the national approach but used more detailed regional information, which therefore allowed the resilience of the state highway assets to be assessed at a more detailed regional level. The results of these assessments informed the development of the subsequent Programme Business Cases (e.g. Wellington Regional Land Transport Resilience PBC).

The approach used to assess the resilience exposure of state highway routes at a corridor or regional level is summarised below:

- Identify corridor for resilience assessment;
- Determine scope / & assessment level;
- Collate data;
- Develop characterisation scheme;
- Carry out site reconnaissance;
- Characterise the road corridor;
- Assess the hazard impacts;
- Apply resilience metrics and;
- Capture into GIS

This assessment was based on the approach developed by Brabhaharan et al. (2001, 2006), and is consistent with the approach developed for the national level resilience assessment (Brabhaharan & Mason, 2016).

The objectives of the regional assessment process were to:

- Enable assessment of the resilience exposure of state highway corridors to low frequency, high impact natural hazards at a more detailed level than the national assessment, so that it can be used for the development of programme business cases for corridors and for planning resilience enhancement and network asset and emergency management;
- Provide a consistent basis for assessment of the resilience for the state highways in all the regions;
- Enable detailed understanding of the resilience of the network, particularly sections of corridors with poor resilience;
- Underpin the evaluation of gaps in resilience (desired resilience vs current resilience);
- Provide outputs suitable for the development of strategic responses and be able to be used for development of resilience enhancement measures (including emergency response planning) and;
- Provide a toolkit, including a process map and appropriate evidence/references that could be used in the process, and which has flexibility for adaptation/innovation for specific issues.

These objectives have provided the basis of the development of the regional assessment methodology for resilience exposure to low frequency, high impact events.

5. National State Highway Resilience: 9 Priority Programme Business Case Corridors, OPUS, 2016

Overview

Following the 2014 Resilience Programme Business Case, which identified that 'Priority 1' corridors should be assessed under their own PBC, the 2016 national level resilience assessment of the 9 priority corridors was published and identified sections of the state highways that are vulnerable to failure from a variety of natural hazards. The project had involved collection of national data on natural hazards for use in the assessment of the resilience of the state highway network, and existing assessments of the vulnerability of components of the state highway (e.g. bridge seismic assessment or scour).

The national level resilience assessment had been initially carried out for 9 priority programme business case corridors, located throughout the country.

The outputs of the national level resilience assessment were:

- A series of maps showing the resilience states for the state highways, presented as availability, outage and disruption states, and highlighting key areas of vulnerability of the state highways;
- A map showing prioritisation of the state highway network and;
- A brief report summarising the results of the assessment.

The national resilience assessment methodology was designed to address the following objectives:

- Assessment of the resilience across the whole state highway network is enabled;
- Assessment is made at a broad-brush high level, efficiently and quickly;
- Resilience is assessed against large natural hazard events;
- A consistent basis is used applied across the country;
- Assessment is designed to screen and understand the resilience of the network, to appreciate differences, and identify areas of concern;
- Further consideration of areas with poor resilience is enabled and informed and linked with more detailed assessments at corridor levels by regional Agency teams.

These objectives have been the basis of the development of the national assessment methodology for resilience. Resilience metrics have been used to represent these two dimensions, through the resilience states developed by Brabhaharan et al. (2006) which are:

- Availability state – level of access after the event, representing the level of service;
- Outage state – the duration of reduced access at the above availability state.

The project also provided recommendations that:

- A regional level resilience screening methodology be developed, and then implemented for the 9 Priority Programme Business Case Corridors. This will enable the resilience to be assessed with a better definition of local level hazards and the hazards (e.g. local flooding, liquefaction) in more detail. This will also provide insight into whether some of the PBC corridors would need to consider alternative alignments and identify which sections of the corridors are more critical from a resilience perspective.
- The national level resilience screening be continued for the remaining state highway network, after completion of the regional level resilience for the 9 priority corridors. This will enable the programme business cases to proceed but will also allow for testing of the methodology for the regional level assessment, and this may provide insights to refine the national resilience screening methodology.
- The identified national level critical resilience issues be used in asset and emergency management planning for these routes that have been assessed.

6. State Highway Network Resilience National Programme Business Case, NZTA, 2014
State Highway Network Resilience National Strategic Business Case, NZTA, 2013

Overview

The approach taken in this PBC assumes that resilience is concerned with any event, natural or man-made, which could disrupt the Transport Agency's customers travel plans. The definition of resilience used in the development of this Programme Business Case (PBC) is taken from the National Infrastructure Plan (NIP) which states:

'The concept of resilience is wider than natural disasters and covers the capacity of public, private and civic sectors to withstand disruption, absorb disturbance, act effectively in a crisis, adapt to changing conditions, including climate change, and grow over time'.

The PBC was developed in response to the NZTA's Strategic Case for the Highways and Network Operations (HNO) which was developed late in 2013. This Strategic Case focused on the legislative requirements of the Transport Agency in managing the state highway network and was developed to address the three problem areas, identified in the case to deliver significant benefit.

Strategic Case: Problem	Strategic Case: Benefits of addressing the problem
Poor highway resilience may impede critical services from providing disaster response and recovery support	Better enabled disaster response and recovery
Unreliability of some highways impacts businesses and undermines economic growth	Better support for economic growth
The risky environment of some roads increases the possibility of harm to road users	Reduced risk of harm to road users

In the subsequent PBC, (2014) the initial activities developed to fill information gaps and increase preventative maintenance were split into the following three types of activities:

- Resilience Improvements – Priority Corridors;
- Resilience Improvements – Critical spot treatments and;
- Resilience Management and Preparedness.

Methodology included:

- Developing a framework for consistently assessing geologic and hydrologic risks;
- Developing an approach to assessment of risk and response on state highway routes, and dependent communities and;
- Developing a standard for:
  - Assessing Lifelines obligations and responses;
  - Assessing and recording alternative routes and;
  - Emergency response plans, including providing emergency access to isolated communities.

Maps were created from TREIS data on the number and duration of closures over the past five years. This was combined into heat maps showing resilience hot spots. The large number of closures recorded in the TREIS data above and the resilience risk data provided by the regions clearly demonstrated the significant economic impact caused by lost hours to business due to closures, and the potential for a number of people to be hurt due to rock fall risk.

The 2014 Resilience PBC was also identified that 'Priority 1' corridors should be assessed under their own subsequent PBC's.

7. Natural Hazard Road Risk Management Part III: Performance Criteria, OPUS, 2006

Overview

The research completed in the third stage of this programme of research was aimed at developing approaches for the strategic management of natural hazard risks to road networks in New Zealand. To facilitate the process, the resilience of each road link in the network was assessed in terms of appropriate 'resilience states' which were developed as part of this study, namely:

- Damage state;
- Availability state and;
- Outage state.

In Part I, Opus developed strategies for managing natural hazard risks to road networks. This research identified several approaches:

- Firstly, for assessing the spatial risk to road networks with the aid of a geographical information system ( );
- Secondly, considering risk mitigation and;
- Finally, prioritising sections of road for management of the risk.

In Part II, Opus presented different levels at which risk management should be addressed and discussed how this may be integrated to achieve a resilient road network. The study recommended that performance criteria and levels of service for different types of roads forming the road networks in New Zealand should be researched.

A methodology was developed to enable the development of robust criteria for setting performance levels for road networks regarding natural hazards risk performance:

- Literature Research;
- Reviewing road damage and disruption from past natural hazards;
- Consulting road stakeholders;
- Identifying issues and assessing factors which affect performance levels;
- Workshop on performance expectations;
- Developing a framework for setting performance levels;
- Pilot application of the framework to a section of the road network;

A comprehensive review of literature relating to the management of risks associated with road networks was undertaken to review different methods, both nationally and internationally for addressing infrastructure performance criteria, damage states, levels of service, road / bridge classifications and Civil Defence Emergency Management Act requirements. The literature review confirmed that no criteria was available for setting performance levels for road networks, except for performance-based design standards for bridges. Although some have attempted to define the desired levels of performance for a water supply system, little consideration has been given on how to decide on these levels of performance. No information was available to build on from past literature. Guidance for deciding appropriate levels of performance was therefore been developed on the basis of the new research reported as part of this programme.

In order to produce a questionnaire that encompassed all the principal issues, typical natural hazard scenarios were developed. The purpose of the scenarios was to enable the consultation to be based on some realistic scenarios on which the stakeholders could relate to and provide meaningful comment.

The purpose of the performance expectations workshop was to draw on the collective experience of the participants on important issues for setting performance measures. This pooled experience then provided information for developing a framework for setting performance criteria.

The purpose of applying the framework for setting performance levels to the Wellington road network was to demonstrate how the process can be applied in practice to assist practitioners in their road asset and risk management planning.

APPENDIX B – STRATEGIC ALIGNMENT

Alignment to United Nations international priorities

In 2015 all United Nations (UN) Member States including New Zealand adopted the 2030 Agenda for Sustainable Development, which at its core established 17 Sustainable Development Goals (SDG's). This case contributes to three of these goals. This case is also highly aligned to the priorities of the UN Sendai Framework for Disaster Risk Reduction which works hand in hand with the 17 SDG's.

STRATEGY IDENTIFIED	STRATEGY DESCRIPTION	GOALS / PRIORITIES RELEVANT TO THIS CASE	
Sustainable Development Goals	17 goals and 169 targets which will stimulate global action over the next 15 years in areas of critical importance for humanity and the planet.	**Goal 9: Industry, Innovation and Infrastructure**	**Target 9.1:** Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all.
		Goal 11: Sustainable cities and communities	**Target 11B:** By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all level.
		Goal 13: Climate Action	**Target 13.1:** Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries
Sendai Framework for Disaster Risk Reduction	The purpose of this framework is to substantially reduce disaster risk and losses in lives, livelihoods and health in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries. Disaster risk includes risk of natural hazards.	**Priority 1 Understanding disaster risk:** Disaster risk management should be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment. Such knowledge can be used for risk assessment, prevention, mitigation, preparedness and response.	
		Priority 2 Strengthening disaster risk governance to manage disaster risk: Disaster risk governance at the national, regional and global levels is very important for prevention, mitigation, preparedness, response, recovery, and rehabilitation. It fosters collaboration and partnership.	
		Priority 3 Investing in disaster risk reduction for resilience: Public and private investment in disaster risk prevention and reduction through structural and non-structural measures are essential to enhance the economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment.	

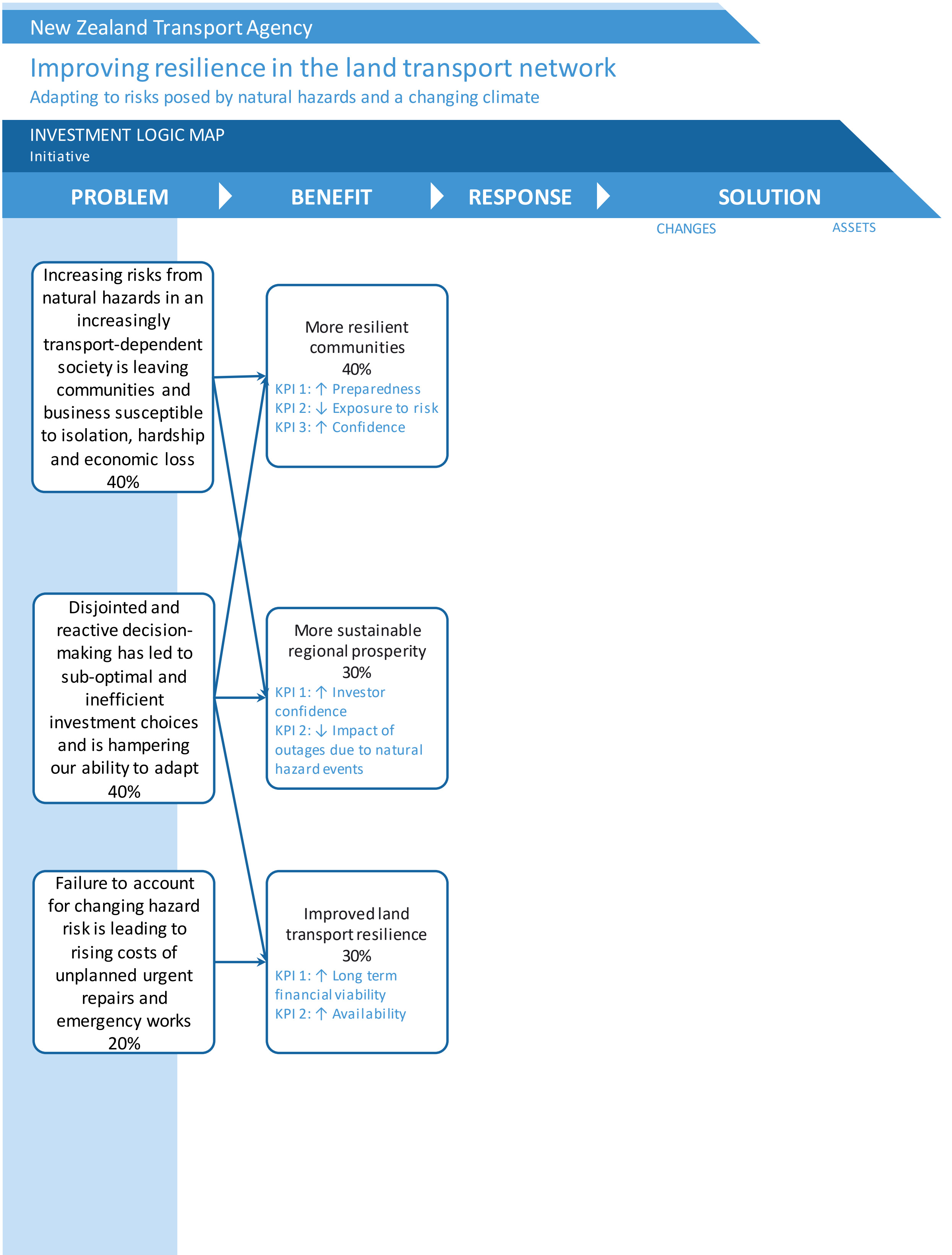
STRATEGY IDENTIFIED	STRATEGY DESCRIPTION	GOALS / PRIORITIES RELEVANT TO THIS CASE
		The framework indicates that priority 4 is Enhancing preparedness for effective response and to improve resilience through recovery, rehabilitation and reconstruction activity: The growth of disaster risk means there is a need to strengthen disaster preparedness for response, take action in anticipation of events, and ensure capacities are in place for effective response and recovery at all levels. The recovery, rehabilitation and reconstruction phase are critical opportunities to improve resilience, including through integrating disaster risk reduction into development measures.

Alignment with relevant organisation strategies

ORGANISATION	STRATEGY IDENTIFIED	DESCRIPTION	RELEVANCE TO THIS CASE
Local Government NZ	LGNZ Policy Statement 2017/19	This Policy Statement establishes LGNZ's 3 strategic goals and 5 policy priorities that will support all local government bodies address the key challenges that currently face New Zealand and its communities.	The Policy Statement recognises increasing urbanisation and climate change as two key challenges that local government is currently facing. One of the LGNZ's five policy priorities that respond to these challenges is Risk and Resilience. This involves 'understanding and addressing risks from natural hazards and other events – both for infrastructure and to support resilience in the economy and our communities.
Ministry for the Environment	A framework for the national climate change risk assessment	This is an all-of-government framework which provides guidance on undertaking the National Climate Change Risk Assessment (NCCRA) to obtain a national scale overview of New Zealand's present and future climate-related risks under different scenarios of climate change.	The objective of the NCCRA (derived from applying this framework) is to support the development of the subsequent National Adaptation Plan. This plan will respond to and prioritise adaptation actions for key risks identified as part of the NCCRA and outline the Government's approach to improving resilience to the effects of climate change. It is designed to safeguard the wellbeing of New Zealand by enhancing the resilience of the built environment to the effects of climate change.

ORGANISATION	STRATEGY IDENTIFIED	DESCRIPTION	RELEVANCE TO THIS CASE
National Emergency Management Agency (NEMA - formerly Ministry of Civil Defence and Emergency Management)	National Disaster Resilience Strategy	The purpose of this Strategy is to outline the vision and long-term goals for civil defence emergency management in New Zealand.	This Strategy sets three priorities to improve our nation's resilience to disasters: **1. Managing risks:** what we can do to minimise the risks we face and limit the impacts to be managed if hazards occur; **2. Effective response to and recovery from emergencies:** building our capability and capacity to manage emergencies when they do happen; and **3. Enabling, empowering, and supporting community resilience:** building a culture of resilience in New Zealand so that everyone can participate in and contribute to communities' – and the nation's – resilience.
National Infrastructure Unit, The Treasury	National Infrastructure Plan 2015	This plan supports setting the national direction for infrastructure management and development. The plan will be updated by the Infrastructure Commission in 2021.	The National Infrastructure Plan has a vision that by 2045, New Zealand's infrastructure is resilient, coordinated and contributes to a strong economy and high living standards. The plan notes that resilience can be achieved through a combination of investing in infrastructure to make it more robust and by making operational changes.
The Treasury	Living Standards Framework	The Living Standards Framework (LSF) is a New Zealand specific framework that draws on a range of national and international approaches to maximise intergenerational wellbeing and prosperity. At the centre of framework are four capitals: natural, social, human and financial / physical.	Natural hazard events impact all four capitals of the LSF in a profound and costly way. This impacts the intergenerational wellbeing of New Zealander's. The LSF recognises that risk management and resilience are critical for the intergenerational wellbeing of New Zealanders. The LSF promotes the establishment of good public policy that enhances the capacity of natural, social, human and financial/physical capital to improve wellbeing for all New Zealanders.

APPENDIX C – NRPBC INVESTMENT LOGIC MAP



Investor:	Stuart Woods (Vanessa Browne)	Version no:	1.7
Facilitator:	Sue Powell	Initial Workshop:	07/11/2019
Accredited Facilitator:	Yes	Last modified by:	Sue Powell 27/01/2020
		Template version:	6.0

APPENDIX D – STAKEHOLDERS ENGAGED IN THE DEVELOPMENT OF THIS CASE

Stakeholders that were engaged in the development of this case are categorised into three distinct groups which are described in the tables below.

NATIONAL LEVEL STAKEHOLDERS		
Description	This group was the steering committee for the development of this case. It was made up of senior representation from those agencies with a major interest in developing resilience, experienced in the challenges that a lack of resilience poses. This group would be engaged to help frame the case (identify the desirable future state) and ensure that it delivers against broader government objectives (check the risk-based approach).	
Stakeholders	Organisation	Stakeholder name
	KiwiRail	Daniel Headifen
	Local Government NZ	Philip Shackleton
	Ministry of Transport	Nic Paterson
	National Lifelines Group	Roger Fairclough
	NZTA (Arataki Programme and Resilience Programme)	Rochelle Hardy (workstream lead: planning and decision making)
	NZTA (Investment Quality Assurance team)	Coral Aldridge
	NZTA (Resilience Programme)	Stuart Woods (project sponsor)
	NZTA	James Shi (project manager)

PLANNING / MITIGATION STAKEHOLDERS		
Description	A selection of stakeholders with a strategic view. This group will also include stakeholders with the responsibilities for managing the existing resilience challenges, and future challenges associated with the legacy of investment in existing development. This group would be involved in helping to understand the problem, check the benefits, to confirm the list of risks and the options analysis process, and agreeing the recommended programme ('the story').	
Stakeholders	Organisation	Stakeholder name
	GNS Science	Kelvin Berryman
	Horizons Regional Council	Ged Shirley
	National Institute of Water and Atmospheric Research (NIWA)	Rob Bell
	Northern Transport Alliance	Jeff Devine

PLANNING / MITIGATION STAKEHOLDERS		
	Organisation	Stakeholder name
	Tauranga City Council	Steve Raynor
	Note: Engagement was also sought from stakeholders from Auckland Transport Group and Ministry for the Environment, but these stakeholders were unable to attend any of the scheduled meetings / workshops.	

REGIONAL STAKEHOLDER ENGAGEMENT GROUPS		
Description	Stakeholders with regional/local expertise and knowledge e.g. local managers and maintenance staff, to support the risk and option assessment process. This group manage local/regional assets and will hold localised, specific information. Input from this group is critical for filling information gaps and providing for a robust process that successfully identifies priority risks and feasible options for responding to these, noting that risks are most likely to be geographic but may also be systemic.	
Northland stakeholders	Organisation	Stakeholder name
	KiwiRail	James Thompson
	NOC - Contract Manager	Rob Kersel
	Northern Transport Alliance – Northland RC	Chris Powell
	Northern Transport Alliance - Whangarei DC	Calvin Thomas
	Northern Transport Alliance - Whangarei DC	Jeff Devine
	Northport	Ben Sweeny
	NZTA - Lead Strategic Planner	Brian Waddell
	NZTA - Network Manager	Brian Childs
	NZTA - Network Manager	David Ingles
	NZTA - Portfolio Manager	Chris Gasson
	NZTA - Principle Transport Planner	Jacqui Hori-Hoult
	NTA	Andy Brown
	NTA	Warren Feek
Canterbury / West Coast stakeholders		
	Christchurch City Council	David Plom
	Environment Canterbury	Anna Sanson
	Environment Canterbury	Ben Wong
	Lyttleton Ports	Paul

REGIONAL STAKEHOLDER ENGAGEMENT GROUPS		
	Organisation	Stakeholder name
	NOC - Fulton Hogan	Stephen Lowe
	NZTA - Senior Network Manager	Colin Hey
	Philip Wareing Transport - Sales Manager	Mark Wareing
	WSP	James Ballard
	WSP	Michael Darnell
Top of the South stakeholders		
	Fulton Hogan	Eamon Powick
	Fulton Hogan	Shaun Perrin
	NOC - Tasman Journeys	Dean Hunt
	NZTA - Maintenance Contract Manager	Roger Ashworth
	NZTA - System Manager	Andrew James
	NZTA - Transport Planner	Rhys Palmer
	NZTA	Braeden Lobb
	NZTA	Terry McGavin
	WSP	Matthew Rodwell
Bay of Plenty stakeholders		
	NZTA	Nigel D'Ath
	NZTA	Rob Campbell
	NZTA	Terry Boyle
Southland stakeholder		
	NZTA – Network Manager	Peter Robinson
Taranaki / Whanganui / Manawatu stakeholders		
	NZTA – System Manager	Mark Owen
	NZTA	David Perry
	NZTA	Kew Williams
	NZTA	Richard Ashman
	NZTA	Tim Siau

REGIONAL STAKEHOLDER ENGAGEMENT GROUPS		
Wellington / Manawatu stakeholders	Organisation	Stakeholder name
	NZTA – System Manager	Mark Owen
	NZTA	Iqbal Idris
	NZTA	Sam Twyman
	NZTA	Terry McGavin
Gisborne / Hawkes Bay stakeholders		
	NZTA – Safety	Ben Grapes
	NZTA – Structures	Liam Coleman
	NZTA – System Manager	Oliver Postings
	NZTA – Transport planner	Simon Barnett
	NZTA	Frank Nieuwland
	NZTA	Rob Patridge
Waikato stakeholders		
	NZTA – Investment Advisor	Rob Bullick
	NZTA – Journey Manager One Network	Liam Ryan
	NZTA – Principle Network Manger	Grant Tregigda
Auckland stakeholders		
	NZTA – Portfolio Manager - Auckland (Transport Planner)	Paul Glucina
Otago stakeholders		
	NZTA – Network Manager	Chris Harris
	NZTA – Network Manager	John Jarvis
Milford Road Alliance stakeholder		
	NZTA – Milford Alliance Manger	Kevin Thompson

APPENDIX E – SYSTEM ISSUES RAISED IN REGIONAL WORKSHOPS / CONVERSATIONS

The following table provides a full list of the system issues raised in the regional workshops / conversations. It also identifies how these issues link to the long list of system responses, which were developed in this case.

NORTHLAND STAKEHOLDERS	
Comments on system risks	Relates to responses proposed in the NRPBC
The amalgamation of the councils means there is no management of Northland catchments (Ruakaka particularly). This increases the risk of flooding. Removal of the Drainage boards has been a significant issue in terms of maintaining drains. This applies to management of private off boundary land as well as whole catchment management.	1. Integrate land-use and land transport planning.
	3. Develop land transport resilience strategies.
	5. Develop funding model for non-transport infrastructure solutions.
Communities in Northland rely on daily freight deliveries from Auckland and so disruptions to the State Highway network can cause significant issues. Northland also has a lack of local roads which can serve as alternative routes when disruption to the SH network occur and many of these local roads are unsuitable for HPMVs. There have even been recorded cases of HPMV trucks tipping on local roads.	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.
	10. Work with investment partners to develop community engagement strategies.
A lot of Northland is very low lying and therefore exposed to significant flood risk.	1. Integrate land-use and land transport planning.
	3. Develop land transport resilience strategies.
	4. Implement a risk prioritisation methodology and decision-making framework.
	9. Develop an agreed resilience evidence base.
Congestion and accidents can have significant consequences for the Northland land transport system. They also create complexities for road maintenance.	Out of scope

NORTHLAND STAKEHOLDERS	
Comments on system risks	Relates to responses proposed in the NRPBC
Transport in Northland is not completely reliable as there are limited options. Resilience is about providing a reliable journey on the network – it doesn't matter how people make that journey.	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.
	5. Develop funding model for non-transport infrastructure solutions.
	9. Develop an agreed resilience evidence base.
	10. Work with investment partners to develop community engagement strategies.
Northland is a very narrow region which means that when natural hazards occur, they can likely cause disruptions throughout the whole land transport system (i.e. when SH1 is shutdown it is likely there will be disruptions on other roads as well). So many of the routes i8n Northland are the single access route.	1. Integrate land-use and land transport planning.
	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.
	10. Work with investment partners to develop community engagement strategies.
There are issues around funding and the complexity of obtaining funding. The process is onerous, frustrating, unclear and too long.	6. Establish a targeted resilience fund.
	7. Revise the IDMF to better recognise the long-term benefits of investing in resilience.
	8. Develop rapid assessment mechanism to more readily enable resilience responses to urgent issues (emergencies).
	12. Refresh local government relationship management.
Forestry and agriculture growth in the region.	1. Integrate land-use and land transport planning.
	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.

NORTHLAND STAKEHOLDERS	
Comments on system risks	Relates to responses proposed in the NRPBC
Kaipara KickStart is an initiative which encourages significant agriculture and produce in the area. This will make the land transport section between Ruawai and Dargaville much more important and high risk. There therefore needs to be integration between agricultural land use planning and transport planning in the area.	1. Integrate land-use and land transport planning.
	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.
Asset Integrator's are responsible for approving funding, but they are hard to get a hold of.	12. Refresh local government relationship management.
There needs to be smarter process for how the NLTP is pulled together. The Transport Agency has to stop fleshing out its network and make better investments into the existing system.	1. Integrate land-use and land transport planning.
	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.
	4. Implement a risk prioritisation methodology and decision-making framework.
	9. Develop an agreed resilience evidence base.
The process outside of Low-Cost Low Risk is difficult and most projects are slightly higher than $1M threshold. Going over this threshold then requires the development of a whole BC.	8. Develop rapid assessment mechanism to more readily enable resilience responses to urgent issues (emergencies).
	12. Refresh local government relationship management.
There is a need for resilience to be just as good of an argument as any other benefit stream [to influence investment decisions]. This PBC should be making the case for Resilience to be prioritised.	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.
	6. Establish a targeted resilience fund.
	7. Revise the IDMF to better recognise the long-term benefits of investing in resilience.
	11. Develop an investment partner engagement strategy.

NORTHLAND STAKEHOLDERS	
Comments on system risks	**Relates to responses proposed in the NRPBC**
If there are priorities in the Asset Management Plan, (AMP) then the government can't actually change them. If the priorities of the Transport Agency align with Local AMP's, then projects established within the AMP's should be more easily funded. This alignment however does not currently exist. The NLTP also needs to be aligned with the GPS. If the Business Case and AMPs are right and due diligence has been properly exercised, then the public can hold the government to account for funding. NTLF funding can also be spent where the public intend for it to be spent. There is a need for each region to develop a regional strategy.	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.
	9. Develop an agreed resilience evidence base.
	11. Develop an investment partner engagement strategy.
	12. Refresh local government relationship management.
The road networks should be viewed as regional networks, not separate State Highway and Local road networks. They are all linked together.	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.
	9. Develop an agreed resilience evidence base.
There is a need to link the NLTP to each regions AMP, as this has the link to funding. Resilience needs to be tied to a level of service that is established through the AMP. This can then enable operational funding (OPEX). When regions want to argue for more funding, they want to argue it from their level of service not the technical condition of the asset. This argument should be through each regions AMP – is the region meeting their level of service based on how they manage their asset. OPEX is through the NLTP.	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.
	4. Implement a risk prioritisation methodology and decision-making framework.
	9. Develop an agreed resilience evidence base.
	10. Work with investment partners to develop community engagement strategies (?).
	12. Refresh local government relationship management.
There is a risk of approving significant Low-Cost Low Risk programmes without understanding the wider context and whether these programmes are actually addressing the core issue they set out to address. Low-Cost Low-Risk programmes don't always take the best strategic view.	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.
	4. Implement a risk prioritisation methodology and decision-making framework.
	9. Develop an agreed resilience evidence base.
	10. Work with investment partners to develop community engagement strategies.

NORTHLAND STAKEHOLDERS	
Comments on system risks	Relates to responses proposed in the NRPBC
With regard to climate change we have previously always taken a view of past events. We haven't looked at what the future natural hazard events might look like and how they will impact us.	1. Integrate land-use and land transport planning.
	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.
	4. Implement a risk prioritisation methodology and decision-making framework.
	9. Develop an agreed resilience evidence base.
Before regions make a request for funding, they need to determine how they are currently optimising their existing assets. Can they prove they are appropriately investing their OPEX.	3. Develop land transport resilience strategies.
	9. Develop an agreed resilience evidence base.

CANTERBURY / WEST COAST STAKEHOLDERS	
Comments on system risks	Relates to responses proposed in the NRPBC
It could be helpful for the Transport Agency to clarify where maintenance funding needs to come from.	12. Refresh local government relationship management.
From Hokitika to Haast – aggregate extraction is seen as mining, so there is minimal aggregate available to build rock revetment solutions (only three sources along the West Coast). Transportation is therefore more expensive and it damages relevant roads.	Out of scope
We need to be able to identify parts of the system where investment may be able to achieve multiple benefits such as resilience, safety and capacity.	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.
	9. Develop an agreed resilience evidence base.
Risks should be prioritised around community impacts.	4. Implement a risk prioritisation methodology and decision-making framework.
	10. Work with investment partners to develop community engagement strategies.
Should evacuation routes be included within the ONRC?	3. Develop land transport resilience strategies.
	4. Implement a risk prioritisation methodology and decision-making framework.
	9. Develop an agreed resilience evidence base.

TOP OF THE SOUTH STAKEHOLDERS	
Comments on system risks	Relates to responses proposed in the NRPBC
Emergency works don't currently cover betterment. The priority is currently focused around emergency works as opposed to preventative works. One example is Deadmans slip; undertaking emergency works repairs doesn't solve the core issue – the risk is still there. In reality the road should have been moved out of harm's way. In order to provide the same level of service the capacity of the asset has to be increased. This is because the climate has affected the design requirements. Heavy rainfall results in the blow out of culverts and with Climate Change the frequency and severity of heavy rainfall events will only increase. We should therefore prioritise a culvert upgrade programme across the network to deal with this increased risk. Regional managers should have more discretion around funding. There are also no simple funding pots for resilience where funding can be accessed for smarter resilient solutions. Emergency works currently just means you fix the symptom not the issue.	3. Develop land transport resilience strategies.
	6. Establish a targeted resilience fund.
	8. Develop rapid assessment mechanism to more readily enable resilience responses to urgent issues (emergencies).
	9. Develop an agreed resilience evidence base.
Preventative maintenance funding is not available.	3. Develop land transport resilience strategies.
	6. Establish a targeted resilience fund.
There should be much lower requirements than what is currently expected when it comes to developing a PBC.	8. Develop rapid assessment mechanism to more readily enable resilience responses to urgent issues (emergencies).
	12. Refresh local government relationship management.
There have been programmes designed which could deliver multiple benefits across a lot of areas such as safety, capacity and resilience. However, because some of these programmes do not deliver significant benefits in any one particular benefit stream, they often do not get funded. However, the reality is they could cover a lot of issues.	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.
	7. Revise the IDMF to better recognise the long-term benefits of investing in resilience.
	9. Develop an agreed resilience evidence base.
There is currently limited catchment monitoring and clearance of culverts.	5. Develop funding model for non-transport infrastructure solutions.
	9. Develop an agreed resilience evidence base.

TOP OF THE SOUTH STAKEHOLDERS	
Comments on system risks	Relates to responses proposed in the NRPBC
Stockpile rock for maintenance - there is a required standard for the rock you are supposed to use but this rock ends up being more costly than other alternatives. This is because you have to transport it from much further away. Is there a lower standard of rock which is still fit for purpose?	Out of scope
It is difficult to access funding for the monitoring of natural hazard issues such as landslip/creep and weather monitoring. In Hawkes Bay they have weather monitors which close the road when the wind gets too high for vehicles. Similarly, there is monitoring of sea swell to look at coastal erosion and inundation. Is there the possibility to fund improved monitoring of weather and natural hazard events to allow for pre-emptive maintenance or closures? This could then be fed into land transport maintenance plans. There is a need to address resilience as a multi-pronged approach – for example closure to prevent the wind rolling trucks would also deliver health and safety benefits.	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.
	5. Develop funding model for non-transport infrastructure solutions.
	9. Develop an agreed resilience evidence base.
	11. Develop an investment partner engagement strategy.
There is no resilience owner between Network outcomes contract holders and the bridges / structure teams. Ownership could be clearer to ensure there is understanding around who exactly should be putting in the application for funding and also, who decides the priority.	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.
	4. Implement a risk prioritisation methodology and decision-making framework.
	9. Develop an agreed resilience evidence base.
	11. Develop an investment partner engagement strategy.
There is a need to develop specific hazard response plans for tsunami events. This is in regard to where equipment should be stored etc.	3. Develop land transport resilience strategies.
	4. Implement a risk prioritisation methodology and decision-making framework.
	9. Develop an agreed resilience evidence base.
	10. Work with investment partners to develop community engagement strategies.

BAY OF PLENTY STAKEHOLDERS	
Comments on system risks	Relates to responses proposed in the NRPBC
A number of detours for SH2 out of Whakatane should be prioritised to take heavier vehicles. If you improved the detour routes, then you would make a significant difference [for resilience].	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.
Issues around the Low ONRC and priority on resilience.	3. Develop land transport resilience strategies.
	4. Implement a risk prioritisation methodology and decision-making framework.
	9. Develop an agreed resilience evidence base.
The process of trying to get funding is onerous.	8. Develop rapid assessment mechanism to more readily enable resilience responses to urgent issues (emergencies).
	12. Refresh local government relationship management.
There are ways you can improve resilience to reduce the amount spent on emergency works. The current expenditure on emergency works is high. Resilience needs to be able to protect the land transport system through a whole transport corridor e.g. SH 35.	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.
	4. Implement a risk prioritisation methodology and decision-making framework.
	9. Develop an agreed resilience evidence base.

TARANAKI / WHANGANUI / MANAWATU STAKEHOLDERS	
Comments on system risks	Relates to responses proposed in the NRPBC
Criticality ratings of certain routes should encompass more than what they currently do, and the criticality should be updated to address resilience issues.	3. Develop land transport resilience strategies.
	4. Implement a risk prioritisation methodology and decision-making framework.
	9. Develop an agreed resilience evidence base.

WELLINGTON / MANAWATU STAKEHOLDERS	
Comments on system risks	Relates to responses proposed in the NRPBC
Improvements following the 2016 Kaikoura Earthquake did not take into account sea level rise.	3. Develop land transport resilience strategies.
	9. Develop an agreed resilience evidence base.
Petone foreshore issues include liquefaction – potentially more serious than sea level rise and is not currently accounted for.	1. Integrate land-use and land transport planning.
	3. Develop land transport resilience strategies.
	9. Develop an agreed resilience evidence base.
Bridges are assed for seismic risks but not necessarily the approaches to them.	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.
	9. Develop an agreed resilience evidence base.

WAIKATO STAKEHOLDERS	
Comments on system risks	Relates to responses proposed in the NRPBC
Investment should target more than just resilience and include other benefits for the economy, tourism and health and safety	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.
	9. Develop an agreed resilience evidence base.
	10. Work with investment partners to develop community engagement strategies.
ONRC doesn't reflect criticality at a bigger scale – its only level of service at traffic volumes, only lifeline routes and doesn't look at anything outside of that.	3. Develop land transport resilience strategies.
	4. Implement a risk prioritisation methodology and decision-making framework.
	9. Develop an agreed resilience evidence base.

OTAGO STAKEHOLDERS	
Comments on system risks	Relates to responses proposed in the NRPBC
Low-Cost Low-Risk projects typically illicit a response where a 'band aid' gets put over the symptom. The response needs to take greater consideration of the whole risk.	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.
	4. Implement a risk prioritisation methodology and decision-making framework.
	8. Develop rapid assessment mechanism to more readily enable resilience responses to urgent issues (emergencies).
	9. Develop an agreed resilience evidence base.
During the extreme weather events that impacted the Otago region in the lead up to Christmas, all communications excluding radio (e.g. internet, cell phone etc) were severed to the south of the Rangitata bridge for approximately 12 hours. This made it extremely difficult to know what was going on and how to get anything up and running to respond. There needs to be better coordination between all agencies / stakeholders including communications, internet and transport providers to have a more resilient network.	2. Incorporate long term planning for resilience between all land transport investment partners and key users.
	3. Develop land transport resilience strategies.
	5. Develop funding model for non-transport infrastructure solutions.

APPENDIX F – SUMMARY OF A PRELIMINARY EVALUATION OF EXTREME AND MAJOR RISKS

REPORT

NZTA National Resilience PBC

Regional Risk Assessment Summary

Prepared for
New Zealand Transport Agency
Prepared by
Tonkin & Taylor Ltd
Date
May 2020
Job Number
1011128.v4

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Document Control

Title: NZTA National Resilience PBC					
Date	Version	Description	Prepared by:	Reviewed by:	Authorised by:
25/02/2020	1	Draft for consultation	R Robertson	J Hughes C Purchas	R Reinen-Hamill
1/04/2020	2	Final	R Robertson	J Hughes C Purchas	R Reinen-Hamill
20/04/2020	3	Final including Auckland	R Robertson	J Hughes C Purchas	R Reinen-Hamill
28/05/2020	4	Waka Kotahi Board Approval	R Robertson	J Hughes C Purchas	R Reinen-Hamill

Distribution:

New Zealand Transport Agency — 1 electronic copy

Tonkin & Taylor Ltd (FILE) — 1 electronic copy

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1 Introduction

New Zealand faces a range of natural hazards and risks, which are increasing in complexity and uncertainty because of climate change. The Waka Kotahi New Zealand Transport Agency (the Transport Agency) is working to better understand the resilience of their land transport system to withstand these increasing and ever-changing natural hazard risks through the development of their National Resilience Programme Business Case (PBC).

The National Resilience PBC aims to provide context, initial evidence, coordination, priority and initial direction to interventions and activities seeking to improve the New Zealand's land transport system's resilience.

This report details the outcome of a Portfolio Risk Assessment (PRA) completed across New Zealand's land transport system. The identification of priority risks through this approach is one of the responses identified in the development of the National Resilience PBC. Applying the risk assessment provides a view on priority risks across the national land transport system. The methodology adopted is presented in NZTA National Resilience PBC - Portfolio Risk Assessment Methodology (Appendix F).

For the purpose of the National Resilience PBC the PRA focused on state highways (SH), local roads which provide alternate routes to SHs, and the KiwiRail network. In some cases, the improved resilience of local roads is a potential solution to address risks on a SH. This means risks to local roads may also be identified where relevant.

1.1 Approach

The Portfolio Risk Assessment (PRA) methodology is described in detail within the accompanying *Risk Assessment Methodology Report* however at a high level, the approach consisted of:

- Compiling background information to provide a consistent evidence base for identifying hazards.
- Completing a desktop evaluation of resilience related risks based on hazard and asset data and other relevant resilience related documents.
- Testing the preliminary analysis and identifying key risk locations at a regional stakeholder workshop. This has been done on a regional basis (based on the Network Outcomes Contract (NOC) regions) but could also be undertaken on a corridor, journey or other basis.
- Utilising available hazard information, the regional stakeholder workshop results were cross checked and updated where deemed appropriate.
- Developing initial 'response' options with stakeholders for priority risks, drawing on stakeholder knowledge, and recommending next steps.

As per the detail in the *Portfolio Risk Assessment Methodology*, a *combined consequence* rating with scores of 1 to 5 is combined with the *combined likelihood* (scale ranging from unlikely (UL) to very likely (VL)) to assess the overall <u>risk</u> to the asset or section of network. Risks are rated as minor, moderate, major or extreme (refer Table 1.1).

Table 1.1: Risk matrix

		Combined Likelihood		
		UL	L	VL
Combined Consequence	1	1UL	1L	1VL
	2	2UL	2L	2VL
	3	3UL	3L	3VL
	4	4UL	4L	4VL
	5	5UL	5L	5VL

Rating Key
Minor
Moderate
Major
Extreme

Note: UL – Unlikely, L – Likely, VL – Very Likely. For example, 1UL = a combination of a consequence score of 1 and a likelihood score of Unlikely.

1.2 Suggested response category and next steps

Through the regional stakeholder workshops, a range of suggested response options (grouped in wider response categories) were identified and have been documented within the summary tables against each risk in the 'Suggested Response Category' column. The discussions within the workshops focussed primarily on direct Transport Agency interventions, such as physical works, maintenance or emergency management responses.

As noted in the *Portfolio Risk Assessment Methodology Report,* the majority of identified risks will require further investigation and development of specific business cases. During these processes a broader suite of response categories should be considered. These could include:

- Physical works (NZTA)
- Physical works (third party – e.g. local road detour improvements, stop banks)
- BAU maintenance, monitoring and/or emergency response planning
- Enhanced maintenance and/or monitoring
- Enhanced emergency response plans and/or preparedness
- Land use and/or development controls
- Real time info, community emergency information systems and/or education.

For all <u>major</u> and <u>extreme</u> risks identified, two categories of 'next steps' have been recommended which indicate next steps in the process rather than the proposed solution. The process should identify the most appropriate solution considering an entire suite of potential response categories (as listed above), along with the suggested solution from the regional stakeholder workshop. As such, the two next step categories are:

- *Business Case funded or underway*: The next step is to proceed with the current business case development ensuring that an appropriate suite of response options is considered.
- *Business Case required*: The next step is development of a 'right sized' business case to address the identified risk, considering an appropriate suite of response options. The business case point of entry will determine the level of effort required.

2 National PRA summary

2.1 National hazard and risk overview

Some 370 risks were identified across the whole country (Figure 2.1). In accordance with the approach set out in the *Portfolio Risk Assessment Methodology Report.* The risks are grouped by regions that correlate with the Transport Agency NOC areas.

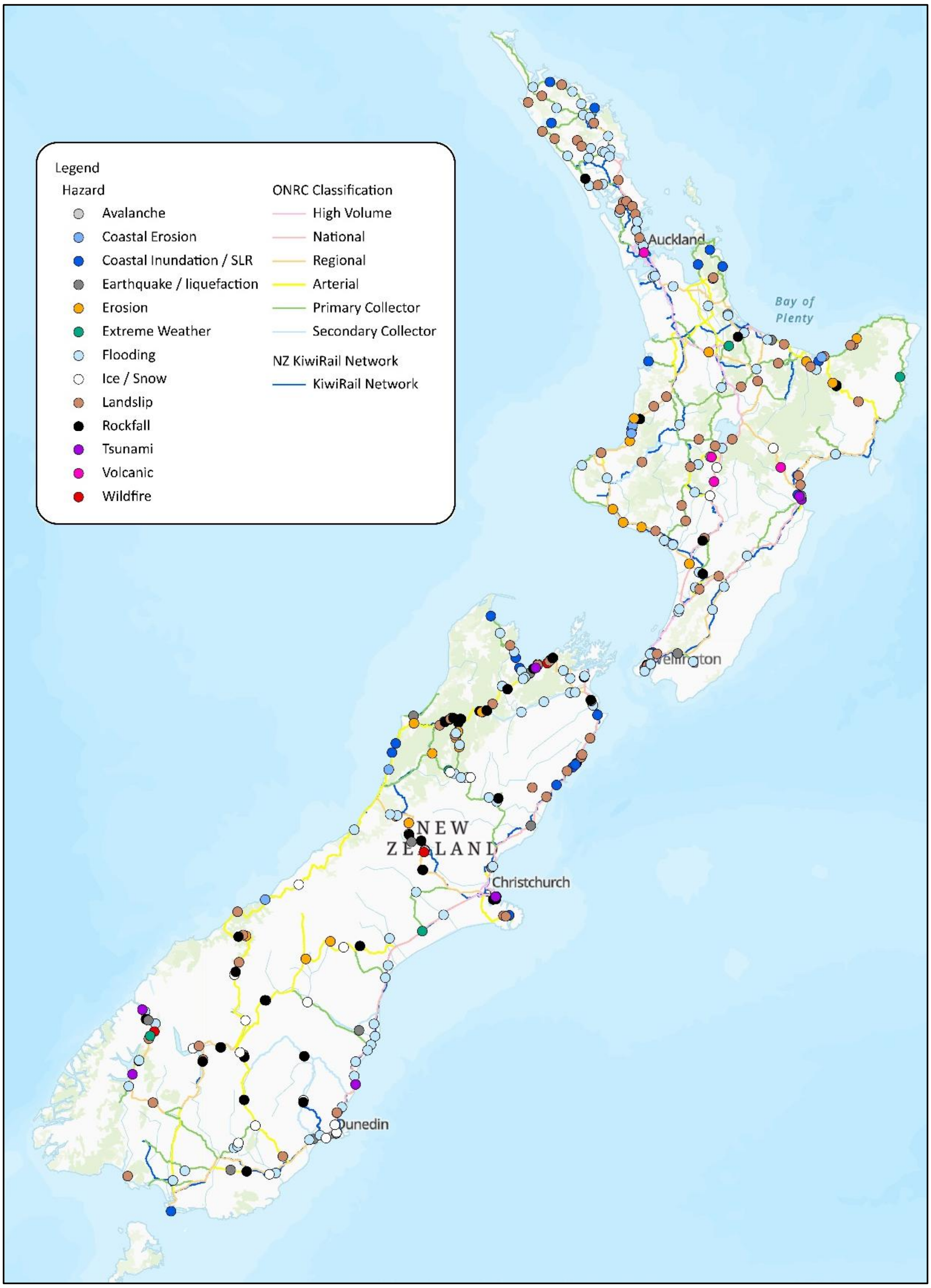

Figure 2.1: Distribution of risks by hazard type

Figure 2.2 shows the risks by region according to hazard type. The Top of the South (Marlborough, Nelson and Tasman Districts), Otago and Canterbury have the greatest number of risks across the regions, with the majority of these being related to flooding, landslip, rockfall, snow and ice. The lowest numbers of risks are within the Gisborne[1], Auckland[2], Hawke's Bay and Southland regions.

The most common hazard is flooding, followed by landslip.

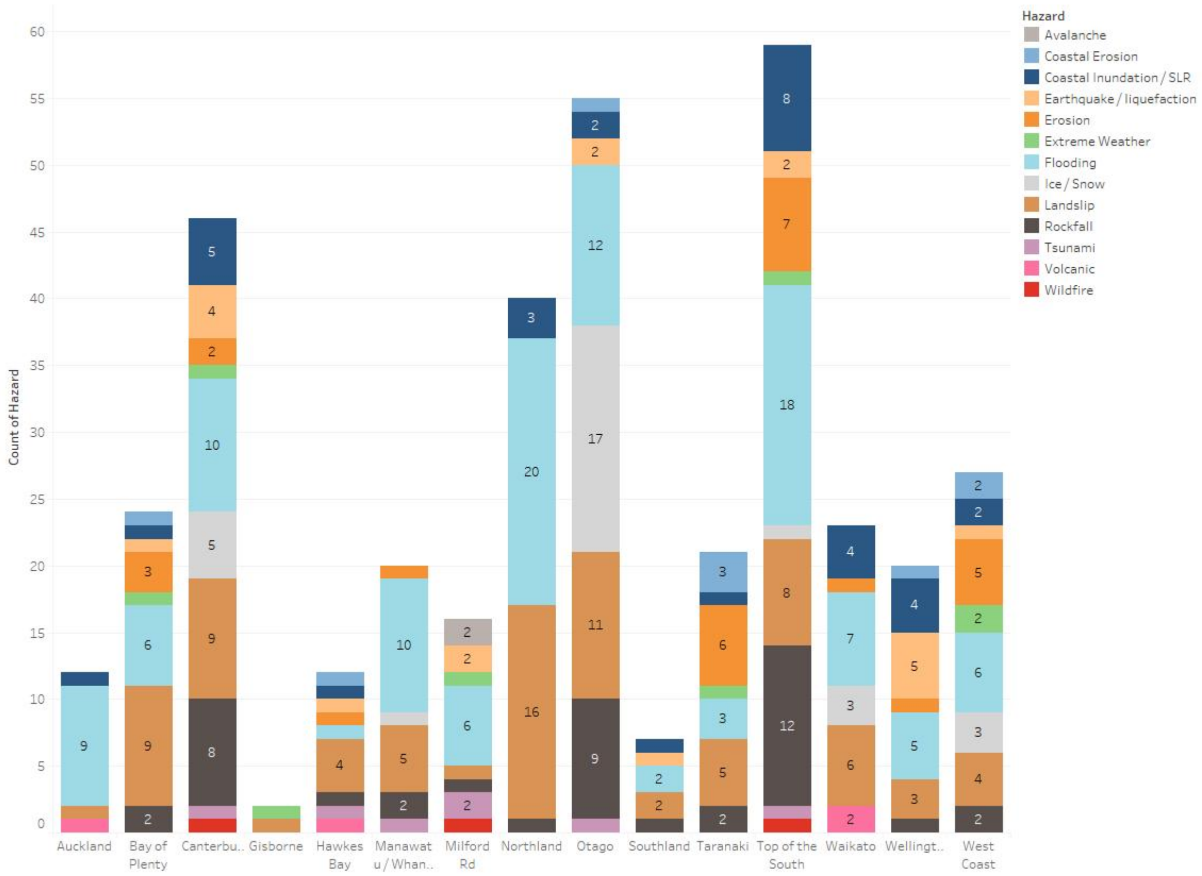

Figure 2.2: Summary of the number of risks by region and hazard type

2.2 National present-day risk summary

This section presents a summary of the present-day risks which were identified as _extreme_ or _major_ across the country through the regional stakeholder workshops. These represent the risks which pose the greatest risk to the Transport Agency national transport system due to their likelihood of damage and consequence of failure[3]. These should be prioritised in terms of mitigation responses.

Figure 2.3 presents the present-day risks within each region along with the risk rating as determined during the regional stakeholder workshops. Since participants were asked to focus on the most important risks within their region, there is likely a natural bias towards higher risks.

[1] The small number of risks within Gisborne is partially due to the fact that many are located within adjacent regions - Hawkes Bay and the Bay of Plenty.
[2] The relatively small number of documented risks within Auckland is predominantly due the high level of investment over the years in network upgrades and resilience.
[3] Refer to *Portfolio Risk Assessment Methodology* for detailed description of likelihood and consequence ratings (T+T, 2020).

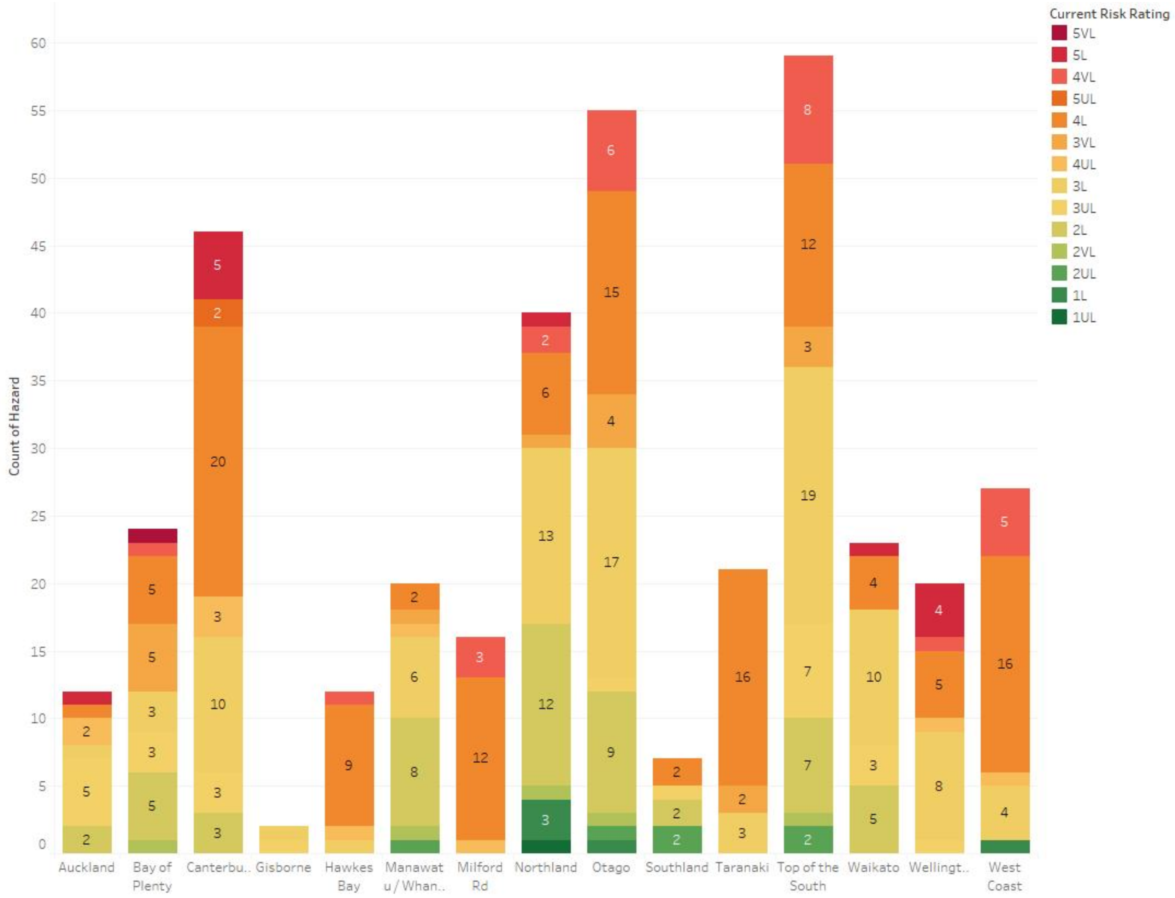

Figure 2.3: Summary of the number of present day risks by region and risk rating

Figure 2.4 shows the extreme (5VL, 5L, 4VL) and major (5UL, 4L, 3VL) risks, broken down by subcategory. As shown, Canterbury, Otago, Top of the South (Marlborough, Nelson and Tasman Districts), West Coast have the highest numbers of extreme and major risks, with Auckland, Southland and Gisborne[4] identifying the lowest number. The Bay of Plenty has the only 5VL[5] extreme risk.

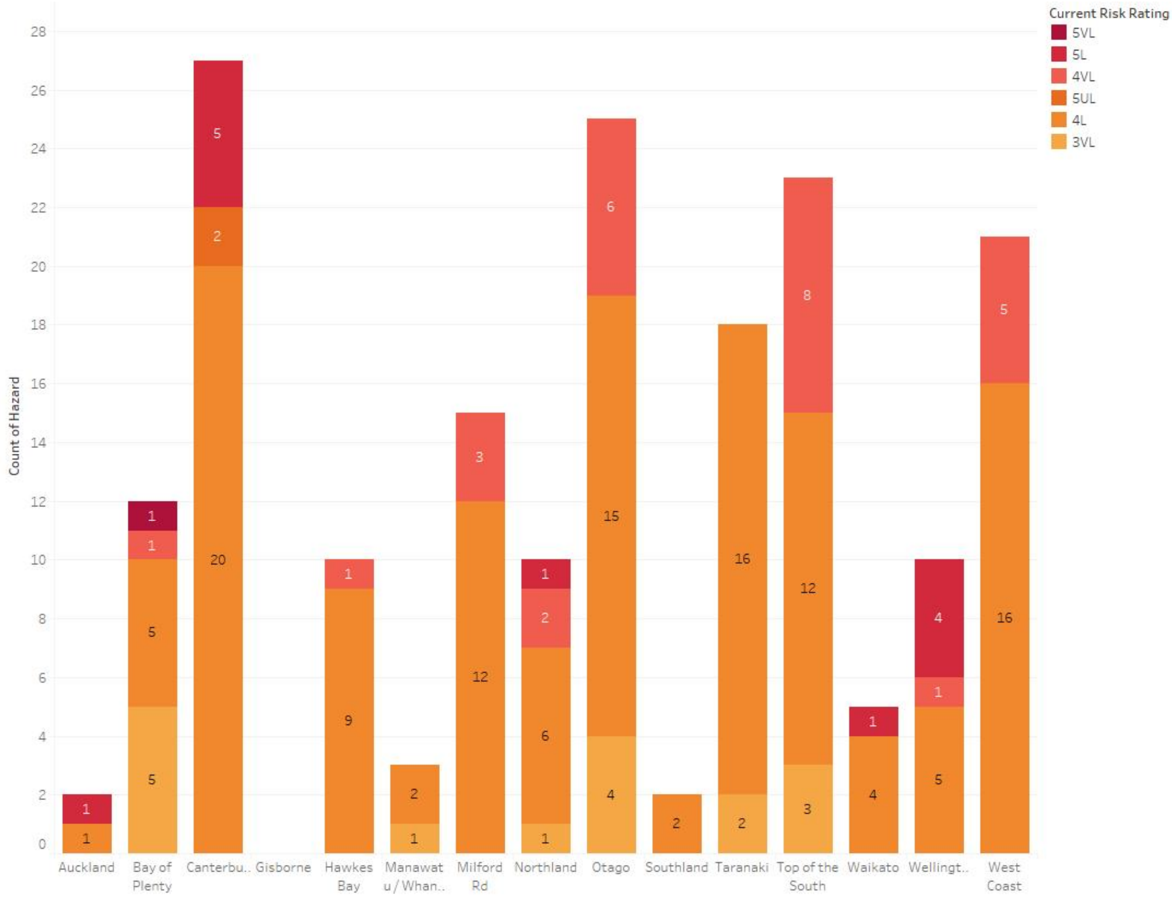

Figure 2.4: Summary of number of major and extreme risks by region

2.2.1 Interpretation of risk summary tables

The following should be noted when interpreting each table:

- Risk ID: This is a unique identification number which can be cross referenced to each map
- SH No, Location Name, Asset Type, Hazard: These are key identifiers for each risk. The location name is often a 'colloquial' name as provided during the workshops.
- Description of hazard: This is a description of the risk as provided during the workshop / engagement.
- Current risk rating: This is the present-day risk rating as provided by attendees (see *PRA Methodology Report* for list of attendees in section 3.2.1) at the engagement meetings – as

[4] There are no major and extreme risks captured within Gisborne. This is due the relatively small network extent, and the fact that the majority of the network has a low ONRC rating (SH35 – primary collector). Higher rated risks ((SH2) are located within the Hawkes Bay and BOP regions. Southland recorded no major/extreme risks - as verified through the engagement workshops. Auckland has only 2 major/extreme risks. This is due to the high-density of the transport network and the high availability of alternate routes, which result in lower impacts across the land transport network as a whole.
[5] The Waioeka Gorge is rated as 5VL (extreme risk) due to rockfall, with impacts related to connectivity for Gisborne. The location of the risk is in the Bay of Plenty Region, however is also acknowledged as the key risk for the Gisborne region.

per the risk framework detailed within the accompanying *Risk Assessment Methodology Report*. This accounts for criticality of the route, hazard likelihood, availability/suitability of detour and likely outage duration.

- 2050 risk rating: This is an estimate of a future level of risk considering the impacts of climate change (including sea level rise). This relates to coastal hazards, as well as flooding and landslips and other hazards, and has resulted in the likelihood being uprated by 'one step' (e.g. 'L' to 'VL'). In some cases, the current likelihood was already set at 'VL', in which case the cell has been shaded a darker colour to indicate the additional risk posed from climate change. Where no change is anticipated due the impacts of climate the cell is grey.
- Already funded? This indicates where there is already funding in place to mitigate the risk – based on comments provided at regional stakeholder workshops.
- Suggested Response Category: These indicate the most likely mitigation response as suggested by participants within the workshops. It is noted that unless the suggested responses have been determined through a full business case process, other options will need to be investigated through an appropriately detailed business case process. The categories suggested at the workshops included:
  - 'Physical works' broken into 4 bands as follows (derived through discussions in workshops):
    - Physical works ($): < $1,000,000
    - Physical works ($$): $1,000,000 - $5 Million
    - Physical works ($$$): $5 - 25 Million
    - Physical works ($$$$): > $25 Million
  - 'BAU maintenance'
  - 'Enhanced proactive maintenance'
  - 'Emergency response plans / preparedness'
  - 'Land use / development controls'
  - 'Unknown / further investigations required'.
- Suggested solution: This describes the suggested solution proposed by regional workshop participants.
- Next steps: This indicates likely next steps to develop an appropriate response (refer response categories above). Options include:
  - *Business Case funded or underway:* The next step is to proceed with the current business case development ensuring that an appropriate suite of response options are considered.
  - *Business Case required:* The next step is development of a 'right sized' business case to address the identified risk, considering an appropriate suite of response options. The business case point of entry will determine the level of effort required.

In some cases there are multiple extreme risks on a corridor, for example SH1 north of Kaikoura (C10, C16, C17, C18, C19), the Waioeka Gorge between Opotiki and Gisborne (BP8, BP9) and SH6 south of Nelson (TS7, TS9, TS10, TS12, TS28, TS30). In these cases, developing a programme business case to consider multiple responses is a logical next step.

In other cases, current or proposed projects present an opportunity to address resilience issues. Examples include SH1 Whangarei to Ruakaka (N4[6]), SH1 Petone to Ngauranga (W1[7]) and flooding issues at SH1 at Kuku (W6[8]).

2.2.2 Present-day risk summary tables

Table 2.1 summarises the 39 present day-extreme risks identified across the country. . Where risk is anticipated to change as a result of climate change the revised rating is noted in the column headed 2050 risk rating.

[6] The corridor will be upgraded as part of the recently announced upgrade to the Whangarei to Marsden Point project
[7] The implementation of the Ngauranga to Petone cycleway provides an opportunity to address resilience related risks for the highway and railway.
[8] This section of SH1 is scheduled to be upgraded as part for the recently announced Otaki to north of Levin project.

Table 2.1: Summary of present day extreme risks

Risk ID	SH No	Location name	Asset type	Hazard	Description of hazard	Current risk rating	2050 risk rating	Already funded?	Suggested response category	Suggested solution	Next steps
WK1	1	Along Lake Karapiro	Road	Erosion	Erosion of riverbank can undermine road. There are significant detour issues along this road if it were out of service.	5L	-	No	Physical works ($$$)	Realignment, new bridge or possible retaining wall. Also invest in upgrades to Maungatautari Road (detour route) through strengthening of structures to carry HMPV's.	Business Case required
C16	1	Blue Slip	Road	Landslip	Site at risk to mass earth movement, which would likely affect both road and KiwiRail. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	5L	-	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance.	Business Case required
N1	1	Brynderwyn to Ruakaka	Road	Landslip	Landslip risk on Brynderwyn hills with limited detour HPMV incapable. No HMPV both ways. Detour route has a number of one-way bridges. If the Brynderwyn route is out, the whole upper north is out. Currently working on the major detour route to address the risk to Brynderwyn. There are also a lot of outages because of accidents and breakdowns etc. Southern side has more issues. Traffic going south goes through Mangawhai and north goes through Paparoa.	4VL	-	No	Physical works ($$$$)	Short term solution is to upgrade alternate routes. Costs for this will likely be less than construction of a new alignment. There is a wider PBC under way to look at a range of options.	Business Case funded or underway
TS6	6	Canvastown along Pelorus River	Road	Flooding	River floods and inundates the road.	4VL	4VL	No	Physical works ($$$)	Raise the road.	Business Case required
C19	1	Clarence Bridge	Bridge	Flooding	Clarence river bridge is at risk to river and surface flooding - requiring ongoing groyne maintenance. High sediment loads can cause the riverbed to aggrade up to 2m. This risk also extends across most of the streams along the Northern Kaikoura coastline. Some sediment retention devices are being built to address this. This risk is manageable in individual locations, however in a significant event such as Tropical Cyclone Fehi / Gita there is the potential for all rivers to flood, which could cause significant remedial works. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	5L	5VL	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance.	Business Case required
MR2	94	Cleddau River	Road	Flooding	Cleddau River - flood risk. There are regular flooding events which inundate the road and damage structures.	4VL	4VL	No	Unknown. Pending further investigations	Difficult to address. Further work required.	Business Case required
O7	6	Cromwell to Frankton	Road	Rockfall	Sites at risk to rockfall throughout the Kawarau Gorge.	4VL	-	No	Physical works ($$$)	Scaling, stabilisation and catch fences / structures.	Business Case required
O8	6	Cromwell to Frankton	Road	Landslip	Landslip risk throughout the Kawarau Gorge. There is some Low Cost Low Risk (LCLR, projects less than $1M capital spend) investigation work underway, however still residual risk.	4VL	4VL	No	Physical works ($$$)	Retaining walls and drainage improvements.	Business Case required
TS7	6	Dallows Bluff	Road	Rockfall	Frequent rockfall on SH6 stretch between intersections with SH65 and SH63 (Murchison to St Arnaud). High priority for the Top of the South	4VL	-	No	Physical works ($$)	Requires netting.	Business Case required
HB1	2	Devil's Elbow	Road	Landslip	~10km of Devil's Elbow (north of Napier pm SH2) is at risk to landslip.	4VL	4VL	No	Unknown. Pending further investigations	An alternative local road can be utilised however it is unsealed and narrow and cannot take heavy vehicles. Upgrading the local road is potentially a better use of money.	Business Case required

Risk ID	SH No	Location name	Asset type	Hazard	Description of hazard	Current risk rating	2050 risk rating	Already funded?	Suggested response category	Suggested solution	Next steps
O48	6	Frankton to Kingston	Road	Landslip	Landslips along the side of Lake Wakatipu.	4VL	-	No	Unknown. Pending further investigations	Corridor investigation to determine vulnerable areas and possible solutions to mitigate.	Business Case required
TS9	6	Granity Rockfall	Road	Rockfall	Frequent rockfall on SH6 stretch between intersections with SH63 and WC boundary. High priority for the Top of the South.	4VL	-	No	Physical works ($$)	Requires netting.	Business Case required
WC6	6	Greymouth to Westport	Road	Coastal Erosion	Coastal erosion during a cyclone has the potential to affect the whole region. Increased frequency to approx. once a year. Typically, NZTA will still be carrying out repair works from the previous event when then next one comes. Still recovering from Fehi 2018. All works are currently reactive. There are 4 sites where preventative works would significantly help, these could be prioritised.	4VL	4VL	No	Enhanced proactive maintenance	Rock protection.	Business Case required
WC9	6	Haast Pass	Road	Landslip	Route at risk from landslip. Currently all reactive works with proactive management on some sites, however there is still a risk of losing the whole road. A few landslip sites could potentially be managed more proactively.	4VL	4VL	Yes	Enhanced proactive maintenance	Some areas could have more proactive work undertaken. Further investigation required.	Business Case required
O50	6	Haast to Hawea	Road	Rockfall	Numerous large scale rockfall locations along the corridor. Improved funding would be a starting point to improve resilience but not resolve the issue in its entirety. Funding currently allocated through the National Rockfall programme to address isolated high priority sites with a supporting Rockfall Hazard Rating System (RHRS) score.	4VL	-	No	Physical works ($$$)	Scaling, stabilisation and catch fences/structures.	Business Case required
TS28	65	Higgins Bluff	Road	Rockfall	Rockfall risk along the bluff.	4VL	-	No	Physical works ($$)	Requires netting.	Business Case required
MR16	94	Homer Tunnel	Tunnel	Rockfall	Reinvestment issues for tunnel and portals but there is a Business Case being developed for replacement portal/protection structures. Resilience for future EQ/Rockfall. The structure is ageing, soon to be a historic site – heritage assessment currently in draft but recommends some very intensive improvement and maintenance works to protect nature of the site.	4VL	-	No	Physical works ($$$)	A smart design for replacement of the tunnel portals could deal with strengthening and upgrading, aiding avalanche and rockfall risks at the same time. In short term, Rockfall prevention measures e.g. scaling, fences and bunds. But has cross over with avalanche zone - avalanches will destroy rockfall structures. Longer term needs to reinforce and upgrade the portals/tunnel before it is designated as a historical site. A smart design for replacement of the tunnel portals could deal with strengthening and upgrading, aiding avalanche and rockfall risks at the same time. Portals are under the largest avalanche zones. In addition, remote control avalanche systems could be employed. This is a significant tourism route and also safety issues.	Business Case funded or underway.
TS10	6	Hope saddle	Road	Landslip	Ongoing landslip risk.	4VL	4VL	No	Physical works ($$)	Requires netting.	Business Case required
WC12	6	Knights Point	Road	Landslip	Most vulnerable piece of road to landslip in New Zealand and currently only has reactive work underway.	4VL	4VL	No	Enhanced proactive maintenance	Also, would require further investigation.	Business Case required
O47	6	Lake Hawea and Lake Wanaka	Road	Landslip	Landslips along the side of lakes Wanaka & Hawea. This links to risk Id WC9 which identifies landslip issues along Haast Pass.	4VL	-	No	Unknown. Pending further investigations	Corridor investigation to determine vulnerable areas and possible solutions to mitigate.	Business Case required
TS30	65	Mauria River	Road	Erosion	Surface flooding and undercutting / erosion where river is next to the road.	4VL	4VL	No	Physical works ($$$)	Rock protection along river to protect road.	Business Case required

Risk ID	SH No	Location name	Asset type	Hazard	Description of hazard	Current risk rating	2050 risk rating	Already funded?	Suggested response category	Suggested solution	Next steps
MR15	94	Milford Rd - Te Anau Downs to Milford	Road	Landslip	Landslides and under slip risk in a number of locations.	4VL	-	No	Enhanced proactive maintenance	Preventative works and repairs.	Business Case required
O51	6	Nevis Bluff	Road	Rockfall	Nevis Bluff is a significant unstable feature between Cromwell and Queenstown. Proactive monthly inspections are undertaken and programmed rock scaling pre & post winter to remove fractured material is funded and managed through the NOC. Regular additional funding is required to address high other priority/urgent unstable features in the order of $1M-$5M per intervention. Alternate long-term options could be investigated such as a tunnel.	4VL	-	No	Enhanced proactive maintenance	More detailed investigation required which would assess all possible options. Continued proactive monitoring and maintenance intervention.	Business Case required
C10	1	North of Kaikoura - Clarence Bridge	Road	Landslip	Landslip and mass movement risk (site similar to Blue Slip, see for details). No known solution, and if a landslip or mass movement were to occur the road and rail will be completely destroyed. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	5L	-	No	Emergency response and preparedness planning only (typically HI/LF)	Further investigations needed.	Business Case required
C17	1	Ohau Point	Road	Coastal Inundation / SLR	Ohau Point is at risk from coastal inundation– it overtopped three times in 2019 in a combined high tide and storm event. There is a potential design in NCTIR to address this, however with the effects of climate change this may not address the issues. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	5L	5VL	No	Unknown. Pending further investigations	Monitor.	Business Case required
TS12	6	O'Sullivans Bluff	Road	Rockfall	Frequent rockfall on SH6 stretch between intersections with SH65 and SH63. High priority for the Top of the South.	4VL	-	No	Physical works ($$)	Requires netting.	Business Case required
N4	1	Ruakaka and Whangarei	Road	Flooding	Flood risk between Ruakaka and Whangarei. Both river and tidal flooding during king tides. Typically, when there are issues on the SH there are issues on the local roads so there are no alternate options.	5L	5VL	No	Unknown. Pending further investigations	Requires further detailed study.	Business Case required
WC20	6	Scout Lodge Straight	Road	Erosion	Significant river erosion risk.	4VL	4VL	No	Physical works ($$$)	River protection works (groynes) to train river and realign road.	Business Case required
W3	1	SH1 Centennial Highway	Road	Rockfall	Rock, debris comes down off the steep slopes and covers the road and rail network. NZTA are trying to get KiwiRail to input into funding. Risk will be reduced once Transmission Gulley is open. Even with completion of Transmission Gully, access will still be required for the rail line.	5L	-	No	Physical works ($$$)	Ongoing slope stabilisation works required.	Business Case required
W4	1	SH1 Centennial Highway	Road	Coastal Inundation / SLR	Coastal inundation and SLR risk with water over topping the road in larger events. Currently reactive maintenance is prioritised as opposed to proactive. A culvert near Paekakariki blocks frequently due to lose material causing flooding in the town. Catchments flood in short duration events causing slips and debris/blockages. KiwiRail assets are adjacent (up-catchment) and also are affected. Even with completion of Transmission Gully, access will still be required for the rail line.	5L	5VL	No	Physical works ($$$)	Will continue to flood in the long term but will require ongoing repair and maintenance. More work required to determine appropriate solutions.	Business Case required
W5	1	SH1 Centennial Highway	Road	Coastal Erosion	Sea level rise, storm events, high seas causing damage to seawall.	5L	5VL	No	Physical works ($$$)	Ongoing armouring. More work required to determine appropriate solutions.	Business Case required

Risk ID	SH No	Location name	Asset type	Hazard	Description of hazard	Current risk rating	2050 risk rating	Already funded?	Suggested response category	Suggested solution	Next steps
W6	1	SH1 Kuku	Road	Flooding	Flooding occurs frequently in low lying area - caused by a land drainage issue where water builds up on the highway approx. once a year. Flooding can often reduce traffic down to one lane and has affected both lanes for a couple of hours. With help from Council it could be improved. Risk could also be reduced if Otaki to Levin is confirmed.	5L	5VL	No	Physical works ($$)	Requires Council to address adjacent land drainage and runoff - less of an issue once O2NL is constructed. Could significantly improve the flood issue - especially considering the detour is extensive.	Business Case required
W1	2	SH2 Petone to SH1	Road	Coastal Inundation / SLR	Coastal inundation and SLR are the biggest issue for this area. Regular events over recent years have caused outages and damage.	4VL	4VL	Yes	Physical works ($$$$)	There is a proposed seawall/cycleway which will help mitigate this risk.	Business Case required
C18	1	Shingle Fans	Road	Landslip	Shingle Fans - North of Clarence is at risk to landslip. There are three shingle fans which flow through culverts however, in large events these flow over the road. Landslip overtopping occurs approximately once every 3-4 years. Generally, response teams can keep the shingle within the water way. Generally, there is a quick response, with short term closures and damage to infrastructure is unlikely. Smaller retention dams are being located upstream. KiwiRail relies on NZTA for clearing the culverts. This is still flagged as a high risk due to the frequency and importance of the road. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	5L	-	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance.	Business Case required
WC21	6	South of Ross to Haast Pass	Road	Flooding	All rivers south of Ross (~15 rivers) need training/stop banking and active management to reduce flood risk.	4VL	4VL	No	Enhanced proactive maintenance	Ongoing training works and management	Business Case required
TS20	60	Takaka Hill	Road	Landslip	Landslip risk with both under and over slips. Mainly on the Nelson side. Occurs at least once a year. There are also a number of drainage issues.	4VL	4VL	No	Physical works ($$$)	Realignment improve drainage and catchment management. Even with improvements, there would still be ongoing issues, requiring response and BAU maintenance.	Business Case required
BP8	2	Waioeka Gorge	Road	Rockfall	Significant rockfall issues along the entirety of Waioeka Gorge for both the Bay of Plenty and Gisborne / Hawke's Bay. Very significant issue for Gisborne community as in the event of a long closure communities have the potential to be isolated. Also affects time critical delivery of food produce to the port and Auckland. Supplies to the hospital could also become an issue quickly. Regional managers support a change to the ONRC classification to 'Regional' level. Significant crash rates and safety issues with response limited due to poor telephone coverage. Waioeka Gorge PBC identifies all major sites and pinch points.	5VL	-	No	Physical works ($$$)	Geotechnical improvements: combinations of rock fall protection, slope stabilisation etc over a multiple year programme. In an ideal world you would do a multi-year programme across all significant sites - that links to the PBC that Simon Barnett / Gisborne is working on. Aurecon has previously carried out an assessment to identify the sites.	Business Case required
BP9	2	Waioeka Gorge	Road	Landslip	Landslip risk for the entirety of Opotiki to the Bay of Plenty boundary. Potential for significant effects commercially and for small communities.	4VL	4VL	No	Physical works ($$$$)	Over a multiple year programme. In an ideal world you would do a multi-year programme across all significant sites - that links to the PBC that Simon Barnett / Gisborne is working on.	Business Case required
N10	1	Wayby Road on SH1	Road	Landslip	Existing landslip, however, there has been no work done to understand the landslip risk. Ongoing land movement.	4VL	-	No	Unknown. Pending further investigations	Requires further detailed study.	Business Case required

Risk ID	SH No	Location name	Asset type	Hazard	Description of hazard	Current risk rating	2050 risk rating	Already funded?	Suggested response category	Suggested solution	Next steps
A11	1	Lonely Track Road North Slip	Road	Landslip	Landslip issues. This is currently viewed as being one of the highest risks on the Auckland network - which has potential to cause a loss of system availability. Significant land instability issues detected with ongoing movement since construction in late 90's as part of the SH1 ALPURT A1 Project. Close monitoring and proactive sealing of tension cracks to slow down failures is currently funded under ASM TOC for initial investigation (only).	5L	5VL	No	Unknown. Pending further investigations	Significant issue - Currently investigation works are underway to better understand the scale of the risk and any resultant work needs. This includes additional monitoring and investigation of the likelihood and consequence of a slip. Auckland System Management (ASM) TOC funding to a capped budget is available for the current investigation stage. Monitoring in various forms has been occurring since 2008. ASM TOC funding for investigation in the last year has been made available to confirm the risk profile and any recommendations on mitigation. Additional funding would be needed for any physical works.	Business Case funded or underway

2.3 National climate-related risks summary

In total, approximately 160 climate change related risks were identified throughout the country. These relate to coastal inundation and sea level rise (SLR), erosion (both coastal and along river banks), flooding, rainfall induced landslips, extreme weather, wildfire and avalanche (Figure 2.5). The highest number of identified climate risks are within the Top of the South, West Coast and Bay of Plenty regions.

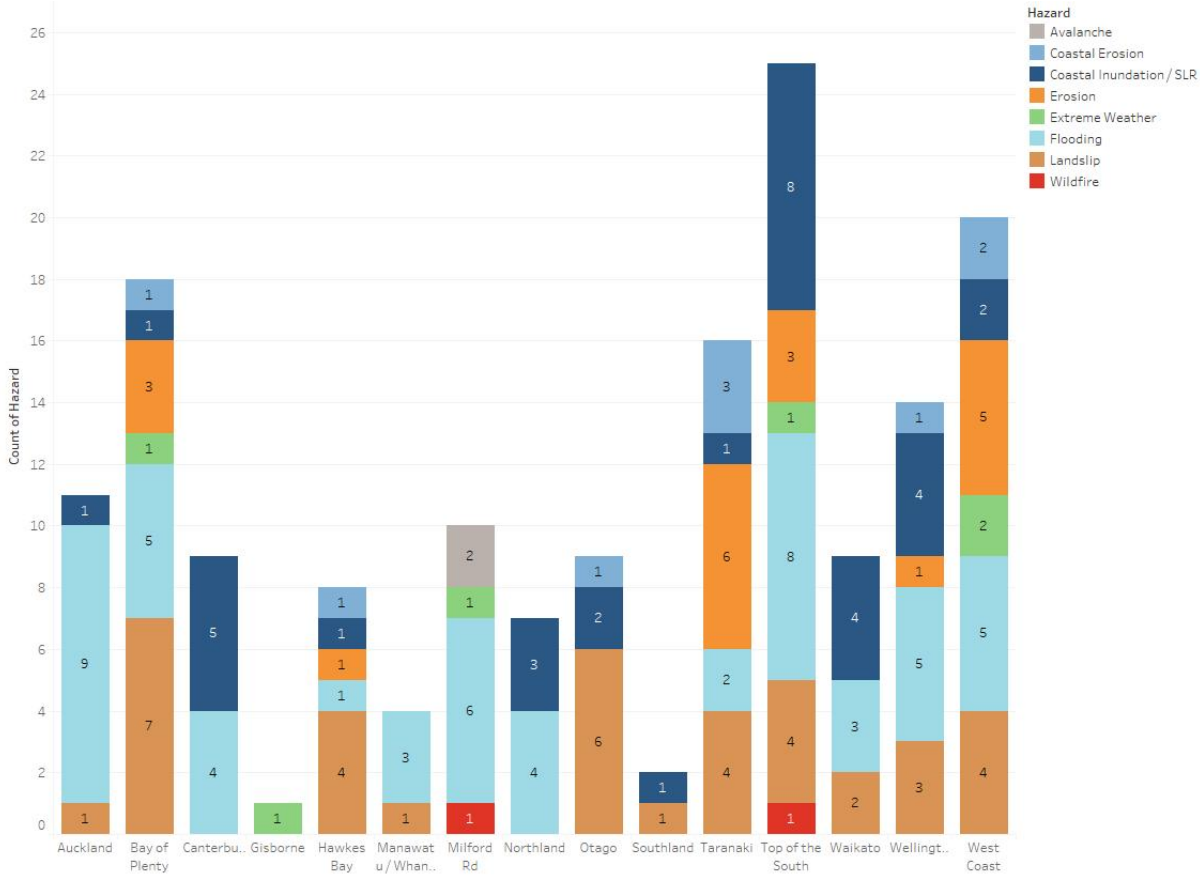

Figure 2.5: Summary of the number of climate related hazards by region

Figure 2.6 illustrates the same risks within each region along with the risk rating as determined during the regional stakeholder workshops.

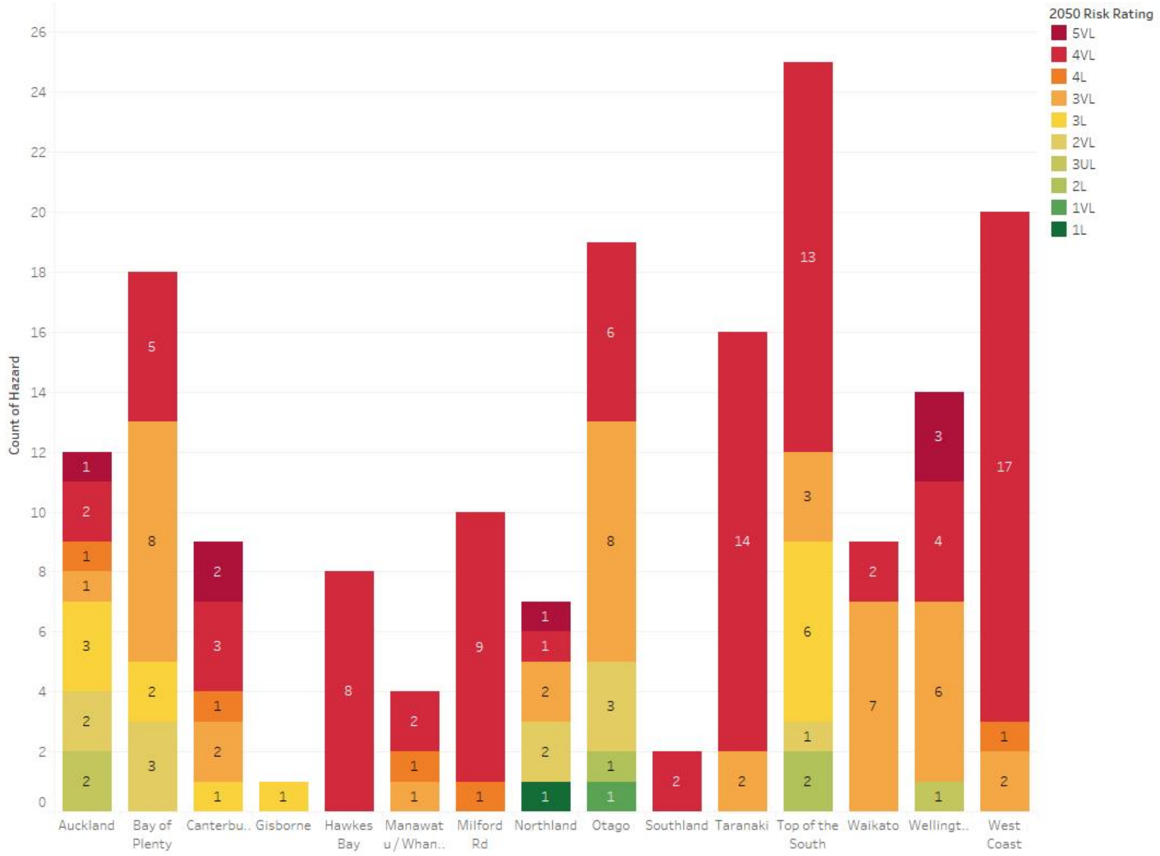

Figure 2.6: Summary of climate related risks in 2050 by region

Figure 2.7 shows only the extreme (5VL, 5L, 4VL) and major (5UL, 4L, 3VL) risks, broken down by subcategory. The highest numbers of extreme and major risks occur within the West Coast, Top of the South, Taranaki, Otago and Bay of Plenty.

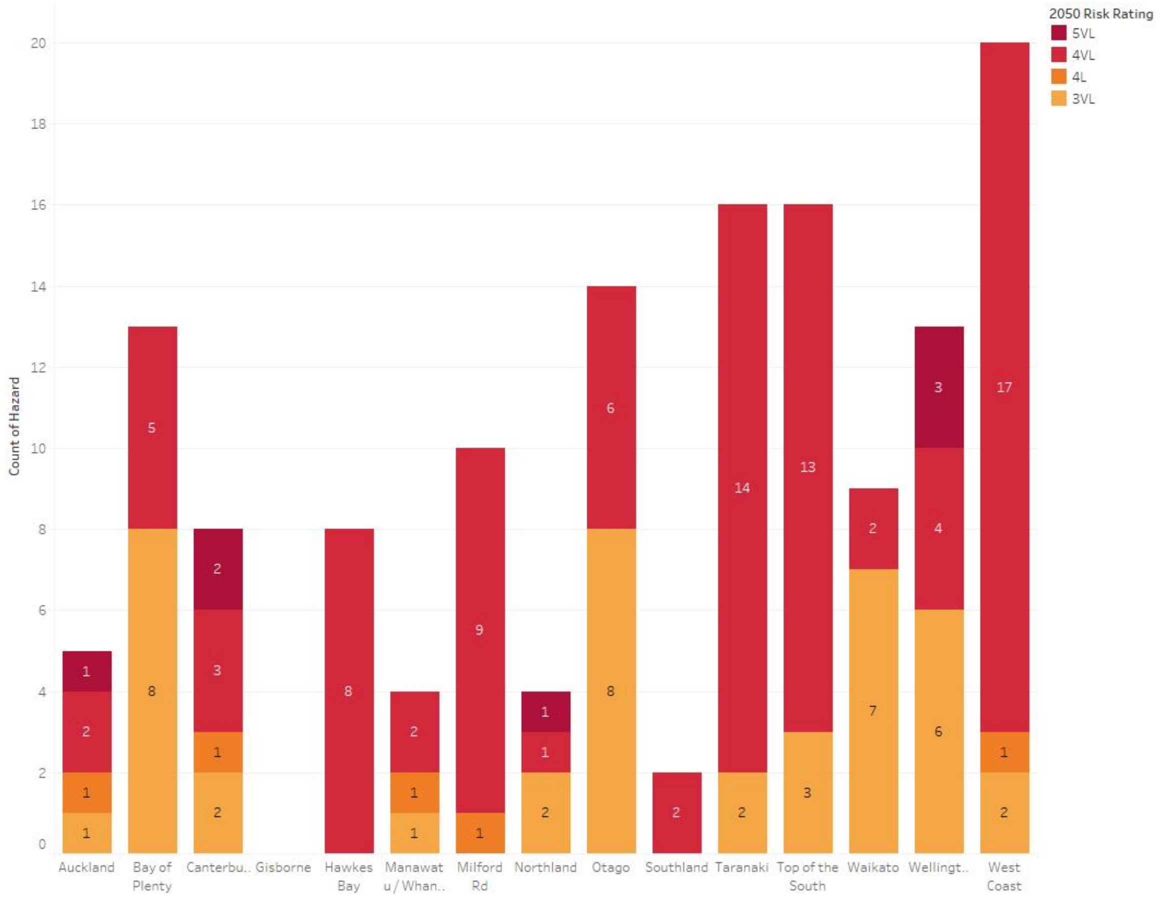

Figure 2.7: Summary of major and extreme climate related risks in 2050 by region

The climate related risks have been divided into two categories: *coastal hazards* (including coastal erosion and coastal inundation); and *other* (including flooding, rainfall induced landslide, erosion, extreme weather and wildfire).

2.3.1 Coastal climate-related risks

This section summarises the coastal climate related risks identified and rated. Top of the South, Wellington and Canterbury have the greatest number of coastal risks of which the majority relate to coastal inundation and SLR (Figure 2.8).

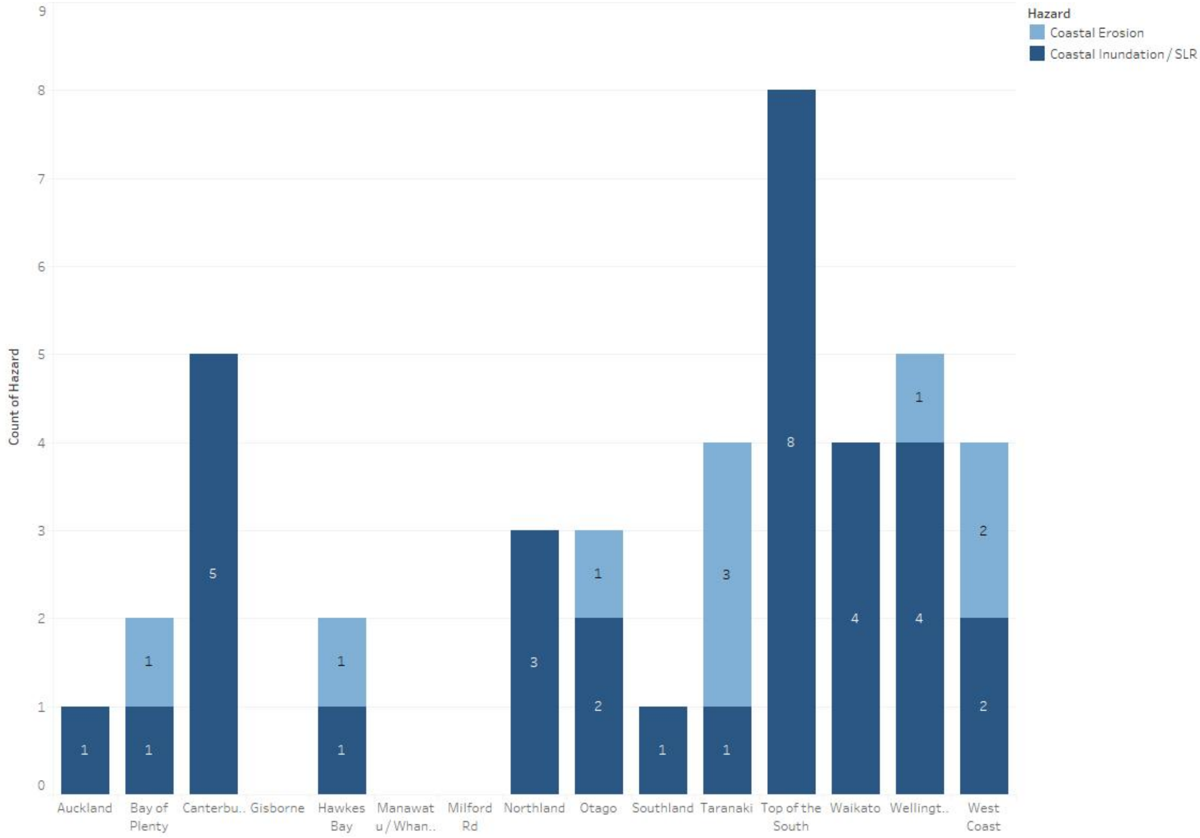

Figure 2.8: Coastal climate related hazards by region

Figure 2.9 details the <u>extreme</u> (5VL, 4VL, 4L) and <u>major</u> (3VL) coastal climate-related risks by region. Wellington, Canterbury and the West Coast show the greatest number of <u>extreme</u> and <u>major</u> coastal climate related risks with both Wellington and Canterbury having risks rated at 5VL in the future.

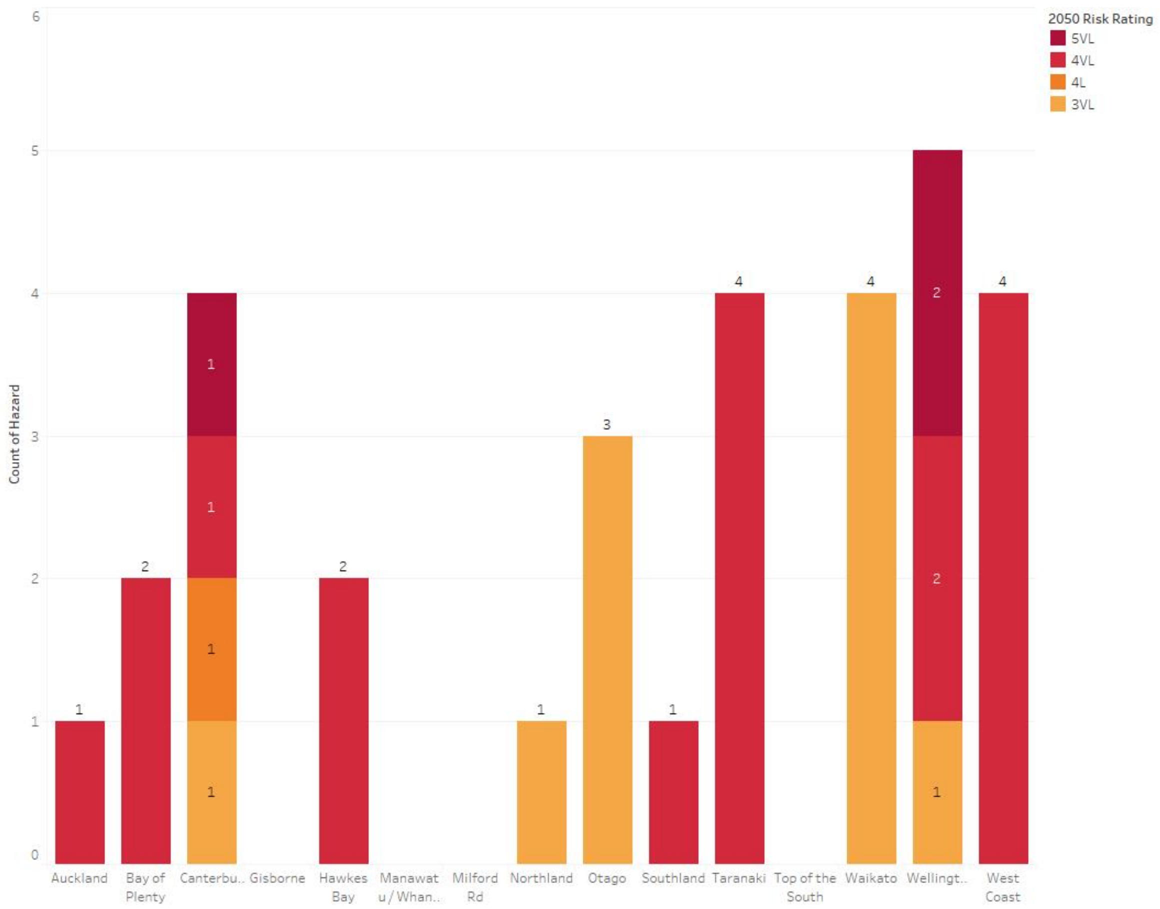

Figure 2.9: Major and extreme coastal climate related hazards with 2050 risk rating

Table 2.2 summarises the national extreme (5VL, 4VL, 4L) coastal climate related risks in 2050. Refer to section 2.2.1 for interpretation of the risk tables.

Table 2.2: National summary of extreme coastal climate related risks

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
W21	1	Along Porirua Harbour	Road	Coastal Inundation / SLR	KiwiRail and road has the potential to be subject to coastal inundation in the future.	4UL	4VL	No	Physical works ($$$)	Various high-risk areas across the region that require slope stabilisation.	Business Case required
A1	1	Tank Farm Culvert to Exmouth Footbridge	Road	Coastal Inundation / SLR	Southbound lanes between Tank Farm Culvert and Exmouth St Footbridge get inundated during high tides (and storm surge). This results in varying amounts of inundation across 4 lanes: from bus lane only through to all lanes. This can cause significant disruption to the availability and resilience of the system. In extreme cases this results in significant disruption (and loss of multiple lanes) for about 2 hours at high tide.	4L	4VL	No	Physical works ($$)	There is a coastal inundation resilience study that is underway for this location. Funding is only for the investigation and options assessment. Several options are being explored such as raising the road (partial or fully), flood barriers, using new concrete barriers with pumps and/or non return systems. There are a range of other risks including to the Transpower NAaN 220kV.	Business Case funded or underway
T14	3	Awakino Village	Road	Coastal Erosion	Awakino Village at risk of coastal erosion.	4L	4VL	No	Physical works ($$)	In the short term continue rock fencing. Realignment and smoothing the corner and cut into the bluff is the long-term solution. ~60-70m bluff.	Business Case required
WC2	6	Bruce Bay	Road	Coastal Erosion	Route at risk from erosion. Rock protection measures are starting to be implemented through emergency works funding following Cyclone Fehi (2018). However, if there was another cyclone a large section of the road has the potential to be lost regardless of current resilience work.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Rock protection however there will still be residual risk.	Business Case required
C24	1	Clarence to Kaikoura	Road	Coastal Inundation / SLR	Overtopping occurs along the whole corridor, only out for a couple hours either side of high tide. Unsure whether this will damage the road as it is all new (NCTIR), likely this will no longer damage the road. However, this is ongoing and likely to increase with the impacts of CC. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	4L	4VL	No	Unknown. Pending further investigations	Further investigations needed.	Business Case required
S1	1	Entire coastal section at Ocean view north of Bluff	Road	Coastal Inundation / SLR	Ocean view route to the port - risk to coastal inundation that will need to be addressed within the next 10 years. Combination of coastal and rainfall flooding at high tide resulting in traffic lanes being submerged over a length of approximately ~70m. This is the key route to the port, with no detour. Compounding issue is that the lagoon doesn't drain.	4L	4VL	No	Physical works ($$)	Raise the road for around 70m.	Business Case required
WC5	6	Fox River	Road	Coastal Inundation / SLR	Fox River - low lying with sea level rise risk.	4L	4VL	No	Enhanced proactive maintenance	Ongoing monitoring and maintenance.	Business Case required
WC6	6	Greymouth to Westport	Road	Coastal Erosion	Coastal erosion during a cyclone has the potential to affect the whole region. Increased frequency to approx. once a year. Typically, NZTA are still carrying out repair works from the previous event when then next one comes. Still recovering from Cyclone Fehi (2018). All works are currently reactive. 4 sites where preventative works, these could be prioritised.	4VL	4VL	No	Enhanced proactive maintenance	Rock protection.	Business Case required
BP2	2	Kutarere	Road	Coastal Inundation / SLR	Tidal flooding occurs with significant rainfall.	4L	4VL	No	Physical works ($$)	Raise the road <1km.	Business Case required

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
T10	3	Mohakatino and Tongaporutu estuaries	Road	Coastal Inundation / SLR	Mohakatino and Tongaporutu estuaries could potentially have coastal inundation and erosion issues.	4L	4VL	No	Unknown. Pending further investigations	Requires a detailed study.	Business Case required
T12	3	Mohakatino Bridge	Road	Coastal Erosion	Potential for erosion risk due to it being low lying and in an estuary. The causeway is very narrow and vulnerable to erosion due to wave action. Currently a low cost, low risk project to provide rock armour. One side of the wall had rock armour which has been washed out. Could have coastal inundation issues in the future, however the geomorphology of the estuary could change this.	4L	4VL	No	Physical works ($$)	Rock armour improvements in the short term, but needs a long-term plan.	Business Case required
HB5	2	Napier airport	Road	Coastal Inundation / SLR	Road to Napier airport is highly vulnerable to a number of hazards.	4L	4VL	No	Unknown. Pending further investigations	Regional problem and tied to climate change and emergency response issues.	Business Case required
C17	1	Ohau Point	Road	Coastal Inundation / SLR	Ohau Point is at risk from coastal inundation– it overtopped three times in 2019 in a combined high tide and storm event. There is a potential design in NCTIR to address this, however with the effects of climate change this may not address the issues. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	5L	5VL	No	Unknown. Pending further investigations	Monitor.	Business Case required
W5	1	SH1 Centennial Highway	Road	Coastal Erosion	Sea level rise, storm events, high seas causing damage to seawall.	5L	5VL	No	Physical works ($$$)	Ongoing armouring. More work required to determine appropriate solutions.	Business Case required
W4	1	SH1 Centennial Highway	Road	Coastal Inundation / SLR	Coastal inundation and SLR risk with water over topping the road in larger events. Currently reactive maintenance is prioritised as opposed to proactive. Culvert near Paekakariki blocks frequently due to lose material causing flooding in the town. Catchments flood in short duration events causing slips and debris/blockages. KiwiRail assets are adjacent (up-catchment) and also are affected. Even with completion of Transmission Gully, access will still be required for the rail line.	5L	5VL	No	Physical works ($$$)	Will continue to flood in the long term but will require ongoing repair and maintenance. More work required to determine appropriate solutions.	Business Case required
W1	2	SH2 Petone to SH1	Road	Coastal Inundation / SLR	Coastal inundation and SLR are the biggest issue for this area. Regular events over recent years have caused outages and damage.	4VL	4VL	Yes	Physical works ($$$$)	There is a proposed seawall / cycleway which will help mitigate this risk.	Business Case funded or underway
WC22	6	Southern side of Punakaiki	Road	Coastal Inundation / SLR	Low lying and vulnerable to sea level rise.	4L	4VL	No	Physical works ($$$)	Rock protection.	Business Case required
T23	3	Tongaporutu estuary	Road	Coastal Erosion	Route has coastal erosion risk due to the estuary and also has potential to be at risk from coastal inundation.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Requires ongoing monitoring and potential stabilisation.	Business Case required
BP11	2	Waiotahi Bridge	Road	Coastal Erosion	Coastal erosion along the bridge is possible. Solvable in the short to medium term, but not long term with climate change. 6hr detour for HCV and HPMV.	4L	4VL	No	Physical works ($$)	Erosion protection required around bridge.	Business Case required
HB12	2	Whirinaki Bluff	Road	Coastal Erosion	Coastal erosion risk. Coastal erosion likely to cut off the entire road northward.	4L	4VL	No	Physical works ($$)	Need to understand the effects of climate change and develop options.	Business Case required

2.3.2 Other (non-coastal) climate related hazards

The following summarises the other (non-coastal) climate related hazards including erosion along riverbanks, extreme weather, flooding, avalanche, rainfall induced landslip and wildfire. Similar to the coastal hazards, Top of the South has the greatest number of non-coastal climate related hazards, specifically flooding and landslip (Figure 2.10). This is followed equally by the Bay of Plenty and the West Coast.

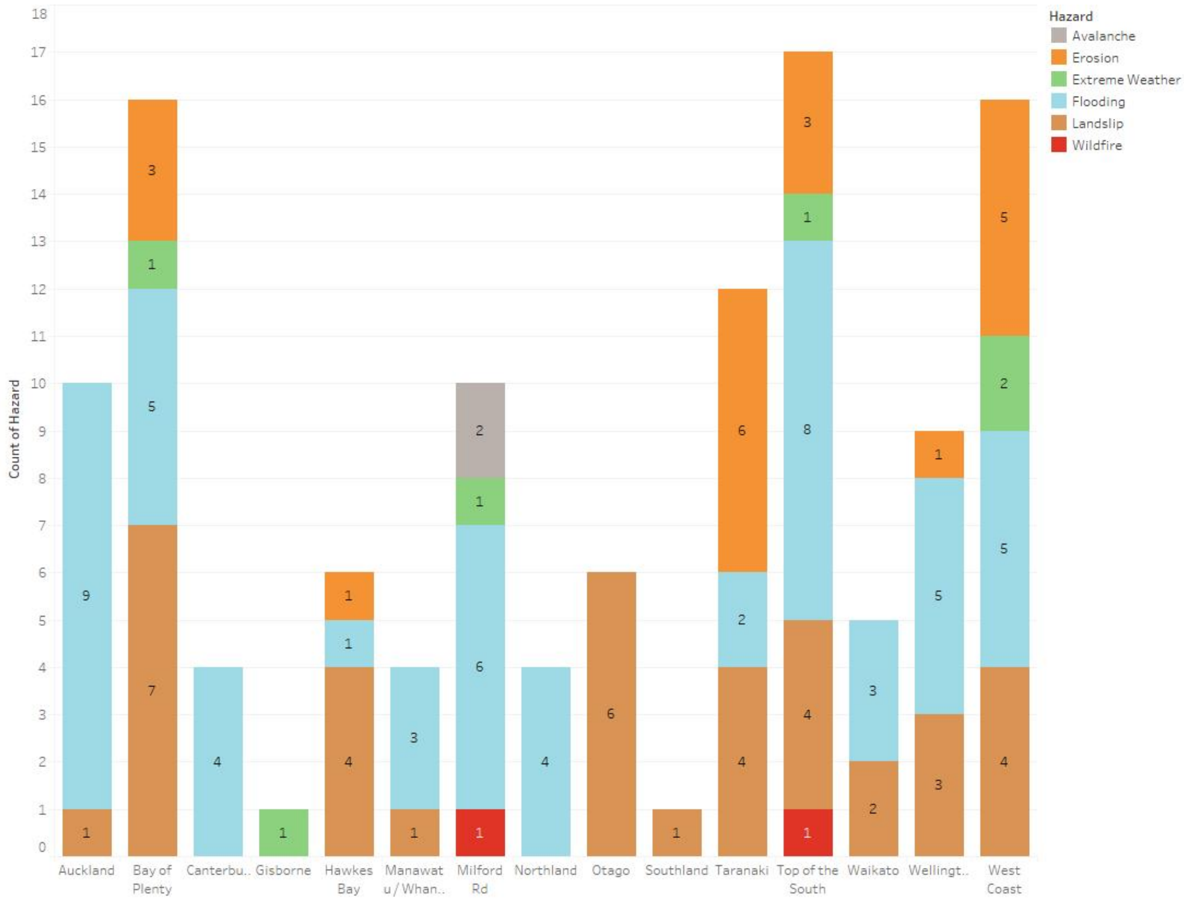

Figure 2.10: National summary of non-coastal climate related hazards

Figure 2.11 details the <u>extreme</u> (5VL, 4VL, 4L) and <u>major</u> (3VL) non-coastal climate related risks by region. West Coast, Top of the South and Taranaki show the greatest number of <u>extreme</u> and <u>major</u> non-coastal climate related risks with Northland, Wellington, Canterbury and Auckland having risks rated at 5VL in the future.

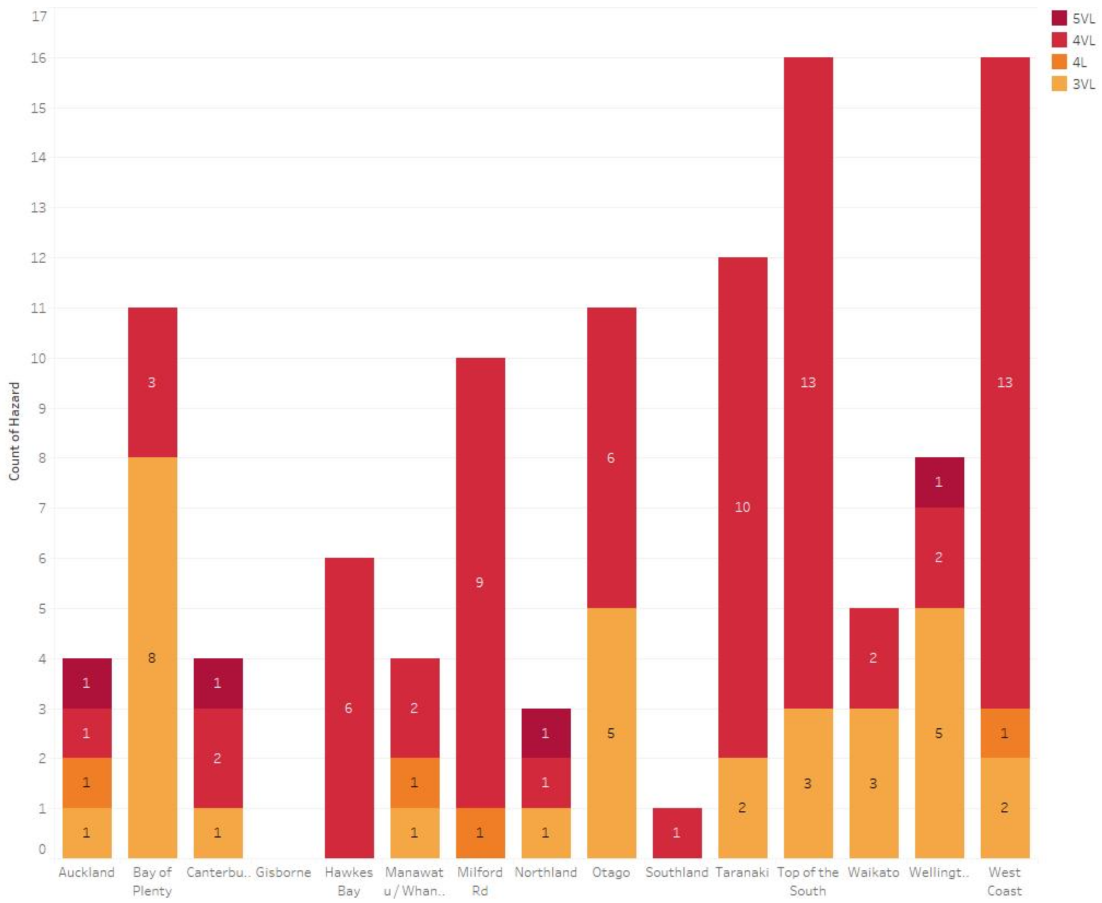

Figure 2.11: National summary of *<u>extreme</u>* *and* *<u>major</u>* *non-coastal climate related hazard with 2050 risk rating*

Table 2.3 summarises the national extreme (5VL, 4VL, 4L) non-coastal climate related risks in 2050. Refer to section 2.2.1 for interpretation of the risk tables.

Table 2.3: National summary of extreme non-coastal climate related risks

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
O4	1	Balclutha Bridge	Bridge	Flooding	Flooding of the Balclutha river has potential to impact / compromise the Balclutha Bridge. This is the only bridge and detour routes are significant.	4L	4VL	No	Unknown. Pending further investigations	Requires a detailed study.	Business Case required
O15	1	Big Kuri River	Road	Flooding	Big Kuri River north of Hampden deposits a large amount of gravels which causes water to flow over the bridge. 4-5-hour detour.	4L	4VL	No	Physical works ($$$)	The plan is to wait for the bridge to get to the end of its life then construct a new bridge with improved freeboard.	Business Case required
WC1	7	Black Point	Road	Erosion	A few river erosion sites near Reefton river. Ongoing rock armouring.	4L	4VL	No	Enhanced proactive maintenance	Rock protection.	Business Case required
WC3	6	Buller Gorge	Road	Extreme Weather	Extreme weather risk with tree fall along gorge.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Regular maintenance in tree cutting.	Business Case required
TS6	6	Canvastown along Pelorus River	Road	Flooding	River floods and inundates the road.	4VL	4VL	No	Physical works ($$$)	Raise the road.	Business Case required
C19	1	Clarence Bridge	Bridge	Flooding	Clarence river is at risk to river and surface flooding - requiring ongoing groyne maintenance. High sediment loads can cause the riverbed to aggrade up to 2m. This risk also extends across most of the streams along the Northern Kaikoura coastline. Some sediment retention devices are being built to address this. This risk is manageable in individual locations, however in a significant event such as Tropical Cyclone Fehi / Gita there is the potential for all rivers to flood, which could cause significant remedial works. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	5L	5VL	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance.	Business Case required
MR2	94	Cleddau River	Road	Flooding	Cleddau River - flood risk. There are regular flooding events which inundate the road and damage structures.	4VL	4VL	No	Unknown. Pending further investigations	Difficult to address. Further work required.	Business Case required
TS22	63	Connors Bend along Wairau River	Road	Flooding	Flooding risk where land drains river.	4L	4VL	No	Physical works ($$)	Better drainage required.	Business Case required
O8	6	Cromwell to Frankton	Road	Landslip	Landslip risk throughout the Kawarau Gorge. Some LCLR investigation work underway.	4VL	4VL	No	Physical works ($$$)	Retaining walls and drainage improvements.	Business Case required
HB1	2	Devil's Elbow	Road	Landslip	~10km of Devil's Elbow is at risk to landslip.	4VL	4VL	No	Unknown. Pending further investigations	An alternative local road can be utilised however it is unsealed and narrow and cannot take heavy vehicles. Upgrading the local road is potentially a better use of money.	Business Case required
MR3	94	Eglington River	Road	Flooding	There are regular flooding events which inundate the road and damage structures. The river is a wide braided river which aggrades. There are current operating flood protection structures. Each year material is removed from under the bridge as it builds up.	4L	4VL	No	Unknown. Pending further investigations	Difficult to address. Further work required.	Business Case required

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
T3	3	Entire length of SH3 north of New Plymouth	Road	Landslip	Landslip risk to strategic highway on Taranaki network. Lack of viable alternative route with the nearest detour being SH4, adding a large amount of time and distance. Substantial geotechnical structures for slope instability along the road south of Piopio (in the gorges). Some structures are very old.	4L	4VL	No	Physical works ($$)	Requires a detailed study.	Business Case required
HB14	5	Entire length of SH5	Road	Landslip	Significant issues with Landslips and instability along entire route. Highest ONRC and connects the Bay to inland. The detour is long and less resilient, via Palmerston North.	4L	4VL	No	Physical works ($$$)	Response plan for the route needs to be developed. A large number of geotechnical solutions would be required to address the landslips.	Business Case required
TS8	6	Entire Region	Road	Wildfire	Wildfire risk to wooden structures such as bridges and retaining walls which exist across the entire region.	4L	4VL	No	Enhanced proactive maintenance	Preparedness.	Business Case required
WK4	3	Entire stretch of SH3	Road	Landslip	Landslip risk with road instability. Key route for LPG to get trucked from New Plymouth to Auckland.	4L	4VL	No	Unknown. Pending further investigations	Business Case required.	Business Case required
WK20	1	Flooding just north of Turangi	Road	Flooding	Surface flooding issues along SH 1 through Waiotaka Straight (within Waiotaka Valley). This is a low-lying wetland area (South Taupo Wetlands) which is prone to flooding.	4L	4VL	No	Unknown. Pending further investigations	Business Case required.	Business Case required
S2	94	Gorge Hill	Road	Landslip	Landslip risk at Gorge Hill. Slip has failed previously, completely damaging the road. Currently no detour, however a subsidiary road could be built through farmers land. Has been stable, with preventative maintenance undertaken. Slumping is topped up approximately monthly. Annual visits to survey the movement. Low volume but strategic for tourist reasons. 4-hour detour.	4L	4VL	No	Emergency response and preparedness planning only (typically HI/LF)	Pre buy section in advance to be able to build an alternate/backup road.	Business Case required
WC7	73	Griffiths Bridge	Bridge	Erosion	Erosion and scour risk around the bridge.	4L	4VL	No	Physical works ($$$)	New bridge.	Business Case required
WC10	6	Haast Pass	Road	Erosion	Erosion risk along Haast River.	4L	4VL	No	Physical works ($$$$)	Expensive protection works.	Business Case required
WC9	6	Haast Pass	Road	Landslip	Route at risk from landslip. Currently all reactive works with proactive management on some sites, however there is still a risk of losing the whole road. A few landslip sites could potentially be more proactive some of it which would be less than $1m, however it is more like $5m altogether.	4VL	4VL	Yes	Enhanced proactive maintenance	Some areas could have more proactive work undertaken.	Business Case required
MR4	94	Hollyford Rd to Chasm	Road	Avalanche	Avalanche risk for the winter season is the major focus which drives most of the work throughout winter (April/May-October/November). Twice a day there is an avalanche hazard forecast put out which drives public access, restrictions and control work. Climate trends: winter is arriving later but staying longer. This affects tourism. Increased precipitation and snow – however more rain on snow increases the risk. Risk level is rising with annual increasing traffic volumes.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Ongoing prevention.	Business Case required
MR5	94	Hollyford River	Road	Flooding	Flood risk on the Hollyford River. There are regular flooding events which inundate the road and damage structures.	4L	4VL	No	Unknown. Pending further investigations	Difficult to address. Further work required.	Business Case required

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
MR17	94	Homer Tunnel	Tunnel	Avalanche	Significant reinvestment issues for tunnel and portals but there is a BC being developed for replacement portal/protection structures. Resilience for future EQ/Rockfall. The structure is ageing, soon to be a historic site – heritage assessment currently in draft but recommends some very intensive improvement and maintenance works to protect nature of the site.	4L	4VL	No	Physical works ($$$$)	A smart design for replacement of the tunnel portals could deal with strengthening and upgrading, aiding avalanche and rockfall risks at the same time. In short term, Rockfall prevention measures e.g. scaling, fences and bunds. But has cross over with avalanche zone - avalanches will destroy rockfall structures. Longer term needs to reinforce and upgrade the portals/tunnel before it is designated as a historical site. A smart design for replacement of the tunnel portals could deal with strengthening and upgrading, aiding avalanche and rockfall risks at the same time. Portals are under the largest avalanche zones. In addition, remote control avalanche systems could be employed. This is a significant tourism route and also safety issues.	Business Case funded or underway
TS10	6	Hope saddle	Road	Landslip	Ongoing landslip risk.	4VL	4VL	No	Physical works ($$)	Requires netting.	Business Case required
TS11	6	Kawatiri to Owen	Road	Erosion	At risk to river erosion and drop out.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance.	Business Case required
HB3	5	Kaweka Ranges - Mohaka River Rail and Road Bridge	Road	Landslip	Mohaka river at the road and rail bridge which has fundamental flaws in its design and is subject to landslip risk along the entire length of the ranges. It is a narrow road with minimal space to carry out physical works or install geotechnical solutions such as debris fences. Work is being done to cut the slip back further. A debris fence is however being installed in one section from Pakipaki to Peka Peka.	4L	4VL	No	Physical works ($$$)	Investigation into options to retreat into hillside/ behind rail viaduct 'Raupunga retreat'.	Business Case funded or underway
WC12	6	Knights Point	Road	Landslip	Most vulnerable piece of road to landslip in New Zealand and currently only has reactive work underway.	4VL	4VL	No	Enhanced proactive maintenance	Also, would require further investigation.	Business Case required
C13	7	Lewis Pass	Road	Flooding	Currently a lot of maintenance work being carried out to stop flooding inundation of the road. The road and riverbed are currently at the same level.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Requires further investigation to develop a long-term solution.	Business Case required
WC15	7	Lewis Pass	Road	Flooding	Shingle fans depositing on the road, as well as surface flooding risk.	4L	4VL	No	Physical works ($$$)	Solvable with upgrade to double lane bridges and bridge realignment away from rockface.	Business Case required
O15	1	Maheno	Bridge	Flooding	Flooding issues within a number of river catchments. Options have been scoped. Overland flow path floods the road between Clarks Mill and where the road crosses the railway. There is a plan to put culverts in to allow water to run from one side of the road to the other to stop flooding. When this floods the bridge also floods and the detour is ~ 4-5 hours.	4L	4VL	No	Physical works ($$)	Upgrade culverts and overland flow paths.	Business Case required
T8	3	Mangaotaki gorge	Road	Landslip	Mangaotaki Gorge is at risk of landslip. Currently has no geotechnical barriers.	4L	4VL	No	Physical works ($$$)	Active/priority sites have been funded but the whole corridor has a resilience issues. Retaining walls.	Business Case required
MW2	2	Mangatainoka	Road	Flooding	SH2 Mangatainoka - moderate flood risk (1 every 10 years).	4L	4VL	No	Physical works ($)	Drainage improvements required.	Business Case required
TS30	65	Mauria River	Road	Erosion	Surface flooding and undercutting / erosion where river is next to the road.	4VL	4VL	No	Physical works ($$$)	Rock protection along river to protect road.	Business Case required

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
MR10	94	Milford Road	Road	Extreme Weather	Tree fall due to extreme weather is a significant risk that is partly managed through an extensive tree removal programme however this is still resulting in significant residual risk which is likely to increase due to climate change. Tree fall hazard has led to fatalities in the last 5 years. The tree fall risk strategy in place primarily focuses on investment over time for managing (>3000 at present) and removing trees from along the roadside.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance.	Business Case required
MR7	94	Milford Road Bridges	Bridge	Flooding	In addition to the individually listed bridges, there are a number of 1-way truss and concrete bridges that are at risk to flooding. Greater than 30 bridges experience 8-9m of rain every year. Currently the alliance handles this well, however a single failure will break the entire network. A number of the bridges require ongoing work however, a reduction in bridge maintenance funds by NZTA will limit the amount of work that can be completed.	4L	4VL	No	Enhanced proactive maintenance	Enhanced maintenance.	Business Case required
MR9	94	Milford Township	Road	Flooding	Flood risk. Currently there are a number of flood protection works being carried out to protect property. However, there is residual risk, but this is less of a highway risk. DOC have some ongoing work that involves increasing the ground level of Milford by 0.5-1m, as a significant portion of Milford is on reclaimed land and flood plain/fan. To provide slightly more protection for SLR and tsunami.	4L	4VL	No	Physical works ($$)	Raise village height and build higher stop banks. Some work is already underway.	Business Case required
T13	3	Mokau Bluff	Road	Erosion	Mokau Bluff, at risk of coastal erosion.	4L	4VL	No	Physical works ($$)	In the short term continue rock fencing. Realignment and smoothing the corner and cut into the bluff is the long-term solution. ~60-70m bluff.	Business Case required
T15	3	Mt Messenger	Road	Landslip	South of Mt Messenger is at risk of landslip- Uruti Valley has a number of cuttings prone to slipping.	4L	4VL	No	Unknown. Pending further investigations	Requires a detailed study.	Business Case required
N12	1	Oakley and Mata Flooding	Road	Flooding	Combined coastal inundation and river flooding risk. Key freight route. Used to occur every 5 years. Has been blocked twice in less than 10 years. Catchment boards involved in flood risk management were lost in the amalgamation of councils.	4L	4VL	No	Unknown. Pending further investigations	Requires a detailed study.	Business Case required
WC17	73	Otira River at Otira	Road	Erosion	River erosion risk. Already funded but has ongoing issues in other areas as well.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Monitor and reactive maintenance.	Business Case required
T16	3	Patea Bridge	Bridge	Erosion	Bridge built between 60's-70's at risk to erosion.	4L	4VL	No	Physical works ($$)	Strengthening or realignment of the bridge would be a more beneficial outcome in comparison to a new route.	Business Case required
O19	6	Queenstown to Frankton	Road	Landslip	Highly vulnerable to rainfall induced landslips.	4L	4VL	No	Physical works ($$$)	Retaining walls and improving lakeside stability to minimise under slips.	Business Case required
WC19	7	Rahu Saddle	Road	Extreme Weather	Extreme weather risk with trees falling from high winds.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Annual inspections and selective removals where risk identified.	Business Case required
N4	1	Ruakaka and Whangarei	Road	Flooding	Flood risk between Ruakaka and Whangarei. Both river and tidal flooding during king tides. Typically, when there are issues on the SH there are issues on the local roads so there are no alternate options.	5L	5VL	No	Unknown. Pending further investigations	Requires further detailed study.	Business Case required
TS24	63	Salt Lake	Road	Flooding	Runoff leads to flooding of road.	4L	4VL	No	Physical works ($$)	Box culverts and raise road.	Business Case required

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
WC20	6	Scout Lodge Straight	Road	Erosion	Significant river erosion risk.	4VL	4VL	No	Physical works ($$$)	River protection works (groynes) to train river and realign road.	Business Case required
W6	1	SH1 Kuku	Road	Flooding	Flooding occurs frequently in low lying area - caused by a land drainage issue where water builds up on the highway approx. once a year. Flooding can often reduce traffic down to one lane and has affected both lanes for a couple of hours. With help from Council it could be improved. Risk could also be reduced if Otaki to Levin is confirmed.	5L	5VL	No	Physical works ($$)	Requires Council to address adjacent land drainage and runoff - less of an issue once O2NL is constructed. could significantly improve the flood issue - especially considering the detour is extensive.	Business Case required
W19	1	SH1 Ngauranga Gorge	Road	Landslip	Rockfall risk and landslides - targeting low cost, low risk funding. Multiple users including cyclists. Debris screen is a hard structure and the footpath has become a combined pathway with no room left for construction. Low cost, low risk would address most of these.	4L	4VL	No	Physical works ($$$)	Some minor works planned, but would require significant infrastructure to fully mitigate.	Business Case required
W2	1	SH1 Porirua	Road	Flooding	Some flooding. The roads go through wetland like material, some of the culverts and streams are full of gravel and upper reaches of streams need clearing and maintaining. NZTA ends up with the problem but they have very little control of what happens up or down stream of the road.	4L	4VL	No	Physical works ($$$)	Ongoing improvements to manage high intensity rainfall events - will require Council to improve stormwater catchment.	Business Case required
T19	3	SH3 Midhurst rail overbridge	Road	Erosion	SH3 Midhurst rail overbridge has the potential for erosion and scour - which may in turn affect the road below. The detour route is also very long and is not ideal for HPMV.	4L	4VL	No	Unknown. Pending further investigations	There is no specific risk at the moment, but the solution should be similar to what occurred in Normandy, bridge realignment and creation of a viable detour. Main pinch points are all bridges with no detour routes.	Business Case required
T18	3	SH3 Midhurst rail overbridge	Road	Flooding	SH3 Midhurst rail overbridge has the potential for flooding. The rail and river bridge are back to back with detours that are not ideal for HPMV. The detour route is also very long. There is no specific hazard at the moment, but the solution should be similar to what occurred in Normandy, bridge realignment and creation of a viable detour. Main pinch points are all bridges with no detour routes.	4L	4VL	No	Unknown. Pending further investigations	Requires a detailed study.	Business Case required
T20	3	South of Mt Messenger	Road	Erosion	Erosion risk where river runs adjacent to SH3 South of Mt Messenger.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Requires ongoing monitoring and potential stabilisation.	Business Case required
WC21	6	South of Ross to Haast Pass	Road	Flooding	All rivers south of Ross (~15 rivers) need training/stop banking and active management to reduce flood risk.	4VL	4VL	No	Enhanced proactive maintenance	Ongoing training works and management.	Business Case required
C21	7	Stuarts Fan	Road	Flooding	Flooding risk to bridge when extreme events mobilise the shingle and cause overflow at culverts underneath the bridge. The culverts get cleaned out annually which closes the road for a few hours. Justification for funding in resilience measures could be difficult.	4L	4VL	No	Physical works ($$$)	There is a plan developed for realignment and box culverts however this hasn't received funding. Requires regular maintenance.	Business Case required
WC23	73	Taipo Bridge	Bridge	Flooding	Flood risk along one lane bridge.	4L	4VL	No	Physical works ($$$$)	replace whole bridge and double lane.	Business Case required
TS20	60	Takaka Hill	Road	Landslip	Landslip risk with both under and over slips. Mainly on the Nelson side. Occurs at least once a year. There are also a number of drainage issues.	4VL	4VL	No	Physical works ($$$)	Realignment improve drainage and catchment management. Even with improvements, there would still be ongoing issues, requiring response and BAU maintenance.	Business Case required
TS25	63	The wash	Road	Flooding	Flooding risk through the Wairau Valley as road follows river in floodplains.	4L	4VL	No	Physical works ($$)	Raise road and provide river protection.	Business Case required
T22	3	Tongahoe	Bridge	Erosion	Bridge built between the 60's-70's and is at risk to erosion. Tongahoe should be a high priority as it has a bluff and the river.	4L	4VL	No	Physical works ($$)	Strengthening or realignment of the bridge would be a more beneficial outcome in comparison to a new route.	Business Case required

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
TS2	1	Tuamarina to Picton	Road	Flooding	Surface flooding risk from adjacent catchment runoff.	4L	4VL	No	Unknown. Pending further investigations	Requires a detailed study.	Business Case required
TS16	6	Upper Buller Gorge	Road	Erosion	Erosion risk along the Buller Gorge in both Top of South and West Coast.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance.	Business Case required
TS13	6	Upper Buller gorge	Road	Extreme Weather	Extreme weather risk with strong winds resulting in tree fall.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance.	Business Case required
TS14	6	Upper Buller gorge	Road	Landslip	At risk to landslips both over and under slips.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance.	Business Case required
MR11	94	Upukerora River	Road	Flooding	There are semi regular flooding events that inundate the road and damage structures.	4L	4VL	No	Unknown. Pending further investigations	Difficult to address. Further work required.	Business Case required
O15	1	Waikouati River	Road	Flooding	Waikouati River floods the highway.	4L	4VL	No	Physical works ($$)	Raise level of road to clear flood level.	Business Case required
WC24	73	Wainihinini Bridge	Bridge	Flooding	Flood risk to bridge. Bridge replacement is critical from a HMPV point of view. Currently reaching end of life.	4L	4VL	No	Physical works ($$$)	Replace bridge.	Business Case required
BP9	2	Waioeka Gorge	Road	Landslip	Landslip risk for the entirety of Opotiki to the Bay of Plenty boundary. Significant effects commercially and for small communities.	4VL	4VL	No	Physical works ($$$$)	over a multiple year programme. In an ideal world you would do a multi-year programme across all significant sites - that links to the PBC that Simon Barnett / Gisborne is working on.	Business Case required
BP24	2	Waioeka River	Road	Erosion	Erosion from Waioeka river and failure of the groynes could mean loss of road.	4L	4VL	No	Physical works ($$)	New groynes.	Business Case required
HB9	2	Wairoa River	Road	Erosion	Erosion risk along Wairoa River where the slip undercuts the road.	4L	4VL	No	Physical works ($$)	Opportunities to raise level of road alongside river corridor and/ or look at investing in improving resilience of local road network as alternative.	Business Case required
HB10	2	Wairoa River	Road	Flooding	Wairoa River Flood once a year with the road closed and the river is cutting into the road - Cyclone Bola took out the bridge. Removing every year flood risk would be better than trying to address the big events - which would involve raising the road. Sheer bank on one side of the road where you could raise the road and put in slip control. Wouldn't make this high priority above the other issues where this is only closed for a day vs the other ones closed for weeks.	4L	4VL	No	Physical works ($$)	Response plan for the route needs to be developed and look at improving resilience of Mohaka Bridge and approaches.	Business Case required
T24	3	Waitotara bridges	Bridge	Erosion	Erosion risk to the bridge. Built between 60's-70's.	4L	4VL	No	Physical works ($$)	Strengthening or realignment would be of more value than creating a new route.	Business Case required
BP13	29	West side of the Kaimai's	Road	Extreme Weather	Extreme weather can cause re-mobilisation of the fine/ash material. Could be difficult to clean up.	4L	4VL	No	Physical works ($)	Some sort of geotechnical response to stabilize slope. Needs investigation.	Business Case required
MW1	3	Whangaehu (link between Whanganui and Bulls)	Road	Flooding	SH3 Whangaehu area floods regularly (every 5 years). It is a critical link between Whanganui and Bulls where water generally flows over the road. The road could be built up to the same height as the bridge adjacent to it. Currently the surrounding houses and community are under water, they effectively dam the water causing it to significantly back up, significant stormwater management would be needed.	4L	4VL	No	Physical works ($$)	Raise the section of the road to the east of the bridge. However, the flood waters need to cross the road corridor or the Whangaehu town will get flooded. The options are a bridge or several very large culverts. A raised embankment will not work.	Business Case required

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
A11	1	Lonely Track Road North Slip	Road	Landslip	Landslip issues. This is currently viewed as being one of the highest risks on the Auckland network - which has potential to cause a loss of system availability. Significant land instability issues detected with ongoing movement since construction in late 90's as part of the SH1 ALPURT A1 Project. Close monitoring and proactive sealing of tension cracks to slow down failures is currently funded under ASM TOC for initial investigation (only).	5L	5VL	No	Unknown. Pending further investigations	Significant issue - Currently investigation works are underway to better understand the scale of the risk and any resultant work needs. This includes additional monitoring and investigation of the likelihood and consequence of a slip. Auckland System Management (ASM) TOC funding to a capped budget is available for the current investigation stage. Monitoring in various forms has been occurring since 2008. ASM TOC funding for investigation in the last year has been made available to confirm the risk profile and any recommendations on mitigation. Additional funding would be needed for any physical works.	Business Case funded or underway
HB11	2	Whirinaki Bluff	Road	Landslip	Landslip risk. Slip likely to cut off the entire road northward.	4L	4VL	No	Physical works ($$)	Need to understand the effects of climate change and develop options.	Business Case required

3 Regional PRA extreme and major risk summaries

This section summarises the extreme and major risks identified within each region following the regional stakeholder workshops. These relate to those risks identified as extreme or major in the present day. Climate related risks (2050) are shown as well. Refer to section 2.2.1 for interpretation of the risk tables.

Appendix A contains the detailed risk ratings for all risks captured, along with the sub-components which make up the risk rating.

Appendix B contains the detailed maps showing the locations of the regional extreme and major risks.

3.1 Auckland

A total of two major / extreme risks were identified for the Auckland Region. The small number of risks within Auckland is predominantly due to the high-density of the regional transport network and the availability of alternate routes which result in lower impacts across the land transport network as a whole.

Table 3.1: Summary of major and extreme risks in the Auckland

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
A1	1	Tank Farm Culvert to Exmouth Footbridge	Road	Coastal Inundation / SLR	Southbound lanes between Tank Farm Culvert and Exmouth St Footbridge get inundated during high tides (and storm surge). This results in varying amounts of inundation across 4 lanes: from bus lane only through to all lanes. This can cause significant disruption to the availability and resilience of the system. In extreme cases this results in significant disruption (and loss of multiple lanes) for about 2 hours at high tide.	4L	4VL	No	Physical works ($$)	There is a coastal inundation resilience study that is underway for this location. Funding is only for the investigation and options assessment. Several options are being explored such as raising the road (partial or fully), flood barriers, using new concrete barriers with pumps and/or non return systems. There are a range of other risks including to the Transpower NAaN 220kV.	Business Case funded or underway
A11	1	Lonely Track Road North Slip	Road	Landslip	Landslip issues. This is currently viewed as being one of the highest risks on the Auckland network - which has potential to cause a loss of system availability. Significant land instability issues detected with ongoing movement since construction in late 90's as part of the SH1 ALPURT A1 Project. Close monitoring and proactive sealing of tension cracks to slow down failures is currently funded under ASM TOC for initial investigation (only).	5L	5VL	No	Unknown. Pending further investigations	Significant issue - Currently investigation works are underway to better understand the scale of the risk and any resultant work needs. This includes additional monitoring and investigation of the likelihood and consequence of a slip. Auckland System Management (ASM) TOC funding to a capped budget is available for the current investigation stage. Monitoring in various forms has been occurring since 2008. ASM TOC funding for investigation in the last year has been made available to confirm the risk profile and any recommendations on mitigation. Additional funding would be needed for any physical works.	Business Case funded or underway

3.2 Bay of Plenty

A total of 12 major and extreme risks were identified within the Bay of Plenty region. These relate to rockfall, landslip, erosion, flooding and coastal inundation/erosion. The highest rated risk was the Waioeka Gorge which sits within both the Bay of Plenty and Gisborne areas. Coastal risks are high now and are anticipated to increase due to climate change.

Table 3.2: Summary of major and extreme risks in the Bay of Plenty

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
BP2	2	Kutarere	Road	Coastal Inundation / SLR	Tidal flooding occurs with significant rainfall.	4L	4VL	No	Physical works ($$)	Raise the road <1km.	Business Case required
BP3	35	Motu Bluff	Road	Landslip	Land stability issues at Motu Bluff	3VL	3VL	No	Physical works ($$)	Rockslide netting to divert the rocks. 10-20-year programme to improve rain / storm water control to avoid emergency works	Business Case required
BP4	2	Nukuhou	Road	Flooding	4 locations of flooding which generally occur at the same time. The local road has already been raised to provide a better route instead of raising the SH.	3VL	3VL	No	Physical works ($$$)	Raise 2km of road	Business Case required
BP5	29	Ruahihi Bluff	Road	Rockfall	Rockfall ~5 cubic m blocks which pose a significant safety risk. 30-40% of trucks would be HPMV which equals ~800 trucks on a 2-hour detour.	4L	-	No	Physical works ($$)	There is a significant resilience and safety benefit. Solution designed and ready to go, mesh and rockfall. Should be highest risk stretch of road.	Business Case required

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
BP6	35	Tirohanga to Bay of Plenty Boundary	Road	Landslip	Landslip issues along entire East Cape. Also, sedimentation with significant rainfall washing sediment down valleys.	3VL	3VL	No	Physical works ($$$)	Further investigations needed	Business Case required
BP12	2	Waimana Gorge	Road	Landslip	Both large and small slips through the gorge. Currently already spending $6million just to get it open from previous events.	3VL	3VL	No	Physical works ($$$)	Requires stabilizing slopes.	Business Case required
BP9	2	Waioeka Gorge	Road	Landslip	Landslip risk for the entirety of Opotiki to the Bay of Plenty boundary. Potential for significant effects commercially and for small communities.	4VL	4VL	No	Physical works ($$$$)	over a multiple year programme. In an ideal world you would do a multi-year programme across all significant sites - that links to the PBC that Simon Barnett / Gisborne is working on.	Business Case required
BP8	2	Waioeka Gorge	Road	Rockfall	Significant rockfall issues along the entirety of Waioeka Gorge for both the Bay of Plenty and Gisborne / Hawke's Bay. Very significant issue for Gisborne community as in the event of a long closure communities have the potential to be isolated. Also affects time critical delivery of food produce to the port and Auckland. Supplies to the hospital could also become an issue quickly. Regional managers support a change to the ONRC classification to 'Regional' level. Significant crash rates and safety issues with response limited due to poor telephone coverage. Waioeka Gorge PBC identifies all major sites and pinch points.	5VL	-	No	Physical works ($$$)	Geotechnical improvements: combinations of rock fall protection, slope stabilisation etc. over a multiple year programme. In an ideal world you would do a multi-year programme across all significant sites - that links to the PBC that Simon Barnett / Gisborne is working on. Aurecon has previously carried out an assessment of the sites.	Business Case required
BP24	2	Waioeka River	Road	Erosion	Erosion from Waioeka river and failure of the groynes could mean loss of road.	4L	4VL	No	Physical works ($$)	New groynes	Business Case required
BP10	2	Waiotahi Bluffs	Road	Landslip	Land instability issues along the Bluff. Ideally need to enhance detour route so that it can take HPMVs which will limit the impacts of outage.	3VL	3VL	No	Physical works ($$)	Roughly 10 -15kms of upgrading detour route. There are a few tight bends which could be widened.	Business Case required
BP11	2	Waiotahi Bridge	Road	Coastal Erosion	Coastal erosion along the bridge is possible. Solvable in the short to medium term, but not long term with climate change. 6hr detour for HCV and HPMV.	4L	4VL	No	Physical works ($$)	Erosion protection required around bridge	Business Case required
BP13	29	West side of the Kaimai's	Road	Extreme Weather	Extreme weather can cause re-mobilisation of the fine/ash material. Could be difficult to clean up.	4L	4VL	No	Physical works ($)	Some sort of geotechnical response to stabilize slope. Needs investigation	Business Case required

3.3 Canterbury

A total of 27 major and extreme risks were identified within the Canterbury region. These relate to rockfall, landslip, ice and snow, flooding, coastal inundation/erosion and earthquake/liquefaction. The highest rated risks relate to rockfall and landslip and are located on SH1 North of Kaikoura. SH1 North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (which is a vital freight route). SH1 south of Kaikoura has an alternative route (via the inland road). Otherwise, the alternate route involves a significant detour (via SH63 and Lewis Pass).

Table 3.3: Summary of major and extreme risks in Canterbury

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
C8	73	Arthurs Pass	Road	Ice / Snow	SH73 through Arthurs Pass is subject to snow and ice disruptions. Arthurs Pass is one of three key routes which link the West Coast with the East Coast of the South Island.	4L	-	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	Business Case required
C9	73	Arthurs Pass	Road	Rockfall	SH73 through Arthurs Pass is subject to rockfall. Arthurs Pass is one of three key routes which link the West Coast with the East Coast of the South Island.	4L	-	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	Business Case required

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
C4	1	Ashburton Bridge	Road	Extreme Weather	SH1 at the Ashburton bridge is subject to extreme weather events. This is a significant pinch point on the network and has a limited detour with resilience and capacity issues. KiwiRail and electricity lines also follow parallel to the road and are likely to be subject to the same risk.	4L	-	No	Physical works ($$$)	Duplicate bridge required	Business Case required
C7	73	Bealey Bridge	Bridge	Earthquake / liquefaction	SH73 at the Bealey bridge is at risk from seismic shaking, scour and capacity issues.	4L	-	No	Physical works ($$$$)	Replace bridge	Business Case required
C16	1	Blue Slip	Road	Landslip	Site at risk to mass earth movement, which would likely affect both road and KiwiRail. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	5L	-	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	Business Case required
C5	8	Burkes Pass	Road	Ice / Snow	SH6 through Burkes Pass is subject to snow and ice risk resulting in closures and disruption. Burkes Pass is a key tourist and freight route between the East Coast and Central Otago.	4L	-	No	BAU / Ongoing maintenance / Reactive	Winter maintenance LOS and improved communication. VMS required at each end of route where alternative routes exist	Business Case required
C19	1	Clarence Bridge	Bridge	Flooding	Clarence river is at risk to river and surface flooding - requiring ongoing groyne maintenance. High sediment loads can cause the riverbed to aggrade up to 2m. This risk also extends across most of the streams along the Northern Kaikoura coastline. Some sediment retention devices are being built to address this. This risk is manageable in individual locations, however in a significant event such as Tropical Cyclone Fehi / Gita there is the potential for all rivers to flood, which could cause significant remedial works. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	5L	5VL	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	Business Case required
C24	1	Clarence to Kaikoura	Road	Coastal Inundation / SLR	Overtopping occurs along the whole corridor, only out for a couple hours either side of high tide. Unsure whether this will damage the road as it is all new (NCTIR), likely this will no longer damage the road. However, this is ongoing and likely to increase with the impacts of CC. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	4L	4VL	No	Unknown. Pending further investigations	Further investigations needed	Business Case required
C23	1	Clarence to Kaikoura	Road	Rockfall	Clarence to Kaikoura is subject to rockfall risk, some of which will have been addressed in the NCTIR project. However, behaviour is unpredictable due to Kaikoura works but it is assumed that there will be residual risk for rockfall and debris flows. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	5UL	-	No	Unknown. Pending further investigations	Monitor	Business Case required
C28	73	Craigieburn	Road	Landslip	Landslip risk at Craigieburn along SH73.	4L	-	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	Business Case required

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
C30	1	Hapuku Dam	Road	Landslip	Landslide dam but not significant. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	5UL	-	No	Physical works ($$)	Could remove the landslide dam to eliminate dam outbreak flood risk.	Business Case required
C26	1	Hundalees	Road	Landslip	Soft soils and landslip risk. Large number of truck crashes. Large landslips can occur every ~10 years with smaller annual events. The BAU response to the smaller events typically results in the road being back to one lane within 12 hours. The larger events cause traffic to be diverted through the alternate route for 48 hours. Slip generally comes onto the road rather than under cutting.	4L	-	No	Physical works ($$)	Solution could be to revegetate the farm area to stabilise slopes.	Business Case required
C11	1	Hurunui River Bridge	Bridge	Earthquake / liquefaction	The single lane Hurunui bridge on SH1 is subject to seismic risk and safety issues involving a large number of accidents and safety issues for cyclists. This is a high volume and significant freight route with a poor detour route.	4L	-	No	Physical works ($$$)	Replace bridge and upgrade to two lanes	Business Case required
C13	7	Lewis Pass	Road	Flooding	Currently a lot of maintenance work being carried out to stop flooding inundation of the road. The road and riverbed are currently at the same level.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Requires further investigation to develop a long-term solution	Business Case required
C25	7	Lewis Pass	Road	Ice / Snow	Snowstorms on the Lewis Pass cut off the route and all routes to the north.	4L	-	No	BAU / Ongoing maintenance / Reactive	Winter maintenance LOS and improved communication. VMS required at each end of route where alternative routes exist	Business Case required
C27	1	Movern	Road	Flooding	Surface flooding due to land use changes, short duration. SH culverts undersized.	4L	-	No	Enhanced proactive maintenance	Improved drainage required	Business Case required
C10	1	North of Kaikoura - Clarence Bridge	Road	Landslip	Landslip and mass movement risk (site similar to Blue Slip, see for details). No known solution, and if a landslip or mass movement were to occur the road and rail will be completely destroyed. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	5L	-	No	Emergency response and preparedness planning only (typically HI/LF)	Further investigations needed	Business Case required
C17	1	Ohau Point	Road	Coastal Inundation / SLR	Ohau Point is at risk from coastal inundation– it overtopped three times in 2019 in a combined high tide and storm event. There is a potential design in NCTIR to address this, however with the effects of climate change this may not address the issues. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	5L	5VL	No	Unknown. Pending further investigations	Monitor	Business Case required
C29	73	Porters Pass to Arthurs Pass	Road	Ice / Snow	Ice and snow risk - occurs throughout winter along the passes.	4L	-	No	BAU / Ongoing maintenance / Reactive	Winter maintenance LOS and improved communication. VMS required at each end of route where alternative routes exist	Business Case required

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
C3	1	Rakaia Bridge	Road	Flooding	SH1 at the Rakaia bridge is subject to extreme weather events and flooding due to limited drainage capacity around the bridge. This is a nationally significant road with a poor detour. Outage of this bridge was experienced in the lead up to Christmas 2019 and caused significant disruption throughout Canterbury. KiwiRail and electricity lines are parallel to the road and are likely subject to the same risk. Currently a large number of accidents cause disruptions on the bridge. Bridge also thought to have poor seismic strength.	4L	-	No	Physical works ($$$)	Duplicate bridge required	Business Case required
C1	77	Rakaia Gorge Bridges	Road	Flooding	This is a major tanker route for the Darfield Fonterra plant and Phillip Wareing as well as the detour route for SH1 around the Rakaia and Ashburton bridges. Some of the bridges have restrictions and limits for HPMVs. There are significant flooding issues throughout the route and the road often goes down to one lane. It's likely this road would be significantly damaged in an earthquake which would leave no detour for SH1. Electricity lines and KiwiRail are parallel to SH1 line.	4L	-	No	Physical works ($$$)	Upgrade both one lane bridges at the gorge to provide a more robust detour route. Improve traffic management procedures during outages.	Business Case required
C48	1	Rangitata and Arundel Bridges	Bridge	Flooding	Flooding has potential to cause bridge washouts through scour for both bridges on the Rangitata River.	4L	-	No	Enhanced proactive maintenance	Enhanced maintenance of river groynes	Business Case required
C14	75	Road to Akaroa	Road	Landslip	Landslip risk on either side of the summit, along the road to Akaroa through Banks Peninsula.	4L	-	No	Enhanced proactive maintenance	Maintenance and monitor	Business Case required
C18	1	Shingle Fans	Road	Landslip	Shingle Fans - North of Clarence is at risk to landslip. There are three shingle fans which flow through culverts however, in large events these flow over the road. Landslip overtopping occurs approximately once every 3-4 years. Generally, response teams can keep the shingle within the water way. Generally, there is a quick response, with short term closures and damage to infrastructure is unlikely. Smaller retention dams are being located upstream. KiwiRail relies on NZTA for clearing the culverts. This is still flagged as a high risk due to the frequency and importance of the road. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	5L	-	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	Business Case required
C21	7	Stuarts Fan	Road	Flooding	Flooding risk to bridge when extreme events mobilise the shingle and cause overflow at culverts underneath the bridge. The culverts get cleaned out annually which closes the road for a few hours. Justification for funding in resilience measures could be difficult.	4L	4VL	No	Physical works ($$$)	There is a plan developed for realignment and box culverts however this hasn't received funding. Requires regular maintenance.	Business Case required
C2	7a	Waiau Ferry Bridge	Bridge	Rockfall	The Waiau Ferry bridge is at risk from rockfall and is the key route into Hanmer Springs which is the most significant tourism / economic hub for the Hurunui district, hence a higher consequence rating was assigned. There are also some concerns around the bridge abutments. Note during workshops there was differing opinions of the criticality of this route from a regional perspective.	4L	-	No	Physical works ($$$$)	Bridge replacement and alternative alignment.	Business Case required
C6	73	Waimakariri Bluff	Road	Rockfall	SH73 at Waimakariri Bluff is subject to rockfall risk at many locations. There is currently one location being addressed under LCLR, however the issue extends over a wider area.	4L	-	No	Physical works ($$$)	more funding would mean that more sites can be addressed.	Business Case required

3.4 Gisborne / Hawke's Bay

A total of 10 major and extreme risks were identified within the combined Gisborne and Hawke's Bay area. These relate to landslip, flooding, coastal inundation/erosion and earthquake/liquefaction. Of particular note are the risks at Whirinaki Bluff and Napier Airport - relating to coastal inundation and erosion which will exacerbated by climate change and sea level rise. The Devil's elbow is the highest rated current risk in the region.

Table 3.4: Summary of major and extreme risks in Gisborne / Hawke's Bay

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
HB1	2	Devil's Elbow	Road	Landslip	~10km of Devil's Elbow is at risk to landslip.	4VL	4VL	No	Unknown. Pending further investigations	An alternative local road can be utilised however it is unsealed and narrow and cannot take heavy vehicles. Upgrading the local road is potentially a better use of money.	Business Case required
HB14	5	Entire length of SH5	Road	Landslip	Significant issues with Landslips and instability along entire route. Highest ONRC and connects the Bay to inland. The detour is long and less resilient, via Palmerston North.	4L	4VL	No	Physical works ($$$)	Response plan for the route needs to be developed. A large number of geotechnical solutions would be required to address the landslips.	Business Case required
HB3	5	Kaweka Ranges - Mohaka River Rail and Road Bridge	Road	Landslip	Mohaka river at the road and rail bridge which has fundamental flaws in its design and is subject to landslip risk along the entire length of the ranges. It is a narrow road with minimal space to carry out physical works or install geotechnical solutions such as debris fences. Work is being done to cut the slip back further. A debris fence is however being installed in one section from Pakipaki to Peka Peka.	4L	4VL	No	Physical works ($$$)	Investigation into options to retreat into hillside/ behind rail viaduct 'Raupunga retreat'	Business Case funded or underway
HB4	5	Kaweka Ranges - Mohaka River Rail and Road Bridge	Road	Rockfall	Mohaka river at the road and rail bridge which has fundamental flaws in its design and is subject to rockfall risk along the entire length of the ranges. It is a narrow road with minimal space to carry out physical works or install geotechnical solutions such as debris fences. A debris fence is however being installed in one section from Pakipaki to Peka Peka.	4L	-	No	Physical works ($$$)	Investigation into options to retreat into hillside/ behind rail viaduct 'Raupunga retreat'	Business Case funded or underway
HB5	2	Napier Airport	Road	Coastal Inundation / SLR	Road to Napier airport is highly vulnerable to a number of hazards.	4L	4VL	No	Unknown. Pending further investigations	Regional problem and tied to climate change and emergency response issues	Business Case required
HB6	50	Napier Port	Road	Earthquake / liquefaction	An earthquake in Wellington could cause Centre Port to be out of service. Consideration of routes to other ports such as Napier and Tauranga become more relevant- equally if there is an earthquake in Napier. CDEM accept that some things will likely stop economically. The road to the port is an urban highway and is less likely to be impacted by slips or a highly frequent event.	4L	-	No	Emergency response and preparedness planning only (typically HI/LF)	Link into work being undertaken by Civil defence around risks of Hikurangi Trench and Alpine Fault to understand the Agency's role in being able to respond to these large-scale events.	Business Case required
HB9	2	Wairoa River	Road	Erosion	Erosion risk along Wairoa River where the slip undercuts the road.	4L	4VL	No	Physical works ($$)	Look at opportunities to raise level of road alongside river corridor and/ or look at investing in improving resilience of local road network as alternative.	Business Case required
HB10	2	Wairoa River	Road	Flooding	Wairoa River Flood once a year with the road closed and the river is cutting into the road - Cyclone Bola took out the bridge. Removing every year flood risk would be better than trying to address the big events - which would involve raising the road. Sheer bank on one side of the road where you could raise the road and put in slip control. Wouldn't make this high priority above the other issues where this is only closed for a day vs the other ones closed for weeks.	4L	4VL	No	Physical works ($$)	Response plan for the route needs to be developed and look at improving resilience of Mohaka Bridge and approaches.	Business Case required
HB12	2	Whirinaki Bluff	Road	Coastal Erosion	Coastal erosion risk. Coastal erosion likely to cut off the entire road northward	4L	4VL	No	Physical works ($$)	Need to understand the effects of climate change and develop options	Business Case required
HB11	2	Whirinaki Bluff	Road	Landslip	Landslip risk. Slip likely to cut off the entire road northward.	4L	4VL	No	Physical works ($$)	Need to understand the effects of climate change and develop options	Business Case required

3.5 Manawatu / Whanganui

A total of 3 major risks were identified within the Manawatu/ Whanganui area. These relate to landslip and flooding. One of the risks is the Manawatu Gorge which is currently closed due to landslip and a PBC is underway. Flooding at SH3 Whangaehu is considered a significant risk that would require further investigations to determine the best solution and is likely to increase to extreme due to climate change. Similarly flooding at Whangaehu is also likely to increase to extreme in the long term.

Table 3.5: Summary of major and extreme risks in Manawatu / Whanganui

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
MW24	3	Manawatu Gorge	Road	Landslip	Significant land instability issues through the entire Manawatu Gorge. Currently closed and a PBC underway to decide the best option moving forward. Traffic goes through a local road which is requiring significant strengthening to deal with large vehicles and increased traffic loads.	3VL	3VL	No	Physical works ($$$$)	Business case underway	Business Case funded or underway
MW2	2	Mangatainoka	Road	Flooding	SH2 Mangatainoka - moderate flood risk (1 every 10 years).	4L	4VL	No	Physical works ($)	Drainage improvements required	Business Case required
MW1	3	Whangaehu (link between Whanganui and Bulls)	Road	Flooding	SH3 Whangaehu area floods regularly (every 5 years). It is a critical link between Whanganui and Bulls where water generally flows over the road. The road could be built up to the same height as the bridge adjacent to it. Currently the surrounding houses and community are under water, they effectively dam the water causing it to significantly back up, therefore significant stormwater management would be needed.	4L	4VL	No	Physical works ($$)	Raise the section of the road to the east of the bridge. However, the flood waters need to cross the road corridor or the Whangaehu town will get flooded. The options are a bridge or several very large culverts. A raised embankment will not work.	Business Case required

3.6 Milford Road

A total of 15 major and extreme risks were identified along Milford Road. These relate to rockfall, avalanche, earthquake, tsunami, landslip and flooding. Key risks include numerous, significant landslip and flooding risks along the route, affecting both roads and bridges. Avalanche is also a key risk in winter and requires significant, ongoing proactive maintenance and likely to increase with the impacts of climate change. Treefall during extreme weather is also a risk that requires ongoing management even with the extensive programme which already occurs, this is also likely to increase with climate change.

The Homer Tunnel has a number of risks associated with it – including seismic, rockfall and avalanche. There is a current Business Case underway for strengthening of the portal and for protection structures, however further work would also be required.

Table 3.6: Summary of major and extreme risks on the Milford Road

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
MR1	94	Along Lake Te Anau	Road	Tsunami	Significant risk of landslide induced tsunami which could be triggered in a significant earthquake event such as the Alpine Fault.	4L	-	No	Emergency response and preparedness planning only (typically HI/LF)	Emergency response planning only	Business Case required
MR2	94	Cleddau River	Road	Flooding	Cleddau River - flood risk. There are regular flooding events which inundate the road and damage structures.	4VL	4VL	No	Unknown. Pending further investigations	Difficult to address. Further work required. Address through integrated route strategy with MR3, MR5 and MR11	Business Case required
MR3	94	Eglington River	Road	Flooding	There are regular flooding events which inundate the road and damage structures. The river is a wide braided river which aggrades. There are current operating flood protection structures. Each year material is removed from under the bridge as it builds up.	4L	4VL	No	Unknown. Pending further investigations	Difficult to address. Further work required. Address through integrated route strategy with MR2, MR5 and MR11	Business Case required

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
MR4	94	Hollyford Rd to Chasm	Road	Avalanche	Avalanche risk for the winter season is the major focus which drives most of the work throughout winter (April/May-October/November). Twice a day there is an avalanche hazard forecast put out which drives public access, restrictions and control work. Climate trends: winter is arriving later but staying longer. This affects tourism. Increased precipitation and snow – however more rain on snow increases the risk. Risk level is rising with annual increasing traffic volumes.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Ongoing prevention	Business Case required
MR5	94	Hollyford River	Road	Flooding	Flood risk on the Hollyford River. There are regular flooding events which inundate the road and damage structures.	4L	4VL	No	Unknown. Pending further investigations	Difficult to address. Further work required. Address through integrated route strategy with MR2, MR3 and MR11	Business Case required
MR6	94	Homer Tunnel	Tunnel	Earthquake / liquefaction	Reinvestment issues for tunnel. There is a BC being developed for replacement portal/protection structures to build resilience for future earthquake, rockfall and avalanche events. The structure is ageing and will soon become a historic site, this will limit the works that can occur on the tunnel. A heritage assessment is currently in draft but recommends some very intensive improvement and maintenance works to protect the nature of the site.	4L	-	No	Physical works ($$$)	A smart design for replacement of the tunnel portals could deal with strengthening and upgrading, aiding avalanche and rockfall risks at the same time. In short term, Rockfall prevention measures e.g. scaling, fences and bunds. But has cross over with avalanche zone - avalanches will destroy rockfall structures. Longer term needs to reinforce and upgrade the portals/tunnel before it is designated as a historical site. A smart design for replacement of the tunnel portals could deal with strengthening and upgrading, aiding avalanche and rockfall risks at the same time. Portals are under the largest avalanche zones. In addition, remote control avalanche systems could be employed. This is a significant tourism route and also safety issues.	Business Case funded or underway
MR17	94	Homer Tunnel	Tunnel	Avalanche	Significant reinvestment issues for tunnel and portals but there is a BC being developed for replacement portal/protection structures. Resilience for future EQ/Rockfall. The structure is ageing, soon to be a historic site – heritage assessment currently in draft but recommends some very intensive improvement and maintenance works to protect nature of the site.	4L	4VL	No	Physical works ($$$$)		Business Case funded or underway
MR16	94	Homer Tunnel	Tunnel	Rockfall	Reinvestment issues for tunnel and portals but there is a BC being developed for replacement portal/protection structures. Resilience for future EQ/Rockfall. The structure is ageing, soon to be a historic site – heritage assessment currently in draft but recommends some very intensive improvement and maintenance works to protect nature of the site.	4VL	-	No	Physical works ($$$)		Business Case funded or underway
MR15	94	Milford Rd - Te Anau Downs to Milford	Road	Landslip	Landslides and under slip risk in a number of locations.	4VL	-	No	Enhanced proactive maintenance	Preventative works and repairs	Business Case required
MR14	94	Milford Road	Road	Earthquake / liquefaction	Significant earthquake risk across entire length of Milford road.	4L	-	Yes	Enhanced proactive maintenance	Monitoring and response procedures	Business Case required
MR10	94	Milford Road	Road	Extreme Weather	Tree fall due to extreme weather is a significant risk that is partly managed through an extensive tree removal programme however this is still resulting in significant residual risk which is likely to increase due to climate change. Tree fall hazard has led to fatalities in the last 5 years. The tree fall risk strategy in place primarily focuses on investment over time for managing (>3000 at present) and removing trees from along the roadside.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	Business Case required
MR7	94	Milford Road Bridges	Bridge	Flooding	In addition to the individually listed bridges, there are a number of 1-way truss and concrete bridges that are at risk to flooding. Greater than 30 bridges experience 8-9m of rain every year. Currently the alliance handles this well, however a single failure will break the entire network. A number of the bridges require ongoing work however, a reduction in bridge maintenance funds by NZTA will limit the amount of work that can be completed.	4L	4VL	No	Enhanced proactive maintenance	Enhanced maintenance	Business Case required

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
MR9	94	Milford Township	Road	Flooding	Flood risk. Currently there are a number of flood protection works being carried out to protect property. However, there is residual risk, but this is less of a highway risk. DOC have some ongoing work that involves increasing the ground level of Milford by 0.5-1m, as a significant portion of Milford is on reclaimed land and flood plain/fan. To provide slightly more protection for SLR and tsunami.	4L	4VL	No	Physical works ($$)	Raise village height and build higher stop banks. Some work is already underway	Business Case required
MR8	94	Milford Township	Road	Tsunami	Significant risk of landslide induced tsunami which could be triggered in a significant earthquake event such as the Alpine Fault. Also, tsunami waves at Milford Township from offshore sources.	4L	-	No	Emergency response and preparedness planning only (typically HI/LF)	Emergency response planning only	Business Case required
MR11	94	Upukerora River	Road	Flooding	There are semi regular flooding events that inundate the road and damage structures.	4L	4VL	No	Unknown. Pending further investigations	Difficult to address. Further work required. Address through integrated route strategy with MR2, MR3 and MR5	Business Case required

3.7 Northland

A total of 10 major and extreme risks were identified within the Northland region. These relate predominantly to landslip and flooding. It is noted that some well-known risks in more remote areas do not appear on this list but do in the regional catalogue (refer Appendix A) as the risk rating is driven by both likelihood and consequence (criticality). The lower ONRC ratings in these remote areas result in a lower criticality and hence lower overall risk. Of note is the section of SH1 from the Brynderwyn's to Whangarei which is subject to both landslip and flooding – which is likely to increase in the future due to the impacts of sea level rise.

Table 3.7: Summary of major and extreme risks in Northland

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
N1	1	Brynderwyn to Ruakaka	Road	Landslip	Landslip risk on Brynderwyn hills, and limited detour HPMV incapable. No HMPV both ways. Detour route has a number of 1-way bridges. If the Brynderwyn route is out, the whole upper north is out. Currently working on the major detour route to address the risk to Brynderwyn. There are also a lot of outages because of accidents and breakdowns etc. The southern side has more issues. Traffic going south goes through Mangawhai and north goes through Paparoa.	4VL	-	No	Physical works ($$$$)	Short term solution is to upgrade alternate routes. Costs for this will likely be less than construction of a new alignment. There is a wider PBC under way to look at a range of options.	Business Case funded or underway
N3	16	Entire length of SH16	Road	Flooding	Flood risk to route. It is the only alternate route for SH1, but it is not a high-quality section of road. During the holiday season they strongly advise people to take SH16. Due to it being a key alternate route it should be higher than a primary collector. The ONF will look to address this.	4L	-	No	Unknown. Pending further investigations	Requires a detailed study	Business Case required
N9	16	Lookout slip	Road	Landslip	Significant landslip risk - Slip has occurred, there is a solution, but it has not been funded.	4L	-	No	Physical works ($)	Realign road as it could be a significant issue. Low cost low risk. Already designed.	Business Case required
N12	1	Oakley and Mata Flooding	Road	Flooding	Combined coastal inundation and river flooding risk. Key freight route. Used to occur every 5 years. Has been blocked twice in less than 10 years. Catchment boards involved in flood risk management were lost in the amalgamation of councils.	4L	4VL	No	Unknown. Pending further investigations	Requires a detailed study	Business Case required
N4	1	Ruakaka and Whangarei	Road	Flooding	Flood risk between Ruakaka and Whangarei. Both river and tidal flooding during king tides. Typically, when there are issues on the SH there are issues on the local roads so there are no alternate options.	5L	5VL	No	Unknown. Pending further investigations	Requires further detailed study.	Business Case required
N15	1	South of Kawakawa	Road	Landslip	Landslip risk. Lack of detour unless travellers go onto SH 15 (> 4 hours detour), detour would cause issues for trucks.	4L	-	No	Unknown. Pending	Requires a detailed study	Business Case required

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
									further investigations		
N34	12	Te Pouahi to Waiotemarama	Road	Landslip	No detour, relevant for tourism (ONRC increase)	4L	-	No	Unknown. Pending further investigations	Requires a detailed study	Business Case required
N13	Twin Coast Discovery Road	Twin Coast Discovery Road - Herekino Forest	Road	Landslip	Largest area of slips/geological movement in the area, probably most exposed area.	3VL	-	No	Physical works ($$$)	BC developed, multi hazard area needs thought.	Business Case funded or underway
N18	12	Waipoa Forest	Road	Flooding	Removing trees due to Kauri Die back has increased flooding issues along SH12 through Waipoa Forest. $1.5M has already been spent to repair roads from damage caused by excavating trees.	4L	-	No	Unknown. Pending further investigations	Requires further detailed study.	Business Case required
N10	1	Wayby Road on SH1	Road	Landslip	Existing landslip, however, there has been no work done to understand the landslip risk. Ongoing land movement.	4VL	-	No	Unknown. Pending further investigations	Requires further detailed study.	Business Case required

3.8 Otago

A total of 25 major and extreme risks were identified within the Otago region. These relate predominantly to rockfall, landslip, flooding and ice / snow along State Highways 6, 8 and 88. The steep and unstable terrain presents significant risk that in many cases has both a high likelihood and significant consequence should the hazard occur.

Table 3.8: Summary of major and extreme risks in Otago

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
O1	8	Alexandra to Clarkes Junction (Milton)	Road	Ice / Snow	Risk from snow and ice.	4L	-	No	Physical works ($$)	Winter maintenance LOS and improved communication. VMS required at each end of route where alternative routes exist	Business Case required
O4	1	Balclutha Bridge	Bridge	Flooding	Flooding of the Balclutha river has potential to impact / compromise the Balclutha Bridge. This is the only bridge and detour routes are significant.	4L	4VL	No	Unknown. Pending further investigations	Requires a detailed study	Business Case required
O15	1	Big Kuri River	Road	Flooding	Big Kuri River north of Hampden deposits a large amount of gravels which causes water to flow over the bridge. 4-5-hour detour.	4L	4VL	No	Physical works ($$$)	The plan is to wait for the bridge to get to the end of its life then construct a new bridge with improved freeboard.	Business Case required
O46	8	Cromwell to Alexandra	Road	Landslip	Cromwell Gorge landslip risk. Numerous active landslips throughout the man-made Cromwell Gorge (part of the Clyde Dam construction). Actively dewatered on an ongoing basis to maintain slope stability.	4L	-	No	Physical works ($)	Corridor investigation to determine vulnerable areas and possible solutions to mitigate	Business Case required
O5	8	Cromwell to Alexandra	Road	Rockfall	Cromwell Gorge and Clyde Dam, current LCLR investigation project. A low number of rockfalls have occurred in the past, however there is potential for future rock fall. Relaxed and partially cracked benches which have accumulated debris and pose future risks.	4L	-	Yes	Physical works ($$)	Scaling, stabilisation and catch fences/structures	Business Case required

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
O8	6	Cromwell to Frankton	Road	Landslip	Landslip risk throughout the Kawarau Gorge. Some LCLR investigation work underway.	4VL	4VL	No	Physical works ($$$)	Retaining walls and drainage improvements	Business Case required
O6	6	Cromwell to Frankton	Road	Ice / Snow	Risk from snow and ice.	4L	-	No	BAU / Ongoing maintenance / Reactive	Winter maintenance LOS and improved communication. Additional VMS required at selected locations along route where alternative routes exist	Business Case required
O7	6	Cromwell to Frankton	Road	Rockfall	Sites at risk to rockfall throughout the Kawarau Gorge.	4VL	-	No	Physical works ($$$)	Scaling, stabilisation and catch fences/structures	Business Case required
O9	88	Dunedin to Port Chalmers	Road	Landslip	Constructed as side cast fill – cut into the bank and the compacted the fill on the side so one good lane and one lane that is likely to slip in an EQ. Corridor which probably needs a holistic view across its whole length. Freight and rail would likely be knocked out as well as it is on fill and therefore would rely on shallower draft ships to drop off goods. This is the main trunk line from CHCH to Bluff. Slips occur during storm events as a result of water coming down from hillsides. Small washouts of roadside barriers also occur.	3VL	3VL	Yes	Physical works ($$$)	Retaining walls and drainage in the short term, with wider investigation required for the longer term	Business Case required
O34	6	Frankton to Kingston	Road	Ice / Snow	Risk from snow and ice.	4L	-	No	BAU / Ongoing maintenance / Reactive	Winter maintenance LOS and improved communication. VMS required at each end of route where alternative routes exist	Business Case required
O48	6	Frankton to Kingston	Road	Landslip	Landslips along the side of Lake Wakatipu.	4VL	-	No	Unknown. Pending further investigations	Corridor investigation to determine vulnerable areas and possible solutions to mitigate	Business Case required
O11	6	Haast Pass to Lake Hawea	Road	Ice / Snow	Risk from ice and heavy snow. Passes through a national park with overhanging trees, prone to falling.	4L	-	Yes	Enhanced proactive maintenance	Winter maintenance LOS and improved communication	Business Case required
O50	6	Haast to Hawea	Road	Rockfall	Numerous large scale rockfall locations along the corridor. Improved funding would be a starting point to improve resilience but not resolve the issue in its entirety. Funding currently allocated through the National Rockfall programme to address isolated high priority sites with a supporting Rockfall Hazard Rating System (RHRS) score.	4VL	-	No	Physical works ($$$)	Scaling, stabilisation and catch fences/structures	Business Case required
O12	1	Katiki Coast	Road	Coastal Erosion	Both bottom up and top down erosion along the coast. Some coastal erosion funding has been provided. If coastal route is gone there is a light vehicle detour but heavy's will be 4-5 hours. Mini Kaikoura as KiwiRail is located directly next to the road. The only coastal section of SH1 and vulnerable to high seas and erosion.	3VL	3VL	No	Physical works ($$$)	Continuation of rock revetment. Assessment and development of overland flow measures to prevent top down erosion.	Business Case required
O13	1	Katiki Coast	Road	Coastal Inundation / SLR	Only coastal section of SH1 and vulnerable to high seas and inundation. Some bridges are within 2m of high tide level	3VL	3VL	No	Physical works ($$$)	Requires continuation of rock revetment.	Business Case required
O47	6	Lake Hawea and Lake Wanaka	Road	Landslip	Landslips along the side of lakes Wanaka & Hawea. This links to risk Id WC9 which identifies landslip issues along Haast Pass.	4VL	-	No	Unknown. Pending further investigations	Corridor investigation to determine vulnerable areas and possible solutions to mitigate	Business Case required
O15	1	Maheno	Bridge	Flooding	Flooding issues within a number of river catchments. Options have been scoped. Overland flow path floods the road between Clarks Mill and where the road crosses the railway. There is a plan to put culverts in to allow water to run from one side of the road to the other to stop flooding. When this floods the bridge also floods and the detour is ~ 4-5 hours.	4L	4VL	No	Physical works ($$)	Upgrade culverts and overland flow paths.	Business Case required

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
O51	6	Nevis Bluff	Road	Rockfall	Nevis Bluff is a significant unstable feature between Cromwell and Queenstown. Proactive monthly inspections are undertaken and programmed rock scaling pre & post winter to remove fractured material is funded and managed through the NOC. Regular additional funding is required to address high other priority/urgent unstable features in the order of $1M-$5M per intervention. Alternate long-term options could be investigated such as a tunnel.	4VL	-	No	Enhanced proactive maintenance	More detailed investigation required which would assess all possible options. Continued proactive monitoring and maintenance intervention	Business Case required
O16	8	Omarama to Tarras	Road	Ice / Snow	Continuous snow in winter. Winter events affect both sides of Lindis Pass. This is within the corridor management plan from Christchurch to Queenstown.	4L	-	Yes	Enhanced proactive maintenance	Winter maintenance LOS and improved communication	Business Case required
O17	8	Omarama to Tarras	Road	Rockfall	Rockfall risk predominantly to the south of Lindis Pass (Central Otago side).	4L	-	No	Physical works ($$)	Scaling, stabilisation and catch fences/structures. Detail in the corridor management plan.	Business Case required
O36	1	Palmerston to Dunedin	Road	Ice / Snow	Snow and ice risk.	4L	-	Yes	Enhanced proactive maintenance	Winter maintenance LOS and improved communication	Business Case required
O19	6	Queenstown to Frankton	Road	Landslip	Highly vulnerable to rainfall induced landslips.	4L	4VL	No	Physical works ($$$)	Retaining walls and improving lakeside stability to minimise under slips	Business Case required
O18	6	Queenstown to Kingston	Road	Rockfall	Highly vulnerable to rockfall.	4L	-	No	Physical works ($$$)	Scaling, stabilisation and catch fences/structures	Business Case required
O15	1	Waikouati River	Road	Flooding	Waikouati River floods the highway.	4L	4VL	No	Physical works ($$)	Raise level of road to clear flood level	Business Case required
O21	1	Wakouaiti to Evansdale	Road	Landslip	The Kilmog is a very unstable length of road. Grout columns have been installed through sections of highway but are now protruding through the road surface. Haven't considered options in depth due to multimillion-dollar need. Extremely slip prone ground. National Criticality. Light traffic can use Coast Road as a detour. There are a couple of sites with options which could greatly enhance or remove the issues with the right solution.	3VL	3VL	No	Physical works ($$$)	Piling works to retain active slopes. Drainage improvements and ongoing pavement and surfacing intervention to maintain LOS	Business Case required

3.9 Southland

A total of 2 major risks were identified within the Southland area. The most significant of these relates to a coastal section of SH1 to the Port. This is at risk from coastal inundation and sea level rise with current flooding likely to increase to extreme in the long term.

Table 3.9: Summary of major and extreme risks in Southland

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
S1	1	Entire coastal section at Ocean view north of Bluff	Road	Coastal Inundation / SLR	Ocean view route to the port - risk to coastal inundation that will need to be addressed within the next 10 years. Combination of coastal and rainfall flooding at high tide resulting in traffic lanes being submerged over a length of approximately ~70m. This is the key route to the port, with no detour. Compounding issue is that the lagoon doesn't drain.	4L	4VL	No	Physical works ($$)	Raise the road for around 70m	Business Case required
S2	94	Gorge Hill	Road	Landslip	Landslip risk at Gorge Hill. Slip has failed previously, completely damaging the road. Currently no detour, however a subsidiary road could be built through farmers land. Has been stable, with preventative maintenance undertaken.	4L	4VL	No	Emergency response and preparedness planning only	Pre buy section in advance to be able to build an alternate/backup road.	Business Case required

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
					Slumping is topped up approximately monthly. Annual visits to survey the movement. Low volume but strategic for tourist reasons. 4-hour detour.				(typically HI/LF)		

3.10 Taranaki

A total of 18 major and extreme risks were identified within the Taranaki area. These relate predominantly to rockfall, landslip, erosion and flooding - primarily along SH3. All of the risks are rated major in the short term, but the majority increase to extreme under a future climate scenario.

Table 3.10: Summary of major and extreme risks in Taranaki

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
T2	3	Awakino gorge	Road	Rockfall	Rockfall risk, erosion drop out, over and under slips and severe weather (>2m rainfall a year). This is a priority for significant rockfall and vegetation removal (due to rockfall). Currently Awakino Gorge tunnel only bypasses ~500m of the gorge. Difficult to predict where rockfall will occur next, therefore difficult to plan for unless the entire 8km was realigned. High risk gorge environment with no viable detour.	4L	-	No	Physical works ($$$)	Rockfall protection, mesh, clearing material and retaining walls.	Business Case required
T14	3	Awakino Village	Road	Coastal Erosion	Awakino Village at risk of coastal erosion.	4L	4VL	No	Physical works ($$)	In the short term continue rock fencing. Realignment and smoothing the corner and cut into the bluff is the long-term solution. ~60-70m bluff.	Business Case required
T3	3	Entire length of SH3 north of New Plymouth	Road	Landslip	Landslip risk to strategic highway on Taranaki network. Lack of viable alternative route with the nearest detour being SH4, adding a large amount of time and distance. Substantial geotechnical structures for slope instability along the road south of Piopio (in the gorges). Some structures are very old.	4L	4VL	No	Physical works ($$)	Requires a detailed study	Business Case required
T4	3	Entire length of SH3 north of New Plymouth	Road	Rockfall	Significant rockfall risk.	4L	-	No	Physical works ($$)	Requires a detailed study	Business Case required
T8	3	Mangaotaki gorge	Road	Landslip	Mangaotaki Gorge is at risk of landslip. Currently has no geotechnical barriers.	4L	4VL	No	Physical works ($$$)	Active/priority sites have been funded but the whole corridor has a resilience issue. Retaining walls.	Business Case required
T9	4	Mapara North road through to Ohura road	Road	Flooding	Occurs from approximately 12km in Mapara North road through to Ohura road - over slip, under slip and localised flooding during extreme weather. Requires preventative maintenance works. Waterfall Hills - reasonable geotechnical remediation being put in place to address under slip and bluff rock fall.	3VL	3VL	No	Physical works ($$)	Further investigations needed	Business Case required
T10	3	Mohakatino and Tongaporutu estuaries	Road	Coastal Inundation / SLR	Mohakatino and Tongaporutu estuaries could potentially have coastal inundation and erosion issues.	4L	4VL	No	Unknown. Pending further investigations	Requires a detailed study	Business Case required

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
T12	3	Mohakatino Bridge	Road	Coastal Erosion	Potential for erosion risk due to it being low lying and in an estuary. The causeway is very narrow and vulnerable to erosion due to wave action. Currently a low cost, low risk project to provide rock armour. One side of the wall had rock armour which has been washed out. Could have coastal inundation issues in the future, however the geomorphology of the estuary could change this.	4L	4VL	No	Physical works ($$)	Rock armour improvements in the short term, but needs a long-term plan	Business Case required
T13	3	Mokau Bluff	Road	Erosion	Mokau Bluff, at risk of coastal erosion.	4L	4VL	No	Physical works ($$)	In the short term continue rock fencing. Realignment and smoothing the corner and cut into the bluff is the long-term solution. ~60-70m bluff.	Business Case required
T15	3	Mt Messenger	Road	Landslip	South of Mt Messenger is at risk of landslip- Uruti Valley has a number of cuttings prone to slipping.	4L	4VL	No	Unknown. Pending further investigations	Requires a detailed study	Business Case required
T16	3	Patea Bridge	Bridge	Erosion	Bridge built between 60's-70's at risk to erosion.	4L	4VL	No	Physical works ($$)	Strengthening or realignment of the bridge would be a more beneficial outcome in comparison to a new route.	Business Case required
T17	45	Ratahei to Whanganui	Road	Landslip	Raetihi to Whanganui major landslip which occurred in 2019. This already has a PBC underway.	3VL	3VL	Yes	Physical works ($$$$)	PBC already underway	Business Case funded or underway
T19	3	SH3 Midhurst rail overbridge	Road	Erosion	SH3 Midhurst rail overbridge has the potential for erosion and scour - which may in turn affect the road below. The detour route is also very long and is not ideal for HPMV.	4L	4VL	No	Unknown. Pending further investigations	There is no specific risk at the moment, but the solution should be similar to what occurred in Normandy, bridge realignment and creation of a viable detour. Main pinch points are all bridges with no detour routes.	Business Case required
T18	3	SH3 Midhurst rail overbridge	Road	Flooding	SH3 Midhurst rail overbridge has the potential for flooding. The rail and river bridge are back to back with detours that are not ideal for HPMV. The detour route is also very long. There is no specific hazard at the moment, but the solution should be similar to what occurred in Normandy, bridge realignment and creation of a viable detour. Main pinch points are all bridges with no detour routes.	4L	4VL	No	Unknown. Pending further investigations	Requires a detailed study	Business Case required
T20	3	South of Mt Messenger	Road	Erosion	Erosion risk where river runs adjacent to SH3 South of Mt Messenger	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Requires ongoing monitoring and potential stabilisation	Business Case required
T22	3	Tongahoe	Bridge	Erosion	Bridge built between the 60's-70's and is at risk to erosion. Tongahoe should be a high priority as it has a bluff and the river.	4L	4VL	No	Physical works ($$)	Strengthening or realignment of the bridge would be a more beneficial outcome in comparison to a new route.	Business Case required
T23	3	Tongaporutu estuary	Road	Coastal Erosion	Route has coastal erosion risk due to the estuary and also has potential to be at risk from coastal inundation.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Requires ongoing monitoring and potential stabilisation	Business Case required
T24	3	Waitotara bridges	Bridge	Erosion	Erosion risk to the bridge. Built between 60's-70's.	4L	4VL	No	Physical works ($$)	Strengthening or realignment would be of more value than creating a new route,	Business Case required

3.11 Top of the South

A total of 23 major and extreme risks were identified within the Top of the South area. These relate predominantly to rockfall, landslip, erosion and flooding, as well as extreme weather, ice/snow and wildfire. The significant number of landslip risks on SH's 6 and 65 (including Dallows Bluff, Deadman's slip, Higgins Bluff, Hope Saddle and the Upper Buller Gorge) were considered to be the highest risk section of the regions transport system (as per commentary from regional stakeholders). A significant number of the major risks are likely to increase to extreme in the long-term.

Table 3.11: Summary of major and extreme risks in the 'top of the south'

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
TS6	6	Canvastown along Pelorus River	Road	Flooding	River floods and inundates the road	4VL	4VL	No	Physical works ($$$)	Raise the road -	Business Case required
TS22	63	Connors Bend along Wairau River	Road	Flooding	Flooding risk where land drains river.	4L	4VL	No	Physical works ($$)	Better drainage required	Business Case required
TS7	6	Dallows Bluff	Road	Rockfall	Frequent rockfall on SH6 stretch between intersections with SH65 and SH63. High priority for the Top of the South	4VL	-	No	Physical works ($$)	Requires netting.	Business Case required
TS27	65	Deadman's Slip	Road	Landslip	Undercutting of the road caused by the river	3VL	3VL	No	Physical works ($$)	Requires armouring and protection.	Business Case required
TS8	6	Entire Region	Road	Wildfire	Wildfire risk to wooden structures such as bridges and retaining walls which exist across the entire region.	4L	4VL	No	Enhanced proactive maintenance	Preparedness	Business Case required
T65	6	Glenhope to Murchison	Road	Ice / Snow	Ice and snow risk through hills from Glenhope to Murchison	4L	-	No	BAU / Ongoing maintenance / Reactive	Winter maintenance LOS and improved communication. VMS required at each end of route where alternative routes exist	Business Case required
TS9	6	Granity Rockfall	Road	Rockfall	Frequent rockfall on SH6 stretch between intersections with SH63 and WC boundary. High priority for the Top of the South	4VL	-	No	Physical works ($$)	Requires netting.	Business Case required
TS28	65	Higgins Bluff	Road	Rockfall	Rockfall risk along the bluff.	4VL	-	No	Physical works ($$)	Requires netting.	Business Case required
TS10	6	Hope saddle	Road	Landslip	Ongoing landslip risk	4VL	4VL	No	Physical works ($$)	Requires netting.	Business Case required
TS11	6	Kawatiri to Owen	Road	Erosion	At risk to river erosion and drop out.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	Business Case required
TS30	65	Mauria River	Road	Erosion	Surface flooding and undercutting / erosion where river is next to the road.	4VL	4VL	No	Physical works ($$$)	Rock protection along river to protect road	Business Case required
TS29	65	Mauria river	Road	Flooding	Surface flooding and undercutting / erosion where river is next to the road	3VL	3VL	No	Physical works ($$$)	Rock protection	Business Case required
TS12	6	O'Sullivans Bluff	Road	Rockfall	Frequent rockfall on SH6 stretch between intersections with SH65 and SH63. High priority for the Top of the South	4VL	-	No	Physical works ($$)	Requires netting.	Business Case required
TS1	1	Redwood Pass	Road	Rockfall	Rockfall risk through Redwood Pass.	4L	-	No	Physical works ($$)	rockfall protection	Business Case required

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
TS24	63	Salt Lake	Road	Flooding	Runoff leads to flooding of road	4L	4VL	No	Physical works ($$)	Box culverts and raise road.	Business Case required
TS20	60	Takaka Hill	Road	Landslip	Landslip risk with both under and over slips. Mainly on the Nelson side. Occurs at least once a year. There are also a number of drainage issues.	4VL	4VL	No	Physical works ($$$)	Realignment improve drainage and catchment management. Even with improvements, there would still be ongoing issues, requiring response and BAU maintenance.	Business Case required
TS25	63	The wash	Road	Flooding	Flooding risk through the Wairau Valley as road follows river in floodplains.	4L	4VL	No	Physical works ($$)	Raise road and provide river protection	Business Case required
TS2	1	Tuamarina to Picton	Road	Flooding	Surface flooding risk from adjacent catchment runoff.	4L	4VL	No	Unknown. Pending further investigations	Requires a detailed study	Business Case required
TS16	6	Upper Buller Gorge	Road	Erosion	Erosion risk along the Buller Gorge in both Top of South and West Coast.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	Business Case required
TS13	6	Upper Buller gorge	Road	Extreme Weather	Extreme weather risk with strong winds resulting in tree fall.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	Business Case required
TS14	6	Upper Buller gorge	Road	Landslip	At risk to landslips both over and under slips.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	Business Case required
TS15	6	Upper Buller Gorge	Road	Rockfall	Rockfall risk with rockfall occurring along the Buller Gorge in both Top of South and West Coast.	4L	-	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	Business Case required
TS26	63	Windy Point	Road	Rockfall	Constant Rockfall on the beginning stretch of SH63	3VL	-	No	Physical works ($$)	Requires netting.	Business Case required

3.12 Waikato

A total of 5 major and extreme risks were identified within the Waikato area. These relate predominantly to landslip, erosion, flooding along SH1, as well as the potential for and ice/snow along SH5 (Kaweka Ranges). The most significant risk was rated as erosion risk along Lake Karapiro.

Table 3.12: Summary of major and extreme risks in Waikato

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
WK1	1	Along Lake Karapiro	Road	Erosion	Erosion of riverbank can undermine road. There are significant detour issues along this road if it were out of service.	5L	-	No	Physical works ($$$)	Realignment, new bridge or possible retaining wall. Also invest in upgrades to Maungatautari Road through strengthening of structures to carry HMPV's. Realignment, bridge or possible retaining wall.	Business Case required
WK7	1	Bulli Point	Road	Landslip	Bulli point drop out combined with narrow carriage way significantly lowers the resilience. Typically to repair you need to close both sides of the road. Even for repairs you need to close the road.	4L	-	No	Physical works ($$$)	Build retaining wall(s) on Lakeside and/or cut into adjacent rock face. Ultimate solution is to construct the proposed Hatepe to Motuoapa realignment project.	Business Case required
WK4	3	Entire stretch of SH3	Road	Landslip	Landslip risk with road instability. Key route for LPG to get trucked from New Plymouth to Auckland.	4L	4VL	No	Unknown. Pending	Business Case required	Business Case required

									further investigations		
WK20	1	Flooding just north of Turangi	Road	Flooding	Surface flooding issues along SH 1 through Waiotaka Straight (within Waiotaka Valley). This is a low-lying wetland area (South Taupo Wetlands) which is prone to flooding.	4L	4VL	No	Unknown. Pending further investigations	Business Case required	Business Case required
WK8	5	Kaweka Ranges	Road	Ice / Snow	Major snow event caused power lines to drop and this blocked the road, preventing snow removal. This led to a significant event. Potential for undergrounding of the lines to stop the road from going out. Poor to no cell phone connection means if there are any issues its very hard to call any emergency services.	4L	-	No	Physical works ($$$)	Underground overhead lines and improve telecommunications/cell phone reception	Business Case required

3.13 Wellington

A total of 9 major and extreme risks were identified within the Wellington area. These relate to rockfall, landslip, erosion, flooding, coastal inundation and earthquake/liquefaction - along SH1 and SH2. A large number of the identified risks are projected to increase as a result of climate change.

Table 3.13: Summary of major and extreme risks in Wellington

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
W14	1	Aotea	Road	Earthquake / liquefaction	Seismic risk to Aotea off-ramp as it is thought that the Wellington fault is located underneath it.	4L	-	No	Physical works ($$$$)	Requires interface with various asset owners - WCC, KiwiRail & The Port Authority to agree full mitigation option	Business Case required
W15	1	CBD to Ngauranga	Road	Earthquake / liquefaction	A number of critical road and rail bridges, structures, utilities etc located in this corridor and within a high earthquake zone.	4L	-	No	Physical works ($$$$)	Would require a prioritised list and mitigation option for each structure	Business Case required
W5	1	SH1 Centennial Highway	Road	Coastal Erosion	Sea level rise, storm events, high seas causing damage to seawall.	5L	5VL	No	Physical works ($$$)	Ongoing armouring. More work required to determine appropriate solutions	Business Case required
W4	1	SH1 Centennial Highway	Road	Coastal Inundation / SLR	Coastal inundation and SLR risk with water over topping the road in larger events. Currently reactive maintenance is prioritised as opposed to proactive. Culvert near Paekakariki blocks frequently due to lose material causing flooding in the town. Catchments flood in short duration events causing slips and debris/blockages. KiwiRail assets are adjacent (up-catchment) and also are affected. Even with completion of Transmission Gully, access will still be required for the rail line.	5L	5VL	No	Physical works ($$$)	Will continue to flood in the long term but will require ongoing repair and maintenance. More work required to determine appropriate solutions.	Business Case required
W3	1	SH1 Centennial Highway	Road	Rockfall	Rock, debris comes down off the steep slopes and covers the road and rail network. NZTA are trying to get KiwiRail to input into funding. Risk will be reduced once Transmission Gulley is open.	5L	-	No	Physical works ($$$)	Ongoing slope stabilisation works required.	Business Case required
W6	1	SH1 Kuku	Road	Flooding	Flooding occurs frequently in low lying area - caused by a land drainage issue where water builds up on the highway approx. once a year. Flooding can often reduce traffic down to one lane and has affected both lanes for a couple of hours. With help from Council it could be improved. Risk could also be reduced if Otaki to Levin is confirmed.	5L	5VL	No	Physical works ($$)	Requires Council to address adjacent land drainage and runoff - less of an issue once O2NL is constructed. could significantly improve the flood issue - especially considering the detour is extensive.	Business Case required

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
W19	1	SH1 Ngauranga Gorge	Road	Landslip	Rockfall risk and landslides - targeting low cost, low risk funding. Multiple users including cyclists. Debris screen is a hard structure and the footpath has become a combined pathway with no room left for construction. Low cost, low risk would address most of these.	4L	4VL	No	Physical works ($$$)	Some minor works planned, but would require significant infrastructure to fully mitigate	Business Case required
W2	1	SH1 Porirua	Road	Flooding	Some flooding. The roads go through wetland like material, some of the culverts and streams are full of gravel and upper reaches of streams need clearing and maintaining. NZTA ends up with the problem but they have very little control of what happens up or down stream of the road.	4L	4VL	No	Physical works ($$$)	Ongoing improvements to manage high intensity rainfall events - will require Council to improve stormwater catchment	Business Case required
W17	2	SH2 Remutaka Hill	Road	Earthquake / liquefaction	Whole SH 2 Remutaka Hill (13km) is at risk to earthquake shaking. If there is an EQ it will be out of service due to many risks. Focus should be on SH1 first to get a route open to the north before addressing SH2.	4L	-	No	BAU / Ongoing maintenance / Reactive	Requires ongoing investment to improve resilience, but likely to always be a risk in large earthquakes	Business Case required

3.14 West Coast

A total of 21 major and extreme risks were identified within the West Coast area. These relate to extreme weather, ice/snow, erosion, rockfall, landslip and flooding - along state highways 6, 7, and 73.

Table 3.14: Summary of major and extreme risks on the West Coast

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
WC1	7	Black Point	Road	Erosion	A few river erosion sites near Reefton river. Ongoing rock armouring.	4L	4VL	No	Enhanced proactive maintenance	Rock protection	Business Case required
WC2	6	Bruce Bay	Road	Coastal Erosion	Route at risk from erosion. Rock protection measures are starting to be implemented through emergency works funding following Cyclone Fehi (2018). However, if there was another cyclone a large section of the road has the potential to be lost regardless of current resilience work.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Rock protection however will still be residual risk	Business Case required
WC3	6	Buller Gorge	Road	Extreme Weather	Extreme weather risk with tree fall along gorge.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Regular maintenance in tree cutting	Business Case required
WC5	6	Fox River	Road	Coastal Inundation / SLR	Fox River - low lying with sea level rise risk.	4L	4VL	No	Enhanced proactive maintenance	Ongoing monitoring and maintenance	Business Case required
WC25	6	Franz Josef to Fox Glacier	Road	Ice / Snow	Snow and ice over hill between Franz Josef and Fox Glacier	4L	-	No	BAU / Ongoing maintenance / Reactive	Winter maintenance LOS and improved communication. VMS required at each end of route where alternative routes exist	Business Case required
WC6	6	Greymouth to Westport	Road	Coastal Erosion	Coastal erosion during a cyclone has the potential to affect the whole region. Increased frequency to approx. once a year. Typically, still repairing from the previous event when then next one comes. Still recovering from Fehi 2018. All works are currently reactive. 4 sites where preventative works, these could be prioritised.	4VL	4VL	No	Enhanced proactive maintenance	Rock protection	Business Case required

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Next Steps
WC7	73	Griffiths Bridge	Bridge	Erosion	Erosion and scour risk around the bridge.	4L	4VL	No	Physical works ($$$)	New bridge	Business Case required
WC10	6	Haast Pass	Road	Erosion	Erosion risk along Haast River.	4L	4VL	No	Physical works ($$$$)	Expensive protection works	Business Case required
WC9	6	Haast Pass	Road	Landslip	Route at risk from landslip. Currently all reactive works with proactive management on some sites, however there is still a risk of losing the whole road. A few landslip sites could potentially be more proactive some of it which would be less than $1m, however it is more like $5m altogether.	4VL	4VL	Yes	Enhanced proactive maintenance	Some areas could have more proactive work undertaken.	Business Case required
WC8	6	Haast Pass	Road	Rockfall	Rockfall along the Haast River with only reactive works occurring.	4L	-	No	Enhanced proactive maintenance	could be more proactive	Business Case required
WC12	6	Knights Point	Road	Landslip	Most vulnerable piece of road to landslip in New Zealand and currently only has reactive work underway.	4VL	4VL	No	Enhanced proactive maintenance	Also, would require further investigation	Business Case required
WC15	7	Lewis Pass	Road	Flooding	Shingle fans depositing on the road, as well as surface flooding risk.	4L	4VL	No	Physical works ($$$)	Solvable with upgrade to double lane bridges and bridge realignment away from rockface.	Business Case required
WC13	7	Lewis Pass	Road	Ice / Snow	Ice and snow risk at summit.	4L	-	No	BAU / Ongoing maintenance / Reactive	Winter operations	Business Case required
WC17	73	Otira River at Otira	Road	Erosion	River erosion risk. Already funded but has ongoing issues in other areas as well.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Monitor and reactive maintenance	Business Case required
WC19	7	Rahu Saddle	Road	Extreme Weather	Extreme weather risk with trees falling from high winds.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Annual inspections and selective removals where risk identified	Business Case required
WC18	7	Rahu Saddle	Road	Ice / Snow	Snowfall and ice risk.	4L	-	No	BAU / Ongoing maintenance / Reactive	Winter operations	Business Case required
WC20	6	Scout Lodge Straight	Road	Erosion	Significant river erosion risk.	4VL	4VL	No	Physical works ($$$)	River protection works (groynes) to train river and realign road.	Business Case required
WC21	6	South of Ross to Haast Pass	Road	Flooding	All rivers south of Ross (~15 rivers) need training/stop banking and active management to reduce flood risk.	4VL	4VL	No	Enhanced proactive maintenance	Ongoing training works and management	Business Case required
WC22	6	Southern side of Punakaiki	Road	Coastal Inundation / SLR	Low lying and vulnerable to sea level rise.	4L	4VL	No	Physical works ($$$)	Rock protection	Business Case required
WC23	73	Taipo Bridge	Bridge	Flooding	Flood risk along one lane bridge.	4L	4VL	No	Physical works ($$$$)	replace whole bridge and double lane	Business Case required
WC24	73	Wainihinini Bridge	Bridge	Flooding	Flood risk to bridge. Bridge replacement is critical from a HMPV point of view. Currently reaching end of life.	4L	4VL	No	Physical works ($$$)	Replace bridge.	Business Case required

4 Closing comments

This report summarises the physical natural hazard and climate change risks for the NZTA network. The risks have been identified through both review of existing information and a series of stakeholder workshops around New Zealand. They have been rated using a specific risk assessment methodology and suggested solutions for risks were documented at workshops (based on knowledge of regional staff).

The next steps will be for NZTA to review the extreme and major risks for each region and make decisions on how to progress mitigation responses.

5 Applicability

This report has been prepared for the exclusive use of our client New Zealand Transport Agency, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

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Appendix A: Regional PRA catalogues

A1.1 Auckland regional risk catalogue

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outa
A1	1	Tank Farm Culvert to Exmouth Footbridge	Road	Coastal Inundation / SLR	Southbound lanes between Tank Farm Culvert and Exmouth St Footbridge get inundated during high tides (and storm surge). This results in varying amounts of inundation across 4 lanes: from bus lane only through to all lanes. This can cause significant disruption to the availability and resilience of the system. In extreme cases this results in significant disruption (and loss of multiple lanes) for about 2 hours at high tide.	4L	4VL	No	Physical works ($$)	There is a coastal inundation resilience study that is underway for this location. Funding is only for the investigation and options assessment. Several options are being explored such as raising the road (partial or fully), flood barriers, using new concrete barriers with pumps and/or non return systems. There are a range of other risks including to the Transpower NAaN 220kV.	Yes	3	2	5	0	5	2	3	3
A2	1	Silverdale North Weiti Stream	Road	Flooding	Flooding of the road, loss of system access and availability. Potentially some secondary erosion in significant events.	3UL	3L	No	Physical works ($$)	Couple of options physical works or land use planning. Physical works would look to supplement existing infrastructure or build a new asset. Stand alone business case unlikely to be found justified due to the risk to cost ratio. Emergency response plan is available for flooding across roads.	Yes	1	2	5	0	5	1	2	3
A3	1	Titford Bridge Puhoi	Road	Flooding	Flooding of the highway at/adjacent to Titfords bridge which can be exacerbated by high sea/tides. Loss of system access and availability. Potentially some secondary erosion in significant weather events (rain/tide combination).	4UL	4VL	Yes	Physical works ($$$)	This hazard is being engineered out by current SH1 Puhoi to Warkworth project with a new road alignment, and viaduct system. Once the new highway is built the existing highway will be relocated to the local authority and risk will no longer fall with the agency and the road will no longer be ONRC band 5.	Yes	1	1	5	0	5	2	3	3

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outa
A4	1	John Creek	Road	Flooding	Flooding across the highway resulting in loss of system access/availability. Contributing catchment area is being earmarked for significantly development under a Structure Plan Change. Without right development controls this could result in increased runoff and increased resilience risk. If/when South Silverdale Interchange floods it is a fairly lengthy detour with next interchanges at South at Oteha Valley.	4UL	4L	No	Physical works ($$)	Couple of options - either physical works or land use planning. Physical works would look to supplement existing infrastructure or build a new culvert/bridge asset. Stand alone business case unlikely to be found justified due to the risk to cost ratio. Emergency response plan is available for flooding across roads.	Yes	1	2	5	0	5	2	2	3
A5	1	Greville Interchange	Road	Flooding	Flooding of the road (from Southbound On Ramp to Mainline) reducing service at SH1 Southbound.	3UL	3L	No	Physical works ($$$)	Falls within the current northern corridor interchange (NCI) project which is supposed to be engineered to the agencies minimum standards. Not sure if the regional flood risk here is resolved. Stand alone business case unlikely to be found justified due to the risk to cost ratio. Emergency response plan is available for flooding across roads.	Unsure	1	1	5	0	5	1	2	2
A6	1	Hillcrest Stream	Road	Flooding	Flooding of the road at the culvert - only has a capacity of 13m3/s however demand from catchment is approximately 30m3/in a 1%AEP event. Loss of system access. Concrete barriers at the southern bound lanes at the busway and could result in damming of the road and loss of system access/availability resilience	3UL	3UL	No	Physical works ($$$)	Renewed bridge structure and or land use and planning development controls. Stand alone business case unlikely to be found justified due to the risk to cost ratio. Emergency response plan is available for flooding across roads.	Yes	1	1	5	0	5	1	2	1

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outa
A7	1	Khyber to Gillies - Mountain Road	Road	Flooding	High potential for pooling of water. Is 100% reliant on soakage disposal. Surface water collection, conveyance and disposal systems area all of limited design capacity. A 1% AEP rainfall event could result in loss of system access and availability.	3UL	3L	No	Physical works ($$$)	A significant component of an alternative drainage system here be in securing land. For example to tunnel (via TMB) for stormwater management away from system would require purchasing of land away from infrastructure. Relatively convenient detours available but regional system disruption will be significant	Yes	1	1	5	0	5	1	2	2
A8	22	Whangapouri Stream	Road	Flooding	Flooding of the road due to the stream. Significant development occurring in the contributing catchment at this location.	2L	2VL	No	Physical works ($$)	Couple of options physical works or land use planning. Physical works would look to supplement existing infrastructure or build a new bridge/culvert asset. Major development occuring in contributing catchment will increase risk unless right development controls in place. Stand alone business case for bridge/culvert renewal unlikely to be found justified due to the risk to cost ratio. Emergency response plan is available for flooding across roads.	Yes	2	3	3	0	3	1	3	3
A9	22	Oira Stream	Road	Flooding	SH22 gets inundated by flooding at the Oira Stream	2L	2VL	No	Physical works ($$)	Couple of options physical works or land use planning. Physical works would look to supplement existing infrastructure or build a new bridge/culvert asset. Major development occuring in contributing catchment will increase risk unless right development controls in place. Stand alone business case for bridge/culvert renewal unlikely to be found justified due to the risk to cost ratio. Emergency response plan is available for flooding across roads.	Yes	2	2	3	0	3	1	3	3

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outa
A10	2	SH1 to SH25	Road	Flooding	Significant vulnerability to road becoming impassable across the much of SH2 between SH1 through to SH25. There exist 97 culverts at this 30km section of SH2 with many significantly inadequate for performance capability (relative to demand) as well as being of marginal condition (limited life to structural failure). Plans for major Capital Project Upgrades across 5 sections (A-E) have been put on hold. Only the Mangatawhiri Deviation (section B) has good resilience.	3L	3VL	No	Physical works ($$$$)	Waka Kotahi already has capital project designs available which includes the correct designed culverts to deliver the correct level of service. Agency already has a PBC but for about 30 years upgrade needs have not been funded. In the interim this is dealt with in emergency preparedness and response planning, including traffic control measures (and detours available if/when required). There are 5 sections of individual capital project designs which could be funded individually. Some of the highway would be built in place other locations would be built in new green sites. SH2 Section A (SH1 to Mangatawhiri), and/or Section B (Mangatangi to SH25) is most likely to be the first section/s funded.	Yes	2	3	3	0	3	2	3	3
A11	1	Lonely Track Road North Slip	Road	Landslip	Landslip issues. This is currently viewed as being one of the highest risks on the Auckland network - which has potential to cause a loss of system availability. Significant land instability issues detected with ongoing movement since construction in late 90's as part of the SH1 ALPURT A1 Project. Close monitoring and proactive sealing of tension cracks to slow down failures is currently funded under ASM TOC for initial investigation (only).	5L	5VL	No	Unknown. Pending further investigations	Significant issue - Currently investigation works are underway to better understand the scale of the risk and any resultant work needs. This includes additional monitoring and investigation of the likelihood and consequence of a slip. Auckland System Management (ASM) TOC funding to a capped budget is available for the current investigation stage. Monitoring in various forms has been occurring since 2008. ASM TOC funding for investigation in the last year has been made available to confirm the risk profile and any recommendations on mitigation. Additional funding would be needed for any physical works.	Unsure	2	3	5	0	5	3	3	3

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outa
A13	1	Khyber to Gillies Tomos	Road	Volcanic	Potential for Tomo's beneath the ground which have the potential to collapse or open up.	3L	-	No	Unknown. Pending further investigations	Currently would be addressing any failure under emergency response planning such as detours. There is some scope for proactive management in the form of enhanced geotechnical understand such as thorough ground penetrating radar assessment for more detailed analysis of any risks/residual risks. In event of a Tomo collapse the immediate response will be filling with concrete to reinstate availability of highway	Unsure	1	2	5	0	5	1	-	-

A1.2 Bay of Plenty regional risk catalogue

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
BP17	35	East Cape	Road	Erosion	Increased rainfall in the ranges will result in increased sedimentation along the coast and increased scour along bridges	3UL	3L	No	Unknown. Pending further investigations	Further investigations needed	No	1	2	2	0	2	3	2	3
BP14	29A	Greerton Flooding	Road	Flooding	Culvert stops flood waters	3UL	3L	No	Physical works ($$)	Could lift the road but would create other issues.	Yes	2	1	5	0	5	1	3	1
BP1	2	Kaikokopu Bridge	Road	Flooding	Flooding of approaches to the bridge. Traffic gets diverted through old coach road	3L	3VL	No	Physical works ($$)	Raise road and bridge	Yes	3	2	3	0	3	2	3	3
BP2	2	Kutarere	Road	Coastal Inundation / SLR	Tidal flooding occurs with significant rainfall.	4L	4VL	No	Physical works ($$)	Raise the road <1km.	Yes	2	2	3	0	3	3	3	3
BP18	30	Lynmore and Airport	Road	Flooding	Attenuation dams have been put in place to reduce the amount of water which can flood the roads. However, flooding still occurs when the ARI exceeds the attenuation dam's capacity.	2L	-	No	BAU / Ongoing maintenance / Reactive	BAU reactive maintenance	Unsure	2	2	3	0	3	1	-	-
BP23	2	Matata Straights	Road	Landslip	Big storms cause landslip / removal of bluffs takes the road out and can flood for days.	2L	2VL	No	Physical works ($$)	Remove slips	yes	2	3	3	0	3	1	3	3

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
BP3	35	Motu Bluff	Road	Landslip	Land stability issues at Motu Bluff	3VL	3VL	No	Physical works ($$)	Rockslide netting to divert the rocks. 10-20-year programme to improve rain / storm water control to avoid emergency works	Yes	3	3	2	0	2	3	3	3
BP19	30	North of Lake Rotoiti	Road	Landslip	20km of the road sits on a razor back ridge which has resulted in a number of failures which have undermined the road.	2L	-	No	BAU / Ongoing maintenance / Reactive	BAU reactive maintenance	Unsure	2	2	3	0	3	1	-	-
BP4	2	Nukuhou	Road	Flooding	4 locations of flooding which generally occur at the same time. The local road has already been raised to provide a better route instead of raising the SH.	3VL	3VL	No	Physical works ($$$)	Raise 2km of road	Yes	3	3	3	0	3	2	3	3
BP22	2	Philip Walter Dr	Road	Flooding	Embankment / tributary low-lying valley. Massive culvert but the culvert cannot cope ~2m diameter. Less than 12 hours but should be higher than the Uretawa bridge.	3L	3VL	No	Physical works ($$)	Raise section of road and put in and additional culvert. should be included in the Kati Kati bypass	Yes	3	1	3	0	3	2	3	3
BP20	5	Pukehina to Pongakawa	Road	Landslip	Volcanic extension processes results in sediment piping, ground settlement and lateral spread of the ground beneath the road which then gets washed out in heavy rainfall.	2L	-	No	Emergency response and preparedness planning only (typically HI/LF)	Currently investigating	Unsure	1	3	3	0	3	1	-	-
BP15	2	Rangiruru to Pukehina	Road	Earthquake / liquefaction	Settlement issues along SH2. Both rail and road. Soft soil settlement. Not immediate priority	3UL	-	No	Physical works ($$)	Need a long-term management plan	Yes	1	2	3	0	3	2	-	-
BP25	30	Rotoma Bluff	Road	Landslip	SH30 at Rotoma Bluff is subject to large amounts of material collapsing onto the road.	2L	2VL	No	Physical works ($$$)	Soil nails and rock netting etc	Yes	2	3	2	0	2	2	3	3
BP5	29	Ruahihi Bluff	Road	Rockfall	Rockfall ~5 cubic m blocks which pose a significant safety risk. 30-40% of trucks would be HPMV which equals ~800 trucks on a 2-hour detour.	4L	-	No	Physical works ($$)	There is a significant resilience and safety benefit. designed and ready to go, mesh and rockfall. Should be highest risk stretch of road.	Yes	2	2	5	0	5	2	-	-

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BP16	2	Tanetua (Pekatahi Bridge)	Bridge	Erosion	Significant scour issues. You have to wait until the water has dropped to do scour assessment before you can let people through. Same highway as Waioeka Gorge and could create the same issues re community severance and loss of productivity for fresh foodstuff business. Consider lifting ONC weighting	2VL	2VL	No	Physical works ($$)	Replace bridge - however have temp solution and not a priority	Yes	3	3	3	0	3	1	3	3
BP6	35	Tirohanga to Bay of Plenty Boundary	Road	Landslip	Landslip issues along entire East Cape. Also, sedimentation with significant rainfall washing sediment down valleys.	3VL	3VL	No	Physical works ($$$)	Further investigations needed	Unsure	3	3	2	0	2	3	3	3
BP21	2	Uretawa bridge	Bridge	Flooding	Approaches get submerged. rainfall plus high tide - tide related only. likely to get worse with climate change and SLR to 5-6hours. Half a km to the north also floods.	3L	3VL	No	Physical works ($$)	Raising the road could increasing issues further up. Potentially extra span in the bridge to allow more water to pass through. If you put in a stop bank you would also need pumps. Should be included in Kati Kati bypass	Yes	3	1	3	0	3	2	3	3
BP12	2	Waimana Gorge	Road	Landslip	Both large and small slips through the gorge. Currently already spending $6million just to get it open from previous events.	3VL	3VL	No	Physical works ($$$)	Requires stabilizing slopes.	Yes	3	3	3	0	3	2	3	3
BP9	2	Waioeka Gorge	Road	Landslip	Landslip risk for the entirety of Opotiki to the Bay of Plenty boundary. Potential for significant effects commercially and for small communities.	4VL	4VL	No	Physical works ($$$$)	Over a multiple year programme. In an ideal world you would do a multi-year programme across all significant sites - that links to the PBC that Simon Barnett / Gisborne is working on.	Yes	3	3	3	0	3	3	3	3

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BP8	2	Waioeka Gorge	Road	Rockfall	Significant rockfall issues along the entirety of Waioeka Gorge for both the Bay of Plenty and Gisborne / Hawke's Bay. Very significant issue for Gisborne community as in the event of a long closure communities have the potential to be isolated. Also affects time critical delivery of food produce to the port and Auckland. Supplies to the hospital could also become an issue quickly. Regional managers support a change to the ONRC classification to 'Regional' level. Significant crash rates and safety issues with response limited due to poor telephone coverage. Waioeka Gorge PBC identifies all major sites and pinch points.	5VL	-	No	Physical works ($$$)	Geotechnical improvements: combinations of rock fall protection, slope stabilisation etc. over a multiple year programme. In an ideal world you would do a multi-year programme across all significant sites - that links to the PBC that Simon Barnett / Gisborne is working on. Aurecon has previously carried out an assessment of the sites.	Yes	3	3	3	2	5	3	-	-
BP24	2	Waioeka River	Road	Erosion	Erosion from Waioeka river and failure of the groynes could mean loss of road.	4L	4VL	No	Physical works ($$)	New groynes	Yes	2	3	3	0	3	3	3	3
BP10	2	Waiotahi Bluffs	Road	Landslip	Land instability issues along the Bluff. Ideally need to enhance detour route so that it can take HPMVs which will limit the impacts of outage.	3VL	3VL	No	Physical works ($$)	Roughly 10 -15kms of upgrading detour route. There are a few tight bends which could be widened.	Yes	3	3	3	0	3	2	3	3
BP11	2	Waiotahi Bridge	Road	Coastal Erosion	Coastal erosion along the bridge is possible. Solvable in the short to medium term, but not long term with climate change. 6hr detour for HCV and HPMV.	4L	4VL	No	Physical works ($$)	Erosion protection required around bridge	Yes	2	2	3	0	3	3	3	3
BP13	29	West side of the Kaimai's	Road	Extreme Weather	Extreme weather can cause re-mobilisation of the fine/ash material. Could be difficult to clean up.	4L	4VL	No	Physical works ($)	Some sort of geotechnical response to stabilize slope. Needs investigation	Yes	3	1	5	0	5	2	3	3

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C39	75	Akaroa Harbour	Road	Coastal Inundation / SLR	Coastal inundation and sea level rise risk	4UL	4L	No	Unknown. Pending further investigations	Further investigations needed	Unsure	2	1	3	0	3	3	3	2
C8	73	Arthurs Pass	Road	Ice / Snow	SH73 through Arthurs Pass is subject to snow and ice disruptions. Arthurs Pass is one of three key routes which link the West Coast with the East Coast of the South Island.	4L	-	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	No	3	2	3	0	3	3	-	-
C9	73	Arthurs Pass	Road	Rockfall	SH73 through Arthurs Pass is subject to rockfall. Arthurs Pass is one of three key routes which link the West Coast with the East Coast of the South Island.	4L	-	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	No	3	2	3	0	3	3	-	-
C15	73	Arthurs Pass	Road	Ice / Snow	Snow and ice disruption through the Pass due to high elevation.	3L	-	No	Unknown. Pending further investigations	Further investigations needed	No	3	2	3	0	3	2	-	-
C4	1	Ashburton Bridge	Road	Extreme Weather	SH1 at the Ashburton bridge is subject to extreme weather events. This is a significant pinch point on the network and has a limited detour with resilience and capacity issues. KiwiRail and electricity lines also follow parallel to the road and are likely to be subject to the same risk.	4L	-	No	Physical works ($$$)	Duplicate bridge required	Yes	2	3	4	0	4	3	-	-
C20	1	Ashley River Bridge	Bridge	Earthquake / liquefaction	SH1 at the Hurunui River is subject to seismic risk as well as safety issues involving a large number of accidents as well as safety issues for cyclists. This is a high volume and significant freight route with a poor detour available.	3L	-	No	Physical works ($$$)	upgrade bridge	Yes	2	3	4	0	4	2	-	-
C7	73	Bealey Bridge	Bridge	Earthquake / liquefaction	SH73 at the Bealey bridge is at risk from seismic shaking, scour and capacity issues.	4L	-	No	Physical works ($$$$)	Replace bridge	Yes	2	3	3	0	3	3	-	-

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C16	1	Blue Slip	Road	Landslip	Site at risk to mass earth movement, which would likely affect both road and KiwiRail. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	5L	-	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	No	3	1	4	1	5	3	-	-
C5	8	Burkes Pass	Road	Ice / Snow	SH6 through Burkes Pass is subject to snow and ice risk resulting in closures and disruption. Burkes Pass is a key tourist and freight route between the East Coast and Central Otago.	4L	-	No	BAU / Ongoing maintenance / Reactive	Winter maintenance LOS and improved communication. VMS required at each end of route where alternative routes exist	No	3	2	3	0	3	3	-	-
C42	73	Canterbury Region	Road	Wildfire	The Canterbury side of both the Lewis and Arthurs pass has the potential for significant wildfire events. Train sparks can be a cause. Boundary to boundary mows currently occur twice a year which help with the risk but do not eliminate it. There needs to be better cross organisational management between NZTA and TA's to help push the vegetation out from the roads.	2L	-	No	Enhanced proactive maintenance	Don't build timber structures, all guard railing is timber. Not necessarily a capital maintenance response but should be included in regular maintenance. Discuss mitigation with KiwiRail.	Unsure	2	2	2	0	2	2	-	-

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C19	1	Clarence Bridge	Bridge	Flooding	Clarence river is at risk to river and surface flooding - requiring ongoing groyne maintenance. High sediment loads can cause the riverbed to aggrade up to 2m. This risk also extends across most of the streams along the Northern Kaikoura coastline. Some sediment retention devices are being built to address this. This risk is manageable in individual locations, however in a significant event such as Tropical Cyclone Fehi / Gita there is the potential for all rivers to flood, which could cause significant remedial works. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	5L	5VL	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	Unsure	3	1	4	1	5	3	3	3
C24	1	Clarence to Kaikoura	Road	Coastal Inundation / SLR	Overtopping occurs along the whole corridor, only out for a couple hours either side of high tide. Unsure whether this will damage the road as it is all new (NCTIR), likely this will no longer damage the road. However, this is ongoing and likely to increase with the impacts of CC. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	4L	4VL	No	Unknown. Pending further investigations	Further investigations needed	Unsure	3	2	4	1	5	2	3	3

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C23	1	Clarence to Kaikoura	Road	Rockfall	Clarence to Kaikoura is subject to rockfall risk, some of which will have been addressed in the NCTIR project. However, behaviour is unpredictable due to Kaikoura works but it is assumed that there will be residual risk for rockfall and debris flows. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	5UL	-	No	Unknown. Pending further investigations	Monitor	Unsure	1	2	4	1	5	3	-	-
C28	73	Craigieburn	Road	Landslip	Landslip risk at Craigieburn along SH73.	4L	-	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	Yes	2	2	3	0	3	3	-	-
C38	82	Elephant Hill	Bridge	Earthquake / liquefaction	Elephant hill stream bridge is deemed to be under strengthened and therefore subject to damage from earthquakes and liquefaction.	2L	-	No	Physical works ($$$)	realignment	Yes	3	2	2	0	2	2	-	-
C32	74A	Evans Pass	Road	Rockfall	Rockfall, substantially addressed on Lyttelton side but not the Sumner side. This is part of the Dangerous goods route.	3L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	2	2	3	0	3	2	-	-
C46	79	Geraldine to Fairlie	Road	Rockfall	Rockfall risk	3UL	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	1	2	3	0	3	2	-	-
C30	1	Hapuku Dam	Road	Landslip	Landslide dam but not significant. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	5UL	-	No	Physical works ($$)	Could remove the landslide dam to eliminate dam outbreak flood risk.	Yes	1	1	4	1	5	3	-	-

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C26	1	Hundalees	Road	Landslip	Soft soils and landslip risk. Large number of truck crashes. Large landslips can occur every ~10 years with smaller annual events. The BAU response to the smaller events typically results in the road being back to one lane within 12 hours. The larger events cause traffic to be diverted through the alternate route for 48 hours. Slip generally comes onto the road rather than under cutting.	4L	-	No	Physical works ($$)	Solution could be to revegetate the farm area to stabilise slopes.	Yes	3	1	4	0	4	3	-	-
C11	1	Hurunui River Bridge	Bridge	Earthquake / liquefaction	The single lane Hurunui bridge on SH1 is subject to seismic risk and safety issues involving a large number of accidents and safety issues for cyclists. This is a high volume and significant freight route with a poor detour route.	4L	-	No	Physical works ($$$)	Replace bridge and upgrade to two lanes	Yes	2	2	4	0	4	3	-	-
C43	70	Inland Route - Whales Back Slip	Road	Landslip	Hurunui district route, whales back slip. This is a detour route through to Kaikoura. A wider issue around SH traffic using alternate routes which don't have funding. Huge amount of work to make it truly resilient, however this could potentially make more problems than you solve. NZTA doesn't have any oversight of the route and what state it's in, Council keeps trying to give it back to NZTA.	2L	-	No	Unknown. Pending further investigations	Further investigations needed	No	2	2	2	0	2	2	-	-
C37	8	Lake Pukaki	Road	Erosion	Erosion along lake edge but lake level managed by Meridian energy	4UL	-	No	BAU / Ongoing maintenance / Reactive	Monitor and reactive maintenance	Yes	1	2	3	0	3	3	-	-
C36	8	Lake Tekapo	Road	Erosion	Erosion along lake edge however lake level managed by Genesis energy	4UL	-	No	BAU / Ongoing maintenance / Reactive	Monitor and reactive maintenance	Yes	1	2	3	0	3	3	-	-
C13	7	Lewis Pass	Road	Flooding	Currently a lot of maintenance work being carried out to stop flooding inundation of the road. The road and riverbed are currently at the same level.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Requires further investigation to develop a long-term solution	Yes	2	2	2	1	3	3	3	3
C25	7	Lewis Pass	Road	Ice / Snow	Snowstorms on the Lewis Pass cut off the route and all routes to the north.	4L	-	No	BAU / Ongoing maintenance / Reactive	Winter maintenance LOS and improved communication. VMS required at each end of route where alternative routes exist	No	3	1	2	1	3	3	-	-

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C40	75	Little River to Duvauchelle	Road	Landslip	Landslip either side of the Hill summit. Detour is available on the east side but not west side.	3L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	2	2	3	0	3	2	-	-
C33	74	Lyttleton Tunnel	Tunnel	Rockfall	Rockfall risk on both sides of the tunnel. Currently there is a temporary solution in place. The tunnel control building has been upgraded and therefore not at imminent risk.	3L	-	No	Enhanced proactive maintenance	can be managed through tunnel management plan.	Yes	2	2	5	0	5	1	-	-
C47	Main Rd	Main road around Monks Bay	Road	Coastal Inundation / SLR	Peacock's gallop and Monks bay, sea wall in place but low elevation, risk of inundation, however it's only a Dangerous Goods route so very low issue.	3L	3VL	No	Unknown. Pending further investigations	Further investigations needed	Yes	2	3	3	0	3	2	3	3
C12	Main Rd	Main road around Monks Bay	Road	Tsunami	Main road around Monks Bay ('dangerous goods' route) is at risk from tsunami inundation. This is a significant route for dangerous goods coming from Lyttleton Port to the South Island and cannot go through Lyttleton Tunnel.	3L	-	No	Emergency response and preparedness planning only (typically HI/LF)	Emergency response planning only	No	1	3	3	0	3	2	-	-
C27	1	Movern	Road	Flooding	Surface flooding due to land use changes, short duration. SH culverts undersized.	4L	-	No	Enhanced proactive maintenance	Improved drainage required	Yes	3	1	4	0	4	3	-	-
C10	1	North of Kaikoura - Clarence Bridge	Road	Landslip	Landslip and mass movement risk (site similar to Blue Slip, see for details). No known solution, and if a landslip or mass movement were to occur the road and rail will be completely destroyed. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	5L	-	No	Emergency response and preparedness planning only (typically HI/LF)	Further investigations needed	Unsure	1	3	4	1	5	3	-	-

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C17	1	Ohau Point	Road	Coastal Inundation / SLR	Ohau Point is at risk from coastal inundation– it overtopped three times in 2019 in a combined high tide and storm event. There is a potential design in NCTIR to address this, however with the effects of climate change this may not address the issues. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	5L	5VL	No	Unknown. Pending further investigations	Monitor	Unsure	3	1	4	1	5	3	3	3
C41	73	Porters Pass	Road	Rockfall	Rockfall along the pass.	3L	-	No	Enhanced proactive maintenance	Some preventative maintenance in rock sailing could help, however the risk is manageable	Yes	2	2	3	0	3	2	-	-
C29	73	Porters Pass to Arthurs Pass	Road	Ice / Snow	Ice and snow risk - occurs throughout winter along the passes.	4L	-	No	BAU / Ongoing maintenance / Reactive	Winter maintenance LOS and improved communication. VMS required at each end of route where alternative routes exist	Yes	2	2	3	0	3	3	-	-
C44	1	Puketa to Oaro	Road	Coastal Inundation / SLR	Over topping and inundation of road	3UL	3L	No	Unknown. Pending further investigations	Further investigations needed	Unsure	2	1	4	0	4	2	3	2
C3	1	Rakaia Bridge	Road	Flooding	SH1 at the Rakaia bridge is subject to extreme weather events and flooding due to limited drainage capacity around the bridge. This is a nationally significant road with a poor detour. Outage of this bridge was experienced in the lead up to Christmas 2019 and caused significant disruption throughout Canterbury. KiwiRail and electricity lines are parallel to the road and are likely subject to the same risk. Currently a large number of accidents cause disruptions on the bridge. Bridge also thought to have poor seismic strength.	4L	-	No	Physical works ($$$)	Duplicate bridge required	Yes	2	3	4	0	4	3	-	-

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C1	77	Rakaia Gorge Bridges	Road	Flooding	This is a major tanker route for the Darfield Fonterra plant and Phillip Wareing as well as the detour route for SH1 around the Rakaia and Ashburton bridges. Some of the bridges have restrictions and limits for HPMVs. There are significant flooding issues throughout the route and the road often goes down to one lane. It's likely this road would be significantly damaged in an earthquake which would leave no detour for SH1. Electricity lines and KiwiRail are parallel to SH1 line.	4L	-	No	Physical works ($$$)	Upgrade both one lane bridges at the gorge to provide a more robust detour route. Improve traffic management procedures during outages.	Yes	2	3	2	1	3	3	-	-
C48	1	Rangitata and Arundel Bridges	Bridge	Flooding	Flooding has potential to cause bridge washouts through scour for both bridges on the Rangitata River.	4L	-	No	Enhanced proactive maintenance	Enhanced maintenance of river groynes	Yes	2	2	3	0	3	3	-	-
C14	75	Road to Akaroa	Road	Landslip	Landslip risk on either side of the summit, along the road to Akaroa through Banks Peninsula.	4L	-	No	Enhanced proactive maintenance	Maintenance and monitor	No	2	2	3	0	3	3	-	-
C31	1	Saltwater Creek	Road	Flooding	Tidal flooding, salt marshes and land run off cause surface flooding at high tide. We are seeing more unusual extreme events with all-weather events and high tide occurring at the same time to flood the road.	3L	3VL	No	Unknown. Pending further investigations	Further investigations needed	Unsure	2	2	4	0	4	2	3	3

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C18	1	Shingle Fans	Road	Landslip	Shingle Fans - North of Clarence is at risk to landslip. There are three shingle fans which flow through culverts however, in large events these flow over the road. Landslip overtopping occurs approximately once every 3-4 years. Generally, response teams can keep the shingle within the water way. Generally, there is a quick response, with short term closures and damage to infrastructure is unlikely. Smaller retention dams are being located upstream. KiwiRail relies on NZTA for clearing the culverts. This is still flagged as a high risk due to the frequency and importance of the road. SH North of Kaikoura is considered higher criticality than south of Kaikoura due the importance of this route in terms of connecting to the north (including freight). In addition, the alternate route involves a significant detour (via SH63 and Lewis Pass).	5L	-	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	No	3	1	4	1	5	3	-	-
C21	7	Stuarts Fan	Road	Flooding	Flooding risk to bridge when extreme events mobilise the shingle and cause overflow at culverts underneath the bridge. The culverts get cleaned out annually which closes the road for a few hours. Justification for funding in resilience measures could be difficult.	4L	4VL	No	Physical works ($$$)	There is a plan developed for realignment and box culverts however this hasn't received funding. Requires regular maintenance.	Yes	3	1	2	1	3	3	3	3
C45	1	Temuka	Road	Flooding	Both rail and road bridge will fail if washed out	3UL	-	No	Enhanced proactive maintenance	Further investigations needed	Yes	1	2	4	0	4	2	-	-

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C2	7a	Waiau Ferry Bridge	Bridge	Rockfall	The Waiau Ferry bridge is at risk from rockfall and is the key route into Hanmer Springs which is the most significant tourism / economic hub for the Hurunui district, hence a higher consequence rating was assigned. There are also some concerns around the bridge abutments. Note during workshops there was differing opinions of the criticality of this route from a regional perspective.	4L	-	No	Physical works ($$$$)	Bridge replacement and alternative alignment.	Yes	2	3	2	1	3	3	-	-
C6	73	Waimakariri Bluff	Road	Rockfall	SH73 at Waimakariri Bluff is subject to rockfall risk at many locations. There is currently one location being addressed under LCLR, however the issue extends over a wider area.	4L	-	No	Physical works ($$$)	more funding would mean that more sites can be addressed.	Yes	3	2	3	0	3	3	-	-
C35	1	Washdyke	Road	Flooding	Road and bridge at risk of flooding from the creek and from pleasant point.	3L	-	No	Physical works ($$)	River control works	Yes	2	2	4	0	4	2	-	-

A1.4 Gisborne / Hawke's Bay regional catalogue

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
HB1	2	Devil's Elbow	Road	Landslip	~10km of Devil's Elbow is at risk to landslip.	4VL	4VL	No	Unknown. Pending further investigations	An alternative local road can be utilised however it is unsealed and narrow and cannot take heavy vehicles. Upgrading the local road is potentially a better use of money.	Unsure	3	3	3	0	3	3	3	3
HB14	5	Entire length of SH5	Road	Landslip	Significant issues with Landslips and instability along entire route. Highest ONRC and connects the Bay to inland. The detour is long and less resilient, via Palmerston North.	4L	4VL	No	Physical works ($$$)	Response plan for the route needs to be developed. A large number of geotechnical solutions would be required to address the landslips.	Yes	3	2	3	0	3	3	3	3
HB13	5	Entire length of SH5	Road	Volcanic	Potential ashfall disruption depending on wind direction	4UL	-	No	Emergency response and preparedness planning only (typically HI/LF)	Develop volcanic response plan	No	1	2	3	0	3	3	-	-
HB3	5	Kaweka Ranges - Mohaka River Rail and Road Bridge	Road	Landslip	Mohaka river at the road and rail bridge which has fundamental flaws in its design and is subject to landslip risk along the entire length of the ranges. It is a narrow road with minimal space to carry out physical works or install geotechnical solutions such as debris fences. Work is being done to cut the slip back further. A debris fence is however being installed in one section from Pakipaki to Peka Peka.	4L	4VL	No	Physical works ($$$)	Investigation into options to retreat into hillside/ behind rail viaduct 'Raupunga retreat'	Yes	3	2	3	0	3	3	3	3
HB4	5	Kaweka Ranges - Mohaka River Rail and Road Bridge	Road	Rockfall	Mohaka river at the road and rail bridge which has fundamental flaws in its design and is subject to rockfall risk along the entire length of the ranges. It is a narrow road with minimal space to carry out physical works or install geotechnical solutions such as debris fences. A debris fence is however being installed in one section from Pakipaki to Peka Peka.	4L	-	No	Physical works ($$$)	Investigation into options to retreat into hillside/ behind rail viaduct 'Raupunga retreat'	Yes	3	2	3	0	3	3	-	-
HB5	2	Napier airport	Road	Coastal Inundation / SLR	Road to Napier airport is highly vulnerable to a number of hazards.	4L	4VL	No	Unknown. Pending further investigations	Regional problem and tied to climate change and emergency response issues	Unsure	3	2	3	0	3	3	3	3

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
HB6	50	Napier Port	Road	Earthquake / liquefaction	An earthquake in Wellington could cause Centre Port to be out of service. Consideration of routes to other ports such as Napier and Tauranga become more relevant- equally if there is an earthquake in Napier. CDEM accept that some things will likely stop economically. The road to the port is an urban highway and is less likely to be impacted by slips or a highly frequent event.	4L	-	No	Emergency response and preparedness planning only (typically HI/LF)	Link into work being undertaken by Civil defence around risks of Hikurangi Trench and Alpine Fault to understand the Agency's role in being able to respond to these large-scale events.	No	1	3	5	0	5	2	-	-
G3	2	Napier to Gisborne - south of Wairoa as well as over Whareas	Road	Landslip	Whilst there are areas, they would like to fix you basically just have to deal with it otherwise you would need to move the whole road out of the hills. There are a number of ongoing resilience issues which are monitored and dealt with as mitigating them would be unimaginable. A number of earth works would be required to reduce slips blocking the SH.	3L	-	No	Physical works ($$$$)	Realign whole road	Unsure	2	2	2	0	2	3	-	-
HB7	2B	Pandora Pond Bridge	Road	Tsunami	Single bridge carries all the main services - Pandora Pond - is also tsunami evacuation route. You could run something over the expressway. Expressway links the hospital	3L	-	No	Emergency response and preparedness planning only (typically HI/LF)	Identified by vulnerability study in Civil Defence- no solutions available- may well be a response plan	No	1	3	3	0	3	2	-	-
G2	35	SH35 north of Gisborne and into Bay of Plenty.	Road	Extreme Weather	North of Gisborne - currently $12m to improve the resilience of that work. There will be a whole list that needs to be done that will likely be more than $12m. Major resilience issues where the bypass is SH2. SH35 is a good route to try and invest substantial subsidence impacts, lots of hills that are on the move under the highway. There is not a lot of traffic, but it is a community lifeline for northern communities to access doctors etc. ~100 sites of subsidence in Gisborne alone as well as on the northern section around to the BOP. there are two options of local roads, but they cannot get approval from the local council to get it officially recognised. Waimate valley road and whakatoutou road - need approval from Local council to let heavy vehicles through North of Te Puia springs - Kopuaroa Road is the alternative north of Te Puia Springs. Council district plan shows the land instability. There is an alternate new alignment to bypass slip areas. 5-10km - preliminary designs. SH35 route	3UL	3L	No	Unknown. Pending further investigations	Further investigations needed	Unsure	2	1	2	0	2	3	3	2

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
HB9	2	Wairoa River	Road	Erosion	Erosion risk along Wairoa River where the slip undercuts the road.	4L	4VL	No	Physical works ($$)	Look at opportunities to raise level of road alongside river corridor and/ or look at investing in improving resilience of local road network as alternative.	Yes	3	2	3	0	3	3	3	3
HB10	2	Wairoa River	Road	Flooding	Wairoa River Flood once a year with the road closed and the river is cutting into the road - Cyclone Bola took out the bridge. Removing every year flood risk would be better than trying to address the big events - which would involve raising the road. Sheer bank on one side of the road where you could raise the road and put in slip control. Wouldn't make this high priority above the other issues where this is only closed for a day vs the other ones closed for weeks.	4L	4VL	No	Physical works ($$)	Response plan for the route needs to be developed and look at improving resilience of Mohaka Bridge and approaches.	Yes	3	2	3	0	3	3	3	3
HB12	2	Whirinaki Bluff	Road	Coastal Erosion	Coastal erosion risk. Coastal erosion likely to cut off the entire road northward	4L	4VL	No	Physical works ($$)	Need to understand the effects of climate change and develop options	Yes	3	2	3	0	3	3	3	3
HB11	2	Whirinaki Bluff	Road	Landslip	Landslip risk. Slip likely to cut off the entire road northward.	4L	4VL	No	Physical works ($$)	Need to understand the effects of climate change and develop options	Yes	3	2	3	0	3	3	3	3

A1.5 Manawatu / Whanganui regional risk catalogue

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
MW4	1	Bulls Bridge	Bridge	Erosion	SH1N Bulls bridge - rock armour built in 2016, the 2015 event washed all the rock out, rock armour is because the bridge behind that the piers are underpinned, half this bridge has disappeared down the river before ~70's/80's, scour along this bridge and pinch point on the network should that bridge go, there is a viable detour via kakariki road and Holcombe, not top of the list for resilience as long as the rock armour stays, in a massive event if the rock armour goes the bridge is at high risk, if this bridge goes there would be significant impact nationally as it would be out for a significant amount of time, Kakariki road has both the road and the train bridge, the kakariki road bridge is not high off the bank and potential if there is a significant event which takes out SH1 bridge then there could be potential for the kakariki bridge to go, Cycle path forces people to cross the SH and cyclists have to go over the small cycle path which only fits one bike wide, a lot of people cycle for	3L	-	No	Physical works ($$$$)	New bridge/new alignment/Bulls Bypass	Yes	2	3	3	0	3	2	-	-
MW21	3	Cobham Bridge	Bridge	Flooding	Cobham bridge on SH3 is subject to flooding of its approaches.	2L	-	No	Physical works ($$$)	Further investigations needed	Yes	3	1	3	0	3	1	-	-
MW9	54	Fielding and Palmerston North	Road	Rockfall	One lane bridges along SH54 which would mean the whole SH is out, for inspections the whole bridge is closed, not nationally significant but regionally significant. Between Fielding and Palmy - some low-lying road and flooding issues 1 every 10 years.	2L	-	No	Physical works ($$$)	Duplicate bridge	Yes	2	3	3	0	3	1	-	-
MW5	3	Kai Iwi	Road	Landslip	SH3 Over slips at Kai Iwi - but solved in maintenance / operations	3L	-	No	BAU / Ongoing maintenance / Reactive	Business as usual reactive works	Yes	2	2	3	0	3	2	-	-
MW24	3	Manawatu Gorge	Road	Landslip	Significant land instability issues through the entire Manawatu Gorge. Currently closed and a PBC underway to decide the best option moving forward. Traffic goes through a local road which is requiring significant strengthening to deal with large vehicles and increased traffic loads.	3VL	3VL	No	Physical works ($$$$)	Business case underway	Yes	3	3	4	0	4	2	3	3
MW22	3	Mangaone River Bridge	Bridge	Flooding	Flooding and debris on bridge	3L	-	No	Physical works ($$)	Further investigations needed	Yes	3	1	3	0	3	2	-	-

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
MW14	56	Mangaone stream bridge	Road	Flooding	Significant flooding occurs Mangaone stream bridge which results in debris covering the bridge.	2L	-	No	BAU / Ongoing maintenance / Reactive	Business as usual reactive works	Yes	2	2	3	0	3	1	-	-
MW2	2	Mangatainoka	Road	Flooding	SH2 Mangatainoka - moderate flood risk (1 every 10 years).	4L	4VL	No	Physical works ($)	Drainage improvements required	Yes	2	2	3	0	3	3	3	3
MW16	3	Marybank	Road	Flooding	Marybank used to have flooding issue but in the last 4-5 years this seems to have reduced, low lying section of road, before that it was quite regular, Raising the road could mitigate some issues.	2UL	-	No	Physical works ($$)	Raise the road	Yes	2	1	3	0	3	1	-	-
MW7	2	Matamau	Road	Flooding	SH2 Matamau - flooding, not very regular, 1 every 10 years. North of Woodville - capital projects have solved issues.	4UL	4L	Yes	Physical works ($$)	Largely resolved.	Yes	1	1	3	0	3	3	2	2
MW15	51	Napier to Clive	Road	Tsunami	Tsunami risk along SH15 from Napier to Clive, however there are good alternate routes available.	2L	-	No	Emergency response and preparedness planning only (typically HI/LF)	Emergency response planning only	No	1	3	3	0	3	1	-	-
MW12	1	Ohau	Road	Flooding	South of Levin through Ohau - gets flooded a lot with a bridge washout happen before, flooding particularly in the main town, currently a project in place for larger culverts which only gets rid of the water doesn't solve the issue, there are alternate routes via SH57 but to a much lower level of service, significant SW drainage system could help, happens ~1 a year and not full closure, typically over the middle of one lane so reduces width of road, hopefully solvable through better drainage, well over $1M so not in low cost.	2L	-	No	Enhanced proactive maintenance	Better drainage systems	Yes	3	2	4	0	4	1	-	-
MW6	56	Opiki	Road	Flooding	SH56 Opiki - over Manawatu river, floods 2-3 times a year closed for 3 days, known and relatively managed floodway, arterial road and it is solvable if you built a trestle structure, part of the accessing central strategy for freight routes and is likely to become more important, serves the inland port at long burn, solutions is doable, and is an increasingly important road which is shut regularly, currently not PBC to address this. This section of Highway acts a secondary overflow for the Manawatu flood plain so gaining resource consent will be very challenging.	2L	-	No	Physical works ($$$)	Further investigations needed	Yes	3	2	3	0	3	1	-	-

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
MW23	4	Raetihi to Whanganui	Road	Landslip	Raetihi Landslip. Significant land instability through the entire length of SH4 from Raetihi to Whanganui	2VL	-	No	Unknown. Pending further investigations	Currently a PBC underway to respond to the Raetihi landslip which occurred in 2019. This has resulted in the decision to make repairs to the current Raetihi landslip location only instead of creating a bypass.	Yes	3	3	2	0	2	2	-	-
MW10	54	SH1 intersection to Waituna West	Road	Rockfall	SH54 Rockfall for first 12km from south of SH1 - Rewa rockfall down to 1 lane. SH54 Provides an alternate route for SH1 and not full HPMV compliant - this is just for bridges, can't divert freight from SH1 down 54.	3L	-	No	Physical works ($$)	The usual geotechnical solutions like retaining walls, soil nail, benching etc will be appropriate	Yes	3	1	4	0	4	2	-	-
MW8	2	South of Eketahuna	Road	Flooding	SH2 South of Eketahuna - series of dropouts, whole corridor dropouts, risk from river flooding. No significant issues	3L	-	Yes	Physical works ($)	Currently in construction. A LC/LR solution has been put in place so we expect this issue to arise in 10-20years - therefore a business case may be required in the future to address future risk	Yes	2	2	3	0	3	2	-	-
MW13	57	Tokomaru to Linton	Road	Landslip	SH57 Tokomaru - some under slips north of Tokomaru to Linton, this is getting worse at the shoulder is quite narrow, treatable under low cost low risk. Possible realignment of road through Linton.	2L	-	No	Physical works ($)	The usual geotechnical solutions like retaining walls, soil nail, benching etc will be appropriate	Yes	3	1	4	0	4	1	-	-
MW11	1	Vinegar hill / Hunterville,	Road	Landslip	SH1 at Vinegar hill to Huntersville, is subject to reoccurring landslip events. 'Slippery' material which comes down every winter with rainfall / extreme weather events and covers the road. Stakeholders note its likely a more significant landslip event could eventually occur.	2L	-	No	BAU / Ongoing maintenance / Reactive	Business as usual reactive works	Yes	3	2	4	0	4	1	-	-
MW3	1	Waiouru	Road	Ice / Snow	Waiouru - snow and ice which closes the road, alternative route is 49 / 4, significant snow does get as far south as Taihape, can't prevent it but can manage it.	3L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	3	2	4	0	4	2	-	-

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
MW1	3	Whangaehu (link between Whanganui and Bulls)	Road	Flooding	SH3 Whangaehu area floods regularly (every 5 years). It is a critical link between Whanganui and Bulls where water generally flows over the road. The road could be built up to the same height as the bridge adjacent to it. Currently the surrounding houses and community are under water, they effectively dam the water causing it to significantly back up, therefore significant stormwater management would be needed.	4L	4VL	No	Physical works ($$)	Raise the section of the road to the east of the bridge. However, the flood waters need to cross the road corridor or the Whangaehu town will get flooded. The options are a bridge or several very large culverts. A raised embankment will not work.	Yes	2	2	3	0	3	3	3	3

A1.6 Milford Road regional risk catalogue

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
MR1	94	Along Lake Te Anau	Road	Tsunami	Significant risk of landslide induced tsunami which could be triggered in a significant earthquake event such as the Alpine Fault.	4L	-	No	Emergency response and preparedness planning only (typically HI/LF)	Emergency response planning only	No	1	3	3	0	3	3	-	-
MR2	94	Cleddau River	Road	Flooding	Cleddau River - flood risk. There are regular flooding events which inundate the road and damage structures.	4VL	4VL	No	Unknown. Pending further investigations	Difficult to address. Further work required. Address through integrated route strategy with MR3, MR5 and MR11	Unsure	3	3	3	0	3	3	3	3
MR3	94	Eglington River	Road	Flooding	There are regular flooding events which inundate the road and damage structures. The river is a wide braided river which aggrades. There are current operating flood protection structures. Each year material is removed from under the bridge as it builds up.	4L	4VL	No	Unknown. Pending further investigations	Difficult to address. Further work required. Address through integrated route strategy with MR2, MR5 and MR11	Unsure	3	1	3	0	3	3	3	3
MR4	94	Hollyford Rd to Chasm	Road	Avalanche	Avalanche risk for the winter season is the major focus which drives most of the work throughout winter (April/May-October/November). Twice a day there is an avalanche hazard forecast put out which drives public access, restrictions and control work. Climate trends: winter is arriving later but staying longer. This affects tourism. Increased precipitation and snow – however more rain on snow increases the risk. Risk level is rising with annual increasing traffic volumes.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Ongoing prevention	Unsure	3	2	3	0	3	3	3	3
MR5	94	Hollyford River	Road	Flooding	Flood risk on the Hollyford River. There are regular flooding events which inundate the road and damage structures.	4L	4VL	No	Unknown. Pending further investigations	Difficult to address. Further work required. Address through integrated route strategy with MR2, MR3 and MR11	Unsure	3	2	3	0	3	3	3	3

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
MR6	94	Homer Tunnel	Tunnel	Earthquake / liquefaction	Reinvestment issues for tunnel. There is a BC being developed for replacement portal/protection structures to build resilience for future earthquake, rockfall and avalanche events. The structure is ageing and will soon become a historic site, this will limit the works that can occur on the tunnel. A heritage assessment is currently in draft but recommends some very intensive improvement and maintenance works to protect the nature of the site.	4L	-	No	Physical works ($$$)	A smart design for replacement of the tunnel portals could deal with strengthening and upgrading, aiding avalanche and rockfall risks at the same time. In short term, Rockfall prevention measures e.g. scaling, fences and bunds. But has cross over with avalanche zone - avalanches will destroy rockfall structures. Longer term needs to reinforce and upgrade the portals/tunnel before it is designated as a historical site. A smart design for replacement of the tunnel portals could deal with strengthening and upgrading, aiding avalanche and rockfall risks at the same time. Portals are under the largest avalanche zones. In addition, remote control avalanche systems could be employed. This is a significant tourism route and also safety issues.	Yes	1	3	3	0	3	3	-	-
MR17	94	Homer Tunnel	Tunnel	Avalanche	Significant reinvestment issues for tunnel and portals but there is a BC being developed for replacement portal/protection structures. Resilience for future EQ/Rockfall. The structure is ageing, soon to be a historic site – heritage assessment currently in draft but recommends some very intensive improvement and maintenance works to protect nature of the site.	4L	4VL	No	Physical works ($$$$)		Yes	3	2	3	0	3	3	3	3
MR16	94	Homer Tunnel	Tunnel	Rockfall	Reinvestment issues for tunnel and portals but there is a BC being developed for replacement portal/protection structures. Resilience for future EQ/Rockfall. The structure is ageing, soon to be a historic site – heritage assessment currently in draft but recommends some very intensive improvement and maintenance works to protect nature of the site.	4VL	-	No	Physical works ($$$)		Yes	3	3	3	0	3	3	-	-
MR13	94	Milford Rd - Te Anau to Park boundary	Road	Wildfire	Fires affecting SH94 from adjacent farmland and/or DOC lands (2 in 10 years)	4UL	4L	Yes	Enhanced proactive maintenance	Help advise park users of fire risks & have response available e.g. VMS and stopping points	No	2	1	3	0	3	3	3	2
MR15	94	Milford Rd - Te Anau Downs to Milford	Road	Landslip	Landslides and under slip risk in a number of locations.	4VL	-	No	Enhanced proactive maintenance	Preventative works and repairs	No	3	3	3	0	3	3	-	-

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
MR14	94	Milford Road	Road	Earthquake / liquefaction	Significant earthquake risk across entire length of Milford road.	4L	-	Yes	Enhanced proactive maintenance	Monitoring and response procedures	No	1	3	3	0	3	3	-	-
MR10	94	Milford Road	Road	Extreme Weather	Tree fall due to extreme weather is a significant risk that is partly managed through an extensive tree removal programme however this is still resulting in significant residual risk which is likely to increase due to climate change. Tree fall hazard has led to fatalities in the last 5 years. The tree fall risk strategy in place primarily focuses on investment over time for managing (>3000 at present) and removing trees from along the roadside.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	Unsure	3	1	3	0	3	3	3	3
MR7	94	Milford Road Bridges	Bridge	Flooding	In addition to the individually listed bridges, there are a number of 1-way truss and concrete bridges that are at risk to flooding. Greater than 30 bridges experience 8-9m of rain every year. Currently the alliance handles this well, however a single failure will break the entire network. A number of the bridges require ongoing work however, a reduction in bridge maintenance funds by NZTA will limit the amount of work that can be completed.	4L	4VL	No	Enhanced proactive maintenance	Enhanced maintenance	Yes	2	3	3	0	3	3	3	3
MR9	94	Milford Township	Road	Flooding	Flood risk. Currently there are a number of flood protection works being carried out to protect property. However, there is residual risk, but this is less of a highway risk. DOC have some ongoing work that involves increasing the ground level of Milford by 0.5-1m, as a significant portion of Milford is on reclaimed land and flood plain/fan. To provide slightly more protection for SLR and tsunami.	4L	4VL	No	Physical works ($$)	Raise village height and build higher stop banks. Some work is already underway	Yes	3	2	3	0	3	3	3	3

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
MR8	94	Milford Township	Road	Tsunami	Significant risk of landslide induced tsunami which could be triggered in a significant earthquake event such as the Alpine Fault. Also, tsunami waves at Milford Township from offshore sources.	4L	-	No	Emergency response and preparedness planning only (typically HI/LF)	Emergency response planning only	No	1	3	3	0	3	3	-	-
MR11	94	Upukerora River	Road	Flooding	There are semi regular flooding events that inundate the road and damage structures.	4L	4VL	No	Unknown. Pending further investigations	Difficult to address. Further work required. Address through integrated route strategy with MR2, MR3 and MR5	Unsure	2	3	3	0	3	3	3	3

A1.7 Northland regional risk catalogue

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
N36	1	Awanui	Road	Flooding	Lack of catchment, no catchment clearance, forestry roads, slow land movement, issues with geology, no detour for SH 1 in the north, beach road a "worry" CDEM decision	3L	-	No	Emergency response and preparedness planning only (typically HI/LF)	Unsealed roads that could be sealed, no local roads that loop only option is forestry	Yes	1	3	2	0	2	3	-	-
N2	12	Between Ruawai and Paparoa	Road	Flooding	Culverts being damaged and popping up the road. There is a test design underway to ensure that there is something in place to be able to respond	3L	-	No	Physical works ($$)	Further investigations needed	Yes	2	3	2	1	3	2	-	-
N1	1	Brynderwyn to Ruakaka	Road	Landslip	Landslip risk on Brynderwyn hills, and limited detour HPMV incapable. No HMPV both ways. Detour route has a number of 1-way bridges. If the Brynderwyn route is out, the whole upper north is out. Currently working on the major detour route to address the risk to Brynderwyn. There are also a lot of outages because of accidents and breakdowns etc. Southern side has more issues. Traffic going south goes through Mangawhai and north goes through Paparoa.	4VL	-	No	Physical works ($$$$)	Short term solution is to upgrade alternate routes. Costs for this will likely be less than construction of a new alignment. There is a wider PBC under way to look at a range of options.	Unsure	3	3	4	0	4	3	-	-
N38	10	Cable Bay	Road	Coastal Inundation / SLR	Coastal erosion and slips	2L	2VL	No	Unknown. Pending further investigations	Further investigations needed	Unsure	3	2	2	0	2	2	3	3
N46	1	Dome valley	Road	Landslip	More accident related	3L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	3	1	5	0	5	1	-	-
N42	15	Entire length of SH15	Road	Flooding	Flooding all along SH15.	2L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	3	2	2	0	2	2	-	-
N3	16	Entire length of SH16	Road	Flooding	Flood risk to route. It is the only alternate route for SH1, but it is not a high-quality section of road. During the holiday season they strongly advise people to take SH16. Due to it being a key alternate route it should be higher than a primary collector. The ONF will look to address this.	4L	-	No	Unknown. Pending further investigations	Requires a detailed study	Unsure	3	2	2	1	3	3	-	-

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N5	1	Hikurangi Swamp	Road	Flooding	SH15 and 14 are generally a result of SH1 flooding.	3L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	3	2	4	0	4	2	-	-
N43	14	Hikurangi Swamp - Whole river catchment down to the Western inlet which takes out all roads across Sh1, SH15 and SH12.	Road	Flooding	All flooding occurs around the swamp and takes out all roads. 1 in 5 years. Rail has been built	2L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	3	2	2	0	2	2	-	-
N40	14	Hikurangi Swamp Flooding	Road	Flooding	Flooding between Dargaville and Whangarei	2L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	3	2	2	0	2	2	-	-
N22	11	Hururu Falls to Ridglen Road	Road	Coastal Inundation / SLR	Coastal inundation occurs over the road for approximately 8 hours over high tide.	1UL	1L	No	BAU / Ongoing maintenance / Reactive	Could raise the road	Yes	1	2	2	0	2	1	2	3
N6	12	Inlet in Opononi	Road	Coastal Inundation / SLR	SLR and coastal inundation	3L	3VL	No	Physical works ($$$)	Short fix strengthening, midterm fix, existing works stopped the erosion, but still an issue. Raise the road? Need to raise land as well.	Yes	3	2	2	1	3	2	3	3
N26	10	Kaeo	Road	Flooding	Frequent flood area that is being partially addressed through current works. However likely to remain a flood issue in the future.	2VL	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	3	3	2	0	2	2	-	-
N7	15	Kaikohe to Pakotai	Road	Landslip	Fastest route to port, relevant for logging (ONRC increase)	3L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	2	3	2	1	3	2	-	-
N31	11	Kawakawa	Road	Flooding	Significant flooding especially with tides	2L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	3	1	2	0	2	2	-	-
N39	10	Kerikeri	Road	Flooding	Urban development, lack of storm water facilities	2L	-	No	Enhanced proactive maintenance	No meetings with local authorities, need more connected “convos”, systematic issue - strategic road network plan (storm water)	Yes	3	2	2	0	2	2	-	-
N8	12	Length of SH12 north of Dargaville	Road	Flooding	Culverts blocked	3L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	3	2	2	1	3	2	-	-
N9	16	Lookout slip	Road	Landslip	Significant landslip risk - Slip has occurred, there is a solution, but it has not been funded.	4L	-	No	Physical works ($)	Realign road as it could be a significant issues. Low cost low risk. Already designed.	Yes	2	3	2	1	3	3	-	-
N33	1	Mangamuka to Okaihau	Bridge	Flooding	Flood risk along SH1 where the Mangamuka and Waihou Rivers come close to the road.	2L	-	No	Enhanced proactive maintenance	There is funding for Mangamuka River but no funding for Waihou River. Could be solved by improving the catchment management (drainage)	Yes	3	1	2	0	2	2	-	-

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N37	10	Matauri Bay Road to Taupo Bay Road	Road	Landslip	Detour for SH 1	2L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	2	3	2	0	2	2	-	-
N28	1	Maungataniwha Range	Road	Landslip	Landslips due to heavy rainfall occur through the Maungataniwha ranges. There are currently no VMS boards to be able to inform road users of closures.	2L	-	No	Emergency response and preparedness planning only (typically HI/LF)	Emergency response planning only	Unsure	1	3	2	0	2	2	-	-
N12	1	Oakley and Mata Flooding	Road	Flooding	Combined coastal inundation and river flooding risk. Key freight route. Used to occur every 5 years. Has been blocked twice in less than 10 years. Catchment boards involved in flood risk management were lost in the amalgamation of councils.	4L	4VL	No	Unknown. Pending further investigations	Requires a detailed study	Unsure	3	2	4	0	4	3	3	3
N23	15	Otaika Valley	Road	Flooding	Typically, short term surface flooding which clears quickly.	1L	-	No	BAU / Ongoing maintenance / Reactive	Further investigations needed	Unsure	3	1	2	0	2	1	-	-
N29	10	Pakaraka to Awanui	Road	Landslip	Landslip risk across SH10 from Pakaraka to Awanui which causes disruption. This is also the main detour route for SH1.	1L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	2	3	2	0	2	1	-	-
N4	1	Ruakaka and Whangarei	Road	Flooding	Flood risk between Ruakaka and Whangarei. Both river and tidal flooding during king tides. Typically, when there are issues on the SH there are issues on the local roads so there are no alternate options.	5L	5VL	No	Unknown. Pending further investigations	Requires further detailed study.	Unsure	3	2	5	0	5	3	3	3
N14	12	Ruawai	Road	Flooding	Almost identical to SH14 flooding. Massive tidal surge. Prominent tourist route	3L	3VL	No	Enhanced proactive maintenance	Lifting the road, better drain management currently but with SLR then potentially raising the road.	Yes	3	2	2	1	3	2	3	3
N41	12	Ruawai to Brynderwyn	Road	Landslip	Slips and flooding between Ruawai and Brynderwyn. 5-10 years like to get worse with CC	3L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	3	1	2	1	3	2	-	-
N32	1	Schedways	Road	Landslip	Constantly moving but P2W will bypass	2L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	3	1	4	0	4	1	-	-
N15	1	South of Kawakawa	Road	Landslip	Landslip risk. Lack of detour unless travellers go onto SH 15 (> 4 hours detour), detour would cause issues for trucks.	4L	-	No	Unknown. Pending further investigations	Requires a detailed study	Yes	2	3	3	0	3	3	-	-
N44	15	South of twin bridges	Road	Landslip	Landslips occur along the road adjacent to the river south of the twin bridges.	2L	-	No	Enhanced proactive maintenance	Further investigations needed	Yes	3	2	2	0	2	2	-	-

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N34	12	Te Pouahi to Waiotemarama	Road	Landslip	No detour, relevant for tourism (ONRC increase)	4L	-	No	Unknown. Pending further investigations	Requires a detailed study	Unsure	2	3	2	1	3	3	-	-
N27	1	Tehana Bridge	Bridge	Flooding	Critical rail and road bridge. Look to upgrade the detour - waybe valley road floods, tidal flooding which could get worse with CC.	2L	2VL	No	Unknown. Pending further investigations	Work with AT, they have identified it as a key route. Potentially try and address flooding	Yes	3	1	4	0	4	1	3	3
N16	12	Tokatoka Bluff	Road	Rockfall	Highest priority in risk register	3L	-	No	Physical works ($$$)	Potentially realign the road because it would also address the coastal erosion.	Yes	2	3	2	1	3	2	-	-
N17	1	Turntable hill	Bridge	Flooding	Flooding of approaches at Turntable hill bridge	3L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	2	3	2	0	2	3	-	-
N13	Twin Coast Discovery Road	Twin Coast Discovery Road - Herekino Forest	Road	Landslip	Largest area of slips/geological movement in the area, probably most exposed area.	3VL	-	No	Physical works ($$$)	BC developed, multi hazard area needs thought.	Yes	3	3	2	0	2	3	-	-
N18	12	Waipoa Forest	Road	Flooding	Removing trees due to Kauri Die back has increased flooding issues along SH12 through Waipoa Forest. $1.5M has already been spent to repair roads from damage caused by excavating trees.	4L	-	No	Unknown. Pending further investigations	Requires further detailed study.	Unsure	3	2	3	2	5	2	-	-
N19	12	Waipoa Forest	Road	Landslip	Land stability issues along the stretch of SH12 through Waipoa forest	3L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	3	2	2	1	3	2	-	-
N10	1	Wayby Road on SH1	Road	Landslip	Existing landslip, however, there has been no work done to understand the landslip risk. Ongoing land movement.	4VL	-	No	Unknown. Pending further investigations	Requires further detailed study.	Unsure	3	3	4	0	4	3	-	-
N24	Wayby Valley Road	Wayby Valley Road Detour route	Road	Flooding	Flooding along Wayby Valley Rd which is a key detour route.	1L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	3	1	2	0	2	1	-	-
N45	16	Wellsford to Punganui	Road	Landslip	Landslip risk from Wellsford to Punganui	3L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	2	2	2	1	3	2	-	-

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O1	8	Alexandra to Clarkes Junction (Milton)	Road	Ice / Snow	Risk from snow and ice.	4L	-	No	Physical works ($$)	Winter maintenance LOS and improved communication. VMS required at each end of route where alternative routes exist	Yes	3	2	3	0	3	3	-	-
O3	8	Alexandra to Clarkes Junction (Milton)	Road	Landslip	Shingle Creek landslip feature. Manuka Gorge, tight narrow alignment through a gorge with lots of rock bluffs and areas of fill.	3L	-	No	Physical works ($$$)	Retaining walls and drainage	Yes	3	2	3	0	3	2	-	-
O2	8	Alexandra to Clarkes Junction (Milton)	Road	Rockfall	Isolated areas of rockfall. Unlikely to warrant capital intervention at this stage.	3L	-	No	BAU / Ongoing maintenance / Reactive	Minor rockfall and can be addressed through Emergency Works if required	Yes	3	1	3	0	3	2	-	-
O23	86	Allanton to Dunedin Airport	Road	Flooding	Airport is at or just below SL, protected by stop banks but has flooded a couple of times. Pump system could potentially work however you get lower and lower ground level as you head towards the airport.	2UL	2L	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance to ensure SWC and culverts are clear pre-event	No	2	1	3	0	3	1	3	1
O4	1	Balclutha Bridge	Bridge	Flooding	Flooding of the Balclutha river has potential to impact / compromise the Balclutha Bridge. This is the only bridge and detour routes are significant.	4L	4VL	No	Unknown. Pending further investigations	Requires a detailed study	Unsure	2	2	3	0	3	3	3	3
O15	1	Big Kuri River	Road	Flooding	Big Kuri River north of Hampden deposits a large amount of gravels which causes water to flow over the bridge. 4-5-hour detour.	4L	4VL	No	Physical works ($$$)	The plan is to wait for the bridge to get to the end of its life then construct a new bridge with improved freeboard.	Yes	3	2	4	0	4	3	3	3
O46	8	Cromwell to Alexandra	Road	Landslip	Cromwell Gorge landslip risk. Numerous active landslips throughout the man-made Cromwell Gorge (part of the Clyde Dam construction). Actively dewatered on an ongoing basis to maintain slope stability.	4L	-	No	Physical works ($)	Corridor investigation to determine vulnerable areas and possible solutions to mitigate	Unsure	2	3	3	0	3	3	-	-
O5	8	Cromwell to Alexandra	Road	Rockfall	Cromwell Gorge and Clyde Dam, current LCLR investigation project. A low number of rockfalls have occurred in the past, however there is potential for future rock fall. Relaxed and partially cracked benches which have accumulated debris and pose future risks.	4L	-	Yes	Physical works ($$)	Scaling, stabilisation and catch fences/structures	Yes	2	3	3	0	3	3	-	-

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O8	6	Cromwell to Frankton	Road	Landslip	Landslip risk throughout the Kawarau Gorge. Some LCLR investigation work underway.	4VL	4VL	No	Physical works ($$$)	Retaining walls and drainage improvements	Yes	3	3	3	0	3	3	3	3
O6	6	Cromwell to Frankton	Road	Ice / Snow	Risk from snow and ice.	4L	-	No	BAU / Ongoing maintenance / Reactive	Winter maintenance LOS and improved communication. Additional VMS required at selected locations along route where alternative routes exist	Yes	3	2	3	0	3	3	-	-
O7	6	Cromwell to Frankton	Road	Rockfall	Sites at risk to rockfall throughout the Kawarau Gorge.	4VL	-	No	Physical works ($$$)	Scaling, stabilisation and catch fences/structures	Yes	3	3	3	0	3	3	-	-
O37	1	Dunedin to Mosgiel	Road	Ice / Snow	Snow & Ice	3L	-	No	Enhanced proactive maintenance	Winter maintenance LOS and improved communication. VMS required at each end of route where alternative routes exist	Yes	3	1	4	0	4	2	-	-
O53	88	Dunedin to Port Chalmers	Road	Coastal Inundation / SLR	Multiple low-lying areas and therefore potential to be exposed to coastal inundation in the future	3UL	3VL	No	Unknown. Pending further investigations	Further investigations needed	Unsure	1	1	4	0	4	2	3	3
O45	88	Dunedin to Port Chalmers	Road	Earthquake / liquefaction	Constructed as side cast fill – cut into the bank and the compacted the fill on the side so one good lane and one lane that is likely to slip in an earthquake. Rail would likely be knocked out as well as it is on fill and therefore would rely on shallower draft ships to drop off goods into Dunedin. Rail is part of the South Island main trunk line from Christchurch to Bluff. Event would be significant to take out the highway and the rail – significant or local EQ.	3L	-	No	Emergency response and preparedness planning only (typically HI/LF)	Corridor investigation to determine vulnerable areas and possible solutions to mitigate	Unsure	1	3	4	0	4	2	-	-

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O9	88	Dunedin to Port Chalmers	Road	Landslip	Constructed as side cast fill – cut into the bank and the compacted the fill on the side so one good lane and one lane that is likely to slip in an EQ. Corridor which probably needs a holistic view across its whole length. Freight and rail would likely be knocked out as well as it is on fill and therefore would rely on shallower draft ships to drop off goods. This is the main trunk line from CHCH to Bluff. Slips occur during storm events as a result of water coming down from hillsides. Small washouts of roadside barriers also occur.	3VL	3VL	Yes	Physical works ($$$)	Retaining walls and drainage in the short term, with wider investigation required for the longer term	Yes	3	3	4	0	4	2	3	3
O40	88	Dunedin to Port Chalmers	Road	Ice / Snow	Snow & Ice	3L	-	No	Enhanced proactive maintenance	Winter maintenance LOS and improved communication. VMS required at each end of route where alternative routes exist	Yes	3	1	4	0	4	2	-	-
O34	6	Frankton to Kingston	Road	Ice / Snow	Risk from snow and ice.	4L	-	No	BAU / Ongoing maintenance / Reactive	Winter maintenance LOS and improved communication. VMS required at each end of route where alternative routes exist	Yes	3	1	3	0	3	3	-	-
O48	6	Frankton to Kingston	Road	Landslip	Landslips along the side of Lake Wakatipu.	4VL	-	No	Unknown. Pending further investigations	Corridor investigation to determine vulnerable areas and possible solutions to mitigate	Unsure	3	3	3	0	3	3	-	-
O42	6A	Frankton to Queenstown	Road	Ice / Snow	Snow & Ice	3L	-	No	Enhanced proactive maintenance	Winter maintenance LOS and improved communication. Small urban style VMS required at each end of route where alternative routes exist	Yes	3	1	3	1	4	2	-	-
O10	6a	Frankton to Queenstown	Road	Landslip	Only route that links Queenstown and airport; alternate route would take an extra hour, however, is complicated by the single lane Edith Cavell bridge. SH6a is built on landslides, is the key route between Qtown and airport. Several known active and monitored slips	3L	3VL	No	Physical works ($$$$)	Retaining walls and drainage	Unsure	2	3	3	0	3	2	3	3
O11	6	Haast Pass to Lake Hawea	Road	Ice / Snow	Risk from ice and heavy snow. Passes through a national park with overhanging trees, prone to falling.	4L	-	Yes	Enhanced proactive maintenance	Winter maintenance LOS and improved communication	Yes	3	2	3	0	3	3	-	-

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O50	6	Haast to Hawea	Road	Rockfall	Numerous large scale rockfall locations along the corridor. Improved funding would be a starting point to improve resilience but not resolve the issue in its entirety. Funding currently allocated through the National Rockfall programme to address isolated high priority sites with a supporting Rockfall Hazard Rating System (RHRS) score.	4VL	-	No	Physical works ($$$)	Scaling, stabilisation and catch fences/structures	Unsure	3	3	3	0	3	3	-	-
O41	6	Hawea to Cromwell	Road	Ice / Snow	Snow & Ice	3L	-	No	Enhanced proactive maintenance	Winter maintenance LOS and improved communication. VMS required at each end of route where alternative routes exist	Yes	3	1	3	0	3	2	-	-
O12	1	Katiki Coast	Road	Coastal Erosion	Both bottom up and top down erosion along the coast. Some coastal erosion funding has been provided. If coastal route is gone there is a light vehicle detour but heavy's will be 4-5 hours. Mini Kaikoura as KiwiRail is located directly next to the road. The only coastal section of SH1 and vulnerable to high seas and erosion.	3VL	3VL	No	Physical works ($$$)	Continuation of rock revetment. Assessment and development of overland flow measures to prevent top down erosion.	Yes	3	3	4	0	4	2	3	3
O13	1	Katiki Coast	Road	Coastal Inundation / SLR	Only coastal section of SH1 and vulnerable to high seas and inundation. Some bridges are within 2m of high tide level	3VL	3VL	No	Physical works ($$$)	Requires continuation of rock revetment.	Yes	3	3	4	0	4	2	3	3
O14	1	Katiki Coast	Road	Tsunami	Coastal section exposed to tsunami.	3L	-	Yes	Physical works ($$$)	Partially funded Further funding will be required to continue rock revetment to armour toe of the slope against SLR and tsunami impact	Yes	1	3	4	0	4	2	-	-
O38	83	Kurow to Omarama	Road	Ice / Snow	Snow & Ice	2L	-	No	Enhanced proactive maintenance	Winter maintenance LOS and improved communication. VMS required at each end of route where alternative routes exist	Yes	3	1	2	0	2	2	-	-
O47	6	Lake Hawea and Lake Wanaka	Road	Landslip	Landslips along the side of lakes Wanaka & Hawea. This links to risk Id WC9 which identifies landslip issues along Haast Pass.	4VL	-	No	Unknown. Pending further investigations	Corridor investigation to determine vulnerable areas and possible solutions to mitigate	Unsure	3	3	3	0	3	3	-	-

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O15	1	Maheno	Bridge	Flooding	Flooding issues within a number of river catchments. Options have been scoped. Overland flow path floods the road between Clarks Mill and where the road crosses the railway. There is a plan to put culverts in to allow water to run from one side of the road to the other to stop flooding. When this floods the bridge also floods and the detour is ~ 4-5 hours.	4L	4VL	No	Physical works ($$)	Upgrade culverts and overland flow paths.	Yes	3	2	4	0	4	3	3	3
O31	87	Mosgiel	Road	Flooding	Heavy rainfall results in surface flooding through Mosgiel on SH97. Often the first 2km of the road gets closed to protect the local businesses to stop water washing into buildings when cars drive by.	2L	2VL	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance to ensure drainage structures are clear pre-event	No	3	1	2	1	3	1	3	3
O44	1	Mosgiel to Gore	Road	Ice / Snow	Snow & Ice	3L	-	No	Enhanced proactive maintenance	Winter maintenance LOS and improved communication. VMS required at each end of route where alternative routes exist	Yes	3	2	3	0	3	2	-	-
O30	87	Mosgiel to Kyeburn	Road	Rockfall	There are isolated areas of minor rockfall along SH87 from Mosgiel to Kyeburn however it is thought to not be a significant enough issue for capital intervention.	2L	-	No	BAU / Ongoing maintenance / Reactive	Minor rockfall and can be addressed through EW if required	Yes	3	1	2	0	2	2	-	-
O51	6	Nevis Bluff	Road	Rockfall	Nevis Bluff is a significant unstable feature between Cromwell and Queenstown. Proactive monthly inspections are undertaken and programmed rock scaling pre & post winter to remove fractured material is funded and managed through the NOC. Regular additional funding is required to address high other priority/urgent unstable features in the order of $1M-$5M per intervention. Alternate long-term options could be investigated such as a tunnel.	4VL	-	No	Enhanced proactive maintenance	More detailed investigation required which would assess all possible options. Continued proactive monitoring and maintenance intervention	Unsure	3	3	3	0	3	3	-	-

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O16	8	Omarama to Tarras	Road	Ice / Snow	Continuous snow in winter. Winter events affect both sides of Lindis Pass. This is within the corridor management plan from Christchurch to Queenstown.	4L	-	Yes	Enhanced proactive maintenance	Winter maintenance LOS and improved communication	Yes	3	2	3	0	3	3	-	-
O49	8	Omarama to Tarras	Road	Landslip	Land instability around Cluden Hills area north of Tarras	3L	-	No	Physical works ($)	Retaining wall and drainage	Yes	2	2	3	0	3	2	-	-
O17	8	Omarama to Tarras	Road	Rockfall	Rockfall risk predominantly to the south of Lindis Pass (Central Otago side).	4L	-	No	Physical works ($$)	Scaling, stabilisation and catch fences/structures. Detail in the corridor management plan.	Yes	3	2	3	0	3	3	-	-
O35	87	Outram to Kyeburn	Road	Ice / Snow	Snow & Ice	2VL	-	Yes	Enhanced proactive maintenance	Winter maintenance LOS and improved communication	Yes	3	3	2	0	2	2	-	-
O22	85	Palmerston to Alexandra	Road	Ice / Snow	Snow and ice, closed half a dozen times a year	3L	-	Yes	Enhanced proactive maintenance	Winter maintenance LOS and improved communication	Yes	3	2	2	0	2	3	-	-
O25	85	Palmerston to Alexandra	Road	Landslip	Dead Horse Pinch is a section of highway built on poor material. Monitored twice a year with a ground-based survey and gradually moving downhill. Repeat intervention to maintain ride quality and safety. Williamsons landslip near Lauder. Slow gradual movement with repeated intervention. Secondary collector route – would be wanting to put money into SH 8 first	2L	2VL	No	Physical works ($$)	Retaining wall and drainage	Yes	2	2	2	0	2	2	3	3
O29	85	Palmerston to Alexandra	Road	Rockfall	There are isolated areas of minor rockfall along SH85 from Palmerston to Alexandra however it is thought to not be a significant enough issue for capital intervention.	2L	-	No	BAU / Ongoing maintenance / Reactive	Minor rockfall and can be addressed through EW if required	Yes	3	1	2	0	2	2	-	-
O36	1	Palmerston to Dunedin	Road	Ice / Snow	Snow and ice risk.	4L	-	Yes	Enhanced proactive maintenance	Winter maintenance LOS and improved communication	Yes	3	2	4	0	4	3	-	-
O26	90	Pomahaka Bridge	Bridge	Flooding	There is regular flooding of the river where a significant amount of debris catches around bridge. This typically results in water spilling over and flooding the northern approach to bridge	1L	1VL	No	Physical works ($$$)	Raise the level of the northern approach, install culverts	Yes	3	2	2	0	2	1	3	3

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O33	83	Pukeuri to Omarama	Road	Flooding	SH83 from Pukeuri to Omarama is subject to flooding. There are effectively two separate climates across the stretch of road the coastal section and the dryer inland section where flooding is induced by two different mechanisms. Increased dairy farming which has therefore increased the amount of irrigation has reduced the lands ability to absorb heavy rainfall along the coastal section of the route. Farmers have also closed over the old overflow / flood pathways and which result in flooding of the highway instead. Inland is barren and dry and therefore slightly different issues. There are also a number of culverts which block in very large rainfall events due to heavy rainfall on gravely slopes.	2L	-	No	Enhanced proactive maintenance	Ongoing maintenance to ensure drainage structures are clear pre-event. Working through minor drainage improvements as part of annual plan funding	Yes	3	2	2	0	2	2	-	-
O19	6	Queenstown to Frankton	Road	Landslip	Highly vulnerable to rainfall induced landslips.	4L	4VL	No	Physical works ($$$)	Retaining walls and improving lakeside stability to minimise under slips	Yes	3	2	3	0	3	3	3	3
O18	6	Queenstown to Kingston	Road	Rockfall	Highly vulnerable to rockfall.	4L	-	No	Physical works ($$$)	Scaling, stabilisation and catch fences/structures	Yes	3	2	3	0	3	3	-	-
O24	90	Raes Junction	Road	Flooding	Regular flooding at the junction of SH90 & SH8	2L	2VL	No	Physical works ($)	Routine debris removal, creek bed training, rock armouring and site concrete to prevent scour	Yes	3	2	2	0	2	2	3	3
O39	90	Raes Junction to McNab	Road	Ice / Snow	Snow & Ice	2L	-	No	Enhanced proactive maintenance	Winter maintenance LOS and improved communication. VMS required at each end of route where alternative routes exist	Yes	3	2	2	0	2	2	-	-

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
O20	8	Roxburgh	Road	Flooding	Flooding in Roxburgh which affects all assets not just road due to climate and topography of the mountains and predominant in spring due to heat inversion, 'thunder plumps / cloud bursts' generally develop on a hot sunny day. At least once a year for the last 3 years with significant flooding. Low cos Low risk project is currently underway to address some of the issues as well as a catchment study done by the regional council. Started to design the upsizing of 3 highway culverts. When it does rain heavily it brings down a massive amount or debris and block up culverts and wash out abutments. Almost debris flow like.	3L	3VL	Yes	Physical works ($$)	New increased capacity culverts under SH8. Currently being addressed under LCLR. Main link from Central Otago to Dunedin.	Yes	3	2	3	0	3	2	3	3
O32	86	SH1 to Dunedin Airport	Bridge	Earthquake / liquefaction	Bridge located on SH86 between SH1 and Dunedin airport is potentially vulnerable to liquefaction.	2L	-	No	Emergency response and preparedness planning only (typically HI/LF)	Re-engineer piles. Alternate routes exist however all use bridges to cross the same river	No	1	3	3	1	4	1	-	-
O43	8	Tarras to Alexandra	Road	Ice / Snow	Snow & Ice	3L	-	No	Enhanced proactive maintenance	Winter maintenance LOS and improved communication. VMS required at each end of route where alternative routes exist	Yes	3	1	3	0	3	2	-	-
O15	1	Waikouati River	Road	Flooding	Waikouati River floods the highway.	4L	4VL	No	Physical works ($$)	Raise level of road to clear flood level	Yes	3	2	4	0	4	3	3	3
O27	1	Waitaki Bridge	Bridge	Flooding	Waitaki bridge through to Oamaru – regular flooding. Recent seismic strengthening but a few vulnerabilities, braided river. A lot of river protection works and erosion on the north bank. Vegetation management in Longest structure in Otago. Detour adds about an hour and a half should the Waitaki Bridge get taken out. Doesn't need massive capital investment.	3L	3VL	Yes	BAU / Ongoing maintenance / Reactive	Ongoing maintenance through structures contract	Yes	3	1	4	0	4	2	3	3

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
O33	1	Waitaki Bridge to Oamaru	Road	Flooding	Hilderthorpe straight south of the Waitaki Bridge to Pukeuri is flood prone. Currently looking to address in LCLR working with KiwiRail, WDC & ORC. Some unmaintained flood channels and undersized culverts. The channels don't reach the ocean and sometimes back up and flood the area approx. one every three years. Detour route is subject to flooding in the same event so not always viable	3L	-	No	Physical works ($$)	Ditching, culvert upgrades where required, ongoing maintenance of flood channels by responsible parties (ORC)	Yes	3	2	4	0	4	2	-	-
O52	1	Waitati to Dunedin	Road	Ice / Snow	Ice and snow issues from Waitati as you pass over the hill into Dunedin	3L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	3	1	4	0	4	2	-	-
O21	1	Wakouaiti to Evansdale	Road	Landslip	The Kilmog is a very unstable length of road. Grout columns have been installed through sections of highway but are now protruding through the road surface. Haven't considered options in depth due to multimillion-dollar need. Extremely slip prone ground. National Criticality. Light traffic can use Coast Road as a detour. There are a couple of sites with options which could greatly enhance or remove the issues with the right solution.	3VL	3VL	No	Physical works ($$$)	Piling works to retain active slopes. Drainage improvements and ongoing pavement and surfacing intervention to maintain LOS	Yes	3	3	4	0	4	2	3	3

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Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
S1	1	Entire coastal section at Ocean view north of Bluff	Road	Coastal Inundation / SLR	Ocean view route to the port - risk to coastal inundation that will need to be addressed within the next 10 years. Combination of coastal and rainfall flooding at high tide resulting in traffic lanes being submerged over a length of approximately ~70m. This is the key route to the port, with no detour. Compounding issue is that the lagoon doesn't drain.	4L	4VL	No	Physical works ($$)	Raise the road for around 70m	Yes	3	1	3	0	3	3	3	3
S2	94	Gorge Hill	Road	Landslip	Landslip risk at Gorge Hill. Slip has failed previously, completely damaging the road. Currently no detour, however a subsidiary road could be built through farmers land. Has been stable, with preventative maintenance undertaken. Slumping is topped up approximately monthly. Annual visits to survey the movement. Low volume but strategic for tourist reasons. 4-hour detour.	4L	4VL	No	Emergency response and preparedness planning only (typically HI/LF)	Pre buy section in advance to be able to build an alternate/backup road.	No	1	3	3	0	3	3	3	3
S7	96	Hedgehope	Road	Flooding	Flooding from the Makarewa River - similar to Makarewa Junction	2UL	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	2	1	2	0	2	2	-	-
S8	6	Makarewa Junction	Road	Flooding	Flooding from the Makarewa River - similar to Hedgehope	2UL	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	2	1	3	0	3	1	-	-
S10	90	Mataura River	Bridge	Earthquake / liquefaction	Mataura river bridge is the most vulnerable to seismic hazard in the southland region and has no funding allocated for any maintenance works under LC/LR.	2L	-	No	Emergency response and preparedness planning only (typically HI/LF)	Emergency response planning only	No	1	3	3	0	3	1	-	-
S4	99	McCracken's Rest	Road	Landslip	McCracken's rest land stability. visited site once in 11 years. there is a detour for small vehicles but minimal for heavies.	2L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	2	2	2	0	2	2	-	-
S6	90	Old Coach Road	Road	Rockfall	Old coach road - minor rockfall	3UL	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	1	1	3	0	3	2	-	-

A1.10 Taranaki regional risk catalogue

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
T2	3	Awakino gorge	Road	Rockfall	Rockfall risk, erosion drop out, over and under slips and severe weather (>2m rainfall a year). This is a priority for significant rockfall and vegetation removal (due to rockfall). Currently Awakino Gorge tunnel only bypasses ~500m of the gorge. Difficult to predict where rockfall will occur next, therefore difficult to plan for unless the entire 8km was realigned. High risk gorge environment with no viable detour.	4L	-	No	Physical works ($$$)	Rockfall protection, mesh, clearing material and retaining walls.	Yes	3	2	3	0	3	3	-	-
T14	3	Awakino Village	Road	Coastal Erosion	Awakino Village at risk of coastal erosion.	4L	4VL	No	Physical works ($$)	In the short term continue rock fencing. Realignment and smoothing the corner and cut into the bluff is the long-term solution. ~60-70m bluff.	Yes	2	2	3	0	3	3	3	3
T3	3	Entire length of SH3 north of New Plymouth	Road	Landslip	Landslip risk to strategic highway on Taranaki network. Lack of viable alternative route with the nearest detour being SH4, adding a large amount of time and distance. Substantial geotechnical structures for slope instability along the road south of Piopio (in the gorges). Some structures are very old.	4L	4VL	No	Physical works ($$)	Requires a detailed study	Unsure	3	2	3	0	3	3	3	3
T4	3	Entire length of SH3 north of New Plymouth	Road	Rockfall	Significant rockfall risk.	4L	-	No	Physical works ($$)	Requires a detailed study	Unsure	3	2	3	0	3	3	-	-

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
T5	43	Entire length of SH43	Road	Extreme Weather	Severe weather events, under and over slips, flooding the entire length of SH43 ~ 150km. No detour routes, it is not a suitable detour route for SH3 because its already down to 1 lane due to slips and dropouts and not suitable as a detour due to its low resilience. Project would be transmission gulley to solve the issues. A few structures which are currently being maintained but in terms of upgrading its not seen as viable. In terms of tourism it is seen as a key highway.	3L	-	No	Unknown. Pending further investigations	Massive realignment of road	Yes	3	2	2	0	2	3	-	-
T6	43	Entire length of SH43	Road	Landslip	Severe weather events, under and over slips, flooding the entire length of SH43 ~ 150km. No detour routes, it is not a suitable detour route for SH3 because its already down to 1 lane due to slips and dropouts and not suitable as a detour due to its low resilience. Project would be transmission gulley to solve the issues. A few structures which are currently being maintained but in terms of upgrading its not seen as viable. In terms of tourism it is seen as a key highway.	3L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	3	2	2	0	2	3	-	-
T8	3	Mangaotaki gorge	Road	Landslip	Mangaotaki Gorge is at risk of landslip. Currently has no geotechnical barriers.	4L	4VL	No	Physical works ($$$)	Active/priority sites have been funded but the whole corridor has a resilience issues. Retaining walls.	Yes	3	2	3	0	3	3	3	3
T9	4	Mapara North road through to Ohura road	Road	Flooding	Occurs from approximately 12km in Mapara North road through to Ohura road - over slip, under slip and localised flooding during extreme weather. Requires preventative maintenance works. Waterfall Hills - reasonable geotechnical remediation being put in place to address under slip and bluff rock fall.	3VL	3VL	No	Physical works ($$)	Further investigations needed	Unsure	3	3	2	0	2	3	3	3

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
T10	3	Mohakatino and Tongaporutu estuaries	Road	Coastal Inundation / SLR	Mohakatino and Tongaporutu estuaries could potentially have coastal inundation and erosion issues.	4L	4VL	No	Unknown. Pending further investigations	Requires a detailed study	Unsure	2	2	3	0	3	3	3	3
T12	3	Mohakatino Bridge	Road	Coastal Erosion	Potential for erosion risk due to it being low lying and in an estuary. The causeway is very narrow and vulnerable to erosion due to wave action. Currently a low cost, low risk project to provide rock armour. One side of the wall had rock armour which has been washed out. Could have coastal inundation issues in the future, however the geomorphology of the estuary could change this.	4L	4VL	No	Physical works ($$)	Rock armour improvements in the short term, but needs a long-term plan	Yes	2	2	3	0	3	3	3	3
T13	3	Mokau Bluff	Road	Erosion	Mokau Bluff, at risk of coastal erosion.	4L	4VL	No	Physical works ($$)	In the short term continue rock fencing. Realignment and smoothing the corner and cut into the bluff is the long-term solution. ~60-70m bluff.	Yes	2	2	3	0	3	3	3	3
T15	3	Mt Messenger	Road	Landslip	South of Mt Messenger is at risk of landslip- Uruti Valley has a number of cuttings prone to slipping.	4L	4VL	No	Unknown. Pending further investigations	Requires a detailed study	Unsure	3	2	3	0	3	3	3	3
T16	3	Patea Bridge	Bridge	Erosion	Bridge built between 60's-70's at risk to erosion.	4L	4VL	No	Physical works ($$)	Strengthening or realignment of the bridge would be a more beneficial outcome in comparison to a new route.	Yes	2	2	3	0	3	3	3	3
T17	45	Ratahei to Whanganui	Road	Landslip	Raetihi to Whanganui major landslip which occurred in 2019. This already has a PBC underway.	3VL	3VL	Yes	Physical works ($$$$)	PBC already underway	Yes	3	3	2	0	2	3	3	3
T19	3	SH3 Midhurst rail overbridge	Road	Erosion	SH3 Midhurst rail overbridge has the potential for erosion and scour - which may in turn affect the road below. The detour route is also very long and is not ideal for HPMV.	4L	4VL	No	Unknown. Pending further investigations	There is no specific risk at the moment, but the solution should be similar to what occurred in Normandy, bridge realignment and creation of a viable detour. Main pinch points are all bridges with no detour routes.	Yes	3	2	3	0	3	3	3	3

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T18	3	SH3 Midhurst rail overbridge	Road	Flooding	SH3 Midhurst rail overbridge has the potential for flooding. The rail and river bridge are back to back with detours that are not ideal for HPMV. The detour route is also very long. There is no specific hazard at the moment, but the solution should be similar to what occurred in Normandy, bridge realignment and creation of a viable detour. Main pinch points are all bridges with no detour routes.	4L	4VL	No	Unknown. Pending further investigations	Requires a detailed study	Unsure	3	2	3	0	3	3	3	3
T20	3	South of Mt Messenger	Road	Erosion	Erosion risk where river runs adjacent to SH3 South of Mt Messenger	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Requires ongoing monitoring and potential stabilisation	Yes	3	2	3	0	3	3	3	3
T21	45	Tataraimaka	Road	Flooding	Tataraimaka - 'z' shaped alignment, flooding issues and previously a culvert has washed out the whole road with no detour around the area at all and there is increasing development in the area to connect to new Plymouth, Bridge alignment is not ideal, re alignment would be the best option to straighten up the road. lower priority than SH3 - some sections of 45 have the highest volumes on the network.	3L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	3	2	2	0	2	3	-	-
T22	3	Tongahoe	Bridge	Erosion	Bridge built between the 60's-70's and is at risk to erosion. Tongahoe should be a high priority as it has a bluff and the river.	4L	4VL	No	Physical works ($$)	Strengthening or realignment of the bridge would be a more beneficial outcome in comparison to a new route.	Yes	2	3	3	0	3	3	3	3
T23	3	Tongaporutu estuary	Road	Coastal Erosion	Route has coastal erosion risk due to the estuary and also has potential to be at risk from coastal inundation.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Requires ongoing monitoring and potential stabilisation	Yes	1	3	3	0	3	3	3	3
T24	3	Waitotara bridges	Bridge	Erosion	Erosion risk to the bridge. Built between 60's-70's.	4L	4VL	No	Physical works ($$)	Strengthening or realignment would be of more value than creating a new route,	Yes	2	2	3	0	3	3	3	3

A1.11 Top of the South regional risk catalogue

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
TS5	6	Atawhai	Road	Landslip	Slow moving landslips	3L	-	No	Physical works ($$$)	realign road	Yes	3	2	3	0	3	2	-	-
TS49	6	Atawhai through to Nelson	Road	Coastal Inundation / SLR	Low lying and water over the road. Does coincide with spring tides and so likely get more frequent	3UL	3L	No	Physical works ($$)	raise road	Yes	2	1	3	0	3	2	3	2
TS35	6	Atawhai through to Nelson	Road	Flooding	Low lying and water over the road. Does coincide with spring tides	3L	3VL	No	Physical works ($$)	Raise road	Yes	3	1	3	0	3	2	3	3
TS36	6	Atawhai through to Richmond	Road	Tsunami	Tsunami Risk along Rocks Road.	3L	-	No	Emergency response and preparedness planning only (typically HI/LF)	Emergency response planning only	No	1	3	3	1	4	2	-	-
TS52	6	Brightwater Bridge	Bridge	Flooding	Flooding of approaches	2L	-	No	Physical works ($$)	raise approaches	Yes	3	1	3	1	4	1	-	-
TS54	60	Bronte	Road	Coastal Inundation / SLR	SLR in the future with 0.5m SLR will complicate. moving from low frequency and outage to high and medium	3UL	3L	No	Physical works ($$$)	Raising the road	Yes	2	1	3	0	3	2	2	2
TS6	6	Canvastown along Pelorus River	Road	Flooding	River floods and inundates the road	4VL	4VL	No	Physical works ($$$)	Raise the road	Yes	3	3	3	0	3	3	3	3
TS48	6	Collins Valley	Road	Flooding	Collins valley slips and flooding	3UL	3L	No	Physical works ($$)	River protection	Yes	2	1	3	0	3	2	3	2
TS34	6	Collins Valley	Road	Landslip	Under slip	3L	-	No	Physical works ($$$$)	Realignment	Yes	2	2	3	0	3	2	-	-
TS22	63	Connors Bend along Wairau River	Road	Flooding	Flooding risk where land drains river.	4L	4VL	No	Physical works ($$)	Better drainage required	Yes	3	1	2	1	3	3	3	3
TS7	6	Dallows Bluff	Road	Rockfall	Frequent rockfall on SH6 stretch between intersections with SH65 and SH63. High priority for the Top of the South	4VL	-	No	Physical works ($$)	Requires netting.	Yes	3	3	3	1	4	3	-	-
TS27	65	Deadman's Slip	Road	Landslip	Undercutting of the road caused by the river	3VL	3VL	No	Physical works ($$)	Requires armouring and protection.	Yes	3	3	2	1	3	2	3	3
TS46	1	Delegats	Road	Flooding	Surface runoff	3L	-	No	Physical works ($$)	Culvert upgrade	Yes	3	1	4	0	4	2	-	-
TS8	6	Entire Region	Road	Wildfire	Wildfire risk to wooden structures such as bridges and retaining walls which exist across the entire region.	4L	4VL	No	Enhanced proactive maintenance	Preparedness	Unsure	2	3	3	0	3	3	3	3
T65	6	Glenhope to Murchison	Road	Ice / Snow	Ice and snow risk through hills from Glenhope to Murchison	4L	-	No	BAU / Ongoing maintenance / Reactive	Winter maintenance LOS and improved communication. VMS required at each end of route where alternative routes exist	Unsure	3	2	3	1	4	3	-	-

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TS9	6	Granity Rockfall	Road	Rockfall	Frequent rockfall on SH6 stretch between intersections with SH63 and WC boundary. High priority for the Top of the South	4VL	-	No	Physical works ($$)	Requires netting.	Yes	3	3	3	1	4	3	-	-
TS47	6	Havelock to Renwick	Road	Flooding	Surface flooding	3L	-	No	Enhanced proactive maintenance	Improve land drainage	Yes	3	1	3	0	3	2	-	-
TS28	65	Higgins Bluff	Road	Rockfall	Rockfall risk along the bluff.	4VL	-	No	Physical works ($$)	Requires netting	Yes	3	3	2	1	3	3	-	-
TS40	6	Hope	Road	Flooding	Surface flooding occurs along SH6 from Brightwater to Richmond.	2L	-	No	Physical works ($$$)	Improve drainage	Yes	3	2	3	1	4	1	-	-
TS10	6	Hope saddle	Road	Landslip	Ongoing landslip risk	4VL	4VL	No	Physical works ($$)	Requires netting.	Yes	3	3	3	1	4	3	3	3
TS53	63	Howard Junction	Road	Erosion	River erosion	3UL	-	No	Physical works ($$)	River protection	Yes	2	1	2	0	2	3	-	-
TS23	63	Howard Narrows	Road	Rockfall	Rockfall hazard for ~3km	3L	-	No	Physical works ($$$)	netting	Yes	3	2	2	0	2	3	-	-
TS11	6	Kawatiri to Owen	Road	Erosion	At risk to river erosion and drop out.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	No	2	3	3	1	4	3	3	3
TS42	6	Kohatu Bridge	Road	Erosion	Scour	2L	-	No	Physical works ($$)	scour protection and raise approaches	Yes	2	3	3	1	4	1	-	-
TS43	6	Kohatu Bridge	Road	Flooding	Flooding of bridge approaches	2L	-	No	Physical works ($$)	raise approaches	Yes	2	3	3	1	4	1	-	-
TS56	1	Lake Grassmere	Road	Coastal Inundation / SLR	Sea level rise has potential to inundate the road	3UL	3L	No	Physical works ($$$)	Raise road. co-fund through annual plans and renewals	Yes	2	1	4	0	4	2	3	2
TS55	60	Mariri	Road	Coastal Inundation / SLR	moving from low frequency and outage to high and medium	3UL	3L	No	Physical works ($$$)	raise road	Yes	2	1	3	0	3	2	3	2
TS30	65	Mauria River	Road	Erosion	Surface flooding and undercutting / erosion where river is next to the road.	4VL	4VL	No	Physical works ($$$)	Rock protection along river to protect road	Yes	3	3	2	1	3	3	3	3
TS29	65	Mauria river	Road	Flooding	Surface flooding and undercutting / erosion where river is next to the road	3VL	3VL	No	Physical works ($$$)	Rock protection	Yes	3	3	2	1	3	2	3	3
TS64	60	Milnthorpe	Road	Coastal Inundation / SLR	Coastal inundation and sea level rise risk. Moving from low frequency and outage to high and medium	2UL	2L	No	Unknown. Pending further investigations	Further investigations needed	No	2	1	2	0	2	2	3	2
TS12	6	O'Sullivans Bluff	Road	Rockfall	Frequent rockfall on SH6 stretch between intersections with SH65 and SH63. High priority for the Top of the South	4VL	-	No	Physical works ($$)	Requires netting.	Yes	3	3	3	1	4	3	-	-
TS37	6	Port / QEII Drive	Road	Earthquake / liquefaction	Liquefaction on reclaimed land.	3L	-	No	BAU / Ongoing maintenance / Reactive	Emergency response planning only	No	1	3	3	1	4	2	-	-

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
TS50	6	QEII Bridge	Bridge	Coastal Inundation / SLR	Approaches currently Low now but this is moving up to more frequent. If SH6 is closed, then Waimea road is at capacity	3UL	3L	No	Unknown. Pending further investigations	Further investigations needed	Unsure	1	2	3	1	4	2	2	3
TS1	1	Redwood Pass	Road	Rockfall	Rockfall risk through Redwood Pass.	4L	-	No	Physical works ($$)	rockfall protection	Yes	3	1	4	1	5	2	-	-
TS45	63	Renwick creek	Road	Flooding	annual flooding	2L	-	No	Physical works ($$)	Better drainage and stormwater management	Yes	3	2	2	1	3	1	-	-
TS39	6	Richmond to Nelson	Road	Earthquake / liquefaction	Earthquake and liquefaction risk from Richmond to Nelson.	3L	-	No	Emergency response and preparedness planning only (typically HI/LF)	Emergency response planning only	No	1	3	3	1	4	2	-	-
TS19	60	Richmond to O'Connor's bridge	Road	Flooding	Surface flooding	3L	-	No	Physical works ($$$)	Further investigations needed	Yes	3	2	3	0	3	2	-	-
TS44	60	Riwaka River	Road	Flooding	Flooding of road adjacent to Riwaka river	2L	-	No	Physical works ($$)	Could have upgrade of drainage and culverts	Yes	3	2	2	0	2	2	-	-
TS51	6	Rocks Road	Road	Coastal Inundation / SLR	Aged sea wall moving towards a medium to high outage. Detour is low but the ONRC should be increased. Detour is over Waimea which is at capacity	2L	2VL	No	Physical works ($$$)	Further investigations needed	Yes	3	1	3	1	4	1	3	3
TS38	6	Rocks Road	Road	Rockfall	Rockfall Risk from Atawhai through to Richmond as the road runs adjacent to a number of bluffs and rock faces.	3L	-	No	Physical works ($$)	Further investigations needed	Yes	3	1	3	1	4	2	-	-
TS24	63	Salt Lake	Road	Flooding	Runoff leads to flooding of road	4L	4VL	No	Physical works ($$)	Box culverts and raise road.	Yes	3	1	2	1	3	3	3	3
TS31	65	Shenandoah Bridge	Bridge	Erosion	Rockfall and erosion	3L	-	No	Physical works ($$)	River training	Yes	3	2	2	1	3	2	-	-
TS41	6	Spooners	Road	Rockfall	Rockfall	2VL	-	No	Physical works ($$)	netting	Yes	3	3	3	1	4	1	-	-
TS59	6	Tahunanui to Richmond.	Road	Coastal Inundation / SLR	Coastal inundation and sea level rise risk. Moving from low frequency and outage to high and medium	2UL	2L	No	Physical works ($$$)	raise road	Yes	2	1	3	1	4	1	2	2
TS20	60	Takaka Hill	Road	Landslip	Landslip risk with both under and over slips. Mainly on the Nelson side. Occurs at least once a year. There are also a number of drainage issues.	4VL	4VL	No	Physical works ($$$)	Realignment improve drainage and catchment management. Even with improvements, there would still be ongoing issues, requiring response and BAU maintenance.	Unsure	3	3	2	1	3	3	3	3
TS21	60	Takaka Hill to Puramhoi	Road	Flooding	Flooding which could increase with climate change	3L	-	No	Unknown. Pending further investigations	Further investigations needed	No	3	2	2	0	2	3	-	-
TS25	63	The wash	Road	Flooding	Flooding risk through the Wairau Valley as road follows river in floodplains.	4L	4VL	No	Physical works ($$)	Raise road and provide river protection	Yes	3	2	2	1	3	3	3	3

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TS2	1	Tuamarina to Picton	Road	Flooding	Surface flooding risk from adjacent catchment runoff.	4L	4VL	No	Unknown. Pending further investigations	Requires a detailed study	Unsure	3	2	4	1	5	2	3	3
TS16	6	Upper Buller Gorge	Road	Erosion	Erosion risk along the Buller Gorge in both Top of South and West Coast.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	No	2	3	3	1	4	3	3	3
TS13	6	Upper Buller gorge	Road	Extreme Weather	Extreme weather risk with strong winds resulting in tree fall.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	No	3	2	3	1	4	3	3	3
TS14	6	Upper Buller gorge	Road	Landslip	At risk to landslips both over and under slips.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	No	2	3	3	1	4	3	3	3
TS15	6	Upper Buller Gorge	Road	Rockfall	Rockfall risk with rockfall occurring along the Buller Gorge in both Top of South and West Coast.	4L	-	No	BAU / Ongoing maintenance / Reactive	Ongoing maintenance	No	2	3	3	1	4	3	-	-
TS33	65	Warwick	Road	Erosion	Erosion and flooding along river	3L	-	No	Physical works ($$)	rock protection works	Yes	3	2	2	1	3	2	-	-
TS32	65	Warwick	Road	Flooding	Flooding and erosion	3L	-	No	Physical works ($$)	rock protection	Yes	3	2	2	1	3	2	-	-
TS4	1	Welds Pass	Road	Landslip	rockfall and over / underlips	3L	-	No	Physical works ($$$)	realignment	Yes	2	3	4	0	4	2	-	-
TS3	1	Welds pass	Road	Rockfall	rockfall and over under slips	3L	-	No	Physical works ($$$)	realignment	Yes	2	3	4	0	4	2	-	-
TS18	6	Whangamoas	Road	Landslip	Slips and rockfall	3L	-	No	Enhanced proactive maintenance	an alternate route has been designed. a number of sites where you could do different things. There is a realignment option and could be better bang for your buck with the number of sites	Yes	3	2	3	0	3	2	-	-
TS17	6	Whangamoas	Road	Rockfall	Same as Landslip results	3L	-	No	Physical works ($$$$)	realignment	Yes	3	2	3	0	3	2	-	-
TS26	63	Windy Point	Road	Rockfall	Constant Rockfall on the beginning stretch of SH63	3VL	-	No	Physical works ($$)	Requires netting.	Yes	3	3	2	0	2	3	-	-

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Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
WK1	1	Along Lake Karapiro	Road	Erosion	Erosion of riverbank can undermine road. There are significant detour issues along this road if it were out of service.	5L	-	No	Physical works ($$$)	Realignment, new bridge or possible retaining wall. Also invest in upgrades to Maungatautari Road through strengthening of structures to carry HMPV's. Realignment, bridge or possible retaining wall.	Yes	2	3	5	0	5	3	-	-
WK7	1	Bulli Point	Road	Landslip	Bulli point drop out combined with narrow carriage way significantly lowers the resilience. Typically to repair you need to close both sides of the road. Even for repairs you need to close the road.	4L	-	No	Physical works ($$$)	Build retaining wall(s) on Lakeside and/or cut into adjacent rock face. Ultimate solution is to construct the proposed Hatepe to Motuoapa realignment project.	Yes	2	3	4	0	4	3	-	-
WK22	1	Desert Road	Road	Volcanic	Volcanic hazard risk along the desert road, this may include ashfall disruption or damage from hazards including lahar and ballistics.	3L	-	No	Emergency response and preparedness planning only (typically HI/LF)	Emergency response planning only	No	1	3	4	0	4	2	-	-
WK3	25	Entire Coromandel Peninsula	Road	Coastal Inundation / SLR	Flooding around entire coromandel peninsula. Likely the alpine route and coromandel have the most closures in the Waikato region.	3L	3VL	No	Physical works ($$$$)	PBC has been written for 25 and 25A loop	Unsure	3	2	2	0	2	3	3	3
WK2	25a	Entire Coromandel Peninsula	Road	Flooding	Flooding around entire coromandel peninsula. Likely the alpine route and coromandel have the most closures in the Waikato region.	3L	3VL	No	Physical works ($$$)	PBC has been written for 25 and 25a loop	Yes	3	2	3	0	3	2	3	3
WK6	25	Entire Coromandel Peninsula	Road	Landslip	Landslip risk occurs along the entire coromandel 'loop route' this can be induced by rainfall and earthquake shaking.	3L	3VL	No	Physical works ($$$)	PBC has been written for 25 and 25a loop	Yes	3	2	2	0	2	3	3	3
WK4	3	Entire stretch of SH3	Road	Landslip	Landslip risk with road instability. Key route for LPG to get trucked from New Plymouth to Auckland.	4L	4VL	No	Unknown. Pending further investigations	Business Case required	No	3	2	3	1	4	3	3	3
WK13	46	Entire stretch of SH46	Road	Flooding	Flooding issues along SH	2L	-	No	Physical works ($$)	Increase culvert sizes along vulnerable route.	Unsure	3	2	3	0	3	1	-	-
WK14	46	Entire stretch of SH46	Road	Volcanic	ashfall in the water course is still causing significant scour issues along the road, lifts the road surface from 2012 eruption event	2L	-	No	Physical works ($)	Install large box culvert under SH46 to allow for the large amount of ash to flow to the other side of the SH.	Yes	3	2	3	0	3	1	-	-

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WK11	49	Entire stretch of SH47	Road	Flooding	Flooding issues along SH	3L	-	No	Unknown. Pending further investigations	Build the carriageway up out of flood level. Increase culvert sizes along vulnerable route.	Unsure	3	2	3	0	3	2	-	-
WK20	1	Flooding just north of Turangi	Road	Flooding	Surface flooding issues along SH 1 through Waiotaka Straight (within Waiotaka Valley). This is a low-lying wetland area (South Taupo Wetlands) which is prone to flooding.	4L	4VL	No	Unknown. Pending further investigations	Business Case required	Unsure	3	2	4	0	4	3	3	3
WK8	5	Kaweka Ranges	Road	Ice / Snow	Major snow event caused power lines to drop and this blocked the road, preventing snow removal. This led to a significant event. Potential for undergrounding of the lines to stop the road from going out. Poor to no cell phone connection means if there are any issues its very hard to call any emergency services.	4L	-	No	Physical works ($$$)	Underground overhead lines and improve telecommunications/cell phone reception	Yes	3	2	3	0	3	3	-	-
WK10	47	National Park end of SH47	Road	Flooding	Flooding along SH47 towards National Park	3L	-	No	Physical works ($$)	Build the carriageway up out of flood level. Increase culvert sizes along vulnerable route.	Unsure	3	2	3	0	3	2	-	-
WK21	47	National Park end of SH47	Road	Landslip	Landslip issues along SH4 towards national park over the saddle.	3L	-	No	Unknown. Pending further investigations	Further investigations needed	Unsure	3	2	3	0	3	2	-	-
WK5	26	North of Te Aroha Township	Road	Flooding	Flooding between Te Aroha and Paeroa	3L	3VL	No	Physical works ($$)	Culvert and Drainage System Upgrade.	Yes	3	2	3	0	3	2	3	3
WK25	31	Puti Bridge to Waipapa Marae	Road	Coastal Inundation / SLR	Low-lying areas potentially exposed to coastal inundation in the future	3UL	3VL	No	Unknown. Pending further investigations	Further investigations needed	Unsure	1	1	2	0	2	3	3	3
WK15	41	SH 41 to Taumaranui	Road	Landslip	Land instability issues through	2L	-	No	Physical works ($$)	Build retaining walls at unstable locations where there's visible subsidence.	Unsure	3	2	2	0	2	2	-	-
WK23	25	Tairua along Pauanui Inlet	Road	Coastal Inundation / SLR	Low-lying areas potentially exposed to coastal inundation in the future	3UL	3VL	No	Unknown. Pending further investigations	Further investigations needed	Unsure	1	1	2	0	2	3	3	3
WK17	32	Tokoroa to Whakamaru	Road	Flooding	Flooding due to deforestation which is causing more run off and therefore more flooding.	2L	-	No	Physical works ($$)	Construct deep water tables and/or retaining ponds. Change the District Plan to enforce adjacent landowners to hold/retain stormwater runoff.	Unsure	3	1	2	0	2	2	-	-
WK12	41	Waihi Hill	Road	Landslip	Ongoing mass movement	3L	-	No	Physical works ($$)	Build retaining walls at unstable locations where there's visible subsidence.	Unsure	2	3	2	0	2	3	-	-

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WK16	1	Waihononu Bridge	Road	Ice / Snow	Snow and Ice, snow closes the road however black ice has a bigger impact to drivers. The three tight curves of the northern end of the desert road are the ice issues the only way to be able to deal with ice is build a new road that doesn't go into the icy areas. CMA only works for a certain temperature range and if there is too much water it washes out and dilutes. Waihononu bridge shipping container has temperature gages which automatically sprays CMA	2L	-	No	Physical works ($$)	Heat road, using geothermal energy	Unsure	3	1	4	0	4	1	-	-
WK9	1	Waiouru	Road	Ice / Snow	Waiouru - snow and ice which closes the road, alternative route is 49 / 4, significant snow does get as far south as Taihape, can't prevent it but can manage it.	3L	-	No	Physical works ($$)	Heated road, using geothermal energy	Unsure	3	2	4	0	4	2	-	-
WK24	25	Whitianga Inlet	Road	Coastal Inundation / SLR	Multiple low-lying areas and therefore potentially exposed to coastal inundation in the future	3UL	3VL	No	Unknown. Pending further investigations	Further investigations needed	Unsure	1	1	2	0	2	3	3	3

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Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
W20	58	Along Pauatahanui Inlet	Road	Coastal Inundation / SLR	Low-lying areas potentially exposed to coastal inundation in the future	3UL	3VL	No	Physical works ($$$)	Various high-risk areas across the region that require slope stabilisation	Unsure	1	1	3	0	3	2	3	3
W21	1	Along Porirua Harbour	Road	Coastal Inundation / SLR	KiwiRail and road has the potential to be subject to coastal inundation in the future	4UL	4VL	No	Physical works ($$$)	Various high-risk areas across the region that require slope stabilisation	Unsure	1	1	5	0	5	2	3	3
W14	1	Aotea	Road	Earthquake / liquefaction	Seismic risk to Aotea off-ramp as it is thought that the Wellington fault is located underneath it.	4L	-	No	Physical works ($$$$)	Requires interface with various asset owners - WCC, KiwiRail & The Port Authority to agree full mitigation option	Yes	1	3	5	0	5	2	-	-
W8	1	CBD	Road	Earthquake / liquefaction	Liquefaction will impact such a significant length of the highway. We need to understand what our expected level or service after an event. You can spend a lot of time on building resilience; however, do you just accept that something is going to happen, hunker down and then go back to normal levels in 12 hours.	3L	-	No	Physical works ($$$$)	Full impacts difficult to quantify	Unsure	1	3	5	0	5	1	-	-
W13	1	CBD	Road	Flooding	Kilbirnie flood modelling and sea level rise. There is good understanding of the historic flood areas, but future flooding is not well understood. There is nothing finalised in terms of what to actually do about the flooding due to the low-lying nature or the land - needs to be more operational response to flood such as partnering with wellington water etc. There are future flooding risks that are not well understood. We need to understand what our expected level or service after an event. You can spend a lot of time on building resilience; however, do you just accept that something is going to happen, hunker down and then go back to normal levels in 12 hours.	3L	3VL	No	Physical works ($$$)	Would require joint project with Wellington City Council	Unsure	3	2	5	0	5	1	3	3

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W15	1	CBD to Ngauranga	Road	Earthquake / liquefaction	A number of critical road and rail bridges, structures, utilities etc located in this corridor and within a high earthquake zone.	4L	-	No	Physical works ($$$$)	Would require a prioritised list and mitigation option for each structure	Unsure	1	3	5	0	5	2	-	-
W10	58	Haywood's	Road	Landslip	Some water, power and gas utilities along SH 58 - The Haywards.	3L	3VL	No	Physical works ($$$$)	Further slope stabilisation works required	Yes	2	3	3	0	3	2	3	3
W18	58	Haywood's	Road	Landslip	GNS are doing a landslide assessment along SH58.	3L	3UL	No	Physical works ($$$)	Linked to SH 58 Haywards	Yes	3	2	3	0	3	2	1	2
W16	2	Korokoro Stream	Road	Flooding	Korokoro Stream: Petone 1 in 5-year ARI culverts, significant issues to build ourselves out. They have monitoring in place, the best you can do is let people know and be able to respond to close the road and keep people moving however there isn't anything you can do in the next 10 years to deal with that. Will likely be $100M but is being addressed in the Petone to Grenada piece of work.	3L	3VL	No	Physical works ($$$$)	Linked to proposed interchange at SH 2 Petone on//off ramp - include building relocation and interface with KiwiRail assets - has current flood monitoring system, but only as early warning device	Yes	3	2	4	0	4	2	3	3
W5	1	SH1 Centennial Highway	Road	Coastal Erosion	Sea level rise, storm events, high seas causing damage to seawall.	5L	5VL	No	Physical works ($$$)	Ongoing armouring. More work required to determine appropriate solutions	Yes	3	2	5	0	5	3	3	3
W4	1	SH1 Centennial Highway	Road	Coastal Inundation / SLR	Coastal inundation and SLR risk with water over topping the road in larger events. Currently reactive maintenance is prioritised as opposed to proactive. Culvert near Paekakariki blocks frequently due to lose material causing flooding in the town. Catchments flood in short duration events causing slips and debris/blockages. KiwiRail assets are adjacent (up-catchment) and also are affected. Even with completion of Transmission Gully, access will still be required for the rail line.	5L	5VL	No	Physical works ($$$)	Will continue to flood in the long term but will require ongoing repair and maintenance. More work required to determine appropriate solutions.	Unsure	2	2	5	0	5	3	3	3
W3	1	SH1 Centennial Highway	Road	Rockfall	Rock, debris comes down off the steep slopes and covers the road and rail network. NZTA are trying to get KiwiRail to input into funding. Risk will be reduced once Transmission Gulley is open.	5L	-	No	Physical works ($$$)	Ongoing slope stabilisation works required.	Yes	3	2	5	0	5	3	-	-

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W6	1	SH1 Kuku	Road	Flooding	Flooding occurs frequently in low lying area - caused by a land drainage issue where water builds up on the highway approx. once a year. Flooding can often reduce traffic down to one lane and has affected both lanes for a couple of hours. With help from Council it could be improved. Risk could also be reduced if Otaki to Levin is confirmed.	5L	5VL	No	Physical works ($$)	Requires Council to address adjacent land drainage and runoff - less of an issue once O2NL is constructed could significantly improve the flood issue - especially considering the detour is extensive.	Yes	3	1	5	0	5	3	3	3
W19	1	SH1 Ngauranga Gorge	Road	Landslip	Rockfall risk and landslides - targeting low cost, low risk funding. Multiple users including cyclists. Debris screen is a hard structure and the footpath has become a combined pathway with no room left for construction. Low cost, low risk would address most of these.	4L	4VL	No	Physical works ($$$)	Some minor works planned, but would require significant infrastructure to fully mitigate	Yes	3	1	5	0	5	2	3	3
W2	1	SH1 Porirua	Road	Flooding	Some flooding. The roads go through wetland like material, some of the culverts and streams are full of gravel and upper reaches of streams need clearing and maintaining. NZTA ends up with the problem but they have very little control of what happens up or down stream of the road.	4L	4VL	No	Physical works ($$$)	Ongoing improvements to manage high intensity rainfall events - will require Council to improve stormwater catchment	No	3	2	5	0	5	2	3	3
W1	2	SH2 Petone to SH1	Road	Coastal Inundation / SLR	Coastal inundation and SLR are the biggest issue for this area. Regular events over recent years have caused outages and damage.	4VL	4VL	Yes	Physical works ($$$$)	There is a proposed seawall/cycleway which will help mitigate this risk.	Yes	3	3	4	0	4	3	3	3
W17	2	SH2 Remutaka Hill	Road	Earthquake / liquefaction	Whole SH 2 Remutaka Hill (13km) is at risk to earthquake shaking. If there is an EQ it will be out of service due to many risks. Focus should be on SH1 first to get a route open to the north before addressing SH2.	4L	-	No	BAU / Ongoing maintenance / Reactive	Requires ongoing investment to improve resilience, but likely to always be a risk in large earthquakes	No	1	3	4	0	4	3	-	-

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W12	1	Southern Rail over bridge	Road	Earthquake / liquefaction	Southern Rail over bridge - box bridge liquefaction piles will fail in a large event. Thordon overbridge - if this goes likely so much else will go so not much you can do.	3L	-	No	Physical works ($$$)	Current twin box culvert would require significant retrofit to fully mitigate this risk	Yes	1	3	4	0	4	2	-	-
W11	53	Waihina Bridge	Bridge	Flooding	Waihina Bridge often gets closed due to high river levels but well managed. Occasionally Martinborough gets cut off for a max 12 hours as the 2 detour routes can sometimes be closed as well as the bridge. No point to spend $12m to upgrade the bridge. Much more bang for your buck is to upgrade a road in and out of Martinborough. small number of vehicles in and out a day not sure that is worth $12m on a single bridge. Should be in there but not high priority (altern. route around Martinborough)	3L	3VL	No	Physical works ($$$)	new bridge but not worth it	Yes	3	1	2	0	2	3	3	3
W9	58	Wellington regionwide	Road	Erosion	some vulnerability and a safety project with bank stabilisation but potentially high.	3L	3VL	No	Physical works ($$$)	Various high-risk areas across the region that require slope stabilisation	Yes	3	1	3	0	3	2	3	3

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WC1	7	Black Point	Road	Erosion	A few river erosion sites near Reefton river. Ongoing rock armouring.	4L	4VL	No	Enhanced proactive maintenance	Rock protection	Unsure	2	2	2	1	3	3	3	3
WC2	6	Bruce Bay	Road	Coastal Erosion	Route at risk from erosion. Rock protection measures are starting to be implemented through emergency works funding following Cyclone Fehi (2018). However, if there was another cyclone a large section of the road has the potential to be lost regardless of current resilience work.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Rock protection, however, will still be residual risk	Unsure	2	3	3	0	3	3	3	3

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WC3	6	Buller Gorge	Road	Extreme Weather	Extreme weather risk with tree fall along gorge.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Regular maintenance in tree cutting	Unsure	3	2	3	0	3	3	3	3
WC4	6	Buller Gorge	Road	Rockfall	Rockfall along steep slopes	3L	-	No	Enhanced proactive maintenance	Better ongoing maintenance to pull down loose material and lower rockfall	Yes	3	2	3	0	3	2	-	-
WC5	6	Fox River	Road	Coastal Inundation / SLR	Fox River - low lying with sea level rise risk.	4L	4VL	No	Enhanced proactive maintenance	Ongoing monitoring and maintenance	Unsure	2	2	3	0	3	3	3	3
WC25	6	Franz Josef to Fox Glacier	Road	Ice / Snow	Snow and ice over hill between Franz Josef and Fox Glacier	4L	-	No	BAU / Ongoing maintenance / Reactive	Winter maintenance LOS and improved communication. VMS required at each end of route where alternative routes exist	Unsure	3	2	3	0	3	3	-	-
WC6	6	Greymouth to Westport	Road	Coastal Erosion	Coastal erosion during a cyclone has the potential to affect the whole region. Increased frequency to approx. once a year. Typically, still repairing from the previous event when then next one comes. Still recovering from Fehi 2018. All works are currently reactive. 4 sites where preventative works, these could be prioritised.	4VL	4VL	No	Enhanced proactive maintenance	Rock protection	Unsure	3	3	3	0	3	3	3	3
WC7	73	Griffiths Bridge	Bridge	Erosion	Erosion and scour risk around the bridge.	4L	4VL	No	Physical works ($$$)	New bridge	Yes	1	3	3	0	3	3	3	3
WC10	6	Haast Pass	Road	Erosion	Erosion risk along Haast River.	4L	4VL	No	Physical works ($$$$)	Expensive protection works	Unsure	2	3	3	0	3	3	3	3
WC9	6	Haast Pass	Road	Landslip	Route at risk from landslip. Currently all reactive works with proactive management on some sites, however there is still a risk of losing the whole road. A few landslip sites could potentially be more proactive some of it which would be less than $1m, however it is more like $5m altogether.	4VL	4VL	Yes	Enhanced proactive maintenance	Some areas could have more proactive work undertaken.	Unsure	3	3	3	0	3	3	3	3
WC8	6	Haast Pass	Road	Rockfall	Rockfall along the Haast River with only reactive works occurring.	4L	-	No	Enhanced proactive maintenance	could be more proactive	Yes	2	3	3	0	3	3	-	-
WC11	6	Junction of SH6 and SH69	Road	Landslip	At junction of SH6 and SH69 - large mass land movement slip into the Buller River.	3L	3VL	No	Physical works ($$$)	Rock toe at bottom of slip to stabilize	Yes	2	3	3	0	3	2	3	3
WC12	6	Knights Point	Road	Landslip	Most vulnerable piece of road to landslip in New Zealand and currently only	4VL	4VL	No	Enhanced proactive maintenance	Also, would require further investigation	Unsure	3	3	3	0	3	3	3	3

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
					has reactive work underway.														
WC15	7	Lewis Pass	Road	Flooding	Shingle fans depositing on the road, as well as surface flooding risk.	4L	4VL	No	Physical works ($$$)	Solvable with upgrade to double lane bridges and bridge realignment away from rockface.	Yes	3	1	2	1	3	3	3	3
WC13	7	Lewis Pass	Road	Ice / Snow	Ice and snow risk at summit.	4L	-	No	BAU / Ongoing maintenance / Reactive	Winter operations	No	3	2	2	1	3	3	-	-
WC25	7	Maruia Flats	Road	Flooding	Flooding - River is at the same height as road.	3L	-	No	Physical works ($$$)	Stop banking river	Yes	2	2	2	1	3	2	-	-
WC16	6	Newman's Slip	Road	Landslip	Upper Buller Gorge, right on the boundary of Canterbury and West Coast. A number of studies potentially would put road out for 6 - 12 months. Monthly monitoring of landslip being undertaken.	3L	3VL	No	Enhanced proactive maintenance	Little can be achieved without spending millions and currently not worth doing it due to cost. Options to use remote sensing and drone monitoring across a number of slips would help with more proactive maintenance.	Unsure	2	3	3	0	3	2	3	3
WC28	67	Orawati Bridge	Bridge	Earthquake / liquefaction	Approaches to the Orawati bridge are in liquefiable/lose material which could result in damage during a significant earthquake.	1L	-	No	Physical works ($$)	Strengthen and raise approach to bridge	Yes	1	3	2	0	2	1	-	-
WC17	73	Otira River at Otira	Road	Erosion	River erosion risk. Already funded but has ongoing issues in other areas as well.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Monitor and reactive maintenance	No	2	2	3	0	3	3	3	3
WC19	7	Rahu Saddle	Road	Extreme Weather	Extreme weather risk with trees falling from high winds.	4L	4VL	No	BAU / Ongoing maintenance / Reactive	Annual inspections and selective removals where risk identified	Yes	3	1	2	1	3	3	3	3
WC18	7	Rahu Saddle	Road	Ice / Snow	Snowfall and ice risk.	4L	-	No	BAU / Ongoing maintenance / Reactive	Winter operations	No	3	1	2	1	3	3	-	-
WC20	6	Scout Lodge Straight	Road	Erosion	Significant river erosion risk.	4VL	4VL	No	Physical works ($$$)	River protection works (groynes) to train river and realign road	Yes	3	3	3	0	3	3	3	3
WC21	6	South of Ross to Haast Pass	Road	Flooding	All rivers south of Ross (~15 rivers) need training/stop banking and active management to reduce flood risk.	4VL	4VL	No	Enhanced proactive maintenance	Ongoing training works and management	Yes	3	3	3	0	3	3	3	3
WC22	6	Southern side of Punakaiki	Road	Coastal Inundation / SLR	Low lying and vulnerable to sea level rise.	4L	4VL	No	Physical works ($$$)	Rock protection	Unsure	2	2	3	0	3	3	3	3
WC26	7	Springs Junction	Road	Flooding	Flooding of road during heavy rainfall	4UL	4L	No	BAU / Ongoing maintenance / Reactive	Monitor and reactive maintenance	Unsure	2	1	2	1	3	3	3	2
WC23	73	Taipo Bridge	Bridge	Flooding	Flood risk along one lane bridge.	4L	4VL	No	Physical works ($$$$)	replace whole bridge and double lane	Yes	1	3	3	0	3	3	3	3

Risk ID	SH No	Location Name	Asset type	Hazard	Description of hazard	Current Risk Rating	2050 Risk Rating	Already funded?	Suggested Response Category	Suggested solution	Solvable	Current Hazard Likelihood	Current Outage	ONRC Category	Increase ONRC	ONRC + inc	Detour issues	2050 Hazard Likelihood	2050 Outage
WC24	73	Wainihinini Bridge	Bridge	Flooding	Flood risk to bridge. Bridge replacement is critical from a HMPV point of view. Currently reaching end of life.	4L	4VL	No	Physical works ($$$)	Replace bridge.	Yes	2	3	3	0	3	3	3	3

Appendix B: Regional major and extreme risk location maps

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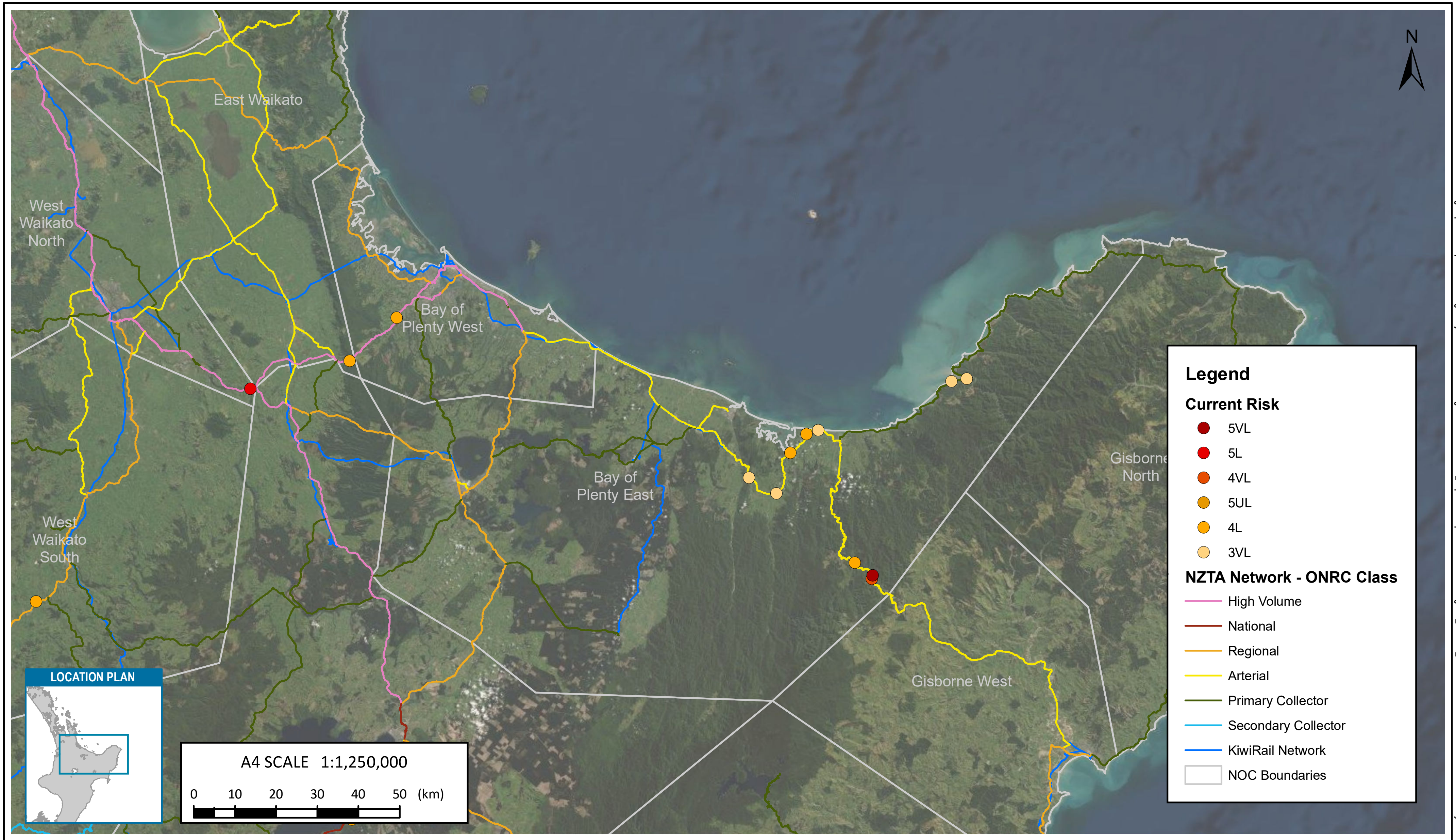
TITLE	NATURAL HAZARDS RISK RATING AUCKLAND AND NORTHLAND
SCALE (A4)	1:2,500,000
FIG No.	FIGURE B1
REV	0



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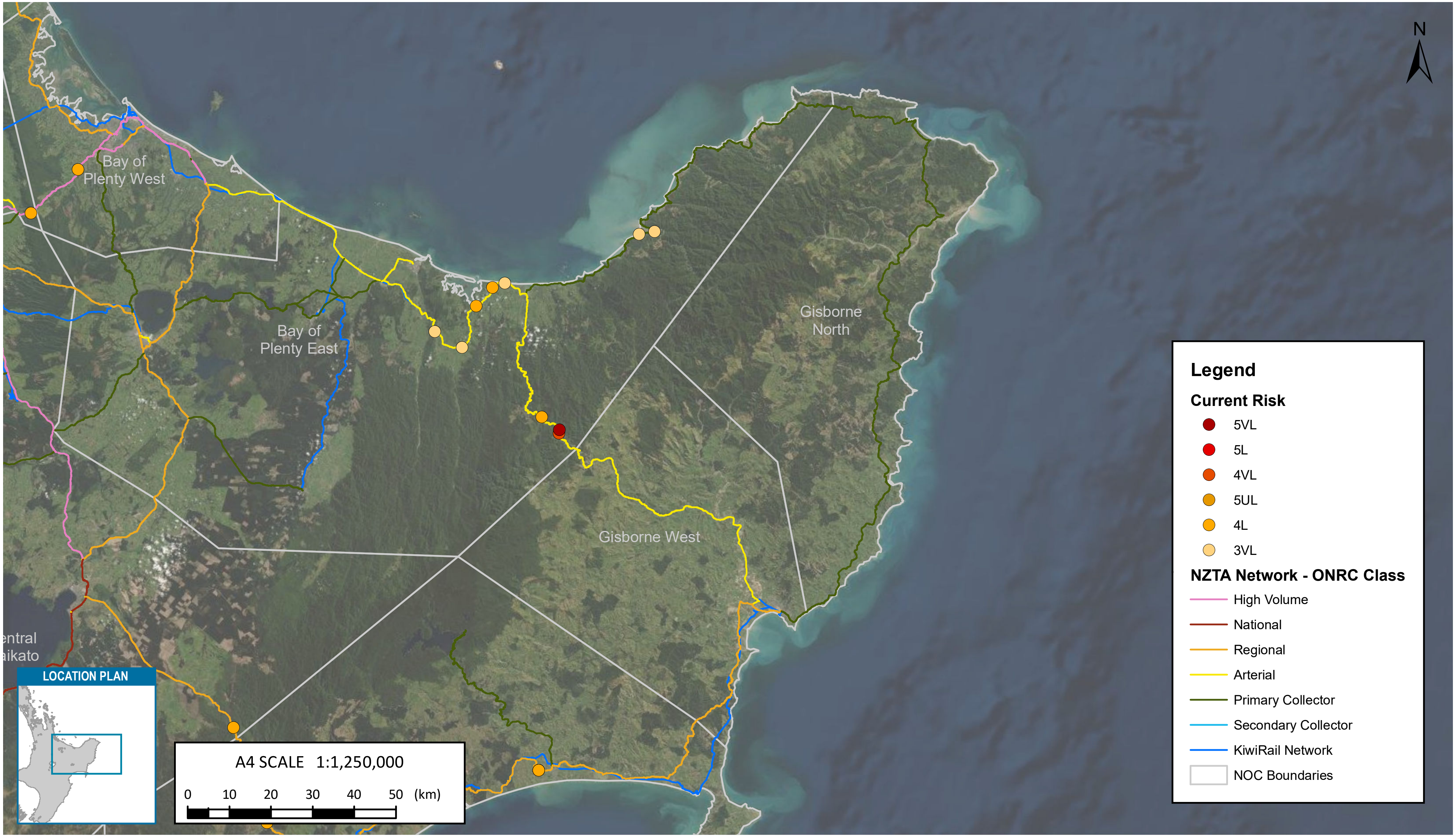
TITLE NATURAL HAZARDS RISK RATING
BAY OF PLENTY

SCALE (A4) 1:1,250,000 **FIG No.** FIGURE B2 **REV** 0



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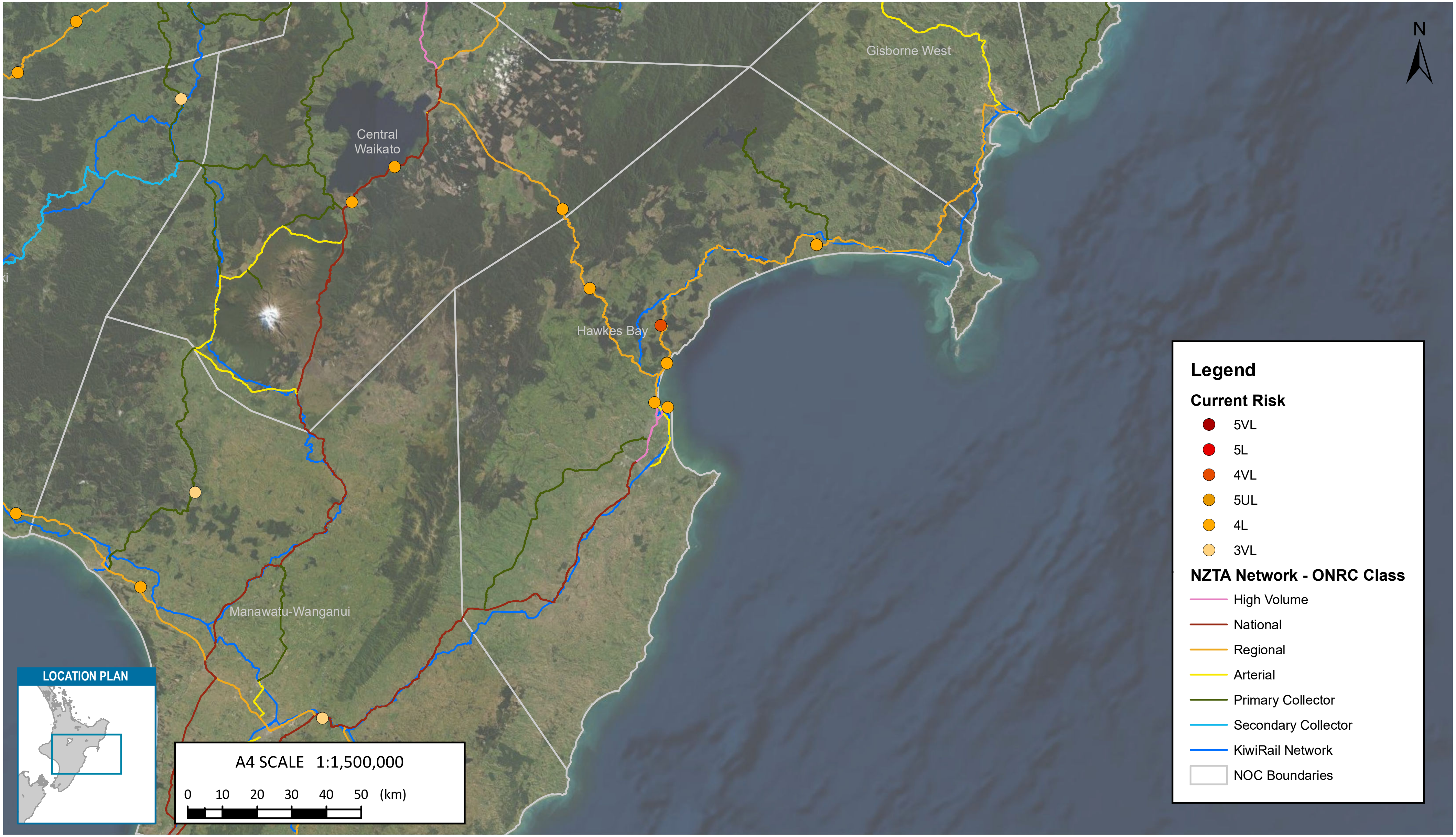
TITLE NATURAL HAZARDS RISK RATING
GISBORNE
SCALE (A4) 1:1,250,000 FIG No. FIGURE B3 REV 0



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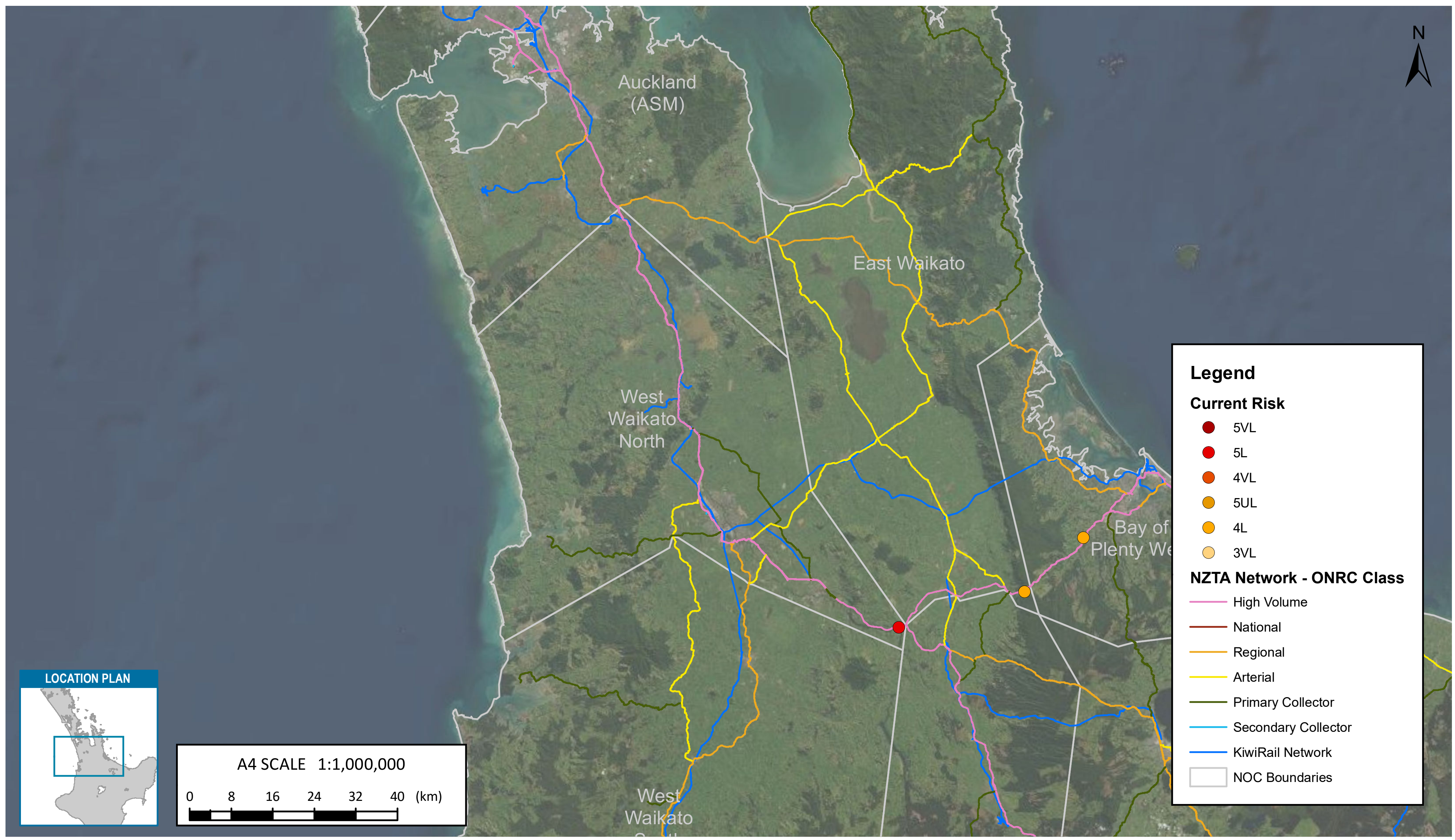
HAWKES BAY

SCALE (A4) 1:1,500,000 **FIG No.** FIGURE B4 **REV** 0



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TITLE NATURAL HAZARDS RISK RATING
WEST AND NORTH WAIKATO

SCALE (A4) 1:1,000,000 FIG No. FIGURE B5 REV 0

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TITLE	NATURAL HAZARDS RISK RATING CENTRAL WAIKATO
SCALE (A4)	1:1,750,000
FIG No.	FIGURE B6
REV	0

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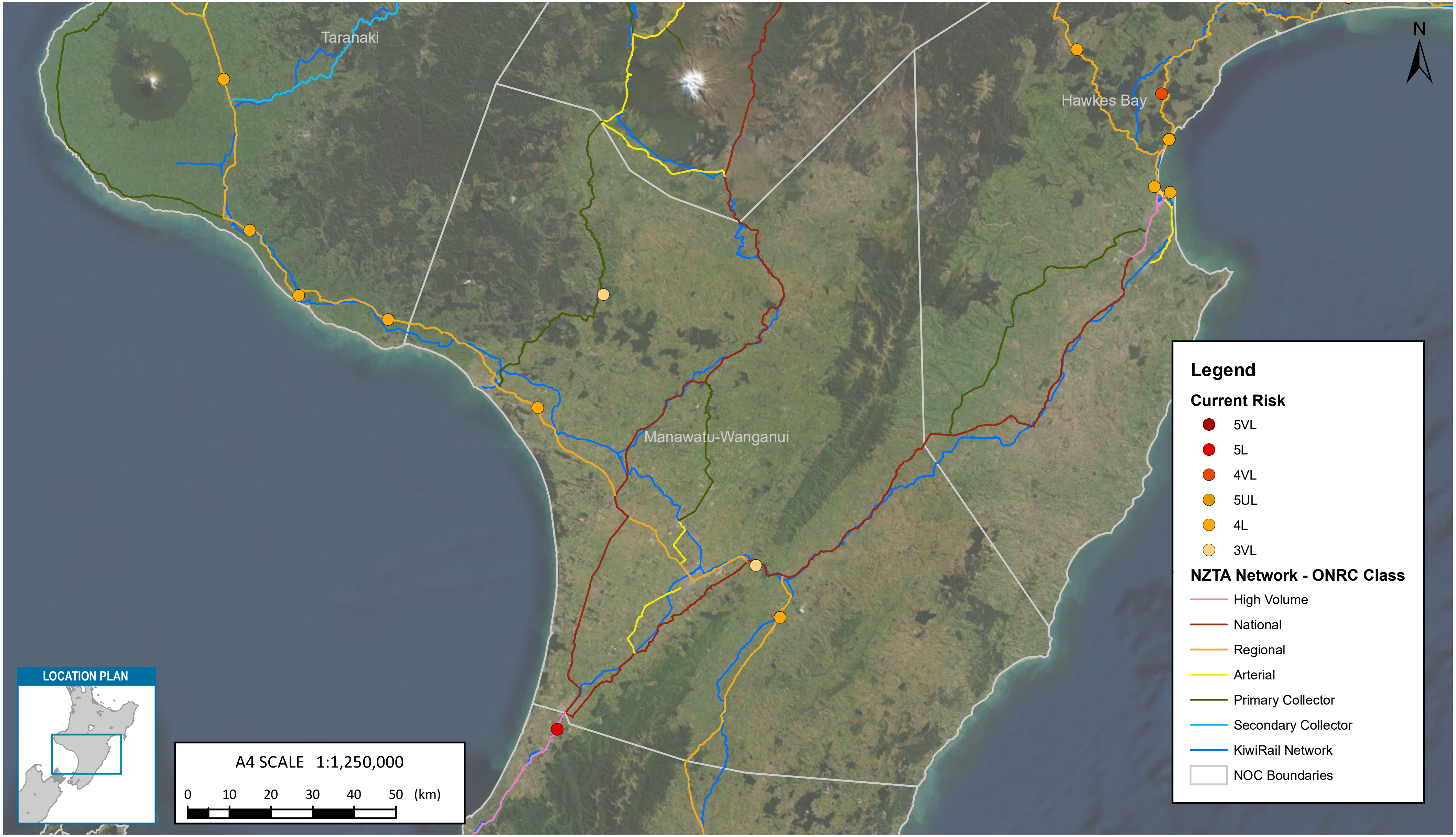
TITLE	NATURAL HAZARDS RISK RATING TARANAKI
SCALE (A4)	1:1,250,000
FIG No.	FIGURE B7
REV	0



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CLIENT NEW ZEALAND TRANSPORT AGENCY
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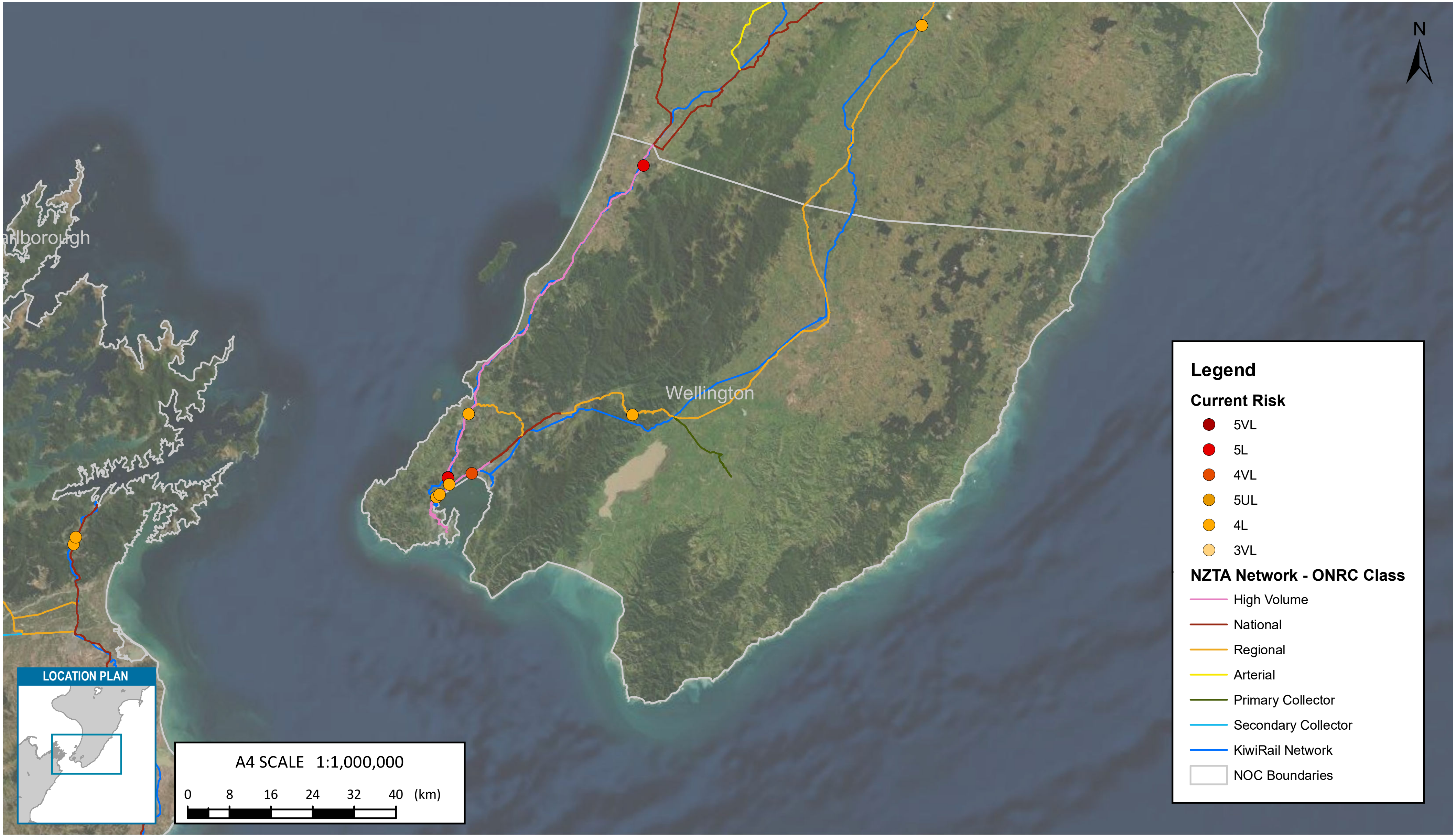
TITLE NATURAL HAZARDS RISK RATING
MANWATU/WHANGANUI

SCALE (A4) 1:1,250,000 FIG No. FIGURE B8 REV 0



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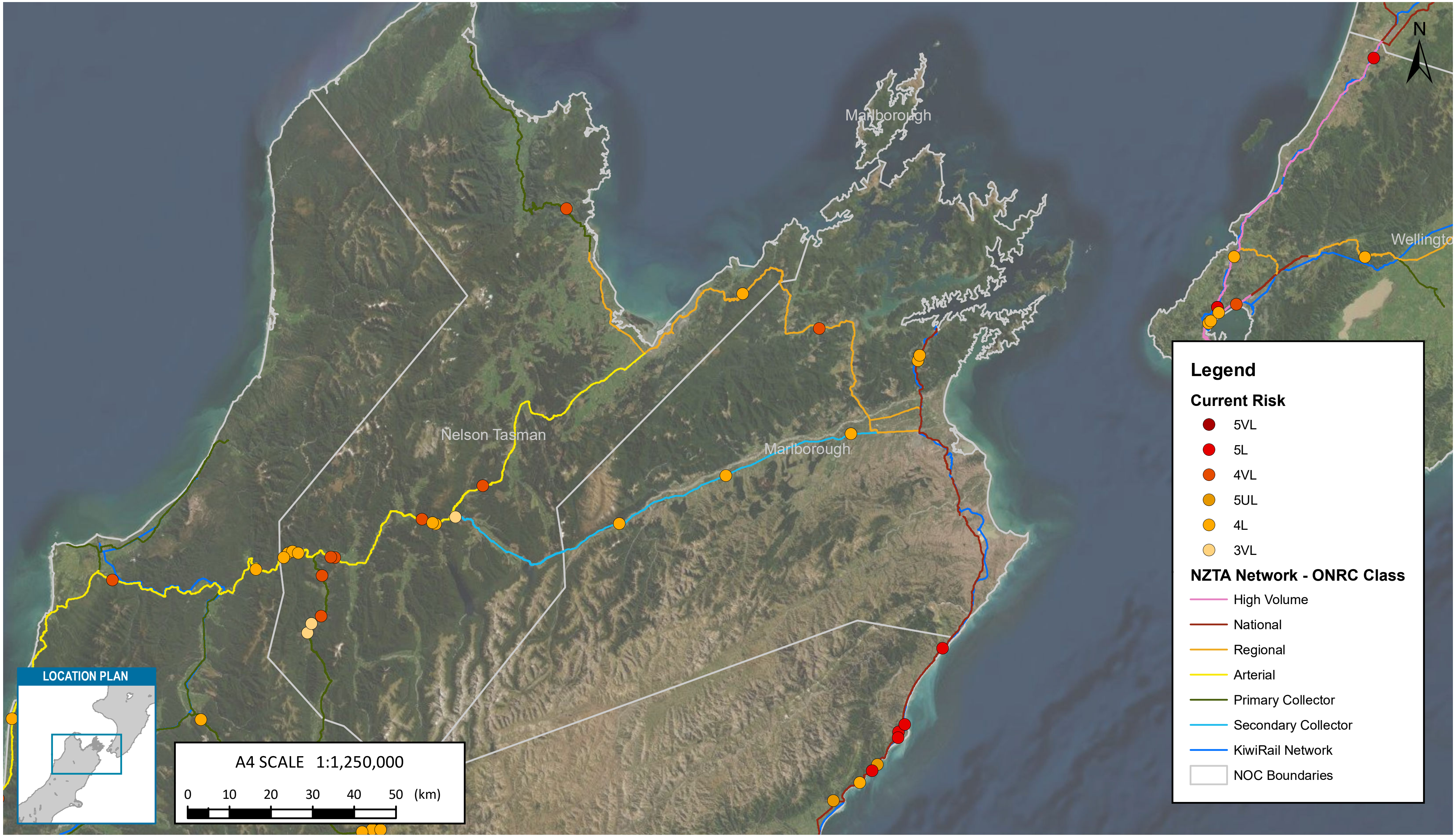
TITLE NATURAL HAZARDS RISK RATING WELLINGTON

SCALE (A4) 1:1,000,000 **FIG No.** FIGURE B9 **REV** 0



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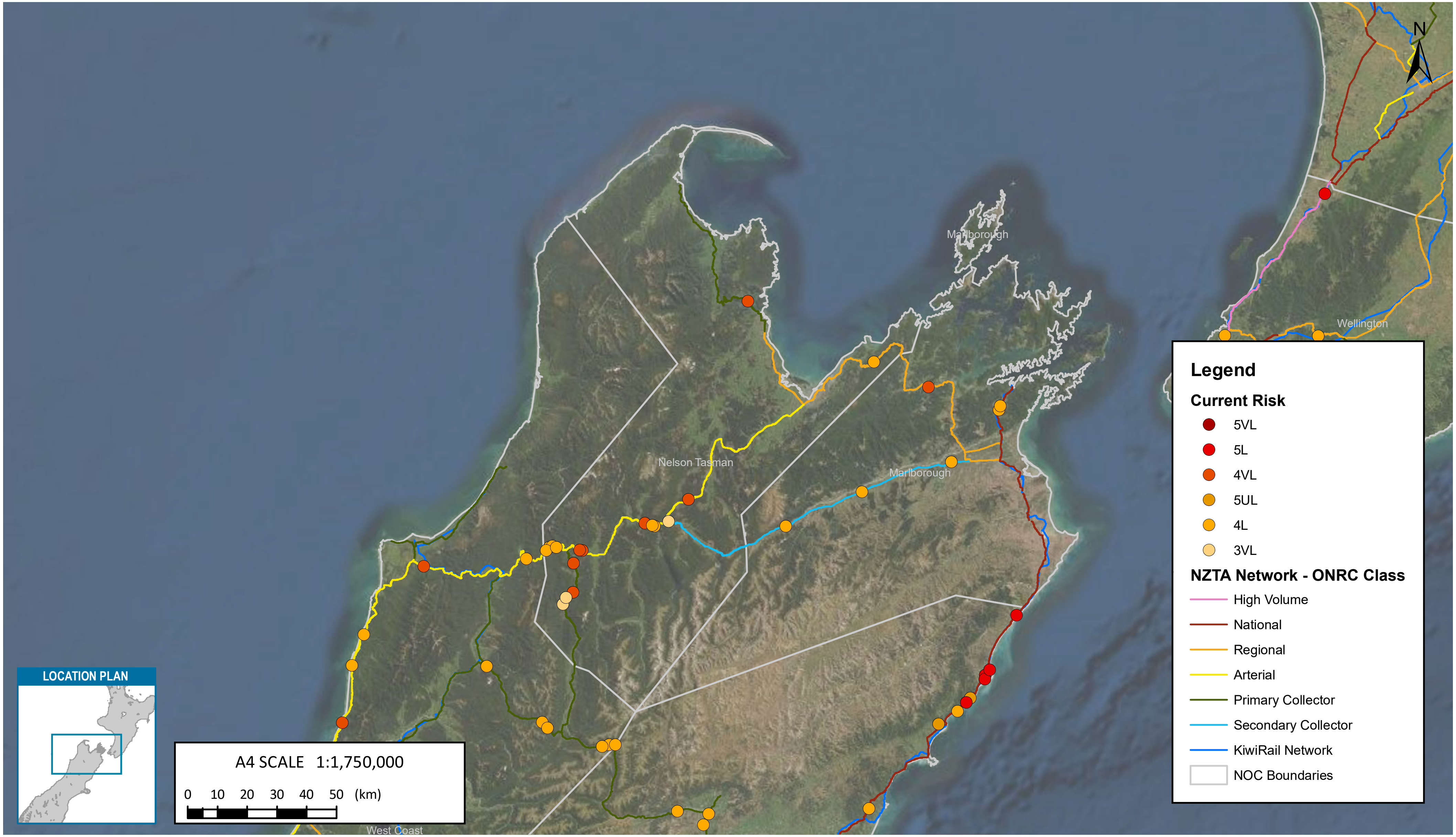
TITLE NATURAL HAZARDS RISK RATING MARLBOROUGH

SCALE (A4) 1:1,250,000 **FIG No.** FIGURE B10 **REV** 0



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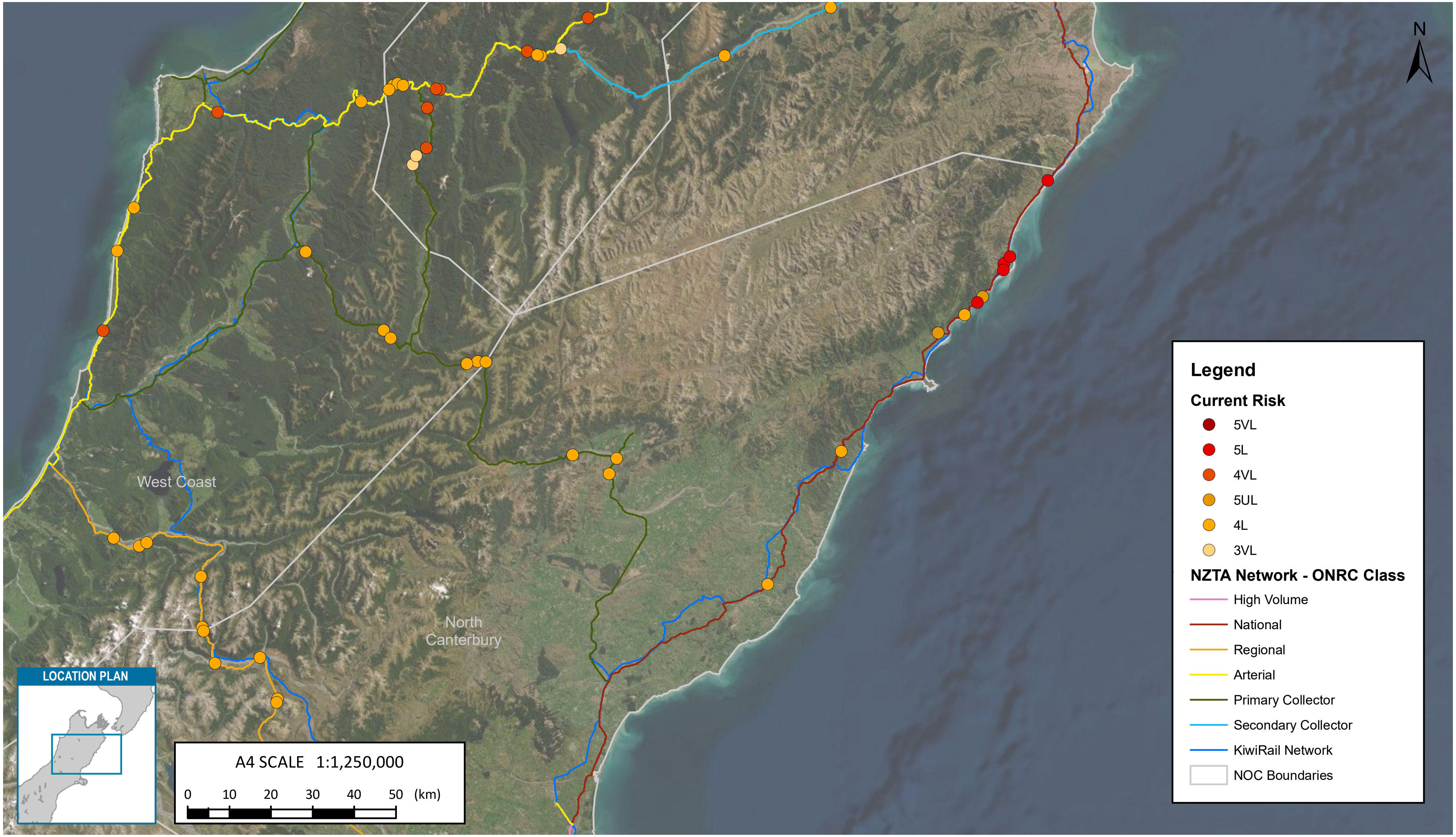
NELSON/TASMAN

SCALE (A4) 1:1,750,000 FIG No. FIGURE B11 REV 0



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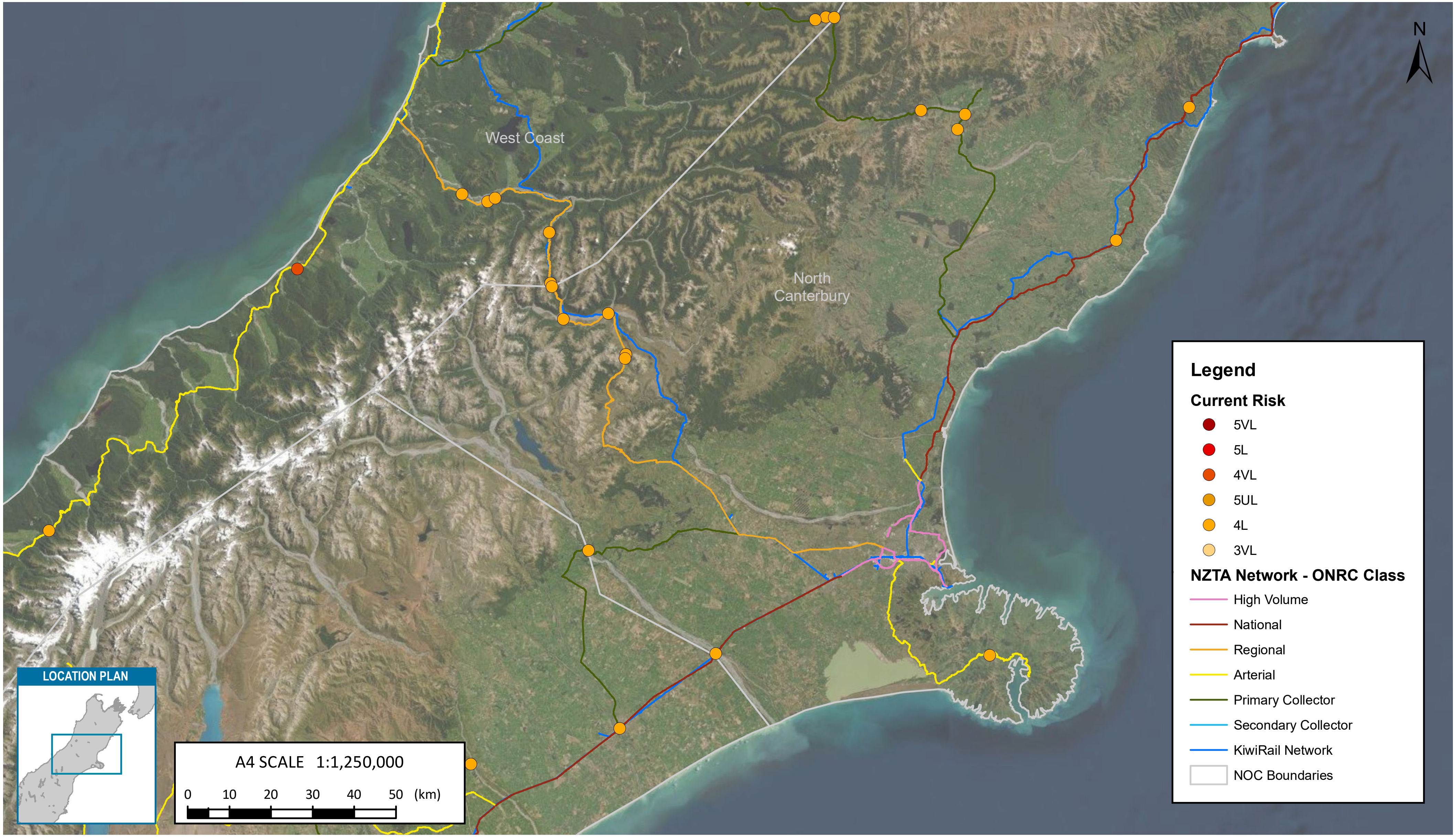
NORTH CANTERBURY I

SCALE (A4) 1:1,250,000 FIG No. FIGURE B12 REV 0



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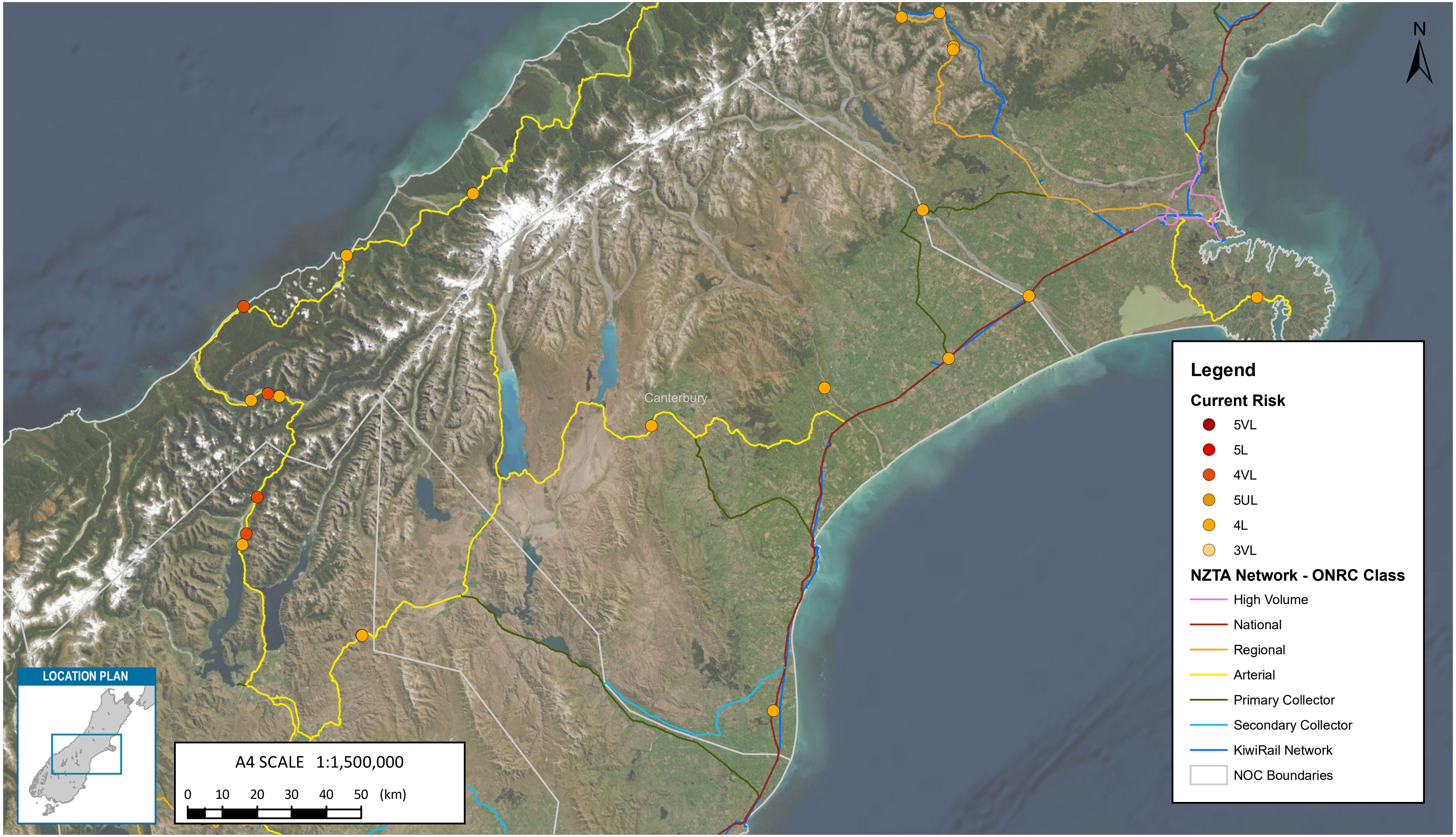
TITLE NATURAL HAZARDS RISK RATING
NORTH CANTERBURY II

SCALE (A4) 1:1,250,000 **FIG No.** FIGURE B13 **REV** 0



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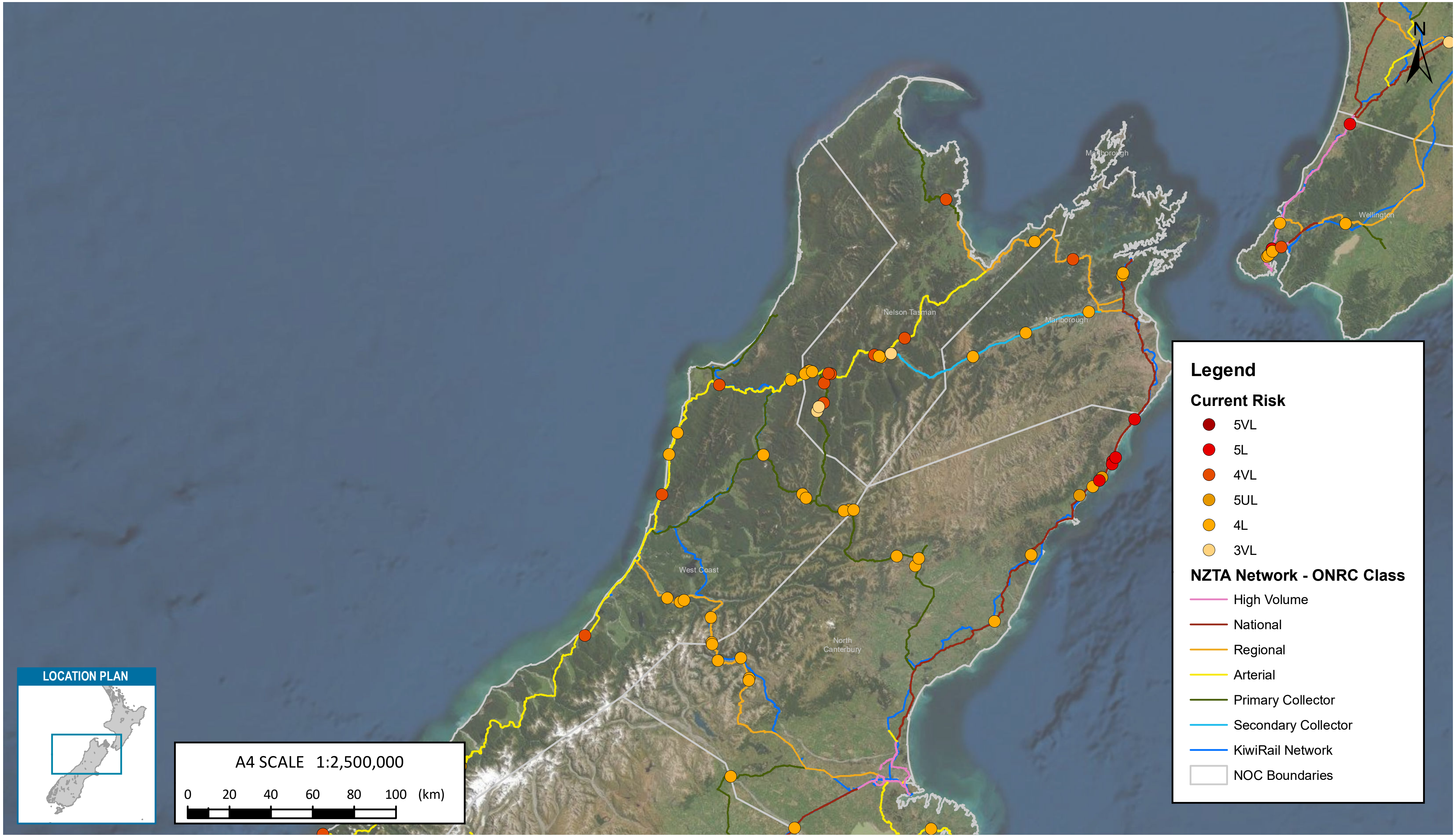
PROJECT	RESILIENCE PROGRAMME BUSINESS CASE
TITLE	NATURAL HAZARDS RISK RATING CANTERBURY SOUTH
SCALE (A4)	1:1,500,000
FIG No.	FIGURE B14
REV	0



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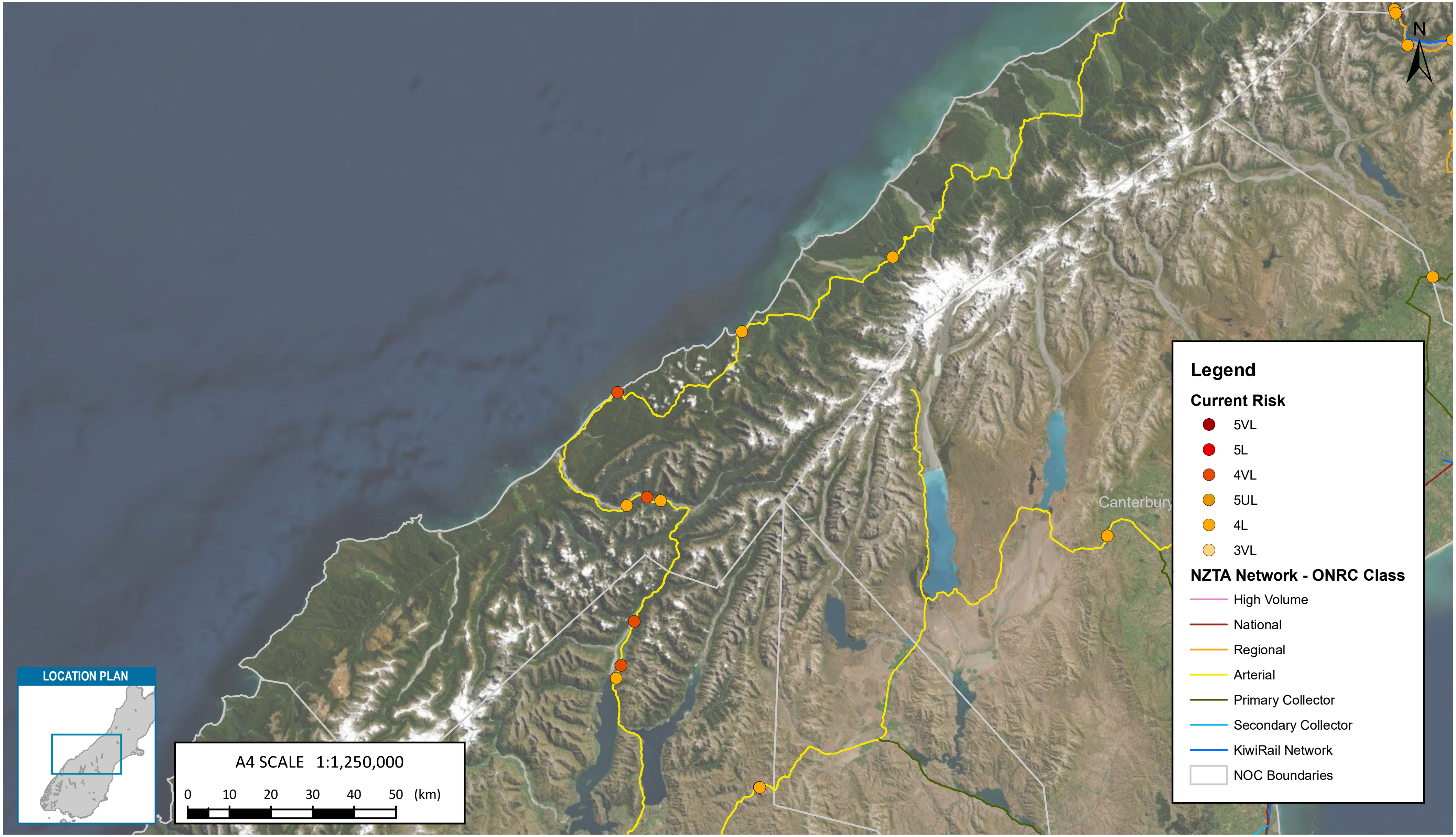
TITLE NATURAL HAZARDS RISK RATING
WEST COAST I

SCALE (A4) 1:2,500,000 **FIG No.** FIGURE B15 **REV** 0



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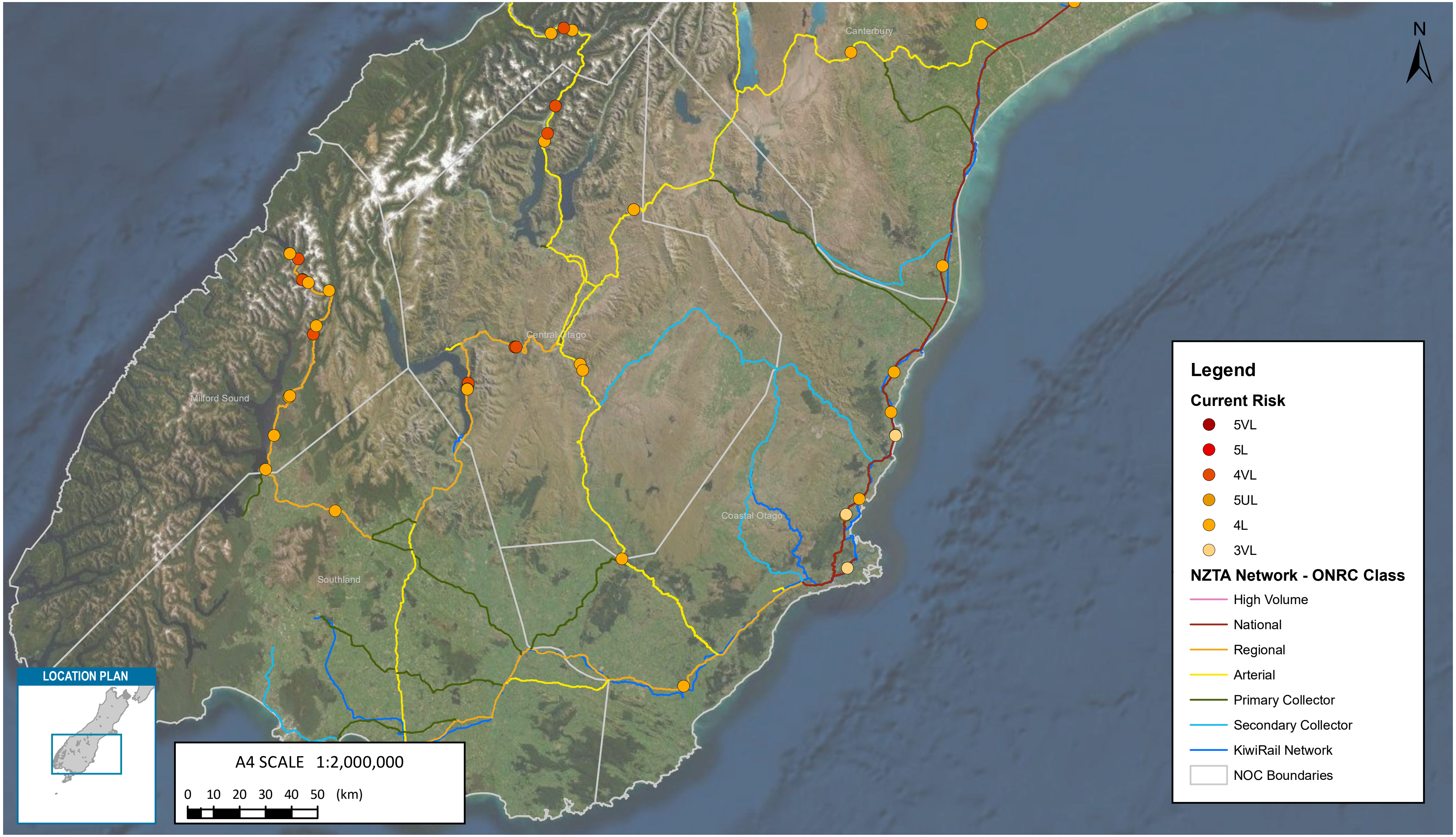
TITLE NATURAL HAZARDS RISK RATING WEST COAST II
SCALE (A4) 1:1,250,000
FIG No. FIGURE B16
REV 0



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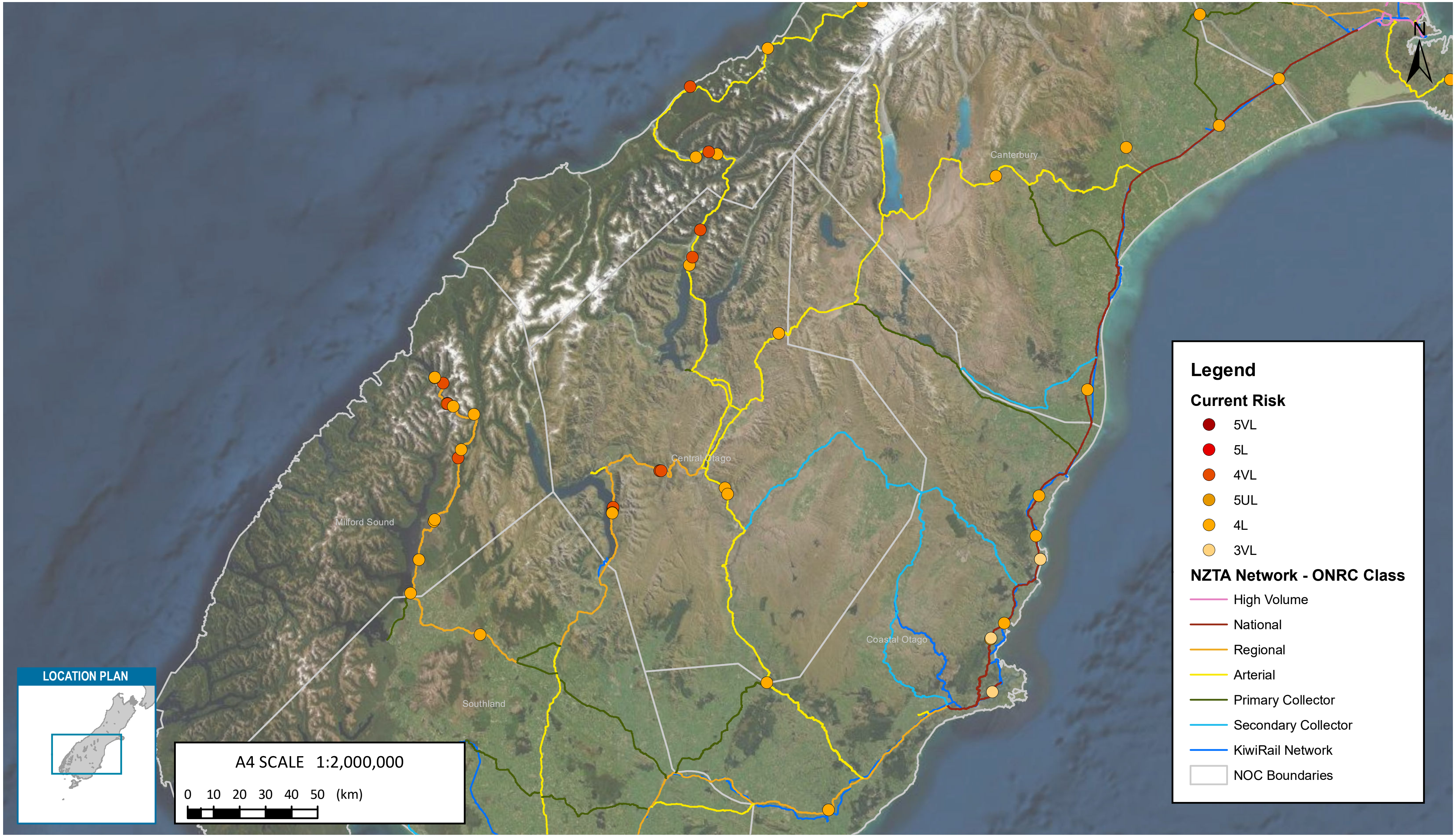
PROJECT RESILIENCE PROGRAMME BUSINESS CASE
TITLE NATURAL HAZARDS RISK RATING COASTAL OTAGO

SCALE (A4) 1:2,000,000 **FIG No.** FIGURE B17 **REV** 0



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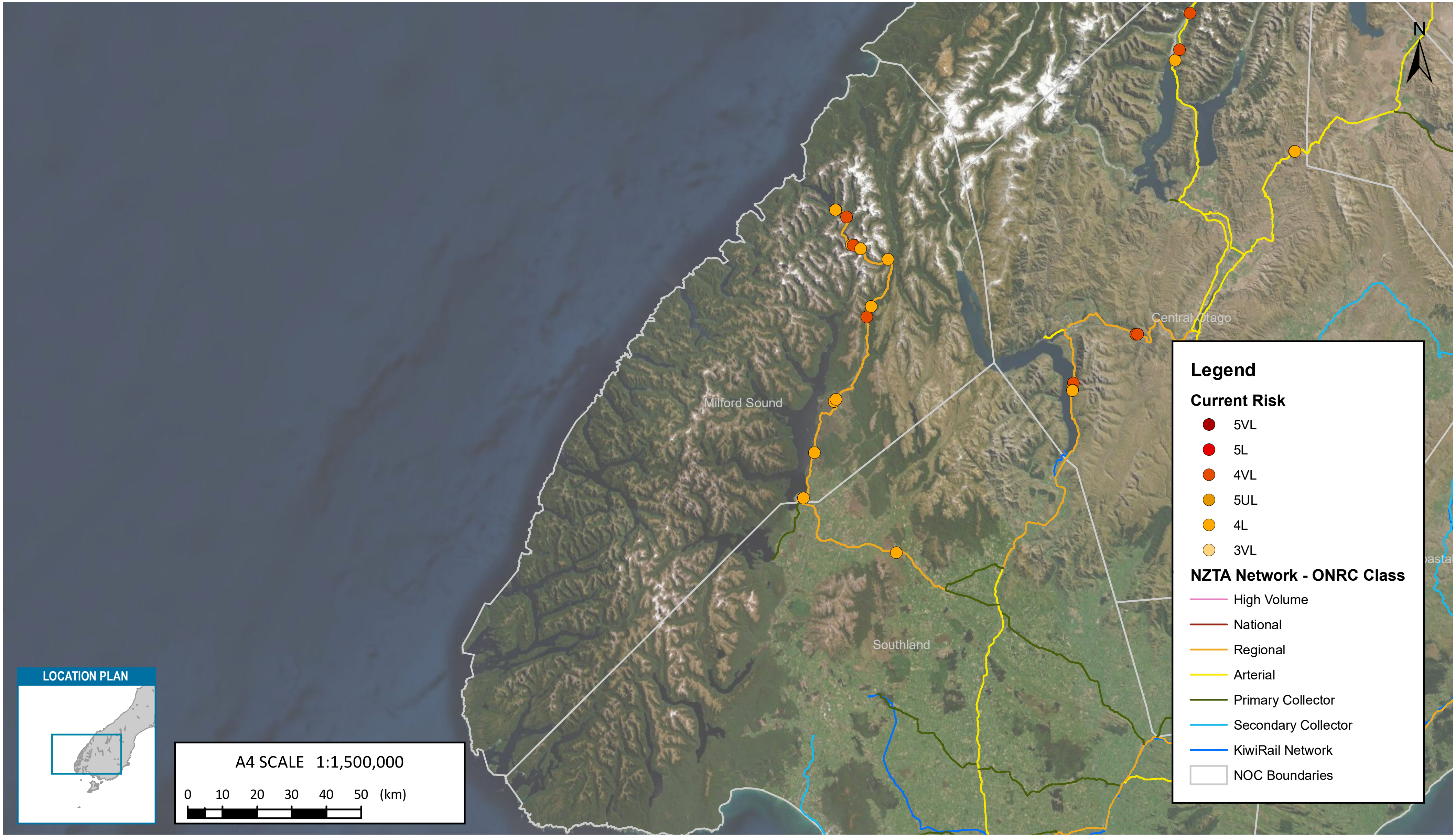
TITLE NATURAL HAZARDS RISK RATING
CENTRAL OTAGO
SCALE (A4) 1:2,000,000 FIG No. FIGURE B18 REV 0



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TITLE NATURAL HAZARDS RISK RATING
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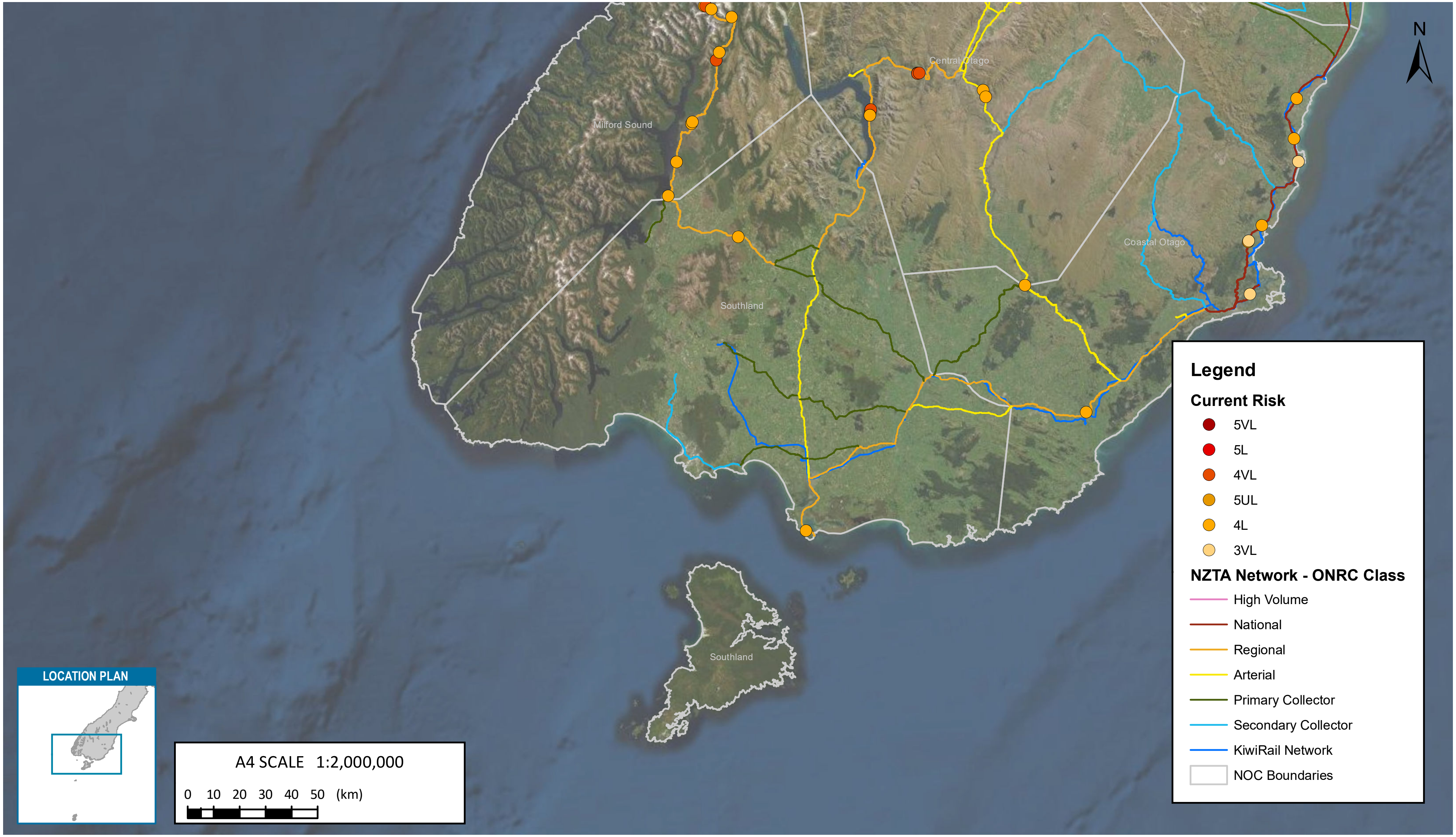

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DESIGNED	MOLI	MAY.20
DRAWN	MLO	MAY.20
CHECKED		
APPROVED	DATE	

CLIENT NEW ZEALAND TRANSPORT AGENCY
PROJECT RESILIENCE PROGRAMME BUSINESS CASE
TITLE NATURAL HAZARDS RISK RATING
SOUTHLAND

SCALE (A4) 1:2,000,000 FIG No. FIGURE B20 REV 0

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APPENDIX G – RISK PRIORITISATION METHODOLOGY AND DECISION-MAKING APPROACH

REPORT

Tonkin+Taylor

NZTA National Resilience PBC

Portfolio Risk Assessment Methodology

Prepared for
New Zealand Transport Agency

Prepared by
Tonkin & Taylor Ltd

Date
May 2020

Job Number
1011128.v3

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Document Control

Title: NZTA National Resilience PBC					
Date	Version	Description	Prepared by:	Reviewed by:	Authorised by:
20/12/19	1	Draft	R Robertson	J. Hughes C Purchas A Robertson	R Reinen-Hamill
1/04/2020	2	Final	R Robertson	J Hughes C Purchas A Robertson	R Reinen-Hamill
28/05/2020	3	Waka Kotahi Board Approval	R Robertson	J Hughes C Purchas A Robertson	R Reinen-Hamill

Distribution:

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1 Introduction

New Zealand faces a range of natural hazards and risks, which are increasing in complexity and uncertainty because of climate change. The Waka Kotahi New Zealand Transport Agency (the Transport Agency) is working to better understand the resilience of their land transport system to withstand these increasing and ever-changing natural hazard risks through the development of their National Resilience Programme Business Case (PBC).

The National Resilience PBC aims to provide context, initial evidence, coordination, priority and initial direction to interventions and activities seeking to improve the New Zealand's land transport system's resilience.

This report details the Portfolio Risk Assessment (PRA) methodology for identifying the full portfolio of natural hazard and climate change risks across the land transport network. The development of an agreed risk assessment approach is one of the responses identified in the development of the National Resilience PBC. Applying the risk assessment provides a view on priority risks across the national land transport system. An assessment of priority risks completed in early 2020 is presented in the Report *NZTA National Resilience PBC - Regional Risk Summaries (Appendix G).*

For the purpose of the National Resilience PBC the PRA focused on state highways (SH), local roads which provide alternate routes to SHs, and the KiwiRail network. In some cases, the improved resilience of local roads is a potential solution to address risks on a SH. This means risks to local roads may also be identified where relevant.

At a high level, the approach involved:

- Compiling background information to provide a consistent evidence base for identifying hazards.
- Completing a desktop evaluation of resilience related risks based on hazard and asset data and other relevant resilience related documents.
- Testing the preliminary analysis and identifying key risk locations at a regional stakeholder workshop. This has been done on a regional basis (based on the Network Outcomes Contract (NOC) regions) but could also be undertaken on a corridor, journey or other basis.
- Utilising available hazard information, the regional stakeholder workshop results were cross checked and updated where deemed appropriate.
- Developing initial 'response' options with stakeholders for priority risks, drawing on stakeholder knowledge, and recommending next steps.

2 Background information and evidence base

In completing an assessment of risk, it is important to use appropriate evidence to inform the process. The information presented in the remainder of Section 2 provides background on both previous assessments and available datasets. These datasets formed an agreed evidence base that is used to inform and test discussions with stakeholders about priority risks at a regional or corridor level, and to cross reference the PRA results post each of the regional workshops.

Information on natural hazards, the impacts of specific events and the condition of assets is constantly changing. This means the evidence base will evolve over time and should ideally be maintained in a way that provides for quick and simple integration of new information.

2.1 Review of previous resilience work

Previously completed resilience business cases have been reviewed to provide useful context within the PRA regional workshops. These included:

- The Transport Agency, 2013 – Strategic Resilience in the State Highway Network
- The Transport Agency, 2014 - State Highway Network Resilience National Programme Business Case
- Opus, 2016 - National State Highway Resilience: 9 Priority Programme Business Case Corridors
- The Transport Agency, 2019 - National Resilience Strategic Case.

The National Resilience Strategic Case (2019) includes a review of the previous the Transport Agency business cases which has been summarised below.

The 2019 National Resilience Strategic Case notes that previous Transport Agency business cases on resilience were considered to have taken a narrower lens that was no longer considered fit-for-purpose in order to carry out a 'whole of system' approach across the land transport network. The *2013 Strategic Case: Resilience in the State Highway Network* focussed on the legislative requirements of the Transport Agency in managing the state highway network to:

- Improve access to support disaster response and recovery
- Improve network reliability to support economic growth
- Reduce risk from rock falls and slips.

The resulting *2014 National Resilience Programme Business Case*, directed investments to improve resilience in three areas:

- Priority corridors
- Critical spot treatments
- Improve management and preparedness.

The *2014 Resilience PBC* identified that 'Priority 1' corridors should be assessed under a separate PBC. The *2016 9 Priority Programme Business Case Corridors* focused on addressing these 'Priority 1' corridors across the network.

The *2013 Strategic Case* also initiated the *2014-2017 Resilience Business Improvement Project* (Figure 2.1), which focussed on three work streams: business continuity plans; emergency response plans; and the business case process.

Appendix B provides a summary of other relevant reports that have also been reviewed.

In preparation for the regional stakeholder workshops, all Corridor Management Plans[1] and the National Transport Planning Overview (NTPO)[2] were also considered to provide an overview of resilience issues along key regional routes.

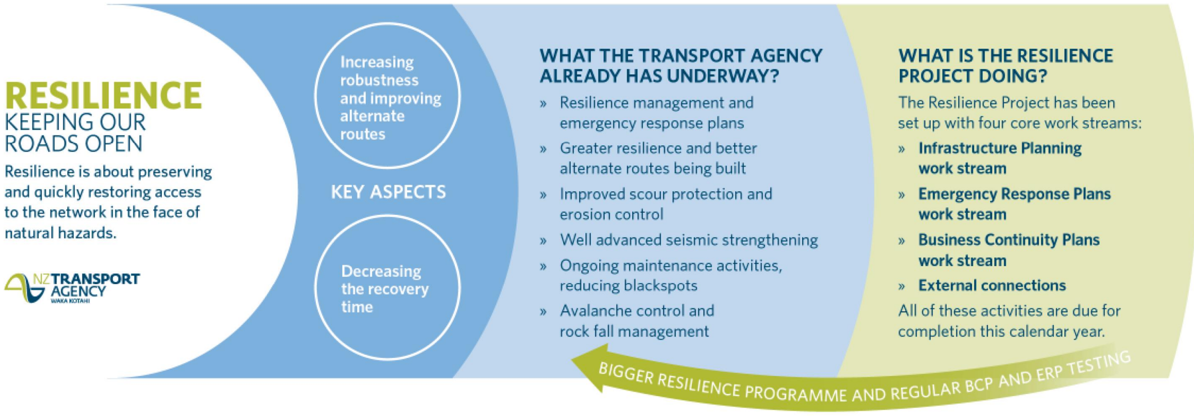

Figure 2.1: Resilience Business Improvement Project overview[3]

2.2 Natural hazard and asset data collection and review

Appendix C presents an overview of the natural hazard and asset data collected and reviewed prior to the regional stakeholder workshops. This data review is summarised below and provided a first pass at identifying key risk areas which were discussed in workshops with regional stakeholders.

2.2.1 Asset data

Transport system data was collected from the Transport Agency and publicly available data sources such as LINZ and is detailed in Appendix C. This data primarily focuses on network infrastructure e.g. roads and rail, as well as critical infrastructure locations such as ports, bridges, airports, and other utility infrastructure served by transport corridors.

Data was gathered on a range of key lifeline interdependencies (such as electricity generation sites) in order to identify which road elements service these key lifelines – and therefore have potential to create an interdependency (and increase the criticality).

Local road data was also obtained and was used to understand potential detour routes or access to critical lifelines/interdependencies.

The road network data contained associated One Network Road Classification (ONRC) ratings which provide a key input within the PRA method.

2.2.2 Hazard and risk data

When identifying hazards of interest, we have:

- Considered the range of natural hazard events that occur within each region where appropriate data is available
- Considered human – made hazards (technological and socio/political) where relevant, noting that none of these were prioritised during the assessment.

[1] The Transport Agency, Corridor Management Plans
[2] 2015, The Transport Agency, NTPO Resilience Table
[3] 2019, The Transport Agency, National Resilience Strategic Case

- Identified exacerbating factors – factors that could amplify or exacerbate hazard magnitudes and frequencies should be considered. This particularly relates to climate change effects.

Information on applicable hazard data coverage, return periods and limitations has been obtained and summarised in Appendix C. Most of these datasets are at a national level, providing a consistent comparison across the country, enabling identification of areas of higher hazard exposure and risk.

The national datasets are generally of a 'coarse' resolution, however are considered appropriate for this National Resilience PBC level assessment. They should not be used for detailed analysis. For example, the National Seismic Hazard Model provides a good understanding of impacts within proximity to fault locations, therefore can be used to indicate potential impacts for transport networks. National climate change data however has higher levels of uncertainty within datasets, and is usually presented at a regional scale, limiting detailed assessments of impacts.

2.3 Previous Transport Agency hazard/risk assessments

The Transport Agency provided a dataset entitled "Natural Hazard Resilience Prioritisation" road asset information, which gives varying risk ratings including low, major, significant or vital. The dataset is intended to highlight the level of risk for SH segments (in relation to natural hazards) across the network. The effective risk rating within this assessment is derived from the following:

- Low frequency – high impact events (earthquake, volcano, storm, tsunami)
- Resilience costs related to network maintenance costs from high frequency hazards including slips, ice/frost, and floods (assumed that these costs are indicative costs which are inferred from the predicted degree of damage)
- The relative importance of the road segment based on the ONRC.

More information on both the natural hazard resilience prioritisation and bridge data can be found on the Transport Agency Resilience Hazard Maps[4]. As this dataset is currently the primary information source available for natural hazard risk across the Transport Agency network and is readily available, this information was used to compare with the outcomes of the regional workshops for high frequency hazard events (refer Section 3.3)

[4] The Transport Agency Resilience Hazard Maps

3 Portfolio risk assessment methodology

This section details the Portfolio Risk Assessment (PRA) methodology developed to assess and identify natural hazard and resilience risks on the land transport system. A PRA is not a detailed risk assessment, but a practical high-level assessment that enables the Transport Agency to better prioritise resilience works and develop investment strategies. In a PRA, the risk relating to different system elements in the portfolio is assessed based on historically available information as well as information gathered through elicitation in workshops with informed stakeholders.

The PRA methodology adopts a *Likelihood* and *Consequence* approach to assess risk as outlined in ISO:31000 Risk Management Principles and Guidelines (ISO 2009). This approach is considered good practice, simple to understand, and aligns with the current the Transport Agency approaches. The PRA methodology was developed and refined with regional staff during workshops which ensured the criteria for assessing risk across the network was tailored to the Transport Agency context and purpose of the National Resilience PBC.

Ultimately, the PRA aims to identify risks (prioritising high and extreme risks), across the transport system with primary regard to present day natural hazards as well emerging, climate change related hazards. Note that while technological and 'man-made' risks were raised at workshops, no risks of this nature were captured or prioritised.

3.1 Risk assessment for present day hazards

Present day hazards relate to known hazard events such as earthquake, tsunami, rock-fall, storm-induced flooding and landslip, coastal hazards (erosion and inundation). Hazards which are potentially exacerbated by climate change were addressed as well. This is covered in Section 3.2.

This PRA approach uses combined *likelihood* and *consequence* parameters that influence the level of risk (refer Figure 3.1). The *likelihood* is addressed by combining the hazard frequency and the duration of outage which is indicative of the level of potential damage to the asset from its exposure to the hazard (i.e. the greater the damage the greater the duration of outage). The *consequence* is addressed by combining the criticality of the road (ONRC) and the availability of a viable detour.

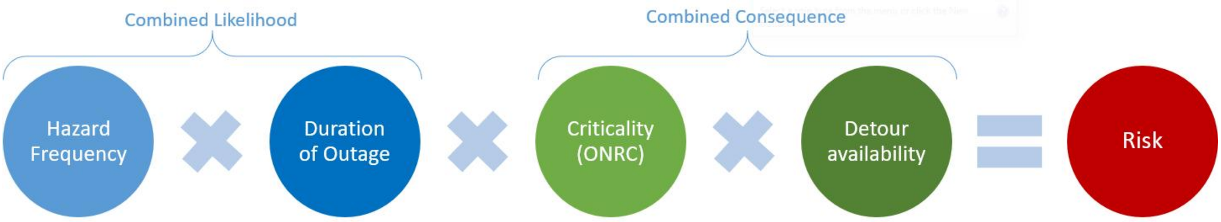

Figure 3.1: Risk assessment methodology/framework

3.1.1 Combined likelihood

As mentioned, in order to manage the key parameters within a '*likelihood* and *consequence*' approach, a *combined likelihood* parameter was developed which represents a combination of the hazard likelihood and the duration of outage.

Typically, a 1 to 5 scale was used to assign likelihood ratings. However, for simplicity and ease of use in a workshop situation, three categories were used to rate both the hazard likelihood and the duration of outage in terms of low (1), medium (2) and high (3) (refer Table 3.1).

Table 3.1: Combined likelihood rating criteria

Descriptor	Hazard Likelihood/Frequency
Low (1)	Occurs approximately every 50 years or more
Medium (2)	Occurs approximately every 5-50 years
High (3)	Occurs approximately every 5 years or less

Descriptor	Duration of Outage
Low (1)	Less than 12 hours
Medium (2)	12 – 48 hours
High (3)	> 48 hours

The initial categories and descriptors were determined through internal project team discussions and then verified and adjusted at the initial regional stakeholder workshops. While using a 1 to 3 scale reduces granularity of the assessment, a good spread of combined likelihood outcomes was still able to be achieved via an improved, efficient process.

Table 3.2 details the matrix used to combine the hazard frequency and duration of outage ratings into a combined likelihood of damage rating of unlikely (UL), likely (L) or very likely (VL).

Table 3.2: Combined likelihood matrix

		Hazard		
		Low (1)	Medium (2)	High (3)
Outage	Low (1)	1	2	3
	Medium (2)	2	4	6
	High (3)	3	6	9

Rating Key
Unlikely (UL)
Likely (L)
Very likely (VL)

3.1.2 Combined consequence

The *combined consequence* parameter was assessed by combining the criticality of the road network, which has been based on both the Transport Agency One Network Road Classification (ONRC), and the availability of viable detours.

Criticality

The ONRC is a classification system, which divides New Zealand's roads into six categories based on a range of criteria, including: traffic volume; whether they connect to important destinations; and if they are the only route available. Discrete categories include[5]: High volume, National, Regional, Arterial, Primary collector, Secondary collector, Access, Low volume.

Criticality is a broader concept and should also consider roads which provide access for/to essential services and lifeline utilities and regionally important economic activities. During initial discussions with Transport Agency staff, it was highlighted that the ONRC does not necessarily reflect a road's criticality/importance to a region (or nation). To enable the risk assessment to account for situations where the ONRC underrepresented the *criticality* of a particular road, an adjustment factor is included to enable the ONRC rating to be increased to reflect a more realistic criticality or importance level.

An example of this is SH7 through Lewis Pass in north Canterbury/West Coast. The route is one of four routes which provide access between the east and west coasts of the South Island (the other three being Arthurs Pass, Haast Pass and the Buller Gorge). The Lewis Pass has a lower ONRC rating than the other two (Primary collector as opposed to Regional and Arterial), however represents a key economic and community lifeline route between Canterbury, Top of the South and the West

[5] The Transport Agency, One Network Road Classification https://www.The Transport Agency.govt.nz/roads-and-rail/road-efficiency-group/projects/onrc

Coast, as well as a key alternate route during a significant natural hazard event. This was emphasised after the Kaikoura Earthquake when it became the primary route north from Canterbury.

Detour availability

The availability (and duration) of viable detour routes plays a key factor in the *consequence* of hazards impacting the land transport network. For example, a road that has a high ONRC rating with a short alternative detour suitable for all vehicle types, would potentially cause less disruption to the network compared to a lower ONRC road with a significant (or no) detour.

Combined consequence rating

Similar to the *combined likelihood*, the *combined consequence* was separated into categories; 5 categories for the ONRC banding and for simplicity, the detour issues were placed into three categories in terms of low (1), medium (2) or high (3) - refer Table 3.3. As per the outage scores above, while using a 1 to 3 scale for detour issues reduces granularity of the assessment, a good spread of combined consequence outcomes were still able to be achieved via an improved, efficient process.

Table 3.3: Combined consequence rating criteria

Descriptor	ONRC Banding
1	Access/Low Volume
2	Primary/Secondary Collector
3	Regional/Arterial
4	National
5	High Volume

Descriptor	Detour Issues
Low (1)	Short (<1hr) and easy to manage detour for all vehicles
Medium (2)	Moderate detour (<3hr) OR shorter hard to manage detour and no HPMV option
High (3)	Long detour (>3hr), hard to manage AND no HPMV option

Table 3.4 details the matrix used to combine the ONRC rating and detour issues into a *combined consequence* rating of 1 – 5.

Table 3.4: Combined consequence matrix

		Detour		
		Low (1)	Medium (2)	High (3)
ONRC + weighting	1	1	2	3
	2	2	4	6
	3	3	6	9
	4	4	8	12
	5	5	10	15

Rating Key
1
2
3
4
5

3.1.3 Risk rating

The *combined consequence* can then be combined with the *combined likelihood* to assess the overall risk to the asset or section of network as minor, moderate, major or extreme (refer Table 3.5).

Table 3.5: Risk matrix

		Combined Likelihood		
		UL	L	VL
Combined Consequence	1	1UL	1L	1VL
	2	2UL	2L	2VL
	3	3UL	3L	3VL
	4	4UL	4L	4VL
	5	5UL	5L	5VL

Rating Key
Minor
Moderate
Major
Extreme

3.2 Risk assessment for climate-related hazards

As previously mentioned, where hazards are potentially exacerbated by climate change, they have been addressed separately. These hazards include: coastal inundation, coastal erosion, flooding, river erosion, avalanche risk and hazards relating to extreme weather, such as wind.

Present day hazards already affecting the land transport system were identified and evaluated via the PRA process to provide a risk score for present day. These were then given a risk rating for the expected likelihood and consequence in 2050 based on the current projections under Representative Concentration Pathway (RCP) 8.5 (median value) for New Zealand. RCP8.5 was selected as this is assumes little to no reduction in GHG emissions.

When assessing risk at 2050 under RCP8.5, the hazard likelihood typically increases, and/or the duration of outage increases - resulting in an increase in the risk rating for an identified risk location.

It is noted that coastal, climate-related risks identified in the workshops were cross referenced against a recent (draft) study by Tonkin & Taylor Ltd (T+T)[6] for the Transport Agency - to ensure consistency and that areas of potential high or extreme risk were captured. This study utilises the coastal inundation mapping which was completed by the National Institute of Water and Atmospheric Research (NIWA)[7,8] and represents the current best available information on future coastal inundation projections for New Zealand.

Areas identified in the T+T study as being highly exposed to coastal inundation in the future but were not picked up in the regional stakeholder workshops were then added to the risk database with a relatively low current risk rating (currently not affecting the land transport system on a regular basis). However the risk at 2050 was increased based on the information provided within the T+T[6] and NIWA[7,8] studies.

[6] *Coastal Exposure Assessment – Stage 2 Exposure Assessment to Coastal Hazards,* Tonkin & Taylor Ltd (2020) - Draft
[7] *National and regional risk exposure in low-lying coastal areas*, Bell, R.G., R. Paulik, S. Wadwha, (2015)
[8] *Coastal Flooding Exposure under Future Sea-level Rise for New Zealand*, Paulik, R., S. Stephens, S. Wadhwa, R. Bell, B. Popovich, B. Robinson, (2019)

3.3 Regional stakeholder workshops

Regional stakeholder workshops were held for each NZTA region. These were either held in person, or remotely via teleconference. Attendees varied by region (see Appendix D for a full list of stakeholders consulted) and included:

- The Transport Agency Regional Managers/key identified staff
- Network Outcomes Contract (NOC) key staff
- Regional Transport Committee members (including local Councils)
- Regional and/or strategic planning staff from KiwiRail, Ports, Airports, and commercial road user groups.

The workshops built on the hazard assessments and data review undertaken previously, and stakeholders then focussed on checking and identifying risks on the local network utilising the PRA methodology detailed above. This information was recorded geospatially by the project team.

The workshops covered the following broad topics:

- A discussion around the context and background to the National Resilience PBC.
- Presentation of existing knowledge around natural and human-made hazards (including climate change), previous work and known gaps. This included all information presented in the sections above.
- A discussion around 'criticality' in the context of the local transport system and critical routes.
- Discussion and elicitation of key known risks within the network (in relation to specific hazards), documented geospatially in a web viewer.
- Assessing and ranking risks and prioritisation based on the PRA methodology set out in Section 3.1. Developing a series of possible response options to address those risks identified.

3.4 Developing potential response options

Through the regional stakeholder workshops, a range of suggested response options (grouped into wider response categories) were identified and were documented within the summary tables provided in the accompanying *Regional PRA Summaries Report*[9]. The response option discussions within the workshops focussed primarily on direct Transport Agency interventions, such as physical works, maintenance or emergency management responses.

In some cases, there were multiple hazards/risks for a section of the transport system or corridor. Examples include the Waioeka Gorge (subject to rockfall and landslip hazards), and SH north of Dunedin (subject to landslip and coastal hazards). Each of these were recorded as separate risk locations, however, where possible a solution was suggested to help address multiple issues along a corridor.

It is noted that the solutions developed in the workshops are high-level 'suggested' solutions, based on the knowledge and experience of those staff present. The majority of identified risks will require further investigation and development of specific business cases. During these processes a broader suite of response categories should be considered. These could include:

- Physical works (NZTA)
- Physical works (third party – e.g. local road detour improvements, stop banks)
- BAU maintenance / monitoring / emergency response planning
- Enhanced maintenance / monitoring

[9] (2020) Tonkin + Taylor, *Regional Risk Assessment Summary Report – NZTA National Resilience PBC*

- Enhanced emergency response plans / preparedness
- Land use / development controls
- Real time info / community emergency information systems/education.

For all major and extreme risks identified, two categories of 'next steps' have been recommended by the project team - which indicate next steps in the process rather than the proposed solution. The process should identify the most appropriate solution considering an entire suite of potential response categories (as listed above), along with the suggested solution from the regional stakeholder workshop. As such, the two next step categories are:

- *Business Case funded or underway:* The next step is to proceed with the current business case development ensuring that an appropriate suite of response options are considered.
- *Business Case required*: The next step is development of a 'right sized' business case to address the identified risk, considering an appropriate suite of response options. The business case point of entry will determine the level of effort required.

3.5 Systemic risks

Systemic or operational/management type risks and issues, which hinder the ability to respond to natural hazard events or build resilience across the land transport network, were also discussed and captured in the workshops. Examples include limitations and complexity around funding for improvements, limited river catchment monitoring and management or other operational or management issues across multiple organisations.

These risks are documented within the main Programme Business Case report and are not mentioned herein.

3.6 Cross referencing of PRA regional stakeholder workshop results

Following the regional stakeholder workshops to elicit natural hazard information, identified risks, their corresponding risk ratings and possible solutions were then reviewed by key stakeholders in a series of follow up phone calls / meetings. The purpose of this process was to confirm the risk ratings and ensure key risks were not missed and the appropriate ratings were applied and agreed upon.

Once the results of the PRA had been confirmed through follow up phone calls, the results were also compared geospatially against the available natural hazard and risk information collated - specifically the NZTA Resilience Prioritisation[10]. This was undertaken to ensure consistency and accuracy of the regional stakeholder workshops.

As previously mentioned in section 3.2, coastal, climate-related risks identified in the workshops were cross referenced against a recent (draft) study by T+T[11] for the Transport Agency - to ensure consistency and that areas of potential high or extreme risk were captured.

It is important to note that cross-referencing is largely dependent on the availability and associated quality of the supplied hazard datasets. The methodology used to develop each dataset varies and this has not been considered in putting together the evidence base for this process. Given that the cross-referencing process is designed to further identify any areas of missing hazard identification, and not remove any identified hazards, this is seen to be acceptable.

[10] 2017, The Transport Agency, State highway resilience prioritisation maps
[11] *Coastal Exposure Assessment – Stage 2 Exposure Assessment to Coastal Hazards,* Tonkin & Taylor (2020) - Draft

4 Limitations

The following details limitations to consider regarding the PRA methodology and accompanying results:

- Due to the nature of the workshops and the National Resilience PBC which is focusing on Major and Extreme risks only, there is likely to be a bias towards higher risks in the regional results.
- Issues that have no real option for mitigation such as South Island Alpine Fault EQ or tsunami may not be captured in detail through workshops.
- Datasets used for cross referencing were not verified as part of this process. Furthermore, only available hazard datasets were used to cross reference identified hazards. Where there were no specific hazard datasets, these were not cross referenced.
- The resilience prioritisation[10] data for low frequency hazards has been pulled from RAMM which indicates that the Transport Agency has spent money on responding to a certain hazard. This means the data misses any sections of road or bridges which are affected but have not had any response. It also means that any sections of road which have had a significant amount of resilience or response work done may now no longer be exposed or at risk but are showing as the highest risk.
- The national datasets are generally of a ‘coarse’ resolution, however are considered appropriate for this National Resilience PBC level assessment. They should not be used for detailed analysis. For example, the National Seismic Hazard Model provides a good understanding of impacts within proximity to fault locations, therefore can be used to indicate potential impacts for transport networks. National climate change data however has higher levels of uncertainty within datasets, and is usually presented at a regional scale, limiting detailed assessments of impacts.

5 Applicability

This report has been prepared for the exclusive use of our client New Zealand Transport Agency, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

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Appendix A: Key terminology

Key to any discussion, study or project is a common understanding of taxonomy. Below are established definitions based on existing literature across the climate change and natural hazard risk space:

Adaptation: The process of adjustment to actual or expected climate and its effects.

Adaptive capacity: The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.

Asset: The physical hardware (e.g. pipes, wires), software and systems to own, operate and manage Lifelines Utilities (energy, transport, telecommunications, water).

Climate Change[12]: A change in the state of the climate that can be identified by changes in the mean variability of its properties, and that persists for an extended period.

Criticality: informed (defined) by the consequence of the asset failing. That is if there is an unacceptable consequence should a particular asset fail, then that asset would be classed as highly critical.

Exposure: The location of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.

Hazard: The potential occurrence of a natural or human-induced physical event that may cause harm. Harm can be both physical and non-physical, such as economic, social and/or cultural.

Mitigation (of climate change): A human intervention to reduce the sources or enhance the sinks of greenhouse gases.

Resilience[13]: The transport system's ability to enable communities to withstand and absorb impacts of unplanned disruptive events, perform effectively during disruptions, and respond and recover functionality quickly. It requires minimising and managing the likelihood and consequences of small-scale and large-scale, frequent and infrequent, sudden and slow-onset disruptive events, caused by natural or man-made disasters.

Risk: Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur.

Sensitivity: The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change; or the degree to which results change due to perturbations in key input variables.

Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

12 IPCC, 2013 Motu Paper

13 Derived and aligned with resilience definitions from the Sendai Framework for Disaster Risk Reduction, draft National Resilience Strategy (CDEM, Nov 2017) and The Transport Agency's Four-Year Excellence Horizon.

Appendix B: Summary of previous risk/resilience projects

Appendix B Table 1: Summary of previous risk and resilience projects

Resilience of State Highways: Lessons from the 2016 Kaikoura Earthquake, OPUS, 2017

Overview

This project aimed to assess the resilience of the state highway network at a broad national level and develop a methodology for implementation at regional level. The Kaikoura EQ then provided an opportunity to calibrate the resilience studies against observations from this earthquake and bring together key learnings for future resilience studies. Resilience of roads has been defined as being dependent on the loss of quality or serviceability, and the time taken to bring the road back into its original usage state:

Resilience State	Description of State
Availability state	Availability State indicates whether the road section would be able to be used either at full level, at various reduced levels or not at all. This gives an indication of the degree of access on a link after an event.
Outage state	Outage State indicates the duration over which the road will be in the Availability State above. This gives an indication of the duration of loss or reduced access in links along the road network.

Methodology included:

1 Characterisation of the 14 November 2016 Kaikoura earthquake.

2 Review of previous work

3 Gathering of earthquake damage data

4 Mapping of the availability state of the Kaikoura section of State Highway 1 after the earthquake.

5 Gap analyses by reviewing and comparing the previous resilience assessments with the observed post-earthquake resilience of SH1 in the Kaikoura earthquake, subsequent after-shocks and storm events.

6 Preparation of report with observations and recommendations for future resilience assessments

Prior to this a more detailed corridor level resilience study was carried out. This was also calibrated against the observations of resilience after the Kaikoura earthquake. It allowed comparison between the expected performance and the actual damage from the Kaikoura earthquake in discrete sections.

Overall, the national resilience study predicted the outcome of a large earthquake to close the highway both north and south of Kaikoura and the 2016 Kaikoura earthquake has validated this. The route was closed over most of the coastal sections of the highway, as predicted in the 2001 resilience study as well as the 2016 national state highway resilience study.

A key observation by Brabhaharan et al (2006) that was reinforced following the Kaikoura earthquake was that the restoration of access following an event occurs in stages rather than as a linear process from loss of service to full. In many instances particularly following a large event, access may be restored to restricted access, single lane and full access in several stages.

It should be recognised that safety hazards such as potential for rock fall could compromise availability of the route, even when the route is not closed, until the source areas for rock fall can be made safe, by scaling, sluicing or rock anchoring. This needs to be considered in response planning.

NZ Lifelines Infrastructure Vulnerability Assessment, NZ Lifelines Council, 2017

Overview

This report is a first pass at collating and summarising key findings from regional lifelines studies and other major national hazard studies such as DeVoRA, AF8 and WENIRP1. It aims to provide insights on New Zealand's critical lifelines infrastructure and its resilience (and conversely its vulnerability) to major hazards and several knowledge gaps in our understanding and mitigation of New Zealand's critical infrastructure vulnerabilities.

The longer-term goal, to be delivered through Stages 2 and 3 of this project is to provide government and industry with a strategic understanding of nationally significant infrastructure, its vulnerability and resilience to hazards, and strategies to mitigate risks to a nationally agreed 'acceptable' level.

Recent lifelines projects have followed a criticality assessment approach, which identifies lifelines infrastructure within the region as nationally, regionally or locally significant. Nationally significant infrastructure assets are often where there are 'pinch points' in the supply chain – sometimes these are single sites which would cause a significant loss of national service.

Along with key sector pinch points such as those described above, many regional lifelines projects look at risks associated with infrastructure 'hotspots' where critical assets from a number of sectors converge with a high consequence of failure associated with cumulative loss of services at that site.

The aim of this Stage 1 assessment is to provide a national view of critical infrastructure and vulnerabilities. It is intended to inform a range of activities, including:

- Regional lifelines projects, to provide an understanding of the cross-boundary issues that need to be considered in regional vulnerability assessments (impacts within the region impacting outside the region and vice versa).
- Lifeline utility resilience planning (e.g. support prioritisation of resilience projects with consideration of wider infrastructure impacts).
- National policy and strategy setting, such as the National Disaster Resilience Strategy and future review of the National Infrastructure Plan.
- Future infrastructure and hazard research priorities

A number of knowledge gaps have been identified and suggested projects to support ongoing resilience improvements are presented in Section 7. Coming out of work in the 'lifelines' sector, these projects are focussed on aspects such as improving our understanding of critical infrastructure, major hazards and the intersection between the two. Further work is also needed to understand the dependence of critical community sectors (health, emergency services, Fast Moving Consumer Goods, etc) on lifelines services and backup arrangements if those services fail.

Resilience of State Highways: Recommended Regional Assessment Methodology for Low Frequency Hazard Exposure, The Transport Agency, 2016

Overview

This report presents the methodology developed for the regional level assessment of the resilience exposure of the state highway network for low frequency, high impact natural hazards. This framework is consistent with the national approach but uses more detailed regional information, and therefore allows the resilience of the state highway assets to be assessed at a more detailed regional level. The results of these assessments informed the development of Programme Business Cases.

The approach to assess the resilience exposure of state highway routes at a corridor or regional level is summarised below:

- Identify corridor for resilience assessment
- Determine scope/& assessment level
- Collate data
- Develop characterisation scheme
- Carry out site reconnaissance
- Characterise the road corridor
- Assess the hazard impacts
- Apply resilience metrics
- Capture into GIS

This is based on the approach developed by (Brabhaharan, et. al., 2001 & 2006), and is consistent with the approach developed for the national level resilience assessment (Brabhaharan and Mason 2016)

The objectives of the regional assessment process are:

- Enable assessment of the resilience exposure of state highway corridors to low frequency, high impact natural hazards at a more detailed level than the national assessment, so that it can be used for the development of programme business cases for corridors and for planning resilience enhancement and network asset and emergency management;
- Provide a consistent basis for assessment of the resilience for the state highways in all the regions;
- Enable detailed understanding of the resilience of the network, particularly sections of corridors with poor resilience;
- Underpin the evaluation of gaps in resilience (desired resilience vs current resilience);
- Provide outputs suitable for the development of strategic responses and be able to be used for development of resilience enhancement measures (including emergency response planning);
- Provide a toolkit, including a process map and appropriate evidence/references that could be used in the process, and which has flexibility for adaptation/innovation for specific issues.

These objectives have provided the basis of the development of the regional assessment methodology for resilience exposure to low frequency, high impact events.

National State Highway Resilience: 9 Priority Programme Business Case Corridors, OPUS, 2016
Overview The national level resilience assessment of the 9 priority corridors has identified sections of the state highways that are vulnerable to failure from a variety of natural hazards. The project involved collection of national data on natural hazards for use in the assessment of the resilience of the state highway network, and existing assessments of the vulnerability of components of the state highway (e.g. bridge seismic assessment or scour). The national level resilience assessment has been initially carried out for 9 priority programme business case corridors, located throughout the country. The outcomes of the national level resilience assessment are: · Maps showing the resilience states for the state highways, presented as availability, outage and disruption states, and highlighting key areas of vulnerability of the SH · Map showing prioritisation of the state highway network. · A brief report summarising the results of the assessment. This report presents the maps and summarises the results of the assessment. The national resilience assessment methodology addresses the following objectives: · Enables assessment of the resilience across the whole state highway network. · Assesses at a broad-brush high level, efficiently and quickly. · Assesses resilience to large natural hazard events. · Uses a consistent basis applied across the country. · Assesses to screen and understand the resilience of the network, to appreciate differences, and identify areas of concern. · Enables further consideration of areas with poor resilience and inform and link with more detailed assessments at corridor levels by regional Agency teams. These objectives have been the basis of the development of the national assessment methodology for resilience. resilience metrics have been used to represent these two dimensions, through the resilience states developed by (Brabhaharan, Wiles and Freitag 2006) of: · Availability state – level of access after the event, representing the level of service. · Outage state – the duration of reduced access at the above availability state. The report recommends that: · A regional level resilience screening methodology be developed, and then implemented for the 9 Priority Programme Business Case Corridors. This will enable the resilience to be assessed with a better definition of local level hazards and the hazards (e.g. local flooding, liquefaction) in more detail. This will also provide insight into whether some of the PBC corridors would need to consider alternative alignments and identify which sections of the corridors are more critical from a resilience perspective.

- The national level resilience screening be continued for the remaining state highway network, after completion of the regional level resilience for the 9 priority corridors. This will enable the programme business cases to proceed but will also allow testing the methodology for the regional level assessment, and this may provide insights to refine the national resilience screening methodology.
- The identified national level critical resilience issues be used in asset and emergency management planning for these routes that have been assessed.

State Highway Network Resilience National Programme Business Case, The Transport Agency, 2014

Overview

The approach taken in this PBC assumes that resilience is concerned with any event, natural or man-made, which could disrupt our customers travel plans. The definition of resilience used in the development if this Programme Business Case (PBC) is taken from the National Infrastructure Plan (NIP) which states:

'The concept of resilience is wider than natural disasters and covers the capacity of public, private and civic sectors to withstand disruption, absorb disturbance, act effectively in a crisis, adapt to changing conditions, including climate change, and grow over time'. A Strategic Case for the NZ Transport Agency, Highways and Network Operations (HNO) was developed late in 2013. It identified three problem areas, which would result in significant benefit when effectively addressed.

Strategic Case: Problem	Strategic Case: Benefits of addressing the problem
Poor highway resilience may impede critical services from providing disaster response and recovery support	Better enabled disaster response and recovery
Unreliability of some highways impacts businesses and undermines economic growth	Better support for economic growth
The risky environment of some roads increases the possibility of harm to road users	Reduced risk of harm to road users

The initial activities to fill information gaps and increase preventative maintenance were split into the following three types of activities:

- Resilience Improvements – Priority Corridors
- Resilience Improvements – Spot treatments
- Resilience Management and Preparedness

Methodology included:

- Developing a framework for consistently assessing geologic and hydrologic risks
- Developing an approach to assessment of risk and response on state highway routes, and dependent communities
- Developing a standard for:
  - Assessing Lifelines obligations and responses
  - Assessing and recording alternative routes
  - Emergency response plans, including providing emergency access to isolated communities

Maps were created from TREIS data on the number and duration of closures over the past five years. This has been combined into heat maps showing resilience hot spots. The large number of closures recorded in the TREIS data above and the resilience risk data provided by the regions clearly demonstrates the significant economic impact caused by lost hours to business due to closures, and the potential for a number of people to be hurt due to rock fall risk.

Natural Hazard Road Risk Management Part III: Performance Criteria, OPUS, 2006
Overview This research is the third stage of a programme of research aimed at developing approaches for the strategic management of natural hazard risks to road networks in New Zealand. To facilitate the process, the resilience of each road link in the network can be assessed in terms of appropriate 'resilience states' developed as part of this study, namely: · Damage state, · Availability state, and · Outage state In Part I, Opus developed strategies for managing natural hazard risks to road networks. This research identified several approaches, firstly for assessing the spatial risk to road networks with the aid of a geographical information system (GIS); secondly, considering risk mitigation; and, finally, prioritising sections of road for management of the risk. In Part II, Opus presented different levels at which risk management should be addressed and discussed how this may be integrated to achieve a resilient road network. This study recommended that performance criteria and levels of service for different types of roads forming the road networks in New Zealand should be researched. A methodology was developed to enable the development of robust criteria for setting performance levels for road networks regarding natural hazards risk performance: · Literature Research · Reviewing road damage and disruption from past natural hazards · Consulting road stakeholders · Identifying issues and assessing factors which affect performance levels · Workshop on performance expectations · Developing a framework for setting performance levels · Pilot application of the framework to a section of the road network A comprehensive review of literature relating to the management of risks associated with road networks was undertaken to review different methods both nationally and internationally for addressing infrastructure performance criteria, damage states, levels of service, road/bridge classifications and Civil Defence Emergency Management Act requirements. The literature review confirmed that no criteria are available for setting performance levels for road networks, except for performance-based design standards for bridges. Although some have attempted to define the desired levels of performance for a water supply system, little consideration has been given on how to decide on these levels of performance. No information is available to build on from past literature. Guidance for deciding appropriate levels of performance has been developed on the basis of the new research reported here. In order to produce a questionnaire that encompassed all the principal issues, typical natural hazard scenarios were developed. The purpose of the scenarios was to enable the consultation to be based on some realistic scenarios on which the stakeholders could relate to and provide meaningful comment. The purpose of the workshop was to draw on the collective experience of the participants on important issues for setting performance measures. This pooled experience would provide information for

developing a framework for setting performance criteria. The purpose of applying the framework for setting performance levels to the Wellington road network is to demonstrate how the process can be applied in practice to assist practitioners in their road asset and risk management planning.

Appendix C: Hazard and asset data review

· Appendix C Table 1: Overview of the information utilised during portfolio risk assessment

Asset Data		
Category	Asset	Commentary
Roads	The Transport Agency Roads	GIS spatial data and ONRC data has been obtained for state highways and local roads, which provides a useful proxy for criticality. The Transport Agency provided "Natural Hazard Resilience Prioritisation" road asset information which provides varying risk ratings to highlight the level of risk for SH segments (in relation to natural hazards) across the network. Further information on the "Natural Hazard Resilience Prioritisation" data can be found below this table.
Rail	Rail	KiwiRail data was downloaded from their online data portal[14] and provides geospatial information on both their electrified and non-electrified network.
Critical utilities	Airports	Location of airports were presented during stakeholder workshops to inform discussions around criticality of connecting transport routes.
	Electricity	Location of transmission lines and generation sites were presented during stakeholder workshops to inform discussions around criticality of connecting transport routes.
	Ports	Location of ports were presented during stakeholder workshops to inform discussions around criticality of connecting transport routes.
Hazard Data		
Category	Hazard	Commentary
Low Frequency Hazards	Seismic, tsunami and volcanic	The Transport Agency provided "Natural Hazard Resilience Prioritisation" (Woods and O'Neil 2017) road asset information which provides varying risk ratings to highlight the level of risk for SH segments (in relation to low frequency natural hazards) across the network. Tsunami evacuation zones were also used.
High Frequency Hazards	Landslip, rockfall and flooding	The Transport Agency provided "Natural Hazard Resilience Prioritisation" (Woods and O'Neil 2017) road asset information which provides varying risk ratings to highlight the level of risk for SH segments (in relation to high frequency natural hazards) across the network.

[14] KiwiRail Data Portal

Climate	Coastal inundation / erosion and sea level rise	A recent (draft) study by Tonkin & Taylor (2020) for the Transport Agency was utilised and represents the current best available information on future coastal inundation projections for New Zealand. This was based on the coastal inundation mapping which was completed by the National Institute of Water and Atmospheric Research (NIWA) (Bell, Paulik and Wadwha 2015, Paulik, et al. 2019).
	Rainfall, temperature and extreme weather	Projections for changes in wind have been sourced from MfE (2018) national projections

Appendix D: Stakeholders engaged

Appendix D Table 1: List of stakeholders engaged

Name	Organisation / role
Northland	
Jacqui Hori-Hoult	Principle Transport Planner
David Ingles	Network Manager
Brian Childs	Network Manager
Rob Kersel	Contract Manager
Jeff Devine	Northern Transport Alliance - Whangarei DC
Chris Powell	Northern Transport Alliance - Northland RC
Ben Sweeny	Northport
Calvin Thomas	Northern Transport Alliance - Whangarei DC
Chris Gasson	Portfolio Manager
James Thompson	KiwiRail
Wayne Norris	Heavy Haulage
Brian Waddell	Lead Strategic Planner
Andy Brown	Head of Network and Infrastructure
Canterbury / West Coast	
Colin Hey	Senior Network Manager
Stephen Lowe	Fulton Hogan
Paul Williams	Lyttleton ports
Mark Wareing	Philip Wareing Transport - Sales Manager
Ben Wong	ECAN
Lorraine Johns	ECAN
James Ballard	Asset Management Engineer – NOC Manager
David Plom	Transport Team Leader
Auckland	
Paul Glucina	Portfolio Manager - Auckland (Transport Planner)
Paul Geck	Asset Integrator
Waikato	
Liam Ryan	Journey Manager One Network
Grant Tregidga	Principal Network Manager
Rob Bullick	Senior Investment Advisor
Bay of Plenty	
Nigel Dath	Journey Manager
Terry Boyle	Risk Management
Rob Campbell	System Manager
Gisborne / Hawkes Bay	
Oliver Postings	System Manager

Simon Barnett	Transport planner
Frank Nieuwland	Senior Network Manager
Liam Coleman	Principle Structures Engineer
Ben Grapes	Senior Safety Engineer
Taranaki / Manawatu / Whanganui	
Mark Owen	System Manager
Richard Ashman	Maintenance Contract Manager
David Perry	Regional Transport Committee
Kevin Williams	Structures and Asset Management
Tim Siau	Senior Network Manager
Wellington	
Mark Owen	System Manager
Iqbal Idris	Principal Network Manager
Sam Twyman	Senior Network Manager
Top of the South	
Andrew James	System Manager
Braeden Lobb	Senior Network Manager
Roger Ashworth	Maintenance Contract Manager
Dean Hunt	Tasman Journeys
Steve Murrin	Marlborough Roads Manager
Rhys Palmer	Transport Planner
Eamon Powick	Operations Manager: Tasman Journeys
Matthew Rodwell	Senior Asset Manager
Shaun Perrin	Performance Manager
Terry McGavin	Transport Agency Senior Network Manager, Tunnels and Structures
Milford Road	
Kevin Thompson	Milford Alliance Manger
Otago	
John Jarvis	Network Manager
Chris Harris	Network Manager
Southland	
Peter Robinson	Network Manager

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APPENDIX H - PROGRAMME OPTIONS ANALYSIS DETAIL

			1. Status Quo	2. Improved decision-making	3. Integrated investment model	4. Invest for resilience
Description			Includes integrate land-use and land transport planning, revise the IDMF, investment partner engagement strategy and refresh local government relationship	Status Quo responses plus risk prioritisation methodology and decision making framework, rapid assessment mechanism and evidence base	Do Minimum responses plus long terms resilience planning between investment partners, regional resilience strategies, and community engagement strategies	Preferred responses plus funding model for non-infrastructure solutions targeted resilience programme.
Investment Objectives		All communities and businesses are well informed about what the risks of disruption to their transport connections are, and what their choices are	**No** Limited information available on resilience related risks to the land transport system and alternatives available should their prefered connection(s) be disruipted.	**Partial** Improved evidence base and prioritisation methodology means information is available on resilience related risks to the land transport syustem and alternative connections available.	**Partial** Improved evidence base and prioritisation methodology means information is available on resilience related risks to the land transport syustem and alternative connections available.	**Yes** Improved evidence base and prioritisation methodology means information is available on resilience related risks to the land transport syustem and alternative connections available. Targeted investment raises the profile of resilience risks to the land transport system.
		The land transport system will be more resilient in the face of a changing hazard profile	**Partial** Addressing resilience based risks to the land transport system will be in the context of emergency response or where reslience improvements are delivered in the context of capital projects delivering other benefits.	**Partial** Addressing resilience based risks to the land transport system will be in the context of emergency response or where reslience improvements are delivered in the context of maintenance activity or capital projects delivering other benefits.	**Yes** Addressing resilience based risks to the land transport system will be an integrel part of planning, maintenence and capital investment across the land transport system. Extreme and major risks will be prioritised.	**Yes** Addressing resilience based risks to the land transport system will be an integrel part of planning, maintenence and capital investment across the land transport system. Extreme and major risks will be prioritised and addressed, where appropriate applying new funding model for non infrastructure solutions and where necessary drawing on dedicated funding.
Critical Success Factors	Strategic Fit	Aligned to GPS, MoT Transport Outcomes Framework, NZTA Resilience Framework	**No** Increasing severity of natural hazard impacts and increasing reliance on the land transport system results in decreasing resilience. Ad hoc responses are at odds with a focus on connectivity and holistic view of transport outcomes.	**Partial** Introduces standard approach to evaluating resilience related risks, improved evidence base. Provides for improving resilience through effective maintenance and emergency response.	**Yes** Introduces strategic, integrated planning to address resilience risks, community engagement and close collaboration with partners on addressing resiluience risks. Projects include those that improve the ability of the transport system to accomodate reslience related risks or involve retreat from heavily imapcted parts of the system.	**Yes** Introduces dedicated funding for activities that address reslience rtisks without co-benefits that will assist with the case for investment. Addresses limitations in the current model with respect to funding a wider range of non infrastructure responses. Projects include those that improve the ability of the transport system to accomodate reslience related risks or involve retreat from heavily imapcted parts of the system.
	Value for Money	Must demonstrate good benefits for the expenditure required	**Yes** The existing investment framework requires poroposed investments to demonstrate appropriate benefits The approach requires a high level of demonstrable benefit to justify investment	**Yes** The proposed revisions to the investment framework require poroposed investments to demonstrate appropriate benefits. The approach requires a high level of demonstrable benefit to justify investment	**Yes** The proposed revisions to the investment framework require poroposed investments to demonstrate appropriate benefits. The approach requires a high level of demonstrable benefit to justify investment	**Partial** The proposed revisions to the investment framework require poroposed investments to demonstrate appropriate benefits. A dedicated fund is likely to enable addition al investment in activities that improve resolience, potenitally supplanting alternative investments that provide greater benefits.
	Affordability	Can be done within existing budgets	**Yes** This is the status quo	**Partial** Additional funding will be required to complete evaluation of resilience related risks and to address reslience risks through maintenance and emergency response activities.	**Partial** Additional funding will be required to complete evaluation of resilience related risks to address reslience risks through maintenance and emergency response activities and to progress projects with resilience benefits under the revisewed investment decision making framework	**No** In addition to the funding increases noted for Options 2 and 3, this option includes a dedicated funding stream for projects that deliver reslience benefits alone.
	Achievabl	Agencies have the capability and capacity to deliver	**Yes** This is the status quo	**Yes** Subject to appropriate funding, ther ei s capacity to deliver additional maintenance and emergency response activities/	**Yes** Subject to sufficient funding there is capability to deliver additional maintenance, emergency response, investment planning and projects.	**Yes** Subject to sufficient funding there is capability to deliver additional maintenance, emergency response, investment planning and projects.
	Feasibility	Possible to deliver in current environment	**Yes** This is the status quo	**Yes** The proposed changes can be achieved under the existing institutional arrangements and investment planning framework	**Yes** The proposed changes can be achieved under the existing institutional arrangements and investment planning framework	**No** The proposed changes would require a change to allow transport system investors to invest in non infrastructure solutions.
Summary			Makes some progress towards resilience, but investment decisions likely to be tactical rather than strategic	Establishes a methodology for prioritising resilience risks, and a national view of the challenges, and provides mechanisms that enable repair work to take resilience into account, but remains tactical	Provides a strategic view of risks and preferred approaches that guides and informs investment planning in the long term, short term and for emergency works. Increases community engagement to ensure that communities are well informed.	Provides a strategic view of risks and preferred approaches, and creates a protected funding mechanism to ensure that resilience investments do not get crowded out by other priorities.

APPENDIX I – DEPENDENCIES WITH OTHER TRANSPORT AGENCY PROGRAMMES

PROGRAMME	PROGRAMME OUTCOME
Programme 1: Road safety and harm reduction	The land transport system has safety interventions in place across all the safe system pillars.
Programme 2: Safe network programme	A reduction in the instances of deaths and road trauma caused as a direct result of unsafe roads, roadsides, and unsafe speeds.
Programme 4: Arataki programme (Version 1)	There is one view, shared between the Transport Agency, Ministry of Transport, local government and transport sector stakeholders, of opportunities and challenges facing the transport system over the next 30 years, and a prioritised direction for the next 10 years has been developed.
Programme 6: Transitioning through GPS changes and supporting investment management	The right systems and processes are in place to ensure local government networks can respond to the GPS and investment requirements.
Programme 10: Optimisation programme	Optimisation activities implemented across transport modes to improve the operation of the network to support day-to-day journeys for our customers.
Programme 12: Travel demand management programme	Travel Demand Management, capability and promotion programme delivered.
Programme 15: Future transport technology national programme	A national programme of work (road map) developed to explore and analyse new and emerging technology.
IDMF Review	This review was initiated in response to changes in the 2018 GPS and to a review of the system carried out late in 2018. It has specifically looked at how we consider all transport modes and alternatives in our planning and investment decisions, to ensure the IDMF reflects government expectations around social, economic, cultural and environmental outcomes for transport. It also addressed our co-investment partners' concerns about the framework, in particular about making it easier to navigate and to understand how we make our investment decisions.