ARATAKI METHODOLOGY

PURPOSE

This document sets out the methodology used for developing Arataki. It has been updated to reflect the key updates made to Arataki Version 2.

OVERVIEW

A key focus for Version 2 was to analyse the potential impacts and implications of the COVID-19 pandemic on the land transport system.

Waka Kotahi NZ Transport Agency commissioned research on the regional impacts of COVID-19 on New Zealand's economy and demographic patterns to inform the analysis.

Our approach to integrating this evidence into Arataki V2 is set out in the COVID-19 Impacts and Implications section below. The key implications of COVID-19 pandemic called for an update to the regional development step change.

We also took the opportunity to ensure alignment across the step changes and related work programmes that have progressed since Version 1.1 was released. This included reviewing the rationale and/or amending ratings for some of the step changes as follows:

- **Transform urban mobility** and **improve urban form** – to ensure alignment with the *National Policy Statement on Urban Development, 2020;*
- **Significantly reduce harms** – reflecting more recent data on personal and collective risk;
- **Tackle climate change** – to reflect evidence contained in our National Resilience Programme Business Case adopted by the Waka Kotahi Board in May 2020.

In addition, we explored and strengthened the inter-relationships between the step changes by clarifying 'what good looks like'. Our approach and is set out in Arataki Step Changes.

Further resources and reference documents are available on the Arataki Resources Page.

COVID-19 IMPACTS AND IMPLICATIONS

New Zealand's economy is currently undergoing volatility as a result of the global COVID-19 pandemic and the ongoing impacts of the public health response. Waka Kotahi wanted to better understand the potential implications of the downturn on the land transport system, particularly the potential impacts on regional economies and communities.

Waka Kotahi commissioned Martin Jenkins and Infometrics to consider the potential impacts of COVID-19 on New Zealand's economy and demographics, as these are two key drivers of transport demand. In addition to providing a scan of national and international COVID-19 trends, the research involved modelling the economic impacts of three of the Treasury's COVID-19 scenarios, to a regional scale, to help us understand where the impacts might be greatest.

The analysis primarily focuses on the potential impacts over the next four years as the country recovers from the initial pandemic and subsequent economic slow-down, but it also contains estimates of what will happen between years 5-10 in terms of the 'direction of travel' for demographics and the economy.

The table below summarises the three Treasury scenarios modelled as part of the COVID-19 research commissioned by Waka Kotahi, including the key attributes and assumptions for each.

Table 1 Scenarios modelled

Scenario	COVID-19 Alert Level	Other assumptions
Scenario 1: Faster Recovery Scenario	Level 4 – 1 month Level 3 – 1 month Level 1/2 – 10 months	Borders assumed closed to foreign visitors for up to 12 months. World annual average real GDP growth is lower than HYEFU by 6% in calendar 2020.
Scenario 4: Steeper Decline Scenario	Level 4 – 3 months Level 3 – 3 months Level 1/2 – 6 months	May be interpreted as a number of shorter periods at Level 4 and/or Level 3 linked by periods at Level 1 and 2.
Scenario 5: Slower Recovery Scenario	As in Scenario One	World annual average real GDP growth is lower than Scenario One by 3% in calendar2020 and 4% in 2021

The research indicates that the 'slow recovery scenario' (Treasury's Scenario 5) is the most likely due to continuing high levels of uncertainty regarding global efforts to manage the pandemic (and the duration and scale of the resulting economic downturn).

The updates to Arataki V2 have been framed around the 'Slower Recovery Scenario', and to date this scenario remains the most closely aligned with the unfolding impacts of COVID-19, both in New Zealand and globally. We will continue to monitor the situation and keep up to date with other cross-Government scenario development and COVID-19 related work.

Waka Kotahi has considered the longer-term impacts of COVID-19 on the land transport system and incorporated this thinking into Arataki V2. It presents the evidence and insights at a national, pan-regional and regional scale. Specifically, in Arataki V2 we have:

a. presented evidence and insights about the impacts of COVID-19 on the land transport system and regions over the next decade, including where flattening or additional pressures are forecast

b. updated text about the six key drivers that will shape the future land transport system, based on the impacts of COVID-19. We also took the opportunity to add material about the key driver of

technology, including information and data, as we acknowledged this needed further work in Arataki V1

c. confirmed the importance of the five step changes for the land transport system and identified the need to consider issues of equity over the next decade to respond to the impacts of COVID-19

d. shifted the focus of the regional development step change from the government's six 'surge' regions to those regions hardest hit by the impacts of COVID-19 and thought further about the role of the land transport system as an enabler of socio-economic outcomes. (This is discussed in further detail below)

e. updated the support Waka Kotahi needs to provide for the sector so it can be agile and responsive to future shocks

f. amended the areas of focus required to deliver the five step changes both at a national scale and for each region, reflecting the impacts of COVID-19

g. signaled where COVID-19 will have impacts on future transport demand at a pan-regional scale and what the key issues are likely to be as a result.

High levels of uncertainty remain around the scale of impact of the pandemic and the duration of the subsequent economic recovery. The uncertainty increases over time, and the further ahead we look, the less certainty we have.

Things that we have greater certainty about include the more immediate impacts of border closures and travel restrictions, including a sharp drop off in international tourists and students, and a significant reduction in immigration over the short to medium-term.

The modelling has produced employment forecasts for each region and district over three time periods – 2021, 2025 and 2031. The forecasts for 2021 carry the greatest certainty as they reflect the impacts of current events. The 2025 and 2031 forecasts carry significant uncertainty because of the potential for shifts in the socio-economic situation over the intervening years. While these forecasts are useful in helping to understand the relative scale and duration of potential COVID-19 related impacts around the country, they need to be treated with care recognising the higher levels of uncertainty.

Within Arataki the following time periods have been used to help describe the potential impacts of COVID-19:

- Immediate: now-1 year
- Short-term: 1-2 years
- Medium-term: 2-5 years
- Long-term: 5-10 years

Regional Development Step Change – shifting the focus of the regional development step change from the government's six 'surge' regions

As part of Arataki V2 the geographic focus of the regional development step change has moved from the government's six "surge" regions to those regions hit hardest by the socio-economic impacts of COVID-19.

We considered the difference COVID-19 recovery scenario five is expected to make to business as usual projections of economic activity (GDP) and employment (total filled jobs) in each region in 2025 and 2031. We identified whether the impact on each region is expected to be higher or lower than the national average projected for each of these four factors in each of these two timeframes. This helped identify the relative impact of COVID-19 on each region over the coming decade.

We assigned each region a COVID-19 impact rating depending on how many of these factors were worse than the national average: High (3-4), Medium (2) or Low (0-1). We also considered long-term socio-economic performance in each region by looking at median household income (average 1998-2018), productivity (GDP per capita average 2000 to 2018) and unemployment (average 2006 to 2019) as well as

socio-economic deprivation (the proportion of the population in deprivation quintile 5 in 2013). We assessed whether the performance of each region was higher or lower than the national average for each of these four factors. This applies the methodology used in Arataki V1 to all regions for consistency.

We assigned each region a long-term socio-economic performance rating depending on how many of these factors were worse than the national average: High (3-4), Medium (2) or Low (0-1). Our primary data sources were the Regional Economic Activity Web Tool provided by the Ministry of Business, Innovation and Employment and the New Zealand Index of Multiple Deprivation provided by the University of Auckland's School of Population Health.

The Arataki V2 rating for each region is an average of these two ratings, with the COVID-19 impact rating used in regions where the average is a half-score. The rating for the Top of the South combines the ratings for the Tasman, Nelson and Marlborough regions. Further information regarding the COVID-19 research is available here.

ARATAKI STEP CHANGES

This section summarises the methodology used to develop the regional ratings for each step change in Arataki, it sets out the methodology for Arataki V1 and our further assessment and any changes to V2 released in August 2020.

How were the step change regional ratings developed?

Arataki contains five step changes:

1. Transform urban mobility
2. Improve urban form
3. Significantly reduce harms
4. Tackle climate change
5. Support regional development

For each of the five step changes Arataki provides regional ratings, shown in the 'rainbow graphic' on the front page of each regional summary. The purpose of the ratings is to:

- enable a comparison of how significant each step change is in each region
- indicate where the greatest effort is required in order to deliver system-level outcomes
- signal where the Transport Agency will be focusing its efforts over the 2021-31 period
- signal where we anticipate being able to make the most significant progress on delivering the step changes.

The ratings reflect the Government's criteria for broader programmes (including the Provincial Growth Fund and Urban Growth Agenda) and are evidence-driven.

The ratings do not determine where investment will be made.

The table below outlines how the regional ratings for each step change were developed.

Step change	Icon	Methodology
Transform urban mobility		In prioritising effort to **transform urban mobility**, Arataki aligned with the National Policy Statement on Urban Development and Capacity (NPS UDC) 2016, recognising that the highest growth urban centres provide the greatest potential to deliver the outcomes sought and achieve a significant scale of change. The NPS UDC was reviewed in December 2019 and replaced by the National Policy Statement on Urban Development 2020 (NPS-UD) which was Gazetted on 23 July 2020. Arataki V2 has been updated to reflect this change. The geographic targeting of the NPS-UD policies uses a three-tier static approach. The tiers are based on high, medium and low demand urban areas. The criteria used to classify the three tiers are population growth and size. The NPS-UD lists Councils that are Tier 1 or Tier 2, with all other urban environments with populations greater than 10,000 classified as Tier 3 (by default). Five Tier 1 urban centres are a focus for Government efforts to improve urban development, remove minimum parking requirements and increase intensification and housing affordability. They reflect New Zealand's fastest growing urban centres: Auckland, Hamilton, Tauranga, Wellington, and Christchurch. Regions containing a Tier 1 urban centre received a high rating for transforming urban mobility. While the focus for transforming urban mobility is the Tier 1 urban centres, Arataki recognises that there is scope for improving urban mobility to support wellbeing and liveability, in other urban areas. To reflect this, regions containing an urban centre identified in the NPS UD as Tier 2, have been given medium ratings. These

<table>
<tr><th>Step change</th><th>Icon</th><th>Methodology</th></tr>
<tr><td></td><td></td><td>centres are Whangarei, Rotorua, Napier-Hastings, Palmerston North, New Plymouth, Nelson-Richmond, Dunedin and Queenstown.</td></tr>
<tr><td>Improve urban form</td><td>  </td><td>As per transform urban mobility above, the greatest scope to deliver a step change relating to improved urban form is in the largest, fastest growing urban centres. Improving urban form is relevant to all urban areas but there is potential to achieve the greatest benefits in areas experiencing higher levels of growth and urban change.
Arataki V1 attributed a high rating to regions containing a ‘main urban centre’ under the NPS UDC 2016, while regions containing a city other than a main urban centre have been given medium ratings.
Arataki V2 applies the same methodology and has been updated to reflect the Tier system introduced under the NPS UD, 2020. Under this approach, Tier 1 urban centres are given a ‘high’ rating while regions containing Tier 2 centres have been given medium ratings.</td></tr>
<tr><td>Significantly reduce harms</td><td>  </td><td>While the significantly reduce harms step change encompasses both safety and health elements, the current regional ratings for this step change are restricted to analysis of the safety issues in each region. Health harms are addressed primarily through other step changes at this stage. For Arataki V1 the regional ratings were developed using death and serious injury (DSI) data for the 2017-18 period. For Arataki V2 the assessment was repeated using data for the three years from 2016/17 to 2018/19.

The assessments for V1 and V2 considered both total DSI (collective risk) and DSI per 100,000 population (personal risk).

Collective risk is a measure of the total number of fatal and serious injury crashes within each region. It highlights those regions with higher traffic volumes, as this is where the majority of crashes occur.

Personal risk is a measure of the danger to each individual using the road network in each region. Unlike collective risk, personal risk takes into account the resident population in each region. Personal risk shows the likelihood of a road user, on average, being involved in a fatal or serious crash in a particular region. Personal risk tends to be highest in regions with more difficult terrain, and where traffic volumes and road standards are often lower.

For both collective and personal risk the regions were given a high, medium or low rating depending on how their figures compared to other regions, as set out in Table 2 . As a rule of thumb, we sought to attribute three highs, eight mediums and three lows across the 14 regions to help focus effort, but there was scope to adjust these proportions if there were natural groupings or break-points within the data.

Table 2 Collective and personal risk per region
<table>
<tr><th>Region</th><th>Collective Risk
Average total DSI (2016/17-2018/19)</th><th>Personal Risk
Average DSI per 100,000 population (2016/17-2018/19)</th></tr>
<tr><td>Northland</td><td>198</td><td>112</td></tr>
<tr><td>Auckland</td><td>716</td><td>44</td></tr>
<tr><td>Waikato</td><td>426</td><td>92</td></tr>
</table></td></tr>
</table>

Step change	Icon	Methodology

Bay of Plenty	175	57
Gisborne	44	92
Hawkes Bay	120	72
Taranaki	83	70
Manawatu - Whanganui	189	78
Wellington	230	45
N-M-T	108	72
West Coast	50	155
Canterbury	364	60
Otago	196	87
Southland	94	96
New Zealand	2701	55

In terms of providing regional ratings and delivering a step change in safety outcomes, it was considered that Arataki should focus on those regions where the majority of DSI occur, as this is where there is the greatest scope to reduce harms. However, it is also important to recognise those regions that have high personal risk ratings, as travel in these regions carries the greatest risk.

The matrix below was used to combine the collective and personal risk ratings into a single rating for each region for the Reduce harms step change:

Table 3 Collective and personal risk ratings

Regional rating: Collective Risk (Total DSI)				
	High	H	H	H
	Medium	M	M	H
	Low	L	L	M
		Low	**Medium**	**High**
	Regional rating: Personal risk (DSI per 100,000 people)			

The matrix enabled Arataki to focus on those regions with the highest collective risk (Total DSI), while also giving increased weighting to regions with higher personal risk (DSI per 100,000 population) to recognise the increased risk for customers travelling in those regions.

Table 4 sets out the final regional ratings for the Reduce harm step change, for both the previous V1 and updated V2.

<table>
<tr><th>Step change</th><th>Icon</th><th>Methodology</th></tr>
<tr><td></td><td></td><td>
Table 4 Final ratings for reduce harm step change
<table>
<tr><th>Region</th><th>Regional rating Arataki V1 (2017/18)</th><th>Regional rating Arataki V2 (2016/17-2018/19)</th></tr>
<tr><td>Northland</td><td>High</td><td>High</td></tr>
<tr><td>Auckland</td><td>High</td><td>High</td></tr>
<tr><td>Waikato</td><td>High</td><td>High</td></tr>
<tr><td>Bay of Plenty</td><td>Medium</td><td>Medium</td></tr>
<tr><td>Gisborne</td><td>Medium</td><td>Low</td></tr>
<tr><td>Hawkes Bay</td><td>Medium</td><td>Medium</td></tr>
<tr><td>Taranaki</td><td>Low</td><td>Medium</td></tr>
<tr><td>Manawatu - Whanganui</td><td>Medium</td><td>Medium</td></tr>
<tr><td>Wellington</td><td>Medium</td><td>Medium</td></tr>
<tr><td>N-M-T</td><td>Medium</td><td>Medium</td></tr>
<tr><td>West Coast</td><td>Medium</td><td>Medium</td></tr>
<tr><td>Canterbury</td><td>High</td><td>High</td></tr>
<tr><td>Otago</td><td>Medium</td><td>Medium</td></tr>
<tr><td>Southland</td><td>Low</td><td>Medium</td></tr>
</table>
</td></tr>
<tr><td>Tackle climate change</td><td></td><td>
The tackle climate change step change captures both mitigation (reducing emissions to minimise the scale of future climate change) and adaptation (managing the impacts of climate change). The regional rankings for climate change mitigation and adaptation are combined.

Ranking climate change is complex as the effects of climate change are far-reaching and variable across the regions. Floods are some of New Zealand's most frequent, most damaging and most disruptive natural hazards. As our climate changes, flooding caused by both increased rainfall and rising sea levels, in coastal areas and on floodplains, is expected to increase. This has significant implications for the land transport system in areas with the greatest exposure to flooding, coastal erosion and extreme weather. In addition, the highest regional level population and built asset exposure occurs in populous regions: Auckland, Waikato, Wellington and Canterbury.

We considered the projections for exposure of the land transport system and population under a 0.9m sea level rise and associated flooding during extreme storm events. This is a longer term view to ensure we develop the right foundation during the next decade, to prepare for the long term effects of climate change.

Climate mitigation is a relevant issue for all New Zealand, however, our focus on climate mitigation is in particularly focused in larger urban areas where there is the more scope to affect change and reduce emissions. Climate change mitigation is being progressed through implementation of the Waka Kotahi sustainability action plan: Toitū Te Taiao and other step changes (transforming urban mobility and urban form).
</td></tr>
</table>

Step change	Icon	Methodology
		For Arataki , the adaptation ranking takes precedence, where there is a difference between the mitigation and adaptation ratings for a region because of the localised effects of climate change on the land transport system and communities. A more detailed description of the methodology used to develop Arataki V1 can be found in Appendix 1 of this document. **Informing Arataki V2** We continue to monitor implementation of the Climate Change Response (Zero Carbon) Amendment Act 2019, government policy on climate change and concurrent work on at Waka Kotahi, to ensure rankings are appropriate and current evidence is captured. As such, Arataki V2 reflects updated evidence and information from the National Resilience Programme Business Case (PBC), which was endorsed by the Waka Kotahi Board in May 2020.The PBC identifies and rates nationally important risks from natural hazards (including climate change related) in the New Zealand land transport system and addresses a range of system-wide resilience process issues. The PBC includes an evidence-base for future planning and investment decisions and provides a national picture of vulnerability and exposure of New Zealand's highway network to natural hazards. Waka Kotahi commissioned the PBC 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-wide responses that Waka Kotahi and its co-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 focused on the NLTP) or initiatives across Waka Kotahi 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. • reflect the significance of resilience issues affecting the land transport system and associated infrastructure. The PBC also identifies potential actions for the Waka Kotahi Business Plan and for Regional Land Transport Plans. The National Resilience PBC does not replace or remove the need for localised place-based business cases. This analysis provides the basis for additional detail on key risks to the state highway network and associated land transport system reflected in Arataki V2. The overall findings set out in the PBC are relatively consistent with the existing information in Arataki and **no changes have been made to the regional ratings** for the Tackle Climate Change step change as a result of the PBC. The PBC rating of natural hazard risks in the land transport system identified 40 extreme risks. Of these, 20 risk sites have been grouped to 13 new Business Cases to be proposed for inclusion in the NLTP. This have been used to form the evidence based in the Regional Summaries.

Step change	Icon	Methodology
		This PBC details the process and methodology of a Portfolio Risk Assessment (PRA) completed across New Zealand's land transport system to identify and rate natural hazard risks which can be accessed here: Appendix G of the National Resilience Programme Business Case [PDF, 296 KB].
Support regional development		The Government identified six 'surge' regions that are a focus for government efforts to improve social and economic outcomes. These are the regions that are currently lagging behind other regions in terms of measures such as GPD per capita, unemployment rates and median household incomes. Arataki V1 reflected the government's position and attributed a high rating to the six surge regions; Northland, Bay of Plenty, Gisborne, Hawkes Bay, Manawatū-Whanganui and West Coast. We also analysed data on GDP, unemployment and household incomes to see if there were other parts of the country that had similar socio-economic profiles to the surge regions. As a result of this analysis, urban areas in southern and western Auckland and parts of Porirua and the Hutt Valley were identified as facing particular social and economic challenges. These two areas have been rated medium in Arataki for support regional development. **Updates to Arataki V2** As indicated, the impact of the COVID-19 pandemic on New Zealand's economic structure means the geographic focus of the regional development step change has moved from the government's six "surge" regions to those regions hit hardest by the socio-economic impacts of COVID-19. We considered the difference COVID-19 recovery scenario five is expected to make to business as usual projections of economic activity (GDP) and employment (total filled jobs) in each region in 2025 and 2031. We identified whether the impact on each region is expected to be higher or lower than the national average projected for each of these four factors in each of these two timeframes. This helped identify the relative impact of COVID-19 on each region over the coming decade. Drawing on the projections set out in our COVID-19 research (Martin Jenkins and Infometrics, 2020), each region was assigned a COVID-19 impact rating depending on how many of these factors were worse than the national average: High (3-4), Medium (2) or Low (0-1). The long-term socio-economic performance in each region was also considered using the median household income (average 1998-2018), productivity (GDP per capita average 2000 to 2018) and unemployment (average 2006 to 2019) as well as socio-economic deprivation (the proportion of the population in deprivation quintile 5 in 2013). We assessed whether the performance of each region was higher or lower than the national average for each of these four factors. This applies the methodology used in Arataki V1 to all regions for consistency. Each region was given a long-term socio-economic performance rating depending on how many of these factors were worse than the national average: High (3-4), Medium (2) or Low (0-1). Our primary data sources were the Regional Economic

Step change	Icon	Methodology
		Activity Web Tool provided by the Ministry of Business, Innovation and Employment and the New Zealand Index of Multiple Deprivation provided by the University of Auckland's School of Population Health. The regional ratings in **Arataki V2** is an average of these two ratings, with the COVID-19 pandemic impact rating used in regions where the average is a half-score. The rating for the Top of the South combines the ratings for the Tasman, Nelson and Marlborough regions. The revised rankings are provided below. *Table 5 Regional Development Ranking*

Regional Development Ranking		
Region	**Arataki V1 Rating**	**Arataki revised rating**
Northland	High	Medium
Auckland	Medium	High
Waikato	Low	Medium
Bay of Plenty	High	High
Gisborne	High	Medium
Hawke's Bay	High	Medium
Manawatu-Whanganui	High	Medium
Taranaki	Low	Low
Wellington	Medium	Low
N-M-T	Low	Low
Canterbury	Low	Medium
West Coast	High	Medium
Otago	Low	High
Southland	Low	Low

Understanding success – what good looks like

As indicated, the step changes set out in Arataki identify where a change in response is needed based on the current state of the land transport system and the key drivers. Each regional summary signals the relative scale and/or effort needed to achieve each step change in a given region to achieve the desired future state.

Much of the focus during development of step changes in Arataki V1 was on developing the evidence base and ensuring the focus of effort for each step change was appropriate for each region. As Arataki matures and evolves, the focus on the inter-relationship between the five step changes must be strengthened to ensure multiple benefits are realised and the right levers applied by Waka Kotahi and its partners. The step changes will prove more successful if the synergies, complimentary aspects and integration of each step change are clear.

This interrelationship between step changes provides an opportunity for Waka Kotahi to prioritise responses that deliver across a range of outcomes with shared results in our cities and regions. The aim is to focus on the levers and interventions that deliver across a range of step changes will have the most effective results. As part of developing Arataki V2 we revisited the step changes to ensure they remained relevant and to sharpen what our view of 'what good looks like' by achieving step change. The overall purpose was to:

- explore and strengthen the inter-relationships between the step changes
- ensure the step changes and their implementation programmes can 'talk' to each other easily

- develop a common set of results / what 'good' looks like that we can chase in an integrated way through the step change
- clearly articulate our contribution to what 'good' looks like as our value proposition to the sector
- test against what each step change lead is focused on and identify the multiple benefits.

We considered shared results between step changes where appropriate, supplemented by results as needed for individual step changes. For example, many of the approaches to land use planning bring additional benefits relating to lower carbon emissions. Other outcomes may have single, but equally important benefit, for example addressing natural hazards on key transport routes.

This review also considered progress on key work programmes since Arataki V1.1 was released including, for example: *Toitu te Taiao (Our Sustainability Action Plan)*, progress with mode shift plans in major urban centres, our increased focus on spatial and urban planning and progress on the national resilience programme business case. Each of these programmes strengthens the shared evidence base and apply consistent levers and interventions.

As a result, Arataki V2 includes an integrated list that will allow us to 'test' whether step changes are achieved as follows:

- urban form and land-use that reduces the need to travel
- urban mobility options that are designed to make shared and active travel choices the preferred choice for most daily travel needs
- optimisation of networks to prioritise the movement of active and shared modes for people and improve the efficient movement of freight
- significant uptake of electric light vehicles and decarbonisation of the heavy vehicle fleet to enable the transition to a low carbon vehicle fleet
- a safe land transport system where no one dies or is seriously injured.
- communities that are less exposed and better prepared, to deal with the impacts of natural hazards, climate change and other disruptive events on the transport system
- regional communities that are connected, self-sustaining and have access to employment and services.

Land-use and urban form are consistent themes throughout the levers and interventions. Evidence indicates that shaping urban form is the single most effective means of addressing the multiple challenges on the land transport system in the long term. Optimising the use of existing transport infrastructure assets will also be critical during the economically constrained period arising from COVID-19.

It is anticipated that the RLTPs will draw on the evidence base of Arataki, this provides an opportunity to work with our partners to ensure the right step changes and levers are applied through this process.

As we progress, we will more clearly define our role in achieving each of the step changes in Arataki and supporting actions, particularly around land use, spatial planning and urban form which are less well developed compared with, for example safety.

KEY DRIVERS

How were the key drivers identified?

As part of the Waka Kotahi's Performance Improvement Framework Review (PIF) completed in April 2018, seven external factors were identified that will shape our operating environment over the next 10-15 years. The key drivers identified in Arataki draw on these factors.

Further review of the key issues affecting, and affected by, the land transport system was undertaken in light of the PIF Review. This included:

- making observations about what is occurring currently and anticipated to occur for each driver of change
- identifying the opportunities and challenges of these changes for the land transport system over the next 10 years
- working with identified key Waka Kotahi staff to confirm the evidence base for each driver; and
- consulting subject matter experts within Waka Kotahi and the Ministry of Transport.

Arataki merged two of the PIF factors (**technological change** and **information and data**) into one (technology) and described the following six key drivers:

- Demographic change
- Climate change
- Technology and data
- Customer desire
- Changing economic structure
- Funding and financing challenges

The key drivers draw on and are consistent with the Ministry of Transport's (MoT) strategic thinking across the wider transport system for New Zealand and draw on the MoTs transport futures thinking, primarily the base case set out in the Transport Outlook: Future State (2017).

The key drivers inform the direction and pace needed for step changes. We need to understand the scale, nature, timing, urgency and location of each of these drivers and how they influence the land transport system. This is done by identifying the implications of the key drivers nationally, before assessing how they impact aspects of the land transport system.

LEVEL OF SERVICE DEFICIENCY MAPS

How were the pan-regional Levels of Service deficiency maps developed?

The pan-regional level of service (LoS) deficiency maps show existing and emerging LoS deficiencies on the state highway network, for journey reliability, safety and system resilience. The maps also contain rail constraints where these have been identified by other processes such as the Upper North Island Freight Plan. It is anticipated that additional rail constraints will be identified through engagement with KiwiRail.

The maps were developed to indicate where Waka Kotahi anticipates the need to intervene in the future in order to maintain appropriate base LoS. The maps are focused on inter-regional connections, and do not cover the main urban centres.

The maps anticipate completion of committed projects such as the Waikato Expressway, Transmission Gully north of Wellington and SH1 Peka Peka to Otaki when describing level of service deficiencies. The maps also reflect the LoS described in the One Network Road Classification for different categories of road.

The pan-regional LoS deficiency maps were developed using a combination of evidence as to existing LoS deficiencies, modelling of future network capacity pressures, input from Transport Agency experts and emerging analysis regarding resilience risks, the potential impacts of climate change, and road safety issues.

The approach to developing the LoS deficiency maps contained in Arataki V1 is described below.

Journey Reliability

Journey reliability refers to extent to which the transport system delivers reliable travel times to customers. Delivering reliable journeys does not imply that a trip will be free of delay, but ideally customers should generally experience consistent travel times when making the same journey at different times of day, and from day-to-day.

On inter-regional corridors journey reliability tends vary most in and around major urban centres (where urban peak traffic periods impact on inter-regional traffic) and on corridors with extended sections that have limited opportunities to safely overtake slower traffic (i.e. Kaikoura Coast, Desert Road).

In some parts of the country journey reliability can also be impacted by increased demand caused by holidays, large events (such as concerts and sporting events) and severe weather events.

The journey reliability maps indicate both those sections of the state highway network that currently experience poor journey reliability, and sections where journey reliability is expected to deteriorate over the coming decades. Looking to the future it is anticipated that forecast growth in traffic volumes will cause some parts of the network to reach or exceed maximum capacity, leading to reduced journey reliability.

The journey reliability forecasts were developed in 2015 as part of the development of the draft State Highway 30 Year Vision. That work combined expected growth in traffic demand (driven primarily by population growth) with modelling of the capacity of the existing road network to identify those corridors where journey reliability is expected to drop below an acceptable level if nothing is done to manage demand or increase network capacity. The analysis identified that these corridors are generally located in the upper North Island (where the majority of population growth is forecast), and around Wellington and Christchurch urban areas.

Safety

The safety LoS deficiency ratings indicate a risk rating for different sections of the state highway network. The analysis is based on the degree to which the physical form of the existing road corridor aligns with the safety LoS outlined in the One Network Road Classification (described in terms of the KiwiRAP star ratings expected for different road classifications).

The original map has been checked against the various state highway corridor management plans (CMP's) and re-evaluated business cases and updated to ensure that any significant existing LoS gaps identified in the CMP's are recorded.

Resilience

The resilience LoS deficiency maps indicate those parts of the network that are at particular risk of closure and disruption due to unplanned events (natural or human). The ratings reflect both the risk of disruption and the impact of disruption, and also emphasise connections with high potential impacts on customers and/or corridors with no viable alternate routes.

The maps were developed using records of road closures contained in the TREIS database, analysis of vulnerability and impact of low frequency/high impact events (seismic, tsunami, volcanic and storm) undertaken by OPUS Consulting, and input from Waka Kotahi experts.

The maps were also checked against the various state highway CMP's and re-evaluated business cases, to check that any significant existing LoS gaps identified in the CMP's were captured.

Work is ongoing to better understand the potential impacts of climate change on the resilience of communities and the transport system. As our understanding develops, the LoS maps will be updated to indicate those parts of the transport system particularly at risk from the impacts of climate change, including sea level rise.

Ongoing review of maps

We will continue to test the maps with the resilience and safety teams to ensure that the maps are aligned with the latest analysis and prioritisation emerging from the national resilience programme business case and Road to Zero road safety strategy delivery programme. Ongoing analysis of real-time traffic data will enhance our understanding of journey reliability.

The maps also will be updated over time where activities are delivered to address existing LoS gaps.

APPENDIX 1

ARATAKI: STEP CHANGE TACKLE CLIMATE

This following methodology is relevant to Arataki but has not been updated for Version 2. Updates to Version 2 are set out in the Methodology: step changes section.

CHANGE (ADAPTATION)

Priority Ranking and risks

This appendix summarises climate-related risks to the land transport system identified in external and internal research, along with the process for establishing regional rankings and triggers for measuring climate change adaptation.

Sea Level Rise (SLR) is included as a key measure for climate change. This is a relevant measure for New Zealand given the prevalence of communities and infrastructure located in coastal areas and the long-term effects on significant infrastructure from the effects of rising sea levels and combined effects of climatic events, e.g. storm surges. Four key issues arise from sea level rise and have varying implications for the land transport system:

1. Flooding along coasts when the sea flows over low-lying land
2. Erosion from waves and currents along shorelines
3. Groundwater levels and salinity (PCE, 2015)
4. Sea level risk also increases the height of tsunami

Several reports have assessed the likely implications for distance and cost of SLR as summarised in Table 1. There is relative consistency of length of road and railway affected by SLR in the reports.

The most recent approach set out in Paulik et. al (2019a) is aligned with the Waka Kotahi Resilience programme business case. Paulik et. al (2019) model NZs exposure to 1% annual exceedance probability (AEP) coastal flooding events under present-day and future higher sea levels. The SLR modelling in this report builds on flood mapping work undertaken by the Parliamentary Commissioner for the Environment in 2015. The 2015 report did not take in account flooding during an extreme storm.

The 0.9m SLR projections (in the green column in Table 1) is used to inform ranking in Arataki V1.

Table 6 SLR projections across reports

Region	Exposure at 0.3m SLR (km)		Road exposed at 1.0 SLR (km)	Exposure at 0.9m SLR (km)		Road length below 5 m (km)
	Paulik, et. al (2019)		Simonson et. al (2019)	Paulik, et. al (2019)		Gardiner et. al (2009)
	Road	Rail	Road	Road	Rail	Road
Northland	99.3	5.1	Not listed	153.7	11.4	216
Auckland	70.6	12	95	136.6	16.2	77
Waikato	395	1.68	Not listed	503.5	8.9	201
BOP	281.5	16.6	114	379.9	28	58
Gisborne	17.8	9.8	Not listed	34.9	11	18

Hawkes Bay	**133.9**	**1.5**	**158**	**208.1**	**5**	**148**
Manawatu-Whanganui	53.4	3.3	Not listed	72.8	4.6	58
Taranaki	14	1.4	Not listed	22.2	1.9	1
Wellington	68.7	4	Not listed	157.1	7.7	107
Marlborough	32.9	0.9	Not listed	52.1	1.9	88[1]
Nelson	15.5	0	Not listed	39.9	0	4
Tasman	**62.5**	**0**	**217**	**102**	**0**	**33**
Canterbury	**320.8**	**10.1**	**176**	**497.2**	**19.1**	**463**
West Coast	Not listed	Not listed	Not listed	Not listed		76
Otago	**207**	**30.6**	**191**	**286.8**	**48.1**	**357**
Southland	50.8	11.7	Not listed	66.8	12.4	205

Note: *For a rise in sea level of 30 centimetres, extreme high-water levels would be expected to occur approximately: every 4 years at the port of Auckland; once a year at the port of Wellington and port of Christchurch (Lyttelton; Every 2 years at the port of Dunedin (PCE, 2015).*

SUMMARY OF REPORTS AND KEY FINDINGS

The following section sets out key findings from a review of recent reports to inform the climate change rankings and evidence base in Arataki V1.

Flooding (from Paulik et. al, 2019a)

Floods are some of New Zealand's most frequent, most damaging and most disruptive natural hazards. As our climate changes, flooding caused by both increased rainfall and rising sea levels, in coastal areas and on floodplains, is expected to increase.

- *There is currently no national, consistent flood hazard map for New Zealand for identifying populations and assets in fluvial and pluvial floodplains.*
- *A 'composite' flood hazard area map (FLHA) from modelled and historic flood hazard maps and flood prone soil maps, publicly available in August 2018. The map represents known or mapped floodplains and was deemed enough for a first attempt at enumerating national, region and territory level population and asset exposure.*
- *Road network exposure in the FLHA exceeds 1,000 km in five regions.*
- *The highest regional level population and built asset exposure occurs in populous regions: Auckland, Waikato, Wellington and Canterbury.*
- *Canterbury region has the most exposure for population, buildings, roads, electricity network components (transmission lines, structures and sites), potable water pipelines and both built and production land cover. The region's exposed population and built assets are mostly in Christchurch City.*
- *Production land is most exposed in key dairy and pastoral production regions including: Waikato, Canterbury and Southland.*
- *Railway network exposure in the FLHA exceeds 200 km in Manawatu-Wanganui and West Coast regions, and 150 km in Auckland, Waikato, Northland and Canterbury.*

[1] Listed as "Blenheim"

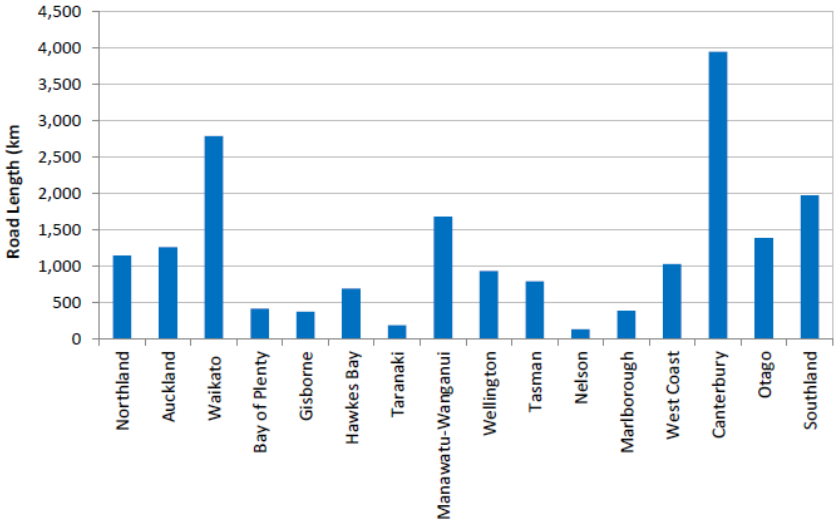


Figure 1 Region level road network exposure to FLHA
Source Paulik, R. (2019)

- *Outside regions with the three main urban centres, railways in Manawatu-Whanganui region are the only built asset type with higher exposure at regional level. Natural or undeveloped land cover is most exposed on the West Coast, a region with high amenity value for tourism.*
- *There is considerable uncertainty over the effects of climate change on flood inundation. Sea level rise will increase the hazard in coastal areas and increases in the amount or intensity of rainfall could also increase flood hazard.*

SLR - National Implications (Simonson et al 2019)

LGNZ's research assesses the scale and value of infrastructure exposed to sea level rise at four increments: 0.5, 1.0, 1.5 and 3.0 metres to quantify replacement value. The scope primarily includes roads, three waters infrastructure and buildings. Key finding for the land transport system are:

- approximately 2,050 kilometres of roads are exposed up to the 1.5 metre increment, with a replacement value of $1.0 billion
- at the 1.0 metre elevation, priority South Island regions comprise 71% of the total of the South Island's exposed roading network.

The relevant findings are summarised in Table 7, below and set out in additional detail at Attachment 3 to this summary. From this work identified 'priority areas' which were also considered when developing the ratings for each region.

Table 7 Kilometres of Road affected by SLR scenarios

	Sea Level Rise and km affected			
	0.5	**1.0**	**1.5**	**3.0**[2]
North	377	804	1199	2862
South	364	591	847	1697
Total (km)	**741**	**1,395**	**2,100**	4559

[2] Based on a small portion of Council data sets

Additional findings are:

- *The North Island has a total value of exposed roading infrastructure of approximately $400 million at the 1.0 metre increment, equating to approximately 800 kilometres of road. Generally, the North Island has higher levels of exposure for roading infrastructure than the South Island*
- *In the South Island, Canterbury, Otago and Tasman record the highest estimated value of exposed roading infrastructure.*
- *The quantum of exposed roading at 1.5 metres is more than 2,000 kilometres.*
- *South Island has a greater burden per capita to pay for potential adaptation measures*
- *In some regions critical coastal infrastructure drawing tourism will be deeply impacted, potentially affecting local economic productivity and business development.*
- *45% of total length of exposed within the North Island; 186 bridges (significant increase above 1m)*
- *71% of the South Island exposed roading network; 95 bridges (significant increase above 1m)*
- *The total replacement value of all exposed infrastructure (three waters, roading, buildings/facilities, green space and landfills) at the 1.5 metre increment is estimated at approximately $8 billion.*
- *Costs will likely go far beyond tangible measures; not only will infrastructure be exposed, so will potential economic development and growth, community health and safety, and social support system.*
- *At each noted increase of sea level rise between 0.5 and 3.0 metres, the incremental increase in value is between 50 and 90%. Between 1.5 and 3.0 metres, the increase is an approximate doubling of value exposed creating a total estimated value greater than $13 billion*
- *The greatest value of exposed local government owned infrastructure is different at varying increments. Generally, at the 1.5 metre increment, Canterbury's exposure is the greatest, followed by the Hawke's Bay and by Auckland. Additional noted areas include Greater Wellington, Bay of Plenty, Otago, and Waikato.*

Comparative Findings – Flood Exposure

Table 8 below summarises projected exposure to flooding from several sources including Local Government New Zealand (LGNZ).

Table 8 Flood exposure and disruption

Region	Bridges exposed @ 1m SLR[3]	Flood Risk[4]		Extreme Storm disruption risk[5] (snapshot) (From NZTA Maps)	Comment
		Roads (km)	Railway (km)		
Northland	53	1141	163	SH1 Cape Reinga to Kawakawa and bridge risks SH10 Awanui to Pakaraka between (Taumarere Bridge and Whangae Bridge)	• Multiple communities (and transport infrastructure) located in low lying coastal areas
Auckland	Not included	**1259**	196	SH16 Wellsford to Whenuapai	• **Priority region under LGNZ** • High level of population and built asset exposure to floods
Waikato	58	**2542**	176	SH25A Hikuai to Kopu (Kiriki Stream Bridge) SH25 Thames to Waihi (MacBeths Road)	• High level of population and built asset exposure to floods

[3] Simonson et. al (2019)

[4] Paulik, R., H. Craig, D. Collins (2019) New Zealand Fluvial and Pluvial Flood Exposure. Prepared for The Deep South Challenge. NIWA, Wellington

[5] SH Resilience Maps https://nzta.maps.arcgis.com/apps/MapSeries/index.html?appid=5a6163ead34e4fdab638e4a0d6282bd2

				SH 2 Pokeno to Tauranga -School Road to Owharoa Stream Bridge	• High level of dairy and production land exposed to flooding
BOP	Not included	667	36		• **Priority region under LGNZ**
Gisborne	Not included	371	18	SH2 Paengaroa to Gisborne – Gerrards Bridge; Anzac Slip; Parahohnu Whitmore Road SH35 Opotiki to Gisborne, end of passing lane NOC Boundary and some pockets	• Port disruption – SLR & storm surges
Hawkes Bay	Not included	681	86	SH38 Waiotapu to Wairoa - various sites SH2 Gisborne to Napier – various SH5 Taupo to Erksdale– various	• **Priority region under LGNZ**
Manawatu-Whanganui	Not included	1213	233	SH1 Waiouru to Levin SH43 Taunarunui to Straford	• Railways higher exposure at regional level
Taranaki	Not included	74	7	SH3, 33 Hamilton to New Plymouth: Totoro Road; Onaero River Road	
Wellington	Not included	**1515**	37	SH3 New Plymouth to Woodville, Upper Gorge Bridge SH1 Levin to Wellington Airport SH58 Whitby to Haywards SH2 Rimutaka Hill (Te Marua to Masterton) Wellington Port Access- Ngauranga Junction SH2	• Local roads; ferry disruptions from storms • High population and built asset exposure to floods
Marlborough		387	25	SH1 Picton to Kaiapoi – Pukapuka Stream Bridge	• Main north rail vulnerable
Nelson	12	130	0	SH6/62 Blenheim to Motueka & Bisley Road	
Tasman	Not included	789	0	SH6 Collingwood to Motueka	• **Priority region under LGNZ**
Canterbury	48	**3947**	156	SH1 – CHCH to Dunedin Back Creek Bridge to Nth Palmerston; Waikouaiti River	• **Priority region under LGNZ** • Most affected by incremental change • High level of population and built asset exposure to floods • High level of dairy & production land exposed to flooding
West Coast	Not included	1025	212	SH7 – Maruia Springs Bridge; Various bridges SH6 - Richmond to West Port - Inanganua Junction; Blackwater River Bridge, Sandy Creek Bridge; Taylorville Road; Parkers Creek Bridge; Sth of HariHari; Omoeroa River Bridge; Waikukupa River Bridge, Roaring Swine Bridge, etc.	• Most exposed unproductive land
Otago	**27**	**1386**	**136**	**SH8 Timaru to Milton – Lake Dunstan Sh6/6A Cromwell to Five Rivers – Lumber Box Creek; SH1 – Fea Street – Bank Street**	• **Priority region under LGNZ**

				SH88 - Port Chalmers	
Southland	Not included	1971	95	SH1 – Bluff SH 94 Mossburn to Milford Sound	• High level of dairy and production land exposed to flooding

Projected climatic changes across the regions were also reviewed to understand key weather events that may affect the land transport system. The information is drawn from the Ministry and the Environments, *Coastal hazards and climate change: Guidance for local government*. Projections are for 2040 and 2090.

Based on the latest climate projections for New Zealand, by the end of this century we are likely to experience higher temperatures greater increases in the North Island than the South, with the greatest warming in the northeast. The amount of warming in New Zealand is likely to be lower than the global average rising sea levels.

There will be more frequent extreme weather events including droughts (especially in the east of New Zealand) and floods. Rainfall patterns will also change with increased summer rainfall in the north and east of the North Island and increased winter rainfall in many parts of the South Island.

Final Ranking V1

Based on these findings, the following ranking (Table 5) has been included in Arataki V1. This reflects:

- Projected exposure for the land transport system to flooding
- LGNZ priority areas (under 1m SLR)
- Population exposed /affected
- Current and proposed infrastructure exposure

Table 9 Ranking

Region	Adaptation Ranking[6]	Overall Ranking[7]	Rationale
Northland	M	M	• Multiple communities (and transport infrastructure) located in low lying coastal areas • >100km road affected
Auckland	H	H	• Priority region under LGNZ • High level of population and built asset exposure to floods
Waikato	H	H	• High level of population and built asset exposure to flood • >500km road affected • High level of dairy and production land exposed to flooding
BOP	H	H	• Priority region under LGNZ • >500km road affected
Gisborne	L	L	• <100km roading affected • Low population and infrastructure affected
Hawkes Bay	H	M	• Priority region under LGNZ • >100km road affected
Manawatu-Whanganui	L	M	• Railways higher exposure at regional level • <100km roading affected
Taranaki	L	L	• >50km road affected
Wellington	H	H	• Local roads; ferry disruptions from storms • High population and built asset exposure to floods • >100km road affected

[6] Based on overall km affected by SLR, flood risk and NZTA Resilience Maps

[7] Combined ranking based on climate mitigation ranking

Marlborough	M	L	• <100km road affected
Nelson	M	M	• Main north rail vulnerable • <100km road affected
Tasman	H	H	• >100km road affected • Priority region under LGNZ
Canterbury	H	H	• Most affected by incremental change • High level of population and built asset exposure to floods • High level of dairy & production land exposed to flooding • >100km road affected
West Coast	M	M	• Most exposed unproductive land • Low population
Otago	H	H	• Priority region under LGNZ • >100km road affected
Southland	L	L	• <100km road affected • Dairy and production land exposed to flooding

Table 10 Summary of effects (2040/90 from MFE)

Region	Northland	Auckland	Waikato	BOP	Gisborne	Hawkes Bay	Manawatū-	Taranaki	Wellington	Marlborough	Nelson & Tasman	Canterbury	West Coast	Otago	Southland
Temperature															
0.7·C – 1.1.C warmer by 2040	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
0.7·C – 0.9.C warmer by 2040		✓			✓	✓									
0.6C – 0.9.C warmer by 2040														✓	✓
0.7– 3.1·C warmer by 2090	✓		✓	✓			✓	✓							
0.6 – 2.8.C warmer by 2090														✓	✓
0.6 – 3.0·C warmer by 2090													✓		
0.7– 3.0·C warmer by 2090									✓	✓	✓	✓			
Extra days >25.C	17-35	11-70	10-60	10-59	8-51	8-51	7-47	5-41	6-40	6-38	5-43	6-35	30	4-25	16
Fewer frosts	✓	Rare	✓	✓	✓	✓	✓	Rare	✓	✓	✓	✓	✓	✓	✓
Rain															
Variable across region	✓	✓	✓		✓	✓	✓	✓	✓[8]	✓	✓	✓	✓	✓	
Decrease in rain – Spring	✓	✓	✓	✓											
Increase in rain – Winter / Spring			✓				✓	✓[9]			✓		**W,S**[10]	**W,S**[11]	W
Increase summer and/or autumn rainfall					✓	✓				✓	✓				
Decrease in winter rainfall					✓										
Decrease in extreme rainfall	✓														
Increase in extreme rainfall										✓	✓		✓	✓	✓
Wind															
Increase westerly wind (winter) and spring for South Island	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓
Increase NE wind flow (summer)	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓				
Decrease in extreme windy days	✓	✓	✓												
Increase in extreme windy days									✓	✓		✓	✓	✓	✓

[8] < in Paraparaumu; > in Masterton by 2090

[9] New Plymouth

[10] Winter rainfall in Hokitika is projected to increase by 8-29% by 2090.

[11] 4-10% increase winter rainfall (Dunedin); 4-27% increase winter rainfall Queenstown

[12] Summer rainfall increase in Blenheim

[13] Increase frequency of westerly wings over the South Island particularly winter and spring

Storm															
Increase in storm intensity, local wind extremes and thunderstorms	✓	✓	✓	✓	✓	✓		✓	✓	✓			✓	✓	✓
Ex-tropical cyclone stronger, more damage from heavy rain / winds	✓	✓	✓	✓	✓	✓									
Snowfall															
Decrease in seasonal snow and number of snow days							✓			✓	✓	✓	✓	✓	✓

REFERENCES

Gardiner L., D. Firestone, A. Osbourne, B. Kouvelis, A.Clark and A.Tait (2009) *Change Effects on the Land Transport Network Volume Two: Approach to Risk Management* NZ Transport Agency Research Report 378 [www.nzta.govt.nz/assets/resources/research/reports/378/docs/378-v2.pdf]

MfE 2017. Coastal hazards and climate change: Guidance for local government. Ministry for the Environment Publication ME1341. Wellington, Ministry for the Environment. 279 p. + Appendices [www.mfe.govt.nz/publications/climate-change/coastal-hazards-and-climate-change-guidance-local-government]. Wellington, Ministry for the Environment.

Parliamentary Commissioner for the Environment (2015) *Preparing New Zealand for rising seas: Certainty and Uncertainty* [www.pce.parliament.nz/publications/regional-land-elevation-maps]

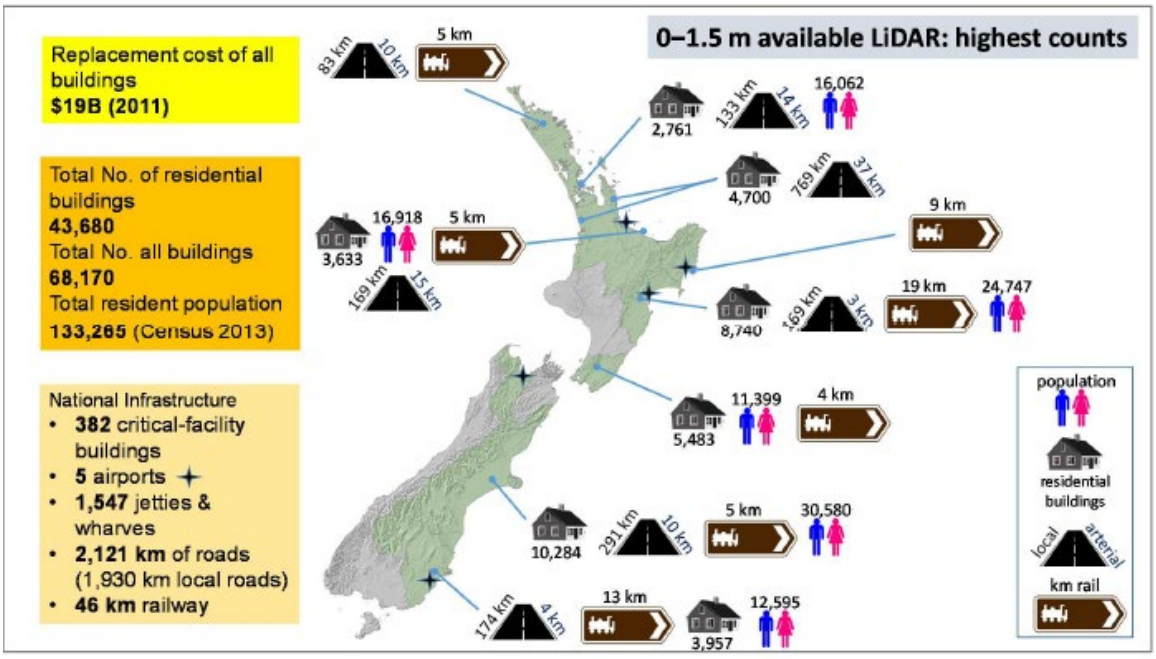
Paulik R., S. Stephens, S. Wadhwa, R. Bell, B. Popovic, B. Robinson (2019) *Coastal Flooding Exposure Under Future Sea-level Rise for New Zealand.* Prepared for The Deep South Challenge. NIWA, Wellington. [www.deepsouthchallenge.co.nz/sites/default/files/2019-08/2019119WN_DEPSI18301_Coast_Flood_Exp_under_Fut_Sealevel_rise_FINAL%20%281%29_0.pdf]

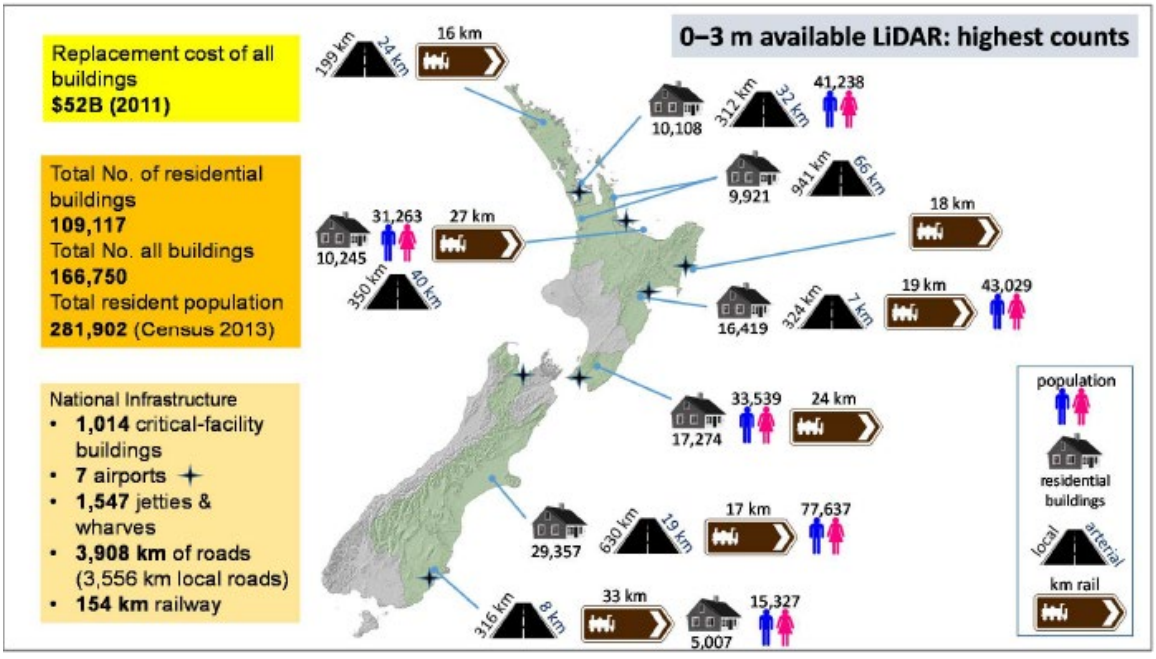
Paulik, R., H. Craig, D. Collins (2019) *New Zealand Fluvial and Pluvial Flood Exposure.* Prepared for The Deep South Challenge. NIWA, Wellington [www.deepsouthchallenge.co.nz/sites/default/files/2019-08/2019118WN_DEPSI18301_Flood%20Exposure_Final%20%281%29.pdf]

Simonson, T and G. Hall (2019) *Vulnerable: the quantum of local government infrastructure exposed to seal level rise* [www.lgnz.co.nz/assets/Uploads/d566cc5291/47716-LGNZ-Sea-Level-Rise-Report-3-Proof-FINAL-compressed.pdf]

ATTACHMENT 1: SUMMARY OF REGIONS WITH THE HIGHEST COUNTS OF ASSETS OR POPULATIONS AND NATIONAL TOTALS FOR COASTAL RISK EXPOSURE ACROSS REGIONS WITH LIDAR AVAILABLE

Source: https://www.pce.parliament.nz/media/1384/national-and-regional-risk-exposure-in-low-lying-coastal-areas-niwa-2015.pdf





ATTACHMENT 2: REGIONAL LAND ELEVATION MAPS (2015)

Source: Preparing New Zealand for rising seas: Certainty and Uncertainty https://www.pce.parliament.nz/publications/regional-land-elevation-maps

Northland	https://www.pce.parliament.nz/media/1375/regional-land-elevation-maps-wellington.pdf
Auckland	https://www.pce.parliament.nz/media/1376/regional-land-elevation-maps-auckland.pdf
Hawkes Bay	https://www.pce.parliament.nz/media/1372/regional-land-elevation-maps-hawkes-bay.pdf
Gisborne	https://www.pce.parliament.nz/media/1371/regional-land-elevation-maps-gisborne.pdf
Waikato	https://www.pce.parliament.nz/media/1386/regional-land-elevation-maps-waikato.pdf
Wellington	https://www.pce.parliament.nz/media/1375/regional-land-elevation-maps-wellington.pdf
Bay of Plenty	https://www.pce.parliament.nz/media/1375/regional-land-elevation-maps-wellington.pdf
Nelson and Tasman	https://www.pce.parliament.nz/media/1389/regional-land-elevation-maps-nelson-tasman-new.pdf
Canterbury	https://www.pce.parliament.nz/media/1373/regional-land-elevation-maps-canterbury.pdf
Otago	https://www.pce.parliament.nz/media/1370/regional-land-elevation-maps-otago.pdf

Figure 2 Coverage of LiDAR DEMs across A-NZ

ATTACHMENT 3: TOTAL COUNT AND REPLACEMENT FOR ROADING

Source: Simonson et. al http://www.lgnz.co.nz/assets/Uploads/d566cc5291/47716-LGNZ-Sea-Level-Rise-Report-3-Proof-FINAL-compressed.pdf

Total Count and Replacement Value for Roading- National								
	MHWS + 0.5	(KM) MHWS + 0.5	MHWS + 1.0	(KM) MHWS + 1.0	MHWS + 1.5	(KM) MHWS + 1.5	MHWS + 3.0 *	(KM) MHWS + 3.0
Roads	$ 335,000,000.00	741	$ 657,000,000.00	1395	$ 1,012,000,000.00	2046	$ 2,290,000,000	4559
Total Count and Replacement Value for Roading- Islands Compared								
	MHWS + 0.5	(KM) MHWS + 0.5	MHWS + 1.0	(KM) MHWS + 1.0	MHWS + 1.5	(KM) MHWS + 1.5	MHWS + 3.0 *	(KM) MHWS + 3.0
North Island	$ 187,000,000	377	$ 401,000,000	804	$ 624,000,000	1199	$ 1,510,000,000	2862
South Island	$ 148,000,000	364	$ 256,000,000	591	$ 388,000,000	847	$ 777,000,000	1697
Total Count and Replacement Value for Roading- Priority Areas North Island								
	MHWS + 0.5	(KM) MHWS + 0.5	MHWS + 1.0	(KM) MHWS + 1.0	MHWS + 1.5	(KM) MHWS + 1.5	MHWS + 3.0 *	(KM) MHWS + 3.0
Bay of Plenty Region	$ 22,000,000	50	$ 49,000,000	114	$ 76,000,000	177	$ 179,000,000	397
Hawkes Bay Region	$ 67,000,000	78	$ 126,000,000	158	$ 170,000,000	232	$ 280,000,000	402
Auckland Region	$ 34,000,000	43	$ 78,000,000	95	$ 139,000,000	155	$ 414,000,000	371
Total	**$ 101,000,000.00**	**171**	**$ 253,000,000**	**367**	**$ 385,000,000**	**564**	**$ 873,000,000**	**1170**
Note: All of the above regions had LiDAR contour information available.								
Total Count and Replacement Value for Roading- Priority Areas South Island								
	MHWS + 0.5	(KM) MHWS + 0.5	MHWS + 1.0	(KM) MHWS + 1.0	MHWS + 1.5	(KM) MHWS + 1.5	MHWS + 3.0 *	(KM) MHWS + 3.0
Canterbury Region	$ 29,000,000	77	$ 74,000,000	176	$ 135,000,000	311	$ 298,000,000	664
Otago Region	$ 65,000,000	133	$ 92,000,000	191	$ 123,000,000	251	$ 184,000,000	371
Tasman Region	$ 52,000,000	153	$ 78,000,000	217	$ 97,000,000	265	$ 117,000,000	319
Total	**$ 146,000,000**	**363**	**$ 244,000,000**	**584**	**$ 355,000,000**	**827**	**$ 599,000,000**	**1354**

ATTACHMENT 4: TOTAL COUNT AND REPLACEMENT FOR ROADING

Source: Paulik, R., H. Craig, D. Collins (2019) *New Zealand Fluvial and Pluvial Flood Exposure Prepared for The Deep South Challenge.* NIWA, Wellington

Table 1-1: National and regional level exposure of elements at risk within identified New Zealand flood hazard areas.

Region*	Population (#)	Buildings		Transport			Electricity (National Grid)			Three-Waters		Land Cover (km²)		
		Total (#)	Replacement Value (2016 NZD$ Billion)	Roads (km)	Railway (km)	Airports (#)	Transmission Lines (km)	Structures (#)	Sites (#)	Pipelines (km)	Nodes (#)	Built	Production	Natural or Undeveloped
Northland	15,237	14,263	3.4	1,141	163	0	51	53	0	515	15,619	9	896	141
Auckland	118,172	48,167	27.6	1,259	196	3	214	243	4	4,409	146,165	29	622	177
Waikato	89,012	60,008	15	2,542	176	1	583	1,262	8	1,614	25,228	58	2,288	391
Bay of Plenty	18,322	13,450	3.3	667	36	2	57	119	0	1,269	37,034	15	310	223
Gisborne	15,455	11,804	2.2	371	18	1	0	0	0	417	8,663	9	228	31
Hawkes Bay	17,788	13,942	3.5	681	86	1	270	116	3	796	22,489	10	531	117
Taranaki	2,145	2,195	0.4	74	7	0	43	14	1	114	1,683	4	97	23
Manawatu-Whanganui	26,975	25,206	5.2	1,213	234	3	388	1,006	4	571	9,503	12	1,544	232
Wellington	77,675	43,360	13.8	1,515	37	0	93	138	6	3,453	73,053	34	511	184
Tasman	20,740	11,072	2.9	789	0	0	38	2	0	620	19,063	10	424	118
Nelson	12,029	6,873	2.1	130	0	1	3	85	1	895	24,336	7	21	12
Marlborough	4,674	3,760	1.0	387	25	1	205	160	1	8**	126**	3	394	140
West Coast	9,136	5,901	1.5	1,025	212	2	247	180	5	281	7,885	6	1,038	1,207
Canterbury	189,012	116,713	40	3,947	156	2	808	672	10	4,177	No Data	112	2,991	949
Otago	41,447	21,684	8.7	1,386	136	1	126	1,355	2	1,782	47,482	23	1,111	410
Southland	17,672	13,118	4.2	1,971	95	2	268	443	4	250	4,170	15	2,180	979
NZ Total	**675,491**	**411,516**	**135**	**19,098**	**1,577**	**20**	**3,397**	**8,848**	**49**	**21,173**	**442,499**	**358**	**15,190**	**5,335**

*2016 regional council boundaries.