Changing focus on transport resilience

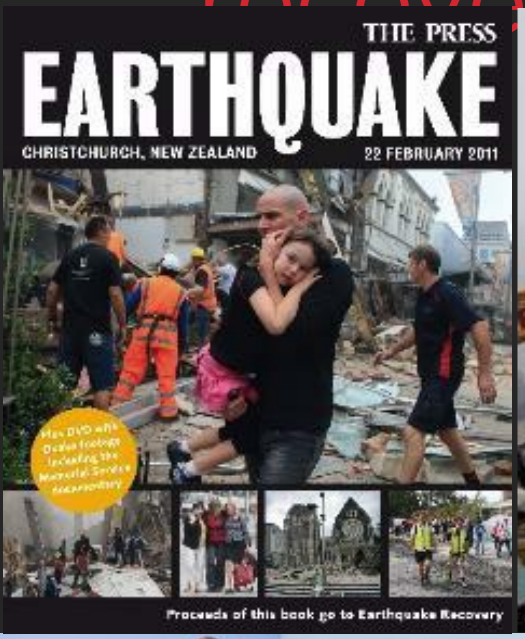
Doug Mason

WSP | OPUS

Transport Group Conference 2019

- Why resilience?

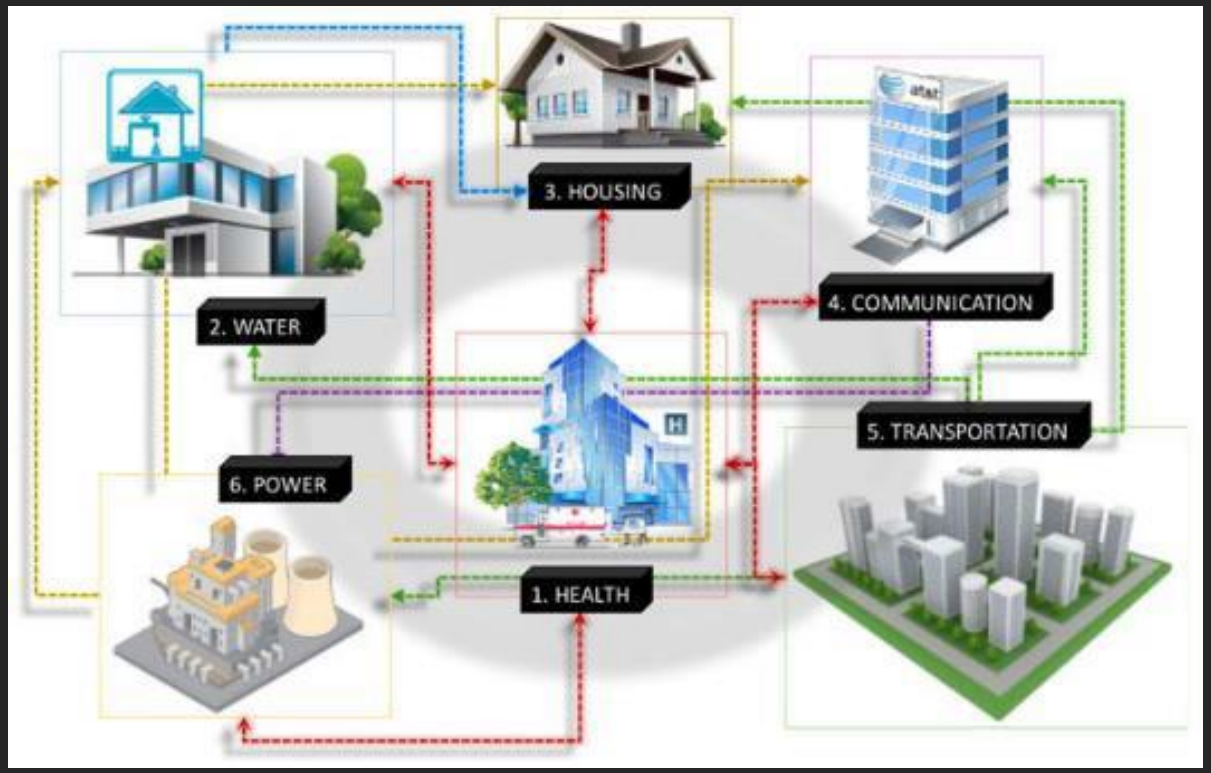
Transport is critical for response and recovery



Interdependencies

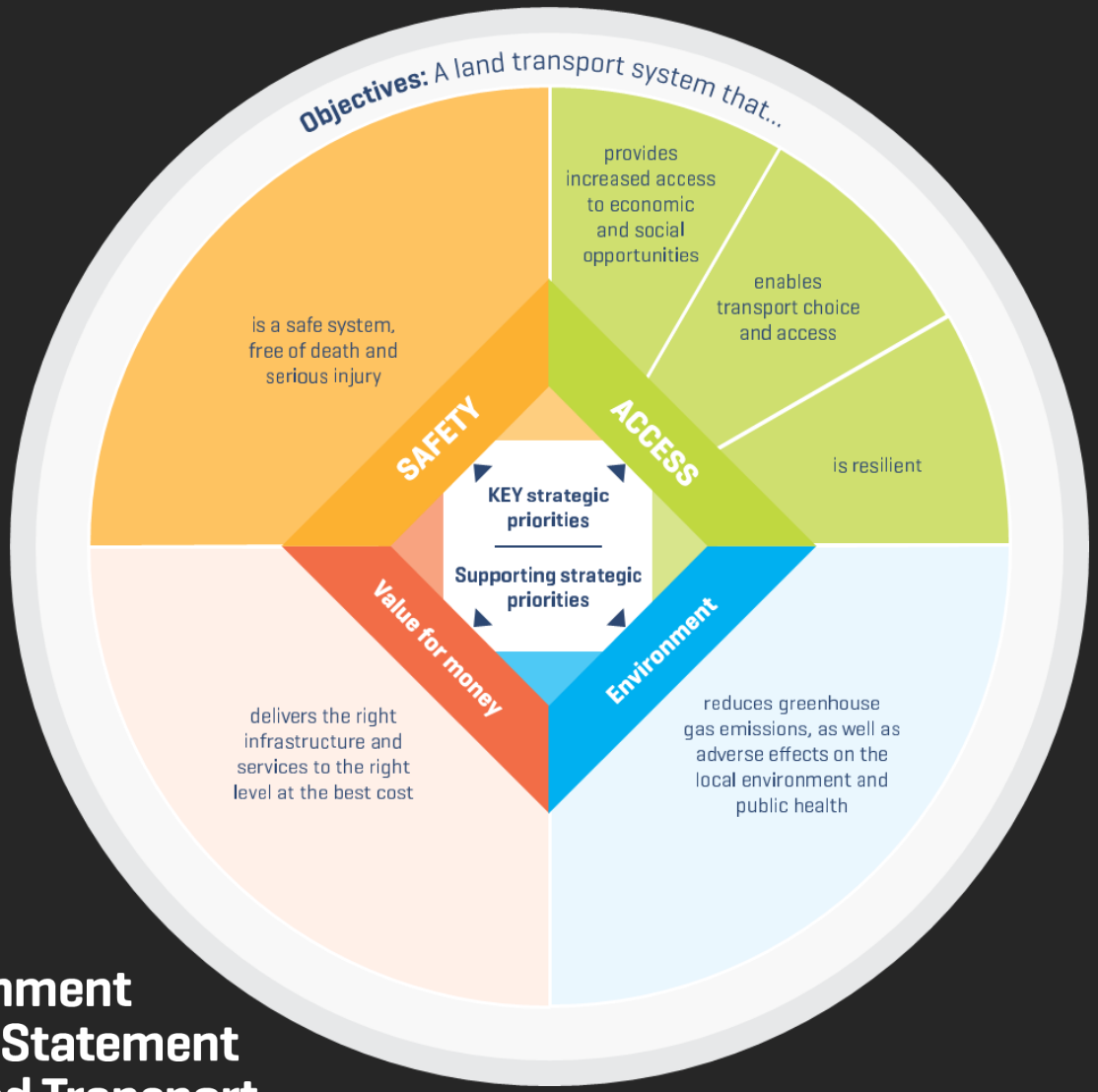
Transport is critical for

- Access
- Food and medicine
- Fuel
- Hospital
- Airport
- Port
- Recovery of water, power, telecommunications



Policy

Our vision is that in 2045 New Zealand's infrastructure will be resilient and coordinated, and contribute to a strong economy and high living standards.



Government Policy Statement on Land Transport

2018/19 – 2027/28

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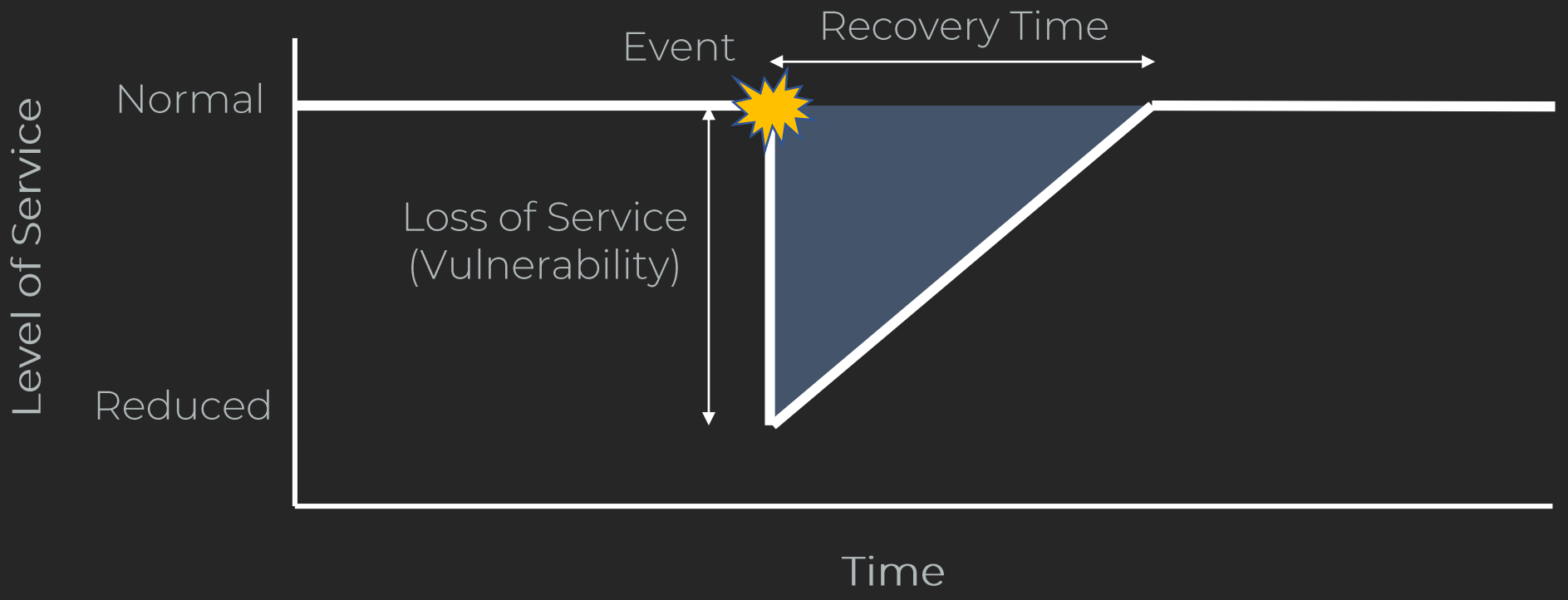
- What is transport resilience?

Transport network performance

- Robustness / damage to links (loss of availability)
- Response time to reinstate access (outage duration)
- Redundancy and inter-connectivity (network resilience)

Measuring resilience

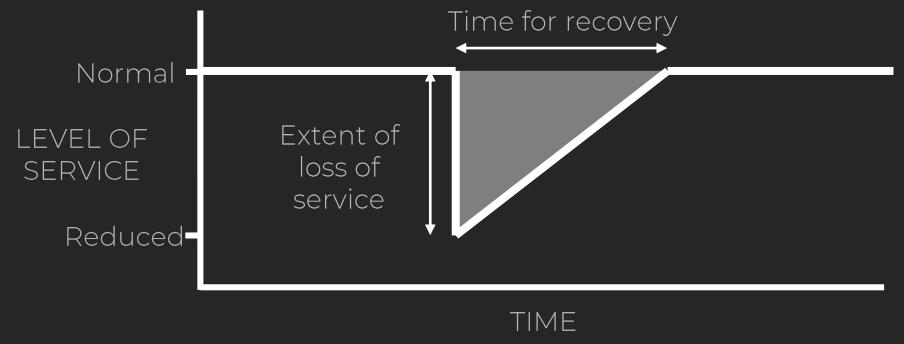
- *Ability to recover quickly and resume original service after damage*



Resilience metrics

Availability State

Level	State	Description
1	Full	Full access except condition may require care.
2	Poor	Available for slow access, but with difficulty by normal vehicles due to partial lane blockage, erosion or deformation.
3	Single lane	Single lane access only with difficulty due to poor condition of remaining road.
4	Difficult	Road accessible single lane by only 4x4 off road vehicles.
5	Closed	Road closed and unavailable for use.



Outage State

Level	State	Description
1	Open	No closure, except for maintenance
2	Minor	Condition persists for up to 1 day
3	Moderate	Condition persists for 1 day to 3 days
4	Short term	Condition persists for 3 days to 2 weeks
5	Medium term	Condition persists for 2 weeks to 2 months
6	Long term	Condition persists for 2 months to 6 months
7	Very long term	Condition persists for greater than 6 months

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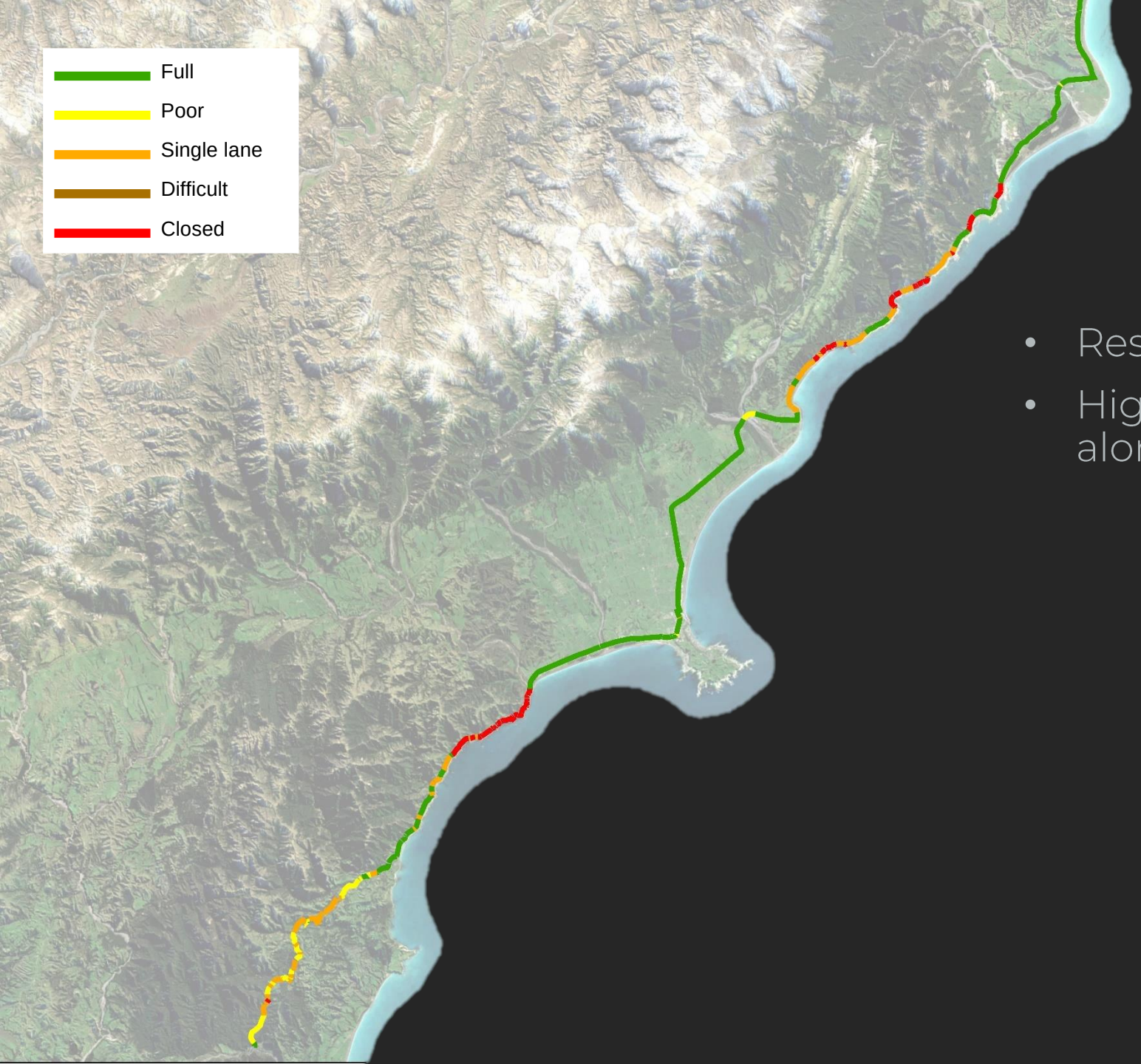
- Network resilience assessments



SH1 Kaikōura (2000)

- Resilience to large earthquake
- Highlighted areas of vulnerability along coastal corridor

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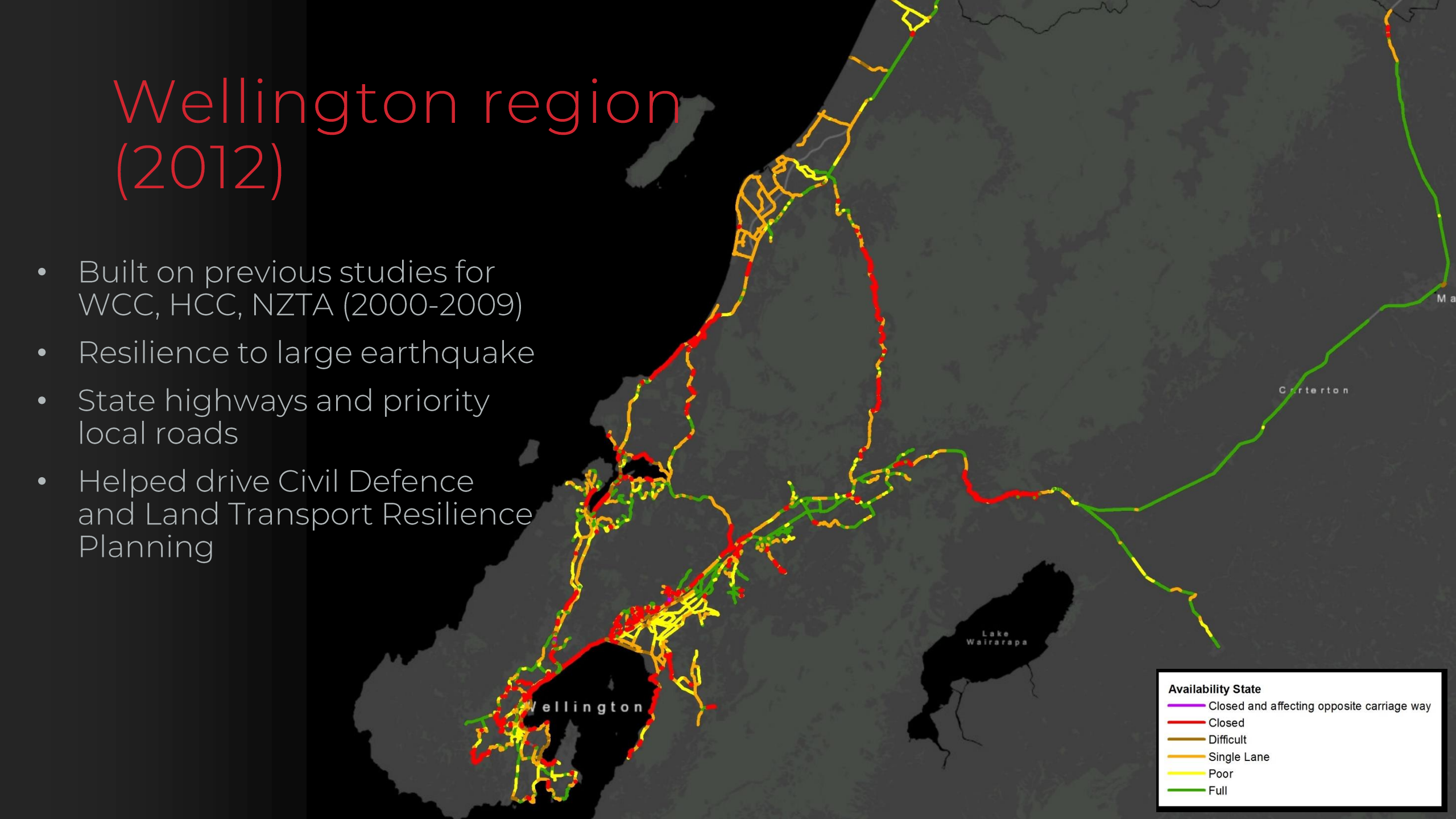
Wellington region (2012)

- Built on previous studies for WCC, HCC, NZTA (2000-2009)
- Resilience to large earthquake
- State highways and priority local roads
- Helped drive Civil Defence and Land Transport Resilience Planning



National state highway network (2016)

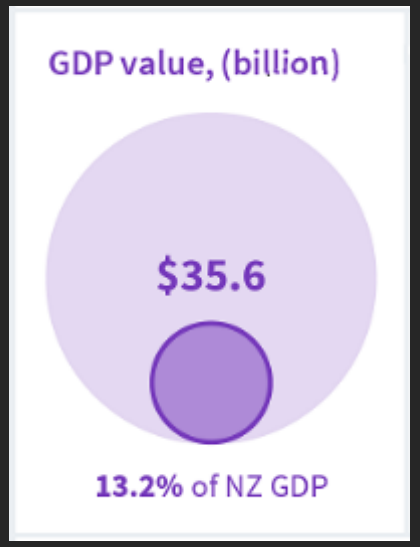
- Assess the resilience of the whole state highway network at a broad brush high level
- High impact low probability natural hazards
  - Large earthquake
  - Large storm / flooding
  - Tsunami
  - Volcanic eruption
- Use a consistent basis applied across the country

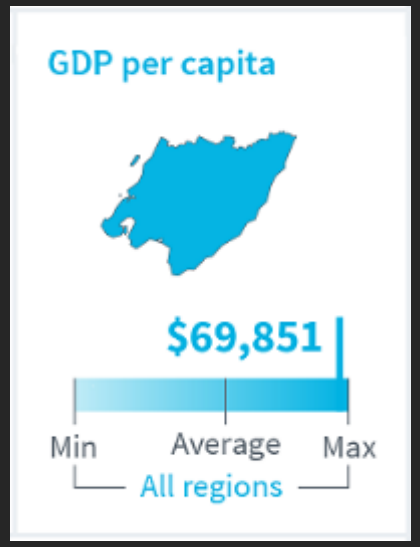
SH1 Kaikōura

Wellington Land Transport Resilience

Business Case developed, but yet to be confirmed by NZ Transport Agency

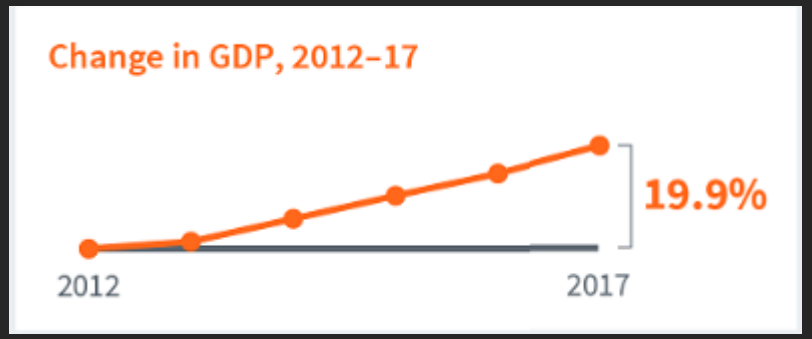
Wellington's economic context





Location of:

- Central Government
- ½ of employed population
- International airport
- International port



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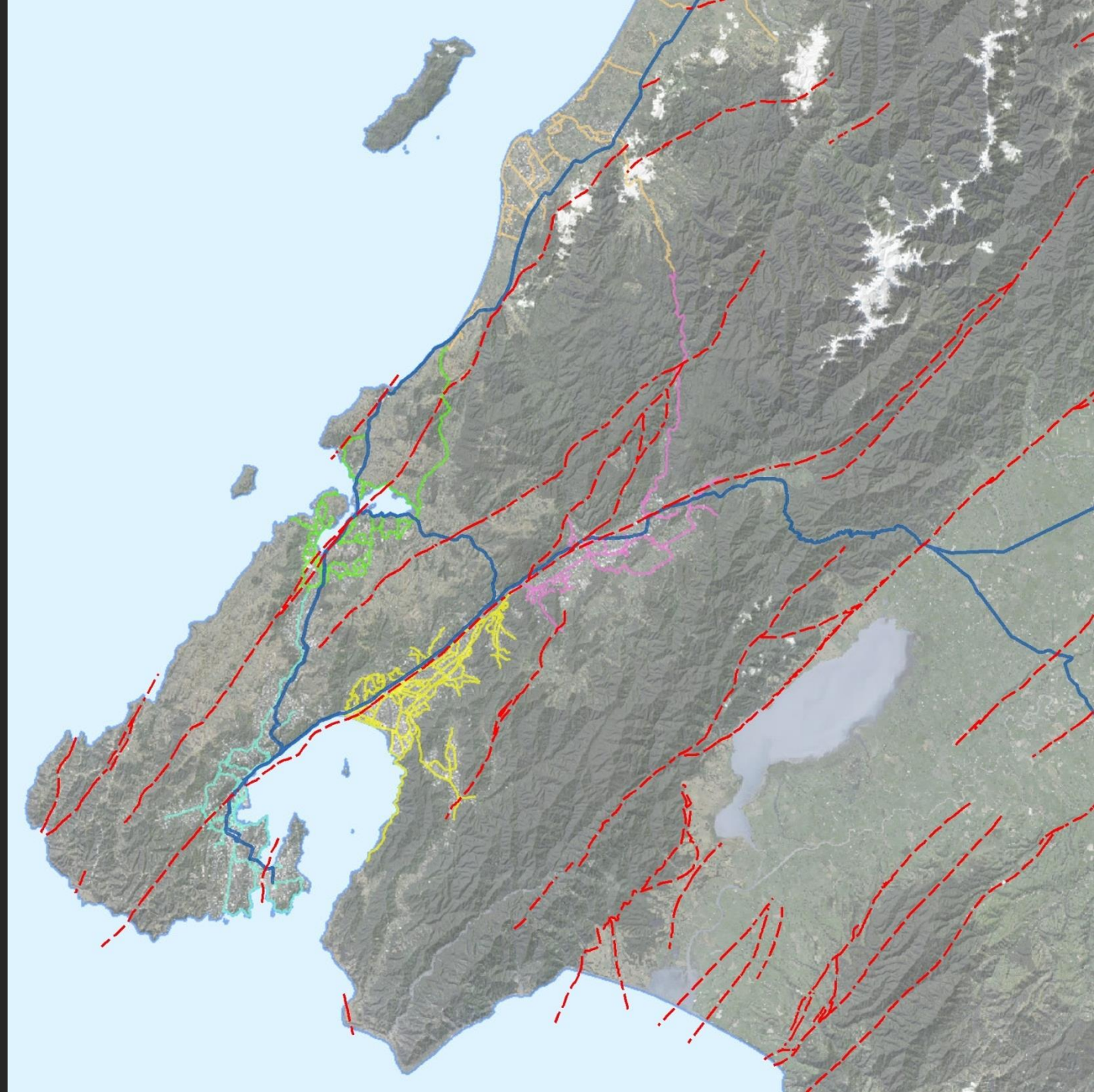
Transport context

- Daily employment trips (road / rail)

Physiographic context



Lessons from Christchurch and Kaikōura

Christchurch

- Series of major to moderate earthquakes 2010 to 2011
- Major road closures (45% of roads damaged)
- Passenger and freight rail disruption
- Extensive road network redundancy; response and recovery largely unaffected

Wellington

- Wellington region prone to multitude of hazards and will be isolated following a large earthquake
- Major urban centres would be cut off from each other
- Very little transport redundancy

Kaikōura

- Single major earthquake 2016
- Major rail and road closures
- Disruption to passengers and freight for over 1 year (and disruption continuing)
- Lack of redundancy – community isolation
- $360M impact to national GDP
- $1.2B rebuild cost
- Loss of resilience – impacts ongoing for many years from storms

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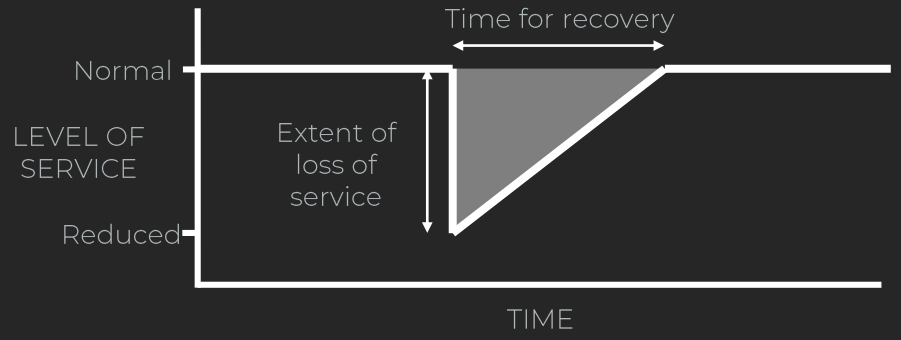
Land transport resilience business case

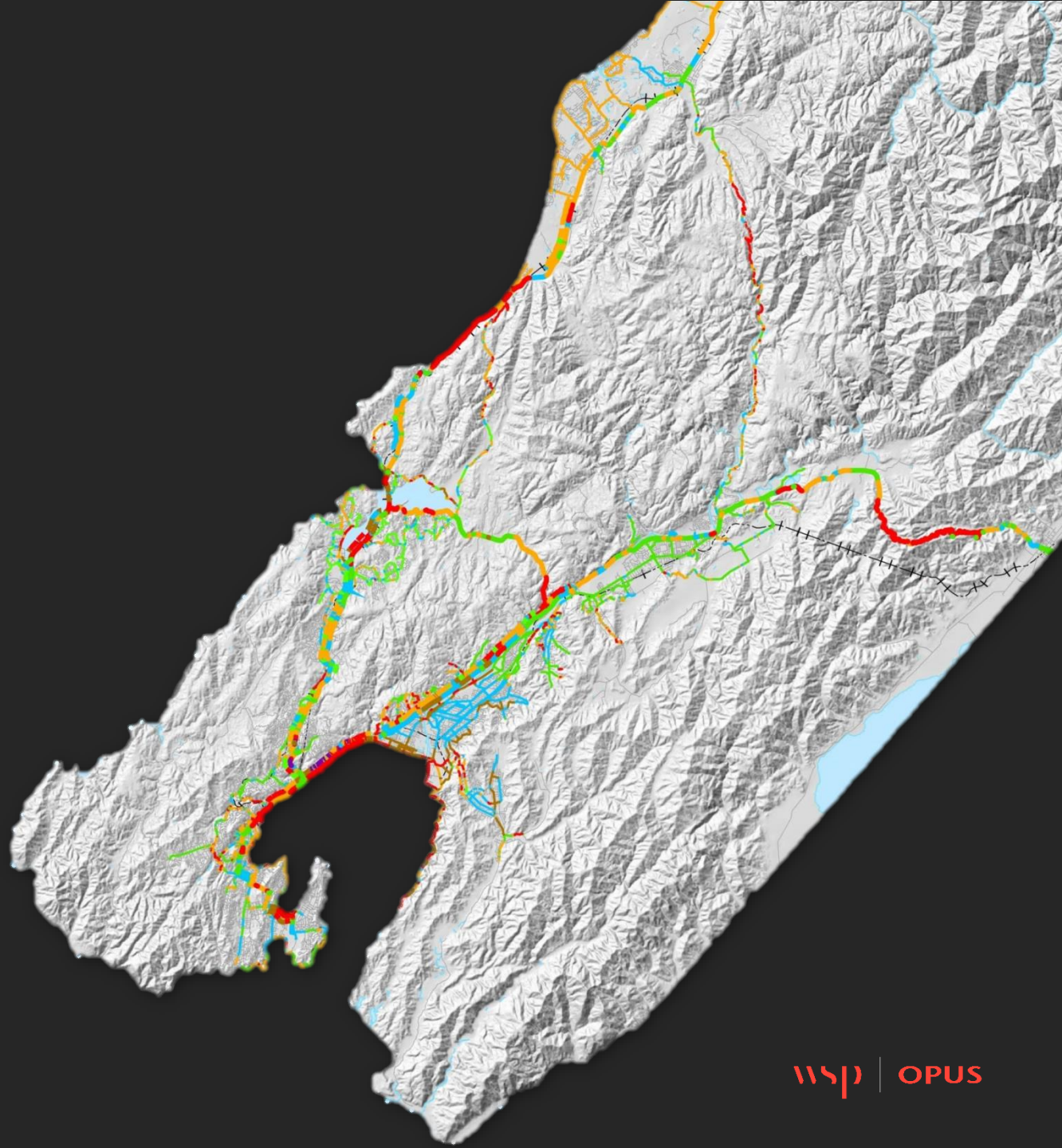
Wellington Land Transport Programme Business Case covers local roads and state highways

Assess resilience

Availability

- 6 - Closed and affecting opposite carriageway
- 5 - Closed
- 4 - Difficult
- 3 - Single Lane
- 2 - Poor
- 1 - Full





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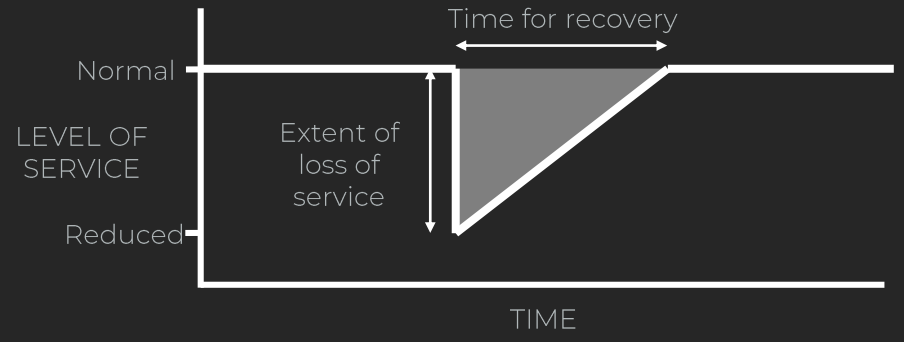
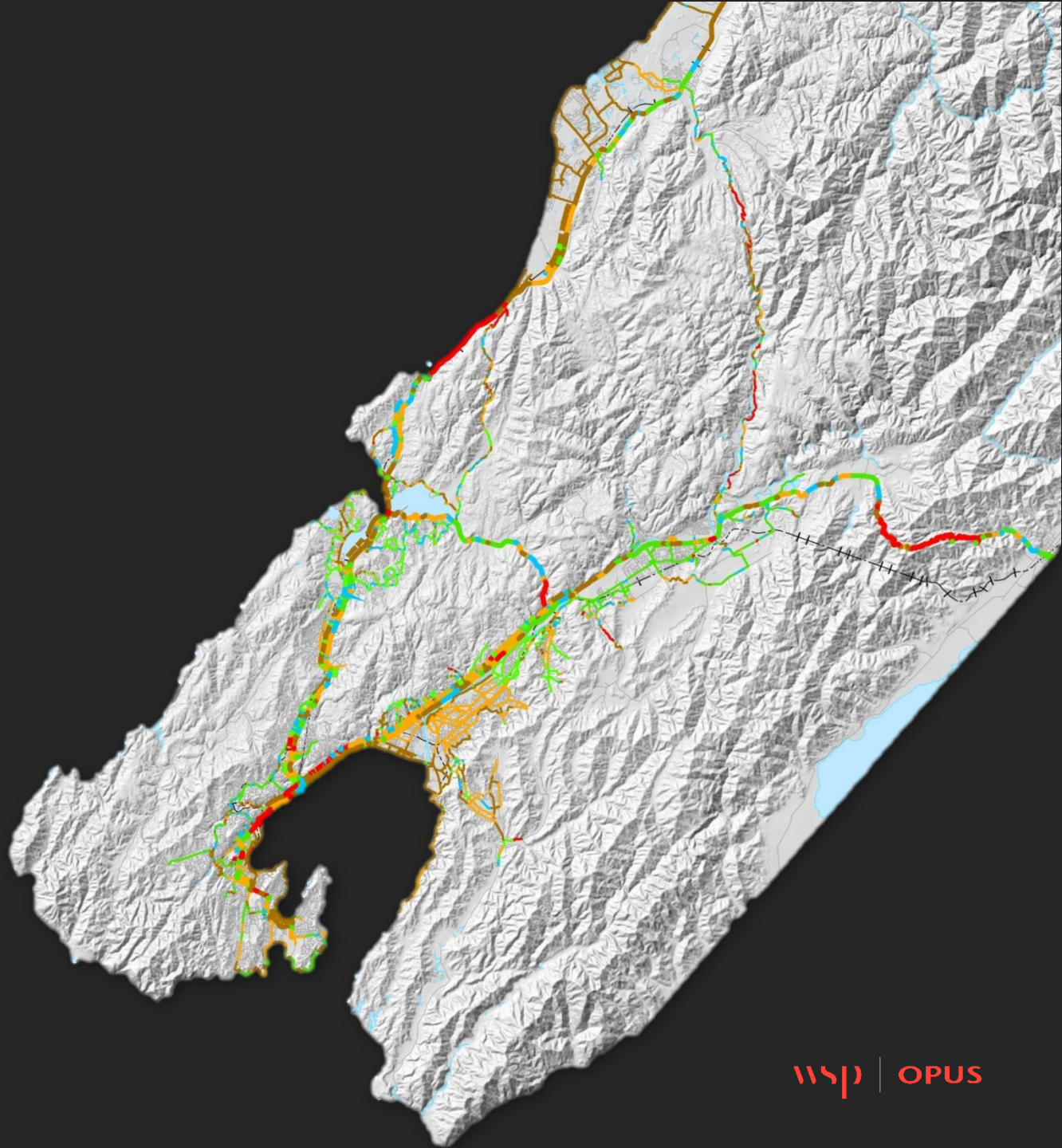
Assess resilience

Outage

- 5 - Long Term (> 3 months)
- 4 - Severe (2 weeks to 3 months)
- 3 - Moderate (3 days to 2 weeks)
- 2 - Minor (up to 3 days)
- 1 - Open (no closure)





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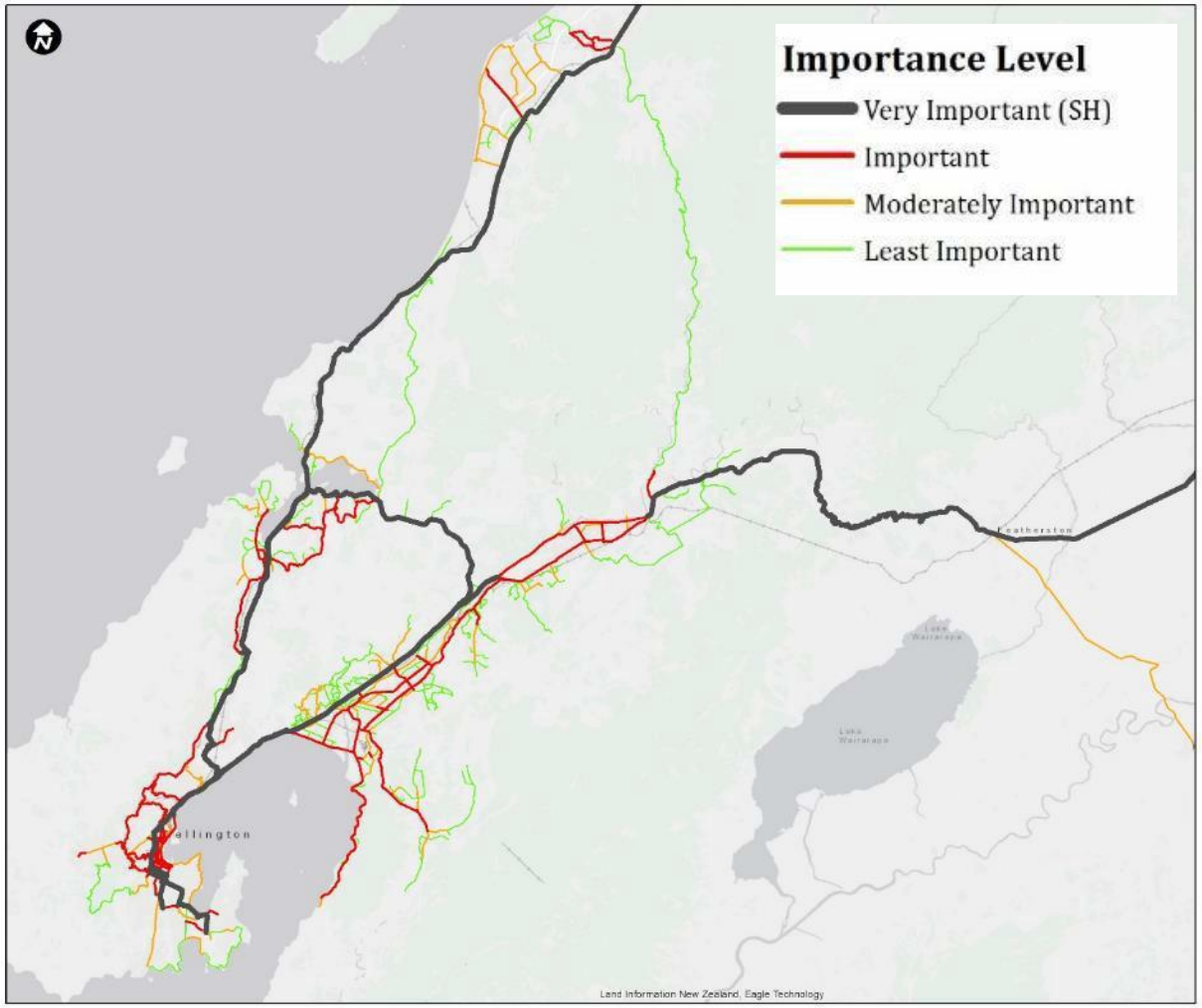
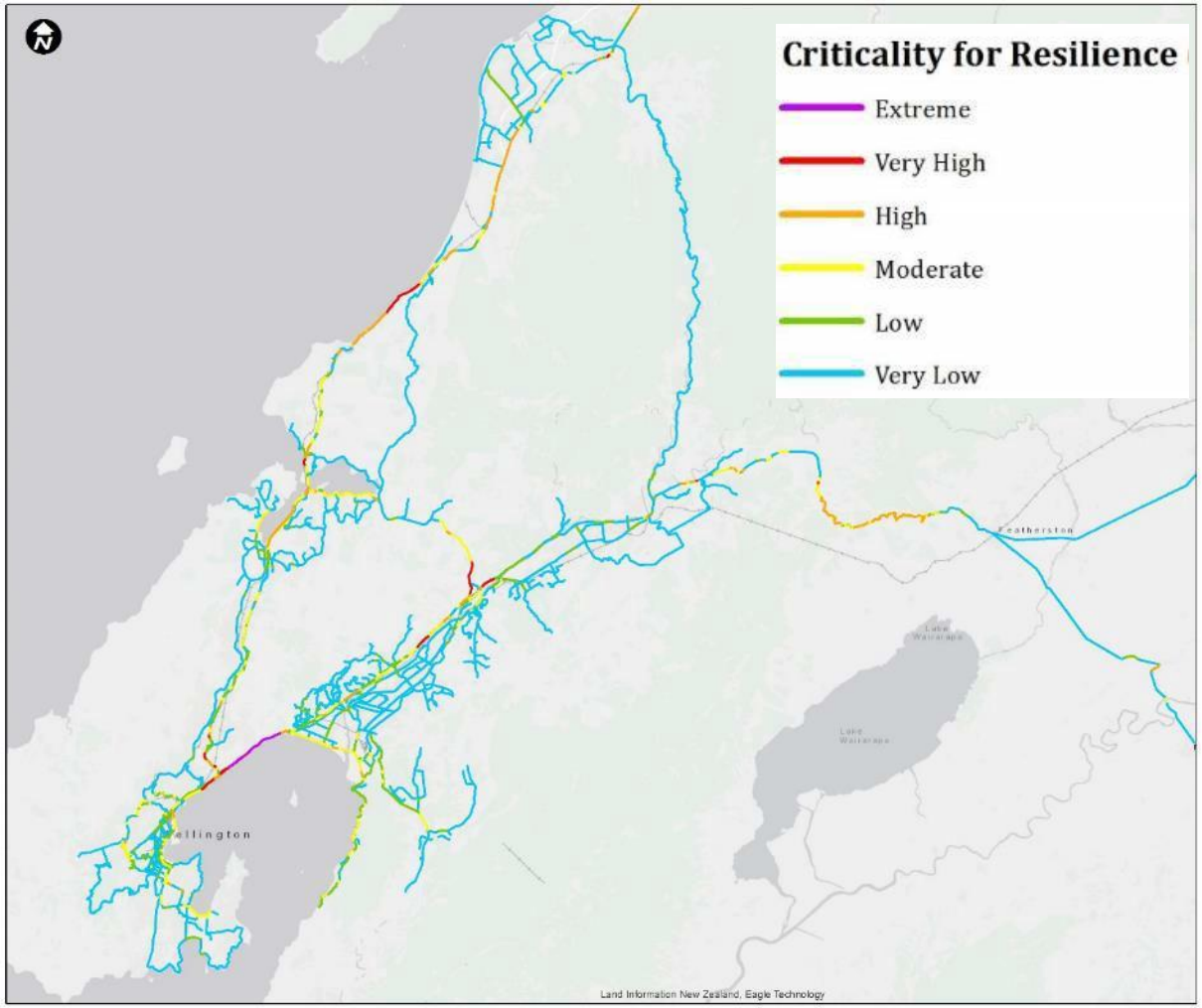
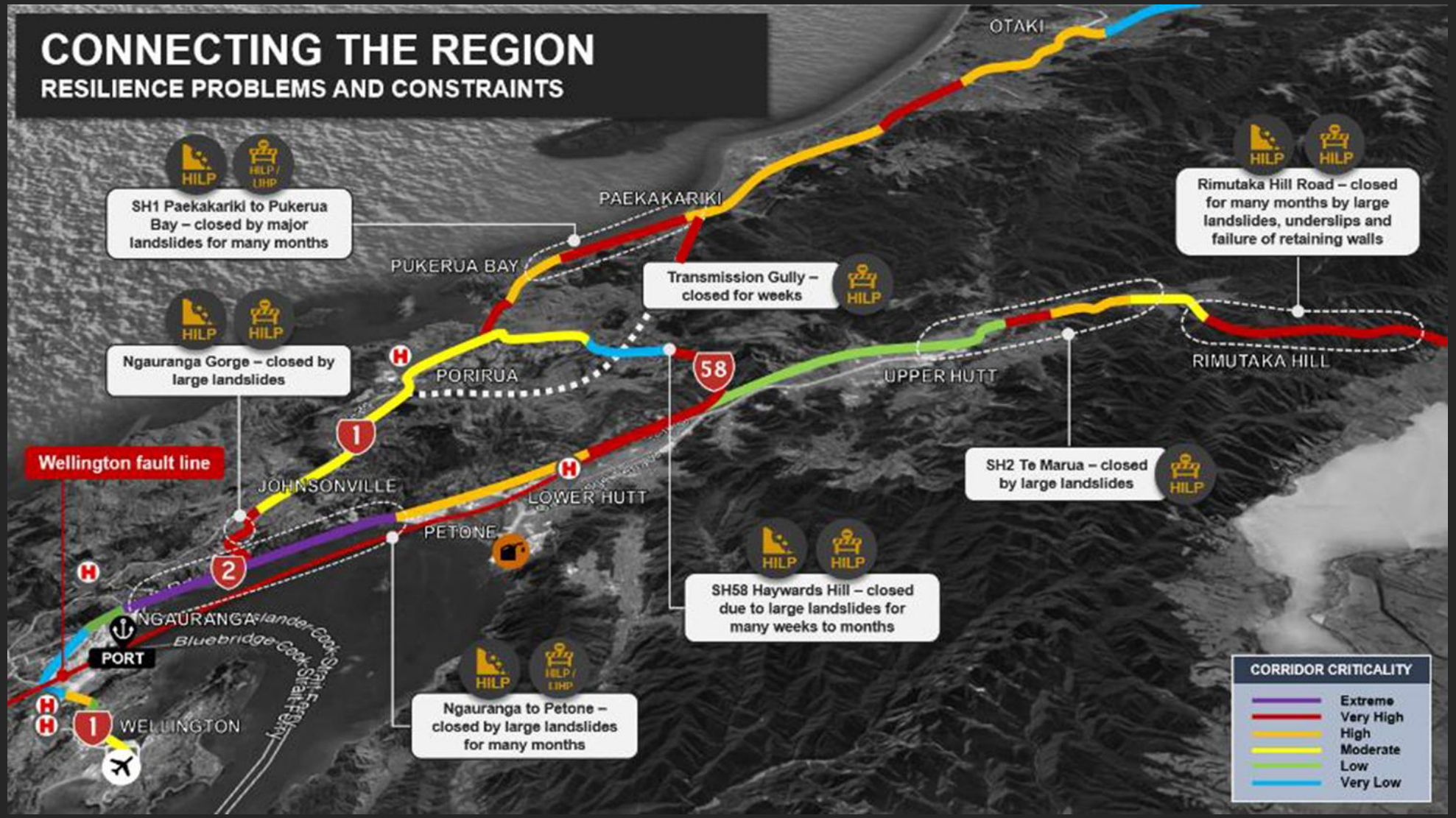
Importance and criticality of links





Prioritised resilience risks



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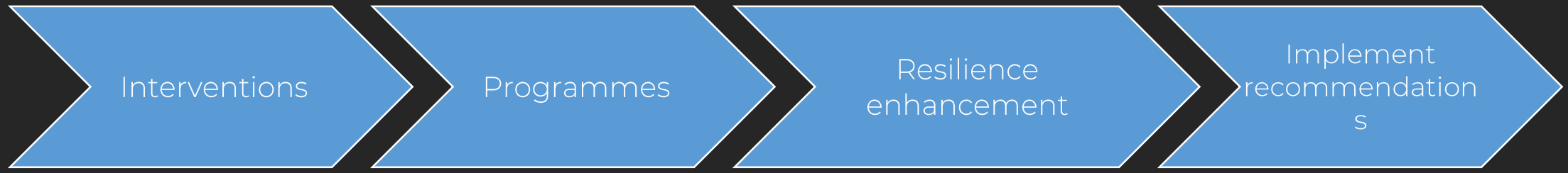
Prioritised resilience risks

Criticality Rating	RCA Owner	Network Segment	Critical Section	E Quake	Tsunami	Storm	Nature of Vulnerability	Current Interventions	Effect of interventions	Zone
Extreme	NZTA	SH2 Petone to Ngauranga	Petone to Ngauranga	Yes	Yes	Yes	This is the only and critical access between the Hutt Valley and Wellington. The highway is expected to be closed in moderate to large earthquakes and storms by large landslides on the eroded fault scarp hillside, with run-out extending across the full width of the highway and railway. Likely to be closed for many months after major M7.5 earthquake. Also prone to flooding and debris flows, particularly between Petone and Horokiwi. Also vulnerable to tsunami inundation. Closed by small to moderate events with closure of days to a week. Recovery will be slow as access only available from Ngauranga (Kiwi Point Quarry) and Petone (Hutt Valley) ends and possibly from Horokiwi Quarry near Petone. The corridor is also shared by the railway line and bulk water main and hence is of greater importance than road access issues.	None funded. HV to W cycleway and P2G under considera tion.	HV cycleway could provide pedestrian access. P2G would provide limited alternate access into Hutt Valley, but no direct access from Wellington City. P2G also likely to be closed for several weeks in major event, and could not provide capacity between Wellingtojn and Hutt Valley in small to moderate events because of limited capacity of SH1.	Wellington North / Hutt City
Extreme	NZTA	SH1 Ngauranga Interchange		Yes	Yes	Yes	Key SH1 motorway access into Wellington and Hutt Valley. In major earthquakes and tsunami likely to be closed by liquefaction / lateral spreading towards the harbour, retaining wall damage and slips from hills above. The section can be also affected by performance of the railway bridge above at the south end of Nguranga Gorge. The corridor is shared with railway line and bulk water main.	None funded.		Wellington North
Very High	NZTA	SH2 Manor Park to Silverstream	Taita Gorge: Manor Pk to Silverstream	Yes	No	Yes	SH2 section through Taita Gorge between SH58 Interchange and Silverstream Bridge access, is vulnerable to landslides. Expected to be closed for weeks in a major M7.5 earthquake. The tight corridor is shared with the railway line and the Kaitoke bulk water main. The Wellington Fault runs in close proximity to this section of road.	None		Hutt City
Very High	NZTA	SH1 Southern Rail Overbridge	full	Yes	Yes	No	This is a bridge which carries the SH1 motorway over the Masterton – Hutt Valley railway line, and the structure has poor capacity and is also vulnerable to damage from liquefaction and lateral spreading. Collapse of bridge will also close the Wairarapa railway line.	None		Wellington North
Very High	NZTA	SH1 Thorndon Overbridge	Full length	Yes	Yes	No	This is a 1.1km long overbridge over the Ferry terminal, main railway line and railyards, which is adjacent to a high seawall. The bridge was partially retrofitted in the mid-1990s, but remains vulnerable to liquefaction and lateral spreading and failure of the seawall, and also rupture of the Wellington Fault. The fault rupture will lead to loss of a span, and while there are catch frames to prevent the span falling on the railyards, access will still be disrupted.	None	NZTA considering limited resilience improvements to prop the span vulnerable to fault rupture, the overbridge is still likely to be affected by liquefaction, lateral spreading and fault displacements.	Wellington North
Very High	NZTA	SH1 Thorndon to Ngauranga	Kaiwharawhara to Ngauranga IC	Yes	Yes	Yes	The motorway is expected to be damaged by liquefaction and lateral spreading. While this may not entirely close the motorway, this section also has the Southern Rail Overbridge and Thorndon Overbridge which are more vulnerable to longer period closure. The corridor is shared with railway lines.	None		Wellington North
Very High	NZTA	SH1 Ngauranga Gorge	Johnsonville Bypass and Ngauranga wall	Yes	No	Yes	SH1 Ngauranga Gorge is vulnerable to landslides and retaining wall failure / dropout at the south end just north of rail overbridge. Single lane access can be quickly restored except along Johnsonville bypass which is likely to be fully closed by landslides and underslips. Also failure of the Helston Road bridge will affect access at the north end of this section.	Limited resilience improve ments being considere d.	NZTA considering limited resilience improvements which is as yet undefined.	Wellington North
Very High	NZTA	Transmission Gully	Battle Hill to Paekakariki	Yes	No	Yes	The steep very high hillside terrain and the very high and steep cut slopes proposed make the Battle Hill to Paekakariki section of TG vulverable to landslides and debris flows, and closure for long periods in large earthquakes and possibly major storm events.	None		Kapiti
Very High	NZTA	SH1 MacKays Crossing to Raumati Road	South of Poplar Avenue	Yes	No	Yes	Key SH1 western spine access into greater Wellington. Highway expected to be closed by landslides from the terrace and hills to the east and lateral spreading towards swamp to the west, in major M7.5 earthquakes and storm events.	M2PP expressw ay	Provides alternate access with greater separation from hillside. But a section of the route between MacKays Cossing and the Poplar Road Interchange will still be affected by run out from major landslides.	Kapiti
Very High	NZTA	SH 58 Haywards to Moonshine	Haywards Hill	Yes	No	Yes	The Haywards Hill section of SH 58 is vulnerable to closure by large landslides, debris flows and some underslips in large earthquake and storm events. Expected to be closed for many months in a major ~M7.5 earthquake.	None	NZTA considering limited resilience improvements which is as yet undefined.	Hutt City
Very High	NZTA	SH2 Rimutaka Hill Road	Pakuratahi to Featherston	Yes	No	Yes	SH2 Rimutaka Hill section expected to be closed in moderate to large earthquakes and storms by large landslides, failure of retaining walls, underslips and debris flows. Likely to be closed for many many months in a major M7.5 earthquake. This is the only access in the Wairarapa from Wellington Region, and one of two access routes (SH1 and SH2) into the Region from outside.	None		UpperHutt - Rimutakas
Very High	NZTA	SH2 Brown Owl to Te Marua	Birchville to Mangaroa River Bridge	Yes	No	Yes	SH2 section expected to be closed by landslides and underslips in major earthquake or storm events. This is a critical access to Te Marua bulk water facilities as well as from the Wairarapa and outside the region. This section is likely to also be closed by flooding and river erosion in a major storm event.	None		UpperHutt - Rimutakas
High	NZTA	SH1 Paremata to Plimmerton	Paremata & Goat Point	Yes	Yes	No	SH1 vulnerable to liquefaction lateral spreading north of Paremata bridges, and landslides at Goat Point. This corridor is also shared by the railway line.	Transmiss ion Gully expressw ay under construct ion.	Transmission Gully will provide alternate route when completed. Vulnerability of TG will then become critical. Will remain critical for Plimmerton and Pukerua Bay communities.	Porirua
High	NZTA	SH1 Cobham Drive	Kilbirnie Crescent – Calabar Rd	Yes	Yes	Yes	Key SH1 access to Wellington Regional Airport and Miramar peninsula. Highway expected to be closed by liquefaction/ lateral spreading towards Evans Bay in a major M7.5 earthquake and tsunami. Will take several weeks to few months to restore access. Also provides access to Miramar and Seatoun communities.	None		Wellington East
High	NZTA	SH 1 Mt Victoria Tunnel	Portal / Approaches	Yes	No	Yes	The Mt Victoria Tunnel on SH1 is a key route to the Wellington Regional Airport, and while the tunnel is expected to be resilient, the steep slopes adjacent to the portal areas are likely to fail in a large ~ M7.5 earthquake leading to closure of the tunnel access for days to few weeks.	Mt Victoria Tunnel duplicati		Wellington East

Land transport resilience business case



Impacts on society

LIHP		HILP
Potentially large economic disruption	TRANSPORT ROUTES	MAJOR disruption / closures
OPEN but disrupted	INTER-REGIONAL JOURNEYS	CLOSED
Potentially large losses, unnecessary	ECONOMY	MAJOR losses, completely stopped
Minimal / no disruption	CENTRAL GOVT	MAJOR disruption; contingency plan required
Temporary loss of access to jobs, schools, emergency services, supplies	SOCIAL WELLBEING	Potential for isolation, harm, lack of access to basic needs. Longer term disruption of access
Variable cost to society		 Differential impacts – lower socio-economic classes are less resilient

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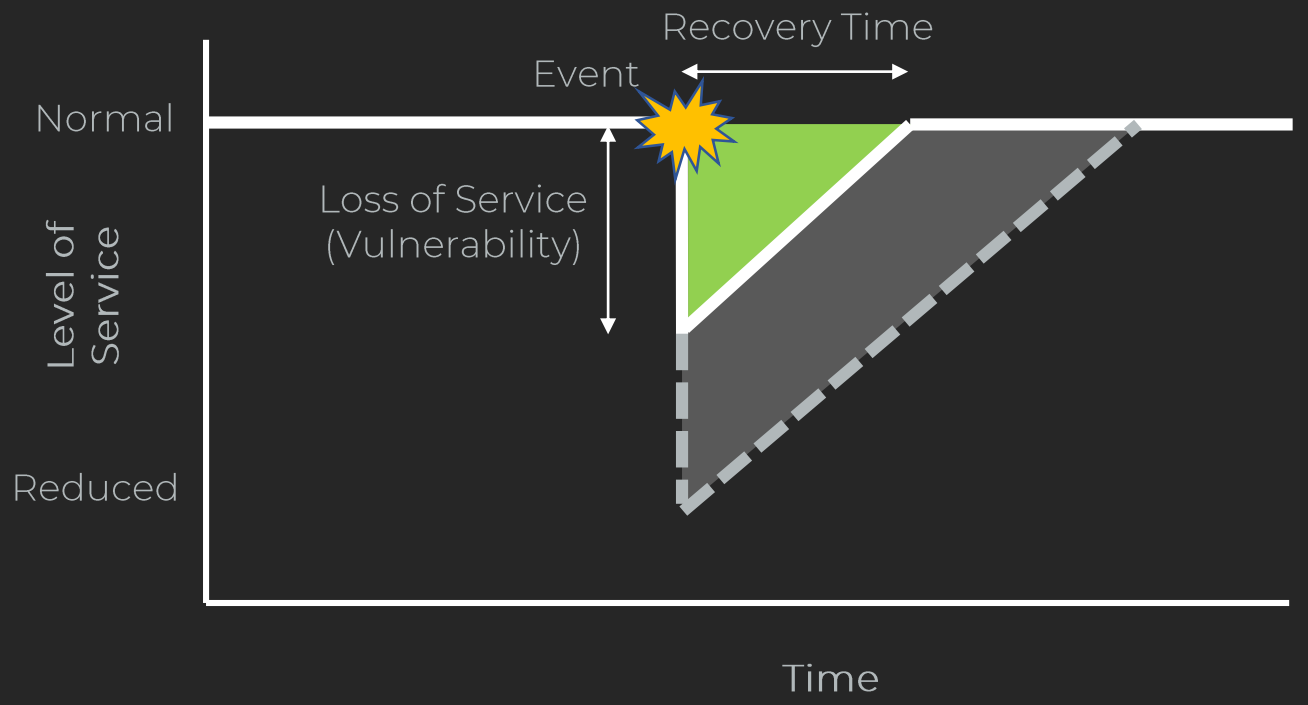
Resilience interventions

Interventions consider:

- Robustness – minimise loss of access
- Response – planning
- Alternate routes
- Recovery – as quick as possible
- Range of HILP, LIHP and routine events



Resilience enhancement

Resilience Investment Objectives		
1	2	3
Improve response & recovery, reduce closure times	Reduce population isolation, restore access	Economic and social functionality (LIHP & HILP)

Non-infrastructure	Enhance infrastructure	New infrastructure
Median barrier gates	Reduce vulnerability of existing strategic routes	New alternative routes
Information / communications	Improve robustness/ availability of existing alternate routes	Alternative access options
Emergency response plans		

EXAMPLES: Wadestown route strengthening, Ngauranga I/C strengthening

EXAMPLES: Haywards – Eastern Hutt Link, Petone to Grenada Link Road

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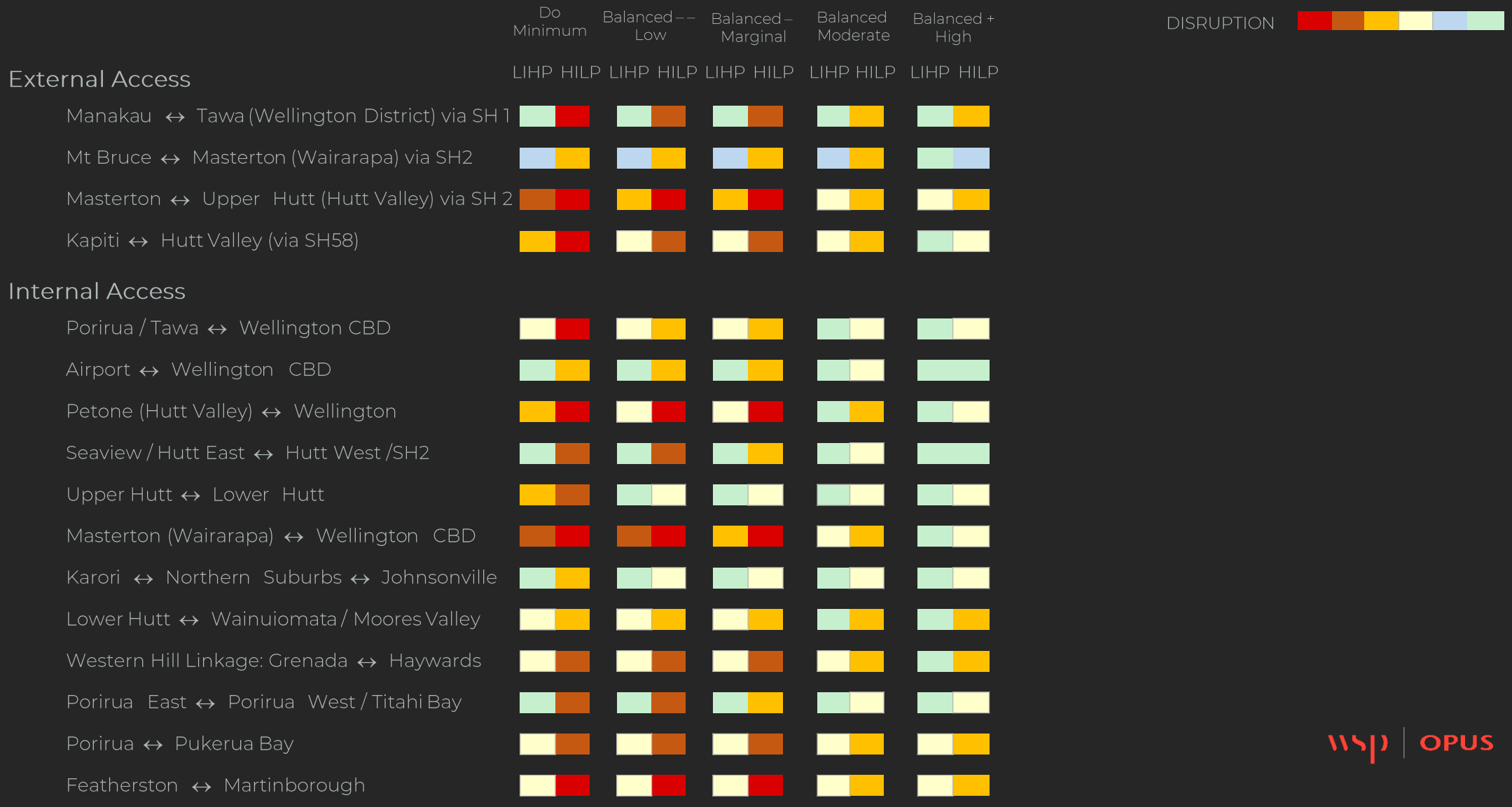
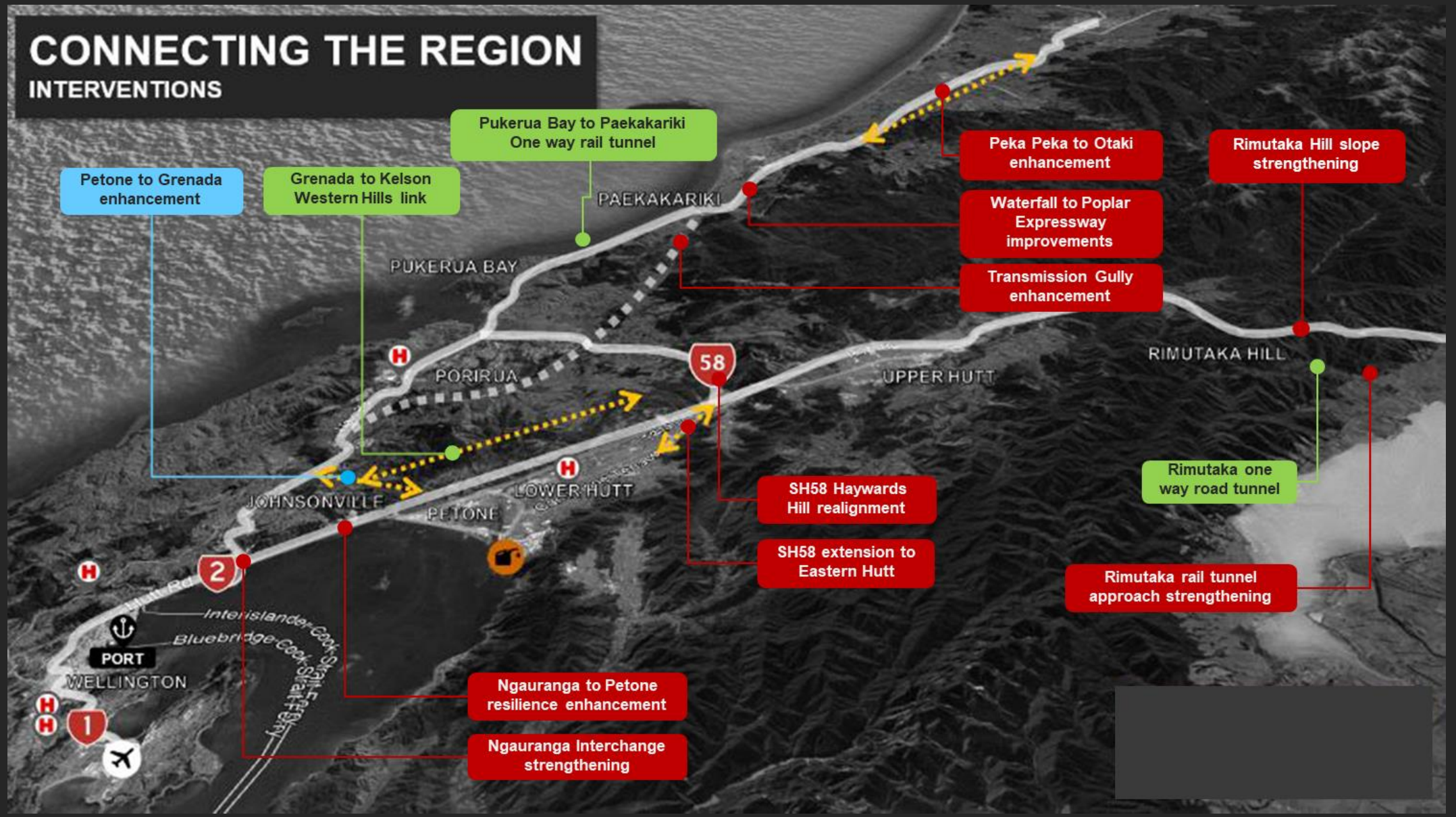
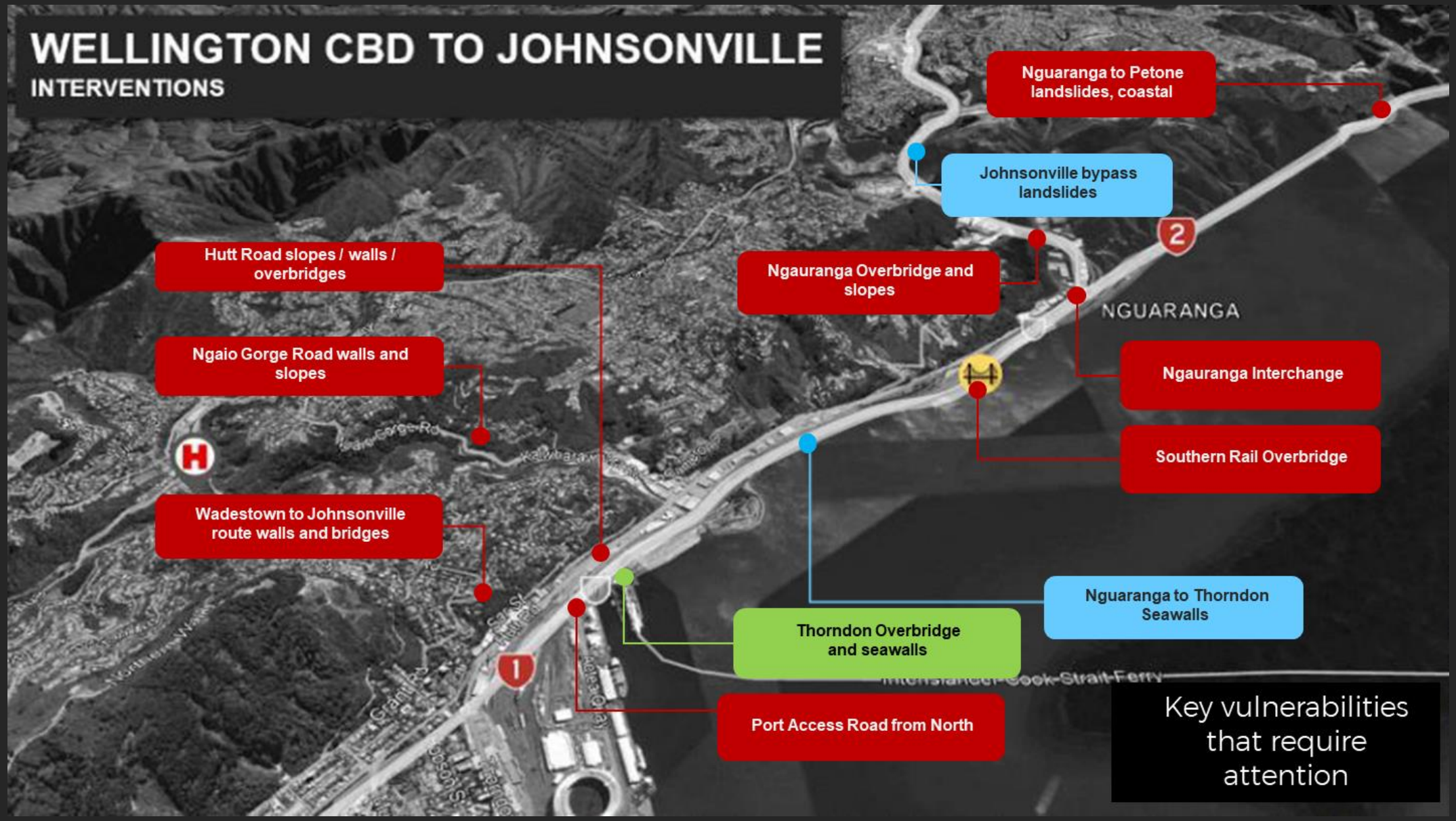
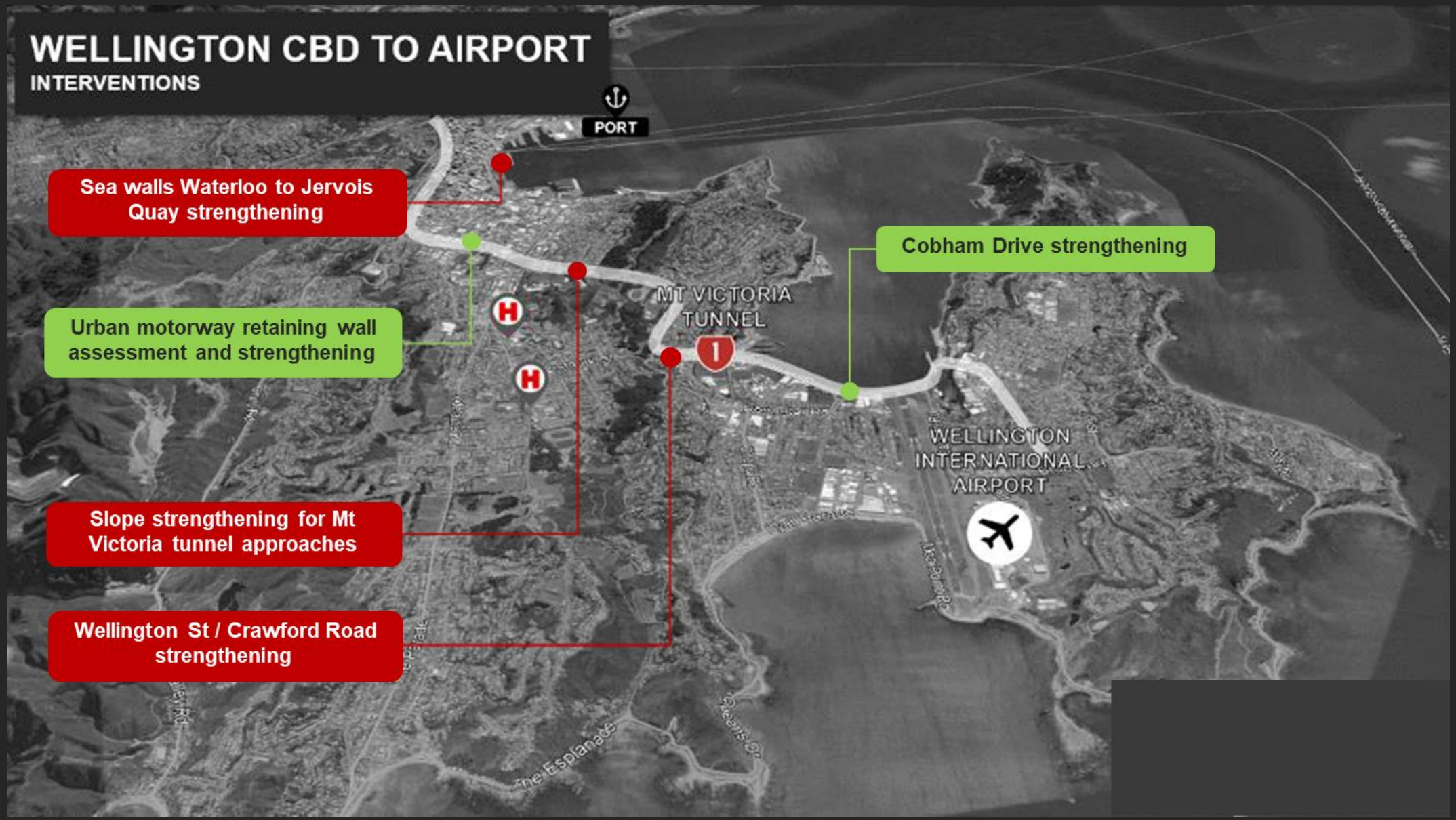
Improvement of critical journeys




CONNECTING THE REGION
INTERVENTIONS
Pukerua Bay to Paekakariki One way rail tunnel
Petone to Grenada enhancement
Grenada to Kelson Western Hills link
Peka Peka to Otaki enhancement
Rimutaka Hill slope strengthening
Waterfall to Poplar Expressway improvements
Transmission Gully enhancement
PAEKAKARIKI
PUKERUA BAY
PORIRUA
58
UPPER HUTT
RIMUTAKA HILL
Rimutaka one way road tunnel
SH58 Haywards Hill realignment
SH58 extension to Eastern Hutt
Rimutaka rail tunnel approach strengthening
JOHNSONVILLE
PETONE
LOWER HUTT
2
Interislander
Bluebridge
Cook Strait Ferry
PORT
WELLINGTON
1
Ngauranga to Petone resilience enhancement
Ngauranga Interchange strengthening


WELLINGTON CBD TO JOHNSONVILLE
INTERVENTIONS
Nguaranga to Petone landslides, coastal
Johnsonville bypass landslides
Hutt Road slopes / walls / overbridges
Ngauranga Overbridge and slopes
NGUARANGA
Ngaio Gorge Road walls and slopes
Ngauranga Interchange
Southern Rail Overbridge
Wadestown to Johnsonville route walls and bridges
Nguaranga to Thorndon Seawalls
Thorndon Overbridge and seawalls
Port Access Road from North
Key vulnerabilities that require attention


WELLINGTON CBD TO AIRPORT
INTERVENTIONS
PORT
Sea walls Waterloo to Jervois Quay strengthening
Urban motorway retaining wall assessment and strengthening
Slope strengthening for Mt Victoria tunnel approaches
Wellington St / Crawford Road strengthening
Cobham Drive strengthening
MT VICTORIA TUNNEL
WELLINGTON INTERNATIONAL AIRPORT
The Esplanade

Recommended management case

- Recommendations to infuse resilience into existing projects
- Stand-alone strengthening works – pre-implementation study
- Local road strengthening
- New transport links – detailed business case
- Recommendations to address resilience as part of planned projects
- Consider as part of corridor improvements
- Integrated with urban and land use planning

Summary

- Roads are vital lifelines – damage and disruption posed by hazards – access is key
- Resilience mapping captured in spatial databases – help consider issues across geographies and society
- Multiple hazards and spectrum of hazard levels need consideration (LIHP to HILP)
- Integrated approach between state highways, local roads and rail essential to address transport resilience issues
- Impact on customers – society – is important, and addressed by considering:
    - Response
    - Recovery
    - Socio-economic functionality
    - Social resilience
- Business case approach adopted – not used for resilience projects previously – required innovative thinking
- Affordability and risk appetite are challenging – introduces personal views


Thank you
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