

# Bridges 2020: *Management for Long Term Performance*



23 November 2004 **Rudolph Kotze** CPEng IntPE(NZ) - Manager Structures NZTA **Cambridge**  
**September 2009**



NZ TRANSPORT AGENCY  
WAKA KOTAHI

New Zealand Government

# 2011 Rugby World Cup





# Risk-based Bridge Asset Management in New Zealand

- Asset description
- Funding priorities
- Asset management
- Risk management
- The future.....



# State Highway Network

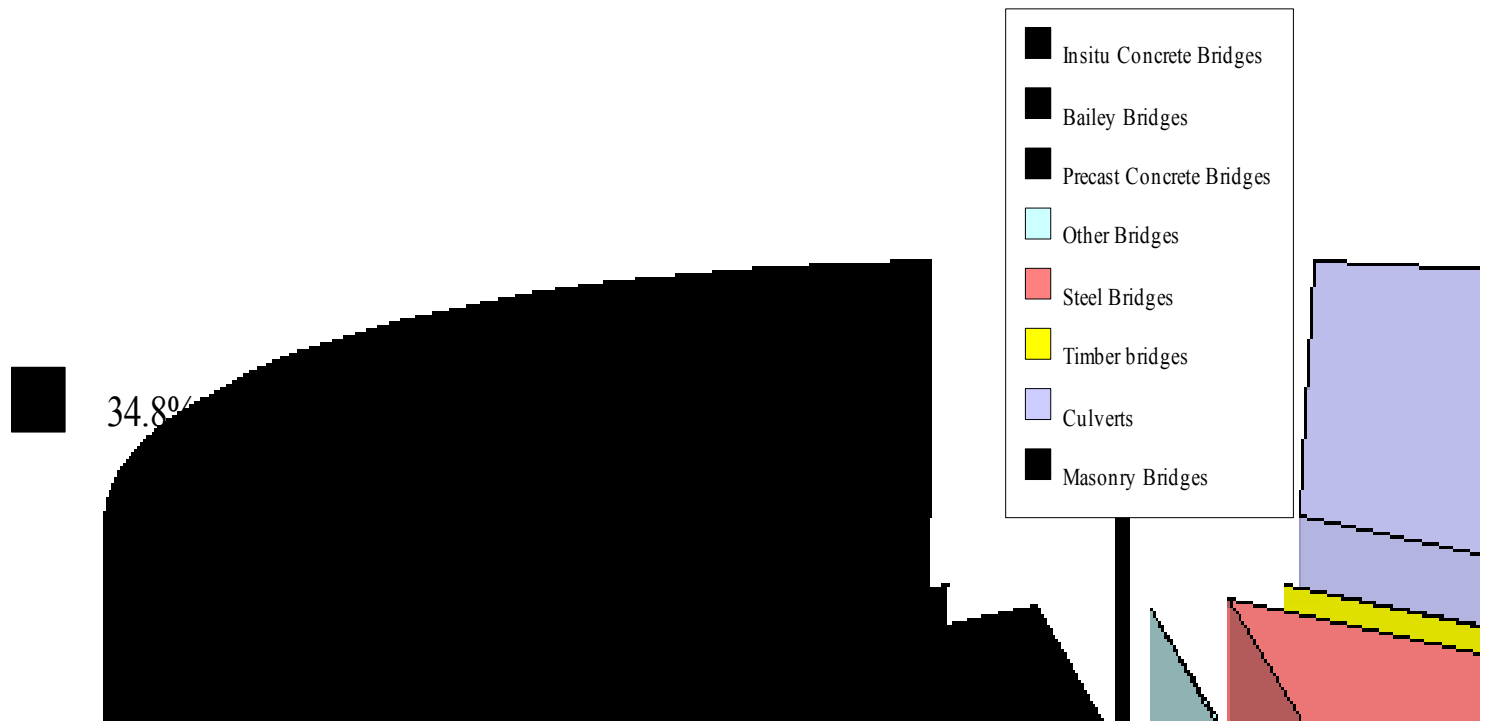
- 4,020 bridges and large culverts ( $>3.5\text{m}^2$ )
- Bridge stock equivalent to average Australian State
- Replacement  $\sim\text{NZ\$}6.0\text{B}$
- Depreciated  $\sim\text{NZ\$}3.7\text{B}$



# Asset description

## 4020 Bridges & Large Culverts

### Bridge Types



# Asset Performance Criteria

## Load Capacity

- All bridges  $\geq$  Class I
- 4 bridges “One at a time”
- 17 reduced speed

## Height Clearance

- 13 bridges  $< 4.55\text{m}$
- 7 tunnels  $< 4.55\text{m}$

## Bridge Width

- 327 bridges  $<$  LOS width thresholds





# State Highway Bridges

- Precast concrete
- In-situ concrete
- Steel beam
- Steel truss
- Stone arch
- Suspension
- AHB



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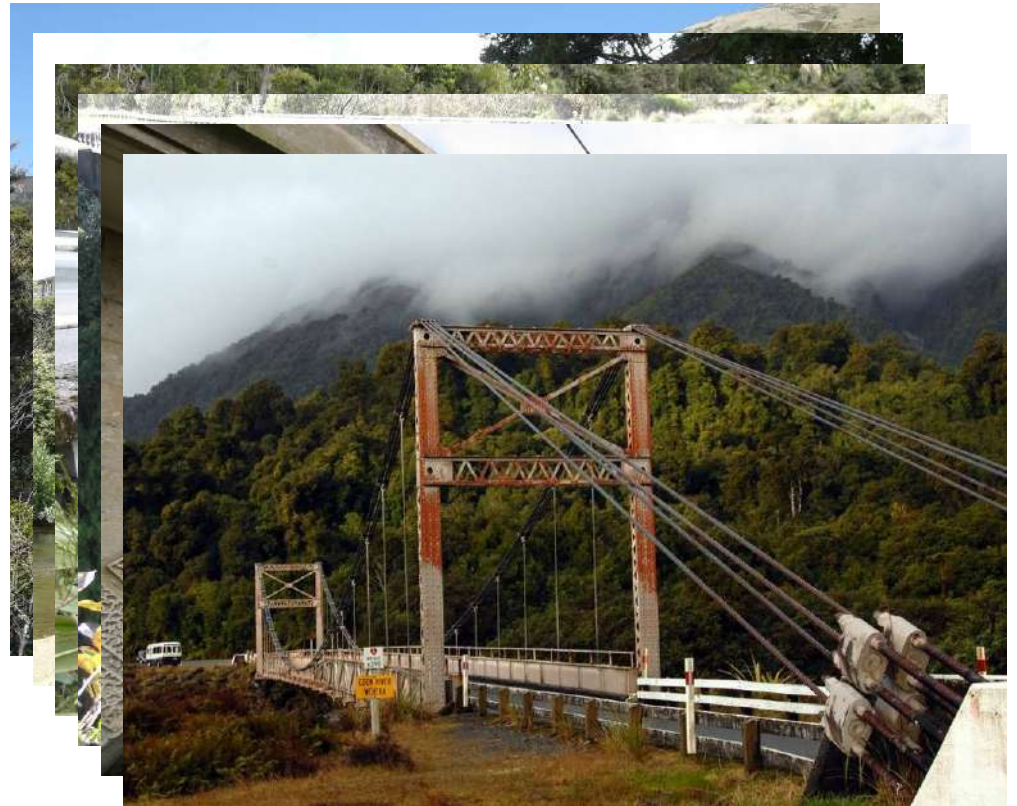
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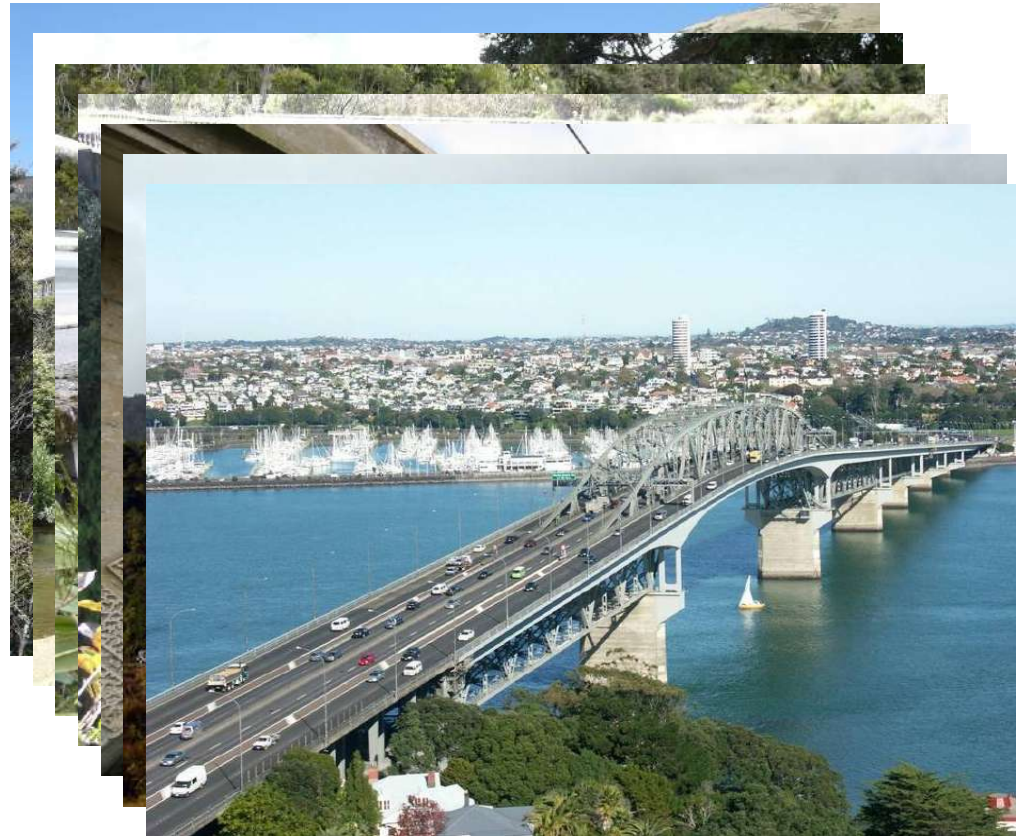
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- Mt Victoria
- Terrace
- Lyttelton
- Homer
- Johnstone's Hill





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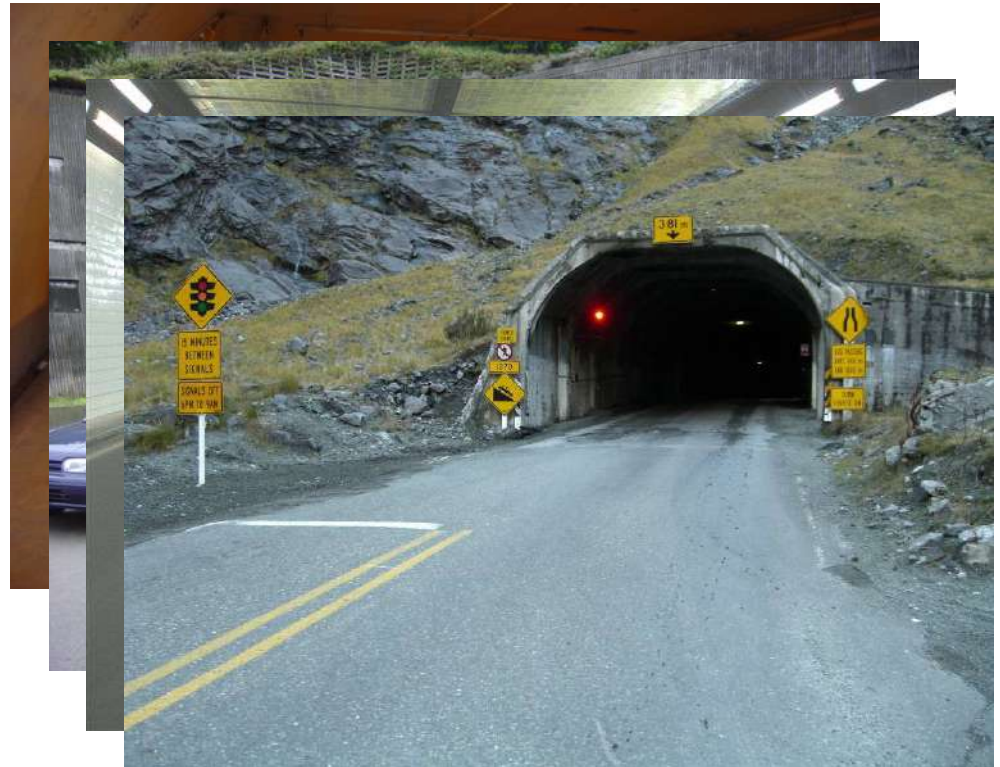
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# SH Other Structures

- Retaining walls
- Sea walls
- Gantries & large signs
- Culverts



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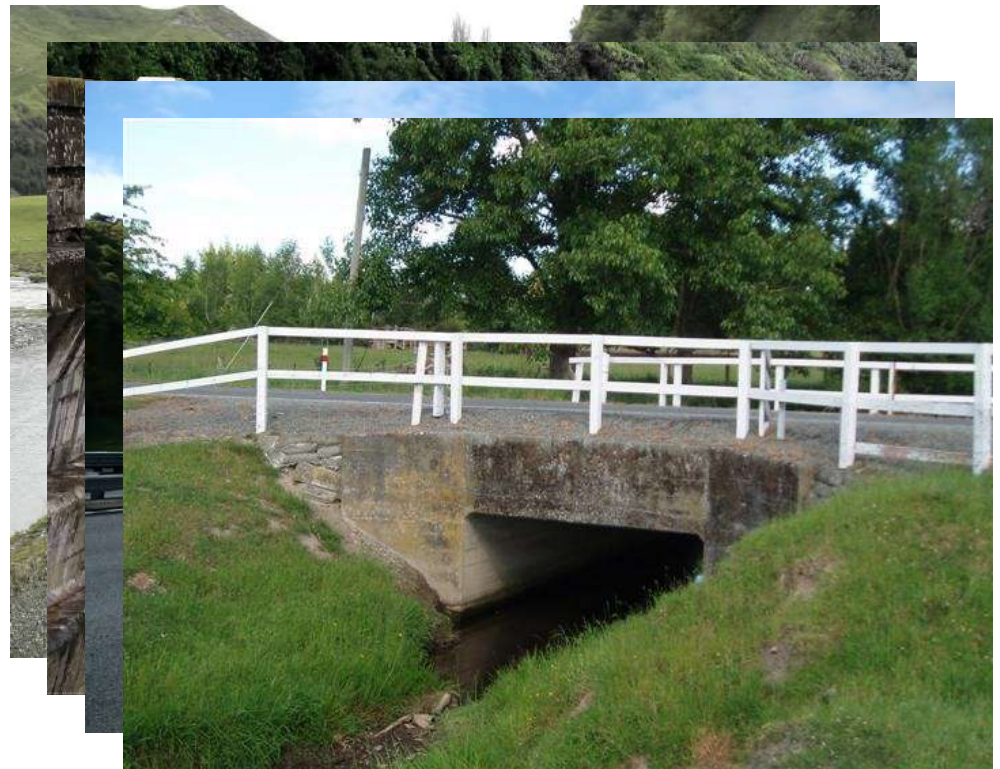
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# Non SH Structures Assets

- Footbridges
- Overbridges
- Redundant bridges
- Historic bridges
- Stock underpasses
- Shared bridges
- Bailey bridges





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# New Bridge Assets

- Otira Viaduct
- Upper Harbour
- Meeanee Road
- Waiwera Viaduct
- Dowse Interchange



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# Funding

## *Government Policy Statement*

- Issued by the Minister of Transport every 3 years
- Sets out short to medium term objectives
- Can be amended by the Minister at anytime
- NZTA **must** 'give effect to it'
- New government amended GPS (May 2009)
  - Targets replaced with **impacts**
  - Strong focus on **economic growth and productivity**

### Investment Strategy



# GPS – Impacts

- Economic growth and productivity impacts
- Improvements in the provision of infrastructure and services that enhance transport efficiency and lower the cost of transportation through:
  - improvements in journey time reliability
  - easing of severe congestion
  - more efficient freight supply chains
  - better use of existing transport capacity.
- Better access to markets.
- ***A secure and resilient transport network.***

# Effectiveness – strategic fit

Low	Medium	High
<b>Minimum</b> <ul style="list-style-type: none"><li>• Meets LTMA objectives</li><li>• Affordable</li><li>• Considers appropriate alternatives and options</li><li>• Considers adverse effects or impacts</li><li>• Appropriate scale</li></ul>	<b>Low criteria PLUS</b> <ul style="list-style-type: none"><li>• Part of a strategy, package or plan</li><li>• Enduring benefits</li><li>• Considers land use strategies and implementation plans</li><li>• Significantly effective in achieving 'strategic fit' assessment potential</li></ul>	<b>Low + Med PLUS</b> <ul style="list-style-type: none"><li>• Integrated between transport modes</li><li>• Integrated with land use and other infrastructure</li><li>• Supports networks from national perspective</li><li>• Is an optimised transport solution</li></ul>

# Economic efficiency

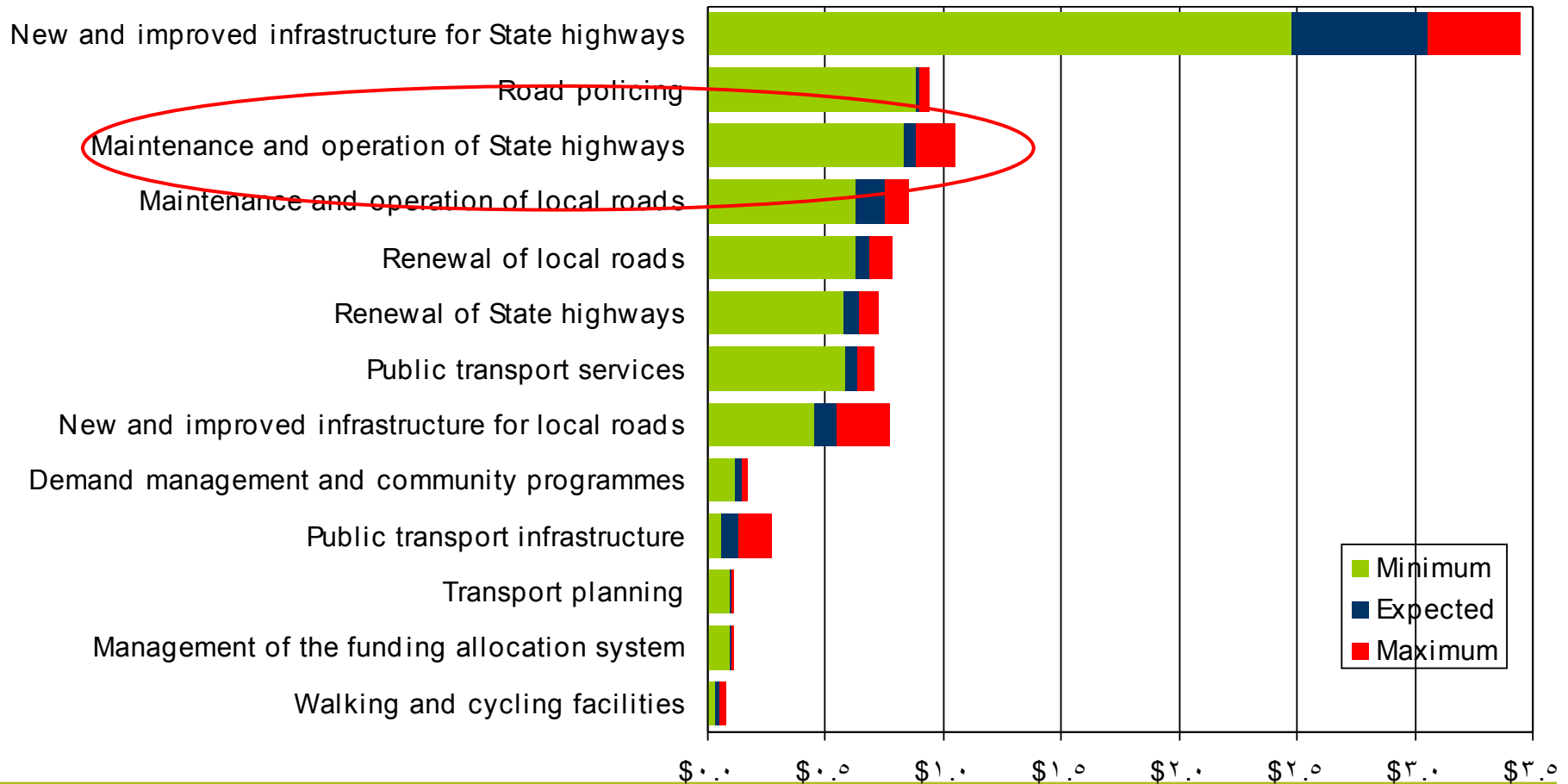
- For improvements the primary measure of economic efficiency is benefit cost ratio

Low	Medium	High
$\text{BCR} \geq 1 \text{ and } < 2$	$\text{BCR} \geq 2 \text{ and } < 4$	$\text{BCR} > 4$

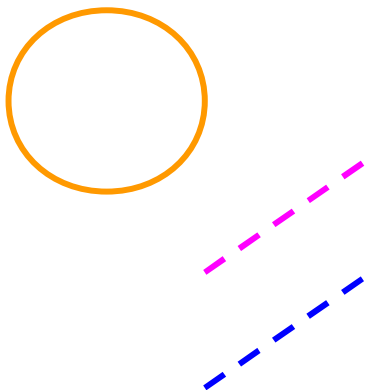
- $\text{BCR} < 1$  only considered in exceptional circumstances and at discretion of Board



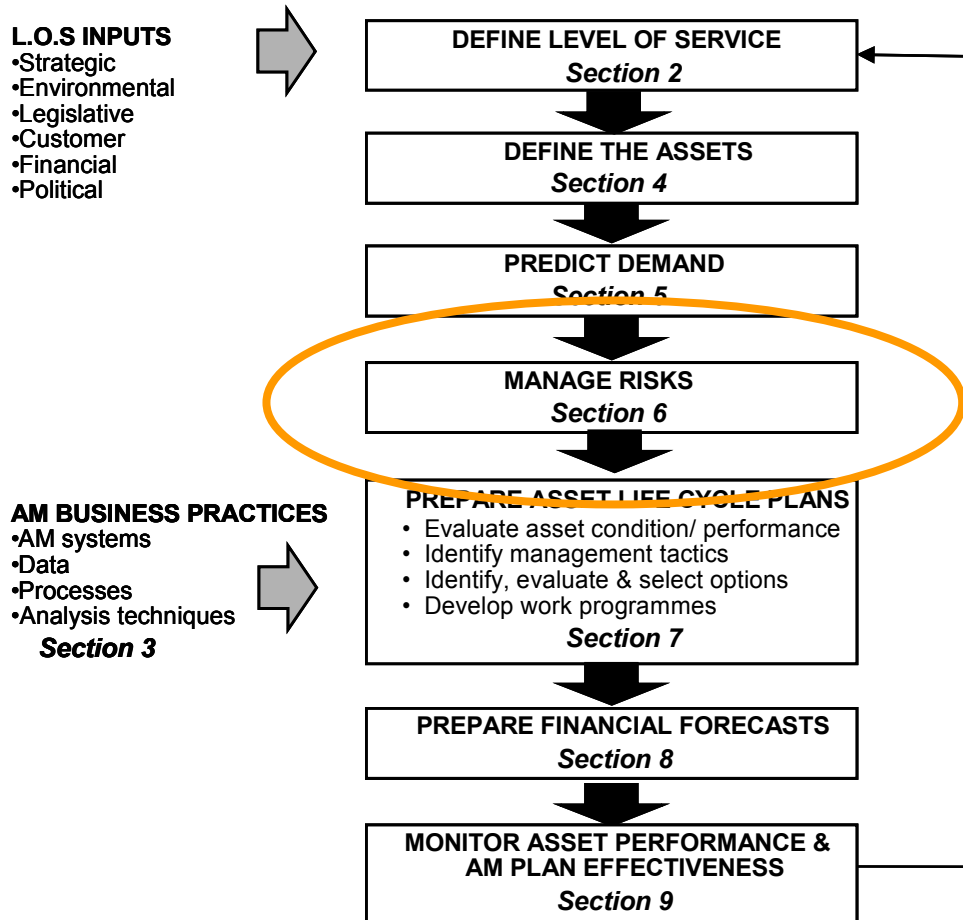
# 2009/10 to 2011/12 expenditure ranges



# Funding forecast -maintenance



# Asset Management Framework





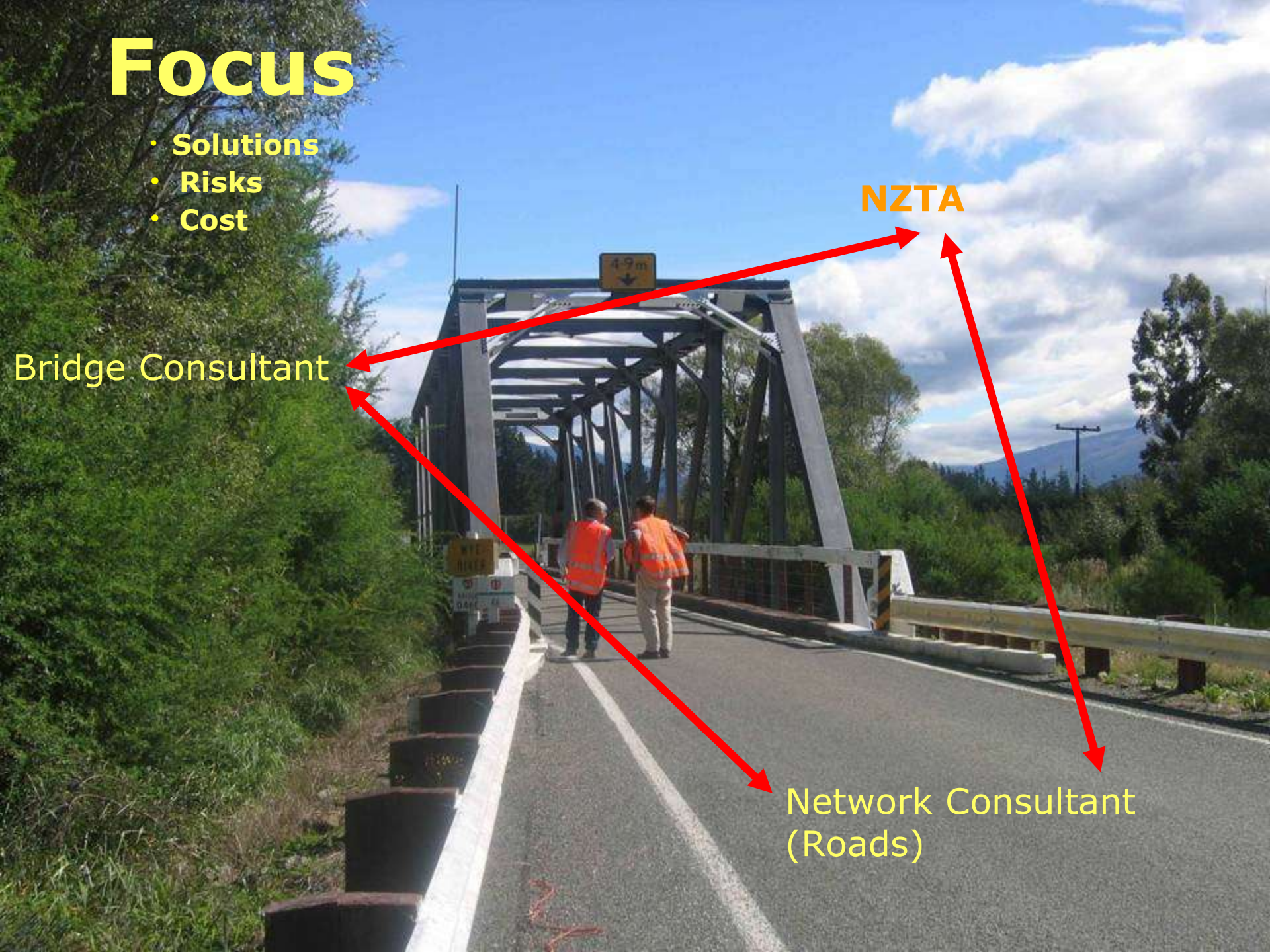
# Focus

- Solutions
- Risks
- Cost

NZTA

Bridge Consultant

Network Consultant  
(Roads)



# Regional Bridge Consultants

## Region 1 – Northland

- Opus Whangarei

## Regions 3&4 – Waikato & Bay of Plenty

- BBO Hamilton

## Regions 7&8 – Taranaki & Manawatu-Wanganui

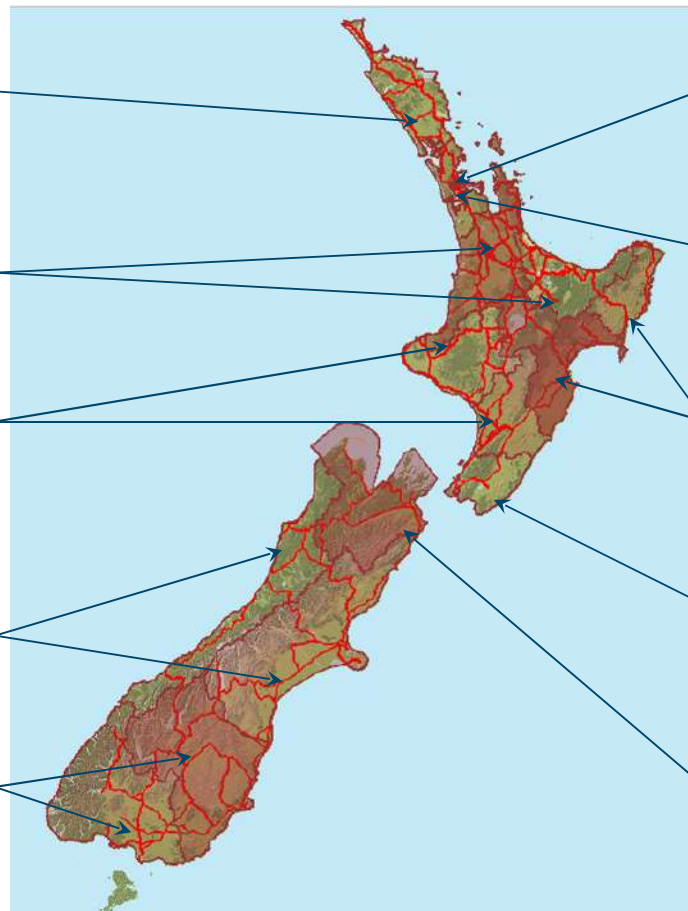
- BBO Hamilton

## Regions 11&12 – Canterbury & W Coast

- Opus Christchurch

## Regions 13&14 – Otago & Southland

- Opus Dunedin



## PSMC003 – Auckland Harbour Bridge

- Total Bridge Services

## Region 2 – Auckland

- Auckland MA

## Regions 5&6 – Gisborne & Hawkes Bay

- Opus Napier

## Region 9 – Wellington

- Opus Wellington

## Region 10 – Nelson-Marlborough


- Opus Blenheim

# Inspection Regime

Inspections undertaken in accordance with NZTA S6  
*Bridges & Other Structures Inspection Policy:*

Inspection type	Frequency	Undertaken by
Superficial	Monthly	Network Consultant
General	2 years	Bridge Consultant
Detailed	6 years	Bridge Consultant
Special	When required	Bridge Consultant





RAMP

New Zealand Government

# Bridge Maintenance Works

## Routine works

- Clear vegetation
- Clean joints
- Clean drainage
- Scour repairs
- Guardrail repairs



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## Structural works

- Painting
- Strengthening
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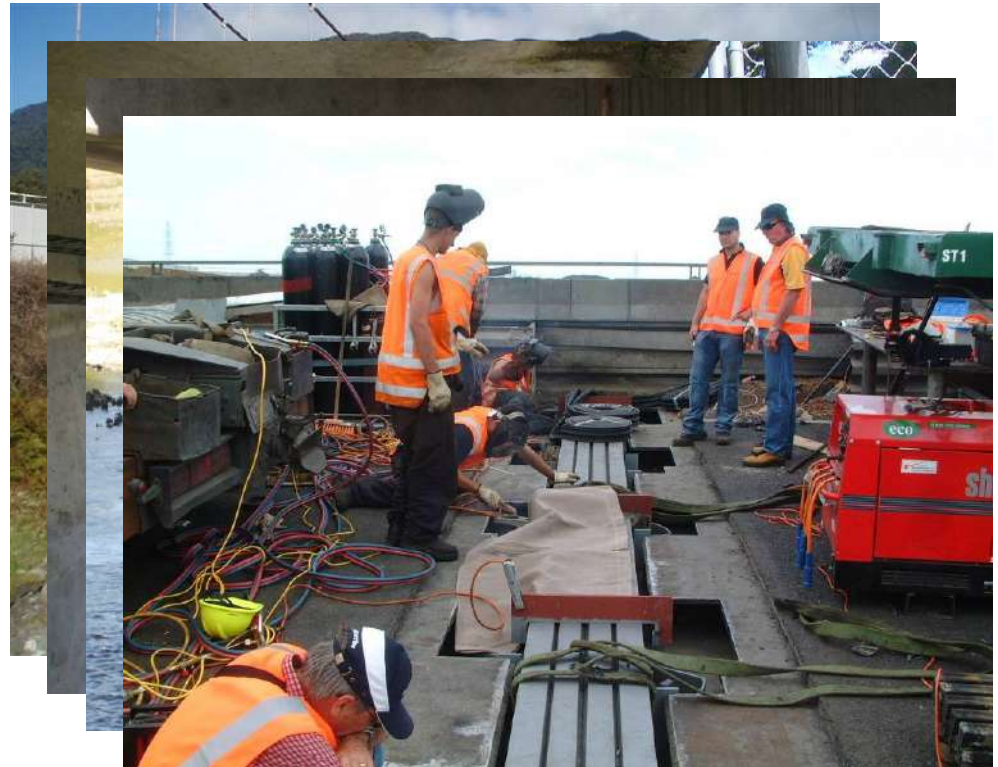
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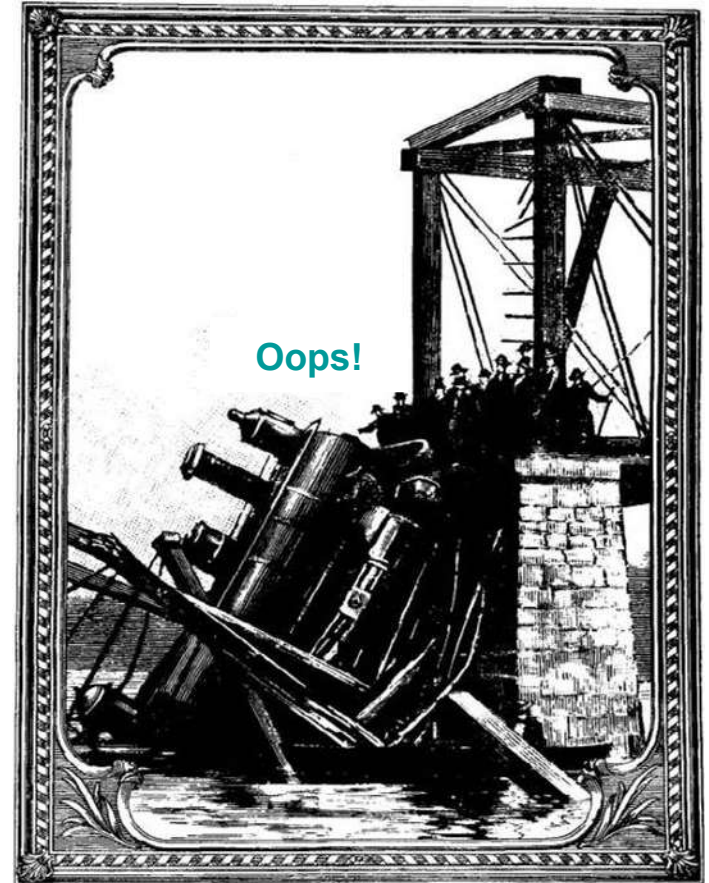
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# Risk Management



# **Risk Management**

**Identification**

**Assessment**

**Decision Criteria**

**Reduction & Control**

**Monitoring and Review**

**Transfer**



# Risk Management

## Emergency Management and Response Planning

Civil Defence & EM Act requires NZTA to;

- Identify and understand hazards and risks
- Prepare plans to manage hazards and risks

NZTA has developed;

- Contingency Plans
- Disaster Recovery Plans
- Emergency Procedure Manuals
- ***Bailey Bridges***



# Risks faced by structures

- Condition
- Loading
- Environmental
- Construction (Quality)
- Design Standards

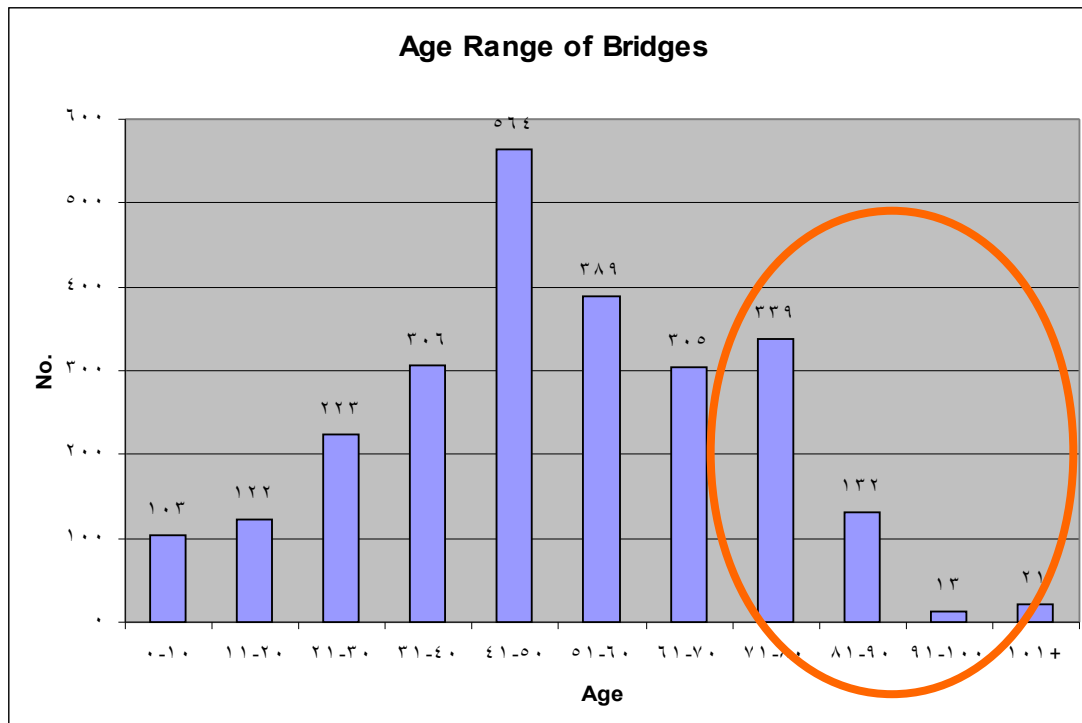
*Whole-of-Life*





# Condition Risks

The average age of SH bridges is 50 years



Historical overview

# Asset Condition

Condition is relatively good:

- Average age of 50 years
- Climate is moderate: no de-icing salts used
- History of effective inspection and maintenance programmes



# Condition



*80 years*

*less than 30 years*





# SH6 Kawarau River Bridge

- Built 1963
- Fatigue cracks found 2008





# SH6 Kawarau River Bridge



Transom  
cracks



# Atiamuri SH1 - fatigue





# Box Girder Extensions

Completed 1969



# 1970 to date....

Early 70's box girders first strengthened

1985 - HCV's banned for 4 years -strengthened

1987 - live load upgrade

1990's - ongoing fatigue repairs

1995 – Poly-urathane road surfacing started

2000 - seismic upgrade completed

2002 onwards - traffic/structural assessments

2007 – strengthening/upgrade (live load)



# Loading Risks

The loads that bridges need to carry have changed beyond recognition



- Traction Engine 1912



- Volvo 2009

# Overweight Permitting

Overloads

**OPERMIT**

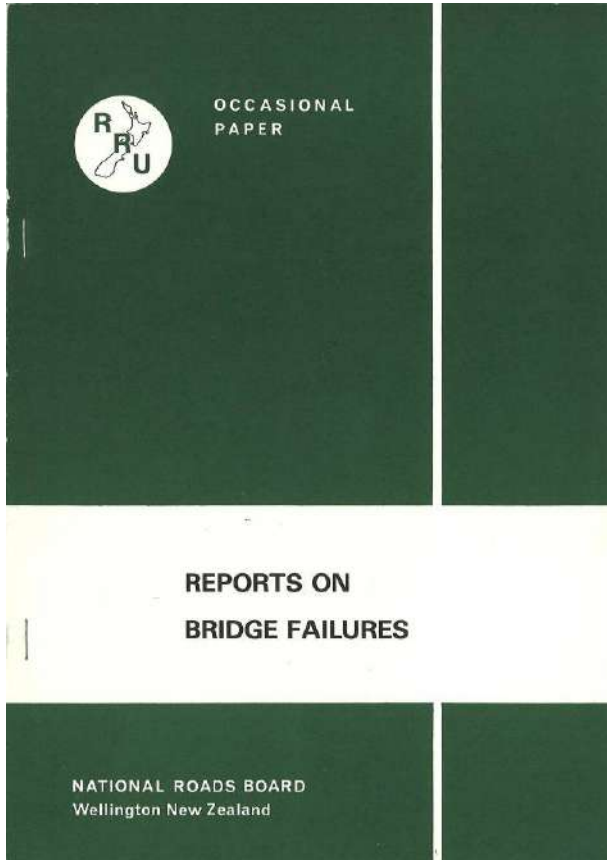


# Environmental risks





# Environmental Risks – Scour



A survey of 108 bridge failures between 1961 and 1984

CAUSE OF FAILURE	NUMBER	PERCENTAGE
Approach/Abutment Scour	29	26.8
Pier Scour	34	31.5
General Scour	5	4.6
Aggradation	2	1.9
Insufficient Waterway	10	9.3
Earthquake	6	5.6
Structural Failure	14	13.0
Falsework Failure	3	2.8
Settlement	2	1.9
Landslide	3	2.8

} 74%  
1968 Inangahua





# Environmental risks





# SH82 Waitaki River Bridge No.1

- Built 1881
- History of scour problems



# SH54 Jamiesons Bridge

- Built 1932
- Pier dropped in 2004 flood





## SITE INSPECTION OBSERVATIONS




N = No, U = Unknown, Y = Yes

LOCAL SCOUR AT PIERS / ABUTMENTS				Hazard Rating 1 - 5 (1 = low 5 = high)
Evidence of woody debris accumulation on piers (identify location of debris accumulation)	N	U	Y	
Evidence of pier scour (identify location of scour)	N	U	Y	
Evidence of pier foundation tilt / movement (identify location of tilt / movement)	N	U	Y	
Piers skewed at angle to direction of river flow (estimate angle of skew)	N	U	Y	
One or more piers sited in deepest part of channel	N	U	Y	
One or more piers sited close to confluence of two braid channels	N	U	Y	
Evidence of woody debris accumulation on abutment (identify location of debris accumulation)	N	U	Y	
Evidence of abutment scour (identify location and nature of scour)	N	U	Y	
Abutments skewed to direction of river flow (estimate angle of skew)	N	U	Y	

HAZARD SUMMARY		
Hazard Category	Hazard Rating	Key Hazard Factor
Catchment / channel characteristics		
Bridge location / waterway adequacy		
Channel cross-section shape / bed degradation & aggradation		
Bank stability / approach embankment integrity		
Local scour at piers / abutments		
Summation of hazard ratings		
Hazard rating summation as percentage (summation of risk ratings x 100 / 25)		
Maximum hazard rating		

GENERAL COMMENTS / RECOMMENDATIONS FOR MONITORING / MAINTENANCE ETC.

**Table A1** Summary of guidelines for definition of hazard ratings

Hazard rating	Catchment / Channel Characteristics	Bridge location / Waterway adequacy	Channel Cross-section shape / Bed Degradation and Aggradation	Bank Stability / Approach Embankment Integrity	Local Scour at Piers / Abutments
5	Widespread deforestation of catchment.  Widespread catchment erosion.  Dam located upstream cutting off sediment supply.		bed.  abutment foundations.  symmetric side ment.  bed.	Extreme bank erosion upstream impinging on bridge abutment or piers.  Extreme abutment / approach embankment erosion.	Extensive debris raft on piers / abutments.  Evidence of extreme scour at piers / abutments.  Evidence of pier tilt / movement.  One or more piers sited close to confluence of two braid channels.  Piers / abutment skewed at more than 45 degrees to direction of river flow.
4				Severe bank erosion upstream impinging on bridge abutment or piers.  Severe abutment / approach embankment erosion.	Piers / abutments skewed at more than 30 degrees to direction of flow.  Severe debris raft formation on piers / abutments.  Severe scour at piers / abutments.
3	Partial deforestation of catchment.  Moderate landslide activity in catchment.  Channel bed infested with large willow trees or other vegetation.  Severe stream river / stream	Bridge sited on moderate bend.  Bridge sited on moderately meandering channel.  Bridge sited at moderate channel constriction.	Moderate degradation of bed.  Moderately exposed piles / abutment foundations.  Channel shape slightly asymmetric slightly deeper to one side.  Moderate aggradation of bed.	Moderate bank erosion.  Moderate abutment / approach embankment	Piers skewed at more than 15 degrees to direction of flow.
2	Catchment  Occasional  Natural  Moderate river / stream  Channel			 banks well protected.	to
1	Catchment  Channel  Extensive structure.  Low gradient river / stream.  Tidal or lake influence on water levels.		active channel degradation intermeasures downstream.  active channel aggradation intermeasures upstream.		No scour evident at piers / abutments.







**CAUTION**

**THIS SIGN HAS  
SHARP EDGES**

**DO NOT TOUCH THE EDGES OF THIS SIGN**



**ALSO, THE BRIDGE IS OUT AHEAD**



# Environmental Risks – Seismic

- Screening from 1996
- Response to significant events in US and Japan





# Bridge Seismic Screening

Programme	Total	P1	P2	P3
Detail Assessments	335	192	72	71
Linkages	173	92	45	36

## ➤ **Linkage Retrofit**

### ➤ **Completed**

## ➤ **Detailed Assessments**

### ➤ **Re-prioritise 50 completed assessments**

## ➤ **Detail Design & Construction**

### ➤ **Target 3 to 5 bridges/annum**

### ➤ **Funding \$5 to \$10million pa**





# Seismic Retrofits

- SH6 Kawarau River – retrofit
- SH26 Waihou River - linkages



# Design Standards / LoS Risks

Risks associated with Standards and Levels of Service:

- Construction & Design
- Narrow bridges
- Low headroom (bridge strikes)
- Guardrails

# Construction & Design

***Newmarket Viaduct 1965***

***Continuous prestressed concrete box -girder***

***Replacement started 2009***



NZ TRANSPORT AGENCY  
WAKA KOTAHİ

New Zealand Government



# Levels of Service

Level of Service	Current LOS	Desired LOS
Load Capacity	Class I	HN-HO-72
Height Clearance	4.55m	6.0m
Bridge Width		
Motorway	8.0m	10.0m
Urban	8.0m	10.0m
>10,000 vpd	8.0m	10.0m
4,000 – 10,000 vpd	8.0m	10.0m
1,000 – 4,000 vpd	6.8m	10.0m
<1,000 vpd (2 lane)	6.0m	8.5m
<1,000 vpd (1 lane)	3.0m	4.7m
Bridge Barriers	varies	varies



# Narrow Bridges

- 324 bridges defined as narrow
- 61 of these are single lane
- 124 non-deficient single lane bridges (AADT < 1000)



# Narrow Bridges

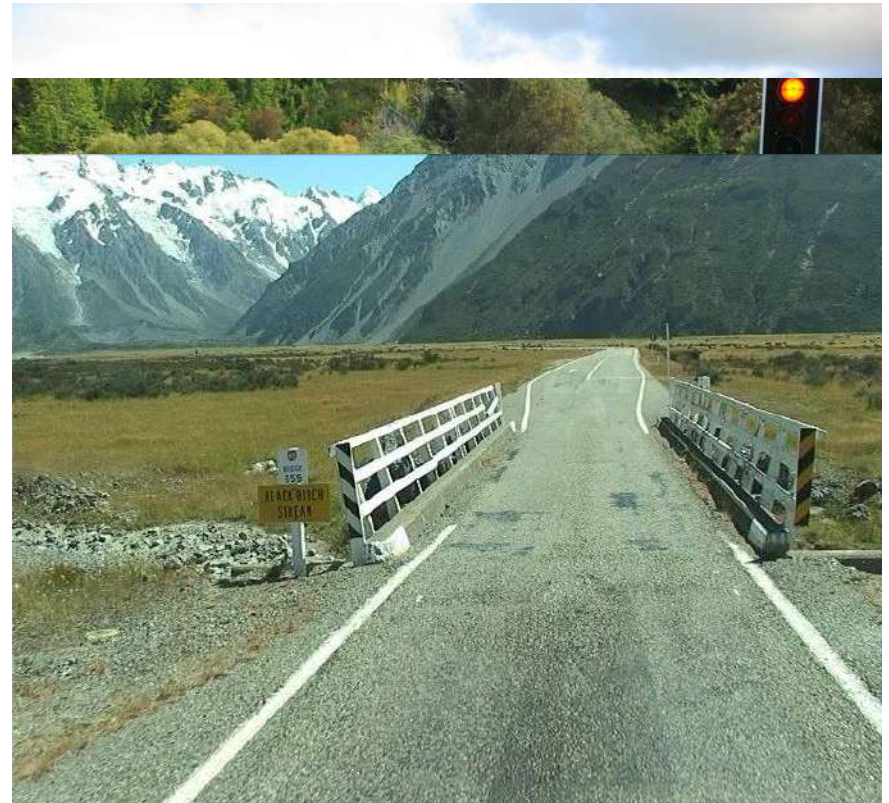
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- Bridge strikes are a significant issue in Auckland
- Not just in Auckland



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# Guardrails

- Tombstone guardrails
- Post and rail
- Retrofit Guidelines



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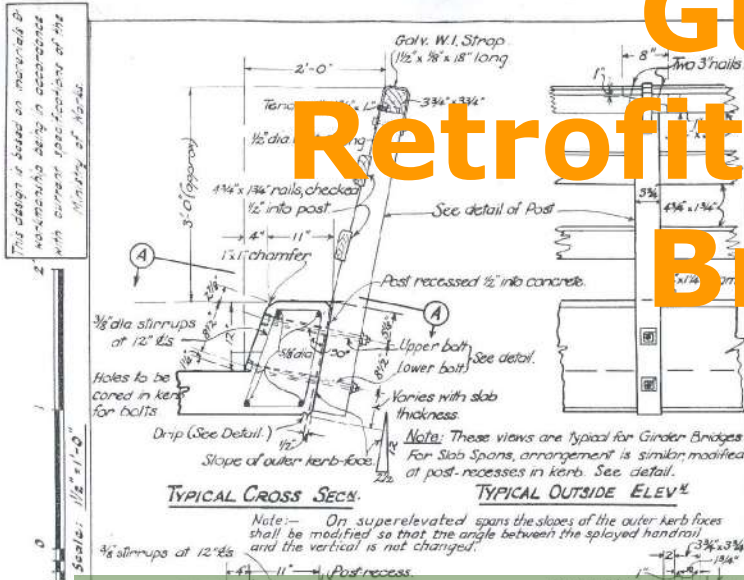


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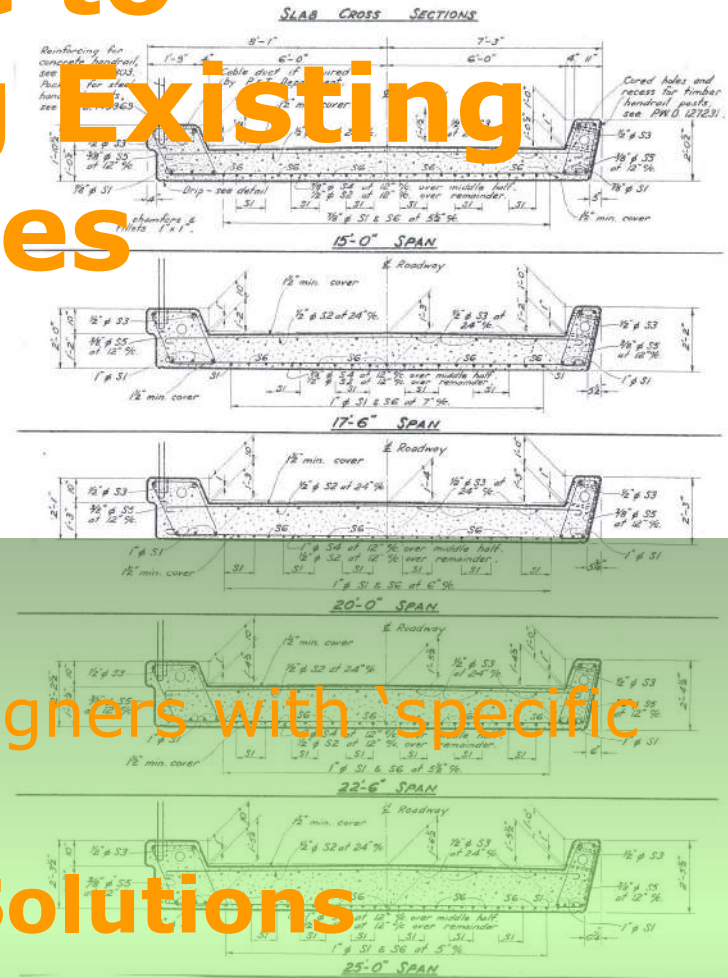
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# Guide to Retrofitting Existing Bridges



REDUCED PLANS  
SCALES REDUCED ACCORDINGLY



## Part 1: Design

NZTA wish to provide designers with 'specific design guidance notes'

## Part 2: Acceptable Solutions

NZTA wish to provide 'standard solutions' for typical deck configurations

# Bridge Replacement Programme

Bridges on programme for

- Levels of Service
- Condition - all risks
- Road alignment



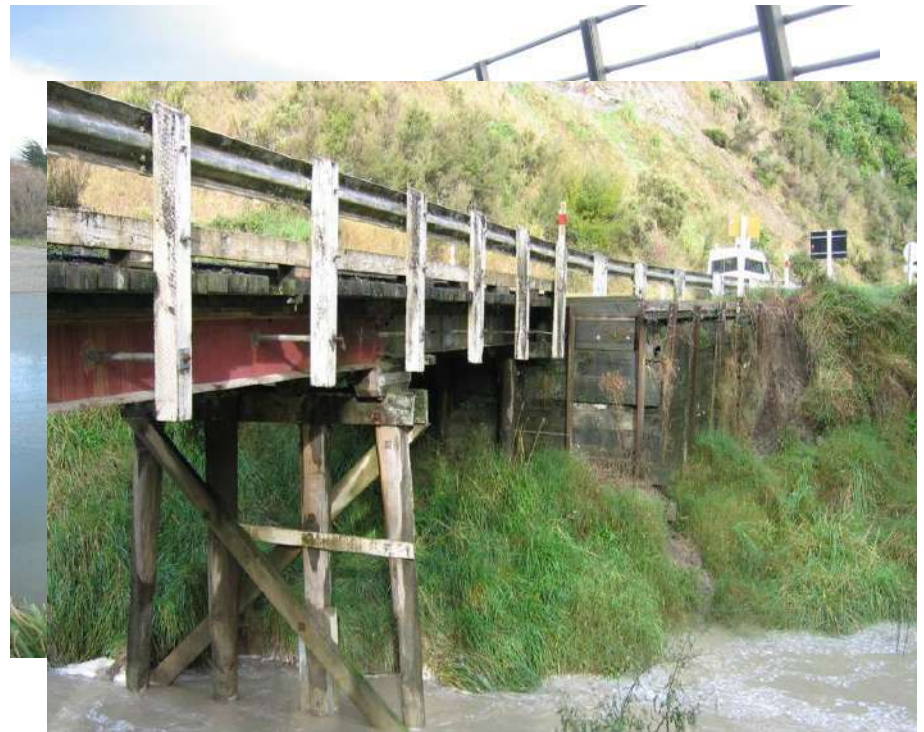
Tell compelling Risk Story



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Tell compelling Risk Story





# Tunnel Management






# Tunnels

Biggest risk associated  
with SH tunnels:

**Funding secured \$60million**




# Bridge Data System



Search

User Guide

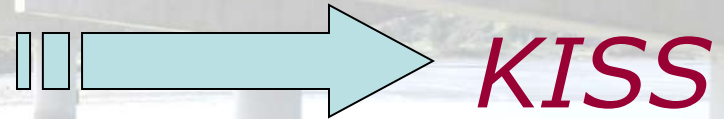
Forms



Welcome to the NZ Transport Agency  
Bridge Data System

# Bridge Information System

- Bridge Inventory
- Inspection & Forward Work Category Lists
- Maintenance Records – History & Costs
- Construction Details
- **Condition Rating**
- Overweight Vehicle Management
- Access to As-Builts and GPS system





# Future Demand

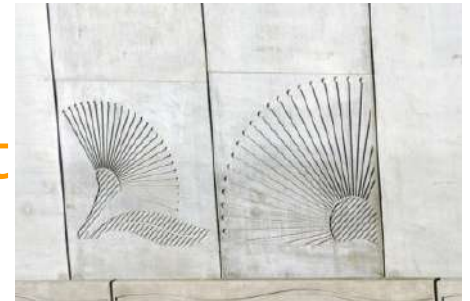
## Key factors

- Average traffic growth of 4% per annum
- Very high growth in Auckland
- Pressure to increase vehicle weight and dimension limits
- Quality systems



# Future challenges

- **People** – passionate about bridges!
- Funding - GPS
- Climate Change - Sustainability – Durability
- Retrofitting & replacing existing structures
- Heavier loads – 50t plus
- Sensitivity to communities
- Increased Research & Development







# **Bridge Management Vision:**

## **"NZTA Centre of Excellence - Bridges"**

- ***Best Practice Systems – BIS***
- ***Effective Maintenance of Existing Assets***
- ***Effective input in Capital Works – 100+ years life***
- ***Overweight Vehicle Management***
- ***Resource in-house skills***



# Conclusions



*1000's years design life .....*



# Discussion

