Transport Accident Investigation Commission

Final report
Tuhinga whakamutunga

Rail inquiry RO-2024-103
Bridge 57 Main South Line, Pier 8 collapse
Rangitata
12 April 2024

June 2026

The Transport Accident Investigation Commission
Te Kōmihana Tirotiro Aituā Waka

No repeat accidents – ever!

"The principal purpose of the Commission shall be to determine the circumstances and causes of accidents and incidents with a view to avoiding similar occurrences in the future, rather than to ascribe blame to any person."

Transport Accident Investigation Commission Act 1990, s4 Purpose

The Transport Accident Investigation Commission is an independent Crown entity and standing commission of inquiry. We investigate selected maritime, aviation and rail accidents and incidents that occur in New Zealand or involve New Zealand-registered aircraft or vessels.

Our investigations are for the purpose of avoiding similar accidents and incidents in the future. We determine and analyse contributing factors, explain circumstances and causes, identify safety issues, and make recommendations to improve safety. Our findings cannot be used to pursue criminal, civil, or regulatory action.

At the end of every inquiry, we share all relevant knowledge in a final report. We use our information and insight to influence others in the transport sector to improve safety, nationally and internationally.

Commissioners

Chief Commissioner	David Clarke
Deputy Chief Commissioner	Stephen Davies Howard
Commissioner	Paula Rose, QSO
Commissioner	Bernadette Roka Arapere (until 6 November 2025)

Key Commission personnel

Chief Executive	Martin Sawyers
Chief Investigator of Accidents	Louise Cook
Lead Investigator for this inquiry	Michael McKay
Commission General Counsel	Sid Wellik

Notes about Commission reports
Kōrero tāpiri ki ngā pūrongo o te Kōmihana

Photographs, diagrams, pictures

The Commission owns the photographs, diagrams and pictures in this report unless otherwise specified.

Verbal probability expressions

For clarity, the Commission uses standardised terminology where possible.

One example of this standardisation is the terminology used to describe the degree of probability (or likelihood) that an event happened, or a condition existed in support of a hypothesis. The Commission has adopted this terminology from the Intergovernmental Panel on Climate Change and Australian Transport Safety Bureau models. The Commission chose these models because of their simplicity, usability, and international use. The Commission considers these models reflect its functions. These functions include making findings and issuing recommendations based on a wide range of evidence, whether or not that evidence would be admissible in a court of law.

Terminology	Likelihood	Equivalent terms
Virtually certain	> 99% probability of occurrence	Almost certain
Very likely	> 90% probability	Highly likely, very probable
Likely	> 66% probability	Probable
About as likely as not	33% to 66% probability	More or less likely
Unlikely	< 33% probability	Improbable
Very unlikely	< 10% probability	Highly unlikely
Exceptionally unlikely	< 1% probability	

Figure 1: Bridge 57 Main South Line (July 2020)
(Credit: KiwiRail)

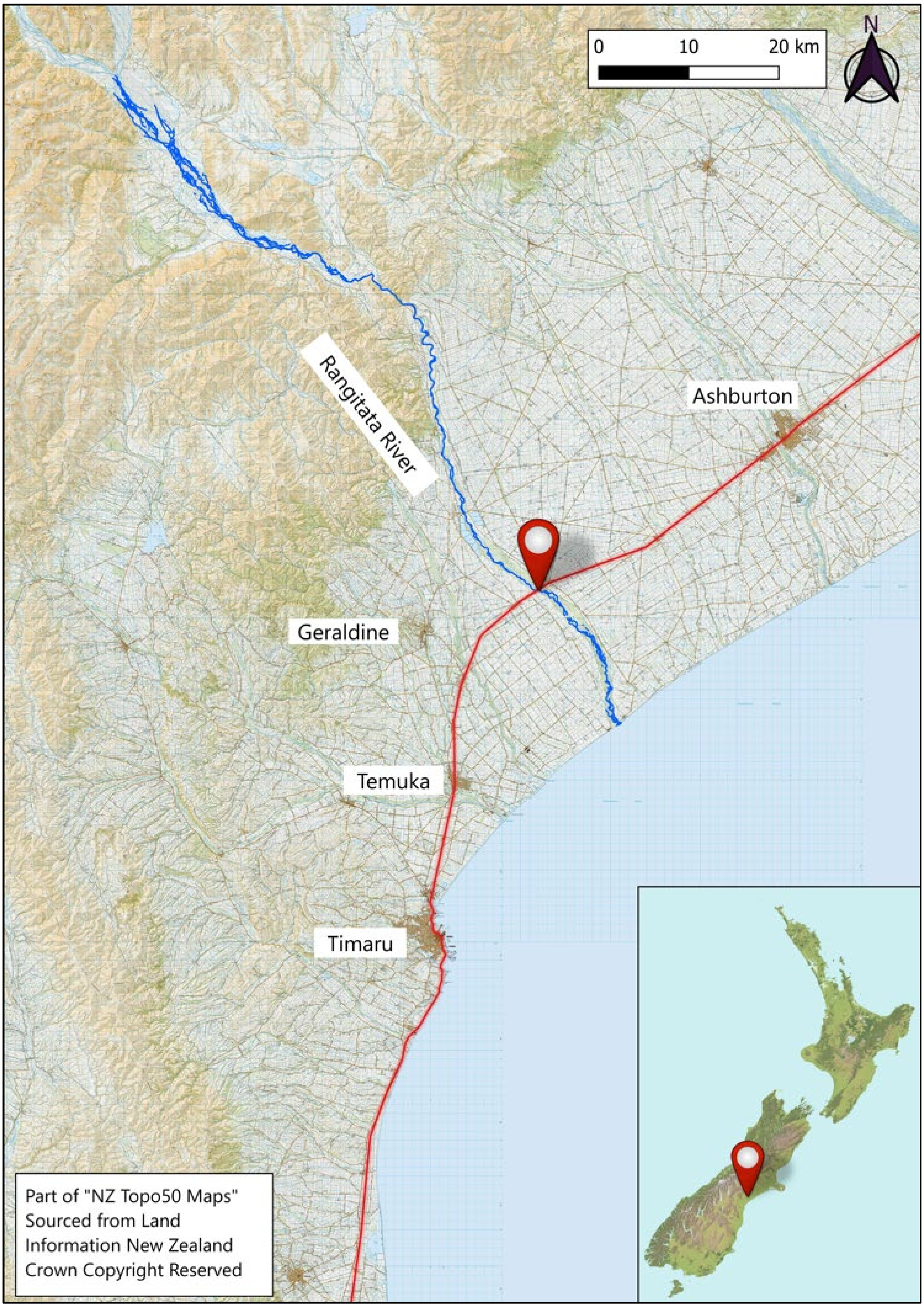

Figure 2: Location of incident

(Credit: Land Information New Zealand Toitū Te Whenua)

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1 Executive summary
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What happened

1.1 On 10, 11 and 12 April 2024, heavy rainfall on the foothills of the Southern Alps, South Island, resulted in elevated river flows within the Rangitata River. The river flow peaked at the Rangitata rail bridge at about 0800 on 12 April 2024.

1.2 At approximately 1030 on 12 April 2024, Pier 8 of Bridge 57 on the Main South Line collapsed into the water. No rail vehicles were on the bridge at the time. There were no fatalities or injuries, but the pier collapse caused significant structural damage to the bridge.

1.3 The line remained open for scheduled rail traffic after the collapse occurred, putting those services at risk of derailment and harm.

1.4 A member of the public reported the damage to KiwiRail at 1128 on 12 April 2024, who subsequently closed the line.

Why it happened

1.5 The braided river characteristics of the Rangitata River, combined with elevated water flow, caused significant scour around the piles supporting Pier 8 of Bridge 57. The scour removed critical riverbed material that had provided foundational support.

1.6 The concrete piles beneath Pier 8 were no longer able to sustain the vertical load of the bridge structure. This led to the pier sinking vertically and rotating approximately 45° (degrees), eventually collapsing toward the eastern flow of the river.

1.7 KiwiRail had been monitoring the severe weather that created this high-river-flow event. The bridge was inspected by track personnel at 0853 on 12 April 2024 and deemed to be safe for operation. The line was open when this collapse occurred.

1.8 KiwiRail was aware of the scour risk at Bridge 57 but was not proactively monitoring or managing the risk. There was no requirement within their quality management system to impose operational restrictions for bridges during severe weather events to manage the risk to operations.

What we can learn

1.9 As the frequency of severe weather events increases, precise asset-specific risk management is critical to ensure the rail network can operate safely. It is fundamental that all hazards are identified, and appropriate controls are in place to limit their impact and for the safety of all who are operating vehicles on the network.

1.10 Quality-management systems are reliant on audit systems to check they are being implemented as designed.

1.11 Asset-management systems for infrastructure within a rail network are complex and require a high level of technical input to maintain their integrity. It is critical that all risks to the infrastructure are included in the asset-management system so the impact of the risk on operations can be mitigated.

Who may benefit

1.12 Rail personnel, transport operators, infrastructure maintainers and anyone involved in planning and responding to the impacts of weather events on transport networks may benefit from the findings.

2 Factual information
Pārongo pono

Background

2.1 The Rangitata River (the river) is one of the braided rivers of the Canterbury Plains. It flows southeast for approximately 120 km from the Southern Alps to the Pacific Ocean.

2.2 A distinctive feature of the river is its braided channel morphology. Braided rivers are characterised by having multiple interweaving channels separated by temporary sediment islands.

2.3 Braided rivers are more unstable[1] than single-channel rivers, making it more difficult to design structures in and around them. This is because of their higher rates of sediment transport, deposition and erosion.

2.4 A large proportion of the Rangitata catchment area lies on the eastern sections of the Southern Alps, approximately 90 km from the location of Rail Bridge 57 MSL (Bridge 57).

2.5 Bridge 57 is located across the river from 127.204 km to 127.814 km on the Main South Line (MSL).

Narrative

2.6 On 10, 11 and 12 April 2024, the tributary areas[2] of the river were experiencing heavy rainfall.[3]

2.7 From 7 April 2024 to 11 April 2024, KiwiRail Holdings Limited (KiwiRail) received regular notifications from both Meteorological Solutions Limited[4] (MetSolutions) and MetService alerting them to weather conditions that were forecast to create high flow within the river.

2.8 The weather update that was issued by MetSolutions at 0916[5] on 11 April 2024 stated that a flood surge in the river was expected to reach the Rangitata rail bridge on the morning of 12 April 2024. This surge could be a flow with a return period[6] of two years.

2.9 Conference calls involving members of the Infrastructure and Train Control groups were held by KiwiRail on 9, 10 and 11 April 2024 to discuss the implications of the

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[1] The river channel is not consistently in the same location.

[2] The land area that drains water into a river and its tributaries. It's also known as a drainage basin or catchment area.

[3] Greater than 100 mm of rainfall over a 24-hour period, or a period of rainfall of 10–50 mm/hr, as classified by Earth Sciences New Zealand.

[4] MetSolutions is contracted to KiwiRail to provide general weather updates and alerts when severe weather is predicted.

[5] Times used in this report are New Zealand Standard Time (Universal Time Coordinated + 12 hours) and are expressed in 24-hour mode.

[6] The return period is the average time between occurrences of an event of a given magnitude or greater. It is commonly used in hydrology and engineering to describe the likelihood of events occurring. A return period of two years would indicate that statistically a flow event should occur once every two years.

weather event for the network and the required actions to mitigate the risk that the weather event posed.

2.10 During the conference call on 11 April 2024, it was noted that flow within the river was due to peak at midnight on 12 April 2024. The advisory status for the event was set as amber. KiwiRail's system for classifying advisory status levels during severe weather events is explained from paragraph 2.28 below.

2.11 Because of the heavy rainfall, a flow event with a return period of 0.89 years in the river occurred from 11 April 2024 through to 12 April 2024. The flow peaked between 0200 and 0220 on 12 April 2024 at 1100 cubic metres per second (m^3/s)[7] (*see* Figure 3).

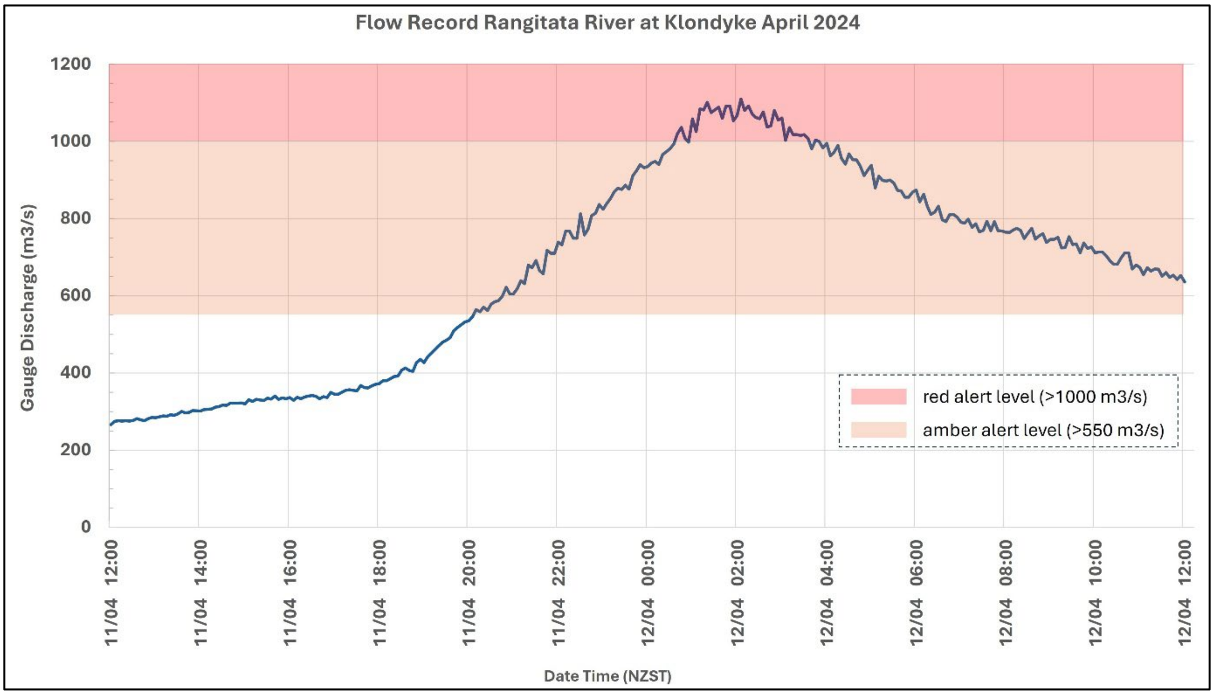


Figure 3: Flow record for the Rangitata River, extracted from Environment Canterbury's river-flow data system in the days following the event

2.12 The flow gauge for the river is located at Klondyke, approximately six hours[8] upstream from Bridge 57 (*see* Figure 4). This meant that the peak flow rate that occurred between 0200 and 0220 would be experienced at Bridge 57 at approximately 0800.

[7] Cubic metres per second (m^3/s) is the unit typically used to measure the flow of a river. The flow is used for alert functions as it is representative of a river's height and speed.

[8] The duration for the peak flow at Klondyke to reach Bridge 57 depends on the flow rate of the river. Six hours is based on a flow rate of 1000 m^3/s.

Figure 4: Location of Rangitata river-flow gauge

2.13 At about 0610 on 12 April 2024, northbound KiwiRail freight Train 926 crossed Bridge 57. The locomotive engineer (LE) made no contact with train control[9] to report concerns with the bridge.

2.14 At about 0830, KiwiRail's Lower South Island Infrastructure Production Manager (Production Manager) requested an inspection of Bridge 57 be carried out by a track ganger[10] because of the high flow in the river.

2.15 KiwiRail was aware that the flow in the river overnight had exceeded the red-alert level according to its severe weather response standards. The train controller[11] received hourly notifications from Environment Canterbury (ECan) from 0000 to 0500, and members of the infrastructure group were aware of and actively checking the flow levels using ECan's publicly available data.

2.16 At about 0830, KiwiRail freight Train 930 traversed Bridge 57. The LE made no contact with train control to report concerns with the bridge.

2.17 At 0853, a track ganger started the requested inspection along Bridge 57. This inspection consisted of a track run across the bridge in a hi-rail vehicle[12] and taking

[9] KiwiRail's national train control centre, responsible for track authorisations and the safe movement of rail traffic throughout New Zealand.

[10] A track ganger's primary role is working on track maintenance, repair and renewal work. Their area of expertise is on the track infrastructure, as opposed to the structural or civil assets of the railway.

[11] A person qualified to authorise rail movements and track access. Train controllers operate in a train control centre.

[12] A vehicle fitted with retractable rail wheels that can travel on both road and rail.

photographs of the river level to provide to the Production Manager. The inspection did not specifically look at the bridge piers or accumulated debris. The track ganger completed the inspection by 0941.

2.18 After the inspection, the track ganger reported to the Production Manager that the line was safe to remain open.

2.19 At 1037, KiwiRail received a further weather update from MetSolutions. This update included information that the river had peaked at the location of the bridge.

2.20 At some point after the inspection was completed at 0941, Pier 8 of Bridge 57 was washed out by the river flow, which caused a partial collapse of the bridge (*see* Figure 5).

Figure 5: Collapsed Bridge 57 (12 April 2024)

2.21 At 1128, a member of the public contacted train control to alert KiwiRail to the partial collapse of the bridge. The track was immediately closed and an emergency inspection was then carried out to confirm the collapse.

2.22 There were no people or rail vehicles on Bridge 57 at the time of the collapse.

2.23 The next scheduled train to cross the bridge was a southbound freight train expected at about 1445.

Organisational information

2.24 KiwiRail is a New Zealand state-owned enterprise. It operates trains and rail vehicles, controls rail movements on the national rail network and maintains the railway infrastructure as the rail access provider.

2.25 KiwiRail manages approximately 1600 bridges across the rail network, including Bridge 57. The KiwiRail Infrastructure Group was responsible for the maintenance and management of these bridges.

2.26 Within the Infrastructure Group, the Lower South Island (LSI) region was responsible for the inspection and maintenance of the bridges within their section of the network.

2.27 The KiwiRail Engineering Department provided technical assistance to each region and was responsible for the technical governance of the bridges. They also audited and reviewed compliance of the work completed by the LSI region.

KiwiRail's severe weather management

2.28 KiwiRail's risk-management approach to planning, preparing and coordinating activities ahead of severe weather is defined by Standard 14-SHE-008-COM Severe Weather Events Management.[13]

2.29 The severe weather event process flow is broken into five stages:

- Stage 1: Notification/Alert
- Stage 2: Preliminary assessment
- Stage 3: Conference call
- Stage 4: Trigger Action Response Plan (TARP) actions
- Stage 5: Monitoring
- Stage 6: De-escalation and close out.

2.30 MetSolutions provided KiwiRail with weather forecasts three times a week. When escalating weather conditions are identified, the updates are provided daily or twice daily, depending on the severity of the events.

2.31 In addition to the weather forecasting system, the KiwiRail train controller received live notifications from ECan alerting it to high river flows within the river.

2.32 Determination of the severity of events is based on the weather risk matrix (*see* Figure 6) and the river flow risk matrix (*see* Figure 7).

Region	Lines	Yellow Significant weather but minimal impact expected on the network	Amber Elevated risks of impacts at high, very high and extreme risk locations on the network	Red Potential for widespread impacts on network
Lower South Island (Lower SI)	MSL	- 24-hour rainfall totals 25+ mm - Wind gusts 80+ km/h - Snow accumulation 5+ cm - Thunderstorm/downpour risk	- Widespread heavy rainfall with event totals 75+ mm (within 48 hours) - Wind gusts 120+ km/h - East coast river level warnings for alpine rain events totals 250+ mm - Waves/swell 4+ m Otago coast area - Snow accumulation on network 10+ cm	- Widespread heavy rain with event totals 200+ mm (within 48 hours) - Wind gusts 140+ km/h - Wave/swell height 5+ m

Figure 6: Weather risk matrix for Lower South Island
(Credit: KiwiRail)

[13] 14-STD-008-COM was first issued on 3 September 2024, which was after Bridge 57's failure. The approach followed in response to the weather event at the time of the collapse of the bridge followed this process as the standard was in draft form at the time.

River	Line/mileage (km)	Mean annual flood (cumecs)	Amber risk level	Red risk level	Additional Notes
Rangitata	MSL 128	1230	550	1,000	Flow takes about 5 hours to reach network

Figure 7: River-flow risk matrix for Rangitata River

(Credit: KiwiRail)

2.33 If deemed necessary, KiwiRail holds conference calls to establish the required response to weather events. A conference call template is available to facilitate risk-based triaging and decision-making.

2.34 The Trigger Action Response Plan (TARP) also includes suggested actions for yellow, amber and red-alert levels. The actions are 'Go – but Stay Alert', 'Go BUT (take actions)' and 'NO GO (cease operations)' for the yellow, amber and red alerts respectively.

2.35 The weather risk matrix did not include asset-specific mitigation measures for each warning level. The process of ensuring the network remained safe to operate was managed by the Production Manager and Asset Engineer for the region.

KiwiRail asset management and maintenance regime

2.36 KiwiRail's Safety Case[14] documents the arrangements it has in place to manage the rail activities[15] to which the Railways Act 2005 applies. A component of the safety case is the Network Engineering Principles and Standards.

2.37 The Network Engineering Principles and Standards ensure that the infrastructure assets, such as the track, formation, bridges and the signalling system, are fit for purpose. Compliance with these Principles and Standards is key to ensuring the safety of these assets.

2.38 The quality management system (QMS) that KiwiRail uses to ensure compliance with its Principles and Standards puts the relevant documents into a hierarchy (*see* Figure 8).

[14] A comprehensive document that outlines the safety risks associated with a system or installation and explains how these risks are managed. Further details on the contents of a safety case are contained in the Railways Act 2005, section 30 Contents of safety case.

[15] As defined in the Railways Act 2005, section 4(2).

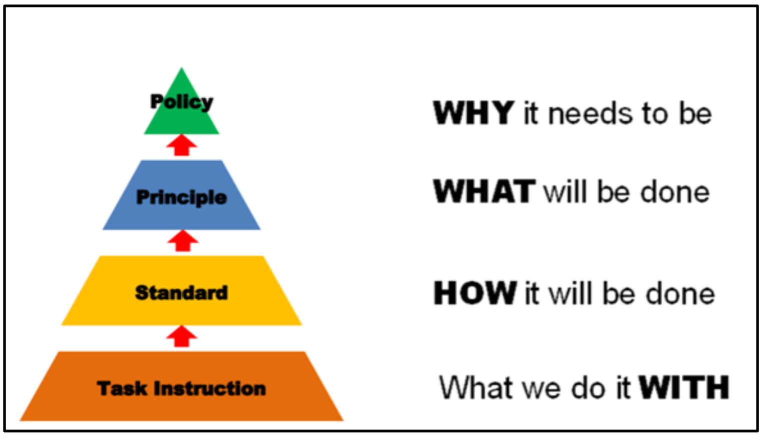


Figure 8: KiwiRail principles and standards hierarchy
(Credit: KiwiRail)

2.39 KiwiRail's Structures Engineering Principle (B-PR-GE-3011) sets out the guiding principles for the design, construction and management of structures assets.

Structures Health Index (SHI)

2.40 KiwiRail used its Structures Health Index (SHI) Standard (B-ST-AS-3112) to calculate a number that was then used to form a broad view of an asset's health. This number was used to make decisions on risk mitigation across the network, with a view to manage risk at a network level.

2.41 The asset's health was determined by the following parameters:

- condition
- strength
- fatigue
- foundation
- scour
- seismic
- vehicle strike
- knowledge gap.

2.42 A score was assigned to each of the above parameters, which then provided an index that could be used to compare bridges across the network and the risk level relative to one another. The index ranged from 0 to 100, with 0 representing a very poor performance level and 100 a good performance level.

2.43 The index rating for Bridge 57 was 78, signifying a satisfactory level of performance. This rating indicated that the structure aligned broadly with anticipated future operating parameters, and that the application of load or speed restrictions would be required infrequently.

Structures inspections

2.44 KiwiRail's structures inspection regime was defined by the following standards:

- General inspections: B-ST-AS-3106

- Detailed inspections: B-ST-AS-3114[16]
- Engineering inspections: B-ST-AS-3110.[17]

General and detailed inspections

2.45 General inspections are completed annually and detailed inspections are completed once every six years. The main purpose of both of these inspections is to identify defective components, deteriorating materials and serviceability issues on bridges. The specific procedure to be followed during the inspection was described in KiwiRail's W200: Structures Inspection Manual.

2.46 General and detailed inspections are undertaken by the Structures Inspector for the region, with the results of the inspection being signed off by the Inspectorate Engineer for the region.

2.47 The general and detailed inspections had been completed at the required intervals for Bridge 57.

Engineering inspections

2.48 Engineering inspections are completed at the discretion of the Structures Professional Head.[18] Their purpose was to apply practical and theoretical engineering knowledge to ensure the bridge remained safe for use.

2.49 Engineering inspections were completed by Structures Engineering staff. The standard specifies that, before the inspection takes place, the Engineer should be familiar with all elements of the bridge, including flood histories, scour calculations and ratings.

Auditing

2.50 KiwiRail uses internal quality audits to ensure that its QMS is operating as intended. These audits inform management and alert them to areas that need improvement.

2.51 The audit schedule for each discipline is determined by that discipline's Professional Head, based on a risk assessment. The audit requirements for the structures discipline were defined by B-ST-IN-3111 Structures Audit.[19]

2.52 The Structures Audit standard specified that the structures inspectors and inspectorate engineers should be audited four times each year to ensure the detailed inspection process was being completed according to the standards.

2.53 KiwiRail provided limited evidence of audits completed in the previous six years, contrary to its QMS. This is discussed further in the analysis section of this report.

Bridge 57 Main South Line

2.54 Bridge 57 is 610 m long, comprised of 34 steel spans that sit on 2 concrete abutments and 33 concrete piers. The piers are spaced at 18.3 m from centre to

[16] B-ST-AS-3106 and B-ST-AS-3114 were amalgamated into a single standard B-ST-GE-3040 in February 2024.
[17] B-ST-AS-3110 was effective from July 2017 and withdrawn from use in February 2024.
[18] Professional Head is a job title within KiwiRail's infrastructure team. They are responsible for guiding the technical direction of their structures discipline.
[19] B-ST-IN-3111 was withdrawn from use in February 2024. The audit requirements were included in B-ST-GE-3040, published in February 2024.

centre and are 6.4 m high. The piles underneath the piers extend 7.6 m below the base of the pier (*see* Figure 9).

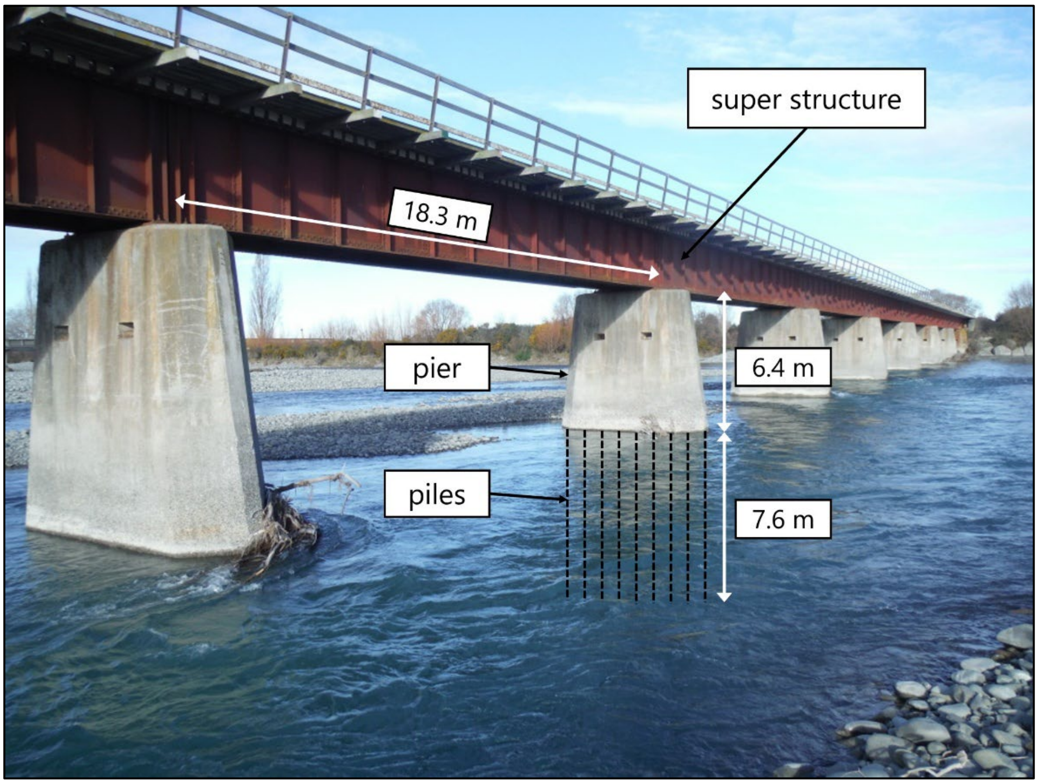


Figure 9: Bridge 57 pier 'as built' measurements
(Credit: KiwiRail – annotated by the Commission)

2.55 Bridge 57 was constructed in 1936. KiwiRail was able to provide limited evidence confirming the height of the piers and depth of the piles that form part of Bridge 57. The Commission has therefore determined the pile depth based on the available evidence, which was the design documentation for the bridge.

2.56 KiwiRail records from 1983 refer to some 'as built' measurements, which indicate that the assumed depths shown in Figure 9 are a reasonable, conservative assumption for the depth of the piles and height of the pier.

Meteorological information

2.57 MetService forecast heavy rainfall for the headwaters of the Canterbury lakes and rivers south of Arthur's Pass from 9 April 2024 to the evening of 11 April 2024. A total of 400–600 mm of rain was forecast with peak rates of 20–30 mm/h predicted.

2.58 The Rangitata River's catchment area is primarily within this region and MetSolutions predicted that this rainfall would create a flow event in the river with a two-year return period.

2.59 The peak flow in the river as a result of this rainfall was recorded as 1100 m^3/s at the Klondyke flow gauge.

Tests and research

2.60 The Commission engaged Stantec New Zealand Limited (Stantec) to provide civil and structural engineering services to assist with the investigation of the pier stability.

2.61 ECan provided flood hydrology and modelling information to the Commission.

Previous occurrences

2.62 The following reports are relevant to this inquiry as the Commission found similarities relating to the response to severe weather events on the rail network.

RO-2023-102 Freight Train 360 derailment, Te Puke, 29 January 2023

2.63 On 27 and 28 January 2023, the Bay of Plenty region experienced heavy rainfall. On 28 January, the crew of a KiwiRail freight train observed and reported to train control a high water level at rail Bridge 85 on the East Coast Main Trunk Line, north of Te Puke.

2.64 On receipt of this information, train control arranged for a track inspection to be conducted to assess the risks. The track inspection occurred at an incorrect location, resulting in clearance being given for trains to resume normal operations.

2.65 At about 0430 on 29 January 2023, a KiwiRail freight train encountered substantial floodwater across the track north of Te Puke, not far from rail Bridge 85. The floodwaters had washed out the track formation, which led to the majority of the wagons uncoupling and derailing.

2.66 Following an investigation into this accident, the Commission recommended that KiwiRail review its adverse weather response system and processes to ensure they are effective in maintaining a safe rail network.

2.67 KiwiRail responded to the recommendation by developing and publishing a Severe Weather Event Standard.

RO-2021-106 Derailment of Train 220, south of Hunterville, 13 December 2021

2.68 On 13 December 2021, an adverse weather event with heavy rainfall resulted in streams and waterways being overwhelmed in the Hunterville area along the North Island Main Trunk line. An investigation by the Commission found that floodwater had undermined the track formation, resulting in the derailment of a freight train.

2.69 The Commission found that there were no severe-weather-warning or flood-monitoring measures in place in the accident area.

2.70 KiwiRail undertook safety action following the accident, including completing a hydrology assessment and flood modelling, planning the replacement of existing culverts with pipes, and planning the installation of a flood-monitoring system.

RO-2021-104 Passenger Train 6205 derailment, Kāpiti, 17 August 2021

2.71 On 17 August 2021, a Wellington-based passenger train was operating a scheduled service from Waikanae to Wellington. The area had experienced moderate rainfall in the hills adjacent to the rail corridor, overwhelming the waterways and drainage systems.

2.72 The train rounded a right-hand curve next to the hillside and the driver sighted a landslide covering both main lines in front of the train. The driver applied the emergency brake before the train hit the slip debris, derailed and lost all power. There were no injuries to crew or passengers.

2.73 Following an investigation into this accident, the Commission recommended that KiwiRail review the trigger settings of its rainfall-monitoring equipment and weather risk matrix to ensure they can identify and respond to rainfall that occurs within a short time period.

2.74 KiwiRail accepted and implemented this recommendation through the implementation of its Severe Weather TARP.

RO-2002-101 Train 929 embankment washout, near Rangitata, 4 January 2002

2.75 On 4 January 2002, Train 929 ran into a track subsidence beside the Rangitata River on the Main South Line, resulting in two locomotives and five wagons derailing and going into the river (*see* Figure 10).

Figure 10: Train 929 locomotive DC4686 submerged in the Rangitata River

2.76 The Commission found that there was:

- a lack of an early warning for river-flow levels
- a lack of a defined process for implementing special track inspections during inclement weather
- no specified time between a special track inspection and arrival of a train.

2.77 The Commission made the following recommendations in relation to the incident:

- establish an early warning system that is linked to the existing river-flow gauges
- conduct inspections immediately ahead of all trains during and immediately following defined river flows.

2.78 Tranz Rail (KiwiRail's predecessor) took safety action following the accident, but some of the identified issues are still present in this investigation report.

3 Analysis
Tātaritanga

Introduction

3.1 On 12 April 2024, Pier 8 of Bridge 57 collapsed after a high-river-flow event. The line remained open for scheduled rail traffic after the collapse occurred, putting those services at risk of derailment and harm.

3.2 The line was closed after a member of the public called KiwiRail to inform them of the collapse. There were no people or rail vehicles on the bridge at the time of the collapse, but the pier collapse caused significant structural damage to the bridge.

3.3 The following section analyses the circumstances surrounding the event to identify those factors that increased the likelihood of the event occurring or increased the potential severity of its outcome. It also examines the safety issues that have the potential to adversely affect future operations.

Structural analysis of Pier 8

Scour depth

3.4 Scour depth is the vertical distance below a reference surface that will be eroded and removed by the action of flowing water. This phenomenon, known as scour, is particularly relevant around hydraulic structures such as bridge piers.

3.5 The scour depths relating to Bridge 57 have been determined through the tests and research that have been completed and are detailed in Appendix 1.

3.6 The theoretical scour depth and flow height on the day of the event for Pier 8 are represented graphically in Figure 11. Because of the uncertainty around the precise velocity of the water flow around Pier 8 on the day of the event, a range of probable scour depths is represented.

3.7 The reference point of the soffit of the pier (bottom of the pier section) has been selected to represent the depths and heights.

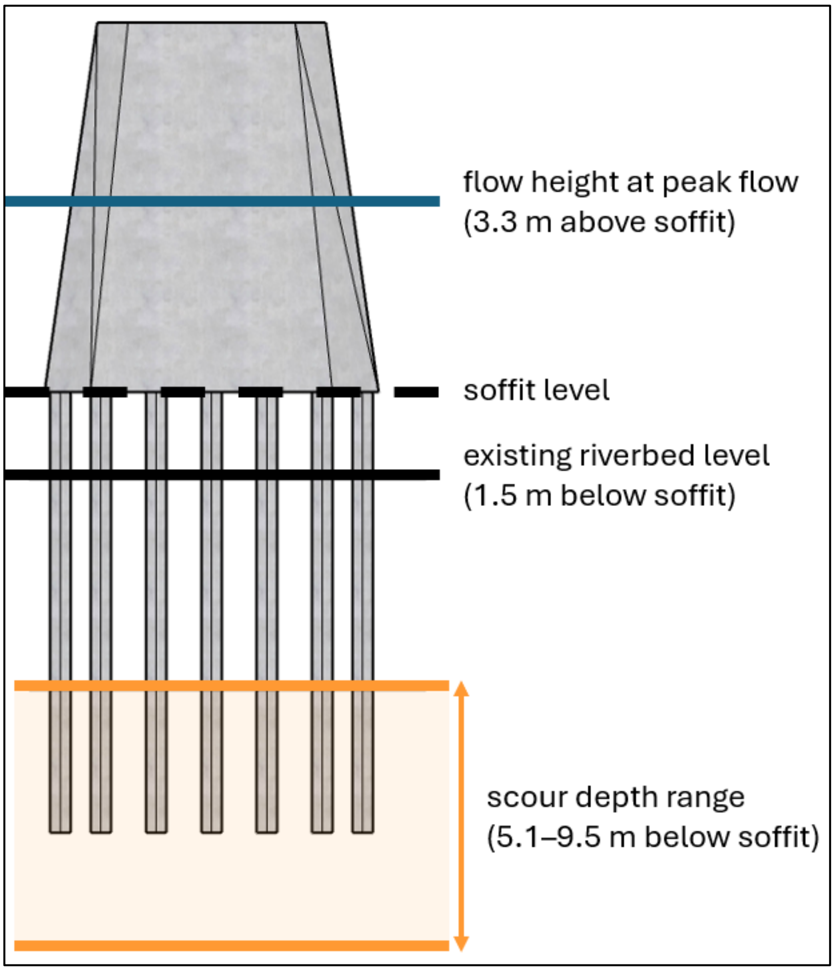


Figure 11: Pier 8 scour depths

Mechanism of failure

3.8 The precise mechanism of failure for Pier 8 is difficult to determine, because of the inherent complexity of the structural elements of Pier 8 and because many details of the bridge and the river on the day of the collapse are not known with certainty and rely on modelling and assumptions to determine. Some of these factors are:

- flow rate and flow speed at Bridge 57
- depth of the piles of Bridge 57.

3.9 Based on the evidence available, the Commission has come to the following conclusions on the mechanism of failure of the bridge pier and surrounding spans.

3.10 The failure of Pier 8 was **very likely** caused by the loss of vertical support from the piles due to the scouring of the riverbed material around the piles. The riverbed material around the piles provides the vertical support through a combination of skin friction and end bearing (*see* Figure 12).

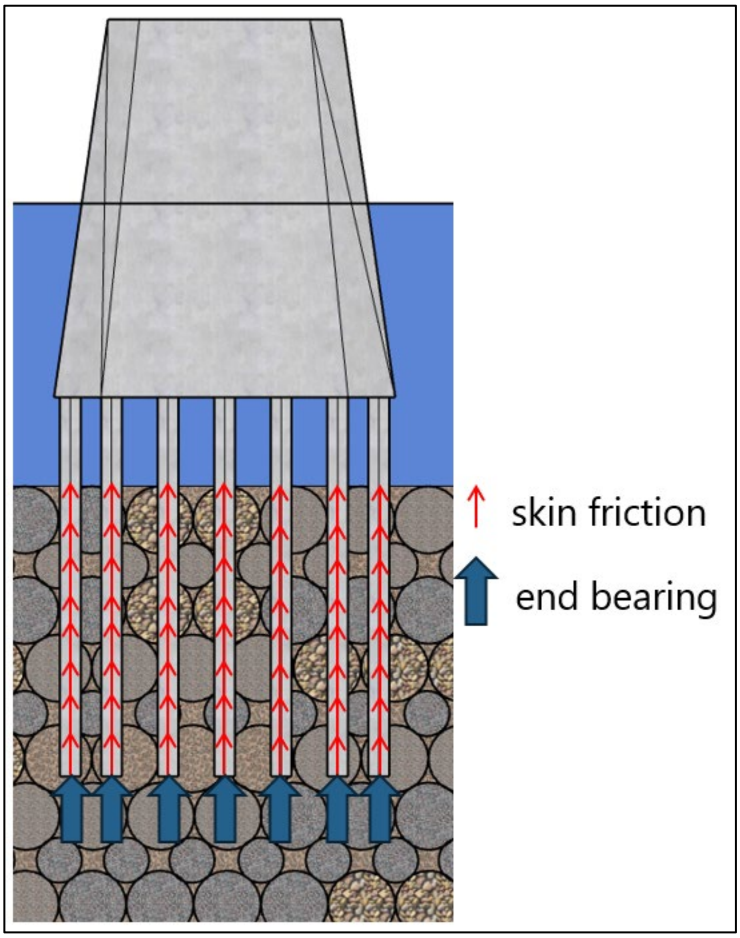


Figure 12: Vertical support mechanism of piles

3.11 The mechanism of failure was **very likely** as follows:

(i) sufficient bed material would have been scoured away such that the piles were unable to support the vertical load of the bridge, causing the pier to begin to sink into the riverbed (*see* Figure 13).

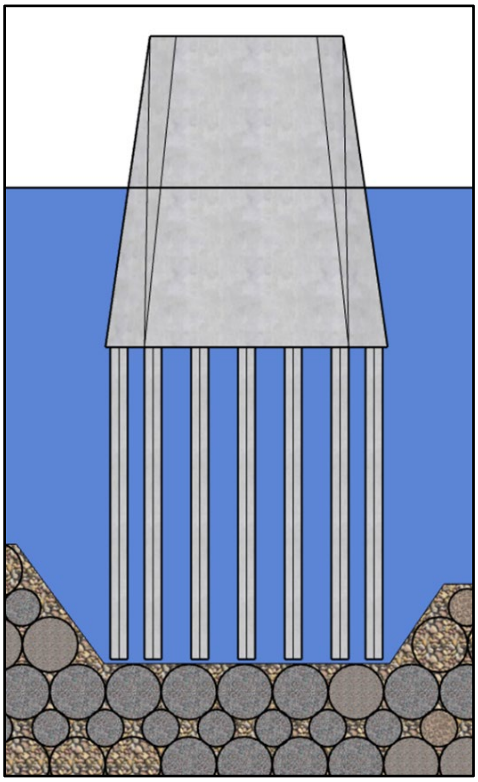


Figure 13: Loss of riverbed through scour

(ii) As the pier dropped vertically, the beam ends butted together and began to support their own weight. This resulted in the pier being momentarily suspended from the beams, before the holding down bolts failed under tension (*see* Figure 14).

Figure 14: Vertical settlement of pier

(Credit: KiwiRail)

(iii) Once the connection between the top of the pier and the beams was lost, the pier toppled into the river and settled on the eastern side of the bridge in a downstream river flow (*see* Figure 15).

Figure 15: Final location of Pier 8
(Credit: KiwiRail)

Structures inspections

Safety issue 1: KiwiRail's inspections of Bridge 57 were not in accordance with its standards, missing an opportunity to identify and respond to the risk that the flood event presented to the bridge.

3.12 The inspection process is a key aspect in the management of rail structures. Inspections ensure the condition of the structure stays within the intended safety and performance limits and is compatible with operating parameters.

3.13 The KiwiRail Structures Inspection Manual makes multiple references to the importance of monitoring the changes in the riverbed cross sections from one inspection to the next, as it can be an indication of scour risk at the bridge. Sections of the Structures Inspection Manual that specify this are shown in Appendix 3.

3.14 Commission investigators reviewed the past nine detailed inspection reports for Bridge 57 to determine whether the river profile had been monitored as required in the procedure set out in the Structures Inspection Manual.

3.15 The recording of the riverbed profile was found to be inconsistent, with some inspections including profiles that showed the riverbed depth. However, others were limited to comments indicating where the river was flowing at the time of the inspection.

3.16 Commission investigators reviewed the most recent detailed inspection reports on a further nine bridges across the network that had been identified by KiwiRail as having a high scour risk in a desktop study. The recording of the riverbed profile in these reports was also inconsistent, with only some of the reports making note of the riverbed profile.

3.17 The riverbed profile is a key indicator of the scour risk that any given bridge may have. The lower the riverbed level, the less pile embedment that is available to support the bridge structure and any trains that traverse it. By monitoring how the riverbed changes over time, the risk of scour failure can be closely managed to ensure that it stays within acceptable limits.

3.18 The purpose of engineering inspections was to apply practical and theoretical engineering knowledge to identify features that may prevent a bridge from being safe for use. They are supplementary to the general and detailed inspections, with the aim of studying the adequacy of a bridge as a whole by assessing technical aspects such as scour depths.

3.19 KiwiRail could not provide evidence of any engineering inspections of Bridge 57 despite the scour risk having been previously identified.

3.20 KiwiRail could provide evidence of only one engineering inspection (as defined in B-ST-AS-3110) being completed across the entire rail network over the period the standard was in place (July 2016 to February 2024).

3.21 Had an engineering inspection of Bridge 57 been completed, it is **likely** the risk of the scour failure would have been better understood. An engineering inspection could have provided an opportunity to identify the level of river flow that would create an unacceptable scour risk at Bridge 57. This would have allowed KiwiRail to make informed risk-based decisions when operating on the infrastructure.

3.22 An effective audit system provides an opportunity for an organisation to identify inconsistencies between how work is being completed in the field on a day-to-day basis and how it is specified to be completed as part of a quality management system.

3.23 KiwiRail had not been completing a formalised and documented audit process in accordance with its quality management system. This meant an opportunity was missed to drive continuous improvement and identify areas where the structural inspection regime could have been improved. Had the audit system been implemented as specified in the QMS, it is **likely** that the inconsistent riverbed monitoring would have been identified and improved upon.

Risk-based asset management

Safety issue 2: KiwiRail's asset management plan for Bridge 57 did not include a plan to mitigate the identified scour risk. This increased the risk of a structural failure.

3.24 Another key component of KiwiRail's Safety Case is asset management.

3.25 KiwiRail's Strategic Asset Management Plan documents how its asset management objectives are to be achieved. It states the importance of having a thorough understanding of an asset's performance and condition, and how this affects risk to the operation on the network.

3.26 KiwiRail's SHI Standard was effective at ranking the risk for each bridge on the network, relative to other bridges on the network. The standard, however, did not prescribe mitigation methods that should be used for a given risk level.

3.27 KiwiRail gained a high-level understanding of the scour risk across the network in 2013 through a desktop scour-risk assessment. This assessment determined which bridges across the network needed further attention because of scour risk. However, it did not provide a 'thorough understanding of an asset's performance and condition and how this impacts risk for the operation on the network' as required in KiwiRail's Strategic Asset Management Plan, nor did it provide an impetus for the known scour risk at Bridge 57 to be studied further.

3.28 Some overseas jurisdictions have a dedicated standard that specifies how scour risk should be managed, such as the United Kingdom's *CS 469 – Management of scour and other hydraulic actions at highway structures* (National Highways, 2024). This standard provided procedures to determine the level of risk associated with scour and other hydraulic actions on structures in severe weather events. It also contained advice on mitigation actions that could reduce risk.

3.29 KiwiRail did not rely on such a dedicated standard. Instead, decisions to impose operational restrictions were left to individuals, which did not provide the level of rigour that a well-functioning asset management system requires and increased the risk of structural failures.

Adverse weather procedures

Safety issue 3: KiwiRail's planned response to adverse weather events did not take into account asset-specific risks, increasing the likelihood of inadequate mitigation measures being implemented.

3.30 Weather-alert systems and robust procedures to respond to alerts are critical parts of operating a safe rail network. Well-known procedures and timely communications are crucial when a weather event is forming, while it is occurring, and after it passes. These enable potential safety risks to the rail network to be monitored and responded to.

3.31 KiwiRail had been informed of the weather conditions within the Rangitata River catchment, and its severe-weather management system was effective in providing that information to key members of the business. Train control and Infrastructure departments were aware that the flow in the river had exceeded the red-alert level in the early hours of 12 April 2024.

3.32 A red-alert level indicated potential for widespread impacts on the network and the suggested action within KiwiRail's procedures was to cease operations.

3.33 Despite knowledge that the river flow had reached the red-alert level, the line remained open. Two freight trains passed over Bridge 57 before the bridge was inspected and deemed safe to remain open.

3.34 The flow at the bridge was **very likely** above the red-alert level during the passage of two freight trains and an inspection. This presented a significant and unmitigated risk to the locomotive engineers and the track ganger carrying out the inspection.

3.35 The loss of Pier 8 of Bridge 57 compromised the structural integrity of the bridge, leaving it with unsupported spans.

3.36 If the line had remained open after Pier 8 had collapsed and a train had traversed the bridge, it is **virtually certain** that a loss of vertical support and derailment of the train would have occurred over the compromised spans.

3.37 KiwiRail would not have been aware of the collapse without the member of the public contacting them.

3.38 The consequences of this would have been catastrophic and would **very likely** have resulted in serious injury to the train crew, and significant damage to the locomotive and leading wagons of the train. Additionally, there would **very likely** have been significant environmental damage to the river and further structural damage to the bridge.

3.39 The bridge inspection was completed according to the KiwiRail Track Inspection Standard T-ST-IN-5109. This standard refers to inspections required following adverse weather (Section 16.14.2) and inspection of other disciplines' assets[20] (Section 13). Relevant sections of this standard are provided in Appendix 2.

3.40 These sections of the standard refer to the risk of debris buildup at bridge piers and its impact on scour. However, they do not contain any guidance on the acceptable level of debris buildup or on a river flow that would present an unacceptable risk of structural collapse.

3.41 The decision to keep the line open was based on previous events in which the river had flowed higher without causing any damage to the bridge.

3.42 The track ganger had received no training in how to inspect a bridge under a river-flow event or to identify signs of scour.

3.43 The track ganger's assessment was based on their historical knowledge, as opposed to a scientific and statistical basis that could have been implemented had a risk-based asset management approach been implemented (*see* Safety issue 2).

3.44 The action taken to ensure the line remained safe to operate in the adverse weather conditions was not a well-defined or documented process and did not include mitigation measures specific to the hazards for Bridge 57. The actions to be taken for yellow-, amber- and red-alert levels were not defined and documented. As a result, the inspection that was completed was based on the requirements of the Track Inspection Standard, which did not focus on risks specific to the structure.

[20] KiwiRail's assets are categorised into disciplines such as track, signals, and structures.

4 Findings
Ngā kitenga

4.1 The risk of scour failure was included in the overall asset-management strategy for Bridge 57 but did not trigger any additional risk mitigation measures. It was not specifically addressed in the inspection regime and operational requirements for the bridge.

4.2 The failure of Pier 8 was **very likely** caused by the loss of vertical support from the piles due to the scouring of the riverbed material around the piles. The riverbed material around the piles provides the vertical support through a combination of skin friction and end bearing.

4.3 Had an engineering inspection been completed, it is **likely** the risk of the scour failure would have been better understood. An engineering inspection could have provided an opportunity to identify the level of river flow that would create an unacceptable scour risk at Bridge 57. This would have allowed KiwiRail to make informed risk-based decisions when operating on the infrastructure.

4.4 Recent detailed inspections completed on the bridge had not recorded the river profile, as specified in the inspection standards. This contributed to difficulty in quantifying the risk that certain flood events presented to the structure.

4.5 KiwiRail had not been completing a formalised and documented audit process in accordance with its quality management system. This meant an opportunity was missed to drive continuous improvement and identify areas where the structural inspection regime could have been improved. Had the audit system been implemented by KiwiRail, as specified in its QMS, it is **likely** that the inconsistent riverbed monitoring would have been identified and improved upon.

4.6 The decision to impose operational restrictions on a high scour risk bridge was not based on a standard. The decision was left to individuals, which did not provide the level of rigour that a well-functioning asset management system requires and increased the risk of structural failures.

4.7 The flow at the bridge was **very likely** above the red-alert level during the passage of two freight trains and an inspection. This presented a significant and unmitigated risk to the locomotive engineers and the track ganger carrying out the inspection.

4.8 If the line had remained open after Pier 8 had collapsed and a train had traversed the bridge, it is **virtually certain** that a loss of vertical support and derailment of the train would have occurred over the compromised spans.

4.9 The consequences of this would have been catastrophic and would **very likely** have resulted in serious injury to the train crew, and significant damage to the locomotive and leading wagons of the train. Additionally, there would **very likely** have been significant environmental damage to the river and further structural damage to the bridge.

5 Safety issues and remedial action
Ngā take haumaru me ngā mahi whakatika

General

5.1 Safety issues are an output from the Commission's analysis. They may not always relate to factors directly contributing to the accident or incident. They typically describe a system problem that could adversely affect future transport safety.

5.2 Safety issues may be addressed by safety actions taken by a participant; otherwise the Commission may issue a recommendation to address the issue.

Safety issue 1: KiwiRail's inspections of Bridge 57 were not in accordance with its standards, missing an opportunity to identify and respond to the risk that the flood event presented to the bridge.

5.3 No action has been taken to address this safety issue. Therefore, the Commission has made a recommendation in Section 6 to address this issue.

Safety issue 2: KiwiRail's asset-management strategy for Bridge 57 did not include a plan to mitigate the identified scour risk. This increased the risk of a structural failure.

5.4 Since the incident, KiwiRail have made improvements to its Structures Inspection Standard B-ST-GE-3040. The standard has been updated to include specific requirements for a drone survey to be conducted on braided rivers following a major flood event.

5.5 The Commission welcomes the safety action to-date. However, it believes more action needs to be taken to ensure the safety of future operations. Therefore, the Commission has made a recommendation in Section 6 to address this issue.

Safety issue 3: KiwiRail's planned response to adverse weather events did not take into account asset-specific risks, increasing the likelihood of inadequate mitigation measures being implemented.

5.6 Since the incident, KiwiRail has made improvements to how severe weather conditions that affect rivers are monitored. River flows and current alert levels are shown live within the KiwiRail weather status webpage. This is a significant improvement and ensures that the river-flow-based alerts are readily available for anyone within KiwiRail to view.

5.7 KiwiRail have also implemented an asset-specific TARP for Bridge 57. This TARP clearly defines the actions, and who is responsible for completing them, at each alert level to ensure that the bridge is safe for operations. KiwiRail intends to establish individual TARPs for all high scour risk bridges.

5.8 In the Commission's view, this safety action has addressed the safety issue with respect to Bridge 57 but not with respect to other rail bridges across the rail network. Therefore, the Commission has made a recommendation in Section 6 to address this issue.

6 Recommendations
Ngā tūtohutanga

General

6.1 The Commission issues recommendations to address safety issues found in its investigations. Recommendations may be addressed to organisations or people and can relate to safety issues found within an organisation or within the wider transport system that have the potential to contribute to future transport accidents and incidents.

6.2 In the interests of transport safety, it is important that recommendations are implemented without delay to help prevent similar accidents or incidents occurring in the future.

New recommendations

6.3 On 30 April 2026, the Commission recommended that the Chief Executive of KiwiRail Holdings Limited ensure that all structural-asset inspections and audit procedures are in full compliance with KiwiRail's quality management system and standards, particularly with regard to riverbed-profile monitoring. **[016/26]**

6.4 On 15 May 2026, the Chief Executive of KiwiRail replied:

> **This recommendation is accepted and has been implemented**.
>
> KiwiRail's inspection standard B-ST-GE-3040 (dated 7/02/2025 Version 3) has been updated to require UAV drone survey of the upstream and downstream extents of the river for all braided rivers as part of the cyclic detailed inspection process. The drone survey is to be reviewed by a KiwiRail Water Engineer. Following a major flood event on a braided river (typically >1,000 cumecs) a supplementary drone survey is required to assess whether changes in river flow or morphology may compromise bridge performance in future flood events.

6.5 On 30 April 2026, the Commission recommended that the Chief Executive of KiwiRail Holdings Limited develop and document KiwiRail's risk-based asset management and maintenance system for flood and scour risk to rail bridges across the rail network. **[017/26]**

6.6 On 15 May 2026, the Chief Executive of KiwiRail replied:

> **This recommendation is accepted.**
>
> KiwiRail's Structures Health Index Standard (B-ST-AS-3112) requires bridges with a Scour Health Index (SHI) score of 4 to be on the Essential Features List. Following the event, it was identified that trigger actions response plans (TARP) are required for all bridges on the Essential Features List due to their scour SHI scores, to ensure bridge-specific scour risks are effectively captured and managed. The following tasks are required to complete the TARP development:
>
> • Commission and undertake a refresh of the scour screening results for all operational bridges.
>
> • Develop individual TARPs.

There are currently 152 separate rail bridges on the Essential Features List. The reviews will be prioritised based on known scour risk. This is expected to be completed by 30 September 2029.

6.7 On 30 April 2026, the Commission recommended that the Chief Executive of KiwiRail Holdings Limited review the Trigger Action Response Plans for all high-risk assets to ensure they contain adequate responses to mitigate the risks specific to that asset. **[018/26]**

6.8 15 May 2026, the Chief Executive of KiwiRail replied:

This recommendation is accepted.

The infrastructure team is reviewing all high-risk assets which require TARPs, including bridge

structures. The following tasks are required to complete the review:

• Develop bow-tie risk assessments for high-risk assets.

• Develop TARPs - see response to 017/26.

• Compare bow-tie assessments, Essential Features Lists, and TARPs.

• Review and close information gaps.

Inclusion on the Essential Features List means that each of these assets already has a required action post an event. Existing TARPS are generally for an area and include high level requirements covering multiple assets. The reviews will validate the existing TARPS and other controls or result in a more detailed TARP or controls specific to the individual asset.

There are currently 690 separate assets on the Essential Features List, including bridges. Development of bow-tie assessments has already started and, once complete, each asset on the Essential Features List will be reviewed against the appropriate bowtie, and controls and mitigations including TARPS will be amended or developed as necessary. Undertaking these reviews will require a substantial amount of resource and is expected to be completed by 30 September 2030.

7 Other safety lessons
Ngā akoranga matua

7.1 Bridges are complex assets. Visual inspections alone may be inadequate to determine their structural integrity and safety.

7.2 All asset management plans require the identification of key risks to the asset, which should be reviewed and updated regularly to ensure they remain fit for purpose.

7.3 As the frequency of adverse weather events increases, transport operators and those responsible for the infrastructure need to future proof the safety of those transport operations.

8 Data summary
Whakarāpopoto raraunga

Infrastructure particulars

Bridge:	Bridge 57 Main South Line
Year of manufacture:	1936
Infrastructure owner:	KiwiRail Holdings Limited

Date and time 12 April 2024

Location Rangitata River Bridge – Main South Line 127.204 km

Injuries Nil

Damage Extensive to a section of Bridge 57 structure.

9 Conduct of the inquiry
Te whakahaere i te pakirehua

9.1 On 16 April 2024, the New Zealand Transport Agency notified the Commission of the occurrence. The Commission subsequently opened an inquiry under section 13(1) of the Transport Accident Investigation Commission Act 1990 and appointed an Investigator-in-Charge.

9.2 On 17 April 2024, a protection order was issued for the site and evidence to this inquiry.

9.3 Commission investigators attended the site on 18 April 2024 and conducted a site investigation.

9.4 The Commission obtained records and information from sources that included:

- train control graphs
- meteorological data for the area
- technical specifications and historical information for Bridge 57
- KiwiRail's severe weather procedures
- KiwiRail's structural-inspection and risk-management regimes.

9.5 On 19 November 2025, the Commission approved a draft report for circulation to seven interested parties for their comment.

9.6 Two interested parties provided a detailed submission and five interested parties replied that they had no comment. Any changes as a result of the submissions have been included in the final report.

9.7 On 30 April 2026, the Commission approved the final report for publication.

Abbreviations
Whakapotonga

ECan	Environment Canterbury
km	kilometre
LE	locomotive engineer
m	metre
mm	millimetre
m^3/s	cubic metres per second
MSL	Main South Line
QMS	quality management system
TARP	Trigger Action Response Plan

Glossary
Kuputaka

heavy rainfall	greater than 100 mm of rainfall over a 24-hour period, or a period of rainfall of 10–50 mm/hr, as classified by Earth Sciences New Zealand
hi-rail vehicle	a vehicle fitted with retractable rail wheels that can travel on both road and rail
locomotive	a rail transport vehicle that provides motive power to pull or push other rail vehicles on a rail network
locomotive engineer	an engineer certified to operate in-cab speed and braking controls in response to signals on the rail network
Professional Head	Professional Head is a job title within KiwiRail's infrastructure team. They are responsible for guiding the technical direction of their structures discipline
return period	the average time between occurrences of an event of a given magnitude or greater. It is commonly used in hydrology and engineering to describe the likelihood of events occurring. A return period of two years would indicate that statistically an event should occur once every two years
safety case	a comprehensive document that outlines the safety risks associated with a system or installation and explains how these risks are managed. Further details on the contents of a safety case are contained in the Railways Act 2005, section 30 Contents of safety case
track ganger	a track ganger's primary role is working on track maintenance, repair and renewal work. Their area of expertise covers track infrastructure, as opposed to the structural or civil assets of the railway
train controller	a person qualified to authorise rail movements and track access; train controllers operate in a train control centre
Trigger Action Response Plan	a plan giving guidance on responding and acting or following a defined procedure in an event

Citations
Ngā tohutoru

National Highways. (2024). CS 469 – Management of scour and other hydraulic actions at highway structures. In *Design Manual for Roads and Bridges.* Retrieved from https://www.standardsforhighways.co.uk/search/056a01ec-4028-4a07-9a21-7168c952cc99

Appendix 1 Stantec report on the structural analysis of pier stability

Stantec New Zealand
Level 15
10 Brandon Street
Wellington 6011
NEW ZEALAND
Mail to: PO Box 13052, Christchurch 8140

22 June 2025

[redacted]

Transport Accident Investigation Commission
10 Brandon St
Wellington 6011

Attention: **Michael McKay**

Dear Michael

Reference: Rangitata Bridge 57 – MSL 127.2km – Investigation into Pier Collapse

Introduction

This letter summarises the works and assessment to meet the Stantec offer of service dated 17 December 2024. It incorporates feedback from the Transport Accident Investigation Commission (TAIC) on Stantec's draft letter dated 23 April 2025, and includes Stantec's responses to TAIC's comments log, also attached.

Scope

Stantec's revised scope, provided by the TAIC in an email from Michael McKay on 7th November 2024, and amended slightly to reflect discussions during the meeting on the 26th November 2024, is as follows:

- The TAIC are to provide Stantec with river modelling data from Environment Canterbury Regional Council (ECan) to assist with determining the flow rate, flow speed and flow depth at the bridge during the collapse.
- Calculate scour depth based on the NZTA Bridge Manual v3.4/Rail Bridge Design Annex, May 2023, for the river flow on the day of the event. Calculations to include a scour depth sensitivity based on using actual calculated river velocities, as follows:

  o Scour depth using an upper bound velocity (actual velocity +1m/s)

  o Scour depth using actual velocity on the day

  o Scour depth using a lower bound value (actual velocity -1m/s)

- Determine the mechanism of failure for the minimum and maximum scour depths from the available records, for Pier 8 only, using the scour depths determined above. The TAIC has requested the following to be determined:

  o Calculate pier drag forces in accordance with the NZ Bridge Manual v3.4/Rail Bridge Design Annex

  o Calculate pile section strength based on NZ Bridge Manual and NZS 3101

  o Calculate pile foundation stability, in accordance with B1/VM4

- Summarise findings in a letter to TAIC.

Background Data

The Rangitata Bridge

The bridge information supplied by TAIC states that the Rangitata Bridge (Bridge 57 MSL127.2) was constructed circa 1936 and carries the Main South Line of the South Island Main Trunk (SIMT) railway over the Rangitata River. It comprises 34 steel girder spans on 35 concrete piers and has a total length of 610m.

At approximately 11am on morning of the 12 April 2024, a member of the public reported that Pier 8 was collapsing. The bridge was closed shortly after by KiwiRail and they commenced recovery actions.

Flood Records for the 12 April 2024

ECan provided flood hydrology and modelling information summary table on 17 December 2024 with derived flow speeds and depths from a 1D river hydraulics model. ECan provided supplementary information on the Rangitata Gorge at Klondyke flow gauge data on the day of the failure of Pier 8 (that is: between 0941 and 1128 on 12 April 2024). The flood travel time between the gauge site and the bridge site is estimated at 6 hours in a 1,000m3/s flow and 4 hours at 2,000m3/s, with longer travel times for smaller flows. On 12 April 2024, the flow gauge peaked at 1,100m3/s for 20 minutes duration between 02:00 and 02:20 before receding. This is 8-9 hours before failure, which is considered close to the 6 hours estimated flood travel time.

The 1D hydraulic model did not model the bridge piers in the cross section and gave average velocity across the cross section. The bridge spans are 18.2m and the pier thicknesses are 1.9m, giving a 10% cross section reduction. Using a ratio of available areas for the same discharge, the velocity through the bridge would be 10% greater than average.

Historical aerial photos back to 2013 show that Pier 8 is consistently in the main flow channel (or one of several main flow channels) on the true left of the river. In a general sense, the deeper part of the cross section will have less channel resistance, see more efficient flow and have higher than average velocity. The 1D model output does not distribute velocity across the cross section, but given Pier 8 in the deepest part of the river cross section at the bridge would likely experience velocity in the order of ~10% higher than the average.

ECan model results are provided for 1,068m3/s which is approximately the peak recorded flow at the approximate correct time prior to pier failure with the flood travel time matching closely the 11am time of failure on 12 April 2024. The model A river roughness of Mannings n=0.040 seems appropriate and this gives an average velocity of 2.6m/s at an elevation of RL102.9m. Applying 10% extra velocity for the deepest section of the river, and then 10% extra velocity past the piers, the velocity for scour analysis is assumed to be 3.1m/s.

Therefore, for analysis of scour depth, the three velocities will be 2.1m/s, 3.1m/s and 4.1m/s at a top water level of RL102.90m.

Pier 8 Configuration

Railway bridge as-built drawings show the dimensions from rail level to pile foundations in imperial units. The rail level is RL160.25 feet and "all piles driven at least to reduced level RL112.00 feet. This is 48.25 feet level difference (converted to 14.6m metric). Refer Figure 1.

From the 1D model cross section at the railway bridge, the rail level is approximately RL108.5m. Therefore, base of pile foundation will be at least RL93.9m. The bridge support structure depth of 14.6m is made up of 1.8m girder beam depth, 6.4m pier depth, leaving at least 6.4m pile length. The pier base level (underside of pile cap) is approximately RL100.23m.

The hydraulic model took cross sections from LiDAR data captured in 2018 and from 2010 where coverage was needed to support 2018 data. The riverbed width is 600m at the bridge cross section, with elevations ranging between RL100m and 104m. At Pier 8 position, 122m from Abutment (Pier) 1, the 2018 LiDAR bed level was approximately RL102m. This indicates a gravel beach at Pier 8, with RL100.5m bed levels close by. Historical aerial photos from GoogleEarth 2022-2024 indicate that one of the two or three deepest parts of the riverbed consistently intersects with Pier 8, and for general scour analysis an average bed level of RL100.5m is assumed.

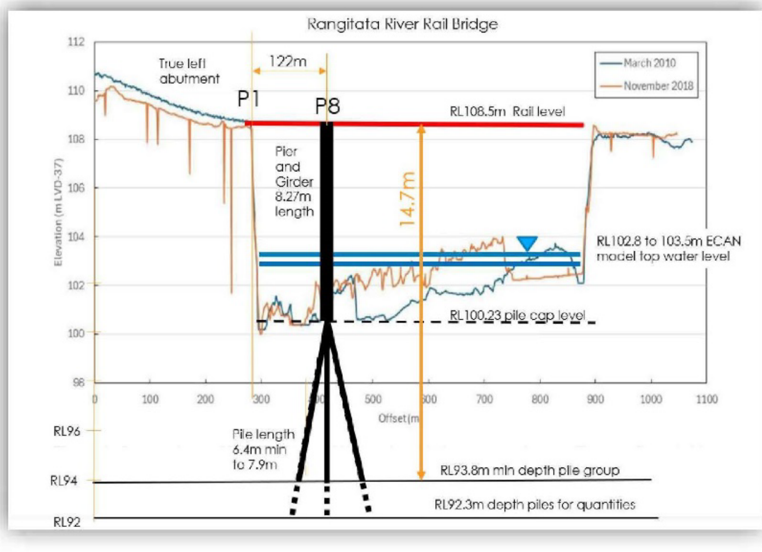


Figure 1: Bridge Support Structure at Pier 8 - main dimensions relevant to scour

Scour Analysis

The NZTA Bridge Manual v3.4 and Rail Bridge Design Annex references Melville BW and Coleman SE (2000) *Bridge scour*, Water Resources Publications, LLC. Highlands Ranch, CO, USA for non-cohesive scenarios – and this covers the Rangitata River. The Holmes method has been used as it has connections with NZ railway bridge scour cases, and another method (HEC18) was used as a check method.

Total scour depth, for three scenarios, are shown in Figure 2, Figure 3 and Figure 4. The three scenarios are:

- 45 degree flow attack angle, with 10m by 1.5m debris raft (Figure 2)
- 45 degree flow attack angle, with no debris raft (Figure 3)
- 0 degree flow attack angle, with no debris raft (Figure 4)

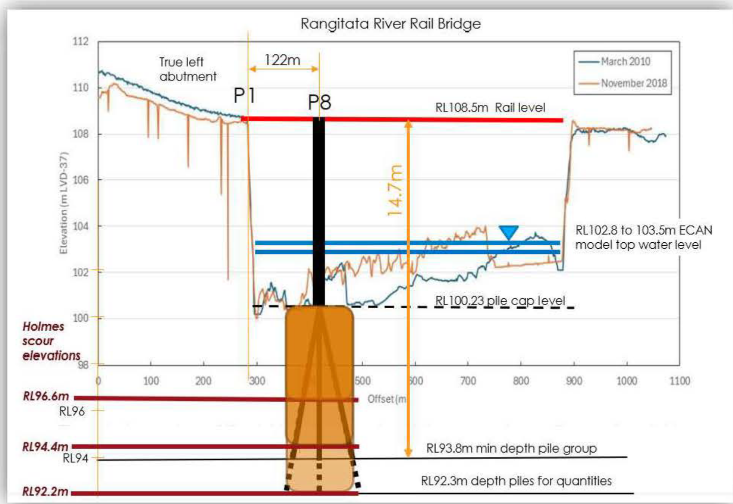


Figure 2: Total scour depth results for velocity = 4.1m/s, 3.1m/s, 2.1m/s assuming 45 degree angle of flow attack on the pier, 10m by 1.5m debris raft, pier width 1.9m

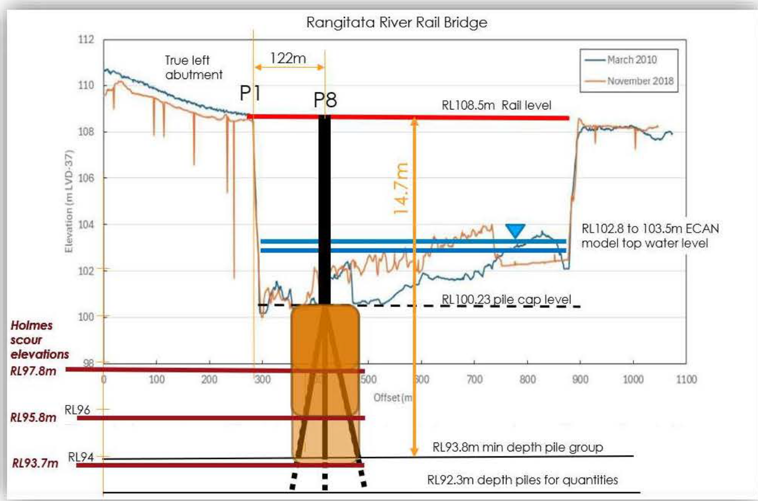


Figure 3: Total scour depth results for velocity = 4.1m/s, 3.1m/s, 2.1m/s assuming 45 degree angle of flow attack on the pier, no debris, pier width 1.9m

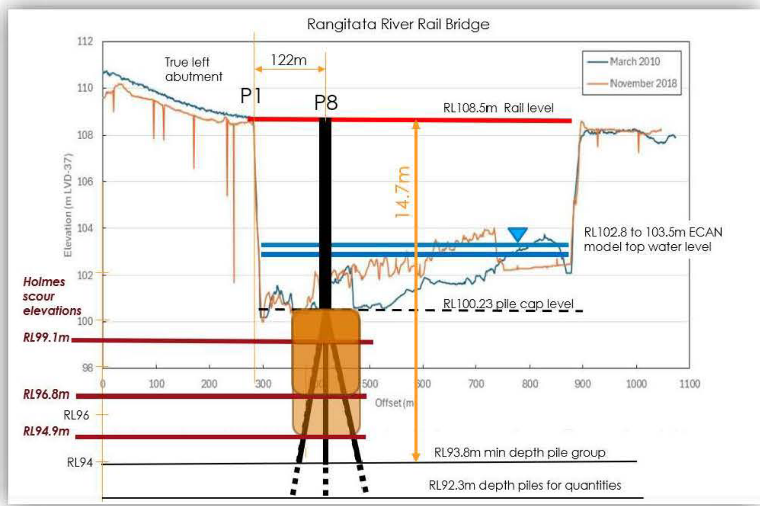


Figure 4: Total scour depth results for velocity = 4.1m/s, 3.1m/s, 2.1m/s assuming 0 degree angle of flow attack on the pier, no debris, pier width 1.9m

Scour analysis indicates cases where the total scour (general plus local scour) could reach pile base level and remove support. In one case (Figure 2), the parameters to achieve this critical scour depth require a debris raft to form.

The other case to reach a critical scour depth, and is a non-debris case (Figure 3), requires a velocity of 4.1m/s past the pile set and a focus of the flood flow into a narrow width of the overall bridge cross section. That is, for example, 80% of the 1068m3/s flow would need to be focussed to 175m width of the bridge or 10 spans to achieve a 4.1m/s flow velocity. Given the flow is a less than annual recurrence event, the focussed flow width could occur if gravel beaches were to develop.

The critical scour depth analysis also requires two flows to converge at the Pier 8 location to incur more scour depth. From historical aerial images, this could occur.

The analysis also indicates that pier width would need to be wider due to flow attack angle. Aerial images show that this is possible with the presence of debris raft and with some images showing flows are near parallel to the bridge.

It should also be noted that the above conclusions ignore the 1.5m of exposed piles visible below the underside of pile cap on piers 8, 9 and 10. Refer Figure 6. This loss of material pre-flood only proves to exacerbate the above scour issues and has been included in Table 1 below.

The following table summarises the scour assessment results. The values in the red box (i.e. with debris raft) are deemed most appropriate for the situation being considered:

Table 1 : Summary table of remaining pile embedment lengths

Velocity (m/s)	RL scour depth with debris raft (m)	Remaining pile embedment* (m)	RL scour depth without debris (m)	Remaining pile embedment* (m)
2.1 (-1m/s)	96.6	2.7 (1.2)	97.8	3.9 (2.4)
3.1 (estimated)	94.4	0.5 (-1.0)	95.8	1.9 (0.4)
4.1 (+1m/s)	92.2	-1.7 (-3.2)	93.7	-0.2 (-1.7)

*the remaining pile embedment calculations are derived from a bed level of RL100.5m which is approximately the base of the pier concrete. Photographic evidence indicates exposure of the pier piles in the low flow channel due to river degradation over time had occurred prior to the April 2024 flood event reducing the bed level by a further 1.5m for pier 8 (scaled from photos). The remaining pile embedment values shown in brackets, take this existing scour into account.

Pier 8 Drag Forces

The drag forces on Pier 8 have been assessed in accordance with Section 16 of AS5100.2, except as modified by the NZ Bridge Manual v3.4.

Forces on piers are dependent on pier shape, pier configuration, water velocity and direction of flow. The supplied drawings have been used in deriving the following values. The three velocities previously established have been considered during this assessment and are detailed in the table below:

Reference: **Rangitata Bridge 57 –** MSL 127.2km – Investigation into Pier Collapse

Table 2 : Summary of Forces

Velocity (m/s) @ RL102.8m	θ_w (assumed)	Wetted area (A_d)	Drag coefficient (C_d)	Drag force (F_d)	Wetted area (A_L)	Side force coefficient (C_s)	Side force (F_L)
2.1 (-1m/s)	45	4.2	0.8	7.4kN	12.8	1.0	28.2kN
3.1(estimated)	45	4.2	0.8	16.1kN	12.8	1.0	61.5kN
4.1(+1m/s)	45	4.2	0.8	28.2kN	12.8	1.0	107.6kN

The pier shape and the increased angle that the river flow currently impacts the piers, and hence the coefficients adopted, increases the flood force on the piers by approximately 20%.

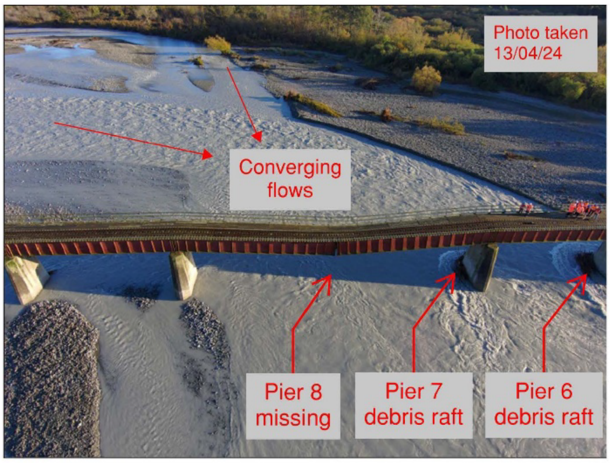


Figure 5: Photo taken above the bridge failure

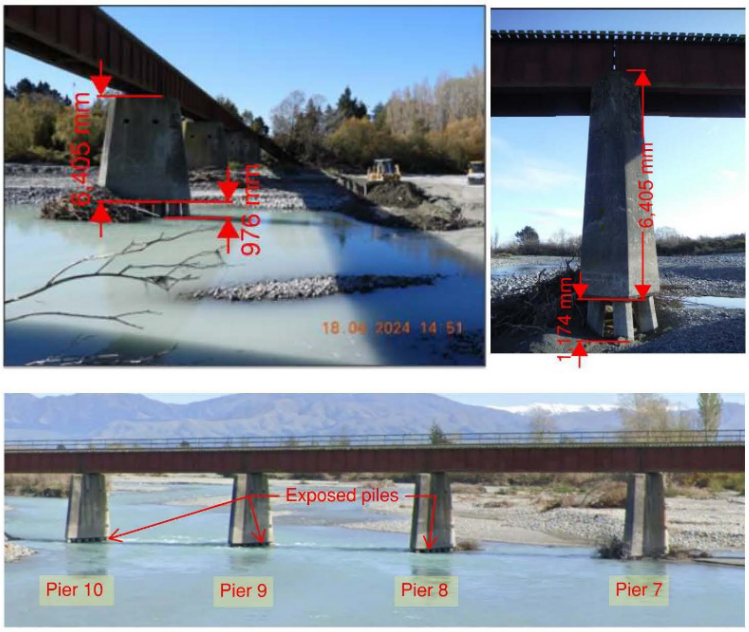


Figure 6: Photos at riverbed level showing scaled dimensions of Pier 6 (top left) with exposed piles and debris raft, 18 April 2024 (post-flood event), Pier 7 (right) with debris raft in 2020 (top right) and pile exposure evident on Piers 8, 9 and 10 pre-flood (bottom).

The top left photograph, taken on 18 April 2024, shows that flood waters have receded exposing the debris raft around pier 6 and exposing approximately 1.0m of pile above the water. A further 0.5m of exposed pile has been assumed below the water level. According to historical inspection records Pier 7 had a similar level of pile exposure pre-flood (top right). Pile exposure is also evident on piers 8, 9 and 10 above water level with further exposure highly likely below water level. Based on the above information a similar sized debris raft and pile exposure has been assumed for pier 8 in the scour analysis. What is apparent is from the above photographic information is that the river bed is highly mobile.

The flood level during the event did not rise sufficiently to impact on the bridge superstructure therefore the drag and lift forces or the 'design superstructure moment' associated with such loading have not been calculated.

Pile Capacity

Stantec have not attended site to visually inspect the collapsed pier. Inspection provides invaluable insights into actual material condition and allows confirmation of the type of concrete and reinforcement failure at both the pier top (as the pier detached from the beams) and the underside of the pier (as the pier broke away from the piles).

From the supplied drawings it is evident that pier 8, like all the other bridge piers on this structure, was supported on 12No. 16" (406mm) reinforced concrete octagonal piles.

The drawings identify the pile concrete strength as 1:2.5:5. This equates to 1 part cement, 2.5 parts sand and 5 parts aggregate. A mix of this type would be expected to produce a concrete strength of approximately 20MPa. This correlates well with the NZ Bridge Manual nominal historical value for a 1933 reinforced concrete of 17MPa. As concrete typically gains strength as it ages 20MPa is considered reasonable for this assessment.

The pile reinforcement strength is not detailed on the drawings so the nominal historical value of 250MPa has been adopted from the NZ Bridge Manual for a 1933 structure.

The total mass of pier 8 has been calculated at approximately 122 tonnes.
The mass of a single 60' bridge span has been calculated at approximately 27 tonnes.
Therefore, the total unfactored dead load of the pier and span is approximately 149 tonnes.

A simple pile capacity check has been carried out based on the pile details in the drawings and concluded the following:

Single pile shear capacity with axial load = 132.2kN (unfactored)

The above shear capacity reduces to 122.6kN (unfactored) when the superstructure detaches.

Single pile bending capacity with axial load = 118kNm (unfactored)

The above bending capacity reduces to 107kNm (unfactored) when the superstructure detaches.

A detailed pile group analysis is outside the scope of this investigation. Load concentrations would be expected as the load shifts under lateral flood water pressure and the rear pier piles go into compression and the front pier piles go into tension.

Foundation Stability

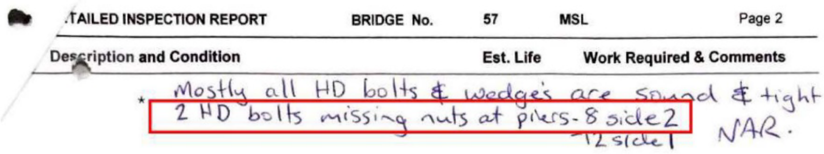
TAIC have requested a calculation of pile foundation stability in accordance with B1/VM4, however, the findings of the scour analysis indicate that the piles for the 'estimated' and '+1m/s' events had the potential to be exposed over their entire length. Even the "-1m/s" event only had 1.2m embedment. Therefore, by inspection alone, the foundation stability would not satisfy B1/VM4 requirements.

Observations Summary

The following is apparent:

- Based on the photographic evidence for piers 6, 7, 8, 9 and 10 provided and the presence of a debris raft on piers 6 and 7, the presence of a debris raft on pier 8 pre-collapse is considered highly likely considering its shared position in the main channel.
- With a debris raft present, and based on the analysis carried out, there is potential for the scour depth to reach below the base of the pile group for two out of the three scenarios.
- Convergent flows are evident upstream of the bridge focussed on or within the vicinity of Pier 8.
- The river flow runs almost parallel to the bridge piers increasing their effective width and attracting higher flood loading
- Pier 8 is located centrally in the main low water flow channel.
- The Pier 8 piles were exposed by at least 1.0m prior to the flood event.

- Flood harvesting for crop irrigation is apparent upstream of the bridge and provides reduced opportunity for natural healing of scoured areas around the piers.
- Gravel extraction has a similar effect to flood harvesting by slowing or preventing healing of scoured areas.
- The groyne installation on the true right bank appears to direct river flows parallel to the bridge and towards the true left bank.
- A detailed inspection by KiwiRail in 2014 identified the following:

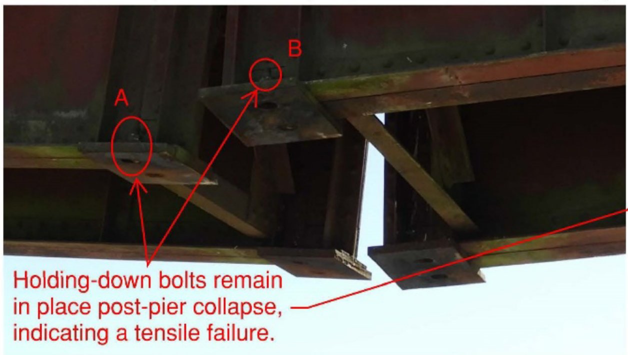


.TAILED INSPECTION REPORT BRIDGE No. 57 MSL Page 2

Description and Condition	Est. Life	Work Required & Comments
Mostly all HD bolts & wedge's are sound & tight 2 HD bolts missing nuts at piers-8 side 2 -12 side 1		NAR.

It is noted that the “missing nuts” comment is marked “NAR”, an acronym for “No Action Required”. Future inspection records do not appear to record this defect or its remediation.

- A TAIC photo from 18 April 2024 identified the following:



Close up of nut and washer at location "A". Note the "fresh" uneven orange fracture surface of the holding down bolt at the underside of the hole.

Likely Mode of Failure

It is evident from photographs provided by TAIC that the bridge beams and/or diaphragms at pier 8 have not suffered any appreciable buckling. Some lateral beam displacement is noted but not considered significant considering the weight of the pier and the lateral flood loading on it. Furthermore, inspection records from 2014 indicate that there may have been nuts missing on the holding down bolts and the above photographs show a tension-like failure of the remaining connected beam holding down bolts.

The lack of beam damage suggests the pier dropped vertically, initially, causing the remaining connected holding-down bolts to fail in tension prior to the pier toppling under the effects of a 45-degree flood loading and debris raft. Calculations indicate the mass of the pier exceeds the combined tensile capacity of the beam holding down bolts, so this mode of failure seems viable. It is also considered highly likely that the holding-down bolts that remain connected have suffered some corrosion and/or wear over the last ~90 years resulting in some minor section loss to these elements and a further reduction in holding down bolt strength.

So how does the pier drop vertically?
Driven piles in non-cohesive riverbed materials are driven to a required "set" or load resistance. This resistance is achieved through a combination of skin friction along the shaft of the pile and end bearing at the tip.
As the riverbed material around the piles is scoured out there is an increasing reduction in skin friction resistance. As more and more bed material is lost at the top the piles become increasingly reliant on end bearing. End bearing on its own is insufficient to support the combined weight of the pier and superstructure and the piles start to sink into the riverbed. As the pier drops vertically the beam ends butt together and lock off against each other, with the train tracks above the beams acting as continuous tension members. This results in the pier being suspended momentarily from the superstructure until the remaining connected holding-down bolts fail in tension. Once the fixity at the top of the pier is lost the resultant reduction in axial load on the piles reduces their bending and shear capacity and the increased lateral flood loading (caused by the 45-degree angle of river flow) topples the pier snapping the precast piles about the pier's weakest axis.

Recommendations

- In accordance with current best practice, the asset owner implements a scour inspection and monitoring regime for this bridge, with immediate emphasis on the remaining piers that already exhibit exposed piles. Refer KiwiRail's Structure Inspection Standard, Issue No.1, 2024 (Doc Ref: B-ST-GE-3040).
- Consider in-stream modifications, such as the installation of riprap, around affected piers to protect them from further scour.

Please do not hesitate to contact the undersigned if you have any queries.

Yours sincerely

Stantec New Zealand

[redacted]

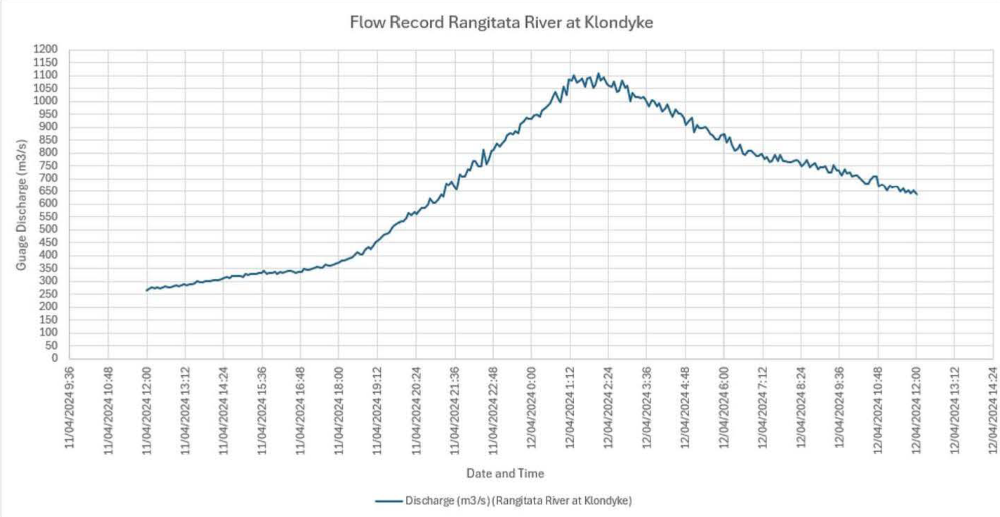


Figure 7: Chart of Rangitata at Klondyke, ECan flow gauge data at time of pier failure. ECan disclaimer: Provisional information has not yet been checked fully using the Council's Quality Assurance audit procedures.

Appendix 2 KiwiRail Track Inspection Standard sections

13. Inspection of other Disciplines Assets

The competent person completing a Basic Visual Inspection or Detailed Inspection is to undertake a general inspection of infrastructure maintained by other engineering disciplines.

Any defects noted during the inspection must be reported immediately to Network Control if they require action within seven days or if not urgent within seven days of the inspection to the Field Engineer managing that asset so that discipline gangs or inspectors can follow up. All defects noted are to be recorded on the M125 track inspection form. The following table is an example of defects that may be observed however this is not an exhaustive list:

Track Standard: T-ST-IN-5109 **Issue 2.0**

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Track Inspection KiwiRail

Table 13.1 Example of defects

Structures	Civils	Signalling	Traction and Electrical
Damage to any structure component or potential risk of damage, any debris build-up around piers and/or scour risks	Falling debris or vegetation in cuttings or on embankments	Damage to signalling equipment at point ends	Loose bonds or other cables showing signs of heating, burning or melting
Rail vehicle strikes on tunnels and other structures	Any blockage to line side drains or culverts	Damage to signal posts, location cases, IJ's or line side signs	Any items hanging from overhead line equipment
Structures where a loss of ballast is being observed	Areas of flooding or washouts	Level crossing tests of equipment (if agreed and included as part of inspection plan)	Damage to T&E signage
Structures over roads where spillage of ballast may cause damage or injury to the public	Areas showing sign of slope instability for both cuttings or embankments	Damage to signal cabling	Masts leaning out of verticality or appear to be damaged
Poor alignment over bridge potentially caused by structure movement	Damage to river and coastal protection assets	Damage to level crossing equipment such as barriers and signs	Vegetation encroachment near electrification system

16.14.2 Inspection following adverse weather

Information on the reporting and declaration of severe and adverse weather conditions is located in the Rail Operating Rules and Procedures section 1 Rule 6.

In certain areas information contained in the local and train control instructions may need to be considered.

Information contained in the RORP may be changed at any time by semi-permanent bulletin, it is the responsibility of rail personnel to ensure that they read and understand all current bulletins affecting them.

The essential features list for the section of track being inspected must be used as a reference to locate previously identified issues and decide when inspections should take place.

Special inspections throughout a route and/or at known risk areas may be required after periods of adverse weather and inspection staff nominated for these should be checking for the signs shown in the following table.

If any serious defects are noted during the inspection the inspector must take suitable actions to ensure the safety of line (ie impose a temporary speed restriction or block the line).

Appendix 3 KiwiRail Structures Inspection Manual extracts

Signs to Look For:

- Check for signs of pile settlement – is the track out of line at any bridge pier? Is there a gap between timber pile and cap when the bridge is unloaded? Check ground around pile for signs of lateral movement. Does any pile appear to be pumping? (Fine sands or mud around the pile can indicate pumping).

- Check for deterioration and decay in timber. Check for loose fastenings, worn holes, splits in the pile head. Measure the minimum pile diameter and check with previous report. Look for worm and borer attack in marine areas.

- Check for dry brush and similar material around timber piles. Is it a fire risk?

- Check for concrete cracking, spalling, wastage and deterioration. Check for drummy concrete. Look for corrosion and loss of section in exposed reinforcing steel.

- Check for signs of a broken pile. Does it appear to be out of line? Are any fastenings loose or bent in a timber pile? Is the junction between concrete pile and cap damaged?

- Check for damage to the visible parts of caissons. Some old caissons may have cast iron or steel liner plates, which can fracture. If the pile has weak concrete or rubble in-fill, cracked or broken plates are a structural weakness.

- Check the depth marks (if any) on piles. Is the waterway lower than the indicated founding level? Is this of any concern?

- Check for evidence of scour. Does the stream bed look active? Is there any tendency for the river to meander or erode laterally? Is there any debris caught up in the piles? Has the river bed cross section changed since the last inspection?

abutments. Waterway banks can slump after a period of high flow – this is because the saturated soils in the bank are less stable than in their drained condition. Such slumping is known as a *drawdown* failure.

Signs to Look For:

- Check that the control or protection work appears to be doing the job required of it. Does the structure look to be in the right place? Is the bridge or railway embankment currently unaffected by scour? Has the river changed course significantly since the last inspection?
- Check the integrity and stability of river control works, particularly after major floods. Look for displaced and missing rock, damaged rails, broken tie wires, uprooted trees etc.
- Check that weirs are sound and are performing adequately. Observe whether there have been and significant bed level changes in the vicinity of the weir or the bridge.
- Check that the waterway in the immediate vicinity of the structure is stable and clear of debris. Look for signs of excessive debris being carried by the stream following upstream vegetation clearance work.

Kōwhaiwhai - Māori scroll designs

TAIC commissioned its four kōwhaiwhai, Māori scroll designs, from artist Sandy Rodgers (Ngāti Raukawa, Tūwharetoa, MacDougal). Sandy began from thinking of the Commission as a vehicle or vessel for seeking knowledge to understand transport accident tragedies and how to avoid them. A 'waka whai mārama' (i te ara haumaru) is 'a vessel/vehicle in pursuit of understanding'. Waka is a metaphor for the Commission. Mārama (from 'te ao mārama' – the world of light) is for the separation of Rangitāne (Sky Father) and Papatūānuku (Earth Mother) by their son Tāne Māhuta (god of man, forests and everything dwelling within), which brought light and thus awareness to the world. 'Te ara' is 'the path' and 'haumaru' is 'safe' or 'risk free'.

Corporate: Te Ara Haumaru - the safe and risk free path

The eye motif looks to the future, watching the path for obstructions. The encased double koru is the mother and child, symbolising protection, safety and guidance. The triple koru represents the three kete of knowledge that Tāne Māhuta collected from the highest of the heavens to pass their wisdom to humanity. The continual wave is the perpetual line of influence. The succession of humps represents the individual inquiries.

Sandy acknowledges Tāne Māhuta in the creation of this Kōwhaiwhai.

Aviation: Ngā hau e whā - the four winds

To Sandy, 'Ngā hau e whā' (the four winds), commonly used in Te Reo Māori to refer to people coming together from across Aotearoa, was also redolent of the aviation environment. The design represents the sky, cloud, and wind. There is a manu (bird) form representing the aircraft that move through Aotearoa's 'long white cloud'. The letter 'A' is present, standing for a 'Aviation'.

Sandy acknowledges Ranginui (Sky father) and Tāwhirimātea (God of wind) in the creation of this Kōwhaiwhai.

Maritime: Ara wai - waterways

The sections of waves flowing across the design represent the many different 'ara wai' (waterways) that ships sail across. The 'V' shape is a ship's prow and its wake. The letter 'M' is present, standing for 'Maritime.

Sandy acknowledges Tangaroa (God of the sea) in the creation of this Kōwhaiwhai.

Rail: rerewhenua - flowing across the land

The design represents the fluid movement of trains across Aotearoa. 'Rere' is to flow or fly. 'Whenua' is the land. The koru forms represent the earth, land and flora that trains pass over and through. The letter 'R' is present, standing for 'Rail'.

Sandy acknowledges Papatūānuku (Earth Mother) and Tāne Mahuta (God of man and forests and everything that dwells within) in the creation of this Kōwhaiwhai.

Transport Accident Investigation Commission

Recent Rail Occurrence reports published by the Transport Accident Investigation Commission (most recent at top of list)

RO-2025-103	Mainline shunt, Train 170S, Signal passed at danger and near miss with passenger train, Westfield, Auckland, 1 February 2025
RO-2025-102	Y20 shunt, runaway rail vehicle collision and near miss with rail crew, Port Chalmers, Dunedin, 23 January 2025
RO-2024-104	Freight train MR1, Signal passed at danger and near miss with HRV, Kereone Station, 2 August 2024
RO-2025-101	Train 931, safe working irregularity, 553.82 km Main South Line, Mataura, 12 January 2025
RO-2023-105	Derailment of Tamper 703, Purewa tunnel, Auckland, 9 October 2023
RO-2024-102	Freight Train 882, near miss with track workers, Main South Line, Hornby 27 km, 7 March 2024
RO-2023-106	Passenger train 804, TranzAlpine, train parting, Arthur's Pass, 17 December 2023
RO-2024-101	Loaded coal train 850, signal passed at danger, Cora Lynn, Midland line, 27 February 2024
RO-2023-104	Passenger train (Te Huia) signal passed at danger and potential conflict, Penrose, Auckland, 17 June 2023
RO-2021-104	Passenger train 6205, train derailment, Kāpiti, 17 August 2021
RO-2023-102	Freight train 360, derailment, Te Puke, 29 January 2023
RO-2023-101	Hi rail vehicle collision near Te Puna, 86.43 km East Coast Main Trunk Line, 10 January 2023
RO-2023-103	Safe working irregularity, 3.85km, Johnsonville line, tunnel 5, 4 May 2023
RO-2022-104	Shunt train L51 and heavy goods vehicle, level crossing collision and derailment, Whangārei, 7 December 2022
RO-2022-102	L71 Mainline Shunt, derailment and subsequent rollover, Tamaki, 1 June 2022

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