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Dunedin City Council
DCC Landslide Monitoring Report

Puketeraki Landslide

23 February 2026

6-CD109.A9

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Puketeraki Landslide

Dunedin City Council

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1 INTRODUCTION

WSP New Zealand Limited (WSP) was engaged by Dunedin City Council (DCC) to undertake a geological site walkover and an Unmanned Aerial Vehicle (UAV) survey of the Puketeraki Landslide as part of the LTES Long-term Landslide Monitoring project. The scope of services is presented in the WSP Offer of Service dated 6 October 2025, and is summarised below;

- Conduct a site walkover to identify any geological features related to land movement or notable observations
- Undertake an UAV survey and create an aerial image to aid in feature mapping
- Compile site observations and UAV information into a site-specific report with a high-level interpretation of the geologic setting

The inspection was undertaken by Ben Winmill (Engineering Geologist) and David Moffat (Surveyor) on 27 January 2026. The inspection was limited to a site walkover within the Otago Regional Council's (OCR) defined landslide boundaries, and an UAV survey.

This report summarises the inspection observations, presents an interpretation on the mode of failure, ground condition observations, and provides a qualitative risk assessment of the Puketeraki Landslide.

2 SITE DESCRIPTION

The Puketeraki Landslide ('the site') is located near Karitane, approximately 25 km north of Dunedin Central Business District (CBD). The site is in a rural area surrounded by farmland and hillsides, with the Main South Line located at the toe of the landslide. The approximate extent of the landslide is annotated in Figure 1.

The landslide is ~1.5 km in length and is ~800 m wide within the "definite" landslide probability (pink) as assigned by the Otago Regional Council's natural hazards database[1].

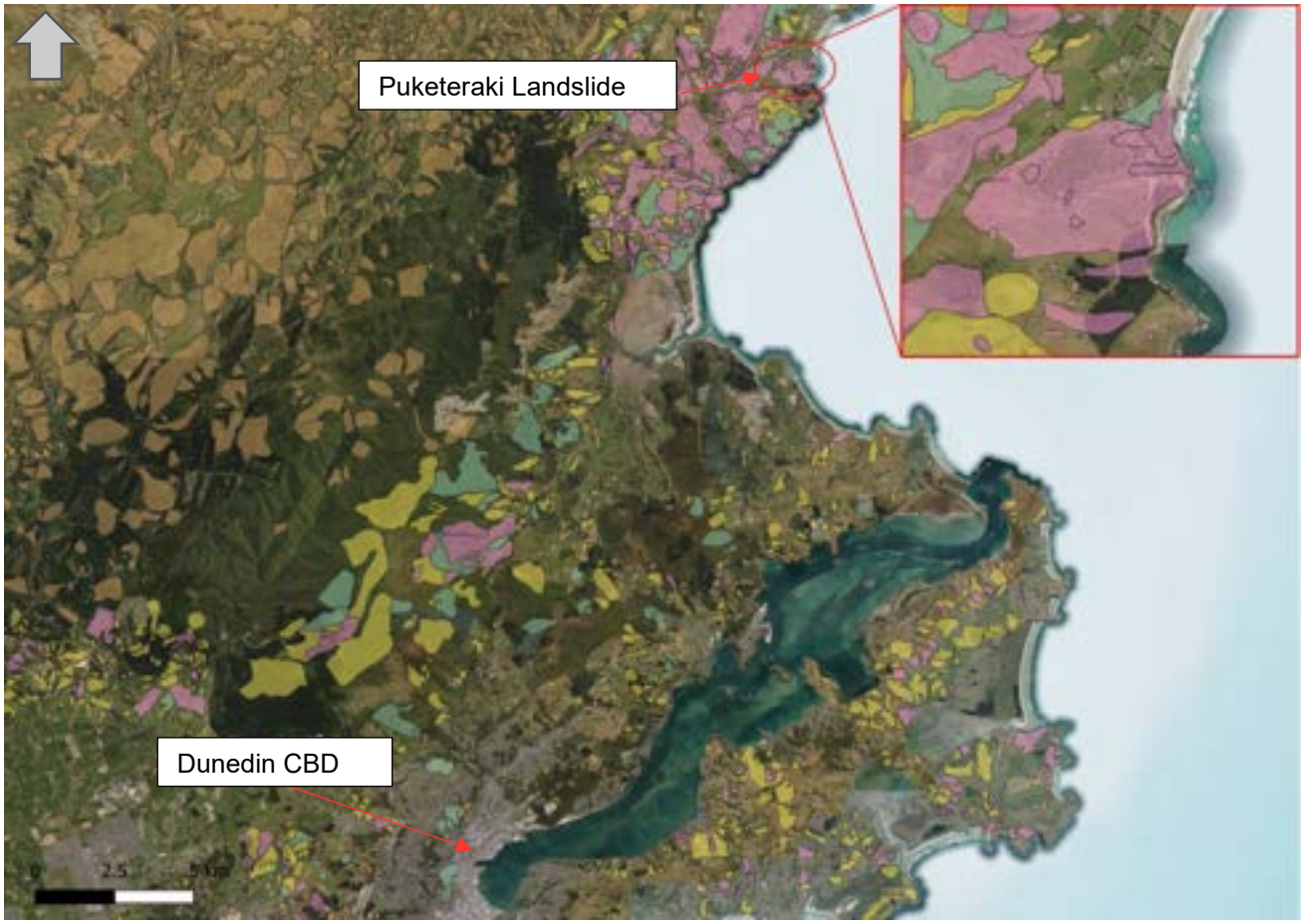

Figure 1 : Location of the Puketeraki Landslide, with reference to Dunedin CBD.

[1] Otago Natural Hazards Portal

3 GEOLOGY

3.1 REGIONAL GEOLOGY

The geology of the Otago Region comprises a complex arrangement of Mesozoic schist basement and Miocene shield volcanism, with erosional surfaces and Quaternary sedimentary deposits interspersed. Puketeraki Landslide is located in the North Otago Sedimentary Sequence, with a thin layer of Quaternary-aged Loess blanketing the region[2].

3.2 LOCAL GEOLOGY

The published Geology Map (1:250,000 Map)[2] (Figure 2) indicates that the landslide is largely located in Undifferentiated Otakou Group sandstone, which is comprised of “Blue-grey siltstone sandstone and carbonaceous mudstone in shallowing-up sequence (north of Waihemo Fault Zone); outer shelf sandstone and impure limestone further south”.

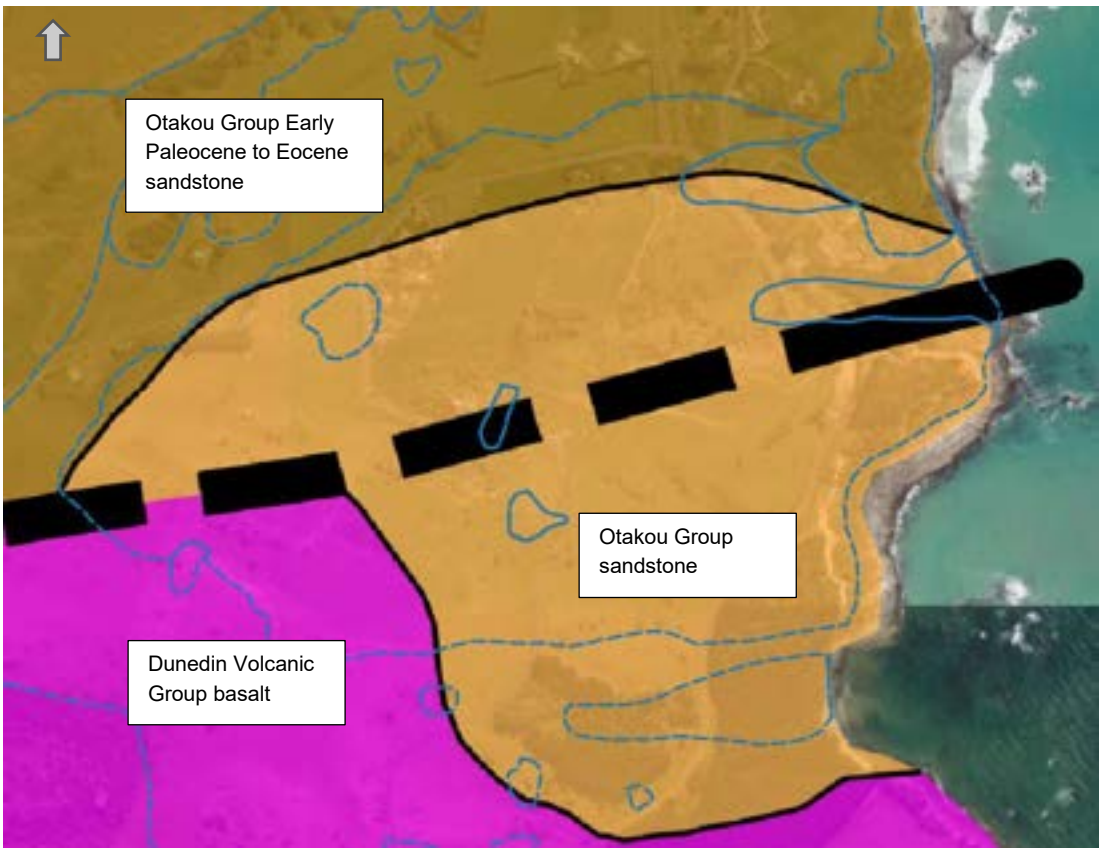

Figure 2: Geology as indicated by GNS with the outline of definite landslides in blue dashed lines. The thick black line indicates an inferred fault trace

A small northern section of the landslide boundaries falls within the Undifferentiated Onekara Group Early Paleocene to Eocene sandstone, comprised of “Quartzose and glauconitic sandstone, siltstone, shell beds

[2] Geology 2.0.0

and limestone". The southwest corner of the landslide falls within Dunedin Volcanic Group basalt described as "Alkali basalt lava flows, plugs, agglomerate, tuff and shallow intrusions including those offshore, dikes".

3.3 TOPOGRAPHY AND SLOPE ANGLE

For the Puketeraki landslide, the topography is a mix of gentle and steeply sloping farmland which has remained unchanged for several years. The average slope angle of this farmland (derived from the UAV data) is ~28 degrees to the horizontal. The surrounding area exhibits a general topography comprising of slopes at estimated angles of 20 – 40 degrees to the horizontal. A semi-vertical cut face at the toe of the landslide allows for a continuous railway line.

3.4 ACTIVE FAULTS

No active faults are noted within 50 km of the site. The GNS Geology Web Map indicates a potential fault trace that passes through the site, however there is no information regarding this fault expression in Figure 2. Given the distances of active faults from the site, the risk of associated ground movements at the site in the event of a rupture is considered to be 'low'.

4 INSPECTION OBSERVATIONS

The site visit was undertaken in overcast conditions with Dunedin experiencing 46 mm in the previous 72 hrs[3].

After the recent rainfall, the majority of the site's ground conditions remained moist to saturated at the time of the site visit. Inspection observations were limited to a site walkover and UAV survey. Two distinct geological units were observed whilst onsite, one being vent breccia isolated at the top of conical hills and the remainder of the surrounding area was largely bioclastic limestone.

Several areas of past movement were evident, in the form of circular slumps and displacement of lithological units.

The tension cracks and damage previously identified along Coast Road during the last site visit have been repaired. However, new tension cracks have developed within the recently repaired section of road (refer to Photograph 10, Appendix B).

The saturated ground conditions observed on site included an area of soil pugging and surface water. Two ponds that appeared following the 2024 rainfall event have now dried up. Anecdotal evidence from the landowners indicates a series of springs appear in the area to the west that fluctuate depending on rainfall conditions.

A difference in topography was noted in the middle of the site, where large vertical deformation had occurred. A height difference of approximately 2-3 m between blocks was noted along the trace of the inferred fault shown in Figure 2 (refer to photograph 15, Appendix B).

Land affected by the 2024 rainfall event along the KiwiRail Main South Line has been remediated and contoured in an attempt to control water runoff in future high rainfall events (refer to photographs 16 and 17, Appendix B)

A preliminary engineering geological map of the identified geological site features is included in Appendix A, with a photographic log in Appendix B.

4.1 PRELIMINARY MAPPING

Landslide mapping can aid the decision around avoidance, prevention or mitigation of the existing and future landslide hazards. Notable observations have been compiled into a preliminary map provided in Appendix A and used to inform the risk assessment for this report. An outline of the risk assessment methodology is discussed in Section 5.

The close proximity of residential dwellings to the landslide and the KiwiRail Main South Line are the main drivers of the mapping, to inform the risk assessment below.

4.2 SLOPE FAILURE MECHANISM AND EXTENT

The primary drivers of landsliding are the slope angle and topography of the slope, driven by gravity along with reduction in friction driven by groundwater. The modification of the landslide toe for railway developments (tunnel and trunk line) has the possibility to destabilise the slope above.

The movement appears to be a complex slide, mass moves along a roughly planar surface to a shallow depth (surficial material and upper bedrock). However, the exact mechanism was unable to be constrained with the limited observations made onsite and the large extent of the area encompassed by this landslide.

[3] ORC's Data portal ID Pine Hill

5 RISK ASSESSMENT

Based on the findings of the site assessment the landslide is active, with the majority of the survey marks having moved >50 mm in the previous 12 months. This movement, along with the large site area, and the complexity of the region, makes the future behaviour of the landslide difficult to constrain.

On this basis the following risk assessment has been derived. It is important to note that this risk assessment is limited to the boundaries of the Puketeraki “Definite” Landslide as per the scope of this project. The assessment produced below is qualitative only and mainly reliant on published information, site observations and cumulative survey results.

5.1 QUALITATIVE RISK ASSESSMENT

A qualitative risk assessment has been undertaken to determine the risk of landslide instability to the safety of residential dwellings, rail and road users, and farmland. The assessment considers factors such as soil conditions, geological features, historical ground movements, downstream developments and nearby hazards.

This assessment is based on a qualitative methodology guided by AGS (2007) Guidelines for Landslide Risk Management[4] and provides a framework for evaluating risks through observable features.

The risks have also been assessed under both the ‘normal operating conditions’ and ‘extreme conditions’. The extreme conditions are considered to be as follows:

- A heavy rainfall event, typically defined by the Otago Regional Council (ORC) as rainfall exceeding 40 mm in a 24-hour period or 60 mm in a 48-hour period.
- A seismic event of sufficient intensity (typically considered to be an Ultimate Limit State (ULS) shaking event in Dunedin).

Additionally, partial failure and full failure scenarios of the landslide are considered to be as follows:

- A partial collapse refers to a situation where only a portion of the landslide mass moves or fails (i.e. localised failures).
- A full collapse involves the complete failure of the landslide mass, resulting in a more significant movement of material.

5.1.1 LIKELIHOOD

The assessment involves the evaluation of likelihood, which considers geomorphological features, historical movement and observable features indicative of ground movement.

We estimate the likelihood of the scenarios as follows:

- The partial collapse (localised failure) under normal operating conditions has an ‘Unlikely’ likelihood of occurrence
- The partial collapse (localised failure) under extreme operating conditions has a ‘Possible’ likelihood of occurrence
- The full collapse (complete failure) under normal operating conditions has an ‘Unlikely’ likelihood of occurrence

[4] Australian Geomechanics Volume 42 No 1 March 2007 "Practice Note Guidelines for Landslide Risk Management 2007"

- The full collapse (complete failure) under extreme operating conditions has an ‘Possible’ likelihood of occurrence

Table 1: Risk likelihood categories from AGS (2007). Red dashed line represents partial collapse scenario, and red highlighted represents full collapse scenario

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	Notional Boundary					
10^{-1}	$5x10^{-1}$	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	$5x10^{-2}$	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-3}$	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-4}$	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-5}$	100,000 years	200,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}		1,000,000 years		The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

5.1.2 CONSEQUENCE

When assessing consequences, consideration for potential impacts to infrastructure and road users are considered. We estimate the consequences categories for the scenarios as follows;

- The partial collapse scenario may have ‘Minor’ damage.
- The full collapse scenario may have ‘Medium’ to ‘Major’ damage.

Table 2: Risk consequence categories from AGS (2007). Red dashed line represents partial collapse scenario, and red highlighted represents full collapse scenario

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	Notional Boundary			
200%		Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	100% 40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

5.1.3 RISK

For the purpose of this assessment, we have only considered risk to the health and safety of the following:

1) Inundation or potential loss of function of the KiwiRail main line, and damage to Coast Road impacting on driver safety and travel delays.
2) Damage to farmland or dwellings in the downstream vicinity of the landslide.

The resulting level of risk to property at the site is presented in Table 3 and is summarised as follows:

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	1: CATASTROPHIC 200%	2: MAJOR 60%	3: MEDIUM 20%	4: MINOR 5%	5: INSIGNIFICANT 0.5%
A - ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or L (5)
B - LIKELY	10^{-2}	VH	VH	H	M	L
C - POSSIBLE	10^{-3}	VH	H	M	M	VL
D - UNLIKELY	10^{-4}	H	M	L	L	VL
E - RARE	10^{-5}	M	L	L	VL	VL
F - BARELY CREDIBLE	10^{-6}	L	VL	VL	VL	VL

Table 3: Property risk matrix from AGS (2007). Red dashed line represents partial collapse scenario, and red highlighted represents full collapse scenario

RISK LEVEL IMPLICATIONS

Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

With the above considered, the risk assessment results are presented in Table 4 below.

Table 4: Risk assessment findings

Hazard	Likelihood	Consequence	Risk Level
Partial Failure – Normal Operating Conditions	Unlikely	Minor	**Low**
Full Failure – Normal Operating Conditions	Unlikely	Medium to major	**Low to Moderate**
Partial Failure – Extreme Conditions	Possible	Minor	**Moderate**
Full Failure – Extreme Conditions	Possible	Medium to major	**Moderate to High**

6 CONCLUSIONS AND RECOMMENDATIONS

- The Puketeraki landslide is a large landslide that in the event of failure has the potential to affect rail services as well as farmland and scenic road access.
- The landslide appears to be active with the majority of the survey marks having moved >50 mm in the previous 12 months.
- There is active localised landsliding across the larger landslide area, and areas that are likely to have been affected by minor faulting.
- Groundwater ponding and gradual release of ground stress over time are evident across the site.

Considering the risk posed by the Puketeraki Landslide the following is recommended

- Continue with scheduled monitoring every 12 months, unless there is a significant rainfall or seismic event.
- A site-specific report every two years including more detailed field mapping.
- Due to the medium to high risk of full failure under normal conditions the installation of a remote landslide monitoring system such as GNSS sensor monitoring should be considered.

7 LIMITATIONS

This report (‘Report’) has been prepared by WSP exclusively for Dunedin City Council (‘Client’) in relation to the landslide monitoring at selected sites in Dunedin (Landslide Monitoring Long-Term SoW DCC Reference 9662). The scope of this Report is to present the survey monitoring results and recommendations for future surveys for the site (‘Purpose’). The findings in this Report are based on and subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

In preparing this Report, WSP has relied upon data, surveys, analyses, designs, plans and other information (‘Client Data’) provided by or on behalf of the Client. Except as otherwise stated in this Report, WSP has not verified the accuracy or completeness of the Client Data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in this Report are based in whole or part on the Client Data, those conclusions are contingent upon the accuracy and completeness of the Client Data. WSP will not be liable for any incorrect conclusions or findings in the Report should any Client Data be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to WSP.

APPENDIX A

PRELIMINARY OBSERVATIONS / UAV MAP


N
Ponding from October 2024 rainfall has dried up
Saturated ground conditions (potential expressions of groundwater/springs?)
Remediation work by KiwiRail after the 2024 rainfall event (refer photographic log)
Tension cracks appearing in recent road repair (refer photographic log)
Limestone and volcanic agglomerate outcrop
Fence posts on a lean
Natural watercourse
Approximately 2-3 m vertical difference between upper and lower block, that extends a further 3 m bgl. decreases eastward
Dislocated block
Volcanic breccia / conical vent
0
100
200 m
Legend
Observed slump
Inferred slump
Observed watercourse
Inferred watercourse
Tension crack / fissure
Direction of movement

APPENDIX B

PHOTOGRAPHIC LOG

PHOTOGRAPHIC LOG

Client Name	Site Location	Project No.
Dunedin City Council	Puketeraki Landslide	6-CD109.A9

Photograph No.	Date
1	27/01/2026

Description

View of Puketeraki look out. Image taken facing northeast above Coast Road

Photograph No.	Date
2	27/01/2026

Description

Small slump forming in farmland opposite Coast Road. Image taken facing north

	PHOTOGRAPHIC LOG	
Client Name Dunedin City Council	**Site Location** Puketeraki Landslide	**Project No.** 6-CD109.A9

Photograph No.	**Date**
3	27/01/2026

Description

View of recent scarps from the 2024 rainfall event (red circle). Image taken facing southwest

Photograph No.	**Date**
4	27/01/2026

Description

Puketeraki Landslide main scarp identified in red circle. Rotational slide in foreground (ORC Landslide ID: 101416). Image taken facing south

	PHOTOGRAPHIC LOG	
Client Name Dunedin City Council	**Site Location** Puketeraki Landslide	**Project No.** 6-CD109.A9

Photograph No.	**Date**
5	27/01/2026

Description

Image of headscarp observed in Photograph 4 above, in volcanic agglomerate.

Photograph No.	**Date**
6	27/01/2026

Description

T Slump above Coast Road. Image taken facing northeast

	PHOTOGRAPHIC LOG	
Client Name Dunedin City Council	**Site Location** Puketeraki Landslide	**Project No.** 6-CD109.A9

Photograph No.	Date
7	27/01/2026

Description

Slump above Coast Road. Image taken facing north

Photograph No.	Date
8	27/01/2026

Description

View of main scarp (background) off Puketeraki. Image taken facing southwest

	PHOTOGRAPHIC LOG	
Client Name Dunedin City Council	**Site Location** Puketeraki Landslide	**Project No.** 6-CD109.A9

Photograph No.	**Date**
9	27/01/2026

Description

View of repaired section of Coast Road after damage caused by the October 2024 rainfall event

Photograph No.	**Date**
10	27/01/2026

Description

Close up of tension cracks forming in the repaired section of Coast Road from Photograph 9 above.

	PHOTOGRAPHIC LOG	
Client Name Dunedin City Council	**Site Location** Puketeraki Landslide	**Project No.** 6-CD109.A9

Photograph No.	**Date**
11	27/01/2026

Description

Fence posts above the road repair on a lean.

Photograph No.	**Date**
12	27/01/2026

Description

View of dislodged block. Image taken facing west

	PHOTOGRAPHIC LOG	
Client Name Dunedin City Council	**Site Location** Puketeraki Landslide	**Project No.** 6-CD109.A9

Photograph No.	**Date**
13	27/01/2026

Description

Close up of fossiliferous limestone observed in photograph 11.

	PHOTOGRAPHIC LOG	
Client Name Dunedin City Council	**Site Location** Puketeraki Landslide	**Project No.** 6-CD109.A9

Photograph No.	**Date**
14	27/01/2026

Description

Block slumping and exposure of slope (lower end of field area).

Photograph No.	**Date**
15	27/01/2026

Description

Block slumping and exposure of slope along the trace of the inferred fault.

	PHOTOGRAPHIC LOG	
Client Name Dunedin City Council	**Site Location** Puketeraki Landslide	**Project No.** 6-CD109.A9

Photograph No.	**Date**
16	27/01/2026

Description

Remedial works taken place after the October 2024 rainfall event along the KiwiRail Main South Line

Photograph No.	**Date**
17	27/01/2026

Description

Closer view of the remedial works along the KiwiRail Main South Line