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Client: NX2 LP

Pūhoi To Warkworth (P2Wk)– Landslide Risk Assessment

# Geotechnical Review of Cut Slopes and Landslide Risks

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Revision E

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# EXECUTIVE SUMMARY

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s 9(2)(b)(ii) and 9(2)(ba)(i) has been engaged by Northern Express Group (NX2) PL to provide a geotechnical landslide risk assessment for the Pūhoi to Warkworth (P2Wk) project.

The earthworks construction of the P2Wk project commenced in 2017. During and after completion of cut slope excavations multiple landslides occurred at various locations of the project site since late 2019. The initial scope of s 9(2)(b)(ii) review scope comprised 19 locations of landslides.

Slope failures continued to occur into late 2022, some of which are either under repair or remedial work designs are yet to be confirmed. The 2023 Auckland Anniversary rainfall event and Cyclone Gabrielle caused further soil slope failures and topsoil slips.

This report summarises our review of geotechnical site observations and findings based on a desktop study and provides an assessment of likelihood of geotechnical and cut slope stability failures and risk assessment. This report has been developed and updated to incorporate additional information, particularly regarding the slope failures which occurred since 2022 and the rockfall risk assessments.

This report is submitted as the final report (Revision E). Previous draft reports were issued for comments in November and December 2021, and February and April 2022. The previous reports were prepared utilising the provided documents and site observations until December 2021 and the findings from our site observations dated until 12 November 2021.

This assessment includes the review of additional remedial works designs, Design Engineer Instructions (DEI), review of Non-Conformance Reports (NCR) and four additional site observations. The assessment presented in this final report Revision E is valid based on the provided information at the time of writing the report.

Post issue of the draft report (Rev A) in November 2021, further meetings were held with representatives of NX2 and the CJV. We also received feedback on the draft report (Rev A) and additional information regarding rockfall trials and rockfall simulations carried out in March 2019, June 2019, August 2021 and March 2022.

The initial rockfall trials comprised two sets of trials (CN7 West and CS16D East) to verify rockfall below the rock mesh drapery at the 85-degree steep rock cut slopes and rockfall simulations for the 85-degree steep rock cut at Cut CS16D. Further rockfall simulations were carried out for the upper 2H:1V rock exposures at Cut S1. In addition, rockfall trials and simulations for the upper 2H:1V exposed rock slopes at Cut CS3 were prepared by the CJV in various reports dated 25 March 2022. A summary of the provided rockfall trials and simulations is given in Section 1.10.5.



This revision D report includes our review of the rockfall trials and assessment analyses which were provided in December 2021 and March 2022. The additional rockfall assessments provided by the CJV allowed to reduce the rockfall risk to low.

The construction works at the Pūhoi to Warkworth (P2Wk) project are near completion and any future or remedial works which is not documented (or where documents have not been provided to us) have not been assessed. Therefore, the final risk assessment utilises the information available to date.

Remedial works are required at three cut slopes, Cut N1A, Cut CN12B and Cut CS13.

We have undertaken an independent geotechnical review of all cut slopes of the P2Wk which are adjacent to permanent SH1 motorway alignment. The review and risk assessment are based on the following items:

- Geotechnical design reports and construction drawings for ground improvements,
- Geological maps and cross sections and selected site-specific geotechnical investigations,
- Geometrical alignment design sections,
- Limited site observations during our 7 site visits from February 2021 to February 2023,
- Review of aerial photos and drone flyover videos,
- Remedial designs included in the Design Engineer Instructions (DEI),
- Non-Conformance Report (NCRs)
- Slope movement monitoring and piezometer monitoring data where available,
- Peer review reports prepared by PSM.
- Rockfall trials and rockfall analysis assessments.

We note that our review does not comprise or substitute a peer review and we have not carried out independent geotechnical analyses.

The report provides a summary of the likely causes of the landslides, and likelihoods of potential future landslips at cut slopes, associated risks and recommendations on possible mitigation measures that could be explored.

Our assessment includes cut slopes where landslides have occurred and cut slopes where (to our knowledge) failures have not yet occurred. As part of our assessment, we reviewed 48 cut slopes (each side of the alignment) which are adjacent to the future SH1 alignment or where slope failure may have adverse impacts on the SH1 alignment.

It should be noted that where a landslip occurred not necessarily all of the cut slope was affected. In order to determine the potential future likelihood and associated risks of landslides that occurred, we needed to understand which aspects caused the existing landslides.

Where landslides occurred, the following possible main causes were identified:

1. Unfavourably orientated bedding fabric dipping (may even be gently) out of the slope,



2. (Multiple) softened shear planes with clay infill as orientated parallel to bedding fabric between the completely weathered and highly weathered Pakiri Formation rock interface,
3. Softened shear planes which are stratified, planar, polished and saturated.
4. Sub horizontal bedding dipping obliquely out of the slope,
5. Multiple (at least two) sets of moderately to steeply inclined joints,
6. Evidence of historic complex, shallow-seated or deep-seated landslide activity within the cut slope, including large scale historic block sliding,
7. Colluvial material within the cut slope,
8. Saturated material above the soil/rock interface,
9. Groundwater relatively close to surface with ongoing seepage observed during construction,
10. High groundwater pressures during construction,
11. Toe unloading due to proposed cut,
12. Presence of damaged stormwater drains discharging into the head of the slope. It is noted that based on our site observation dated 2 November 2021, it appears that recharge of groundwater into the back of the slopes remains an ongoing issue at Cut CN5A and may have caused the slip in November 2021. The remedial works at this location are now completed.
13. Prolonged and heavy rainfall causing surficial erosion, saturation of the ground and increase of groundwater levels.
14. Geology and ground conditions are not fully understood and the design solution may not be suitable at the cut slope.

This report and reviews focus primarily on the soil slope failure above the rock cuts. However, the long-term stability and performance of the rock cuts likely have profound impact on potential future maintenance aspects.

Remedial works designs for the soil slope landslides comprised the following mitigations measures:

- Removal of slipped material,
- Laying back of cut slopes from 2H:1V to typically 3H:1V or 4H:1V, or as required,
- Installation of counterfort drains,
- Installation of horizontally bored subsoil drains,
- Installation of cut-off drains,
- Placement of shear keys and buttress fill within the cut slopes,
- Wider rock benches at the soil-rock interface,

At cut slopes where landslides have occurred, either of the following items were completed to support the remedial design solutions:

- Additional geotechnical investigations,
- Additional geological site mapping,
- Topographical survey of as-built slopes and groundwater monitoring,
- Remedial works designs including design reviews.



However, there could be a perceived optimistic assurance that these cut slopes have no future risk of landslides. Reasons are that some landslides occurred only at specific locations at these cut slopes and remedial works were only carried out at the failed parts of the cut slopes. Nevertheless, it appears that the landslides occurred at the highest cut section and nearby likely have a lower risk.

We also note that the designs and peer review rely on the design sections at specific locations utilising models and slope stability analyses to determine the slope stability factors of safety. There is a remaining risk that design models do not capture accurately the conditions on site.

We have identified the following key risk items with regards to future failures and maintenance requirements:

1. Soil slope slips where design models potentially not represent the site conditions adequately. This includes over-steepened soil slopes, i.e. constructed slopes are steeper than the design slopes.
2. Geological models adopted in the design are not fully representative of the geological conditions in the site, i.e. bedding plane direction and properties of the bedding shears.
3. Locations were the alignment transitions from embankments into cut slopes. The side slopes at the transition are over-steepened and may be prone to failure.
4. Insufficient inspection and maintenance intervals of slope drainage systems, which could compromise the slope stability,
5. Locations of softened ground (soil, weathered rock, fill) caused by groundwater seepage or surface water run-off.
6. Rockfall risk from slopes above mesh drapery. Rockfall risk may results from rock debris on exposed rock slopes and deterioration from constructed buttress fill.
7. Rock cut failures particularly where overhanging rock cuts is present.
8. Surficial failure rock slopes and rockfall behind mesh draping and/or subsequent wedge failures at rock cut slopes between rock bolts or at locations without rock bolts,
9. Unsuitable remedial works design, potentially not addressing the underlying geological issue or being a potential hazard itself, i.e. buttress fill within cut slopes high above rock cuts.
10. Scour/erosion and debris flow from soil slopes or soil-rock interface above rock slopes. These conditions may cause a rock fall risk.
11. Topsoil slumps and surficial erosion.

For the risk assessment, six predominant failure modes are adopted from the items listed above. To determine the overall weighted risk at each cut slope, a weighting factor was applied to each of the six failure modes:

- Soil slope failure: Weighting factor 0.30 (30% contribution to overall risk rating at each cut slope)
- Sliding at soil-rock interface: Weighting factor 0.35 (35%)
- Rock slope failure (including wedge type failure): Weighting factor 0.15 (15%)
- Scour/ erosion at cut transition zone: Weighting factor 0.05 (5%)
- Rockfall: Weighting factor 0.10 (10%)
- Topsoil slips: Weighting factor 0.05 (5%)



The contribution of soil slope failures and sliding mechanism at the soil-rock interface to the overall weighted risk rating is 65%. At the previous revision D report, this factor was only 35%.

The summary table in Appendix A provides the individual and overall weighted ratings. Due to the weighted risk rating, an individual rating for one of the above failure modes may have a moderate to high risk rating, but the overall risk may be low.

We have assessed all cut slopes along the P2Wk alignment, including cuts where landslides have occurred and cuts where no failures were reported. Our assessment covers 49 individual cut sections which were reviewed separately at both sides of the alignment. A total of 98 risk reviews have been undertaken.

It should be noted that the length of cut sections varies from 60m (Cut N2D) to 670m (Cut CN1), therefore it is more likely that any of the above risk items occurs at the longer cut sections.

Likewise, not all of the above risk items occur at all cut locations or have different risk profiles.

Our risk assessment comprises six risk ratings:

- **Very low risk:** Not expected to occur and very low consequences
- **Low risk:** Unlikely to occur and low consequences
- **Low to moderate risk:** Low possibility of occurrence and moderate consequences
- **Moderate risk:** Possible to occur and moderate consequences
- **Moderate to high risk:** Likely to occur and moderate to high consequences
- **High risk:** Expected to occur with potential high consequences

A comparison of the occurrences of the risk ratings at each of the reviewed cut slope locations between previous Revision D and updated Revision E risk assessment is summarised in Table 1 below.

**Table 1: Risk Rating Summary**

Risk Rating	Revision D Assessment	Revision E Assessment
Very low Risk	21	51
Low Risk	64	26
Low to moderate Risk	4	14
Moderate Risk	3	2
Moderate to high risk	0	0
High risk	0	0
<b>Total</b>	<b>92</b>	<b>98</b>

The risk rating was adjusted from the initial revision A report to this latest revision E report. The amendments were as more information or observations were available.



The revision C report presented two 'moderate to high' and four 'high' risk locations for rockfall. The additional assessments and availability of rockfall trials and simulations as well as the other remedial works which were completed prior to the Revision D report allowed to reduce the risk profile at the time.

This assessment is consistent in this Revision E report.

An overall weighted low to moderate risk of failure or occurrence of risk items were determined at the following 14 cut locations. The change of risk rating is due to the change of weighting factors.

The reasoning for the assessment is provided for each cut location.

1. **N7A West:** As per previous revision D assessment. Ongoing groundwater seepage is observed at the lower slope. The initial landslide was caused by translation sliding on a softened clay seam, which could still present within the slope. The long-term performance may rely on the subsoil drainage system and/or potential maintenance. Blockage of subsoil drains could cause porewater pressure built up within the slope. Thus, subsoil drains need to be inspected during the design life of the cut slope.
2. **CN1 West:** Increased risk rating due to amendments of weighting factors.
3. **CN5A East:** The risk rating has been lowered from moderate risk due to performance of the cut over the last 12 months (since the issue of the revision D report) and the amendment of weighting factors.
4. **CN5B East:** The risk rating has been decreased, as per reasoning above.
5. **CN5B West:** The risk rating has been lowered from moderate risk, as per reasoning above.
6. **CN12B East:** The weighted rating has been increased due to the landslide and the ongoing slope movement. Also, it is understood that additional remedial works are proposed.
7. **CS2D East:** After the landslide occurred, the cut slope was cut back to a 2H:1V monoslope without lower steep rock cut slope. Apart from cutting back, no further remedial works were installed (i.e. no buttress or drainage) was proposed as part of the remedial works. An additional toe buttress was installed in October 2021 at approximately Ch57450-57500. The cause of the initial slip was daylighting of low angle shear plane. There could be a potential risk that the shear plane may be re-activated. We believe that the soil nail design as per DEI 0566 may not address the intended slope improvement.
8. **CS2F East:** Due to the amended of risk rating.
9. **CS5 East:** Due to ongoing and repetitive slope failures at the upper slope.
10. **CS9G:** As per previous assessment. Seepage and possible softened ground have been observed at north-western transition into the slope at approximately Ch60600 during our site visits on 12 November 2021. Groundwater seepage appears to be present in the February 2022 drone flyovers. Significant landslides and slips were observed on the natural slopes just outside of the designation at Cut CS9G after the 2023 rainfall events.
11. **CS13 West:**  
A natural erosion gully is present in the centre of the cut. Surficial topsoil slips and groundwater seepage have been observed at the lower slope during our site visit on 12 November 2021. Due to the natural depression of the gully, surface water is expected to be funnelled towards a central location.



The overall risk level has been raised to Moderate Risk due to the slips which occurred in July 2022 and January 2023. It is noted the non-conformance report (NCR) review highlighted that the upper of Cut CS13 West was steeper than the required 2H:1V design. This information was not known at time when the revision D report was prepared.

12. **CS16B:** Increased risk level compared to previous assessment. Two landslides (July 2022 and January 2023) have occurred near this cut on natural slopes outside the designation. These slope failures could progress further towards the cut slope.
13. **CS16D:** Increased risk level compared to previous assessment due to increased consequence levels.
14. **S4B:** Due to landslips after the 2023 rainfall events where already remediated (buttress fill and shear key) slopes have slipped again. Substantial slips on natural slopes have also been observed.

Moderate risk of failure or occurrence of risk items were determined at the following 2 cut locations:

1. **N1A East:**

This cut was previously classified as low risk due to the completed re-design and remedial works at this cut. The overall risk rating is now a Moderate Risk. Nevertheless, due to the active slip and large observed movements, the individual risk rating for "Sliding at Soil-Rock Interface" is a High Risk. This also highlights that the general risk, that if ground conditions are not fully understood, the design assessments may not be correct. This risk assessment, as it is not a peer review, relies on the fact that the designer provided a compliant re-design.

2. **CS3 East:**

This cut was previously classified as low risk. The risk level has been elevated to Moderate Risk due to the DJV's independent slope stability assessment of the remedial works which were constructed based on a third-party design (refer to DEI 539 and NCR 1068). The DVJ's independent assessment indicates a static long-term factor of safety of 1.3 instead of the required 1.5.

At the previous revision E report, the following cuts were classified to have a moderate risk. Based on the additional information and observations since the issue of the last revision D report, the risk rating has been amended.

- **CN5A (East):**  
Now classified as low to moderate risk (refer section above).
- **CN5B:**  
Now classified as low to moderate risk (refer section above).
- **Moir Hill Road (approx. MCM0 Ch100-200)**  
The overall conditions of this section have not changed. We understand some movement at this road has occurred during the January 2023 rainfall events.

Moir Hill Road is situated upslope (south-eastern) of a natural gully where landslide hazard mapping suggests a large-scale landslide. The previous landslide occurred at the south-eastern cut slope for the Moir Hill Road widening at approximately MCM0 Ch132-155.



Google StreetView images shows cracks within the edge of the pavement which suggest creep movements of the slope. There is the potential risk of ongoing downslope creep movement of the existing slope supporting Moir Hill Road requiring pavement repairs.

It is noted the individual risk rating for the soil slope failure is high. The overall weighted risk rating is Low Risk.

A detailed summary of the site-specific risks is provided in Table 14 and Appendix A.

Based on our assessment, we recommend that:

- Risk items at the cut locations are reviewed by the designer as summarised in Table 14,
- All high risk and 'moderate to high' risk items to be addressed or reviewed prior to road opening. Based on our latest assessment, there is one high risk location at Cut N1A East which is currently being assessed and two 'moderate to high' risk at Cut CS13 West and Moir Hill Road items which require immediate attention.
- As-built soil slopes and rock cuts are checked that the batter is not steeper (outside of tolerances) than the design slopes.
- The adopted ground and analysis model is suitable and represents the site conditions.
- Remedial works addresses the underlying geological issue.
- Design checks for rock cuts include near vertical and overhanging rock cut faces.
- To mitigate potential future rockfall risks, visual geological inspection of exposed rock slopes should be carried out as part of the general maintenance inspections during operation of SH1. The purpose is to identify any loose rocks or debris on the slope.
- Additional bored drains are installed where ongoing groundwater seepage and softened soils are observed on site.
- Inspections and maintenance of subsoil drains where installed at cut slopes as required for their long-term performance as the slope stability (or required factors of safety) may depend on it.

With regards to rockfall, the following items are recommended:

- The CJV or DJV geotechnical engineers should review based on site observations at each relevant cut slope if further rockfall analyses or assessments are required.
- Conditions at the upper exposed rock slopes may change in the future. The conditions of the rock slopes should be inspected as part of the maintenance scheme. This may include drone flyovers and inspections on the slopes.
- Inspections should include potential deterioration of rock slope conditions, including observation of additional loose rocks or movements of rocks, accumulation of rock debris at the upper bench and swale drains.
- Any rock observed on the carriageway should trigger an immediate review of the slope conditions or geotechnical inspections of the slope.



# 1.0 Introduction

## 1.1 Project Overview

The Pūhoi to Warkworth (P2Wk) project is an extension of the Northern Motorway (SH1) from the Johnstone's Hill tunnels near Orewa to north of Warkworth. The alignment is approximately 18.5km long and is located at the western side of the existing State Highway 1 (SH1).

The project contract type is a Public Private Partnership (PPP). The contract was awarded in November 2016 to NX2 PL and construction commenced in 2017 and completion is planned for 2022.

For design purposes, the alignment has been divided into three earthworks zones with the following sections:

- Northern Zone: Ch47,100 to 52,149
- Central Zone: Ch52,149 to 59,420
- Southern Zone: Ch59,420 to 65,020

The project alignment comprises sequences of alternating large cuts and fill embankments. Each cut and fill location have been assigned with a specific identification number.

## 1.2 Background

During the earthworks construction and cutting of slopes multiple landslides occurred since late 2019 at various locations of the project site.

The main focus is the risk of future landslips at locations outside of the existing landslide locations. The slopes (or slope sections) where the landslides occurred have been remediated by site-specific remedial works designs. The remedial works designs were independently peer reviewed by PSM and reported in their report PSM4203-029R Draft Rev 5 (8 December 2021). This report was made available to <sup>s 9(2)</sup> <sub>(b)(ii)</sub> Engineers for reference.

It is therefore considered that the risk of future landslides at the locations of the existing landslides is lower due to the peer review and completed remedial works. **Nevertheless, at some cut locations further landslides occurred despite a remedial work design was in place.**

## 1.3 Additional Landslides

Since the issue of the previous Report Revision E in April 2022, further landslides have occurred at the project site at the following locations listed in the order the alignment:

1. **N1A (East)** at approximately Ch48,700. Cut N1A is a location of a previous landslip. Options for remedial works are currently being evaluated but design details are not known to us.



Uncertainties of the slip remedial works have been considered as an elevated risk items in this assessment.

2. **N3C (West)** at Ch50,820 to Ch50,840. Initial tension cracks on the slope surface were identified in November 2021. The slip occurred in July 2022 after heavy rainfall. The remedial works design was already prepared based on the observed tension cracks, but the works on site had not commenced when the slip occurred.
3. **CN12 (East)** at Ch56,290~56,370. There is no previous known history of a landslide at this location. The slip occurred in July 2022 following heavy rainfall. Remedial works include the flattening the slope to 4H:1V and the construction of a toe buttress and counterfort drains. We understand that the majority works is completed at the time of writing this report.
4. **S1 (West)** at Ch56,900~57,000 at Moir Hill Road Bridge. The slip occurred in July 2022 following heavy rainfall. The remedial works design is provided in DEI 0608.
5. **CS5 (East)** at Ch58,720~58,780. At least two previous landslips had occurred at this location and remedial works were completed. Large slope movement were observed in June 2022 prior to the landslide which occurred in July 2022 following heavy rainfall. Ponding water was on the top of the slope.
6. **CS13 (West)** at approximate chainage Ch60,980~61,000. A slip occurred at above intermediate slope swale drain located at the upper third of the slope in July 2022. Remedial works comprised removal of the slipped material and the swale drain was reinstated. These works were completed by October 2022. A new slip occurred below the swale drain in late January 2023 after the Anniversary Weekend rainfall event. It is noted that the NCR review highlighted that the upper slope at CS13 has been constructed steeper than the specified 2H:1V batter.
7. **CS16B (West)**. The landslide occurred in July 2022 on the southern natural slope behind the cut slope at Ch61,760~61,800. The location of the slip is mainly outside of the designation.
8. Large landslide/ flow slide at Mahurangi Forestry Road. The slip occurred at the eastern side of Cut CNT3 at approximately Ch56,700~56,800 on a natural slope outside main alignment.

#### 1.4 NCR Reviews

**s 9(2)(b)(ii)** undertook geotechnical reviews of some non-conformance reports (NCR) as provided to us. The NCRs included items related to the earthwork construction and ground improvements at fill embankments and cut slopes. NCRs related to the fill embankments are not considered in this report.

Relevant NCRs affecting the cut slopes performance have been considered in this slope risk assessment.

The following items were stated in the non-conformance reports:

- a. The slope stability factor of safety is only 1.3 (less than the required 1.5) at Cut CS5 based on the DJV's assessment. The ground improvements at Cut CS5 were constructed using an alternative design. Further details can be found in TAR #1068 and DEI 539.
- b. Soil slopes above the rock cuts are constructed steeper than required 2H:1V slopes specified on the drawings.



- c. Bench widths above the rock cuts were constructed narrower than the specified 4m widths.
- d. Details of counterfort drains not constructed as specified.
- e. Slope (face) monitoring was not undertaken at locations and frequencies as specified on drawings.

## 1.5 Slope Movement Monitoring

Slope deformation monitoring data for the period from May 2022 to December 2022 was provided for various cut slopes. The slope monitoring covers monitoring at the slope face. Further details are provided in Section 5.2 and Table 13.

At the cut slopes N1A East, CN12B East and CS5 East, where landslide occurred increased movements were observed prior to the landslide.

The recorded slope movements are in the order 400mm, 275mm and 1900mm respectively.

## 1.6 January 2023 Anniversary Weekend Rainfall and Cyclone Gabrielle

The last site visit prior to writing this report was done on 21 February 2023 after the 2023 Anniversary Weekend and Cyclone Gabrielle Rainfall events. More than 250mm of rainfall was recorded in within 24 hours during the Anniversary Weekend rainfall event.

Widespread flooding and landslides occurred at the existing SH1 to the east of the project side and at the SH1 Dome Valley section to the north.

Multiple landslides on the natural slopes at various locations along the P2Wk alignment were observed. Despite that, the majority of

The site observations are summarised in our letter 2394-01-NX2-89 attached in Appendix D.

## 1.7 Scope of Works

The initial scope of works as per agreement dated 19 December 2020 is summarised below:

- A. *NX2 LP requires a peer review of historical earthworks design development and geotechnical survey information to determine any causal link between original design philosophy/ design assumptions and the current frequency of land slips on the P2Wk construction site.*
- B. *NX2 LP also requires the peer review of third-party causal analysis studies produced by our Construction Sub-Contractor (CJV).*
- C. *NX2 LP requires a summary assessment of the adequacy of remedial measures taken to address these landslips as well as an assessment of potential future land slips that have not yet occurred together with recommendations on possible mitigation measures that could be explored.*



At the time when the agreement was signed, we understood from the provided documents, that the scope of our geotechnical services is to review the third-party reviewer's assessment of the 18 landslides. We also understood that the scope our geotechnical services is limited to the extent of the 18 landslides as summarised in [Table 2](#) below.

However, since commencement of our review the scope of works as been amended as discussed in various meetings.

**Table 2: Summary of Initial Scope of Landslides**

Slip Number	Slope ID Number	Alignment Chainage
1	N1A – West	Ch48,710 – Ch48,730
2	N7A – West	Ch51,650 – Ch51,720
3	CN5A – East	Ch54,020 – Ch54,050
4	CN5B – East	Ch54,100 – Ch54,180
5	CS8A – Bluff	Ch54,600 and 54,700
6	CN9 – West	Ch55,860 – Ch55,940
7	CS1 – Moir Hill Road	Not identified
8	Moir Hill Widening	Not identified
9	CS2B – East	Ch59,670 – Ch59,730
10	CS2D – East	Ch57,450 – Ch57,480
11	CS2F – East	Ch57,720 – Ch57,840
12	CS3C – East	Ch58,070 – Ch58,180
13	CS5C – East	Ch58,740 – Ch58,790
14	CS8D – West	Ch60,080 – Ch60,150
15	CS9A – West	Ch60,350 – Ch60,400
16	CS15A – West	Ch61,200 – Ch61,300
17	S1 – East	Ch63,400 – Ch63,430
18	Wetland WP5	Ch63,730 – Ch63,780
19	S5C – East	Not identified

The schematic overview of the above the landslide locations is provided in [Figure 1](#).

This report presents our geotechnical assessment based on limited site observations, provided field investigations and published geological information, provided documentation and aerial flyover photos and videos.

We note that we have not carried out any independent slope stability analyses or any other analyses or modelling to support our independent risk assessment.

This report does not substitute a peer review of the design or construction works.



## 1.8 Purpose of the Report

The purpose of the report is to provide an independent review of the geotechnical landslide risk of potential landslide affecting the SH1 during the first 25 years after practical completion of the project.

The geotechnical assessment is based on the following input:

- Various geotechnical design reports, earthworks and ground improvement drawings,
- Site observations dated 24 and 25 February 2021, 21 June, 2 and 12 November 2021
- Design Instruction (DEIs) for the remedial works design and DEIs for other selected ground improvement works,
- Peer review report of Remediation Design for Cut Slope Failures (PSM4203-029R Draft Rev 5) and report for Susceptibility of Constructed Slopes (PSM4203-055R Draft Rev 1) by PSM, refer to Section 1.10.4,
- Additional seepage monitoring at cut slopes,

## 1.9 Revisions from the Previous Reports

### 1.9.1 Changes from Revision C to Revision D

This version of the draft report has been updated to include our review of the CJV's rockfall assessment and rockfall trial analyses provided in December 2021 and March 2022.

Additional information regarding rockfall trials carried out in March 2019, June 2019 and August 2021 were provided after the issue of the draft report Rev A.

The rockfall trials comprised two sets of trials (CN7 West and CS16D East) to verify rockfall below the rock mesh drapery at the 85-degree steep rock cut slopes and rockfall simulations for the 85-degree steep rock cut at Cut CS16D. Further rockfall simulations were carried out for the upper 2H:1V rock exposures at Cut S1.

In addition, rockfall trials and simulations for the upper 2H:1V exposed rock slopes at Cut CS3 were prepared by the CJV in various reports dated 25 March 2022. A summary of the provided rockfall trials and simulations is given in Section 1.10.5.

### 1.9.2 Changes from Revision D to Revision E

This Revision E Report includes our finding from the additional landslides which occurred since July 2022, the Non-Conformance Report reviews, slope face movement monitoring, piezometer monitoring and observations from three additional visits in July, November and December 2022, and February 2023.

The last site inspection dated 21 February 2023 was carried out after the Anniversary Rainfall (27 & 28 January 2022) and Cyclone Gabriel (12 to 14 February 2022).



## 1.10 Provided Information

This section provides a selective list of documents which were used as key source for our assessments. It is noted this list not exhaustive and supplementary information which was not adopted for our assessment is not listed here.

### 1.10.1 Detailed Design Reports

The Earthworks and Ground Improvements Design Reports for Northern, Central and Southern Zones respectively:

- 650-RPT-011-NX2\_Early NZ EW & GI Stage 3 Rev E
- 650-RPT-010-NX2\_CZ EW & GI Stage 3 Rev C
- 650-RPT-012-NX2\_SZ EW & GI Stage 3 Rev D

The design reports include drawings such as geological and geotechnical maps, geolocation cross sections, ground improvement plans and detail design sections.

We also considered the alignment cross sections for the northern and central zone of the project.

### 1.10.2 Design Engineer Instructions (DEI)

The following Design Engineer Instructions (DEI) were reviewed as part of our landslide risk assessment.

**Table 3: Provided DEIs**

Cut Location	Item	Chainage	DEI No
N1A	Soil Stabilisation	48700 – 48730	DEI 0444
N3C	Soil Nail Design	50800 – 50840	DEI 0569
N3D	N3 – Soil Cut Stabilisation Design	50810 – 50830	DEI 0600
N7A	Slip Remediation	51710 – 51775	DEI 0305
N7B	Rock Cut – Planning Change Record PCR 20	51920 – 52025	DEI 0432
WM5 near CN2-Fill/ CN1 Cut	South West Counterfort Drain Line	52200 – 52350	DEI 0512
CN1 (East)	Eastern Batter Stabilisation down to 85deg.	52380 – 52690	DEI 0437
CN1	South West Rock Cut Stabilisation	52800 – 52900	DEI 0502
CN4 Perry Road	Perry Road: Landslide Stabilisation	53175 – 53280	DEI 0510
CN1 Perry Road	Perry Road (CN1) South landslip stabilisation measures	Access Road	DEI 0599
CN1 Perry Road	CN1 – Perry Rd North	52785 – 52815	DEI 0604
CN5A	Landslide Remediation	53940 – 54080	DEI 0468
CN5A	CN5A North-North – Stabilisation Design Rev 1	53690 – 53750	DEI 0560
CN5A	Landslip Remediation (Factual Information)	53980 – 54060	DEI 0568
CN5B	Heave Zone 2 & 3	54080 – 54160	DEI 0534
CN5B	Slope Stabilisation Lower One Third	54080 – 54130	DEI 0535



Cut Location	Item	Chainage	DEI No
CN5B	Soil Slope Stabilisation Heave Zone 4	54100 – 54200	DEI 0515
CN5B	Haulage Track Zone	54100 – 54200	DEI 0516
CN5B	Eastern Batter Stabilisation	54110 – 54300	DEI 0390
CN5B	Rock Cut Stabilisation - North east triangles	54130 – 54210	DEI 0541
CN5B	CN5 Stabilisation South West Rock Cut	54450 – 54480	DEI 0533
CN5B	Slope & Landslip Remediation	54480 – 54560	DEI 0548
CN5B	South East Soil Trim & Counterfort drains	54460 – 54535	DEI 0501
CN5B	West 85 Degree Rock Trim Stabilisation	54100 – 54450	DEI 0493
CN5B	CN5 Eastern Southern and Lower Batter Stabilisation	54200 – 54350 and 54350 – 54420	DEI 0473
CN5B	CN5B Lower Batter Wedge Slope Stabilisation	54120 – 54150	DEI 0577
CN5B	CN5 Eastern Batter Dropout Rock Face Stabilisation	54090 – 54120	DEI 0590
CN5B	CN5B Top of Slope – Landslide Remediation	54200 – 54270	DEI 0602
CN7B	Ch551410-55170 Slope Stabilisation	55140 – 55170	DEI 0572
CN7B	Southeast – Soil Cut Stabilisation Design	55360 – 55400	DEI 0573
CN9 (West)	Western Batter Landslide Stabilisation	55840 – 55940	DEI 0474
CN9	Stabilisation south-eastern batter	55990 – 56030	DEI 0470, DEI 0465
CN12B	CN12B Eastern Landslide Stabilisation	56400 – 56270	DEI 0606
CN13	Rock Cut Batter stabilisation	56525 – 56560 NE, 56645 – 56660 SE, 56655 – 56675 SW	DEI 0477
CN13	Planning Change Record PCR26, Rock Slope	56580 – 56590	DEI 0457
CS1 (Moir Hill Bridge)	South West Counterfort Drain Line	57025 – 57090	DEI 0380
CS1	Stabilisation North West Rock Cut	56900 – 56960	DEI 0523
CS1	CS1 Landslide Remedial Solution	56900 – 57000	DEI 0608
Moir Hill Road Widening	Retaining Wall incl. slope stability memorandum Rev C (11/11/2020)	MCM0 Ch132 – 155 (Moir Hill Road)	DEI 0433
CS2D	CS2D – Soil Cut Stabilisation Design including calculation package	57400 – 57480	DEI 0566
CS2F	Landslide Stabilisation	57725 – 57850	DEI 0481
CS3	Landslide Stabilisation	57900 – 58000, 58050 – 58130	DEI 0422
CS3	East Batter Soil Slope Stabilisation	57900 – 58050 58050 – 58160	DEI 0539
CS3	CS3 Landslide Stabilisation – CH58000	57985 – 58050	DEI 0558
CS5C	East Rock cut stabilisation	58715 – 58830	DEI 0401



Cut Location	Item	Chainage	DEI No
CS5 (East)	Eastern Batter Soil Cut Stabilisation	58750 – 58800	DEI 0414
CS5	North East Rock Cut Stabilisation	58715 – 58750	DEI 0507
<b>CS5</b>	<b>CS5 Eastern Landslide Stabilisation</b>	<b>58700 – 58790</b>	<b>DEI 0601</b>
<b>CS8D</b>	<b>CS8D Calculation package</b>	<b>60040 – 60140</b>	<b>DEI 0411</b>
CS9A	Soil Cut Stabilisation	60310 – 60440	DEI 0489
CS16D	Soil Nail Design	62280 – 62360	DEI 0503
S1	S1 Eastern Soil Stabilisation	63260 – 63430	DEI 0438
<b>S4B</b>	<b>S4B West: Landslide Stabilisation</b>	<b>63670 – 63690</b>	<b>DEI 0588</b>
S5 (East)	Soil Stabilisation	64060 – 64100	DEI 0443

### 1.10.3 Non-Conformance Report (NCR)

Non-conformance reports (NCR) were reviewed as per part of the preparation of this risk assessment report.

### 1.10.4 Peer Review and Independent Assessment Reports

We have received and reviewed PSM's peer review and independent review reports:

- Pūhoi to Warkworth Northern Motorway Project – Independent Geotechnical Report of Remediation Design for Cut Slope Failures PSM4203-029R Draft Rev 5 (8 December 2021)
- Pūhoi to Warkworth Northern Motorway Project – Independent Geotechnical Report of Cut Slopes: Susceptibility of Constructed Slopes PSM4203-055R Draft Rev 1 (21 December 2021).

### 1.10.5 Rockfall Assessments Reports

The following rockfall trial and assessments were received after the issue of our draft report Rev A dated 19 November 2021:

- CS16D-C Rock Fall Trial and Analysis of results with RocFall V6.0 dated 10 June 2016
- CN7 Rock Fall Trial Results dated 18 January 2019
- S1-C West Rockfall Assessment dated 5 August 2021
- CN1 West Ch 52540 Rockfall Assessment dated 15 February 2022
- CN5B East Ch 54250 Rockfall Assessment dated 15 February 2022
- N3C Rockfall Assessment dated 15 February 2022
- S1-C West Ch 63400 Rockfall Assessment dated 15 February 2022
- CN5B East Ch 54250 Rockfall Assessment dated 25 March 2022
- CS3 In Situ and Simulated Rockfall Assessment dated 25 March 2022

### 1.10.6 Digital Information

In addition to the provided reports and drawings we accessed the following digital information:

- Monthly drone flyover footage and videos  
<https://nx2group.com/page/10/project-photos-drone-footage-and-videos>
- Mapbox aerial photos including alignment information.
- New Zealand Geotechnical Data Base GIS Maps,  
[www.nzgd.org.nz/](http://www.nzgd.org.nz/)
- Auckland Council GIS Geomaps  
<https://geomapspublic.aucklandcouncil.govt.nz/viewer/index.html>
- Google Earth Pro

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## 2.0 Assessment Methodology

### 2.1 Review Methodology

The intention of this landslide assessment is to provide an independent geotechnical assessment. The following methodology has been adopted.

1. Site inspections at selected cut slopes where landslide sites have occurred and at cut slopes where no signs of instabilities were reported. The purpose of the site inspections is to gain a general project overview and understanding of potential geological issues which lead to the landslides.
2. Independent desktop study and review published geotechnical information of the site geology to obtain an unbiased and independent understanding of the project site.
3. Review of selected geotechnical investigation data,
4. Review of aerial photos and drone flyover footages.
5. Review of design philosophy and design assumptions,
6. Review detailed design drawings and specifications,
7. Independent geological site mapping at selected landslide sites and slopes where no landslides were reported,
8. Review third party remedial peer review reports.
9. Review of geological assessments and slope stability analyses.
10. Provide opinion on the adequacy and risk of the proposed remedial works.

In order to be determine the risk profile of the cut slopes along the NX2 alignment, it is required to determine and/or analyse the causality of the existing landslides.

The following items were reviewed for all the existing landslides.

1. Evidence of the existing landslides at the cut locations as identified on the geological maps. If a landslide was identified, the risk of future landslides or potential slope failure is increased. Where no landslides were identified the landslide risk may need to be determined based on the geological mapping during the construction phase. It is noted that the landslide hazard mapping prior to construction is likely being done based on hill shade modelling, review of ground contours and aerial photos and limited site observations.
2. If a geotechnical model including cross section was prepared during the design phase and if it was updated during the construction phase after the landslide occurred.
3. If a groundwater and hydrogeological model was prepared and implemented in the geological model and design geotechnical design model.
4. If site specific cut slope design analyses were undertaken during the design phase and updated during the remedial design works.
5. If instrumentation were installed and slope monitoring was carried out prior to and after the landslides occurred.



6. If geological field mapping was carried out as part of the observational approach and how these observations were used to modify the slope stability design.

Further to the review of cut slopes and potential causes of landslides, we reviewed issues unrelated to the landslides. This includes potential risks of erosion and topsoil slumps, rockfall caused by loose debris above rock cuts.

## 2.2 Risk Rating

The risk assessment is based on a risk matrix using a Likelihood (L) and Consequence (C) rating approach. The likelihood and consequence definitions are listed in Table 4 and Table 5 respectively below.

**Table 4: Likelihood (L) Definition**

Definition	Description	Rating Number
Very Unlikely/ Rare	Cannot happen, highly unexpected over the next 25 years or may only occur under exception circumstances	1
Unlikely	Has not been observed at the project at similar conditions, could happen in some circumstances	2
Possible	Conditions may have been or <u>not</u> been observed at the project but are considered possible. Cuts were landslides occurred and remedial works were completed, but similar conditions may still be present at the cut slope.	3
Likely	Conditions have been observed at the project at similar cut slope. Calculated static factors of safety are significantly less than design requirements. Expected to occur within the next 10 years.	4
Very Likely/ Almost certain	Has been observed at the specific cut location but not improvements have been made, landslide is active or large movement recorded. Active or expected to occur within the next 2 years.	5

**Table 5: Consequence (C) Definition**

Definition	Description	Rating Number
Negligible	Addressed as part of general maintenance. No specific temporary traffic management (TTM) required. Insignificant addition cost to remediate.	1
Minor	Addressed as part of general maintenance schedule but additional works required. TTM may be required.	2
Moderate	Repair and remedial works above standard maintenance requirements. TTM will be required. Possible temporary shoulder or lane closure.	3
Significant	Road (both lanes 1 direction) or 1 lane closure. Prolonged lane closure with traffic management or speed restrictions in place. Injury or accident of road user caused by instability. Significant cost to complete remedial works.	4
Severe	Long-term road closure (all lanes) with significant repair cost. Possible accident or death of road user caused by instability. Substantial cost and penalties.	5



The risk score/ rating is a multiplication of the likelihood and consequence rating. The individual risk at each cut slope is determined as follows:

Based on the likelihood and consequence rating, six risk levels have been determined with the description summarised in Table 6 below.

**Table 6: Risk Matrix Classification**

Definition	Description	Rating Number
Very low risk	The anticipated maintenance and operation controls are expected to be satisfactory deal with this risk level.	up to 3.1
Low risk	The anticipated maintenance and operation controls are expected to be satisfactory deal with this risk level.	3.1 to 6.1
Low to moderate risk	Increased inspections and maintenance frequency are required to manage the increased risk level	6.1 to 9.1
Moderate risk	To be address and mitigation measured to be developed prior to road opening. An acceptable mitigation/ remedial works methodology and need to place to address the risk.	9.1 to 12.1
Moderate to high risk	Actions need to be taken to eliminate the hazards prior to the road opening.	12.1 to 15.1
High risk	The risk item must not occur, and a remedial works process need to be in place prior to road opening the road.	

Cut slopes where no risk rating was carried out or not applicable.

The risk assessment matrix has been determined for six separate failure modes as listed in

**Table 7: Weighting Factors for Failure Modes**

Failure Mode	Weighting Factor
Soil Slope Failure	0.30
Sliding at Soil-Rock Interface	0.35
Rock Slope Failure	0.15
Scour/Erosion at soil to cut transition zone	0.05
Rockfall	0.10
Topsoil Slip	0.05

As per table above, the soil slope failures and sliding block failures at the soil rock interface contribute to 65% of the overall weighted rating.

The geotechnical description and typical examples of the risk rating for the adopted six risk categories are summarised in Table 8. The risk assessment is based on a qualitative assessment for failures at cut soil slopes or rock cuts, risk of erosion or potential rockfall, and potential issues with geology and ground improvements.

**Table 8: Geotechnical Risk Rating**

Rating	Description	Typical Example
Very low risk	Cut slope failure not expected to occur	<ul style="list-style-type: none"> <li>No cut slope or at grade,</li> <li>Cut slopes, less than 5m high,</li> <li>No rock cut,</li> <li>Soil-rock transition zone is below cut level,</li> <li>No previous landslide or historical landslide mapped,</li> <li>No groundwater seepage</li> </ul>
Low risk	Unlikely to occur and low consequences	<ul style="list-style-type: none"> <li>Low risk of topsoil slumps or erosion due to topography above the cut slope,</li> <li>Gentle inclined soil-rock transition zone sloping at less than 5° into the slope,</li> <li>Minor groundwater seepage only,</li> <li>Subsoil drainage installed, but design does not rely on it,</li> <li>No previous slips or remedial works design appropriate,</li> </ul>
Low to moderate risk	Low possibility of occurrence and moderate consequences	<ul style="list-style-type: none"> <li>Design relies on subsoil drainage</li> <li>Soil-rock transition zone sloping at more than 10° into the slope,</li> <li>Side soil slopes at transitions from embankments into rock cuts are flatter than 2H:1V,</li> <li>Overflow path unlikely results in surface erosion and topsoil slips,</li> </ul>
Moderate risk	Possible to occur and moderate consequences	<ul style="list-style-type: none"> <li>Design relies on subsoil drainage</li> <li>On-going groundwater seepage,</li> <li>Softened soils due to groundwater seepage,</li> <li>Very steep side soil slopes at transitions from embankments into rock cuts,</li> <li>Over-steepened soil slopes,</li> </ul>
Moderate to high risk	Likely to occur and moderate consequences	<ul style="list-style-type: none"> <li>Evidence of slope failures near cut slope,</li> <li>Evidence of erosion and topsoil slips,</li> <li>Topography above cuts sloping towards cut slope,</li> <li>Very steep side soil slopes at transitions from embankments into rock cuts</li> <li>Steeply inclined soil-rock transition zone sloping into the cut at more than 15°</li> <li>Near vertical and/or overhanging rock cuts,</li> <li>Large groundwater seepage. No softening of soil/rock observed, but is expected during the design life,</li> <li>Rockfall or debris from above rock cuts are considered likely and potential impacts should be further assessed.</li> </ul>



Rating	Description	Typical Example
High risk	Expected (almost certain or signs of failure already evident) to occur with potential high consequences	<ul style="list-style-type: none"> <li>• Evidence of imminent failures,</li> <li>• Evidence of erosion and topsoil slips,</li> <li>• Topography above cuts sloping towards cut slope,</li> <li>• Steeply inclined soil-rock transition zone sloping into the cut at more than 20°</li> <li>• Remedial works appear not appropriate,</li> <li>• High and overhanging rock cuts with evidence of existing wedge-type failures,</li> <li>• Large groundwater seepage, softening of soil/rock observed,</li> <li>• Rockfall or debris from above rock cuts are considered highly likely and should be further assessed.</li> </ul>

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## 3.0 Existing Landslides

### 3.1 Overview

Multiple landslides including at temporary works slopes have occurred during the construction since late 2019. Based on the provided CJV weekly progress reports, 19 landslides are being tracked for their progress with regards to their respective status on design, peer review and remedial works completion.

The locations of the landslides are shown in Figure 1 below.

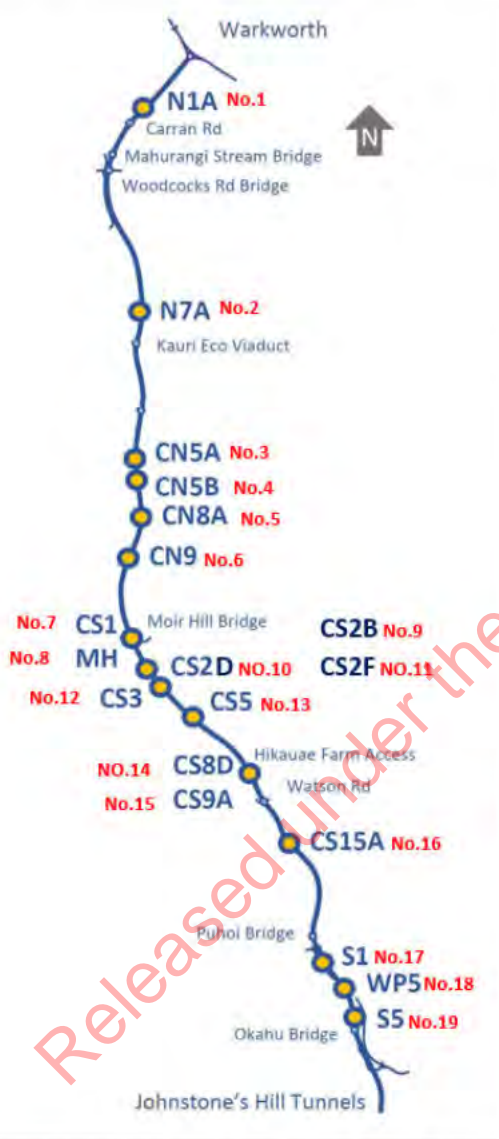


Figure 1: Landslide Locations along the P2Wk Alignment

The followings risk items have been identified:

- Soil slope failures, predominantly failing along the soil rock transition zone,



- Topsoil slumps and surficial erosion,
- Softening of ground (soil, weathered rock, fill) caused by groundwater seepage or surface water run-off,
- Surficial failure rock slopes and rockfall behind mesh draping,
- Wedge failures at rock slopes between rock bolts or at location without rock bolts,
- Scour/erosion and debris flow from soil slopes or soil-rock interface above rock slopes.

After occurrence, the existing landslides were assessed by DJV and CJV geotechnical engineers and remedial works design solutions developed. We understand that the design solutions were developed based on geological site observations and review of geotechnical investigations and detailed designs.

New geotechnical design and analysis models were developed.

### 3.2 Landslide Risk Factors

The geotechnical risks and their respective mitigation measures for the landslides are stated in Table 9 below.

**Table 9: Summary of Slope Stability Key Factors**

Feature (Design Input)	Description	Risk & Assessment
Soil (and Rock) Slope Height	The alignment sections and plans indicate that some of the soil cut slopes are more than 40m high.	The height of a soil slope has a direct effect on the factor of safety against slope failure. If all other features (design inputs) listed in this table are identical, the factor of safety against slope failure decreases with increase in the slope height. Long slopes are also prone to surface erosion.
Soil Slope Batter	Generally, the designed soil slope batters are 2H:1V throughout the project, irrespective of whether slope material, height or site-specific geological settings.	As above. High 2H:1V slopes are also prone to surface erosion.
Strength of Soil	The adopted soil strength is a key design parameter with respect to the slope stability design, under drained and undrained conditions.	Where slope stability analyses utilise homogenous soil models, consideration of bedding planes shall be reviewed to ensure that the geotechnical model reflects the ground conditions on site.
Inclination and direction of rock level	The two-dimensional (2D) alignment cross sections present inferred rock levels, which have been derived from a 3D surface based on a 3D geological model. The 2D alignment cross sections only provide a 2D interpretation of the inclination and direction of the 3D rock level surface. Rock levels may also be inclined in alignment direction (perpendicular to cut slope faces) which may explain that some landslides occurred in oblique direction.	Slopes where the rock surface dips towards the cut slope face are considered higher risk than that with gentle bedding angle. However, from the remedial works design reports (DEIs), it appears that the landslides occurred generally at horizontal to sub-horizontal rock surfaces. The risk of steeply inclined rock surface shall be considered in the design. We would consider dip angles larger than 20 degrees as high risk.



Feature (Design Input)	Description	Risk & Assessment
	The cross sections show that the 2D rock levels are inclined towards and away from the cut slopes. Some rock interfaces are inclined up to 20 to 25 degrees (Note that a 26.5-degree inclined plane is 2H:1V steep).	
Strength of weathered rock at transition zone	A softened transition zone at the weathered rock surface could be present.	The strength of the transition zone and groundwater conditions need to be considered in the geotechnical models, particularly where the rock interface is dipping towards the cut slope face.
Groundwater conditions and recharge of groundwater	Groundwater levels and seepage are a key factor for slope stability and cause of potential failures. The soil rock interface is typically a permeability boundary. The upper soils are more permeable than the underlying Pakiri Formation. Subsequently, groundwater is likely ponding (perched groundwater) on the soil rock interfaces, which can reduce the shear strength at the interface.	Ongoing groundwater seepage with or without direct correlation to rainfall are considered a risk item.
Slopes adjacent to existing landslides	Slopes with similar topographical features and ground conditions would be similarly prone to slope failures unless there are site specific conditions which explain the slope failure.	Soil slopes adjacent to landslides may have similar underlying site-specific geological conditions and potentially similar risk of failure.
Construction Sequence and speed of excavation (temporary conditions)	The excavation a soil or rock slope causes a change of stress state. A rapid change of the stress state (especially slope cutting in winter seasons when the groundwater level is still high) may result in a slope failure under temporary conditions.	If the construction sequence and speed of excavation was a contributing factor of the slope failures, it is considered unlikely that the future stability of adjacent soil slope would be adversely affected. However, it shall be verified that the excavation did not cause any cracking at the slope which may allow ingress of surface water into the slope and subsequent softening.






Any of the above geotechnical features listed in Table 9 may trigger a slope failure if their respective influence is significant. Likewise, any combination of the items may cause a slope failure depending on the weighting of the triggering geotechnical feature.

### 3.3 Typical Slope Failures Modes and Risks




This section provides a summary of the typical slope failure modes and potential future risks encountered at the project site.



**Table 10: Typical Slip and Landslide Features**

Risk Item	Example	Potential Causes	Locations
1. Soil slope failures, predominantly failing along/above the soil rock transition zone	 CN1 North-west (September 2021, now repaired)	<ul style="list-style-type: none"> <li>• Cut slope too steep for geological conditions, i.e. conditions and inclination of soil-rock transition zone,</li> <li>• High groundwater levels or groundwater seepage,</li> <li>• Surface water runoff infiltration into slope,</li> </ul>	<ul style="list-style-type: none"> <li>• Transition into cut slopes from embankment fills,</li> <li>• Soil slope above rock cuts,</li> <li>• CN1 North-west,</li> </ul>
2. Slope failures within transitional rock or highly weathered rock at previous landslides	 CN5B East (12 November 2021)	<ul style="list-style-type: none"> <li>• Surface water runoff infiltration into exposed fractured and highly weathered rock mass or zone of transitional rock,</li> <li>• Groundwater seepage,</li> </ul>	<ul style="list-style-type: none"> <li>• Exposed highly weathered and fractured transitional rock near cut slope surface, particularly where not protected by topsoil,</li> <li>• CN5B East,</li> </ul>
3. Softening of ground (soil, weathered rock, fill) caused by groundwater seepage or surface water run-off	 N7A West (12 November 2021)	<ul style="list-style-type: none"> <li>• Large groundwater seepage,</li> <li>• Inappropriate or not functioning subsoil drainage system</li> </ul>	<ul style="list-style-type: none"> <li>• Groundwater seepage visible at soil slope faces,</li> <li>• N7A West,</li> </ul>
4. Wedge failures at rock slopes between rock bolts or at location without rock bolts Wedge failure may result in large scale failures.	 CN5B East	<ul style="list-style-type: none"> <li>• Intersection defect sets,</li> <li>• Heavily faulted rock mass,</li> <li>• Too steep cut slopes for encountered geology,</li> <li>• Insufficient rock support (rock bolts),</li> <li>• As-built cuts are steeper than design,</li> </ul>	<ul style="list-style-type: none"> <li>• Refer to <a href="#">Table 11</a> for locations of 85°/64 ° steep rock cuts,</li> <li>• CN5B East &amp; West,</li> </ul>
5. Scour/erosion and debris flow from soil slopes or soil-rock interface above rock slopes	 CS2F East (2 November 2021, now replaced by rock lined swale drain)	<ul style="list-style-type: none"> <li>• Insufficient cut off drains at top of slope,</li> <li>• Long and steep slope faces without sufficient slope face erosion protection,</li> <li>• Highly erodible soils/rock exposed at slope face,</li> </ul>	<ul style="list-style-type: none"> <li>• CS2F East,</li> <li>• CS3 East,</li> </ul>



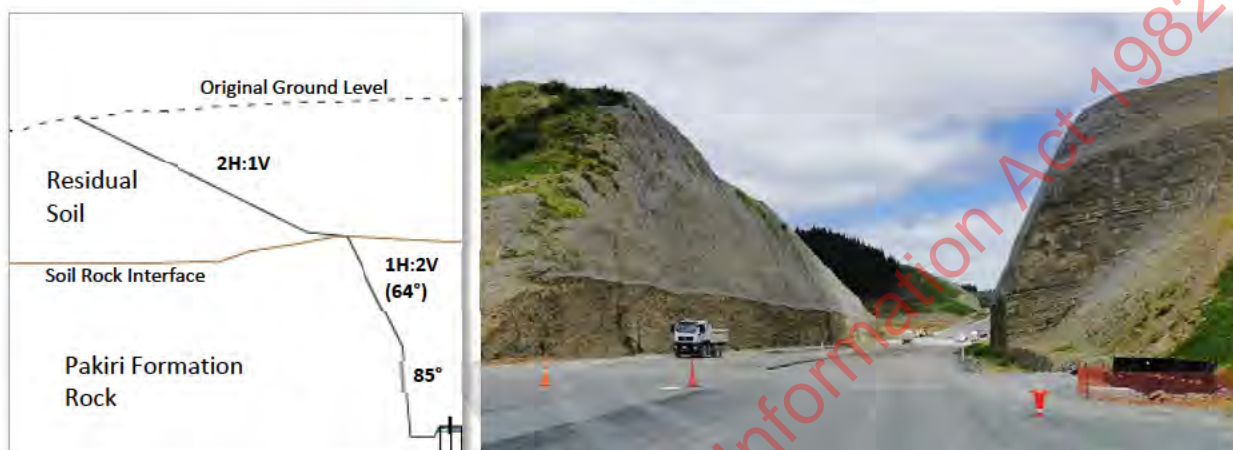
Risk Item	Example	Potential Causes	Locations
<p>6. Rockfall from debris above rock cuts, potentially rolling or dropping on the SH1.</p> <p>Refer to revised rockfall risk assessments in Section 4.2.</p>	 <p>CS2F East (2 November 2021)</p> <p>CN5B East (buttress fill)</p>	<ul style="list-style-type: none"> <li>Exposed weathered and highly fractured rock,</li> <li>Steep slopes above rock cuts without sufficient rockfall catch area or protection,</li> <li>Rock lining fill from swale drains or buttress fill,</li> </ul>	<ul style="list-style-type: none"> <li>Refer to <a href="#">Table 11</a> for locations of 85° steep rock cuts,</li> <li>CN5B (buttress),</li> <li>CN5B East &amp; West,</li> <li>CS2F East,</li> <li>CS3 East,</li> </ul>
<p>7. Topsoil slumps and surficial erosion</p>	 <p>CS16D</p>	<ul style="list-style-type: none"> <li>Soil slopes with smooth surfaces or topsoil placed on rock cuts,</li> <li>Too loosely placed or thick topsoil,</li> <li>Topsoil placed prior to winter (rainfall) season,</li> </ul>	<ul style="list-style-type: none"> <li>Soils slopes, particularly at transition into cut slopes from embankment fills, where batters could be steeper than 2H:1V,</li> <li>CS16D,</li> </ul>
<p>8. Surficial rock dropouts and rockfall behind mesh draping without affecting rock cut integrity.</p>	 <p>CN5B</p>	<ul style="list-style-type: none"> <li>Defect sets of rock mass,</li> <li>Ongoing weathering of exposed rock surface,</li> <li>Groundwater seepage,</li> </ul>	<p>All location of steep rock cuts. Refer to <a href="#">Table 11</a>.</p>

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## 4.0 Rock Cuts

### 4.1 Rock Cuts

The alignment comprises multiple rock cuttings which are formed in the Pakiri Formation sedimentary rocks. Some of the rock cuts are more than 40m high with cut slopes up to 85° steep. A typical design section and photo of these steep rock cuts is given in Figure 2 below. A summary of the rock cuts at the P2Wk alignment is listed in Table 11.



CN5B Photo dated 12 November 2021

Figure 2: Typical Rock Cut Geometry

The rock support design requires the site-specific installation of rock bolts based on the observed rock conditions on site which are confirmed by the designer. Depending on the observed rock conditions, the rock support comprises 3m to 6m long rock bolts installed at typical spacings from 3m (horizontal) by 3m (vertical) for Class II rock to 1m (horizontal) by 1.5m (vertical) for Class IV rock. The stabilisation requirements are given on the respective drawings for each construction zone.

We have not been provided with or reviewed the Construction Observation Records of the rock cuts. We have also not reviewed the designs which led to the rock cut stabilisation requirements given on the drawings.

The project drone flyover videos suggest that at some of the rock cut slopes larger rock dropouts/voids and wedge-type failures are present resulting in vertical and partially overhanging rock cuts. Due to the camera view angle of the drone towards to cut slope, a review of the rock conditions based on the drone videos is not feasible. Specific Design Engineer Instructions (i.e. DEI 0493 for the western site at CN5B) were issued to address the site observations and rock stabilisation requirements.

During our site visits dated 2 and 12 November 2021 we confirmed the presence of the larger voids and overhanging rock cuts, for example at Cut CN5B, and potentially over-steepened cuts and falling rocks behind the mesh drapery.



## 4.2 Rockfall Risks

This section of the report shall be read in conjunction with the 'Executive Summary', Section 1.9 – Revisions from the Previous Report and Section 8.0 – Conclusions.

The rockfall design comprises a mesh drapery system which is anchored at the slope crest but is not pinned to the rock face. The purpose of the rockfall drapery is in limiting the risk of rockfall impacting the future SH1 motorway from rockfall.

Based on the provided design reports, the design addresses the rockfall from the steep rock cuts. It appears that potential rockfall from the upper slopes (typically 2H:1V), where loose transitional rock or debris, rockfill at toe buttresses or rock-lined swale drains may be present, was not addressed.

The potential rockfall risk is schematically shown in Figure 3.



Figure 3: Potential Rockfall Risk

We have highlighted the potential rockfall risks at various cut slopes in our previous draft reports (Rev A, B and C). In absence of any rockfall trials and simulations, and based on our desktop review and site observations only, the potential risk of rockfall at the high-risk locations have previously been identified at the following cuts:

- **CN1 West**
  - Up to 28m high 2H:1V steep slope above rock with exposed weathered rock. Any loose material could roll down the 2H:1V slope and fall/bounce on the SH1 carriageway.
- **CN5B East & West**
  - The constructed buttress fill using the specified 'high strength structural fill' within upper the cut slope appears to comprise loose material, which shows sign of failure.
  - Up to 33m high 2H:1V steep slope above rock with exposed weathered rock. Any loose material could roll down the 2H:1V slope and fall/bounce on the SH1 carriageway.

- CS3
  - The upper 2H:1V steep slope above rock shows exposed weathered rock. Any loose material could roll down the 2H:1V slope and fall/bounce on the SH1 carriageway.
- CS16D
  - The slope comprises a constructed rock-lined chute.
  - The upper 2H:1V steep slope above rock shows exposed weathered rock. Any loose material could roll down the 2H:1V slope and fall/bounce on the SH1 carriageway.

Additional rockfall trials and simulations for the upper 2H:1V exposed rock slopes at Cut CS3 were prepared by the CJV in various reports dated 25 March 2022. Rockfall simulations are also available for the upper 2H:1V rock exposures at Cut S1. A summary of the provided documents is listed in Section 1.10.5.

Based on the review of the provided documentation, we conclude the following:

- The rockfall trials and rockfall analyses at Cut CS3 indicate that the rockfall risk at Cut CS3 is low.
- Based on the February 2022 flyover footage, it appears the rock slope conditions of the upper 2H:1V slopes is representative or shows worse than the conditions at the other slopes at the project.
- Other slopes which were previously identified as having a 'moderate' or 'high' rockfall risk are now (partially) covered with topsoil or are vegetated, which significantly reduces the rockfall risk.
- The slope geometry and geology at Cut CS3 is also considered representative.
- Further rockfall trials at the upper 2H:1V exposed rock slopes are not expected to be required.
- The requirements for further rockfall assessments at the other cut slopes should be reviewed based on site observations.

A summary of the potential rockfall risks based on site observations, drone video reviews and the additional rockfall trials and assessments are given in Table 11.

Table 11: Summary of Rock Cut Slopes

Construction Zone	Cut Number	East (LHS)	West (RHS)	Potential Risk of Rockfall
Northern Zone	N3C-C	Minor rock outcrops cut at 2H:1V	Yes	Low
	N7B-C	No	Yes	Low
Central Zone	CN1-C	Yes	Yes	Low. Refer to Notes 2 and 3
	CN5B	Yes	Yes	Low. Refer to Notes 2 and 3
	CN7A	Yes	No	Low (wetland only)
	CN7B	Yes	Yes	Low
	CN9	Yes	Yes	Low. Refer to Notes 2 and 3
	CN13	Yes	Yes	Low
Southern Zone	CS1 (Moir Hill)	Yes	Yes	Low
	CS2F	Yes	No	Low



Construction Zone	Cut Number	East (LHS)	West (RHS)	Potential Risk of Rockfall
	CS3	Yes	No	Low. Refer to Notes 2 and 3
	CS5	Yes	Yes	Low. Refer to Notes 2 and 3
	CS9A	No	Yes	Low
	CS9G	No	Yes	Low. Refer to Notes 2 and 3
Southern Zone	CS13	No	Yes	Low
	CS15A	Minor rock outcrops cut at 2H:1V	Yes	Low
	CS15B	Rock cut with exposed bedding planes.	Yes	Low
	CS16D	Yes	Yes	Low. Refer to Notes 2 and 3
	S1	Yes	Yes	Low. Refer to Notes 2 and 3
	WP5	Yes	n/a	Low
	S4B	n/a	Yes	Low. Refer to Notes 2 and 3
	S5C	Minor rock outcrops at 2H:1V	Yes	Low. Refer to Notes 2 and 3

Note:

1. Orange highlighted Cuts are locations of previous landslides.
2. No further rockfall analyses at these cut locations have been provided. s 9(2)(b)(ii) We have reviewed the slope geometry, geology and the current slope surface conditions at Cuts CN1 CS16D and S1 based on the February 2022 flyover footage. We consider that the conditions at Cut CS3 are representative or worse than the conditions observed at the other upper 2H:1V steep exposed rock cuts.
3. Based on the CS3 assessment and current observations, the rockfall risk at Cuts CN1 CS16D and S1 is considered low.

We note that we have not carried out independent rockfall risk analyses or assessment in accordance with design guidelines, i.e. Guide to Slope Risk Analysis, Version 4. NSW Government, Roads and Maritime Services (2014).

## 5.0 Summary of Site Observations & Monitoring

### 5.1 Site Observations

Site observations by s 9(2)(b)(ii) and 9(2)(ba)(i) geotechnical engineers or geologists were undertaken at nine over the last 2 years at the dates listed below.

- 24 & 25 February 2021, initial site walkover,
- 2 June 2021
- 29 July 2021
- 2 November 2021
- 12 November 2021
- 21 July 2022, inspection of landslides,
- 15 November 2022
- 6 December 2022
- 20 February 2023, site walkover after Cyclone Gabrielle,

The cut slope locations of site inspections were selected based on the desktop study and previous site inspections where the perceived risks of future slope failures or potential maintenance issues were considered moderate to high. The cut slope locations inspected during our site visits are listed in Table 12 below.

Table 12: Slope Inspections

Construction Zone	Cut Number	Site Inspection Date			
		2 & 12 Nov. 2021	14 July 2022	15 Nov. & 6 Dec. 2022	20 Feb. 2023
Northern Zone	N1A				✓
	N3C	✓	✓		(✓)
	N7A	✓			
	N7B				✓
Central Zone	CN1	✓		✓	✓
	Perry Road Cuts (CN4 Fill)	✓		✓	
	CN5A	✓		✓	
	CN5B	✓	✓	✓	(✓)
	CN7B	✓			✓
	CN12B		✓	✓	✓
	Mahurangi Forestry Road		✓	✓	
	CS1 (Moir Hill)	✓		✓	
	CS2D	✓			
	CS2F	✓		✓	
	CS3	✓			✓
Southern Zone	CS5	✓	✓	✓	✓
	CS8D			✓	
	CS9A	✓			
	CS9G	✓		✓	✓
	CS13	✓	✓	✓	✓



Construction Zone	Cut Number	Site Inspection Date			
		2 & 12 Nov. 2021	14 July 2022	15 Nov. & 6 Dec. 2022	20 Feb. 2023
	CS16B		✓	✓	✓
	CS16D	✓		✓	✓
	S1	✓			✓
	S4B	✓			✓
	S5C	✓			

Notes:

- Orange highlighted Cuts are locations of the initial landslides.
- (✓) Drive by only.

The site observation notes from the November 2021 inspection are attached in Appendix B, the review of the landslides which occurred in July 2022 are attached in Appendix B and the February 2023 site inspections are attached in Appendix C of this report.

## 5.2 Monitoring

Slope monitoring was provided for the selected cut locations as summarised in Table 13 below. The monitoring points were installed in May to November 2022, and monitoring data is available until late November to December 2022.

Significant slope movements more than 200mm were recorded at three cut location, N1A East, CN12B East and CS5 East.

Table 13: Slope Movement Monitoring

Construction Zone	Cut Number	Start / Duration	Number of Monitoring Points	Recorded Movement
Northern Zone	N1A East	June to November 2022	9	up to 400mm, increased movement in August 2022
	N7A South-East	June to December 2022	4	10mm
Central Zone	CN1 North-West	June 2022 to January 2023	1	< 10mm
	Perry Road Cuts	September to December 2022	9	Up to 24mm, increased movement in October 2022
	CN5A East	June 2022 to January 2023	7	< 10mm
	CN5B North-East	July to November 2022	6	up to 12mm
	CN7B North-East	June 2022 to January 2023	3	10 to 20mm
	CN12 East	November to December 2022	5	up to 275mm
	CS2B Northeast	June to November 2022	4	< 14mm
	CS2D East	November to December 2022	6	Up to 41mm Increased movement at 2 points in July 2022 from 5mm to 25mm
CS2F East	July to November 2022	3	22mm – sharp increase in November 2022	

Construction Zone	Cut Number	Start / Duration	Number of Monitoring Points	Recorded Movement
Central Zone	CS5 East	June to July 2022	6	up to 1900mm from early May to late August 2022
	CS8D West	May to December 2022	8	up to 35mm in June 2022, new baseline in July 2022.
	CS15 South-West	June to November 2022	7	up to 20mm
	CS16D East	June to November 2022	4	< 10mm
Southern Zone	S1 North-east	June to November 2022	3	< 10mm
	S4B	August to November 2022	5	up to 28mm, increased movement in mid-November
	WM5	Plotted from September to December 2022	9	30 to 60mm
	S5C	July to November 2022	4	10 to 15mm

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s 9(2)(b)(ii) and 9(2)(ba)(i)



## 6.0 Risk Assessment Summary

Table 14 summarises the slope risk assessment. A detailed review is provided in Section 7.0 of this report.

Table 14: Summary of Risk Assessment

Construction Zone	Cuts facing SH1, Cut Number	East (LHS)	West (RHS)
Northern Zone	N2A	Very low risk	Very low risk
	N2C	Very low risk	Very low risk
	N2D	Very low risk (No cut slope)	Very low risk
	N2E	Very low risk	Very low risk
	N1A (North of Curran Underpass)	Very low risk	Very low risk
	N1A Landslide 1 (East)	Moderate risk Remedial works due to active slope movements at N1A are currently being assessed.	Very low risk
	N4C	Very low risk	Very low risk
	N4E	Very low risk	Very low risk
	N3C	Low risk	Low risk Refer to individual risk rating.
	N3D	Very low risk	Very low risk
	N3E	Very low risk	Low risk
	N7A Landslide 2 (West)	Very low risk	Low risk: • Maintenance of subsoil drains during design life.
	N7B	Very low risk	Low risk
Central Zone	CN1	Low risk	Low to moderate risk
	Perry Road Cuts at western side of CN4 fill	Very low risk (No cut slope)	Low risk
	CN5A Landslide 3 (East)	Low to moderate risk	Very low risk
	CN5B Landslide 4(East)	Low to moderate risk	Low to moderate risk
	CN7A	Low Slope does not directly affect SH1. Parts of the cut slope are backfilled and form part of the spoil site.	Very low (No cut slope)
	CN7B	Low risk	Low risk
	CN8A Landslide 5	Not applicable	Insufficient information to assess risk at this stage.
	CN9 Landslide 6 (West)	Low risk at upper soil slopes perpendicular to the road alignment.	Very low risk
	CN12A	Very low risk Overall stability of original slope improved due to placement of fill CN12.	Very low risk (No cut slope)
	CN12B	Low to moderate risk. Remedial works to be completed.	Very low risk. Soil rock interface is dipping away from cut slope.
	CN13	Low risk. • No significant groundwater seepage observed. • Soil rock interface typically less than 10 degrees inclined.	Low risk. • No significant groundwater seepage observed. • Soil rock interface typically flat or sloping away from cut slope
Southern Zone	CS1 (Moir Hill) Landslide 7 (North-East)	Low risk. All slip debris at transition has been removed. Excludes risks associated with Moir Hill Bridge. Refer to Section 7.25.	Low risk. Additional remedial works completed at north-western side of bridge. Excludes risks associated with Moir Hill Bridge. Refer to Section 7.25.
	Moir Hill Widening Landslide 8 (South East)	Very low risk due to completed stabilisation and remedial works.	Low risk of ongoing downslope movement of existing slope supporting Moir Hill Road.
	CS2B Landslide 9 (East)	Very low risk. 5H:1V slope.	Very low risk (No cut slope)
	CS2D Landslide 10 (East)	Low to moderate risk of slope failure • Slope has been cut back to 2H:1V without lower rock slope. No further remedial works installed (no buttress or drainage). • Cause of slip was daylighting of shear plane. • Potential that shear plane is re-activated.	Very low risk. Minor cut slopes only and generally fill.
	CS2F Landslide 11 (East)	Low to moderate risk of upper soil slope failure due to remedial Works (slope cut back to 3H:1V Buttress and counterfort drains installed). We note that the design solutions relies on the slope drainage system.	Very low risk. Minor cut slope height. Transition below bottom of cut slope.
	CS3 Landslide 12 (East)	Moderate risk Factor of safety assessment suggests that the design requirements of alternative remedial works are not met. Ongoing remedial works at upper slope.	Very low risk. Minor cut slope height. Transition below bottom of cut.
	CS4 (North)	Low risk due to topography	Very low risk (No cut slope)
	CS4 (South)	Low risk due to topography	Very low risk (No cut slope)
	CS5 Landslide 13 (East)	Low to moderate risk Reliance on slope drainage.	Very low risk due to inclination of soil rock transition and topography
	CS7	Very low risk. 5H:1V slope and low slope height	Very low risk. 5H:1V slope
	CS8B	Very low risk. 5H:1V slope and low slope height	Very low risk. 5H:1V slope
Southern Zone	CS8C	Very low risk (No cut slope)	Very low risk. Mainly sidling cut.
	CS8D Landslide 14 (West)	Very low risk (No cut slope)	Low risk. Substantial remedial works design completed. Non-compliant remedial works reviewed by DJV and accepted to remain in place.
	CS9A Landslide 15 (West)	Very low risk. (2H:1V soil slope only)	Low risk. Most of the soil removed. Possible maintenance at rock cut slope.



Construction Zone	Cuts facing SH1, Cut Number	East (LHS)	West (RHS)
	CS9G	Very low risk (minor 2H:1V soil slope only).	Low to moderate risk. Seepage and possible softened ground observed at north-western transition into the slope. Multiple slips observed on the natural slopes outside of the designation after the January 2023 rainfall events.
	CS13	Very low risk (2H:1V soil slope. Topography at back of slope is dipping away)	Low to moderate risk. Erosion gully in the centre of cut. Surficial topsoil slip and groundwater seepage. Two additional slips occurred. Upper slope is cut steeper than designed.
	CS15A Landslide 16 (West)	Very low risk. due to topography.	Low risk. Remedial works completed, and subsoil drains installed. Maintenance for subsoil drains required.
	CS15B	Very low risk due to topography. Very thin soil cover remaining. Note that bedding planes dipping towards slope.	Low Risk. Insufficient information to provide risk assessment.
	CS16B	Very low risk due to topography and slope height. Early completed. However, very limited information.	Low to moderate risk due to topography and slope height. Early completed. No seepage at cut slope observed. Two landslides occurred on natural slopes at the southern ridge just outside the designation.
	CS16D	Low risk of soil slope failure. Erosion at upper soil slopes observed.	Low to moderate risk Erosion/ scour of rock lined chute after the January 2023 rainfall event.
	S1 Landslide 17 (East)	Low risk.	Low risk. Significant groundwater seepage.
	WP5 (Wetland 5) Landslide 18 (East)	Low risk	Not applicable. Refer to S4B West.
	S4B	Not applicable. Refer to WP5 East.	Low to moderate risk of shallow soil slope failure and sliding on transition zone or topsoil slips and erosion.
	S5C Landslide 19 (East)	Very low risk. Planting now established for erosion protection and topsoil slumping	Low risk for slope failure.
	S7	Very low risk (No cut slope)	Very low risk.

Notes:

1. Refer to Appendix A for the risk assessment of individual failure modes.

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## 7.0 Cut Slope Review

This section summarises our review of the cut slope conditions.

### 7.1 N2A

Chainage	Ch47,100 – Ch47,340
Typical <u>Design</u> Slope Geometry	<p>East (LHS = Left-hand side in alignment direction):</p> <ul style="list-style-type: none"> <li>3H:1V slope, less than 5m high</li> </ul> <p>West (RHS= right-hand side in alignment direction):</p> <ul style="list-style-type: none"> <li>3H:1V slope, (slope height unclear based on available information)</li> </ul>
Site & Design Description	<p>East (LHS = Left-hand side in alignment direction):</p> <ul style="list-style-type: none"> <li>Soil slope without rock cut,</li> <li>No backslope above cut slope, terrain slopes away,</li> <li>Planted slope,</li> </ul> <p>West (RHS= right-hand side in alignment direction):</p> <ul style="list-style-type: none"> <li>Ground level at upslope side of cut slope is gently inclining,</li> <li>Existing at south-western side of cut slope, grassed.</li> </ul>
Existing Landslide	None reported <sup>s 9(2)</sup> <sub>(b)(i)</sub>
Landslide Location	Not applicable
Date Landslide occurred	Not applicable
Cut within area of historic landslide	None identified on geological maps.
Geotechnical Investigations	BH6001, BH6002, TP374, TP4023, TP6010
Site Geology	No geological section provided in the report. Ground conditions at road level appear to be residual soils based on February 2020 (flyover time 0:08)
Soil Rock Transition Zone	Unclear. Likely below cut slope.
Rock Cut	No rock cut
Groundwater Seepage Monitoring	No groundwater seepage <b>has been</b> monitoring carried out <b>at this slope section</b> . Based on the drone footage, there appears to be no seepage at the cut slope.
Peer Reviewed in PSM Report Rev4	Not reviewed
Comment	<b>Construction of this slope was completed in December 2021.</b>
Risk of Future Slope Failure	The risk of future slope failure is considered <b>very low</b> .



Mapbox Aerial Photo





July 2021, Time 0:22 – View in southern direction: South-East = left-hand side; North-West = right-hand side



September 2021, Time 0:21 – View in southern direction: South-East = left-hand side; North-West = right-hand side





February 2022, Time 0:23 – View in southern direction: South-East = left-hand side; North-West = right-hand side

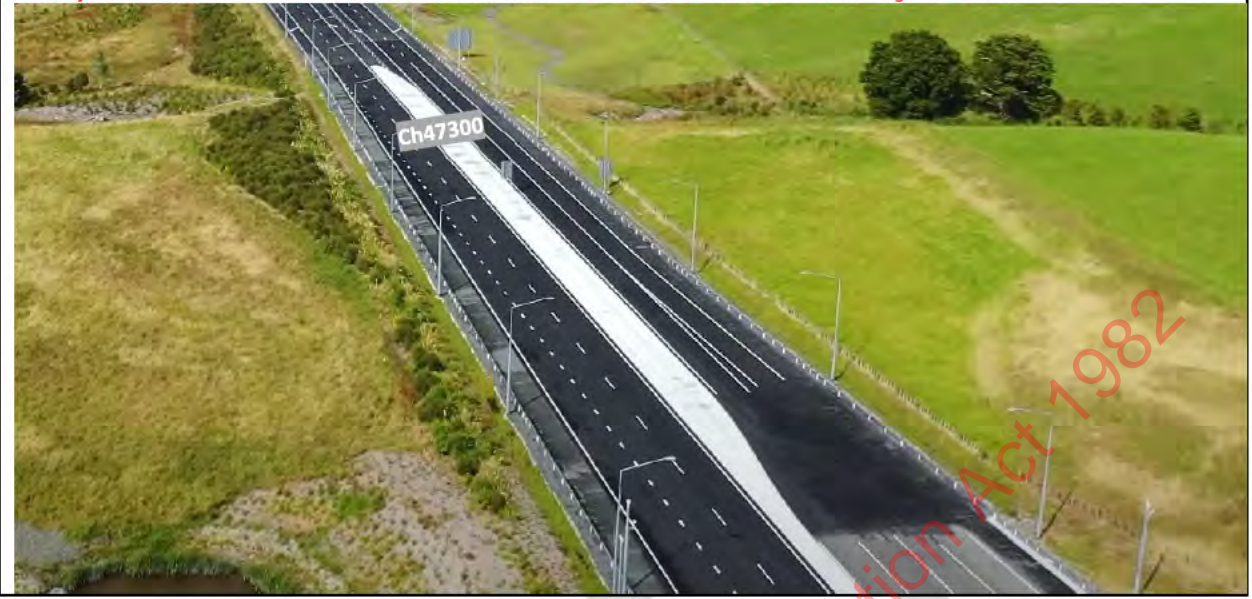


August 2022, Time 0:22 – View in southern direction: South-East = left-hand side; North-West = right-hand side





January 2023, Time 0:36 – View in southern direction: South-East = left-hand side; North-West = right-hand side



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Risk of Future Slope Failure

There appears to be topsoil creep movement on the cut slope in July 2021. Horizontal lines on the grassed surface are still presented in the January 2023 aerial footage. The risk of future slope failure is considered **very low**.

February 2020, Time 0:16 – View in southern direction: South-East = left-hand side; North-West = right-hand side



July 2021, Time 0:29 – View in southern direction: South-East = left-hand side; North-West = right-hand side





September 2021, Time 0:29 – View in southern direction: South-East = left-hand side; North-West = right-hand side



February 2022, Time 0:30 – View in southern direction: South-East = left-hand side; North-West = right-hand side





August 2022, Time 0:29 – View in southern direction: South-East = left-hand side; North-West = right-hand side



January 2023, Time 0:44 – View in southern direction: South-East = left-hand side; North-West = right-hand side





7.3 N2D

Chainage	Ch47,780 – Ch47,840
Typical Design Slope Geometry	<p>East (LHS = Left-hand side in alignment direction):</p> <ul style="list-style-type: none"> <li>• Fill, at grade or cut &lt;3m</li> </ul> <p>West (RHS = right-hand side in alignment direction):</p> <ul style="list-style-type: none"> <li>• 3H:1V cut slope, up to 3m high</li> </ul>
Site & Design Description	<p>East (LHS):</p> <ul style="list-style-type: none"> <li>• No significant cut slope obvious</li> </ul> <p>West (RHS):</p> <ul style="list-style-type: none"> <li>• 3H: 1V, max. 2m to 3m deep cut, grassed,</li> <li>• Ground level above cut slope is inclining at approx. 7H:1V,</li> <li>• Gullies at north-eastern and south-western side of cut slope, likely low stormwater run-off over cut slope,</li> </ul> <p>Note: N2D comprises two fill embankments separated by a sidling cut. The cut slope appears to be mostly completed in June 2019 (Flyover time: 0.08).</p>
Existing Landslide	None reported to s 9(2)(b)(ii) d 9(2)
Landslide Location	Not applicable
Date Landslide occurred	Not applicable
Cut within area of historic landslide	None identified on geological maps.
Geotechnical Investigations	CPT6002, TP371, HA6106
Site Geology	No geological section provided in the report for the cut slope. Drawing P2Wk-DRG-GG-01-1004 present a geological section at Ch47,920 at the fill embankment. The expected ground conditions are Pakiri Formation soils.
Soil Rock Transition Zone	Expected at 15m below cut slope level.
Rock Cut	No rock cut. Ground conditions at road level appear to residual soil based on February 2020 (flyover time 0:23)
Groundwater Seepage Monitoring	No groundwater seepage monitoring has been carried out. No obvious groundwater seepage was observed based on drone footage.
Peer Reviewed in PSM Report Rev4	Not reviewed
Risk of Future Slope Failure	The risk of future slope failure is considered very low.



February 2020, Time 0:21 – View in southern direction: South-East = left-hand side; North-West = right-hand side



July 2021, Time 0:35 – View in southern direction: South-East = left-hand side; North-West = right-hand side





September 2021, Time 0:34 – View in southern direction: South-East = left-hand side; North-West = right-hand side



August 2022, Time 0:34 – View in southern direction: South-East = left-hand side; North-West = right-hand side



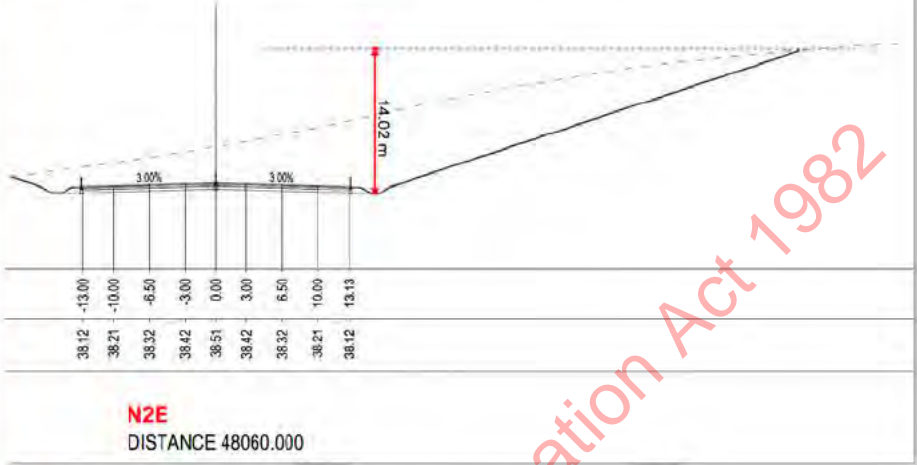


January 2023, Time 0:49 – View in southern direction: South-East = left-hand side; North-West = right-hand side



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7.4 N2E

Chainage	Ch47,935 – Ch48,190
Typical Design Slope Geometry	<p>South-east (LHS): no cut slope            North-west (RHS): 3H:1V, up to 14m high</p> 
Site & Design Description	<p><b>East (LHS):</b>            - Minor cut less than 3m, 3H:1V, grassed,  <b>West (RHS):</b>            - 3H: 1V, up to 11m deep cut, grassed,            - Ground level above cut slope is slightly inclining. Cut appears at end of previous spur.            - Gullies at north-eastern and south-western side of cut slope,            - Farm track above cut slope. Likely low stormwater run-off over cut slope,            - Topsoil movement obvious</p>
Existing Landslide	None reported t s 9(2)(b)(i) and 9(2)
Landslide Location	Not applicable
Date Landslide occurred	Not applicable
Cut within area of historic landslide	Low risk at western part (RHS)
Geotechnical Investigations	BH6005, TP6012, TP6105, TP369, BH6006, BH393
Site Geology	<p>No geological section provided in the report.            The description in the report 650-RPT-011-NX2 suggests the cut is formed in "predominantly Pakiri Formation typically consisting of interbedded layers firm to very stiff clayey to sandy silt and loose to medium dense sand to a depth of 20m underlain by very weak highly weathered siltstone and sandstone."</p>
Soil Rock Transition Zone	Expected below cut slope level.
Rock Cut	No rock cut. Ground conditions at road level appear to residual soil based on February 2020 (Flyover time 0:27)
Groundwater Seepage Monitoring	<p>Seepage monitoring undertaken on the 14/07/2021 within 48 hours of rainfall.</p> <ul style="list-style-type: none"> <li>No recorded or obvious signs of seepage with cut slope dry at time of monitoring</li> <li>Cut slope grassed at time of monitoring</li> </ul>
Peer Reviewed in PSM Report Rev4	Not reviewed
Risk of Future Slope Failure	<p>Based on the Flyover videos, it appears that the slope cutting was mostly completed in June 2019. <b>No instabilities have been observed at this slope.</b>            The risk of future slope failure is considered <b>very low.</b></p>



June 2020, Time 0:35 – View in southern direction: South-East = left-hand side; North-West = right-hand side



October 2020, Time 0:25 – View in southern direction: South-East = left-hand side; North-West = right-hand side





February 2021, Time 0:38 – View in southern direction: South-East = left-hand side; North-West = right-hand side



June 2020, Time 0:37 – View in southern direction: South-East = left-hand side; North-West = right-hand side





July 2021, Time 0:38 – View in southern direction: South-East = left-hand side; North-West = right-hand side



February 2022, Time 0:39 – View in southern direction: South-East = left-hand side; North-West = right-hand side





August 2022, Time 0:39 – View in southern direction: South-East = left-hand side; North-West = right-hand side



January 2023, Time 0:53 – View in southern direction: South-East = left-hand side; North-West = right-hand side





## 7.5 N1A – North of Carran Underpass

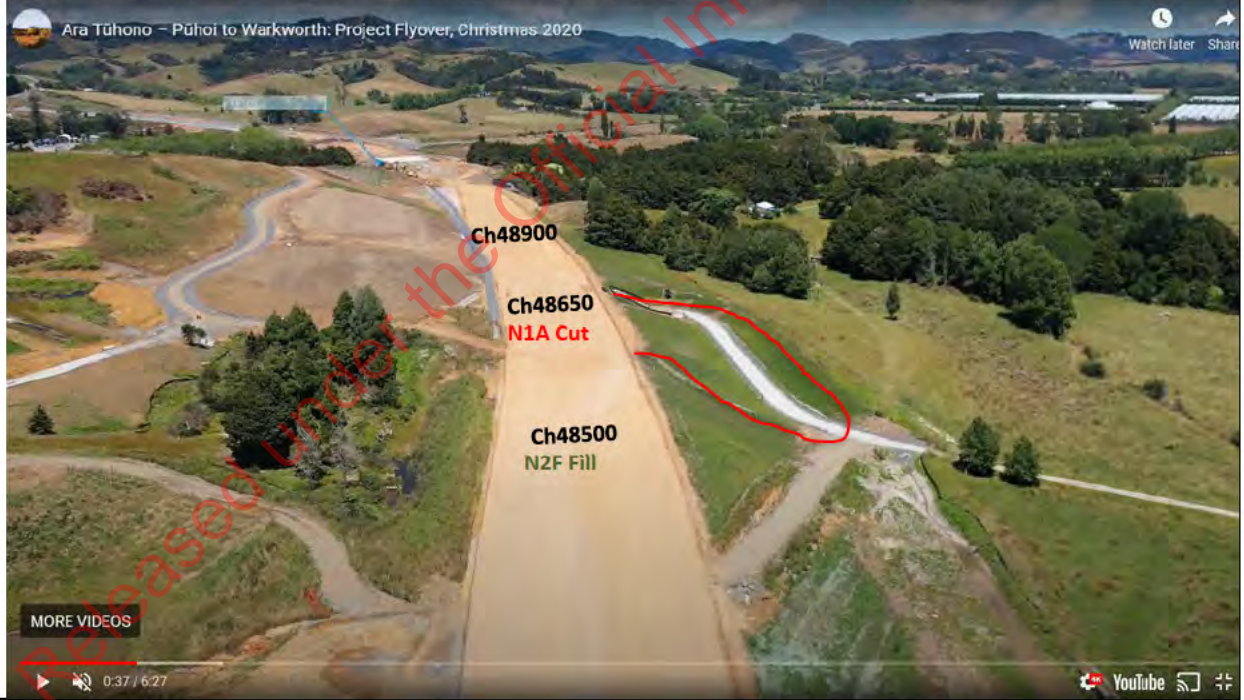
Chainage	Ch48,580 – Ch48,640
Typical Design Slope Geometry	<p>East (LHS):</p> <ul style="list-style-type: none"> <li>3H: 1V, up to 6m high cut</li> </ul> <p>West (RHS):</p> <ul style="list-style-type: none"> <li>3H:1V slope, up to 8m high (supporting SH1)</li> </ul>
Site & Design Description	<p>East (LHS):</p> <ul style="list-style-type: none"> <li>3H: 1V, up to 6m high cut, currently mulched,</li> <li>Cut appears to be done in residual soil,</li> </ul> <p>West (RHS):</p> <ul style="list-style-type: none"> <li>3H: 1V, up to 8m high cut, grassed,</li> <li>Cut slopes to Carran Rd Underpass supporting SH1 alignment</li> </ul>
Existing Landslide	None reported to s 9(2)(b)(ii) and 9(2)
Landslide Location	Not applicable
Date Landslide occurred	Not applicable
Cut within area of historic landslide	Low risk at western part (RHS)
Geotechnical Investigations	BH226, BH390, BH391, BH6009, BH6116A, TP6118
Site Geology	Refer to Section 7.6. Drawing No P2Wk-DRG-GG-01-1007 shows a geological section at Ch48,645. In the design report 650-RPT-011-NX2, the ground conditions are described as <i>"the N1A-C cut generally comprises firm to hard Pakiri Formation soils to 14.5m depth underlain by slightly weathered to unweathered Pakiri Formation rock. The Pakiri Formation soils are residually weathered to completely weathered and are generally described as clayey silt to sandy silt."</i>
Soil Rock Transition Zone	Expected 8m below toe of cut slope.
Rock Cut	No. Ground conditions at road level appear to residual soil based on February 2020 (flyover time 0:38)
Groundwater Seepage Monitoring	No groundwater seepage monitoring carried out. No obvious groundwater seepage observed based on drone footage. The geological section at Ch48,645 on drawing P2Wk-DRG-GG-01-1007 indicates the groundwater level near the bottom of the cut slope.
Peer Reviewed in PSM Report Rev4	Not reviewed
Risk of Future Slope Failure	The risk of future slope failure is considered <b>very low</b> .



February 2020, Time 0:38 – View in southern direction: South-East = left-hand side; North-West = right-hand side



December 2020, Time 0:37 – View in southern direction: South-East = left-hand side; North-West = right-hand side





September 2021, Time 0:49 – View in southern direction: South-East = left-hand side; North-West = right-hand side



August 2022, Time 0:50 – View in southern direction: South-East = left-hand side; North-West = right-hand side



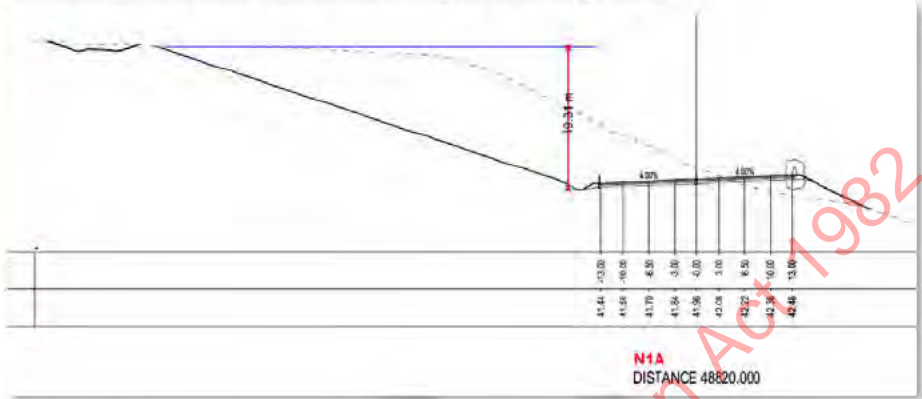
January 2023, Time 1:03 – View in southern direction: South-East = left-hand side; North-West = right-hand side



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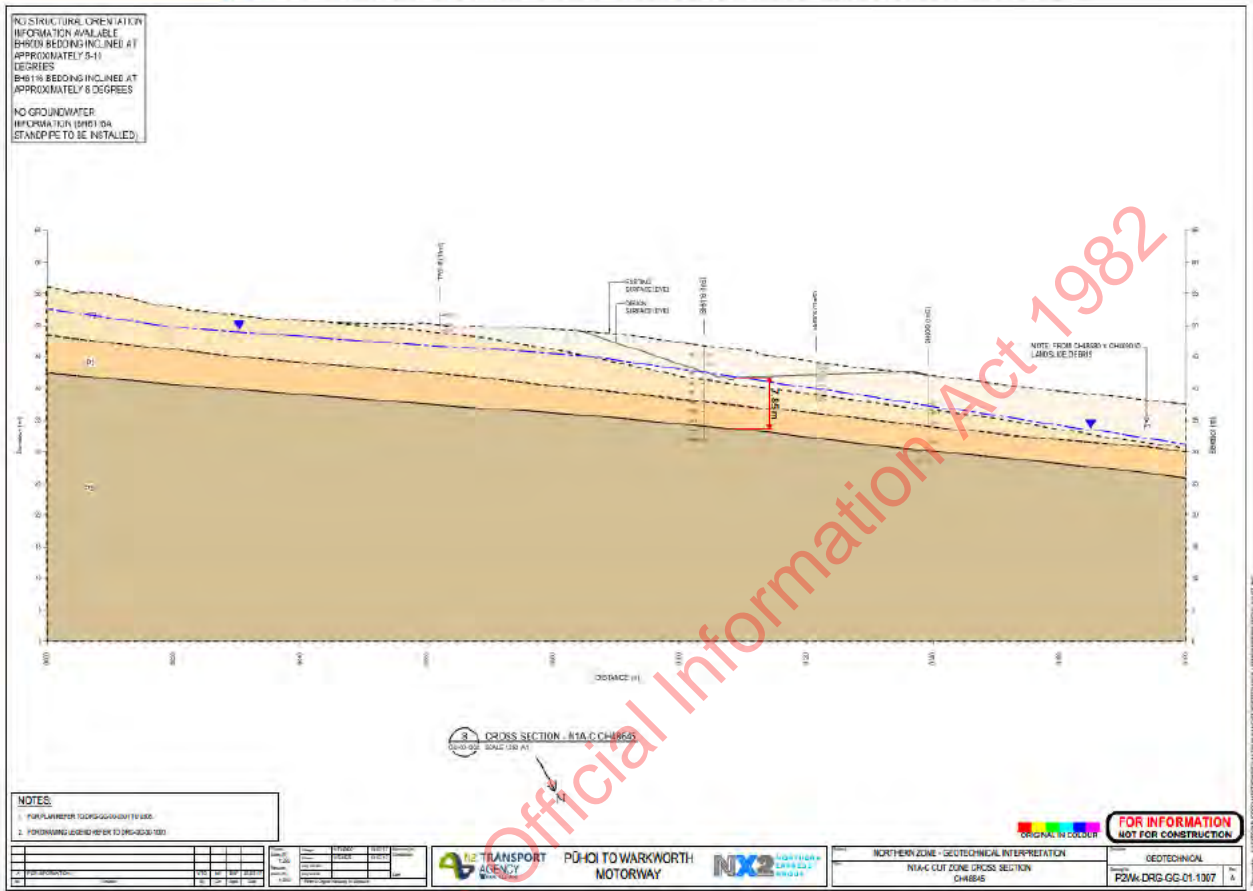
## 7.6 N1A – Landslide 1

Chainage	Ch48,660 – Ch49,010
Typical Design Slope Geometry	<p>East: 3H:1V up to 20m high West: Minor cut and fill less than 5m. Grading into natural ground.</p> 
Site & Design Description	<p><b>East (LHS):</b></p> <ul style="list-style-type: none"> <li>• 3H: 1V (design slope), up to 20m high cut, slope surface mulched in Sept 2021,</li> <li>• Cut appears to be done in residual soil,</li> <li>• N1A cut at western side of NE to SW ridge line, previous landslide feature at cut slope.</li> <li>• Groundwater seepage above rock cut is visible</li> <li>• Geological Section at Ch48645 (drawing P2Wk-DRG-GG-01-1007) indicates that the cut is formed in residual soil &amp; historical landslide debris.</li> <li>• Rock expose near landslide</li> </ul> <p><b>West (RHS):</b></p> <ul style="list-style-type: none"> <li>• N1 Fill embankments,</li> <li>• 3H: 1V, up to 5m deep cut, grassed,</li> <li>• Topography generally dipping in western direction away from the cut slope</li> </ul>
Existing Landslide	Yes (No 1), N1A – East, Ch48,710 – Ch48,780
Cause of Landslide	<ul style="list-style-type: none"> <li>• Evidence of historic landslide activity within and above the excavation footprint.</li> <li>• A secondary softened shear planes orientated parallel to bedding fabric.</li> <li>• The presence of a saturated material above the soil/rock interface</li> </ul>
Date Landslide occurred	<p>March 2020.</p> <p>Further large movements were observed since September/ October 2022. Additional remedial works are required. The slope section at Ch48,700-48,800 is currently considered as an active landslide.</p>
Cut within area of historic landslide	Yes. Low risk sloping in north-western and western direction (Refer drawing P2Wk-DRG-GG-00-0302-D).
Geotechnical Investigations	BH388A, BH6120, BH6010, BH7005, BH6011, BH387, TP367 (Selected investigations, refer to P2Wk-DRG-GG-03-0302 and 0303 for complete information)
Site Geology	<p>Ch48,645 (N1A) - Drawing No P2Wk-DRG-GG-01-1007</p> <ol style="list-style-type: none"> <li>1. Geology - Pakiri Formation (Encountered/inferred stratigraphic thicknesses in order) <ul style="list-style-type: none"> <li>• 0-5.5m - Firm - Residual landslide debris SPT N=1-6</li> <li>• 5.5-9.0m - Stiff - Residual to completely weathered soil and rock (SPT N=1-5)</li> <li>• 9.0-13.0m - Very stiff to hard - Residual to highly weathered soil (SPT N= 11-20)</li> <li>• Slightly weathered to un-weathered rock encountered below 13.0m (SPT N=50+)</li> </ul> </li> <li>2. Structural Features &amp; Defects <ul style="list-style-type: none"> <li>• Bedding dips at between 5°-10° (Not orientated)</li> </ul> </li> </ol>

- Weathering stratigraphy dips E-W at 5°

### 3. Groundwater

- Groundwater encountered 3-5m below surface level within firm residual soils



Soil Rock Transition Zone	5° to 10°
Rock Cut	Rock cut exposure at the eastern side of cut slope formed 4H:1V
Remedial Works Design	DEI 0440, DEI 0444 (Ch48700 – 48730, Soil Stabilisation)
Remedial Works Details	<p><b>First landslide:</b></p> <ul style="list-style-type: none"> <li>• 5x counterfort drains at slip location Ch48,710 – Ch48,780,</li> <li>• Buttress fill</li> <li>• Reshaped from 3H:1V to 4H:1V</li> </ul> <p><b>Second landslide (Ch48,700 – 48,800) October/November 2022</b>          To be confirmed. Final details were not available at the time of writing this report.</p>
Independent Peer Review	Refer to PSM Report PSM4203-029R Draft Rev 4 – Appendix A (only applies for the first landslide)
Rock Cut Slope	Rock outcrop at lower part of cut slope is cut at 4H:1V
Groundwater Seepage Monitoring	<p>Seepage monitoring undertaken on the 14/07/2021 and within 48hours of rainfall. Groundwater seepage observations are as follows:</p> <ul style="list-style-type: none"> <li>• Soil slope was topsoil/mulched at time of inspection</li> <li>• Seepages recorded at northern end of cut slope</li> <li>• Seepage and landslide recorded on eastern cut slope side</li> <li>• Seepages recorded at soil-rock transition</li> <li>• Minor seepage from rock face and typically increased seepage directly after rainfall</li> </ul>



	Very wet and saturated ground was observed at the toe of slope at Ch48,700-48,800 where the recent slope movement was observed.
Risk of Future Slope Failure	<p><b>East:</b> The risk of future slope failure is considered very high as parts of the slope (approx. Ch48,700 – 48,800) have active slope movements. The overall weighted risk rating is a moderate risk. The overall risk rating has been increased from low risk to moderate risk since the Revision D Report.</p> <p><b>West:</b> Very low risk.</p>





February 2021, Time 0:56 – View in southern direction: East = left-hand side; West = right-hand side



June 2021, Time 0:49 – View in southern direction: East = left-hand side; West = right-hand side





July 2021, Time 0:53 – View in southern direction: South-East = left-hand side; North-West = right-hand side

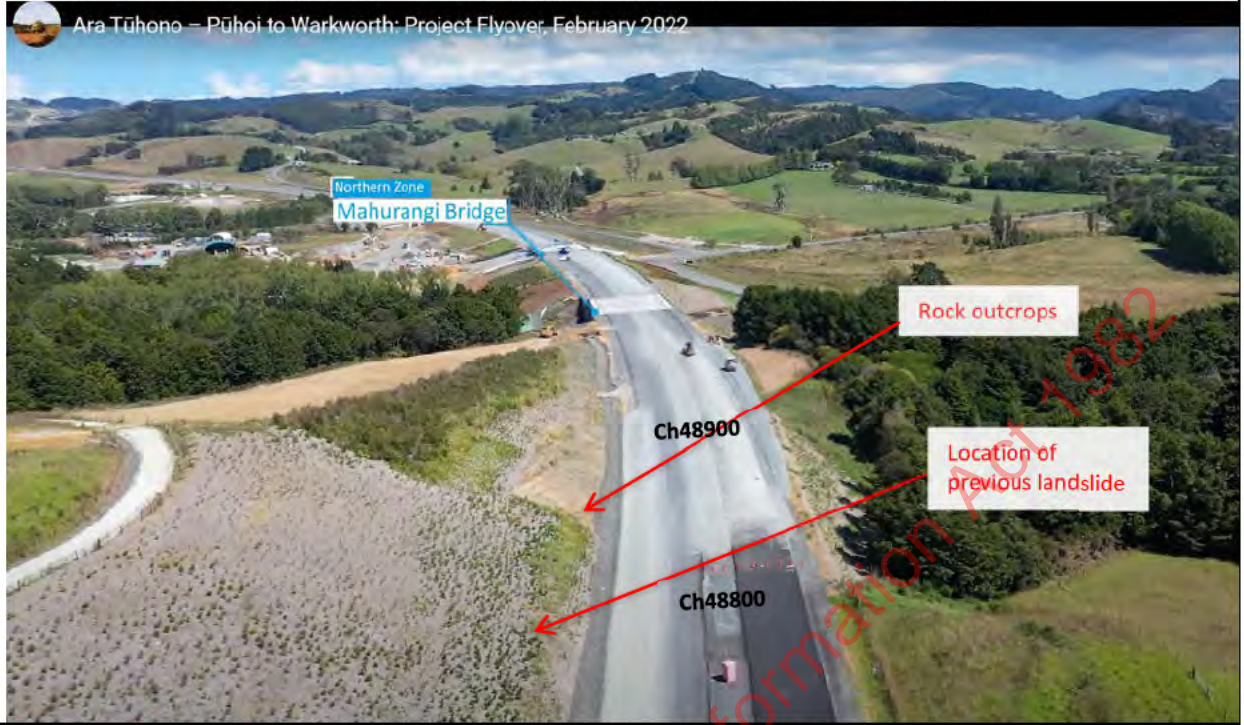


September 2021, Time 0:54 – View in southern direction: South-East = left-hand side; North-West = right-hand side

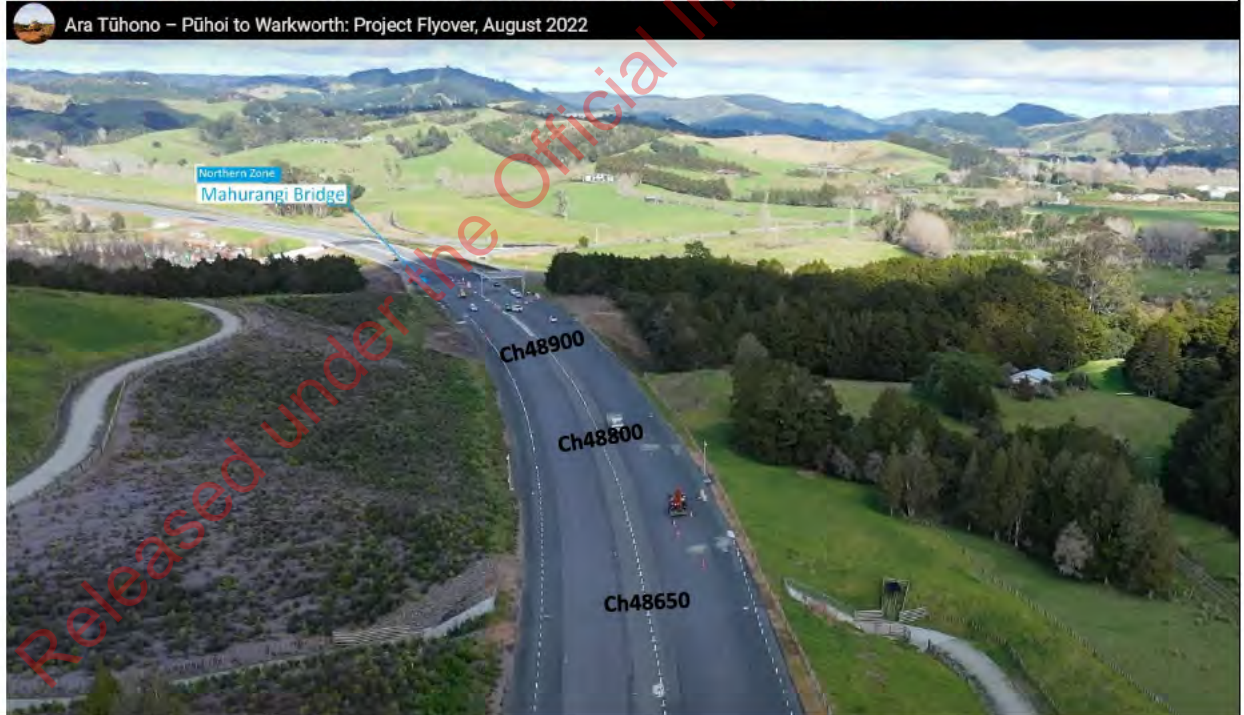




February 2022, Time 0:55 – View in southern direction: South-East = left-hand side; North-West = right-hand side



August 2022, Time 0:50 – View in southern direction: South-East = left-hand side; North-West = right-hand side





January 2023, Time 1:05 – View in southern direction: South-East = left-hand side; North-West = right-hand side



January 2023, Time 1:08





7.7 N4C

Chainage	Ch49,550 – Ch49,835
Typical Design Slope Geometry	<p>East: 3H:1V up to 3m high West: 3H:1V up to 4m high</p> <p style="text-align: center;">D: DISTANCE 49680.000</p>
Site & Design Description	<p><b>East (LHS):</b></p> <ul style="list-style-type: none"> <li>• Topography generally flat, slightly dipping from West to East.</li> <li>• 3H:1V cut slopes in soil (Tauranga Group), less than 3m high, grassed.</li> </ul> <p><b>Notes:</b></p> <ol style="list-style-type: none"> <li>1. Eastern slope appears to be steeper based on flyover footage.</li> <li>2. Cut slope at eastern side near wetland appears to be removed.</li> <li>3. Cut completed by June 2020</li> </ol> <p><b>West (RHS):</b></p> <ul style="list-style-type: none"> <li>- 3H:1V cut slopes in residual soil, less than 4m high, grassed</li> <li>- Cut slopes formed between SH1 and Wyllie Road. Topography gently inclining at western side of Wyllie Rd.</li> </ul>
Existing Landslide	None reported t s 9(2)(b)(ii) and 9(2)(ba)
Cause of Landslide	Not applicable
Date Landslide occurred	Not applicable
Cut within area of historic landslide	None identified on geological maps.
Geotechnical Investigations	BH225, BH4046, BH383, BH7008
Site Geology	Based on geological maps, the cuts are formed in Pakiri Formation residual soils or Tauranga Group. No geological section provided in the report; however, the nearest geological sections are provided for Fill N4B at Ch49,520 (P2Wk-DRG-GG-01-1012), and Fill N4D at Ch49,840 (P2Wk-DRG-GG-01-1012).
Soil Rock Transition Zone	The soil rock transition is expected below cut level and is expected to affect the cut slope design.
Rock Cut	No rock cut or rock exposures at cut slope.
Remedial Works Design	None required.
Remedial Works Details	Not applicable
Peer Reviewed in PSM Report Rev 4	Not reviewed
Groundwater Seepage Monitoring	No groundwater seepage monitoring has been carried out. No obvious groundwater seepage was observed based on the drone footage.
Risk of Future Slope Failure	<p><b>East (LHS):</b></p> <ul style="list-style-type: none"> <li>- The risk of future slope failure is considered <b>very low</b>. Low slope height. Topography dipping away at the back of the cut slope.</li> </ul> <p><b>West (RHS):</b></p> <ul style="list-style-type: none"> <li>- The risk of future slope failure is considered <b>very low</b>. Low slope height.</li> </ul>



The risk rating at both sides has been reduced from low risk to very low risk since the previous Revision D Report.

June 2020, Time 1:07 – View in southern direction: South-East = left-hand side; North-West = right-hand side



July 2021, Time 1:06 – View in southern direction: South-East = left-hand side; North-West = right-hand side





September 2021, Time 1:07 – View in southern direction: South-East = left-hand side; North-West = right-hand side



August 2022, Time 1:07 – View in southern direction: South-East = left-hand side; North-West = right-hand side





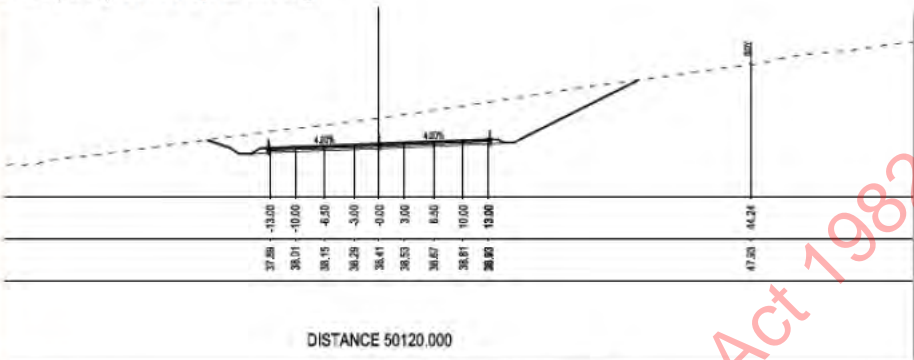
January 2023, Time 1:28 – View in southern direction: South-East = left-hand side; North-West = right-hand side

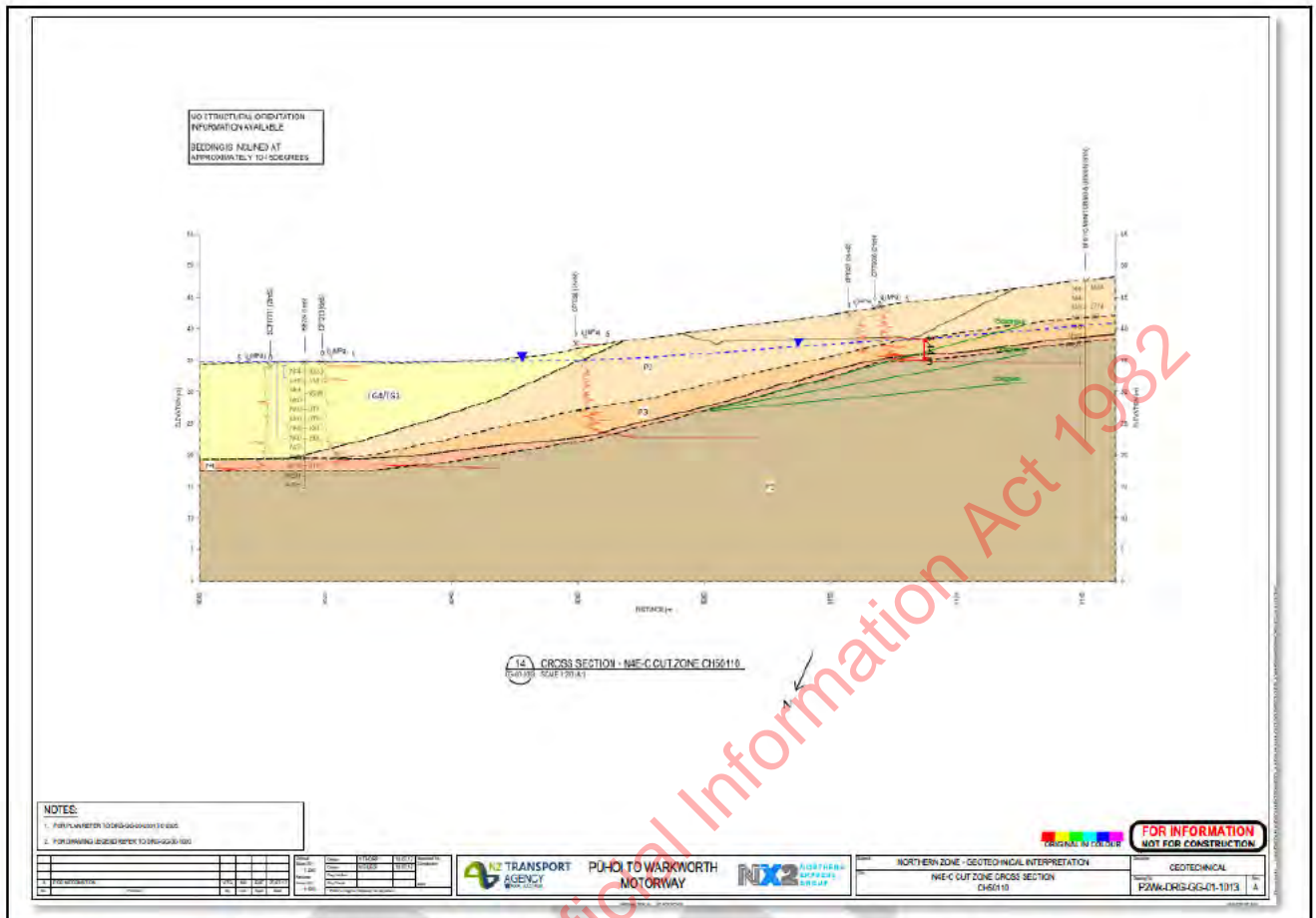


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7.8 N4E

Chainage	Ch50,010 – Ch50,270
Typical Design Slope Geometry	<p>East (LHS): 2H:1V up to 3m high                  West (RHS): 2H:1V up to 8m high</p> 
Site & Design Description	<p>East (LHS):</p> <ul style="list-style-type: none"> <li>Low slope height. Topography dipping away at the back of the cut slope. (Cut completed by June 2020)</li> </ul> <p>West (RHS):</p> <ul style="list-style-type: none"> <li>Low slope height.</li> </ul>
Existing Landslide	None reported to s 9(2)(b)(ii) and 9(2)(ba)(i)
Cause of Landslide	Not applicable
Date Landslide occurred	Not applicable
Cut within area of historic landslide	None identified on geological maps.
Geotechnical Investigations	BH5115, BH224, BH4026, CPT337. CPT338
Site Geology	<p>Ch50,110 (N4E) drawing No P2Wk-DRG-GG-01-1013</p> <ol style="list-style-type: none"> <li><b>Geology - Pakiri Formation</b> (Encountered/inferred stratigraphic thicknesses in order)                     <ul style="list-style-type: none"> <li>Up to 15m - Very soft to soft and firm clay and silt alluvium within gully to east of alignment</li> <li>6-9.5m - Stiff - Residually weathered soil (N=0-4)</li> <li>5.0m-9.0m Stiff to very stiff - Residual to completed weathered soil and rock (SPT N=8)</li> <li>0.5m - 2m - Highly to moderately weathered rock (SPT N=38+)</li> <li>Slightly to unweathered rock encountered 9.5 and 17m below ground level (SPT N=50+)</li> </ul> </li> <li><b>Structural Features &amp; Defects</b>                      Bedding dips at between 5°-10° (no orientation)                      Weathering stratigraphy dips at 10°-15° West to East</li> <li><b>Groundwater</b>                      Groundwater encountered 4-6m below surface level at road cut</li> <li><b>Geomorphological Features</b>                      Alluvial depositional gully</li> </ol>



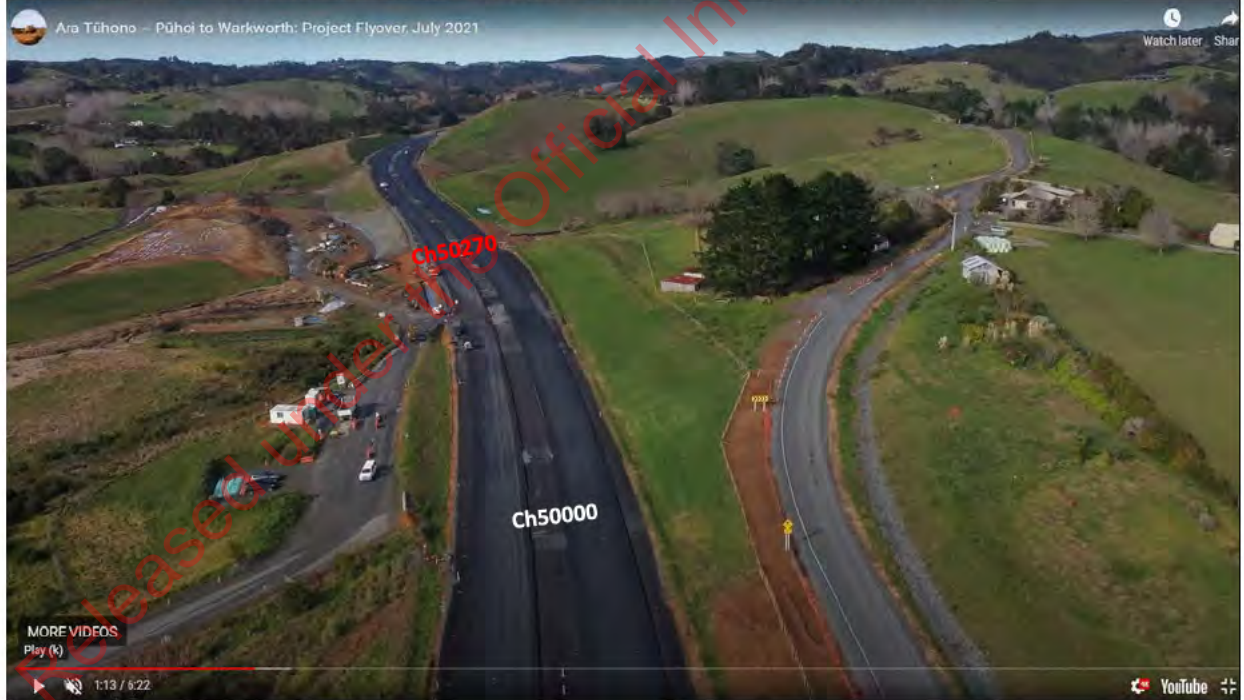
Soil Rock Transition Zone	Transition zone dips at 5-15deg from West to East approx. 3m below toe of slope
Rock Cut	No rock cut or rock exposures at cut slope.
Remedial Works Design	None required.
Remedial Works Details	Not applicable
Peer Reviewed in PSM Report Rev 4	Not reviewed
Groundwater Seepage Monitoring	No groundwater seepage monitoring carried out.
Risk of Future Slope Failure	<p><b>East (LHS):</b> The risk of future slope failure is considered <b>very low</b>. Low slope height. Topography dipping away at the back of the cut slope.</p> <p><b>West (RHS):</b> The risk of future slope failure is considered <b>very low</b>. Low slope height.</p> <p>The risk rating at both sides has been reduced from low risk to very low risk since the previous Revision D Report.</p>



June 2020, Time 1:17 – View in southern direction: South-East = left-hand side; North-West = right-hand side



July 2021, Time 1:13 – View in southern direction: South-East = left-hand side; North-West = right-hand side





September 2021, Time 1:14 – View in southern direction: South-East = left-hand side; North-West = right-hand side



August 2022, Time 1:17 – View in southern direction: South-East = left-hand side; North-West = right-hand side





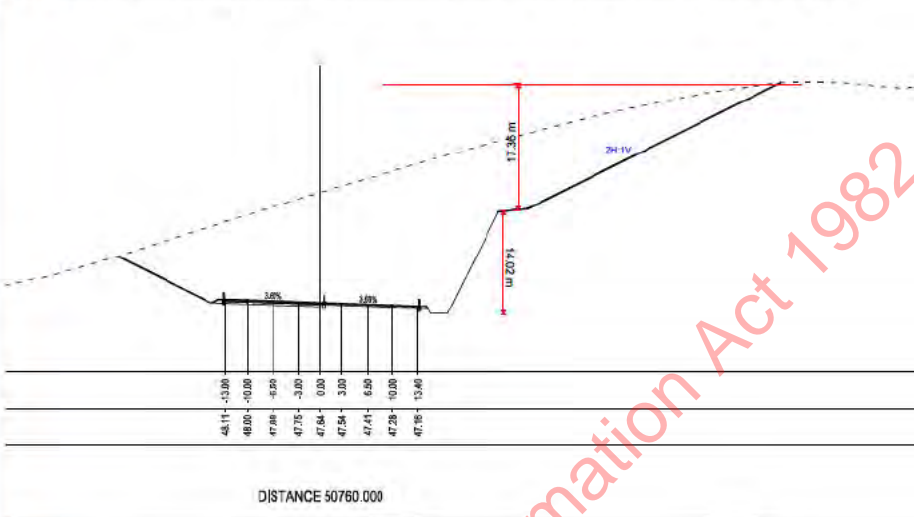
January 2023, Time 1:14 – View in southern direction: South-East = left-hand side; North-West = right-hand side



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7.9 N3C

Chainage	
Typical Design Slope Geometry	<p>East (LHS): 2H:1V up to 8m high, soil rock transition at base of cut, dipping into the cut slope                  West (RHS): 2H:1V up to 20m high, transition zone dipping at 10-15° out of the slope</p> 
Site & Design Description	<p>East (LHS):</p> <ul style="list-style-type: none"> <li>• 2H:1V, max. 8m high,</li> <li>• Ground level is dipping away at the back of the cut slope at approx. 4H:1V.</li> </ul> <p>West (RHS):</p> <ul style="list-style-type: none"> <li>• 2H:1V soil cut above rock cut slope, up to 20m high. Rock cut up to 14m high,</li> <li>• 3H:1V soil cut at southern slope,</li> <li>• Rock cut covered in mesh draping,</li> <li>• Ground level at top of cut slope inclining up to 5H:1V, but generally flat. Dipping towards gully at approx. 30m behind top of cut. Based on topography, potentially small stormwater run-off over cut slope,</li> <li>• Cut slope at end of spur with gullies at northern and southern side,</li> <li>• No/limited vegetation cover at upper 2H:1V cut slope since February 2020. Surface erosion likely.</li> <li>• Upper cut slope appears to be unevenly shaped, potentially due to removal of soil above rock transition zone (refer to comments under Site Geology).</li> </ul> <p>Note:</p> <ol style="list-style-type: none"> <li>1. Cut completed by June 2020. <b>Landslide remedial works completed in August 2022.</b></li> </ol>
Existing Landslide	<p>Not part of the landslide remedial works scheme. A new landslide showing tension cracks was reported s 9(2)(b)(ii) and prior to the site inspected dated 2 Nov. 2021. During the July 2022 rainfall event, the p occurred as the remedial works were not carried out.</p>
Cause of Landslide	<p>Sliding on weathered rock / soil bedding shear planes.</p>
Date Landslide occurred	<p>Initial tension cracks in October/ November 2021. Landslide with large movements in July 2022.</p>
Cut within area of historic landslide	<p>Low risk at south-western part (RHS)</p>
Geotechnical Investigations	<p>BH223, BH379, TP6103, TP6122, TP4014, TP6123</p>
Site Geology	<p>The design report Section 5.3.7.6 described the following conditions: "The soil/rock interface is abrupt, which means that the residually weathered soil transitions to rock without a gradational</p>



weathering profile, which may result in perched water and softened zones at the contact with elevated porewater pressures."

Ch50,740 (N3C) - drawing No P2Wk-DRG-GG-01-1016

**1. Geology - Pakiri Formation (Encountered/inferred stratigraphic thicknesses in order)**

- 7-10.5m Residually weathered to completely and highly weathered stiff to hard soil and rock N=3-9
- Up to 7m of highly to moderately weathered rock in upper slope (west)
- Slightly to unweathered rock encountered 10m below surface level at centre line and up to 14m below surface level in upper slope (West) SPT N=50+

**2. Structural Features & Defects**

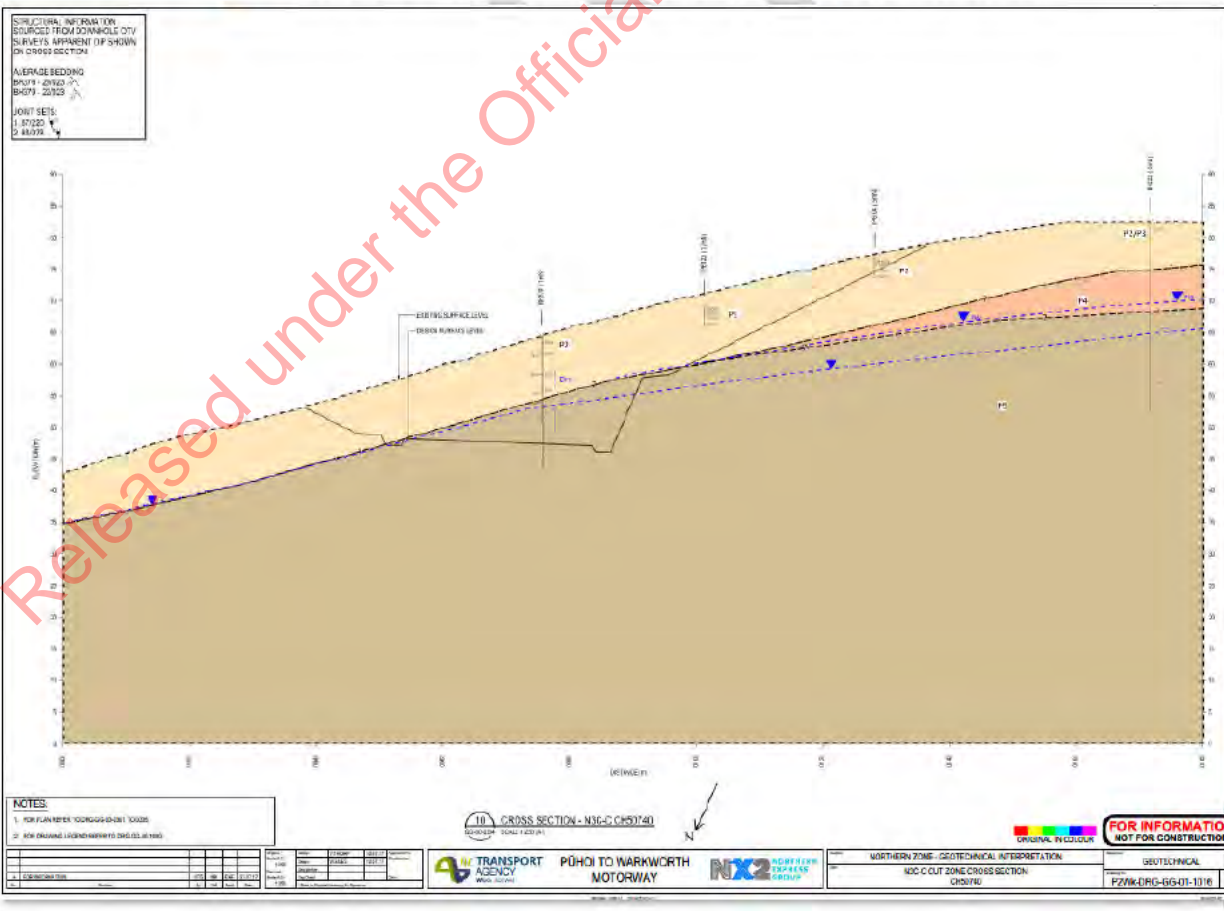
- Slightly/moderately weathered rock and residual soil contact dips out western cut at 7.5°
- Apparent dip of bedding with reference to section is 14° - 20° West to East
- Weathering stratigraphy dips at 7.5° - 20° West to East

Bedding dips: 29/023, 22/078

Joint Sets: 67/220, 80/078

**3. Groundwater**

- Groundwater inferred/modelled at 11m below ground surface level at road cut
- Groundwater inferred/modelled at moderately to slightly weathered contact



Soil Rock Transition Zone	Transition zone is dipping at 10-15° from West to East.
Rock Cut	64° steep, up to 14m high rock cut at western side (RHS) in slightly weathered Pakiri Formation (Unit P5)
Remedial Works Design	Removal of slipped material and soil nails.
Remedial Works Details	7 rows of soil nails as per DEI 0569 (remedial works design of tension crack prior to the landslide). It appears that only 3 rows of soil nails were installed after the slope was reinstated. As-builts are not available to us.
Peer Reviewed in PSM Report Rev 4	Not applicable as landslide occurred after the report was prepared.
Groundwater Seepage Monitoring	<p>Seepage monitoring of the western cut slope was undertaken on the 14/07/2021 within 48 hours of rainfall and an engineering geological site inspection on the 2/11/2021. Groundwater seepage observations and engineering geological observations are as follows:</p> <ul style="list-style-type: none"> <li>• Soil slope was typically dry however grassed/vegetated at time of inspection</li> <li>• Seepage recorded from rock bedding and joint structure</li> <li>• Seepage recorded from soil-rock transition at bench</li> <li>• The slip/failure as observed on 2/11/2021 at southern end between Ch50800 and Ch50840 has been repaired by means of soil nails in March 2022. Refer to DEI 0569.</li> <li>• Seepage/trickle recorded from transition cut between soil and rock slope located directly beneath slip with wet and softened ground present.</li> <li>• Relict bedding structure visible within the highly to completely weathered soil and rock above the bench.</li> <li>• Minor erosional rilling of highly to completely weathered soil and rock</li> </ul>
Risk of Future Slope Failure	<p><b>East (LHS):</b> The risk of future slope failure is considered low. Low slope height. Topography dipping away at the back of the cut slope</p> <p><b>West (RHS):</b> The risk of future slope failure is considered low despite the slope height and the topography at the back of the cut slope. The soil slip at Ch50800 to Ch50840 at the southern side of the rock cut has been repaired in August 2022. The slipped material has been removed and soil nails and subsoil drains are installed.</p> <p>The risk rating is consistent with the Revision D Report.</p>

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June 2020, Time 1:29 – View in southern direction: South-East = left-hand side; North-West = right-hand side



August 2020, Time 1:34 – View in southern direction: South-East = left-hand side; North-West = right-hand side





July 2021, Time 1:24 – View in southern direction: South-East = left-hand side; North-West = right-hand side



September 2021, Time 1:28 – View in southern direction: South-East = left-hand side; North-West = right-hand side





February 2022, Time 1:30 – View in southern direction: South-East = left-hand side; North-West = right-hand side



Mapbox Aerial Photo, February 2022





August 2022, Time 1:30 – View in southern direction: South-East = left-hand side; North-West = right-hand side



January 2023, Time 1:40 – View in southern direction: South-East = left-hand side; North-West = right-hand side





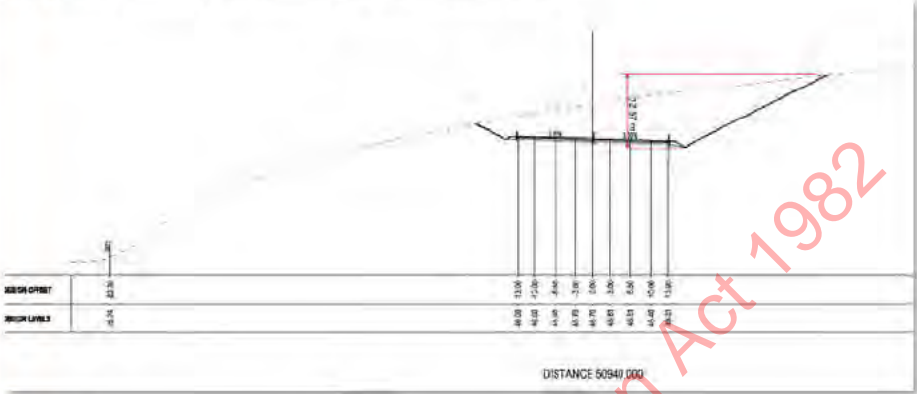
January 2023, Time 1:43 – View in southern direction: South-East = left-hand side; North-West = right-hand side



Reinstated slope with installed soil nails as per DEI 0569

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7.10 N3D

Chainage	Ch50,910 – Ch51,020
Typical Design Slope Geometry	<p>East (LHS): 2H:1V up to 3m high, transition zone unclear                  West (RHS): 2H:1V up to 12m high, transition zone unclear</p> 
Site & Design Description	<p>East (LHS):</p> <ul style="list-style-type: none"> <li>• 2H:1V slope, up to 3m high,</li> <li>• Ground surface dipping away behind cut slope at 3H~5H:1V. At 50m distance dropping 15m at 1H:1V towards Mahurangi River (Right Branch).</li> <li>• Based on flyover footage, cut is formed in residual soil (likely Pakiri formation based on geology).</li> </ul> <p>West (RHS):</p> <ul style="list-style-type: none"> <li>• 2H:1V slope, up to 12m high,</li> <li>• Ground level above cut slope inclining at approx. 6H~8H:1V</li> </ul>
Existing Landslide	None reported to s 9(2)(b)(i) and
Cause of Landslide	Not applicable
Date Landslide occurred	Not applicable
Cut within area of historic landslide	Low risk at south-western part (RHS)
Geotechnical Investigations	TP6042, TP6043, TP358, TP359
Site Geology	No geological section provided in the report. Based on geotechnical investigation data, residually weathered Pakiri Formation soils are expected.
Soil Rock Transition Zone	Not clear, cannot be determined based on test pit investigations.
Rock Cut	No rock cut or rock exposures at cut slope obvious from drone flyover footage.
Remedial Works Design	None required.
Remedial Works Details	Not applicable
Peer Reviewed in PSM Report Rev 4	Not reviewed
Groundwater Seepage Monitoring	No groundwater seepage monitoring has been carried out at this slope.
Risk of Future Slope Failure	<p>East (LHS): The risk of future slope failure is considered <b>very low</b>.                  West (RHS): The risk of future slope failure is considered <b>very low</b>.                  The risk rating at the western side has been reduced from low risk to very low risk since the previous Revision D Report.</p>



August 2020, Time 1:41 – View in southern direction: South-East = left-hand side; North-West = right-hand side



July 2021, Time 1:28 – View in southern direction: South-East = left-hand side; North West = right-hand side





September 2021, Time 1:32 – View in southern direction: South-East = left-hand side; North-West = right-hand side



August 2022, Time 1:33 – View in southern direction: South-East = left-hand side; North-West = right-hand side





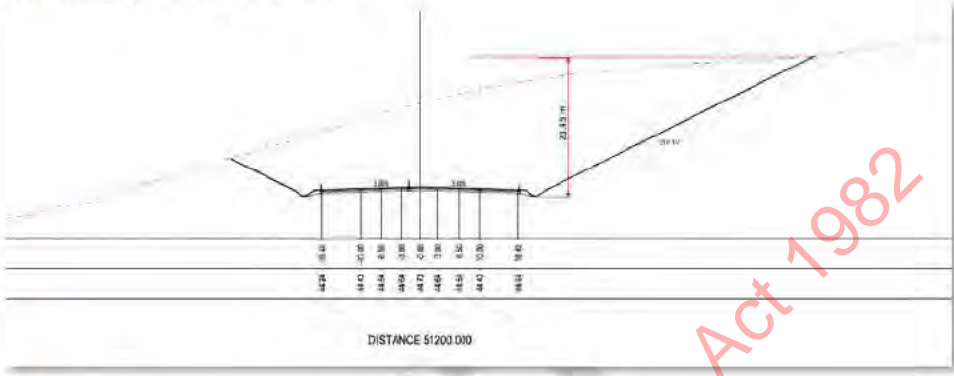
January 2023, Time 1:45 – View in southern direction: South-East = left-hand side; North-West = right-hand side



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7.11 N3E

Chainage	Ch51,085 – Ch51,295
Typical Design Slope Geometry	<p>East (LHS): 2H:1V up to 6m high                  West (RHS): 2H:1V up to 24m high</p>  <p>The diagram shows a cross-section of a road cut. The ground surface is shown as a dashed line, and the cut slope is a solid line. The cut is wider at the top and tapers towards the bottom. A vertical dimension line on the right indicates a height of 23.57 m. The horizontal axis is labeled 'DISTANCE S1200.000'. Chainage markers are shown along the bottom axis, ranging from 51085 to 51295.</p>
Site & Design Description	<p><b>East (LHS):</b></p> <ul style="list-style-type: none"> <li>• 2H:1V slope, up to 6m high,</li> <li>• Ground surface dipping away behind cut slope at 3H~4H:1V.</li> <li>• Wetland at northern end of cut slope.</li> </ul> <p><b>West (RHS):</b></p> <ul style="list-style-type: none"> <li>• 2H:1V slope, up to 23m high,</li> <li>• Ground level above cut slope inclining at approx. 5H:1V</li> <li>• Cut slope at end of spur. Gullies to the North &amp; South of the spur. The southern gully has been filled by spoil site SDS13.</li> <li>• Rock outcrop at lower part of slope. Rock doesn't appear to extent at the SH1 alignment at cut level.</li> <li>• Soil-rock interface unclear. The cut slope appears to be unevenly shaped. Possibly due to removal of transitional rock (unclear).</li> <li>• Groundwater seepage unclear.</li> <li>• Cut slope near final level in June 2019</li> </ul>
Existing Landslide	None reported to s 9(2)(b)(ii) and 9(2)(ba)(i)
Cause of Landslide	Not applicable
Date Landslide occurred	Not applicable
Cut within area of historic landslide	Low risk at south-western part (RHS)
Geotechnical Investigations	BH4028, BH6020, TP6150, TP6051, TP356
Site Geology	<p>No geological section provided in the report. Based on geological maps and nearby cross section, the N3E is mainly cut in Residual Pakiri Formation.</p> <p>The report Section 5.3.7.8 states "<i>The upper 19m of the cut is within stiff Pakiri Formation residual soils with the lower 5m above cut level within Pakiri Formation rock. Groundwater is expected to be encountered during excavation of the cut.</i>"</p>
Soil Rock Transition Zone	Localised rock outcrop at lower slope at western (RHS) side is observed on the drone flyover footage. No rock at eastern cut slopes. Rock transition zone likely dipping in eastern direction, mainly below cut slope faces.
Rock Cut	<ul style="list-style-type: none"> <li>• Based on flyover footage, cut is formed in residual soil (likely Pakiri formation based on geology).</li> <li>• N3E, West: Small outcrop at lower slope</li> </ul>



Remedial Works Design	None required.
Remedial Works Details	Not applicable
Peer Reviewed in PSM Report Rev 4	Not reviewed
Groundwater Seepage Monitoring	Seepage monitoring undertaken on the 14/07/2021 within 48hours of rainfall: <ul style="list-style-type: none"> <li>Slope was dry at time of inspection with no obvious seepages recorded/encountered</li> </ul>
Risk of Future Slope Failure	East (LHS): <ul style="list-style-type: none"> <li>The risk of future slope failure is considered <b>very low</b>.</li> </ul> West (RHS): <ul style="list-style-type: none"> <li>The risk of future slope failure is considered <b>low</b>.</li> </ul>



July 2021, Time 1:30 – View in southern direction: South-East = left-hand side; North-West = right-hand side



September 2021, Time 1:35 – View in southern direction: South-East = left-hand side; North-West = right-hand side





February 2022, Time 1:37 – View in southern direction: South-East = left-hand side; North-West = right-hand side



August 2022, Time 1:36 – View in southern direction: South-East = left-hand side; North-West = right-hand side





January 2023, Time 1:48 – View in southern direction: South-East = left-hand side; North-West = right-hand side

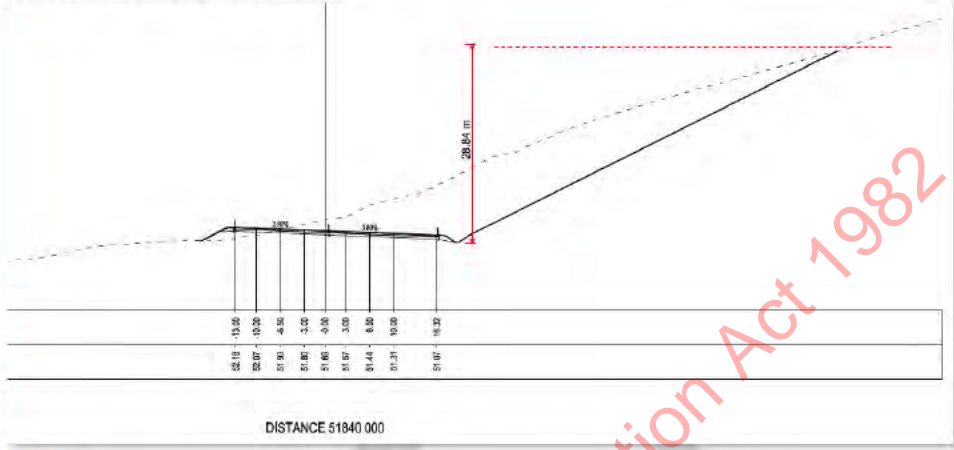


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7.12 N7A – Landslide 2

Chainage	Ch51,660 – Ch51,920
Typical Design Slope Geometry	<p>East (LHS): 2H:1V up to 2m high          West (RHS): 2H:1V up to 29m high</p> 
Site & Design Description	<p><b>East (LHS):</b></p> <ul style="list-style-type: none"> <li>• 2H:1V slope, up to 2m high,</li> <li>• Ground surface dipping gently away behind cut slope at 6H~8H:1V.</li> </ul> <p><b>West (RHS):</b></p> <ul style="list-style-type: none"> <li>• 2H:1V slope up to 29m high.</li> <li>• Ground level above cut slope inclines at 3H~4H:1V.</li> <li>• Rock outcrops at lower slope,</li> <li>• Slope face re-shaped after slip, buttress fill with drainage installed.</li> </ul> <p><b>Note:</b></p> <ol style="list-style-type: none"> <li>1. Clay seams out slope, hummocky ground pre-construction</li> </ol>
Existing Landslide	Yes (No 2), N7A – West, Slip at Ch51,650 – Ch51,720
Cause of Landslide	<ul style="list-style-type: none"> <li>• Evidence of historic landslide activity within and above the excavation footprint.</li> <li>• A secondary softened shear planes orientated parallel to bedding fabric.</li> <li>• The presence of a saturated material above the soil/rock interface</li> </ul>
Date Landslide occurred	15/07/2020
Cut within area of historic landslide	Moderate risk identified. "Landslide debris up to about 5.5m deep is inferred to be present on the existing slope but is expected to be excavated with the cut."
Geotechnical Investigations	BH375, BH376, TP352, TP6152, TP6153
Site Geology	<p>Ch51,780 (N7A) drawing No P2Wk-DRG-GG-01-1019</p> <ol style="list-style-type: none"> <li>1. <b>Geology</b> - Pakiri Formation (Encountered/inferred stratigraphic thicknesses in order)             <ul style="list-style-type: none"> <li>• 4-5m - Firm to very stiff - Colluvium /landslide debris</li> <li>• 3-13m - Stiff residually weathered soil</li> <li>• 1.5m Very stiff to hard - Highly weathered rock</li> <li>• Slightly to unweathered rock encountered 11-15m below surface level</li> <li>• Discrete clay seams daylight out western cut slope at 12.5°, within stiff residual soil (6m above roadside swale at roadside cut)</li> </ul> </li> <li>2. <b>Structural Features &amp; Defects</b> <ul style="list-style-type: none"> <li>• Slightly to moderately weathered rock contact dips at 20° West to East</li> </ul> </li> </ol>

- Apparent dip of bedding with reference to section is 12.5° West to East

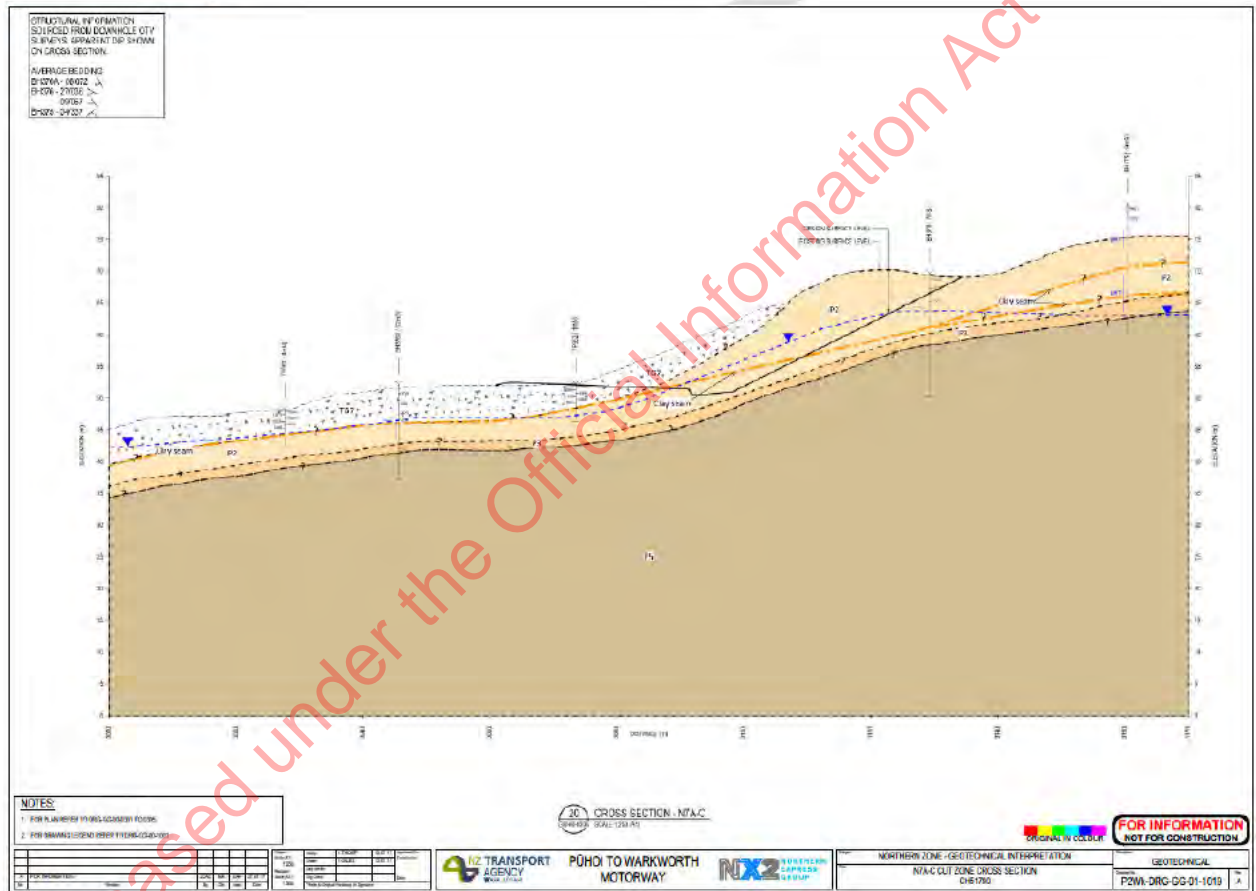
Bedding Average: 06/072, 27/036, 09/067, 04/337

### 3. Groundwater

- Groundwater encountered 5m below surface level at the road cut.
- Groundwater daylight at 13m above of roadside swale cut within soil slope.
- Groundwater recorded within firm residual to completely weathered soil/rock

### 4. Geomorphological Features

- Large rotational landslide feature through middle of site. Sliding occurring along clay seam.
- Groundwater recorded/inferred at contact between landslide deposits at underlying stiff residually weathered soils



Soil Rock Transition Zone	Up to 20° from West to East out of slope
Rock Cut	No rock cut or rock exposures at cut slope.
Remedial Works Design	DEI 0305 (Ch51710 – 51775, Slip Remediation). Remedial works are complete.
Remedial Works Details	<ul style="list-style-type: none"> <li>• 5x counterfort drains,</li> <li>• Buttress fill</li> <li>• Reshape to 3H:1V</li> </ul>
Peer Reviewed in PSM Report Rev 4	Refer to PSM Report PSM4203-029R Draft Rev 4 – Appendix B



<p>Groundwater Seepage Monitoring</p>	<p>Seepage monitoring of the western cut slope was undertaken on the 14/07/2021 within 48 hours of rainfall. Engineering geological site inspections were undertaken on the 2/11/2021 and 12/11/2021.</p> <p>Groundwater seepage and engineering geological observations are as follows:</p> <ul style="list-style-type: none"> <li>• Seepage recorded within lower slope</li> <li>• Multiple small slumps/slips have occurred within topsoil/mulch and upper soil layers, located at crest of toe buttress bench and toe of slope, above swale.</li> <li>• 1 subsoil drain outlet visible at northern end of cut/buttress. Subsoil drain is dry and does not exhibit signs of seepage.</li> </ul>
<p>Risk of Future Slope Failure</p>	<p><b>East (LHS):</b> The risk of future slope failure is considered <b>very low</b>.</p> <p><b>West (RHS):</b> The risk of future slope failure is considered <b>low to moderate</b>. It is unclear how the clay seams have been addressed in the analyses. Slope remain essentially at 2H:1V. Groundwater seepage at lower slope appears to be present. Design may rely on subsoil drains and maintained during the design life of the slope is required.</p> <p>The risk rating at the eastern side has been reduced from low risk to very low risk since the previous Revision D Report.</p>



s 9(2)(b)(ii) and 9(2)(ba)(i)



February 2021, Time 1:42 – View in southern direction: East = left-hand side; West = right-hand side



June 2021, Time 1:38 – View in southern direction: East = left-hand side; West = right-hand side





September 2021, Time 1:48 – View in southern direction: East = left-hand side; West = right-hand side



February 2022, Time 1:50 – View in southern direction: East = left-hand side; West = right-hand side

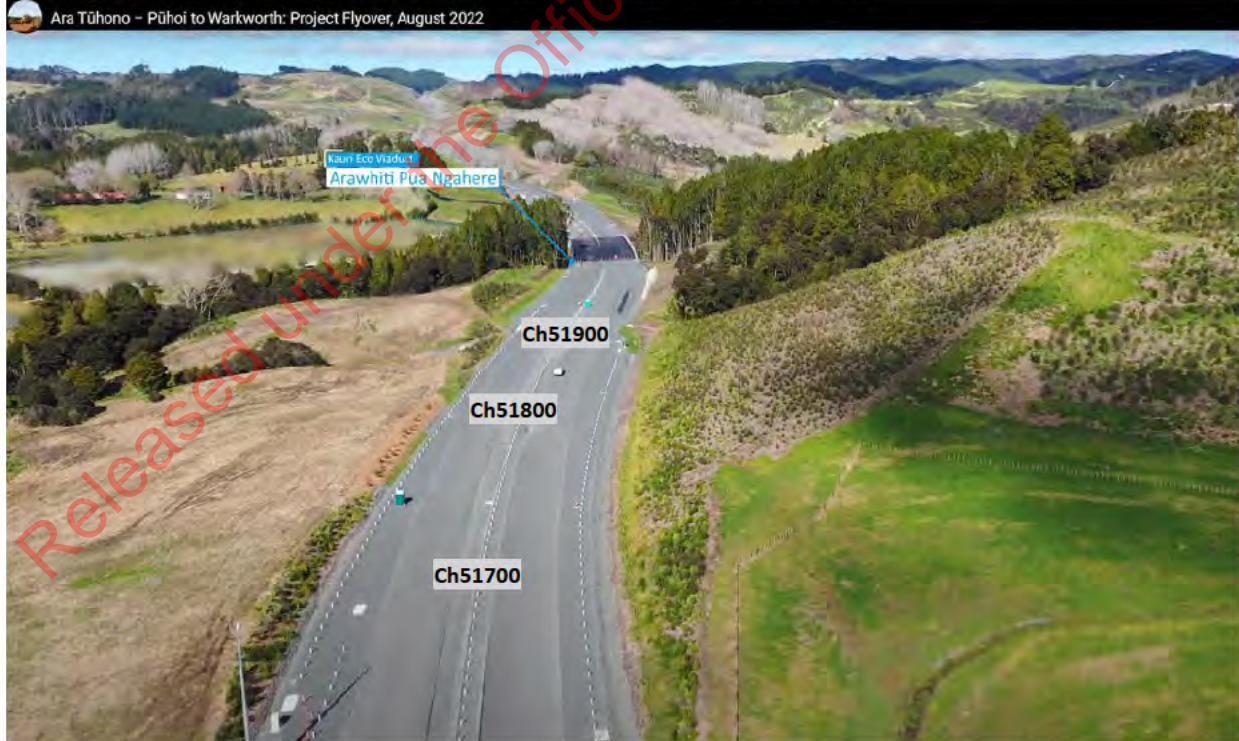




Mapbox Aerial Photo, February 2022



August 2022, Time 1:48 – View in southern direction: East = left-hand side; West = right-hand side






January 2023, Time 1:59 – View in southern direction: East = left-hand side; West = right-hand side



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7.13 N7B

Chainage	Ch51,920 – Ch52,045
Typical Design Slope Geometry	<p>East: 2H:1V soil slope, up to 8m high            West: 2H:1V soil slope up to 18m high</p> 
Site & Design Description	<p><b>East (LHS):</b></p> <ul style="list-style-type: none"> <li>• 2H:1V slope, up to 8m high,</li> <li>• Ground surface dipping away behind cut slope at 3H~5H:1V.</li> <li>• Low risk landslide mapped on Landslide Hazard Map P2Wk-DRG-GG-00-305 at lower slope with inferred headscarp extending under the pavement level. Cut N7B likely provides head unloading of the historic landslide. No construction records available which indicate mapping during construction.</li> </ul> <p><b>West (RHS):</b></p> <ul style="list-style-type: none"> <li>• 2H:1V slope, up to 16m high (based on alignment cross sections),</li> <li>• Rock outcrop encountered during construction. Details included in DEI 0432. The lower rock slope has been stabilised by 4m long rock bolts. Further details are unclear. Slope above rock cut is formed flatter than the design slope of 2H:1V.</li> <li>• Ground level above cut slope is generally flat, inclining up to 5H:1V</li> <li>• Cut slope at end of spur. Gullies to the North &amp; South of the spur. The southern spur is dipping towards a stream.</li> <li>• Soil-rock interface unclear.</li> <li>• Groundwater seepage unclear.</li> <li>• Cut slope near final level in June 2019</li> </ul> <p><b>Modified for rock cut</b>            From the Flyover videos, it appears the soil slope cutting was completed in February &amp; April 2020.</p>
Existing Landslide	None reported to s 9(2)(b)(ii) and 9(2)(ba)(i)
Cause of Landslide	Not applicable
Date Landslide occurred	Not applicable
Cut within area of historic landslide	Low to moderate risk at southern part.
Geotechnical Investigations	BH374, BH6023
Site Geology	No geological section provided in the report. Based on geotechnical investigations and the design report, firm to hard Pakiri Formation residual soils. It is noted that a rock cut was encountered during construction at the lower part of the slope.
Soil Rock Transition Zone	No records available. Based on topography, the soil -rock transition is dipping from West to East.



Rock Cut	Rock cut at lower slope (encountered during construction). The rock cut height is unclear but appears to be 5m high based on the aerial photos.
Remedial Works Design	None required. DEI 0432 (planning record) was prepared to inform of the rock cut below the soil cut slope.
Remedial Works Details	Not applicable
Peer Reviewed in PSM Report Rev 4	Not reviewed
Groundwater Seepage Monitoring	Seepage monitoring undertaken on the 14/07/2021 within 48 hours of rainfall.  Groundwater seepage observations are as follows: <ul style="list-style-type: none"> <li>• Cut slope was topsoil/mulched at time of inspection making observation of any seepages difficult</li> <li>• Installed subsoil drains functioning with minor seepage recorded</li> <li>• Seepage recorded at level of swale drains</li> </ul>
Risk of Future Slope Failure	<p>East (LHS):</p> <ul style="list-style-type: none"> <li>- The risk of future slope failure is considered <b>very low</b>.</li> </ul> <p>West (RHS):</p> <ul style="list-style-type: none"> <li>- The risk of future slope failure is considered <b>low</b>. <b>A topsoil slip has occurred at the slope during the January 2023 rainfall event.</b></li> </ul> <p>The risk rating at the eastern side has been reduced from low risk to very low risk since the previous Revision D Report.</p>





February 2021, Time 1:45 – View in southern direction: East = left-hand side; West = right-hand side



June 2021, Time 1:42 – View in southern direction: East = left-hand side; West = right-hand side





February 2022, Time 1:53 – View in southern direction: East = left-hand side; West = right-hand side



August 2022, Time 1:52 – View in southern direction: East = left-hand side; West = right-hand side





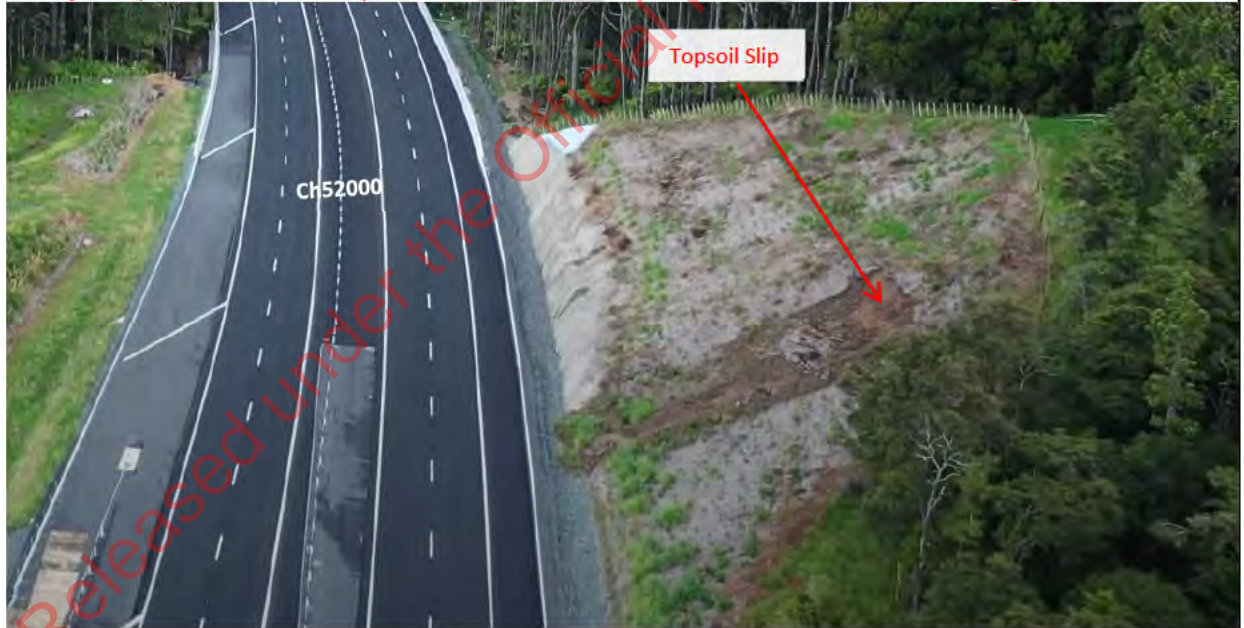
January 2023 (prior to the rainfall event), Time 2:03 – View in southern direction: East = left-hand side; West = right-hand side

Kauri Eco Viaduct

Arawhiti Pua Ngahere

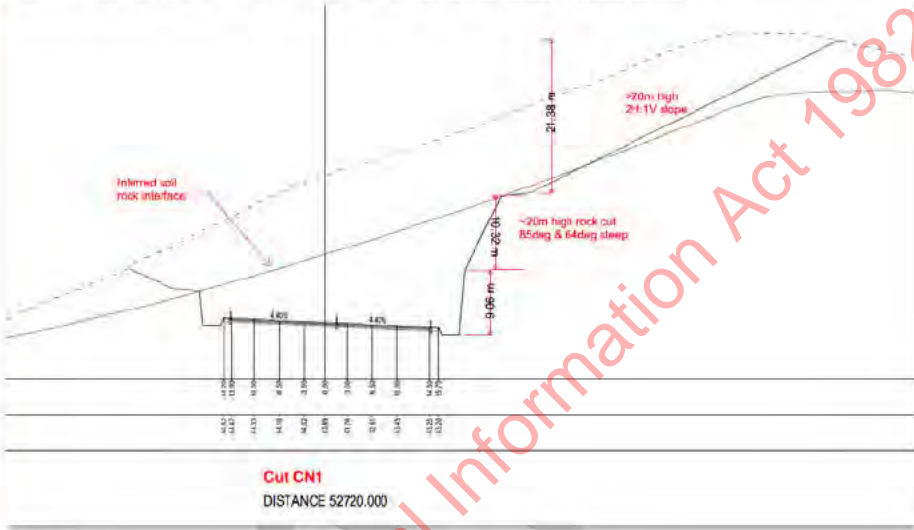


January 2023 (after to the rainfall event), Time 1:49 – View in southern direction: East = left-hand side; West = right-hand side





7.14 CN1

Chainage	Ch52,260 – Ch 52,930
<p>Typical Design Slope Geometry</p>	<p>East (LHS): 2H:1V up to 12m high soil slope above rock cut; 85° (lower 9m) and 64° steep up to 22m high rock cut slope (Ch52,400)</p> <p>West (RHS): 2H:1V up to 28m high soil slope above rock cut; 85° (lower 9m) and 64° steep up to 29m high rock cut slope (Ch52,740)</p> <p><u>We note that soil slope and rock height vary along the alignment at both sides. The above values are maximum values which may not be shown on the presented section.</u></p>  <p style="text-align: center;"><b>Cut CN1</b> DISTANCE 52720.000</p>
<p>Site &amp; Design Description</p>	<p><b>East (LHS):</b></p> <ul style="list-style-type: none"> <li>• 2H:1V slope, up to 12m high,</li> <li>• ground surface dipping away behind cut slope</li> <li>• 4m bench (inclined towards the rock cut) between rock cut and soil cut slope.</li> <li>• Rock cut up to 22m high, rock mesh drapery installed,</li> <li>• Ground level dipping towards the East away from the top of cut. Surface water run-off from cut slopes only.</li> <li>• No obvious groundwater seepage observed (based on drone footage). Based on geological section, the groundwater is within the rock and dipping towards the East away from the cut.</li> </ul> <p><b>West (RHS):</b></p> <ul style="list-style-type: none"> <li>• 2H:1V slope, up to 28m high,</li> <li>• ground surface dipping away behind cut slope</li> <li>• 4m bench (inclined towards the rock cut) between rock cut and soil cut slope.</li> <li>• Rock cut up to 22m high, rock mesh drapery installed,</li> <li>• Soil-rock transition dipping at 15 to 20degrees towards the slope,</li> <li>• Groundwater seepage unclear.</li> <li>• Cut slope near final level in June 2019 (Flyover time 1:22 - 1:30)</li> </ul>
Existing Landslide	None reported to s 9(2)(b)(ii) and 9(2)(ba)(i)
Cause of Landslide	Not applicable
Date Landslide occurred	Not applicable
Cut within area of historic landslide	High risk at western slopes, but sloping away from cut face; Moderate risk at the eastern slope, but sloping away from cut face.
Geotechnical Investigations	BH5201, BH395, BH370, BH220, BH366, BH365, BH6027, BH6028, BH6029, BH6030, BH218, BH219, BH6104,



Site Geology

52,600 (CN1) - drawing P2Wk-DRG-GG-02-102

1. Geology - Pakiri Formation (Encountered/inferred stratigraphic thicknesses in order)

- 4-6m - Stiff to hard - Residually weathered soil
- 2.5m - Highly weathered rock
- 1.5-2.0m - Moderately weathered rock
- Weak to moderately strong, slightly to unweathered rock encountered below 10-11m (UCS 12MPa - 26.4MPa)

Slightly to unweathered rock comprises;

- Thinly bedded, sandstone to siltstone
- Thin to moderately thin bedded, sandstone and siltstone

2. Structural Features & Defects

- Eastern Cut Slope: Weathering stratigraphy boundaries dip into cut slope 10°-15°
- Western Cut Slope: Weathering stratigraphy boundaries dip into cut slope 0°-7.5°

Bedding:

Thin to moderately thin interbedded sandstone and siltstone 20~200mm, 2/227

Joint Set Discontinuities:

Joint set spacing: Widely spaced 600mm-2m

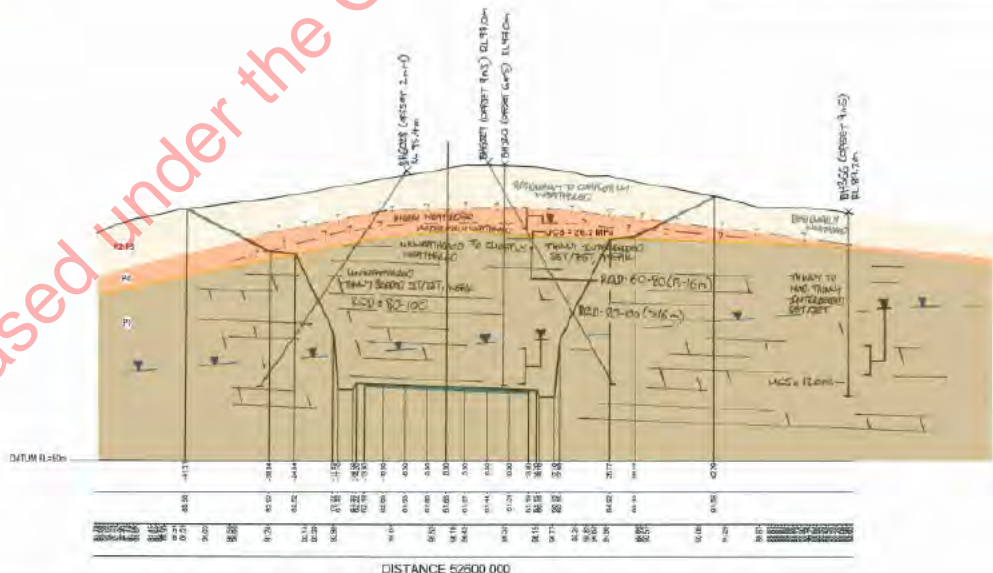
Joint set orientation: 74/260

3. Groundwater

Groundwater recorded within slightly weathered to unweathered rock 28m below surface level.

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UCS TESTS  
 BH360 12.6m 26.2MPa E=4.4GPa  
 BH366 26.4m 12.0MPa E=3.6GPa



COMBINED BOREHOLE DATA ANALYSIS  
 AVERAGE BEDDING 2/227°  
 JOINT SET (S) 74/260°  
 INCLINED BOREHOLES - BOREHOLE B BOREHOLE C  
 CUT SURVEYS - BOREHOLE B BOREHOLE C & BOREHOLE D

JOINTS VERY WIDELY SPACED  
 FEATHERING UNKNOWN  
 CROSS SECTION - CN1-C CH280

NOTES:  
 1. FOR DRAWING LEGEND REFER TO DRG-GG-03-1000  
 2. CROSS SECTION CUT PERPENDICULAR TO MOTORWAY ALIGNMENT

FOR INFORMATION NOT FOR CONSTRUCTION

		GEOTECHNICAL INTERPRETATION GEOTECHNICAL CROSS SECTION CN1-C CH280		GEOTECHNICAL P2Wk-DRG-GG-02-102	
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Soil Rock Transition Zone	<p><b>East (LHS):</b> Generally dipping away at up to 5~10°.</p> <p><b>West (RHS):</b> Up to 15~20°, occasionally larger than 20°</p>
Rock Cut	Up to 30m deep. 85° at lower 9m and 64° above 9m from excavation level.
Remedial Works Design	None required. DEI 0502 (Southwest Rock Cut Stabilisation) contains confirmation design details.
Remedial Works Details	Not applicable
Peer Reviewed in PSM Report Rev 4	Not reviewed
Groundwater Seepage Monitoring	<p>Seepage monitoring undertaken on the 29/07/2021 within 48 hours of rainfall. An engineering geological site inspection was undertaken on the 2/11/2021.</p> <p>Engineering geological and groundwater seepage observations are as follows:</p> <ul style="list-style-type: none"> <li>• The site features a horst and graben geomorphological with slightly weathered to unweathered rock vertically displaced/offset from completely weathered to highly weathered rock/soil by cross cutting steeply inclined to sub-vertical faults.</li> <li>• Vertical offsets range from 2-8m</li> <li>• Bedding structure within rock mass is sub-horizontal</li> <li>• Soil slopes are steeper than the design 2H:1V and up to 30° as recorded on site.</li> <li>• Relatively small, recent translation slip encountered at time of inspection on the 29/07/2021 at northern end of cut, western side.</li> <li>• Translational sliding has occurred along a softened greasy back of relict rock structure (joint release plane) and translational sliding along soil-rock contact</li> <li>• Geology of failed material is typically residual to completely weathered stiff, silty CLAY to CLAY soil with relict rock fabric present</li> <li>• Slip is up to 5m vertical height from toe to scarp with a slip scarp 1-1.5m high. The anticipated zone of influence below ground is 2-3m.</li> <li>• Backslope behind slip is relatively flat</li> <li>• Remnant PVC pipe discharging into top of slip scarp. Orientation and angle of daylighted end suggests it extends NWW – W in the direction of the gully behind the slip.</li> <li>• No standing groundwater or surface water bodies encountered behind slip.</li> <li>• Ground at time of inspection was relatively dry.</li> <li>• Significant flows of groundwater observed at time of remediation of slip 2/11/2021.</li> <li>• Failed material removed, slope laid back and buttressed, counterfort drains installed.</li> <li>• Seepages observed at soil-rock transition both over bench and at transition cuts at northern and southern ends.</li> <li>• Wet and softened ground present at locations of seepage.</li> <li>• Seepage from rock mass bedding and jointing structure</li> <li>• Slumping/failure of soil slope on western side above rock cut at the location of the hanging gully between Ch52,800 and 52,700.</li> <li>• Western rock cut at Ch52,900 is over steepened and near vertical.</li> <li>• Tension cracks &amp; slip scarp developing within the upper soil slope on western side at CH52900.</li> </ul>
Risk of Future Slope Failure	<p><b>East (LHS):</b> The risk of future slope failure is considered <b>low</b> for the soil slopes above the cut cutting. New slips were observed at the wetland at the eastern transition into the cut (approx. Ch52,330) in the September 2021 flyover footage (time 1:56). The slip debris has now been removed <b>and remedial works including counterfort drains were installed.</b></p> <p><b>West (RHS):</b> The risk of future slope failure is considered <b>low to moderate risk.</b></p>



- Rock cut slopes are up to 30m high with 2H:1V steep soil slope above rock cut. 15~20° steep inclined soil rock transition zone.
  - Potential rockfall risks from the upper 2H:1V exposed rock slopes have been reviewed as part of the CJV assessments. Refer to Section 4.2.
  - Seepage at rock slope may cause long-term maintenance issue.
  - The slip at the transition into rock cut which was observed in September 2021 has been repaired.
- The risk rating at the western side has been increased due to the consequence assessment since the previous Revision D Report.

October 2020, Time 1:52 – View in southern direction: East = left-hand side; West = right-hand side



February 2021, Time 1:52 (to 2:01) – View in southern direction: East = left-hand side; West = right-hand side





June 2021, Time 1:51 – View in southern direction: East = left-hand side; West = right-hand side



September 2021, Time 1:58 – View in southern direction: East = left-hand side; West = right-hand side





September 2021, Time 1:56 – View in southern direction: East = left-hand side; West = right-hand side



February 2022, Time 2:00 – View in southern direction: East = left-hand side; West = right-hand side





February 2022, Time 2:08 – View in southern direction: East = left-hand side; West = right-hand side  
Rock slope Ch52600 to Ch52900



August 2022, Time 2:01 – View in southern direction: East = left-hand side; West = right-hand side  
Rock slope Ch52300 to Ch52600





August 2022, Time 2:07 – View in southern direction: East = left-hand side; West = right-hand side  
Rock slope Ch52600 to Ch52900



January 2023, Time 2:13 – View in southern direction: East = left-hand side; West = right-hand side  
Rock slope Ch52400 to Ch52550





January 2023, Time 2:19 – View in southern direction: East = left-hand side; West = right-hand side  
Rock slope Ch52600 to Ch52800



DRAFT

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## 7.15 Perry Road

The Perry Road slips occurred at the western side of the proposed SH1 alignment. The remedial works at this section are complete. Toe buttress fills including shear keys and counterfort drains were installed along Perry Road and the farm access track. The access track was realigned to avoid cutting near the headscarp and mitigate the slope failure risk. The risk of slope failure is considered low.

The remedial works design is summarised in DEI 0559.

The cut slopes do not affect directly the SH1 alignment as the SH1 alignment is constructed on the CN4 fill embankment.





September 2021, Time 2:12 – View in southern direction: East = left-hand side; West = right-hand side

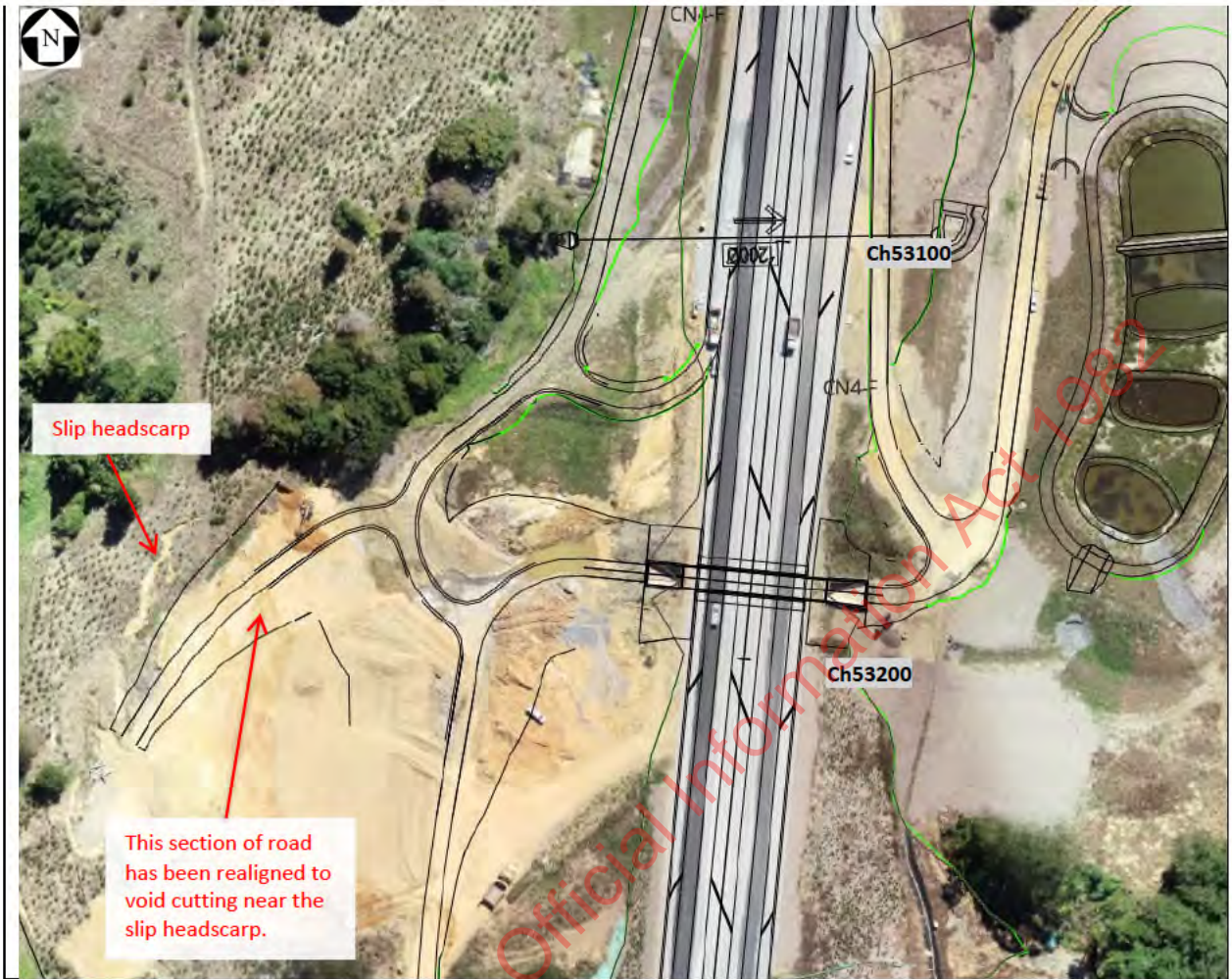


February 2022, Time 2:14 – View in southern direction: East = left-hand side; West = right-hand side



Mapbox Aerial Photo, February 2022





August 2022, Time 2:15 – View in southern direction; East = left-hand side; West = right-hand side

Ara Tūhono – Pūhoi to Warkworth: Project Flyover, August 2022





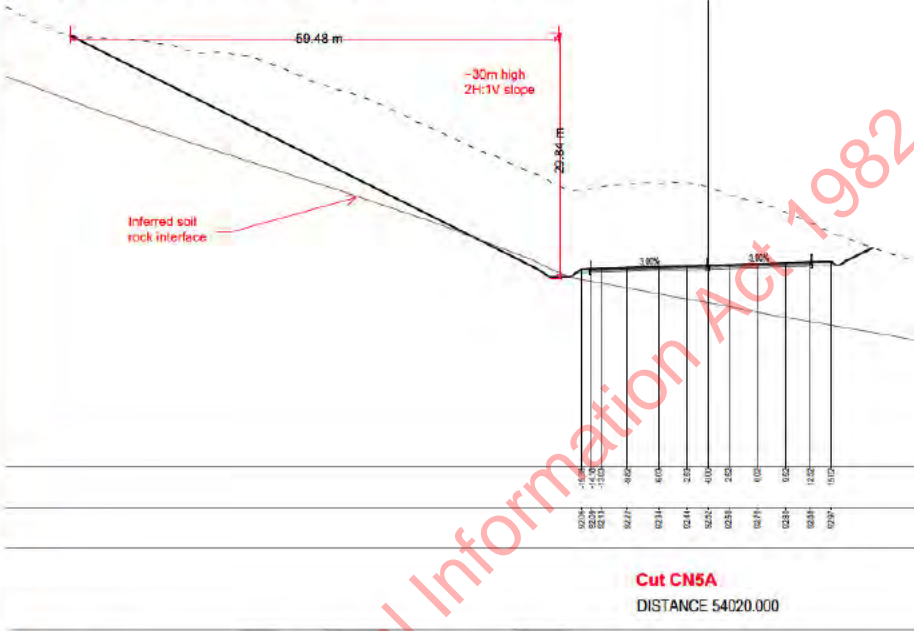
January 2023, Time 2:25 – View in southern direction: East = left-hand side; West = right-hand side



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7.16 CN5A – Landslide 3

Chainage	Ch53,600 – Ch54,060
Typical Design Slope Geometry	<p>East (LHS): 2H:1V up to 30 to 35m high, including up to 14m high rock slope (transition rock) cut at 2H:1V                  West (RHS): 2H:1V, less than 5m high, no rock slope.</p>  <p style="text-align: center;"><b>Cut CN5A</b> DISTANCE 54020.000</p>
Site & Design Description	<p>East (LHS):</p> <ul style="list-style-type: none"> <li>• 2H:1V slope, up to 33m high,</li> <li>• 3H:1V remediated slope with horizontally bored drains and buttress fill,</li> <li>• Ground level generally sloping from East to West.</li> <li>• Groundwater seepage observed (based on drone footage).</li> </ul> <p>West (RHS):</p> <ul style="list-style-type: none"> <li>• 2H:1V slope, up to 5m high,</li> <li>• Ground level is sloping away from the top of cut slope</li> </ul>
Existing Landslide	Yes (No 3), CN5A East, Ch54,020 – Ch54,050
Cause of Landslide	<ul style="list-style-type: none"> <li>• Unfavourably orientated bedding fabric dipping gently out of the slope</li> <li>• Moderately to steeply dipping joints</li> <li>• Evidence of historic shallow translation landslide activity within the cut footprint.</li> <li>• Softened shear planes orientated parallel to bedding fabric.</li> <li>• Confirmation of steep to sub vertical joint planes that could act as rear and/or side release planes.</li> </ul> <p>The presence of a perched groundwater table above the soil/rock interface.</p>
Date Landslide occurred	11/02/2020
Cut within area of historic landslide	Low risk at eastern batter at existing landslide.
Geotechnical Investigations	BH355, BH6034, BH6106, BH4090, BH6036, BH3037, BH3038, BH5306
Site Geology	No geological section provided in the report.
Soil Rock Transition Zone	<p>East (LHS):                  Generally dipping away at up to 10~15°, in parts up to 20°.</p>



	<p><b>West (RHS):</b> Toe of slope above transition zone, dipping away</p>
Rock Cut	Rock and/or transitional rock outcrops encountered at lower parts of the slope which are cut at 2H:1V. Further details are unknown.
Remedial Works Design	DEI 0468 (Ch53940 – 54080, Landslide Remediation), DEI 0560 (Ch53690 – 53750, CN5A North-North – Stabilisation Design) DEI 0568 (Ch53980 – 54060, CN5A Landslip Remediation)
Remedial Works Details	<ul style="list-style-type: none"> <li>• 4x bored drains,</li> <li>• Buttress fill</li> <li>• Reshape to from 2H:1V to 3H:1V</li> </ul>
Peer Reviewed in PSM Report Rev 4	Refer to PSM Report PSM4203-029R Draft Rev 4 – Appendix D
Groundwater Seepage Monitoring	<p>Seepage monitoring undertaken on the 16/06/2021 29/07/21. Engineering geological site inspections were undertaken on the 2/11/2021 and 12/02/2021. Seepage monitoring on the 29/07/2021 was undertaken within 48 hours of rainfall.</p> <p>Engineering geological and groundwater seepage observations are as follows:</p> <p><b>CN5A North</b></p> <ul style="list-style-type: none"> <li>• Geology at location of cut comprises firm to stiff wet clayey SILT soil and completely to highly weathered interbedded sandstone and siltstone.</li> <li>• Relict rock fabric and bedding planes and jointing present within completely weathered rock and residual soil.</li> <li>• Weathering penetrates deep along rock structure defects in to underlying rock mass</li> <li>• Bedding structures dip west to northwest at 4°~5°</li> <li>• Bedding structure is typically moderately thin with highly interbedded siltstone - sandstone</li> <li>• Sharp soil to rock transition from slightly weathered rock overlying highly to completely weathered soil and rock at location of swale.</li> <li>• Seepage observed at varying levels across the slope, typically from bedding structure</li> <li>• Surface water is ponding at the upper slope</li> <li>• Uncontrolled stormwater runoff is flowing over the slope face</li> <li>• Sediment pond located directly above the slope is recharging groundwater to lower slope</li> <li>• Seepage observed coming from completely weathered soil slope.</li> <li>• Seepage observed coming from soil-rock transition</li> <li>• Erosional riling of the residual soils and completely to highly weathered cut slope face with softened ground at the locations of seepage and from uncontrolled stormwater run off</li> <li>• New tension cracks and slip failures observed developing across slope face.</li> <li>• Slips are typically translational sliding in mechanism and groundwater triggered</li> <li>• Toe buttress filling of the lower slope to stabilise slips. Toe buttressing is filling over failed materials rather than removing it. Subsoil drains daylight at toe of buttress.</li> <li>• Softening at toe of buttress with fill wet to saturated</li> <li>• Stormwater flows through swale drain will erode the toe buttress long term.</li> </ul>
Risk of Future Slope Failure	<p><b>East (LHS):</b> The risk of future slope failure is considered <b>low to moderate risk</b> based on remediated design solution. During our site visit dated 2 November 2021, we observed new tension cracks and slip headscarps. This suggested that the design model is not sufficiently representative of the site conditions. New remedial works comprising buttress fills were placed at Ch53690-53750 (Refer to DEI 0560). <b>The construction works at soil disposal site 16 upslope of Cut CN5A have now been completed.</b></p> <p>In absence of <b>our independent</b> detailed geological assessment, it appears that remedial measures <b>may</b> not correctly or accurately address the underlying issue.</p>



- Remedial works comprise a flatter 3H:1V slope, horizontally bored drains & buttress fill.
- Note that the design may rely on the functionality of the drainage system. Therefore, a low to moderate risk has been determined. Inspection and maintenance of the bored drains is likely essential.

**West (RHS):**

The risk of future slope failure is considered very low.

October 2020, Time 2:22 – View in southern direction: East = left-hand side; West = right-hand side



February 2021, Time 2:12 (to 2:21) – View in southern direction: East = left-hand side; West = right-hand side





June 2021, Time 2:11 – View in southern direction: East = left-hand side; West = right-hand side



July 2021, Time 2:14 – View in southern direction: East = left-hand side; West = right-hand side





September 2021, Time 2:21 – View in southern direction: East = left-hand side; West = right-hand side



February 2022, Time 2:14 – View in southern direction, Ch53700: East = left-hand side; West = right-hand side





August 2022, Time 2:24 – View in southern direction, Ch53700: East = left-hand side; West = right-hand side



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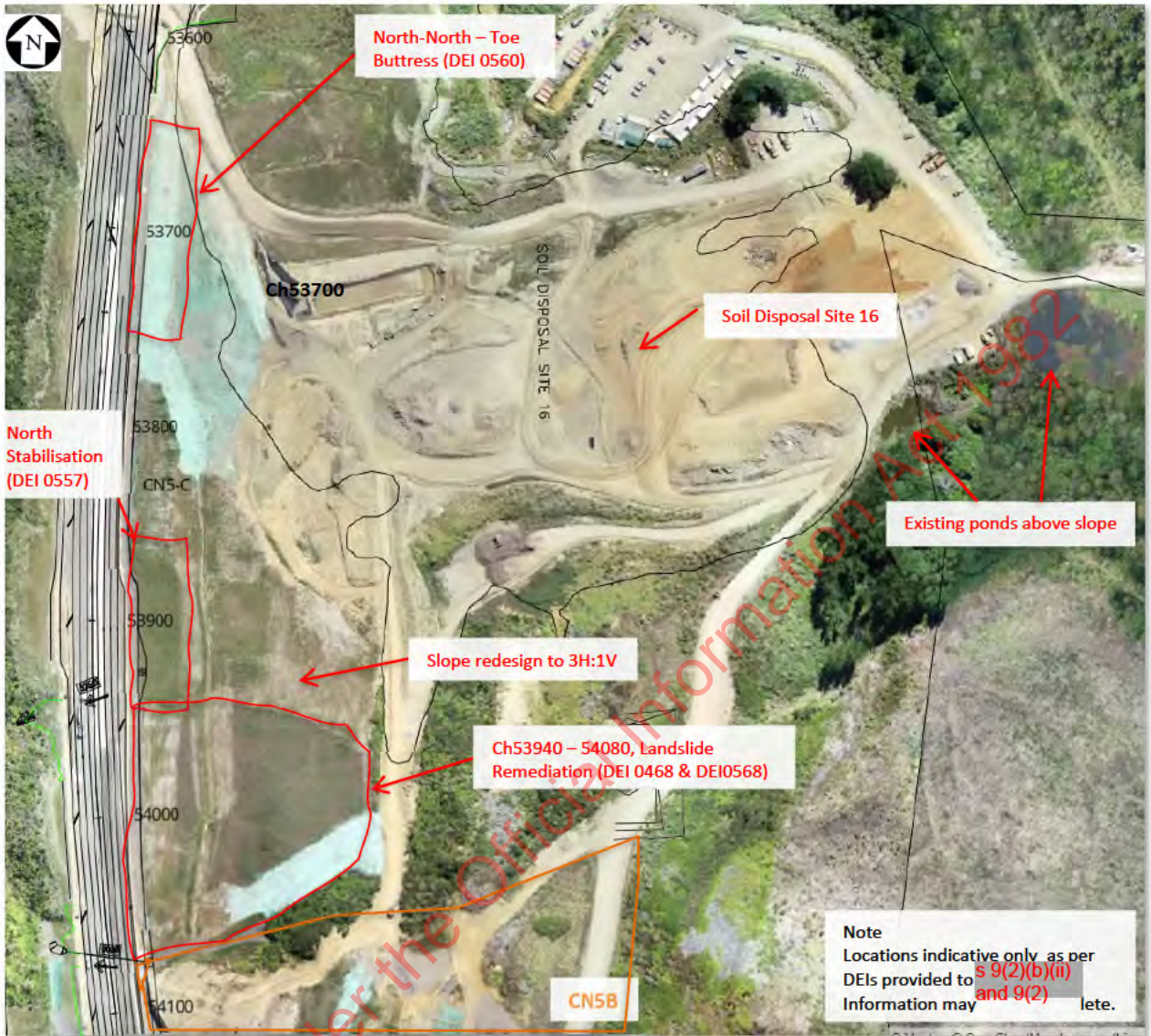


January 2023, Time 2:34 – View in southern direction, Ch53700: East = left-hand side; West = right-hand side



Released under the Official Information Act 1982





Mapbox Aerial Photo, February 2022 between Ch53,600 and Ch54,100



7.17 CN5B – Landslide 4

Chainage	Ch54,080 – Ch54,600
Typical Design Slope Geometry	<p>East (LHS): 2H:1V up to 33m high soil slope, up to 48m high rock slope at Ch54,340,                  West (RHS): 2H:1V up to 30m high soil slope, up to 44m high rock slope at Ch54,400,  <u>We note that soil slope and rock height vary along the alignment at both sides. The above values are maximum values which may not be shown on the presented section.</u></p> <p>Released under the Official Information Act 1982</p>
Site & Design Description	<p>'Ground level and rock levels are generally sloping from East to West between Eastern side (LHS) critical from Ch54,080 to Ch54,360; then from West to East from Ch54,400 to 54,540.</p> <p>East (LHS):</p> <ul style="list-style-type: none"> <li>• Rock slope up to 48m high, 85° (lower 9m height) &amp; 64° steep,</li> <li>• 2H:1V soil slope, up to 33m high,</li> <li>• Soil rock transition zone up 20° steep, sloping towards the slope.</li> </ul>



	<ul style="list-style-type: none"> <li>Remediated slope remains at 2H:1V. Counterfort drains, and buttress fill installed,</li> <li>Groundwater seepage observed at upper slope and rock cut (based on drone footage)</li> </ul> <p>West (RHS):</p> <ul style="list-style-type: none"> <li>Rock slope up to 44m high, 85° (lower 9m height) &amp; 64° steep (see typical section),</li> <li>2H:1V soil slope, up to 30m high,</li> <li>Soil rock transition zone up 20° steep, sloping towards the slope.</li> </ul>
Existing Landslide	Yes (No 4), CN5B East, Ch54,080 – Ch54,600
Cause of Landslide	<ul style="list-style-type: none"> <li>Unfavourably softened or shear surfaces at soil rock interface</li> <li>Groundwater seepage</li> </ul>
Date Landslide occurred	18 May 2020 & 2 June 2020
Cut within area of historic landslide	Moderate risk at eastern side
Geotechnical Investigations	BH3551, BH112, BH6040, BH3555, BH6041, BH4032, BH3550, BH3557
Site Geology	<p><b>Ch54,230 (CN5B), Drawing No P2Wk-DRG-GG-01-1005</b></p> <p>1. Geology - Pakiri Formation (Encountered/inferred stratigraphic thicknesses in order)</p> <ul style="list-style-type: none"> <li>7-8m - Firm - Residually weathered soils</li> <li>Up to 8.5m - Stiff- Residually weathered soils (Upslope-Eastern side)</li> <li>7.5-8.5m Highly to moderately weathered rock</li> <li>Slightly to unweathered rock encountered past 12.5m-17.5m depth</li> </ul> <p>Slightly to unweathered rock comprises:</p> <ul style="list-style-type: none"> <li>Thick/Massive Sandstone</li> <li>Interbedded Sandstone and Siltstone</li> </ul> <p>2. Structural Features &amp; Defects</p> <ul style="list-style-type: none"> <li>Soil - Rock contact dips out of eastern cut slope, east to west at 17.5°</li> <li>Stratigraphic weathering boundaries dip east to west at up to 20° out of eastern cut slope</li> </ul> <p>Bedding: Spacing: Thin ~ 20-60mm, Bedding Dip: 5/289</p> <p>Jointing: No clear set clusters</p> <p>3. Groundwater</p> <ul style="list-style-type: none"> <li>Groundwater recorded at/near highly to moderately weathered and slightly to unweathered contacts</li> </ul> <p><b>54,360 (CN5B), Drawing No P2Wk-DRG-GG-01-1006</b></p> <p>1. Geology - Pakiri Formation (Encountered/inferred stratigraphic thicknesses in order)</p> <ul style="list-style-type: none"> <li>4.5-14m- Stiff - Residually weathered soils</li> <li>2.5-11.5m - Highly to moderately weathered rock</li> <li>Slightly to unweathered rock encountered below 6-25m below surface level</li> </ul> <p>Slightly to unweathered rock comprises</p> <ul style="list-style-type: none"> <li>Weak to Moderately Strong sandstone and siltstone</li> <li>Thinly bedded siltstone-sandstone</li> <li>Massive sandstone</li> <li>Interbedded sandstone/siltstone</li> <li>Moderately thinly bedded Sandstone/siltstone</li> <li>Massive - Moderately thick sandstone</li> </ul>



UCS of slightly to unweathered rock 22.0MPa

**2. Structural Features & Defects**

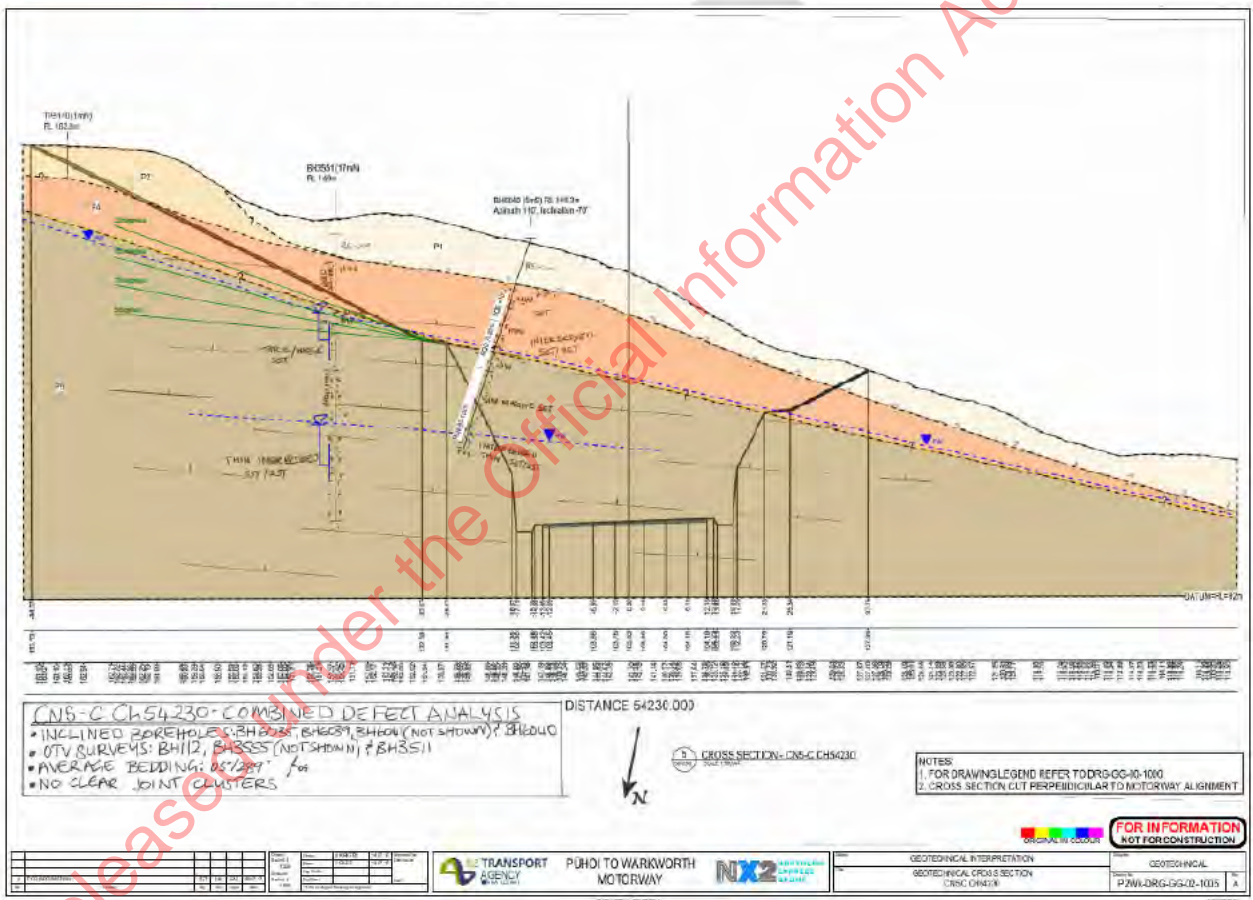
- Slightly to unweathered & moderately weathered rock contacts dips out eastern cut at up to 15°
- Completely to moderately weathered rock contact dips out of western cut at less than 5°
- Slightly to unweathered rock dips out eastern cut slope at up to 5°

Bedding Dip: 05/283

Jointing: 71/260, 54/156, 54/321

**3. Groundwater**

- Upper groundwater level recorded within moderately weathered rock at and at moderately to slightly weathered rock contact



**Soil Rock Transition Zone**

**East (LHS):**  
Generally dipping away at up to 15~20°, occasionally steeper than 20°.  
**West (RHS):**  
Toe of slope above transition zone, dipping away occasionally steeper than 20°.

**Rock Cut**

Large wedge failures on eastern side, wedge failure at start of CN5B (Ch54,100-54,200), (Flyover June 2021 time 2:19) appears overhanging at the end of CN5B.

**Remedial Works Design**

- DEI 0501 (Ch54460 – 54535, South East Soil Trim & Counterfort drains)
- DEI 0515 (Ch54100 – 54200, Soil Slope Stabilisation Heave Zone 4),
- DEI 0534 (Ch 54080 – 54160, Heave Zone 2 & 3),
- DEI 0516 (Ch54100 – 54200, Haulage Track Zone),
- DEI 0535 (Ch54080 – 54130, Slope Stabilisation Lower One Third),



	<p>DEI 0390 (Ch 54110 – 54300, Eastern Batter Stabilisation),  DEI 0541 (Ch54130 – 54210, Rock Cut Stabilisation - North east triangles),  DEI 0548 (Ch54480 – 54560, Slope &amp; Landslip Remediation) includes reference DEI 0533 Ch54,480</p>
Remedial Works Details	<ul style="list-style-type: none"> <li>• Toe buttress</li> <li>• 11m long 3m deep counterfort drains at 10m centres,</li> <li>• Landslide to be regraded</li> </ul>
Peer Reviewed in PSM Report Rev 4	Refer to PSM Report PSM4203-029R Draft Rev 4 – Appendix E
Groundwater Seepage Monitoring	<p>Seepage monitoring undertaken on the 16/06/2021 . Engineering geological site inspections were undertaken on the 29/07/21, 2/11/2021 and 12/11/2021. Seepage monitoring on the 29/07/2021 was undertaken within 48 hours of rainfall</p> <p>Engineering Geological and Groundwater seepage observations are as follows:</p> <ul style="list-style-type: none"> <li>• Rock between Ch54100 to Ch54200 comprises highly interbedded, completely to slightly weathered siltstone and sandstone</li> <li>• Weather penetrates deep within the rock mass along rock structure defects</li> <li>• Bedding dips out the cut slope towards the west to northwest at 10°~14°</li> <li>• Weathering and rock structure defects highly unfavourable for orientation and angle of cut slope.</li> <li>• Groundwater seepages can be observed coming from bedding planes at varying levels across the entire slope.</li> <li>• Groundwater seepage is observed from various weathering contacts across the entire slope.</li> <li>• Seepages observed at soil-rock transition</li> <li>• Seepages on to the toe buttress with wet and softened buttress fill</li> <li>• Cut slope typically wet and surface erosion observed</li> <li>• Translation sliding is occurring along bedding planes shears. Sub vertical joint sets intersect one another forming the rear release wedge plane of the observed slips. Failures are typically rock or relic rock structure controlled and triggered by groundwater/rainfall.</li> <li>• Faulting and joints are filled with softened and highly oxidised limonite and manganese oxide gouge/infilling</li> <li>• Surface water runoff has eroded the buttress face and is causing erosional rilling across the bench surface.</li> <li>• Groundwater observations range from a small seep to significant trickle</li> <li>• Rock mass wedge failure has occurred in 65° rock cut slope at northern end on western side at Ch54100.</li> <li>• 64°-85° rock cut between Ch54100 and Ch54400 comprises highly interbedded to massive/blocky sandstone and siltstone.</li> <li>• Rock cut slope features massive rock blocks overhanging the alignment supported by rock mesh and rock anchor systems.</li> <li>• Seepage can be observed at varying levels from rock structure defects.</li> <li>• Seepages observed at Ch54450 at the transition cut slope from rock to soil with wet and softened ground.</li> <li>• Seepages observed from completely weathered to highly weathered soil and rock on western side between Ch54600 to Ch54500. Buttressing at this location is softened from groundwater infiltration and tension cracks have developed at crest of buttress.</li> </ul>
Risk of Future Slope Failure	<p>East (LHR):</p> <ul style="list-style-type: none"> <li>• It appears that all residual soils are removed from the cut slopes and transitional rock is exposed at the cut slope.</li> </ul>



- Buttress fill placed at upper slope

During our site visit dated 2 November 2021, we observed new tension cracks and slip headscarps. This suggests that the design model is not sufficiently representative of the site conditions.

In absence of detailed geological assessment, it appears that remedial measures do not correctly or accurately address the underlying issue. The weathering, geology and rock structure are highly unfavourable. The buttress fill quality appears not satisfactory based on our independent observations. Surficial failures within the buttress fill were present at the time of our site visit. The buttress slopes are now grassed, and no issues have been observed or reported at the July 2022 and the January 2023 rainfall events.

The risk of slope failure is generally considered low to moderate. The weighted risk level has been lowered since the previous assessment, although the individual risk for slope stability and sliding at soil-rock interface remains moderate.

#### West (RHS)

- Western side (RHS) critical from Ch54,400 to 54,540.
- Upper slope is partially grassed or have exposed (transitional) rock cut slopes.

The risk of slope failure is generally considered low to moderate. The weighted risk level has increased due to the consequence rating.

The rockfall risk of potential debris and/or loose or weathered rock at the upper slopes has been revised since the issue of the Draft Report Rev C. Additional rockfall trials and simulations were provided by the CJV.

Potential rockfall risks from the upper 2H:1V exposed rock slopes have been reviewed as part of the CJV assessments. Refer to Section 4.2. Potential rockfall risks are considered low.

Risk of wedge-type or rock slope failures cannot be determined based on the available information. However, large voids and overhanging rock albeit supported by rock bolts are present.

August 2020, Time 2:47 – View in southern direction: East = left-hand side; West = right-hand side

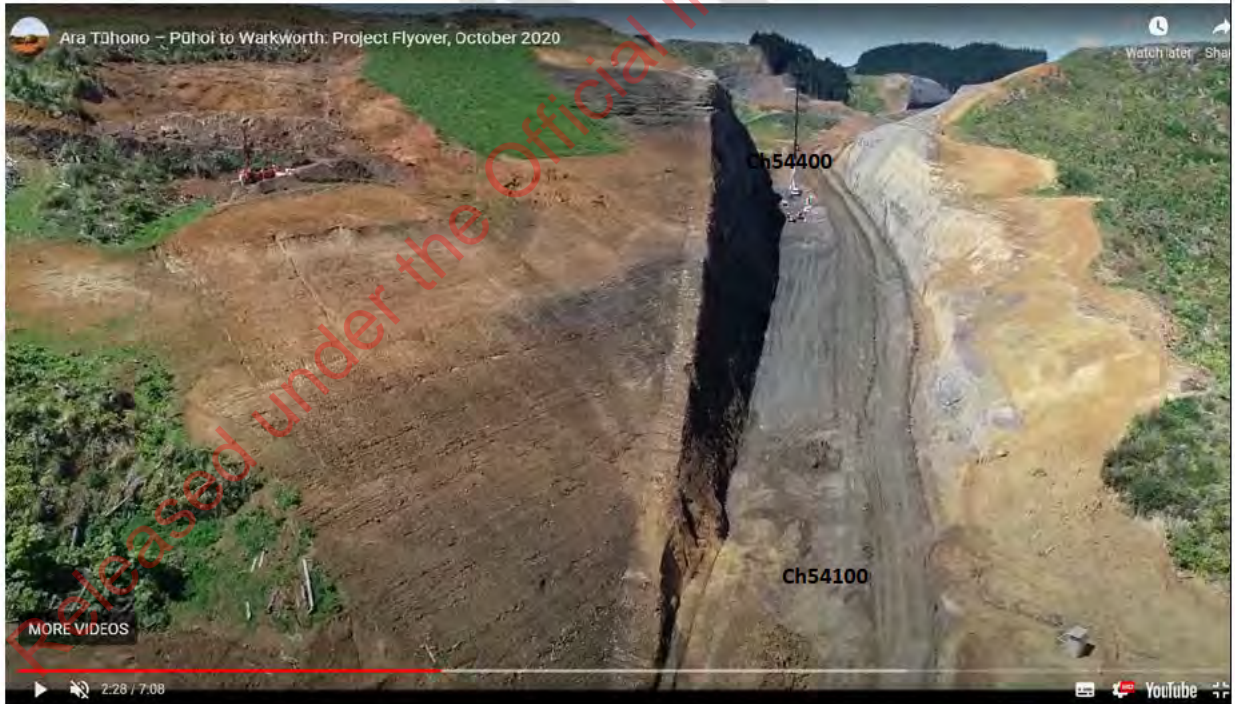




August 2020, Time 2:52 – View in southern direction: East = left-hand side; West = right-hand side

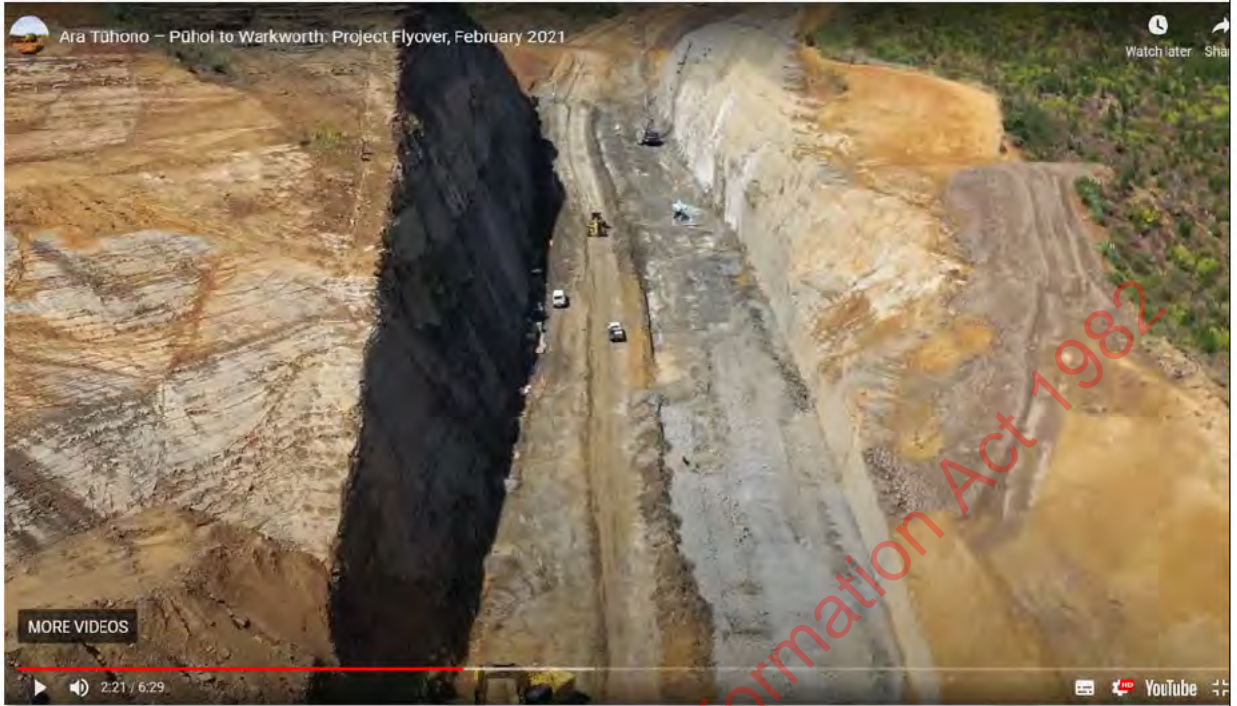


October 2020, Time 2:28 – View in southern direction: East = left-hand side; West = right-hand side





February 2021, Time 2:21 – View in southern direction: East = left-hand side; West = right-hand side



June 2021, Time 2:19 – View in southern direction: East = left-hand side; West = right-hand side





September 2021, Time 2:31 – View in southern direction: East = left-hand side; West = right-hand side



February 2022, Time 2:19 – View in southern direction: East = left-hand side; West = right-hand side





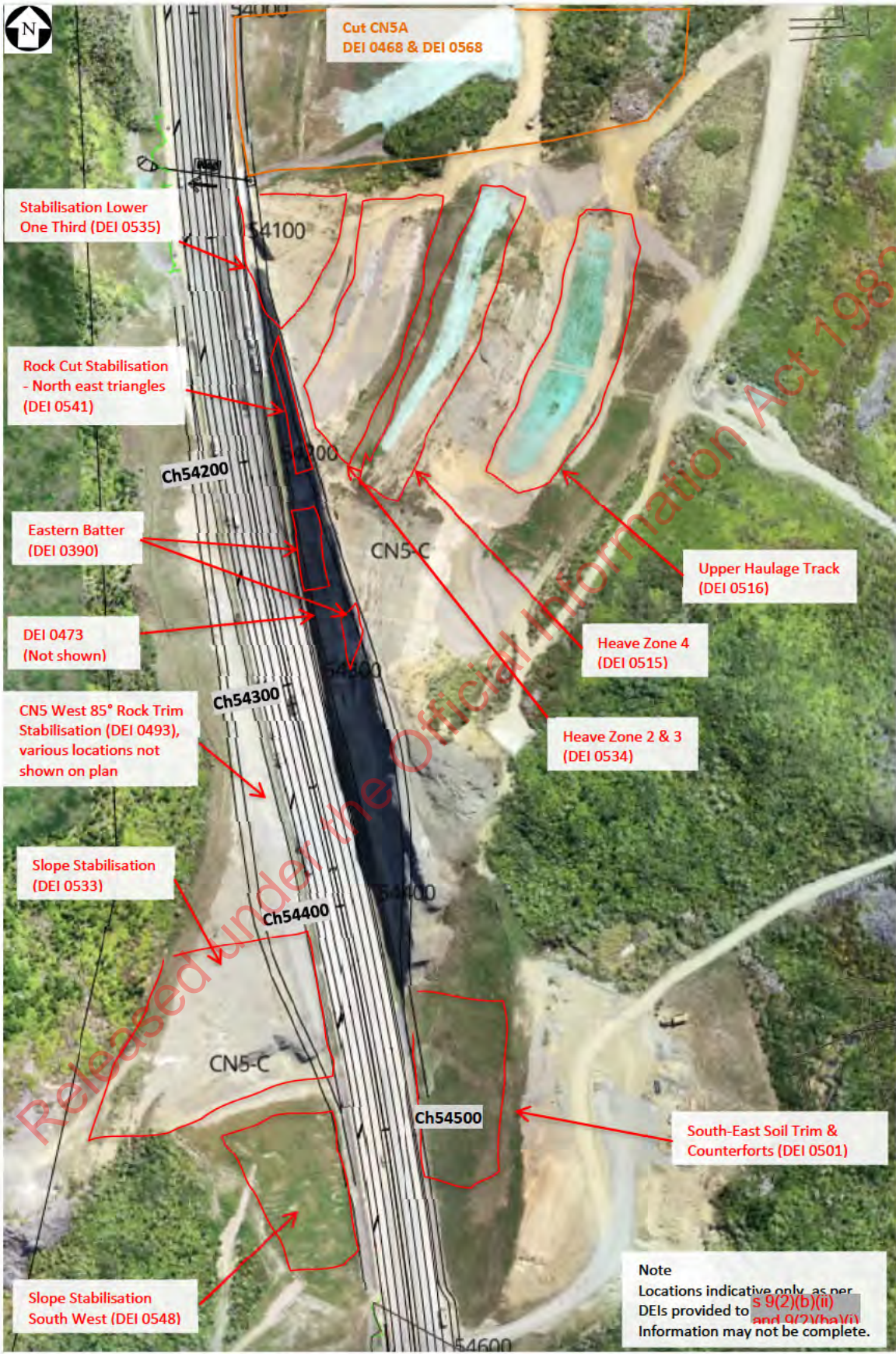
August 2022, Time 2:33 – View in southern direction: East = left-hand side; West = right-hand side



January 2023, Time 2:41 – View in southern direction: East = left-hand side; West = right-hand side







Mapbox Aerial Photo, February 2022 between Ch54,000 and Ch54,600



7.18 CN7A

Chainage	Ch54,940 – Ch 55,020
Typical Design Slope Geometry	East (LHS): Cut slope at eastern side of wetland. West (RHS): No cut slope. Minor fill or at grade.
Site & Design Description	East (LHS): <ul style="list-style-type: none"> <li>No cut slope CN7A between SH1 and wetland. The cut is sliding cut through a west trending spur.</li> <li>Cut slope at eastern side of wetland. Details unclear. Based on the July 2021 flyover footage (time 2:35), the site is still under construction.</li> </ul> West (RHS): <ul style="list-style-type: none"> <li>CN8B fill embankment</li> </ul>
Existing Landslide	None reported to <span style="color: red;">s 9(2)(b)(ii) and 9(2)(ba)(i)</span>
Cause of Landslide	Not applicable
Date Landslide occurred	Not applicable
Cut within area of historic landslide	Low landslide hazard trending in western direction.
Geotechnical Investigations	BH4010, BH6043, BH3543,
Site Geology	No geological section provided in the report.
Soil Rock Transition Zone	Unknown
Rock Cut	Rock cut at eastern side of wetland, partially filled with spoil.
Remedial Works Design	None required.
Remedial Works Details	Not applicable
Peer Reviewed in PSM Report Rev 4	Not reviewed
Groundwater Seepage Monitoring	No observations have been made.
Risk of Future Slope Failure	East (LHS): The risk of future slope failure is considered <b>low</b> . (Cut slope is beyond the wetland and potential failures unlikely effect the usability of the SH1 alignment).  West (RHS): The risk of future slope failure is considered <b>very low</b> (fill embankment, no cut slope) <span style="color: red;">The risk remains unchanged compared to the Revision D Report.</span>



October 2020, Time 2:44 – View in southern direction: South-East = left-hand side; North-West = right-hand side



July 2021, Time 2:45 – View in southern direction: South-East = left-hand side; North-West = right-hand side





September 2021, Time 2:35 – View in southern direction: South-East = left-hand side; North-West = right-hand side

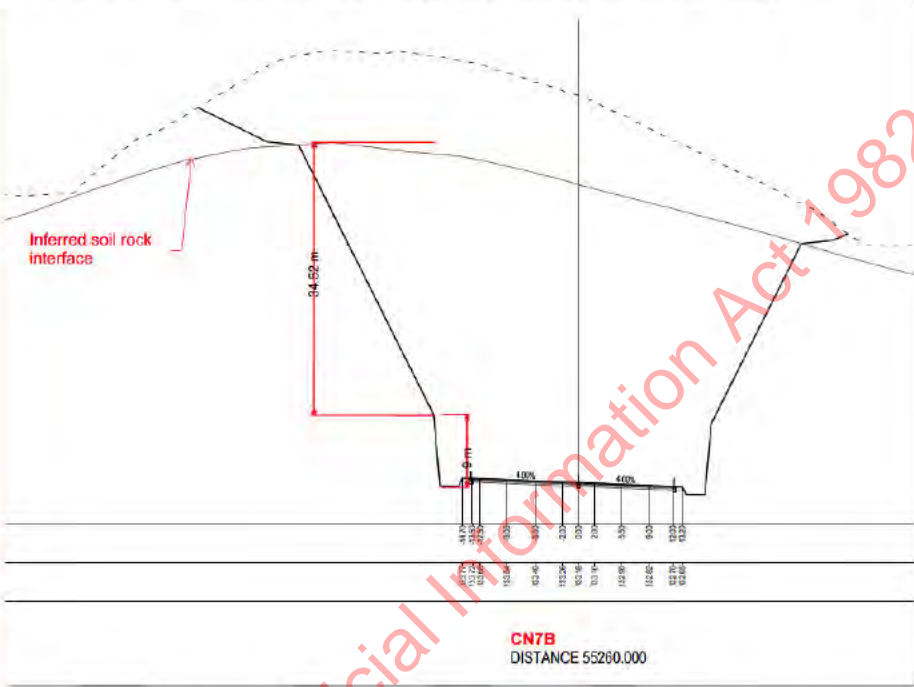


August 2022, Time 2:49 – View in southern direction: South-East = left-hand side; North-West = right-hand side





7.19 CN7B

Chainage	Ch55,230 – Ch55,420
Typical Design Slope Geometry	East (LHS): lower rock cut up to 44m high (Ch55,220), upper 2H:1V soil slopes typically less than 7m high West (RHS): lower rock cut up to 35m high (Ch55,220), upper 2H:1V soil slope less than 11m high. <u>We note that soil slope and rock height vary along the alignment at both sides.</u>  <p style="text-align: center;"><b>CN7B</b> DISTANCE 55260.000</p>
Site & Design Description	Alignment is cutting through North-East to South-West trending ridge line.  East (LHS): <ul style="list-style-type: none"> <li>• Ground level at highest cut section is generally flat,</li> <li>• Soil above rock cut has been removed, soil and potential transitional rock remaining at side slopes,</li> <li>• Ground is sloping away from cut slope</li> <li>• Long slopes at both ends of the cut where stormwater run-off can cause erosion.</li> </ul> West (RHS): <ul style="list-style-type: none"> <li>• Ground level at highest cut section is generally flat,</li> <li>• Soil above rock cut has been removed, soil and potential transitional rock remaining at side slopes,</li> <li>• Ground is sloping away behind cut in western direction</li> <li>• Long slopes at both ends of the cut where stormwater run-off can cause erosion.</li> <li>• Parts of the slope facing SH1 are unmodified.</li> </ul>
Existing Landslide	No landslide as part of the original report scheme. A new slip has been reported on 7 June 2021.
Cause of Landslide	Likely slip at soil rock transition zone at steep slope. Refer to September 2021 flyover footage.
Date Landslide occurred	June 2021. <b>A further landslide occurred on a natural slope outside of the designation at the NE side of the cut.</b>
Cut within area of historic landslide	Low risk at southern transition into fill CN10.
Geotechnical Investigations	BH216, BH3541, BH6108, BH4009, BH6044, BH6045
Site Geology	55,280 (CN7B), Drawing No P2Wk-DRG-GG-02-1007 1. Geology - Pakiri Formation (Encountered/inferred stratigraphic thicknesses in order) <ul style="list-style-type: none"> <li>• 2.5-11.5m -Stiff - Residually weathered CLAY &amp; SILT soil</li> </ul>



- Thin layer of completely to highly weathered rock
- Slightly to unweathered rock below 2.5-11m depth
- Slightly weathered rock comprises very weak to weak sandstone and siltstone
- Thinly bedded and laminated sandstone and siltstone
- Completely to highly weathered UCS = 18MPa
- Slightly weathered UCS ranges from 9.4 to 16MPa

2. Structural Features & Defects

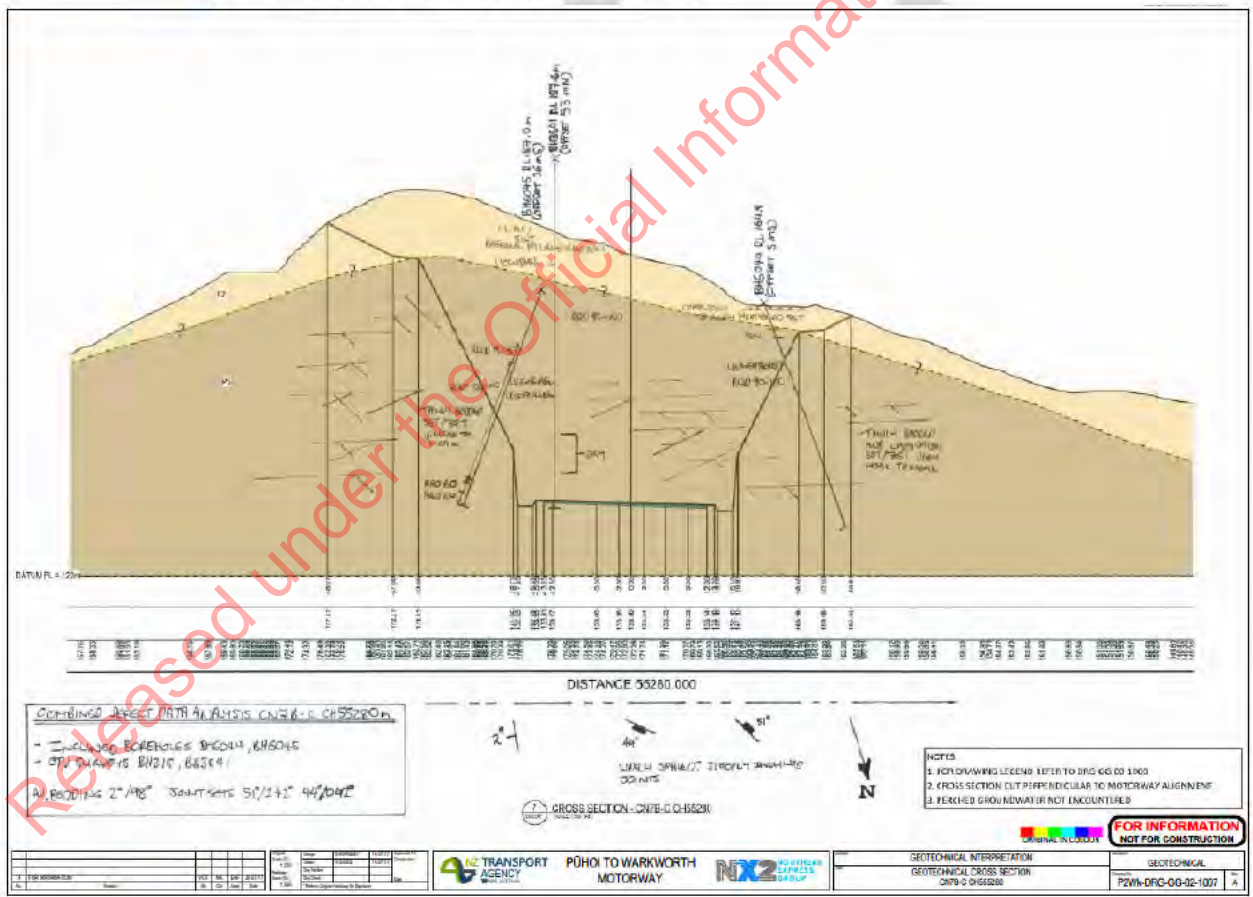
- Residual soil-slightly weathered rock contact dips down and into eastern cut slope at between 15°-20°
- Residual soil-slightly weathered rock contact dips down into western cut slope at between 15°-20°

Bedding (Average): Thinly bedded 20-60mm, Bedding Dip: 2/94

Jointing (Average): 51/242, 44/042

3. Groundwater

- Groundwater not measured - Boreholes dry



Soil Rock Transition Zone

East (LHS):  
Up to 10~15° steep  
West (RHS):  
Generally dipping away at 5~10°

Rock Cut

- Up to 44m deep. 85° at lower 9m and 64° above 9m from excavation level.
- Mesh draping placed over rock face,
- No failures on rock slope in December 2020 (time 2:37),



	<ul style="list-style-type: none"> <li>Seepage at eastern side</li> </ul>
Remedial Works Design	DEI 0572 (Ch55140 – 55170, Ch551410-55170 Slope Stabilisation) DEI 0573 (Ch55360 – 55400, Southeast – Soil Cut Stabilisation Design)
Remedial Works Details	It is expected that the remedial works of the new slip comprise removal of the slipped material.
Peer Reviewed in PSM Report Rev 4	Not reviewed by PSM
Groundwater Seepage Monitoring	Groundwater and engineering geological site inspections were undertaken on the 2/11/2021. Observations included the following: <ul style="list-style-type: none"> <li>Minor slump/new slip developing on the western transition cut slope at Ch55,150 with wet and softened ground at to. The cut slope at this location appears to be steeper than 2H:1V.</li> <li>Seepages at transition slope from soil – rock on eastern side at Ch55,150 with wet and softened ground present.</li> <li>Seepages at transition slope from soil-rock contact on western side at Ch55250</li> <li>Seepage observed from rock structure at varying RL's</li> <li>Seepage observed from soil-rock bench through middle of cut at Ch55,250</li> <li>Rock comprises highly faulted and highly interbedded sandstone and mudstone</li> </ul>
Risk of Future Slope Failure	<p><b>East (LHR)</b></p> <ul style="list-style-type: none"> <li>The risk of future slope failure at upper soil slopes perpendicular to the road alignment is considered low.</li> <li><u>Moderate risk at side slopes transition from the soil to rock slopes.</u></li> <li>Risk at rock slope difficult to determine.</li> </ul> <p><b>West (RHS)</b></p> <ul style="list-style-type: none"> <li>The risk of future slope failure at upper soil slopes perpendicular to the road alignment is considered low.</li> <li><u>Moderate risk at side slopes transition from the soil to rock slopes.</u></li> <li><u>Risk of wedge-type or rock slope failures cannot be determined based on the available information.</u></li> </ul> <p>The risk remains unchanged compared to the Revision D Report.</p>





February 2021, Time 2:37 – View in southern direction: East = left-hand side; West = right-hand side



June 2021, Time 2:37 – View in southern direction: East = left-hand side; West = right-hand side





September 2021, Time 2:52 – View in southern direction: East = left-hand side; West = right-hand side



February 2022, Time 2:54 – View in southern direction, Ch55100: East = left-hand side; West = right-hand side





August 2022, Time 2:53 – View in southern direction, Ch55100: East = left-hand side; West = right-hand side



January 2023 Post Rainfall, Time 2:51 – View in southern direction, Ch55100: East = left-hand side; West = right-hand side





## 7.20 CN8A – Landslide 5

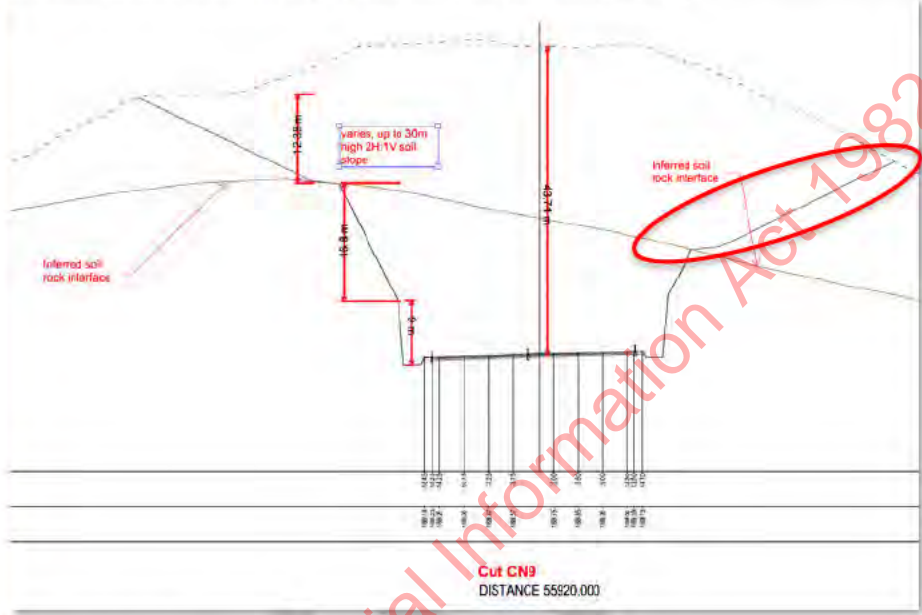
Landslide CN8A (Bluff) is reported in the 'Landslide Design and Construction Updates'. The CN8A landslide is located at the southern side of CN5 cut towards the CN8A fill embankment between Ch54,600 and 54,700 at the western of the alignment.

This landslide has not been further reviewed by s 9(2)(b)  
(ii) and  
9(2)(ba)(i) his stage.

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7.21 CN9A – Landslide 6

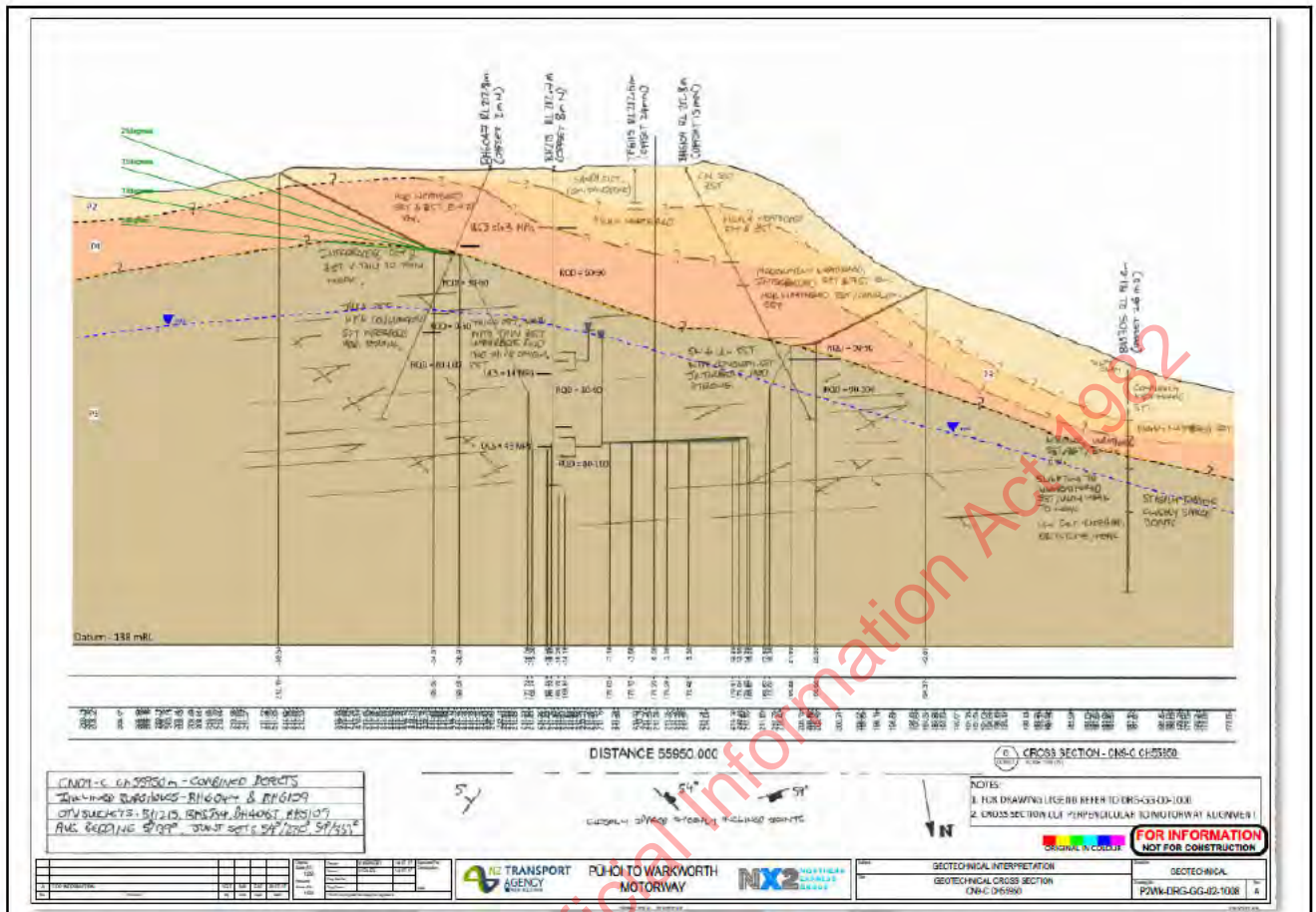
Chainage	Ch55,750 – Ch56,040
Typical Design Slope Geometry	<p>East: 2H:1V up to 28m high, 85° (lower 9m) and 64° steep up to 34m high rock cut slope.                  West: 2H:1V up to 15m high, 85° (lower 9m) and 64° steep up to 17m high rock cut slope.  <u>We note that soil slope and rock height vary along the alignment at both sides. The above values are maximum values which may not be shown on the presented section.</u></p> 
Site & Design Description	<p>Alignment is cutting through an East-West oriented ridge line.</p> <p><b>East (LHS):</b></p> <ul style="list-style-type: none"> <li>• Ground level at highest rock cut section is inclining steeply up,</li> <li>• Soil above rock cut has been removed, soil and potential transitional rock remaining at side slopes,</li> <li>• Ground is sloping away behind the cut slope</li> <li>• Eastern slope fully meshed, rock slope is dipping with transition zone</li> <li>• Long slopes at both ends of the cut where stormwater run-off can cause erosion.</li> </ul> <p><b>West (RHS):</b></p> <ul style="list-style-type: none"> <li>• Ground level at highest cut section is generally flat,</li> <li>• Soil above rock cut has been removed, soil and potential transitional rock remaining at side slopes,</li> <li>• Ground is sloping away behind cut in western direction</li> <li>• Long slopes at both ends of the cut where stormwater run-off can cause erosion.</li> <li>• Parts of the slope facing SH1 are unmodified.</li> </ul>
Existing Landslide	Yes (No 6), CN9 West Slip Ch55,860 – Ch55,940
Cause of Landslide	<ul style="list-style-type: none"> <li>• A combination of high groundwater pressures, weaknesses along existing defects and softened bedding planes.</li> <li>• The back release of the failures appears to line up with the main northwest orientated sub-vertical joint system.</li> <li>• The failed masses are likely sliding along softened horizontal to sub-horizontal bedding planes, determined by the weathering contact and formation of an aquiclude or perched water tables.</li> <li>• Bedding is approximately 8 degrees east.</li> </ul>
Date Landslide occurred	18 August 2020
Cut within area of historic landslide	Low risk at eastern side. Note that the landslide occurred on western side.



Geotechnical Investigations	BH215, BH3533, BH3534, BH3554, BH4063, BH5305, BH6017, BH6019
Site Geology	<p><b>55,950 (CN9), Drawing No P2Wk-DRG-GG-02-1008</b></p> <p><b>1. Geology - Pakiri Formation (Encountered/inferred stratigraphic thicknesses in order)</b></p> <ul style="list-style-type: none"> <li>• Up to 7m - Stiff - Residually weathered sandy SILT to completely weathered sandstone</li> <li>• Up to 10m - Highly weathered sandstone &amp; siltstone</li> <li>• Up to 12m - Moderately weathered rock</li> </ul> <p>Moderately weathered rock comprises:</p> <ul style="list-style-type: none"> <li>• Extremely weak to very weak, interbedded sandstone &amp; siltstone (UCS 1.3MPa)</li> <li>• Extremely weak sandstone, conglomerate and siltstone</li> </ul> <p>Slightly to unweathered rock comprises</p> <ul style="list-style-type: none"> <li>• Weak, very thin to thin, interbedded sandstone and siltstone</li> <li>• Weak to moderately strong, thick sandstone with conglomerate sandstone interbeds</li> <li>• Thick sandstone with thin siltstone interbeds and moderately thick conglomerate sandstone (UCS 14MPa-43MPa)</li> <li>• Moderately strong sandstone with conglomerate siltstone interbeds</li> </ul> <p><b>2. Structural Features &amp; Defects</b></p> <ul style="list-style-type: none"> <li>• Soil-rock contact dips out the eastern cut slope at approx. 5°-10°</li> <li>• Soil-rock contact dips into the eastern cut slope at up to 20°</li> </ul> <p><b>Bedding (Average):</b> Thinly bedded 20-60mm, Bedding Dip: 5°/139°</p> <p><b>Jointing (Average):</b> 54/230, 59/352, Closely spaced, steeply inclined joint set</p> <p><b>3. Groundwater</b></p> <ul style="list-style-type: none"> <li>• Groundwater recorded 30m below surface level</li> <li>• Groundwater recorded in slightly weathered to unweathered rock up to 4.5m below boundary with moderately weathered rock</li> </ul>

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Soil Rock Transition Zone	<p><b>East (LHS):</b>          Ch55,750 – Ch55,940: transition zone dips away from the slope face,          Ch55,980 – Ch56,020: transition zone dips at 15~20° out of the slope face,</p> <p><b>West (RHS):</b>          Ch55,750 – Ch55,980: transition zone dips away from the slope face,          Ch55,980 – Ch56,020: transition zone dips away from the slope face, 5~10° out of the slope,</p>
Rock Cut	Up to 34m deep. 85° at lower 9m and 64° above 9m from excavation level.
Remedial Works Design	DEI 0470 (Ch55990 – 56030, Stabilisation south-eastern batter), DEI 0474 (Ch55840 – 55940, Western Batter Landslide Stabilisation)
Remedial Works Details	<p><b>Western side:</b></p> <ul style="list-style-type: none"> <li>9 nos. counterfort drains, at 10m centres, 8m long, 0.5m deep into rock,</li> <li>Slope reshaped to 3H:1V</li> <li>13m wide rock bench,</li> </ul>
Peer Reviewed in PSM Report Rev 4	Refer to PSM Report PSM4203-029R Draft Rev 4 – Appendix F
Groundwater Seepage Monitoring	Proposed at eastern slope. No seepage monitoring carried out to date.
Risk of Future Slope Failure	<p><b>East (LHR)</b></p> <ul style="list-style-type: none"> <li>Low risk at upper soil slopes perpendicular to the road alignment. Upper slope is covered by mesh drapery.</li> <li>Risk at rock slope difficult to determine as slope face is covered.</li> </ul>



West (RHS)

- **Very low** risk at upper soil slopes perpendicular to the road alignment. All slipped debris has been removed. **This risk level has been reduced from the previous assessment in the Revision D Report.**
- Risk at rock slope difficult to determine. Upper part is covered by mesh drapery.

October 2020, Time 3:04 – View in southern direction: East = left-hand side; West = right-hand side



February 2021, Time 2:48 – View in southern direction: East = left-hand side; West = right-hand side





June 2021, Time 2:50 – View in southern direction: East = left-hand side; West = right-hand side



September 2021, Time 3:04 – View in southern direction: East = left-hand side; West = right-hand side





February 2022, Time 3:04 – View in southern direction, Ch55800: East = left-hand side; West = right-hand side



August 2022, Time 3:06 – View in southern direction, Ch55800: East = left-hand side; West = right-hand side





January 2023, Time 3:13 – View in southern direction, Ch55800: East = left-hand side; West = right-hand side

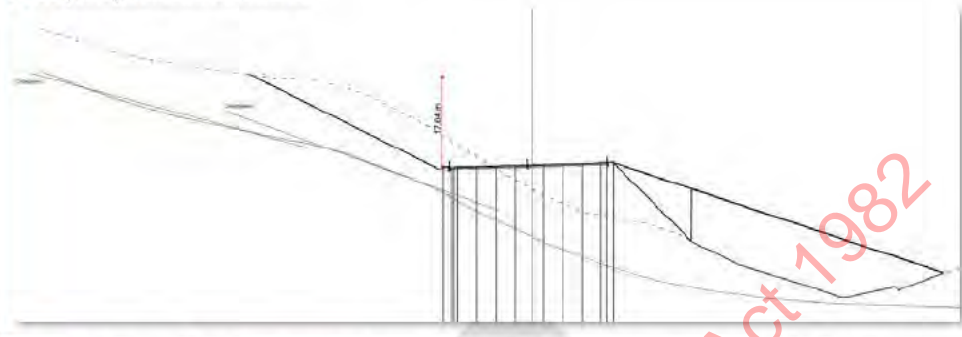


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7.22 CN12A

Chainage	Ch56,100 – Ch 56,150
Typical Design Slope Geometry	<p>East (LHS): 2H:1V up to 18m high            West (RHS): Fill embankment</p> 
Site & Design Description	Sidling cut through existing westerly trending spurs which are sloping in westerly direction.
Existing Landslide	None reported to s 9(2)(b)(ii) and 9(2)(ba)(i)
Cause of Landslide	Not applicable
Date Landslide occurred	Not applicable
Cut within area of historic landslide	Low risk identified at eastern side of cut slopes, but not within footprint of cut slope.
Geotechnical Investigations	BH6048
Site Geology	No geological section provided in the report. Based on the design report and geotechnical investigations, it expected that the cuts are formed in Pakiri Formation soils.
Soil Rock Transition Zone	15~20° below cut level dipping in western direction.
Rock Cut	Not exposed at cut slope (based on flyover footage, construction records were not available).
Remedial Works Design	None required
Remedial Works Details	Not applicable
Peer Reviewed in PSM Report Rev 4	Not reviewed
Groundwater Seepage Monitoring	No observations have been made.
Risk of Future Slope Failure	<p>East (LHS):            The risk of future slope failure is considered <b>very low</b>.            West (RHS):            The risk of future slope failure is considered <b>very low</b>. No cut slope present.</p> <p>The risk remains unchanged compared to the Revision D Report.</p>



December 2020, Time 2:55 – View in southern direction: East = left-hand side; West = right-hand side



June 2021, Time 2:53 – View in southern direction: East = left-hand side; West = right-hand side





September 2021, Time 3:08 – View in southern direction: East = left-hand side; West = right-hand side



February 2022, Time 3:11 – View in southern direction, Ch56050: East = left-hand side; West = right-hand side





August 2022, Time 3:10 – View in southern direction, Ch56050: East = left-hand side; West = right-hand side

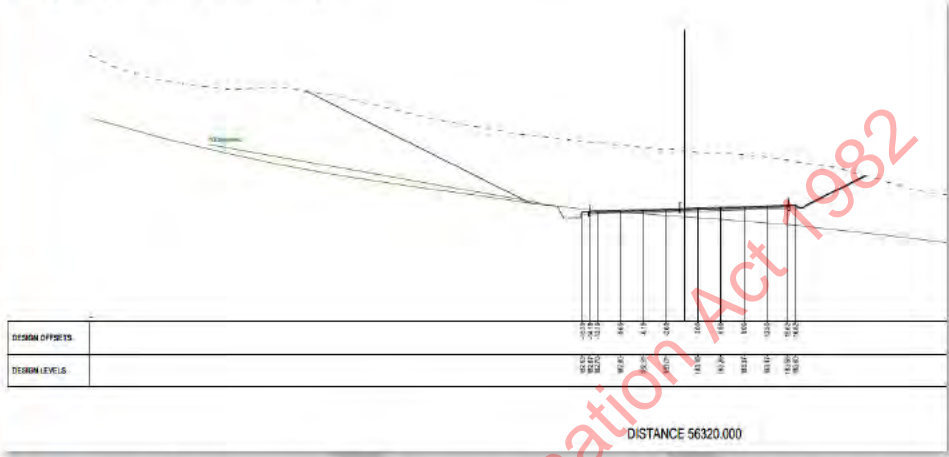


February 2022, Time 3:17 – View in southern direction, Ch56050: East = left-hand side; West = right-hand side





7.23 CN12B

Chainage	Ch56,270 – Ch 56,400
Typical Design Slope Geometry	<p>East (LHS): 2H:1V up to 19m high. Rock cut slope up to 3m high. Two separate slope sections at eastern side.</p> <p>West (RHS): 2H:1V up to 10m high</p> 
Site & Design Description	<p>Sidling cut through existing westerly trending spurs which are sloping in westerly direction.</p> <p><b>East (LHS)</b></p> <ul style="list-style-type: none"> <li>• 2H:1V soil cut slope, up to 10m high, grassed surface.</li> <li>• Northern part of CN12B is a sidling cut of existing East to West sloping ground. Soil rock interface slopes at 5-15 degrees. The rock cut at 2H:1V exposed at lower part in the southern section of CN12B.</li> </ul> <p><b>West (RHS)</b></p> <ul style="list-style-type: none"> <li>• 2H:1V soil cut slope, up to 10m high, grassed surface.</li> </ul>
Existing Landslide	Not part of the original landslide. A new landslide occurred in July 2022 following heavy rainfall event.
Cause of Landslide	Likely block sliding on soil-rock transition zone.
Date Landslide occurred	July 2022
Cut within area of historic landslide	Low risk in the centre of cut existing erosion gully.
Geotechnical Investigations	BH3532
Site Geology	No geological section provided in the report. Based on the design report and geotechnical investigations, it expected that the cuts are formed in Pakiri Formation soils.
Soil Rock Transition Zone	5~10° below cut level dipping in western direction.
Rock Cut	Minor rock cut outcrops at the lower part of the southern section were cut at 2H:1V.
Remedial Works Design	<ul style="list-style-type: none"> <li>• Removal of the slipped material and regrading of the slope to 4H:1V.</li> <li>• Shear key and toe buttress and counterfort drains.</li> </ul> <p>Discussions on addition ground improvements subject to further design and slope movement monitoring.</p>
Remedial Works Details	Details as above.



Peer Reviewed in PSM Report Rev 4	Not applicable. The landslide occurred after the report was issued.
Groundwater Seepage Monitoring	Proposed at eastern side, but no observations have been made.
Risk of Future Slope Failure	<p><b>East (LHS):</b> The risk of future slope failure is considered <b>low to moderate risk</b>. No significant groundwater seepage observed. Soil rock interface typically less than 10 degrees inclined.</p> <p>The overall weighted risk level has been raised to low moderate risk. The individual risk rating for slope failure and sliding at soil-rock interface is moderate. As the slope is now monitoring and remedial works are being carried out, the future risk level should decrease provided the geology and ground conditions are well understood, and a suitable remedial works design is prepared.</p> <p><b>West (RHS):</b> The risk of future slope failure is considered <b>very low</b>. Soil rock interface is dipping away from cut slope. The risk rating has been reduced from low to very low.</p>





July 2021, Time 2:57 – View in southern direction: East = left-hand side; West = right-hand side



September 2021, Time 3:12 – View in southern direction: East = left-hand side; West = right-hand side

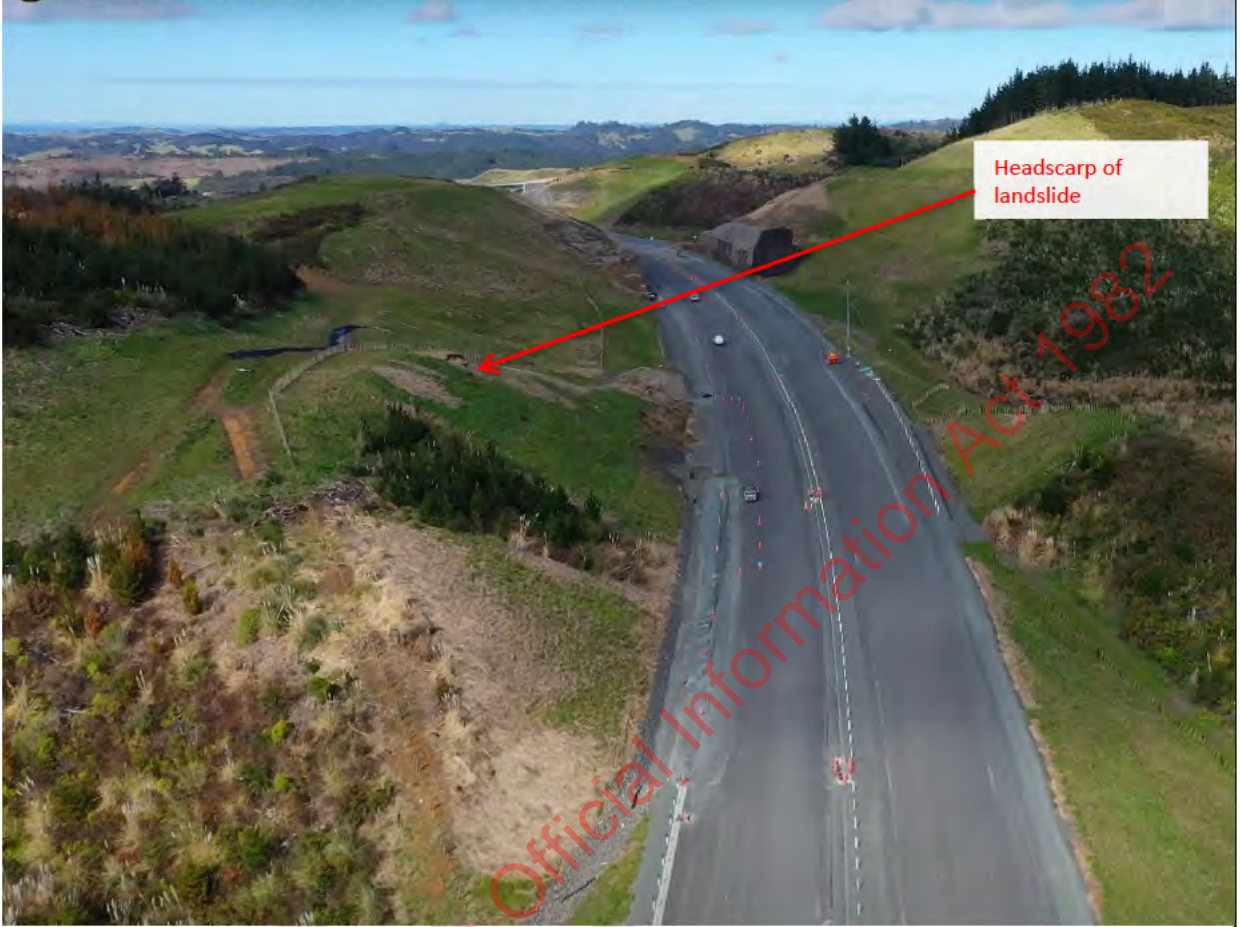




August 2022, Time 3:13 – View in southern direction: East = left-hand side; West = right-hand side



Ara Tūhono – Pūhoi to Warkworth: Project Flyover, August 2022





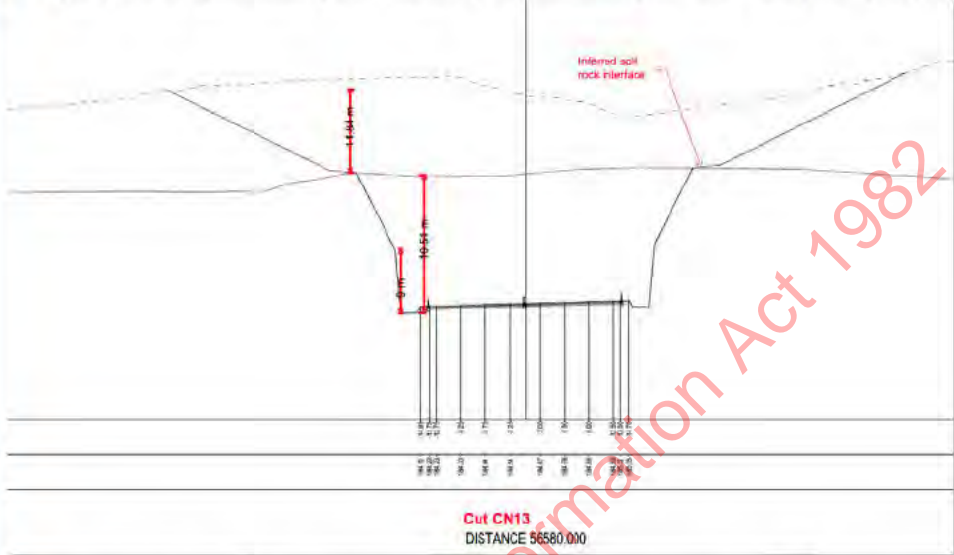
January 2023, Time 3:18 - View in southern direction: East = left-hand side; West = right-hand side



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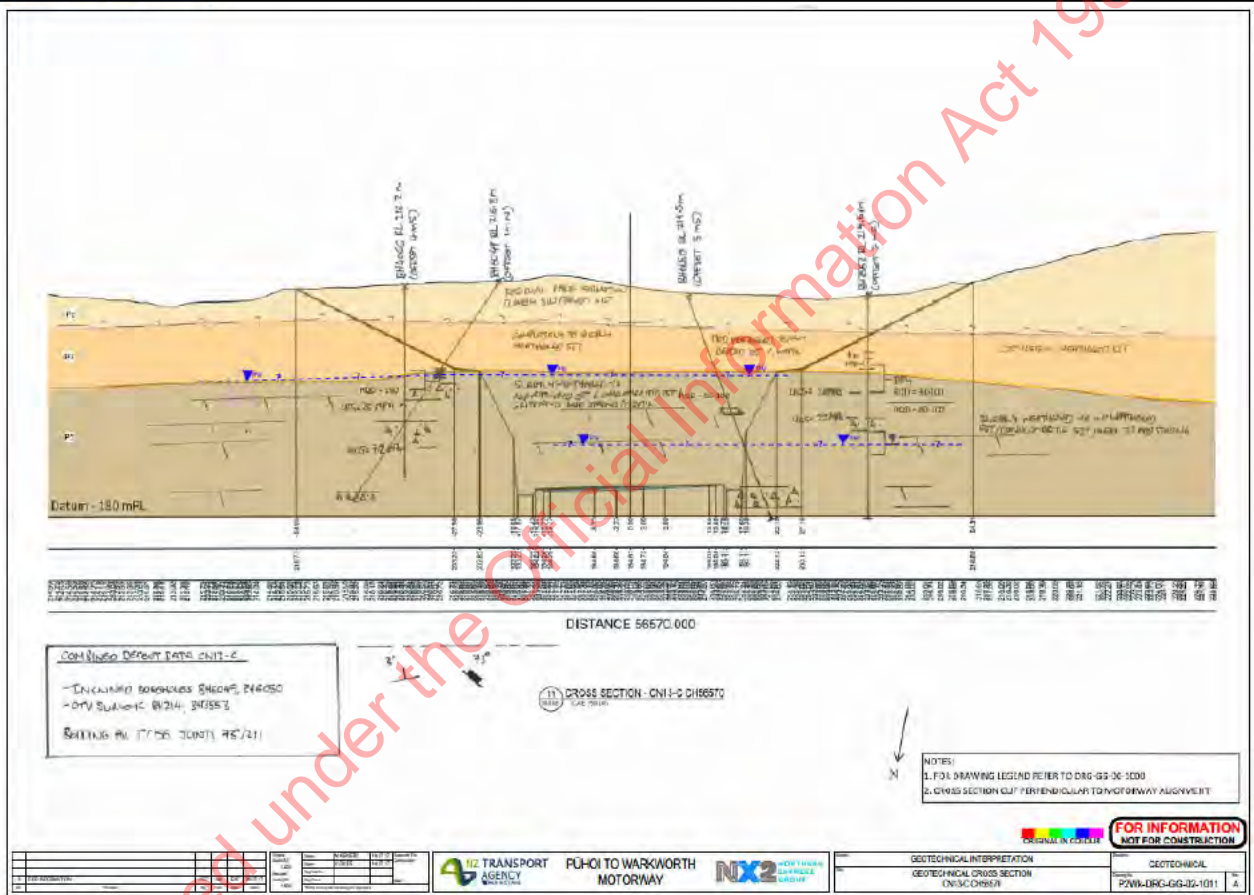
7.24 CN13

Chainage	Ch56,410 – Ch56,730
Typical Design Slope Geometry	<p>East (LHS): 2H:1V up to 19m high. Rock cut slope up to 20m high. Max. total slope height approx. 31m.                  West (RHS): 2H:1V up to 14m high. Rock cut slope up to 20m high. Max. total slope height approx. 32m.</p>  <p>The diagram shows a cross-section of a road cut. On the left (East), there is a soil cut slope of 2H:1V up to 19m high, followed by a rock cut slope up to 20m high. On the right (West), there is a soil cut slope of 2H:1V up to 14m high, followed by a rock cut slope up to 20m high. The total slope height is approximately 31m on the East and 32m on the West. An 'Inferred soil-rock interface' is shown as a dashed line. The cut is labeled 'Cut CN13' and 'DISTANCE 56580.000'.</p>
Site & Design Description	<p>Alignment is cutting through East-West oriented ridge line which is inclining into westerly direction.</p> <p><b>East (LHS)</b></p> <ul style="list-style-type: none"> <li>• 2H:1V soil cut slope, up to 19m high, grassed surface.</li> <li>• Soil rock transition zone up to 10degrees towards slope,</li> <li>• Soil above the transitional rock appears to be removed at the upper part of the slope,</li> <li>• Ground level above the cut slope is flat or sloping away,</li> <li>• Groundwater seepage is not obvious from drone footage,</li> </ul> <p><b>West (RHS)</b></p> <ul style="list-style-type: none"> <li>• 2H:1V soil cut slope, up to 20m high, grassed surface,</li> <li>• Ground level above the cut slope is sloping up at 4H~3H:1V, which increases the stormwater run-off over the cut slope surface,</li> <li>• Groundwater seepage at lower rock slope visible from drone footage</li> </ul>
Existing Landslide	None reported to s 9(2)(b)(ii) and 9(2)(ba)(i)
Cause of Landslide	Not applicable
Date Landslide occurred	Not applicable
Cut within area of historic landslide	Moderate risk at southern part; dipping in alignment direction perpendicular to the slopes
Geotechnical Investigations	BH111, BH214, BH3552, BH3553, BH4066, BH6110, BH3552, BH6049, BH6050
Site Geology	<p>Ch56,570 (CN13), Drawing No P2Wk-DRG-GG-02-1011</p> <p><b>1. Geology - Pakiri Formation (Encountered/inferred stratigraphic thicknesses in order)</b></p> <ul style="list-style-type: none"> <li>• 5-8m – Stiff - Residually weathered clayey SILT/sandy STIL</li> <li>• 7.5-6m - Completely to highly weathered sandstone and very weak moderately weathered sandstone</li> <li>• Weak to moderately strong, slightly weathered to unweathered sandstone and conglomerate sandstone/gritstone encountered past 13-14m. UCS Range = 7.2MPa - 28MPa</li> </ul> <p><b>2. Structural Features &amp; Defects</b></p>



Weathering contacts horizontal to sub-horizontal	Weathering contacts horizontal to sub-horizontal
Bedding (Average): Bedding Dip: 3/156	Bedding (Average): Bedding Dip: 3/156
Jointing (Average): 73/211	Jointing (Average): 73/211
3. Groundwater	<ul style="list-style-type: none"> <li>Measured at moderately weathered to slightly weathered contact</li> <li>Measured at 13.5m below existing ground level within slightly weathered to unweathered rock</li> </ul>

Soil Rock Transition Zone	East: Typically 5~10° towards slope face.
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Rock Cut	<ul style="list-style-type: none"> <li>85° (at lower 9m) and 64° rock slopes with mesh draping</li> <li>bench above rock slope,</li> </ul>
Remedial Works Design	None required
Remedial Works Details	Not applicable
Peer Reviewed in PSM Report Rev 4	Not reviewed
Groundwater Seepage Monitoring	Proposed at eastern side, but no observations have been made.
Risk of Future Slope Failure	<p>East (LHS):</p> <p>The risk of future slope failure is considered <b>low</b>.</p> <ul style="list-style-type: none"> <li>No significant groundwater seepage observed.</li> </ul>



- Soil rock interface typically less than 10° inclined.  
Potential risk of topsoil slip where topsoil is placed on the rock surfaces.

**West (RHS):**

The risk of future slope failure is considered **low**.

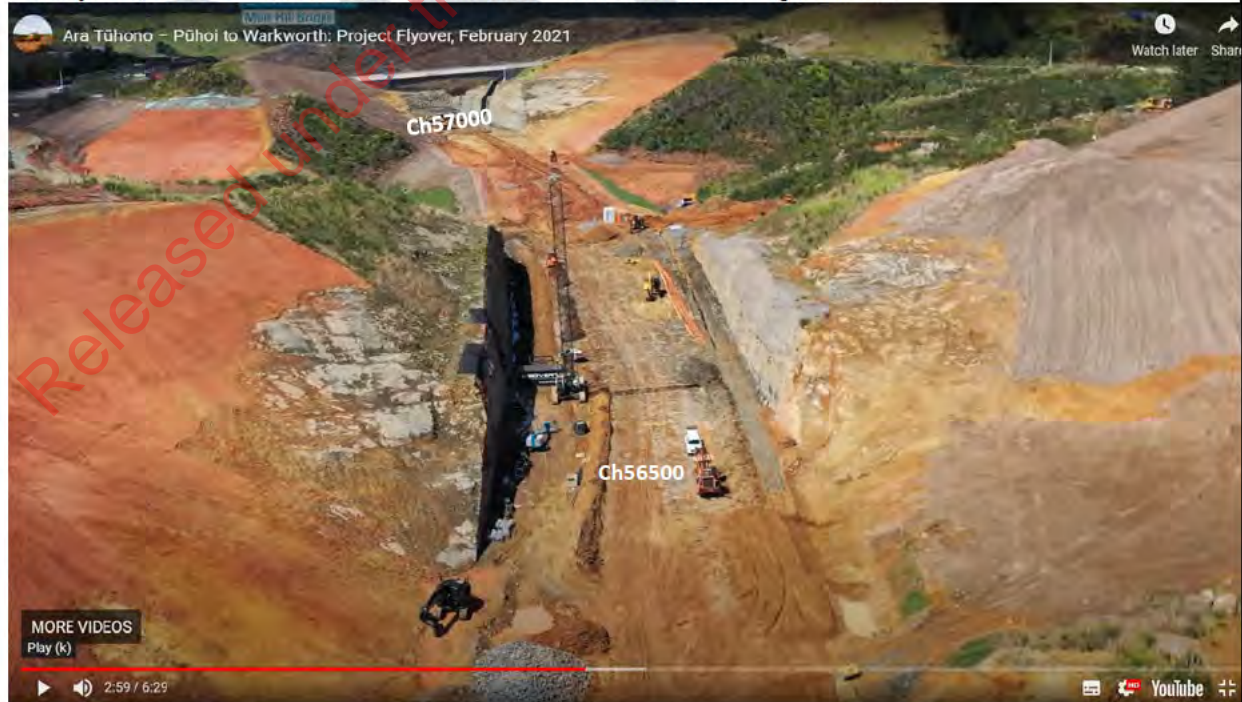
- No significant groundwater seepage observed.
- Soil rock interface typically flat or sloping away from cut slope.

**The risk level remains unchanged since the previous assessment.**

October 2020, Time 3:18 – View in southern direction: East = left-hand side; West = right-hand side



February 2021, Time 2:59 – View in southern direction: East = left-hand side; West = right-hand side





June 2021, Time 3:03 – View in southern direction: East = left-hand side; West = right-hand side



September 2021, Time 3:18 – View in southern direction: East = left-hand side; West = right-hand side





February 2022, Time 3:19 – View in southern direction, Ch56500: East = left-hand side; West = right-hand side



August 2022, Time 3:19 – View in southern direction, Ch56500: East = left-hand side; West = right-hand side





February 2022, Time 3:25 – View in southern direction, Ch56500: East = left-hand side; West = right-hand side



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7.25 CS1 Moir Hill – Landslide 7

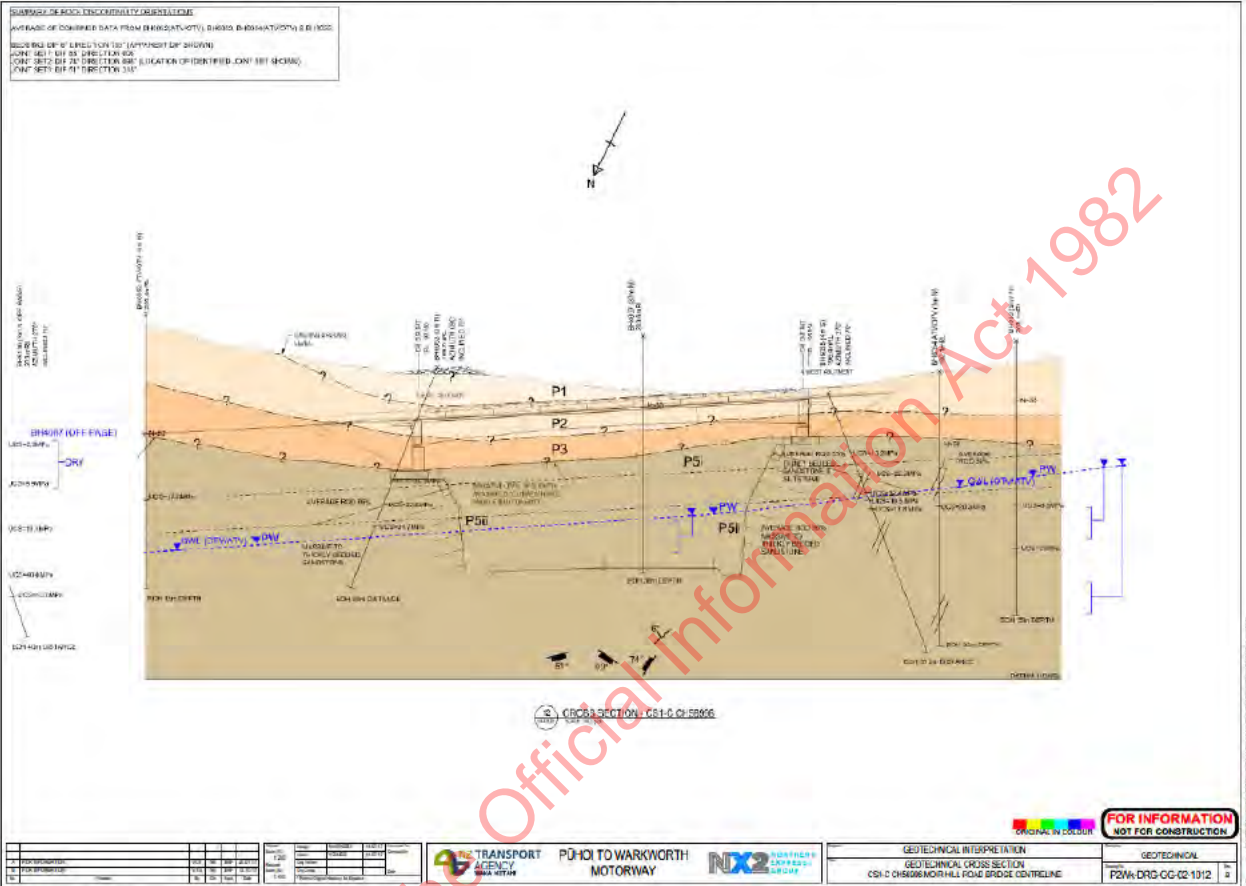
Chainage	Ch56,840 – Ch57,120
Typical Design Slope Geometry	<p>East: 2H:1V up to 25m high, 85° (lower 9m) and 64° steep up to 17m high rock cut slope            West: 2H:1V up to 17m high, 85° (lower 9m) and 64° steep up to 21m high rock cut slope</p> 
Site & Design Description	Alignment cuts through west to east trending ridge line.
Existing Landslide	<p><b>Yes (No 7),</b> North-eastern side Ch56,900 to Ch56,950  <b>A new slip occurred in July 2022 after heavy rainfall at the north-western slope of the bridge at approximately Ch57,000.</b></p>
Cause of Landslide	<b>First landslide: Unknown; Second landslide: Likely sliding at soil-rock transition zone.</b>
Date Landslide occurred	<p><b>First landslide: Unknown</b>  <b>Second landslide: July 2022</b></p>
Cut within area of historic landslide	Low risk landslide hazard in northern direction (perpendicular to alignment) at northern side of Moir Hill Rd.
Geotechnical Investigations	BH353, BH4037, BH4067, BH5106, BH5107, BH6052, BH6054, BH6055, BH6056,
Site Geology	<p>Ch56,996 (CS1), Drawing No P2Wk-DRG-GG-02-1012</p> <p><b>1. Geology - Pakiri Formation (Encountered/inferred stratigraphic thicknesses in order)</b></p> <ul style="list-style-type: none"> <li>• 3-4.5m -Firm - Residually weathered soil</li> <li>• 4-8m Stiff - Residually weathered soil</li> <li>• 2.5-6.5m - Highly to moderately weathered rock</li> <li>• Slightly to unweathered rock encountered past 7-13.5m depth</li> </ul> <p>Slightly to unweathered rock comprises</p> <ul style="list-style-type: none"> <li>• Thinly bedded sandstone &amp; siltstone</li> <li>• Massive to thickly bedded sandstone</li> <li>• Massive thickly bedded sandstone</li> </ul> <p>UCS Range for slightly weathered rock: 13-32.4MPa</p> <p><b>2. Structural Features &amp; Defects</b></p> <ul style="list-style-type: none"> <li>• Slightly weathered to unweathered rock contact dips into eastern cut slope at 5°-10°</li> <li>• Slightly weathered to unweathered rock contact is horizontal at western cut slope</li> </ul> <p>Bedding: 6/155 (Apparent dip)</p>



Jointing: 83/00°, 74/098, 51/318

### 3. Groundwater

- Groundwater recorded at 15-19m below ground surface level



Soil Rock Transition Zone	<p><b>East (LHS):</b> Generally less than 5°~10°.</p> <p><b>West (RHS):</b> Dipping away from cut slope or horizontal</p>
Rock Cut	<ul style="list-style-type: none"> <li>• Rock cuts up to 21m deep supporting the Moir Hill Road Bridge,</li> <li>• 85° at lower 9m and 64° above 9m from excavation level.</li> </ul>
Ground Improvements	DEI 380 (confirmation of ground improvements as per design drawing P2Wk-DRG-GE-00-1007) 7x counterfort drains, 3m deep at 10m centres,
Remedial Works Design	DEI 0380 (Ch57025 – 57090, South West Counterfort Drain Line)
Remedial Works Details	Removal of slipped material and reshape slope (initial landslide). The second landslide at the NW slope comprised a toe buttress with shear keys and counterfort drains.
Peer Reviewed in PSM Report Rev 4	Not reviewed
Groundwater Seepage Monitoring	<p>Groundwater seepage and engineering geological site inspections were undertaken at CS1-C on the 2/11/2021. Observations included the following:</p> <ul style="list-style-type: none"> <li>• Bedding structure is sub-horizontal dipping towards the south</li> <li>• Rock mass structure ranges from massive/homogenous to interbedded widely spaced sandstone/siltstone</li> <li>• Wet/softened soil slope at Ch56850-west with minor erosional rilling</li> </ul>



	<ul style="list-style-type: none"> <li>• Seepages at transition cut slope and from soil-rock contact at Ch 56950-East with wet and softened ground around seepage.</li> <li>• Seepages at bridge abutment contact with rock slope</li> <li>• Seepages from rock bedding structure</li> <li>• Seepages from soil-rock contact bench at Ch57500-west</li> <li>• Seepages from soil-rock contact with very wet and softened ground at Ch57100-west</li> <li>• Sediment at subsoil drain outlets at Ch57100-west</li> </ul>
<p>Risk of Future Slope Failure</p>	<p><u>Risk of wedge-type or rock slope failures cannot be determined based on the available information. A risk assessment with regards to the Moir Hill Bridge has not been made. Our assessment relates to the slopes outside of the bridge.</u></p> <p>East (LHS): The risk of future slope failure is considered <b>low</b>.</p> <ul style="list-style-type: none"> <li>• All slip debris at transition has been removed.</li> </ul> <p>West (RHS): The risk of future slope failure is considered <b>low</b>. Further remedial works at the soil cut to rock cut transition were completed.</p> <p><b>The overall weighted risk level remains low.</b></p>





February 2021, Time 3:05 – View in southern direction: East = left-hand side; West = right-hand side



June 2021, Time 3:09 – View in southern direction: East = left-hand side; West = right-hand side





July 2021, Time 3:09 – View in southern direction: East = left-hand side; West = right-hand side



September 2021, Time 3:25 – View in southern direction: East = left-hand side; West = right-hand side

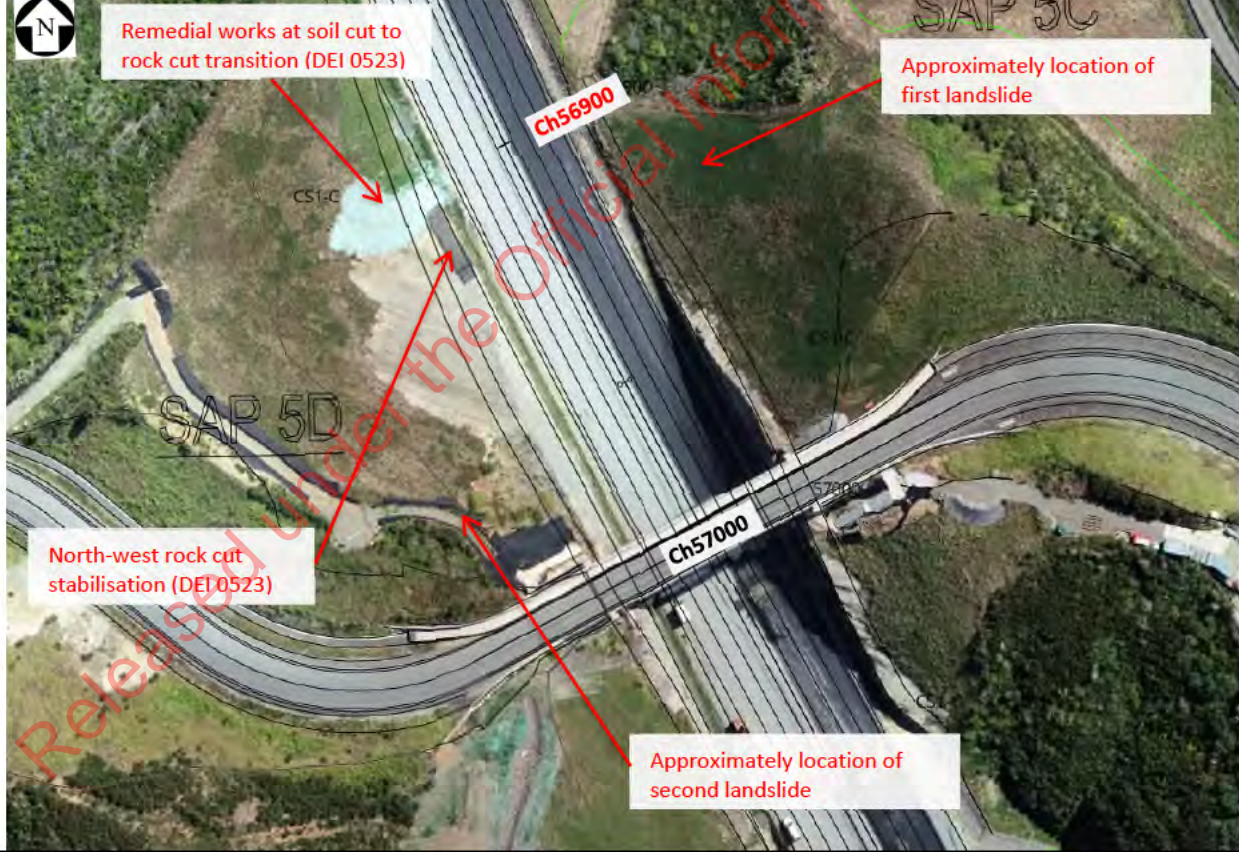




February 2022, Time 3:25 – View in southern direction: East = left-hand side; West = right-hand side



Mapbox Aerial Photo, February 2022





August 2022, Time 3:26 – View in southern direction: East = left-hand side; West = right-hand side



January 2023, Time 3:31 – View in southern direction: East = left-hand side; West = right-hand side



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## 7.26 Moir Hill Road – Landslide 8

Chainage	MCM0 Ch140-170 The site is located approximately 1km East of the new alignment at approximately Ch57,000 near the existing SH1.
Typical <u>Design</u> Slope Geometry	LHS: 1H:3V cut slope at the south-eastern side of the alignment is stabilise with soil nails. RHS: Existing natural slope supporting Moir Hill Road.
Existing Landslide	<b>Yes South-East (No 8)</b>
Cause of Landslide	Shallow soil slope failure at the cut slope which was not improved with soil nails.
Date	14/08/2020
Remedial Works Design	DEI 0433 (Ch132 – 155, Retaining Wall incl. slope stability memorandum Rev C)
Remedial Works Details	Removal of slipped material and construction of Redi-Rock gravity retaining wall.
Independent Peer Review	Refer to PSM Report PSM4203-029R Draft Rev 4 – Appendix M.
Rock Cut Slope	No.
Groundwater Seepage Monitoring	No groundwater seepage monitoring <b>has been</b> undertaken.
Risk of Future Slope Failure	<p><b>South-East (LHS):</b> The risk of future slope failure is considered <b>very low</b>. Slope has been remediated with Redi-Rock retaining wall.</p> <p><b>North-West (RHS):</b> The risk of future slope failure is considered <b>low risk</b>. Ongoing downslope movement of existing slope supporting Moir Hill Road towards the existing gully in north-western direction <b>was expected in assessment of the Revision D Report. We understand some movement has occurred during the January 2023 rainfall event. Moir Hill Road was closed to the public.</b></p> <p><b>Nevertheless, the overall weighted risk rating is low, as potential slips do not affect the new SH1 main alignment and maintenance of this section understood not to be part of the NX2 scope.</b></p>





## 7.27 CS2B – Landslide 9

Chainage	Ch57,200 – Ch 57,340
Typical Design Slope Geometry	East (LHS): 5H:1V up to 8m high, no rock cut slope West (RHS): Fill embankment
Site & Design Description	Original ground level sloping from East to West. Inferred soil rock transition also sloping from East to West.  East (LHS): <ul style="list-style-type: none"> <li>• Potential rock outcrop or soil rock transition zone at toe of slope.</li> <li>• Cut slope appears to be overcut to provide temporary access from Moir Hill Rd/ site compound.</li> </ul> West (RHS): Fill embankment.
Existing Landslide	Yes (No 9) Slip at Ch57,200
Cause of Landslide	No information provided. However, we believe that the slip was caused by too steep temporary cuts in Northland Allochthon.
Date Landslide occurred	Unclear.
Cut within area of historic landslide	Moderate risk at eastern side of alignment. Landslide direction towards alignment.
Geotechnical Investigations	BH210, BH3525
Site Geology	No geological section provided in the report. The report and the Regional Geological Map (drawing P2Wk-DRG-GG-00-0203) suggest Northland Allochthon rock or soils.
Soil Rock Transition Zone	East (LHS): Generally dipping at up to 10~15° into the slope (based on alignment cross sections). West (RHS): n/a
Rock Cut	No rock cut slope or exposed rock observed based on drone flyover footage. No construction records are available.
Remedial Works Design	No DEI reference available.
Remedial Works Details	Cut back from 5H:1V.
Peer Reviewed in PSM Report Rev 4	Not reviewed
Groundwater Seepage Monitoring	No observations have been made.
Risk of Future Slope Failure	East (LHS): The risk of future slope failure is considered <b>very low</b> due to 5H:1V slope. <b>The risk level has been reduced since the previous Revision D assessment.</b> West (RHS): The risk of future slope failure is considered <b>very low</b> due to fill embankment and no cut slope.



February 2020, Time 3:27 – View in southern direction: East = left-hand side; West = right-hand side



July 2021, Time 3:14 – View in southern direction: East = left-hand side; West = right-hand side





September 2021, Time 3:29 – View in southern direction: East = left-hand side; West = right-hand side




February 2022, Time 3:29 – View in southern direction: East = left-hand side; West = right-hand side






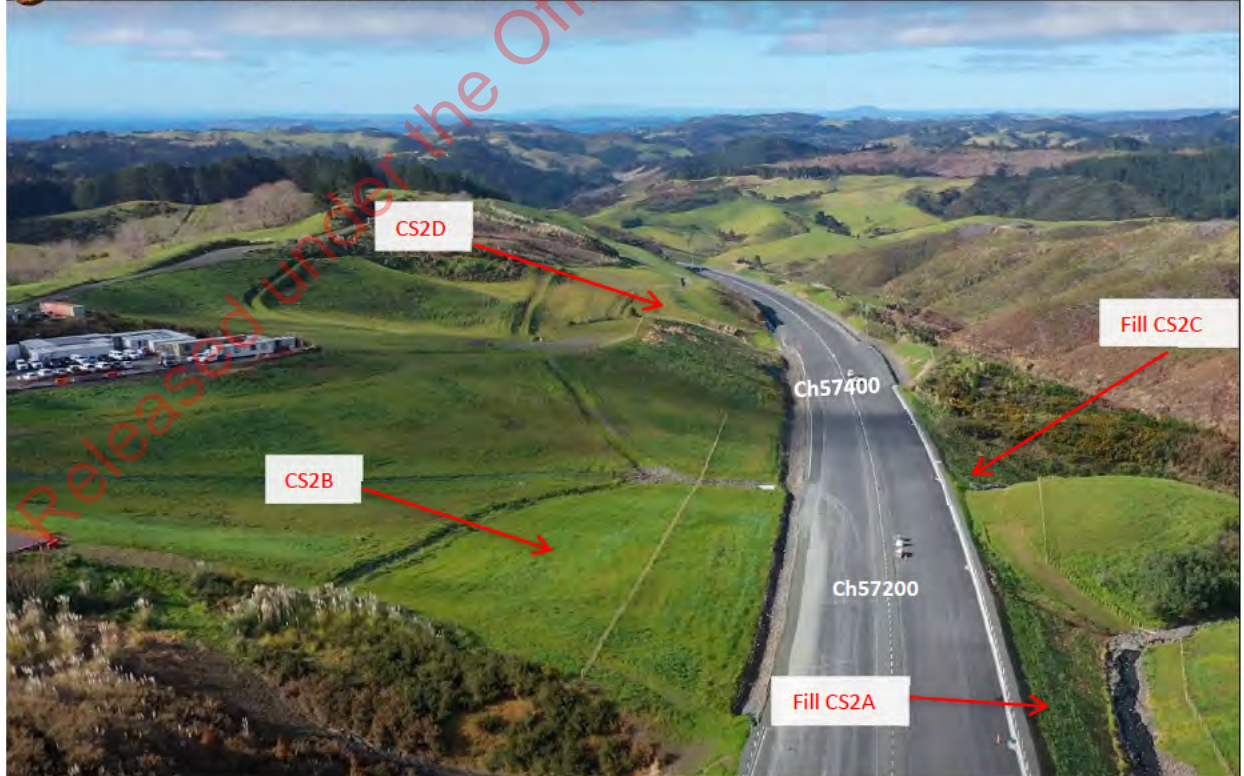
August 2022, Time 3:31 – View in southern direction: East = left-hand side; West = right-hand side

 Ara Tūhono – Pūhoi to Warkworth: Project Flyover, August 2022



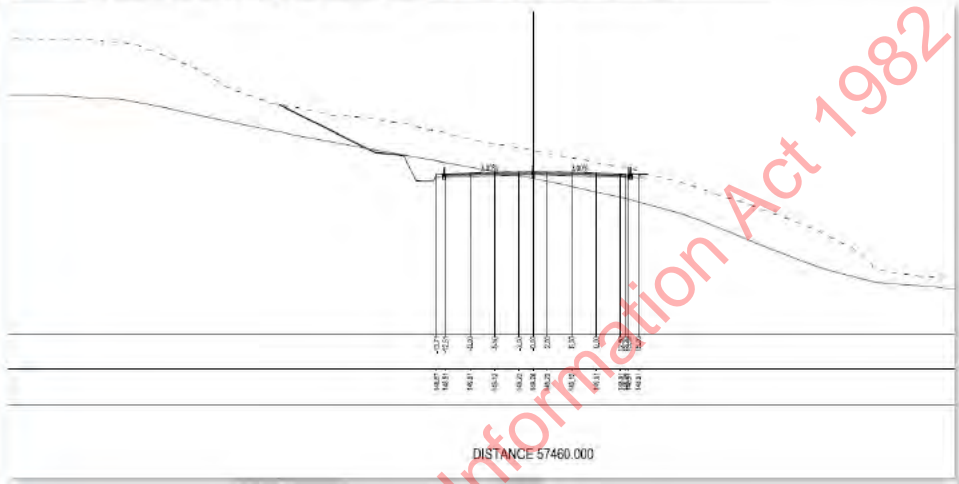
February 2022, Time 3:29 – View in southern direction: East = left-hand side; West = right-hand side

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7.28 CS2D – Landslide 10

Chainage	Ch57,370 – Ch57,615
Typical Design Slope Geometry	<p>East (LHS): 2H:1V up to 17m high, 64° steep up to 5m high rock cut slope at lower part of slope. Note that the entire slope has been constructed at 2H:1V including the rock cutting.</p> <p>West (RHS): 2H:1V cut up to 6m deep. Fill embankment up to 18m (infill of gully at Ch57,380, not shown in section below).</p> <p><u>We note that soil slope and rock height vary along the alignment at both sides. The above values are maximum values which may not be shown on the presented section.</u></p> 
Site & Design Description	<p>Topography is sloping from East to West. CS2D is a sidling cut at the eastern side of the alignment. The cut is formed at the end of a southerly trending ridge line.</p> <p><b>East (LHS)</b></p> <ul style="list-style-type: none"> <li>• 2H:1V soil cut slope, up to 29m high, grassed surface.</li> <li>• Soil rock transition zone up to 10degrees towards slope,</li> <li>• Soil above the transitional rock appears to be removed at the upper part of the slope,</li> <li>• Ground level above the cut slope is flat or sloping away,</li> <li>• Groundwater seepage is not obvious from drone footage,</li> </ul> <p><b>West (RHS)</b></p> <ul style="list-style-type: none"> <li>• 2H:1V soil cut slope, up to 6m high, grassed surface, topography is sloping away from the top of slope.</li> </ul>
Existing Landslide	Yes (No 10) Slip Ch57,450 – Ch57,620
Cause of Landslide	<ul style="list-style-type: none"> <li>• Bedding fabric noted as being sub horizontal and dipping into the slope (06°/035°)</li> <li>• Softened shear planes orientated parallel to bedding fabric.</li> <li>• Evidence of potential historic landslide and fill material contained within the excavated slope.</li> </ul>
Date Landslide occurred	25/06/2020
Cut within area of historic landslide	Low risk at north-eastern side
Geotechnical Investigations	BH5216, TP3518, BH6056, BH6057 (inclined), TP6016
Site Geology	<p>Ch57,540 (CS2D), Drawing P2Wk-DRG-GG-02-1014</p> <p>1. Geology - Pakiri Formation (Encountered/inferred stratigraphic thicknesses in order)</p> <ul style="list-style-type: none"> <li>• 3-9m - Residually weathered to completely weathered soft SILT &amp; loose SAND</li> <li>• 4-6.5m - Highly weathered to moderately weathered siltstone/sandstone</li> <li>• Moderately strong, slightly to unweathered, thick sandstone &amp; thin siltstone</li> </ul>



- Moderately strong, massive siltstone

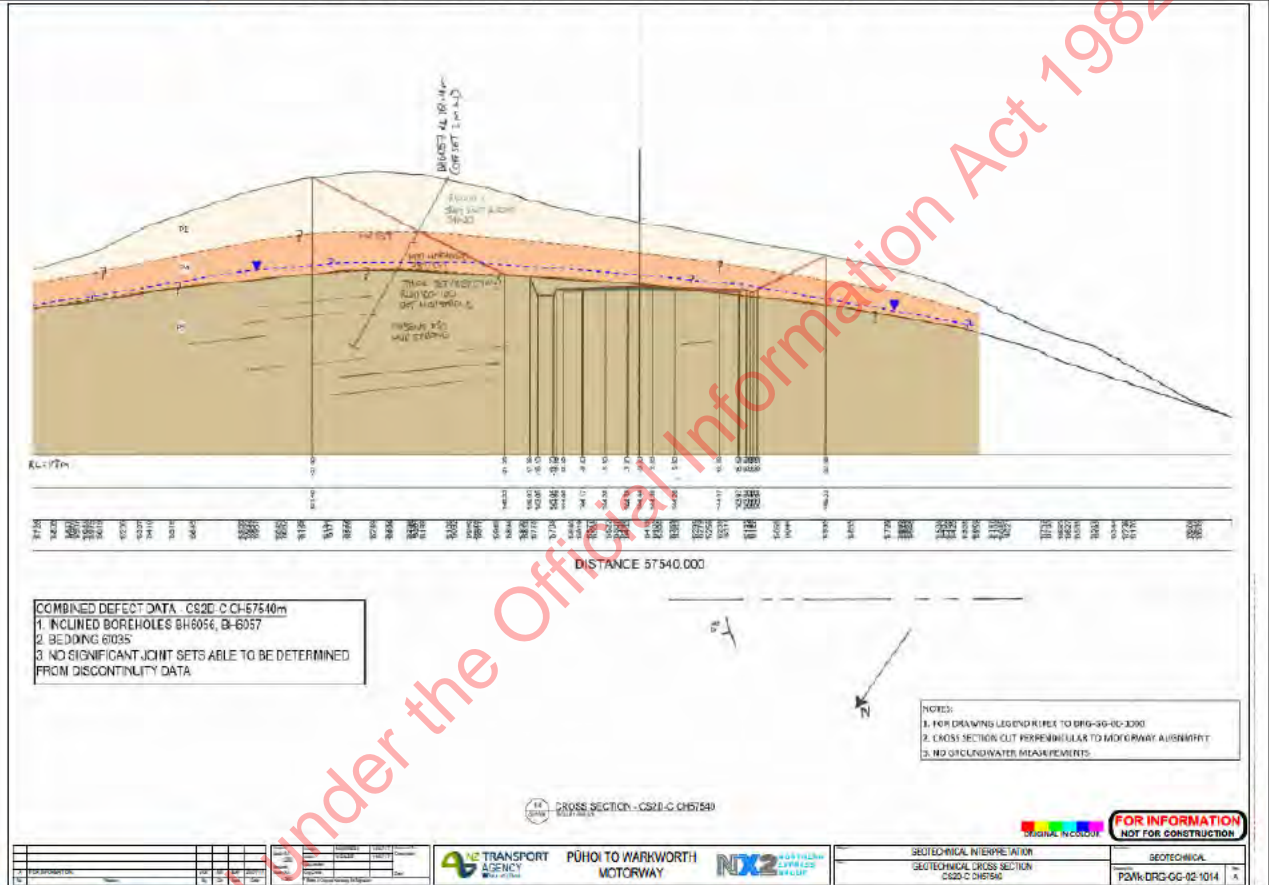
## 2. Structural Features & Defects

- Soil rock contact dips into eastern cut slope at less than 5°
- Soil rock contact dip out of western cut slope at up to 10°

Bedding Dip: 6/035

## 3. Groundwater

- Groundwater recorded at/just above moderately to slightly weathered contacts



Soil Rock Transition Zone	<p><b>East (LHS):</b> Generally dipping away at up to 5~10°.</p> <p><b>West (RHS):</b> Transition zone is dipping away. Rock transition zone is below the cut level.</p>
Rock Cut	Less than 5m high at the eastern (LHS) side. The rock cut slope has been cut at 2H:1V.
Remedial Works Design	DEI 0412 (not provided s 9(2)(b)(ii) and 9(2)(ba) renced in PSM Report PSM4203-029)
Remedial Works Details	Reshape to of 2H:1V (not clear without DEI)
Peer Reviewed in PSM Report Rev 4	Refer to PSM Report PSM4203-029R Draft Rev 4 – Appendix G
Groundwater Seepage Monitoring	<p>Seepage monitoring was undertaken on the 30/06/2021 and an engineering geological site inspection on the 2/11/2021.</p> <p>Groundwater seepage and engineering geological observations are as follows:</p> <ul style="list-style-type: none"> <li>• Surficial topsoil washout and surface erosion observed at Ch57,450</li> </ul>



	<ul style="list-style-type: none"> <li>• Toe buttressing to remediate slope "relaxation" between Ch57,425 to 57,600. Excavation of toe slope and buttressing</li> <li>• Sharp transition between completely and highly weathered soil/rock and underlying slightly weathered rock</li> <li>• Excavations relatively dry at time of inspection</li> <li>• Sediment at counterfort drain outlets</li> <li>• Sediment pond located directly above the cut slope at Ch57,500 is likely recharging groundwater to cut slope</li> <li>• Minor seepages recorded at soil-rock transition with wet and softened ground at location of seepage</li> </ul>
<p>Risk of Future Slope Failure</p>	<p><b>East (LHS):</b> The risk of future slope failure is considered <b>low to moderate risk</b>. The risk level has been increased from low.</p> <ul style="list-style-type: none"> <li>• The slope has been cut back to 2H:1V without lower rock slope. Buttress fill and counterfort drains were installed in October &amp; November 2021.</li> <li>• Cause of slip was daylighting of shear plane. Risk potential that the shear plane is re-activated.</li> </ul> <p><b>West (RHS):</b> The risk of future slope failure is considered <b>very low</b>. The risk rating at the western side has been reduced.</p>





February 2021, Time 3:11 – View in southern direction: East = left-hand side; West = right-hand side



June 2021, Time 3:17 – View in southern direction: East = left-hand side; West = right-hand side





July 2021, Time 3:17 – View in southern direction: East = left-hand side; West = right-hand side



September 2021, Time 3:33 – View in southern direction: East = left-hand side; West = right-hand side





September 2021, Time 3:36 – View in southern direction: East = left-hand side; West = right-hand side



February 2022, Time 3:34 – View in southern direction, Ch57300: East = left-hand side; West = right-hand side





August 2022, Time 3:36 – View in southern direction, Ch57400: East = left-hand side; West = right-hand side



Ara Tūhono – Pūhoi to Warkworth: Project Flyover, August 2022

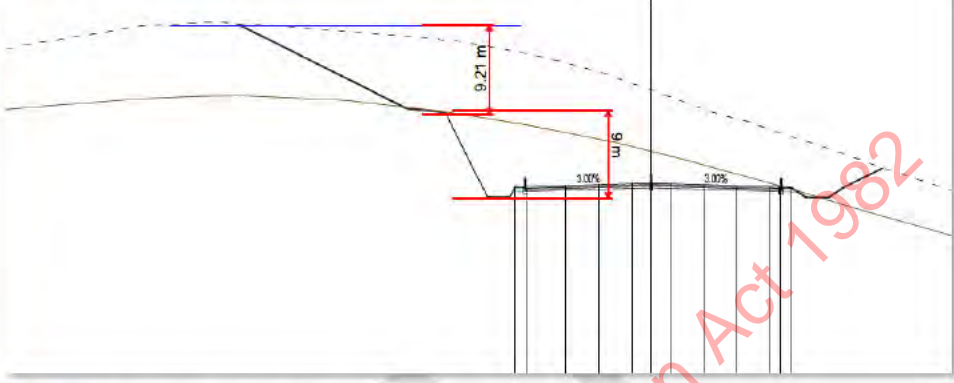


January 2023, Time 3:40 – View in southern direction, Ch57400: East = left-hand side; West = right-hand side





7.29 CS2F – Landslide 11

Chainage	Ch57,655 – Ch 57,750
Typical Design Slope Geometry	<p>East (LHS): 2H:1V up to 9m high, plus rock cut 64° up to 9m high,            West (RHS): Minor cuts less than 4m high or fill embankments</p> 
Site & Design Description	Sidling cut of existing East to West sloping spur.
Existing Landslide	Yes (No 11) Ch57,720 – 57,840
Cause of Landslide	<ul style="list-style-type: none"> <li>• Observations of large-scale historic block sliding in the immediate area.               <ul style="list-style-type: none"> <li>- Sub horizontal bedding fabric dipping obliquely out of the slope</li> <li>- Two sets of moderately to steeply inclined joints.</li> </ul> </li> <li>• Multiple softened shear planes orientated parallel to bedding fabric.</li> <li>• Identification of colluvial material within the slope following excavation and test pit investigations.</li> <li>• The presence a damaged stormwater drain discharging into the head of the slope</li> </ul>
Date Landslide occurred	4/08/2020
Cut within area of historic landslide	Low risk at eastern side. Historic slip features mapped with mid slope benches.
Geotechnical Investigations	BH6058 (inclined 035°/50°), TP3516, TP3517
Site Geology	No geological section provided in the detailed design reports.
Soil Rock Transition Zone	5~10° below cut level dipping in western direction.
Rock Cut	Eastern side only (LHS)
Remedial Works Design	DEI 0481 (Ch57725 – 57850, Landslide Stabilisation)
Remedial Works Details	<ul style="list-style-type: none"> <li>• Ch57,725 and Ch57,750</li> <li>• 12m long counterfort drains at 10m centres,</li> <li>• Reshape slope from 2H:1V to 3H:1V</li> <li>• 2H:1V rock buttress, minimum 7m high</li> </ul>
Peer Reviewed in PSM Report Rev 4	Refer to PSM Report PSM4203-029R Draft Rev 4 – Appendix H
Groundwater Seepage Monitoring	<p>Seepage monitoring was undertaken on the 30/06/2021 and an engineering geological site inspections on the 2/11/2021 with rainfall recorded in the 48 hours prior to inspection on the 30/06/2021. Groundwater seepage and engineering geological observations are as follows:</p> <ul style="list-style-type: none"> <li>• Site is a location of previous landslide with counterfort drains and toe buttressing remediation measures already installed at time of inspection</li> <li>• Minor seepages recorded from rock slope along structural defects (bedding)</li> </ul>



	<ul style="list-style-type: none"> <li>• Minor seepages recorded coming from buttress slope with softened wet ground</li> <li>• Minor seepages recorded at buttress-rock transition with softened wet ground at location of seepage and on rock cut bench.</li> <li>• Subsoil drains were relatively dry at time of inspection</li> <li>• Active surface erosion and soil slumping of cut slope occurring</li> <li>• Buttress fill bench is relatively dry with some minor damp patches</li> </ul>
<p>Risk of Future Slope Failure</p>	<p><b>East (LHS):</b>  The risk of future slope failure is considered <b>low to moderate</b> due to the completed remedial works. <u>However, due to the ongoing minor slips and remedial works at the adjacent Cut CS3, and the DJV's factor of safety assessment of the adjacent Cut CS3 resulted in the increased risk rating.</u></p> <ul style="list-style-type: none"> <li>• Slope cut back to 3H:1V. Buttress fill and counterfort drains are installed. The slope face of the buttress fill is grassed and subsoil drainage outlets are exposed.</li> <li>• <u>Potential increased risk</u> due to reliance on slope drainage system and potential maintenance.</li> </ul> <p>Note that the design requires a 10H:1V slope on top of buttress fill. Topsoil movement visible in June 2021 video footage. The September 2021 drone footage suggested ponding water on the buttress fill. The February 2022 drone footage shows that a rock lined swale drains has been installed and topsoil slips have been repaired.</p> <p><b>West (RHS):</b>  The risk of future slope failure is considered <b>very low</b>.  Small cut slope depth or fill embankments,</p> <ul style="list-style-type: none"> <li>• Soil rock transition zone below bottom of cut slope.</li> <li>• Topography is dipping away from slope.</li> </ul>





February 2021, Time 3:17 – View in south-eastern direction: East = left-hand side; West = right-hand side



June 2021, Time 3:23 – View in southern south-eastern: East = left-hand side; West = right-hand side





September 2021, Time 3:40 ~ 3:43 – View in south-eastern direction: East = left-hand side; West = right-hand side





February 2022, Time 3:41 – View in south-eastern direction, Ch57650: East = left-hand side; West = right-hand side



August 2022, Time 3:41 – View in south-eastern direction, Ch57650: East = left-hand side; West = right-hand side



Ara Tūhono – Pūhoi to Warkworth: Project Flyover, August 2022



January 2023, Time 3:43 – View in south-eastern direction, Ch57650: East = left-hand side; West = right-hand side



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7.30 CS3 – Landslide 12

Chainage	Ch57,750 – Ch58,470
Typical Design Slope Geometry	<p>East (LHS): upper 2H:1V soil slope more than 50m high (Ch58,220), lower rock slope approx. 25m high (Ch58,300),</p> <p>West (RHS): 2H:1V soil slope, less than 10m high (Ch58,300)</p> <p><u>We note that soil slope and rock height vary along the alignment at both sides. The above values are maximum values which may not be shown on the presented section.</u></p>
Site & Design Description	<p>Original ground level sloping from East to West at 2H:1V to 3H:1V. Inferred soil rock transition also sloping from East to West. Soil rock transition zone sloping up 10°.</p> <p><b>East:</b></p> <ul style="list-style-type: none"> <li>• 2H:1V slope, up to 44m high,</li> <li>• Rock slope up to 9m high, 26m wide bench at top of rock slope,</li> <li>• Groundwater seepage from bedding planes at rock cut,</li> <li>• Soil rock transition at bench,</li> <li>• Multiple rock outcrops at upper 2H:1V slope,</li> <li>• Seepage from subsoil drains at buttress above rock bench</li> </ul> <p><b>West:</b></p> <ul style="list-style-type: none"> <li>• 2H:1V slope, up to 11m high (appears to be mostly cut away based on drone footage),</li> <li>• Soil rock transition zone is dipping away steeply, transition zone through cut slope,</li> <li>• Grassed at lower rock and upper soil slope,</li> </ul>
Existing Landslide	Yes (No 12), Slip 57,920 – Ch58,140



Cause of Landslide	<ul style="list-style-type: none"> <li>Unfavourably softened or sheared surfaces within soil or near soil rock interface.</li> <li>Groundwater seepage</li> </ul>
Date Landslide occurred	3 landslides between March and July 2020
Cut within area of historic landslide	Moderate risk at eastern side
Geotechnical Investigations	BH4039, BH4038, BH110, BH6060, BH209
Site Geology	<p>57,800 (CS3), Drawing No P2Wk-DRG-GG-02-1015</p> <p><b>1. Geology - Pakiri Formation</b> (Encountered/inferred stratigraphic thicknesses in order)</p> <ul style="list-style-type: none"> <li>3.5-9.5m – Stiff - Residual to completely weathered soil</li> <li>Slightly weathered, thin to moderately thin sandstone with conglomerate sandstone interbeds encountered directly below residually to completely weathered soil</li> </ul> <p><b>2. Structural Features &amp; Defects:</b></p> <ul style="list-style-type: none"> <li>Residual to completely weathered soil contacts directly with underlying slightly weathered to unweathered rock,</li> <li>Soil-rock contact dips into eastern cut slope at between 5°-10°,</li> <li>Soil-rock contacts dips out of western cut slope at greater than 20°</li> </ul> <p>Bedding (Average): Bedding Dip: 2/159 Jointing (Average): 79/056, 59/167</p> <p><b>3. Groundwater</b> Groundwater recorded just above soil-rock contact @ 5-8m below ground surface level</p> <p>58,230 (CS3), Drawing No P2Wk-DRG-GG-02-1015</p> <p><b>1. Geology - Pakiri Formation</b> (Encountered/inferred stratigraphic thicknesses in order)</p> <ul style="list-style-type: none"> <li>2-9m - Stiff to very stiff - Residual to highly weathered soil and rock</li> <li>2-3m - Moderately weathered sandstone</li> <li>Slightly to unweathered rock encountered past 5m depth and up to 12m depth</li> </ul> <p>Slightly weathered to unweathered rock comprises:</p> <ul style="list-style-type: none"> <li>Thinly interbedded sandstone/siltstone,</li> <li>Sandstone with few moderately thick siltstone beds</li> <li>Sandstone with minor moderately thin siltstone beds</li> <li>Very thin interbedded sandstone/siltstone</li> <li>Sandstone with moderately thick conglomerate beds</li> <li>Sandstone with widely spaced thin interbedded siltstone,</li> <li>Sandstone with few moderately thin siltstone beds and moderately thick conglomeratic sandstone beds</li> </ul> <p>UCS Range: At cut slope slightly to unweathered rock = 22.0MPa Upper slope slightly to unweathered rock = 26.1MPa</p> <p><b>2. Structural Features &amp; Defects</b></p> <ul style="list-style-type: none"> <li>Moderate to steeply inclined weathering contacts dip east to west</li> <li>Moderately weathered to slightly weathered rock contact dips into eastern cut at approx. 25°</li> </ul>



- Heavily incised weathering featured within moderately weathered rock penetrating down into slightly to unweathered rock - water ingress resulting in weathering along inclined joint set discontinuities

Bedding (Average): 04/208

Jointing (Average): 56/226, 73/046

### 3. Groundwater:

Groundwater recorded within slightly weathered rock at 15-20m below ground surface level.

58,290 (CS3), Drawing No P2Wk-DRG-GG-02-1017

### 1. Geology - Pakiri Formation (Encountered/inferred stratigraphic thicknesses in order)

- 3-8m - Soft to firm - Residually weathered SILT to Sandy SILT
- 2-3m - Completely weathered sandstone
- 5-8m - High to moderately weathered sandstone and interbedded siltstone
- Slightly to unweathered rock encountered below 8-14m

Slightly weathered rock comprises weak to moderately strong:

- Thinly bedded sandstone and siltstone
- Conglomeritic sandstone interbeds
- UCS of slightly weathered rock = 22MPa

### 2. Structural Features & Defects

- Rock contact dips down and out the eastern cut slope at approx. 10~15°
- Rock contact dips into western cut slope at approx. 30°
- Weathering stratigraphy steeply inclined east to west

Bedding (Average): Bedding Dip: 04/208

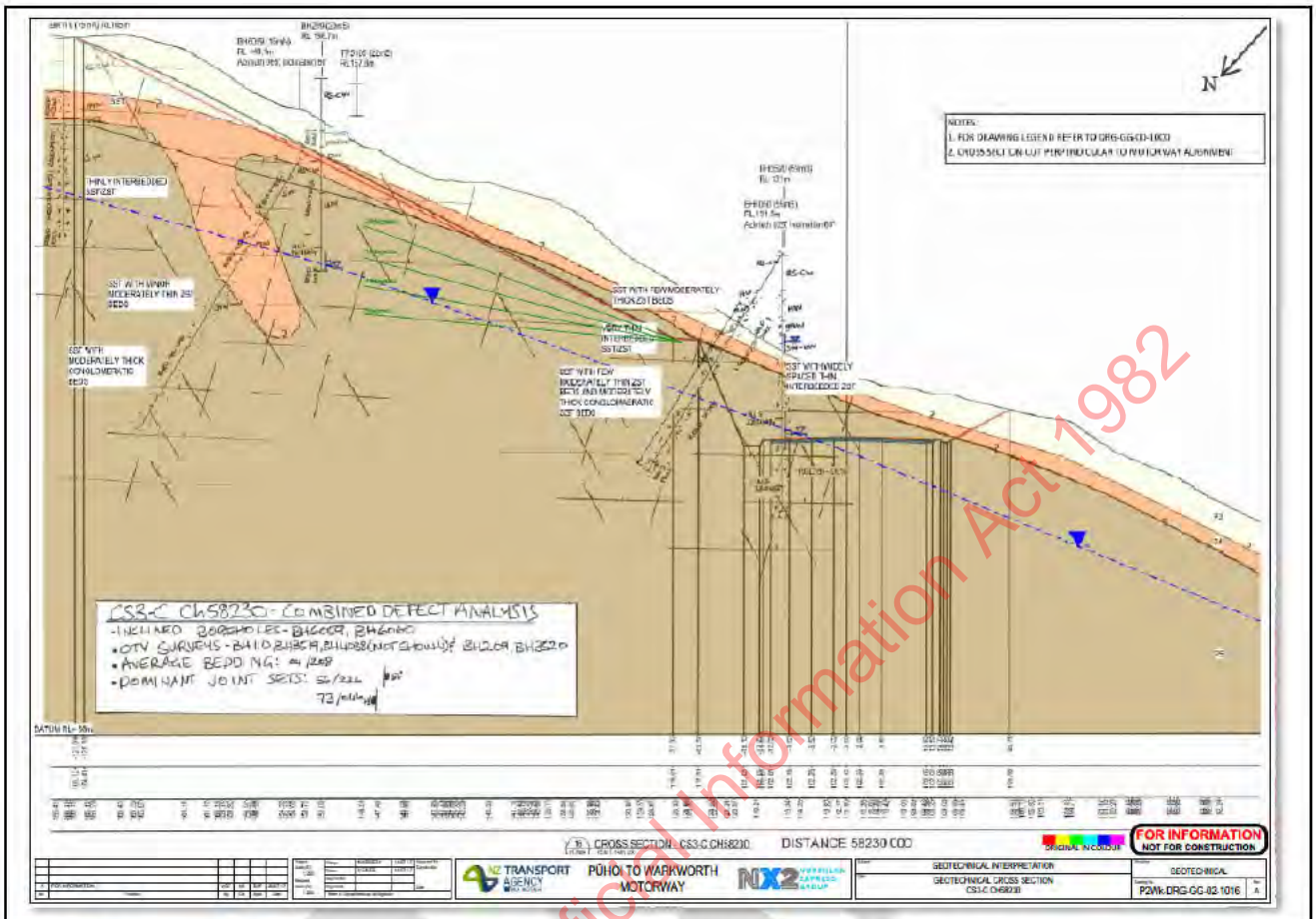
Jointing (Average): 56/226, 73/046

### 3. Groundwater

Groundwater encountered at slightly to moderately weathered rock contact

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Soil Rock Transition Zone	15~20° below cut level dipping in western direction.
Rock Cut	Eastern side only (LHS)
Remedial Works Design	DEI 0422 (Ch57900 – 58000 & Ch58050 – 58130, Landslide Stabilisation) DEI 0539 (Ch57900 – 58050 - & Ch58050 – 58160, East Batter Soil Slope Stabilisation)
Remedial Works Details	<ul style="list-style-type: none"> <li>Toe buttress (2H:1V), Counterfort drains at 10m centres,</li> <li>Cut off drains above headscarp,</li> <li>Slope to be reshape to 3H:1V</li> </ul>
Peer Reviewed in PSM Report Rev 4	Refer to PSM Report PSM4203-029R Draft Rev 4 – Appendix I
Groundwater Seepage Monitoring	<p>Seepage monitoring on the 30/06/2021 and engineering geological site inspections were undertaken and on the 2/11/2021. Rainfall was recorded in the 48 hours prior to inspection on the 30/06/2021. Groundwater seepage observations and engineering geological observations are as follows:</p> <ul style="list-style-type: none"> <li>Toe buttressing and counterfort drain remediation works have been installed at time of inspection</li> <li>Minor seepage encountered coming from bedding structure along the entire length of rock cut slope</li> <li>Minor seepage recorded coming from the buttress-rock transition</li> <li>Active surface erosion with wash out of fill material on to rock bench</li> <li>Washout of rock debris across slope at Ch58100 to Ch58200.</li> <li>Counterfort drains were very wet at time of inspection with trickling water observed</li> <li>Seepage from the entire length of the soil cut slope with softened ground and surface water present</li> <li>Buttress fill is wet/softened in locations with surface water ponding</li> </ul>
Risk of Future Slope Failure	<p>East (LHS):</p> <p>The risk of future slope failure has been raised to moderate risk due to the DJV's slope stability assessment and factor of safety calculations of the third-party design adopted for the toe buttress.</p>



- Remedial works completed (buttress fill with subsoil drains). Potential increased risk where design relies on maintenance of subsoil drains.
- Soil removed above rock transition zone.

Potential rockfall risks from the upper 2H:1V exposed rock slopes have been reviewed as part of the CJV assessments. Refer to Section 4.2.

**West (RHS):**

The risk of future slope failure is considered **very low**.

- Cut slope less than 10m high, or fill embankment,
- Topography dipping away and soil rock transition zone dipping away from cut slope,
- No/insignificant groundwater recharge/ seepage,

October 2020, Time 3:49 – View in southern direction: East = left-hand side; West = right-hand side



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February 2021, Time 3:20 – View in southern direction: East = left-hand side; West = right-hand side



April 2021, Time 2:57 – View in southern direction: East = left-hand side; West = right-hand side





July 2021, Time 3:27 – View in southern direction: East = left-hand side; West = right-hand side



September 2021, Time 3:44 – View in southern direction: East = left-hand side; West = right-hand side





September 2021, Time 3:49



February 2022, Time 3:47 – View in southern direction: East = left-hand side; West = right-hand side





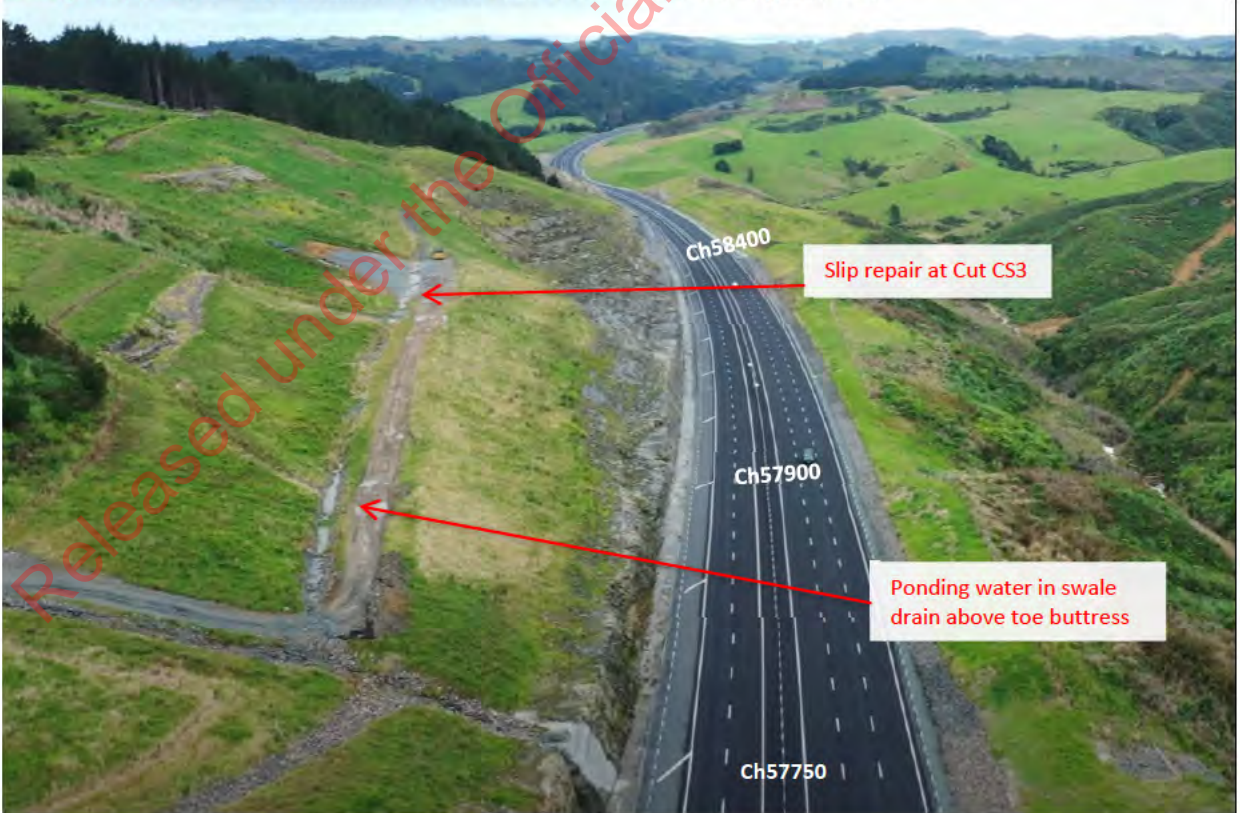
August 2022, Time 4:45 – View in southern direction: East = left-hand side; West = right-hand side



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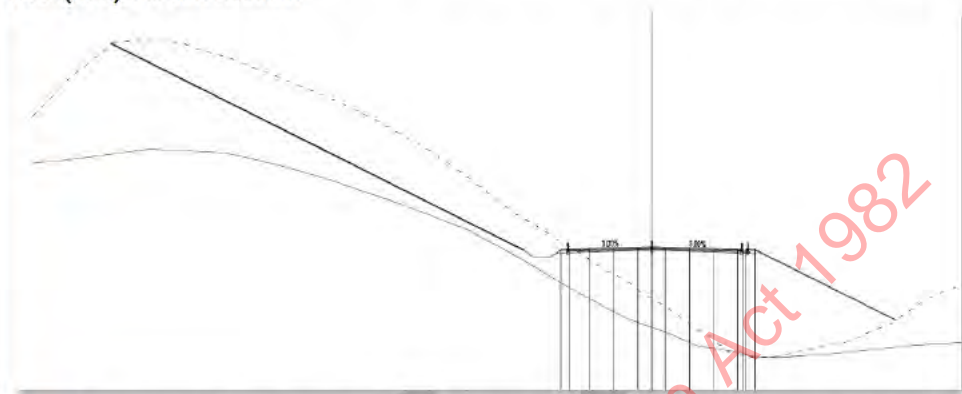


January 2023, Time 3:47 – View in southern direction: East = left-hand side; West = right-hand side





### 7.31 CS4 (North)

Chainage	Ch58,370 – Ch58,470
Typical Design Slope Geometry	<p>East (LHS): 2H:1V up to 33m high, including rock outcrop at southern part which is cut at 2H:1V, West (RHS): Fill embankment</p> 
Site & Design Description	<p>Original ground level sloping steeply from East to West at 1.3H:1V to 2H:1V. Inferred soil rock transition sloping up to 25degrees steep from East to West</p> <p>East (LHS):</p> <ul style="list-style-type: none"> <li>• 2H:1V slope, up to 33m high, sidling cut</li> <li>• Design sections indicate that the rock level below cut slope, outcrops are observed on flyover footage.</li> <li>• Ground level is sloping down at the back of the cut slope,</li> </ul> <p>West (RHS):</p> <ul style="list-style-type: none"> <li>• - CS4 Fill embankment</li> </ul>
Existing Landslide	None reported to s 9(2)(b)(ii) and 9(2)(ba)(i)
Cause of Landslide	Not applicable
Date Landslide occurred	Not applicable
Cut within area of historic landslide	Moderate risk at eastern side
Geotechnical Investigations	BH3519
Site Geology	No geological section provided in the report.
Soil Rock Transition Zone	15~25° towards slope face.
Rock Cut	Rock outcrop cut at 2H:1V
Remedial Works Design	None required
Remedial Works Details	Not applicable
Peer Reviewed in PSM Report Rev 4	Not reviewed
Groundwater Seepage Monitoring	<p>Seepage monitoring undertaken on the 30/06/2021 with rainfall recorded in the 48 hours prior to inspection</p> <ul style="list-style-type: none"> <li>• No obvious seepage, erosion or softened ground encountered or observed at time of inspection</li> </ul>



Risk of Future Slope Failure

East (LHS):

The risk of future slope failure is considered **low**.

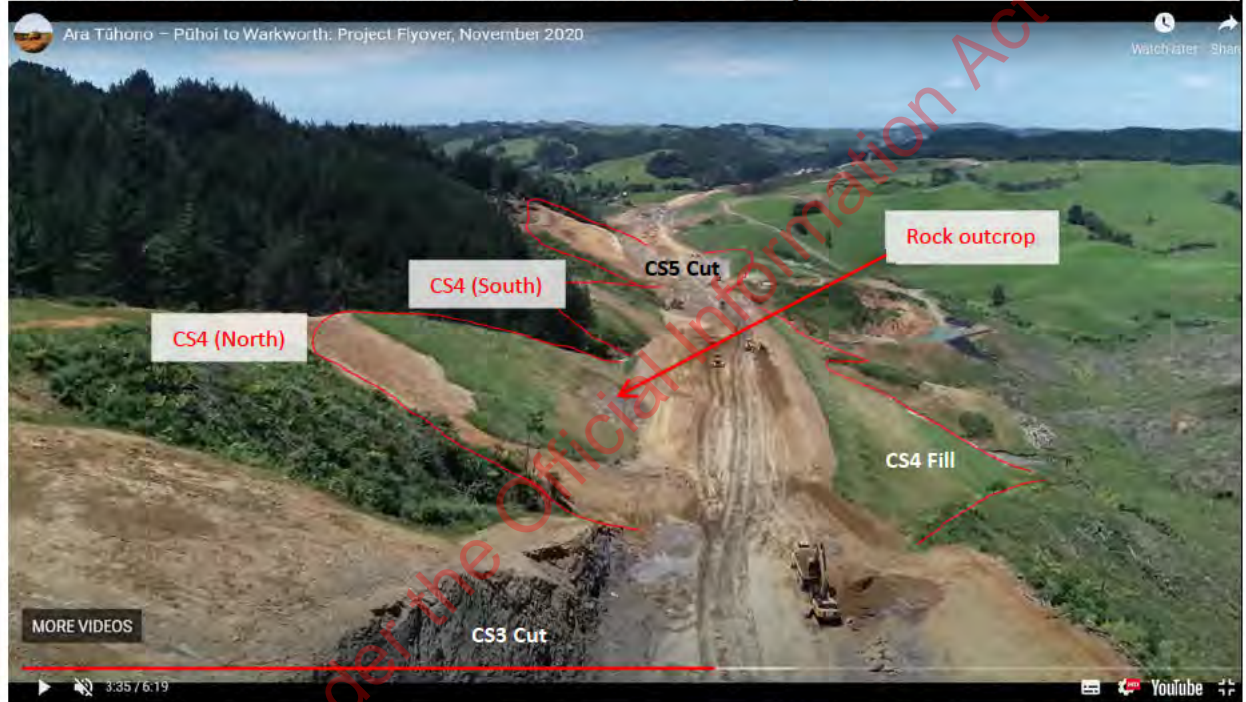
- No significant groundwater seepage observed.
- Top of cut at ridge line, thus no significant groundwater or surface water recharge.
- Overall stability of slope improved due fill embankment.
- Note that the soil rock transition zone is up to 20~25° inclined.

West (RHS):

The risk of future slope failure is considered **very low** due to fill embankment and no cut slope.

The risk rating remains unchanged compared to the previous assessment.

December 2020, Time 3:35 – View in southern direction: East = left-hand side; West = right-hand side



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June 2021, Time 3:34 – View in southern direction: East = left-hand side; West = right-hand side



September 2021, Time 3:54 – View in southern direction: East = left-hand side; West = right-hand side





August 2022, Time 3:53 – View in southern direction: East = left-hand side; West = right-hand side

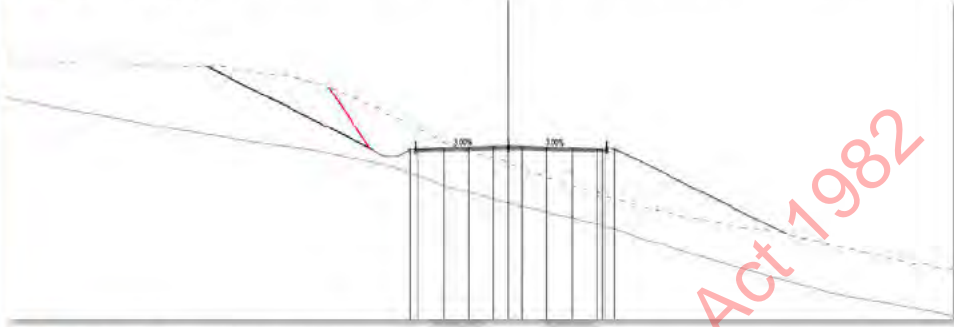


January 2023, Time 3:54 – View in southern direction: East = left-hand side; West = right-hand side





### 7.32 CS4 (South)

Chainage	Ch58,550 – Ch58,605
Typical Design Slope Geometry	<p>East (LHS): 2H:1V up to 12m high. Based on the drone footage, it appears that that this cut has been constructed steeper likely due to higher than expected rock levels (indicated by the red line in the sketch below).</p>  <p>West (RHS): Fill embankment CS4</p>
Site & Design Description	<p>Ground level and rock level flatter than at CS4 (Northern). The geology maps indicate a mid-slope bench at the cut slope location.</p> <p>East (LHS):</p> <ul style="list-style-type: none"> <li>• 2H:1V slope, up to 14m high, sidling cut</li> <li>• Design sections show the rock level below the bottom of cut slope. It appears that the slope has been cut at 1H:2V due to higher rock levels.</li> <li>• Ground level is sloping up at the back of the cut slope,</li> </ul> <p>West (RHS):</p> <ul style="list-style-type: none"> <li>• CS4 Fill embankment</li> </ul>
Existing Landslide	None reported to <span style="background-color: #cccccc; color: red;">s 9(2)(b)(ii) and 9(2)(ba)(i)</span>
Cause of Landslide	Not applicable
Date Landslide occurred	Not applicable
Cut within area of historic landslide	Low risk at eastern side
Geotechnical Investigations	No deep investigations at cut location. Refer to geological maps.
Site Geology	No geological section provided in the report.
Soil Rock Transition Zone	15~20° towards slope face.
Rock Cut	Inferred at 1H:2V based on drone footage.
Remedial Works Design	None required
Remedial Works Details	Not applicable
Peer Reviewed in PSM Report Rev 4	Not reviewed
Groundwater Seepage Monitoring	Groundwater seepage monitoring <b>has not been</b> carried out <b>at this slope</b> . No seepage was observed from the flyover footages.
Risk of Future Slope Failure	<p>East (LHS):</p> <p>The risk of future slope failure is considered <b>low</b>.</p> <ul style="list-style-type: none"> <li>• Minor rock cut only.</li> </ul>



- No significant groundwater seepage observed.
- Overall stability of slope improved due fill embankment.

**West (RHS):**

The risk of future slope failure is considered **very low** due to fill embankment and no cut slope.

**The risk rating remains unchanged compared to the previous assessment.**

October 2020, Time 3:58 – View in southern direction: East = left-hand side; West = right-hand side




May 2021, Time 3:34 – View in southern direction: East = left-hand side; West = right-hand side





August 2022, Time 3:57 – View in southern direction: East = left-hand side; West = right-hand side

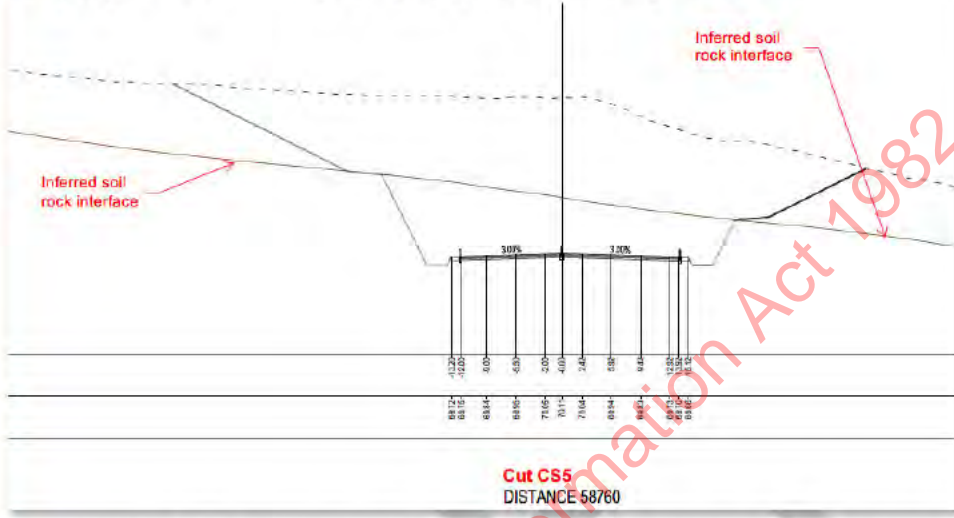
 Ara Tūhono – Pūhoi to Warkworth: Project Flyover, August 2022



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7.33 CS5 – Landslide 13

Chainage	Ch58,680 – Ch58,890
Typical Design Slope Geometry	<p>East (LHS): 2H:1V up to 24m high, 64° (1H:2V) steep up to 14m high rock cut slope at lower part of slope.</p> <p>West (RHS): 2H:1V up to 12m high, 64° (1H:2V) steep up to 6m high rock cut slope</p>  <p>The diagram shows a cross-section of a road cut. The ground surface is a solid line, and the inferred soil-rock interface is a dashed line. The cut is 30m wide with 3.0% slopes on both sides. Chainage markers are provided at the bottom of the diagram.</p> <p style="text-align: center;"><b>Cut CS5</b> DISTANCE 58760</p>
Site & Design Description	<p>The alignment cuts through a north-east to south-west oriented ridge/ spur. The ground level and inferred rock level are also sloping in NE-SW direction in the centre of the cut.</p> <p><b>East (LHS):</b></p> <ul style="list-style-type: none"> <li>• 2H:1V soil slope, up to 24m high,</li> <li>• Soil rock interface inclined at 10-20 degrees, sloping into the cut,</li> <li>• Up to 14m high rock slope with 4m wide bench at soil rock interface</li> </ul> <p><b>West (RHS):</b></p> <ul style="list-style-type: none"> <li>• 2H:1V soil slope, up to 12m high,</li> <li>• Soil rock interface inclined at 10-20 degrees dipping into the slope,</li> <li>• Up to 6m high rock slope with 4m wide bench at soil rock interface</li> </ul>
Existing Landslide	Yes (No 13) Slip Ch58,700 – Ch58,800 East
Cause of Landslide	<ul style="list-style-type: none"> <li>• Unfavourably orientated bedding fabric dipping out of the slope at approximately 6°/276°.</li> <li>• Two sets of moderately to steeply inclined joints</li> <li>• Evidence of historic shallow landslide activity within the cut.</li> <li>• Softened shear planes orientated parallel to bedding fabric.</li> <li>• The presence of a perched groundwater table about the soil/rock interface</li> </ul>
Date Landslide occurred	2/06/2020
Cut within area of historic landslide	Low risk at north-eastern side. Moderate risk at western side but sloping in western direction.
Geotechnical Investigations	BH208, BH3514, BH3515, BH3516, BH4006
Site Geology	<p>Ch58,810 (CS5), Drawing P2Wk-DRG-GG-02-1019</p> <p>1. Geology - Pakiri Formation (Encountered/inferred stratigraphic thicknesses in order)</p> <ul style="list-style-type: none"> <li>• 4.5-6.5m Stiff - Residual to completely weathered SILT/Sandstone</li> <li>• Highly weathered sandstone</li> </ul>



- Moderately weathered sandstone/siltstone with interbedded, very weak to weak slightly weathered layers
- Moderately weathered sandstone/ sandstone conglomerate

Slightly weathered rock comprises:

- Slightly weathered interbedded layers of very weak, moderately thick sandstone, very weak
- Slightly to unweathered sandstone/siltstone, weak
- Slightly weathered thinly bedded sandstone/siltstone
- Thick Sandstone, weak to very weak

**2. Structural Features & Defects**

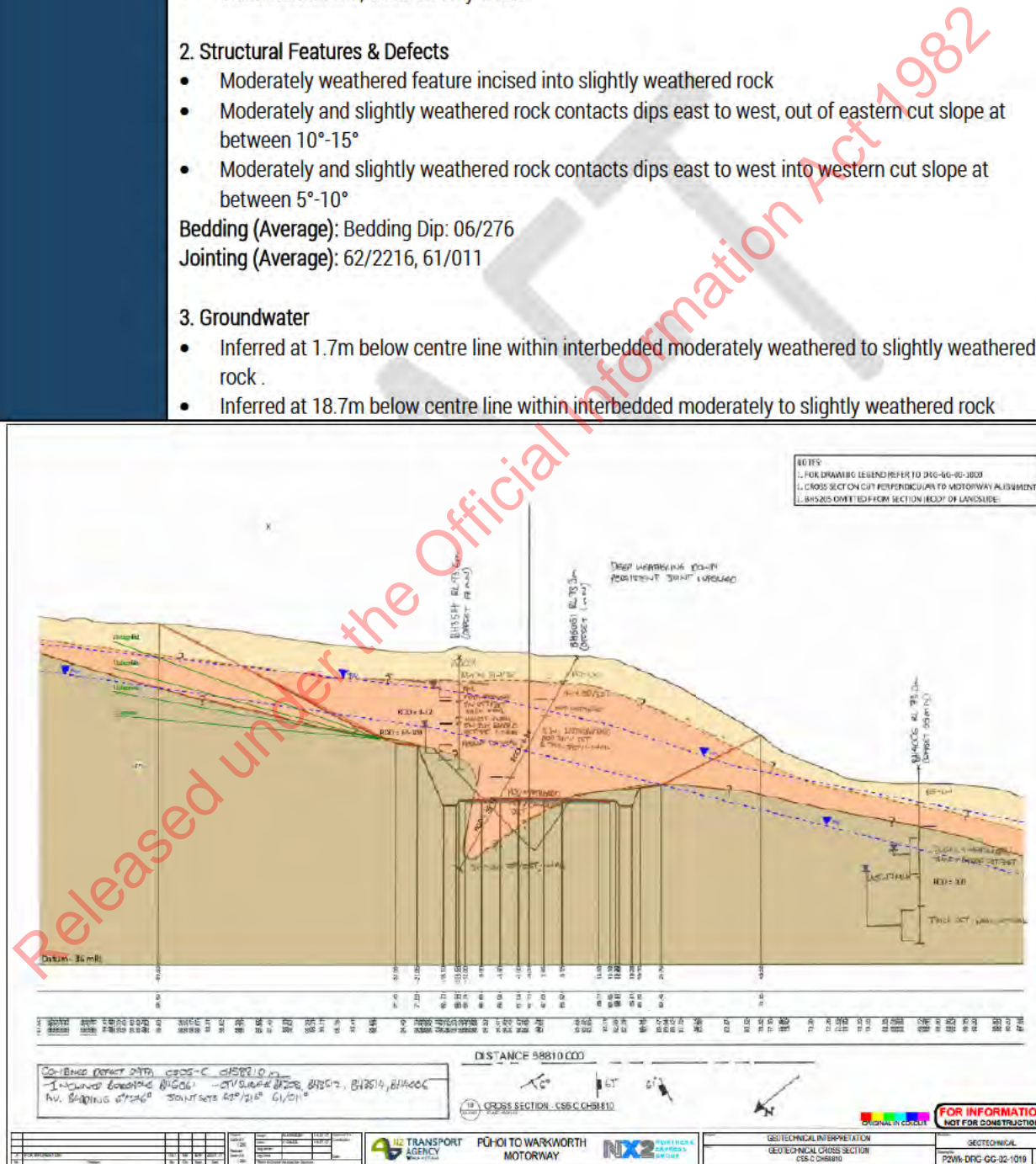
- Moderately weathered feature incised into slightly weathered rock
- Moderately and slightly weathered rock contacts dips east to west, out of eastern cut slope at between 10°-15°
- Moderately and slightly weathered rock contacts dips east to west into western cut slope at between 5°-10°

Bedding (Average): Bedding Dip: 06/276

Jointing (Average): 62/2216, 61/011

**3. Groundwater**

- Inferred at 1.7m below centre line within interbedded moderately weathered to slightly weathered rock .
- Inferred at 18.7m below centre line within interbedded moderately to slightly weathered rock



Soil Rock	East (LHS): Generally dipping out of the slope at up to 10~20° steep in western direction.
Transition Zone	West (RHS): Generally flat or dipping into the cut slope towards the western direction.
Rock Cut	Steep rock cut slope at eastern and western side



Remedial Works Design	DEI 0401 (Ch58715 – 58830, East Rock cut stabilisation), DEI 0414 (Ch58750 – 58800, Eastern Batter Soil Cut Stabilisation), DEI 0507 (Ch58715 – 58750, North East Rock Cut Stabilisation)
Remedial Works Details	<ul style="list-style-type: none"> <li>• 6 nos. counterfort drains at 10m centres,</li> <li>• 2m wide rock bench</li> <li>• Removal of debris and slope regraded to 4H:1V (initial landslide. The upper slope has further be regraded after the July 2022 landslide)</li> </ul>
Peer Reviewed in PSM Report Rev4	Refer to PSM Report PSM4203-029R Draft Rev 4 – Appendix J. It is noted that this report covered only the initial landslide.
Groundwater Seepage Monitoring	Seepage monitoring on site undertaken on the 9/06/2021. An engineering geological site inspection was undertaken on the 12/11/2021. Observations are as follows: <ul style="list-style-type: none"> <li>• Wet and softened ground at buttress-rock transition with wash out of rock and fill debris on to bench</li> <li>• Seepage observed at toe of counterfort drains</li> <li>• Moderately weathered extremely weak rock bench softened and eroded by seepage and surface water run off</li> <li>• Loose debris on bench and above rock slope.</li> </ul>
Risk of Future Slope Failure	<p><b>East (LHS):</b> The risk of future slope failure is considered <b>low to moderate</b>, increased from previous assessment despite additional remedial works.</p> <ul style="list-style-type: none"> <li>• Remedial works completed (buttress fill with subsoil drains). However, there is an increased risk if the design relies on maintenance of subsoil drains.</li> <li>• Soil removed above rock transition zone. Where topsoil is present, there could be a risk of topsoil and surface erosion</li> <li>• Potential rockfall risks from the upper 2H:1V exposed rock slopes have been reviewed as part of the CJV assessments. Refer to Section 4.2.</li> </ul> <p><b>West (RHS):</b> The risk of future slope failure is considered <b>very low</b>, reduced from the previous assessment.</p> <ul style="list-style-type: none"> <li>• Cut slope less than 10m high,</li> <li>• Topography sloping in western direction and soil rock transition zone is dipping into cut slope,</li> <li>• No/insignificant groundwater recharge/ seepage,</li> </ul>

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October 2020, Time 4:01 – View in southern direction: East = left-hand side; West = right-hand side



February 2021, Time 3:31 – View in southern direction: East = left-hand side; West = right-hand side





June 2021, Time 3:39 – View in southern direction: East = left-hand side; West = right-hand side



September 2021, Time 3:59 – View in southern direction: East = left-hand side; West = right-hand side





February 2022, Time 3:59 – View in southern direction, Ch58,700: East = left-hand side; West = right-hand side

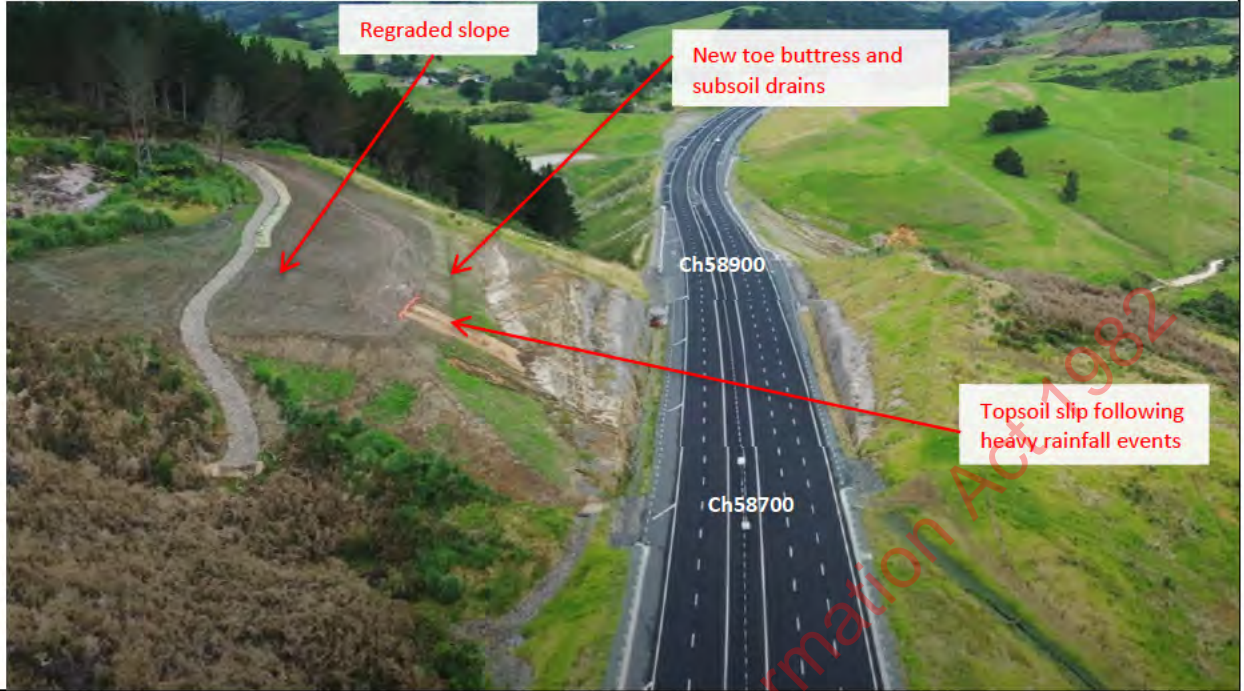


August 2022, Time 4:00 – View in southern direction, Ch58,700: East = left-hand side; West = right-hand side





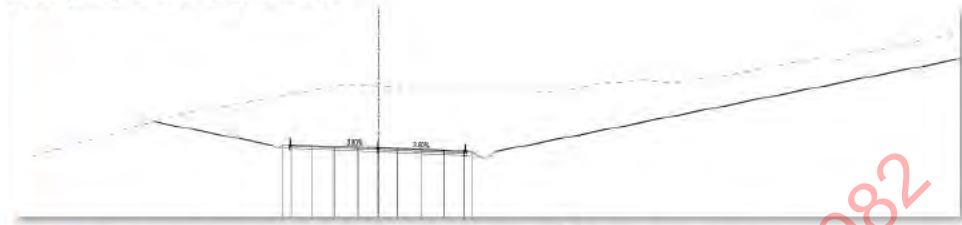
January 2023, Time 4:01 – View in southern direction, Ch58,700: East = left-hand side; West = right-hand side



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7.34 CS7

Chainage	Ch59,200 – Ch 59,430
Typical Design Slope Geometry	<p>East (LHS): 5H:1V up to 31m high, West (RHS): 5H:1V up to 4m high</p> 
Site & Design Description	Topography generally sloping gently from SW to NE in Northland Allochthon.
Existing Landslide	None reported to s 9(2)(b)(ii) and 9(2)(ba)(i)
Cause of Landslide	Not applicable
Date Landslide occurred	Not applicable
Cut within area of historic landslide	Active slope creep in Northland Allochthon soils is mapped.
Geotechnical Investigations	BH109, BH348, BH4004, BH4040, BH4041
Site Geology	No geological section provided in the report. Northland Allochthon based on Regional Geological Map P2Wk-DRG-GG-00-0204. Potential of elevated artesian groundwater may be encountered in the Northland Allochthon.
Soil Rock Transition Zone	Unknown
Rock Cut	Not expected and observed during construction.
Remedial Works Design	None required.
Remedial Works Details	Not applicable
Peer Reviewed in PSM Report Rev 4	Not reviewed
Groundwater Seepage Monitoring	<p>Seepage monitoring undertaken on the 09/06/2021. The groundwater seepage observations are as follows:</p> <ul style="list-style-type: none"> <li>• Seepages recorded coming from soil cut slope</li> <li>• Seepages recorded at counterfort subsoil drain outlets, ranging from a minor trickle to a steady flow</li> </ul>
Risk of Future Slope Failure	<p><b>East (LHS):</b> The risk of future slope failure is considered <b>very low</b> due to the 5H:1V slope batter and very low slope height.</p> <p><b>West (RHS):</b> The risk of future slope failure is considered <b>very low</b> due to the 5H:1V slope batter. A mid-slope swale is provided to limit surface erosion.</p> <p>However, groundwater seepage has been observed at the lower batter. The Northland Allochthon could be further softened by the seepage flow. There is a risk of mudflow downslope from the softened Northland Allochthon cut.</p> <p><u>It is recommended that groundwater seepage needs to be observed and reviewed during the operation of the project.</u></p>



April 2020, Time 4:18 – View in southern direction: East = left-hand side; West = right-hand side



June 2020, Time 4:15 – View in southern direction: East = left-hand side; West = right-hand side





February 2021, Time 3:35 – View in southern direction: East = left-hand side; West = right-hand side



September 2021, Time 4:05 – View in southern direction: East = left-hand side; West = right-hand side





August 2022, Time 4:08 – View in southern direction: East = left-hand side; West = right-hand side

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7.35 CS8B

Chainage	Ch59,670 – Ch 59,730
Typical Design Slope Geometry	East (LHS): 5H:1V up to 4m high, West (RHS): 5H:1V or flatter towards Hikauae Farm Underpass.
Site & Design Description	Topography generally sloping gently from SW to NE in Northland Allochthon. The cut is formed through a broad ridge line.
Existing Landslide	None reported to <sup>s 9(2)(b)(ii) and 9(2)(ba)</sup> (i)
Cause of Landslide	Not applicable
Date Landslide occurred	Not applicable
Cut within area of historic landslide	Translation slides and moderate risk of landslides hazard is identified on Landslide Hazard Map P2Wk-DRG-GG-00-0310.
Geotechnical Investigations	BH107, BH207, TP6034
Site Geology	No geological section provided in the report. Northland Allochthon based on Regional Geological Map P2Wk-DRG-GG-00-0204. Potential of elevated artesian groundwater may be encountered in the Northland Allochthon.
Soil Rock Transition Zone	Unknown
Rock Cut	Not expected and observed during construction.
Remedial Works Design	None required.
Remedial Works Details	Not applicable
Peer Reviewed in PSM Report Rev 4	Not reviewed
Groundwater Seepage Monitoring	No groundwater seepage monitoring carried out.
Risk of Future Slope Failure	<p>East (LHS): The risk of future slope failure is considered <b>very low</b> due to the 5H:1V slope batter and very low slope height.</p> <p>West (RHS): The risk of future slope failure is considered <b>very low</b>. Ridge line removed and cut down towards the Hikauae Farm Underpass Track.</p> <p>The risk rating is unchanged compared to the previous assessment.</p>



September 2021, Time 4:17 – View in southern direction: East = left-hand side; West = right-hand side



August 2022, Time 4:14 – View in southern direction: East = left-hand side; West = right-hand side





### 7.36 CS8C

Chainage	Ch59,870 – Ch 59,900
Typical Design Slope Geometry	East (LHS): At grade and fill embankments CS8C West (RHS): 2H:1V up to 17m high,
Site & Design Description	Sidling cut slope at end of spur of East-West orientated ridge line.
Existing Landslide	None reported to s 9(2)(b)(ii) and 9(2)(ba)(i)
Cause of Landslide	Not applicable
Date Landslide occurred	Not applicable
Cut within area of historic landslide	No landslide hazard has been identified on Landslide Hazard Map P2Wk-DRG-GG-00-0310.
Geotechnical Investigations	BH4044, BH5210, TP332
Site Geology	No geological section provided in the report. Pakiri Formation based on Regional Geological Map P2Wk-DRG-GG-00-0204. Based on the TP332 (TP_64862 NZ Geotechnical Database) and the drone flyover (December 2018, time 4:34) it appears that the excavation is done in residually weathered Pakiri Formation. Rock outcrops appear not to be present.
	
Soil Rock Transition Zone	Unknown. Likely below cut level.
Rock Cut	No rock cut expected and observed during construction.
Remedial Works Design	None required.
Remedial Works Details	Not applicable
Peer Reviewed in PSM Report Rev 4	Not reviewed
Groundwater Seepage Monitoring	Seepage monitoring and inspections undertaken on 9/06/2021 & 30/06/2021 with rainfall recorded in the 48 hours prior to inspection on the 30/06/2021: <ul style="list-style-type: none"> <li>• Slope at time of inspection monitoring grassed/vegetated</li> <li>• Dry to relatively minor seepage recorded</li> <li>• No surface erosion noted</li> <li>• No softened ground</li> </ul>



Risk of Future Slope Failure

East (LHS):

The risk of future slope failure is considered **very low**. Fill embankment or at grade.

West (RHS):

The risk of future slope failure is considered **very low**.

- Mainly sidling cut at end of ridge line. Cutting almost completed in December 2018 (flyover time 4:34). No instabilities have been reported to s 9(2)(b)(ii) and 9(2)(ba)(i)

The risk rating at the western side has been reduced compared to the previous assessment.

March 2019, Time 4:50 – View in southern direction: East = left-hand side; West = right-hand side



April 2020, Time 4:31 – View in southern direction: East = left-hand side; West = right-hand side





July 2021, Time 3:58 – View in southern direction: East = left-hand side; West = right-hand side



August 2022, Time 4:20 – View in southern direction: East = left-hand side; West = right-hand side





February 2023, Time 4:37 – View in southern direction: East = left-hand side; West = right-hand side



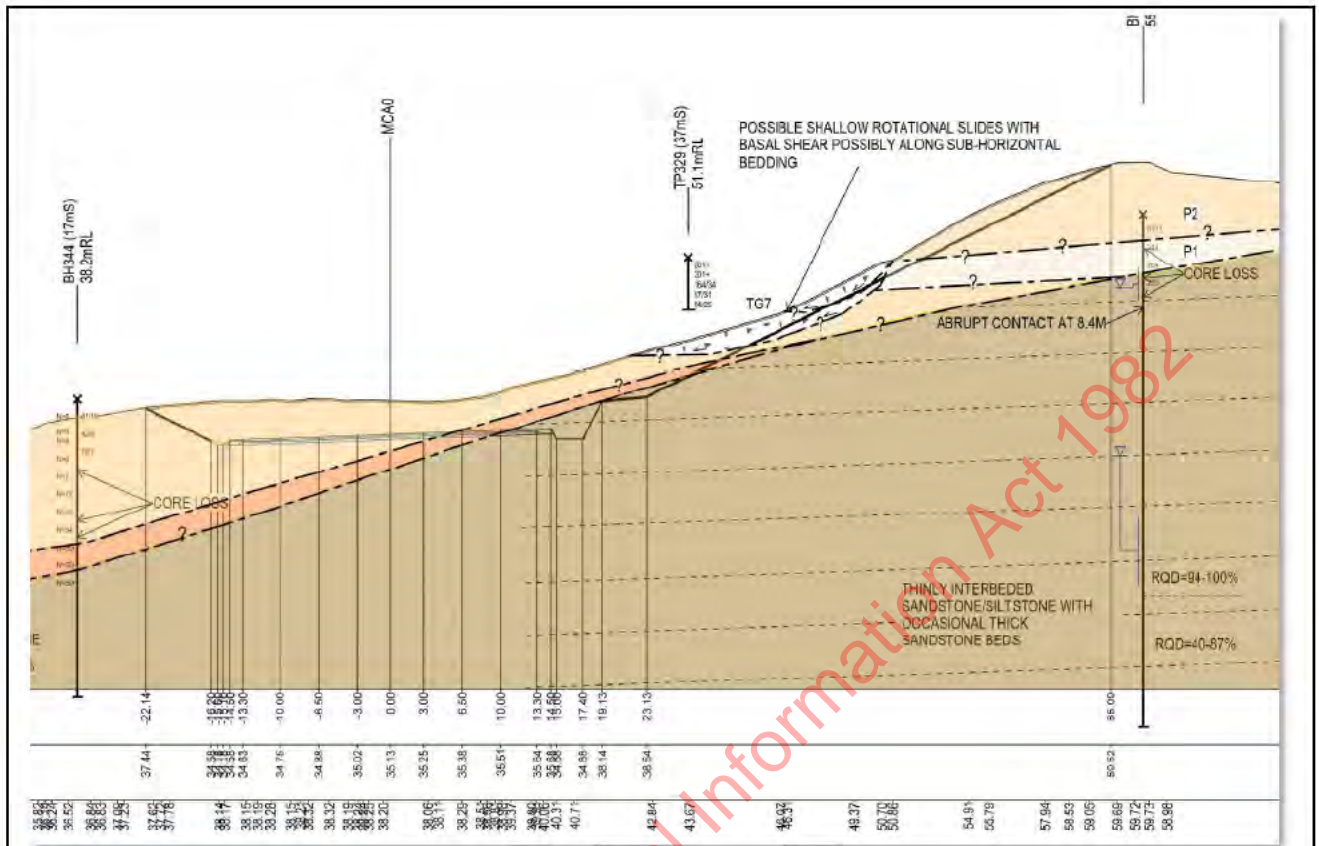
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### 7.37 CS8D – Landslide 14

Chainage	Ch59,950 – Ch60,180
Typical Design Slope Geometry	<p>East (LHS): 2H:1V up to 6m high, 64° (1H:2V) steep up to 42m high rock cut slope at lower part of slope.</p> <p>West (RHS): 2H:1V up to 42m high, 64° (1H:2V) steep up to 6m high rock cut slope.</p>
Site & Design Description	<p>Site topography is generally sloping from West to East. The existing SH1 alignment runs along the eastern downslope side of the cut.</p> <p>One large cut is located on the western side and two smaller cuts at the eastern side which are separated by a natural gully (filled by Fill CS8E).</p> <p>It appears that the slope at the south-eastern cut has been removed/excavated to provide access from SH1.</p>
Existing Landslide	Yes (No 14) Slip Ch60,080 – Ch60,150 West
Cause of Landslide	<ul style="list-style-type: none"> <li>• Sub horizontal bedding fabric dipping obliquely out of the slope.</li> <li>• No records of joint orientations were noted.</li> <li>• Multiple softened shear planes orientated parallel to bedding fabric.</li> <li>• Identification of colluvial material within the slope following excavation and test pit investigations.</li> </ul>
Date Landslide occurred	23/02/2020
Cut within area of historic landslide	Low risk at eastern side, dipping away from cut slope
Geotechnical Investigations	BH344, BH345, BH4045, BH6062
Site Geology	<p>60,100 (CS8-C), Drawing P2Wk-DRG-GG-03-1005</p> <p>1. Geology - Pakiri Formation (Encountered/inferred stratigraphic thicknesses in order)</p> <ul style="list-style-type: none"> <li>• 2.5m-3.5m - Colluvium/landslide debris</li> <li>• 3m – Soft to firm - Residually weathered soil</li> <li>• 5-13m – Stiff - Residual to completely weathered soil</li> <li>• ≤11m - Stiff - Residual to completely weathered soil on north-eastern side, beneath rod cut (SPT N = 0-34)</li> <li>• 1.5-3m - Highly to moderately weathered rock below road cut (SPT N=50+)</li> <li>• Slightly to unweathered rock encountered to 11m depth below existing ground level (downslope side of road cut) (SPT N=50+)</li> </ul> <p>Slightly to unweathered rock comprises thinly interbedded sandstone and siltstone with occasional thick sandstone beds</p> <p>2. Structural Features &amp; Defects</p> <ul style="list-style-type: none"> <li>• Residually weathered and slightly to unweathered rock contact dips out of cut slope at 12.5° ~ 6m above swale/road level</li> <li>• Soil and slightly weathered contact dips at 12.5° out of cut slope</li> <li>• Sub-horizontal bedding dips out of cut slope at 2.5°</li> </ul> <p>3. Groundwater</p> <ul style="list-style-type: none"> <li>• Measured at 11.5m and at 35m within slightly to unweathered rock</li> </ul> <p>4. Geomorphological Features</p> <ul style="list-style-type: none"> <li>• Rotational slide feature at location western cut road cut.</li> </ul>

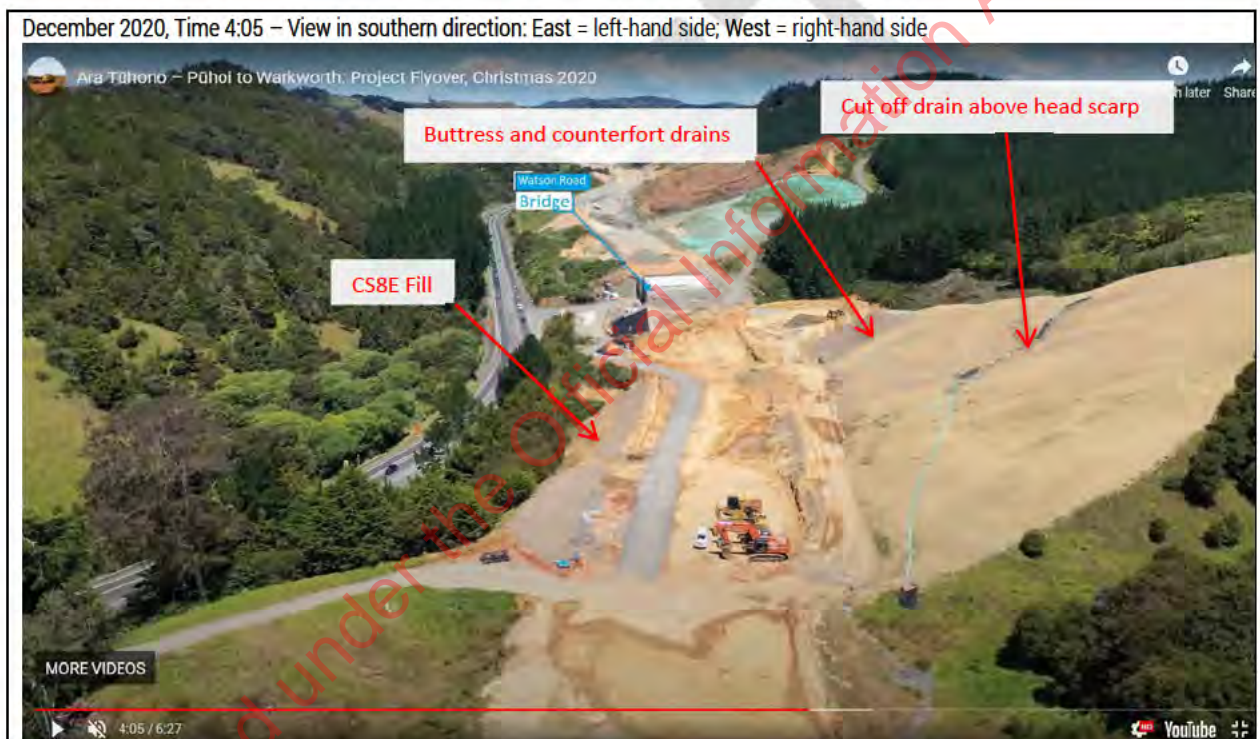




Soil Rock Transition Zone	<p><b>East (LHS):</b> Generally dipping out of the slope at up to 15~20°.</p> <p><b>West (RHS):</b> Soil rock transition zone below excavation level and dipping into the slope below the cut level in eastern direction.</p>
Rock Cut	Geological section indicates steep rock cut at lower part of western slope, which was not encountered during construction (refer photos).
Remedial Works Design	DEI 411
Remedial Works Details	<p>Based on PSM Report PSM4203-029R Appendix K Table 7:</p> <ul style="list-style-type: none"> <li>Reshape slope to 3H:1V</li> <li>Counterfort drains: <ul style="list-style-type: none"> <li>to extend to below sheared surface or a depth of 4 m, 8m centre-to-centre spacing.</li> <li>to extend 12m from the back face of the toe buttress.</li> </ul> </li> <li>Surface water cut-off drain to be installed upslope of the head scarp.</li> </ul> <p><u>Shear Key/Buttress at south eastern part only:</u></p> <ul style="list-style-type: none"> <li>Minimum 6 m wide toe buttress base.</li> <li>Base of toe buttress to be extended minimum 0.5m into UW Pakiri Formation Rock.</li> <li>Buttress to be extended minimum 4m in vertical height above the sheared surface.</li> <li>Base of the toe buttress to comprise of compacted Class 1 Rockfill and Structural 120 Fill above the Class 1 Rockfill.</li> <li>Cut slope behind the toe buttress to be re-graded to maximum 3H:1V.</li> </ul>
Peer Reviewed in PSM Report Rev 4	Refer to PSM Report PSM4203-029R Draft Rev 4 – Appendix K
Groundwater Seepage Monitoring	<p>Seepage monitoring and inspections undertaken 2/06/2021 &amp; 30/06/2021</p> <ul style="list-style-type: none"> <li>Slope topsoiled/grassed at time of inspections</li> <li>Minor seepage at ground/cut slope surface with minor softened ground</li> </ul>



	<ul style="list-style-type: none"> <li>Obscured drainage outlets</li> <li>Subsoil drains typically dry but with evidence of previous seepage via sediment at location of drain outlets</li> </ul>
Risk of Future Slope Failure	<p><b>East (LHS):</b> The risk of future slope failure is considered <b>very low, reduced from previous assessment</b>.</p> <ul style="list-style-type: none"> <li>Cut depth less than 6m and topography is sloping down beyond the cut towards existing SH1.</li> </ul> <p><b>West (RHS):</b> The risk of future slope failure is considered <b>low, as per previous assessment</b>.</p> <ul style="list-style-type: none"> <li>Substantial remedial works design completed.</li> <li>It is noted that the remedial works were not constructed in accordance with DEI 411 as per non-conformance report NCR 1156. However, an independent DJV assessments (DC547) concludes that the as-built can remain in place.</li> </ul>





February 2021, Time 3:51 – View in southern direction: East = left-hand side; West = right-hand side



CS8D – View from in southern direction s 9(2)(b)(ii) and 9(2) sit 24 February 2021



CS8D – View from CS9A in north-western direction, s 9(2)(b)(ii) and 9(2)(ba)(i) 4 February 2021





June 2021, Time 3:59 – View in southern direction: East = left-hand side; West = right-hand side



September 2021, Time 4:23 – View in southern direction: East = left-hand side; West = right-hand side





August 2022, Time 4:23 – View in southern direction: East = left-hand side; West = right-hand side



January 2023, Time 4:52 – View in southern direction: East = left-hand side; West = right-hand side





### 7.38 CS9A – Landslide 15

Chainage	Ch60,310 – Ch60,470
Typical Design Slope Geometry	East (LHS): 2H:1V up to 6m high West (RHS): 5~8m high rock cut at lower slope, upper 2H:1V soil slope, more than 20m high
Site & Design Description	Site topography is generally sloping from West to East. The existing SH1 alignment runs along the eastern downslope side of the cut.
Existing Landslide	Yes (No 15) CS9A – West Slip Ch60,330 – Ch60,440 West
Cause of Landslide	<ul style="list-style-type: none"> <li>Multiple softened shear planes with clay infill as orientated parallel to bedding fabric about the</li> <li>HW/MW interface.</li> <li>In photographs (but not reported in text), underlying "complex" (folded / faulted / unconformable) Pakiri Formation which raises issues about the stability of non-failed portions of the cut that do not appear to have been addressed.</li> </ul>
Date Landslide occurred	DEI calculations state first slip occurred in early Jan 2020 and second slip in May 2020
Cut within area of historic landslide	Low risk at eastern side, sloping away from the eastern cut slope towards existing SH1. No landslide risk indicated on western slope where landslide occurred.
Geotechnical Investigations	BH3511
Site Geology	Pakiri Formation rock overlain by residually weathered Pakiri Formation soils.
Soil Rock Transition Zone	Soil rock interface is dipping at 5 to 15° unfavourable out of the slope face.
Rock Cut	Steep 1H:2V rock cut in the centre of the cut slope, approximately 5m high
Remedial Works Design	DEI 461, DEI 489 (Ch60310 – 60440, Soil Cut Stabilisation)
Remedial Works Details	<ul style="list-style-type: none"> <li>Remove all landslide debris and excavate to slightly weathered Pakiri Formation rock,</li> <li>Counterfort drains at Ch60,460-60,490,</li> <li>Reshaped slope to 4H:1V</li> </ul>
Peer Reviewed in PSM Report Rev 4	Refer to PSM Report PSM4203-029R Draft Rev 4 – Appendix L
Groundwater Seepage Monitoring	<p>Seepage monitoring undertaken on the 30/06/2021, 4/08/2021 and an engineering geological site inspection on the 2/06/2021 and 12/11/2021. Monitoring on 30/06/2021 and 4/08/2021 undertaken within 48 hours of rainfall. Seepage monitoring and engineering geological observations are as follows:</p> <ul style="list-style-type: none"> <li>Cut slope topsoiled from beginning of seepage monitoring</li> <li>Seepage flows recorded from cut slope with water running down slope</li> <li>Seepage encountered at soil-rock interface on all occasions</li> <li>Seepage encountered from rock surface along fold and bedding structures</li> <li>Subsoil drains typically dry, however exhibit signs of working with presence of water via iron oxide build up at outlets</li> <li>Highly oxidised completely weathered rock to residual soil at bench. Evidence of water percolating through transition between soil and rock contact.</li> <li>Minor washout/slumping of soil and erosion protection matting at rock lined swale</li> </ul>
Risk of Future Slope Failure	<p>East (LHS):</p> <p>The risk of future slope failure is considered <b>very low</b>, reduced from the previous assessment.</p> <ul style="list-style-type: none"> <li>All slipped soil removed.</li> <li>Soil removed above rock transition zone.</li> <li>Counterfort drains at southern part (Ch60,460-60,490)</li> </ul>

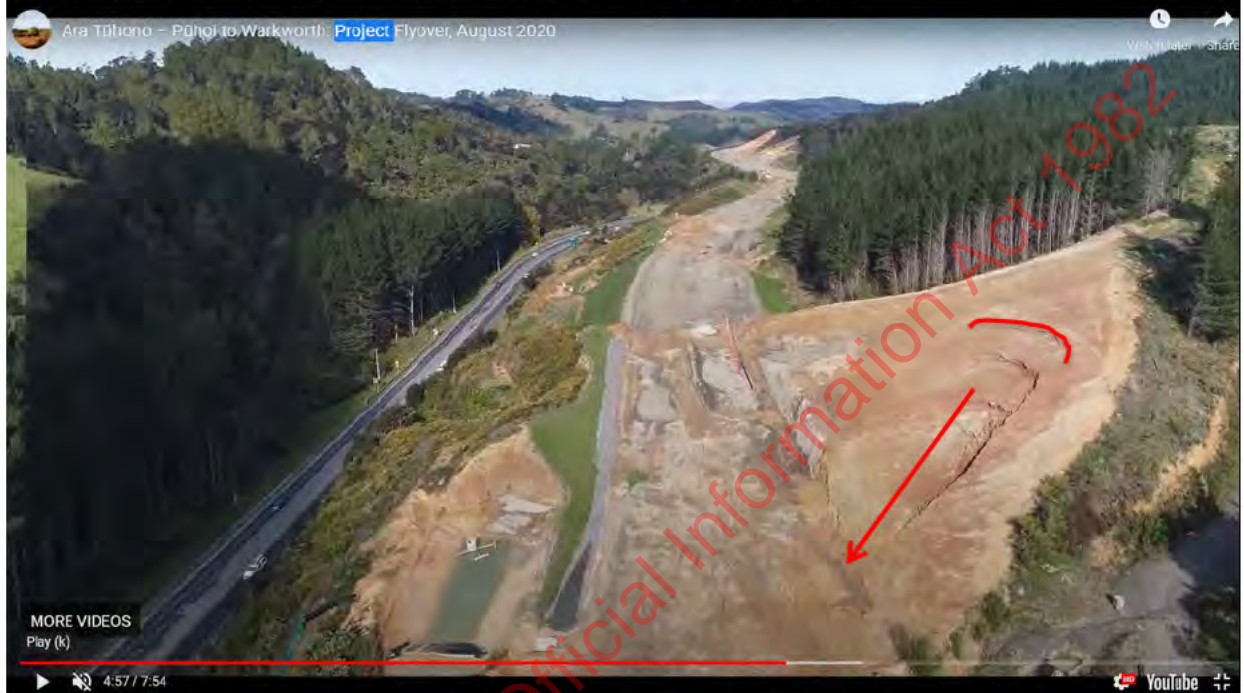


**West (RHS):**

The risk of future slope failure is considered **low**, consistent with the previous assessment.

- Cut slope less than 10m high,
- Topography and soil rock transition zone are dipping away from cut slope,
- No/insignificant groundwater recharge/ seepage,

August 2020, Time 4:57 – View in southern direction: East = left-hand side; West = right-hand side



October 2020, Time 4:34 – View in southern direction: East = left-hand side; West = right-hand side





February 2021, 3:57 – View in southern direction: East = left-hand side; West = right-hand side



June 2021, Time 4:06 – View in southern direction: East = left-hand side; West = right-hand side





September 2021, Time 4:30 – View in southern direction: East = left-hand side; West = right-hand side



February 2022, Time 4:30 – View in southern direction: East = left-hand side; West = right-hand side





August 2022, Time 4:30 – View in southern direction: East = left-hand side; West = right-hand side



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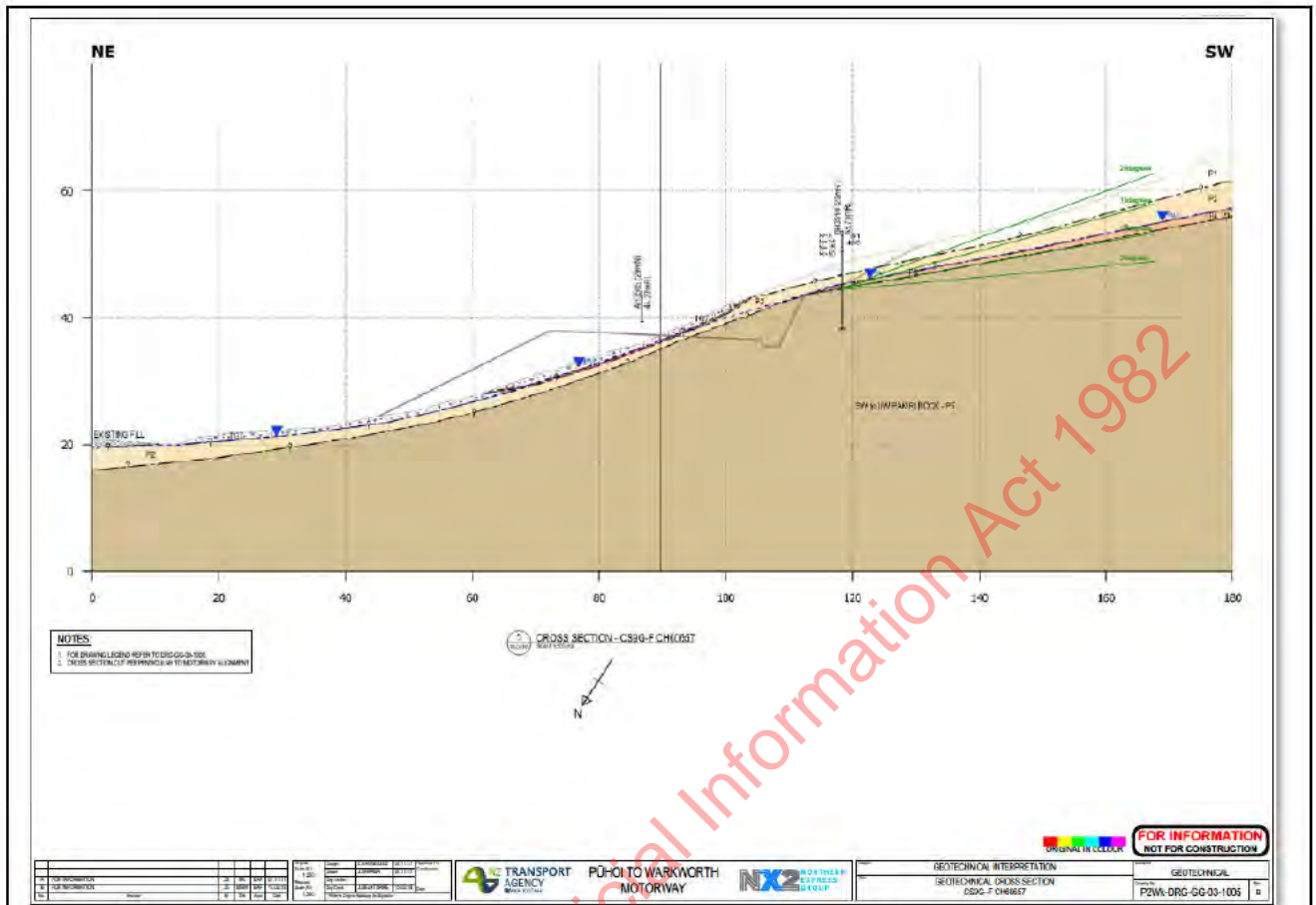


7.39 CS9G

Chainage	Ch60,570 – Ch60,700
Typical Design Slope Geometry	East (LHS): 2H:1V slope up to 3m high, at grade and CS9G fill embankment up 14m high. West (RHS): 2H:1V slope up to 20~22m high, 64° (1H:2V) rock cut, up to 8m high
Site & Design Description	Cut slope at end of spur of East-West orientated ridge line.
Existing Landslide	None reported to s 9(2)(b)(ii) and 9(2)(ba)(i)
Cause of Landslide	Not applicable
Date Landslide occurred	Not applicable
Cut within area of historic landslide	Two low risk landslide hazards have been identified on Landslide Hazard Map P2Wk-DRG-GG-00-0310.
Geotechnical Investigations	BH3510
Site Geology	<p>60,657 (CS9G-F), Drawing P2Wk-DRG-GG-03-1005</p> <p><b>1. Geology-Pakiri Formation</b> (Encountered &amp; inferred thicknesses in stratigraphic order)</p> <ul style="list-style-type: none"> <li>• 0.5m - Colluvium/landslide debris</li> <li>• 2-4m - Firm - Residually weathered soil</li> <li>• 2.5-4.5m – Stiff - Residually weathered soil</li> <li>• 0.5-1.5m Highly to moderately weathered rock</li> <li>• Slightly weathered to unweathered rock encountered between 4-6.5m below existing ground level</li> </ul> <p><b>2. Structural Features &amp; Defects</b> Residual soil and highly to moderately weathered rock contact directly with underlying slightly to unweathered rock. Contact dips out cut slope at level rock cut bench at approx. 10°</p> <p><b>3. Groundwater</b></p> <ul style="list-style-type: none"> <li>• Encountered at soil (Residual/completely weathered) and highly to moderately weathered rock contact</li> <li>• Daylights at level of rock bench</li> </ul> <p><b>4. Geomorphological Features</b> Veneer of colluvial soils/landslide debris across cut section.</p>

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Soil Rock Transition Zone	Dipping in eastern direction at 10° unfavourable out of slope
Rock Cut	64° (1H:2V) up to 8m high at the western side
Remedial Works Design	None required
Remedial Works Details	Not applicable
Peer Reviewed in PSM Report Rev 4	Not reviewed
Groundwater Seepage Monitoring	<p>Seepage monitoring undertaken on the 30/06/2021 and 4/08/2021. Engineering geological site inspection were undertaken on the 2/06/2021 and 12/11/2021. Monitoring on the 30/06/2021 and 4/08/2021 was undertaken within 48 hours of rainfall. Observations are as follows:</p> <ul style="list-style-type: none"> <li>• 4x counterfort drains have been installed at Ch60600-east within the transition cut slope.</li> <li>• Seepages observed from counterfort drain trenches and subsoil drain outlets with water running down slope face and over bench.</li> <li>• <b>Multiple slips have occurred behind and above cut slope.</b></li> <li>• Seepages recorded at soil-rock transition</li> <li>• Seepages recorded from rock bedding structure</li> <li>• Seepages recorded from soil cut surface</li> <li>• Soil surface conditions soft and slippery with moss build-up</li> <li>• Transition cut slope Ch60,700-west appears over steepened of 2H:1V</li> </ul>
Risk of Future Slope Failure	<p><b>East (LHS):</b> The risk of future slope failure is considered <b>very low, reduced compared to the previous assessment.</b></p> <p><b>West (RHS):</b> The risk of future slope failure is considered <b>low to moderate (as per previous assessment),</b> Seepage and possible softened ground observed at north-western transition into the slope.</p>



October 2020, Time 4:39 – View in southern direction: East = left-hand side; West = right-hand side



February 2021, Time 4:01 – View in southern direction: East = left-hand side; West = right-hand side





June 2021, Time 4:09 – View in southern direction: East = left-hand side; West = right-hand side



September 2021, Time 4:35 – View in southern direction: East = left-hand side; West = right-hand side





February 2022, Time 4:35 – View in southern direction, Ch60600: East = left-hand side; West = right-hand side



August 2022, Time 4:34 – View in southern direction, Ch60600: East = left-hand side; West = right-hand side





January 2023, Time 5:00 – View in southern direction, Ch60600: East = left-hand side; West = right-hand side



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## 7.40 CS13

Chainage	Ch60,850 – Ch61,110
Typical Design Slope Geometry	<p>East (LHS): 2H:1V slope up to 8m high, and CS13 fill embankment between northern and southern cut sections</p> <p>West (RHS): 2H:1V slope, more than 30m high. Two separate 64° (1H:2V) rock cut, up to 8~10m high.</p>
Site & Design Description	Cut CS13 is located on the western side of the existing SH1 alignment, which is approximately 15m lower than the new SH1 alignment. Existing cuts are present adjacent to old SH1. The slopes are dipping into the eastern direction. An existing erosion gully is in the centre of the cut slope.
Existing Landslide	A new (initial) landslide/ slip has occurred above the mid-slope swale drain in July 2022, and a second slip occurred below the reinstated swale drain in January 2023. Both slips occurred following rainfall events.
Cause of Landslide	Over steepened slope within erosion gully.
Date Landslide occurred	July 2022 and January 2023
Cut within area of historic landslide	Two low risk landslide hazard areas have been identified at the western side of the cut on Landslide Hazard Map P2Wk-DRG-GG-00-0310. The landslide hazard area is located within the existing erosion gully.
Geotechnical Investigations	BH6064, BH4048, BH339, BH340, BH341
Site Geology	<p>CS13-C CH60,900, Drawing P2Wk-DRG-GG-03-1007</p> <p>1. Geology-Pakiri Formation (Encountered &amp; inferred thicknesses in stratigraphic order)</p> <ul style="list-style-type: none"> <li>• 1.5-2.5m Firm - Residually weathered soil SPT N=0-7</li> <li>• 6-9m Stiff to hard - Residual to completely weathered soil and rock, SPT N=6-12</li> <li>• Up to 3.5m Highly to moderately weathered rock, SPT N= 50 - 50+</li> <li>• Slightly to unweathered rock encountered between 8-10.5m below existing ground level, SPT N=50+, UCS testing range from 11-19MPa</li> <li>• Slightly to unweathered rock comprises moderately thick to thick, weak sandstone with interbedded thin weak siltstone</li> </ul> <p>2. Structural Features &amp; Defects</p> <p>Residually weathered soil and slightly weathered rock contacts dips horizontal at western cut and at 2.5° into eastern cut</p> <p>Bedding: 04/264</p> <p>3. Groundwater</p> <p>Groundwater encountered at moderately weathered and slightly to unweathered contact approximately 10m below existing ground level at centre line</p> <p>CS13-C CH61,030 Drawing P2Wk-DRG-GG-03-1008</p> <p>1. Geology-Pakiri Formation (Encountered &amp; inferred thicknesses in stratigraphic order)</p> <ul style="list-style-type: none"> <li>• Up to 4m Firm - Residually weathered (SPT N=2-3)</li> <li>• 5m-9m Stiff - Residual to completely weathered soil and rock (SPT N=2 - 4)</li> <li>• 1m-1.5m Very stiff to hard - Highly weathered soil &amp; rock (SPT N 50 – 50+)</li> <li>• Slightly weathered to unweathered rock encountered below 10.5m-12m (SPT N &gt;50+)</li> </ul> <ul style="list-style-type: none"> <li>• Slightly weathered to unweathered rock comprises massive to thickly bedded, moderately strong, sandstone with thin weak, siltstone interbeds &amp; thinly interbedded, weak, sandstone and siltstone</li> <li>• Slightly weathered to unweathered UCS 14MPa</li> </ul>



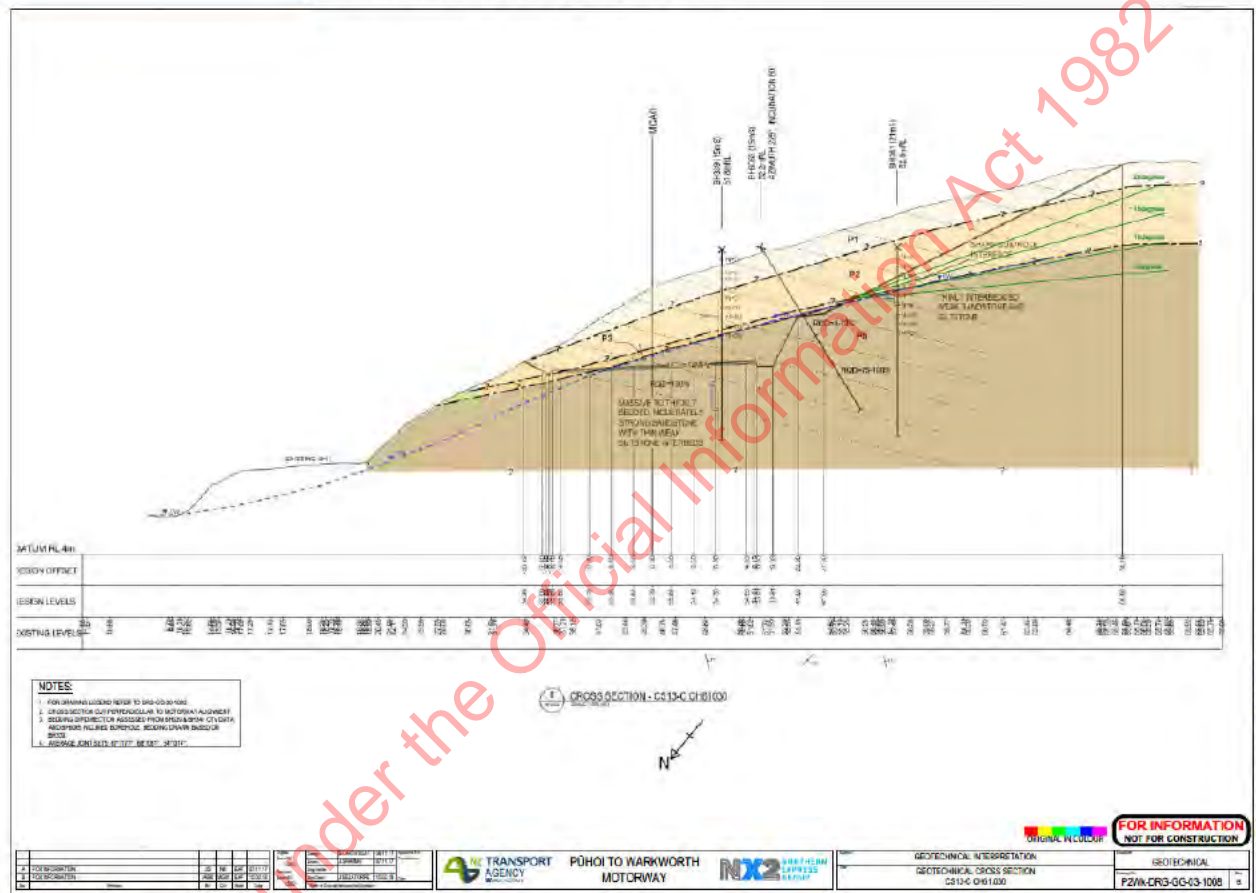
## 2. Structural Features & Defects

- Sharp soil-rock contact at western cut side.
- Soil-rock contact dips out of western cut slope at approx. 10°
- Apparent dip of bedding perpendicular to cut slope at approx. 13° into cut slope

Joint Sets: 67/177, 68/081, 54/014

## 3. Groundwater

Groundwater recorded at soil-rock contact.



Soil Rock Transition Zone	Dipping in eastern direction at 10° unfavourable out of the slope
Rock Cut	64° (1H:2V) up to 10m high at the western side
Remedial Works Design	Remedial works are to be determined.
Remedial Works Details	Not available at time of writing this report Rev E.
Peer Reviewed in PSM Report Rev 4	Not applicable. The new slip occurred after this report was prepared.
Groundwater Seepage Monitoring	<p>Seepage monitoring undertaken on the 30/06/2021 and 4/08/2021. Engineering geological site inspections were undertaken on the 2/06/2021 and 12/11/2021. Monitoring on the 30/06/2021 and 4/08/2021 was undertaken within 48 hours of rainfall. Groundwater seepage monitoring was carried out after the cut slopes had been grassed/hydroseeded</p> <p>Groundwater seepage and engineering geological observations are as follows:</p> <ul style="list-style-type: none"> <li>• Seepage encountered at natural ground</li> <li>• Seepage encountered at soil-rock transition</li> <li>• Softened ground at soil-rock contact</li> <li>• Active surface erosion occurring</li> </ul>



	<ul style="list-style-type: none"> <li>• Active slumping within soil slopes</li> <li>• Subsoil drains typically dry with no evidence of water</li> </ul>
<p>Risk of Future Slope Failure</p>	<p><b>East (LHS):</b>  The risk of future slope failure is considered <b>very low</b>, reduced compared to the previous assessment.</p> <ul style="list-style-type: none"> <li>• Bedding planes dipping in favourable direction,</li> <li>• No groundwater observed,</li> <li>• Slope height is less than 10m height and topography sloping down at top of cut,</li> </ul> <p><b>West (RHS):</b>  The risk of future slope failure is considered <b>low to moderate</b>,</p> <ul style="list-style-type: none"> <li>• Groundwater seepage and active slumping at the soil slopes have been observed.</li> <li>• It is unclear how if the potential debris within the historic erosion gully have been removed.</li> <li>• Potential risk of topsoil erosion and slumping within the previous gully in the centre of Cut CS13.</li> </ul> <p>Remedial works design or any temporary remedial works were not carried out at the time of writing this report. It is expected that the remedial works design will be compliant and will address the current issues.</p> <p>The current landslide is considered an active slip and the highest likelihood rating has been selected for the risk assessment. The overall weighted risk rating is moderate.</p>





February 2021, Time 4:04 – View in southern direction: East = left-hand side; West = right-hand side



April 2021, Time 3:41 – View in southern direction: East = left-hand side; West = right-hand side





June 2021, Time 4:14 – View in southern direction: East = left-hand side; West = right-hand side

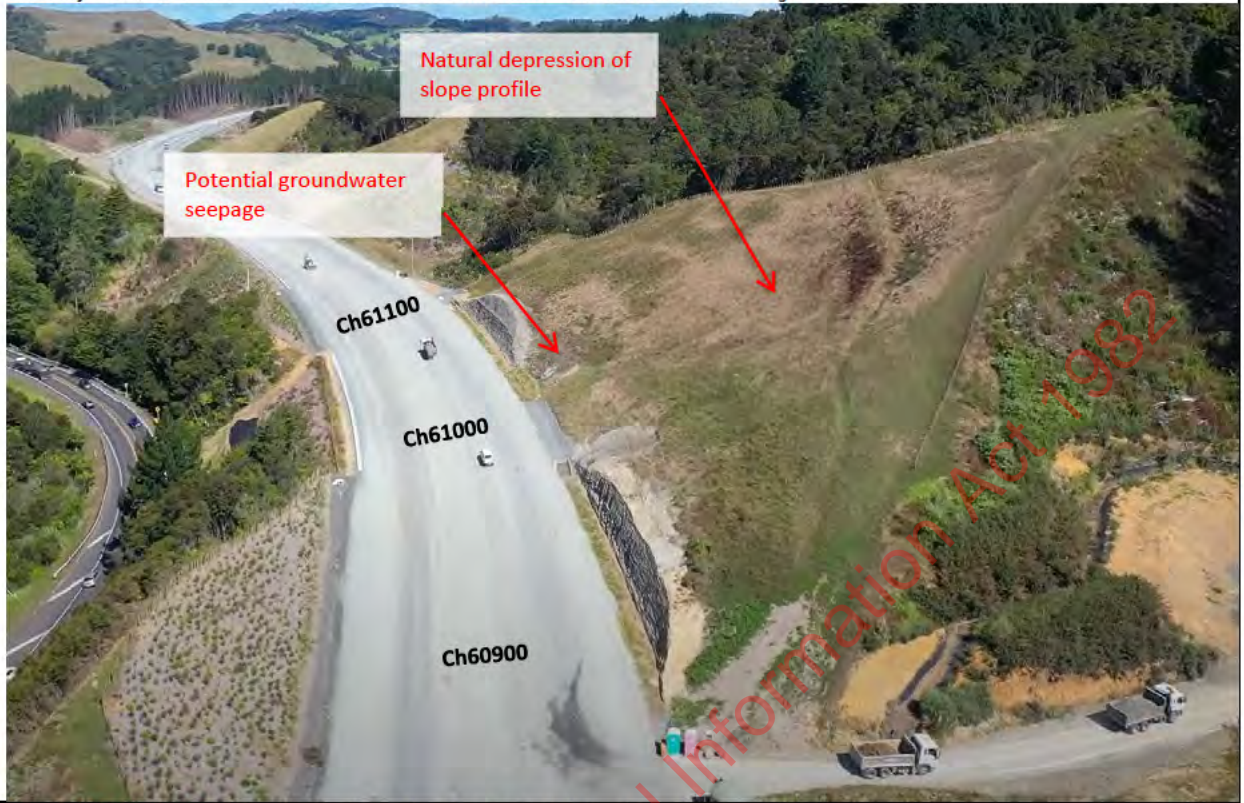


September 2021, Time 4:39 – View in southern direction: East = left-hand side; West = right-hand side





February 2022, Time 4:41 – View in southern direction: East = left-hand side; West = right-hand side



August 2022, Time 4:40 – View in southern direction: East = left-hand side; West = right-hand side





January 2023 (after rainfall event 28/01/2023), Time 5:11 – View in southern direction: East = left-hand side; West = right-hand side



February 2023, Time 4:59

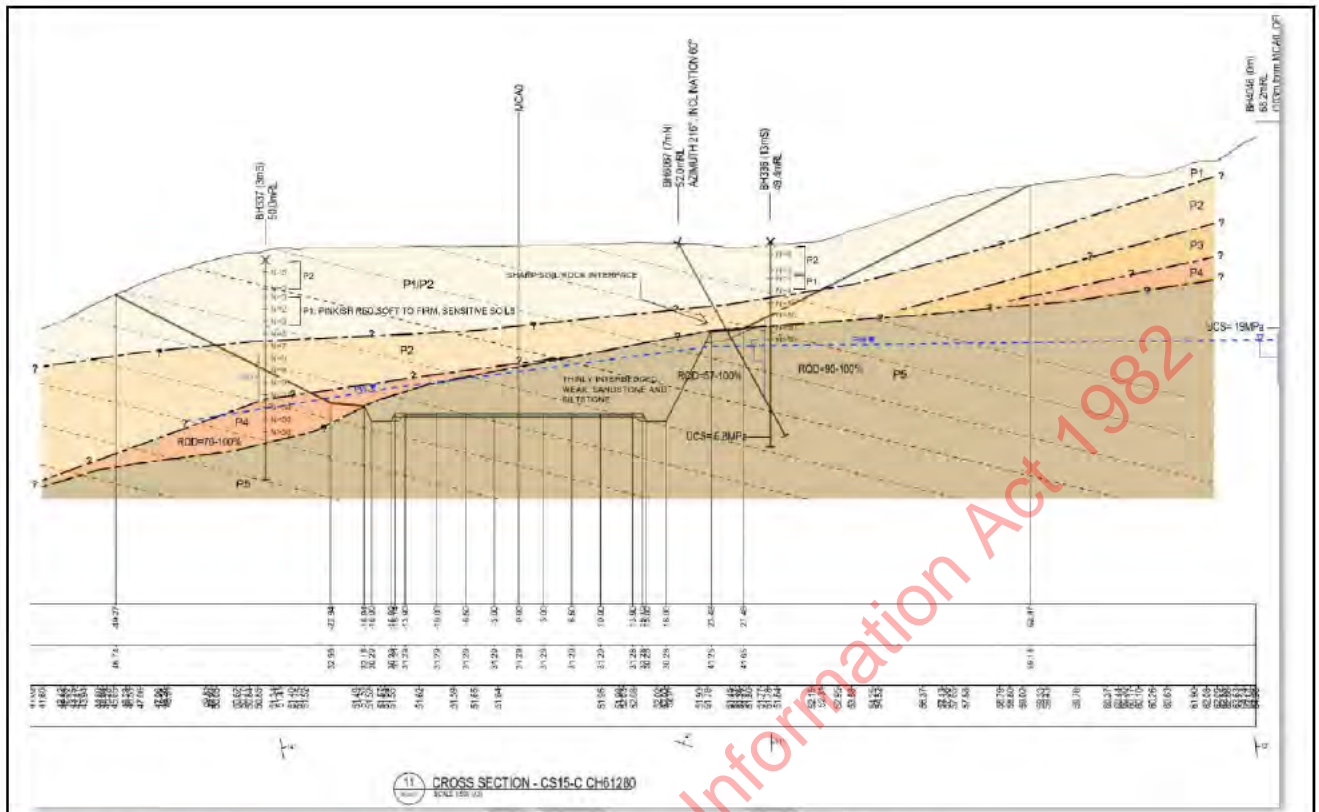




7.41 CS15A – Landslide 16

Chainage	Ch61,200 – Ch61,340
Typical Design Slope Geometry	East (LHS): 2H:1V slope, more than 15m high. West (RHS): 2H:1V slope, more than 24m high. 64° (1H:2V) rock cut, approx. 10m high.
Site & Design Description	Cut CS15A is located approximately 100m at the south-western side of the existing SH1 alignment. The cut is formed through the end of a NE to SW ridge line. The topography is sloping in NE direction.
Existing Landslide	Yes (No 16) CS15A – West Ch61,200 – Ch61,300
Cause of Landslide	Unknown. The landslide occurred within the erosion gully at the western side between Cuts CS15A and CS15B in an oblique angle to the alignment in south-eastern direction.
Date Landslide occurred	30 June 2020 & 4 August 2020
Cut within area of historic landslide	Low risk dipping in south-eastern direction
Geotechnical Investigations	BH336, BH337, BH6067
Site Geology	<p>CS15-C CH61,280, Drawing P2Wk-DRG-GG-03-1011</p> <p>1. Geology-Pakiri Formation (Encountered &amp; inferred thicknesses in stratigraphic order)</p> <ul style="list-style-type: none"> <li>• Up to 11m - Firm to stiff - Residually weathered soil with 1.5-3.5m thick layer soft sensitive soils present (SPT N:1-6)</li> <li>• 3-7m - Stiff - Residually weathered soil (SPT N:7-27)</li> <li>• 3.5-4m - Very stiff to hard - completely weathered soil/rock within upper slope (Western side)</li> <li>• Up to 5m Highly to moderately weathered rock at downslope side (Eastern Side) (SPT N:50 - 50+)</li> <li>• Up to 2.5m Highly to moderately weathered rock (Western side)</li> <li>• Slightly to unweathered rock encountered below 14m at centre line and up to 23.5m below ground level at (Eastern side)</li> <li>• Slightly to unweathered rock comprises thinly interbedded sandstone and siltstone, weak</li> <li>• Slightly to unweathered rock UCS 6.8MPa to 19MPa</li> </ul> <p>2. Structural Features &amp; Defects</p> <ul style="list-style-type: none"> <li>• Sharp soil-rock contact at level of rock cut bench.</li> <li>• Contact between soil and slightly to unweathered rock contact dips at 5° out of western cut slope</li> <li>• Contact between soft to firm residual soil and stiff residual soil dips out slope face at up to 20°</li> <li>• Apparent dip of bedding with reference approximately 12.5° into eastern cut slope</li> </ul> <p>Bedding (Average): 14/210 Joint Sets: 73/123, 65/282</p> <p>3. Groundwater</p> <p>Groundwater inferred at approximately 15m below ground surface level within moderately weathered rock at road centre line.</p>





Soil Rock Transition Zone	Dipping in eastern direction at 5° unfavourable out of slope
Rock Cut	64° (1H:2V) up to 10m high at the western side
Remedial Works Design	Yes. No DEI issued.
Remedial Works Details	<p>Remediation will a toolbox solution already included in the IFC design.</p> <ul style="list-style-type: none"> <li>• Lay back to 3H:1V</li> <li>• Counterfort drains</li> <li>• Cut-off drain</li> </ul>
Peer Reviewed in PSM Report Rev 4	Not reviewed
Groundwater Seepage Monitoring	<p>Seepage monitoring undertaken on the 2/06/2021, 22/06/2021 and 4/08/2021. Monitoring on the 22/06/2021 and 4/08/2021 was undertaken within 48 hours of rainfall. Groundwater seepage monitoring was carried out after the cut slopes had been grassed.</p> <p>Groundwater seepage observations consisted of the following:</p> <ul style="list-style-type: none"> <li>• Soil slope face typically dry/hard with no seepage observed/able to be observed</li> <li>• Seepages were observed at soil-rock transition</li> <li>• Minor seepage recorded at rock cut slope with seepage present along rock bedding structure</li> <li>• Subsoil drains functioning with softened wet ground and surface erosion present at outlets</li> </ul>
Risk of Future Slope Failure	<p><b>East (LHS):</b></p> <p>The risk of future slope failure is considered <b>very low</b>, reduced from previous assessment.</p> <ul style="list-style-type: none"> <li>• Slope height is less than 15m high and topography sloping down at top of cut,</li> <li>• No groundwater observed</li> </ul> <p><b>West (RHS):</b></p> <p>The risk of future slope failure is considered <b>low</b>, consistent with previous assessment.</p> <ul style="list-style-type: none"> <li>• Soil rock transition zone inclined at 5° only,</li> <li>• All slip debris removed, cut flatter at 3H:1V and drainage measures installed.</li> </ul>



- Minor groundwater seepage observed, but no adverse conditions apart from minor surface erosion at the rock slope face expected.



CS15A View in northern direction (Source: Landslide update 2020.45, Photo Date unknown)



CS15A View in northern direction (Source: Landslide update 2021.23, Photo Date unknown)

Released under the Official Information Act 1982



August 2020, Time 5:16 – View in southern direction: East = left-hand side; West = right-hand side



October 2020, Time 4:52 – View in southern direction: East = left-hand side; West = right-hand side





June 2021, Time 4:20 – View in southern direction: East = left-hand side; West = right-hand side



September 2021, Time 4:46 – View in southern direction: East = left-hand side; West = right-hand side





August 2022, Time 4:47 – View in southern direction: East = left-hand side; West = right-hand side



January 2023, Time 5:17 (after) – View in southern direction: East = left-hand side; West = right-hand side





## 7.42 CS15B – East (over-blasted) & West

Chainage	Ch61,340 – Ch61,530
Typical Design Slope Geometry	East (LHS): 2H:1V slope up to 10m high (rock exposures) West (RHS): 2H:1V slope, more than 24m high. 64° steep (1H:2V) rock cut, up to 10~15m high.
Site & Design Description	Cut CS15B adjacent to Cut CS15A in SE direction. Both cuts are separated by an NE-SW gully. The cut is formed through the end of a NE to SW ridge line.
Existing Landslide	None reported t s 9(2)(b)(ii) and 9(2)(ba)(i)
Cause of Landslide	Not applicable
Date Landslide occurred	Not applicable
Cut within area of historic landslide	High risk at south-western side, perpendicular to cut slope.
Geotechnical Investigations	BH335, BH205, TP323, BH6068
Site Geology	No geological section provided in the report.
Soil Rock Transition Zone	Unclear. Based on site observations, it appears that the soil rock interface is dipping gently in NE direction. Refer to geotechnical information provided at CS15A.
Rock Cut	64° (1H:2V) up to 10~15m high at the western side
Remedial Works Design	None required
Remedial Works Details	Not applicable
Peer Reviewed in PSM Report Rev 4	Not reviewed
Groundwater Seepage Monitoring	No groundwater seepage monitoring carried out.
Risk of Future Slope Failure	<p><b>East (LHS):</b> The risk of future slope failure is considered <b>very low</b> based on the review drone footage observations.</p> <ul style="list-style-type: none"> <li>Bedding planes dipping into the slope, but the ground level behind the top of cut slopes is sloping down towards the existing SH1.</li> <li>Broken rock exposures at north-eastern side are likely to deteriorate and regress in long-term.</li> </ul> <p><b>West (RHS):</b></p> <ul style="list-style-type: none"> <li>Very limited information available. The risk is likely to be <b>low (consistent)</b> based on the review of the drone footage.</li> <li>Note that at Cut CS15A, the bedding planes dipping into the slope and the soil rock interface is gently inclined and dipping out of the slope.</li> <li>No significant seepage observed.</li> </ul>



March 2019, Time 5:29 – View in southern direction: East = left-hand side; West = right-hand side



October 2020, Time 4:54 – View in southern direction: East = left-hand side; West = right-hand side





February 2021, Time 4:12 – View in southern direction: East = left-hand side; West = right-hand side



June 2021, Time 4:22 – View in southern direction: East = left-hand side; West = right-hand side





September 2021, Time 4:49 – View in southern direction: East = left-hand side; West = right-hand side



August 2022, Time 4:49 – View in southern direction: East = left-hand side; West = right-hand side





January 2023, Time 5:20 (after rainfall events 28/01/2023) – View in southern direction: East = left-hand side; West = right-hand side



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7.43 CS16B

Chainage	Ch61,700 – 61,800
Typical Design Slope Geometry	East (LHS): 2H:1V slope up to 10m high, West (RHS): 2H:1V slope, up to 15~20m high; rock exposures at lower part of slope.
Site & Design Description	Alignment is cutting through ride line which is orientated in East – West direction.
Existing Landslide	New landslides occurred on a natural slope outside the designation in close proximity to the cut slope. There are also multiple topsoil slips on the slopes outside of the designation.
Cause of Landslide	Likely sliding on soil-rock interface.
Date Landslide occurred	July 2022 and January/ February 2023
Cut within area of historic landslide	Low risk. Movement in eastern direction.
Geotechnical Investigations	BH4051, TP3524
Site Geology	No geological section provided in the report.
Soil Rock Transition Zone	Unclear from available information.
Rock Cut	Unclear. It appears that there are potential rock exposures at lower part of slope, which are now covered grass/ vegetation.
Remedial Works Design	Removal slip debris based on site observations. Possible other items.
Remedial Works Details	No details available.
Peer Reviewed in PSM Report Rev 4	Not reviewed/ not applicable as landslide occurred after the report was prepared.
Groundwater Seepage Monitoring	No groundwater seepage monitoring undertaken.
Risk of Future Slope Failure	We noted that very limited documentation and site observations are available at this location. East (LHS): The risk of future slope failure is considered <b>very low</b> based on review drone footage and site observations. West (RHS): The risk of future slope failure is considered <b>low to moderate</b> based on site observations in July and November 2022 and February 2023.





March 2019, Time 5:36 – View in southern direction: East = left-hand side; West = right-hand side



February 2020, Time 5:05 – View in southern direction: East = left-hand side; West = right-hand side





July 2021, Time 4:29 – View in southern direction: East = left-hand side; West = right-hand side



September 2021, Time 4:55 – View in southern direction: East = left-hand side; West = right-hand side





August 2022, Time 4:55 – View in southern direction: East = left-hand side; West = right-hand side



January 2023, Time 5:25 (post) – View in southern direction: East = left-hand side; West = right-hand side



Released under the Official Information Act 1982



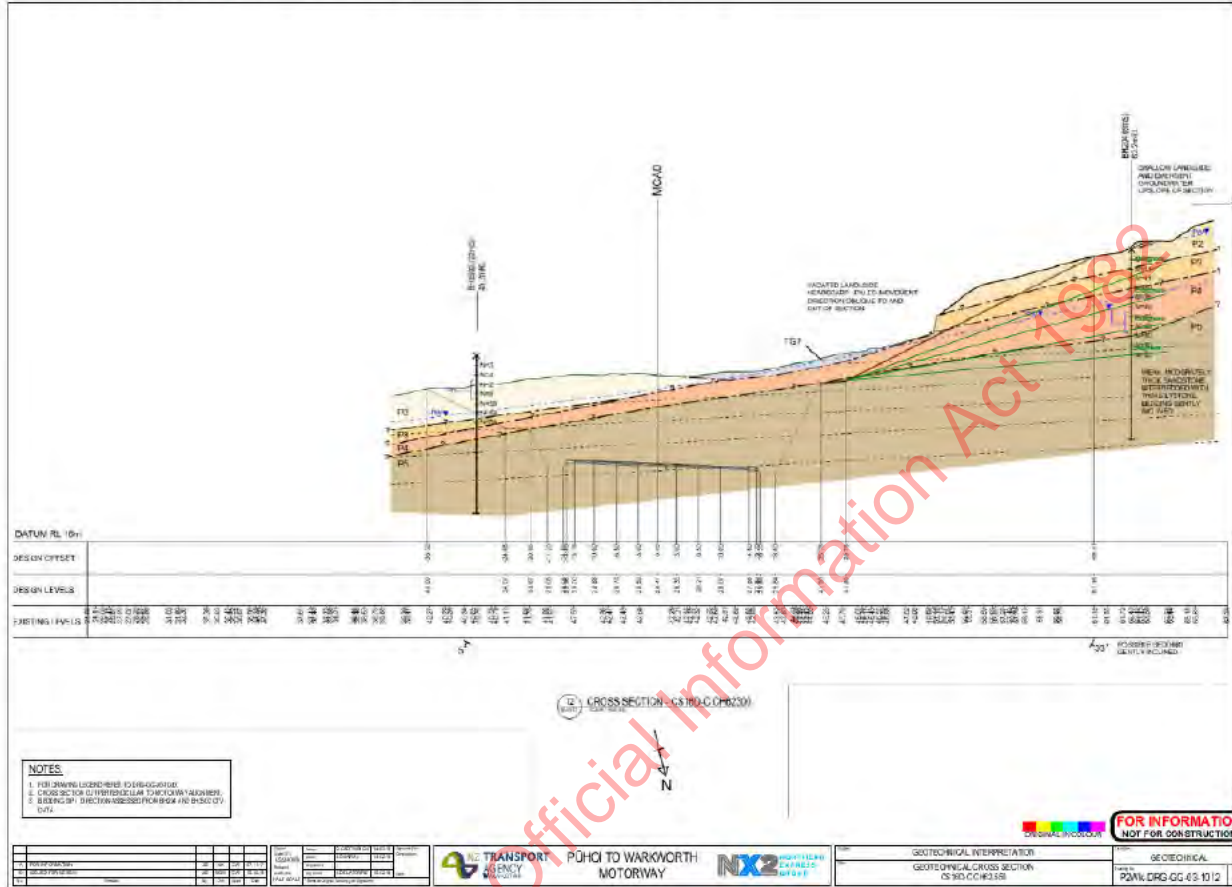
## 7.44 CS16D

Chainage	Ch62,000 – Ch62,580
Typical Design Slope Geometry	East (LHS): 2H:1V slope, up to 12m high, 85° & 64° (1H:2V) steep rock cut, up to 17m high. West (RHS): 2H:1V slope, more than 29m high. 85° & 64° (1H:2V) steep rock cut, up to 30m high.
Site & Design Description	Cut CS16D is located at the northern side of the Pūhoi Viaduct approximately 200m west of the existing SH1. The alignment is excavated through an easterly facing moderately steep slope. There are several sidling gullies and spurs. The upper cut batters comprise 2H:1V slope in Pakiri soils. Rock cut slopes at 1H:2V are along both sides of the alignment between approximately Ch62,300 and 62,500.
Existing Landslide	No "existing landslide". New slip (June 2021) above rock cut. Ch62,380 – Ch62,410 in soil slope above rock cut
Cause of Landslide	<b>New landslide:</b> <ul style="list-style-type: none"> <li>Multiple softened shear planes with clay infill as orientated parallel to bedding fabric about the HW/MW interface.</li> <li>In photographs (but not reported in text), underlying "complex" (folded / faulted / unconformable) Pakiri Formation which raises issues about the stability of non-failed portions of the cut that do not appear to have been addressed.</li> </ul>
Date Landslide occurred	March/April 2021
Cut within area of historic landslide	Low to moderate landslide risk at various location, generally dipping from West to East
Geotechnical Investigations	BH204, BH3501, BH3502, BH3503, BH3504, BH4052, BH4053, BH333, BH6066
Site Geology	<p>Ch62,300 (CS16D-C), Drawing P2Wk-DRG-GG-03-1012</p> <p><b>1. Geology-Pakiri Formation</b> (Encountered &amp; inferred thicknesses in stratigraphic order)</p> <ul style="list-style-type: none"> <li>Up to 1.5m Colluvium/landslide debris - Remnant of vacated landslide movement oblique to section</li> <li>3-3.5m - Stiff - Residual to completely weathered soil (Western-upslope cut) (SPT N=6)</li> <li>Up to 5.5m - Stiff - Residually to completely weathered soil (Eastern-downslope cut) (SPT N=2-9)</li> <li>2.5-3.5m - Very stiff to hard - Completely to highly weathered to hard soil &amp; rock (Western up slope cut) (SPT N=11-41)</li> <li>Up to 2.5m - Very stiff - Completely to highly weathered soil &amp; rock (Eastern downslope of cut) (SPT N=50)</li> <li>2-7m - Highly to moderately weathered rock, laterally continuous beneath section (SPT N= 26-50+)</li> <li>Slightly weathered to unweathered rock encountered below 8-3m across section (SPT N=50+)</li> </ul> <p>Slightly to unweathered rock comprises moderately thick sandstone with interbedded thin siltstone, weak, bedding gently inclined</p> <p><b>2. Structural Features &amp; Defects</b></p> <ul style="list-style-type: none"> <li>Moderately to highly weathered and slightly weathered rock contact dips out proposed cut slope at 10°</li> <li>Soil and moderately to highly weathered contact dips out cut slope at 10°</li> <li>Apparent dip of bedding with reference to section at approx. 2.5° west to east, out of cut slope</li> </ul> <p><b>3. Groundwater</b></p> <ul style="list-style-type: none"> <li>Groundwater emergent upslope at/above head of landslide and at top of proposed cut</li> <li>Groundwater at/just below surface within landslide debris</li> <li>Groundwater recorded within the upper moderately weathered rock upslope of cut (West)</li> <li>Groundwater recorded within stiff residually weathered soils downslope (East)</li> <li>Groundwater inferred approx. 2.5m below surface level at centre line of road cut</li> </ul>



#### 4. Geomorphological Features

Remnant slip deposits present at road alignment - undercut by proposed cut.



#### Ch62,550 (CS16D-C), Drawing P2Wk-DRG-GG-03-1014

##### 1. Geology-Pakiri Formation (Encountered & inferred thicknesses in stratigraphic order)

- Surficial layer of colluvium and shallow landslide debris
- Up to 5.5m -Firm - Residually weathered soils
- 1.5- 4.5m - Very stiff to hard - Highly weathered soil and rock
- 10m - Moderately to highly weathered rock.
- Slightly to unweathered rock encountered past 11.5-16m
- Moderately to highly weathered rock comprised extremely weak, moderately thin interbedded sandstone and siltstone
- Slightly to unweathered rock comprises slightly weathered, moderately thick to thinly bedded sandstone and siltstone, weak

##### 2. Structural Features & Defects

- Apparent dip of bedding with reference to section at approx 7.5° in to eastern cut slope

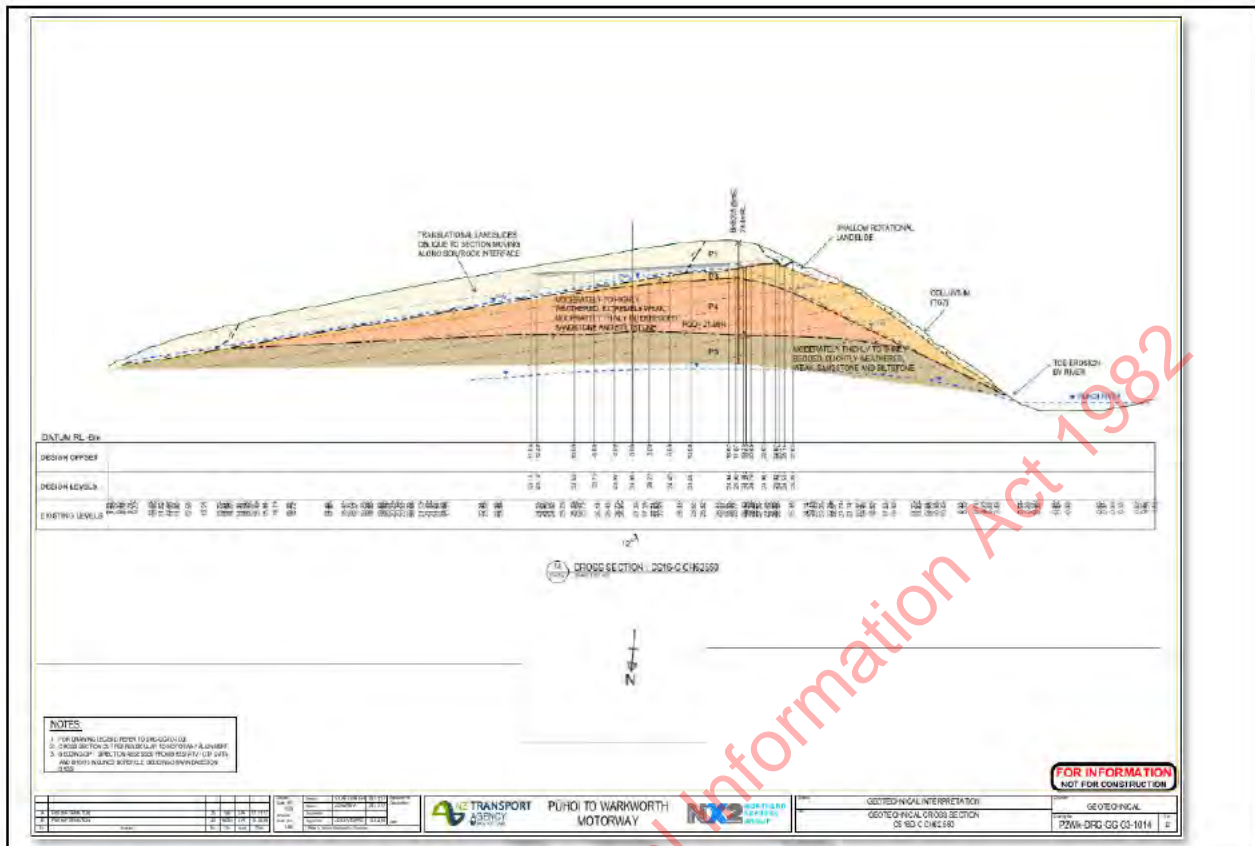
##### 3. Groundwater

- Groundwater encountered 5m below surface level, within residually weathered soils
- Groundwater level 2 encountered between 18-21 below surface level within slightly to unweathered rock

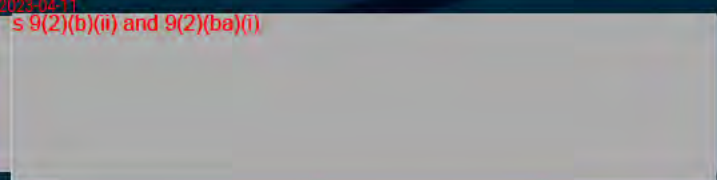
##### 4. Geomorphological Features

- Shallow rotational landslides present at western side
- Deeper seated translation landslides occurring along soil-rock interface present at eastern side.





Soil Rock Transition Zone	Dipping in eastern direction at 5~10° unfavourable out of slope
Rock Cut	85° and 64° (1H:2V) up to 30m high at the western side
Remedial Works Design	DEI 503, DEI 511 (referenced in PSM's report PSM4203-029R Rev 4)
Remedial Works Details	Western soil batter laid back to 4H:1V above rock bench
Peer Reviewed in PSM Report Rev 4	Refer to PSM Report PSM4203-029R Draft Rev 4 – Appendix N
Groundwater Seepage Monitoring	Seepage monitoring and an engineering geological site inspection was undertaken on the 2/11/2021. Observations are as follows: <ul style="list-style-type: none"> <li>• Rock comprises highly interbedded sandstone and siltstone</li> <li>• Seepages observed at various RL from the rock mass structure</li> <li>• Seepages observed from soil-rock transition on to and over rock bench</li> <li>• Transition from rock to soil cut slope at northern end, Ch62000 relatively dry</li> <li>• Washout of mulch, topsoil and upper soil layers at Ch62500-west</li> </ul>
Risk of Future Slope Failure	<p>East (LHS):</p> <p>The risk of future slope failure is considered <b>low</b>, consistent with the previous assessment.</p> <ul style="list-style-type: none"> <li>• Bedding planes generally dipping away from cut slope,</li> <li>• Ground levels on top of cut dipping sloping down. Therefore, limited surface water run-off and groundwater recharge,</li> <li>• Soil cut slopes are less than 12m high.</li> </ul> <p>West (RHS):</p> <p>The risk of future slope failure is considered <b>low to moderate risk</b>.</p> <ul style="list-style-type: none"> <li>• Slope has been remediated to 4H:1V slope. However, drone footage suggest that the slope may be steeper.</li> <li>• Potential rockfall risks from the upper 2H:1V exposed rock slopes have been reviewed as part of the CJV assessments. Refer to Section 4.2.</li> </ul>





October 2020, Time 5:09 – View in southern direction: East = left-hand side; West = right-hand side



February 2021, Time 4:26 – View in southern direction: East = left-hand side; West = right-hand side





June 2021, Time 4:37 – View in southern direction: East = left-hand side; West = right-hand side



September 2021, Time 5:01 to 5:11 – View in southern direction: East = left-hand side; West = right-hand side







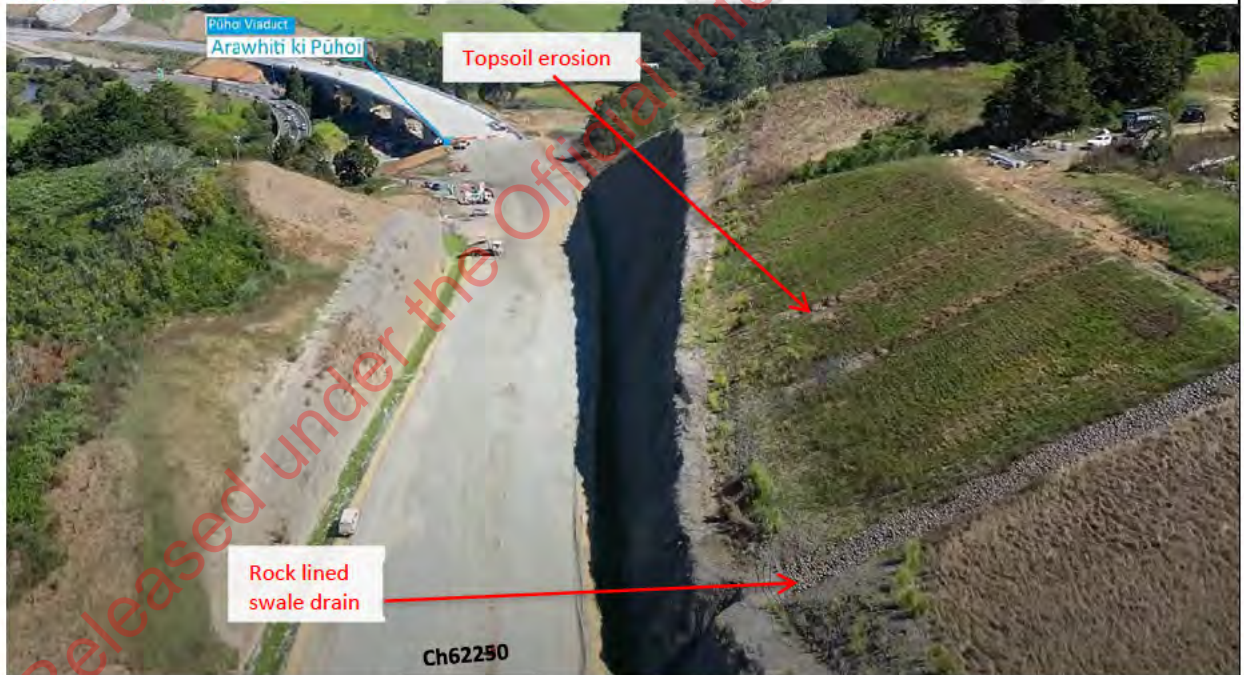


February 2022, Time 5:04 to 5:11 – View in southern direction: East = left-hand side; West = right-hand side

Ch62,100 – Ch62,250



Ch62,250 – Ch62,400





February 2022, Ch62,350 – Ch62,500



August 2022, Time 5:02 to 5:11 – View in southern direction: East = left-hand side; West = right-hand side  
Ch62,100 – Ch62,250





August 2022, Ch62,250 – Ch62,400



January 2023, Time 5:37 (after rainfall events 28/01/2023) – View in southern direction: East = left-hand side; West = right-hand side

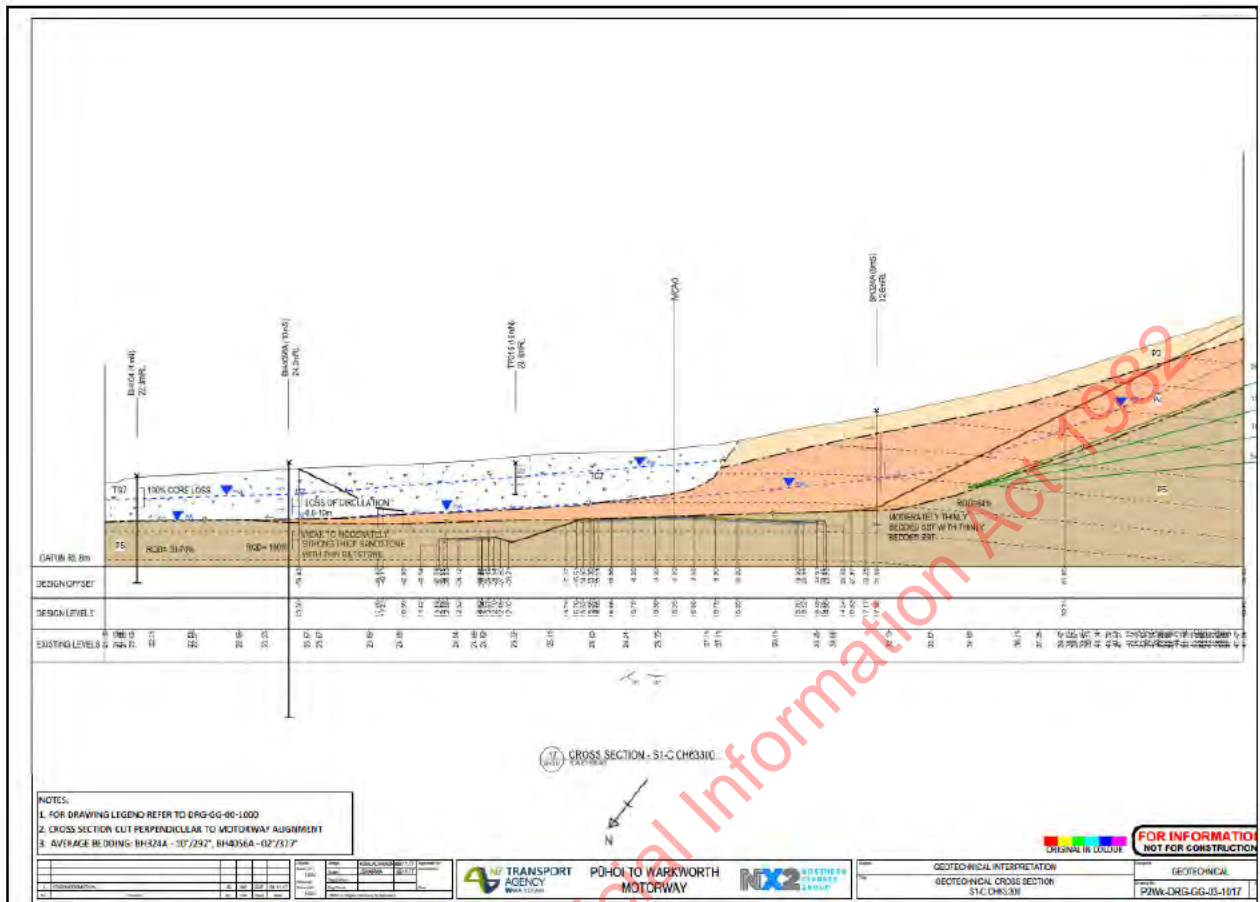




7.45 S1 – Landslide 17

Chainage	Ch63,180 to Ch63,810
Typical Design Slope Geometry	East (LHS): 2H:1V slope, up to 12m high, 64° (1H:2V) steep rock cut, up to 5m high. West (RHS): 2H:1V slope, up to 20m high. 64° (1H:2V) steep rock cut, up to 10~12m high.
Site & Design Description	The alignment cuts obliquely through a northwest to south east trending ridge. The northern side of the ridge has a long and gentle slope with a steep rock cut located at the toe above the existing SH1. The upper cut batters comprise 2H:1V slope in Pakiri soils. 1H:2V rock cuts are along the western side of the alignment.
Existing Landslide	Yes (No 17) S1 – East, Slip Ch63,400 – Ch63,430 East
Cause of Landslide	The exact cause is unknown. However, translational sliding on soil rock interface combined with groundwater is expected the likely cause.
Date Landslide occurred	12 June 2020
Cut within area of historic landslide	Moderate risk. Dipping from south-west to north-east.
Geotechnical Investigations	BH103, BH104, BH323, BH324A, BH325, BH6079, BH6080, BH4056A
Site Geology	<p>Ch63,300 (S1-C), drawing P2Wk-DRG-DD-03-1017</p> <p>1. Geology-Pakiri Formation (Encountered &amp; inferred thicknesses in stratigraphic order)</p> <ul style="list-style-type: none"> <li>• 8-8.5m - Soft to firm - Colluvium/landslide debris (SPT N= 1-5)</li> <li>• 3-4m - Stiff - Residually weathered soil</li> <li>• Up to 12m - Highly to moderately weathered rock</li> <li>• Slightly to unweathered rock encountered between 8.5 and 15m below existing ground level.</li> <li>• Colluvium/landslide debris encountered directly above moderately and slightly weathered rock at location of road cut</li> <li>• Slightly to unweathered rock comprises weak to moderately strong, thick sandstone and thin siltstone to moderately thick bedded sandstone with thinly bedded siltstone</li> </ul> <p>2. Structural Features &amp; Defects</p> <ul style="list-style-type: none"> <li>• Slightly to unweathered rock contact with moderately weathered rock dips out western cut at 15°-20°</li> <li>• Apparent dip of bedding with reference to section at approx. 5° towards West - Southwest in to cut slope</li> </ul> <p>Bedding Average: 10/292, 02/327</p> <p>3. Groundwater</p> <ul style="list-style-type: none"> <li>• Groundwater recorded within landslide debris at 3-4m below surface level</li> <li>• Groundwater recorded 10.5m below surface level within moderately weathered rock at up slope western cut side</li> <li>• Inferred at 8m below surface level at centre line of road cut and at contact of landslide debris and moderately to slightly weathered and unweathered rock</li> </ul> <p>4. Geomorphological Features</p> <p>Large translational landslide feature through alignment</p>





## Site Geology

### Ch63,360 (S1-C), drawing P2Wk-DRG-DD-03-1018

#### 1. Geology-Pakiri Formation (Encountered & inferred thicknesses in stratigraphic order):

- 4-9m Landslide debris/colluvium directly above road cut (SPT N 3-5)
- 4.5-5.5m - Stiff - Residual to completely weathered soils and rock at upslope side within alignment cut (SPT N:7-25)
- Up to 3.5m - Stiff - Residual to completely weathered at Eastern side, downslope of cut
- 0.5 to 1.5m Highly to moderately weathered rock
- Slightly weathered to unweathered rock encountered past 9-10m (SPT N 50+)
- Slightly weathered to unweathered rock comprises:
  - Weak, thinly interbedded to laminated sandstone and siltstone
  - Chaotic stratigraphic thick sequences of gritstone
  - Weak, thick and thinly interbedded sandstone/siltstone and thick siltstone

#### 2. Structural Features & Defects

- Moderately weathered and slightly to unweathered rock contact dips out of cut slope (Western side) at up to 20°
- Apparent dip of bedding with reference to section at approximately 2° out of cut slope (Western Side)

Bedding Average: 3/025,

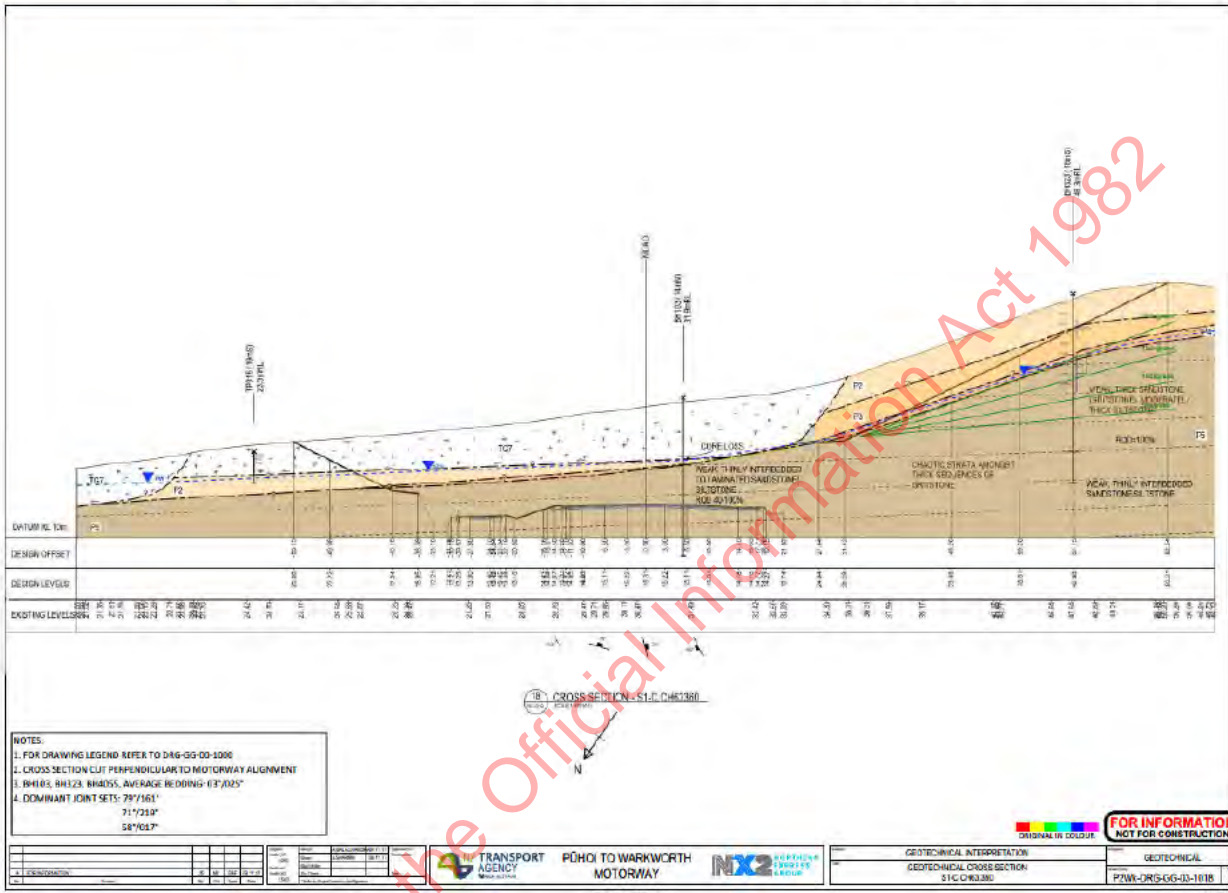
Joint Set Discontinuities: 79/219, 71/219, 58/017

#### 3. Groundwater

- Groundwater recorded between 9.5-10m below surface level, within thin layer of moderately weathered rock and directly above slightly to unweathered rock contact



- Groundwater inferred at boundary of landslide debris and residual to slightly weathered rock
- 4. Geomorphological Features**
- Large west to east translational landslide feature 100-120m long.
  - Landslide debris/colluvium directly contacts with underlying slightly to unweathered rock



**Site Geology**

**63,500 (S1-C), drawing P2Wk-DRG-DD-03-1019**

**1. Geology-Pakiri Formation (Encountered & inferred thicknesses in stratigraphic order)**

- Up to 5.5m - Stiff - Residual weathered soil
- 6-8m - Very stiff to hard - Residual to highly weathered soil
- Up to 1m - Highly to moderately weathered rock
- Slightly to unweathered rock encountered up to 14m below surface level and inferred up to 5.5m below surface level
- Slightly weathered to unweathered rock comprises massive conglomerate sandstone.
- Limonite penetrates slightly weathered to unweathered rock mass along steeply dipping joints.
- Soft sediment deformation features present along joint sets.
- Thick limestone body present

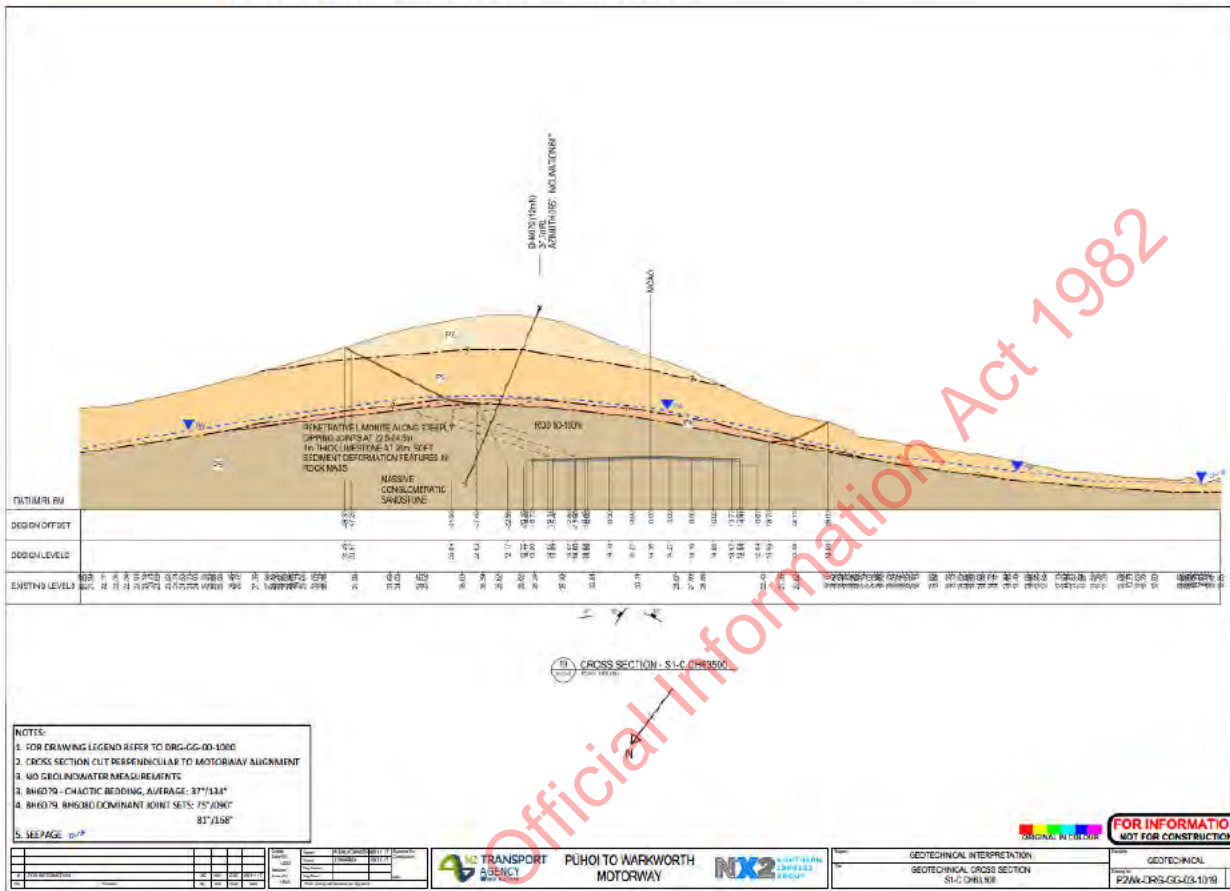
**2. Structural Features & Defects**

- Slightly and unweathered rock contact dips into the eastern and western cut slopes between 5°-10°
- Recumbent fold feature present.



### 3. Groundwater

Groundwater inferred at between 3.5 and 12m below surface level and at/above completely and highly to moderately weathered rock contact.



Soil Rock Transition Zone	Dipping in eastern direction at 5~10° unfavourable out of slope
Rock Cut	85° and 64° (1H:2V) up to 30m high at the western side
Remedial Works Design	DEI 0438 (Ch63260 – 63430, S1 Eastern Soil Stabilisation)
Remedial Works Details	<ul style="list-style-type: none"> <li>Remove all slipped material,</li> <li>Layback slope batter to 3H:1V,</li> <li>Counterfort drains,</li> <li>Wider rock bench</li> </ul>
Peer Reviewed in PSM Report Rev 4	Not included.
Groundwater Seepage Monitoring	<p>Seepage monitoring undertaken on the 23/06/2021 and 29/07/2021. Engineering geological site inspections were undertaken on the 2/06/2021 and 2/11/2021. Monitoring on the 23/06/2021 and 29/07/2021 was undertaken within 48hours of rainfall.</p> <p>Groundwater seepage and engineering geological observations are as follows:</p> <p><b>S1-East</b></p> <ul style="list-style-type: none"> <li>Subsoil drains functioning with minor trickles of water recorded from 2 of 9 subsoil drains and softened ground at outlets</li> <li>Seepage recorded at soil-rock transition</li> <li>Small seepage flows from natural ground slope with wet ground surfaces and surface water running downslope, softening of soil and staining on cut slope face</li> </ul>



	<p><b>S1-West</b></p> <ul style="list-style-type: none"> <li>• Minor seepages recorded coming from soil cut slope face</li> <li>• Seepage from soil-rock transition</li> <li>• Seepage from bedding and fold structure within rock slope approximately 4-8m above road cut</li> <li>• Very minor fretting/unravelling resulting in rock drop out from fractured and highly interbedded rock surface</li> <li>• Exposed lower sections/areas of uncovered soil slope are wet. This may be from surface water run off or groundwater.</li> </ul>
<p><b>Risk of Future Slope Failure</b></p>	<p><b>East (LHS):</b> The risk of future slope failure is considered <b>low</b>.</p> <ul style="list-style-type: none"> <li>• Bedding planes generally dipping away from cut slope,</li> <li>• Ground levels are sloping away behind cut slope.</li> <li>• Remedial works complete. Slipped material removed.</li> </ul> <p><b>West (RHS):</b> The risk of future slope failure is considered <b>low</b>.</p> <ul style="list-style-type: none"> <li>• Bedding planes and soil rock interfaces dipping towards slope,</li> <li>• Significant groundwater seepage observed.</li> </ul>





February 2021, Time 4:40 – View in south-eastern direction: East = left-hand side; West = right-hand side



June 2021, Time 4:53 – View in south-eastern direction: East = left-hand side; West = right-hand side





September 2021, Time 5:24 – View in south-eastern direction: East = left-hand side; West = right-hand side



February 2022, Time 5:24 – View in south-eastern direction, Ch63,200: East = left-hand side; West = right-hand side

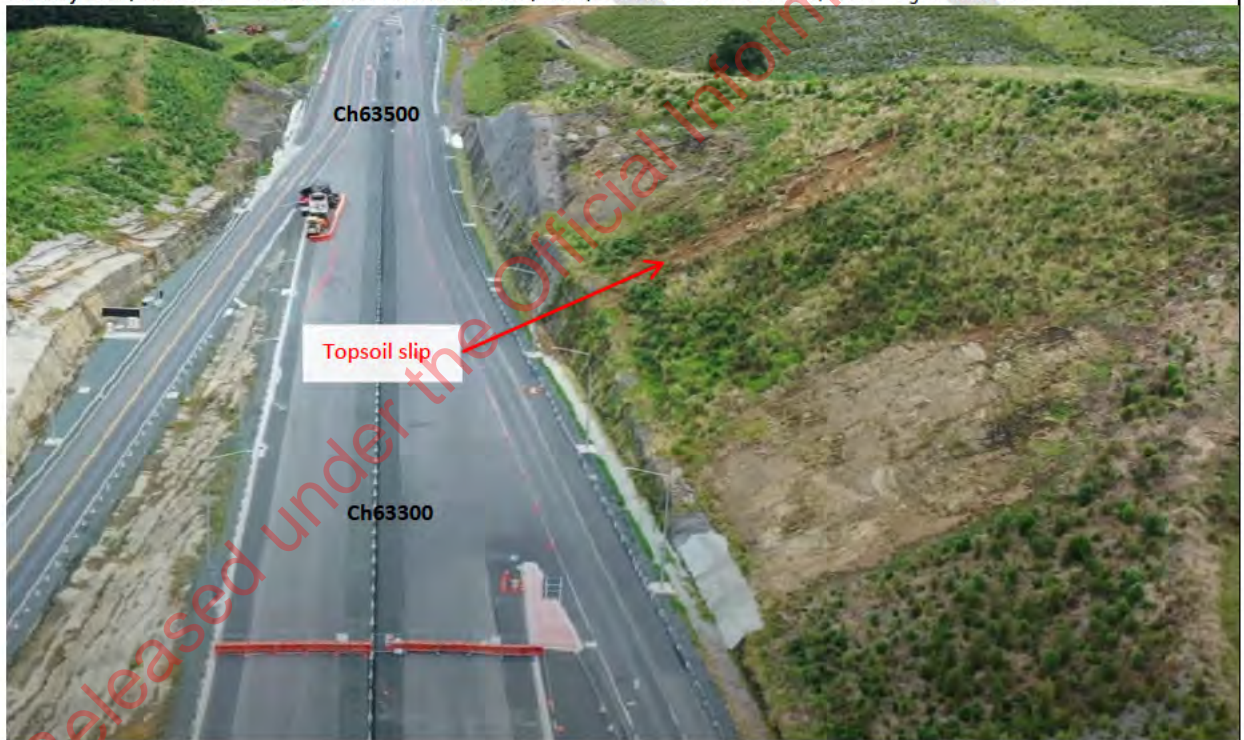




August 2022, Time 5:24 – View in south-eastern direction, Ch63,200: East = left-hand side; West = right-hand side



January 2023, Time 5:57 – View in south-eastern direction, Ch63,200: East = left-hand side; West = right-hand side

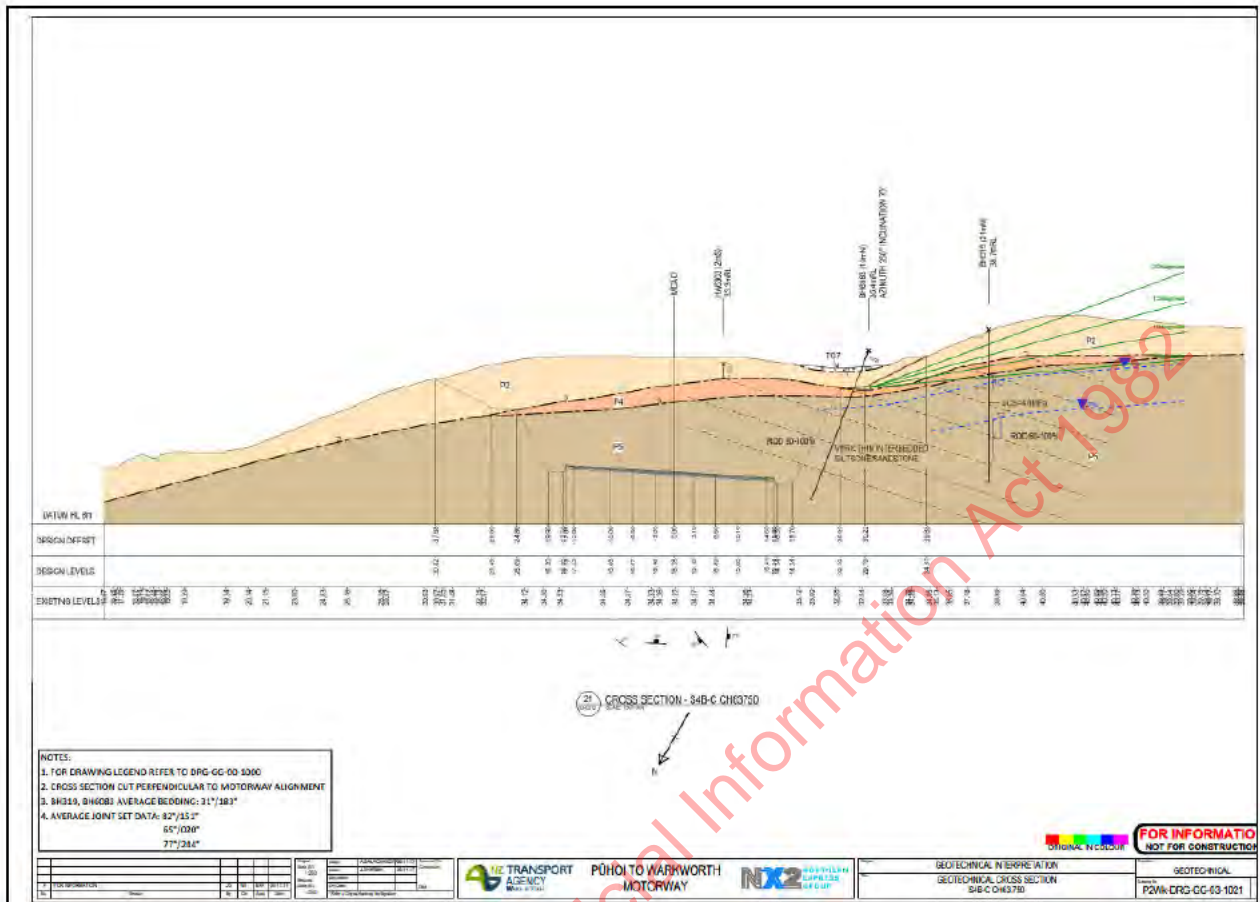




#### 7.46 S4B and Wetland WP5 – Landslide 18

Chainage	Ch63,660 – Ch63,780
Typical Design Slope Geometry	East (LHS) (WP5): No details on slope height available. Up to 10m high (approximated from photos). West (RHS): up to 16m high rock cut (1H:2V), up to 15m high 2H:1V steep soil slope
Site & Design Description	The alignment cuts through a steep sided west to east trending ridge. In the centre of the S4B cut, the lower part is formed in 1H:2V rock cuts. The upper cut batters comprise 2H:1V slope in Pakiri soils. The overall cut slope heights are up to 29m.
Existing Landslide	Yes (No 18), WP5 only
Cause of Landslide	Unclear, like shallow soil slope failures or sliding on soil-rock interface.
Date Landslide occurred	July 2021 Further slips and occurred at the slopes north-west of Cut S4B during the January 2023 rainfall events. The remedial works are yet to commence.
Cut within area of historic landslide	Moderate risk. Dipping from south-west to north-east
Geotechnical Investigations	BH319, BH6083, BH320
Site Geology	Ch63,750 (S4B), Drawing P2Wk-DRG-GG-03-1021 <ol style="list-style-type: none"> <li><b>Geology-Pakiri Formation</b> (Encountered &amp; inferred thicknesses in stratigraphic order): <ul style="list-style-type: none"> <li>Surficial colluvial/landslide debris deposits</li> <li>2.5-8m: Stiff - Residual to completely weathered (SPT N:6-20)</li> <li>1-3m: - Highly to moderately weathered rock (SPT N=50+)</li> <li>Slightly to unweathered rock encountered between 4-9m below existing ground level (SPT N=50+)</li> <li>Slightly to unweathered rock comprises very thin interbedded siltstone and sandstone - UCS 4.8MPa</li> </ul> </li> <li><b>Structural Features &amp; Defects</b> <ul style="list-style-type: none"> <li>Slightly and unweathered rock contact dips out of the cut slope at between 5° and 20° of western side</li> <li>Bedding dips into western cut slope at 8°-9°</li> </ul> </li> </ol> <p>Bedding Average: 31/151 Joint Set Discontinuities: 82/151, 65/020, 77/244</p> <ol style="list-style-type: none"> <li><b>Groundwater</b> <ul style="list-style-type: none"> <li>Groundwater recorded at 8.0m below surface level and 14m below surface level within slightly weathered rock.</li> </ul> </li> </ol>





Soil Rock Transition Zone	Dipping in eastern direction at 5~10° unfavourable out of slope
Rock Cut	Rock cut at eastern side of wetland WP5 (not affecting SH1 alignment). Rock cut at western side at S4B.
Remedial Works Design	No DEI provided. Remedial design is a toolbox solution included in the IFC drawings.
Remedial Works Details	Toolbox solution as per IFC drawings
Peer Reviewed in PSM Report Rev 4	No
Groundwater Seepage Monitoring	<p>Seepage monitoring undertaken on the 23/06/2021, 29/07/2021. Engineering geological site inspection were undertaken on the 2/06/2021 and 12/11/2021</p> <p>Monitoring on the 23/06/2021 and 29/07/2021 was undertaken within 48hours of rainfall</p> <p>Groundwater seepage and engineering geological observations are as follows:</p> <ul style="list-style-type: none"> <li>• Minor seepages with softened, wet soil at the central and northern sections of cut slope</li> <li>• <b>Active</b> soil slumping/slip occurring towards northern end of cut with softened, wet ground at toe of slip. Slumping typically 0.5m high with a zone of influence up to 1-1.5m below surface</li> <li>• Cross slope cut off drains midway up slope may be serving to recharge surface water to lower soil slopes</li> <li>• Seepage at soil-rock contact with water flowing over bench face</li> <li>• <b>Active</b> minor surface erosion</li> </ul>



Risk of Future Slope Failure

East (LHS) – Wetland WP5:

The risk of future slope failure is considered **low**, **reduced risk compared to previous assessment**. Topsoil or erosion induced slumping are likely.

- Bedding planes generally dipping away from cut slope,
- However, topsoil slips were observed in September 2021 on the steep soil slopes (appear to be steeper than 2H:1V).

West (RHS) – S4B:

The risk of future slope failure is considered **low to moderate** for shallow slope failures and topsoil **slips at the north-western-side of the cut**. Multiple shallow slips (even where buttress fills where placed) and topsoil slip occurred during the January 2023 rainfall events.

October 2020, Time 5:41 – View in southern direction: East (Wetland WP5) = left-hand side; West (S4B) = right-hand side





February 2021, Time 4:47 – View in southern direction: East (Wetland WP5) = left-hand side; West (S4B) = right-hand side



June 2021, Time 5:01 – View in southern direction: East (Wetland WP5) = left-hand side; West (S4B) = right-hand side





July 2021, Time 5:01 – View in southern direction: East = left-hand side; West = right-hand side



September 2021, Time 5:32 – View in southern direction: East = left-hand side; West = right-hand side





February 2022, Time 5:33 – View in southern direction: East = left-hand side; West = right-hand side



August 2022, Time 5:27 – View in southern direction: East = left-hand side; West = right-hand side



Shallow slope failures and topsoil slips

January 2023, Time 6:02 (after rainfall events) – View in southern direction: East = left-hand side; West = right-hand side



Multiple shallow slope failures and topsoil slips



## 7.47 S5C – Landslide 19

Chainage	Ch63,960 – 64,190
Typical <u>Design</u> Slope Geometry	<p>East (LHS): 2H:1V slope, up to 12m high, rock cut exposures at lower part of slope cut at 2H:1V</p> <p>West (RHS): 2H:1V slope, more than 20m high. 64° (1H:2V) steep rock cut, up to 10m high.</p>
Site & Design Description	<p>Cut S5 is located at the northern side of the Ōkahu Viaduct approximately 200m west of the existing SH1.</p> <p>The topography consists of complex ridge with multiple spurs and gully features at different orientations.</p> <p>The upper cut batters comprise 2H:1V slope in Pakiri soils. 1H:2V rock cuts at the western batter are up to 10m high. At the eastern batter, the rock exposures are present and at 2H:1V. The overall cut slope heights are up to 24m at the western batter and 17m at the eastern batter.</p>
Existing Landslide	Yes (No 19), S5C – East Ch4,060 to 64,100
Cause of Landslide	Geological rock structure is unclear. Cause of landslide not clear identified.
Date Landslide occurred	March/April 2020 based on drone flyover videos.
Cut within area of historic landslide	Low to high landslide risk at various location and orientated various directions.
Geotechnical Investigations	BH102, BH314, BH315, BH316, BH201, BH202
<b>Site Geology</b>	
<p>64,130 (S5), Drawing P2Wk-DRG-GG-03-1024</p> <p>1. <b>Geology:</b> - Pakiri Formation (Encountered &amp; inferred thicknesses in stratigraphic order)</p> <p>Surficial colluvial/landslide debris deposits</p> <p><b>Eastern Side (Downslope)</b></p> <ul style="list-style-type: none"> <li>• 4.5-8.5m - Firm to Stiff - Residual to completely weathered, interbedded soils</li> <li>• 4-5m - Stiff - Residual to completely weathered soils</li> <li>• 1-3m of Highly to moderately weathered rock laterally continuous across the site</li> <li>• Slightly weathered to unweathered rock encountered below 11.5-14m below surface level</li> </ul> <p><b>Western Side (Upslope)</b></p> <ul style="list-style-type: none"> <li>• 6-7m - Stiff - Residually weathered soils</li> <li>• 3-5m - Highly weathered soil and rock</li> <li>• 1-3m - Highly to moderately weathered rock laterally continuous across the site</li> <li>• Slightly weathered to unweathered rock encountered 11m below surface level</li> </ul> <p>Slightly weathered rock comprises:</p> <ul style="list-style-type: none"> <li>• Interbedded sandstone/siltstone</li> <li>• Massive sandstone with very widely spaced siltstone beds</li> </ul> <p>2. <b>Structural Features &amp; Defects</b></p> <ul style="list-style-type: none"> <li>• Residual soil contact with moderately weathered dips out of the cut western side cut slope at 15°</li> <li>• Bedding dips out of western cut slope at approx. 2.5°</li> </ul> <p>Bedding Average 04/132</p> <p>Joint Set Discontinuities 70/279, 59/157, 64/084</p>	







	<p><b>S5C-East</b></p> <ul style="list-style-type: none"> <li>• Counterfort drains functioning with seepage recorded at southern end of cut slope</li> <li>• Surface erosion and wet/softened ground at counterfort drain outlets</li> <li>• Natural soil slope is wet</li> <li>• Seepages observed at soil-rock interface</li> <li>• Some erosion of topsoil present</li> </ul> <p><b>S5C-West</b></p> <ul style="list-style-type: none"> <li>• Constant seepages recorded from bored drains with water flowing up to 7l/min. Iron oxidisation at drain outlets and down rock slope face where water has flowed</li> <li>• Excavation at transition zone revealed highly fractured moderately weathered rock with sharp weathering transition between overlying residual soil and completely weathered rock and underlying slightly to unweathered rock</li> <li>• Transition between highly to moderately weathered rock and underlying slightly weathered, impermeable rock is forming an aquiclude for the transfer of groundwater.</li> <li>• Seepage at soil-rock interface with wet and softened soil present at contact and over bench</li> <li>• Minor slumping towards southern end of cut slope within topsoil and upper residual soil layers</li> <li>• Softened wet ground present at subsoil drain outlets</li> </ul>
Risk of Future Slope Failure	<p><b>East (LHS):</b> The risk of future slope failure is considered <b>very low</b>.</p> <ul style="list-style-type: none"> <li>• Bedding planes generally dipping into the cut slope,</li> <li>• No significant groundwater seepage observed.</li> </ul> <p><b>West (RHS):</b> The risk of future slope failure is considered <b>low</b>.</p> <ul style="list-style-type: none"> <li>• Cut drain has been installed at top of soil slope batter.</li> <li>• Significant groundwater seepage at rock slope. Need to be monitoring and maintained during operation.</li> <li>• Topsoil slips and erosion at cut interface possible (and observed). Topsoil slips have been repaired.</li> </ul>



October 2020, Time 5:47 – View in southern direction: East = left-hand side; West = right-hand side



February 2021, Time 4:51 – View in southern direction: East = left-hand side; West = right-hand side





June 2021, Time 5:05 – View in southern direction: East = left-hand side; West = right-hand side



July 2021, Time 5:08 – View in southern direction: East = left-hand side; West = right-hand side





September 2021, Time 5:38 – View in southern direction: East = left-hand side; West = right-hand side



February 2022, Time 5:39 – View in southern direction: East = left-hand side; West = right-hand side

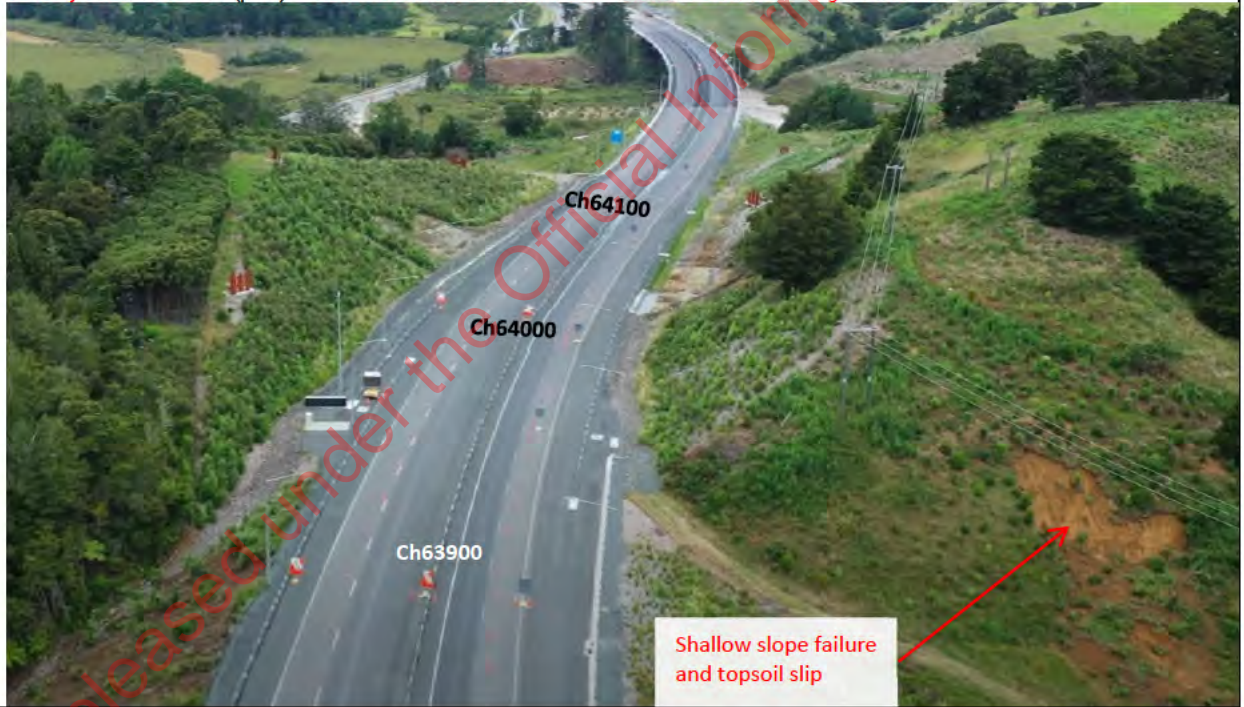




August 2022, Time 5:40 – View in southern direction: East = left-hand side; West = right-hand side



January 2023, Time 6:10 (post) – View in southern direction: East = left-hand side; West = right-hand side





7.48 S7

Chainage	Ch64,660 – Ch65,070
Typical Design Slope Geometry	East (LHS): no slope, transition into existing SH1 West (RHS): no rock cut, up to 10m high 2H:1V soil slope between new SH1 and existing SH1 northbound onramp (to be removed, future maintenance access only).
Site & Design Description	Tie-in of existing SH1 into new SH1 alignment.
Existing Landslide	No
Cause of Landslide	Not applicable
Date Landslide occurred	Not applicable
Cut within area of historic landslide	Low risk. Dipping in north-western direction towards the back of the cut slope.
Geotechnical Investigations	BH302, BH303, BH304, BH305, BH6086
Site Geology	No geological section provided. Expected ground conditions are Pakiri Formation residual soils.
Soil Rock Transition Zone	Dipping in eastern direction at 5~10° unfavourable out of slope
Rock Cut	85° and 64° (1H:2V) up to 30m high at the western side
Remedial Works Design	No DEI provided
Remedial Works Details	Not applicable
Peer Reviewed in PSM Report Rev 4	Not reviewed
Groundwater Seepage Monitoring	No groundwater seepage monitoring proposed
Risk of Future Slope Failure	<p>East (LHS): The risk of future slope failure is considered <b>very low</b>. No cut slope at this location.</p> <p>West (RHS): The risk of future slope failure is considered <b>very low</b>.</p> <ul style="list-style-type: none"> <li>Generally sidling cut. Earthworks were completed February 2023 and but minor works at this location are still outstanding.</li> </ul>

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October 2020, Time 6:00 – View in southern direction: East = left-hand side; West = right-hand side



February 2021, Time 5:03 – View in southern direction: East = left-hand side; West = right-hand side





June 2021, Time 5:18 – View in southern direction: East = left-hand side; West = right-hand side



September 2021, Time 5:54 – View in southern direction: East = left-hand side; West = right-hand side

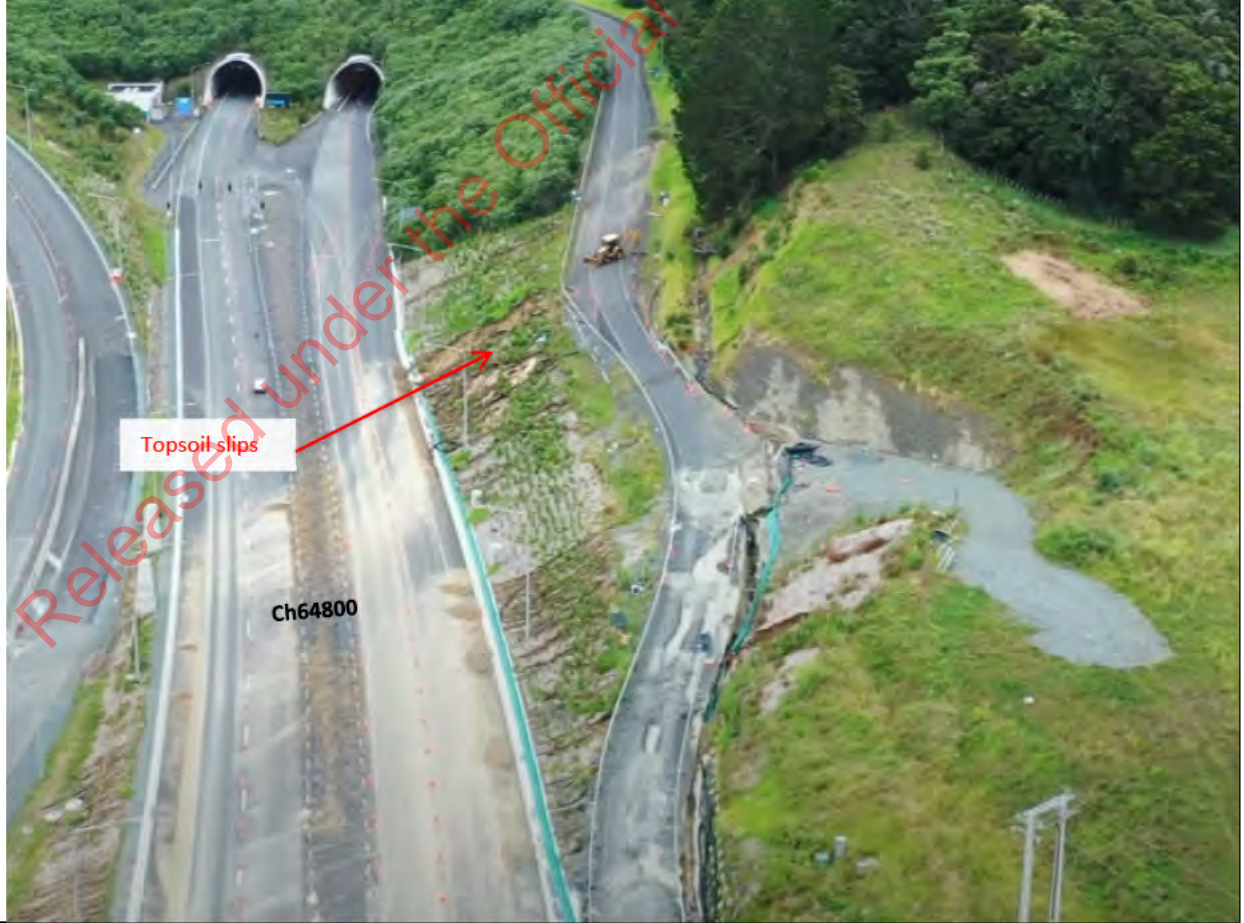




August 2022, Time 5:53 – View in southern direction: East = left-hand side; West = right-hand side



January 2023, Time 6:27 – View in southern direction: East = left-hand side; West = right-hand side





## 8.0 Conclusion

We have identified the following key risk items with regards to future failures and maintenance requirements:

1. Soil slope slips where design models potentially not represent the site conditions adequately, where the actual site conditions differ from those adopted in the design. This includes expected recharging of stormwater or temporary sediment retention ponds or permanent wetlands.
2. Cut slopes which are constructed steeper than the design slopes. **Based on the NCR review, Cut CS13 has been cut steeper than the design batter of 2H:1V at the upper part. Landslips occurred at Cut CS13 during the July 2022 and January 2023 rainfall events. A suitable redesign will be required.**
3. Geological models adopted in the design are not fully representative of the geological conditions in the site.
4. Locations were the alignment transitions from embankments into cut slopes. The side slopes at the transition are over-steepened and may be prone to failure. It is common that groundwater seepage, weathered rock or saturated soils may be present at these transitions. **Slips have occurred at many of these transition zones or additional soil nailing was completed at these locations. No further slips have occurred during the January 2023 rainfall events.**
5. Insufficient inspection and maintenance intervals of slope drainage systems during the design life, which could compromise the slope stability in long-term. **This item needs to be considered during the operation of the motorway.**
6. Locations of softened ground (soil, weathered rock, fill) caused by groundwater seepage or surface water run-off.
7. Rockfall risk from slopes above the mesh drapery. The rockfall risk may result from rock debris on exposed rock slopes. It is noted that the rockfall assessments indicate that the rockfall risk is low. However, potential deterioration of the slope conditions may occur in the future and conditions should be reviewed.
8. Rock cut failures particularly where overhanging rock cuts are present.
9. Surficial failure rock slopes and rockfall behind mesh draping and/or subsequent wedge failures at rock cut slopes between rock bolts or at locations without rock bolts.
10. Unsuitable remedial works design, potentially not addressing the underlying geological issue or being a potential hazard itself, i.e. buttress fill within cut slopes high above rock cuts.
11. Scour/erosion and debris flow from soil slopes or soil-rock interface above rock slopes. These conditions may cause a rock fall risk.
12. Topsoil slumps and surficial erosion, **which have been observed at multiple location following the January 2023 rainfall event.**



Based on our risk assessment at the reviewed cut slope locations, the following occurrences were determined:

- Very low risk: 51
- Low risk: 26
- Low to moderate risk: 14
- Moderate risk: 2
- Moderate to high risk: 0
- High risk: 0

Low to moderate risk of failure or occurrence of risk items were determined at the following 14 cut locations. The reasoning for the assessment is provided for each cut location in Section 7.0.

1. N7A West
2. CN1 West
3. CN5A East
4. CN5B East
5. CN5B West
6. CN12B East
7. CS2D East
8. CS2F East
9. CS5 East
10. CS9G West
11. CS13 West
12. CS16B West
13. CS16D West
14. S4B West

Moderate risk of failure or occurrence of risk items were determined at CN1A East and CS3 East.

The above weighted risk rating applies for the overall risk at each cut slope. Individual risk rating for the six main failure modes may differ from the weighted rating. Details are provided in Appendix A.

Based on our assessment, we recommend that:

- Risk items at the cut locations are reviewed by the designer as summarised in Table 14,
- All high risk and 'moderate to high' risk items to addressed. Based on our latest assessment, there are no high risk and 'moderate to high' risk items which require immediate attention.
- Although, the overall weighted risk at Cuts CN5A and CN5B has been reduced to 'low to moderate', a holistic design review of the various design packages (DEIs) should be undertaken. A comprehensive review will provide more certainty and may reduce the risk rating.
- As-built soil slopes and rock cuts are checked that the batter is not steeper (outside of tolerances) than the design slopes.



- The adopted ground and analysis model is suitable and represents the site conditions.
- Remedial works addresses the underlying geological issue.
- Design checks for rock cuts include near vertical and overhanging rock cut faces.
- To mitigate potential future rockfall risks, visual geological inspection of exposed rock slopes should be carried out as part the general maintenance inspections during operation of SH1. The purpose is to identify any loose rocks or debris on the slope.
- Additional bored drains are installed where ongoing groundwater seepage and softened soils are observed on site.
- Inspections and maintenance of subsoil drains where installed at cut slopes as required for their long-term performance as the slope stability (or required factors of safety) may depend on it.

With regards to rockfall, the following items are recommended:

- The CJV or DJV geotechnical engineers should review based on site observations at each relevant cut slope if further rockfall analyses or assessments are required.
- Conditions at the upper exposed rock slopes may change in the future. The conditions of the rock slopes should be inspected as part of the maintenance scheme. This may include drone flyovers and inspections on the slopes.
- Inspections should include potential deterioration of rock slope conditions, including observation of additional loose rocks or movements of rocks, accumulation of rock debris at the upper bench and swale drains.
- Any rock observed on the carriageway should trigger an immediate review of the slope conditions or geotechnical inspections of the slope.

At cut locations where remedial works are yet to be completed, i.e. Cut N1A, Cut CS13, the new remedial works designs should include existing remedial works.



## Limitations

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*This report presents our geotechnical assessment based on limited amount of site observations, provided field investigations and published geological information only. No inferences should be made regarding the nature and continuity of ground conditions away from the specific test locations.*

*This report presents our geotechnical assessment based on the provided documentation and aerial flyover photos and videos. s 9(2)(b)(ii) and 9(2)(ba)(i) have not carried out any independent analyses. This report is not a peer review of the design or construction works.*

*To the maximum extent permitted by law, s 9(2)(b)(ii) and 9(2)(ba)(i) disclaims all liability and responsibility (in contract or tort, including negligence, or otherwise) for any loss or damage whatsoever which may be suffered as a result of any reliance by any third party on this report, whether that loss is caused by any fault or negligence on the part of s 9(2)(b)(ii) and 9(2)(ba)(i) or otherwise.*

*The Client acknowledges and agrees that the Consultant's employees, directors, officers and agents have no personal liability to the Client in connection with this Agreement or the performance of the Services as it would be unreasonable for the Client to rely on any of them personally. The Client acknowledges and accepts that the Client has relied, and will rely, only on the corporate conduct of the Consultant.*

*Should you be in any doubt as to the applicability of this report for the proposed sites described herein, it is essential that you carry out independent investigations to satisfy your needs.*

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## APPENDIX A – Risk Assessment Summary Table

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Risk Rating	Description
0	Cannot be determined / Not applicable
up to 3.1	Very low risk
3.1 to 6.1	Low risk
6.1 to 9.1	Low to moderate risk
9.1 to 12.1	Moderate risk
12.1 to 15.1	Moderate to high risk
15.1 to 25	High risk

Weighted Rating Factors for Failure Modes

Failure Modes	Weighted Rating
1 Soil Slope Failure	0.30
2 Sliding at Soil-Rock Interface	0.35
3 Rock Slope Failure	0.15
4 Scour/Erosion at soil to cut transition	0.05
5 Rockfall	0.10
6 Topsoil Slip	0.05

Likelihood (L)

1	Very Unlikely/ cannot happen
2	Unlikely/ Has not been observed at the project at similar conditions, could happen in some circumstances
3	Possible/ Conditions may have been or not been observed at the project but are considered possible
4	Likely/ has been observed at the project at similar cuts
5	Very Likely/ has occurred or slip is active/observed at this cut

Consequence (C)

1	Negligible/ deal with standard maintenance/ ignore, no TTM required
2	Minor/ deal with standard maintenance, TTM may be required
3	Moderate/ repair above standard maintenance requirements, TTM required
4	Significant/ road or lane closure (both lanes 1 direction); injury
5	Severe/ long-term road closure (all lanes), significant repair cost; death

No	Cuts facing SH1, Cut Number	East (LHS)	Weighted Rating	Soil Slope Failure			Sliding at Soil-Rock Interface			Rock Cut Failure			Scour/ Erosion at soil to cut transition			Rockfall			Topsoil Slip			
				L	C	R	L	C	R	L	C	R	L	C	R	L	C	R	L	C	R	
1	N2A	Very low risk	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	N2C	Very low risk	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	N2D	Very low risk	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	N2E	Very low risk	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	N1A	Very low risk	1.3	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	N1A East	Moderate risk	9.9	2	4	8	5	4	20	1	1	1	1	1	1	1	1	2	2	4		
7	N4C	Very low risk	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	N4E	Very low risk	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	N3C	Low risk	3.8	2	2	4	2	3	6	1	1	1	1	1	1	1	2	2	4			
10	N3D	Very low risk	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	N3E	Very low risk	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	N7A	Very low risk	3.0	2	2	4	2	2	4	1	1	1	1	1	1	1	1	2	2	4		
13	N7B	Very low risk	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	CN1	Low risk	5.9	2	3	6	2	3	6	2	4	8	2	3	6	1	4	4	1	2	2	2
15	Perry Road Cuts at western side of CN4 fill	Not applicable																				
16	CN5A	Low to moderate risk	8.6	3	4	12	3	4	12	1	1	1	1	1	1	1	3	3	9			
17	CN5B	Low to moderate risk	8.7	3	3	9	2	4	8	3	4	12	3	3	9	2	4	8	1	2	2	2
18	CN7A	Low risk	3.5	2	2	4	2	2	4	1	2	2	2	3	6	1	1	1	2	2	4	
19	CN7B	Low risk	5.7	2	2	4	2	3	6	2	4	8	3	3	9	2	2	4	3	2	6	
20	CN8A	Not applicable																				
21	CN9	Low risk	4.8	1	1	1	2	3	6	2	4	8	2	3	6	2	4	8	1	2	2	2
22	CN12A	Very low risk	2.0	2	2	4	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	2
23	CN12B	Low to moderate risk	7.1	2	4	8	3	4	12	1	1	1	1	1	1	1	1	2	2	4		
24	CN13	Low risk	3.3	1	1	1	2	2	4	2	3	6	3	2	6	1	2	2	2	2	4	
25	CS1 (Moir Hill)	Low risk	5.1	2	2	4	2	3	6	2	3	6	2	2	4	2	3	6	1	2	2	2
26	Moir Hill Widening	Very low risk	2.7	2	3	6	1	1	1	1	1	1	1	1	1	1	1	1	2	2	4	
27	CS2B	Very low risk	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	CS2D	Low to moderate risk	6.2	3	3	9	2	4	8	1	1	1	1	2	2	1	1	1	3	2	6	
29	CS2F	Low to moderate risk	6.3	2	3	6	3	3	9	1	3	3	3	2	6	2	2	4	2	2	4	
30	CS3 (2x slips)	Moderate risk	10.6	3	4	12	3	4	12	2	4	8	3	3	9	3	3	9	2	2	4	
31	CS4 (North)	Low risk	3.4	2	3	6	1	3	3	1	1	1	1	1	1	1	1	1	2	2	4	
32	CS4 (South)	Low risk	3.2	2	3	6	1	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1
33	CS5	Low to moderate risk	6.4	2	2	4	3	3	9	2	3	6	2	3	6	2	3	6	2	2	4	
34	CS7	Very low risk	1.9	2	2	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
35	CS8B	Very low risk	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
36	CS8C	Very low risk	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
37	CS8D	Very low risk	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
38	CS9A	Very low risk	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
39	CS9G	Very low risk	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
40	CS13	Very low risk	1.4	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	2
41	CS15A	Very low risk	2.1	2	2	4	1	1	1	1	1	1	1	1	1	1	1	1	2	2	4	
42	CS15B	Very low risk	1.5	1	1	1	2	1	2	1	1	1	2	1	2	1	1	1	1	2	2	2
43	CS16B	Very low risk	3.0	2	2	4	2	2	4	1	1	1	1	1	1	1	1	1	1	2	2	2
44	CS16D	Low risk	3.55	1	3	3	1	3	3	1	4	4	3	2	6	2	3	6	1	2	2	2
45	S1	Low risk	4.4	2	3	6	2	2	4	2	1	2	2	2	4	2	2	4	3	2	6	
46	WP5	Low risk	3.15	3	1	3	2	2	4	1	1	1	3	2	6	1	1	1	3	2	6	
47	S4B	Not applicable																				
48	S5C	Very low risk	2.75	2	2	4	1	3	3	1	1	1	1	1	1	1	1	1	2	2	4	
49	S7	Very low risk	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

West (RHS)	Weighted Rating	Soil Slope Failure			Sliding at Soil-Rock Interface			Rock Cut Failure			Scour/ Erosion at soil to cut transition			Rockfall			Topsoil Slip					
		L	C	R	L	C	R	L	C	R	L	C	R	L	C	R	L	C	R			
Very low risk	1.3	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Very low risk	1.3	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Very low risk	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Very low risk	2.1	2	2	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	4	
Very low risk	2.0	2	2	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	
Very low risk	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Very low risk	1.9	2	2	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Very low risk	2.7	2	3	6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	4	
Low risk	5.6	2	2	4	2	4	8	1	4	4	3	2	6	2	3	6	2	3	6	2	1	
Very low risk	1.9	2	2	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Low risk	4.4	2	3	6	2	3	6	1	1	1	1	1	1	1	1	1	1	1	2	2	4	
Low to moderate risk	7.4	2	4	8	3	4	12	1	1	1	2	3	6	1	1	1	1	2	2	4		
Low risk	4.3	2	2	4	2	3	6	2	2	4	2	1	2	1	1	1	1	1	2	2	4	
Low to moderate risk	7.1	2	3	6	2	3	6	3	4	12	3	3	9	2	4	8	1	2	2	2	2	
Low risk	3.4	2	2	4	2	2	4	1	1	1	2	2	4	1	1	1	1	3	2	6		
Very low risk	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Low to moderate risk	8.6	2	4	8	2	4	8	3	4	12	3	3	9	2	4	8	2	3	6			
Very low risk	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Low risk	5.8	3	2	6	2	2	4	2	4	8	3	3	9	3	2	6	2	3	6			
Not applicable																						
Very low risk	2.0	1	1	1	1	2	2	1	4	4	2	2	4	1	1	1	1	1	1	1	1	
Very low risk	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Very low risk	1.0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Low risk	5.0	2	2	4	2	3	6	2	3	6	2	2	4	2	2	4	2	2	4	2	4	
Low risk	5.2	2	2	4	2	3	6	2	3	6	2	2	4	2	3	6	2	2	4			



## APPENDIX B – 2021 Site Observation Notes

TO BE ADDED IN FINAL REPORT

LOCATIONS
N3C-C
N7A-C
CN1-C
Perry Road Cuts
CN5A & CN5B
CN7B-C
CS1-C (Moir Hill)
CS2D-C
CS2F-C
CS3-C
CS5-C
CS9A-C
CS9G-C
CS13-C
CS16D-C
S1-C
S4B-C
S5-C

Released under the Official Information Act 1982



# APPENDIX C – Site Observation Notes – July 2022 Landslides

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TO BE ADDED IN FINAL REPORT

DRAFT  
Released under the Official Information Act 1982



# APPENDIX D – Site Observation Notes – February 2023

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TO BE ADDED IN FINAL REPORT

DRAFT  
Released under the Official Information Act 1982