



Appendix E

PC120 Landslide Risk Assessment

LANDSLIDE RISK ASSESSMENT BASED ON PCI20, CHAPTER M, APPENDIX 24



Auckland:
Tel: 09 489 7872
riley@riley.co.nz
Christchurch:
Tel: 03 379 4402
rileychc@riley.co.nz

Project No:	240065	Date:	4-Dec-25
Project Name:	Vineway Russell Road	Check:	JB
Risk assessment critical hazard location selection			
Prepared:	CB	Date:	4-Dec-25
Check:	JB	Date:	5-Dec-25

Site Information and Risk Setting

Desktop Study of Auckland Council Geomaps indicates that site has:

- Multiple mapped landslides within and proximate to site boundaries. For purposes of this assessment, all will be treated as "Recent" landslides (refer to Figure 1 below).
- Variable susceptibility to shallow landslides. For purposes of this assessment, all will be treated as having "High" or "Very High" susceptibility (refer to Figure 2 below).
- Variable susceptibility to deep-seated landslides. For purposes of this assessment, all will be treated as having "High" or "Very High" susceptibility (refer to Figure 3 below).
- Note that mapped landslide susceptibility includes highest landslide susceptibility class mapped within 150m of the site in any direction from which debris could reach the site.
- Based on Geomaps overlays + Riley's experience at the site, we have selected 6 specific locations within the site considered to represent the areas of critical stability risk and have undertaken a PCI20 landslide hazard risk assessment for each. We have also undertaken 1 site-wide assessment of potential landslide impacts on roads and utilities for the entire site.
- The locations of the 6 specific assessments are annotated and numbered in light blue on Figures 1-3 below. The seventh site-wide assessment described above addresses the entire site.
- Each of the 6 location-specific assessments are proximate to proposed residential lots. For the purposes of this assessment, these assessments assume development comprises an Activity sensitive to natural hazards. The activity status of the seventh site-wide assessment is discussed on Page 20.
- Using Table 1 from Appendix 24, this indicates that each of the 6 location-specific assessments for the site will require both Methods 1 and 2 (as seen on Table 1 below). The method selection for the seventh site-wide assessment is discussed on Page 20.
- Individual assessments for all scenarios have their own unique set of scenarios (highest likelihood, median, maximum credible landslides) and risk categories. Refer to individual risk assessments for further information.
- Many of the following assessments have adopted vulnerability values benchmarked on values recommended in the GHD *Waitakere Coastal Communities Landslide Risk Assessment* prepared for Auckland Council, dated 10 January 2024. On recent recovery projects, Council has recommended adopting the vulnerability data outlined in Table E6.1 of this report.
- Many following assessments comment on Riley's stability analysis already undertaken. Where comments are made regarding potential effects of "maximum credible" events, Riley refers to the studies of Meyerhoff (1977), and Wu and Kraft (1970) which indicate a correlation between stability FoS and annual risk of slope failure in order to estimate likely extent of landslide scenarios greater in magnitude than those needing to be analysed as part of normal quantitative stability analysis.

Figure 1: Mapped Landslide Locations from Geomaps



Figure 2: Shallow landslide susceptibility from Geomaps

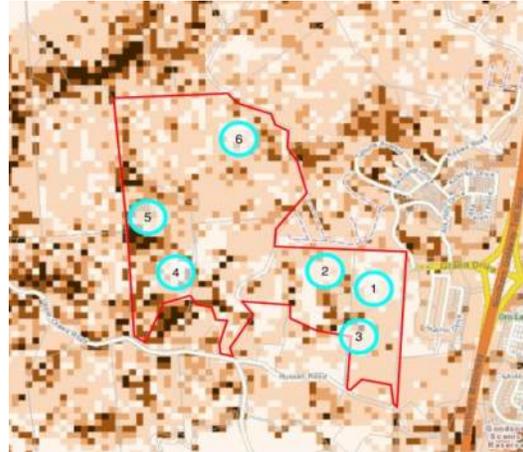


Figure 3: Deep-seated landslide susceptibility from Geomaps

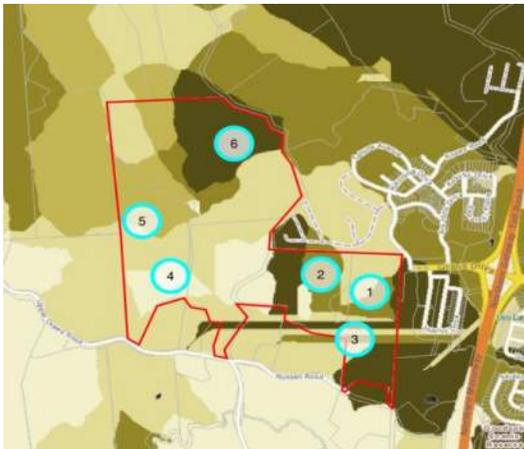


Figure 4: Appendix 24, Table 1 showing methods for assessments 1-6.

Land use activity	Landslide susceptibility class from Auckland Council published landslide susceptibility and landslide inventory maps				
	Recent	Ancient	VH	H	M
Activities sensitive to natural hazards	2	1	2	2	1
Subdivision	2	1	2	2	1
On-site water supply activities	2	1	1	1	1
Activities less sensitive to natural hazards	1	1	1	1	N/A
On-site septic tanks, wastewater treatment and disposal systems, effluent disposal fields, underground storage tanks, water tanks (including rainwater tanks) or stormwater pipes or soakage fields, accessways and private roads	2	1	2	2	1
Re-buildings of materials damaged or destroyed buildings	2	1	2	2	2
Storage of hazardous substances	2	1	1	1	1
Earthworks	1	1	1	1	1
Vegetation alteration or removal	1	1	1	1	1
Discharge of stormwater and/or wastewater directly to ground	1	1	1	1	1

Table 1 - Initial method (1 or 2) to be used to assess landslide risk for each combination of mapped landslide susceptibility and land use activity. Where the method shown is N/A, no further risk assessment is required and the risk can be taken as Low.

Figure 5: Extract from GHD report showing Table E6.1

indicating recommended vulnerability values for overlap and underslip landslides.

Case	Range	Typical value to be used in the assessment	Comments
Person in a building that collapses under impact from debris flow	0.8 - 1.0	0.8	Death to almost certain. Evacuation unlikely to occur
If building is maintained with debris and the person is not buried	0.8 - 1.0	0.8	Very high potential for death. Evacuation unlikely to occur
If building is maintained with debris but no collapse occurs and the person is not buried	0.01 - 0.1	0.1	High chance of survival. Evacuation unlikely to occur
If the debris strikes the building only	0.001 - 0.05	0.01	Very high chance of survival
If failure occurs before the building and results in significant collapse	0.8 - 0.8	0.8	Moderate to high potential for death. The forwarding signs with evacuation unlikely to occur
If failure occurs before the building and results in partial collapse	0.01 - 0.1	0.05	High chance of survival. Signs of building collapse ahead provide occupants with opportunity to take evasive action.
If failure occurs before the building and results in damage. No collapse occurs.	0.001 - 0.05	0.005	Very high chance of survival. Evacuation almost certain.

LANDSLIDE RISK ASSESSMENT BASED ON PC120, CHAPTER M, APPENDIX 24



Auckland:
Tel: 09 489 7872
riley@riley.co.nz
Christchurch:
Tel: 03 379 4402
rileych@riley.co.nz

Project No:	240065	Date:	4-Dec-25
Project Name:	Vineway Russell Road	Date:	5-Dec-25
Prepared:	CB		
Check:	JB		

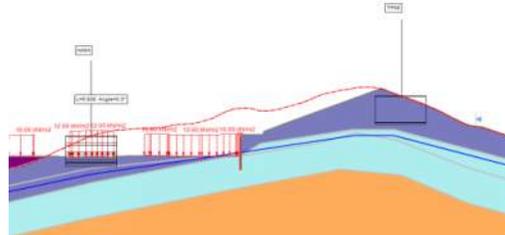
Location Description

Location selected as considered critical risk of inundation by landslide within Stage 1 of development. Assumes landslide occurring upslope of residential lots within eastern part of development. Riley has previously proposed that this cut be supported by a cantilever retaining wall (to be subject to detailed design).

Location on plan



Critical section through hazard showing proposed remedial measures:



HAZARD SCENARIO DESCRIPTIONS	
SCENARIO 1 (median):	Moderate-size landslide comprising significant evacuation of soils from eastern slope, inundating site below. Likely triggered by an extreme rainfall / transient groundwater event OR a ULS seismic event. Failure plane likely to be within residual soil layer.
SCENARIO 2 (most likely):	Small landslide / shallow fritting of a small volume of soil from face of eastern slope, inundating the site below, as a result of "normal" weather conditions over a 100 year period. Event still likely triggered by a relatively heavy (but not extreme / unprecedented) rainfall event. Shallow failure plane entirely within surficial residual soils.
SCENARIO 3 (maximum credible):	Large scale landslide comprising full evacuation of soils, possibly as deep as along soil / rock interface, resulting in large volume of soils inundating site below. Likely triggered by exceptionally large rainfall or seismic event, well beyond what site has previously experienced.

PC120 LANDSLIDE RISK ASSESSMENT METHOD 1

SCENARIO 1 (median)	Initial (no mitigation)	Risk parameter justification	Proposed Mitigation and Effects	Residual (with mitigation)
Likelihood* (Table 3)	Likely	Stability analysis indicates that risk of extreme GW / rainfall event or ULS seismic (1500 year) event could reasonably trigger scenario. Given no obvious signs of instability in this area during 2023 events, recommended at least 1500 year event would be required to trigger moderate size landslide. "Likely" category conservatively adopted.	Proposed retaining wall (RW01) proposed through this area to support eastern slope as part of subdivisional works. Stability analysis indicates adequate FoS with mitigation in place, considered reasonable to assume no injuries and little damage (insignificant).	Likely
Consequence^A (Table 4 or 5)	Minor	Moderate sized landslide likely to cause some inundation of land at toe of slope leading to limited damage to structure requiring repair / some stabilisation works. Considered that 1-10 injuries could be possible, but highly unlikely to cause any deaths. Minor consequence category adopted.		Insignificant
Risk Classification (Table 6)	Medium (Tolerable)			Low (Acceptable)

SCENARIO 2 (most likely)	Initial (no mitigation)	Risk parameter justification	Proposed Mitigation and Effects	Residual (with mitigation)
Likelihood* (Table 3)	Almost Certain	Stability analysis indicates that risk of shallow failure would be almost certain along eastern edge of site within 100 years without mitigation.	Proposed retaining wall (RW01) proposed through this area to support eastern slope as part of subdivisional works. Likelihood of shallow fritting occurring (to a magnitude able to affect building platforms downslope) following construction of walls extremely minimal, so "Likely" category conservatively adopted to simulate a slightly larger event. Consequence of a small evacuation upslope of platform still likely comprises insignificant risk (no injuries / little damage).	Likely
Consequence^A (Table 4 or 5)	Insignificant	Shallow fritting landslide extremely unlikely to cause anything more than extremely minor debris strike / little damage to structures given likely small volume / runout distance of event (insignificant). Highly unlikely that this type of landslide would be capable of causing death or injuries to people at the property (insignificant).		Insignificant
Risk Classification (Table 6)	Medium (Tolerable)			Low (Acceptable)

SCENARIO 3 (max. credible)	Initial (no mitigation)	Risk parameter justification	Proposed Mitigation and Effects	Residual (with mitigation)
Likelihood* (Table 3)	Possible	Intended to represent extraordinarily large magnitude rainfall, well beyond anything site has previously experienced. An absolute minimum 1:1000 event is considered to be on the extremely conservative end of likely return period required to trigger this scenario.	Proposed retaining wall (RW01) proposed through this area to support eastern slope as part of subdivisional works. Stability indicates that wall would effectively mitigate severity of landslide to a point where it may result in minor fritting from top of slope (above wall) only. Likely critical residual consequence comprising debris striking downslope buildings.	Possible
Consequence^A (Table 4 or 5)	Medium	Full soil evacuation likely to result in large scale movement of wider area. Realistically travel distance likely relatively low however significant inundation volume could reasonably cause moderate damage to some of structure / significant part of site requiring stabilisation works (Medium). Realistically 1-10 injuries could occur, however it is unlikely that structures would collapse / people would be buried i.e., death unlikely (Minor). Medium category adopted.	This is unlikely to cause significant damage to structures, however considered plausible it could cause 1-10 injuries in worst case (Minor).	Minor
Risk Classification (Table 6)	Medium (Tolerable)			Low (Acceptable)

Notes:

*Note on Likelihood: Where values / return periods denote rainfall / sea level etc, these include factoring for a SSP8.5 climate change scenario.

^Note on Consequence: taking the highest consequence category across all assessment categories (Human Safety, Lifeline Utilities, Critical Buildings, Community Buildings, Buildings accommodating sensitive activities)

LANDSLIDE RISK ASSESSMENT BASED ON PC120, CHAPTER M, APPENDIX 24



Auckland:
Tel: 09 489 7872
riley@riley.co.nz
Christchurch:
Tel: 03 379 4402
rileychch@riley.co.nz

Project No:	240065	Date:	4-Dec-25
Project Name:	Vineway Russell Road	Date:	5-Dec-25
Prepared:	CB		
Check:	JB		

PC120 LANDSLIDE RISK ASSESSMENT METHOD 2

SCENARIO 1 (median)	Initial (no mitigation)	Risk parameter rational	Proposed Mitigation and Effects	Residual (with mitigation)
P(H) Annual return period* (years)	500	Extreme rainfall event (greater than that experienced during 2023 storms) likely needed to trigger even minor movement of slope given no obvious movement observed during 2023 event (likely approx. 1250 year event). Alternatively some movement could be triggered by US seismic event (MBE defines as 1500 year event). Estimate of 1500 year event adopted.	Proposed retaining wall RW01 proposed through this area to support eastern slope as part of subdivisional works. Stability analysis indicates adequate FoS with mitigation in place for this type of event, decreasing impact probability to nominal value. Critical residual consequence considered extremely minor debris strike at worst, therefore lower end of GHD recommended range adopted.	500
P(S:H) Impact probability	0.5	On top of event trigger above, considered only moderately likely that potential consequence (small volume of soil inundating future dwelling below) could affect building platform downslope.		0.1
P(T:S) Temporal occupancy	0.7	Council recommended occupancy rate for typical residential dwelling.		0.7
V(D:T) Vulnerability	0.01	Most likely consequence considered to be small volume of soil inundating building but no collapse and no people buried. Based on GHD vulnerability recommendations, value at lower end of range adopted. High chance of survival.		0.001
P(LaL) Annual risk of loss of life	7.0E-06			1.4E-07
Subsequent Risk Classification	Medium (Tolerable)			Low (Acceptable)

SCENARIO 2 (most likely)	Initial (no mitigation)	Risk parameter rational	Proposed Mitigation and Effects	Residual (with mitigation)
P(H) Annual return period* (years)	50	Considered likely that a heavy rainfall event (though one considered "normal" over the course of a 100 year period, i.e. a 150 year event) would be required to trigger even extremely minor movement of the slope given lack of obvious historical movement in area despite site likely tolerating higher return period events.	Proposed retaining wall RW01 proposed through this area to support eastern slope as part of subdivisional works. Likelihood of shallow rifting occurring (to a magnitude able to affect building platforms downslope) following construction of walls extremely minimal, so a larger return period event likely required to trigger even extremely minor rifting above wall. Nominal vulnerability adopted as at left, though considered highly conservative for the mitigated scenario.	100
P(S:H) Impact probability	0.5	On top of event trigger above, considered only moderately likely that potential consequence (debris striking the dwelling) could affect building platform downslope.		0.001
P(T:S) Temporal occupancy	0.7	Council recommended occupancy rate for typical residential dwelling.		0.7
V(D:T) Vulnerability	0.001	Most likely consequence considered to be very minor debris striking a future dwelling only. Based on GHD vulnerability recommendations, value at lower end of range adopted. Very high chance of survival.		0.001
P(LaL) Annual risk of loss of life	7.0E-06			7.0E-09
Subsequent Risk Classification	Medium (Tolerable)			Low (Acceptable)

SCENARIO 3 (max. credible)	Initial (no mitigation)	Risk parameter rational	Proposed Mitigation and Effects	Residual (with mitigation)
P(H) Annual return period* (years)	1000	Truly exceptional rainfall event (significantly greater than that experienced during 2023 storms) or seismic event well beyond US likely needed to trigger large scale slope. 11,000 year event considered conservative to represent this scenario.	Proposed retaining wall RW01 proposed through this area to support eastern slope as part of subdivisional works. Former consequence of inundation considered no longer critical, now considered to be potential debris strike from crest of slope above retaining wall. GHD recommended vulnerability value adopted accordingly.	1000
P(S:H) Impact probability	0.1	Slope stability analysis indicates that even in a 11,000 year event, still quite unlikely that large scale movement would occur using equivalent FoS of 1.7 to simulate 11,000 year return period event in line with Meyerhoff (1977 and Wu and Kraft (1976)). Critical consequence likely resulting in building downslope being inundated by debris but not obliteration.		0.1
P(T:S) Temporal occupancy	0.7	Council recommended occupancy rate for typical residential dwelling.		0.7
V(D:T) Vulnerability	0.1	Critical consequence comprising building becoming inundated by debris, but volume of debris considered unlikely to result in collapse + no people are buried. Value in line with GHD recommended vulnerability adopted.		0.01
P(LaL) Annual risk of loss of life	7.0E-06			7.0E-07
Subsequent Risk Classification	Medium (Tolerable)			Low (Acceptable)

Residual Risk Combinations	Combination A	Residual Risk
Scenario 1	Yes	1.4E-07
Scenario 2	Yes	7.0E-09
Scenario 3	Yes	7.0E-07
	Sum of Combined Risk:	8.5E-07
		Low (Acceptable)



Auckland:
Tel: 09 489 7872
riley@riley.co.nz

Christchurch:
Tel: 03 379 4402
rileychc@riley.co.nz

Project No:	240065	Date:	4-Dec-25
Project Name:	Vineway Russell Road	Date:	5-Dec-25
Prepared:	CB		
Check:	JB		

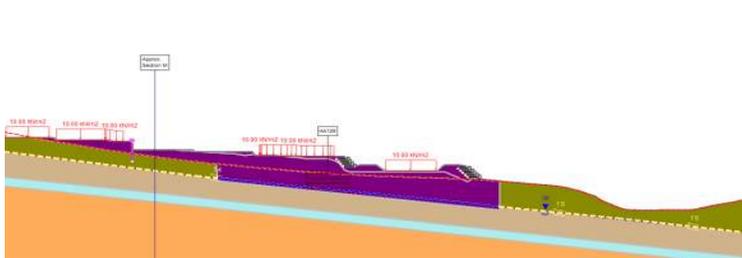
Location Description

Location selected as it is considered critical hazard relating to Northland Allochthon geology within site. Assumes landslide occurring downslope of residential lots within central part of Stage 1. Riley has previously proposed that this cut be supported undercutting Northland Allochthon soils and replacing with engineered fill, all supported by Reinforced Earth Batter walls (to be subject to detailed design).

Location on plan:



Critical section through hazard showing proposed remedial measures:



HAZARD SCENARIO DESCRIPTIONS	
SCENARIO 1 (median):	Deep-seated movement of Northland Allochthon soil over weak layer at soil/rock interface at toe of slope as a result of an extreme rainfall or ULS seismic event. Movement could reasonably reach potential building platforms upslope. Total magnitudes of movement likely relatively low (i.e., <0.1m) but could potentially be widespread across slope.
SCENARIO 2 (most likely):	Slow moving deep-seated creep-like movement of Northland Allochthon soil over weak layer at soil/rock interface at toe of slope as a result of 'normal' weather conditions over a 100 year period. Movement unlikely reach potential building platforms upslope. Total magnitudes of movement likely low but could reasonably be accelerated by a heavy rainfall event to a point where movement becomes noticeable.
SCENARIO 3 (maximum credible):	Wide-spread deep-seated movement of Northland Allochthon soil over weak layer at soil/rock interface at toe of slope as a result of exceptionally large rainfall or seismic event, significantly greater than previously experienced by site. Movement reasonably likely to affect potential building platforms upslope. Again, magnitudes of movement likely relatively modest but potentially greater than Scenarios 1 and 2 above (e.g., possibly in the order of ~0.5m).

PC120 LANDSLIDE RISK ASSESSMENT METHOD 1

SCENARIO 1 (median)	Initial (no mitigation)	Risk parameter justification	Proposed Mitigation and Effects	Residual (with mitigation)
Likelihood* (Table 3)	Likely	Stability analysis indicates that risk of extreme GW / rainfall event could reasonably trigger scenario. Given no obvious signs of instability in this area during 2023 events, recommended at least 1500 year rainfall event (or a ULS seismic 1500 year event) would be required to trigger this scenario. 'Likely' category conservatively adopted.	Proposed excavation of all Northland Allochthon soils (including weak layer at interface of soil / rock) replaced with engineered fill across toe of slope, plus Reinforced Earth Batters constructed downslope as part of subdivisional works. Stability analysis indicates adequate FoS with mitigation in place, considered reasonable to assume no injuries and little damage (Insignificant).	Likely
Consequence^ (Table 4 or 5)	Minor	This scenario could reasonably cause fairly widespread movement but likely only resulting in small magnitudes of movement. This could result in moderate damage to part of a future building platform requiring large stabilisation works to remediate (Medium). Considered that 1-10 injuries could conservatively be possible, but highly unlikely to cause any deaths (Minor). Medium consequence category adopted.		Insignificant
Risk Classification (Table 6)	Medium (Tolerable)			Low (Acceptable)

SCENARIO 2 (most likely)	Initial (no mitigation)	Risk parameter justification	Proposed Mitigation and Effects	Residual (with mitigation)
Likelihood* (Table 3)	Likely	Stability analysis indicates that risk of failure under 'normal' weather / groundwater conditions could occur however it would be quite unlikely for this to actually reach far enough upslope to affect any future building platforms (even without mitigation). 'Likely' category adopted as this risk may not necessarily be realised within 100 years of 'normal' conditions.	Proposed excavation of all Northland Allochthon soils (including weak layer at interface of soil / rock) replaced with engineered fill across toe of slope, plus Reinforced Earth Batters constructed downslope as part of subdivisional works. Proposed works would effectively entirely mitigate risk to a point where the likelihood that 'normal' events could plausibly affect any building platforms decreases significantly. Nominally adopted 'Possible' likelihood category, though acknowledged that initial risk was already Low.	Possible
Consequence^ (Table 4 or 5)	Insignificant	Slow, creep-like movement is extremely unlikely to pose human safety risks, nor cause any specific significant damage to specific building platforms given minimal likelihood that this type of failure could reach a building platform in the first place. Insignificant consequence category adopted.		Insignificant
Risk Classification (Table 6)	Low (Acceptable)			Low (Acceptable)

SCENARIO 3 (max. credible)	Initial (no mitigation)	Risk parameter justification	Proposed Mitigation and Effects	Residual (with mitigation)
Likelihood* (Table 3)	Possible	Intended to represent extraordinarily large magnitude rainfall / seismic event, well beyond anything site has previously experienced. An absolute minimum 11,000 event is considered to be on the extremely conservative end of likely return period required to trigger this scenario.	Proposed excavation of all Northland Allochthon soils (including weak layer at interface of soil / rock) replaced with engineered fill across toe of slope, plus Reinforced Earth Batters constructed downslope as part of subdivisional works. Slope stability analysis indicates that this would likely effectively reduce risk of Medium level damage, however that a small amount of displacement could be expected in case of an extremely large seismic event. Considered conservative that this could lead to some remedial stabilisation works being required (Minor).	Possible
Consequence^ (Table 4 or 5)	Medium	Realistically travel distance of this type of landslide still relatively low to the point where it is considered unlikely to have a significant effect on human safety though several injuries could be considered worst case (Minor). Even though resultant land movement without mitigation would likely be modest, this could cause large stabilisation works to be required. Medium category adopted.		Minor
Risk Classification (Table 6)	Medium (Tolerable)			Low (Acceptable)

Notes:

*Note on Likelihood: Where values / return periods denote rainfall / sea level etc, these include factoring for a SSP8.5 climate change scenario.

^Note on Consequence: taking the highest consequence category across all assessment categories (Human Safety, Lifeline Utilities, Critical Buildings, Community Buildings, Buildings accommodating sensitive activities)

LANDSLIDE RISK ASSESSMENT BASED ON PC120, CHAPTER M, APPENDIX 24



Auckland:
Tel: 09 489 7872
riley@riley.co.nz
Christchurch:
Tel: 03 379 4402
rileychch@riley.co.nz

Project No:	240065	Date:	4-Dec-25
Project Name:	Vineway Russell Road	Date:	5-Dec-25
Prepared:	CB		
Check:	JB		

PC120 LANDSLIDE RISK ASSESSMENT METHOD 2

SCENARIO 1 (median)	Initial (no mitigation)	Risk parameter rational	Proposed Mitigation and Effects	Residual (with mitigation)
P(H) Annual return period* (years)	500	Extreme rainfall event (greater than that experienced during 2023 storms) likely needed to trigger even minor movement of slope given no obvious movement observed during 2023 event (likely approx. 1250 year event). Alternatively some movement could be triggered by US seismic event (MBE defines as 1500 year event). Estimate of 1500 year event adopted.	Proposed excavation of all Northland Allocthon soils (including weak layer at interface of soil / rock) replaced with engineered fill across toe of slope, plus Reinforced Earth Batters constructed downslope as part of subdivisional works. Stability analysis indicates adequate FoS with mitigation in place, considered reasonable to assume only nominal impact probability and further reduction of vulnerability (to lower end of GHD recommended range).	500
P(S:H) Impact probability	0.5	On top of event trigger above, considered only moderately likely that potential consequence (small volume of soil inundating future dwelling below) could affect building platforms upslope.		0.1
P(T:S) Temporal occupancy	0.7	Council recommended occupancy rate for typical residential dwelling.		0.7
V(D:T) Vulnerability	0.005	Most likely consequence considered to be some minor damage to residential dwelling but no collapse. Based on GHD vulnerability recommendations, typical value adopted. Very high chance of survival.		0.001
P(LoL) Annual risk of loss of life	3.5E-06			1.4E-07
Subsequent Risk Classification	Medium (Tolerable)			Low (Acceptable)

SCENARIO 2 (most likely)	Initial (no mitigation)	Risk parameter rational	Proposed Mitigation and Effects	Residual (with mitigation)
P(H) Annual return period* (years)	100	Considered likely that a heavy rainfall event (though one considered 'normal' over the course of a 100 year period, i.e. a 150 year event) would be required to trigger even extremely minor movement of the slope given lack of obvious historical movement in area despite site likely tolerating higher return period events. Furthermore, stability analysis indicates that even a heavy event would unlikely affect any building platforms over a 100 year period, so return period of 100 years considered a conservative estimate.	Proposed excavation of all Northland Allocthon soils (including weak layer at interface of soil / rock) replaced with engineered fill across toe of slope, plus Reinforced Earth Batters constructed downslope as part of subdivisional works. Proposed works would effectively entirely mitigate risk to a point where the likelihood that 'normal' events could plausibly affect any building platforms decreases significantly. Likelihood of event impacting building platforms effectively fully mitigated, and only nominal vulnerability value adopted as at left.	100
P(S:H) Impact probability	0.1	Stability analysis indicates likely that critical consequence (slow, creep-like ground movement of toe of slope) is unlikely to affect building platforms, even without mitigation.		0.01
P(T:S) Temporal occupancy	0.7	Council recommended occupancy rate for typical residential dwelling.		0.7
V(D:T) Vulnerability	0.001	Most likely consequence considered to be extremely minor damage to dwellings, not resulting in any collapse. Nominal value adopted, based on lower end of GHD recommended range. Survival almost certain.		0.001
P(LoL) Annual risk of loss of life	7.0E-07			7.0E-08
Subsequent Risk Classification	Low (Acceptable)			Low (Acceptable)

SCENARIO 3 (max. credible)	Initial (no mitigation)	Risk parameter rational	Proposed Mitigation and Effects	Residual (with mitigation)
P(H) Annual return period* (years)	1000	Truly exceptional rainfall event (significantly greater than that experienced during 2023 storms) or seismic event well beyond US likely needed to trigger large scale slope. 1,000 year event considered conservative to represent this scenario.	Proposed excavation of all Northland Allocthon soils (including weak layer at interface of soil / rock) replaced with engineered fill across toe of slope, plus Reinforced Earth Batters constructed downslope as part of subdivisional works. Slope stability analysis indicates that this would likely reduce probability of damage occurring, however that a small amount of structural damage could still be expected. Vulnerability in line with GHD recommended value now adopted.	1000
P(S:H) Impact probability	1	Slope stability analysis indicates that even in a 1,000 year event, still quite unlikely that large scale movement would occur using equivalent FoS of 1.7 to simulate 1,000 year return period event in line with Meyerhoff (1977 and Wu and Kraft (1970), critical consequence likely resulting in buildings near toe of slope moving as a whole with ground below, i.e. effectively certain that buildings would be affected.		0.2
P(T:S) Temporal occupancy	0.7	Council recommended occupancy rate for typical residential dwelling.		0.7
V(D:T) Vulnerability	0.01	Critical consequence comprising building sliding along with ground below, however given that travel distance likely minimal, some damage to structures expected but no collapse expected. Adopted value at high end of GHD recommended range to simulate more severe damage than Scenarios 1 or 2.		0.005
P(LoL) Annual risk of loss of life	7.0E-06			7.0E-07
Subsequent Risk Classification	Medium (Tolerable)			Low (Acceptable)

Residual Risk Combinations	Combination A	Residual Risk
Scenario 1	Yes	1.4E-07
Scenario 2	Yes	7.0E-08
Scenario 3	Yes	7.0E-07
	Sum of Combined Risk:	9.1E-07
		Low (Acceptable)



Auckland:
Tel: 09 489 7872
riley@riley.co.nz
Christchurch:
Tel: 03 379 4402
rileychch@riley.co.nz

Project No:	240065	Date:	4-Dec-25
Project Name:	Vineway Russell Road	Date:	5-Dec-25
Prepared:	CB		
Check:	JB		

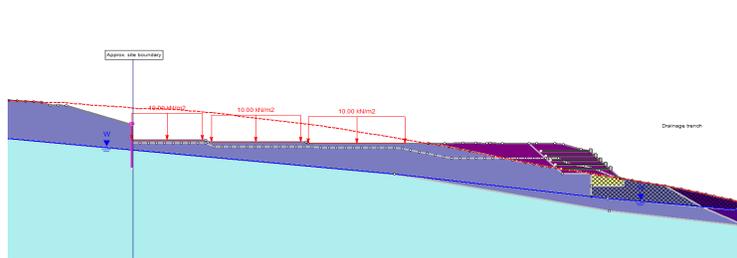
Location Description

Location selected due to several residential lots proposed close to relatively steep slopes both above and below. Landslides could occur either upslope or downslope of residential lots within southern part of development. Riley previously proposed that upslope cut (near boundary) be supported by a cantilever retaining wall and downslope fill be supported by Reinforced Earth Batter.

Location on plan:



Critical section through hazard showing proposed remedial measures:



HAZARD SCENARIO DESCRIPTIONS	
SCENARIO 1 (median):	Moderate-size landslide comprising significant evacuation of soils from proposed north-eastern fill slope downslope of building platforms. Likely triggered by an extreme rainfall / transient groundwater event OR a US seismic event. Failure plane likely to be within residual soil layer.
SCENARIO 2 (most likely):	Small landslide / shallow fritturing of soils upslope (south-west) of building platforms as a result of "normal" weather conditions over a 100 year period. Event still likely triggered by a relatively heavy (but not extreme / unprecedented) rainfall event. Shallow failure plane likely within proposed filled soils due to steepness of proposed slope.
SCENARIO 3 (maximum credible):	Large scale landslide comprising full evacuation of soils from both upslope and downslope (likely two separate landslides as opposed to one large one). Failure plane still likely within residual and/or filled soils. Likely triggered by exceptionally large rainfall or seismic event, well beyond what site has previously experienced.

PC120 LANDSLIDE RISK ASSESSMENT METHOD 1

SCENARIO 1 (median)	Initial (no mitigation)	Risk parameter justification	Proposed Mitigation and Effects	Residual (with mitigation)
Likelihood* (Table 3)	Likely	Stability analysis indicates that risk of extreme GW / rainfall event or US seismic event could reasonably trigger this scenario. Considered reasonable that it would require at least at 1500 year event to trigger this type of landslide. "likely" category conservatively adopted.	Proposed Reinforced Earth Batter REB0x2B proposed downslope of building platforms to support north-eastern slope as part of subdivisional works. Stability analysis indicates adequate FOS with mitigation in place, considered reasonable to assume no injuries and little damage (insignificant).	Likely
Consequence^ (Table 4 or 5)	Minor	Moderate sized landslide likely to result in loss of land downslope of building platforms, potentially requiring some repair / some stabilisation works (Minor). Considered that 1-10 injuries could be possible, but highly unlikely to cause any deaths (Minor). Minor consequence category adopted.		Insignificant
Risk Classification (Table 6)	Medium (Tolerable)			Low (Acceptable)

SCENARIO 2 (most likely)	Initial (no mitigation)	Risk parameter justification	Proposed Mitigation and Effects	Residual (with mitigation)
Likelihood* (Table 3)	Likely	Stability analysis indicates that there is plausible but unlikely risk of shallow failure along upslope south-western edge of site within 100 years without mitigation.	Proposed retaining wall RW12 proposed upslope of building platforms to support south-western slope as part of subdivisional works. Likelihood of shallow fritturing occurring (to a magnitude able to affect building platforms downslope) following construction of walls extremely minimal, so the residual consequence of a small evacuation upslope of platform likely comprises insignificant risk (no injuries / little damage).	Likely
Consequence^ (Table 4 or 5)	Minor	Shallow fritturing landslide extremely unlikely to cause anything more than debris strike / little damage to structures given likely small volume / runout distance of event (insignificant). Unlikely that this type of landslide could realistically cause death but consider it plausible that 1-10 people injured represents conservative estimate (Minor).		Insignificant
Risk Classification (Table 6)	Medium (Tolerable)			Low (Acceptable)

SCENARIO 3 (max. credible)	Initial (no mitigation)	Risk parameter justification	Proposed Mitigation and Effects	Residual (with mitigation)
Likelihood* (Table 3)	Possible	intended to represent extraordinarily large magnitude rainfall, well beyond anything site has previously experienced. An absolute minimum 11,000 event is considered to be on the extremely conservative end of likely return period required to trigger this scenario.	As above, proposed cantilever retaining wall upslope and Reinforced Earth Batter downslope proposed as part of subdivisional works. Stability indicates that walls would effectively mitigate severity of landslide to a point where risk of overslip effectively fully mitigated (insignificant) though conservatively allowing for some Minor damage / few injuries for under-slip damage.	Possible
Consequence^ (Table 4 or 5)	Medium	Full soil evacuation likely to result in large scale under-slip below building platforms but still relatively minor magnitude overslip from above. Critical consequence likely corresponds to few injuries (Minor) and/or damage requiring some reasonably large scale remedial works (Medium). Medium category adopted.		Minor
Risk Classification (Table 6)	Medium (Tolerable)			Low (Acceptable)

Notes:

*Note on Likelihood: Where values / return periods denote rainfall / sea level etc, these include factoring for a SSP8.5 climate change scenario.

^Note on Consequence: taking the highest consequence category across all assessment categories (Human Safety, Lifeline Utilities, Critical Buildings, Community Buildings, Buildings accommodating sensitive activities)

LANDSLIDE RISK ASSESSMENT BASED ON PC120, CHAPTER M, APPENDIX 24



Auckland:
Tel: 09 489 7872
riley@riley.co.nz
Christchurch:
Tel: 03 379 4402
rileychc@riley.co.nz

Project No:	240065	Date:	4-Dec-25
Project Name:	Vineway Russell Road	Date:	5-Dec-25
Prepared:	CB		
Check:	JB		

PC120 LANDSLIDE RISK ASSESSMENT METHOD 2

SCENARIO 1 (median)	Initial (no mitigation)	Risk parameter rational	Proposed Mitigation and Effects	Residual (with mitigation)
P(H) Annual return period* (years)	500	Extreme rainfall event (greater than that experienced during 2023 storms) likely needed to trigger even minor movement of slope. Alternatively some movement could be triggered by US seismic event (MBE defines as 1500 year event). Estimate of 1500 year event adopted.	Proposed Reinforced Earth Batter REB02B proposed downslope of building platforms to support north-eastern slope as part of subdivisional works. Stability analysis indicates adequate FoS with mitigation in place for this type of event, further decreasing impact probability. Critical residual consequence considered to be minor damage to upslope building but no collapse, with recommended GHD value adopted.	500
P(S:H) Impact probability	0.2	On top of event trigger above, slope stability results indicate it is unlikely that potential consequence (underslip downslope of building platforms) would be capable of reaching building platforms.		0.1
P(T:S) Temporal occupancy	0.7	Council recommended occupancy rate for typical residential dwelling.		0.7
V(D:T)Vulnerability	0.005	Most likely consequence from underslip below building platforms considered to be structural damage to building but no collapse. Based on GHD vulnerability recommendations based on Karekare and Pihā landslides, recommended value adopted. High chance of survival.		0.005
P(LoL) Annual risk of loss of life	1.4E-06			7.0E-07
Subsequent Risk Classification	Medium (Tolerable)			Low (Acceptable)

SCENARIO 2 (most likely)	Initial (no mitigation)	Risk parameter rational	Proposed Mitigation and Effects	Residual (with mitigation)
P(H) Annual return period* (years)	100	Considered likely that a very heavy rainfall event (though one technically considered 'normal' over the course of a 100 year period) would be required to trigger even extremely minor movement of the slope above building platforms.	Proposed retaining wall RW12 proposed upslope of building platforms to support south-western slope as part of subdivisional works. Likelihood of shallow fritting occurring (to a magnitude able to affect building platforms downslope) following construction of walls extremely minimal, nominal value adopted. Vulnerability also reduced to lower end of recommended range due to overslip risk effectively being fully mitigated.	100
P(S:H) Impact probability	0.1	On top of event trigger above, considered only modestly likely that potential consequence (debris strike from debris fritting from slope above) could reasonably affect building platform downslope.		0.01
P(T:S) Temporal occupancy	0.7	Council recommended occupancy rate for typical residential dwelling.		0.7
V(D:T)Vulnerability	0.01	Most likely consequence involves debris striking the dwelling resulting in minor damage. Very high chance of survival. Based on GHD vulnerability recommendations based on Karekare and Pihā landslides, recommended value adopted.		0.001
P(LoL) Annual risk of loss of life	7.0E-06			7.0E-08
Subsequent Risk Classification	Medium (Tolerable)			Low (Acceptable)

SCENARIO 3 (max. credible)	Initial (no mitigation)	Risk parameter rational	Proposed Mitigation and Effects	Residual (with mitigation)
P(H) Annual return period* (years)	2000	Truly exceptional rainfall event (significantly greater than that experienced during 2023 storms) or seismic event well beyond US likely needed to trigger large scale slope instability upslope and/or downslope of building platforms. 12000 year event considered conservative to represent this scenario.	As above, proposed cantilever retaining wall upslope and Reinforced Earth Batter downslope proposed as part of subdivisional works. Potential impact probability further reduced (from the REB downslope) and potential consequence likely being less severe damage to the structure, therefore vulnerability reduced to GHD recommended value.	2000
P(S:H) Impact probability	0.3	Slope stability analysis indicates that even in a 12000 year event, still quite unlikely that large scale movement would occur using equivalent FoS of 1.8 to simulate greater than a 11,000 year return period event in line with Meyerhoff (1977 and Wu and Kraft (1970). Critical consequence realistically likely from large underslip undermining building platforms, though considered only modestly likely that this could reach far enough upslope to cause significant damage.		0.1
P(T:S) Temporal occupancy	0.7	Council recommended occupancy rate for typical residential dwelling.		0.7
V(D:T)Vulnerability	0.05	Most likely consequence from underslip below building platforms considered to be structural damage to building but no collapse. Value at high end of GHD recommended values adopted to simulate more severe consequence than Scenario 1 above.		0.005
P(LoL) Annual risk of loss of life	5.3E-06			1.8E-07
Subsequent Risk Classification	Medium (Tolerable)			Low (Acceptable)

Residual Risk Combinations	Combination A	Residual Risk
Scenario 1	Yes	7.0E-07
Scenario 2	Yes	7.0E-08
Scenario 3	Yes	1.8E-07
	Sum of Combined Risk:	9.5E-07
		Low (Acceptable)



Auckland:
Tel: 09 489 7872
riley@riley.co.nz
Christchurch:
Tel: 03 379 4402
rileych@riley.co.nz

Project No:	240065	Date:	4-Dec-25
Project Name:	Vineway Russell Road	Date:	5-Dec-25
Prepared:	CB		
Check:	JB		

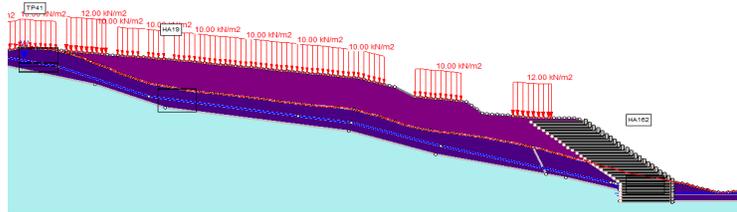
Location Description

Location selected due to several residential lots proposed just above steep fill batter falling away into gully, with potential risks of underslips affecting development. Riley previously proposed that fill batter be supported by a Reinforced Earth Batter underlain by both counterfort drains and a shear key.

Location on plan:



Critical section through hazard showing proposed remedial measures:



HAZARD SCENARIO DESCRIPTIONS	
SCENARIO 1 (median):	Relatively large landslide comprising significant evacuation of soils across fill batter (assuming no mitigation) downslope of proposed building platforms. Likely triggered by an extreme rainfall / transient groundwater event.
SCENARIO 2 (most likely):	Small landslide / shallow fringing of soils downslope of building platforms as a result of "normal" weather conditions over a 100 year period. Event still likely triggered by a relatively heavy (but not extreme / unprecedented) rainfall event. Shallow failure plane likely within proposed fill batter (assuming no mitigation) due to steepness of proposed slope.
SCENARIO 3 (maximum credible):	Very large scale landslide comprising full evacuation of large amount of soil (potentially both fill and underlying residual soils, assuming no mitigation). Likely triggered by exceptionally large rainfall or seismic event, well beyond what site has previously experienced.

PC120 LANDSLIDE RISK ASSESSMENT METHOD 1

SCENARIO 1 (median)	Initial (no mitigation)	Risk parameter justification	Proposed Mitigation and Effects	Residual (with mitigation)
Likelihood* (Table 3)	Likely	Stability analysis indicates that risk of extreme groundwater / rainfall event (or ULS seismic event though this likely does not represent the critical event) could reasonably trigger this scenario. Considered reasonable that it would require at least at 1500 year event to trigger this type of landslide. "likely" category conservatively adopted.	Proposed REB underlain by a shear key and counterfort drains proposed as part of subdivisional works. Stability analysis indicates adequate FoS with mitigation in place, considered reasonable to assume no injuries and little damage (insignificant).	Likely
Consequence^ (Table 4 or 5)	Minor	Relatively large landslide likely to result in loss of land downslope of building platforms, potentially requiring some repair / some stabilisation works (Minor). Considered that 1-10 injuries could be possible, but highly unlikely to cause any deaths (Minor). Medium consequence category adopted.		Insignificant
Risk Classification (Table 6)	Medium (Tolerable)			Low (Acceptable)

SCENARIO 2 (most likely)	Initial (no mitigation)	Risk parameter justification	Proposed Mitigation and Effects	Residual (with mitigation)
Likelihood* (Table 3)	Almost Certain	Stability analysis indicates that there is a risk of shallow failure within the fill batter within 100 years without mitigation. This would likely need to be triggered by a heavy rainfall event, though one with a relatively frequent return period.	Proposed REB underlain by a shear key and counterfort drains proposed as part of subdivisional works. Likelihood of shallow fringing occurring (to a magnitude able to affect building platforms upslope) following construction of mitigation measures extremely minimal, so the residual likelihood now intended to represent an event with a less frequent return period (more in line with "likely" range) and residual consequence posing insignificant risk (no injuries / little damage).	Likely
Consequence^ (Table 4 or 5)	Insignificant	Due to modest magnitude of shallow fringing landslide, this likely would not be capable of causing injury and little damage would be expected to buildings. Insignificant category adopted.		Insignificant
Risk Classification (Table 6)	Medium (Tolerable)			Low (Acceptable)

SCENARIO 3 (max. credible)	Initial (no mitigation)	Risk parameter justification	Proposed Mitigation and Effects	Residual (with mitigation)
Likelihood* (Table 3)	Possible	Intended to represent extraordinarily large magnitude rainfall, well beyond anything site has previously experienced. An absolute minimum 1:1000 event is considered to be on the extremely conservative end of likely return period required to trigger this scenario.	Proposed REB underlain by a shear key and counterfort drains proposed as part of subdivisional works. Stability indicates that walls would effectively mitigate severity of landslide to a point where damage significantly mitigated, however conservatively allowing for some Minor damage / few injuries for underslip damage in case severity of event is larger than expected.	Possible
Consequence^ (Table 4 or 5)	Medium	Full soil evacuation likely to result in large scale underslip below building platforms potentially undermining future building platforms. Critical consequence likely corresponds to few injuries (Minor) and/or damage requiring some reasonably large scale remedial works (Medium). Medium category adopted.		Minor
Risk Classification (Table 6)	Medium (Tolerable)			Low (Acceptable)

Notes:

*Note on Likelihood: Where values / return periods denote rainfall / sea level etc, these include factoring for a SSP8.5 climate change scenario.

^Note on Consequence: taking the highest consequence category across all assessment categories (Human Safety, Lifeline Utilities, Critical Buildings, Community Buildings, Buildings accommodating sensitive activities)

LANDSLIDE RISK ASSESSMENT BASED ON PC120, CHAPTER M, APPENDIX 24



Auckland:
Tel: 09 489 7872
riley@riley.co.nz
Christchurch:
Tel: 03 379 4402
rileychr@riley.co.nz

Project No:	240065	Date:	4-Dec-25
Project Name:	Vineway Russell Road	Date:	5-Dec-25
Prepared:	CB		
Check:	JB		

PC120 LANDSLIDE RISK ASSESSMENT METHOD 2

SCENARIO 1 (median)	Initial (no mitigation)	Risk parameter rational	Proposed Mitigation and Effects	Residual (with mitigation)
P(H) Annual return period* (years)	500	Extreme rainfall event (greater than that experienced during 2023 storms) likely needed to trigger even minor movement of slope. Alternatively some movement could be triggered by US seismic event (MBE defines as 1500 year event). Estimate of 1500 year event adopted.	Proposed REB underlain by a shear key and counterfort drains proposed as part of subdivisional works. Stability analysis indicates adequate FoS with mitigation in place for this type of event, reducing critical residual consequence to lower end of GHD recommended range (even if retaining relatively conservative impact probability).	500
P(S,H) Impact probability	0.1	On top of event trigger above, critical consequence (damage to building but not great enough to cause collapse) would be capable of affecting building platforms even without mitigation.		0.1
P(T,S) Temporal occupancy	0.7	Council recommended occupancy rate for typical residential dwelling.		0.7
V(D,T)Vulnerability	0.05	Most likely consequence from underlip downslope of nearby building platform considered to be structural damage to building but not great enough to cause collapse. Based on GHD vulnerability recommendations, value at upper end of range adopted. High chance of survival.		0.001
P(LoL) Annual risk of loss of life	7.0E-06			1.4E-07
Subsequent Risk Classification	Medium (Tolerable)			Low (Acceptable)

SCENARIO 2 (most likely)	Initial (no mitigation)	Risk parameter rational	Proposed Mitigation and Effects	Residual (with mitigation)
P(H) Annual return period* (years)	50	Considered likely that a very heavy rainfall event (though one technically considered 'normal' over the course of a 100 year period) would be required to trigger even extremely minor movement of the slope above building platforms.	Proposed REB underlain by a shear key and counterfort drains proposed as part of subdivisional works. Stability analysis indicates adequate FoS with mitigation in place for this type of event, indicating that impact probability effectively fully mitigated (nominal value adopted) reducing critical residual consequence to lower end of GHD recommended range (even if retaining relatively conservative impact probability).	50
P(S,H) Impact probability	0.1	On top of event trigger above, critical consequence (damage to building but not great enough to cause collapse) would be capable of affecting building platforms even without mitigation.		0.01
P(T,S) Temporal occupancy	0.7	Council recommended occupancy rate for typical residential dwelling.		0.7
V(D,T)Vulnerability	0.005	Most likely consequence involves undermining the leading edge of the dwelling causing damage but no collapse. Very high chance of survival. Based on GHD vulnerability recommendations, typical value adopted.		0.001
P(LoL) Annual risk of loss of life	7.0E-06			1.4E-07
Subsequent Risk Classification	Medium (Tolerable)			Low (Acceptable)

SCENARIO 3 (max. credible)	Initial (no mitigation)	Risk parameter rational	Proposed Mitigation and Effects	Residual (with mitigation)
P(H) Annual return period* (years)	1000	Truly exceptional rainfall event (significantly greater than that experienced during 2023 storms) or seismic event well beyond US likely needed to trigger large scale slope instability upslope and/or downslope of building platforms. 11000 year event considered conservative to represent this scenario.	Proposed REB underlain by a shear key and counterfort drains proposed as part of subdivisional works. Stability analysis indicates that even if this type of event were to happen, with mitigation in place, damage would likely be relatively minor. Subsequent decreases to impact probability and critical residual consequence to GHD recommended values considered appropriate.	1000
P(S,H) Impact probability	0.1	On top of event trigger above, critical consequence (damage to building but not great enough to cause collapse) would be capable of affecting building platforms even without mitigation.		0.05
P(T,S) Temporal occupancy	0.7	Council recommended occupancy rate for typical residential dwelling.		0.7
V(D,T)Vulnerability	0.05	Most likely consequence from underlip below building platforms considered to be structural damage to building but no collapse (i.e. likely magnitude probably similar to Scenario 1 above). Based on GHD vulnerability recommendations, value at upper end of range adopted. High chance of survival.		0.005
P(LoL) Annual risk of loss of life	3.5E-06			1.8E-07
Subsequent Risk Classification	Medium (Tolerable)			Low (Acceptable)

Residual Risk Combinations	Combination A	Residual Risk
Scenario 1	Yes	1.4E-07
Scenario 2	Yes	1.4E-07
Scenario 3	Yes	1.8E-07
	Sum of Combined Risk:	4.6E-07
		Low (Acceptable)

LANDSLIDE RISK ASSESSMENT BASED ON PC120, CHAPTER M, APPENDIX 24



Auckland:
Tel: 09 489 7872
riley@riley.co.nz
Christchurch:
Tel: 03 379 4402
rileychc@riley.co.nz

Project No:	240065	Date:	4-Dec-25
Project Name:	Vineway Russell Road	Date:	5-Dec-25
Prepared:	CB		
Check:	JB		

PC120 LANDSLIDE RISK ASSESSMENT METHOD 2

SCENARIO 1 (median)	Initial (no mitigation)	Risk parameter rationale	Proposed Mitigation and Effects	Residual (with mitigation)
P(H) Annual return period* (years)	500	Extreme rainfall event likely needed to trigger even minor movement of slope. Alternatively some movement could be triggered by ULS seismic event. Estimate of 1500 year event adopted.	Proposed array of soil nails proposed across crest of slope to support western slope as part of subdivisional works. Stability analysis indicates adequate FoS with mitigation in place for this type of event, decreasing impact probability and critical consequence to nominal values only (and specifically for vulnerability, lower end of GHD recommended range adopted.	500
P(S:H) Impact probability	0.5	On top of event trigger above, considered reasonably likely that potential consequence (small volume of soil inundating future dwelling below) could affect building platform downslope.		0.1
P(T:S) Temporal occupancy	0.7	Council recommended occupancy rate for typical residential dwelling.		0.7
V(D:T) Vulnerability	0.01	Most likely consequence considered to be small volume of soil inundating building but no collapse and no people buried. Based on GHD vulnerability recommendations, typical value adopted. High chance of survival.		0.001
P(LoL) Annual risk of loss of life	7.0E-06			1.4E-07
Subsequent Risk Classification	Medium (Tolerable)			Low (Acceptable)

SCENARIO 2 (most likely)	Initial (no mitigation)	Risk parameter rationale	Proposed Mitigation and Effects	Residual (with mitigation)
P(H) Annual return period* (years)	50	Considered likely that a heavy rainfall event (though one considered "normal" over the course of a 100 year period, i.e. a 150 year event) would be required to trigger even extremely minor movement of the slope given lack of obvious historical movement in area despite site likely tolerating higher return period events.	Proposed array of soil nails proposed across crest of slope to support western slope as part of subdivisional works. Likelihood of shallow rifting occurring (to a magnitude able to affect building platforms downslope) following construction of soil nails extremely minimal, so a larger return period event likely required to trigger even extremely minor rifting above wall. Nominal vulnerability adopted as at left, though considered highly conservative for the mitigated scenario.	100
P(S:H) Impact probability	0.5	On top of event trigger above, considered only moderately likely that potential consequence (debris striking a dwelling) could affect building platforms downslope.		0.001
P(T:S) Temporal occupancy	0.7	Council recommended occupancy rate for typical residential dwelling.		0.7
V(D:T) Vulnerability	0.001	Most likely consequence considered to be very minor debris striking a future dwelling only. Based on GHD vulnerability recommendations, value at lower end of range adopted. Very high chance of survival.		0.001
P(LoL) Annual risk of loss of life	7.0E-06			7.0E-09
Subsequent Risk Classification	Medium (Tolerable)			Low (Acceptable)

SCENARIO 3 (max. credible)	Initial (no mitigation)	Risk parameter rationale	Proposed Mitigation and Effects	Residual (with mitigation)
P(H) Annual return period* (years)	1000	Truly exceptional rainfall event (significantly greater than that experienced during 2023 storms) or seismic event well beyond ULS likely needed to trigger large scale slope. 11,000 year event considered conservative to represent this scenario.	Proposed array of soil nails proposed across crest of slope to support western slope as part of subdivisional works. Former consequence of inundation considered no longer considered possible; critical consequence now considered to be potential debris strike from crest of slope above retaining wall. GHD recommended vulnerability value adopted accordingly.	1000
P(S:H) Impact probability	0.1	Slope stability analysis indicates that even in a 11,000 year event, still quite unlikely that large scale movement would occur using equivalent FoS of 1.7 to simulate 11,000 year return period event in line with Meyerhoff (1977 and Wu and Kraft (1970). Critical consequence likely resulting in building downslope being inundated by debris but not collapses.		0.1
P(T:S) Temporal occupancy	0.7	Council recommended occupancy rate for typical residential dwelling.		0.7
V(D:T) Vulnerability	0.1	Critical consequence comprising building becoming inundated by debris, but volume of debris considered unlikely to result in collapse + no people are buried. Value in line with GHD recommended vulnerability adopted.		0.01
P(LoL) Annual risk of loss of life	7.0E-06			7.0E-07
Subsequent Risk Classification	Medium (Tolerable)			Low (Acceptable)

Residual Risk Combinations	Combination A	Residual Risk
Scenario 1	Yes	1.4E-07
Scenario 2	Yes	7.0E-09
Scenario 3	Yes	7.0E-07
	Sum of Combined Risk:	8.5E-07
		Low (Acceptable)

LANDSLIDE RISK ASSESSMENT BASED ON PC120, CHAPTER M, APPENDIX 24



Auckland:
Tel: 09 489 7872
riley@riley.co.nz
Christchurch:
Tel: 03 379 4402
rileych@riley.co.nz

Project No:	240065	Date:	4-Dec-25
Project Name:	Vineway Russell Road	Date:	5-Dec-25
Prepared:	CB		
Check:	JB		

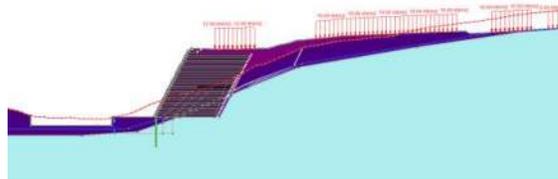
Location Description

Location selected due to several residential lots proposed just above steep fill batter falling away into gully, with potential risks of underslips affecting development. Riley previously proposed that fill batter be supported by a Reinforced Earth Batter underlain by both counterfort drains and a shear key.

Location on plan:



Critical section through hazard showing proposed remedial measures:



HAZARD SCENARIO DESCRIPTIONS	
SCENARIO 1 (median):	Relatively large landslide comprising significant evacuation of soils across fill batter (assuming no mitigation) downslope of proposed building platforms. Likely triggered by an extreme rainfall / transient groundwater event.
SCENARIO 2 (most likely):	Small landslide / shallow frttering of soils downslope of building platforms as a result of "normal" weather conditions over a 100 year period. Event still likely triggered by a relatively heavy (but not extreme / unprecedented) rainfall event. Shallow failure plane likely within proposed fill batter (assuming no mitigation) due to steepness of proposed slope.
SCENARIO 3 (maximum credible):	Very large scale landslide comprising full evacuation of large amount of soil (potentially both fill and underlying residual soils, assuming no mitigation). Likely triggered by exceptionally large rainfall or seismic event, well beyond what site has previously experienced.

PC120 LANDSLIDE RISK ASSESSMENT METHOD 1

SCENARIO 1 (median)	Initial (no mitigation)	Risk parameter justification	Proposed Mitigation and Effects	Residual (with mitigation)
Likelihood* (Table 3)	Likely	Stability analysis indicates that risk of extreme groundwater / rainfall event (or ULS seismic event though this likely does not represent the critical event) could reasonably trigger this scenario. Considered reasonable that it would require at least at 1500 year event to trigger this type of landslide. "likely" category conservatively adopted.	Proposed REB underlain by shear piles proposed as part of subdivisional works. Stability analysis indicates adequate FoS with mitigation in place, considered reasonable to assume no injuries and little damage (insignificant).	Likely
Consequence^ (Table 4 or 5)	Minor	Relatively large landslide likely to result in loss of land downslope of building platforms, potentially requiring some repair / some stabilisation works (Minor). Considered that 1-10 injuries could be possible, but highly unlikely to cause any deaths (Minor). Medium consequence category adopted.		Insignificant
Risk Classification (Table 6)	Medium (Tolerable)			Low (Acceptable)

SCENARIO 2 (most likely)	Initial (no mitigation)	Risk parameter justification	Proposed Mitigation and Effects	Residual (with mitigation)
Likelihood* (Table 3)	Almost Certain	Stability analysis indicates that there is a risk of shallow failure within the fill batter within 100 years without mitigation. This would likely need to be triggered by a heavy rainfall event, though one with a relatively frequent return period.	Proposed REB underlain by shear piles proposed as part of subdivisional works. Likelihood of shallow frttering occurring (to a magnitude able to affect building platforms upslope) following construction of mitigation measures effectively fully mitigated, so the residual likelihood would be unlikely to occur over a 100 year period (i.e., in accordance with "likely" category) and residual consequence posing insignificant risk (no injuries / little damage).	Likely
Consequence^ (Table 4 or 5)	Insignificant	Due to modest magnitude of shallow frttering landslide, this likely would not capable of causing injury and little damage would be expected to buildings. Insignificant category adopted.		Insignificant
Risk Classification (Table 6)	Medium (Tolerable)			Low (Acceptable)

SCENARIO 3 (max. credible)	Initial (no mitigation)	Risk parameter justification	Proposed Mitigation and Effects	Residual (with mitigation)
Likelihood* (Table 3)	Possible	Intended to represent extraordinarily large magnitude rainfall, well beyond anything site has previously experienced. In order to differentiate consequence below from a Scenario 1 landslide, it is intended that in order to cause significant further damage, an absolute minimum of a 12,000 year event would be required to trigger this scenario.	Proposed REB underlain by shear piles proposed as part of subdivisional works. Stability indicates that walls would effectively mitigate severity of landslide to a point where damage significantly mitigated, however conservatively allowing for some Minor damage / few injuries for underslip damage in case severity of event is larger than expected (though considered this would need to represent a barely credible event where there is a large rotational failure through the rock below.	Possible
Consequence^ (Table 4 or 5)	Medium	Full soil evacuation likely to result in large scale underslip below building platforms potentially undermining future building platforms. Critical consequence likely corresponds to few injuries (Minor) and/or damage requiring some reasonably large scale remedial works (Medium). Medium category adopted.		Minor
Risk Classification (Table 6)	Medium (Tolerable)			Low (Acceptable)

Notes:

*Note on Likelihood: Where values / return periods denote rainfall / sea level etc, these include factoring for a SSP8.5 climate change scenario.

^Note on Consequence: taking the highest consequence category across all assessment categories (Human Safety, Lifeline Utilities, Critical Buildings, Community Buildings, Buildings accommodating sensitive activities)

LANDSLIDE RISK ASSESSMENT BASED ON PC120, CHAPTER M, APPENDIX 24



Auckland:
Tel: 09 489 7872
riley@riley.co.nz
Christchurch:
Tel: 03 379 4402
rileychc@riley.co.nz

Project No:	240065	Date:	4-Dec-25
Project Name:	Vineway Russell Road	Date:	5-Dec-25
Prepared:	CB		
Check:	JB		

PC120 LANDSLIDE RISK ASSESSMENT METHOD 2

SCENARIO 1 (median)	Initial (no mitigation)	Risk parameter rational	Proposed Mitigation and Effects	Residual (with mitigation)
P(H) Annual return period* (years)	500	Extreme rainfall event likely needed to trigger even minor movement of slope. Alternatively some movement could be triggered by ULS seismic event. Estimate of 1500 year event adopted.	Proposed RB underlain by shear piles proposed as part of subdivisional works. Stability analysis indicates adequate FoS with mitigation in place for this type of event, reducing critical residual consequence to lower end of GHD recommended range (even if retaining relatively conservative impact probability).	500
P(S:H) Impact probability	0.1	On top of event trigger above, critical consequence (damage to building but not great enough to cause collapse) would be capable of affecting building platforms even without mitigation.		0.1
P(T:S) Temporal occupancy	0.7	Council recommended occupancy rate for typical residential dwelling.		0.7
V(D:T)Vulnerability	0.05	Most likely consequence from underlip downslope of nearby building platform considered to be structural damage to building but not great enough to cause collapse. Based on GHD vulnerability recommendations, value at upper end of range adopted. High chance of survival.		0.001
P(LaL) Annual risk of loss of life	7.0E-06			1.4E-07
Subsequent Risk Classification	Medium (Tolerable)			Low (Acceptable)

SCENARIO 2 (most likely)	Initial (no mitigation)	Risk parameter rational	Proposed Mitigation and Effects	Residual (with mitigation)
P(H) Annual return period* (years)	100	Considered likely that a very heavy rainfall event (though one technically considered "normal" over the course of a 100 year period) would be required to trigger even extremely minor movement of the slope above building platforms.	Proposed RB underlain by a shear key and counterfort drains proposed as part of subdivisional works. Stability analysis indicates adequate FoS with mitigation in place for this type of event, indicating that impact probability effectively fully mitigated (nominal value adopted) reducing critical residual consequence to lower end of GHD recommended range (even if retaining relatively conservative impact probability).	100
P(S:H) Impact probability	0.1	On top of event trigger above, critical consequence (damage to building but not great enough to cause collapse) would be capable of affecting building platforms even without mitigation.		0.01
P(T:S) Temporal occupancy	0.7	Council recommended occupancy rate for typical residential dwelling.		0.7
V(D:T)Vulnerability	0.005	Most likely consequence involves undermining the leading edge of the dwelling causing damage but no collapse. Very high chance of survival. Based on GHD vulnerability recommendations, typical value adopted.		0.001
P(LaL) Annual risk of loss of life	3.5E-06			7.0E-08
Subsequent Risk Classification	Medium (Tolerable)			Low (Acceptable)

SCENARIO 3 (max. credible)	Initial (no mitigation)	Risk parameter rational	Proposed Mitigation and Effects	Residual (with mitigation)
P(H) Annual return period* (years)	2000	Truly exceptional rainfall event (significantly greater than that experienced during 2023 storms) or seismic event well beyond ULS likely needed to trigger large scale slope instability upslope and/or downslope of building platforms. 12000 year event considered conservative to represent this scenario.	Proposed RB underlain by shear piles proposed as part of subdivisional works. Stability analysis indicates that even if this type of event were to happen, with mitigation in place, damage is effectively largely mitigated. Impact probability decreased to nominal (but still considered conservative) value and typical GHD recommended vulnerability value considered appropriate.	2000
P(S:H) Impact probability	0.1	On top of event trigger above, critical consequence (damage to building but not great enough to cause collapse) would be capable of affecting building platforms even without mitigation.		0.01
P(T:S) Temporal occupancy	0.7	Council recommended occupancy rate for typical residential dwelling.		0.7
V(D:T)Vulnerability	0.05	Most likely consequence from underlip below building platforms considered to be structural damage to building but no collapse (i.e., likely magnitude probably similar to Scenario 1 above). Based on GHD vulnerability recommendations, value at upper end of range adopted. High chance of survival.		0.005
P(LaL) Annual risk of loss of life	1.8E-06			1.8E-08
Subsequent Risk Classification	Medium (Tolerable)			Low (Acceptable)

Residual Risk Combinations	Combination A	Residual Risk
Scenario 1	Yes	1.4E-07
Scenario 2	Yes	7.0E-08
Scenario 3	Yes	1.8E-08
	Sum of Combined Risk:	2.3E-07
		Low (Acceptable)

LANDSLIDE RISK ASSESSMENT BASED ON PCI20, CHAPTER M, APPENDIX 24



Auckland:
Tel: 09 489 7872
riley@riley.co.nz
Christchurch:
Tel: 03 379 4402
rileychch@riley.co.nz

Project No:	240065	
Project Name:	Vineway Russell Road	
	Landslide Hazard Assessment for Critical Infrastructure Within Wider Site	
Prepared:	CB	Date: 4-Dec-25
Check:	JB	Date: 5-Dec-25

Intention of Hazard Assessment

1. This assessment is intended to represent overall risk of hazards affecting critical infrastructure within the wider site.
2. Chapter J1 indicates infrastructure including roads and utilities (the critical assets subject to this assessment) fall within the definition of Network Utilities.
3. Network Utilities are defined as Activities less sensitive to natural hazards.
4. Appendix 24, Table 1 indicates that a Method 1 assessment is required to define the risk for this activity. Where roads and utilities are assessed below, these are referred to as Lifeline Utilities in line with Appendix 24, Table 4.

Land use activity	Landslide susceptibility class from Auckland Council published landslide susceptibility and landslide inventory maps				
	Mapped landslide		VH	H	M
	Recent	Ancient			
Activities extremely sensitive to natural hazards	2	1	1	1	1
Activities less sensitive to natural hazards	1	1	1	1	N/A
Activities include: wastewater treatment and disposal systems, effluent disposal fields, underground storage tanks, water tanks (excluding rainwater tanks) or stormwater pipes or soakaway fields, accessways and private roads	2	1	2	2	1
Use buildings of materially damaged or destroyed buildings	2	1	2	2	2
Storage of hazardous substances	2	1	1	1	1
Earthworks	1	1	1	1	1
Vegetation alteration or removal	1	1	1	1	1
Discharge of stormwater and/or wastewater directly to ground	1	1	1	1	1

Table 1 - Initial method 1 (or 2) to be used to assess landslide risk for each combination of mapped landslide susceptibility and land use activity. Where the method shown is N/A, no further risk assessment is required and the risk can be taken as Low.

HAZARD SCENARIO DESCRIPTIONS	
SCENARIO 1 (median):	Relatively large deep-seated landslide occurring either upslope or downslope of a road or utility, likely triggered by an extreme rainfall event OR a ULS seismic event.
SCENARIO 2 (most likely):	Shallow fringing of soils either upslope or downslope of a road or utility as a result of "normal" weather conditions over a 100 year period (though likely would be triggered by a heavy but not extreme / unprecedented rainfall event).
SCENARIO 3 (maximum credible):	Very large deep-seated landslide occurring either upslope or downslope of a road or utility, triggered by an exceptionally large rainfall or seismic event with a magnitude well beyond which the site has ever experienced.

PCI20 LANDSLIDE RISK ASSESSMENT METHOD 1

SCENARIO 1 (median)	Initial (no mitigation)	Risk parameter justification	Proposed Mitigation and Effects	Residual (with mitigation)
Likelihood* (Table 3)	Likely	Some areas of site could reasonably be affected by an extreme rainfall / ULS seismic event. Return period of significantly beyond 1100 years likely required to initiate any large-scale land movement.	Numerous remedial works around proposed subdivision to mitigate critical slope stability risks, including Reinforced Earth Batters, cantilever retaining walls, soil nails, shear pile walls, etc. Risk of large scale landslides likely to be effectively fully mitigated with remedial measures in place, reducing potential consequence of landslides affecting human safety and lifeline utilities to insignificant (no injuries / minimal loss of service).	Likely
Consequence^ (Table 4 or 5)	Minor	Using Appendix 24, Table 4 (for sites larger than 5Ha), scenario could possibly have Minor consequence to Human Safety (1-10 injuries), Lifeline Utilities (loss of service of <1 week affecting <20% of local population). No critical or community buildings proposed as part of subdivisional works. Buildings accommodating activities sensitive to natural hazards intended to be addressed within other specific assessments on		Insignificant
Risk Classification (Table 6)	Medium (Tolerable)			Low (Acceptable)

SCENARIO 2 (most likely)	Initial (no mitigation)	Risk parameter justification	Proposed Mitigation and Effects	Residual (with mitigation)
Likelihood* (Table 3)	Likely	Some areas of site could reasonably be affected by shallow fringing of soils affecting roads or utilities within 100 years of "normal" weather conditions without mitigation.	Numerous remedial works around proposed subdivision to mitigate critical slope stability risks, including Reinforced Earth Batters, cantilever retaining walls, soil nails, shear pile walls, etc. Risk of shallow fringing likely to be effectively fully mitigated with remedial measures in place, further reducing potential consequence of landslides within insignificant category.	Likely
Consequence^ (Table 4 or 5)	Insignificant	Using Table 4, scenario would reasonably have insignificant consequence to Human Safety (no injuries), Lifeline Utilities (loss of service of <1 day affecting <20% of local population).		Insignificant
Risk Classification (Table 6)	Low (Acceptable)			Low (Acceptable)

SCENARIO 3 (max. credible)	Initial (no mitigation)	Risk parameter justification	Proposed Mitigation and Effects	Residual (with mitigation)
Likelihood* (Table 3)	Possible	Intended to represent extraordinarily large magnitude rainfall / seismic event, well beyond anything site has previously experienced. An absolute minimum 11,000 event is considered to be on the extremely conservative end of likely return period required to trigger this scenario.	Numerous remedial works around proposed subdivision to mitigate critical slope stability risks, including Reinforced Earth Batters, cantilever retaining walls, soil nails, shear pile walls, etc. Risk of very large landslides likely largely mitigated by remedial proposals, though considered reasonable to consider Minor residual risk to human safety (1-10 injuries) and Lifeline Utilities (loss of service of <1 week affecting <20% of local population) in absolute worst case.	Possible
Consequence^ (Table 4 or 5)	Medium	During wide-spread and/or very large scale land movement across development, this could reasonably cause Medium consequences to human safety (1-100 injured) and Lifeline Utilities (loss of service up to 6 weeks affecting <20% of local population).		Minor
Risk Classification (Table 6)	Medium (Tolerable)			Low (Acceptable)

Notes:

*Note on Likelihood: Where values / return periods denote rainfall / sea level etc, these include factoring for a SSP8.5 climate change scenario.

^Note on Consequence: taking the highest consequence category across all assessment categories (Human Safety, Lifeline Utilities, Critical Buildings, Community Buildings, Buildings accommodating sensitive activities)