



Geotechnical Assessment Sutton Block Extension

Drury Quarry, Drury

Part 1 of 2 – Report to Appendix D

Geotechnical Assessment

Sutton Block Extension

Drury Quarry, Drury

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Executive Summary

Riley Consultants Ltd (Riley) have been commissioned by Stevenson Aggregates Ltd (Stevenson) to assess the effects of the proposed Sutton Block Quarry Extension, north of the existing Drury Quarry from a geotechnical perspective. This expansion, as designed by Terra Mining Consultants Ltd (Terra Mining), is projected to provide a further 50-years of resource recovery.

The assessment has been undertaken for the proposed maximum quarry shell extent (referred to in the accompanying Assessment of Effects Report as 'Life of Quarry') proposed by Terra Mining. The Terra Mining pit profile is currently an outer shell within which the final faces could be formed.

A geotechnical assessment of the long-term and short-term slope stability of the proposed quarry extension final-shell design has been performed for various geological units expected to be encountered within the full height of the 'whole face'. These units include the Waipapa Group Greywacke, which forms the resource, the Waikato Coal Measures (WCM) that forms a significant overburden within portions of the quarry, and surficial volcanic ash deposits. The WCM have been observed in areas to the north of the proposed quarry expansion to experience instability, in some circumstances on relatively gentle slopes.

An ongoing development of the understanding of their stratigraphy, bedding attitude and strength as the quarry progresses (in addition to knowledge gained as part of this study), will be important to optimising development of the quarry and mitigating potential effects. As such, an observational-type method is recommended for these materials. We would also recommend trial batters within the WCM, and volcanic slopes be undertaken and the findings incorporated into the final design. Prior to and during the main construction phase, the ongoing assessment of the recommended geotechnical design parameters could be significantly optimised through appropriately planned trial batters in WCM and residual volcanic materials well near the proposed final quarry extent. This would likely comprise cutting faces at varying orientations, (e.g. facing north, south, and west) and adoption of an 'observational-type method' in which the performance of the batters is assessed during trials while production extraction occurs elsewhere to minimise risk of poor performance and optimise batter design.

This assessment of the proposed 50-year quarry shell has shown the development of the proposed quarry extension as proposed by Terra Mining as generally feasible from a geotechnical perspective with acceptable margins of safety against instability for the main greywacke resource. To provide satisfactory margins of safety for the WCM preliminary slope stability analysis indicates that this can be achieved by an adaptive strategy with respect to potentially laying back of slopes in WCM overburden materials involving trial cuts and performance monitoring of production faces well within the eventual quarry limits to select suitable batter profiles. The ongoing monitoring and improvements to develop an understanding of greywacke fracture domains will also be an important aspect as the quarry develops.

It is recommended that a Slope Stability Management Plan (SSMP) be prepared following a finalised quarry design, which incorporates an annual stability review of the batters, and review of stormwater control measures, outlines specific hold points and the implementation/construction of any recommended monitoring devices and the results of monitoring, once the quarry extension commences. This approach would allow for a more detailed stability assessment that could be developed as a 'living document' as the quarry progresses and provide for assessment of batter stability in varying materials and any necessary alterations. Priority areas and materials for review have been identified in this study.

It is important that the measurement, collation and analysis of defects, and their potential impacts of excavation and batter stability will continue as the quarry extension is developed. This could be incorporated as part of the annual stability review.

It is envisaged that much of the excavation will be undertaken with blasting, although materials above highly weathered (blue-brown) greywacke could be excavated or heavily ripped by mechanical excavation. Care will need to be taken in blasting when approaching the final face positions to minimise the risk of 'back-break' leading to unnecessarily broken rock in the final face. Trials of a suitable blasting method to minimise structural damage to the final batter profiles should be undertaken and are recommended prior to the formation of these batters. At the time of final excavation, the face should be subject to inspection by a geotechnical professional familiar with the contents of this report.

Geotechnical Assessment

Sutton Block Extension

Drury Quarry, Drury

1.0 Introduction

The following report has been prepared at the request of Stevenson Aggregates Ltd (Stevenson). It presents a geotechnical assessment of the proposed Sutton Block Extension to the existing Drury Quarry with respect to the stability of future batters, with specific focus on the potential effects on surrounding features and neighbouring properties.

This report is intended to support a resource consent application for the proposed Sutton Block Quarry Extension. This expansion, as designed by Terra Mining, is projected to provide a further 50-years of resource recovery to aid development of Auckland.

The assessment has been undertaken for the proposed maximum quarry shell extent proposed by Terra Mining in September 2024. The Terra Mining pit profile is currently an outer shell within which the final faces could be formed. This report supersedes previous report dated 15 December 2023 (Riley Ref: 220245-C).

2.0 Site Description and Development Proposal

The Sutton Block site is located to the north of the existing Drury Quarry operation and Kaarearea Paa volcanic cone, as shown in Figure 1, and on Riley Site Plan Dwg: 220245-10, appended.

The site is defined by elevated ridges forming a watershed encapsulating a basin of approximately 108ha nominated for resource recovery. The basin has several minor gullies that drain towards a stream in the south-western portion of the site to the west of Kaarearea Paa.

The proposed quarry area is currently predominantly in pasture and farmed, with some localised larger trees and scrub within areas of steeper slopes. The slopes that bound the proposed quarry area immediately to the west, north, and east are predominantly covered in areas of exotic pine and regenerating native vegetation. To the south there is Kaarearea Paa with covered predominantly native vegetation.



Figure 1: Looking south-east over Sutton Block with the forested crown Kaarearea Paa in the far right of the photo.

2.1 Proposed Quarry Extension

Drury Quarry is a commercial greywacke aggregate quarry, and the Sutton block is envisaged to be a northern extension of existing quarry operations. The proposed quarry development will be undertaken in stages in general accordance with indicative staging and timeframes based on information developed by Terra Mining and provided by Stevenson as summarised below.

2.1.1 Initial Development Stage 1 (3-Year Plan) – Infrastructure Development

The initial stage of work (Years 1 – 3) involves constructing the site access roads, draining the existing farm dam to establish a sediment retention pond, associated stream diversion, initial offset planting, commencement of overburden removal, stockpiles (including bunding), and establishing the conveyor system.

The existing track will be widened to form a 12m wide by 2.5km long haul road, which will be used to access a bund location to the north. Once established the haul road will also connect the Sutton Block pit to the existing pit.

2.1.2 Interim Development Stage 2 (15-Year Plan) – Operating Quarry

Development to the north-west within the interim pit boundary. The direction of the expansion will depend on market demand. Expansion of the pit will be incremental, widening and deepening as resource is extracted. Internal pit roads will be constructed as the pit expands. At this time, it is envisaged the expansion will be targeted at the western portion of the Sutton Block.

2.1.3 Interim Development Stage 3 (30-Year Plan) – Operating Quarry

The third stage of works is further expansion of the interim pit boundary extending out to a 30-year period from infrastructure set-up. Like Stage 2, the direction of the expansion will depend on market demand. However, indicative staging plans shows the expansion of the pit to the east.

2.1.4 Interim Development Stage 4 (40-Year Plan)– Operating Quarry

The fourth stage of works is further expansion of the interim pit boundary to the east and south-east. It extends out to a 40-year period. Like Stage 3, the direction of the expansion will depend on market demand. During this stage of the works, the expansion of the pit will be incremental, widening and deepening as resource is extracted. Internal pit roads will be constructed as the pit expands.

2.1.5 Final Stage 5 (50-Year Plan) – Life-of-Quarry

Quarry extension developed to full extent of quarry pit over a 50-year total period from the initiation of the quarry extension. During this stage, the temporary northern bund will be removed. Internal pit roads will be constructed as the pit expands. The current assessment of potential effects has been based on the final stage of development with the most extensive and greatest height of excavation. This represents the critical condition.

3.0 Southern Wetland Area

There are existing areas of both exotic and indigenous Raupo wetlands located between the proposed quarry extent and Kaarearea Paa in the area indicated in Figure 2, and on attached Riley Dwg: 220245-10 and -11. It is proposed as far as practical to maintain the wetland areas in the final quarry design.

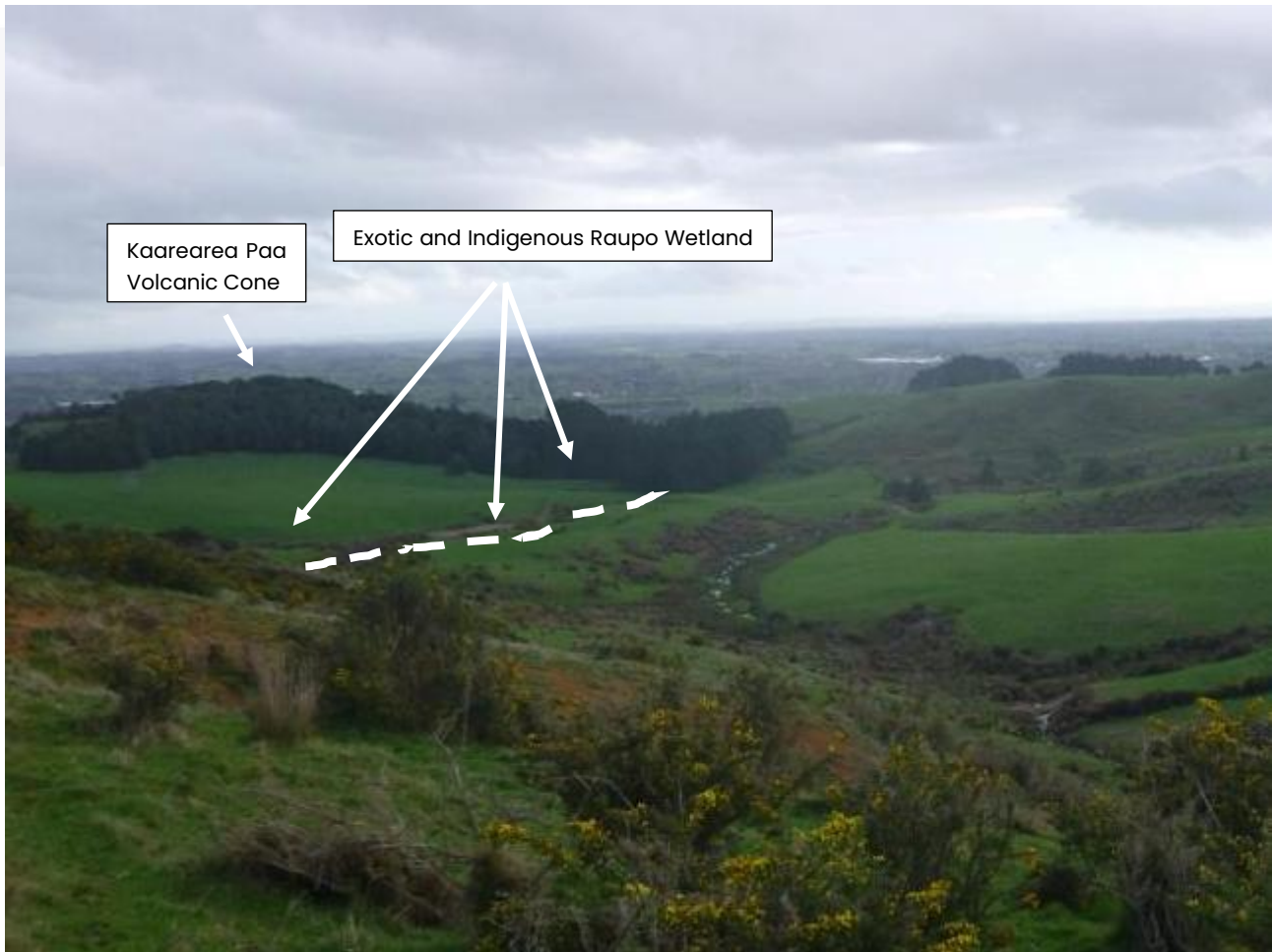


Figure 2: Looking south-west towards Kaarearea Paa and an area of existing exotic and Indigenous Raupo wetland areas to the south of the proposed quarry extent. The portion of eastern exotic wetland that extends further upslope from the site annotated in the photo. The indicative southern extent of the quarry shown by a dashed white line. The indicative location of the main southern wetland areas outside of the proposed quarry extent are highlighted in the photo.

3.1 Description of Proposed Quarry Slopes

The Terra Mining pit profile, dated September 2024 (Terra, 2024), is an outer shell within which the final faces could be formed. This shell represents the maximum quarry extent and has a generic profile. Ultimate final faces could be formed within this shell, depending on encountered site conditions.

Within the current proposed quarry pit design, individual batter (inter-bench) slope angles are designed at either 45° or 60° from horizontal. Generally, the WCM are designed to be cut at 45° inter-bench slopes, although there are some exceptions to this to the north of Ballard's Cone where the proposed design indicates 60° inter-bench slopes. The Waipapa Greywacke is designed to be cut at either 45° or 60° for inter-bench slopes dependent on weathering grade (or quarry code) of the material. Generally, for Overburden (OB) and Brown Rock (BR), inter-bench slopes are cut at 45°, while Blue-Brown Rock (BB) and Blue Rock (BL) inter-bench slopes are cut at 60°.

It is noted, however, that there are exceptions to these both, at different points within the proposed pit design. Table 1 displays the change in proposed inter-bench slope angle with greywacke weathering grade.

The overall pit slope angle (OSA) within the Terra Mining design is generally approximately 34° where inter-bench angles are 45° and OSA is generally approximately 43° where inter-bench angles are 60°.

Table 1: Proposed Slope Angles of Individual Batter Slopes Through Waipapa Greywacke

Quarry Code of Greywacke	Proposed Inter-bench Slope Angle (°)
Overburden (OB)	Typically 45 (locally 60)
Brown Rock (BR)	Typically 45 (locally 60)
Blue-Brown Rock (BB)	Typically 60 (locally 45)
Blue Rock (BL)	Typically 60 (locally 45)

4.0 Regional Geology

Based on the published GNS Science Ltd (GNS) 1:50,000 geologic map the site is inferred to be underlain at varying depth by basement Waipapa Group Greywacke rock that forms the existing and proposed quarry resource. The material is locally inferred to also be overlain by overburden materials consisting of the Early Pleistocene to Late Pleistocene-age (1.6 to 0.5 Mya) South Auckland Volcanic Field basaltic materials associated with Kaarearea Paa (Kerikeri Group), (Figure 1). Volcanic deposits are also inferred to be present to the west and east of the site. These volcanics are inferred to be underlain by Eocene to Oligocene-age (37 to 33 Mya) mudstones of the WCM (Te Kuiti Group) that rests on the greywacke. Geomorphic mapping and subsurface investigations by Riley and others indicate that the WCM form an overburden material inferred to extend to the north of Kaarearea Paa and cover a more significant portion of the site than is shown in the published 1:50,000 geological maps of the site.

The Waipapa Group basement rocks that form the resource comprise of Triassic to Jurassic age (227 to 142 Mya) faulted greywacke. These consist of metasandstone and argillite (sandstone and mudstone that has been weakly metamorphosed). The presence of these materials, along with an area of minor localised fill to the west of Kaarearea Paa volcanic cone was confirmed during the current mapping and subsurface investigation undertaken by Riley. The material is similar to that exposed in the current Drury Quarry pit.

To the west of the site is located the north-north-west to south-south-east orientated inactive Drury Fault. The Drury Fault forms the western extent of the current quarry operations to the south of the Sutton Block. The Drury Fault is outside of the area of the proposed Sutton Block extension. The Drury Fault is inferred to be a Miocene to Quaternary-age normal fault with the downthrown block to the west of the fault plane (dip direction 255°, dip angle approximately 70°, total slip 1km to 10km), and inferred to define the western limit of practical recoverable aggregate resource.

The western portion of the Sutton Block is inferred to be crossed by the north-south trending inactive Hunua Fault, with the central portions of the site inferred to be crossed by the north-east to south-west trending by branch of the main Hunua Fault, which is not shown on the 1:50,000 map (Figure 3 below). The Hunua Fault system is inferred to extend south near the eastern extent of the current Drury Quarry. Geomorphic evidence was consistent with inferred location of these faults. Evidence of crush zones consistent with the presence of the main Hunua Fault and eastern branch fault was also encountered in inclined Riley boreholes in the northern portion of the site (Riley Machine Boreholes DH101 and DH102). The branch fault is inferred to merge with the main Hunua Fault to the south of Kaarearea Paa volcanic cone. The Hunua Fault and the associated branch fault are inferred to be normal (extension) faults with downthrown blocks to the east of the fault planes.

The inferred approximate locations of the above faults are shown on Riley Dwgs: 220245 -10 to -13.

Other structural features include an inferred north-west to south-east orientated syncline crossing the central portion of the existing Drury Quarry excavation based on mapping by Gaia Engineers Ltd (Gaia) (2017b).

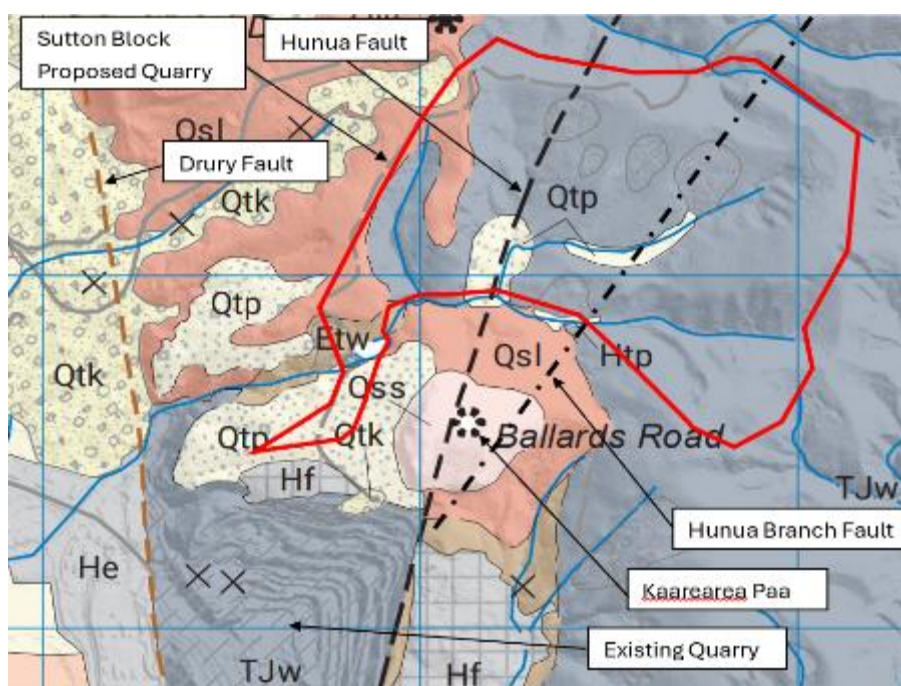


Figure 3: Snapshot of the 1:50,000 (date) GNS published geologic map with the study area highlighted by red outline. The inferred location of Drury Fault to the west of the proposed quarry extension, and Hunua Fault and Hunua Branch Fault that pass through the proposed extension, are shown as labelled dashed lines. Blue geology (noted TJw) represents Waipapa greywacke, yellow/beige represents WCM (noted ETW), and red (noted Qs) represents South Auckland volcanics. Note that map omits assessed true extent of WCM within the proposed quarry pit. Grey patterned sections in upper study area represent soil debris, which are inferred by GNS to be alluvium/colluvium deposits from aerial imagery. Red outline displays approximate proposed quarry extent.

5.0 Material Types

5.1 South Auckland Volcanics

Kaarearea Paa volcanic cone comprises of extrusive South Auckland Volcanic material that has formed above inferred localised conduit of rising magma. The materials are understood from our review of previous work by others (Gaia 2018) to consist of grey basalt lava that is in the order of 11m thick beneath the cone. Lava flows are inferred to thin out relatively rapidly from the central portion of the cone.

The lava has penetrated through and flowed over the mudstones of the WCM. Within the study area, the presence of volcanics is predominantly limited to the southern portion of the site with some surficial remnant volcanic cobbles and boulders exposed on the slopes to the eastern extent of the proposed quarry.

5.2 Waikato Coal Measures (Te Kuiti Group)

Eocene to Oligocene WCM are present throughout the site forming a wedge with the greatest inferred thickness below the elevated Kaarearea Paa in the southern portion of the site. The materials typically consist of dark brown and light grey laminated, carbonaceous mudstones and siltstones with extremely weak organic layers.

The presence and thickness of WCM across the proposed quarry extension is significantly influenced by the Hunua and associated branch fault, creating depressions where WCM has been spared from complete erosion. Within the site, the presence of WCM is noted within the central fault block, to the east of the branch fault, below Kaarearea Paa volcanic cone to the west of the Hunua Fault, and at the western extent of the proposed pit extent.

The Gaia 2018 report describes a potentially highly permeable contact is present between residual soil (or colluvium) and the less weathered materials of WCM, when present near surface. The report describes this zone as including a whitish grey, highly plastic clay and softened WCM. The report outlined these layers being associated with instability. While not encountered in recent investigation boreholes, this potential zone of weakness is a consideration for the quarry development, similar to the encountered weaker organic layers within the mudstone layers. The presence of similar persistent weaker organic layers has been associated with recent instability within overburden above the northern and southern faces of the existing Drury Quarry Main Pit and along nearby Ponga Road to the north of the site. The instability associated with WCM above the Main Pit has been addressed using reducing batter slopes, and construction buttress fills and subsurface drainage.

5.3 Waipapa Group Greywacke

Triassic to Jurassic greywacke basement rocks of the Waipapa Composite Terrane typically consist of volcanoclastic metasandstone and argillite. These materials are generally fractured with original sedimentary structures such as bedding difficult to discern in outcrops and can be cataclastic (extremely fractured rock due to fault movement which removes most reliable bedding indicators). Defects such as jointing and faults have a strong control on stability of batter slopes. Experience with similar materials in Auckland quarries shows relatively small 'structural domains' separated by faults and crushed zones. Within each structural domain are repetitive joint sets, however, each domain can extend from a few metres to hundreds of metres in extent. The Waipapa Greywacke underlays the full extent of the site, with a number of outcrops at the surface.

6.0 Faulting

As outlined previously the Sutton block is inferred to be crossed by the Hunua Fault and associated branch fault. This fault is inferred to have been active in the Miocene and Pliocene displacing both the greywacke and WCM. The feeder for Kaarearea Paa volcanic cone likely exploited the zone of relative weakness associated with this fault. It is not considered active.

7.0 Literature Review

To support the assessment a review of relevant literature and drawings has been undertaken, included that specific to the quarry, and also information relevant to materials expected to be encountered in the proposed extension. These are listed below.

- Boffa Miskell (2024), Drury Quarry (Resource Consent Plans)- Figures 1 to 13, dated 29 October 2024.
- Terra Mining (2023) Stages 1 to 4 and final staging plans, Dwgs: SSQ_23_401 to _404, Rev 2, dated November 2023.
- Gaia (2022a) – Drury Quarry – Terra Mining Consultants Ltd Cut Model – Slope Stability Review, their Ref: 2234/29, dated 29 March 2022.
- Gaia (2022b) – Drury Quarry – Draft – Terra Mining Consultants Ltd Cut Model – Kinematic Stability Review, their Ref: 2234/29, Rev B, dated 1 March 2022.
- Gaia (2018a), Thorburn Gully Managed Fill – Drury Quarry Geotechnical Assessment Report – Draft, their Ref: 2244-01-SRL-01, dated 22 January 2018.
- Gaia (2018b), Factual Geotechnical Report, Drury Quarry Northern Overburden, their Ref: 2144-59-DSL-01, dated 5 November 2018.
- Gaia (2017a), Drury Quarry Engineering Geological Assessment: Volume I – Regional Geology, their Ref: 2074 (Geotechnical Report_Volume I_Rev A), dated January 2017.
- Gaia (2017b), Drury Quarry Engineering Geological Assessment: Volume II – Photogrammetry and major Structures Model, their Ref: 2084 (Geotechnical Report_Volume II_Rev A).

- Tonkin & Taylor Ltd (T+T) (2005), Proposed Whitford Landfill Extension, Geotechnical Assessment Report, their Ref: 22293.102, dated September 2005.
- Gaia (2015), Slope Design Methodology, their Ref: 2084-02-SR-03, dated September 2015.
- Murray Stevens – Consulting Geologist (2005), Geological and Resource Assessment of Drury Quarry, dated September 2004.
- Lindsay, P. and Moore, T. (2001) Slope Stability Probability Classification, WCM, New Zealand, International Journal of Coal Geology, dated January 2001.
- Hegan, B. and Read, S. (1988), A mechanism for Slope Failures Observed in Open Pits, Northern Waikato Coal Region, New Zealand, Fifth, Australia-New Zealand Conference on Geomechanics Sydney, 22-23 August 1988.

8.0 Riley Investigations

To assist in assessing the stability of the proposed quarry extension Riley has undertaken:

- Review of supplied geological and geotechnical information for the quarry and published geology on the surrounding area.
- Geological and geotechnical mapping of the exposures in and to the north and south of the proposed quarry extension.
- Five additional cored machine boreholes to complement existing subsurface information undertaken by others, including:
 - John Ashby & Associates drilling programme, 2000 (00HC1 – 00HC5)
 - Terra Mining Consultants Ltd drilling programme, 2005 (SP001 – SP005)
 - Pattle Delamore Partners (PDP) drilling programme, 2022 (SG11 – SG13)
- Measurement of groundwater levels in machine boreholes.

The location of investigation boreholes by Riley and others are shown on appended Riley Dwgs: 220245-10 to -13. Encountered distribution of geological units are appended in Appendix H and reproduced in Figure 4. Note that this figure displays the out of quarry limits proposed design, as provided by Terra Mining.



Figure 4 Geologic plan of quarry extension site, displaying distribution of geologic units at surface. Red represents distribution of volcanics, green represents distribution of WCM, and blue represents distribution of the Waipapa Greywacke which underlies the entire site. Faults can be seen in black and proposed pit extent is a black dashed line. Note that this figure displays the proposed 50-year quarry extent as provided by Terra Mining. Cross sections for geotechnical assessment are shown in blue.

9.0 Site Walkover and Geomorphology

A detailed site walkover assessment and geomorphic mapping of the topographic features was undertaken by Riley engineering geologists on 22 August 2022. This included mapping of both the geotechnical characteristics of greywacke exposures and geomorphic features within the site noted from a review of aerial photos, published geology and previous assessments by others. This included a walkover assessment and mapping of exposed geology and structural features within the stream to the NE of the proposed quarry expansion, along with mapping and defect analysis of exposed greywacke outcrops in the central portion of the farm, and large-scale geomorphological mapping of the entire farm block. This was followed by several site visits by Riley through to 21 March 2023 as part of the geologic and geotechnical mapping, and the monitoring and logging of machine borehole drilling.

Defect data collected from greywacke outcrops within the stream and farm block are displayed in the rose diagrams on Riley Dwg: 220245-13, appended.

A markup of the geomorphic features identified within the farm block is shown on Riley Dwg: 220245-10, appended.

The farm block, and proposed pit area, consists of a basin with the topographic boundaries of this feature approximately aligning with the proposed pit extents. The inferred Hunua Fault and Hunua Branch Fault planes are expressed within the topography as these faults formed strong lineaments (Figures 4, 5 and 6). The fault plane of the Hunua Fault near the western margin of the basin was expressed within the upthrown block forming a steep, eastwards dipping ridge. The branch fault plane in the central portion of the basin expressed as a moderately eastward dipping ridge on the upthrown side of the fault, in lineament with a truncated spur to the south of this ridge (Figure 5). To the west and south of a small spur beyond the proposed quarry extent are existing wetland areas that are proposed to be retained as part of the development (Figure 2). Multiple signs of localised instability along the Hunua Fault ridge were observed, including historic landslips, slumping, and evidence of active soil creep in the form of hummocky topography. No obvious evidence significant large scale instability features were observed along the ridge and scarp slope inferred to be associated with the branch of the Hunua Fault. Hummocky ground within the north of the basin, adjacent to the branch fault ridge, indicated the presence of active long-term inferred relatively shallow seated soil creep movement of the WCM overlying the Waipapa Greywacke (Photo 2). These areas of hummocky ground along with some of the other steeper slopes are mapped on the GNS 1:50,000 geological map as inferred alluvial/colluvial fan deposits (Figures 3 and 6).

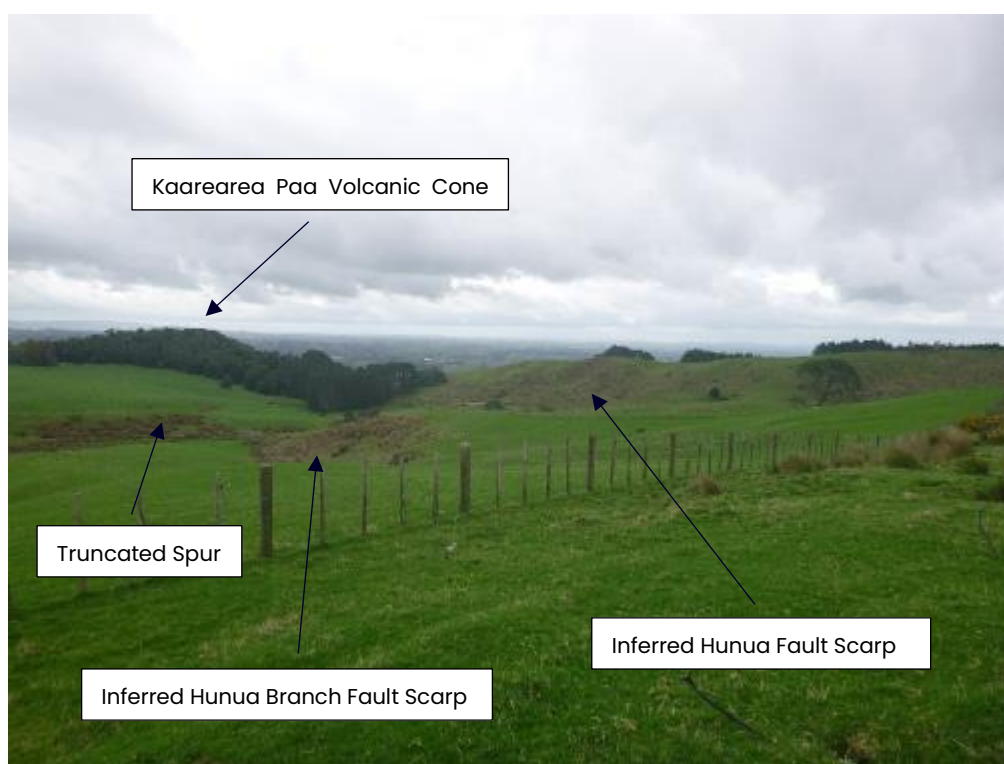


Figure 5: Taken looking south on 22 August 2022 towards Kaarearea Paa with scarps associated with inferred Hunua Fault and Hunua Branch Fault traces labelled.

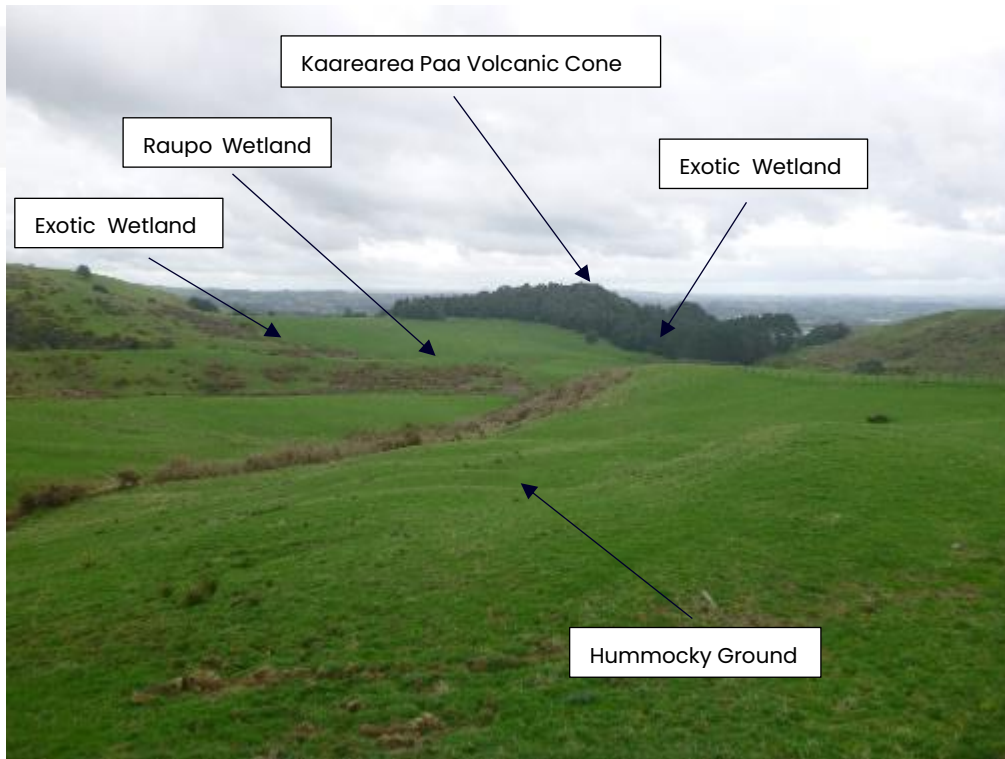


Figure 6: Taken looking south on 22 August 2022 towards Kaarearea Paa with detail of hummocky ground in foreground typical of WCM deposits on the moderate to steeply inclined slopes within the proposed quarry area. The location of the proposed elevated exotic and indigenous Raupo wetland areas to be retained in the quarry design is near the base of steeper slopes in the upper left portion of the photo.

The Kaarearea Paa volcanic cone stands as a prominent high point above the W-E orientated ridge that bounds the basin southern extent (and limit of the proposed quarry extension). There were no significant features indicating instability when investigating the accessible slopes around the base of Kaarearea Paa volcanic cone, however, the majority of the cone is covered with dense vegetation so features further up the cone were not visible at the time of inspection. The eastern extent of the basin includes a large, vegetated gully and two adjacent historic landslips of significant size (Riley Dwg: 220245-10). The head of the gully and landslips are very near the proposed quarry pit extents. The areas inferred to be underlain by colluvium on the published GNS geological map within the northern portion of the proposed quarry were assessed on-site to be more consistent with shallow soil movement of the upper soils, and localised shallow slumping within the Waikato Coal Measure deposits, rather than deep seated movement.

Several drainage channels cut through the site flow downslope into the basin. The main drainage channel for water exiting the basin appears to be the stream flowing into the farm pond in the SW of the site. This water then flows out of the pond and under a culvert westward. Saturated ground was observed in the upper central portion of the basin with water emanating from an area of ground inferred to be a previous borehole drilled by others (i.e. forming a spring). Some tunnelling erosion was also noted in association with this feature.

Lineaments noted from a review of aerial photos and observed within the topography on site are shown as dashed blue lines on the appended Riley Geomorphology site plan (Riley Dwg: 220245-10). These features generally follow stream paths and are oriented NE-SW, N-S, and NW-SE. The NE-SW and NW-SE are noted to be consistent with the noted predominant defect orientation encountered in the Riley boreholes and the N-S lineament with the inferred Hunua Fault trace.

An initial inspection of the northern extent of the existing Drury Quarry pit excavation was also performed to record geotechnical data of greywacke outcrops in a recently excavated top section, directly SW of Kaarearea Paa volcanic cone. Defect data is presented in Section 10.0 and was found to be generally consistent with prominent defects measured within the proposed expansion area.

A site visit was completed on 22 December 2022 to undertake the first round of groundwater monitoring post-drilling. Results are discussed in Section 10.0. During this visit, samples of the machine drilled core stored on-site were collected to be taken for laboratory testing.

A further walkover was completed on 21 March 2023 to gather further geotechnical information on the WCM exposed within area directly SW of Kaarearea Paa volcanic cone that overlies the greywacke. Bedding data was collected, and a cross section measured through a face containing multiple coal seams. No slumping or other signs of large-scale mass instability were observed in this area, however, significant localised gully erosion/rilling through the weaker, weathered material of the face has occurred from stormwater runoff. Both the mudstone and coal seams observed in this exposed batter were frittering significantly in both a blocky manner and along bedding/lamination planes.

During the 21 March 2023 visit, a second round of groundwater monitoring was also completed, results are outlined in Section 10.0. A brief inspection of the farm block was also undertaken to identify any potential new areas of instability following the heavy rainfall event experienced in Auckland on 27 January 2023 and the weeks following. One new area of instability (a shallow landslide) following the event was identified above the pond to the west of Kaarearea Paa volcanic cone, however, this is not assessed as having a significant influence on the wider proposed quarry expansion on the basis that it was an inferred shallow failure of a localised over steepened slope. It does contribute to a database on performance of WCM cuts in the area.

10.0 Machine Borehole Investigation

The machine borehole investigation involved the drilling of five boreholes strategically placed near the extents of the proposed pit extension, as shown on Riley Dwg: 220245-10, appended. The placement of these boreholes aimed to identify the geology and any potential stability issues in locations of future significant batters/cut faces and also to complement existing subsurface data (rather than duplicate). The drilling programme commenced with DH105 on 27 October 2022 and was completed with the termination of DH104 on 13 December 2022. Two of the five boreholes were inclined to an angle of -70° from horizontal, DH101 and DH102, while the other three boreholes were drilled vertically. The intended purpose of the drilling inclination was to encounter sub-vertical faulting and associated crush zones identified to be cutting through the site as outlined above. The boreholes were drilled to varying depths as detailed in Table 2. SPT tests were undertaken in three of the boreholes, DH103, DH104, and DH105, with depths at which these occurred to detailed in Table 2. SPTs (Standard Penetration Tests) consist of an in-situ dynamic penetration test designed to provide information on the geotechnical properties of soil, in particular soil strength.

Table 2: Details of Machine Borehole Drilling Investigation

Machine Borehole	Date Commenced	Date Terminated	Inclination (°) from horizontal	Azimuth of Inclination (°)	Depth Drilled (m)	Depth of SPT (m)
DH101	08/11/2022	14/11/2022	-70	290	69.50	N/A
DH102	01/11/2022	04/11/2022	-70	270	60.00	N/A
DH103	23/11/2022	05/12/2022	-90	N/A	78.00	19.50
DH104	12/12/2022	13/12/2022	-90	N/A	40.50	19.50
DH105	27/10/2022	01/11/2022	-90	N/A	46.89	12.00

Downhole borehole imaging to identify discontinuities on the exposed geology was undertaken by Resource Development Consultants Ltd (RDCL) in all drillholes, subsequent to termination of drilling and flushing of each hole. This work was undertaken to further identify any features that may potentially lead to instability, such as the orientation of defects or shear zones encountered within the boreholes. Results of these surveys can be found in Appendices D and E of this report and are incorporated into our Defect Analysis discussion in Section 13.1.

The machine borehole investigation encountered four main units including South Auckland Volcanics basaltic lava flows, the WCM and associated carbonaceous mudstones of the Te Kuiti Group, Greywacke of the Waipapa Terrane, and a conglomerate of inferred stream bed deposit of Eocene to Oligocene age which filled old channels at the top of the greywacke surface, with each being further detailed below. This conglomerate is considered to be part of the basal WCM. The depths at which each unit was encountered within each borehole are displayed in Table 3.

Table 3: Summary of Materials Encountered at Depths in Riley Boreholes DH101 to DH105

	Elevation at top of hole	Topsoil/Clay/Fill		South Auckland Volcanics and Residual Soils		WCM Mudstones		Conglomera te		Waipapa Greywacke	
		From	To	From	To	From	To	From	To	From	To
DH101	221m	0.0m (0.0m– 1.50m core loss)	2.90m	N/A	N/A	2.90m	39.0m	N/A	N/A	39.0m	69.50m (EOH)
DH102	222m	0.0m (0.0m– 1.50m core loss)	2.30m	N/A	N/A	2.30m	34.30m	N/A	N/A	34.30m	60.0m (EOH)
DH103	181m	0.0m	0.40m	0.40m	8.15m	8.15m	73.0m	N/A	N/A	73.0m	78.0m (EOH)
DH104	165m	0.0m	3.0m	3.0m	5.50m	5.50m	24.80m	24.80 m	30.90 m	30.90m	40.50m (EOH)
DH105	202m	0.0m	3.0m	N/A	N/A	3.0m	4.50m	N/A	N/A	4.50m	47.00m (EOH)

10.1 Machine Borehole DH101

The inclined machine borehole DH101 was drilled to target the inferred main Hunua Fault plane within the eastern portion of the site. The borehole location was inferred from geomorphic mapping and previous subsurface investigations to have been drilled on the eastern downthrown side of the fault. The borehole was inclined 70° (from horizontal) to the west (70/270) to drill through the fault.

Mudstone of the WCM was encountered down to 39.0m depth, underlain by Waipapa Greywacke until the end of the hole. The WCM encountered was generally slightly weathered with closely to moderately-widely spaced fractures preferentially along lamination planes, although a number of softer, highly weathered sections from approximately 17.40m were also encountered. Several moderately wide (approximately 300mm thick) broken and crush zones through greywacke were encountered within DH101 between 44.50m to 46.50m, and from 56.0m to 58.0m. These are inferred to be associated with the main Hunua Fault surface and related splinters. Below the inferred Hunua fault surface, frequency of fracturing within the Waipapa Greywacke increased, becoming generally extremely to very closely spaced.

Greywacke from approximately 37.3m to 44.4m, adjacent to the contact between the WCM and Waipapa Greywacke, appeared hydrothermally altered with chlorite staining, indicating significant groundwater fluid flow through this material.

10.2 Machine Borehole DH102

The inclined machine borehole DH102 targeted the inferred eastern branch of the Hunua Fault that crosses the central portion of the site. The borehole was inclined 70° (from horizontal) to the west (70/290) and sited approximately 20m to the east of the fault trace. The borehole location was inferred from geomorphic mapping and previous subsurface investigations to have been drilled on the downthrown side of the fault.

The borehole encountered an approximately 600mm wide inferred fault gouge layer at 33.8m depth. This consisted of a very soft dark grey silty gravelly clay and was assessed to be consistent with the inferred branch fault from previous assessments of the site. Fracturing was significant to both sides of the fault, although below the fault, there appeared to be significant healing of the defects within greywacke, these either infilled with hard white mineral (quartz or calcite) or clay infill. This was near the contact between the greywacke and the WCM. The borehole also encountered a moderately thick (approximately 300mm wide) crush zone at 23m within the WCM. This is inferred to be a secondary crush zone above the main Hunua Branch Fault. These observed crush zones are consistent with the location of the Hunua branch fault adopted in our Leapfrog geological model as outlined in Section 12.0 and as shown in Figure 7.

10.3 Machine Borehole DH103

Machine borehole DH103 was drilled at the southern extent of the proposed pit on the flanks of Ballard's Cone, to determine both the depth of volcanics and the depth of WCM mudstone between the two faults. DH103 was drilled to 78.0m depth to encounter resource rock.

The borehole encountered completely to residually weathered volcanics to 8.15m depth. A significant depth of mudstone (WCM) was encountered from 8.15m down to 73.0m. The material was generally closely to very closely fractured preferentially along sub-horizontal to low angle lamination planes within the WCM, with several extremely fractured/broken up zones throughout. Greywacke was encountered at 73.0m and is moderately weathered and extremely fractured to crushed down to 76.50m. From 76.50m depth, a greenish tinge was observed indicating hydrothermal alteration in the closely fractured material.

10.4 Machine Borehole DH104

Machine borehole DH104 was drilled to the west of Kaarearea Paa volcanic cone to provide information on the contact between the volcanics and underlying WCM mudstones, and the depth of the mudstone. DH104 was drilled to 40.50m depth. The borehole encountered an inferred volcanic boulder and underlying completely weathered volcanic gravelly clays from 3.0m to 5.50m. This transitioned into residual then competent WCM mudstones with a crush/weak zone at 8.60m and weak organic horizons at 13.50m and 17.70m. From 22.70m, mudstone graded into sandstone and then a conglomerate with several organic horizons throughout. Greywacke was encountered at 31.0m depth and was generally closely to very closely fractured with a moderately thin (approximately 200mm) crushed and highly weathered zone at 39.15m.

10.5 Machine Borehole DH105

Machine borehole DH105 was drilled at the western extent of the proposed pit to determine the depth of the WCM. DH105 was drilled to 47.0m depth.

Borehole DH105 encountered a minor layer of WCM from 3.0m to 4.5m depth, overlying extremely fractured to crushed greywacke to 7.3m depth. Below this, greywacke continued as closely to very closely fractured material with several highly weathered and extremely fractured sections throughout until 15.0m depth, at which the material graded to become generally closely to moderately widely fractured and slightly weathered to unweathered, to the end of the hole at 47.0m depth.

11.0 Groundwater

As part of the current investigation, two piezometers were installed in each of the machine boreholes DH104 and DH105 as summarised in Table 4.

Table 4: Piezometer Details and Measured Groundwater Levels for Riley Machine Boreholes DH104 and 105. Both boreholes having two nested piezometers installed at different depths targeting potentially different layers.

Machine Borehole	Screen Depth*(m)	Geology	Groundwater Level* (m)	
			22/12/2022	21/03/2023
DH104A	3.0 – 4.0	Kerikeri Volcanics (Basalt)	2.18	2.36
DH104B	12.0 – 31.0	WCM (Carbonaceous Sandstone and Mudstone)	9.45	9.11
DH105A	4.0 – 10.0	WCM (Carbonaceous Sandstone and Mudstone)	5.73	5.28
DH105B	17.0 – 20.0	Waipapa Group Greywacke	6.81	7.08

Note: *Below existing ground level

As shown above, groundwater levels displayed minor fluctuations between the two monitoring periods, but no significant changes in water level were observed.

The groundwater levels are considered relatively high, although it is noted that the Auckland region had been in a sustained elevated rainfall climate since June 2022. Regardless, the measured high levels are considered indicative of likely perched and compartmentalised groundwater, contained between geological units and prominent defects.

Discussions have been undertaken with PDP in relation to their hydrogeological model of the proposed quarry pit. These discussions, in combination with a review of their draft report, have been used to better inform our geotechnical model and subsequent stability analyses.

12.0 Geological Model

A 3D geological model has been developed using Leapfrog Works. A screenshot of the model is shown in Figure 7. The model incorporates current topography, the proposed pit shell, main north-south trending Hunua Fault(s) with associated offsets, borehole data, and geological units. Geological units include:

- Greywacke
 - Divided into four subunits (OB, BR, BB, BL) based on borehole data and according to the descriptions given in 'Geological and Resource Assessment of Drury Quarry', Terra Mining Consultants, 2005.
- Carbonaceous Mudstone
 - Based on borehole data, surface mapping, and existing information provided by Stevenson.
- Basalt
 - Based on borehole data, surface mapping, and existing information provided by Stevenson.
- Surficial clay
 - Divided into greywacke-, mudstone-, or basalt-derived. Based on borehole data.

Data used to construct the model includes the following boreholes and reports:

- DH101 to DH105 (Riley, 2023)
- SG11 (Pattle Delamore Partners, 2022)
- Drury Quarry Engineering Geological Assessment; Volume I – Regional Geology (Gaia Engineers, 2017).
- BH4 (AECOM, 2005)
- Geological and Resource Assessment of Drury Quarry (Terra Mining Consultants, 2005)
- SP001 to SP008 (Terra Mining Consultants Ltd, 2005)
- 00HC1 to 00HC5 (John Ashby and Associates, 2000)
- 9831 (Ashby Consultants, 1999).

Based on an assessment of the model, a total of 10 geotechnical cross sections were prepared (from which six critical and representative sections were selected for limit equilibrium analysis), appended in Appendix H. The locations of geotechnical Sections A to J, are shown on appended Riley Dwg: 220245-11 (Section Plan).

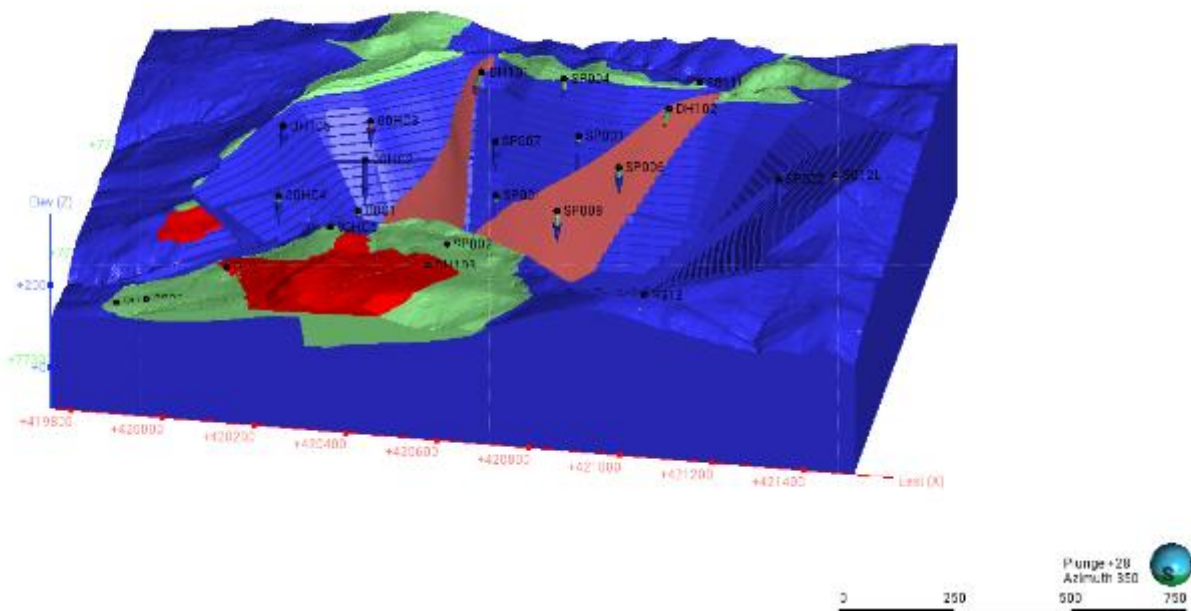


Figure 7: Riley 3D Leapfrog model of the proposed final 50-year quarry profile looking north with Kaarearea Paa volcanic cone in the foreground and the inferred fault planes (in red) of the Hunua Fault and branch fault (to the east) that cross the site. Green represents WCM materials that will be present to the north and south of the ultimate pit. A clear contrast in the depth of the WCM deposits across the faults is shown exposed on the lower southern edge of the model. A thicker layer of WCM present on the downthrown eastern side of the faults.

13.0 Laboratory Testing

13.1 Rock Strength – Greywacke and WCM

Unconfined Compressive Strength testing (UCS) on eight unweathered, slightly, and slightly to moderately weathered greywacke samples recovered from the boreholes gave 20MPa to 135MPa strength (i.e. moderately strong to very strong rock), with a mean value of 53MPa (i.e. strong rock). This is consistent with previous strength testing of greywacke undertaken by Riley at Clevedon and Whitford Quarries. A sample taken from DH102 for testing was assessed not to be suitable due to significant clay and joint infill causing the sample to break during trimming.

There were three lower strength values of 9.1MPa, 10MPa, and 13MPa measured for highly altered greywacke cores sampled between 76.0m and 78.0m depth in DH103 near the northern extent of volcanic materials associated with the Kaarearea Paa volcanic cone, and one at 39.0m depth in DH101 near the Hunua Fault.

The alteration is possibly due to hydrothermal waters circulating near the contact between the WCM and greywacke, possibly influenced by the nearby eruptive centre. Results from greywacke UCS testing are presented in Table 5.

Table 5: UCS Testing of Waipapa Group Greywacke Material

Borehole	Sample Depth	Weathering Grade	UCS (MPa)	Comments
DH101	39m	SW-MW	13	Hydrothermally Altered
DH101	50m	SW	54	
DH102	39m-40m	SW-MW	62	
DH102	43m	MW	-	Significant clay and mineral joint infill, sample not suitable for testing.
DH102	49m	SW	20	
DH102	50m	SW	24	
DH103	76m	SW-MW	10	Hydrothermally Altered
DH103	77m	SW-MW	9.1	Hydrothermally Altered
DH104	33m	SW	23	
DH104	38m	SW	20	
DH105	29m	UW	87	
DH105	45m	UW	135	

Five samples of the WCM mudstones encountered in DH103 and DH104 that are inferred to form a wedge of material through the central portion of the site ranged in strength between 11MPa and 24MPa (i.e. weak to moderately strong rock). Three samples of a conglomerate layer near the base of the WCM taken from DH104 drilled to the west of Kaarearea Paa volcanic cone were also tested, that ranged in strength from 4MPa to 8.2MPa (i.e. very weak to weak rock). A summary of results of WCM and conglomerate UCS testing are presented in Table 6.

Table 6: UCS Testing of WCM Mudstone and Conglomerate

Borehole	Sample Depth	Weathering Grade	UCS (MPa)	Comments
DH103	39m	SW	13	Carbonaceous Mudstone
DH103	71m	SW	24	Carbonaceous Mudstone
DH104	12m	SW	11	Silty Mudstone
DH104	23m	SW	12	Sandy Mudstone
DH104	26m	SW	4	Conglomerate
DH104	28m	SW	5.5	Conglomerate
DH104	29m	SW	8.2	Conglomerate

14.0 Geotechnical Assessment

As part of the geotechnical assessment Riley has undertaken:

- A defect stability assessment utilising the Rocscience Dips computer program to undertake kinematic analysis.
- Selection of five assessed critical and representative geotechnical cross sections through the proposed quarry extension for assessment and analysis.
- Development of geotechnical parameters and groundwater profiles for the sections.
- Limit equilibrium analysis of stability of critical cross sections using the Rocscience SLIDE2 computer program.

14.1 Intact Rock Stability Assessment

To assess the risk of instability due to a reduction in confining pressures on the intact rock near the base of the proposed quarry, an assessment has been made of the maximum vertical height of the quarry compared to the UCS of materials encountered in the investigation. The maximum vertical height of the pit is approximately 320m, and a representative bulk unit weight for unweathered greywacke material is approximately 27kN/m³. The maximum vertical pressure due to the weight of material is therefore unlikely to be greater than 8.6MPa. This is less than the minimum values of 9.1MPa UCS for the hydrothermally altered greywacke material, and 20MPa to 135MPa UCS for slightly weathered to unweathered greywacke material. The risk of the rock near the base of the pit failing due to overburden pressure induced rock burst is therefore assessed to be low.

14.2 Kinematic Defect Stability Assessment

Riley has undertaken Kinematic analysis for the Waipapa Group greywackes and WCM using Rocscience Dips software based on collated surface and subsurface information. This utilises stereonet analysis (lower hemisphere) to estimate the percentage of probability of failures for a given batter slope based on the total number of intersecting defects. Note that results are derived from limited defect data within the greywacke and WCM. No defect patterns have been observed in the conglomerate of overlying volcanic deposits, so these are omitted from specific defect assessment. It is important that the assessment of defects and their potential impacts of excavation and batter stability will continue as the quarry extension is developed. It is recommended that this assessment be incorporated as part of the annual stability review.

Note that kinematic analysis was undertaken using the full dataset of all joint types, and are not separated out into different defect types, e.g. joints, bedding planes, shear zones, unless otherwise specified, although they are divided by material type.

14.2.1 Prominent Waipapa Greywacke Defect Orientations

A large failure has previously occurred within a south facing greywacke slope above RL 91m within the existing main quarry pit. The failure is described as a topple type failure by Gaia Engineers (2022b). Similar toppling, planar and wedge failures occur within all quarries in Auckland greywacke quarries. Examples of the mechanisms are shown in Figure 8. An understanding of common defect characteristics allows for understanding of relative risk of these occurring with various face orientations and cut angles.

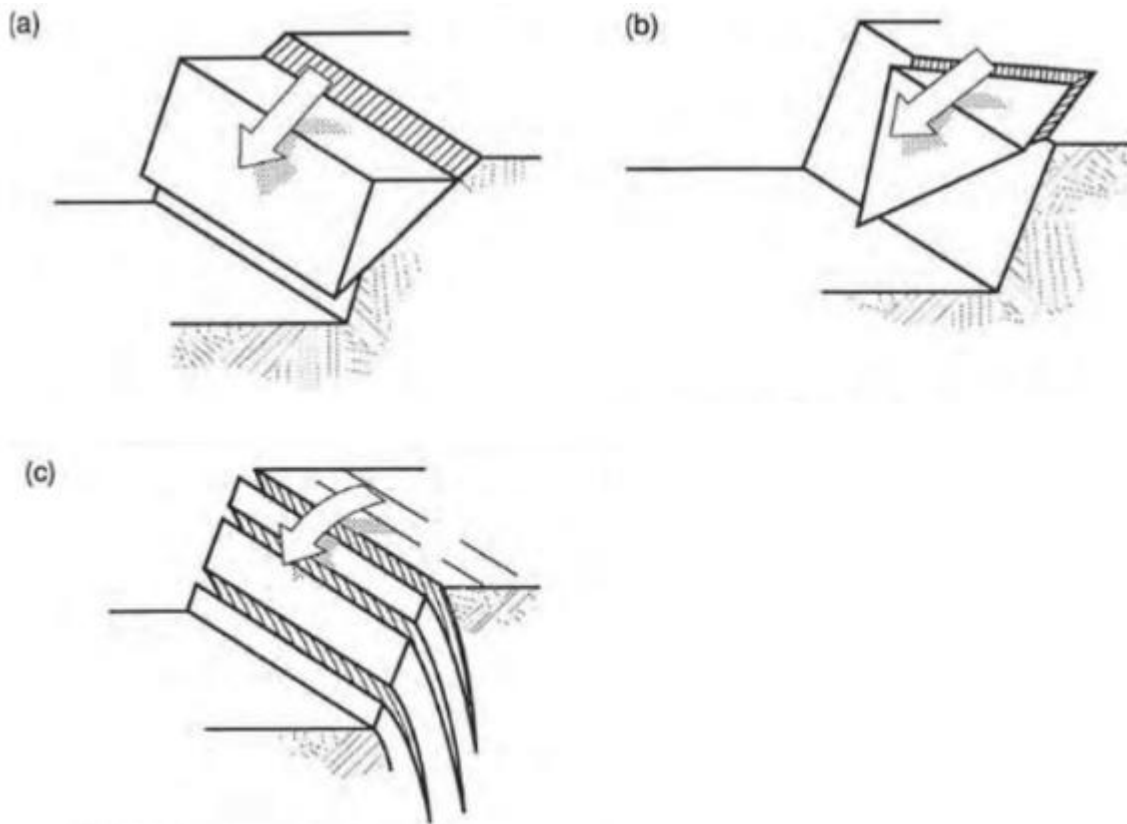


Figure 8: Examples of common failure types in rock that includes planar (a), wedge (b) and toppling (c)¹.

Both central farm and NE stream exposures assessed during the Riley site walkover show a trend of NE-SW oriented defects (a common defect orientation in Hunua greywackes and these are sub-parallel to adjacent prominent faults). Exposures within the upper quarry pit display a strong NNW-SSE (also a common defect orientation in Hunua greywackes) and NW-SE trend, with some minor defect sets oriented at a N-S, NE-SW, and E-W orientation.

The Drury Quarry geological assessment by Terra Mining details two main defect orientations within the Waipapa greywacke of the Sutton Block, an NNE-SSW set of defects parallel to the faults, and a NE-SW to E-W trending joint set. The dips of these are noted to be generally steep without an obvious prominent dip direction (i.e. they can steeply dip either north or south).

¹From Wyllie and Norris (1996), Landslides: investigation and Mitigation, Transportation Research Board, Special report 247, modified from Hoek and Bray (1981) Rock Sope Engineering.

RDCL results from greywacke within the boreholes display a trend of NNE–SSW oriented defects in DH101, DH102, DH103, and DH104. A trend of NE–SW to E–W oriented defects is also identified within DH101, DH102, DH103, and DH104. These trends are consistent with those identified in both the previous Terra Mining investigation and in the surface greywacke exposures discussed in Section 8.0. The RDCL data includes all ‘defect’ types within the greywacke unit. This may include but is not limited to joints, fractures, bedding planes, and shear surfaces.

The prominent NNW–SSE and NW–SE oriented defects identified in the upper existing quarry pit batters, as detailed above, are consistent with strong defect trends within the RDCL results for DH102, DH103, DH104, and DH105.

Additionally, a strong trend of ESE–WNW oriented defects is found in DH105, however, no similar distinct trends are noted in any of the other Riley boreholes or in surface exposures.

Kinematic analysis was undertaken for the proposed 45° to 60° (from horizontal) inter-bench slopes for a number of face orientations using the anticipated final future highwall profile from Terra Mining and is based on combined greywacke defect data from RDCL from all of the Riley boreholes. The slope face locations of each analysis were given a point ID, these are displayed on Riley Dwg: 220245–13. The results are presented as the percentage of critical intersections (that could form feasible failure planes) out of the total number of intersections within the dataset. Results are displayed below in Tables 7 to 10, and Figures 9 to 11. The key findings of the analysis are:

- Kinematic analysis shows that toppling-type failures are the most probable type of structurally controlled failure mechanism, with percentage of critical intersections up to 27.37%.
- Kinematic analysis shows that the frequency of wedge and planar type failures are likely to be kinematically feasible with similar maximum percentages of critical intersections of 10.50% and 10.90%, respectively. The relatively low risk of wedge failures (typically a common high-risk occurrence in cut Hunua greywacke) is due to the relatively low proposed inter-bench face angle of 60° from horizontal. This is consistent with earlier studies by Gaia (2022b) in the current main pit.
- It is expected that the likelihood of wedge failures will increase as excavation progresses into the southern section of the pit, into northwards and north-eastward facing slopes, based on collected data.
- A trend in the likelihood of planar failures indicates increased failures of this type as excavation progresses towards the east, into north-westwards and westwards facing slopes.
- Topple failure occurrences are expected to increase as excavation progresses towards the south and east sides of the quarry pit, into northwards, westwards, and north-westwards facing slopes, although all other slope orientations analysed display critical intersection percentages of greater than 16.0% for toppling type failures.
- Inter-bench slopes of north, north-east, north-west, and west facing orientations are assessed to have the greatest risk for all failure types within Waipapa Greywacke material.

- Compared to the WCM analysed in Section 13.1.2, the Waipapa Greywacke is likely to have a greater probability of wedge failures, a similar probability of planar failures, and a lower probability of topple failures.
- Outputs from Rocscience Dips analysis software are appended (Appendix B).

Table 7: Locations and Slope Details for Kinematic Analysis within Waipapa Greywacke Material for the Proposed Inter-bench Slopes

Kinematic Analysis Locations in Greywacke				
Point ID ⁽¹⁾	Proposed Pit Wall Azimuth (°)	Facing	Proposed Inter-bench Face Angle (°) ⁽²⁾	Location within Proposed Pit
A	112	East	60	Western Wall
B	062	North-east	60	Southwestern Corner
C	320	North-west	60	Along Southern Accessway
D	005	North	60	North of Kaarearea Paa , West of Hunua Fault
E	056	North-east	60	North of Kaarearea Paa, East of Hunua Fault
F	068	North-east	60	Northeast of Kaarearea Paa
G	358	North	60	Southeastern Wall
H	278	West	45	Eastern Wall (upper slope)
I	278	West	60	Eastern Wall (lower slope)
J	298	North-west	45	Eastern Wall (upper slope)
K	298	North-west	60	Eastern Wall (lower slope)
L	201	South-west	45	Northern Wall within central fault block (upper slope)
M	201	South-west	60	Northern wall within central fault block (lower slope)
N	184	South	45	Northern wall East of branch fault (upper slope)
O	184	South	60	Northern wall East of branch fault (lower slope)

⁽¹⁾ See Riley Dwg: 220245-13.

⁽²⁾ Assessment undertaken for individual inter-bench faces (i.e. slope between proposed benches) not overall pit wall angle consisting of multiple benches.

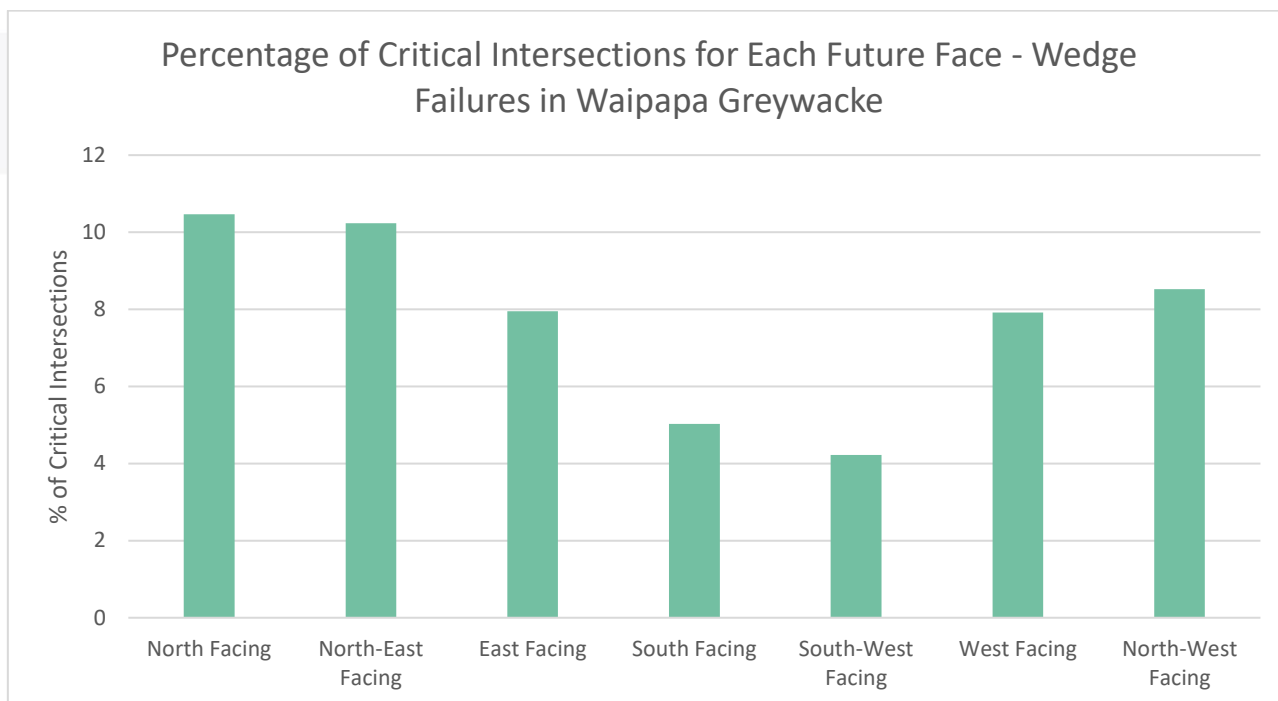


Figure 9: Greatest Probability for Wedge Failures Within Waipapa Greywacke Material For Proposed Inter-Bench Faces Of Various Pit Slope Orientations And Slope Angles (As Outlined In Tables 7 And 8)

Table 8: Kinematic Analysis Results for Wedge Type Failures in Waipapa Greywacke for Proposed Inter-bench Slopes Outlined in Table 7

Greatest Percentage of Critical Intersections – Wedge Failures in Greywacke			
Slope Orientation	% of Critical Intersections for Inter-bench Slope Faces ⁽¹⁾	Azimuth (°)	Point ID ⁽²⁾
North Facing	10.26 – 10.47	358 – 005	D, G
North-East Facing	9.92 – 10.23	058 – 062	B, E, F
East Facing	7.95	112	A
South Facing	2.06 – 5.03	184	N, O
South-West Facing	1.63 – 4.22	201	L, M
West Facing	2.69 – 7.92	278	H, I
North-West Facing	2.51 – 8.52	298 – 320	C, J, K

⁽¹⁾ Assessment undertaken for individual inter-bench faces (i.e. slope between proposed benches) not overall pit wall angle consisting of multiple benches.

⁽²⁾ See Riley Dwg: 220245-13.

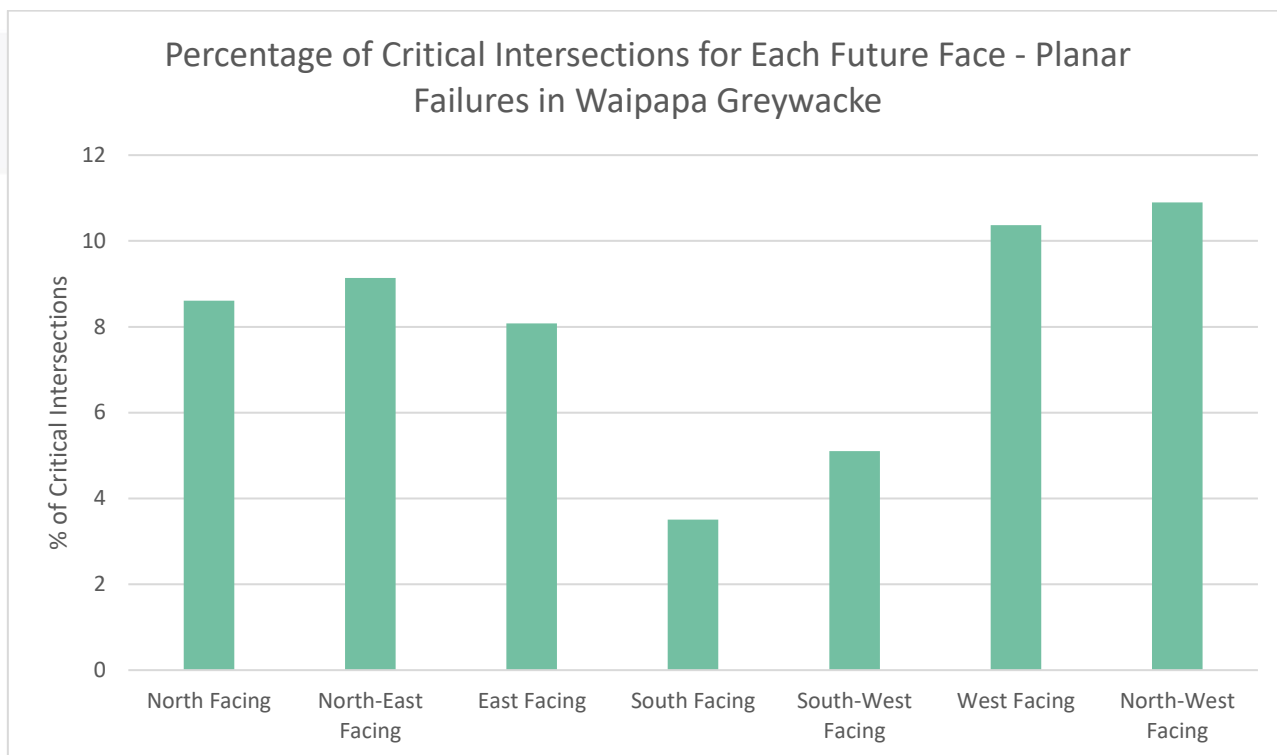


Figure 10: Greatest Probability for Planar Failures within Waipapa Greywacke Material for each Proposed Inter-bench Faces for pit slope orientation and slope angles analysed (as outlined in Tables 7 and 9)

Table 9: Kinematic Analysis Results for Planar Type Failures in Waipapa Greywacke for Proposed Inter-bench Slopes Outlined in Table 7

Greatest Percentage of Critical Intersections – Planar Failures in Greywacke			
Slope Orientation	% of Critical Intersections*	Azimuth (°)	Point ID
North Facing	8.61	358 – 005	D, G
North-East Facing	8.44 – 9.14	058 – 062	B, E, F
East Facing	8.08	112	A
South Facing	1.23 – 3.51	184	N, O
South-West Facing	1.05 – 5.10	201	L, M
West Facing	3.87 – 10.37	278	H, I
North-West Facing	2.81 – 10.90	298 – 320	C, J, K

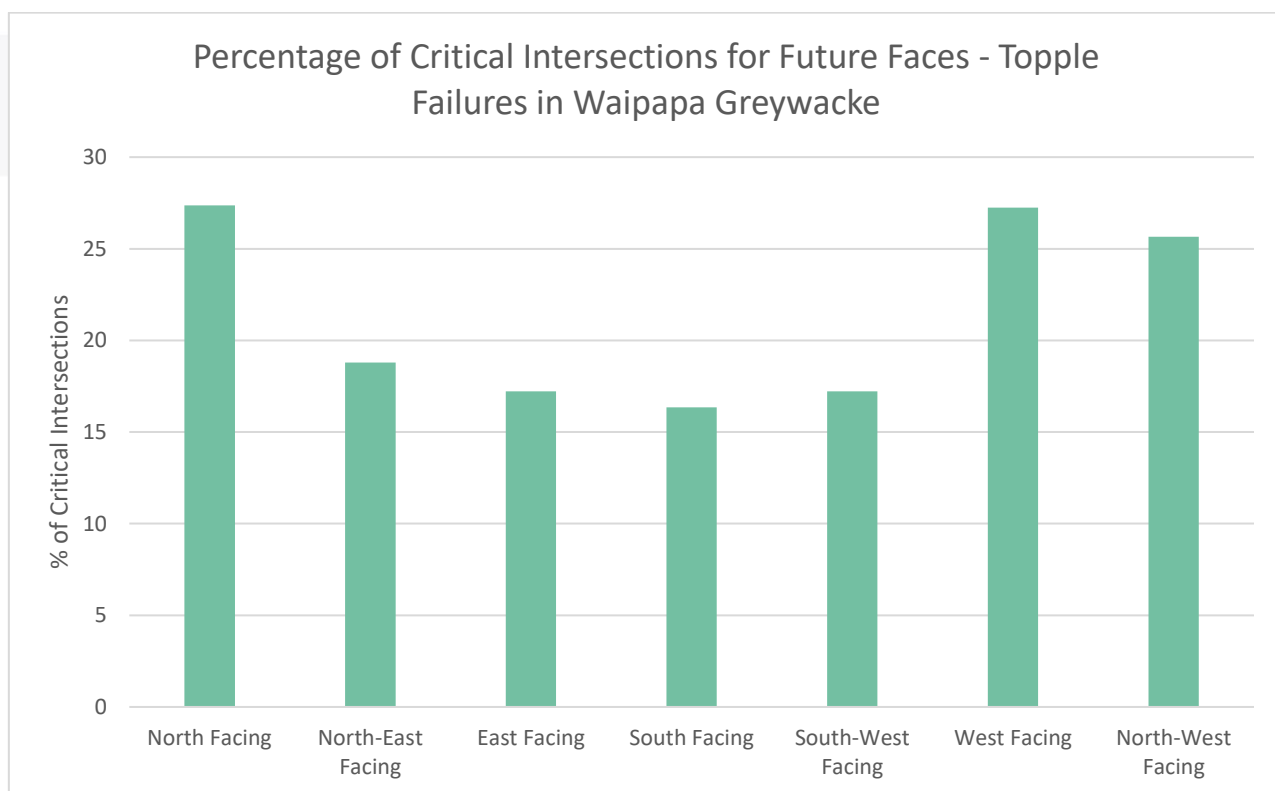


Figure 11: Greatest probability for topple failures within Waipapa Greywacke material each proposed inter-bench faces for pit slope orientation and slope angles analysed (as outlined in Tables 7 and 10)

Table 10: Kinematic Analysis Results for Topple Type Failures in Waipapa Greywacke for Proposed Inter-bench Slopes Outlined in Table 7

Greatest Percentage of Critical Intersections – Topple Failures in Greywacke			
Slope Orientation	% of Critical Intersections	Azimuth (°)	Point ID
North Facing	23.90 – 27.37	358 – 005	D, G
North-East Facing	18.63 – 18.80	058 – 062	B, E, F
East Facing	17.22	112	A
South Facing	15.47 – 16.34	184	N, O
South-West Facing	16.87 – 17.22	201	L, M
West Facing	23.30 – 27.24	278	H, I
North-West Facing	22.32 – 25.66	298 – 320	C, J, K

In practice, it has been commonly observed that planar failure tends to occur only if the dip direction of a plane is within a certain circular angular range of the slope face dip direction. There are, however, nearby examples within Waikato Coal mines in which flat planes relative to the cut slope have experienced planar failure (Hegan & Read, 1988). The results displayed in Table 9 have been modelled with no lateral limits providing more conservative values, as this assumes that all daylighting planes are feasibly possible for planar sliding.

For comparison to the current site, experience with Whitford Quarry showed that while infrequently encountered in the excavated greywacke slopes, potential planar failures along persistent out of slope facing defects can pose a significant risk to bench and multi-bench stability.

The noted frequency of planar type failures from mapping of existing quarry faces was greater within Clevedon Quarry than Whitford, with a significant number of persistent north-west facing defects that dipped out of formed faces that included a previously over-steepened west facing highwall that had batters formed along strike of the defects. For both Whitford and Clevedon Quarries, experience has highlighted the importance of selecting appropriate batter slope design, and the continued monitoring during excavation.

While the measured defects within the greywacke materials show possible dominance of defects within different areas of the proposed quarry, as described above in relation to individual boreholes and as indicated on Riley Dwg: 220245-I3, the limited data typically shows either a NE-SW (DH102 and DH104) or NW to SE (DH101 and DH103) dominance of defect orientations. The Kinematic analysis, however, has been based on a combination of this data due to both the limited sample size and the risk that by compartmentalising defect orientations the analysis could potentially ignore a critical interaction between defects of different areas. This combined analysis of all measured defects indicates, in general, a greater frequency of potentially critical intercepting defects for the proposed eastern, northern, and western facings slopes.

Based on the above analysis, the greatest percentage for kinematically feasible defect-controlled instability is a topple type failure within the north, north-west and west facing proposed slopes. This differs from analysis and experience of the north-west facing slope at Whitford Quarry, where topple type failures were generally assessed as unlikely to occur, and this was supported by on-site observations during the development of the Quarry. For Whitford, there was a large amount of scatter in defect orientations with a broad range of NW-SE set of discontinuities subparallel to the active Waikopua Fault. The analysis for the Sutton Block appears similar to trends noted for Clevedon Quarry where topple type failures have been observed in the north-west facing slopes of the highwall and where there is a dominant measured presence of W-E and NW-SE defect orientation. The analysis for the proposed Sutton Block extension indicates that for all assessed failure types and all geological units, the north, northwest, and west facing batters have the greatest risk of defect-controlled instability.

Based on previous experience, wedge type failures within Whitford and Clevedon Quarries have been the most frequent failure mechanism and have posed the greatest risk to excavation within the unweathered to highly weathered greywacke materials. This type of failure mechanism, therefore, appears relatively underrepresented in the Sutton Block analysis in regard to frequency of potentially critical intersecting defects. However the size of wedge failures in these materials can be greater than topple failures. The analysis does, however, indicate that there is a potential for a relatively greater frequency of wedge type failures in the southern portion of the proposed quarry compared to the northern portion.

Please refer to appended table (Appendix B) for full presentation of Kinematic analysis results.

14.2.2 Prominent WCM Defect Orientations

During observation of cut faces in the upper existing quarry pit, it was noted that faces containing WCM were standing up at cut angles of 26° to 29° (approximately 1V:2H). Coal seam bedding was generally dipping between 4° and 16° out of slope. Bedding of the coal seams were predominantly striking in an NNW–SSE direction, dipping towards the west (therefore west facing slopes have a higher risk, however even east facing slopes can move on bedding planes gently dipping into face, due to low strength on the failure horizon).

RDCL results from within DH102 and DH104 display a strong trend of NNW–SSE oriented defects, consistent with observations within the upper existing quarry pit, as above. DH101 and DH103 do show some similarly oriented defects, although these are not the strongest trends within these datasets. DH101 and DH103 show a strong trend of N–S to NE–SW oriented defects. Other minor trends observed include NNE–SSW in DH102, and ESE–WNW and E–W in DH104. No defect data was collected through the minimal 1.5m section of mudstone within DH105 by RDCL.

Defects within the WCM classified as ‘Bedding Planes’ by RDCL were separated from other defects logged and presented (Appendix B). Across DH101 to DH104, a general trend of N–S to ENE–WSW striking bedding planes was identified, generally dipping westwards to north–westwards.

Kinematic analysis was undertaken for a number of individual proposed inter-bench slope faces between batters (rather the overall quarry slope) using orientations based on the anticipated final future highwall profile from Terra Mining and utilising the combined WCM defect data from RDCL from all of the Riley boreholes. The slope face locations of each analysis were given a point ID, these are displayed on Riley Dwg: 220245–12. The results are presented as the percentage of critical intersections (that could form feasible failure planes) out of the total number of intersections within the dataset. Results are displayed below in Tables 11 to 14, and Figures 12 to 14. The key findings of the analysis of the proposed inter-bench slopes are:

- Kinematic analysis shows that toppling-type failures are the most probable type of structurally controlled failure mechanism, with percentage of critical intersections up to 48.25%.
- Kinematic analysis shows that the frequency of planar and wedge type failures are likely to be kinematically feasible with maximum percentages of critical intersections of 10.80% and 7.80%, respectively (please note additional discussion on planar failure risk at the end of this section).
- It is anticipated that the likelihood of wedge failures will increase as excavation progresses into the south-eastern section of the pit, into north-westwards facing slopes.
- It is anticipated that the likelihood of planar failures would increase as excavation progresses towards the south and south-east of the pit, into northwards and north-westwards facing slopes.
- For interim slopes (ahead of the final batter locations) west facing slopes in the WCM could have elevated risk of failure due to gentle west-dipping bedding planes (i.e. bedding surfaces dipping out of slope).

- Topple failure occurrences are expected to increase as excavation progresses towards the south and south-east sides of the quarry pit, into northwards and north-westwards facing slopes, although all other slope orientations analysed display critical intersection percentages of greater than 22.0% for toppling type failures.
- Slopes of north and north-west facing orientations are assessed to have the greatest risk for all failure types within WCM material.
- Compared to the Waipapa Greywacke material discussed in Section 13.1.1, the WCM has a greater probability of topple type failures, a similar probability of planar type failures, and a lower probability of wedge type failures.

The assessed risks presented here for Drury Quarry vary from findings from other quarries and outcrops such as nearby Ponga Road and existing open pits in the Northern Waikato Coal Region (Hegan & Read, 1988), where planar and planar-wedge type failures along low strength bedding planes and bedding plane shear zones generally dominate in WCM. Relative risks assessed from the Kinematic analyses indicate toppling failure as having a greater probability than planar failure. However, planar failure along gently dipping bedding planes, presents a far greater consequence than toppling due to the mass of displaced material potentially involved. Other important considerations include major defects such as shear zones and organic bedding layers, which may have a dominant effect on stability due to low friction angles and persistence, which makes this type of failure more likely (and likelihood is not accurately assessed based on kinematic analysis techniques).

Results of Kinematic analysis are summarised below and outputs from Rocscience Dips analysis software are appended (Appendix B).

Table 11: Locations and Slope Details for Kinematic Analysis within WCM for Proposed Inter-bench Slopes

Kinematic Analysis Locations in WCM				
Point ID*	Proposed Pit Wall Azimuth (°)	Facing	Proposed Pit Wall Angle (°)	Location within Proposed Pit
A	315	Northwest	45	Along south-east Accessway
B	068	Northeast	60	North of Kaarearea Paa, within central fault block
C	003	North	60	Northeast of Kaarearea Paa
D	027	Northeast	60	Northeast of Kaarearea Paa
E	058	Northeast	60	Northeast of Kaarearea Paa
F	185	South	45	Northern wall east of branch fault
G	197	South	45	Northern wall west of branch fault

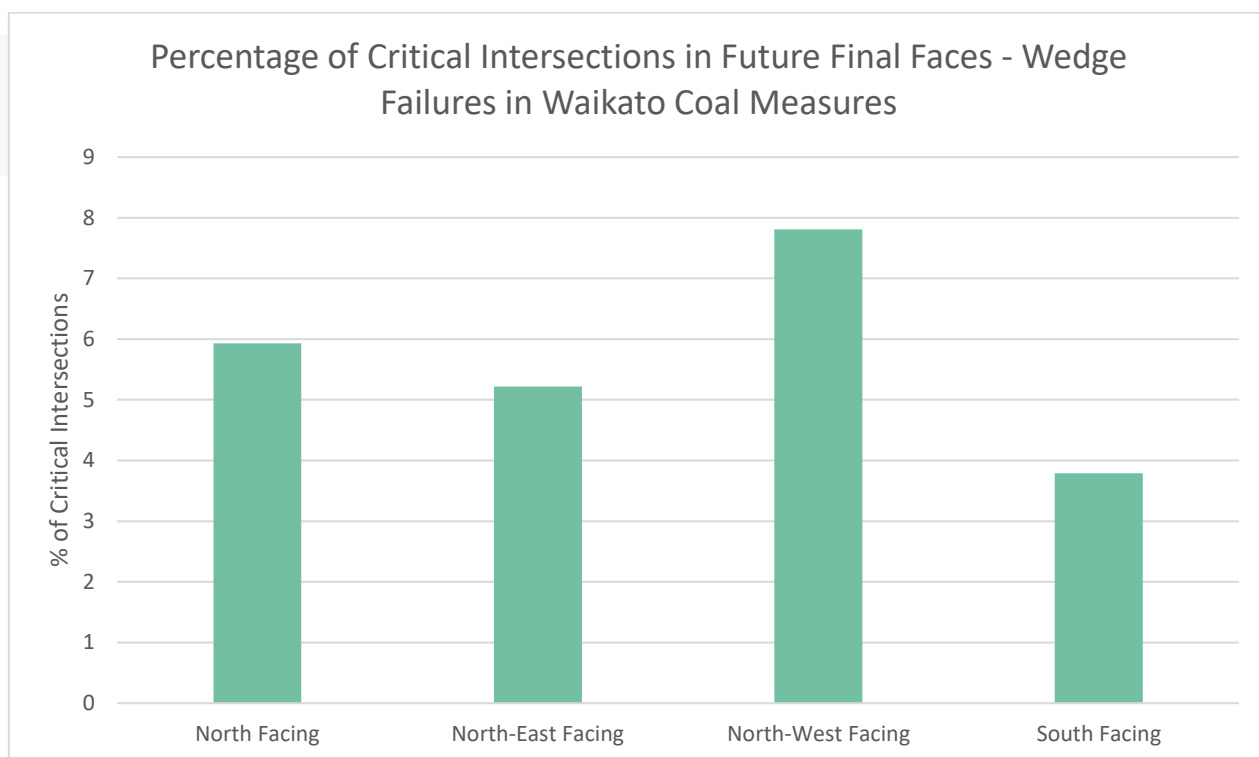


Figure 12 : Greatest probability for wedge failures within WCM for each proposed inter-bench slopes as outlined in Tables 11 and 12

Table 12: Kinematic Analysis Results for Wedge Type Failures in WCM for Inter-Bench Slopes Outlined in Table 11

Greatest % of Critical Intersections – Wedge Failures in WCM			
Slope Orientation	% of Critical Intersections	Azimuth (°)	Point ID
North Facing	5.93	003	C
North-East Facing	4.34 - 5.22	027 – 068	B, D, E
North-West Facing	7.81	315	A
South Facing	3.79	185	F

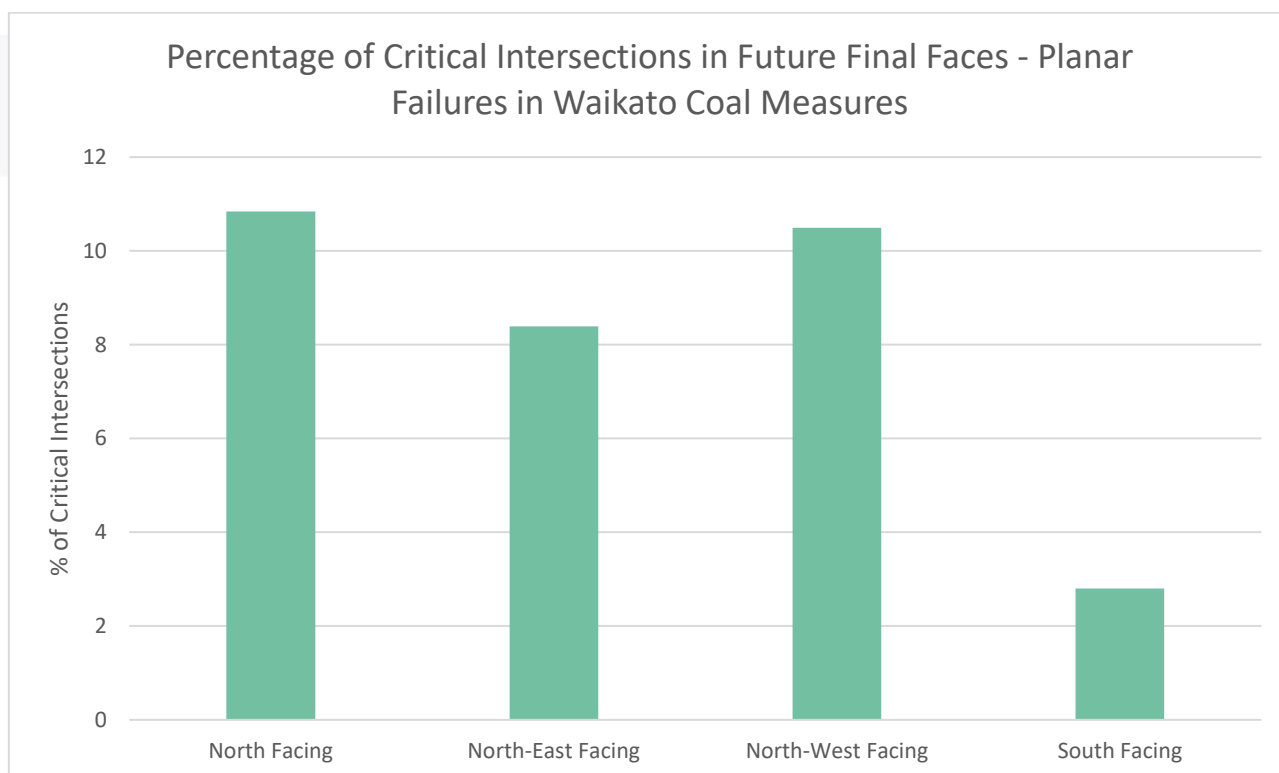


Figure 13: Greatest probability for planar failures within WCM for proposed inter-bench slope profiles, as outlined in Tables 11 and 13

Table 13: Kinematic Analysis Results for Planar Type Failures in WCM for Inter-bench Slopes Outlined in Table 11

Greatest % of Critical Intersections – Planar Failures in WCM			
Slope Orientation	% of Critical Intersections	Azimuth (°)	Point ID
North Facing	10.84	003	C
North-East Facing	6.29 – 8.39	027 – 068	B, D, E
North-West Facing	10.49	315	A
South Facing	2.80	185	F

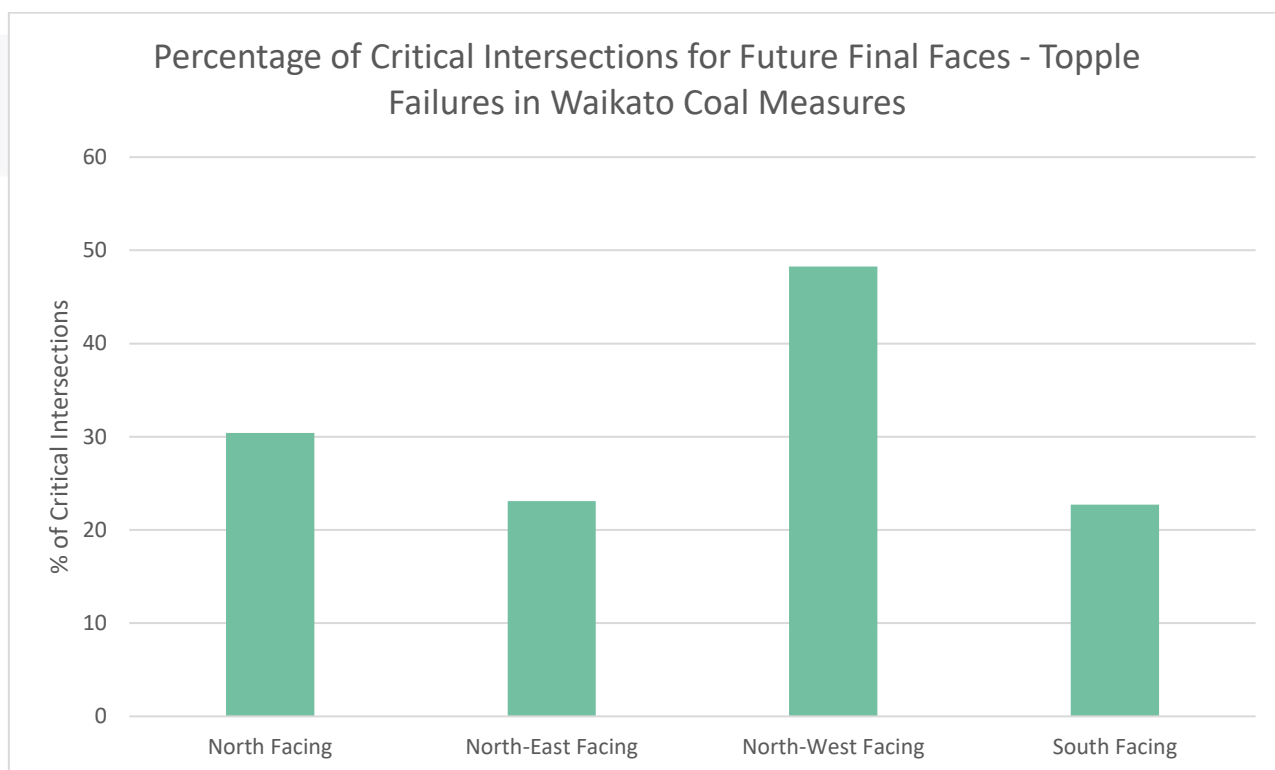


Figure 14: Greatest probability for topple failures within WCM for each proposed pit slope final face orientation analysed for inter-bench slopes as outlining in Tables 11 and 14.

Table 14: Kinematic Analysis Results for Toppling Type Failures in WCM for Inter-bench Slopes Outlined in Table 11

Greatest % of Critical Intersections – Topple Failures in WCM			
Slope Orientation	% of Critical Intersections	Azimuth (°)	Point ID
North Facing	30.42	003	C
North-East Facing	13.99 – 23.08	027 – 068	B, D, E
North-West Facing	48.25	315	A
South Facing	22.73	185	F

Failure probabilities presented in this report section are based on a dataset of limited size and extent, and therefore, some probabilities of failure presented here may be relatively different. The failure probability results presented are linked to the number of defect intersections i.e. kinematically feasible failure surfaces within the dataset that are likely to occur, however, actual likelihood of failure along these intersections is not necessarily represented and can be affected by controlling factors such as persistence of joints and bedding planes, roughness of defect surfaces, localised variations in weathering or infill, etc. Even low presented percentages of defects intersecting do not rule out the possibility of a failure. Note that Kinematic analysis does not take into account potential controlling effects of persistent, dominant defects such as faults and weak bedding planes.

The Kinematic analysis method of assessing failure on low strength planar surfaces may not necessarily provide an accurate representation of the risk presented by bedding plane failures. The Riley assessment of this risk has been combined with limit equilibrium analyses outlined in Section 13.2. The limit equilibrium analyses indicates that, while potential planar failures along persistent weaker layers (i.e. bedding) within WCM on low angle defects may present as low probability based on Kinematic assessment, the persistence of the defects, combined with potential low strengths on the surfaces presents a potential significant hazard to quarry development if not suitably addressed.

14.3 Slope Stability Analysis

Riley has carried out quantitative limit equilibrium slope stability analysis using Rocscience Slide 2 software that is able to calculate the Factor of Safety (FoS) against instability for both circular and non-circular failure surfaces for different load cases for the overall proposed quarry slope design. This 2D Limit equilibrium analysis was undertaken for the final quarry excavation for the five geotechnical sections A, F, G, H, and K assessed to be critical to the proposed quarry extension and representative of key final faces regarding the potential effects on slopes adjacent and nearby the proposed excavation. The analysis has been undertaken for the proposed final quarry extent as provided by Terra Mining.

14.3.1 Target Factors of Safety (FoS)

Limit equilibrium slope stability analysis calculates the assessed forces resisting and driving instability. The ratio of these resisting and driving forces is the FoS, with a FoS of 1.0 indicating marginal stability and FoS of greater than 1.0 an increasing margin against instability. Target FoS adopted for analysis are summarised in Table 15.

Table 15: Summary of Adopted Target Factors of Safety

Design Case	Target FoS
Normal Groundwater Levels	≥ 1.5
Extreme Groundwater Levels	≥ 1.2
100-Year Seismic Event (0.09g)	≥ 1.1

14.3.2 Slope Stability Geotechnical Parameters

Slope stability analysis has utilised parameters based on Mohr-Coulomb effective stress parameters for the soil materials and Generalised Hoek-Brown failure criterion parameters for intact rock mass materials. Parameters used for slope stability analysis are listed in Tables 16 and 17.

Parameters for the WCM have been based on a review of material encountered in Riley boreholes (DH101 to DH105 inclusive) as well as review of existing slopes to the south, including back analysis of existing formed slopes to the south of Kaarearea Paa to assess likely lower bound parameters. Riley has also undertaken a review of previous reporting by Gaia for Thorburn Gully to the south of the site as well as published studies (Hegan, B. and Read, S. (1988), Lindsay, P and Moore, T. (2001)).

It should be noted that for WCM materials we have defined lower strength parameters in the horizontal plane to the vertical plane. This represents the effect of lower strength, gently dipping bedding planes within the WCM.

Parameters for the greywacke material have been based on materials encountered in Riley machine borehole and those developed and utilised by Riley for Whitford Quarry and Clevedon Quarry where materials have been assessed to have similar geotechnical qualities.

Table 16: Recommended Parameters for Limit Equilibrium Analyses for Soil Strength Materials

Material	Unit Weight (kN/m ³)	Cohesion (kPa)	Friction Angle (°)	Comment
South Auckland Volcanic Field	18	3	28	Represents residually weathered material
Carbonaceous Mudstone (WCM Mudstone) (vertical)	18	15	29	
WCM Organic Horizons (Horizontal)	18	8	27	Represents low strength bedding horizons
WCM Conglomerate	18	8	29	
Greywacke Overburden (Completely to Residually Weathered Waipapa Group Greywacke) (OB)	18	19	30	
Highly Weathered Waipapa Group Greywacke (BR)	20	25	32	

Table 17: Recommended Generalised Hoek Brown Parameters for Rock Strength Materials

Material	Unit Weight (kN/m ³)	UCS (kPa)	m	s	a	Comment
Moderately Weathered Waipapa Group Greywacke (BB)	22	3,000	0.687	0.0007	0.516	
Slightly Weathered Waipapa Group Greywacke (BL)	24	8,000	0.764	0.001	0.513	
Fresh Waipapa Group Greywacke (BL)	27	19,000	0.981	0.0022	0.508	
Waipapa Group Greywacke Fault Zone	24	8,000	0.431	0.0002	0.538	
Waipapa Group Greywacke Broken Rock (immediately adjacent to fault)	27	19,000	0.554	0.0004	0.524	

Where OB: Overburden
BR: Brown Rock
BB: Blue-Brown Rock
BL: Blue Rock

14.3.3 Groundwater Assumptions

For the analysis, normal groundwater levels are those typically measured on-site and can usually be divided into a deeper water table within the slightly weathered and fresh rock, along with a perched water table within the completely, highly, and moderately weathered material. Experience at Whitford and Clevedon Quarries indicate that such a perched water table can be transient and may only exist near-surface in response to storm events or prolonged wet periods. Extreme groundwater levels incorporate the deeper groundwater table at between 20.0m and 56.0m above normal level, and with the upper perched water table generally within 6.0m to 12.0m depth of the slope crest.

Based on discussions with PDP and experience at Whitford Quarry, it has been assumed that the excavation of the quarry will result in a significant drawdown of the deeper groundwater table within the typically permeable greywacke rock mass. The Riley slope stability analysis has therefore assumed this drawdown and incorporated it into our slope stability models.

14.3.4 Seismic Assumptions

An assumed earthquake magnitude of 5.9 was adopted based on NZGS guidelines² and a 100-year return period for slope stability assessment purposes for the pseudo-seismic limit state analysis. This was used based on the anticipated design life of the quarry of 50-years, (i.e. when people could be on or below the subject slopes).

This resulted in an assumed horizontal Peak Ground Acceleration (PGA) of 0.09g, which was utilised in the analysis (based on shallow soil class) based on-site specific assessments undertaken for Whitford Quarry (T+T, 2005) and consistent with preliminary seismic design parameters recommended by Gaia for the northern extension of the existing quarry (Gaia, 2015).

14.3.5 Slope Stability Outputs

Slope stability analysis was undertaken within the WCM and the Waipapa Greywacke, under both the proposed Terra Mining pit design, and reduced slope angles proposed by Riley. Results of the slope stability analyses for the following are provided in Tables 18 to 20:

- Proposed WCM batters presented in Terra Mining's pit shell 1V:1H (45°)
- Reduced overall slope angle within WCM to approximately 1V:2H (27°)
- Proposed Waipapa Greywacke presented in Terra Mining's pit shell

The FoS values presented within Tables 18 to 20 represent significant multi-bench failure surfaces i.e. two-bench height or larger. Many of the modelled sections also indicated likelihood of single-bench failures or less with lower FoS values (below target) than indicated in the table, these are included within the comments section of the table, where assessed, with further discussion included below the tables. Whole slope risk is generally represented by the FoS values for the greywacke rock, which indicate stability through this material and the full pit slope under different cases. Slide slope stability outputs for all results are appended (Appendix A).

² New Zealand Geotechnical Society (NZGS) and Ministry of Business Innovation & Employment (MBIE) Earthquake Geotechnical Engineering Practice in New Zealand, Rev 1, Issue Date: November 2021.

Table 18: Summary of Slope Stability for Normal Long-term Static Groundwater Load Case Outputs. Results in **red** text highlight values which do not meet target Factor of Safety values and is constrained to the surficial WCM material.

Cross Section	Normal Long-term Groundwater Case			Target FoS	Comments
	Waikato Coal Measures (1V:1H)	Waikato Coal Measures (~1V:2H)	Greywacke Rock		
A	0.9	1.3	1.6	≥ 1.5	Stability analysis indicates several multi-bench slip surfaces with a FoS <1.0 through WCM cut at 1V:1H and FoS of <1.5 for inter-bench height failures in WCM for 1V:1H and 1V:2H slope profiles
F	N/A	N/A	1.55		No WCM inferred to be present through Section F.
G	1.4	>1.5	1.3		Stability analysis indicates a FoS of <1.5 within greywacke.
H	N/A	N/A	1.4		Stability analysis indicates a FoS of <1.5 within greywacke. No WCM inferred to be present through Section H.
I	>1.5	N/A	1.6		Stability analysis indicates a FoS of >1.5 for WCM and greywacke.
J	1.5	N/A	>1.5		Stability analysis indicates a FoS of >1.5 for WCM and greywacke.
K	N/A	N/A	1.8		No WCM inferred to be present through Section K.

Table 19: Summary of Slope Stability for Extreme Static Groundwater Load Case Outputs. Results in **red** text highlight values which do not meet target Factor of Safety values and is constrained to the surficial WCM material

Cross Section	Extreme Static Groundwater Case			Target FoS	Comments
	WCM (1V:1H)	WCM (~1V:2H)	Greywacke Rock		
A	1.1	1.47	1.5	≥ 1.2	Stability analysis indicates a FoS of <1.2 for localised bench-height failures in WCM cut at 1V:1H.
F	N/A	N/A	1.2		No WCM inferred to be present through Section F.
G	1.4	N/A	1.2		Stability analysis indicates a FoS of >1.2 in WCM and greywacke.
H	N/A	N/A	1.3		Stability analysis indicates a FoS of >1.2 in WCM and greywacke. No WCM inferred to be present through Section H.
I	1.5	N/A	1.5		Stability analysis indicates a FoS of >1.2 in WCM and greywacke.
J	>1.5	N/A	1.7		Stability analysis indicates a FoS of >1.2 in WCM and greywacke.
K	N/A	N/A	1.6		No WCM inferred to be present through Section K.

Table 20: Summary of Slope Stability for 100-Year Seismic Event (0.09g) Load Case Outputs. Results in **red** text highlight values which do not meet target Factor of Safety values and is constrained to the surficial WCM material.

Cross Section	100-Year Seismic Event (0.09g)			Target FoS	Comments
	WCM (1V:1H)	WCM (~1V:2H)	Greywacke Rock		
A	0.9	1.17	1.5	≥ 1.1	Numerous slip surfaces with a FoS <1.1 through WCM (1V:1H).
F	N/A	N/A	1.5		No WCM inferred to be present through Section F.
G	1.2	N/A	1.1		Stability analysis indicates a FoS of >1.1 in WCM and greywacke.
H	N/A	N/A	1.3		No WCM inferred to be present through Section H.
I	1.2	N/A	1.4		Stability analysis indicates a FoS of >1.1 in WCM and greywacke.
J	1.2	N/A	1.7		Stability analysis indicates a FoS of >1.1 in WCM and greywacke.
K	N/A	N/A	1.7		Stability analysis indicates a FoS of 1.1 for localised failures in RW greywacke. Note that benches are cut into residual material within proposed design. No WCM inferred to be present through Section K.

Slope stability results, which did not reach the target FoS value for the associated case, are shown in red text in the above Tables 18 to 20. A summary of below-target slope stability results is included below:

- Sections A did not meet target FoS values under normal groundwater conditions (Table 18) through the WCM at 1V:1H. This section also did not reach target FoS values after flattening the overall WCM slope angle to approximately 1V:2H.
- Sections G did not meet target FoS values under normal groundwater conditions (Table 18) through the WCM at 1V:1H and greywacke. Stability of the WCM was able to achieve target FoS for a reduced 1V:2H slope.
- Sections H did not meet target FoS values under normal groundwater conditions for greywacke slope (Table 18).
- Sections A did not meet target FoS values under extreme groundwater conditions (Table 19) through the WCM 1V:1H. Upon flattening the overall WCM slope angle to approximately 1V:2H, it surpassed the target FoS.

- Sections A did not meet target FoS values under 100-Year Seismic Event conditions (Table 20) through WCM at 1V:1H. Upon flattening the overall WCM slope angle to approximately 1V:2H, it surpassed the target FoS.

The below Sections 13.2.5 and 13.2.6 discuss the slope stability results for both the WCM and Waipapa Greywacke in further detail.

14.3.6 Waikato Coal Measures

Analysis was undertaken with the currently proposed quarry shell provided by Terra Mining that typically included slopes of 1V:1H (45°) for the WCM overburden for Sections A, G, H, I and J. For these cases modelled as above, most of the results were lower than target FoS values (<1.5 for normal long-term groundwater, <1.2 for extreme groundwater, and <1.1 for 100-Year Seismic events).

Analyses were also undertaken for a reduced overall slope angle for the WCM materials of approximately 1V:2H (27°), which increased FoS values for most analysed sections, under all load cases. These increases showed a measurable improvement in the overall stability of the slope. Practical experience with WCM shows flatter batters perform better than steep cuts.

Under normal long-term groundwater conditions, flattening the overall WCM slope to approximately 1V:2H increased FoS values from below to above target values for Section B. While Sections A did not reach target FoS values of >1.5 for either 1V:1H or approximately 1V:2H slopes, reducing the slope angle from 1V:1H to approximately 1V:2H resulted in an increase in the FoS values. Section G and H did not reach target FoS values of >1.5 for 1V:1H slope. However, given FoS >1.3, risk of instability is considered to be low.

Under extreme groundwater conditions by reducing the overall WCM slope to approximately 1V:2H the calculated FoS for the overall quarry wall with WCM overburden was able to be increased above target for Sections A.

Under a 100-year seismic event load case reducing the overall angle of the WCM slope to approximately 1V:2H increased the FoS values above target (>1.1) for Section A.

As noted, single inter-bench height failures were often present within the WCM in the above analyses. Additional modelling was undertaken to assess the general risk within WCM of failure for inter-bench height failures at their varying proposed slope angles. Results are displayed in Table 21, and Slide slope stability outputs are appended (Appendix A).

Table 21: Summary of Slope Stability Results within WCM Inter-Bench Slopes

Inter-bench Slope Angle (°)	Slope Angle Derived From:	Factor of Safety Result (No Groundwater)	Factor of Safety Result (Reasonable Worst-Case Groundwater)
	Target Fos Result	1.5	1.2
45° (1V:1H)	Proposed Terra Mining Pit Design	1.3	1.0
60° (1V:0.6H)	Proposed Terra Mining Pit Design	0.9	0.5
27° (1V:2H)	Proposed Riley Slope Angle	2.0	1.3

The above table indicates challenges with WCM in the presence of high groundwater levels and relatively steep cut faces. Our slope stability analysis for inter-bench slopes is preliminary. An ‘observational approach’ is recommended in which the performance of the batters is assessed during trials to mitigate this risk, this is discussed in the following Section 13.2.9, Minimising Slope Stability Risks.

14.3.7 Waipapa Greywacke

All FoS values within the Waipapa Greywacke rock appear to be sufficient to meet target FoS values within each load case, for each section modelled except Section G under normal and extreme groundwater conditions. The calculated Fos of 1.3 for Normal and 1.2 for extreme are slightly less than the targets of 1.5 and 1.3 respectively. As with the WCM discussed above, the slope stability analyses for these slopes are preliminary and an ‘observational approach’ is recommended in which the performance of the batters is assessed during trials to mitigate risk of failure.

14.3.8 South Auckland Volcanics

Some localised instability within the modelled residual volcanics is observed for Sections C and D. Under credible worst-case conditions, FoS results for battering back the residual South Auckland Volcanics material are satisfactory. However, analysis does indicate that instability may occur under assumed material parameters if the slopes were to become completely saturated. Table 22 displays the FoS results for modelling of residual volcanics as they inferred to be encountered up to approximately 3.6m depth through Sections C and D (with total height of volcanics up to approximately 7m height), flattened back to an overall slope angle of approximately 1V:2H (27°). Slide model outputs are appended.

Table 22: Summary of Slope Stability Results for Reduced Slope Residual Volcanics for Flattened Slope of Approximately 1V:2H (27°)

Cross Sections	Factor of Safety Result (No Groundwater)	Factor of Safety Result (Reasonable Worst-Case Groundwater)	Factor of Safety Results (Saturated)
	1.5	1.2	1.0
C and D	1.7	1.4	0.9

Parameters assumed for the residual volcanics are relatively conservative and based on materials encountered at the surface, the consistency of the material may improve with depth. As with the WCM and Waipapa Group discussed above, the slope stability analyses for these slopes are preliminary and an ‘observational approach’ is recommended in which the performance of the batters is assessed during trials to mitigate risk of failure.

14.3.9 Groundwater Sensitivity Analysis

A stability sensitivity analysis was undertaken for slightly weathered to fresh Waipapa Greywacke material, modelling each of the critical sections with varying groundwater levels. The depths to groundwater at which a FoS through each section resulted in as 1.2, 1.3, and 1.5, were recorded. Results are displayed in Table 23. It is intended these levels could be used for deep groundwater response trigger levels.

Table 23: Slope Stability Sensitivity Analysis of Waipapa Greywacke under Varying Groundwater Cases

	Modelled Groundwater Level (From Crest)	
Target FoS	1.5	1.3
Section A	51.5m	10.3m
Section F	38.4m	
Section G	184m	61m
Section H	150m	67m
Section K	20.3m	<10m

The critical groundwater depths displayed in Table 23 are generally at a lower depth than the Riley monitored results displayed in Table 4. The results from Riley monitoring are assessed to have encountered the ‘perched’ groundwater tables in the upper, more weathered materials, and therefore, display higher groundwater levels. The resulting critical depths displayed in Table 23 are for the deeper groundwater table within slightly weathered to fresh greywacke material. Additionally, the sample size of Riley monitoring bores is limited. We would also envisage that groundwater levels are likely to be significantly lowered by the progressive excavation of the quarry pit due to the typically highly permeable greywacke material.

This method would be further developed and incorporated into a more detailed slope stability management plan for the quarry, such as installing monitoring bores to inform if critical groundwater levels are reached.

14.3.10 Minimising Slope Stability Risks

Slope stability analyses indicate that, for the adopted effective stress parameters, most of the WCM slopes (proposed in the quarry shell model to be cut at 1V:1H) and to a lesser extent the South Auckland volcanic materials do not achieve a satisfactory FoS against instability under some modelled conditions. While this presents a challenge to maximising quarry resource recovery, by potentially reducing the overall slope angle of WCM to approximately 1V:2H for these materials, it was shown that the potential effects could be greatly reduced to more localised-scale surfaces that do not present a significant risk to personnel safety, boundaries, or development of the quarry.

Below is a summary of proposed alterations to the existing pit design based on the results of our slope stability analysis:

- Waikato Coal Measures
 - Flattening back of the overall average slope of WCM material within the proposed pit from 1V:1H to approximately 1V:2H (27°). Refer below for discussion of 'observational-type method' for minimising risk in WCM.
- Waipapa Greywacke
 - It is advised that no benches be cut into residual 'overburden' material. Residual greywacke encountered within the southeastern corner of the proposed pit, in association with Section K analysis, should be flattened back to a maximum slope angle of approximately 1V:2H (27°).
- Residual Volcanics
 - Removing overburden residual volcanics from quarry slopes where possible. Where not possible, flattening back residual volcanic slopes within the quarry pit to a maximum overall slope angle of approximately 1V:2H (27°) is recommended to reduce the risk of slumping of this material. An 'observational-type method', similar to that recommended for WCM is advised.

There are some slopes within the existing natural topography outside of the proposed pit that do not meet our target factors of safety. These are beyond the extents of the proposed quarry and are not directly affected by the proposed pit excavation. Not all natural slopes beyond the pit have been analysed.

14.3.11 Observational-Type Method

It is envisaged that during construction the parameters and assessment could be significantly optimised through planning of trial batters in volcanics and WCM materials well within the quarry limits. This would likely comprise cutting faces at varying orientations (e.g. facing north, south, and west) and adoption of an 'observational-type method' in which:

- Exposed materials can be mapped and where necessary sampled for strength testing where expected to form part of the final face.
- The performance of selected temporary faces with time should be formally monitored and reviewed to assess performance.

- For the upper WCM and residual volcanics it is also envisaged that trial stability enhancement measures could be incorporated, such as maintaining groundwater levels by utilising counterfort drainage or similar to that which has been successfully adopted in other areas of the quarry.
- Particular attention should be paid to faces orientated in the arc of north-west to north-east, as these are assessed as the greatest likelihood of failure.
- Other methods that may be adopted in areas where a reduction in slope angle is not practical include inclined bore drainage, or mechanical reinforcement such as soil nails and shotcrete.

It is recommended that a Slope Stability Management Plan (SSMP) be prepared following finalised quarry design that incorporates an annual stability review of the batters once the quarry extension commences. This plan would allow for a more detailed stability assessment and review of WCM/residual volcanics batters that could be developed as a 'living document' as the quarry progresses. It is recommended that the SSMP also includes an annual review of stormwater control measures, and the implementation/construction of any recommended monitoring devices along with the results of monitoring.

15.0 Southern Wetland Area

There are three main wetland areas to be retained to the south of the proposed quarry extent within the northern portion of the Kaarearea Paa area. These include a more elevated area of exotic wetland that drains into a lower elevation indigenous Raupo wetland adjacent to the proposed southern quarry extent. Both are sited to the east of the Kaarearea Paa volcanic cone. There is another smaller wetland area directly north of the volcanic cone. The indicative locations of these wetland areas are shown on Figure 2 and Riley Dwgs: 220245-10 and -11.

15.1 Geology

The elevated portion of exotic wetland to the south of the proposed quarry excavation and east of the Kaarearea Paa volcanic cone is separated from the proposed pit extent by a small spur (Figures 2, 6 and 15). Based on the current geotechnical model this area is assessed to be underlain predominantly by residual greywacke soils with a surficial layer of WCM material. The western portion of this eastern exotic wetland and the Raupo wetland into which it drains are located in a lower elevation area inferred to be underlain by a significant (approximately 36m) depth of WCM material, as shown in Figure 15 below. The northern portion of the Raupo wetland is located adjacent to the projected quarry pit extent.

The other relatively small wetland to the west of the other wetland areas is inferred to be underlain by volcanics of the Kaarearea Paa volcanic cone and WCM. The western extent of this wetland is inferred to be bound approximately by the N-S trending Hunua Fault. This wetland area is set back approximately 30m from the proposed quarry pit excavation and separated by a stream that flows to the west as shown on the attached Riley Dwg: 220245-11.

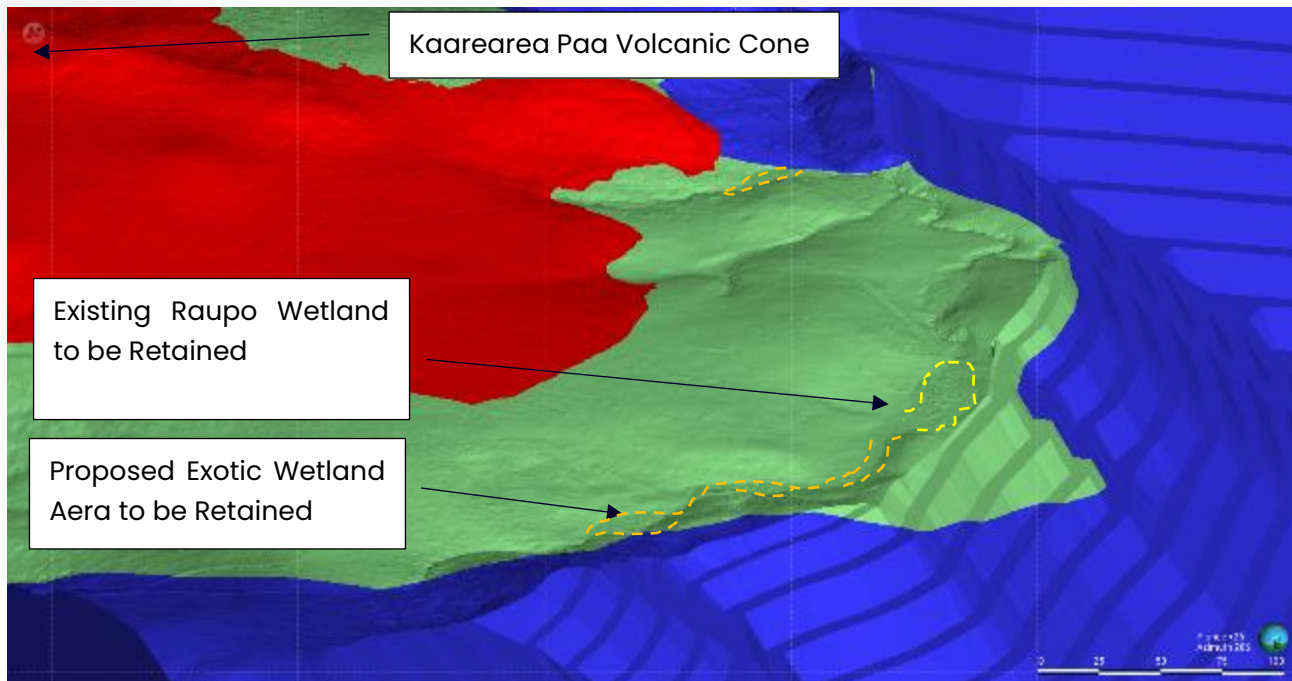


Figure 15: Detail taken from the 3D model to show relative positions and indicative extent of wetland proposed to be retained (exotic – dashed orange, native raupo – dashed yellow). The indicative extent of the ponded water forming the existing Raupo wetland along with the lower elevation portion of the exotic wetland are underlain by a significant depth of WCM materials (inferred extent shaded green). The extent of underlying greywacke (dark blues) is inferred based on the current subsurface investigation.

15.2 Groundwater Assessment

It is inferred that the eastern wetland areas are feed by a combination of surface water and shallow groundwater seepage from the slopes of the Kaarearea Pa to the south. It is likely that the smaller wetland area to the north of the Kaarearea Volcanic cone is fed by a similar combination of surface water and shallow seepage flow.

Recent work by PDP in the northern portion of the main pit indicated that the WCM in this area had low hydraulic conductivity ($K = 6 \times 10^{-8} \text{m/s}$) and little hydraulic connectivity with the nearby main pit excavation. If the materials that underlie the wetland areas along the southern boundary of the proposed quarry are consistent with the WCM along the southern edge of the main pit, approximately 1,300m to the south-west of the wetland, the wetland would be assumed to be perched above the lower groundwater regime, and any seepage flows likely limited to upper shallow soils. This is assessed to be due to the low vertical hydraulic conductivity of the WCM materials. While parameters provided by PDP for the WCM indicate that the hydraulic conductivity of the WCM can vary ($K = 3.8 \times 10^{-6}$ to 1.9×10^{-8})³, the flows within the WCM materials measured to be an order or two magnitudes less vertically, assessed to be due to the highly stratified nature of the materials. This would suggest perched groundwater and preferential horizontal flow, such that vertical barriers that impeded the horizontal flow of groundwater could be a potentially effective option to reduce connectivity between the wetland and proposed quarry pit slope, if required.

³ Peach Hill Study Bore Information from packer test and falling head tests provided by PDP

We expect there could be a reverse sensitivity issue, where close pit excavation potentially draws down groundwater beneath the wetland, potentially affecting wetland viability.

15.3 Slope Stability Assessment of Pit Slope and Wetland

The slope stability Cross Section A as outlined in the previous section 11.0 of this report extends through the native Raupo wetland area. As outlined previously, analysis indicates the WCM would need to be laid back flatter from the current batters proposed by Terra Mining to achieve a satisfactory calculated Factor of Safety (FoS) against instability for the overall slope based on current assumptions. The slope stability assessment has modelled the WCM slope with a water table approximately 28m below the crest of the slope, the face benches being effectively drained as the pit excavation proceeds.

The presence of a wetland directly above this slope is therefore assessed to significantly increase the potential risk of water saturating the upper portion of the slope and reducing the stability of the upper layers of WCM material. Further assessment of the groundwater regime and affect on stability in the WCM is recommended in developing the final quarry slopes to the north of the subject wetland areas.

Based on this hazard and the uncertainty of what effect the perched water associated with the wetland may have on the adjacent cut slope we recommend that stability of cut slopes within the WCM materials are monitoring and subject to ongoing assessment as the excavation of the pit progresses. This would involve forming trial batters as outlined in the previous Section 14.3.11, well clear of the wetland (minimum 20m from wetland perimeter) and monitoring their performance (i.e. deformation and groundwater level effects). Progressive setback hold points could also be specified conditional on monitoring outcomes. Stability of the trial slopes could be monitored by regular visual inspection.

It would be recommended that shallow groundwater monitoring piezometers would be installed to the north of the wetland at commencement of pit excavation. These would help assess the piezometric surface as well as the hydraulic conductivity of the WCM to facilitate more accurate slope stability modelling and assess the connectivity between wetland and quarry face. We would recommend that the installation and ongoing monitoring of the piezometers and other monitoring devices should be outlined in a detailed SSMP for the quarry.

If monitoring shows groundwater associated with the wetland will have a detrimental affect on the face stability, or a close pit face will negatively affect the wetland, then setbacks or groundwater barriers could be assessed. Options to reduce the conductivity between the wetland and quarry and reduce the potential for saturation of the upper slopes within the WCM if required could include installing the below measures along the northern edge of the wetland:

- Sheet piles
- Permeability barrier in the form of a grout curtain or bentonite trench

The above options would require some setback of the quarry face from the Raupo wetland, for construction effectiveness and not adversely impact stability of the faces. To further minimise the loss of resource and potentially steepen the WCM batter's mechanical stabilisation could be considered, such as:

- Soil nails and geotextile
- Soil nails shotcrete facing

16.0 Final Face Condition

It is envisaged that much of the excavation will be undertaken with blasting, although materials above the greywacke could be excavated or heavily ripped by mechanical excavation. Care will need to be taken in approaching the final face positions to minimise the risk of 'back-break' leading to unnecessarily broken rock in the final face and any temporary face. Trials of a suitable blasting method to minimise structural damage to the final batter profiles should be undertaken and are recommended prior to the formation of these batters. At the time of final excavation, the face should be subject to inspection by a geotechnical professional familiar with the contents of this report.

17.0 Summary

An assessment has been undertaken with respect to geotechnical aspects for the proposed quarry expansion. We make the following comments:

- The quarry expansion will encounter South Auckland Volcanics, WCM, and Waipapa Greywacke (being the resource). Localised areas of conglomerate may also be encountered.
- From limited borehole information, the WCM is generally fractured along lamination planes and contains scattered zones of greater weathering and weaker organic horizons. Waipapa Greywacke is generally fractured to varying degrees and is greatly disturbed adjacent to faulting. Several extremely broken to crushed zones are present at different depths.
- Based on limited borehole information, the thickness of the WCM overburden generally increases to the south. The South Auckland Volcanics appear to be contained to the southern portion of the site.
- Our geotechnical assessment indicates that the proposed Sutton Block Quarry extension can be undertaken within the proposed quarry shell extent shown on appended Riley Dwg: 220245-10, subject to detailed design and construction monitoring.
- It is recommended that detailed design and construction monitoring, include implementing trial batters for the proposed quarry slope within the WCM overburden material, be performed.

- It is recommended that a SSMP be prepared as a consent condition which incorporates an annual stability review of the batters, review of trial batters in WCM, review stormwater control measures, outlines any monitoring devices instruments that need to be installed, and ongoing measurements, collation, and analysis of defect orientations and their potential impacts on the excavation once the quarry extension commences. This plan would allow for a more detailed stability assessment that could be developed as a 'living document' as the quarry progresses. It is recommended that this document outlines specific hold points, notably as the proposed quarry approach to final face extents.
- The proposed retention of existing wetlands adjacent to the southern extent of the quarry excavation poses a potential stability/dewatering risk. Management of this risk will require further ongoing assessment and monitoring of the groundwater connectivity between the wetlands and future pit slopes formed in WCM. These risk management measures should be detailed in the SSMP for the quarry, including specific hold points and monitoring requirements for the wetland areas.
- Kinematic analysis of defect data indicates feasibility of planar and wedge failures of the greywacke and WCM materials within the slopes analysed, while topple failures display the greatest probability, with generally increased potential of all failure types expected as excavation progresses into north, north-east, north-west, and west facing slopes.
- Slope stability modelling indicates below target FoS values through most cross sections, under most load cases, for the WCM within the current proposed pit shell design. Flattening back the overall WCM batters to approximately 1V:2H (27°) increases stability through most sections analysed, with several reaching/exceeding target FoS.
- Subject to the results of trial batters and construction monitoring, reduced slopes may need to be adopted for design of final faces for overburden material. Additional stability enhancement measures may also be required to attain sufficient stability through WCM batters.
- Slope stability modelling indicates sufficient stability through the Waipapa Greywacke through the cross sections analysed, within the current pit shell design.
- Slope stability modelling indicates some localised instability through overburden material of residual Waipapa Greywacke and residual South Auckland Volcanics, and hence it is recommended these are flattened back to approximately 1V:2H (27°) to reduce the risk of slumping.
- Pseudo-seismic stability analysis indicates that the overall quarry had a satisfactory FoS against instability for the assumed 100-year return event. Upper WCM for some of the sections assessed do not achieve the target FoS of 1.1. Analysis show that a satisfactory calculated FoS can be achieved if these slopes are flattened back to approximately 1V:2H (27°) to reduce the risk of significant displacement during a seismic event.
- it is envisaged that much of the excavation will be undertaken with blasting. Care will need to be taken in approaching the final face positions to minimise the risk of 'back-break' leading to unnecessarily broken rock in the final face and any temporary face.
- Trials of a suitable blasting method to minimise rock damage to the final batter profiles should be undertaken and are recommended prior to the formation of these batters. At the time of final excavation, the face should be subject to inspection by a geotechnical professional familiar with the contents of this report.

18.0 Limitation

This report has been prepared solely for the benefit of Stevenson Aggregates Ltd as our client with respect to the brief and Auckland Council in processing the consent(s). The reliance by other parties on the information or opinions contained in the report shall, without our prior review and agreement in writing, be at such parties' sole risk.

Recommendations and opinions in this report are based on data from limited test positions. The nature and continuity of subsoil conditions away from the test positions are inferred, and it must be appreciated that actual conditions could vary considerably from the assumed model.

During excavation and construction, the site should be examined by an engineer or engineering geologist competent to judge whether the exposed subsoils are compatible with the inferred conditions on which the report has been based. It is possible that the nature of the exposed subsoils may require further investigation, and the modification of the design based upon this report.

Riley Consultants Ltd would be pleased to provide this service to SAL and believes the project would benefit from such continuity. In any event, it is essential Riley Consultants Ltd is contacted if there is any variation in subsoil conditions from those described in the report as it may affect the design parameters recommended in the report.

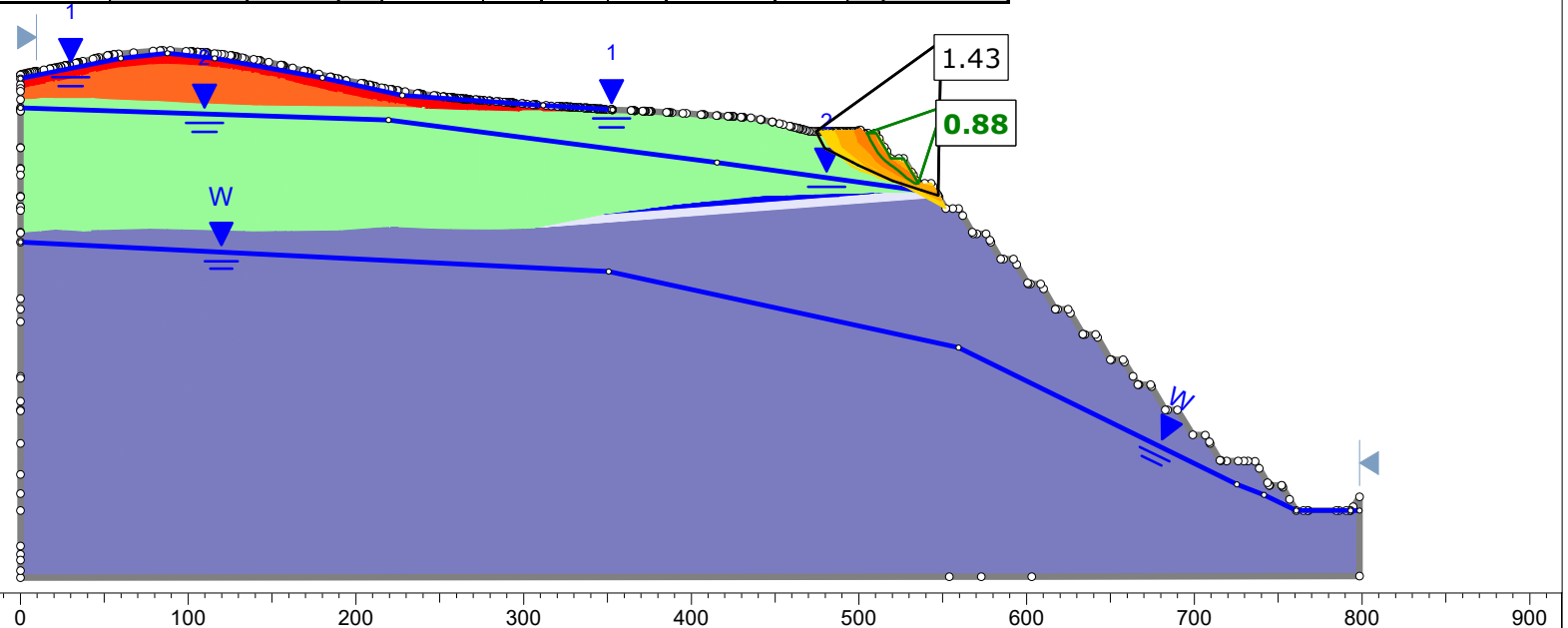


Appendix A

Slope Stability Slide Outputs



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	UCS (intact) (kPa)	m	s	a	Water Surface	Hu Type	Hu	Generalized Function
Residually Weathered Volcanics		18	Mohr-Coulomb	3	28					Piezometric Line 1	Custom	1	
Volcanics - Rock		24	Mohr-Coulomb	1	35					Piezometric Line 1	Custom	1	
Waikato Coal Measures, Mudstone		18	Generalized Anisotropic							Piezometric Line 2	Custom	1	WCM
WCM Vertical		18	Mohr-Coulomb	15	29					Piezometric Line 2	Custom	1	
WCM Bedding		18	Mohr-Coulomb	8	27					Piezometric Line 2	Custom	1	
Moderately Weathered Waipapa Group Greywacke (BB)		22	Generalized Hoek-Brown			3000	0.687	0.0007	0.516	Piezometric Line 2	Custom	1	
Slightly Weathered Waipapa Group Rock		24	Generalized Hoek-Brown			8000	0.764	0.001	0.513	Water Table	Custom	1	
Fresh Waipapa Group Greywacke (BL)		27	Generalized Hoek-Brown			19000	0.981	0.0022	0.508	Water Table	Custom	1	



Drury Quarry - Sutton Block

Group	Terra Minning Slope Profile
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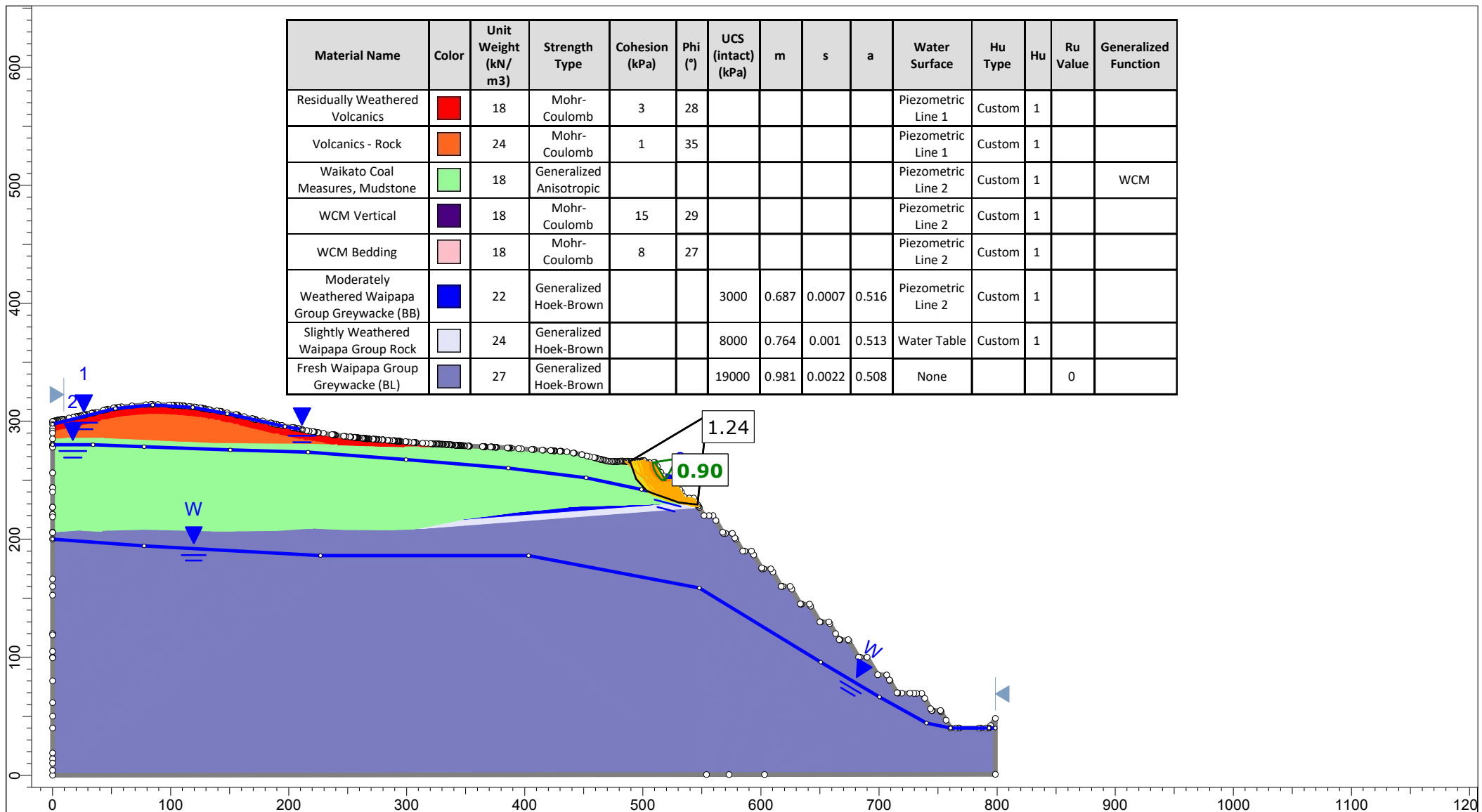
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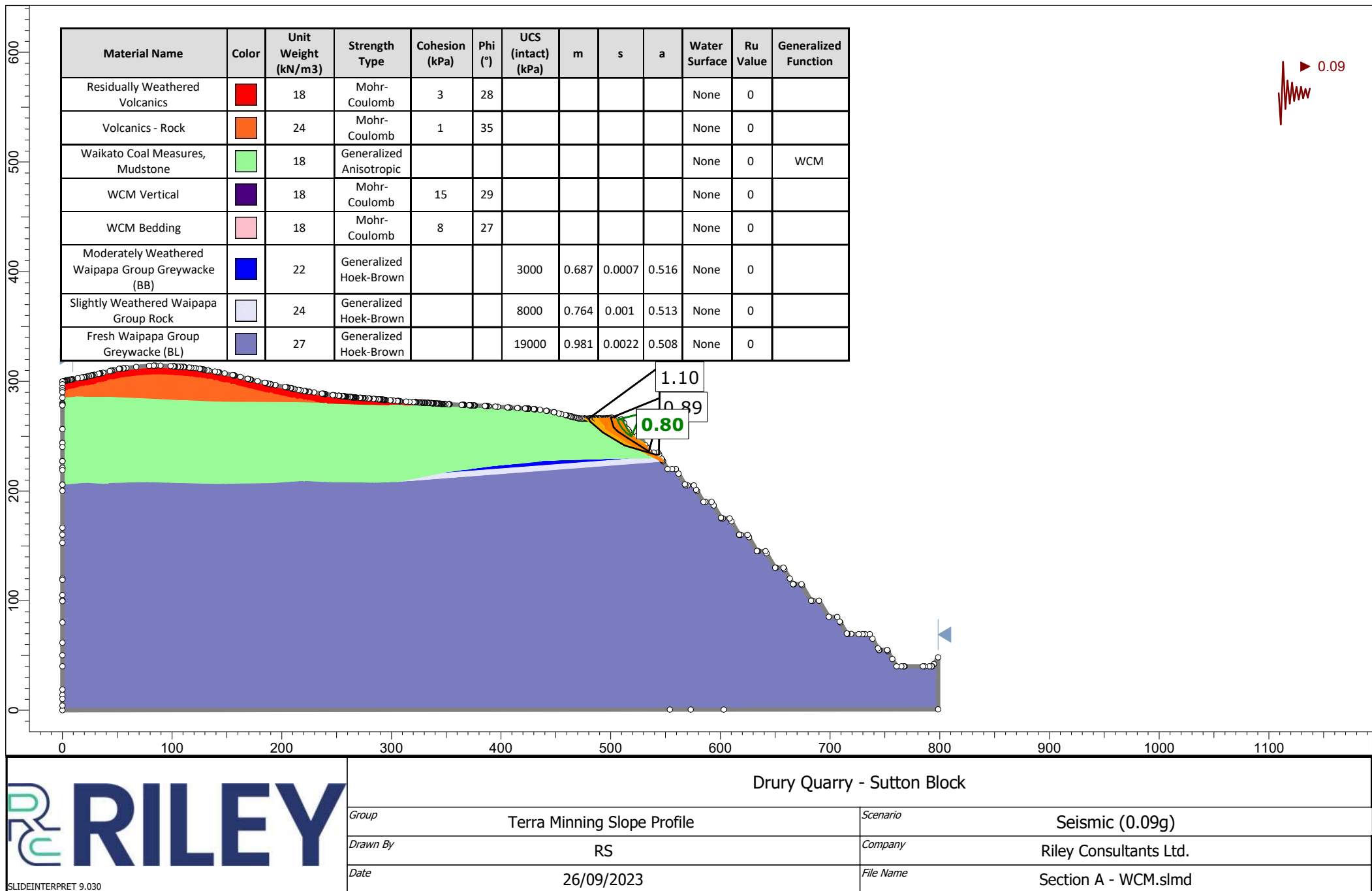
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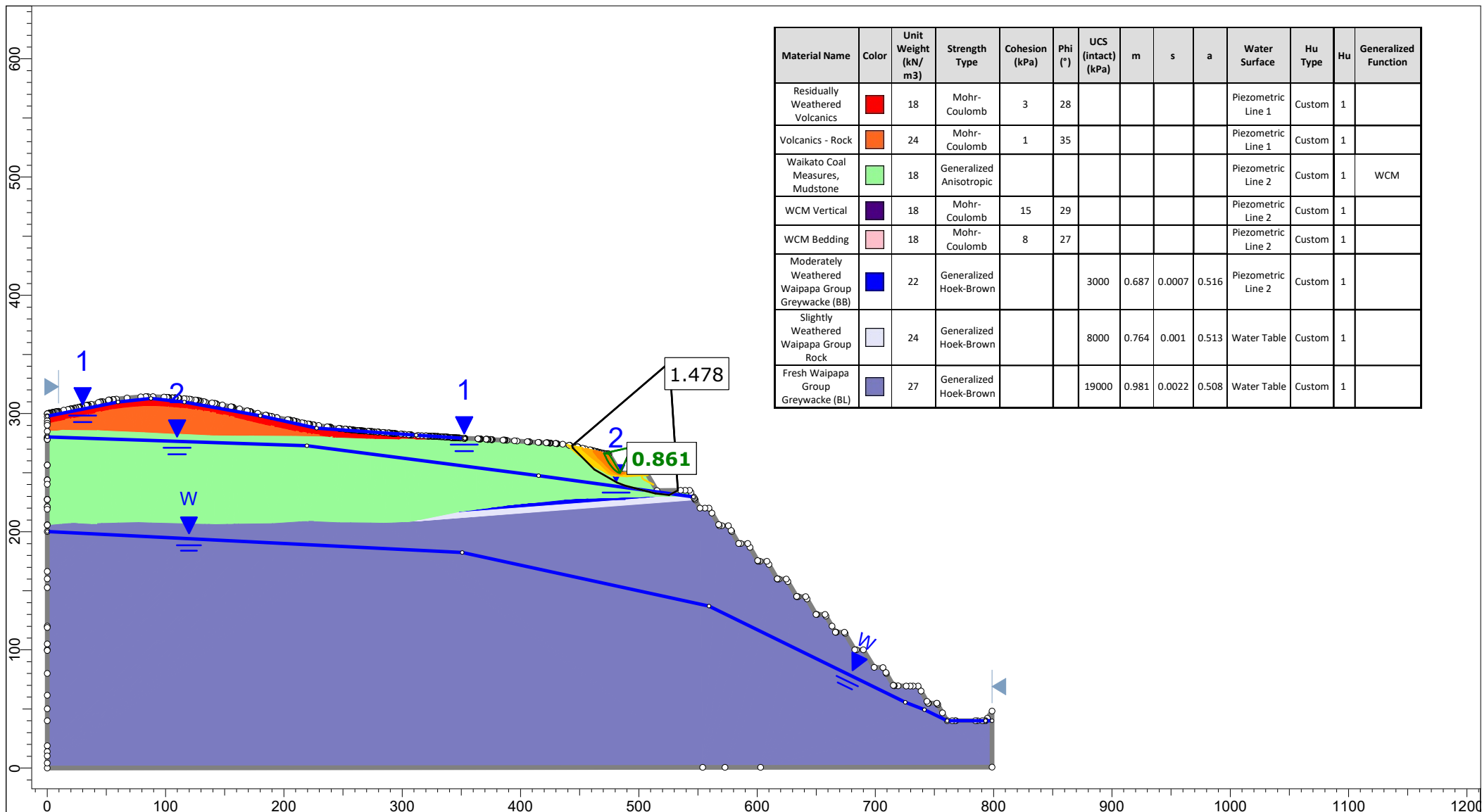
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File Name	Section A - WCM.slmd
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	Date	26/09/2023		File Name
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				Section A - WCM.slmd





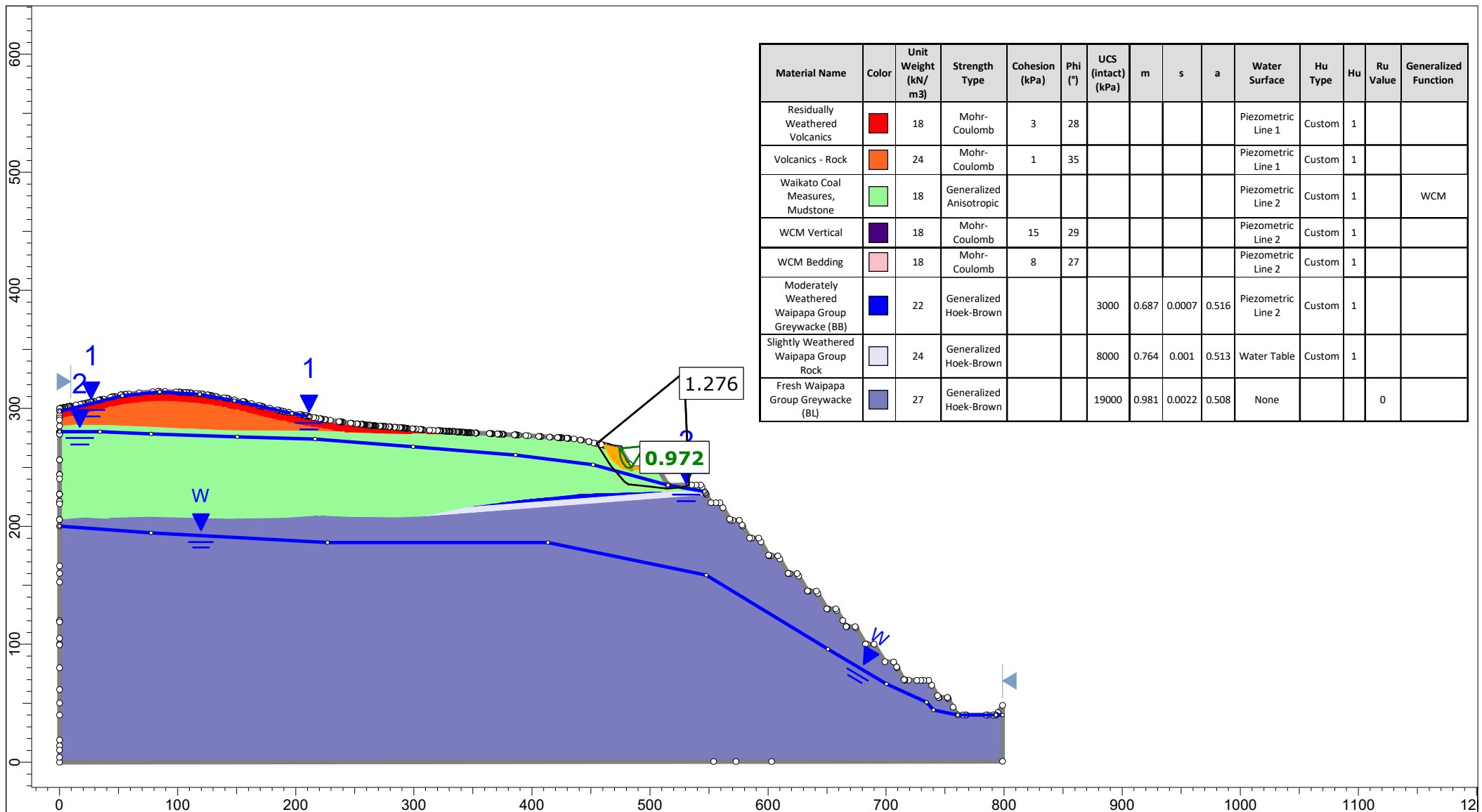
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Residually Weathered Volcanics		18	Mohr-Coulomb	3	28					Piezometric Line 1	Custom	1	
Volcanics - Rock		24	Mohr-Coulomb	1	35					Piezometric Line 1	Custom	1	
Waikato Coal Measures, Mudstone		18	Generalized Anisotropic							Piezometric Line 2	Custom	1	WCM
WCM Vertical		18	Mohr-Coulomb	15	29					Piezometric Line 2	Custom	1	
WCM Bedding		18	Mohr-Coulomb	8	27					Piezometric Line 2	Custom	1	
Moderately Weathered Waipapa Group Greywacke (BB)		22	Generalized Hoek-Brown			3000	0.687	0.0007	0.516	Piezometric Line 2	Custom	1	
Slightly Weathered Waipapa Group Rock		24	Generalized Hoek-Brown			8000	0.764	0.001	0.513	Water Table	Custom	1	
Fresh Waipapa Group Greywacke (BL)		27	Generalized Hoek-Brown			19000	0.981	0.0022	0.508	Water Table	Custom	1	



SLIDEINTERPRET 9.030

Drury Quarry - Sutton Block

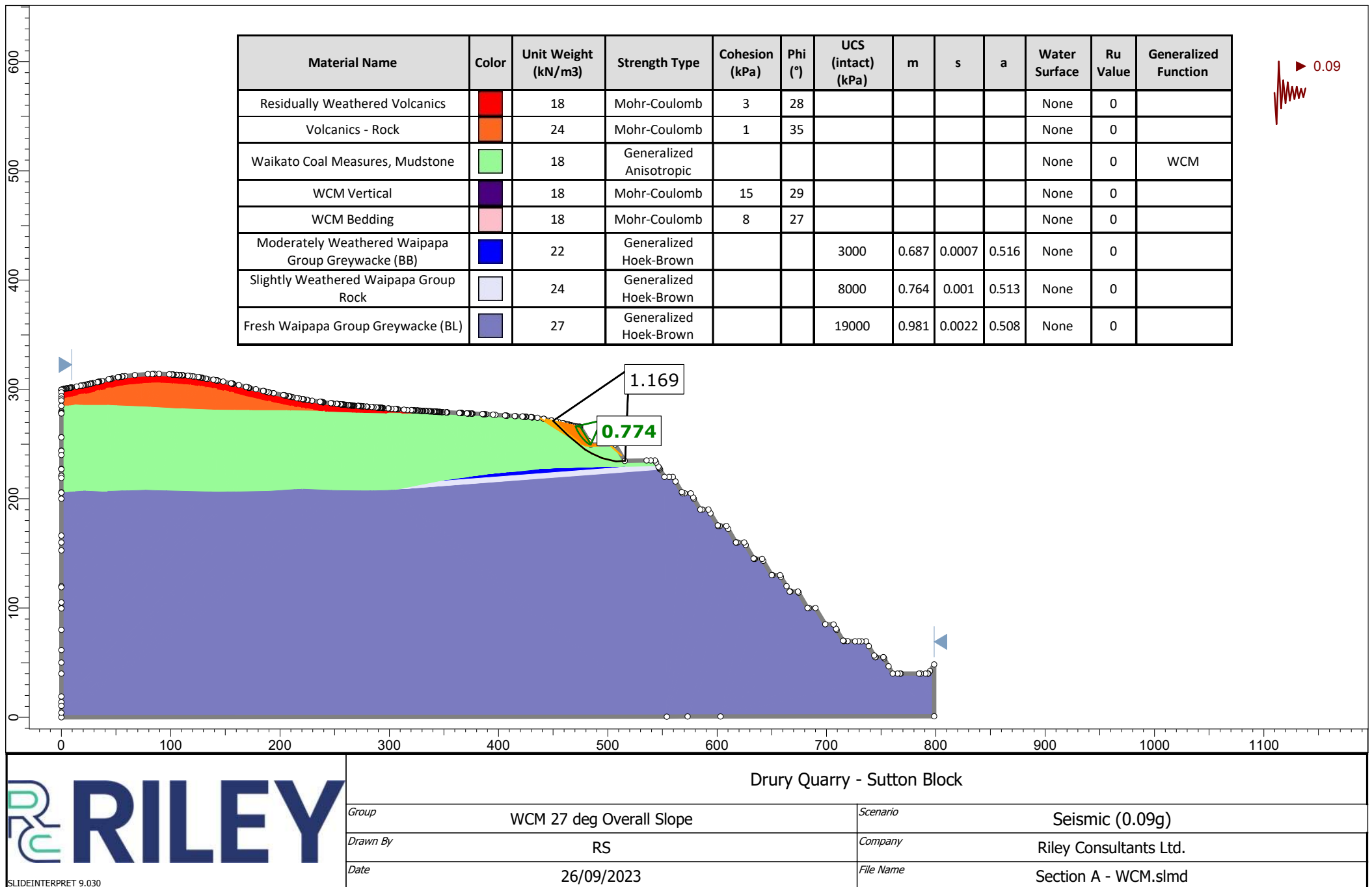
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Drawn By	RS	Company	Riley Consultants Ltd.
Date	26/09/2023	File Name	Section A - WCM.slmd

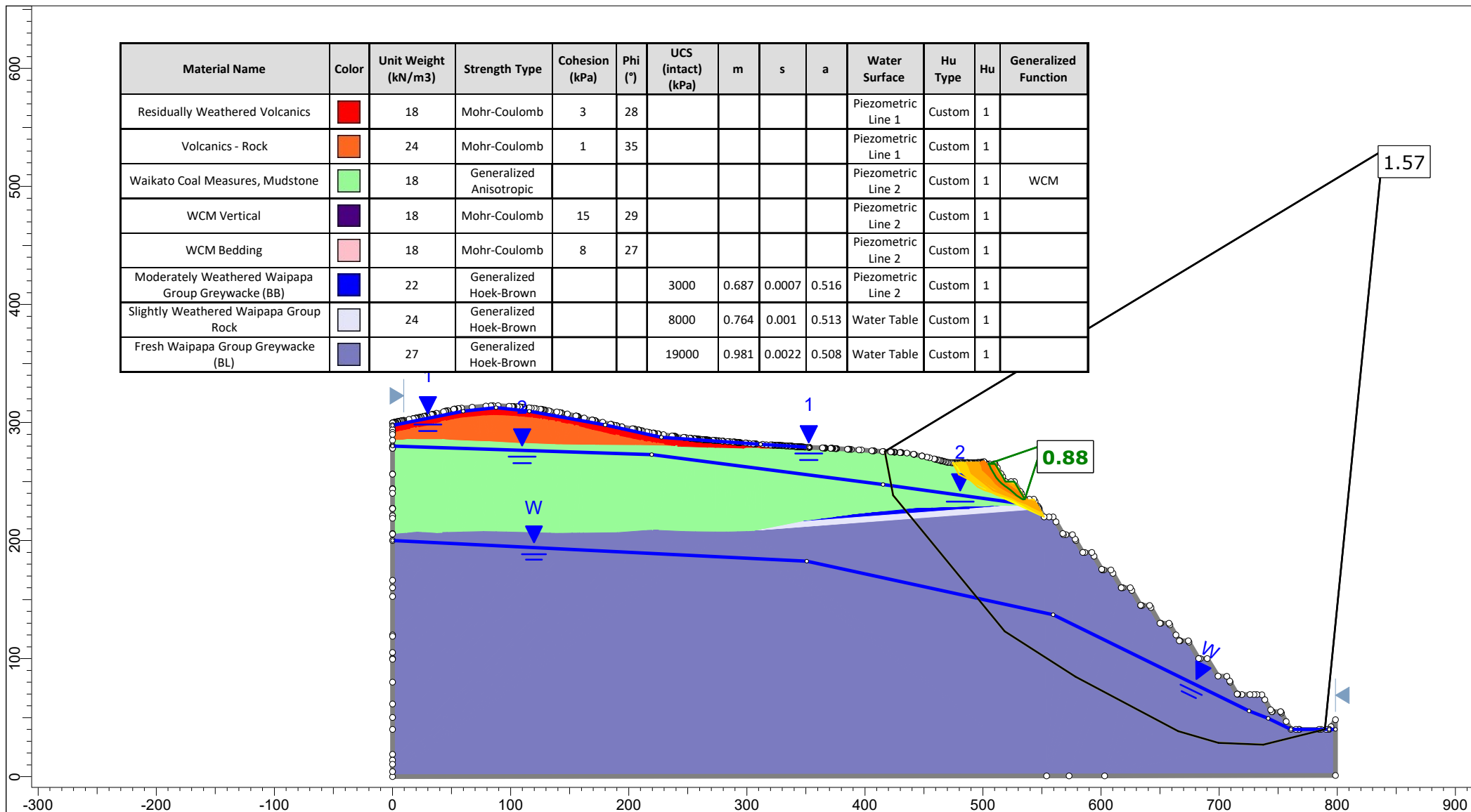


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Drury Quarry - Sutton Block

Group	WCM 27 deg Overall Slope	Scenario	Extreme Groundwater Case
Drawn By	RS	Company	Riley Consultants Ltd.
Date	26/09/2023	File Name	Section A - WCM.slmd





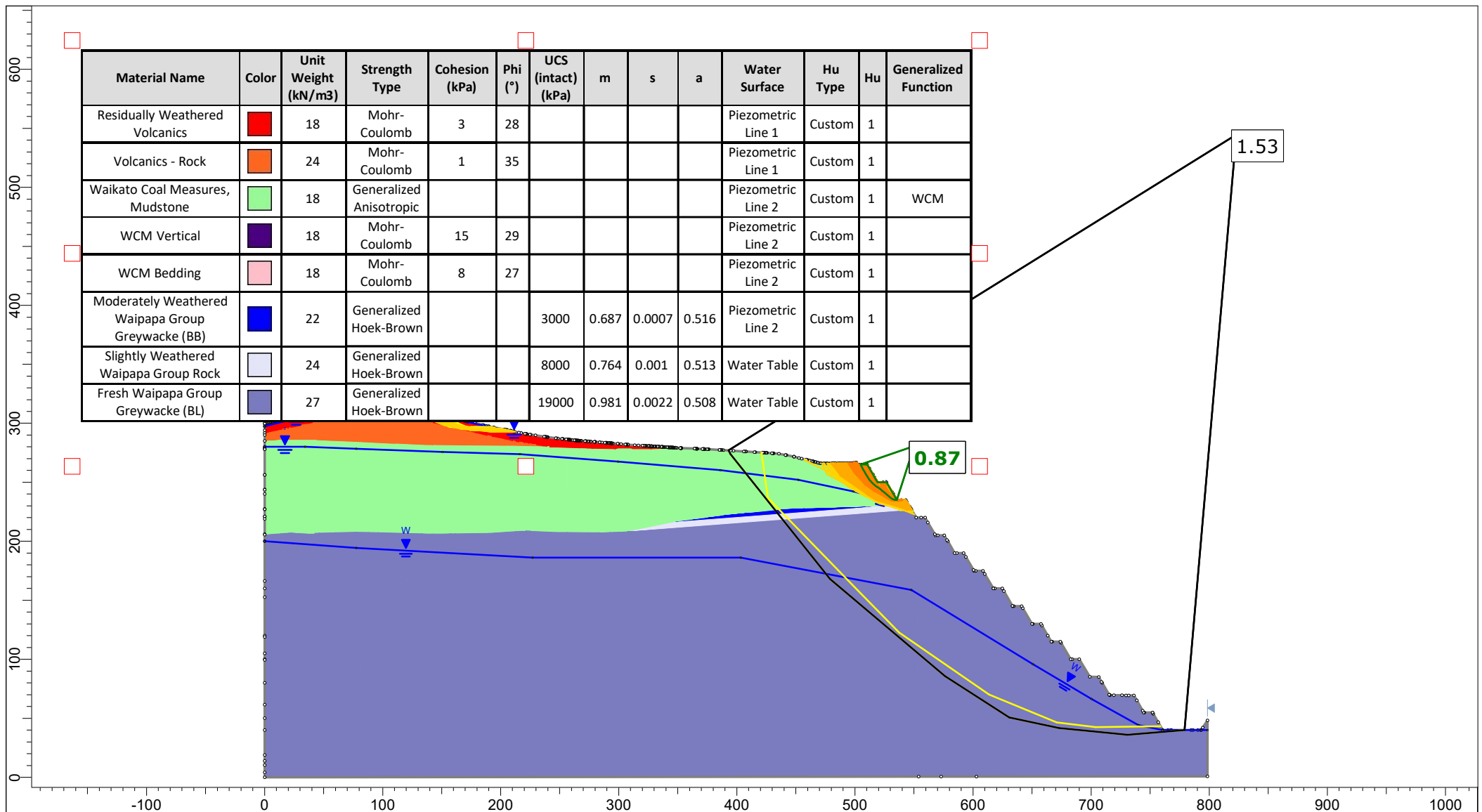
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Volcanics - Rock		24	Mohr-Coulomb	1	35					Piezometric Line 1	Custom	1	
Waikato Coal Measures, Mudstone		18	Generalized Anisotropic							Piezometric Line 2	Custom	1	WCM
WCM Vertical		18	Mohr-Coulomb	15	29					Piezometric Line 2	Custom	1	
WCM Bedding		18	Mohr-Coulomb	8	27					Piezometric Line 2	Custom	1	
Moderately Weathered Waipapa Group Greywacke (BB)		22	Generalized Hoek-Brown			3000	0.687	0.0007	0.516	Piezometric Line 2	Custom	1	
Slightly Weathered Waipapa Group Rock		24	Generalized Hoek-Brown			8000	0.764	0.001	0.513	Water Table	Custom	1	
Fresh Waipapa Group Greywacke (BL)		27	Generalized Hoek-Brown			19000	0.981	0.0022	0.508	Water Table	Custom	1	



SLIDEINTERPRET 9.030

Drury Quarry - Sutton Block

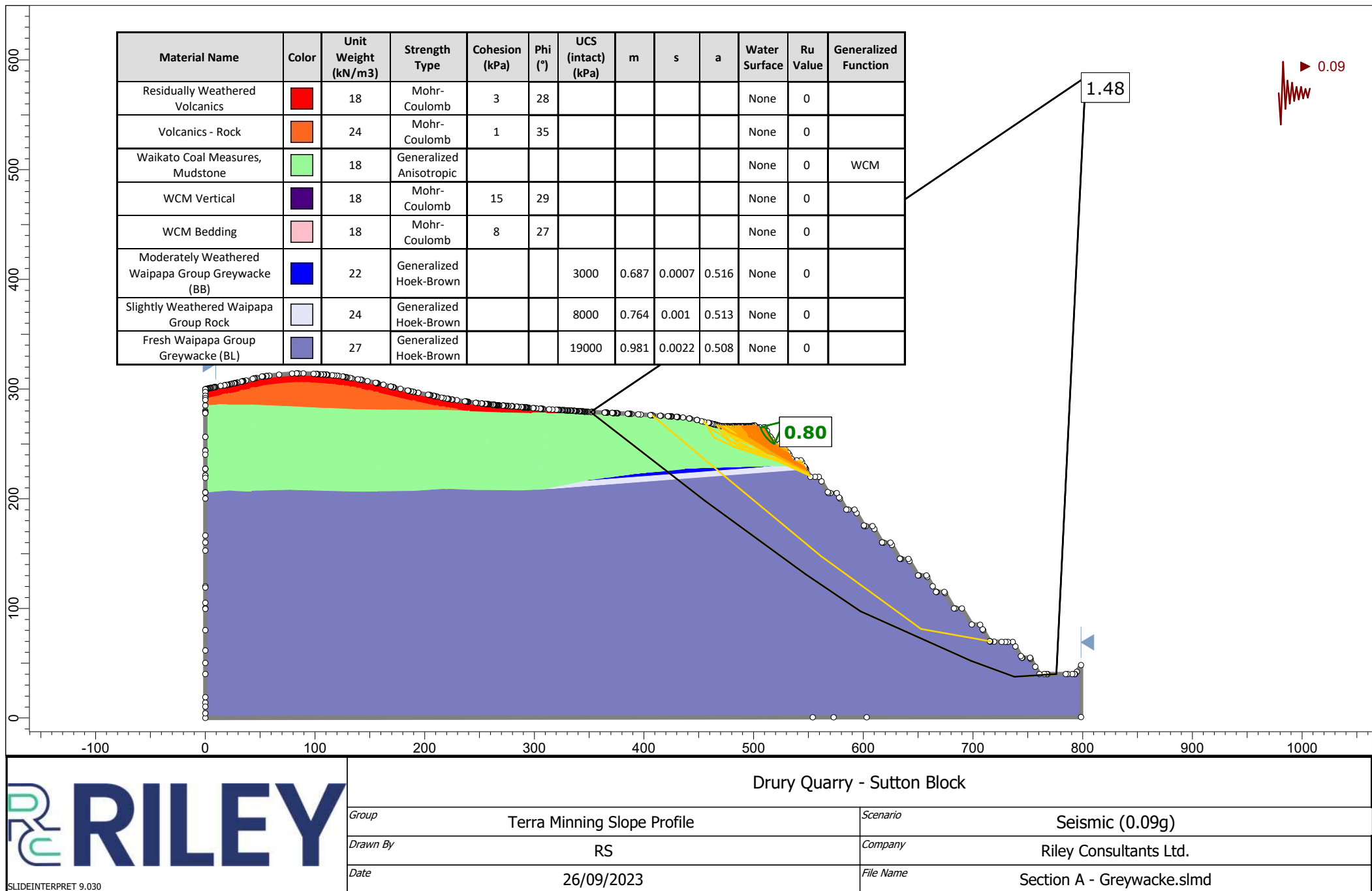
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Date	26/09/2023	File Name	Section A - Greywacke.slmd

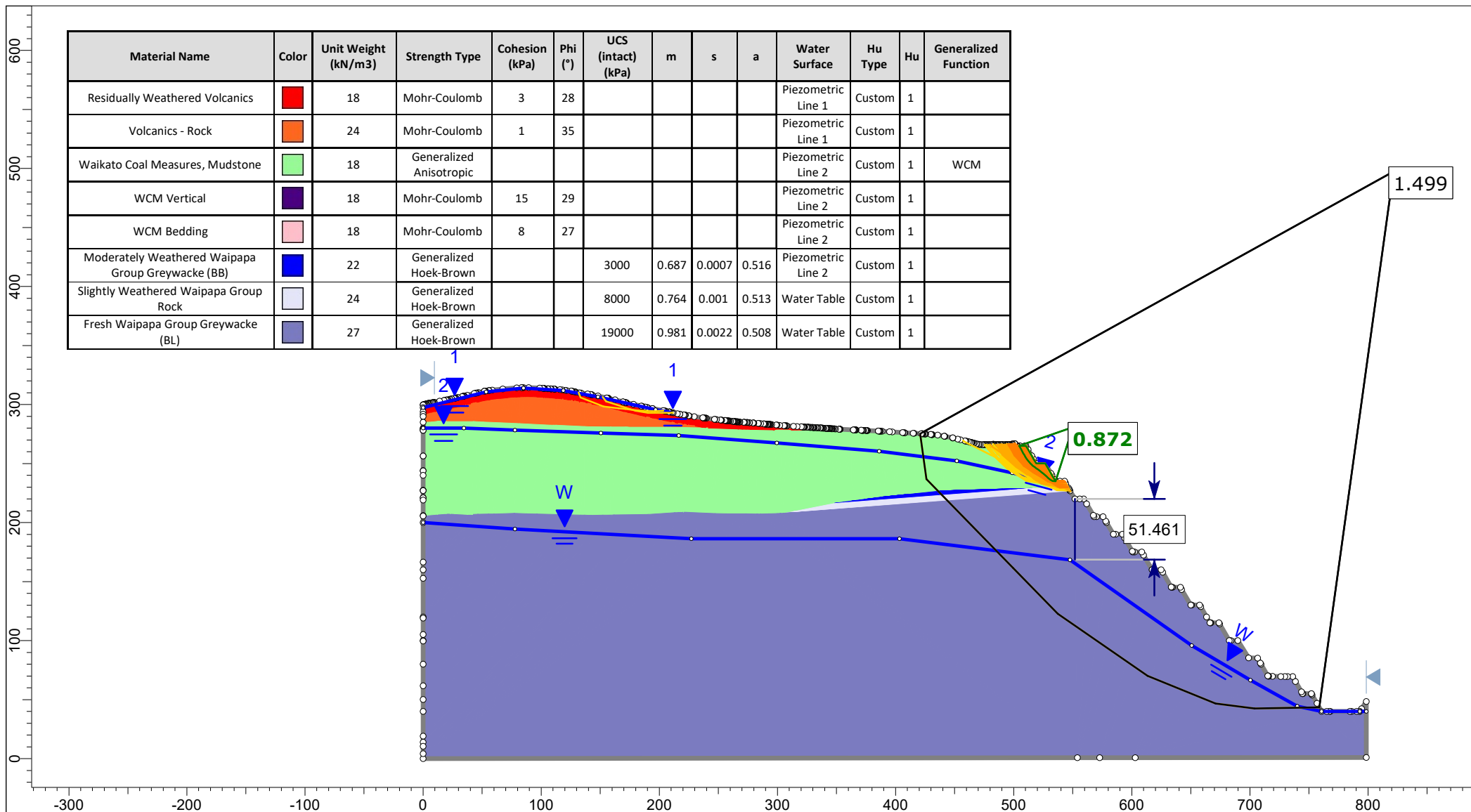


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Drury Quarry - Sutton Block

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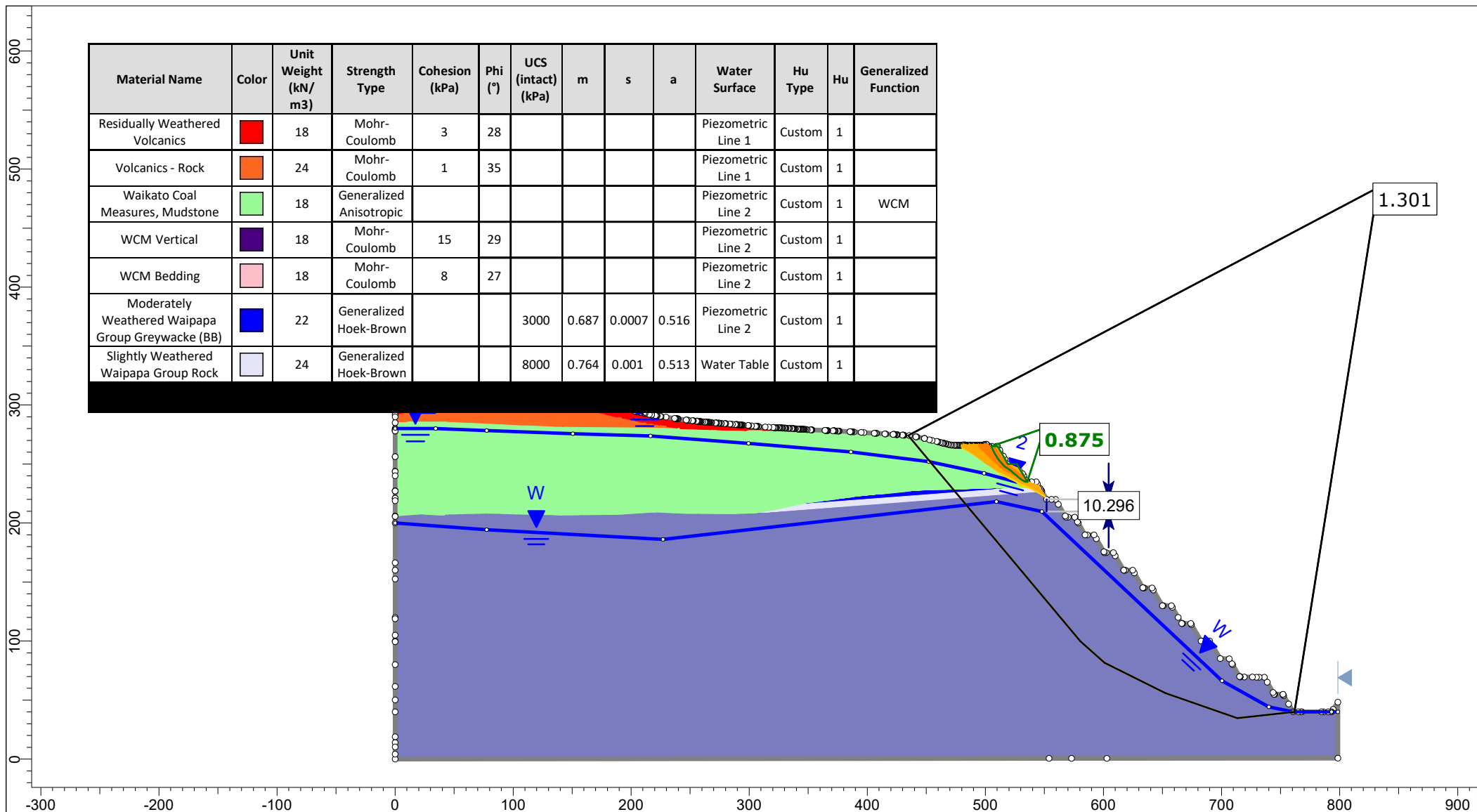




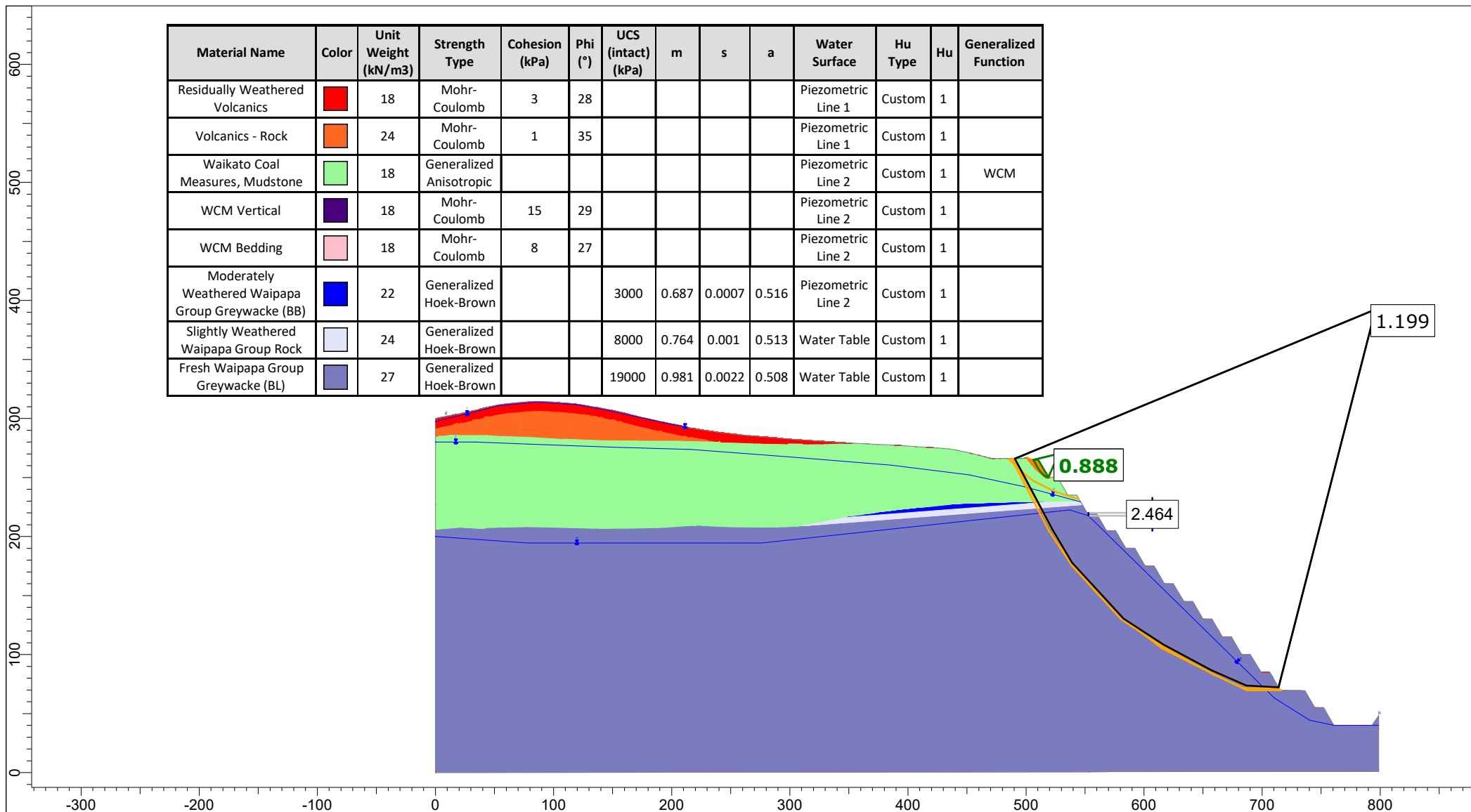
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Drury Quarry - Sutton Block

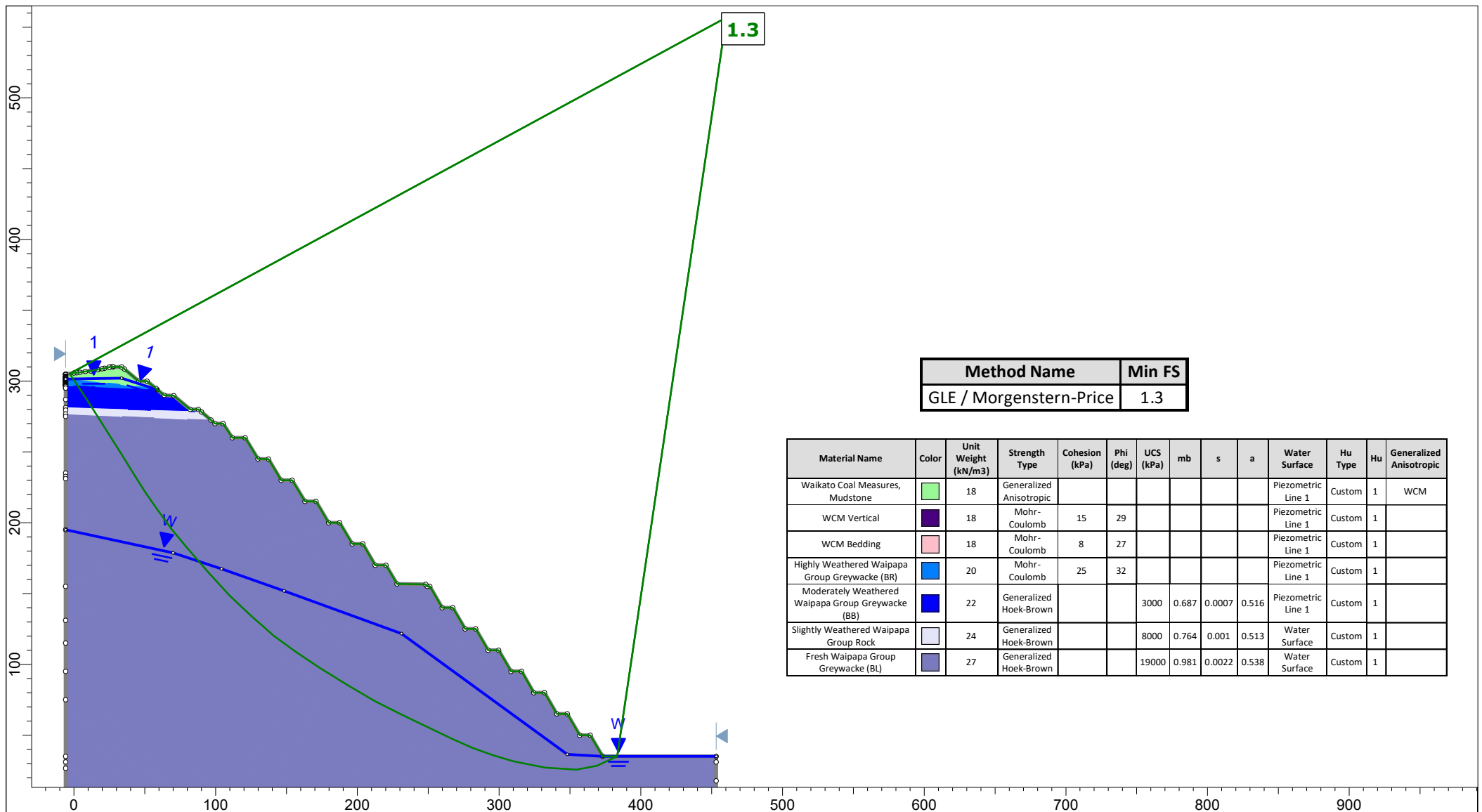
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Date	26/09/2023	File Name	Section A - Greywacke.slmd



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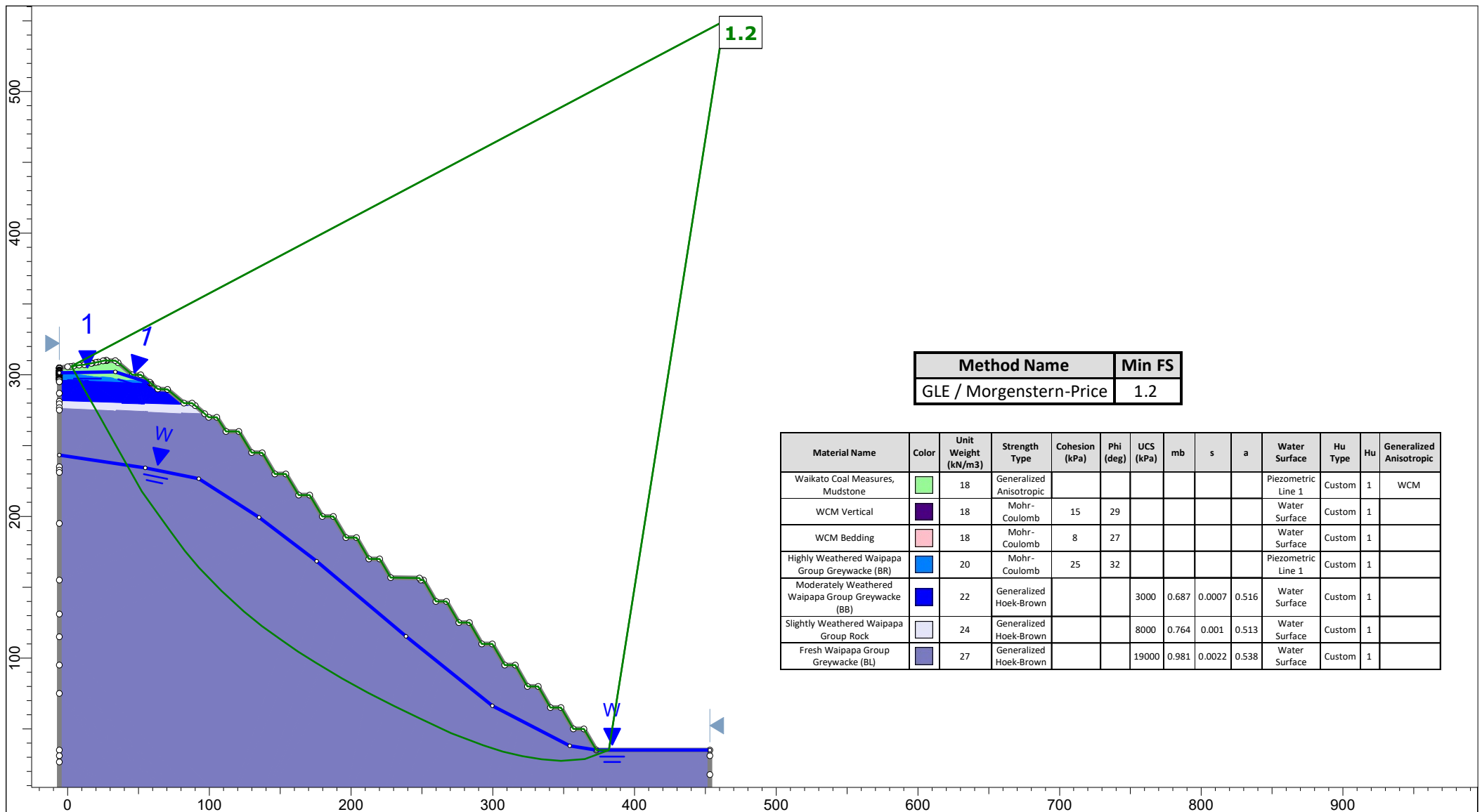


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				Riley Consultants Ltd.
				Section A - Greywacke.slmd

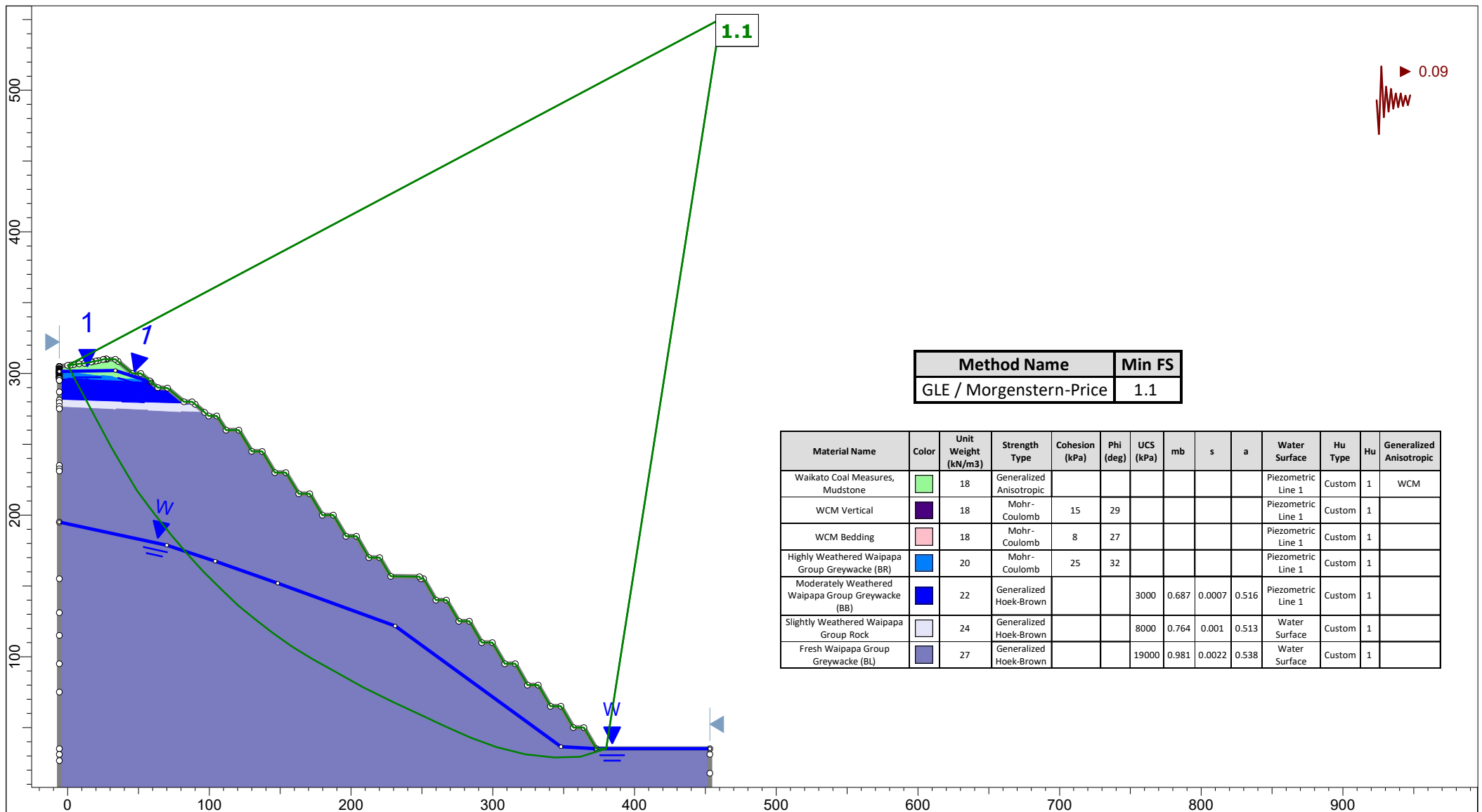


SLIDEINTERPRET 9.027

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Date		30/10/2024	Company
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			File Name
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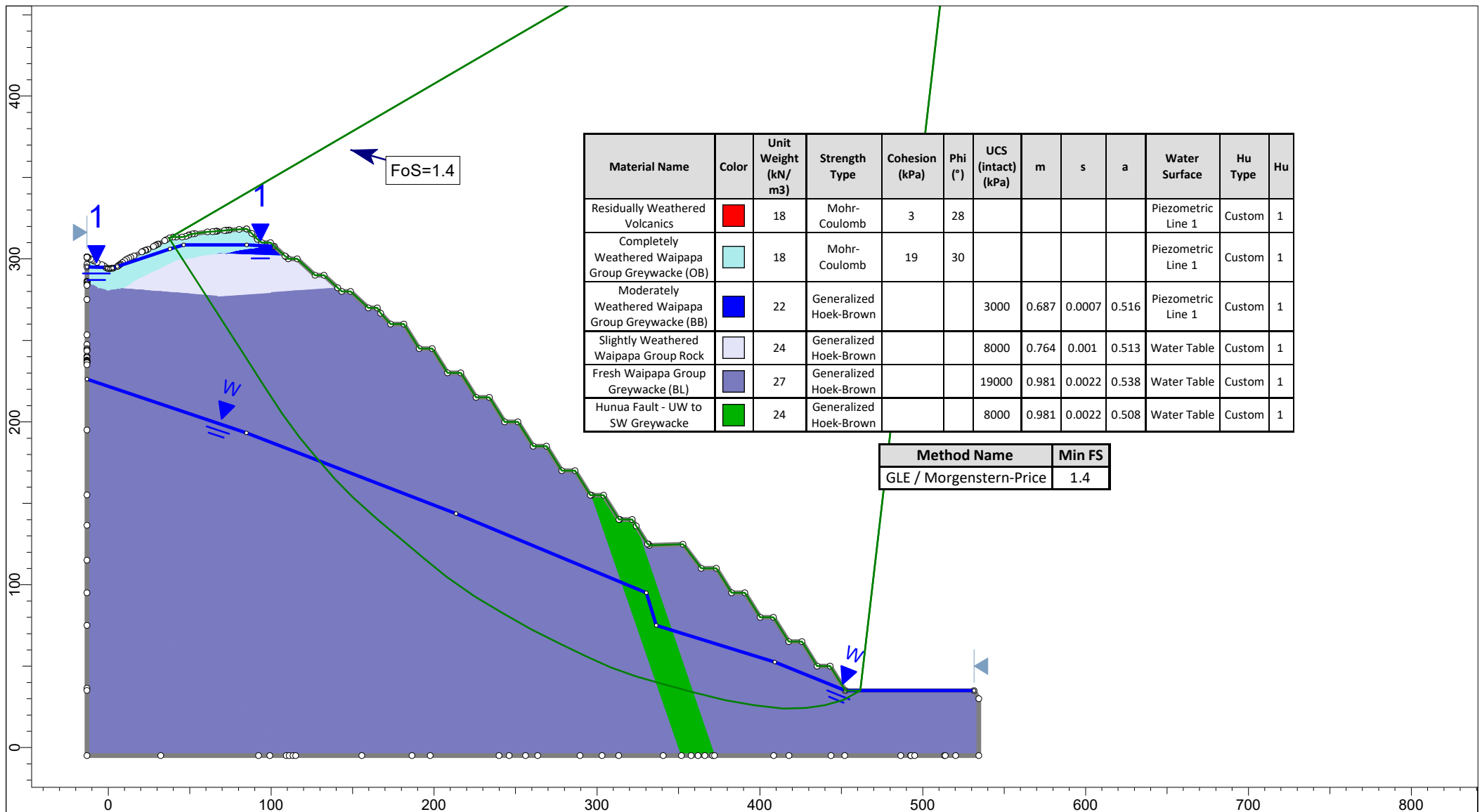


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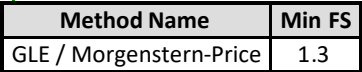
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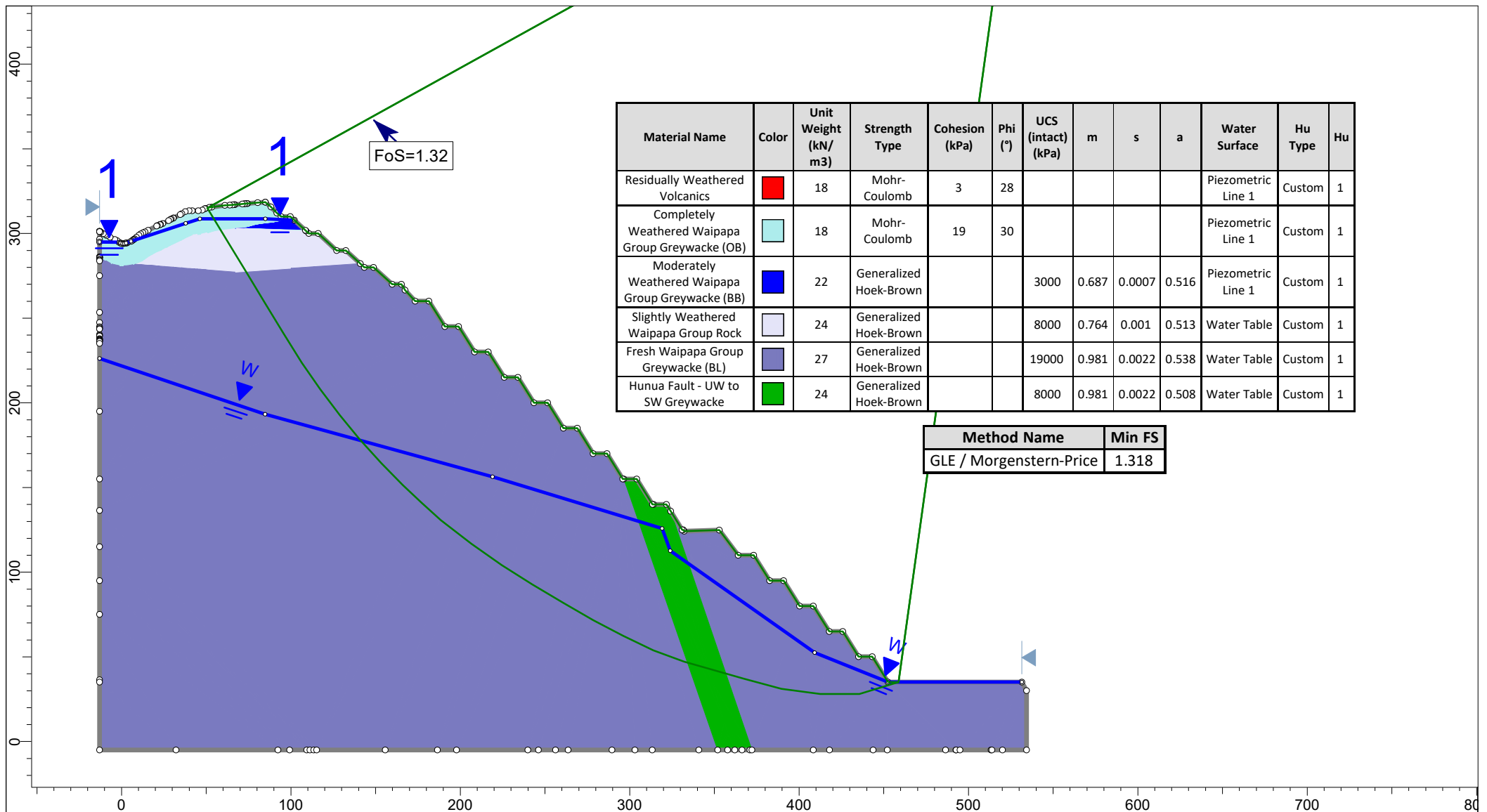
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Date	30/10/2024		File Name Section G - Base Model - updated - 24.10.10.slmld



SLIDEINTERPRET 9.034

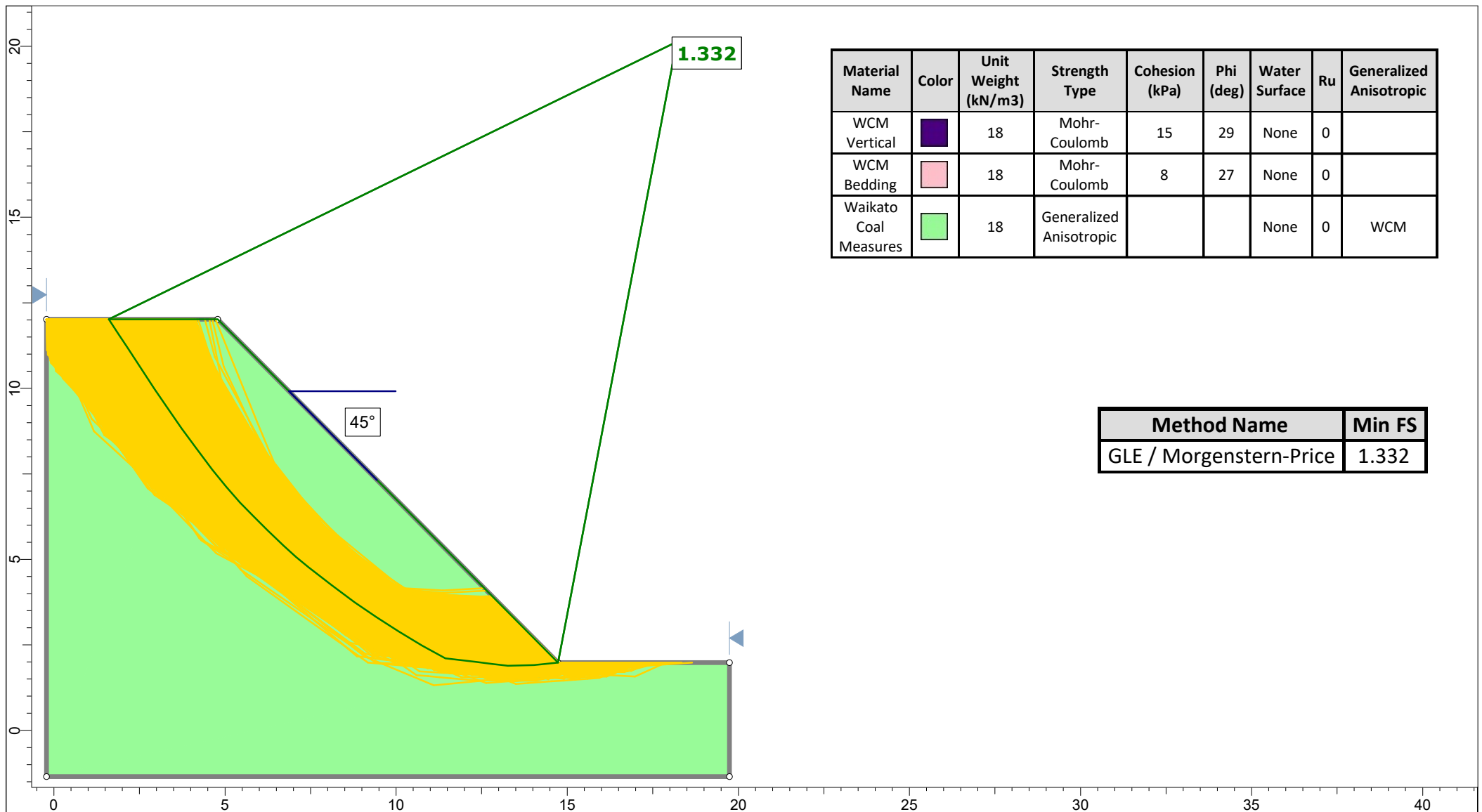
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Drawn By	ADT	Company	Riley Consultants Ltd
Date	14/10/2024	File Name	Section H- Base Model.slmd





SLIDEINTERPRET 9.034

Project	Drury Quarry - Sutton Block - Stage 5		
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Drawn By	ADT	Company	Riley Consultants Ltd
Date	14/10/2024	File Name	Section H- Base Model.slmd



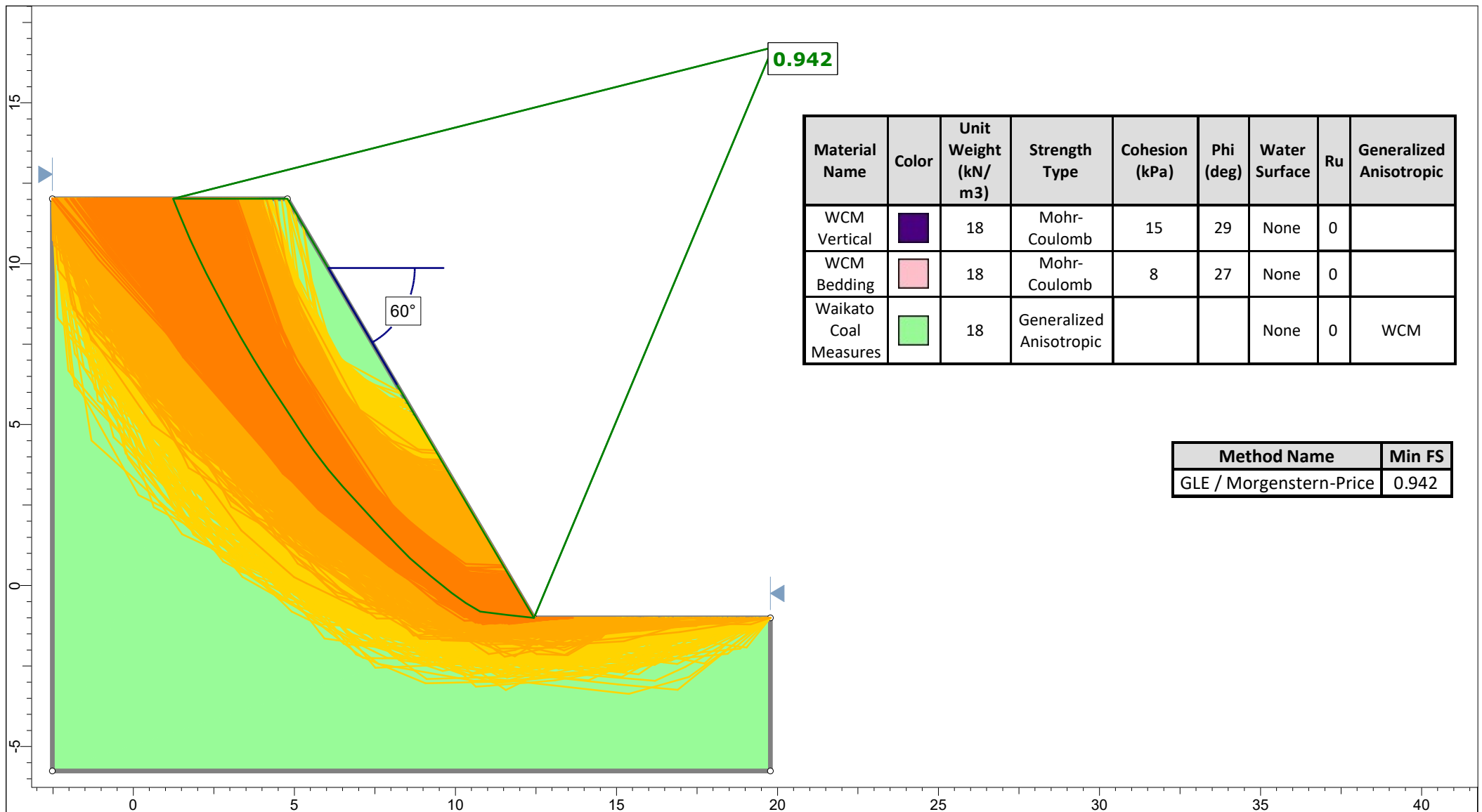
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WCM Bedding		18	Mohr-Coulomb	8	27	None	0	
Waikato Coal Measures		18	Generalized Anisotropic			None	0	WCM

Method Name	Min FS
GLE / Morgenstern-Price	1.332



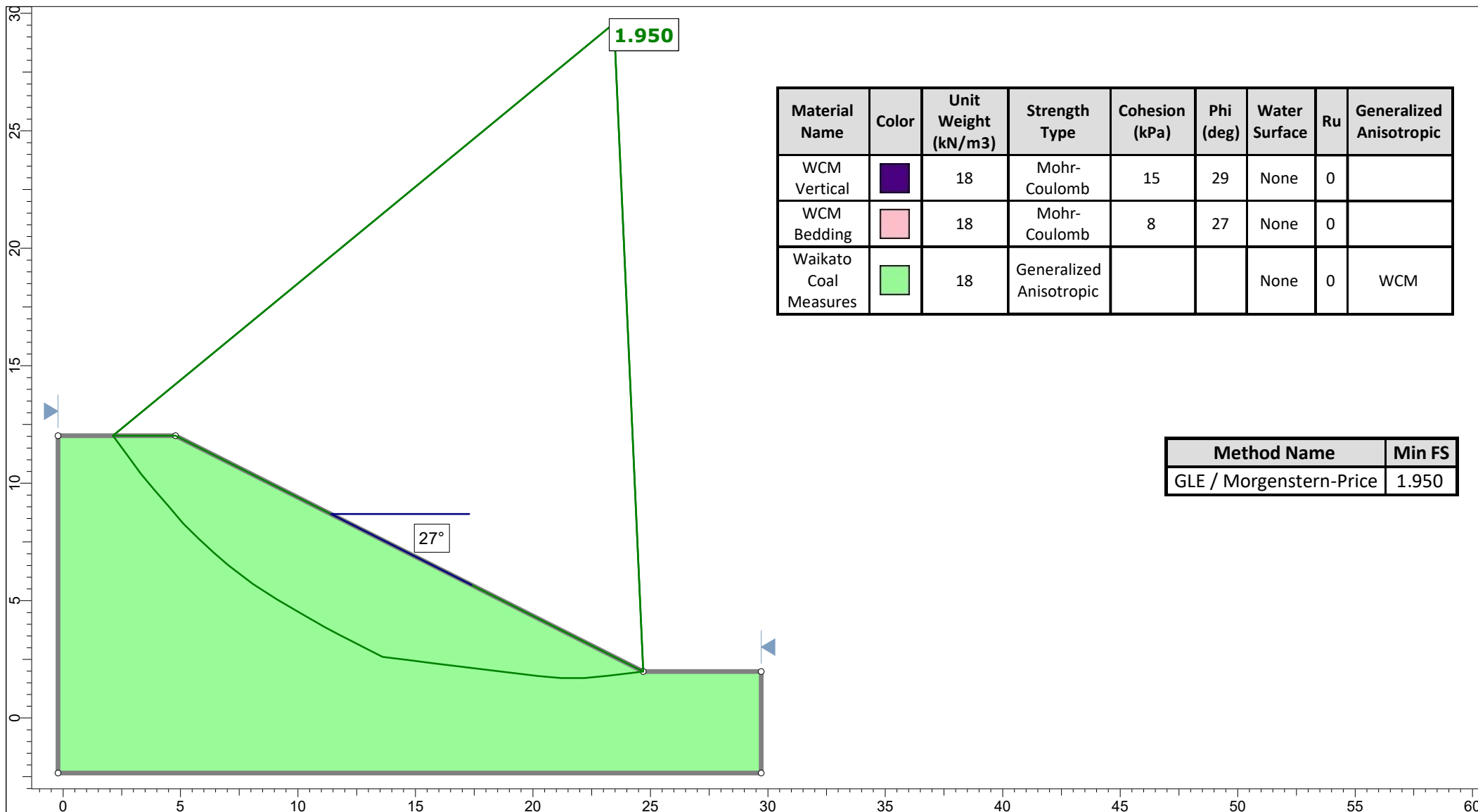
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SLIDEINTERPRET 9.027

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Date		20/06/2023, 9:44:06 am			File Name		
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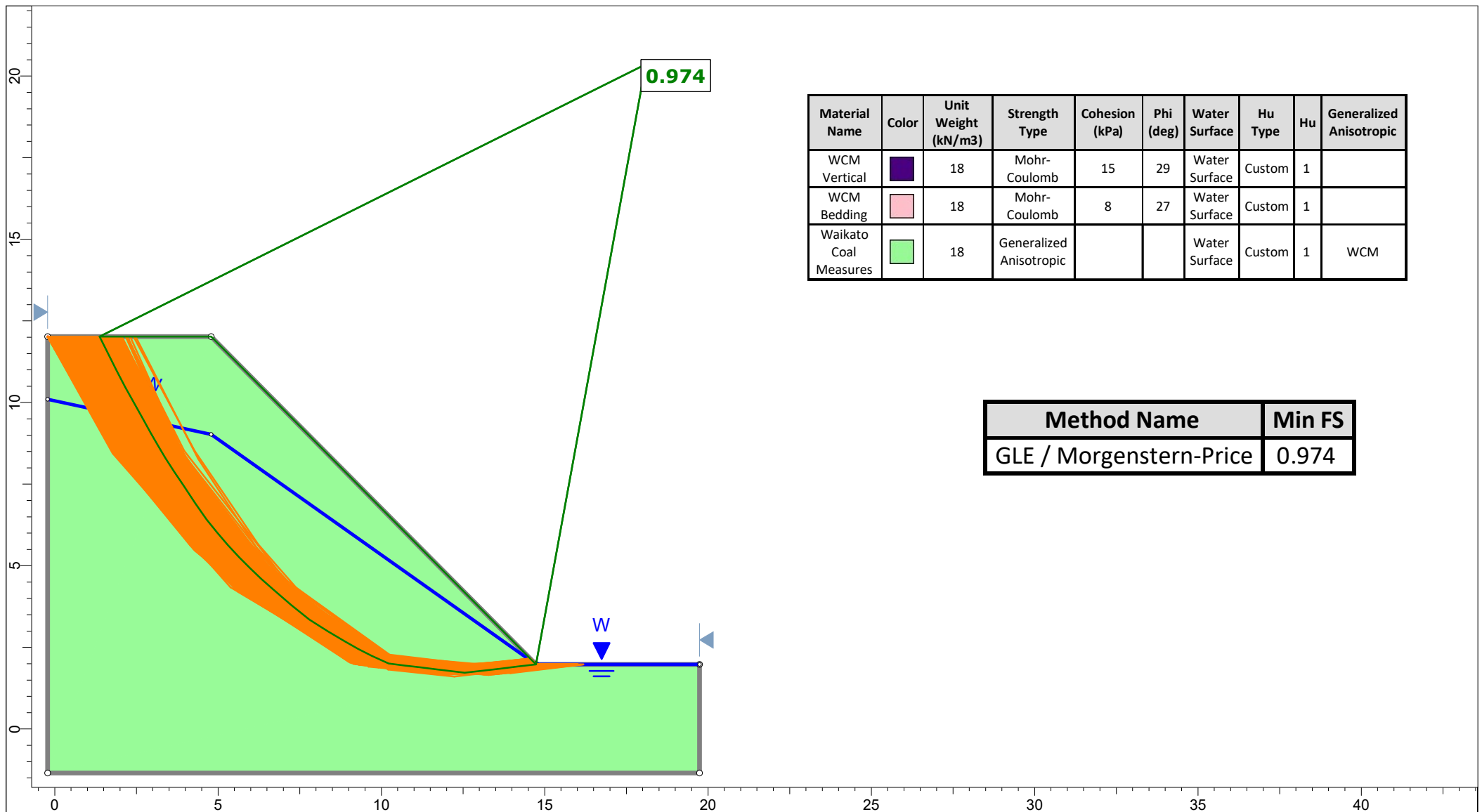
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Ru	Generalized Anisotropic
WCM Vertical		18	Mohr-Coulomb	15	29	None	0	
WCM Bedding		18	Mohr-Coulomb	8	27	None	0	
Waikato Coal Measures		18	Generalized Anisotropic			None	0	WCM

Method Name	Min FS
GLE / Morgenstern-Price	1.950



SLIDEINTERPRET 9.027

Project				Slide2 - An Interactive Slope Stability Program			
Group		WCM Single Bench Analysis			Scenario		
Drawn By					Company		
Date		20/06/2023, 9:44:06 am			File Name		
					Slide Model- Single Bench Analysis WCM.slmd		



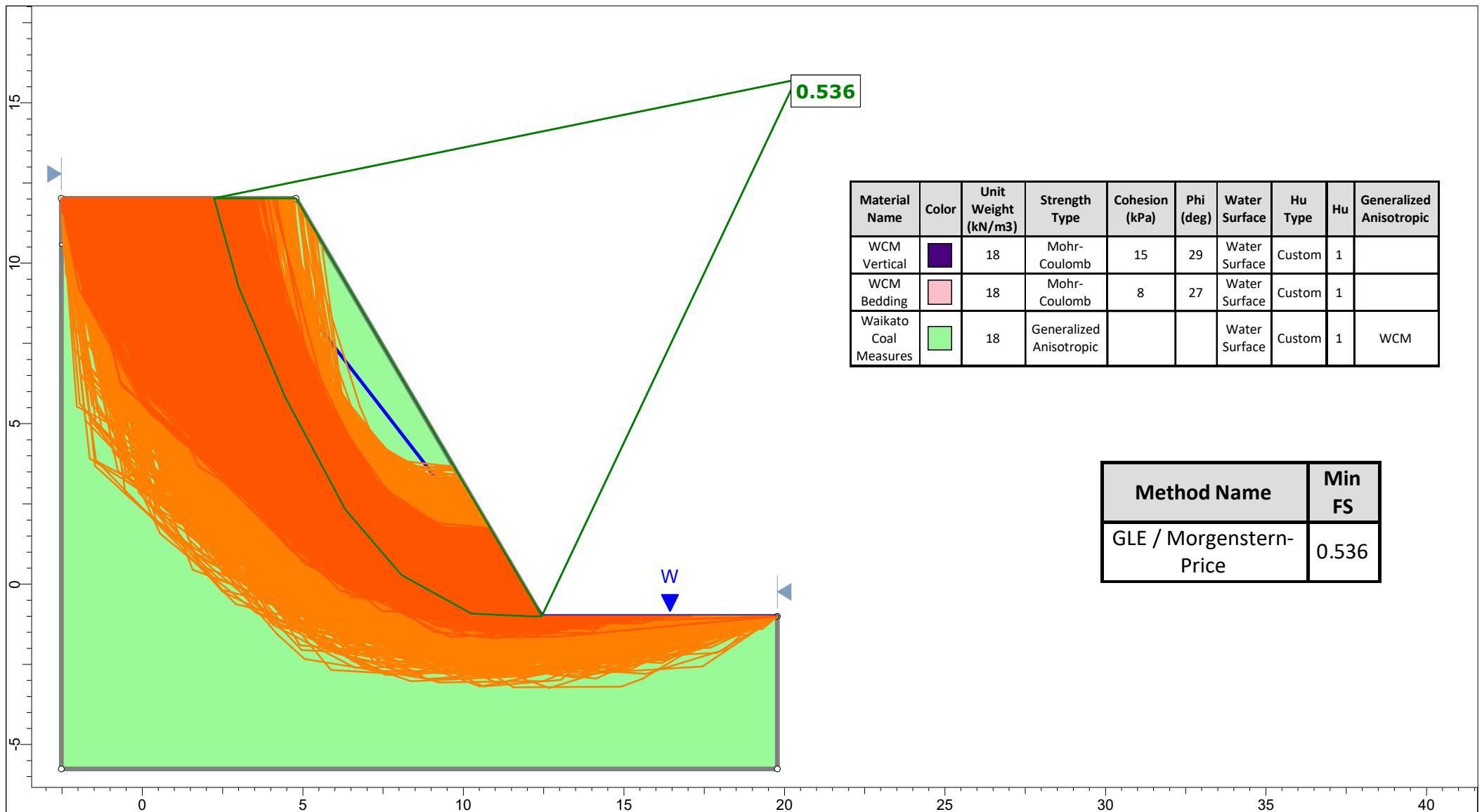
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu	Generalized Anisotropic
WCM Vertical		18	Mohr-Coulomb	15	29	Water Surface	Custom	1	
WCM Bedding		18	Mohr-Coulomb	8	27	Water Surface	Custom	1	
Waikato Coal Measures		18	Generalized Anisotropic			Water Surface	Custom	1	WCM

Method Name	Min FS
GLE / Morgenstern-Price	0.974



SLIDEINTERPRET 9.027

Project	Slide2 - An Interactive Slope Stability Program		
Group	WCM Single Bench Analysis	Scenario	WCM 45° Inter-Bench Slope - RWC Groundwater
Drawn By		Company	
Date	20/06/2023, 9:44:06 am	File Name	Slide Model- Single Bench Analysis WCM and GW.slmd



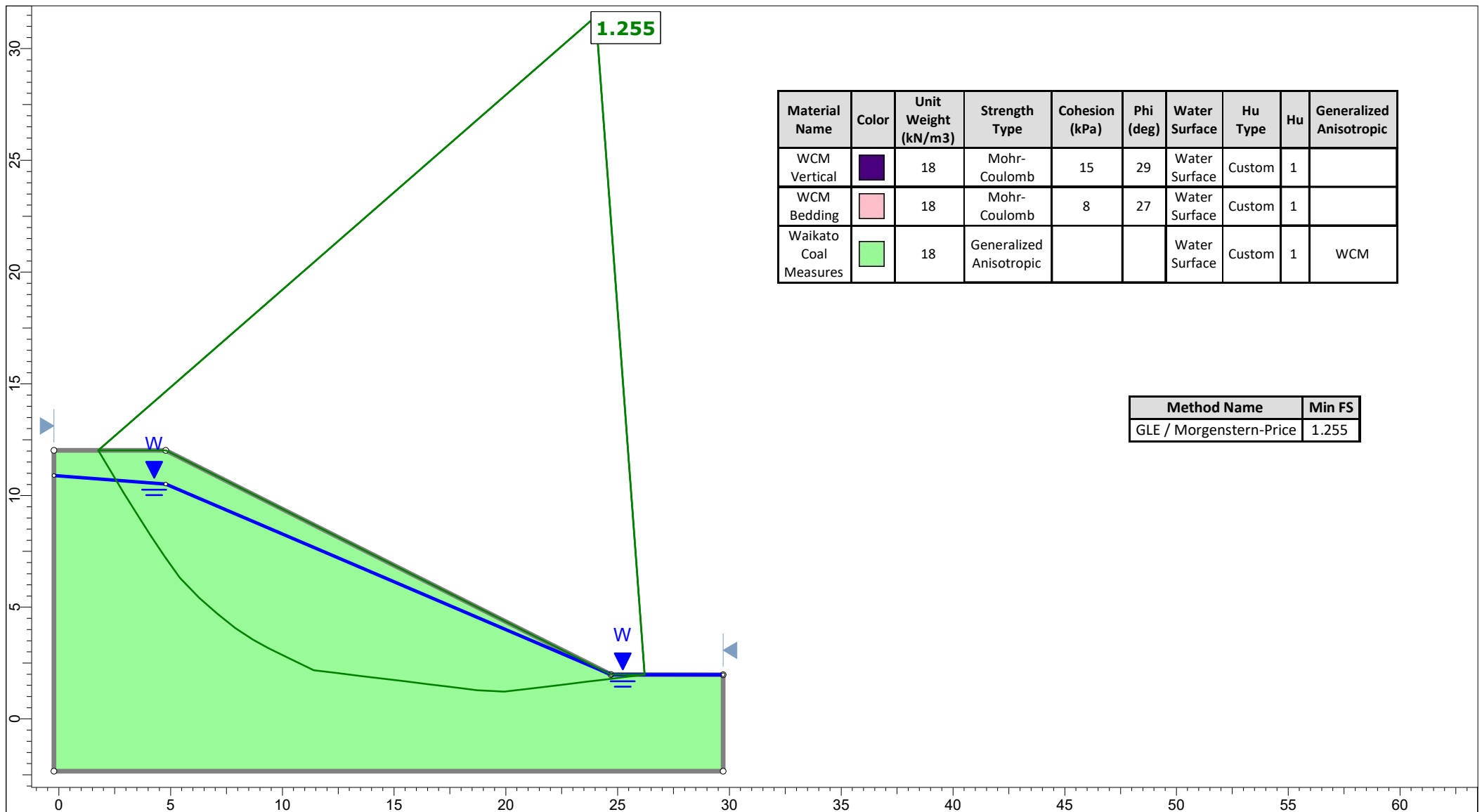
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu	Generalized Anisotropic
WCM Vertical		18	Mohr-Coulomb	15	29	Water Surface	Custom	1	
WCM Bedding		18	Mohr-Coulomb	8	27	Water Surface	Custom	1	
Waikato Coal Measures		18	Generalized Anisotropic			Water Surface	Custom	1	WCM

Method Name	Min FS
GLE / Morgenstern-Price	0.536



SLIDEINTERPRET 9.027

Project	Slide2 - An Interactive Slope Stability Program		
Group	WCM Single Bench Analysis	Scenario	WCM 60° Inter-Bench Slope - RWC Groundwater
Drawn By		Company	
Date	20/06/2023, 9:44:06 am	File Name	Slide Model- Single Bench Analysis WCM and GW.slmd



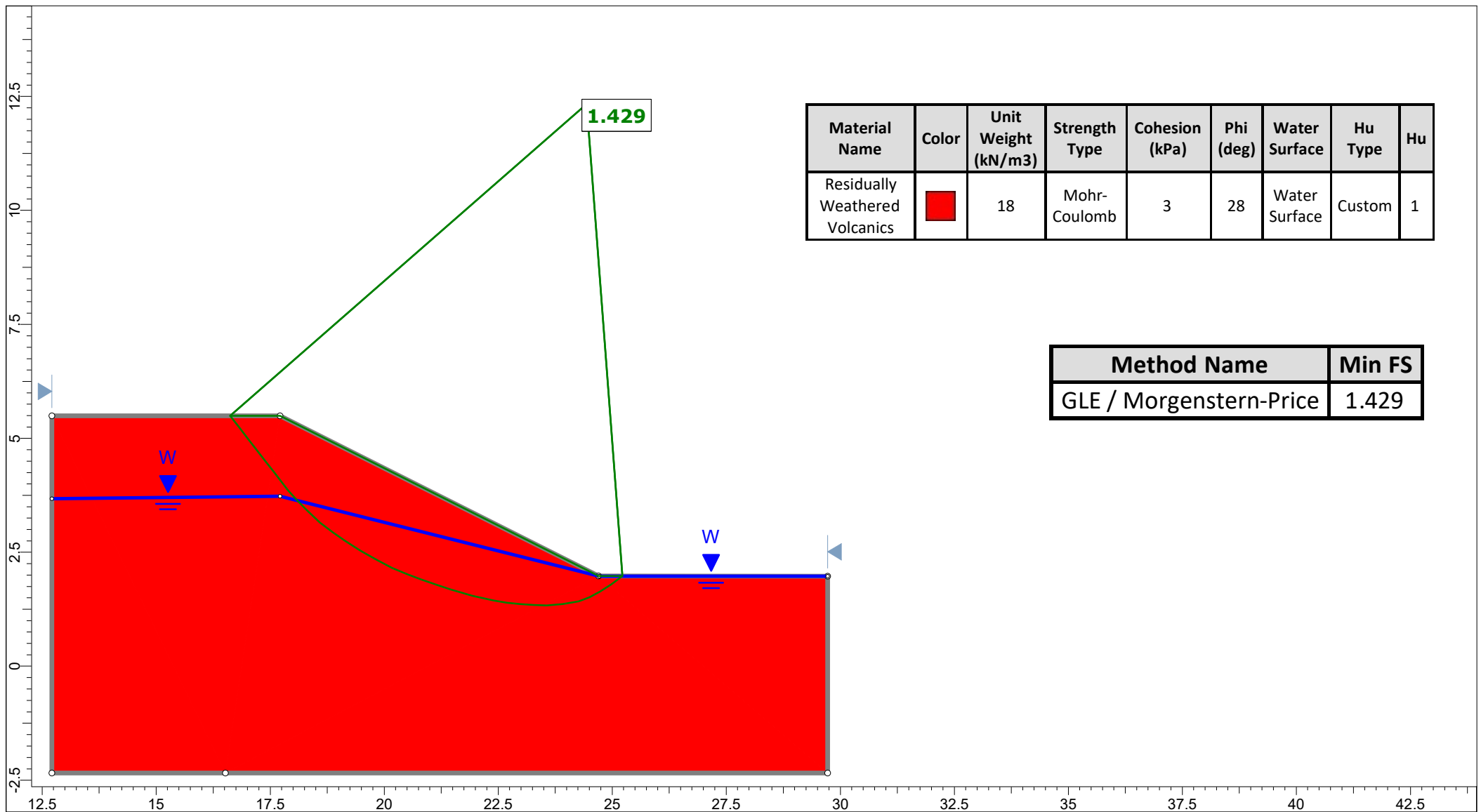
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu	Generalized Anisotropic
WCM Vertical		18	Mohr-Coulomb	15	29	Water Surface	Custom	1	
WCM Bedding		18	Mohr-Coulomb	8	27	Water Surface	Custom	1	
Waikato Coal Measures		18	Generalized Anisotropic			Water Surface	Custom	1	WCM

Method Name	Min FS
GLE / Morgenstern-Price	1.255



SLIDEINTERPRET 9.027

Project	Slide2 - An Interactive Slope Stability Program		
Group	WCM Single Bench Analysis	Scenario	WCM 27° Inter-Bench Slope - RWC Groundwater
Drawn By		Company	
Date	20/06/2023, 9:44:06 am	File Name	Slide Model- Single Bench Analysis WCM and GW.slmd



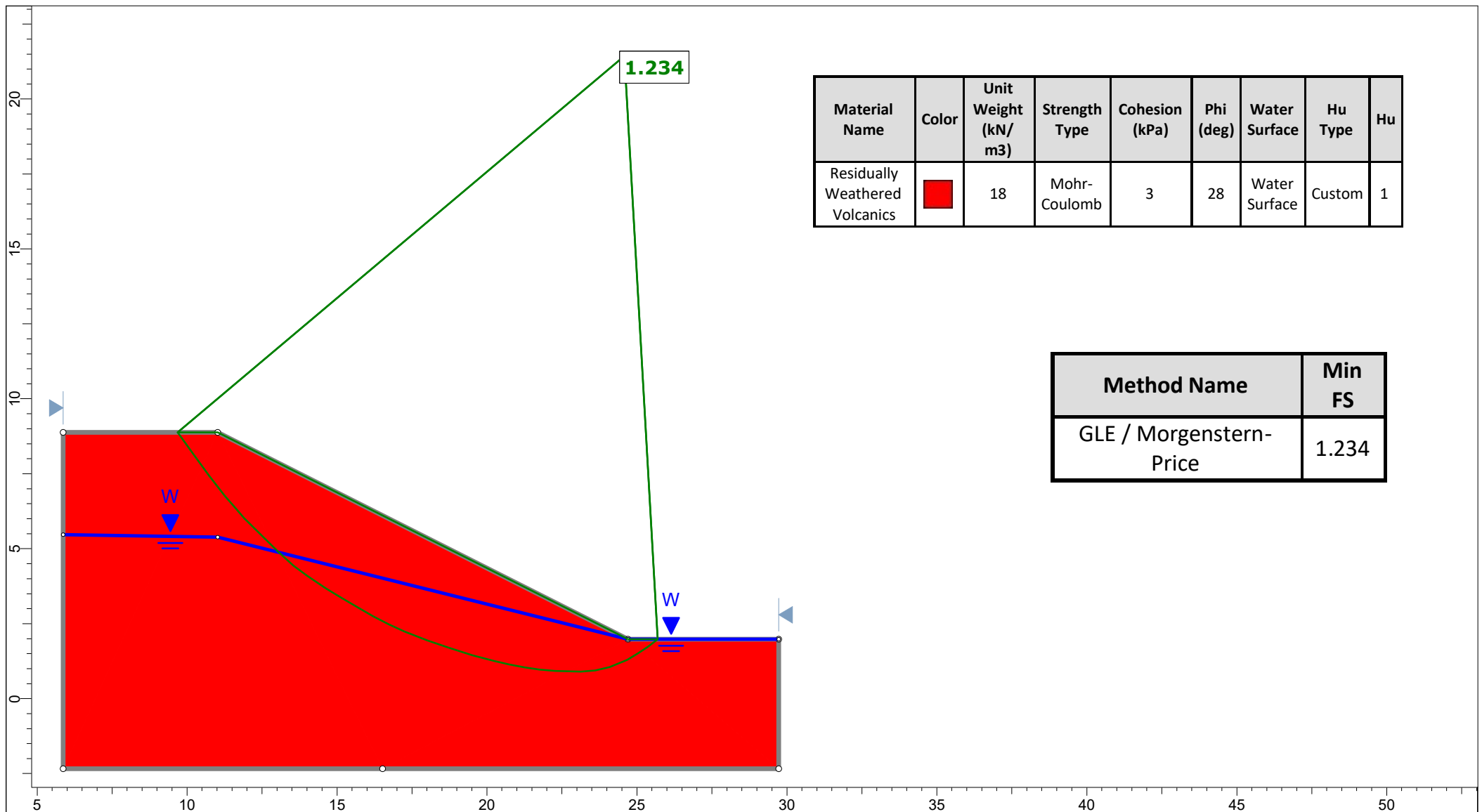
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Residually Weathered Volcanics	■	18	Mohr-Coulomb	3	28	Water Surface	Custom	1

Method Name	Min FS
GLE / Morgenstern-Price	1.429



SLIDEINTERPRET 9.027

Project			Slide2 - An Interactive Slope Stability Program		
Group		Sections C&D - Residual Volcanics		Scenario	27° Flattened Slope Angle - Reasonable Worst-Case Groundwater
Drawn By				Company	
Date		20/06/2023, 9:44:06 am		File Name	Slide Model- Single Bench Analysis WCM and GW.slmd



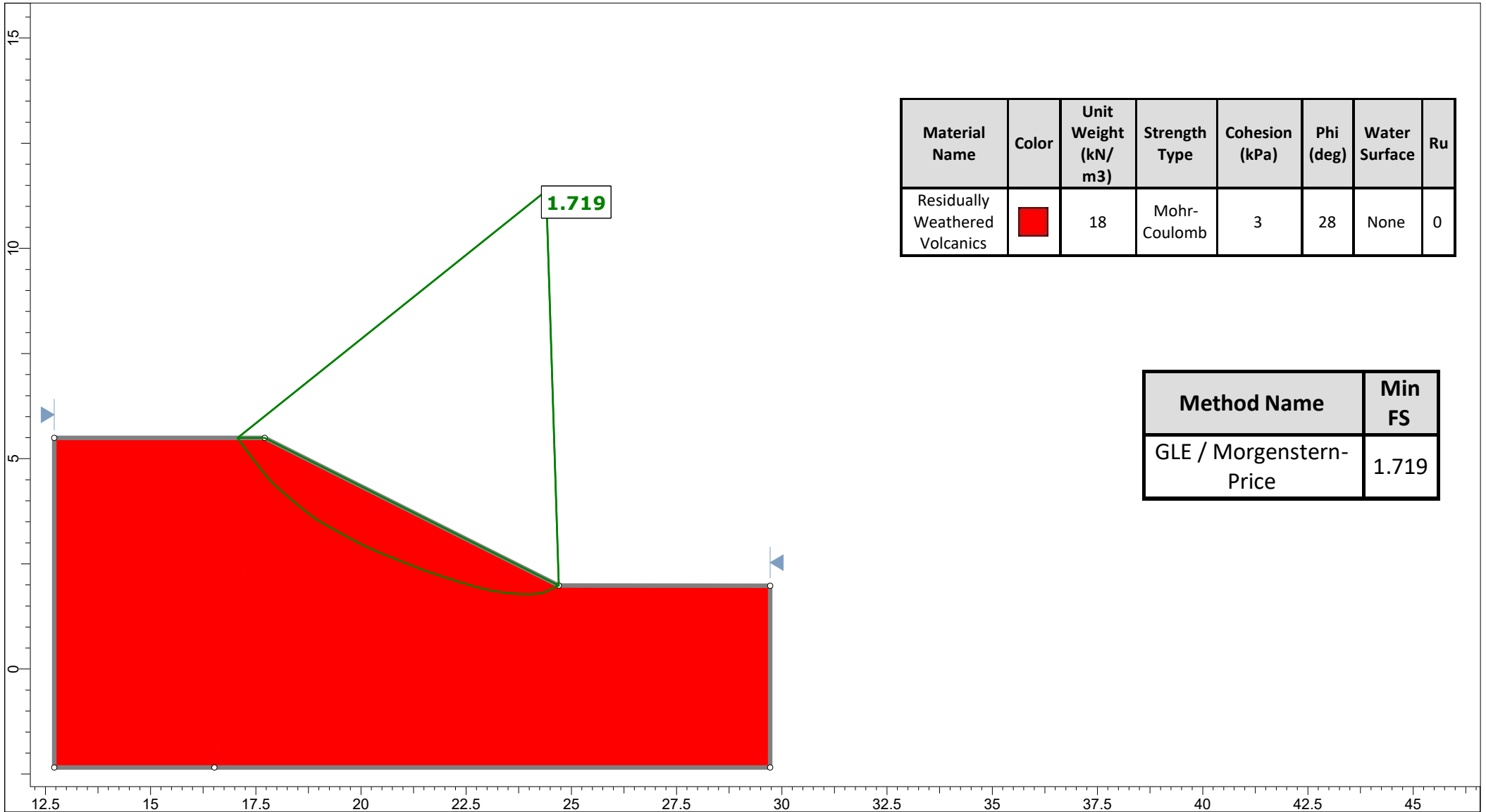
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Residually Weathered Volcanics	■	18	Mohr-Coulomb	3	28	Water Surface	Custom	1

Method Name	Min FS
GLE / Morgenstern-Price	1.234



SLIDEINTERPRET 9.027

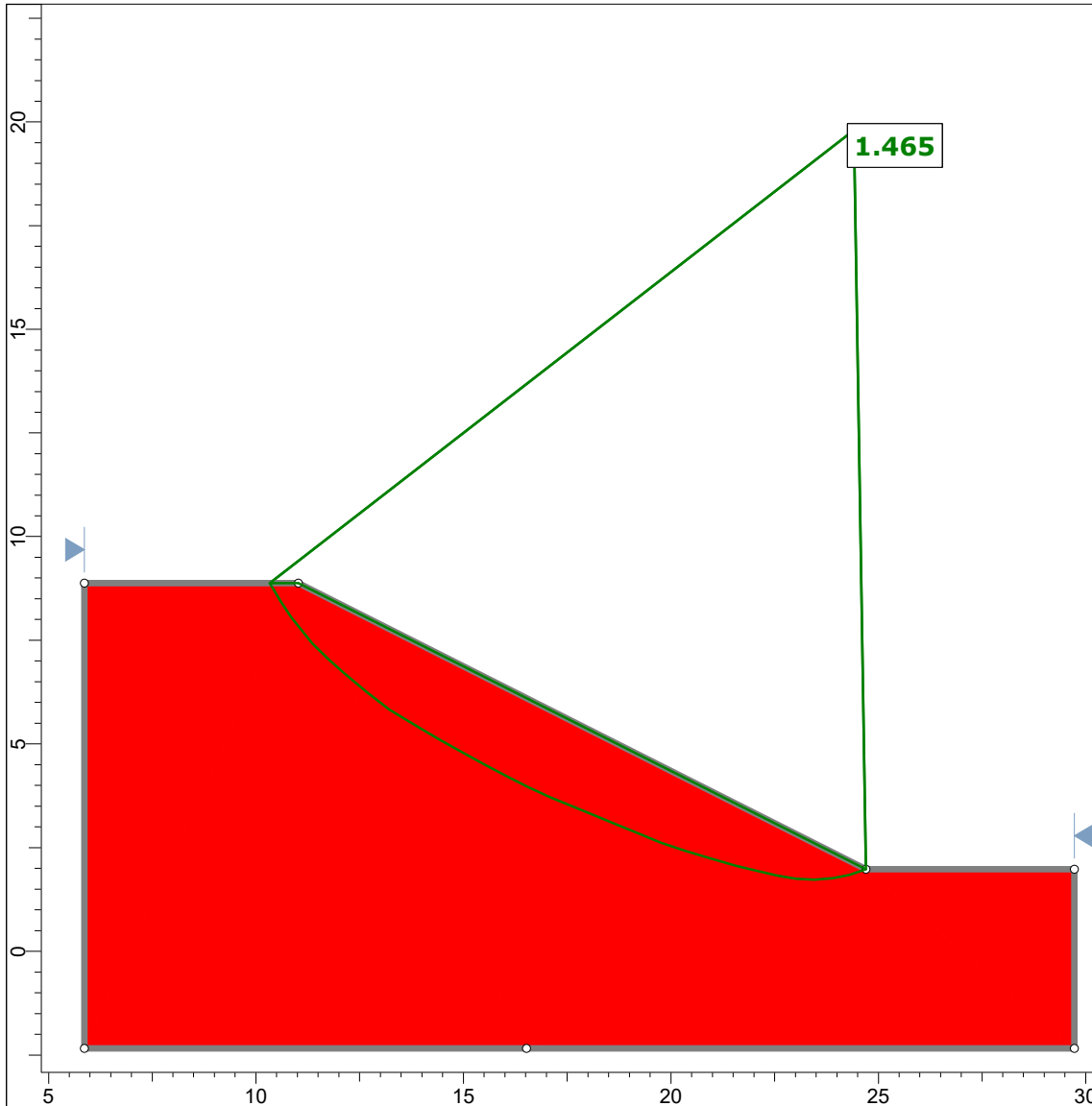
Project			Slide2 - An Interactive Slope Stability Program		
Group			Sections C&D - Residual Volcanics		
Scenario			27° Flattened Slope Angle - Reasonable Worst-Case Groundwater		
Drawn By			Company		
Date			File Name		
20/06/2023, 9:44:06 am			Slide Model- Single Bench Analysis WCM and GW.slmd		



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Ru
Residually Weathered Volcanics	■	18	Mohr-Coulomb	3	28	None	0

Method Name	Min FS
GLE / Morgenstern-Price	1.719

	Project		Slide2 - An Interactive Slope Stability Program	
	Group	Sections C&D - Residual Volcanics	Scenario	27° Flattened Slope Angle - No Groundwater
	Drawn By		Company	
	Date	20/06/2023, 9:44:06 am	File Name	Slide Model- Single Bench Analysis WCM and GW.slmd



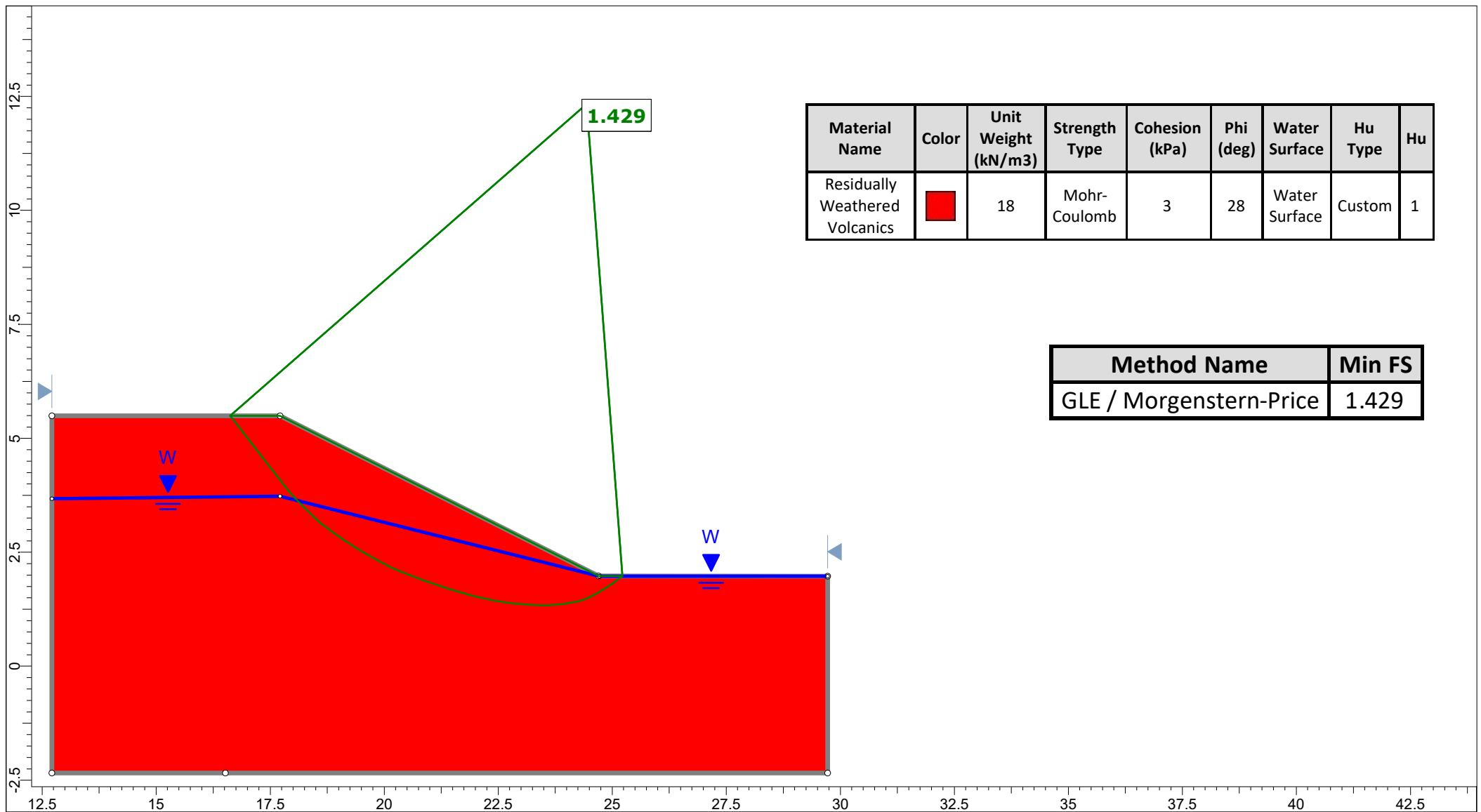
Material Name	Color	Unit Weight (kN/m ³)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Ru
Residually Weathered Volcanics		18	Mohr-Coulomb	3	28	None	0

Method Name	Min FS
GLE / Morgenstern-Price	1.465



SLIDEINTERPRET 9.027

Project		Slide2 - An Interactive Slope Stability Program	
Group		Sections C&D - Residual Volcanics	Scenario 27° Flattened Slope Angle - No Groundwater
Drawn By		Company	
Date		20/06/2023, 9:44:06 am	File Name Slide Model- Single Bench Analysis WCM and GW.slmd



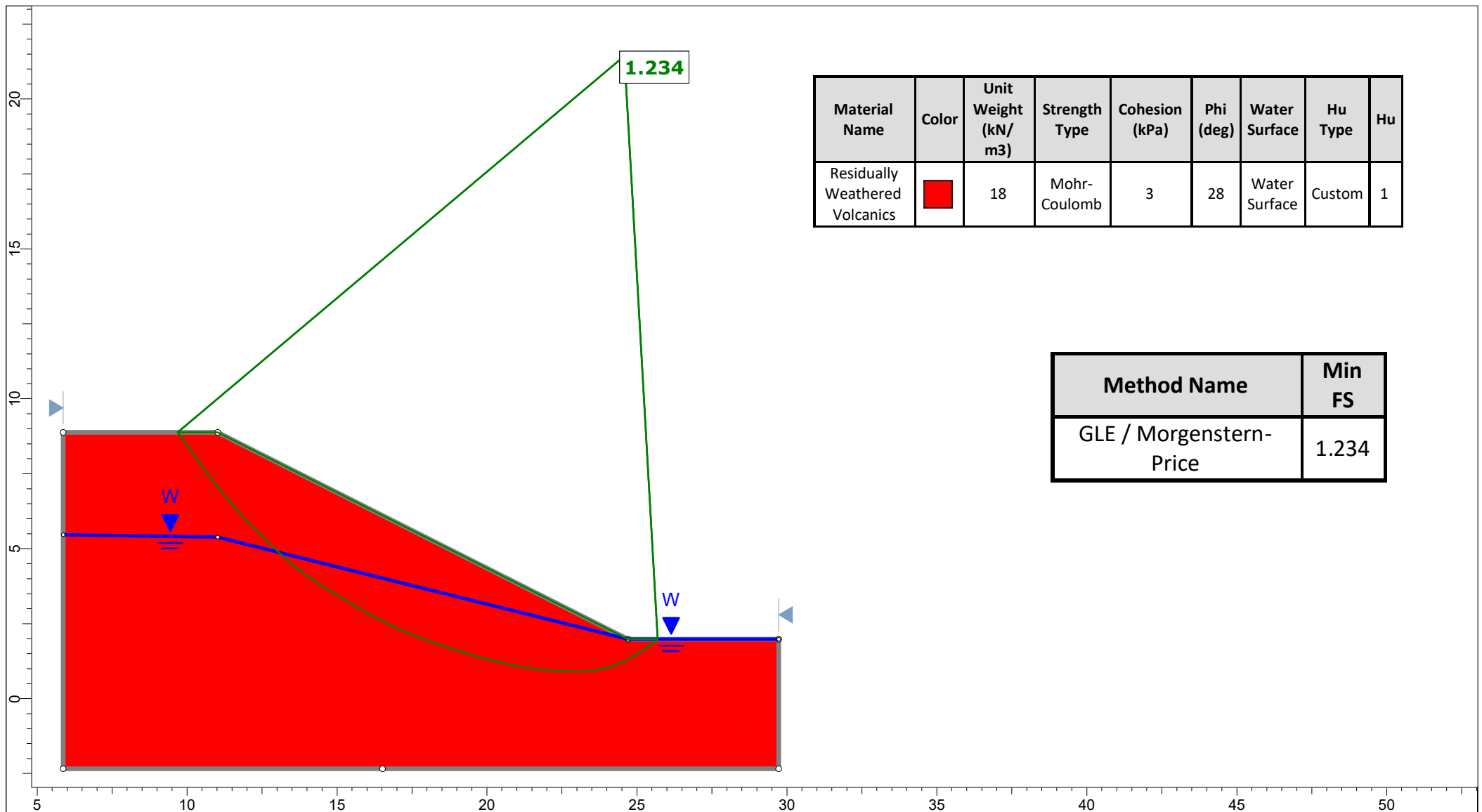
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Residually Weathered Volcanics	■	18	Mohr-Coulomb	3	28	Water Surface	Custom	1

Method Name	Min FS
GLE / Morgenstern-Price	1.429



SLIDEINTERPRET 9.027

Project			Slide2 - An Interactive Slope Stability Program		
Group		Section A - Residual Volcanics		Scenario	27° Flattened Slope Angle - Reasonable Worst-Case Groundwater
Drawn By				Company	
Date		20/06/2023, 9:44:06 am		File Name	Slide Model- Single Bench Analysis WCM and GW.slmd



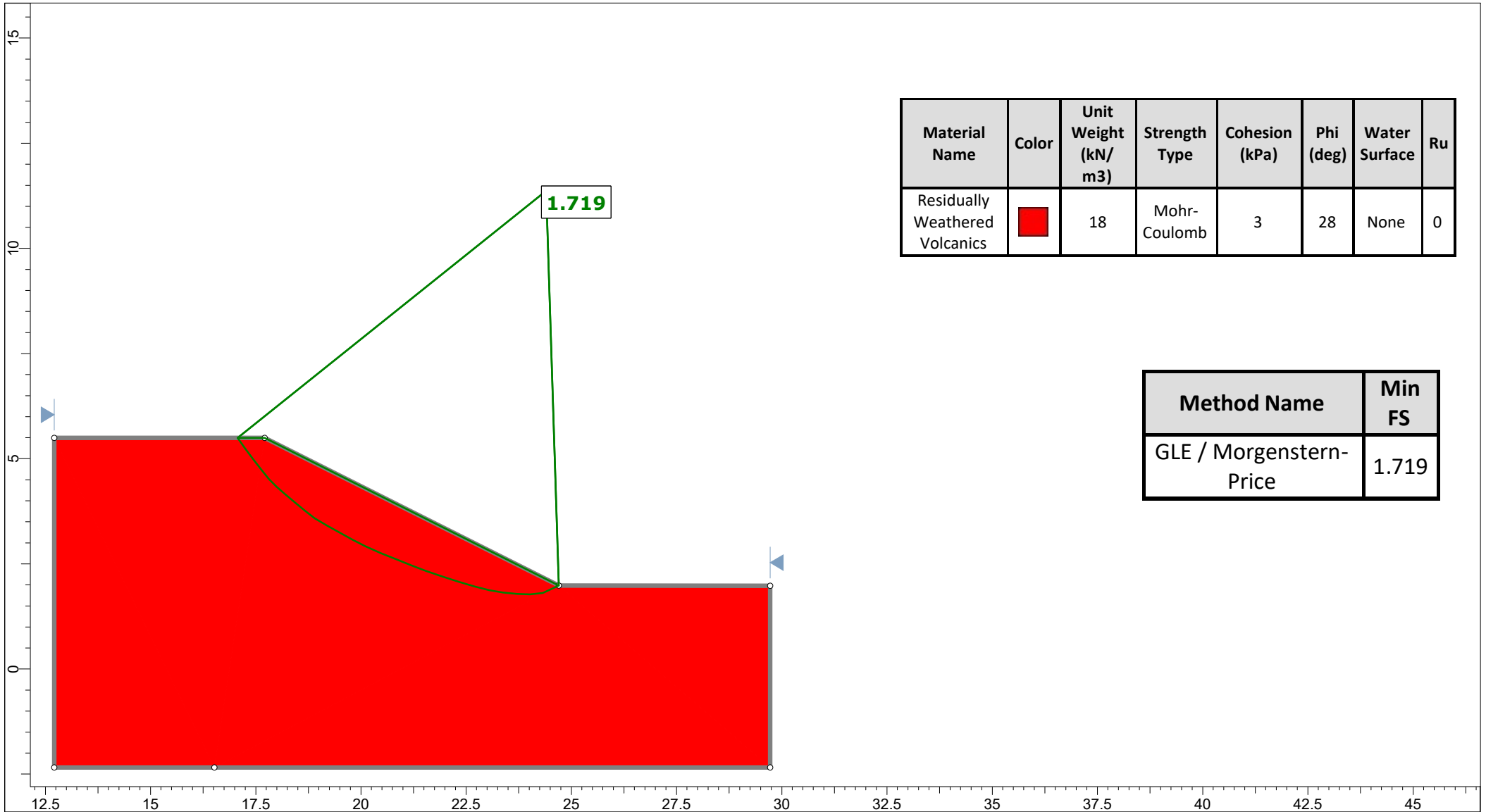
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Residually Weathered Volcanics	■	18	Mohr-Coulomb	3	28	Water Surface	Custom	1

Method Name	Min FS
GLE / Morgenstern-Price	1.234



SLIDEINTERPRET 9.027

Project			Slide2 - An Interactive Slope Stability Program		
Group		Section B - Residual Volcanics		Scenario 27° Flattened Slope Angle - Reasonable Worst-Case Groundwater	
Drawn By				Company	
Date		20/06/2023, 9:44:06 am		File Name Slide Model- Single Bench Analysis WCM and GW.slmd	



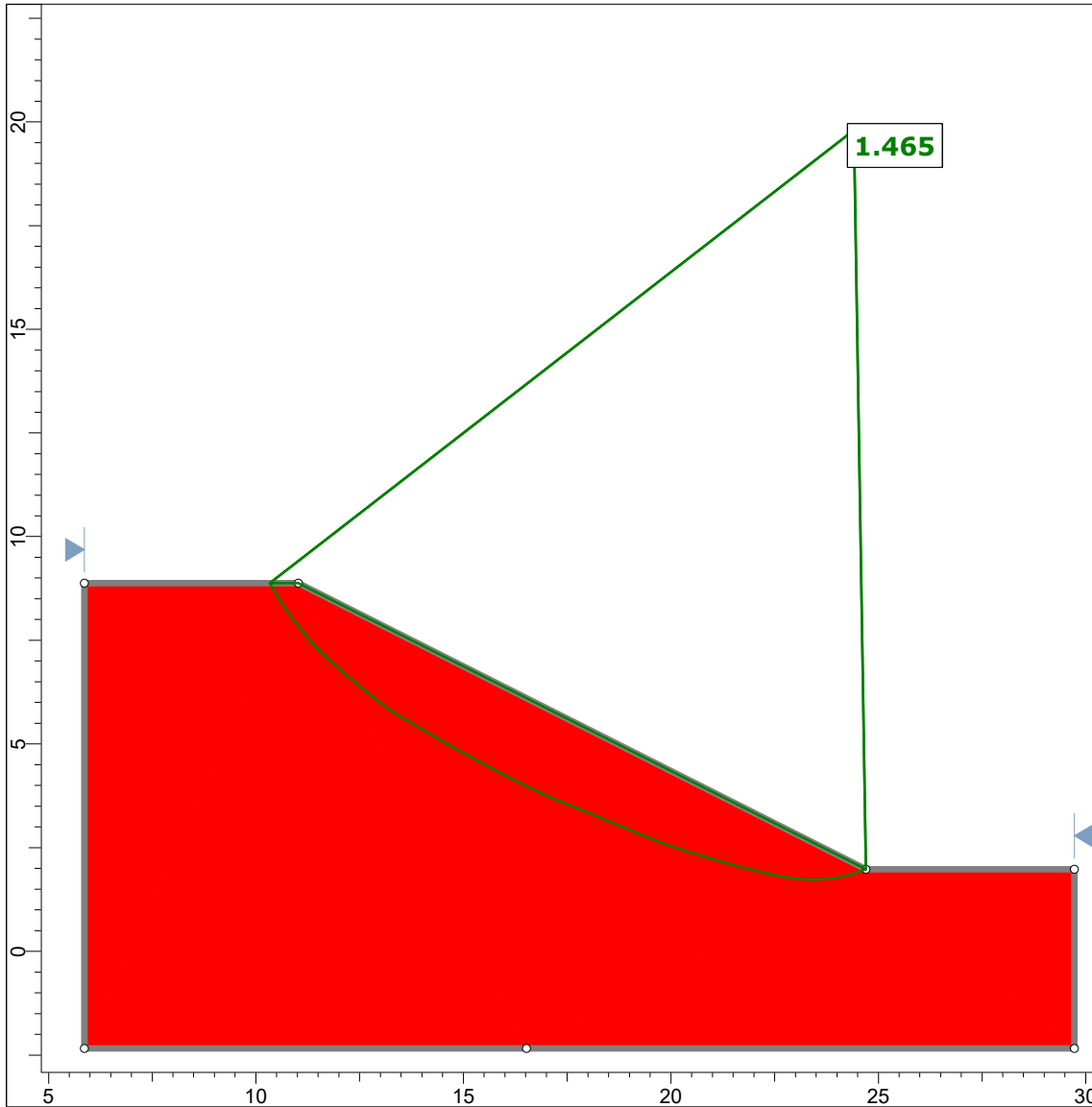
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Ru
Residually Weathered Volcanics	■	18	Mohr-Coulomb	3	28	None	0

Method Name	Min FS
GLE / Morgenstern-Price	1.719



SLIDEINTERPRET 9.027

Project				Slide2 - An Interactive Slope Stability Program			
Group		Section A - Residual Volcanics			Scenario		
					27° Flattened Slope Angle - No Groundwater		
Drawn By					Company		
Date		20/06/2023, 9:44:06 am			File Name		
					Slide Model- Single Bench Analysis WCM and GW.slmd		



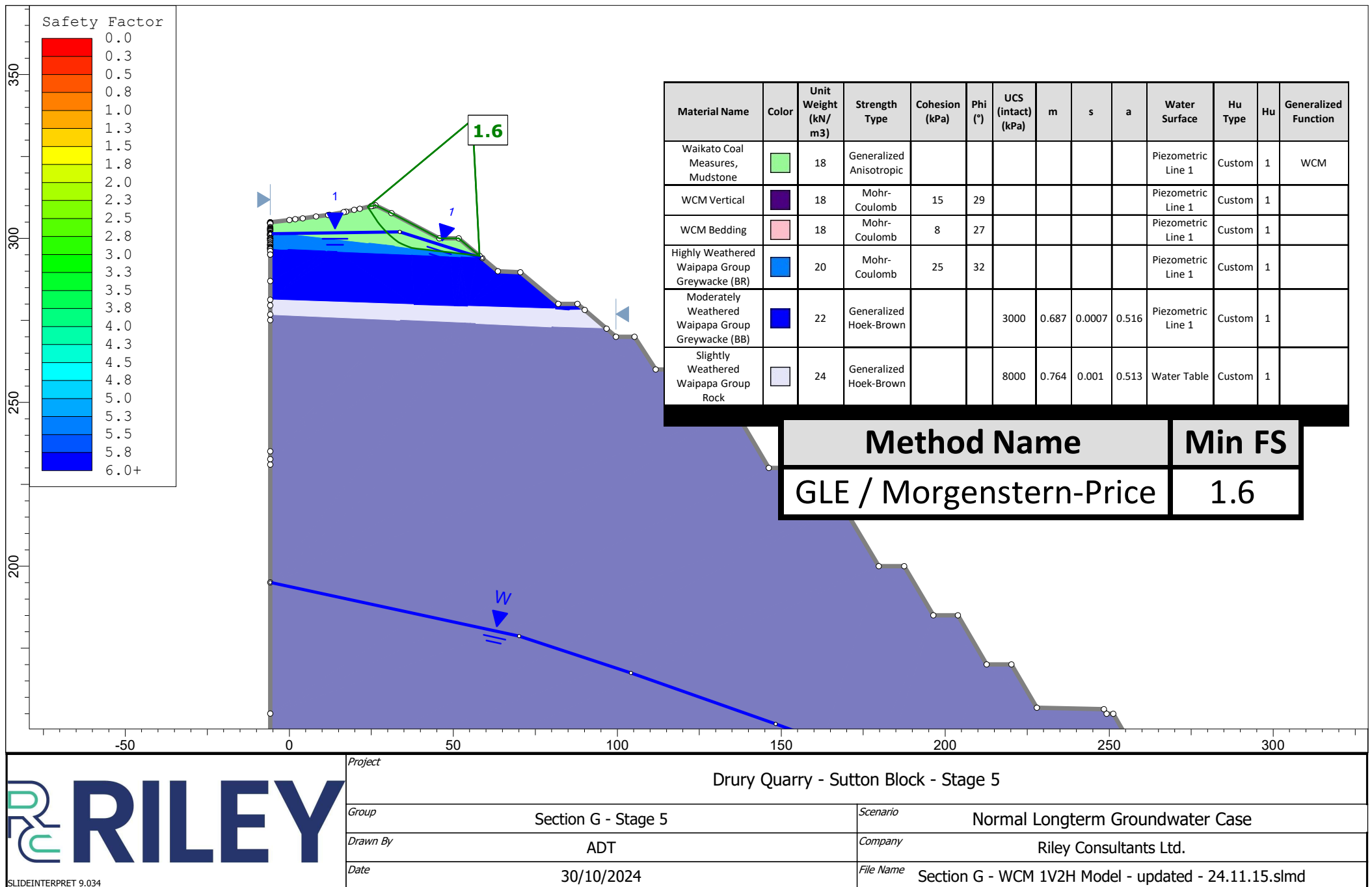
Material Name	Color	Unit Weight (kN/m ³)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Ru
Residually Weathered Volcanics	■	18	Mohr-Coulomb	3	28	None	0

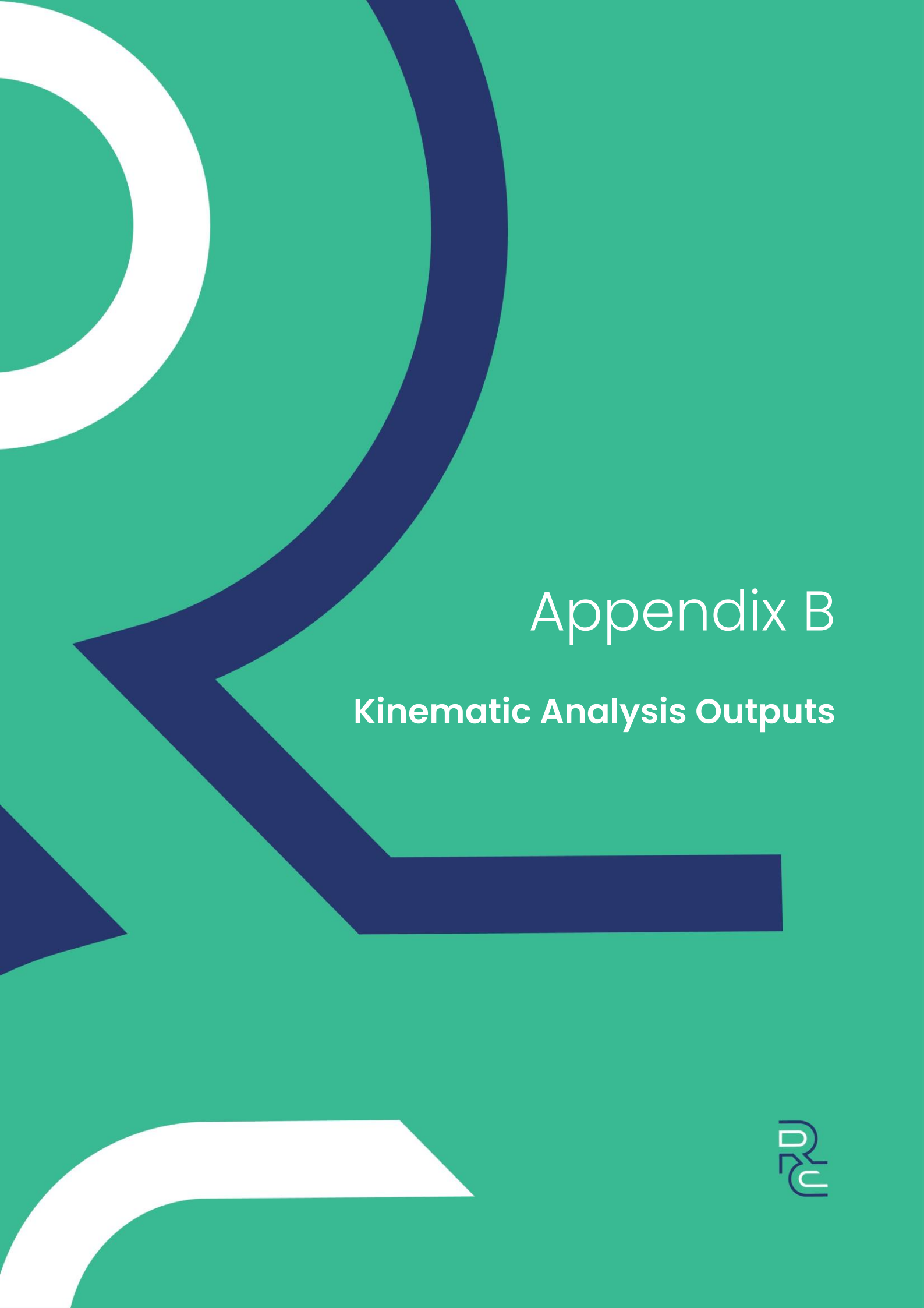
Method Name	Min FS
GLE / Morgenstern-Price	1.465



SLIDEINTERPRET 9.027

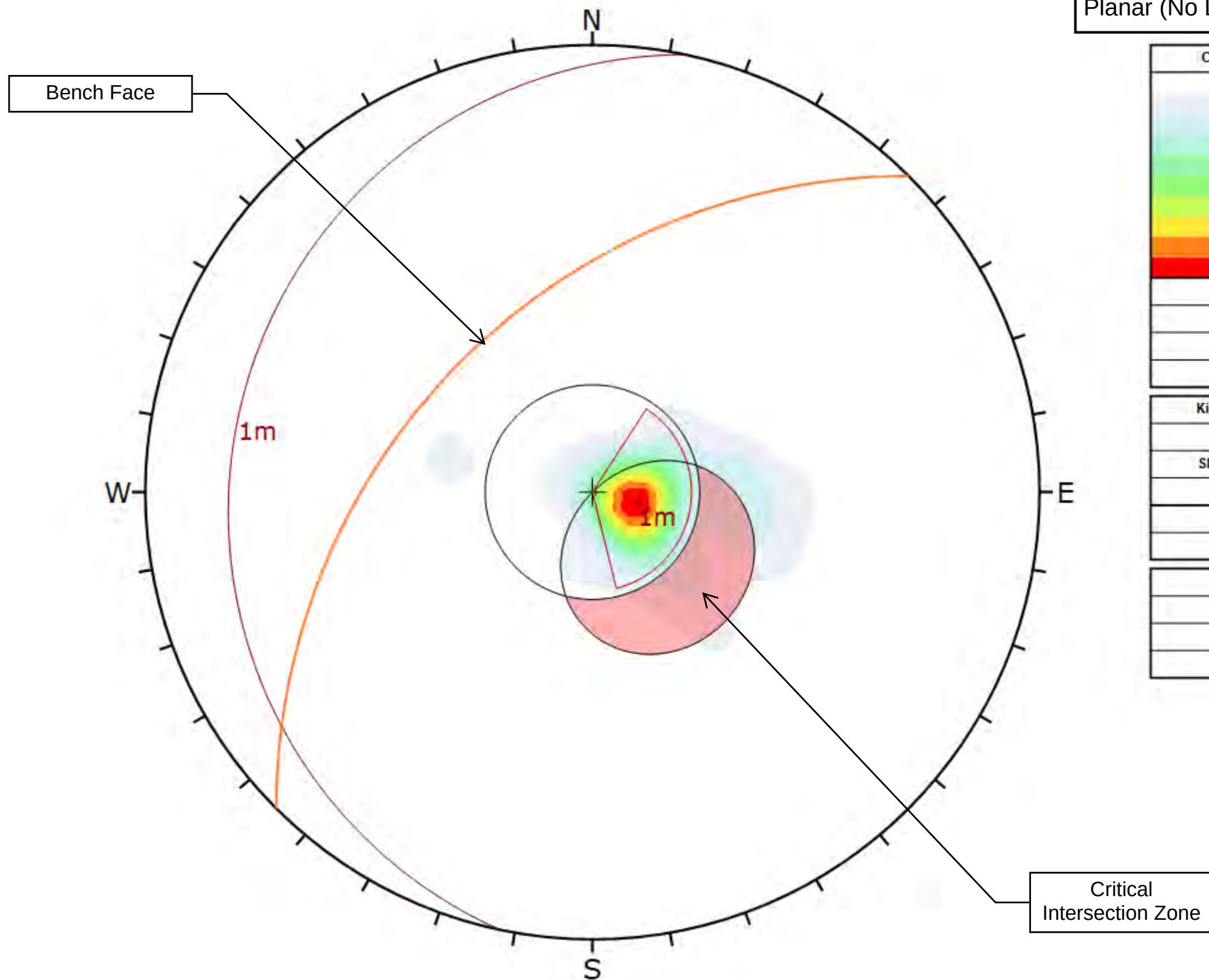
Project				Slide2 - An Interactive Slope Stability Program			
Group		Section B - Residual Volcanics			Scenario		
					27° Flattened Slope Angle - No Groundwater		
Drawn By					Company		
Date		20/06/2023, 9:44:06 am			File Name		
					Slide Model- Single Bench Analysis WCM and GW.slmd		



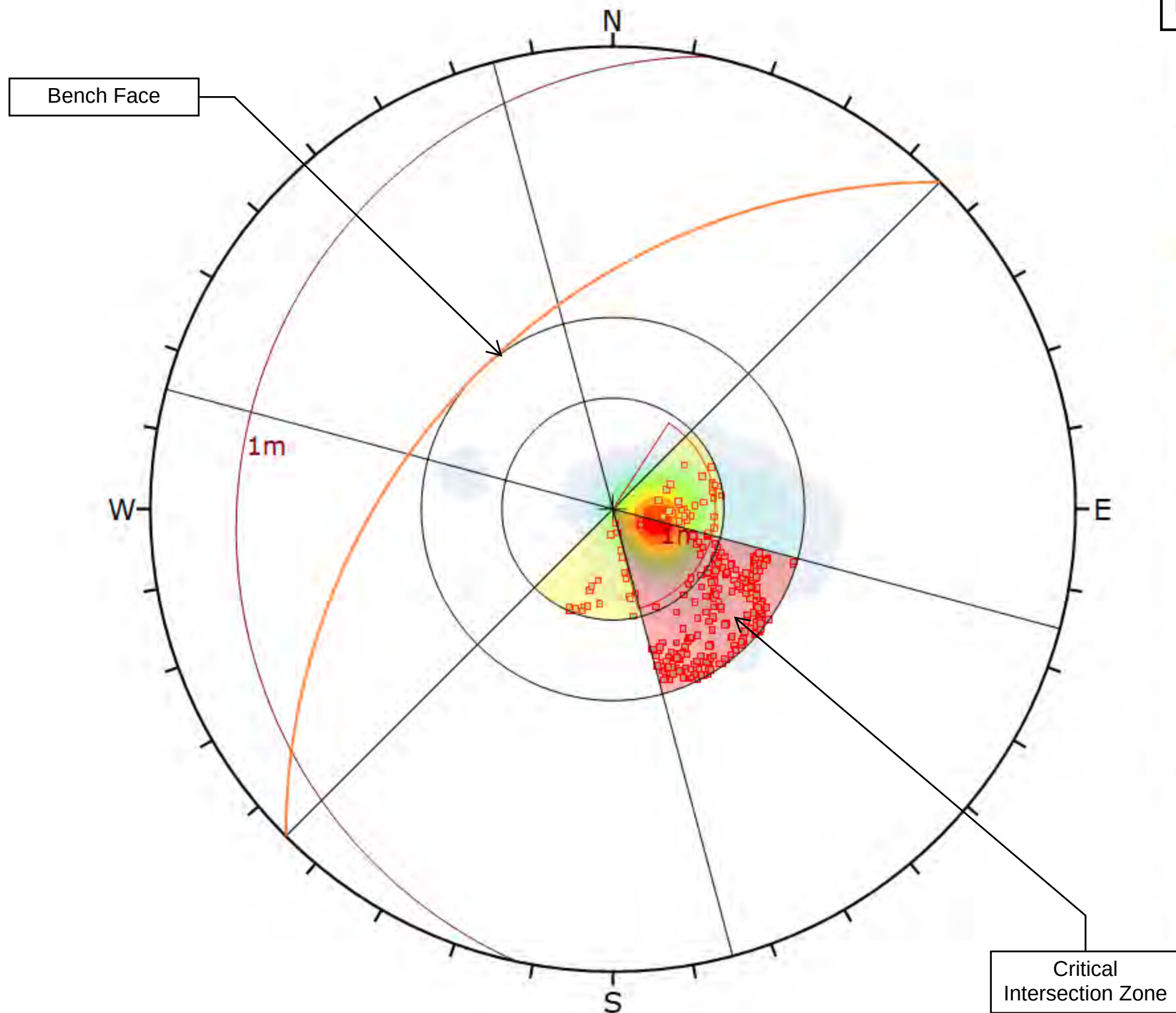


Appendix B

Kinematic Analysis Outputs



Color	Density Concentrations			
	0.00	- 1.80		
	1.80	- 3.60		
	3.60	- 5.40		
	5.40	- 7.20		
	7.20	- 9.00		
	9.00	- 10.80		
	10.80	- 12.60		
	12.60	- 14.40		
	14.40	- 16.20		
	16.20	- 18.00		
Contour Data		Pole Vectors		
Maximum Density		17.67%		
Contour Distribution		Fisher		
Counting Circle Size		1.0%		
Kinematic Analysis		Planar Sliding		
Slope Dip		45		
Slope Dip Direction		315		
Friction Angle		27°		
		Critical	Total	%
Planar Sliding (All)		30	286	10.49%
Plot Mode		Pole Vectors		
Vector Count		286 (286 Entries)		
Hemisphere		Lower		
Projection		Equal Angle		



Symbol	Feature
	Critical Intersection

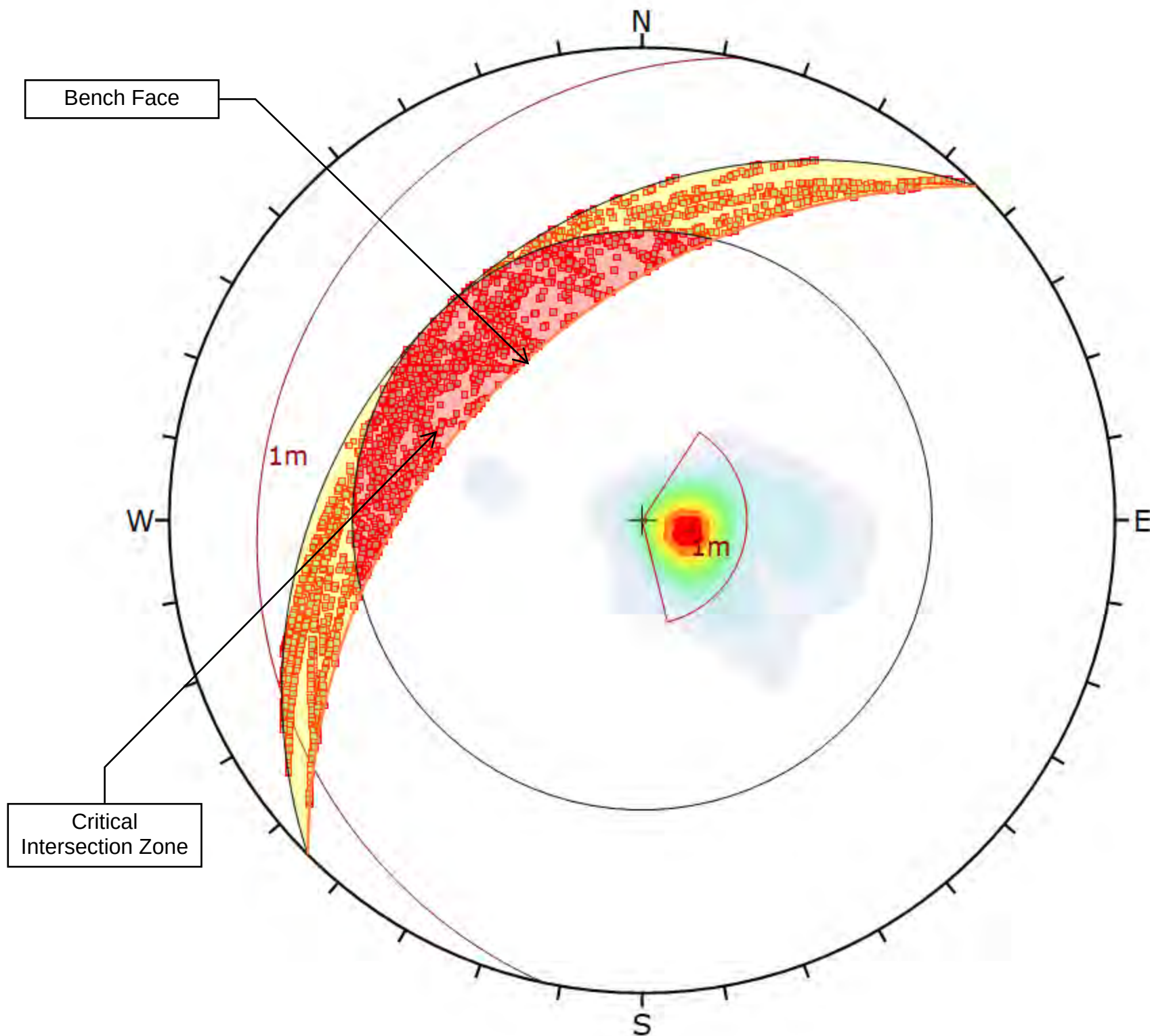
Color	Density Concentrations
	0.00 - 1.80
	1.80 - 3.60
	3.60 - 5.40
	5.40 - 7.20
	7.20 - 9.00
	9.00 - 10.80
	10.80 - 12.60
	12.60 - 14.40
	14.40 - 16.20
	16.20 - 18.00

Contour Data	Pole Vectors
Maximum Density	17.67%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Direct Toppling
Slope Dip	45
Slope Dip Direction	315
Friction Angle	27°
Lateral Limits	30°

	Critical	Total	%
Direct Toppling (Intersection)	261	40755	0.64%
Oblique Toppling (Intersection)	53	40755	0.13%
Base Plane (All)	138	286	48.25%
Base Plane (Set 1)	99	101	98.02%

Plot Mode	Pole Vectors
Vector Count	286 (286 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	40755
Hemisphere	Lower
Projection	Equal Angle



Symbol	Feature
■	Critical Intersection

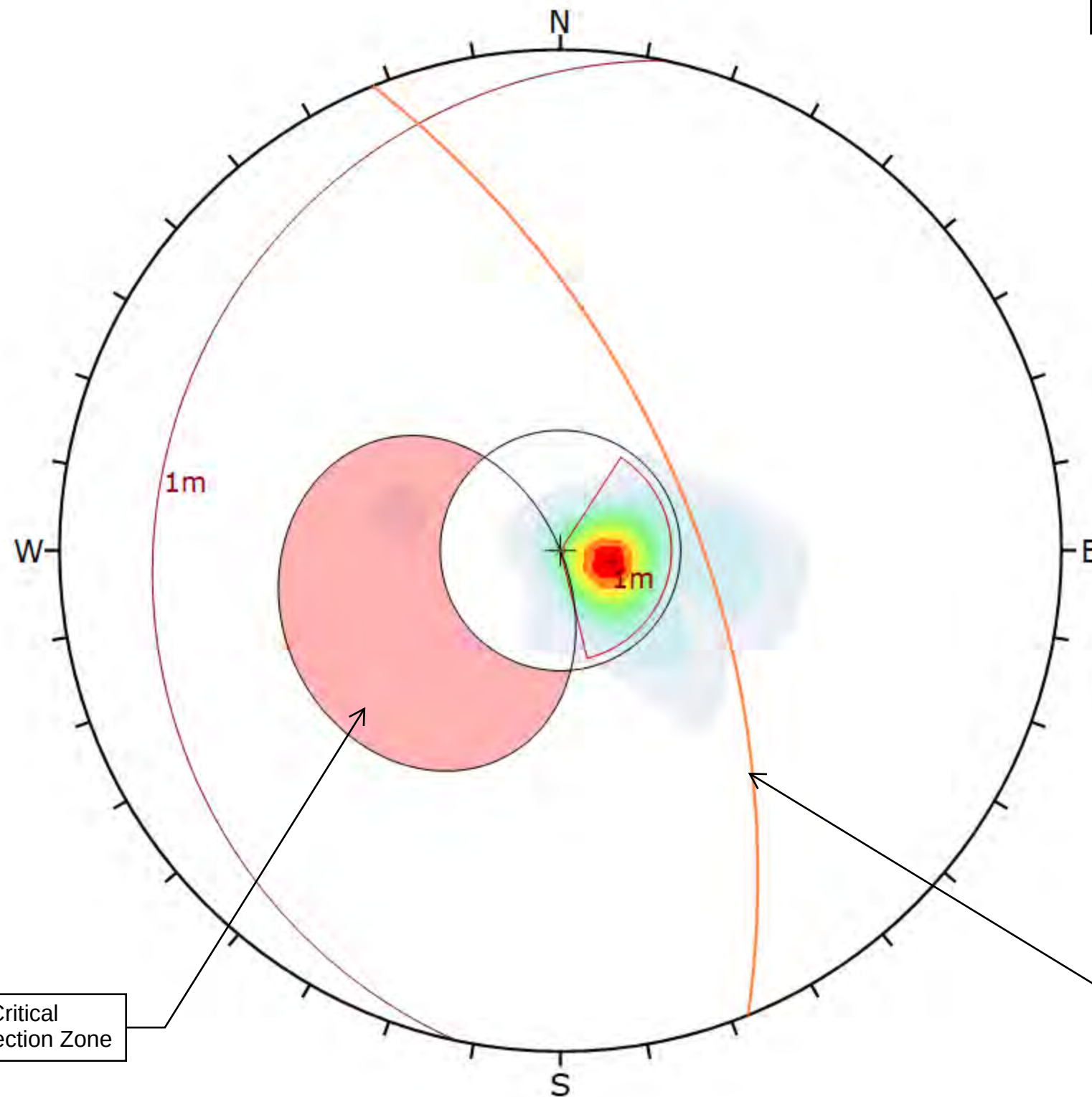
Color	Density Concentrations
	0.00 - 1.80
	1.80 - 3.60
	3.60 - 5.40
	5.40 - 7.20
	7.20 - 9.00
	9.00 - 10.80
	10.80 - 12.60
	12.60 - 14.40
	14.40 - 16.20
	16.20 - 18.00

Contour Data	Pole Vectors
Maximum Density	17.67%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding
Slope Dip	45
Slope Dip Direction	315
Friction Angle	27°

	Critical	Total	%
Wedge Sliding	3181	40755	7.81%

Plot Mode	Pole Vectors
Vector Count	286 (286 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	40755
Hemisphere	Lower
Projection	Equal Angle



Color	Density Concentrations	
	0.00	- 1.80
	1.80	- 3.60
	3.60	- 5.40
	5.40	- 7.20
	7.20	- 9.00
	9.00	- 10.80
	10.80	- 12.60
	12.60	- 14.40
	14.40	- 16.20
	16.20	- 18.00

Contour Data	Pole Vectors
Maximum Density	17.67%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Planar Sliding
Slope Dip	80
Slope Dip Direction	88
Friction Angle	27°

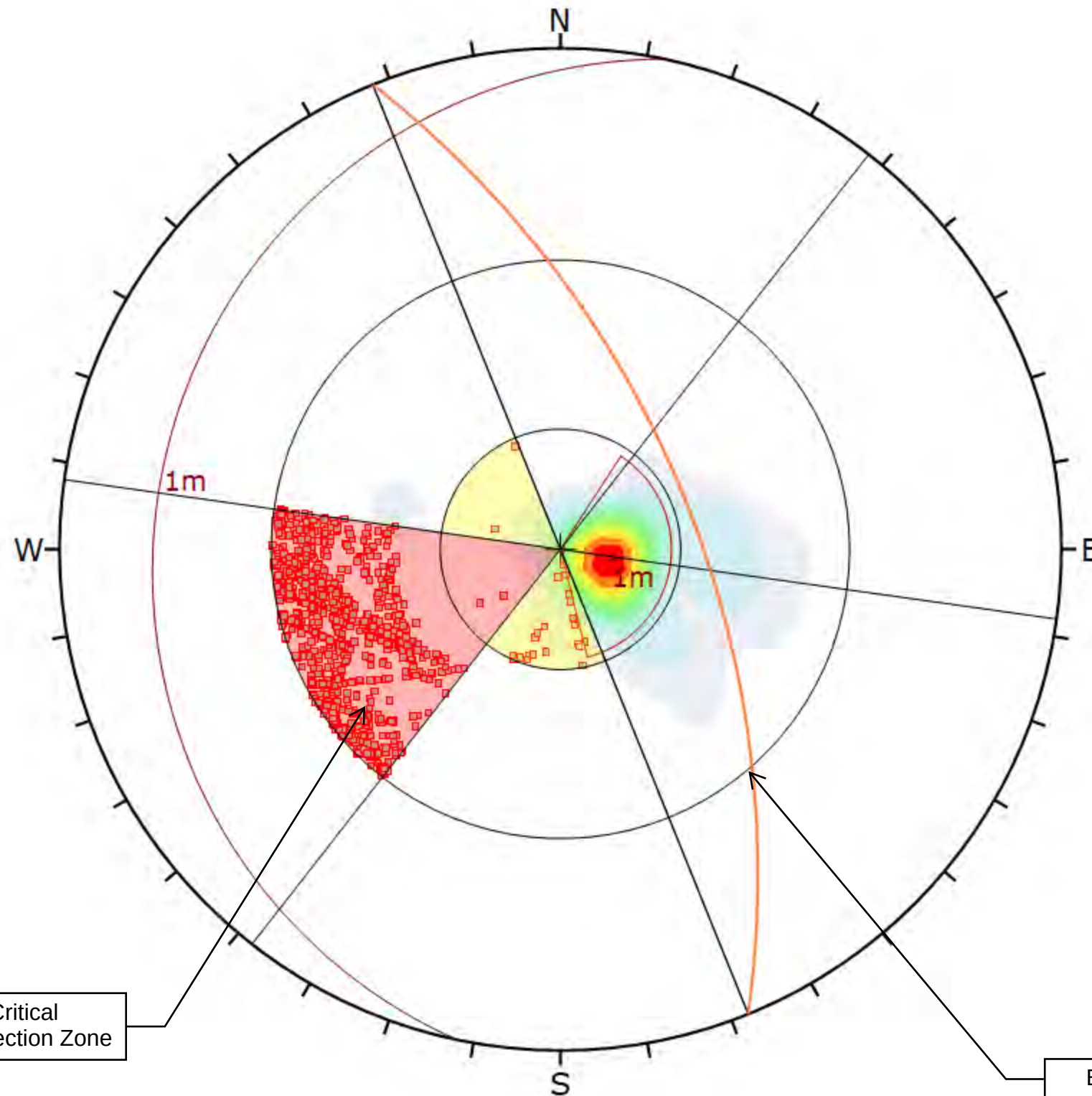
	Critical	Total	%
Planar Sliding (All)	24	286	8.39%

Plot Mode	Pole Vectors
Vector Count	286 (286 Entries)
Hemisphere	Lower
Projection	Equal Angle



Critical
Intersection Zone

Bench Face



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 1.80
	1.80 - 3.60
	3.60 - 5.40
	5.40 - 7.20
	7.20 - 9.00
	9.00 - 10.80
	10.80 - 12.60
	12.60 - 14.40
	14.40 - 16.20
	16.20 - 18.00

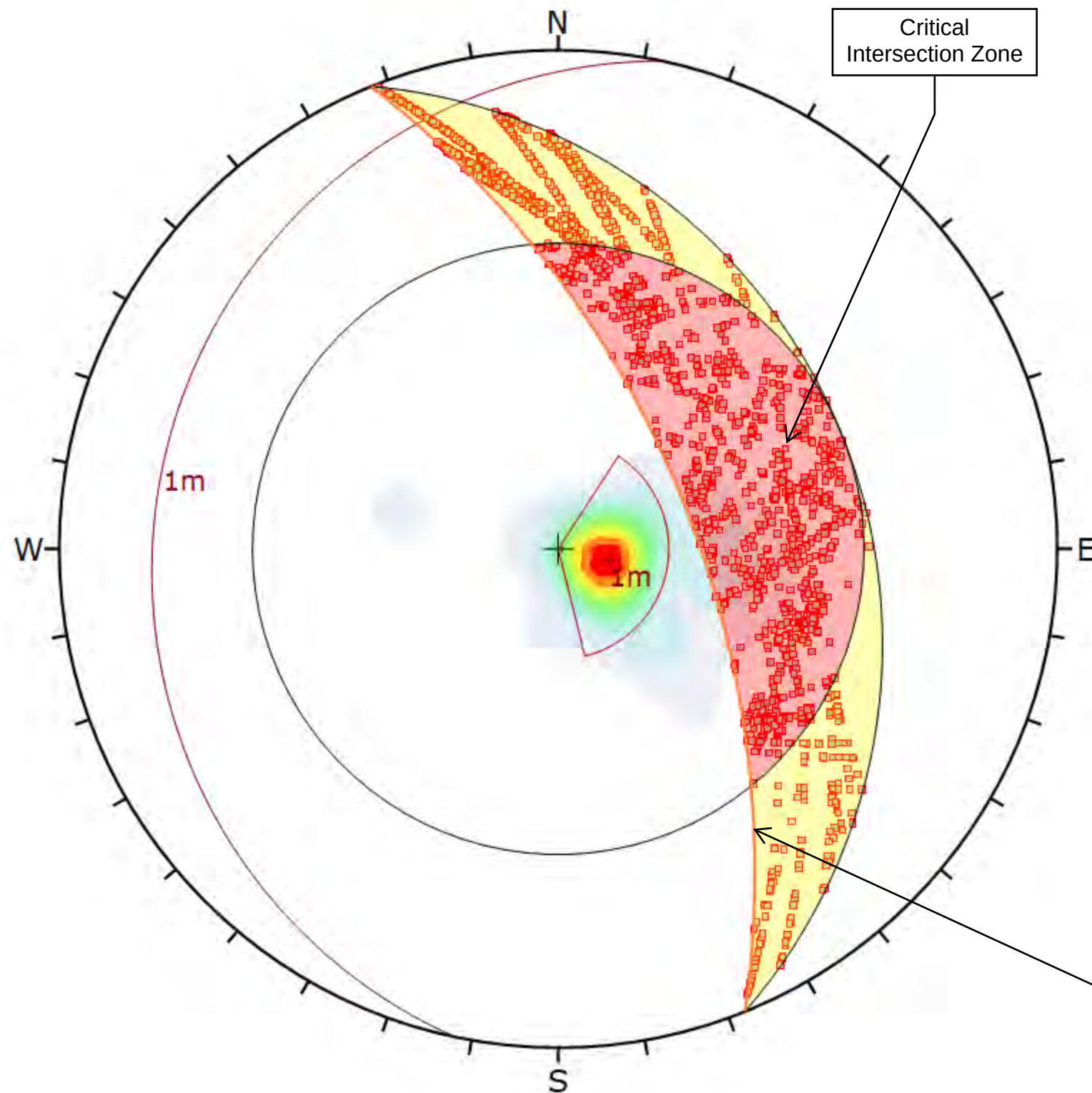
Contour Data	Pole Vectors
Maximum Density	17.67%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Direct Toppling
Slope Dip	60
Slope Dip Direction	88
Friction Angle	27°
Lateral Limits	30°

	Critical	Total	%
Direct Toppling (Intersection)	1287	40755	3.16%
Oblique Toppling (Intersection)	23	40755	0.06%
Base Plane (All)	40	286	13.99%
Base Plane (Set 1)	2	101	1.98%

Plot Mode	Pole Vectors
Vector Count	286 (286 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	40755
Hemisphere	Lower
Projection	Equal Angle

Wedge Failure - Point B Waikato Coal Measures



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 1.80
	1.80 - 3.60
	3.60 - 5.40
	5.40 - 7.20
	7.20 - 9.00
	9.00 - 10.80
	10.80 - 12.60
	12.60 - 14.40
	14.40 - 16.20
	16.20 - 18.00

Contour Data	Pole Vectors
Maximum Density	17.67%
Contour Distribution	Fisher
Counting Circle Size	1.0%

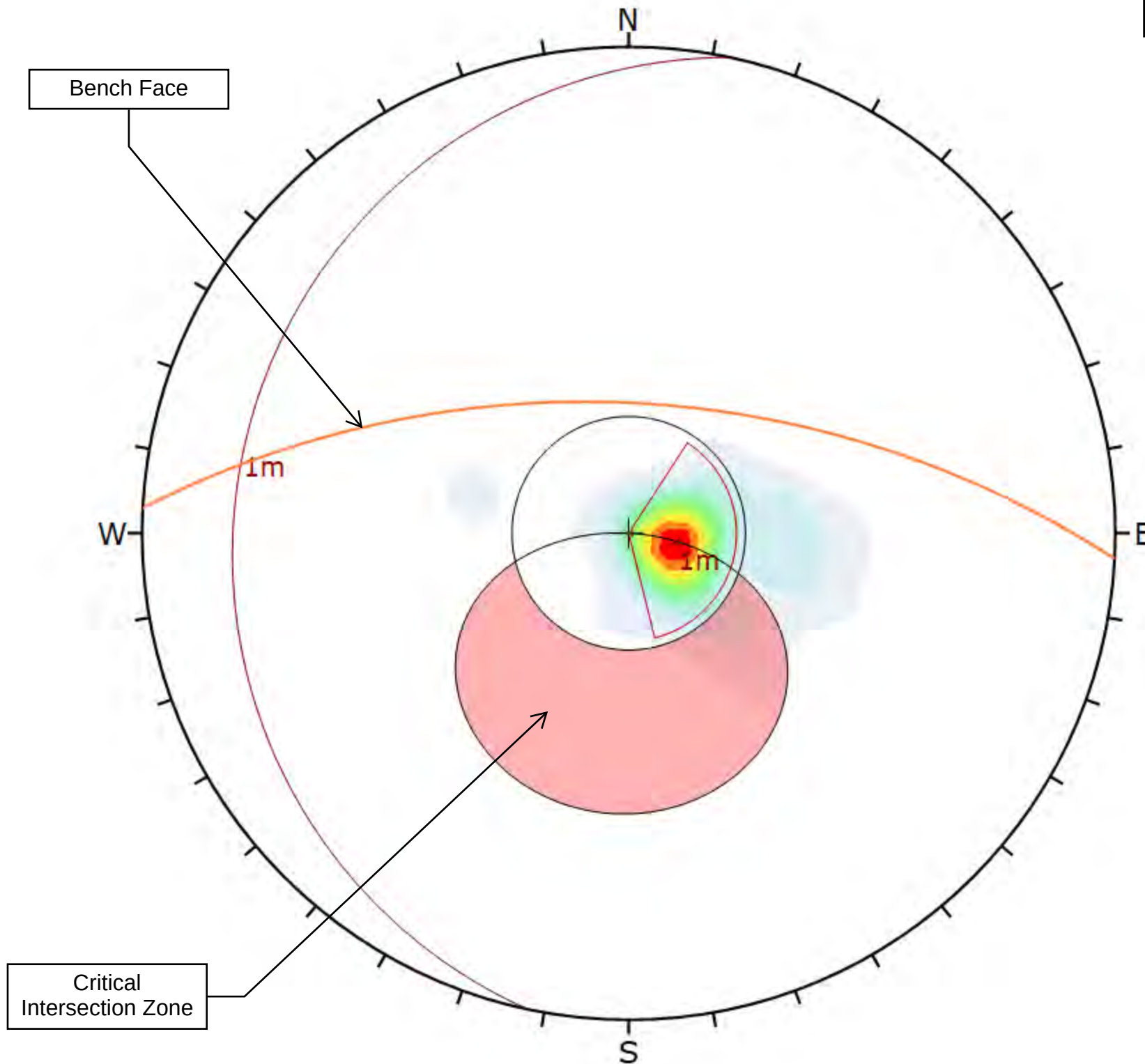
Kinematic Analysis	Wedge Sliding
Slope Dip	60
Slope Dip Direction	88
Friction Angle	27°

	Critical	Total	%
Wedge Sliding	2128	40755	5.22%

Plot Mode	Pole Vectors
Vector Count	286 (286 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	40755
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

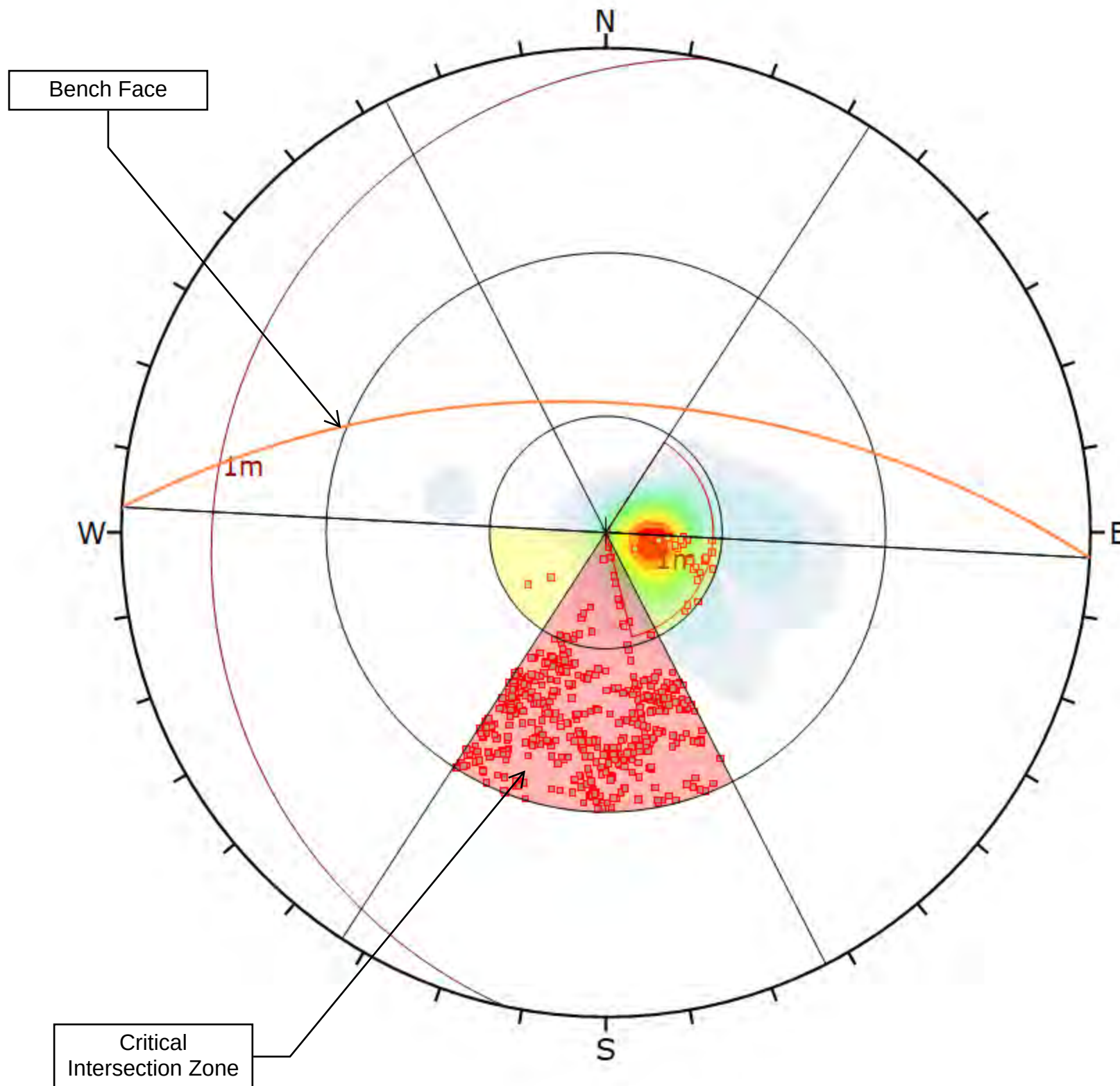
Planar (No Limits) Failure - Point C Waikato Coal Measures



Color	Density Concentrations			
	0.00 - 1.80			
	1.80 - 3.60			
	3.60 - 5.40			
	5.40 - 7.20			
	7.20 - 9.00			
	9.00 - 10.80			
	10.80 - 12.60			
	12.60 - 14.40			
	14.40 - 16.20			
	16.20 - 18.00			
Contour Data		Pole Vectors		
Maximum Density		17.67%		
Contour Distribution		Fisher		
Counting Circle Size		1.0%		
Kinematic Analysis		Planar Sliding		
Slope Dip		80		
Slope Dip Direction		3		
Friction Angle		27°		
		Critical	Total	%
Planar Sliding (All)		31	286	10.84%
Plot Mode		Pole Vectors		
Vector Count		286 (286 Entries)		
Hemisphere		Lower		
Projection		Equal Angle		

RILEY

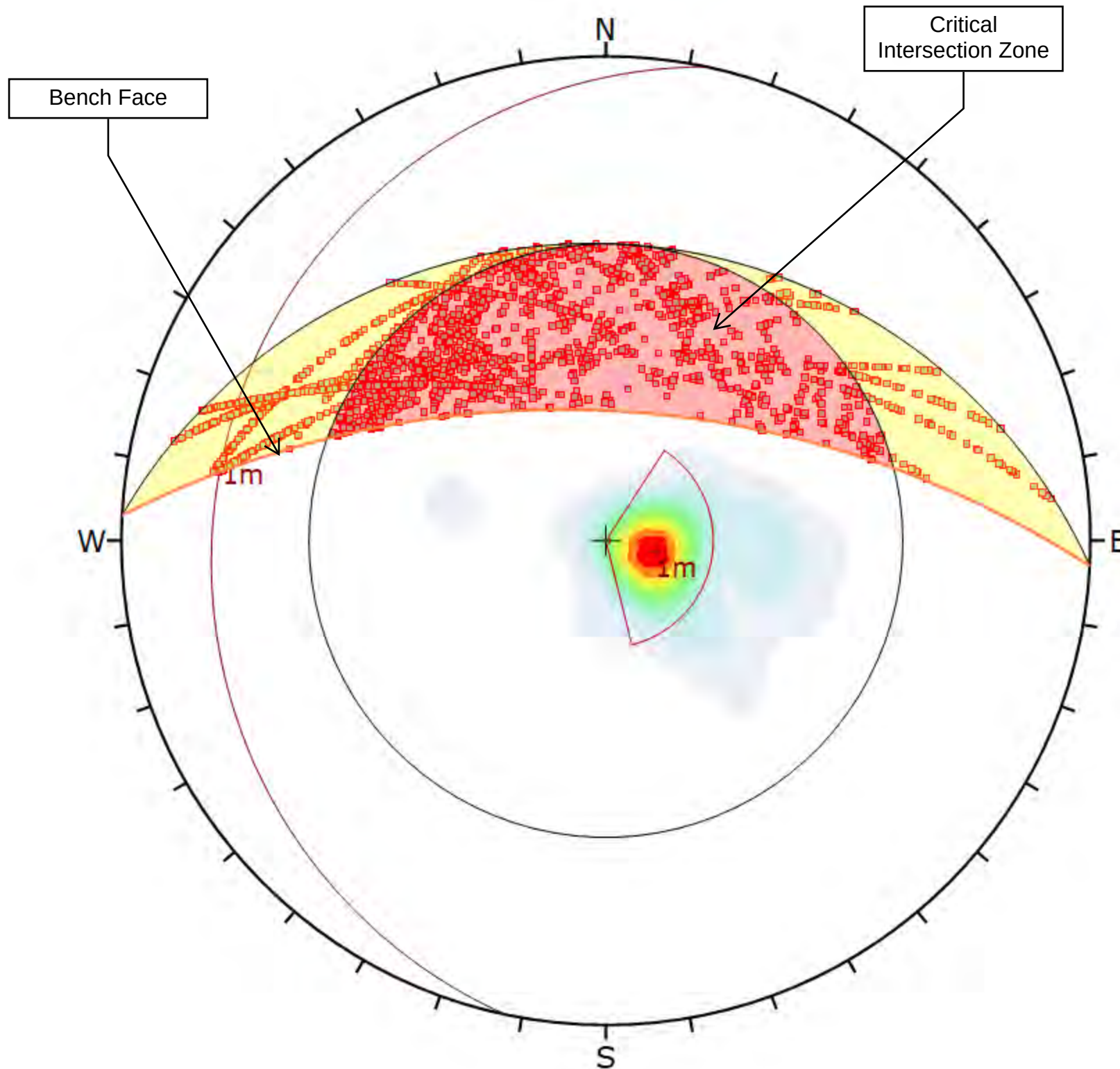
Topple Failure - Point C Waikato Coal Measures



Plot Mode	Pole Vectors
Vector Count	286 (286 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	40755
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Wedge Failure - Point C Waikato Coal Measures



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 1.80
	1.80 - 3.60
	3.60 - 5.40
	5.40 - 7.20
	7.20 - 9.00
	9.00 - 10.80
	10.80 - 12.60
	12.60 - 14.40
	14.40 - 16.20
	16.20 - 18.00

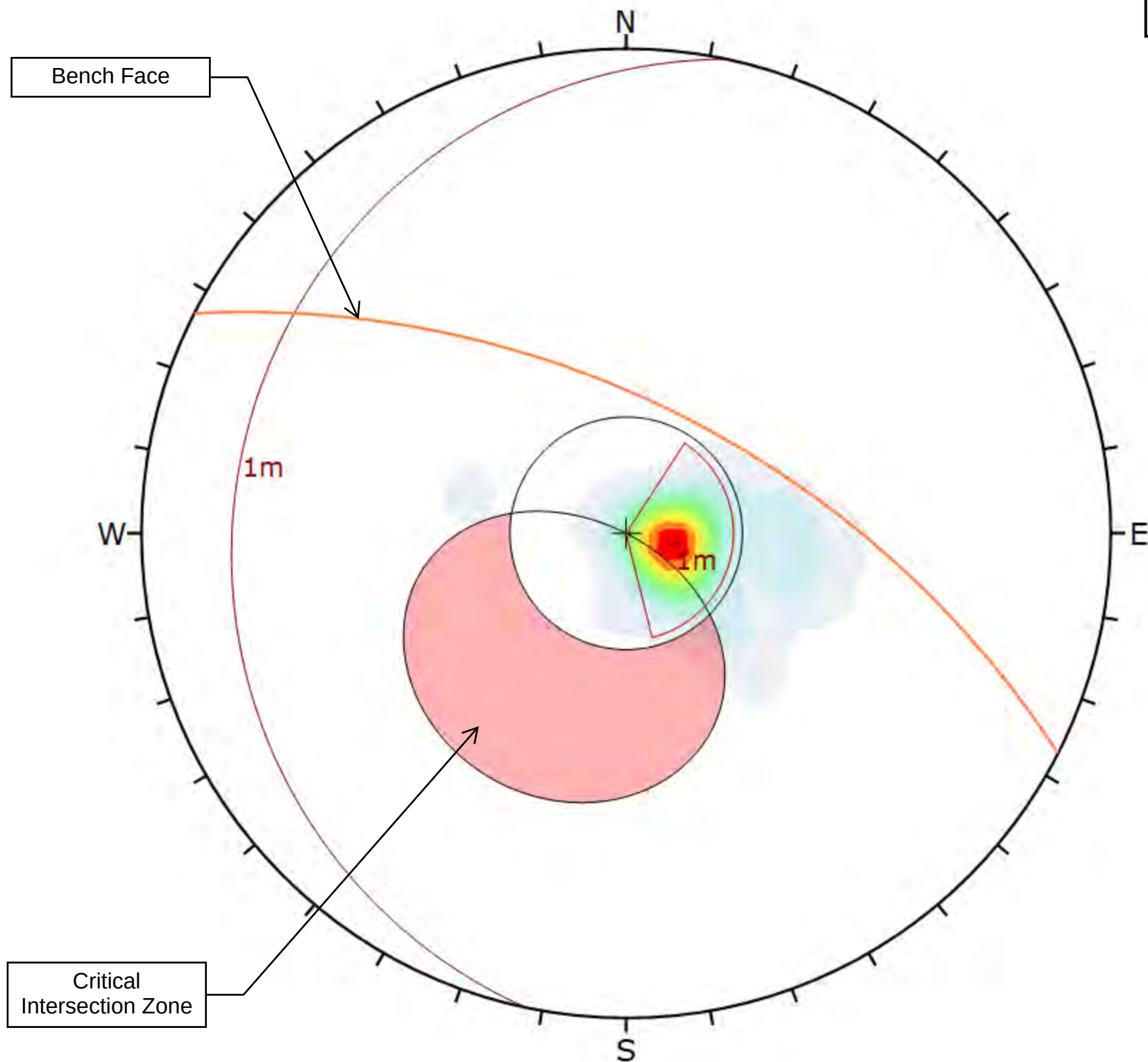
Contour Data	Pole Vectors
Maximum Density	17.67%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding		
Slope Dip	60		
Slope Dip Direction	3		
Friction Angle	27°		
	Critical	Total	%
Wedge Sliding	2417	40755	5.93%

Plot Mode	Pole Vectors
Vector Count	286 (286 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	40755
Hemisphere	Lower
Projection	Equal Angle

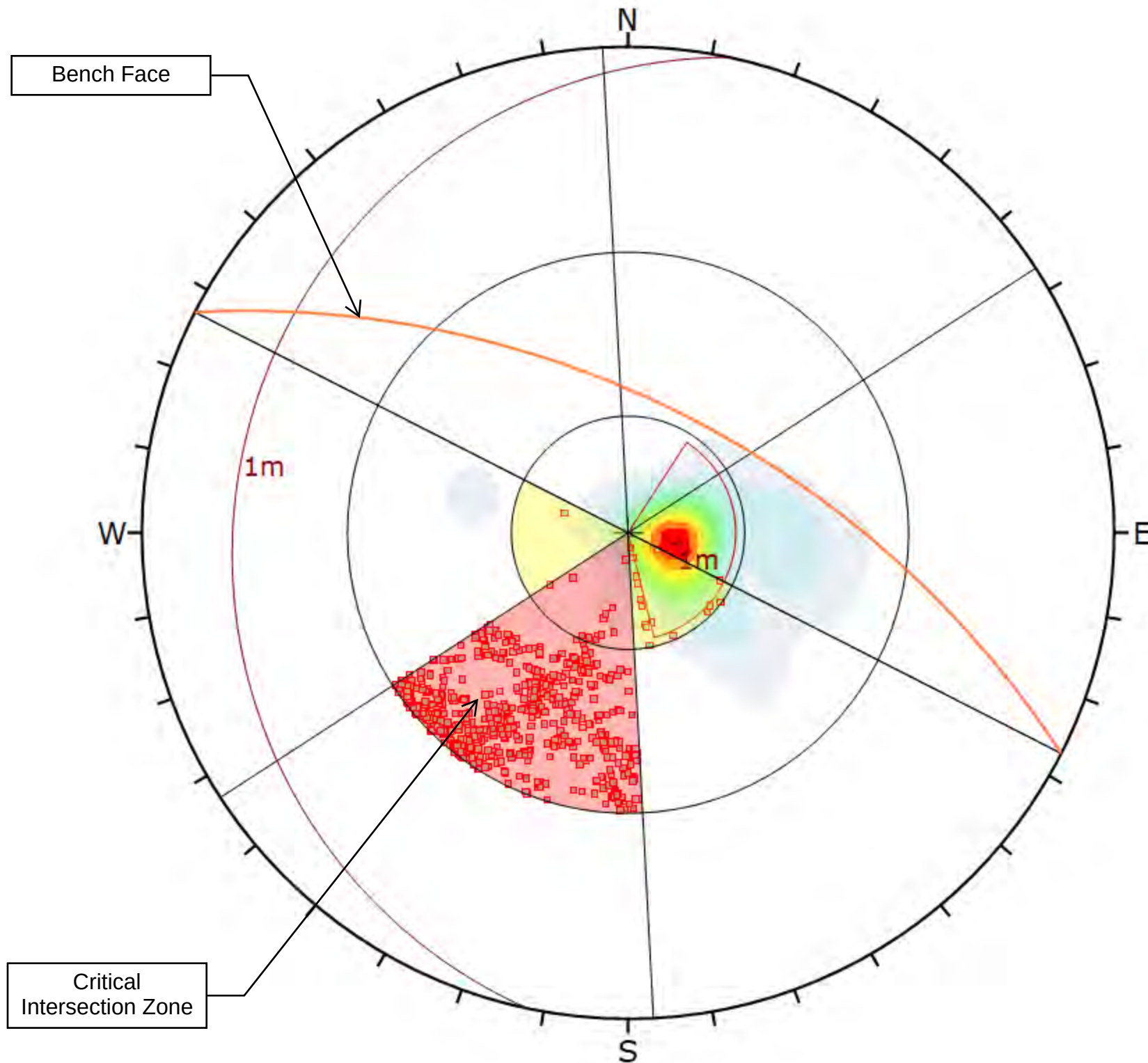
Drury Quarry - Sutton Block Extension

Planar (No Limits) Failure - Point D Waikato Coal Measures



Color	Density Concentrations			
	0.00	-	1.80	
	1.80	-	3.60	
	3.60	-	5.40	
	5.40	-	7.20	
	7.20	-	9.00	
	9.00	-	10.80	
	10.80	-	12.60	
	12.60	-	14.40	
	14.40	-	16.20	
	16.20	-	18.00	
Contour Data		Pole Vectors		
Maximum Density		17.67%		
Contour Distribution		Fisher		
Counting Circle Size		1.0%		
Kinematic Analysis		Planar Sliding		
Slope Dip		80		
Slope Dip Direction		27		
Friction Angle		27°		
		Critical	Total	%
Planar Sliding (All)		18	286	6.29%
Plot Mode		Pole Vectors		
Vector Count		286 (286 Entries)		
Hemisphere		Lower		
Projection		Equal Angle		





Symbol	Feature
■	Critical Intersection

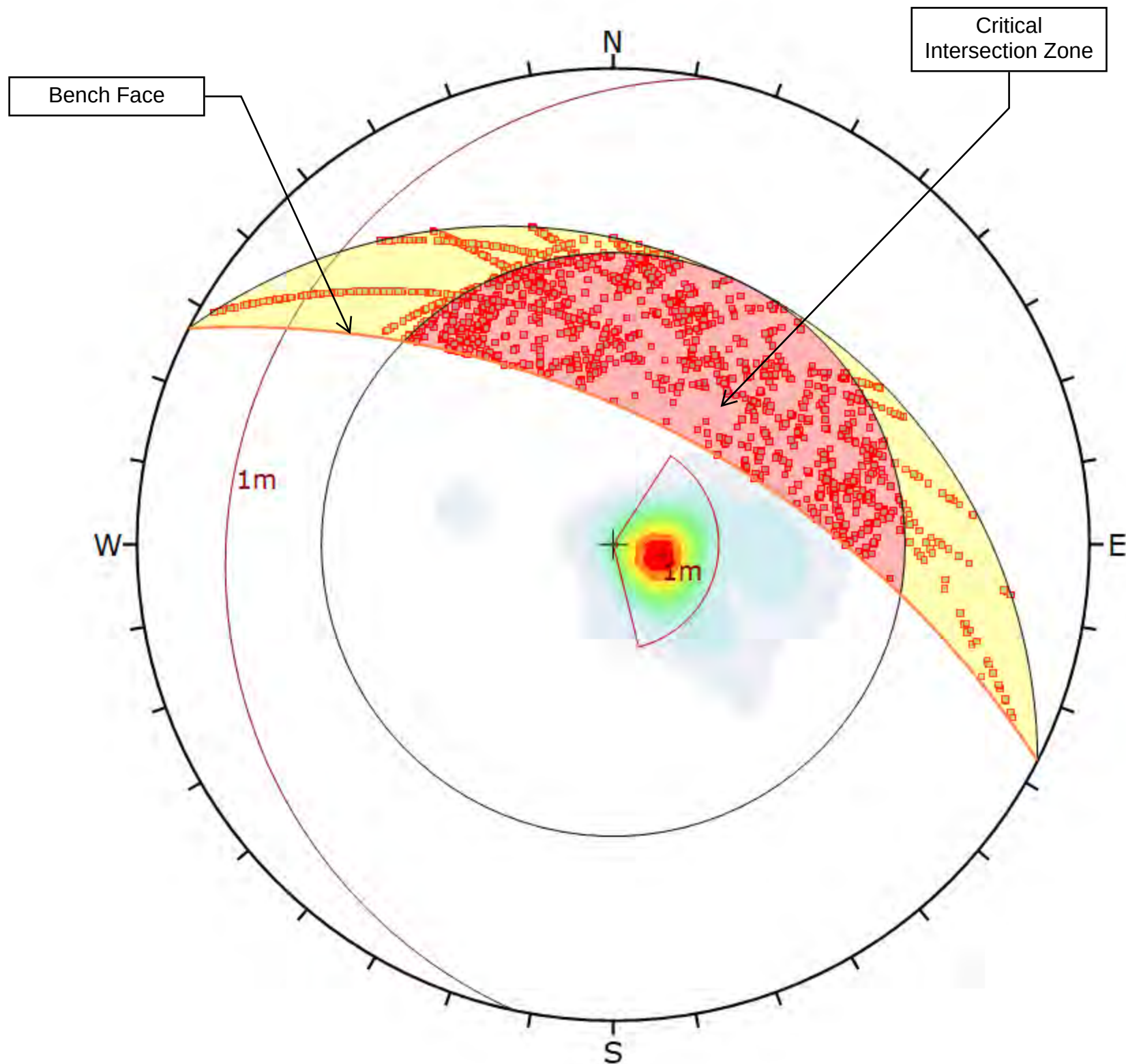
Color	Density Concentrations
	0.00 - 1.80
	1.80 - 3.60
	3.60 - 5.40
	5.40 - 7.20
	7.20 - 9.00
	9.00 - 10.80
	10.80 - 12.60
	12.60 - 14.40
	14.40 - 16.20
	16.20 - 18.00

Contour Data	Pole Vectors
Maximum Density	17.67%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Direct Toppling
Slope Dip	60
Slope Dip Direction	27
Friction Angle	27°
Lateral Limits	30°

	Critical	Total	%
Direct Toppling (Intersection)	852	40755	2.09%
Oblique Toppling (Intersection)	17	40755	0.04%
Base Plane (All)	66	286	23.08%
Base Plane (Set 1)	36	101	35.64%

Plot Mode	Pole Vectors
Vector Count	286 (286 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	40755
Hemisphere	Lower
Projection	Equal Angle



Drury Quarry - Sutton Block Extension

Wedge Failure - Point D Waikato Coal Measures

Symbol	Feature
■	Critical Intersection

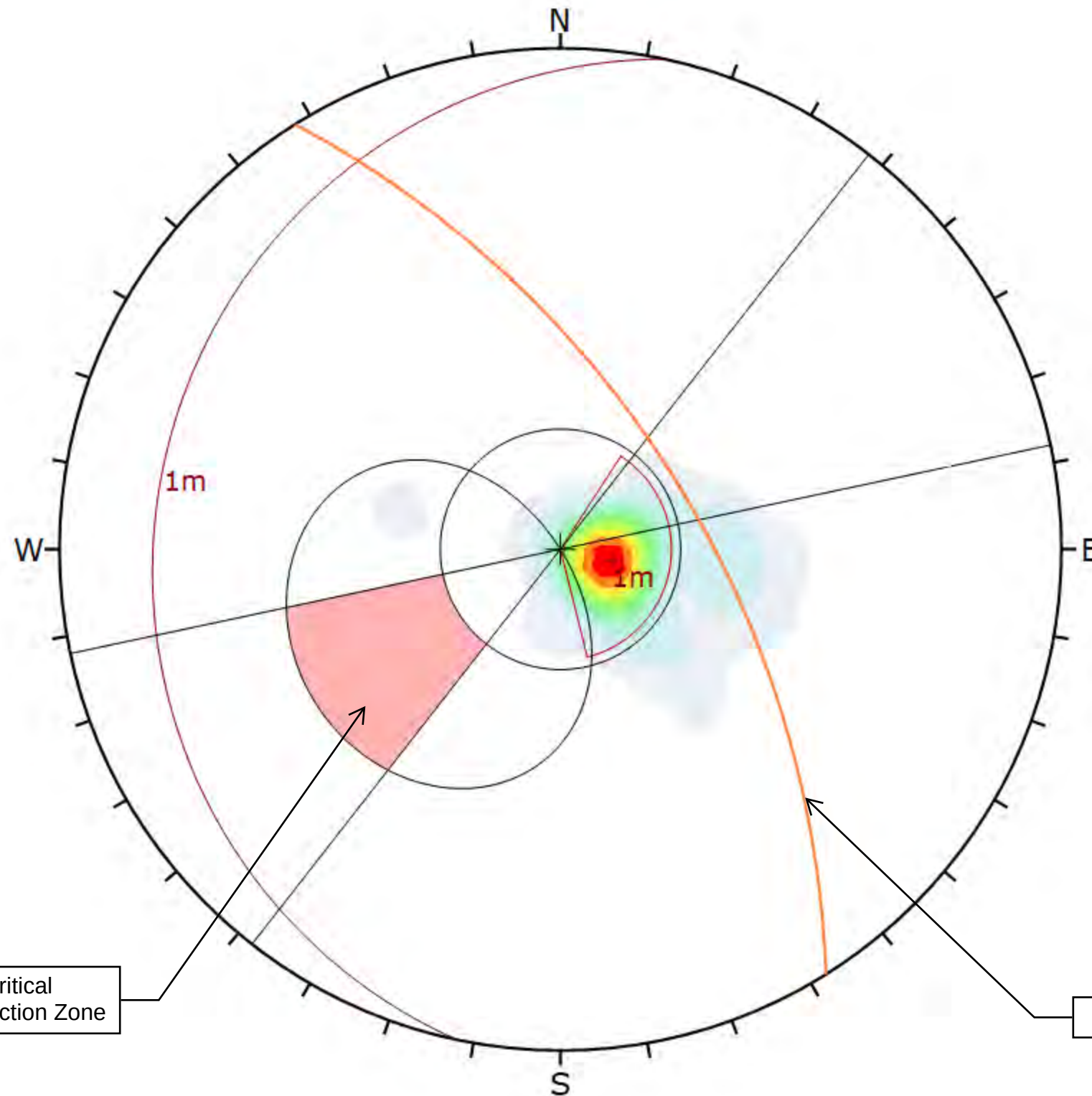
Color	Density Concentrations
	0.00 - 1.80
	1.80 - 3.60
	3.60 - 5.40
	5.40 - 7.20
	7.20 - 9.00
	9.00 - 10.80
	10.80 - 12.60
	12.60 - 14.40
	14.40 - 16.20
	16.20 - 18.00

Contour Data	Pole Vectors
Maximum Density	17.67%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding
Slope Dip	60
Slope Dip Direction	27
Friction Angle	27°

	Critical	Total	%
Wedge Sliding	1768	40755	4.34%

Plot Mode	Pole Vectors
Vector Count	286 (286 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	40755
Hemisphere	Lower
Projection	Equal Angle



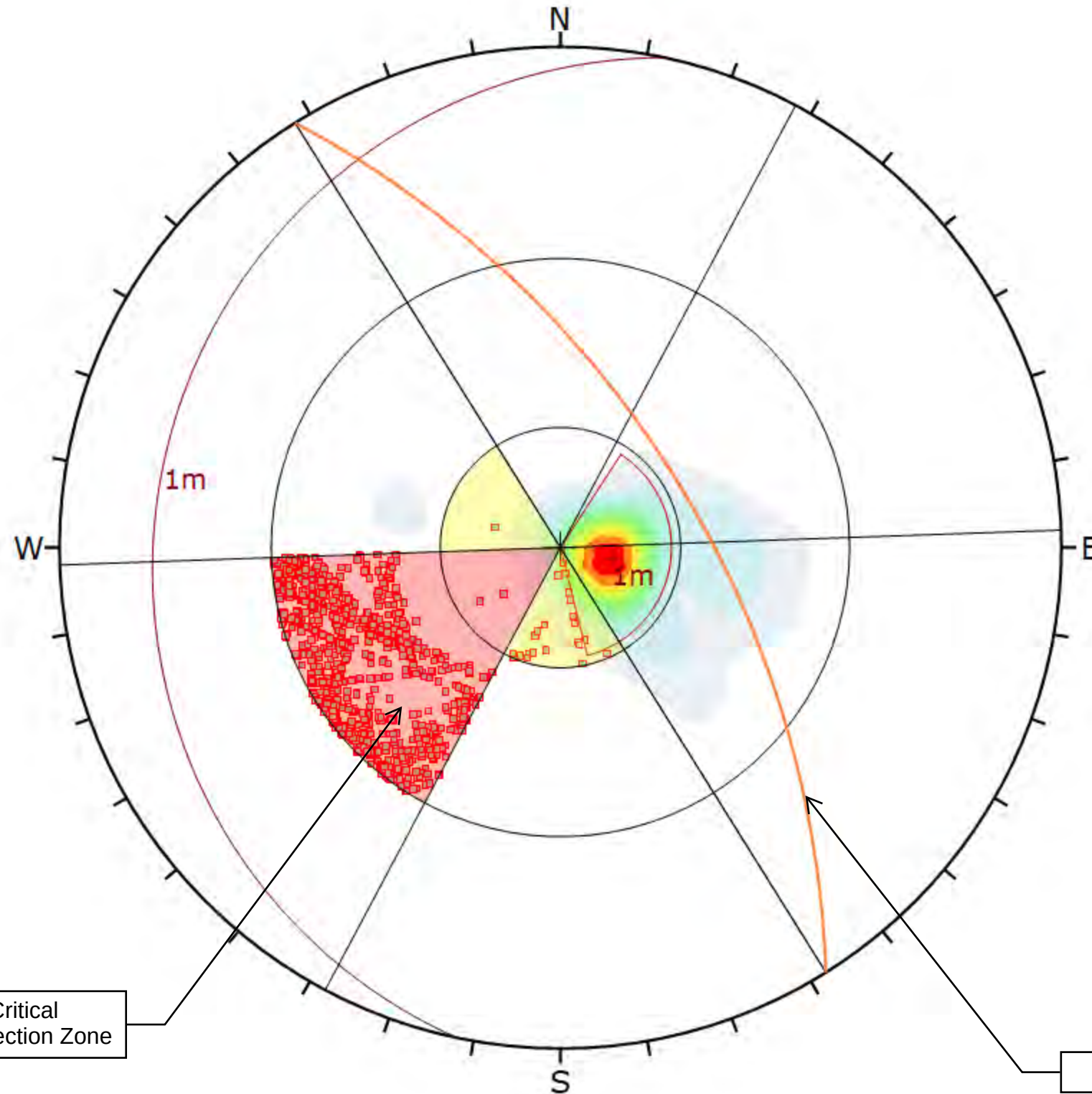
Color	Density Concentrations		
	0.00	-	1.80
	1.80	-	3.60
	3.60	-	5.40
	5.40	-	7.20
	7.20	-	9.00
	9.00	-	10.80
	10.80	-	12.60
	12.60	-	14.40
	14.40	-	16.20
16.20	-	18.00	
Contour Data		Pole Vectors	
Maximum Density		17.67%	
Contour Distribution		Fisher	
Counting Circle Size		1.0%	

Kinematic Analysis	Planar Sliding		
Slope Dip	80		
Slope Dip Direction	58		
Friction Angle	27°		
Lateral Limits	20°		
	Critical	Total	%
Planar Sliding (All)	8	286	2.80%

Plot Mode	Pole Vectors		
Vector Count	286 (286 Entries)		
Hemisphere	Lower		
Projection	Equal Angle		

Drury Quarry - Sutton Block Extension

Topple Failure - Point E Waikato Coal Measures



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 1.80
	1.80 - 3.60
	3.60 - 5.40
	5.40 - 7.20
	7.20 - 9.00
	9.00 - 10.80
	10.80 - 12.60
	12.60 - 14.40
	14.40 - 16.20
	16.20 - 18.00

Contour Data	Pole Vectors
Maximum Density	17.67%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Direct Toppling
Slope Dip	60
Slope Dip Direction	58
Friction Angle	27°
Lateral Limits	30°

	Critical	Total	%
Direct Toppling (Intersection)	1275	40755	3.13%
Oblique Toppling (Intersection)	23	40755	0.06%
Base Plane (All)	44	286	15.38%
Base Plane (Set 1)	7	101	6.93%

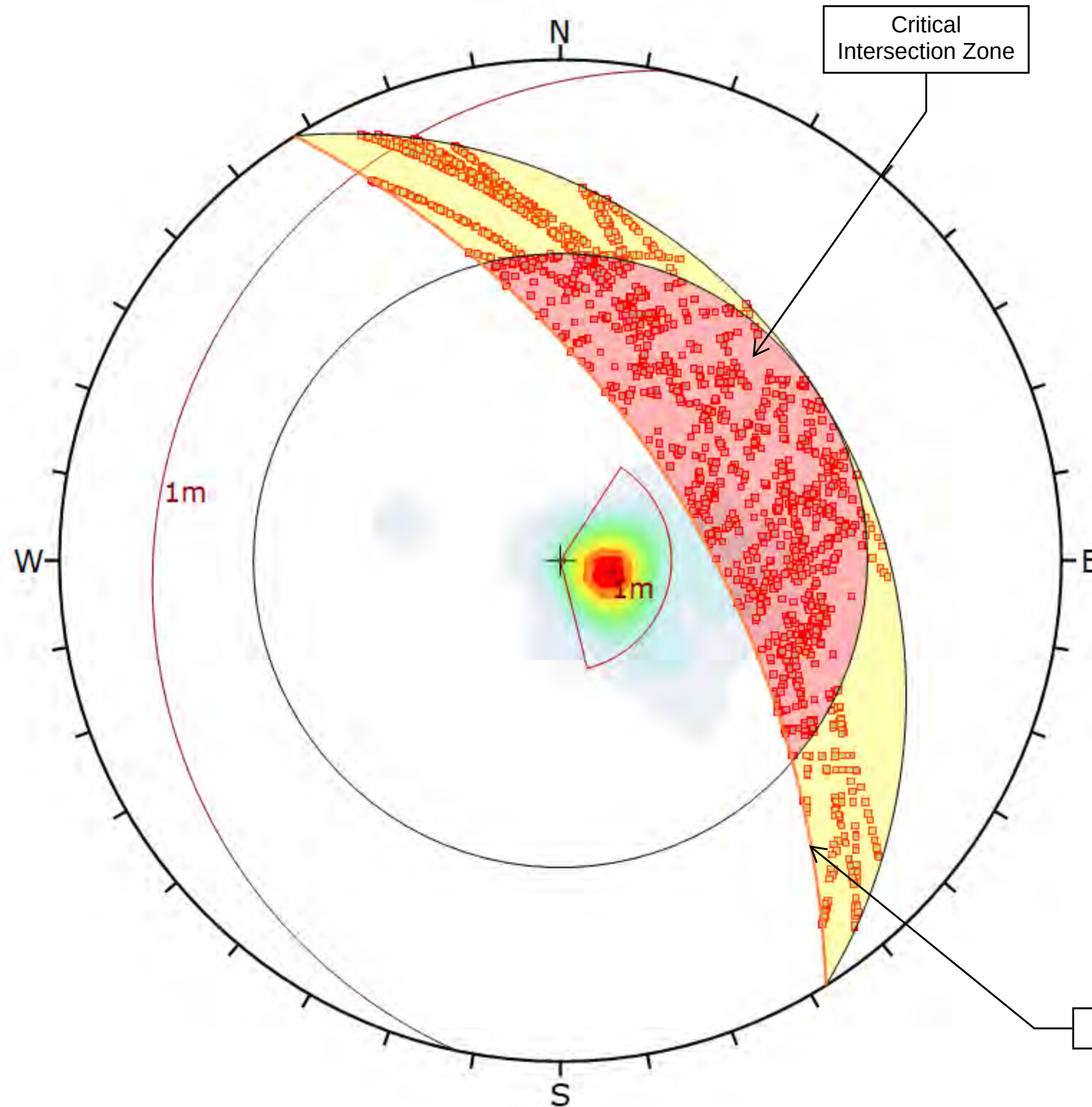
Plot Mode	Pole Vectors
Vector Count	286 (286 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	40755
Hemisphere	Lower
Projection	Equal Angle

Critical Intersection Zone

Bench Face

Drury Quarry - Sutton Block Extension

Wedge Failure - Point E Waikato Coal Measures



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 1.80
	1.80 - 3.60
	3.60 - 5.40
	5.40 - 7.20
	7.20 - 9.00
	9.00 - 10.80
	10.80 - 12.60
	12.60 - 14.40
	14.40 - 16.20
	16.20 - 18.00

Contour Data	Pole Vectors
Maximum Density	17.67%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding
Slope Dip	60
Slope Dip Direction	58
Friction Angle	27°

	Critical	Total	%
Wedge Sliding	2018	40755	4.95%

Plot Mode	Pole Vectors
Vector Count	286 (286 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	40755
Hemisphere	Lower
Projection	Equal Angle

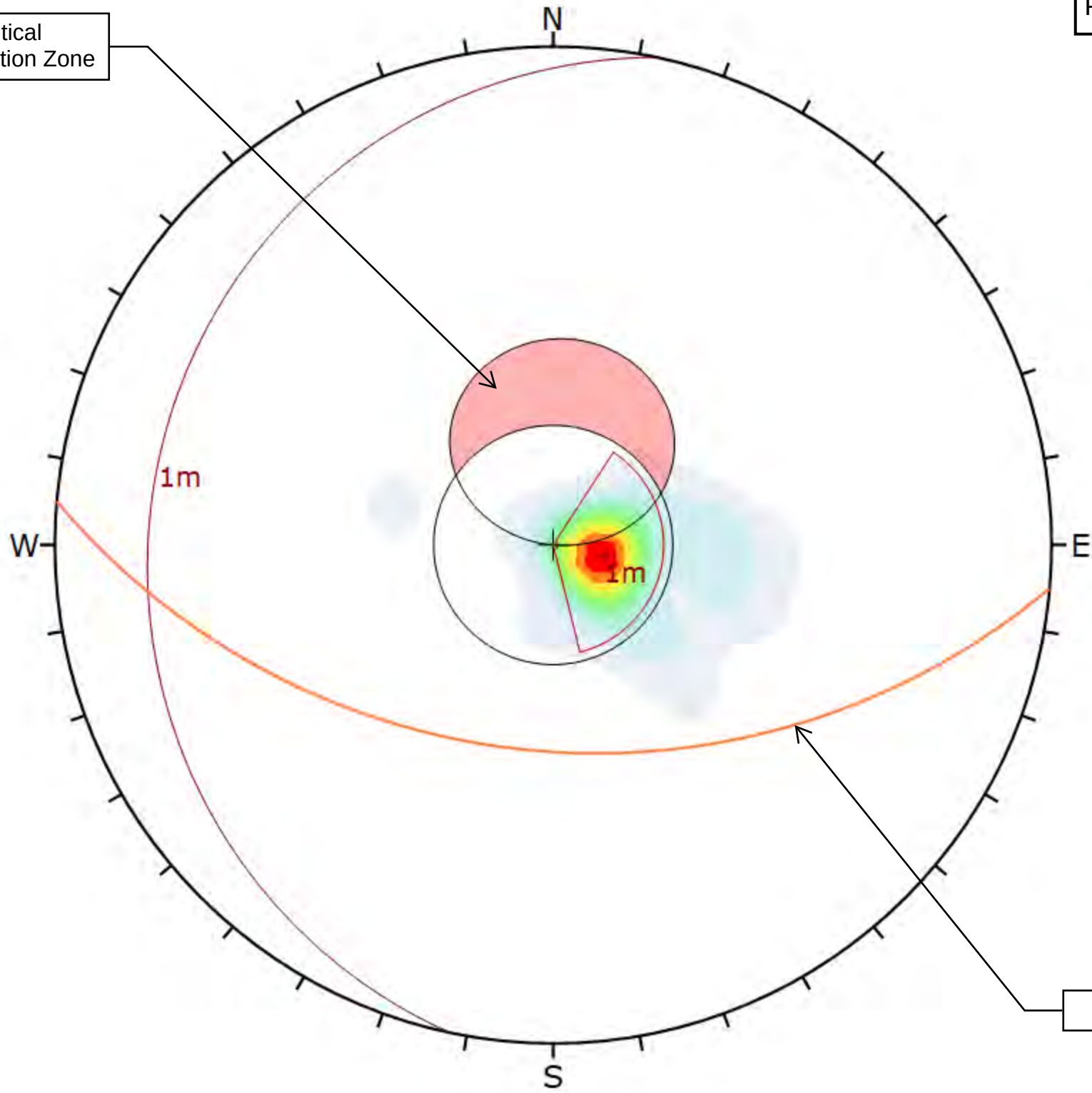


Bench Face

Drury Quarry - Sutton Block Extension

Planar (No Limits) Failure - Point F Waikato Coal Measures

Critical
Intersection Zone

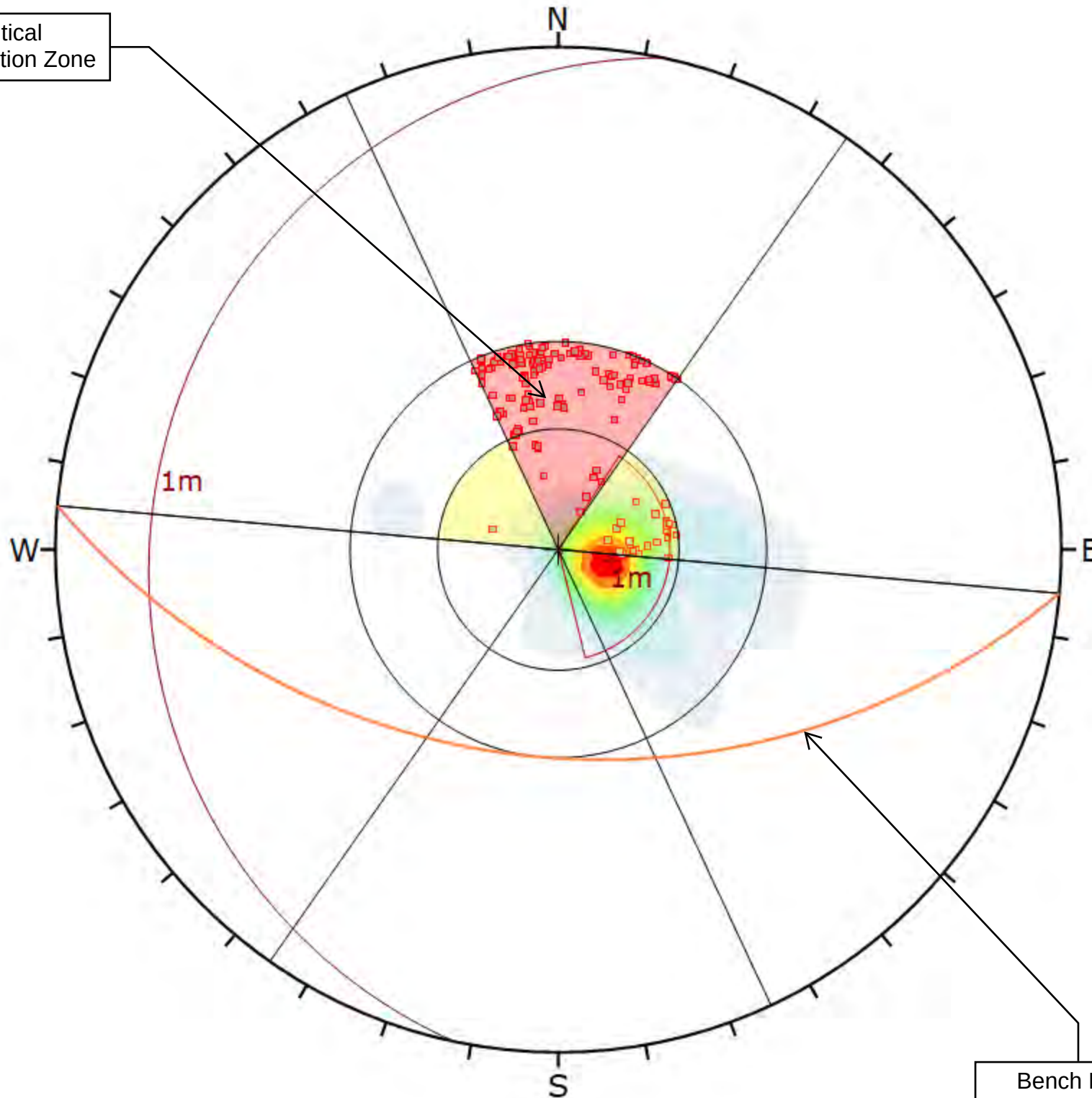


Color	Density Concentrations			
	0.00	-	1.80	
	1.80	-	3.60	
	3.60	-	5.40	
	5.40	-	7.20	
	7.20	-	9.00	
	9.00	-	10.80	
	10.80	-	12.60	
	12.60	-	14.40	
	14.40	-	16.20	
	16.20	-	18.00	
Contour Data		Pole Vectors		
Maximum Density		17.67%		
Contour Distribution		Fisher		
Counting Circle Size		1.0%		
Kinematic Analysis		Planar Sliding		
Slope Dip		45		
Slope Dip Direction		185		
Friction Angle		27°		
		Critical	Total	%
Planar Sliding (All)		8	286	2.80%
Plot Mode		Pole Vectors		
Vector Count		286 (286 Entries)		
Hemisphere		Lower		
Projection		Equal Angle		



Bench Face

Critical
Intersection Zone



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 1.80
	1.80 - 3.60
	3.60 - 5.40
	5.40 - 7.20
	7.20 - 9.00
	9.00 - 10.80
	10.80 - 12.60
	12.60 - 14.40
	14.40 - 16.20
	16.20 - 18.00

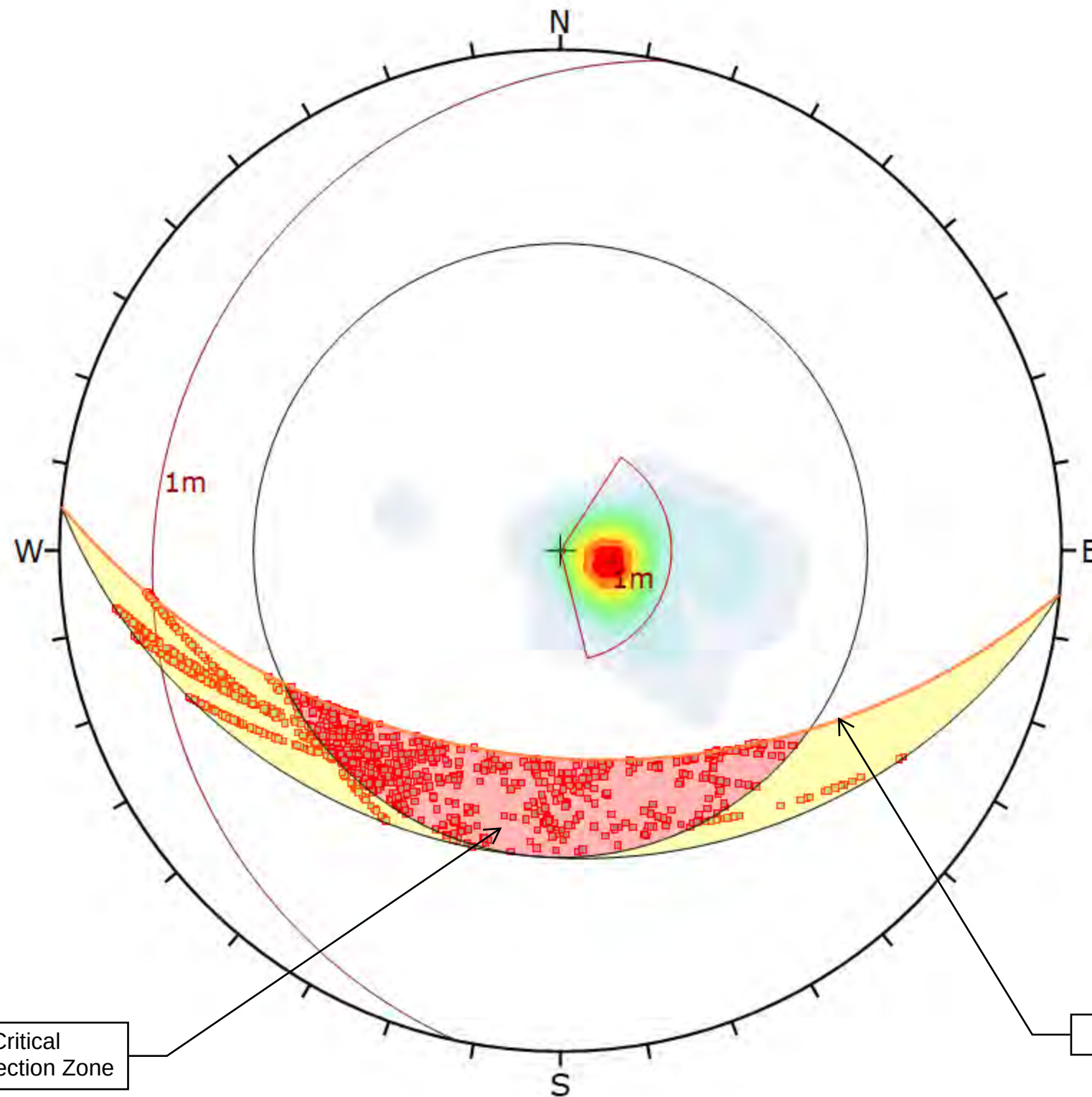
Contour Data	Pole Vectors
Maximum Density	17.67%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Direct Toppling
Slope Dip	45
Slope Dip Direction	185
Friction Angle	27°
Lateral Limits	30°

	Critical	Total	%
Direct Toppling (Intersection)	135	40755	0.33%
Oblique Toppling (Intersection)	25	40755	0.06%
Base Plane (All)	65	286	22.73%
Base Plane (Set 1)	46	101	45.54%

Plot Mode	Pole Vectors
Vector Count	286 (286 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	40755
Hemisphere	Lower
Projection	Equal Angle

Bench Face



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 1.80
	1.80 - 3.60
	3.60 - 5.40
	5.40 - 7.20
	7.20 - 9.00
	9.00 - 10.80
	10.80 - 12.60
	12.60 - 14.40
	14.40 - 16.20
	16.20 - 18.00

Contour Data	Pole Vectors
Maximum Density	17.67%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding		
Slope Dip	45		
Slope Dip Direction	185		
Friction Angle	27°		
	Critical	Total	%
Wedge Sliding	1544	40755	3.79%

Plot Mode	Pole Vectors
Vector Count	286 (286 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	40755
Hemisphere	Lower
Projection	Equal Angle



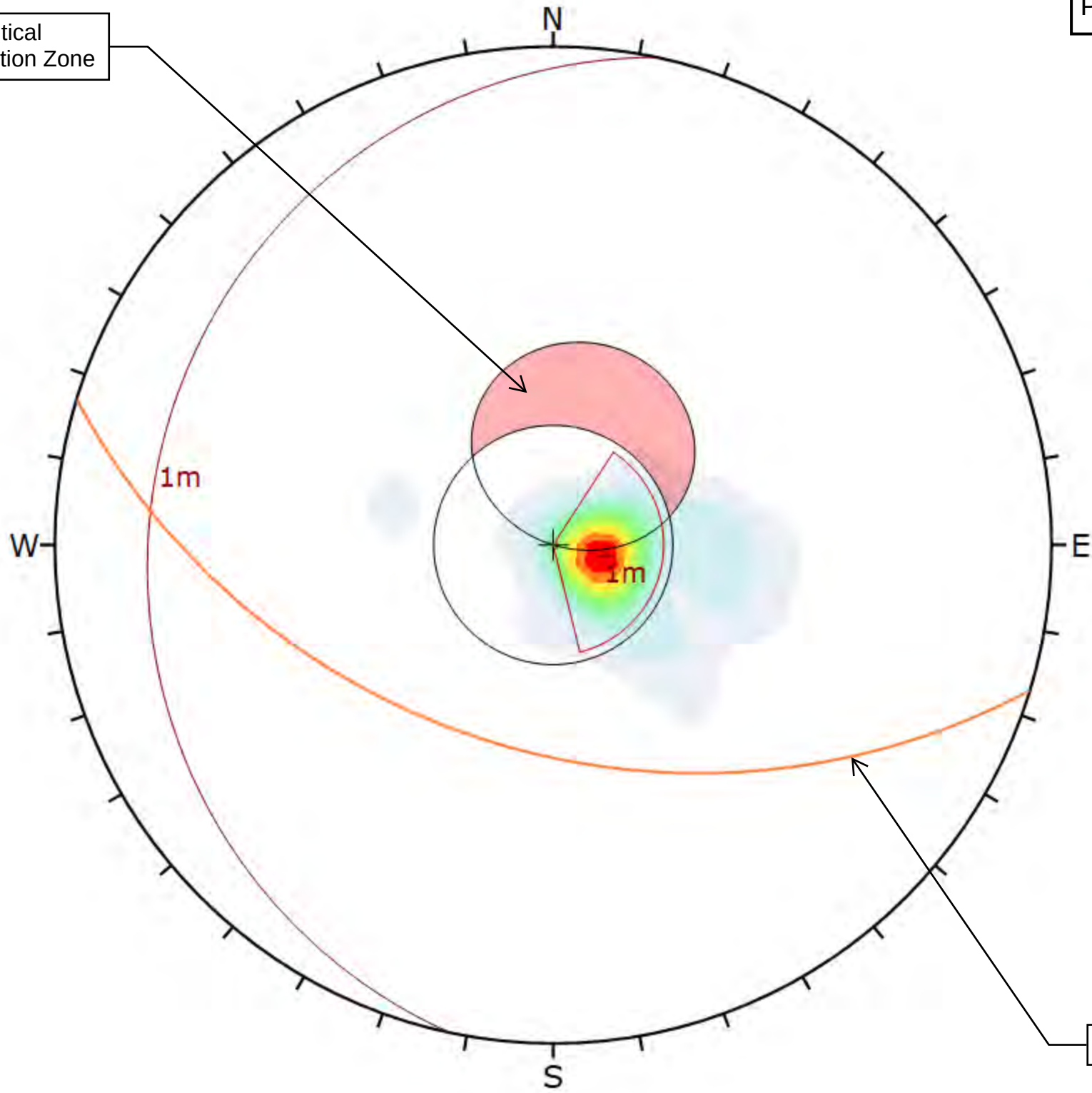
Critical Intersection Zone

Bench Face

Drury Quarry - Sutton Block Extension

Planar (No Limits) Failure - Point G Waikato Coal Measures

Critical
Intersection Zone



Color	Density Concentrations	
	0.00	- 1.80
	1.80	- 3.60
	3.60	- 5.40
	5.40	- 7.20
	7.20	- 9.00
	9.00	- 10.80
	10.80	- 12.60
	12.60	- 14.40
	14.40	- 16.20
	16.20	- 18.00

Contour Data	Pole Vectors
Maximum Density	17.67%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Planar Sliding
Slope Dip	45
Slope Dip Direction	197
Friction Angle	27°

	Critical	Total	%
Planar Sliding (All)	8	286	2.80%

Plot Mode	Pole Vectors
Vector Count	286 (286 Entries)
Hemisphere	Lower
Projection	Equal Angle

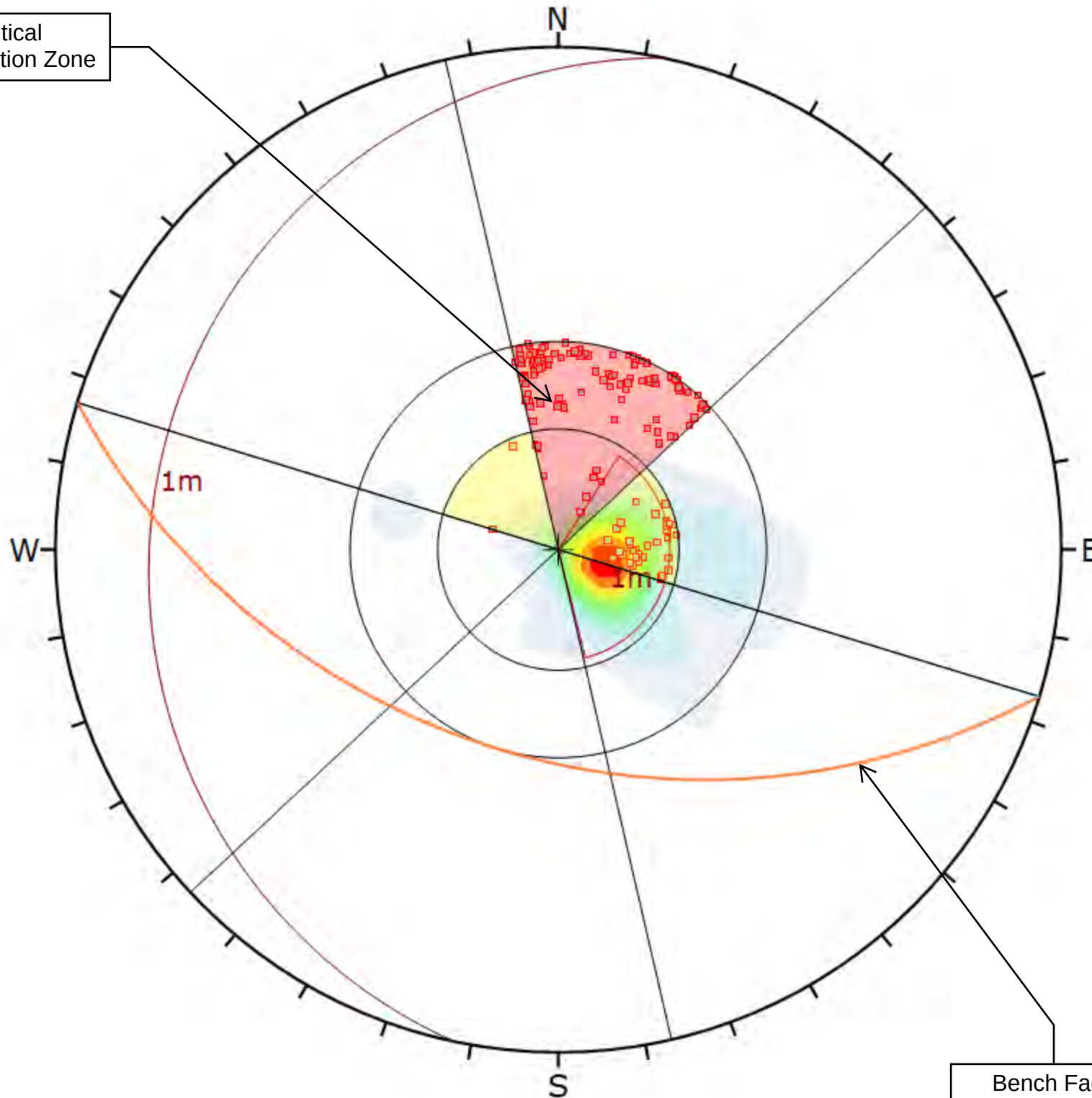
RILEY

Bench Face

Drury Quarry - Sutton Block Extension

Topples Failure - Point G Waikato Coal Measures

Critical
Intersection Zone



Bench Face

Symbol	Feature
■	Critical Intersection

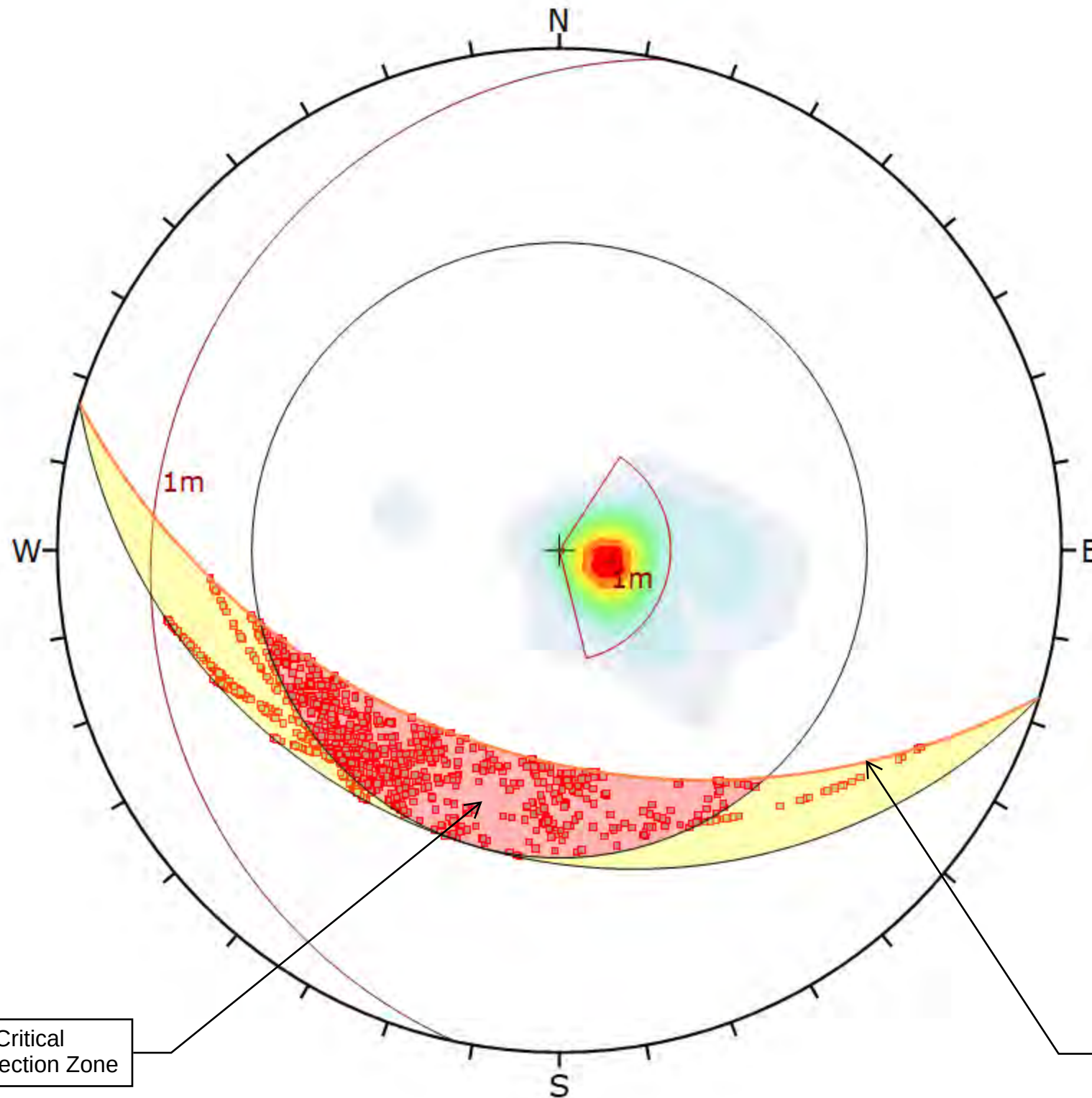
Color	Density Concentrations
	0.00 - 1.80
	1.80 - 3.60
	3.60 - 5.40
	5.40 - 7.20
	7.20 - 9.00
	9.00 - 10.80
	10.80 - 12.60
	12.60 - 14.40
	14.40 - 16.20
	16.20 - 18.00

Contour Data	Pole Vectors
Maximum Density	17.67%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Direct Toppling
Slope Dip	45
Slope Dip Direction	197
Friction Angle	27°
Lateral Limits	30°

	Critical	Total	%
Direct Toppling (Intersection)	121	40755	0.30%
Oblique Toppling (Intersection)	36	40755	0.09%
Base Plane (All)	75	286	26.22%
Base Plane (Set 1)	56	101	55.45%

Plot Mode	Pole Vectors
Vector Count	286 (286 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	40755
Hemisphere	Lower
Projection	Equal Angle



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 1.80
	1.80 - 3.60
	3.60 - 5.40
	5.40 - 7.20
	7.20 - 9.00
	9.00 - 10.80
	10.80 - 12.60
	12.60 - 14.40
	14.40 - 16.20
	16.20 - 18.00

Contour Data	Pole Vectors
Maximum Density	17.67%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding
Slope Dip	45
Slope Dip Direction	197
Friction Angle	27°

	Critical	Total	%
Wedge Sliding	1417	40755	3.48%

Plot Mode	Pole Vectors
Vector Count	286 (286 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	40755
Hemisphere	Lower
Projection	Equal Angle



Critical
Intersection Zone

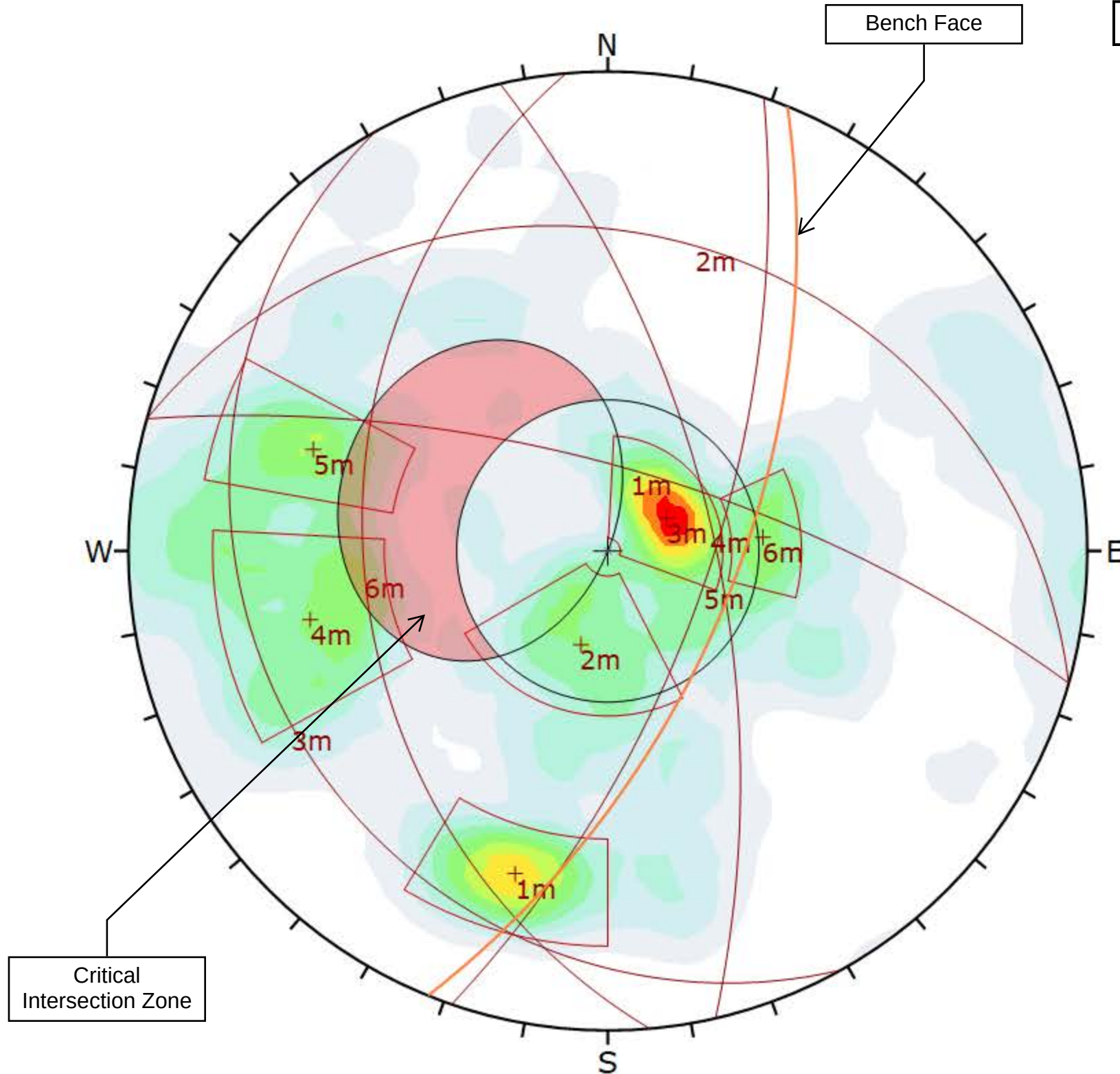
Bench Face

Drury Quarry - Sutton Block Extension

Kinematic Analysis Results - Waikato Coal Measures			
Location	Type	Lateral Limits	%
A	Planar	N/A	10.49
	Wedge	N/A	7.81
	Topple	30°	48.25
B	Planar	N/A	8.39
	Wedge	N/A	5.22
	Topple	30°	13.99
C	Planar	N/A	10.84
	Wedge	N/A	5.93
	Topple	30°	30.42
D	Planar	N/A	6.29
	Wedge	N/A	4.34
	Topple	30°	23.08
E	Planar	N/A	7.7
	Wedge	N/A	4.95
	Topple	30°	15.38
F	Planar	N/A	2.8
	Wedge	N/A	3.79
	Topple	30°	22.73
G	Planar	N/A	2.8
	Wedge	N/A	3.48
	Topple	30°	26.22

Drury Quarry - Sutton Block Extension

Planar (No Limits) Failure - Point A Waipapa Greywacke



Color	Density Concentrations	
	0.00	- 0.45
	0.45	- 0.90
	0.90	- 1.35
	1.35	- 1.80
	1.80	- 2.25
	2.25	- 2.70
	2.70	- 3.15
	3.15	- 3.60
	3.60	- 4.05
	4.05	- 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Planar Sliding
Slope Dip	60
Slope Dip Direction	112
Friction Angle	35°

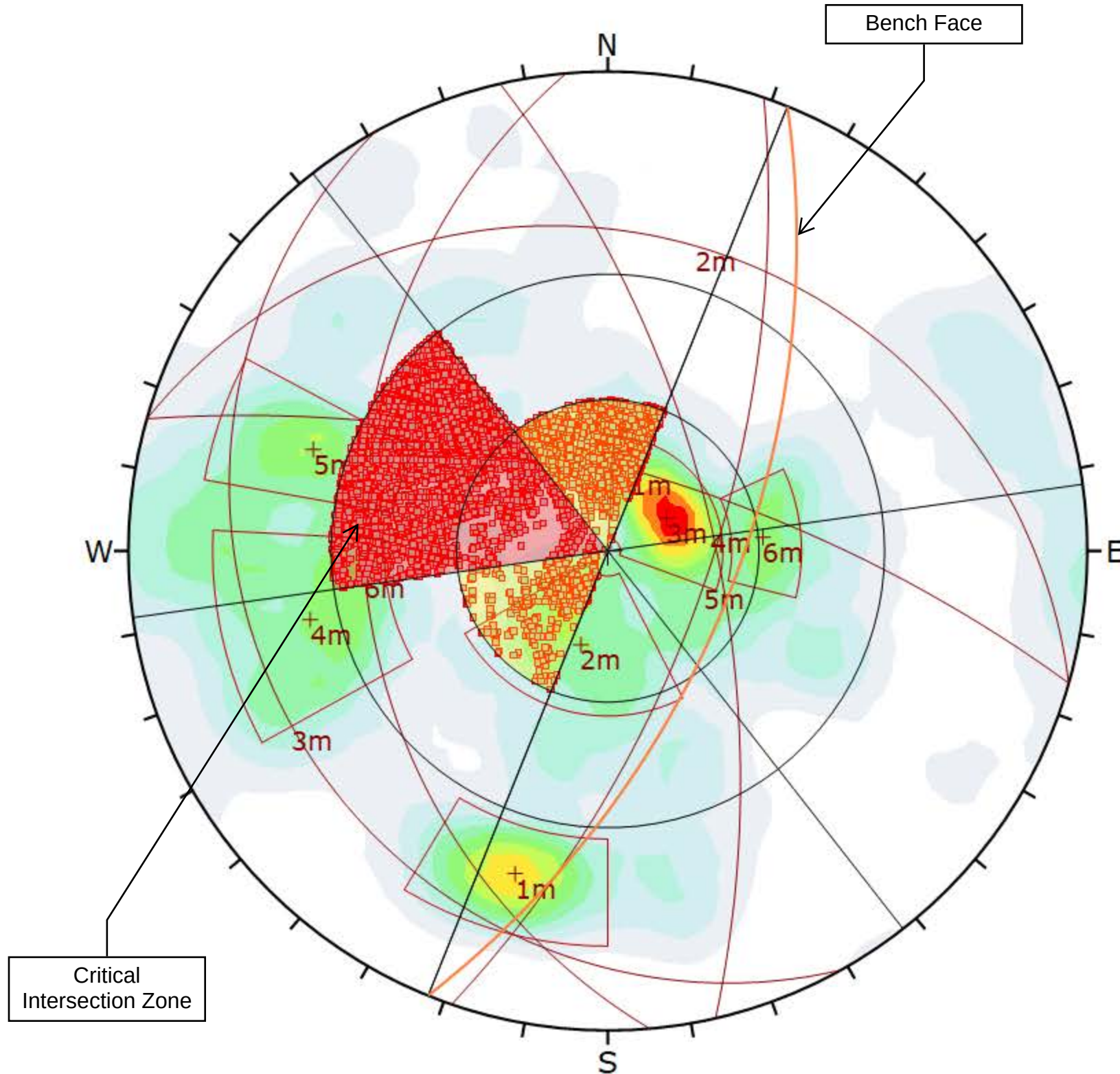
	Critical	Total	%
Planar Sliding (All)	46	569	8.08%
Planar Sliding (Set 2)	1	58	1.72%
Planar Sliding (Set 4)	8	50	16.00%
Planar Sliding (Set 5)	6	27	22.22%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Hemisphere	Lower
Projection	Equal Angle



Drury Quarry - Sutton Block Extension

Topples Failure - Point A Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Direct Toppling
Slope Dip	60
Slope Dip Direction	112
Friction Angle	35°
Lateral Limits	30°

	Critical	Total	%
Direct Toppling (Intersection)	7898	161596	4.89%
Oblique Toppling (Intersection)	4304	161596	2.66%
Base Plane (All)	98	569	17.22%
Base Plane (Set 2)	24	58	41.38%
Base Plane (Set 3)	6	55	10.91%
Base Plane (Set 4)	6	50	12.00%
Base Plane (Set 5)	6	27	22.22%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Wedge Failure - Point A Waipapa Greywacke

Symbol	Feature
■	Critical Intersection

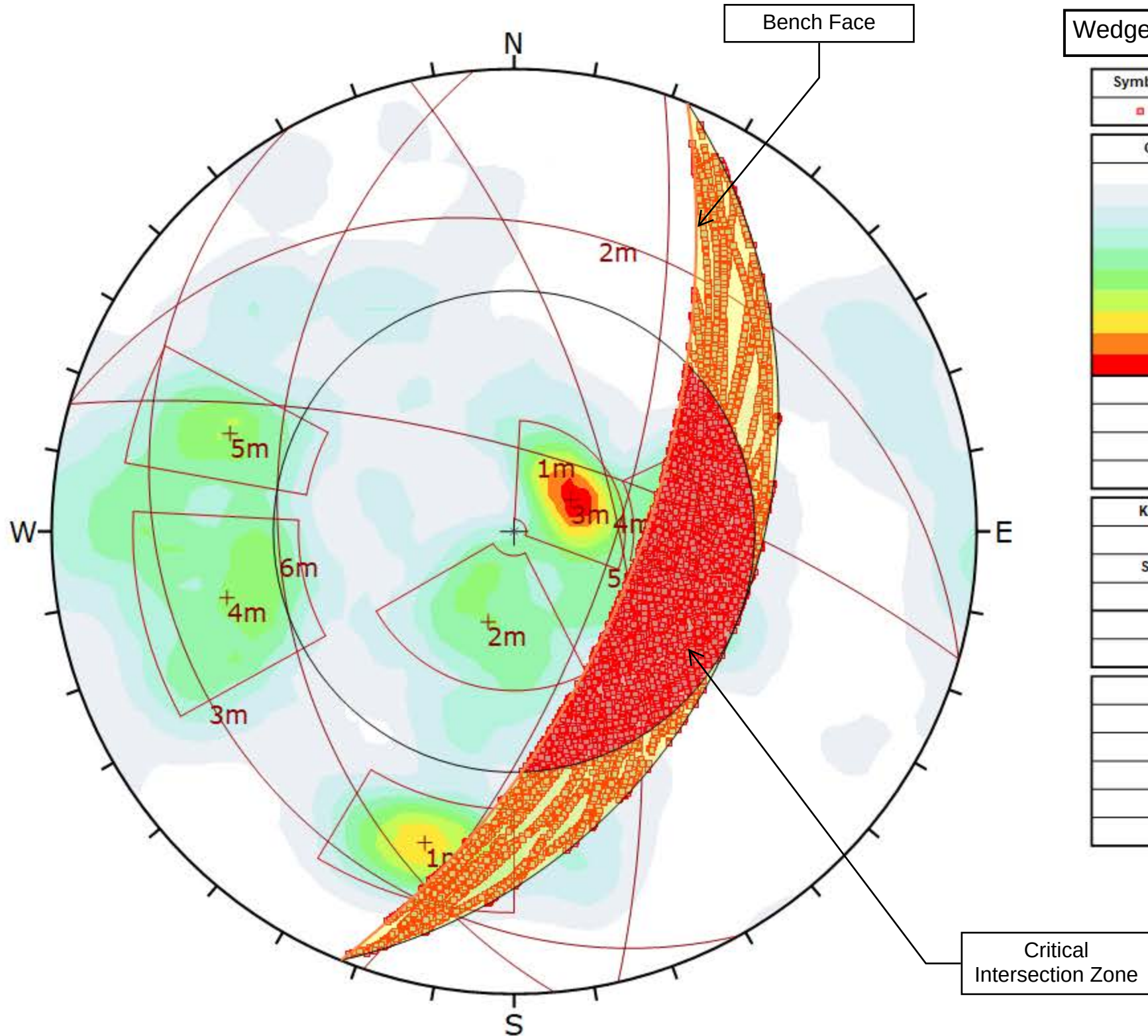
Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding
Slope Dip	60
Slope Dip Direction	112
Friction Angle	35°

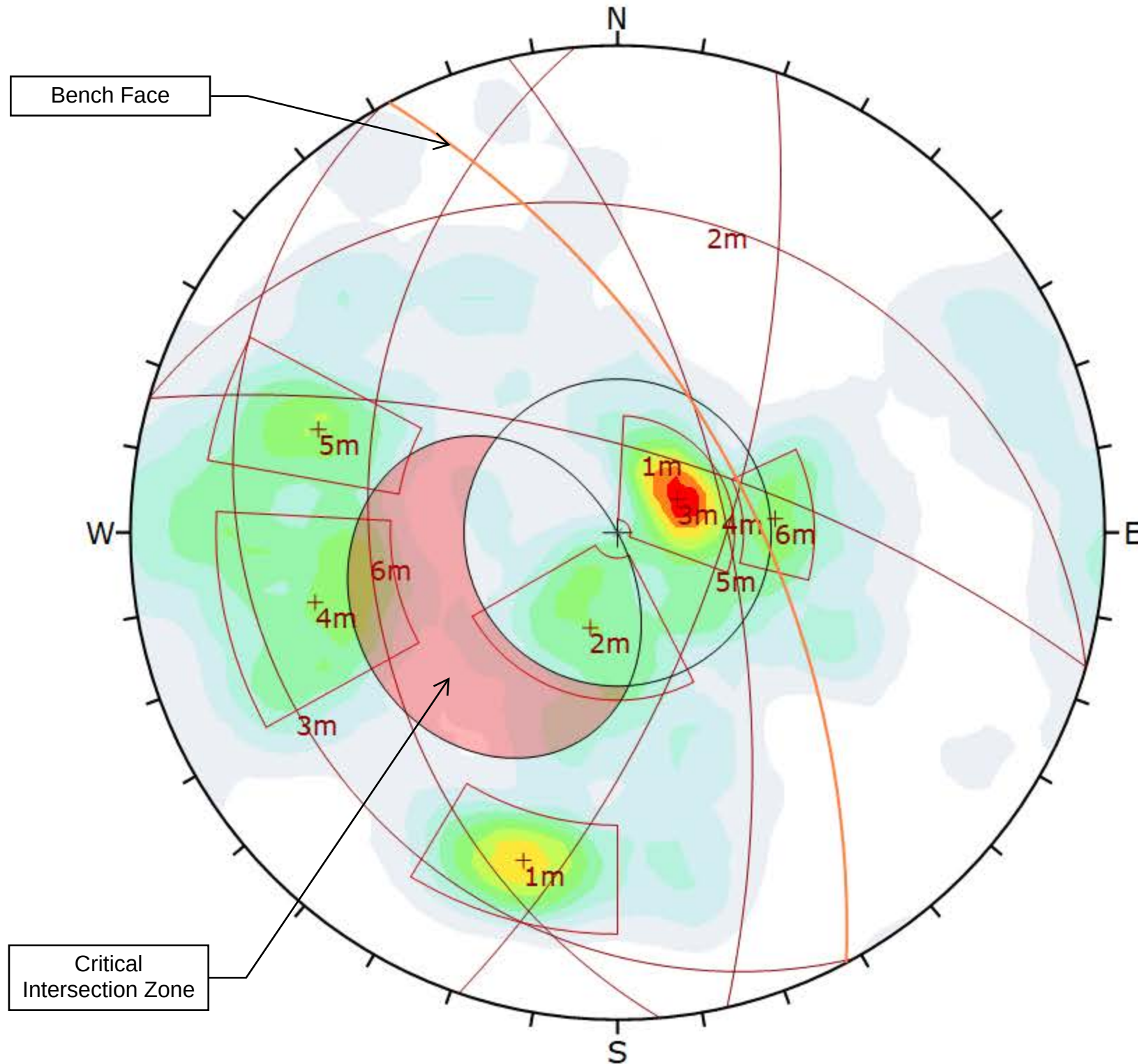
	Critical	Total	%
Wedge Sliding	12853	161596	7.95%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle



Drury Quarry - Sutton Block Extension

Planar (No Limits) Failure - Point B Waipapa Greywacke

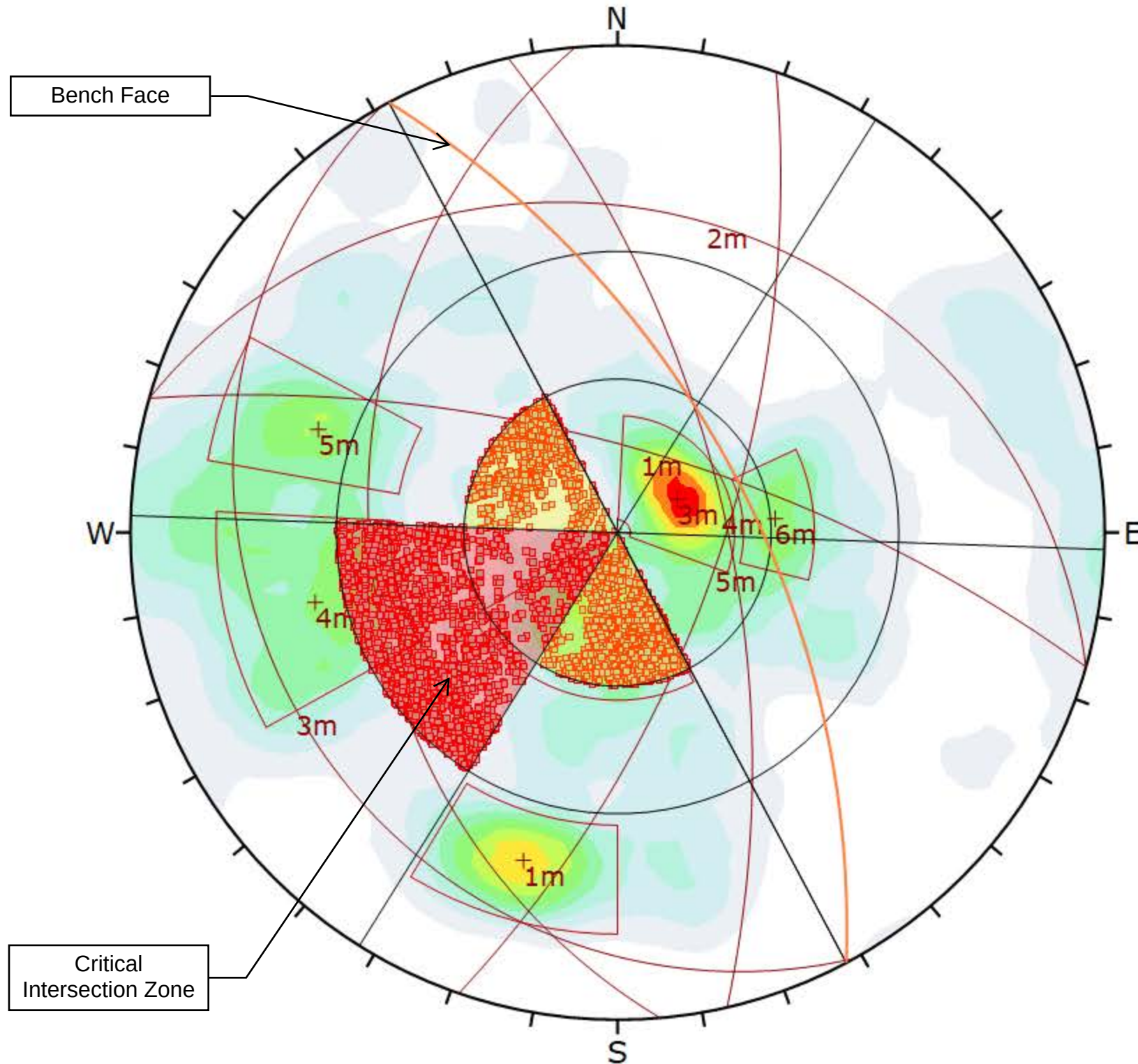


Color	Density Concentrations			
	0.00	-	0.45	
	0.45	-	0.90	
	0.90	-	1.35	
	1.35	-	1.80	
	1.80	-	2.25	
	2.25	-	2.70	
	2.70	-	3.15	
	3.15	-	3.60	
	3.60	-	4.05	
	4.05	-	4.50	
Contour Data		Pole Vectors		
Maximum Density		4.29%		
Contour Distribution		Fisher		
Counting Circle Size		1.0%		
Kinematic Analysis		Planar Sliding		
Slope Dip		60		
Slope Dip Direction		62		
Friction Angle		35°		
		Critical	Total	%
Planar Sliding (All)		52	569	9.14%
Planar Sliding (Set 2)		4	58	6.90%
Planar Sliding (Set 4)		12	50	24.00%
Planar Sliding (Set 5)		1	27	3.70%
Plot Mode		Pole Vectors		
Vector Count		569 (569 Entries)		
Hemisphere		Lower		
Projection		Equal Angle		

RILEY

Drury Quarry - Sutton Block Extension

Topple Failure - Point B Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

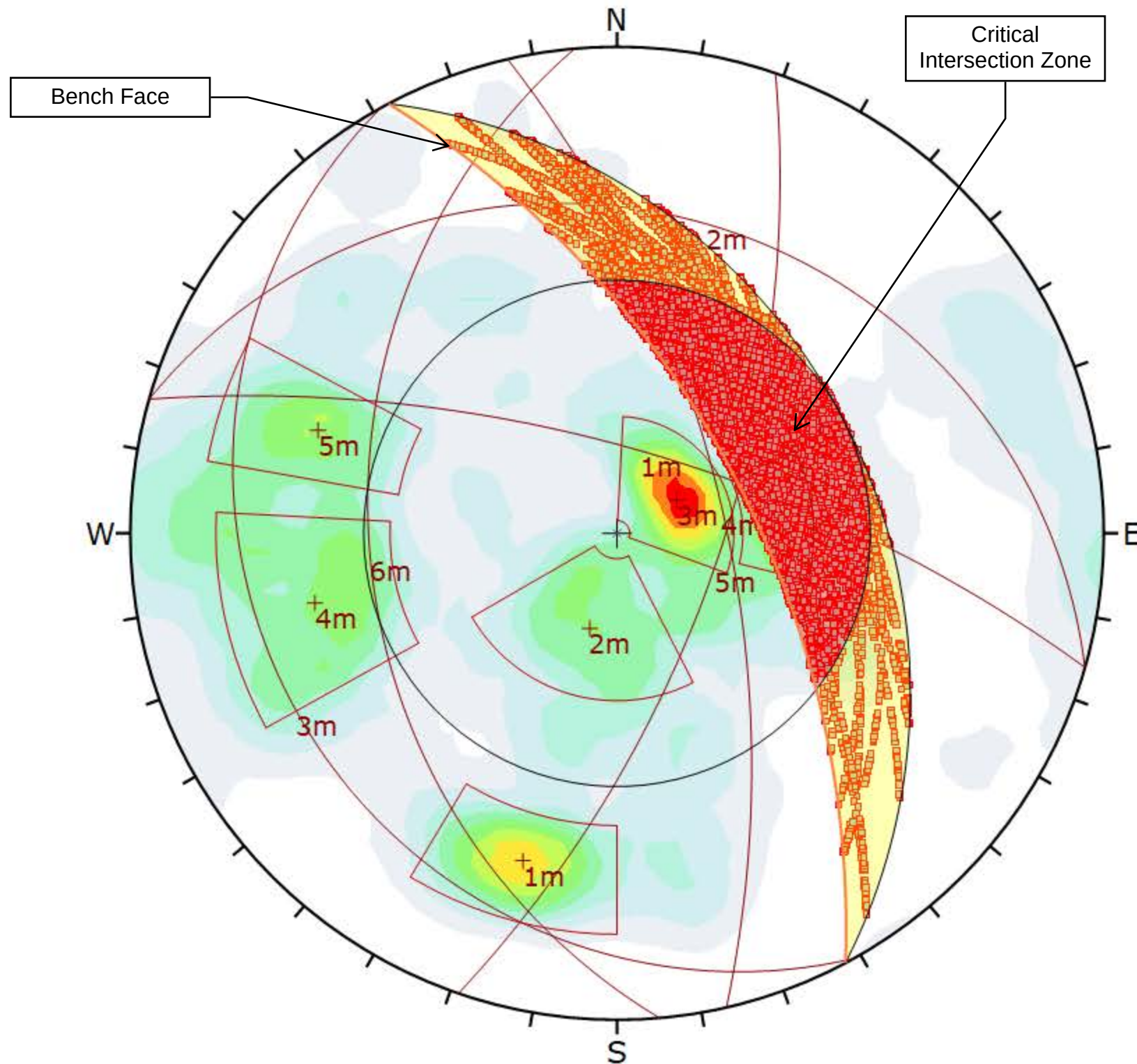
Kinematic Analysis	Direct Toppling
Slope Dip	60
Slope Dip Direction	62
Friction Angle	35°
Lateral Limits	30°

	Critical	Total	%
Direct Toppling (Intersection)	3664	161596	2.27%
Oblique Toppling (Intersection)	3518	161596	2.18%
Base Plane (All)	106	569	18.63%
Base Plane (Set 2)	51	58	87.93%
Base Plane (Set 4)	15	50	30.00%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Wedge Failure - Point B Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

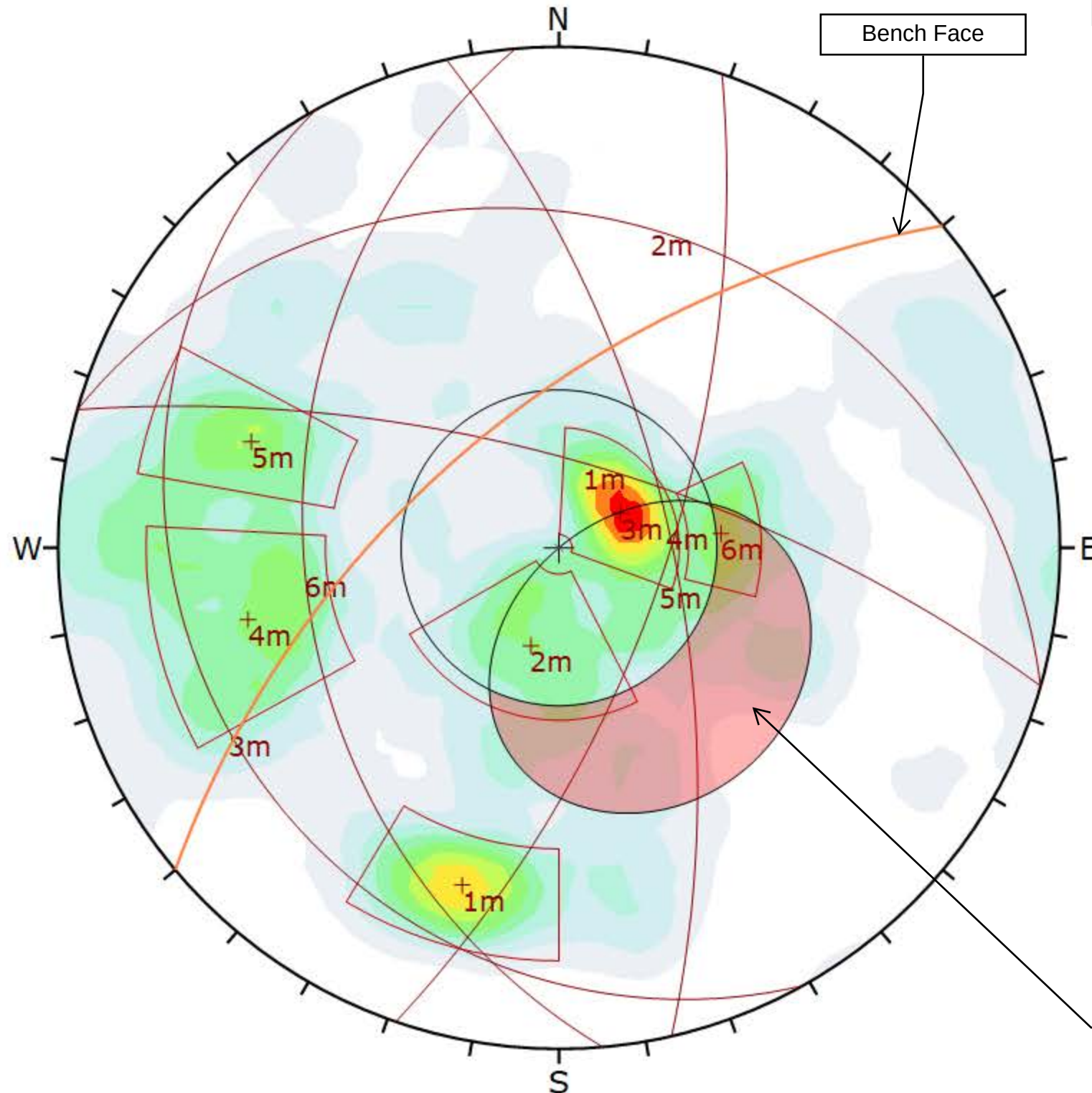
Kinematic Analysis	Wedge Sliding
Slope Dip	60
Slope Dip Direction	62
Friction Angle	35°

	Critical	Total	%
Wedge Sliding	16026	161596	9.92%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Planar (No Limits) Failure - Point C Waipapa Greywacke



Color	Density Concentrations	
	0.00	- 0.45
	0.45	- 0.90
	0.90	- 1.35
	1.35	- 1.80
	1.80	- 2.25
	2.25	- 2.70
	2.70	- 3.15
	3.15	- 3.60
	3.60	- 4.05
	4.05	- 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Planar Sliding
Slope Dip	60
Slope Dip Direction	320
Friction Angle	35°

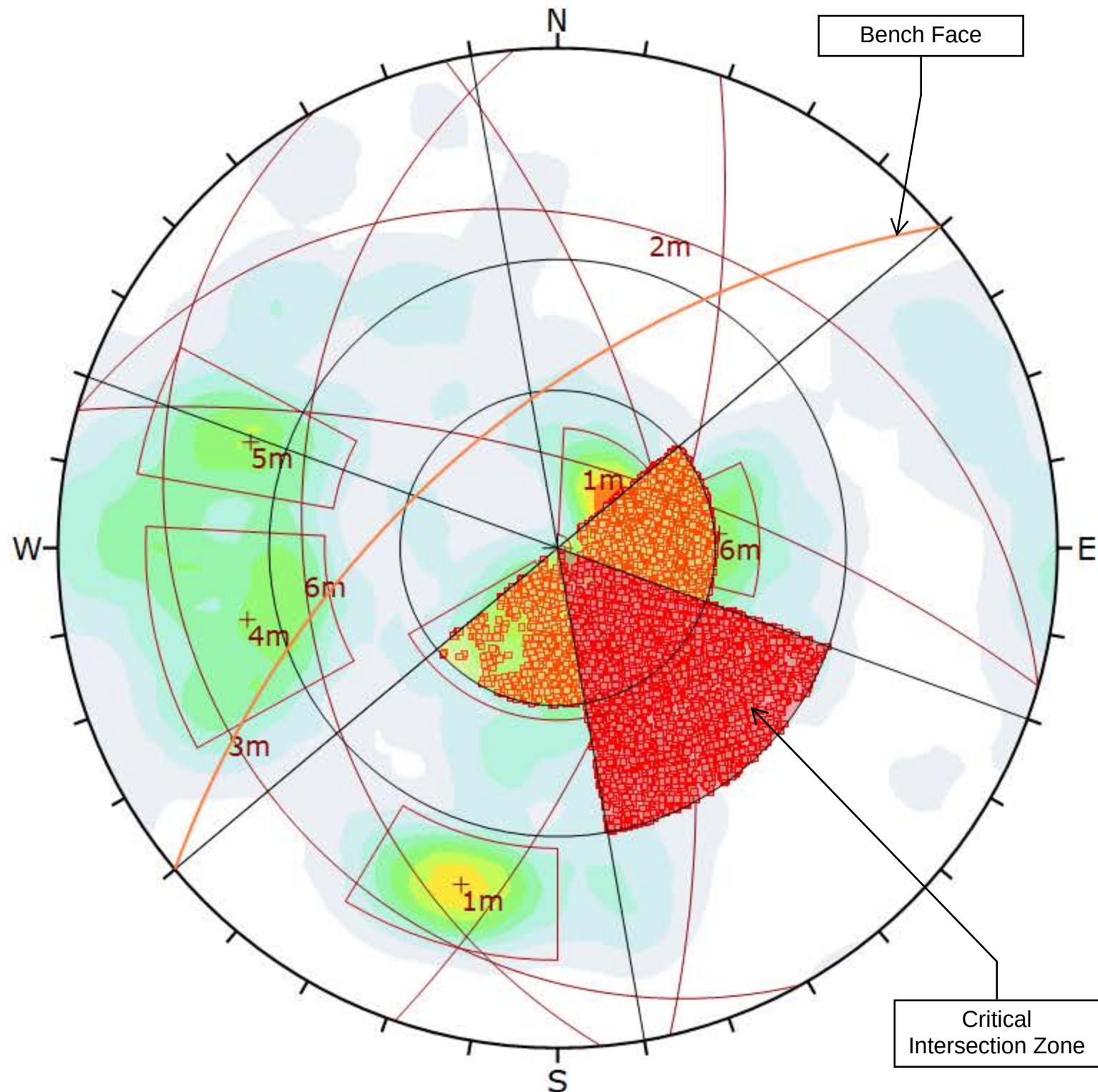
	Critical	Total	%
Planar Sliding (All)	62	569	10.90%
Planar Sliding (Set 2)	7	58	12.07%
Planar Sliding (Set 6)	13	24	54.17%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Hemisphere	Lower
Projection	Equal Angle



Drury Quarry - Sutton Block Extension

Topple Failure - Point C Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

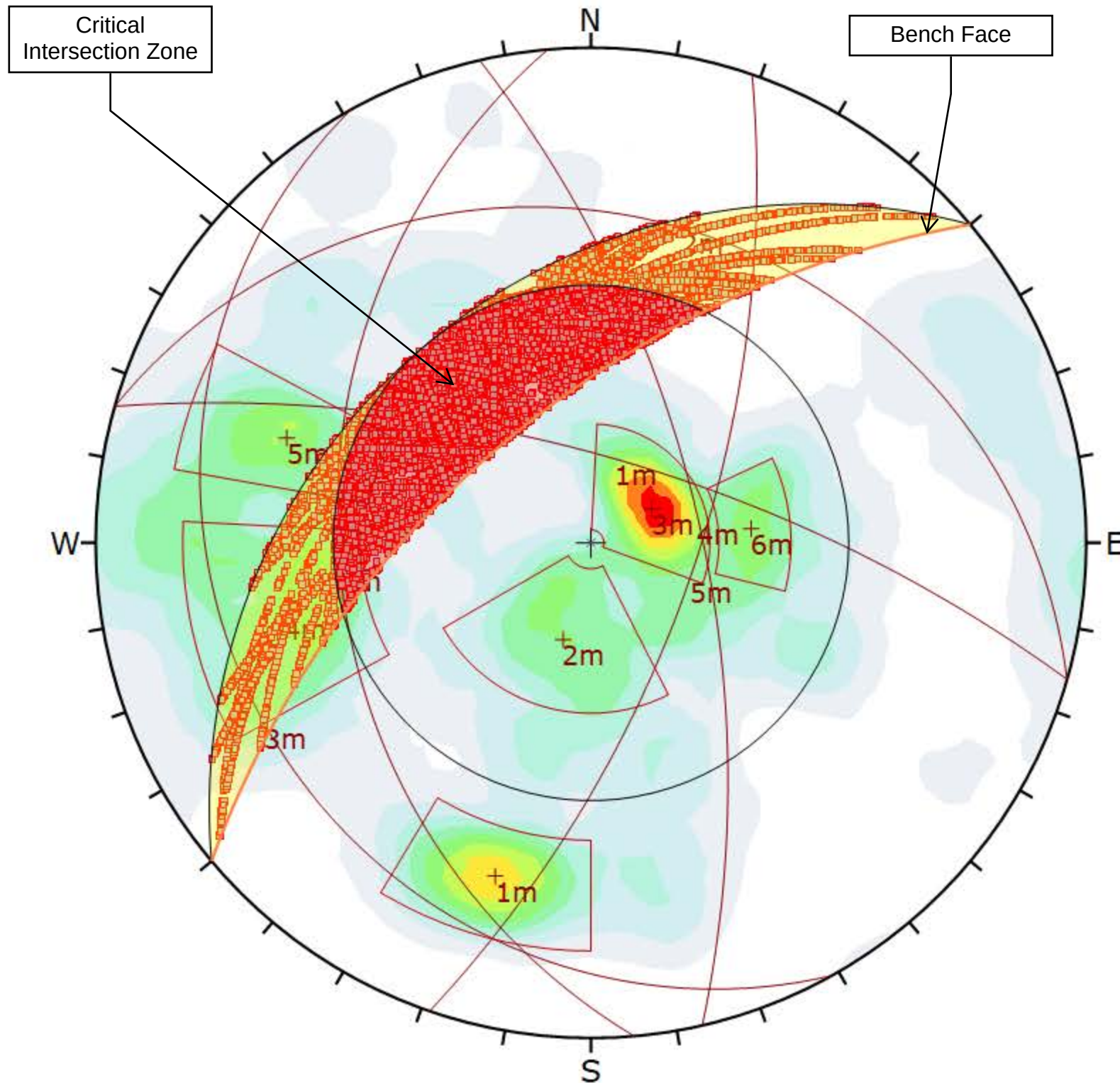
Kinematic Analysis	Direct Toppling
Slope Dip	60
Slope Dip Direction	320
Friction Angle	35°
Lateral Limits	30°

	Critical	Total	%
Direct Toppling (Intersection)	7807	161596	4.83%
Oblique Toppling (Intersection)	7115	161596	4.40%
Base Plane (All)	144	569	25.31%
Base Plane (Set 2)	46	58	79.31%
Base Plane (Set 3)	36	55	65.45%
Base Plane (Set 6)	6	24	25.00%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Wedge Failure - Point C Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

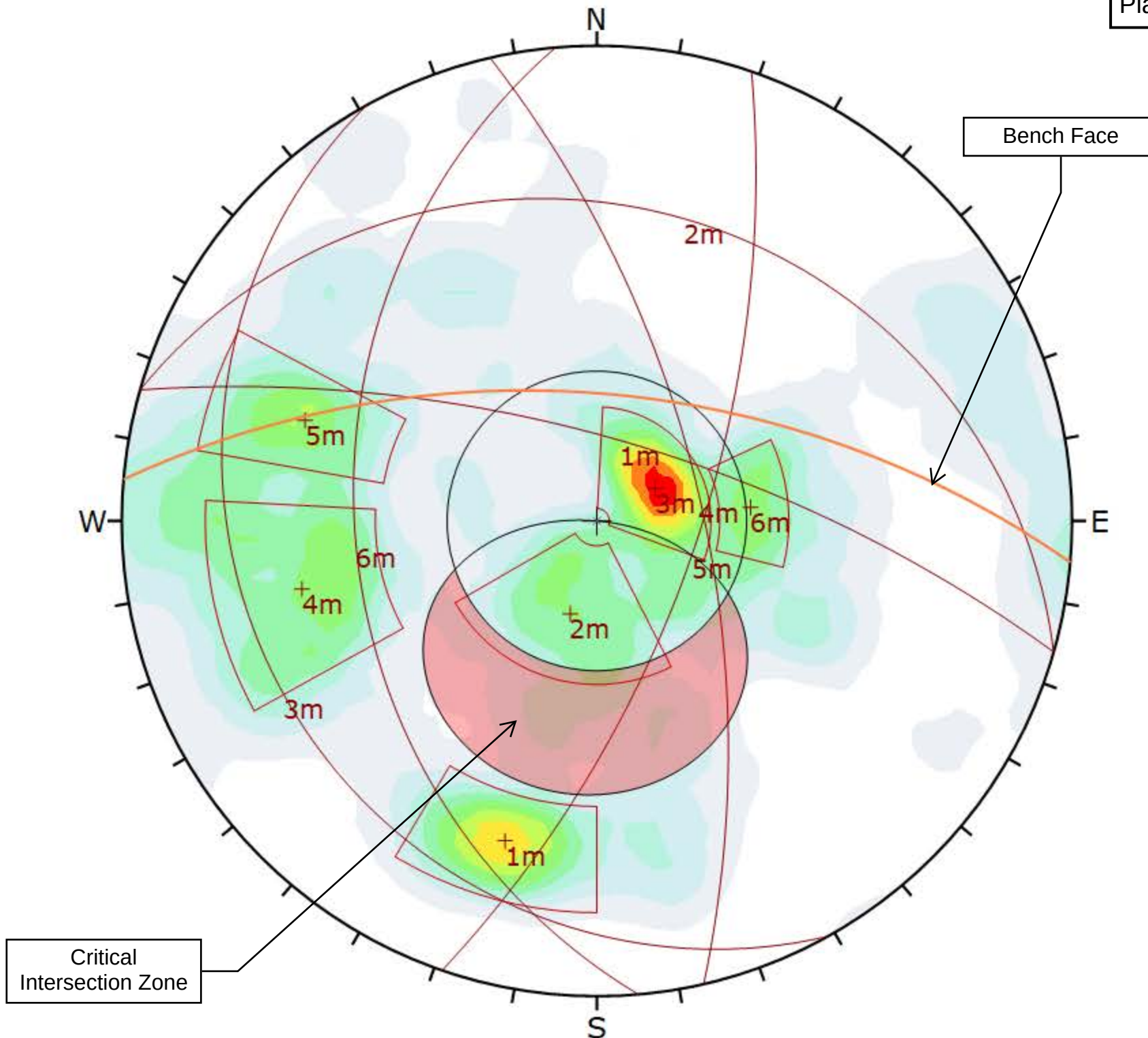
Kinematic Analysis	Wedge Sliding
Slope Dip	60
Slope Dip Direction	320
Friction Angle	35°

	Critical	Total	%
Wedge Sliding	13772	161596	8.52%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Planar (No Limits) Failure - Point D Waipapa Greywacke



Color	Density Concentrations	
	0.00	- 0.45
	0.45	- 0.90
	0.90	- 1.35
	1.35	- 1.80
	1.80	- 2.25
	2.25	- 2.70
	2.70	- 3.15
	3.15	- 3.60
	3.60	- 4.05
	4.05	- 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

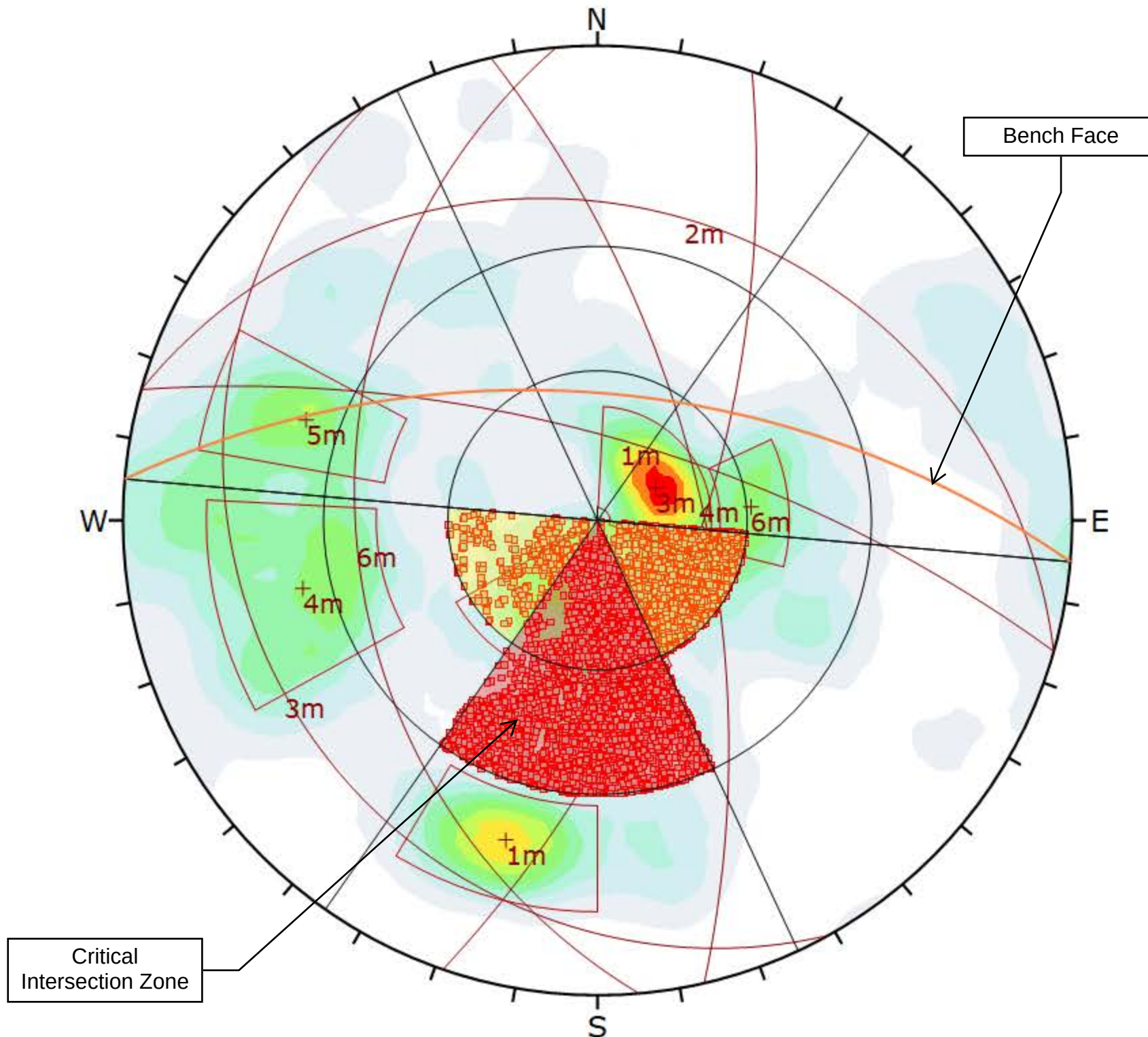
Kinematic Analysis	Planar Sliding		
Slope Dip	60		
Slope Dip Direction	5		
Friction Angle	35°		
	Critical	Total	%
Planar Sliding (All)	49	569	8.61%
Planar Sliding (Set 2)	8	58	13.79%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Hemisphere	Lower
Projection	Equal Angle

RILEY

Drury Quarry - Sutton Block Extension

Topples Failure - Point D Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

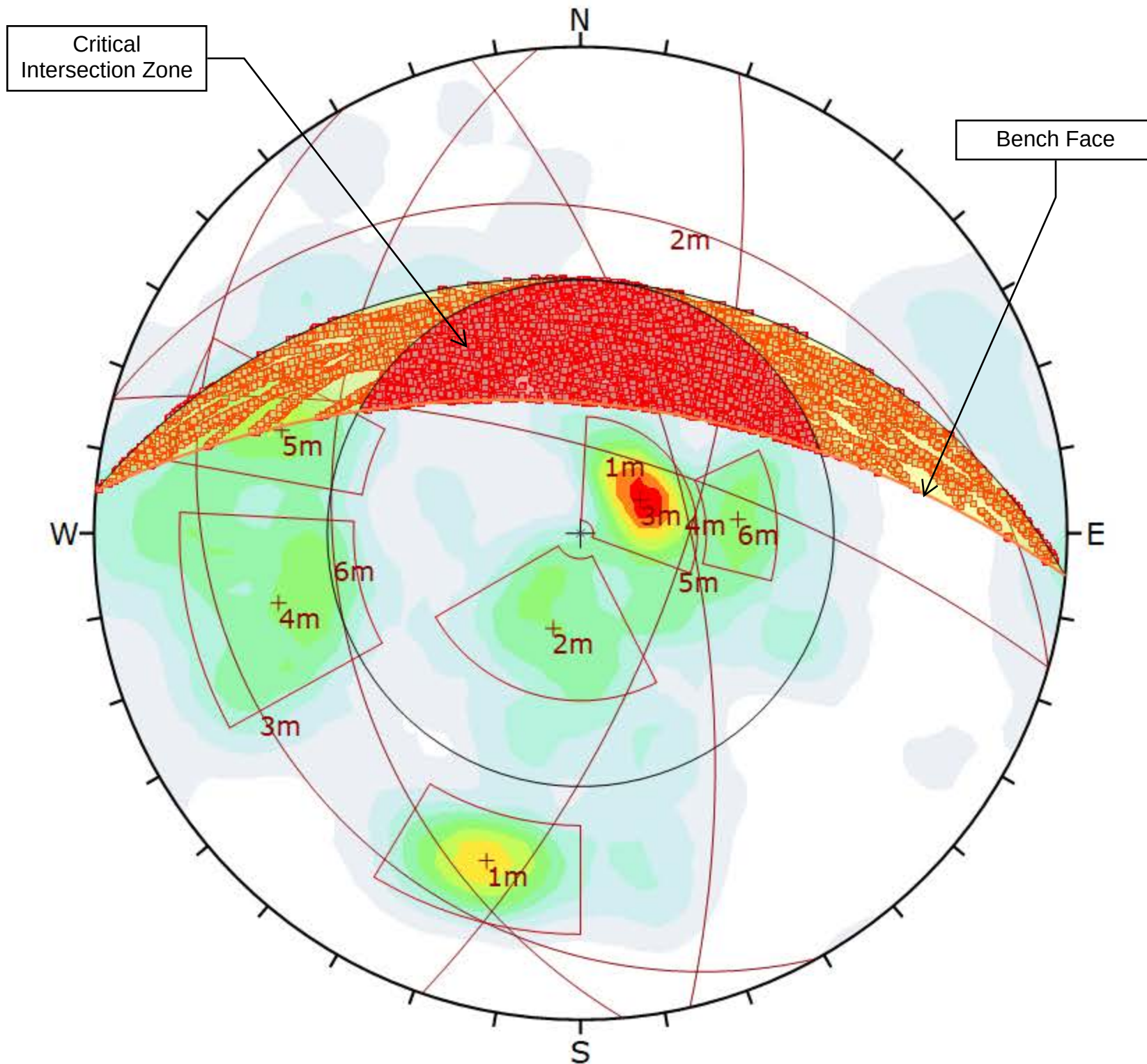
Kinematic Analysis	Direct Toppling
Slope Dip	60
Slope Dip Direction	5
Friction Angle	35°
Lateral Limits	30°

	Critical	Total	%
Direct Toppling (Intersection)	7408	161596	4.58%
Oblique Toppling (Intersection)	3334	161596	2.06%
Base Plane (All)	133	569	23.37%
Base Plane (Set 2)	57	58	98.28%
Base Plane (Set 3)	7	55	12.73%
Base Plane (Set 6)	3	24	12.50%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Wedge Failure - Point D Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding
Slope Dip	60
Slope Dip Direction	5
Friction Angle	35°

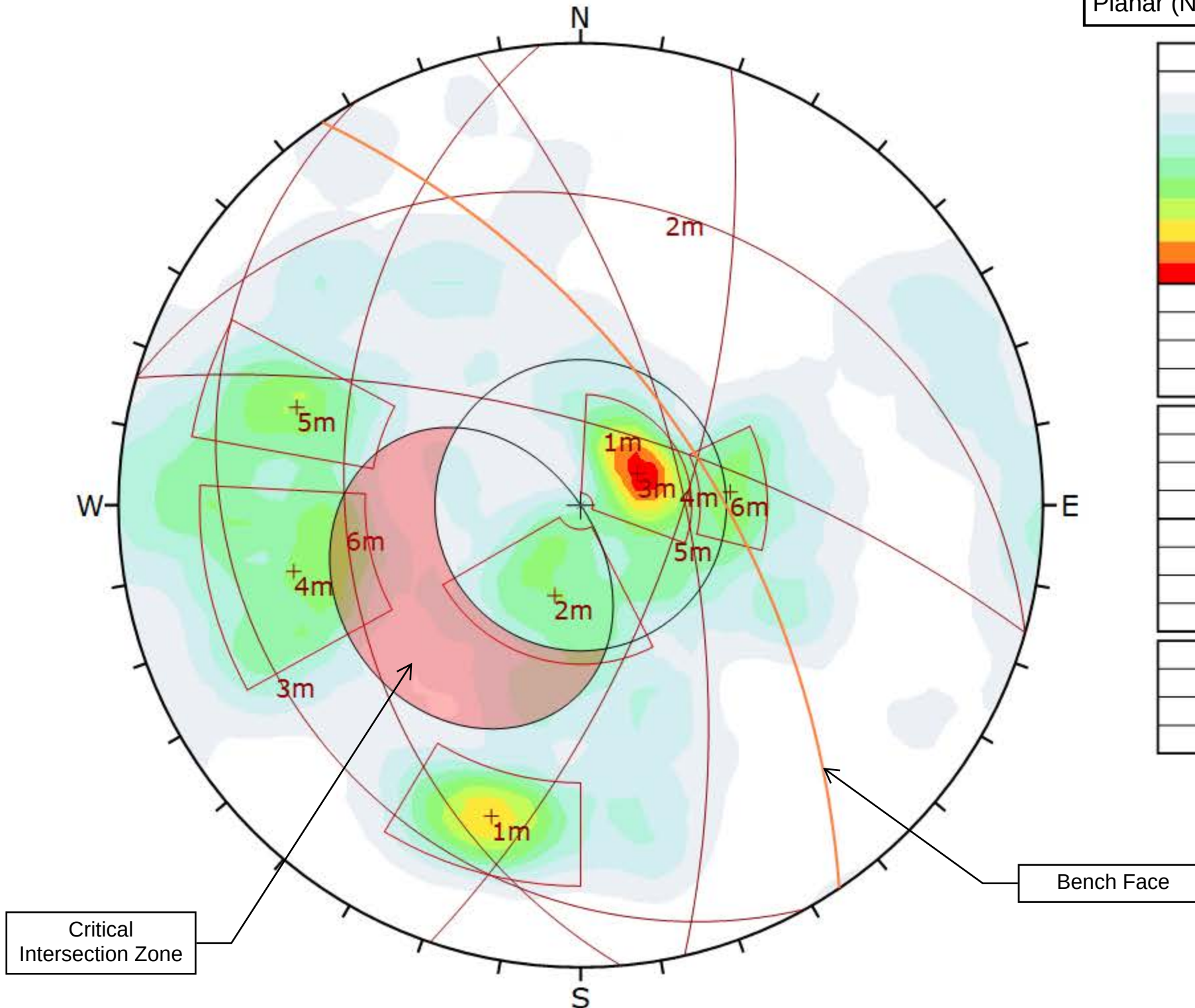
	Critical	Total	%
Wedge Sliding	16918	161596	10.47%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle



Drury Quarry - Sutton Block Extension

Planar (No Limits) Failure - Point E Waipapa Greywacke

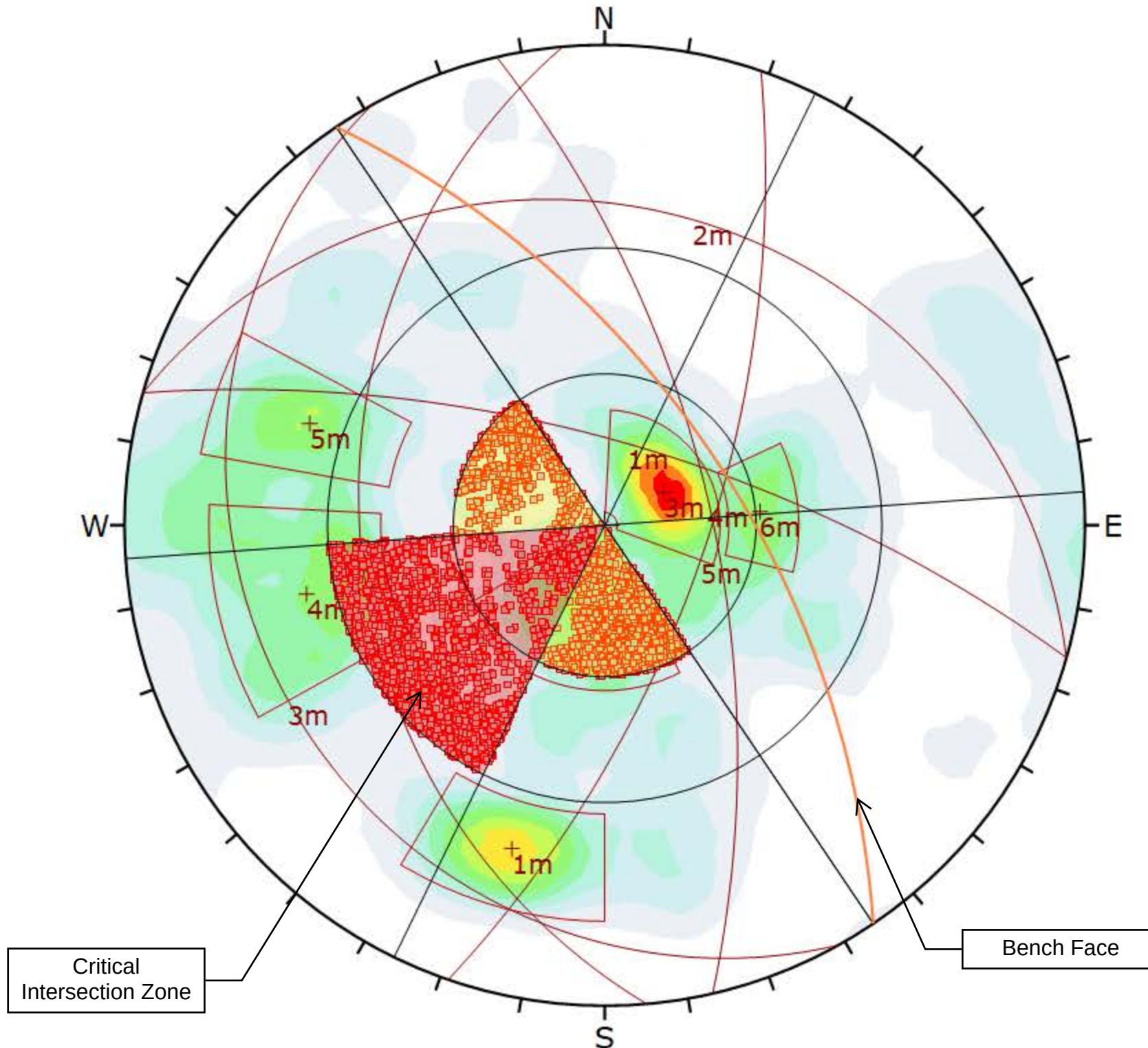


Color	Density Concentrations			
	0.00	-	0.45	
	0.45	-	0.90	
	0.90	-	1.35	
	1.35	-	1.80	
	1.80	-	2.25	
	2.25	-	2.70	
	2.70	-	3.15	
	3.15	-	3.60	
	3.60	-	4.05	
	4.05	-	4.50	
Contour Data		Pole Vectors		
Maximum Density		4.29%		
Contour Distribution		Fisher		
Counting Circle Size		1.0%		
Kinematic Analysis		Planar Sliding		
Slope Dip		60		
Slope Dip Direction		56		
Friction Angle		35°		
		Critical	Total	%
Planar Sliding (All)		48	569	8.44%
Planar Sliding (Set 2)		5	58	8.62%
Planar Sliding (Set 4)		9	50	18.00%
Plot Mode		Pole Vectors		
Vector Count		569 (569 Entries)		
Hemisphere		Lower		
Projection		Equal Angle		



Drury Quarry - Sutton Block Extension

Topple Failure - Point E Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

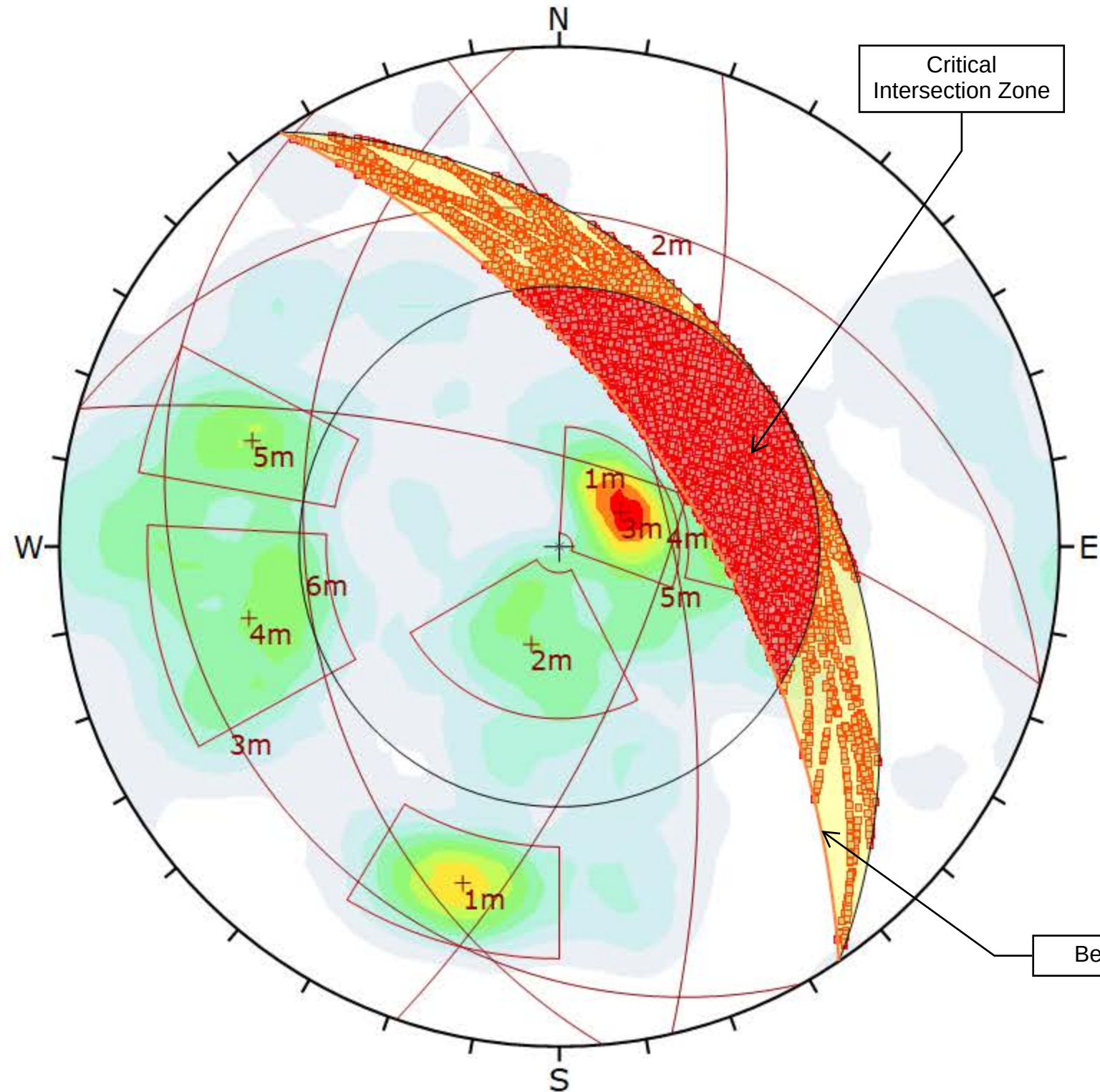
Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Direct Toppling		
Slope Dip	60		
Slope Dip Direction	56		
Friction Angle	35°		
Lateral Limits	30°		
	Critical	Total	%
Direct Toppling (Intersection)	3768	161596	2.33%
Oblique Toppling (Intersection)	3317	161596	2.05%
Base Plane (All)	106	569	18.63%
Base Plane (Set 2)	51	58	87.93%
Base Plane (Set 4)	13	50	26.00%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Wedge Failure - Point E Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

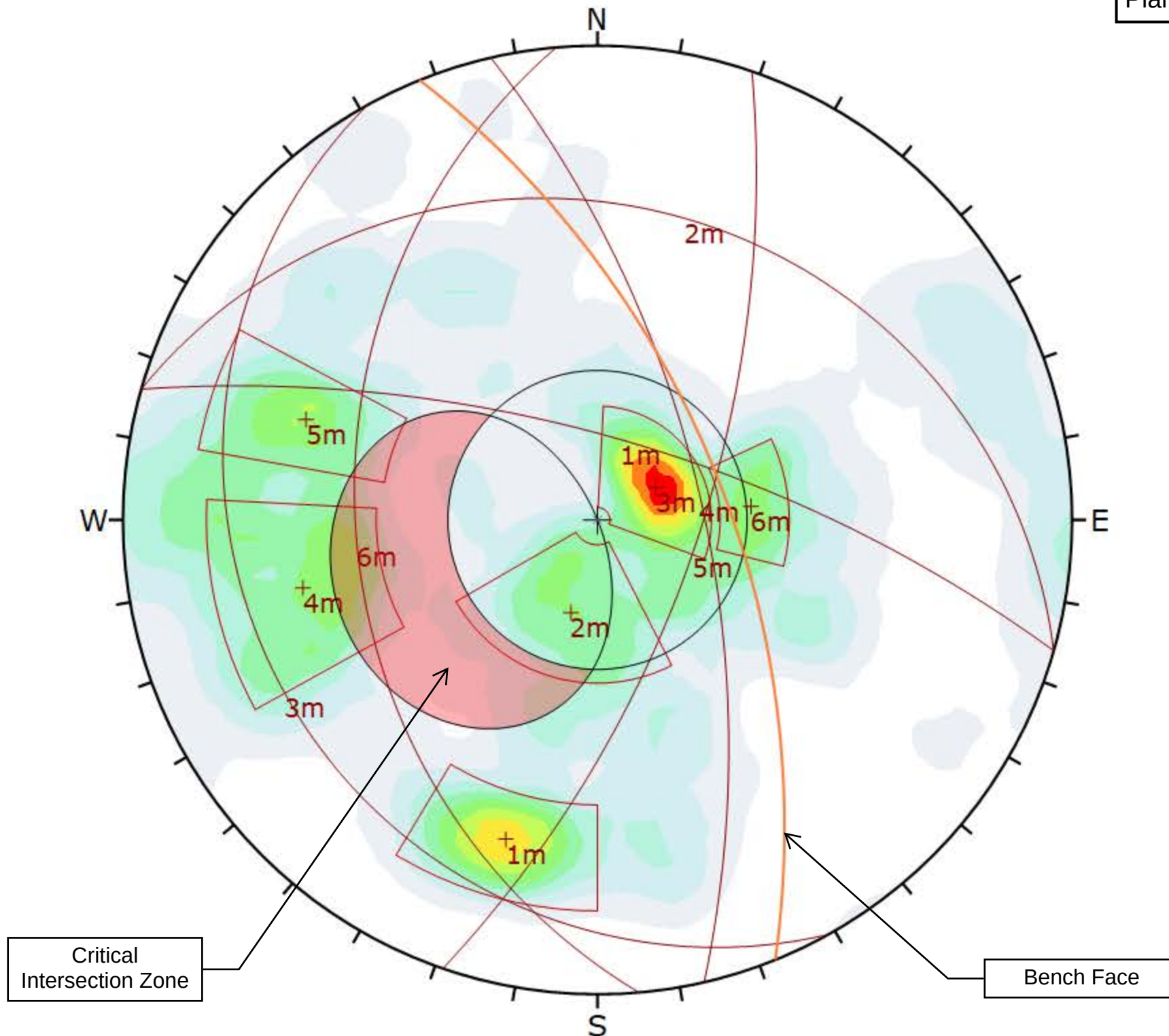
Kinematic Analysis	Wedge Sliding
Slope Dip	60
Slope Dip Direction	56
Friction Angle	35°

	Critical	Total	%
Wedge Sliding	16538	161596	10.23%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Planar (No Limits) Failure - Point F Waipapa Greywacke



Color	Density Concentrations	
	0.00	- 0.45
	0.45	- 0.90
	0.90	- 1.35
	1.35	- 1.80
	1.80	- 2.25
	2.25	- 2.70
	2.70	- 3.15
	3.15	- 3.60
	3.60	- 4.05
	4.05	- 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Planar Sliding
Slope Dip	60
Slope Dip Direction	68
Friction Angle	35°

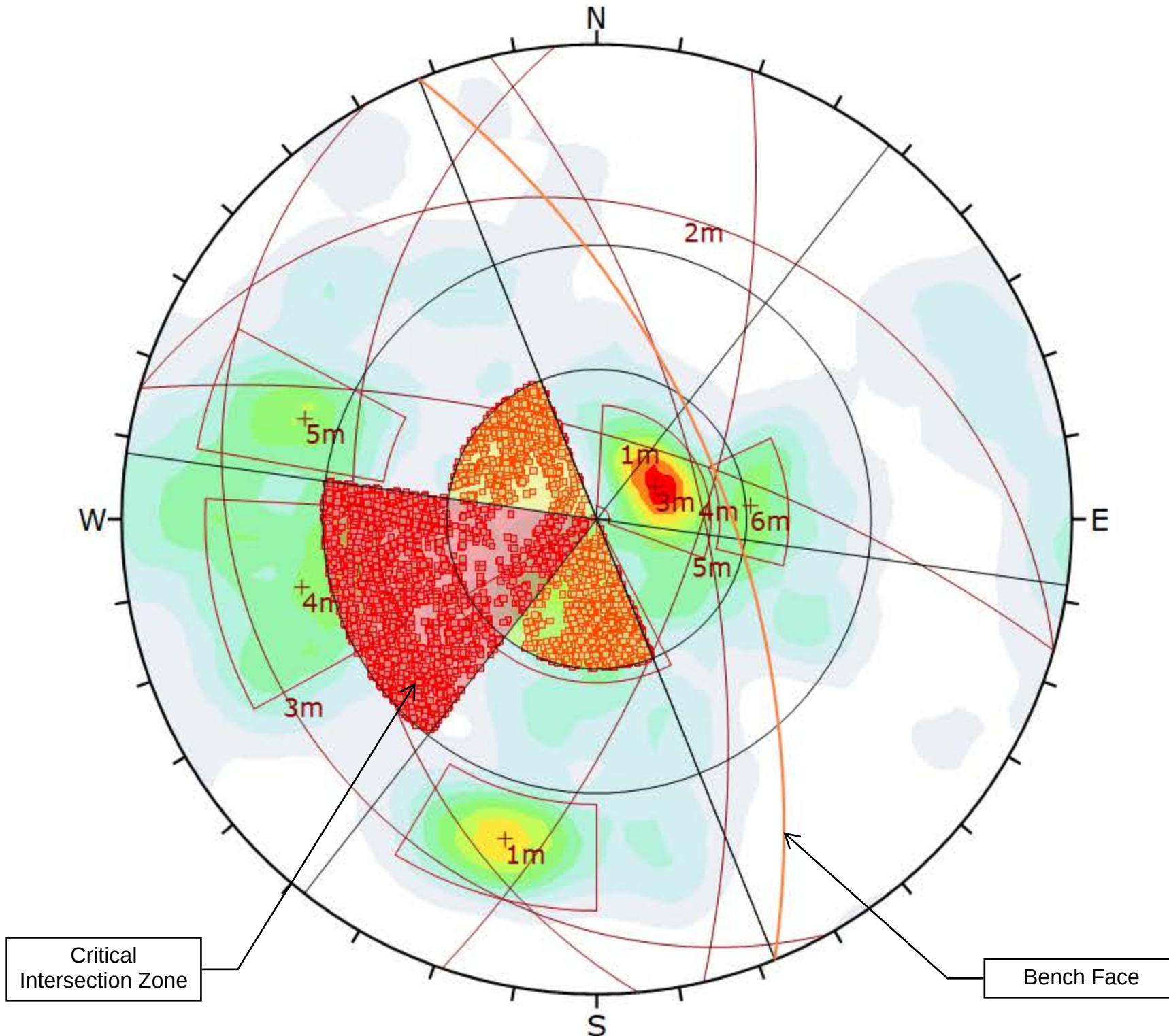
	Critical	Total	%
Planar Sliding (All)	49	569	8.61%
Planar Sliding (Set 2)	4	58	6.90%
Planar Sliding (Set 4)	13	50	26.00%
Planar Sliding (Set 5)	1	27	3.70%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Hemisphere	Lower
Projection	Equal Angle



Drury Quarry - Sutton Block Extension

Topples Failure - Point F Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

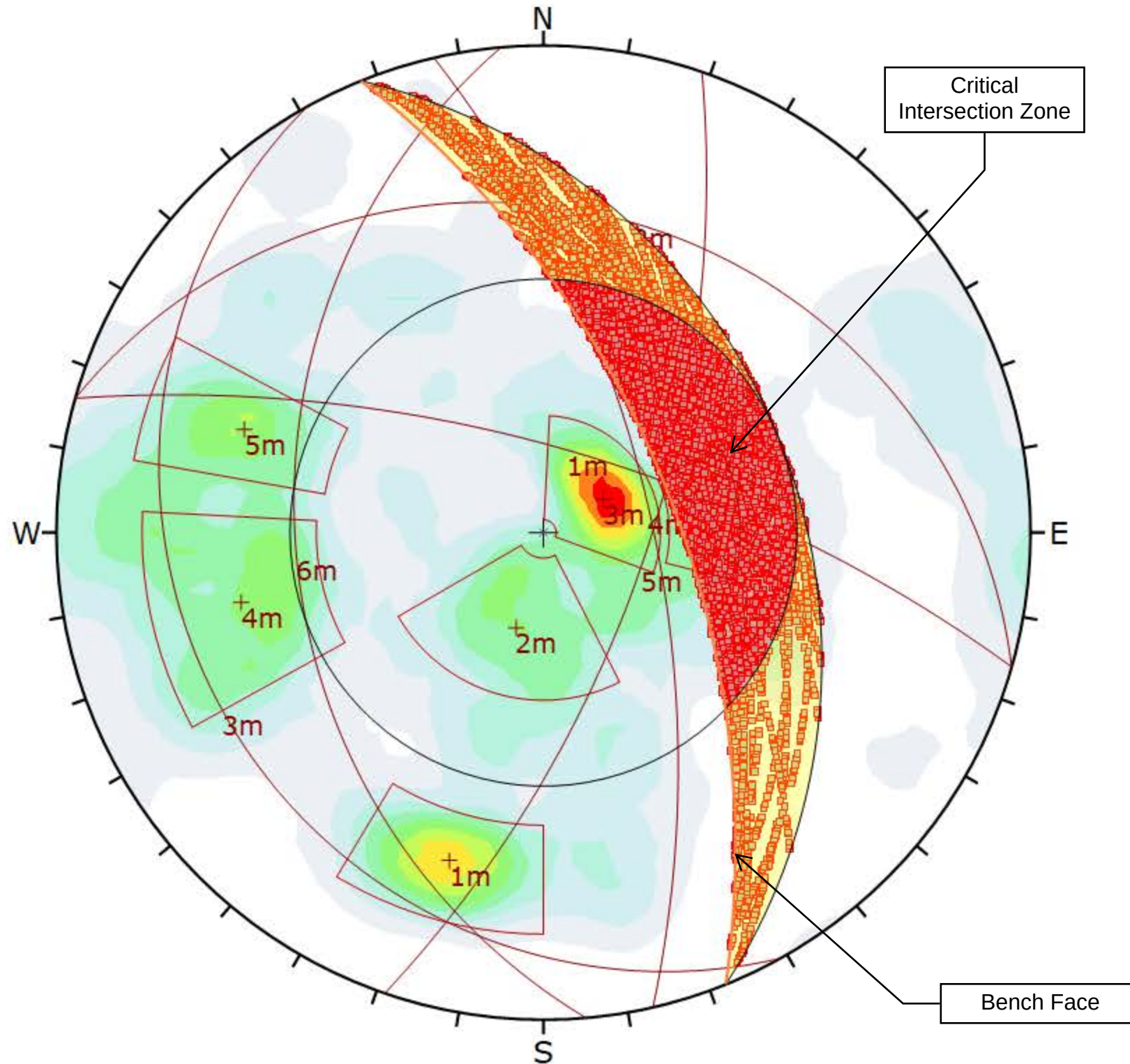
Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Direct Toppling		
Slope Dip	60		
Slope Dip Direction	68		
Friction Angle	35°		
Lateral Limits	30°		
	Critical	Total	%
Direct Toppling (Intersection)	3776	161596	2.34%
Oblique Toppling (Intersection)	3427	161596	2.12%
Base Plane (All)	107	569	18.80%
Base Plane (Set 2)	49	58	84.48%
Base Plane (Set 4)	16	50	32.00%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Wedge Failure - Point F Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

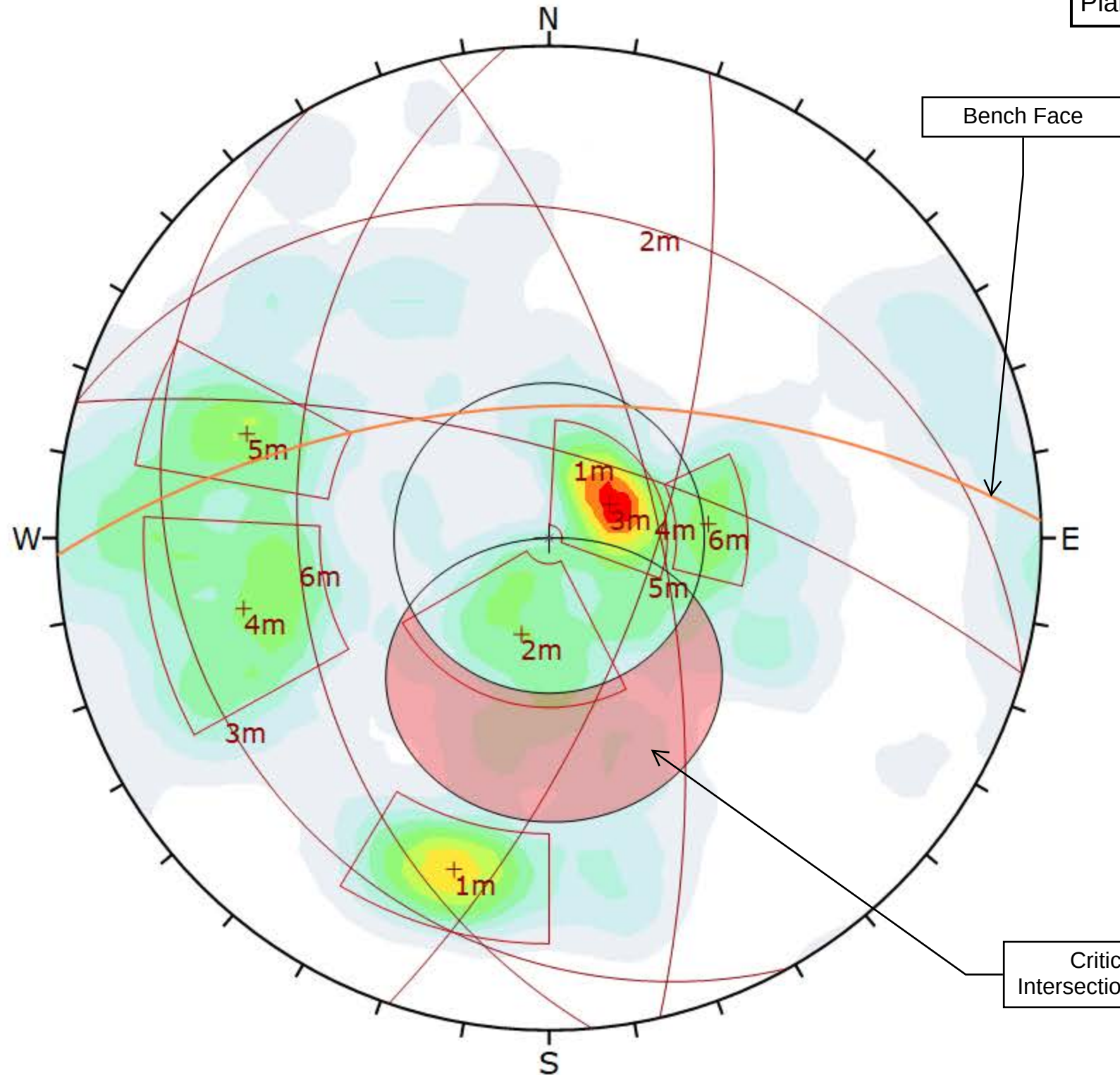
Kinematic Analysis	Wedge Sliding
Slope Dip	60
Slope Dip Direction	68
Friction Angle	35°

	Critical	Total	%
Wedge Sliding	16252	161596	10.06%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Planar (No Limits) Failure - Point G Waipapa Greywacke



Color	Density Concentrations	
	0.00	- 0.45
	0.45	- 0.90
	0.90	- 1.35
	1.35	- 1.80
	1.80	- 2.25
	2.25	- 2.70
	2.70	- 3.15
	3.15	- 3.60
	3.60	- 4.05
	4.05	- 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

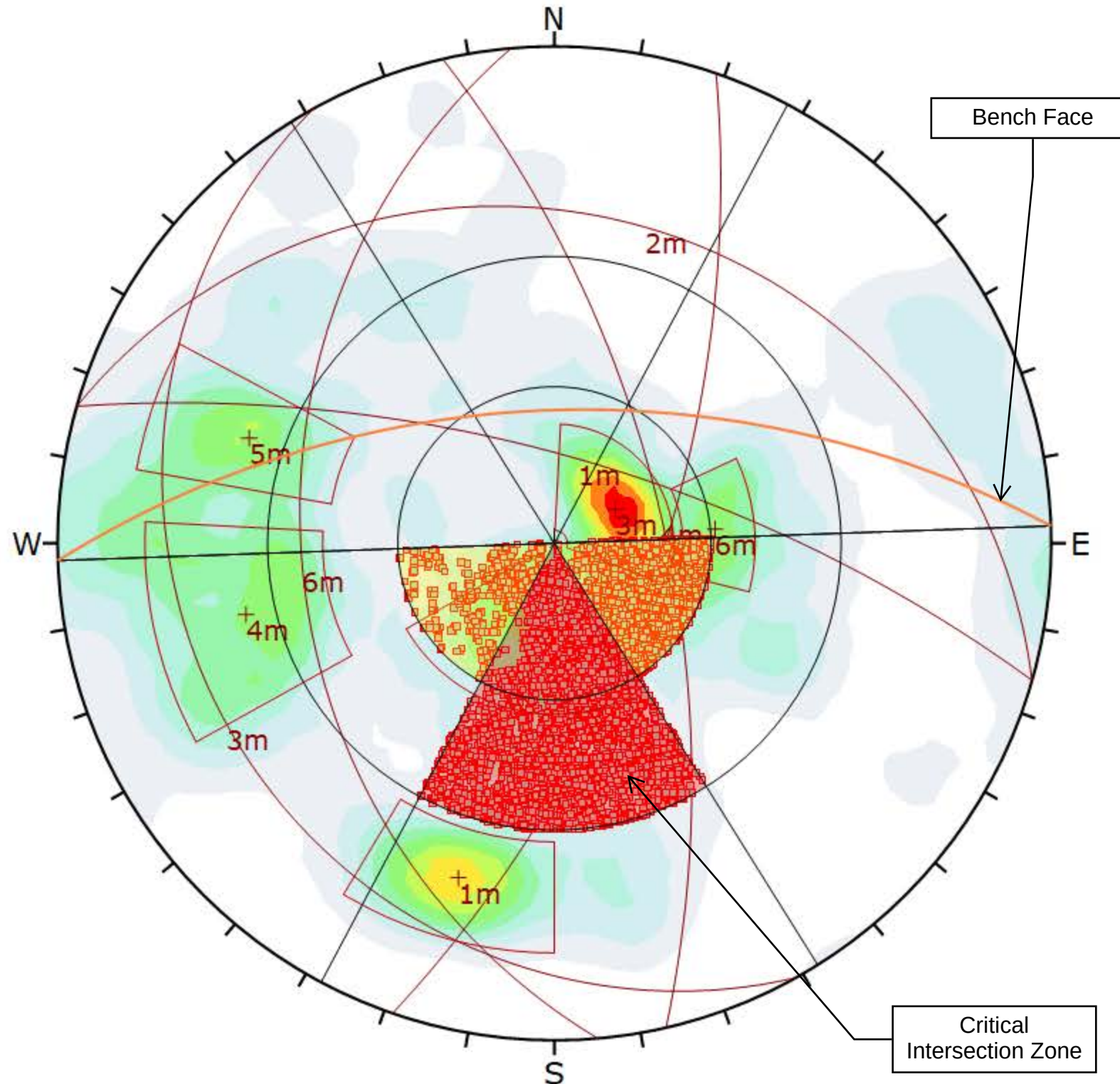
Kinematic Analysis	Planar Sliding		
Slope Dip	60		
Slope Dip Direction	358		
Friction Angle	35°		
	Critical	Total	%
Planar Sliding (All)	49	569	8.61%
Planar Sliding (Set 2)	8	58	13.79%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Hemisphere	Lower
Projection	Equal Angle

RILEY

Drury Quarry - Sutton Block Extension

Topple Failure - Point G Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

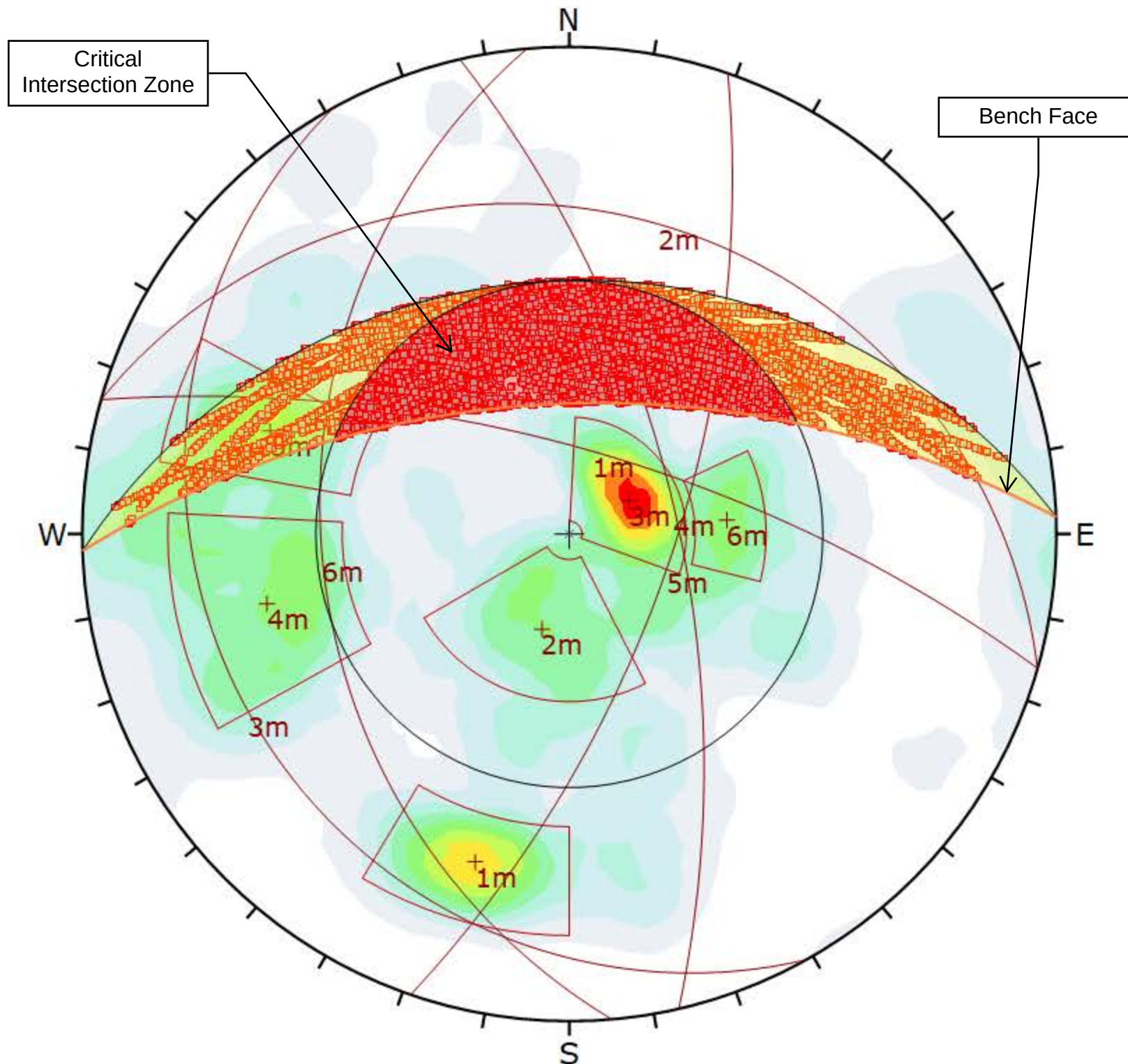
Kinematic Analysis	Direct Toppling
Slope Dip	60
Slope Dip Direction	358
Friction Angle	35°
Lateral Limits	30°

	Critical	Total	%
Direct Toppling (Intersection)	7685	161596	4.76%
Oblique Toppling (Intersection)	3661	161596	2.27%
Base Plane (All)	136	569	23.90%
Base Plane (Set 2)	57	58	98.28%
Base Plane (Set 3)	11	55	20.00%
Base Plane (Set 6)	4	24	16.67%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Wedge Failure - Point G Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

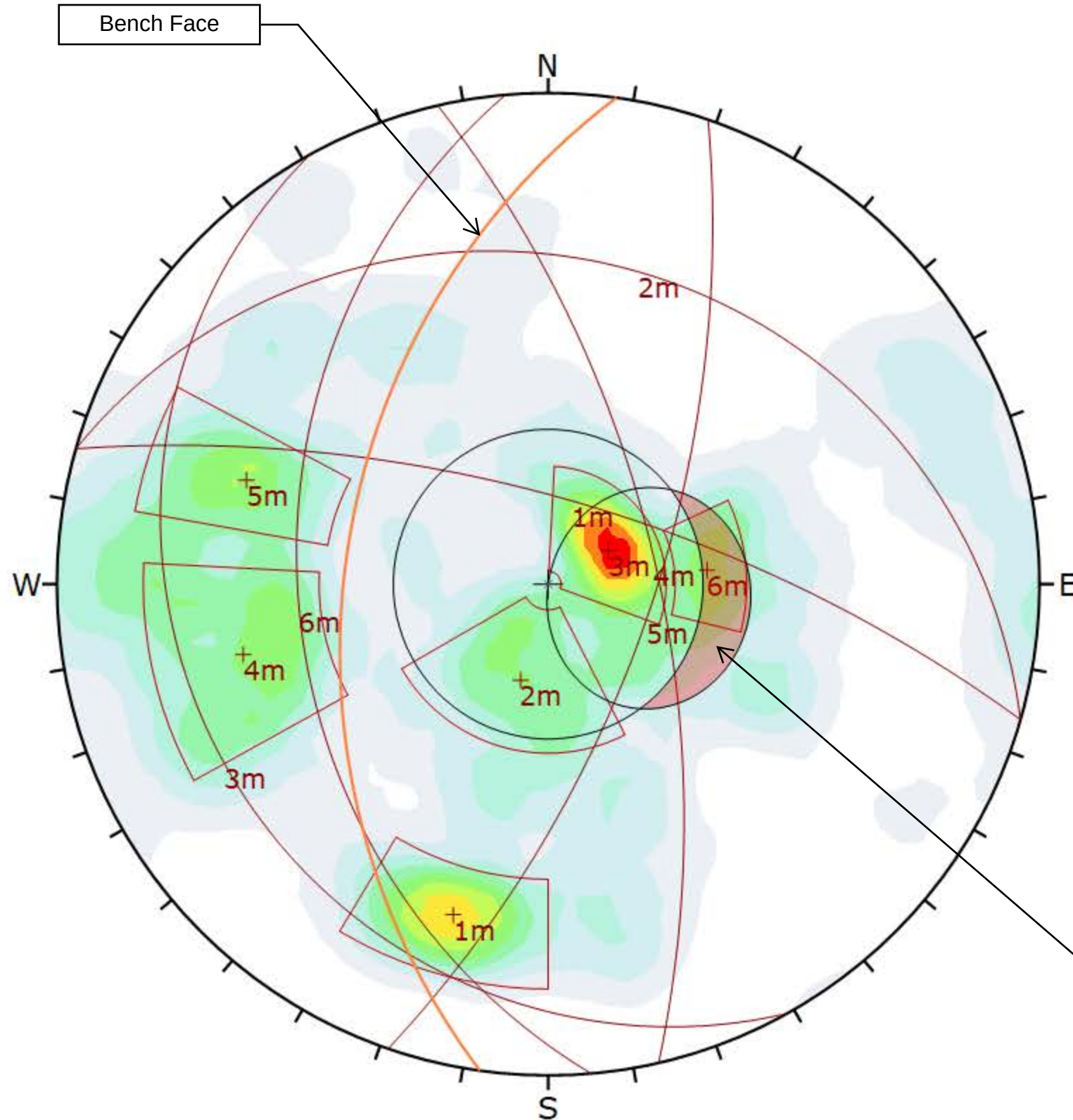
Kinematic Analysis	Wedge Sliding
Slope Dip	60
Slope Dip Direction	358
Friction Angle	35°

	Critical	Total	%
Wedge Sliding	16576	161596	10.26%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Planar (No Limits) Failure - Point H Waipapa Greywacke



Color	Density Concentrations	
	0.00	- 0.45
	0.45	- 0.90
	0.90	- 1.35
	1.35	- 1.80
	1.80	- 2.25
	2.25	- 2.70
	2.70	- 3.15
	3.15	- 3.60
	3.60	- 4.05
	4.05	- 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Planar Sliding		
Slope Dip	45		
Slope Dip Direction	278		
Friction Angle	35°		
	Critical	Total	%
Planar Sliding (All)	22	569	3.87%
Planar Sliding (Set 6)	17	24	70.83%

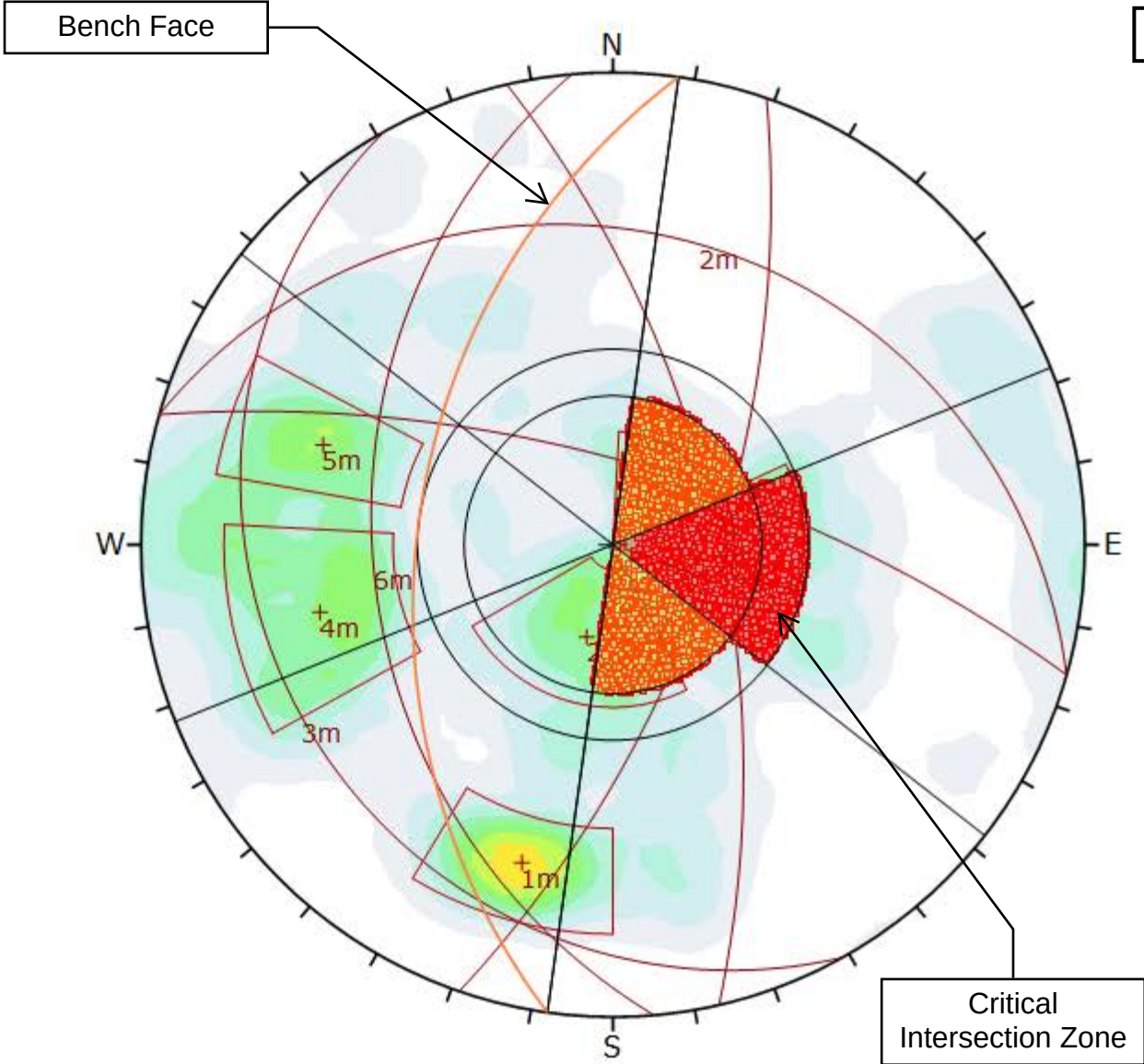
Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Hemisphere	Lower
Projection	Equal Angle

RILEY

Critical
Intersection Zone

Drury Quarry - Sutton Block Extension

Topples Failure - Point H Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

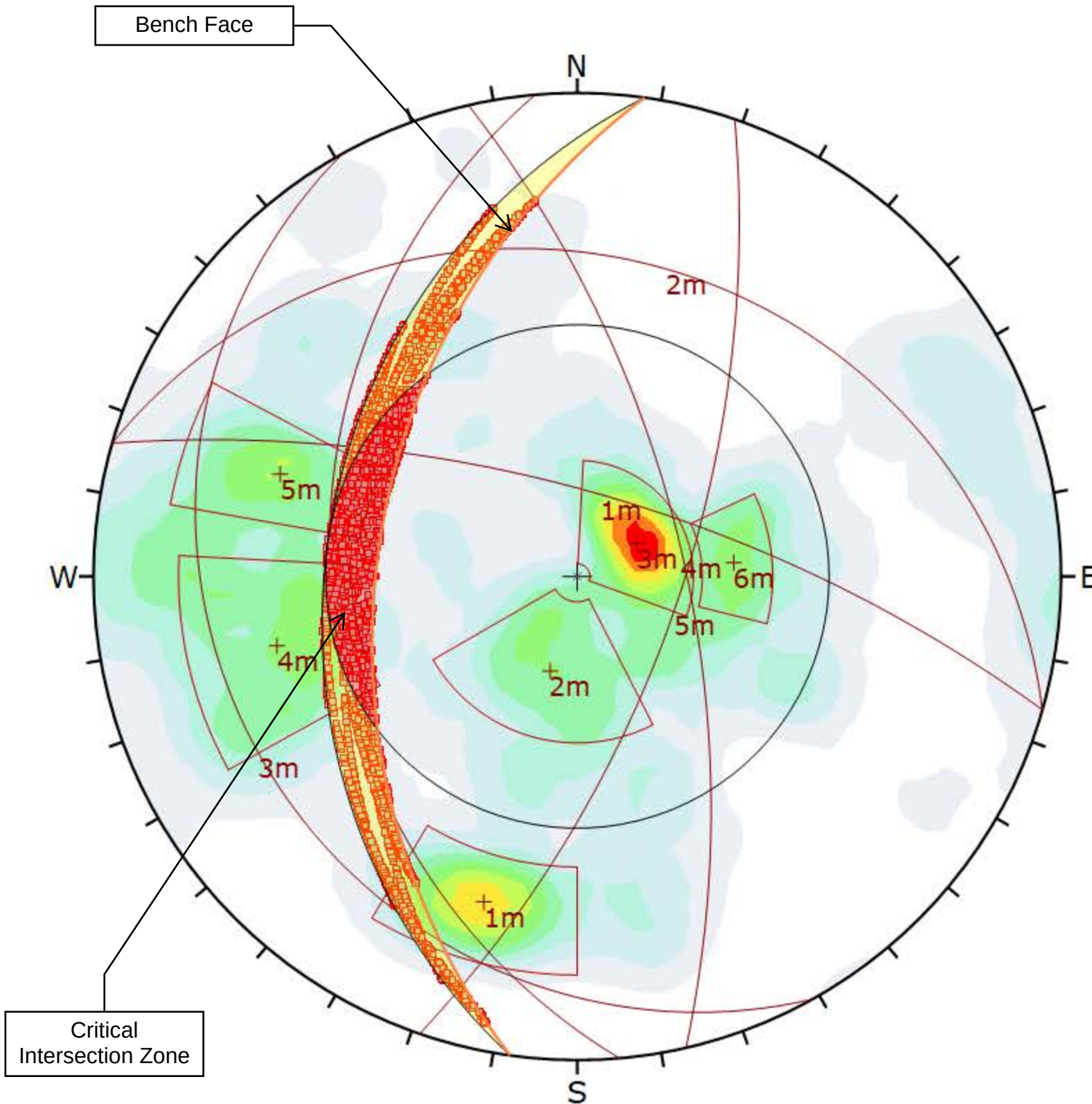
Kinematic Analysis	Direct Toppling
Slope Dip	45
Slope Dip Direction	278
Friction Angle	35°
Lateral Limits	30°

	Critical	Total	%
Direct Toppling (Intersection)	7200	161596	4.48%
Oblique Toppling (Intersection)	8856	161596	5.48%
Base Plane (All)	132	569	23.20%
Base Plane (Set 2)	17	58	29.31%
Base Plane (Set 3)	55	55	100.00%
Base Plane (Set 6)	22	24	91.67%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Wedge Failure - Point H Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

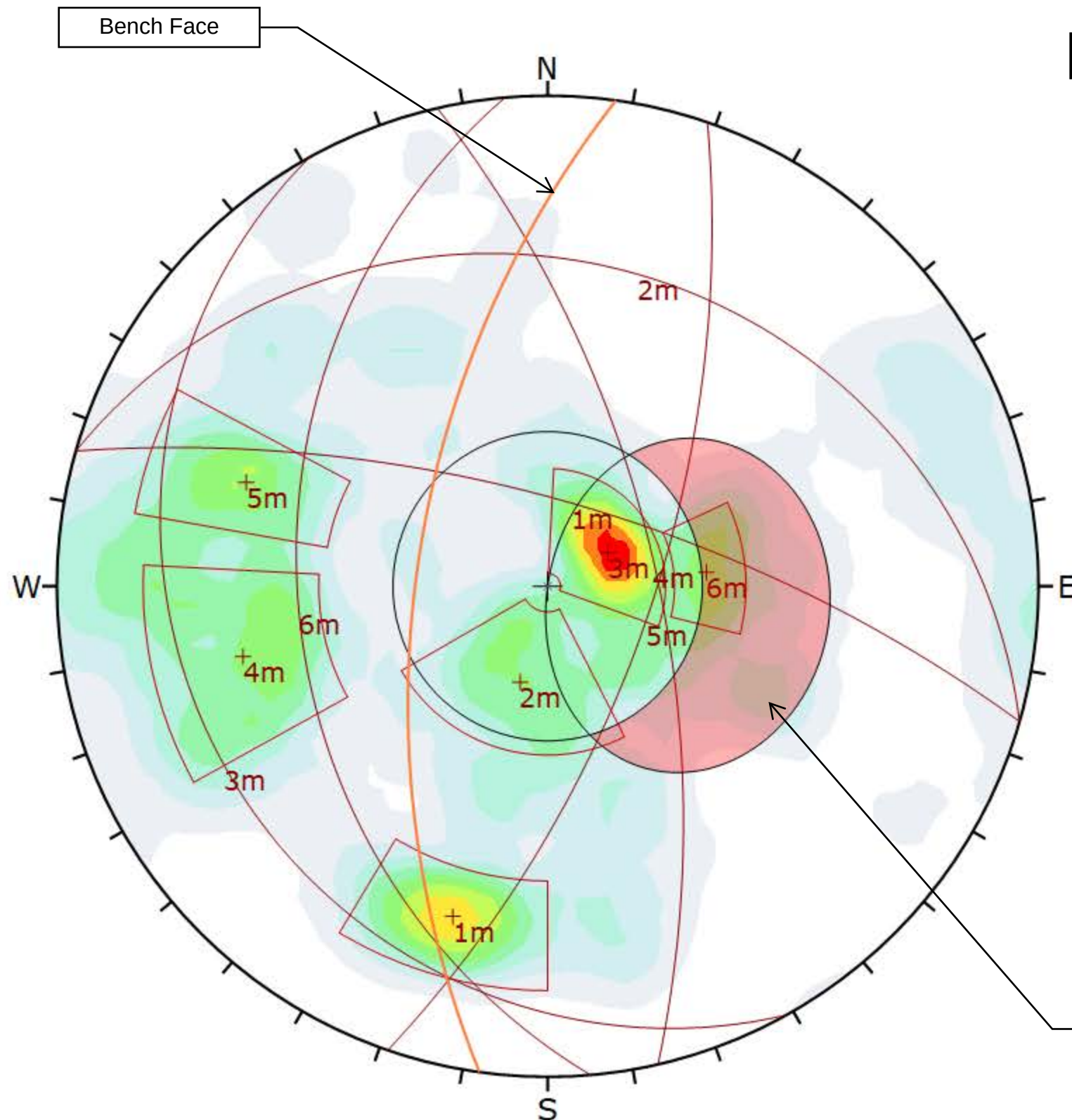
Kinematic Analysis	Wedge Sliding		
Slope Dip	45		
Slope Dip Direction	278		
Friction Angle	35°		
	Critical	Total	%
Wedge Sliding	4354	161596	2.69%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

RILEY

Drury Quarry - Sutton Block Extension

Planar (No Limits) Failure - Point I Waipapa Greywacke



Color	Density Concentrations	
	0.00	- 0.45
	0.45	- 0.90
	0.90	- 1.35
	1.35	- 1.80
	1.80	- 2.25
	2.25	- 2.70
	2.70	- 3.15
	3.15	- 3.60
	3.60	- 4.05
	4.05	- 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

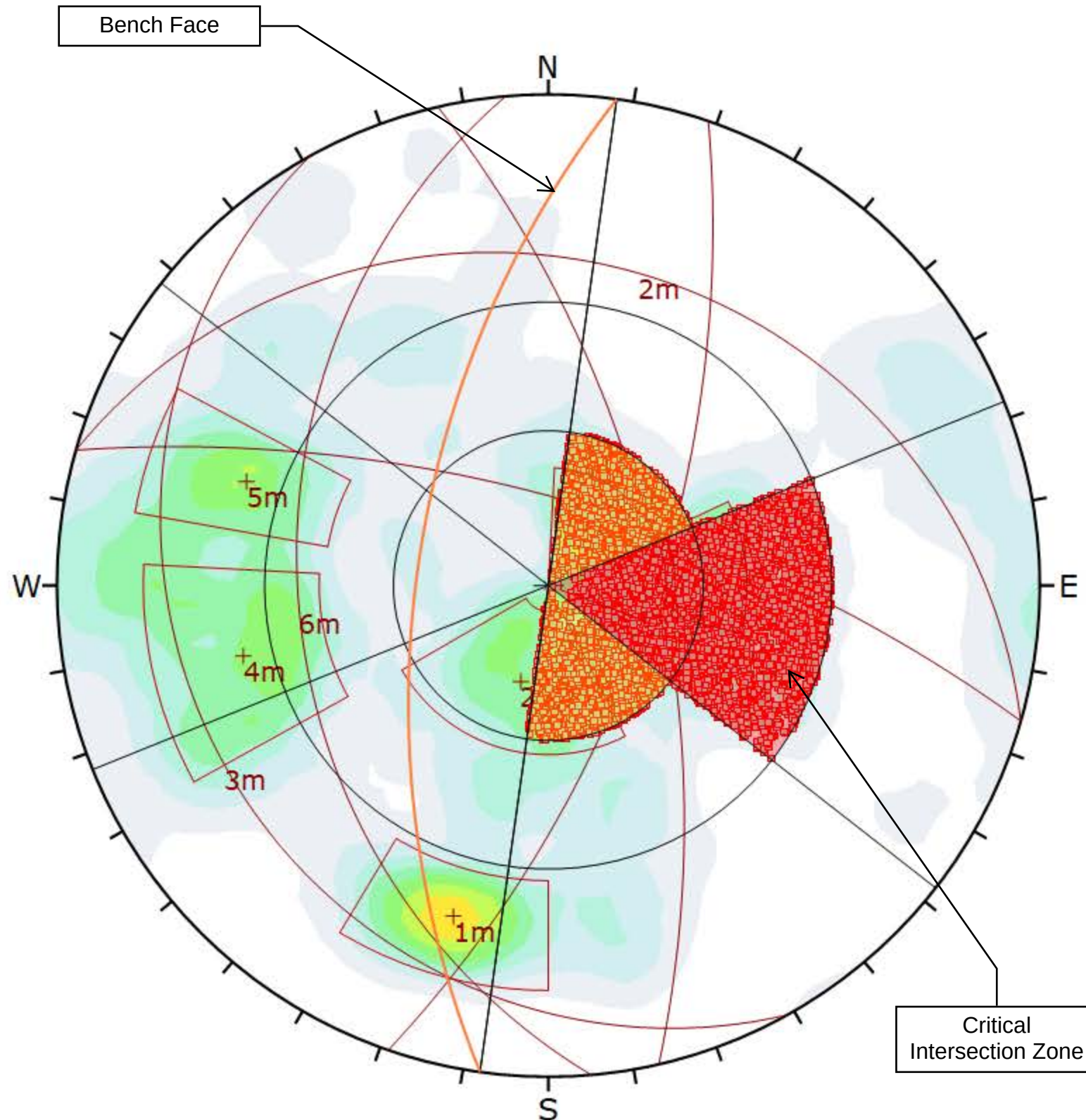
Kinematic Analysis	Planar Sliding		
Slope Dip	60		
Slope Dip Direction	278		
Friction Angle	35°		
	Critical	Total	%
Planar Sliding (All)	59	569	10.37%
Planar Sliding (Set 6)	18	24	75.00%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Hemisphere	Lower
Projection	Equal Angle

RILEY

Drury Quarry - Sutton Block Extension

Topple Failure - Point I Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

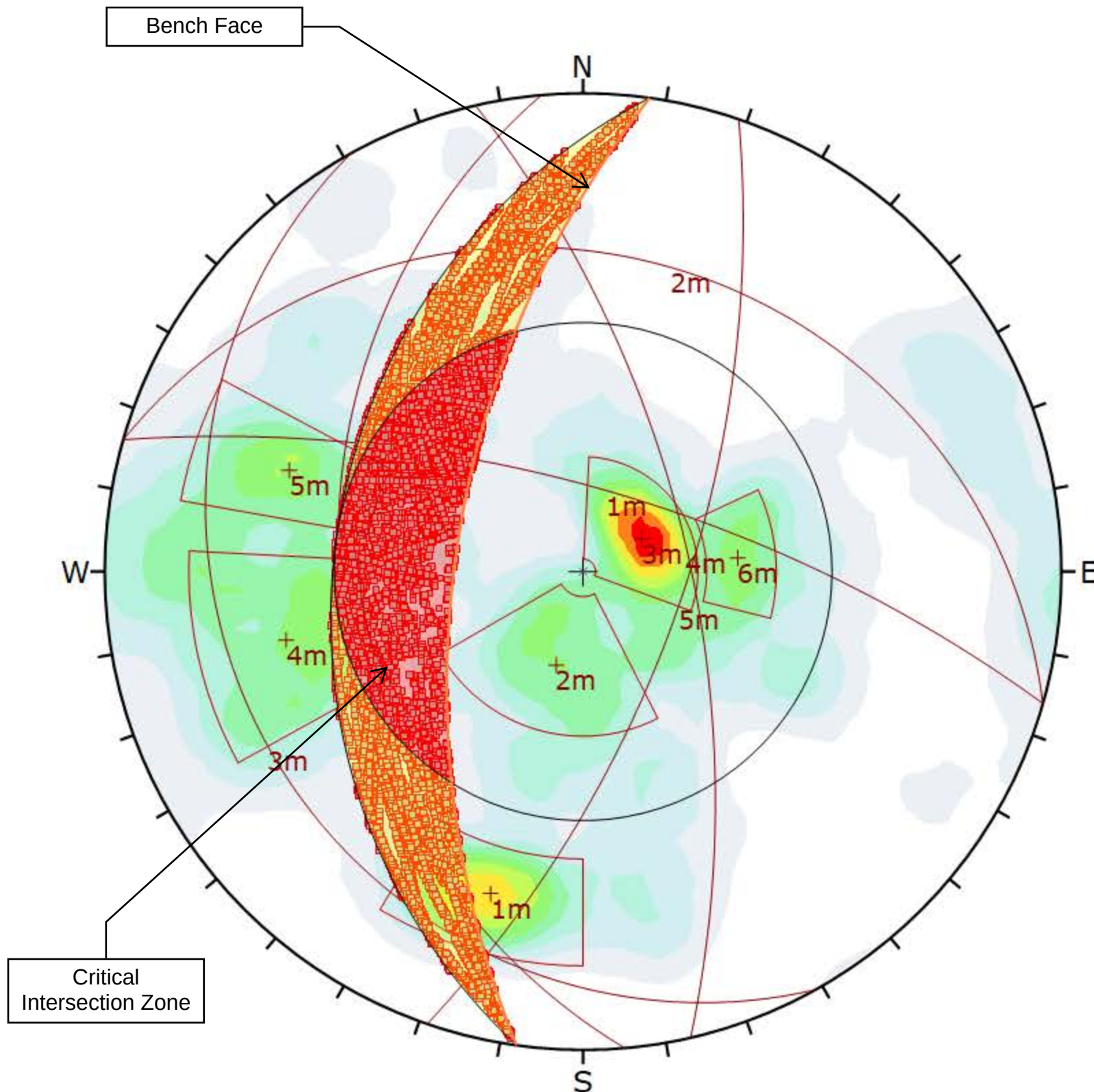
Kinematic Analysis	Direct Toppling
Slope Dip	60
Slope Dip Direction	278
Friction Angle	35°
Lateral Limits	30°

	Critical	Total	%
Direct Toppling (Intersection)	10433	161596	6.46%
Oblique Toppling (Intersection)	8856	161596	5.48%
Base Plane (All)	155	569	27.24%
Base Plane (Set 2)	17	58	29.31%
Base Plane (Set 3)	55	55	100.00%
Base Plane (Set 6)	22	24	91.67%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Wedge Failure - Point I Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

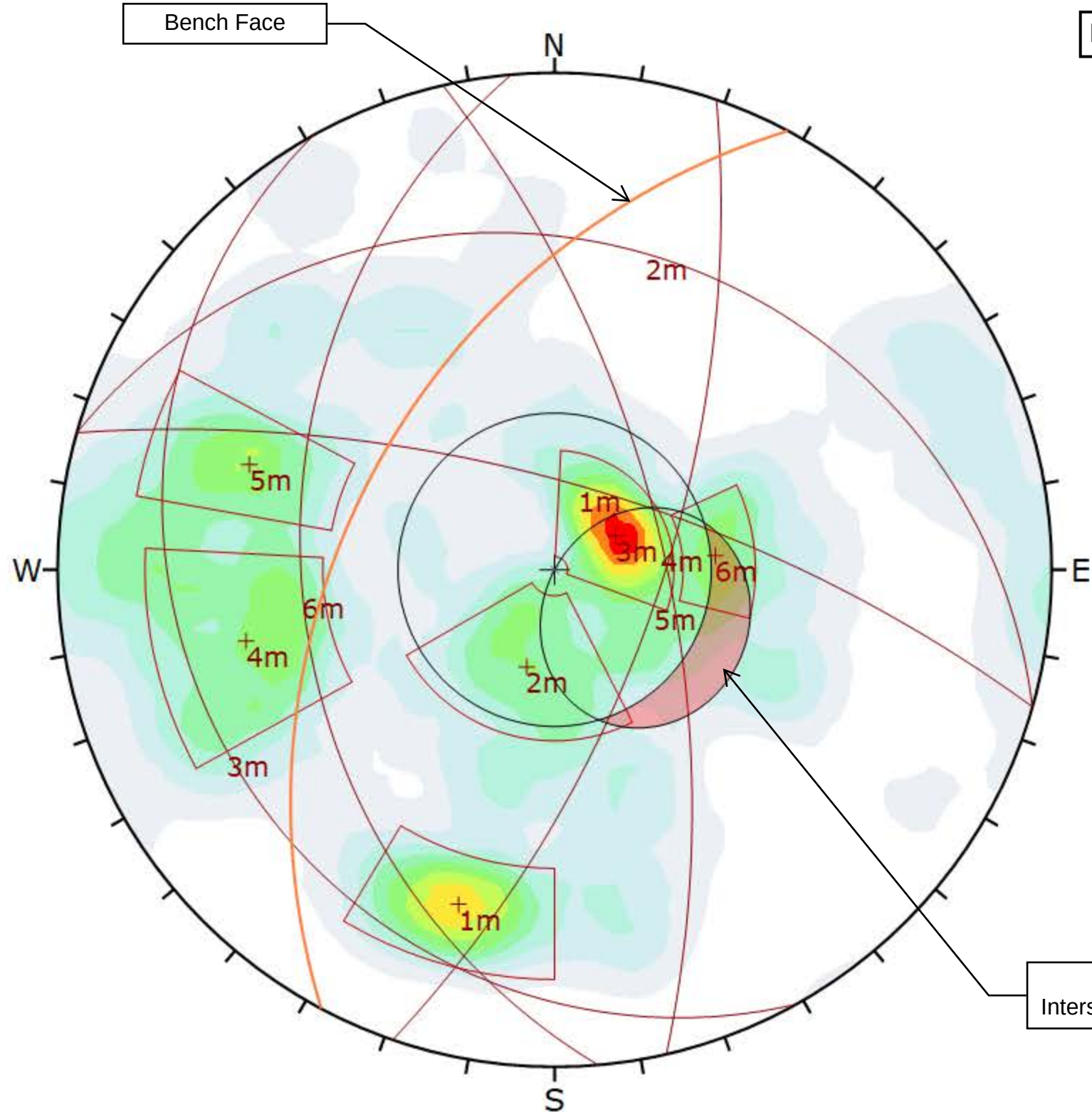
Kinematic Analysis	Wedge Sliding		
Slope Dip	60		
Slope Dip Direction	278		
Friction Angle	35°		
	Critical	Total	%
Wedge Sliding	12792	161596	7.92%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

RILEY

Drury Quarry - Sutton Block Extension

Planar (No Limits) Failure - Point J Waipapa Greywacke



Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

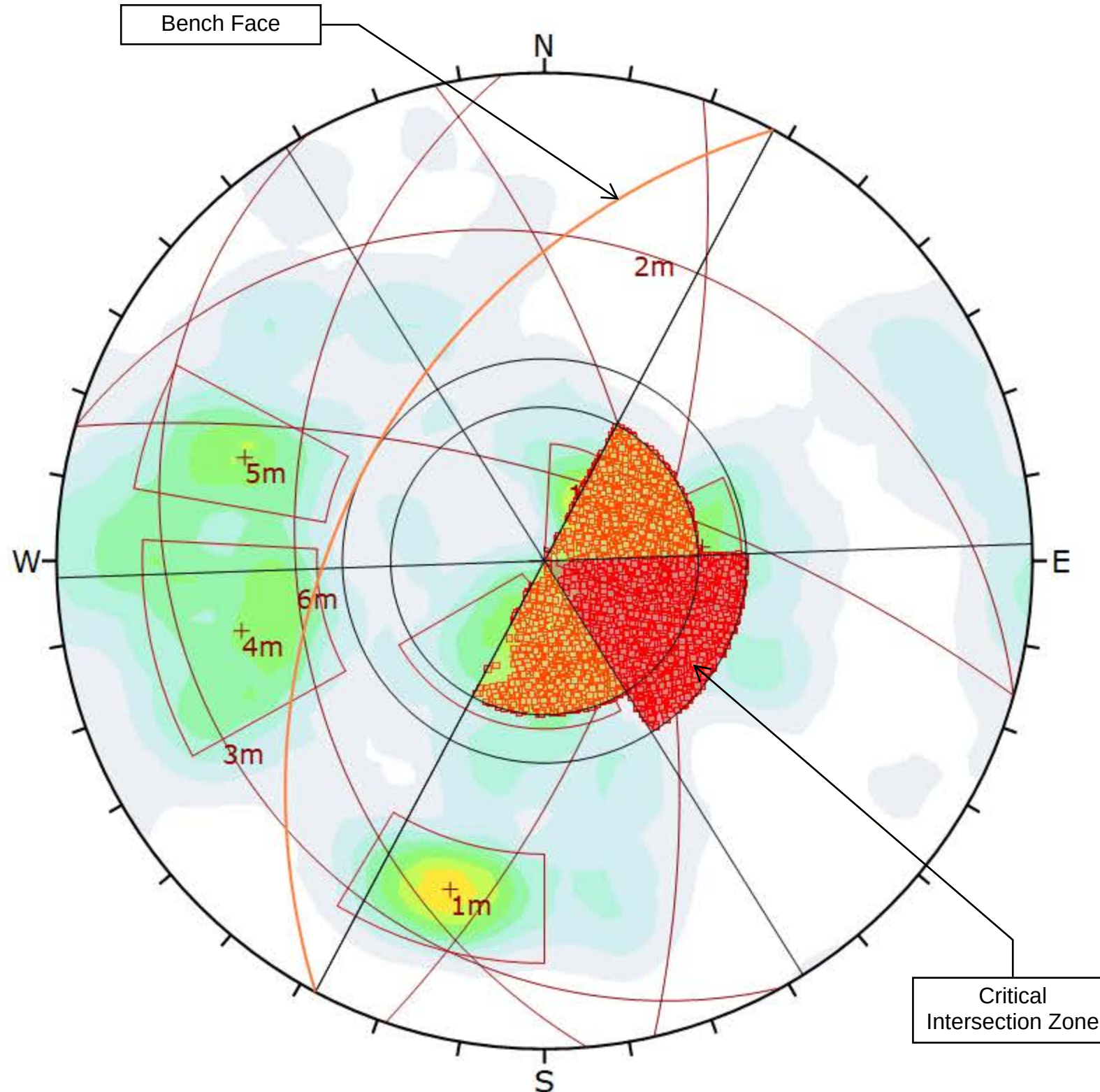
Kinematic Analysis	Planar Sliding		
Slope Dip	45		
Slope Dip Direction	298		
Friction Angle	35°		
	Critical	Total	%
Planar Sliding (All)	16	569	2.81%
Planar Sliding (Set 6)	11	24	45.83%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Hemisphere	Lower
Projection	Equal Angle

RILEY

Drury Quarry - Sutton Block Extension

Topple Failure - Point J Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

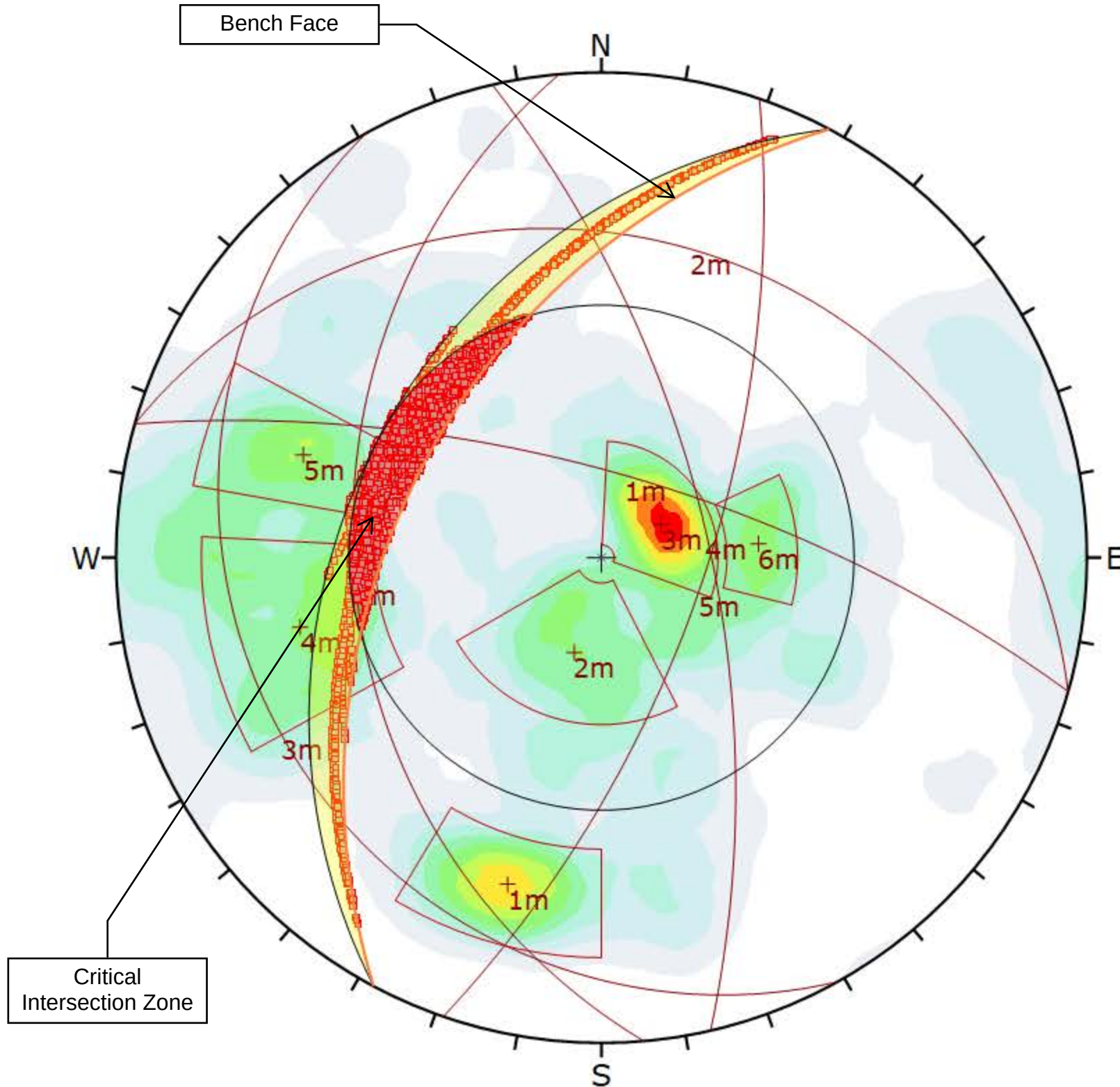
Kinematic Analysis	Direct Toppling
Slope Dip	45
Slope Dip Direction	298
Friction Angle	35°
Lateral Limits	30°

	Critical	Total	%
Direct Toppling (Intersection)	5522	161596	3.42%
Oblique Toppling (Intersection)	8610	161596	5.33%
Base Plane (All)	127	569	22.32%
Base Plane (Set 2)	29	58	50.00%
Base Plane (Set 3)	45	55	81.82%
Base Plane (Set 6)	14	24	58.33%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Wedge Failure - Point J Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

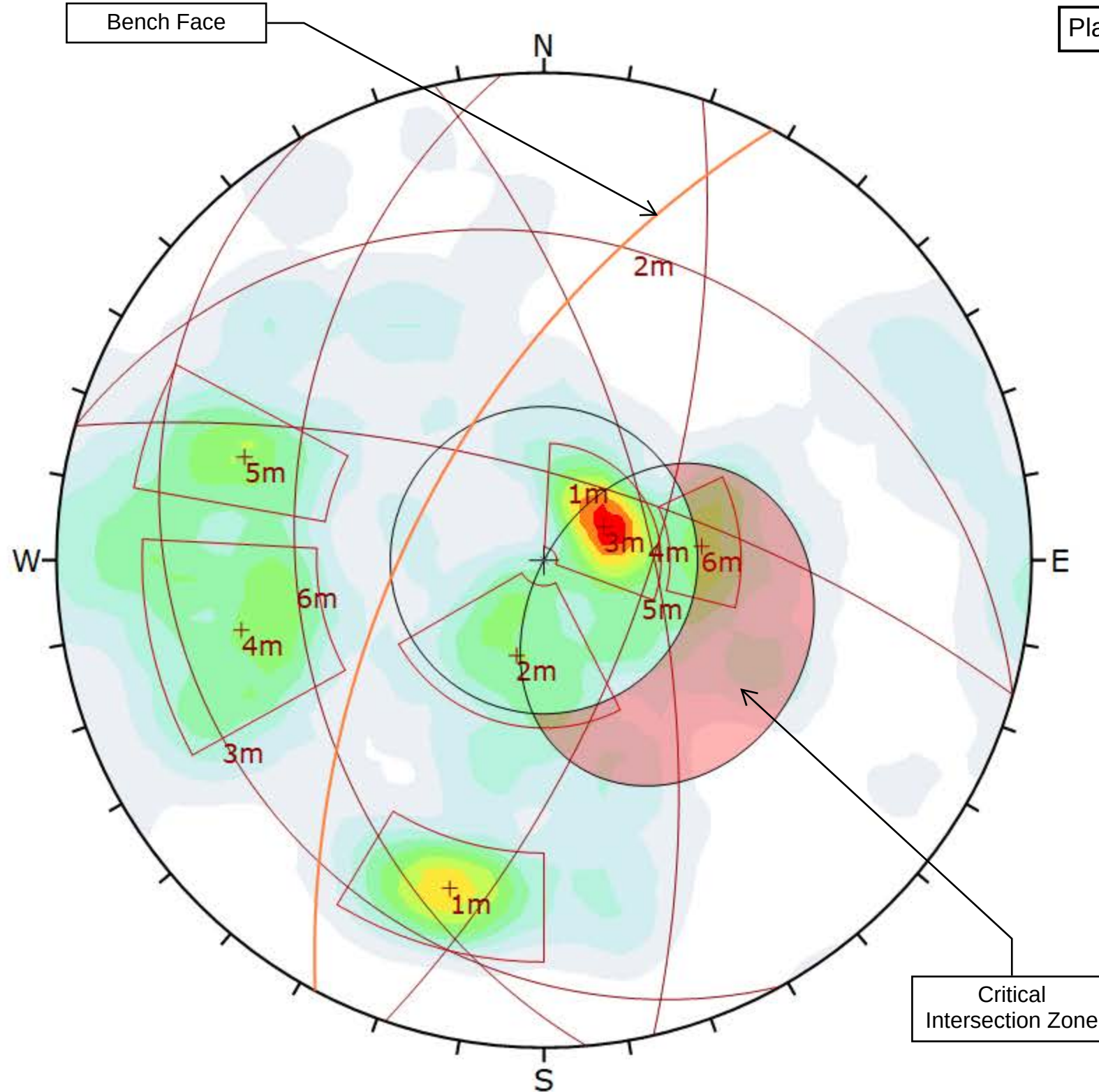
Kinematic Analysis	Wedge Sliding		
Slope Dip	45		
Slope Dip Direction	298		
Friction Angle	35°		
	Critical	Total	%
Wedge Sliding	4049	161596	2.51%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

RILEY

Drury Quarry - Sutton Block Extension

Planar (No Limits) Failure - Point K Waipapa Greywacke

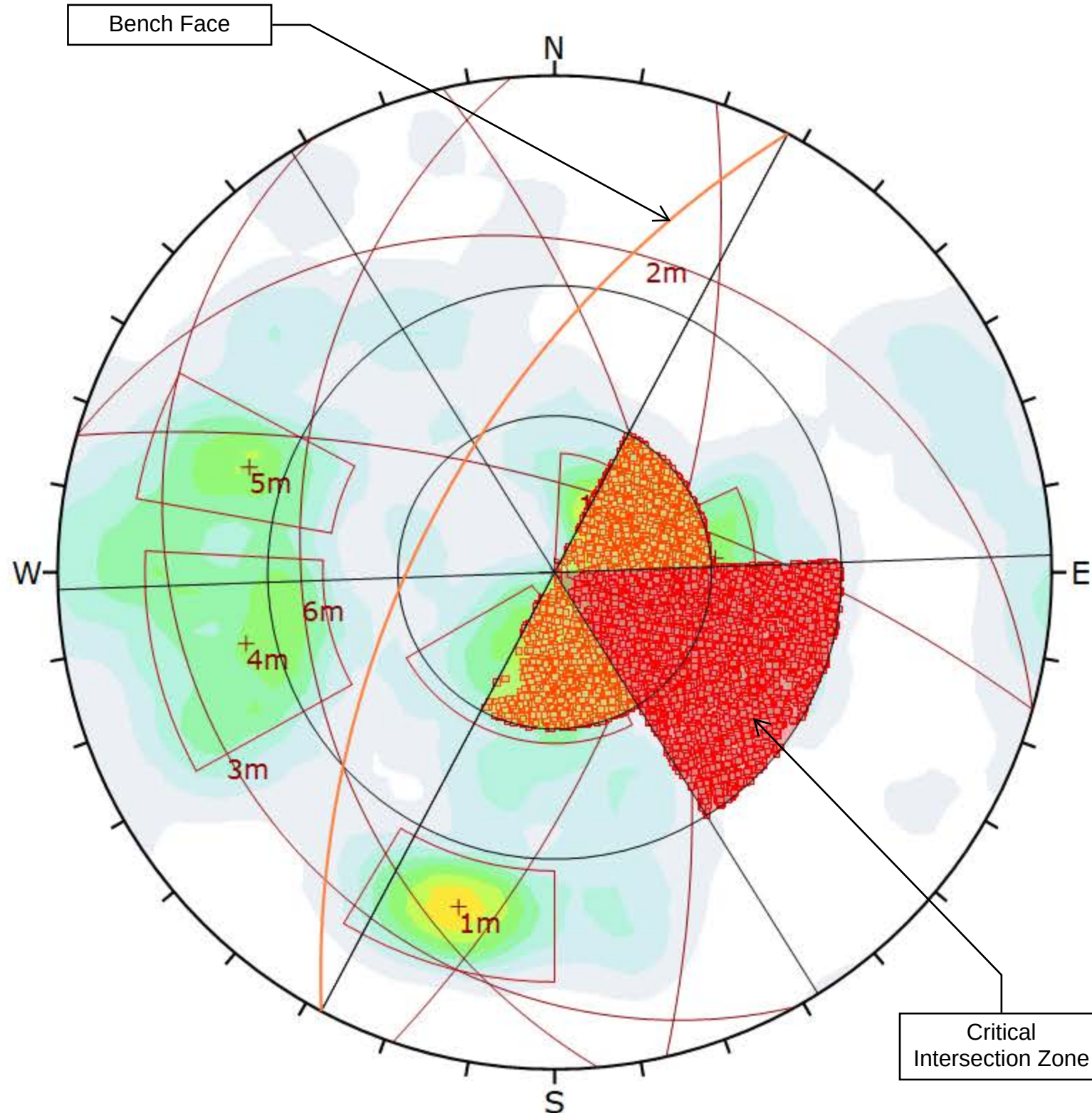


Color	Density Concentrations			
	0.00	-	0.45	
	0.45	-	0.90	
	0.90	-	1.35	
	1.35	-	1.80	
	1.80	-	2.25	
	2.25	-	2.70	
	2.70	-	3.15	
	3.15	-	3.60	
	3.60	-	4.05	
	4.05	-	4.50	
Contour Data		Pole Vectors		
Maximum Density		4.29%		
Contour Distribution		Fisher		
Counting Circle Size		1.0%		
Kinematic Analysis		Planar Sliding		
Slope Dip		60		
Slope Dip Direction		298		
Friction Angle		35°		
		Critical	Total	%
Planar Sliding (All)		61	569	10.72%
Planar Sliding (Set 2)		4	58	6.90%
Planar Sliding (Set 6)		18	24	75.00%
Plot Mode		Pole Vectors		
Vector Count		569 (569 Entries)		
Hemisphere		Lower		
Projection		Equal Angle		



Drury Quarry - Sutton Block Extension

Topple Failure - Point K Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

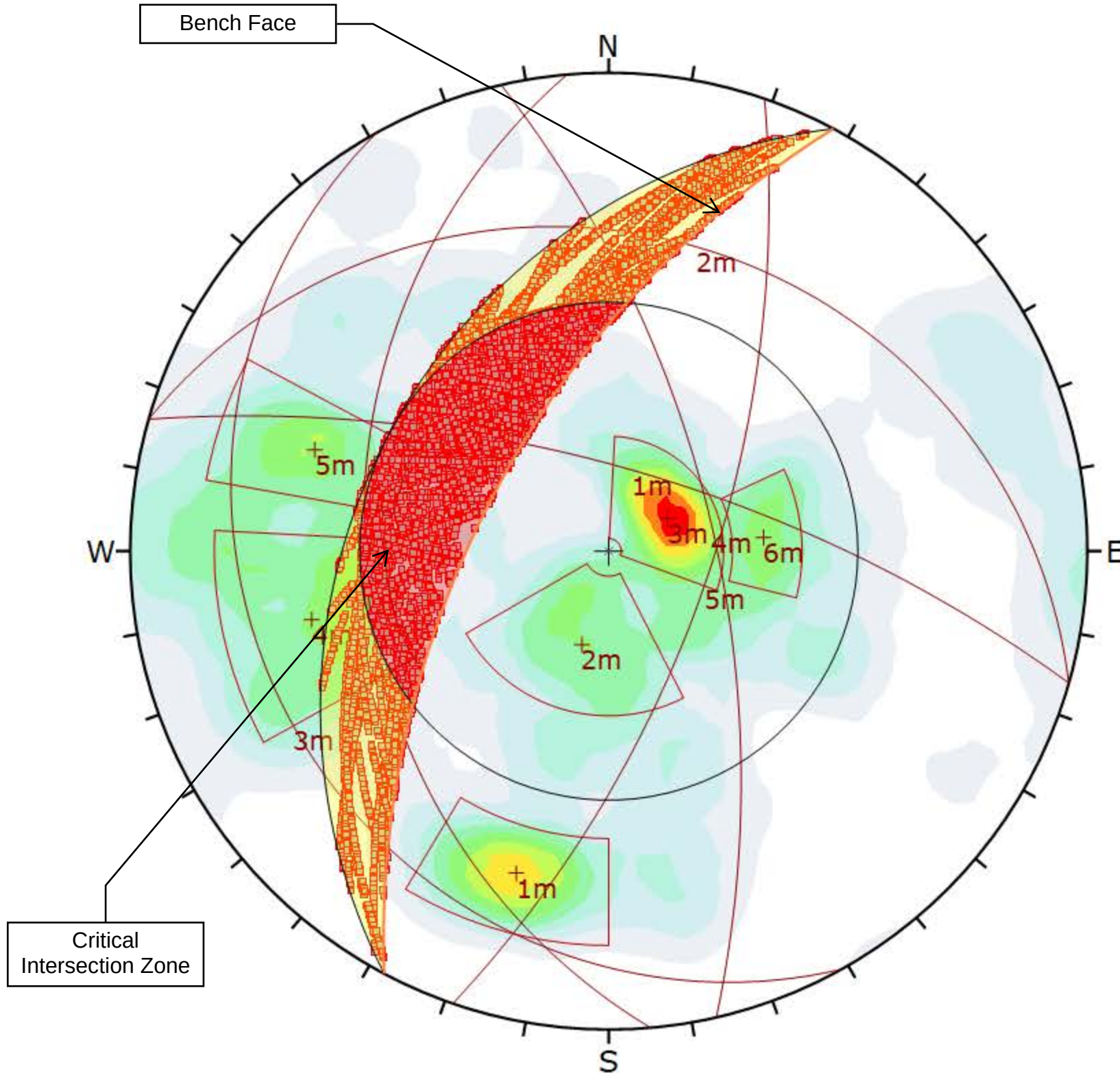
Kinematic Analysis	Direct Toppling
Slope Dip	60
Slope Dip Direction	298
Friction Angle	35°
Lateral Limits	30°

	Critical	Total	%
Direct Toppling (Intersection)	8246	161596	5.10%
Oblique Toppling (Intersection)	8610	161596	5.33%
Base Plane (All)	146	569	25.66%
Base Plane (Set 2)	29	58	50.00%
Base Plane (Set 3)	45	55	81.82%
Base Plane (Set 6)	14	24	58.33%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Wedge Failure - Point K Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

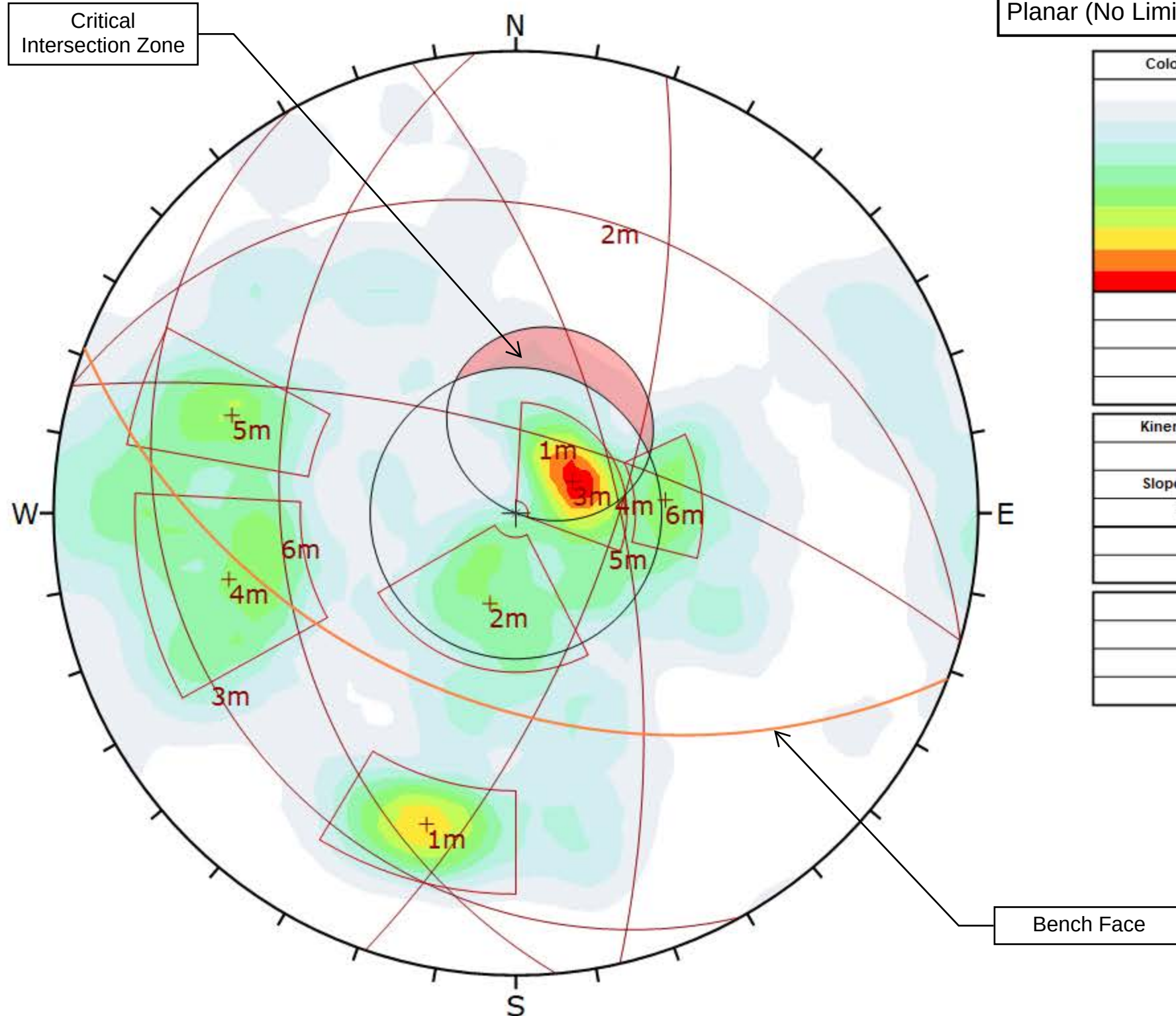
Kinematic Analysis	Wedge Sliding
Slope Dip	60
Slope Dip Direction	298
Friction Angle	35°

	Critical	Total	%
Wedge Sliding	13415	161596	8.30%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Planar (No Limits) Failure - Point L Waipapa Greywacke



Color	Density Concentrations		
	0.00	-	0.45
	0.45	-	0.90
	0.90	-	1.35
	1.35	-	1.80
	1.80	-	2.25
	2.25	-	2.70
	2.70	-	3.15
	3.15	-	3.60
	3.60	-	4.05
	4.05	-	4.50
Contour Data		Pole Vectors	
Maximum Density		4.29%	
Contour Distribution		Fisher	
Counting Circle Size		1.0%	

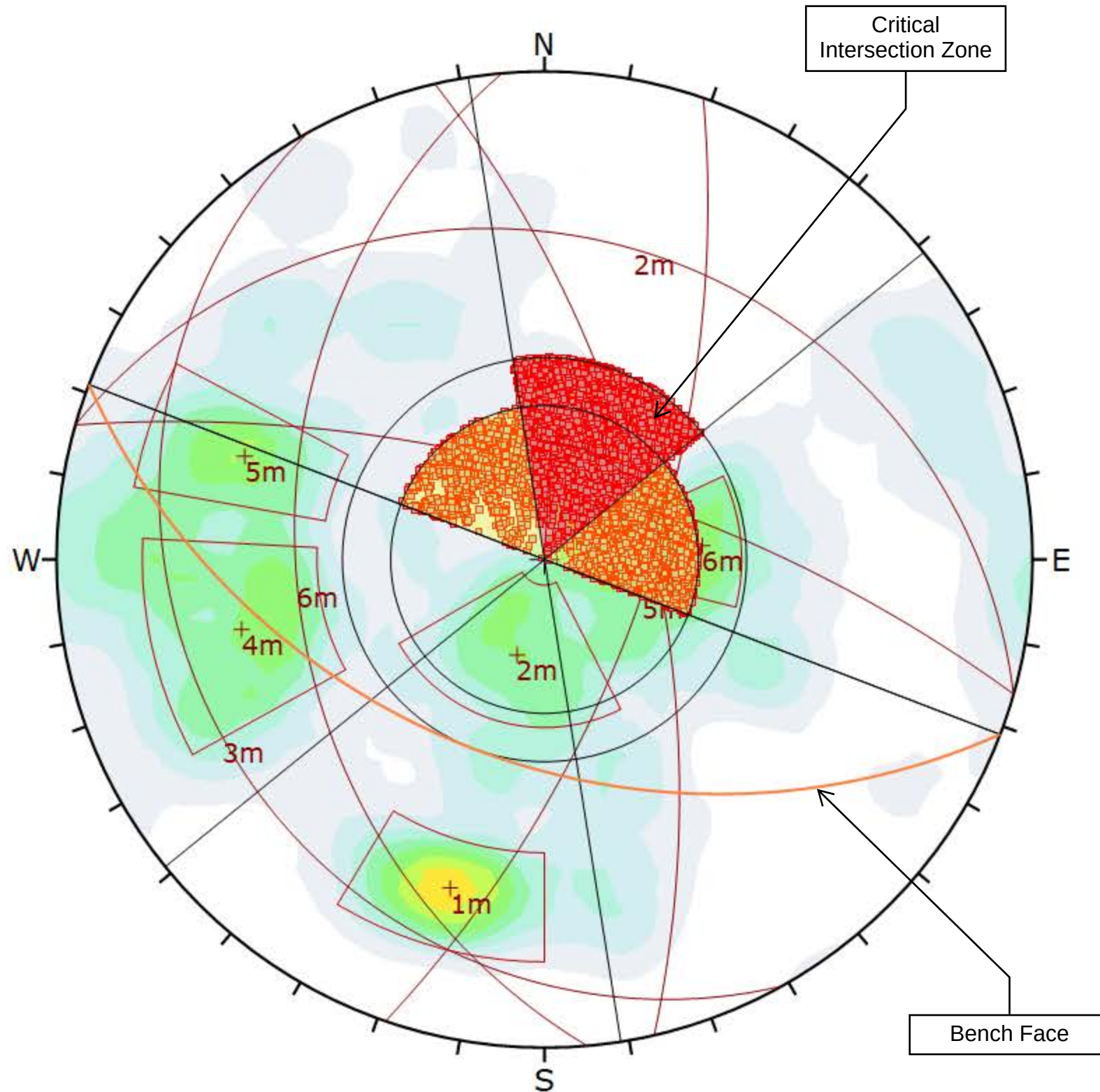
Kinematic Analysis	Planar Sliding		
Slope Dip	45		
Slope Dip Direction	201		
Friction Angle	35°		
	Critical	Total	%
Planar Sliding (All)	6	569	1.05%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Hemisphere	Lower
Projection	Equal Angle

RILEY

Drury Quarry - Sutton Block Extension

Topple Failure - Point L Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Direct Toppling
Slope Dip	45
Slope Dip Direction	201
Friction Angle	35°
Lateral Limits	30°

	Critical	Total	%
Direct Toppling (Intersection)	8153	161596	5.05%
Oblique Toppling (Intersection)	7650	161596	4.73%
Base Plane (All)	96	569	16.87%
Base Plane (Set 3)	55	55	100.00%
Base Plane (Set 6)	6	24	25.00%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Wedge Failure - Point L Waipapa Greywacke

Symbol	Feature
■	Critical Intersection

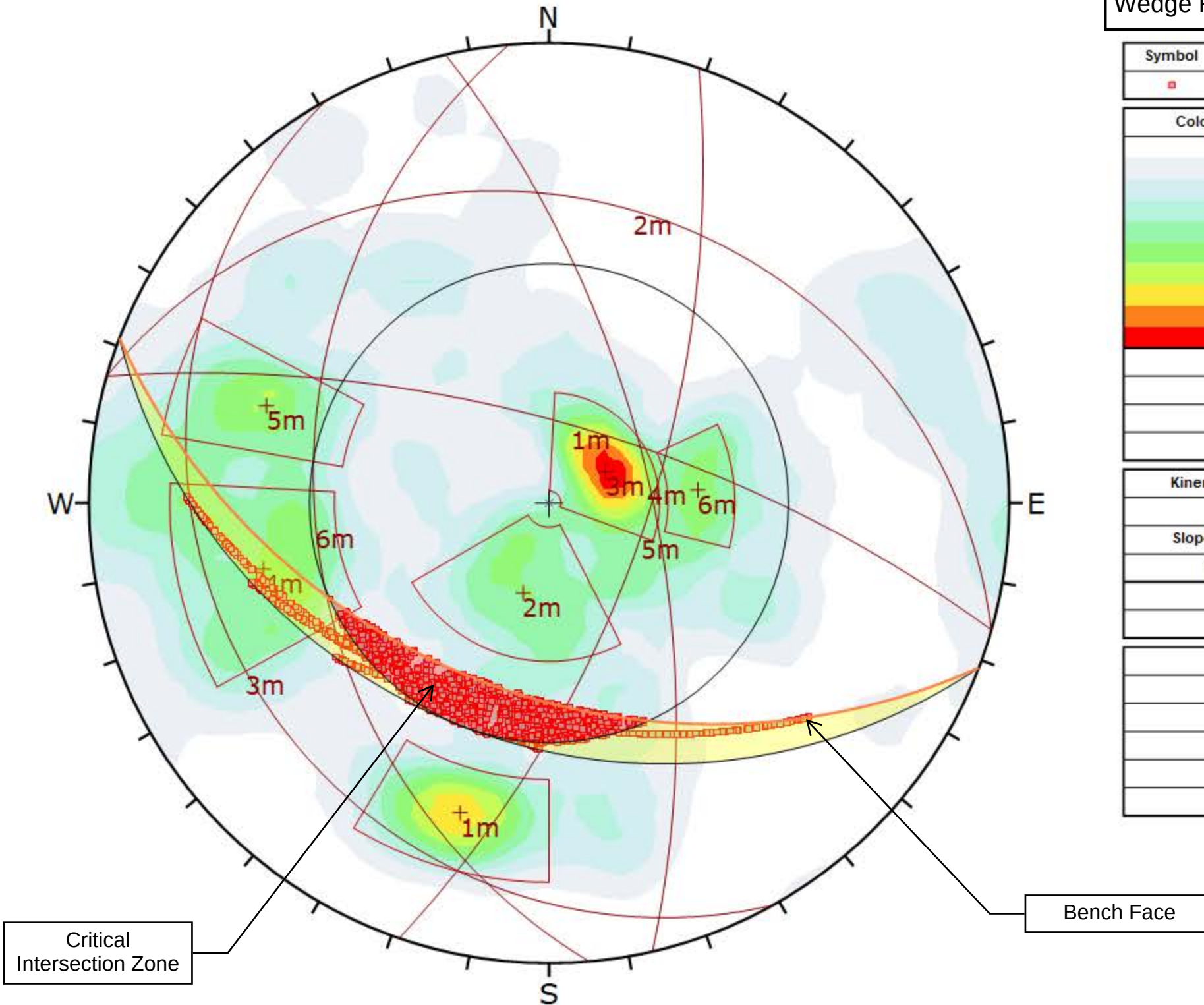
Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding
Slope Dip	45
Slope Dip Direction	201
Friction Angle	35°

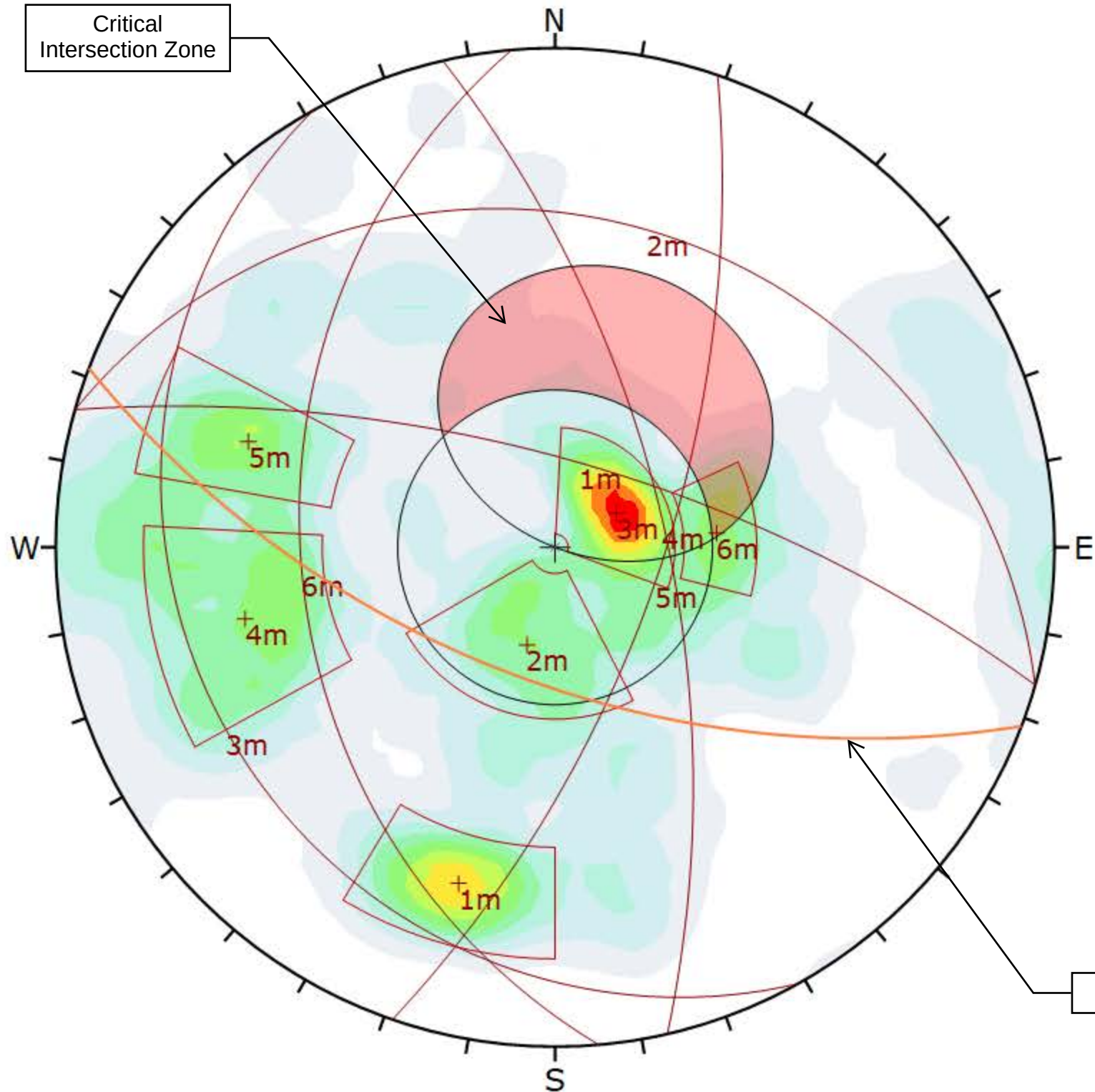
	Critical	Total	%
Wedge Sliding	2639	161596	1.63%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle



Drury Quarry - Sutton Block Extension

Planar (No Limits) Failure - Point M Waipapa Greywacke



Color	Density Concentrations	
	0.00	- 0.45
	0.45	- 0.90
	0.90	- 1.35
	1.35	- 1.80
	1.80	- 2.25
	2.25	- 2.70
	2.70	- 3.15
	3.15	- 3.60
	3.60	- 4.05
	4.05	- 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

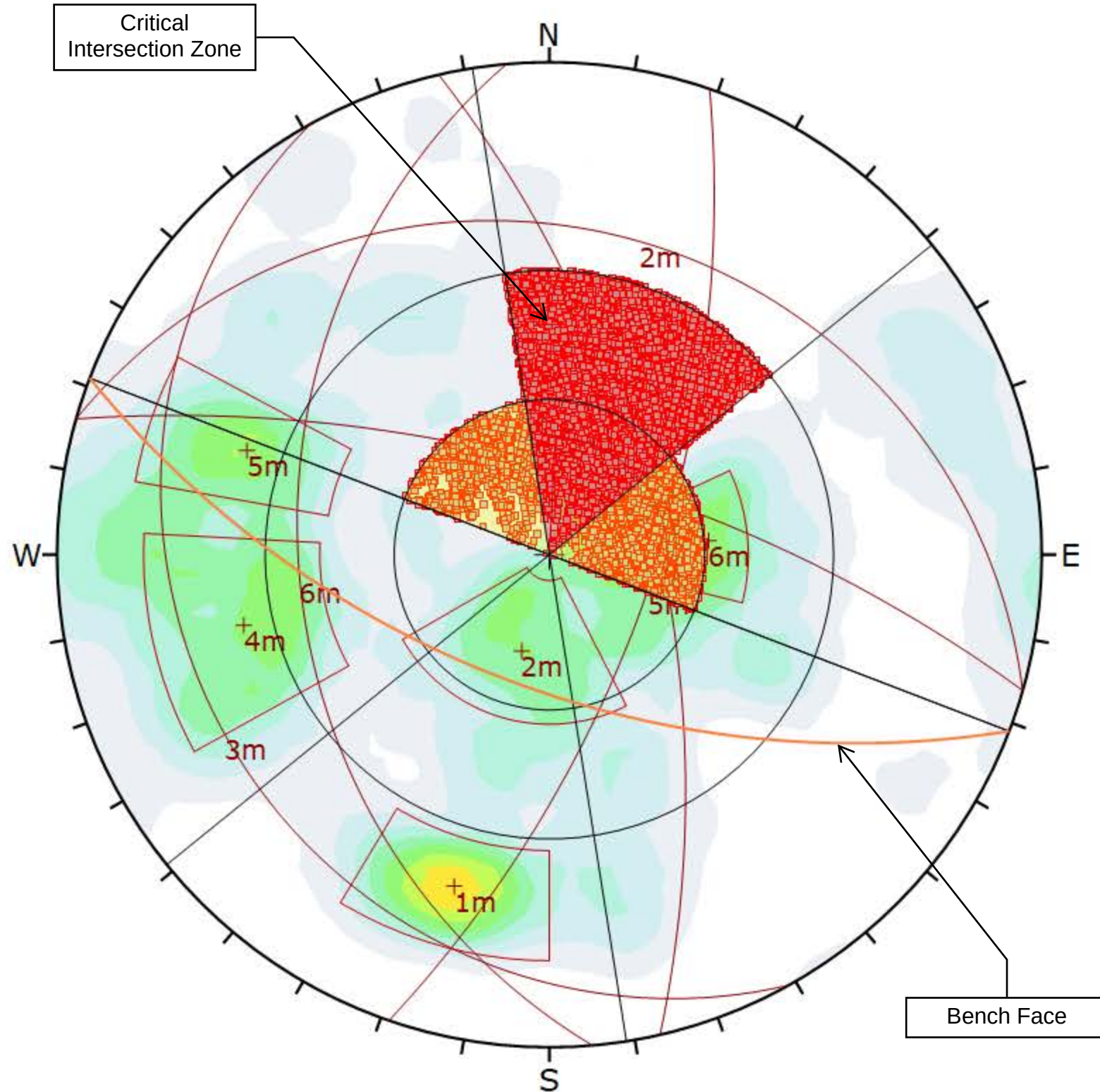
Kinematic Analysis	Planar Sliding		
Slope Dip	60		
Slope Dip Direction	201		
Friction Angle	35°		
	Critical	Total	%
Planar Sliding (All)	29	569	5.10%
Planar Sliding (Set 6)	9	24	37.50%

Plot Mode	Pole Vectors	
Vector Count	569 (569 Entries)	
Hemisphere	Lower	
Projection	Equal Angle	

RILEY

Drury Quarry - Sutton Block Extension

Topple Failure - Point M Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

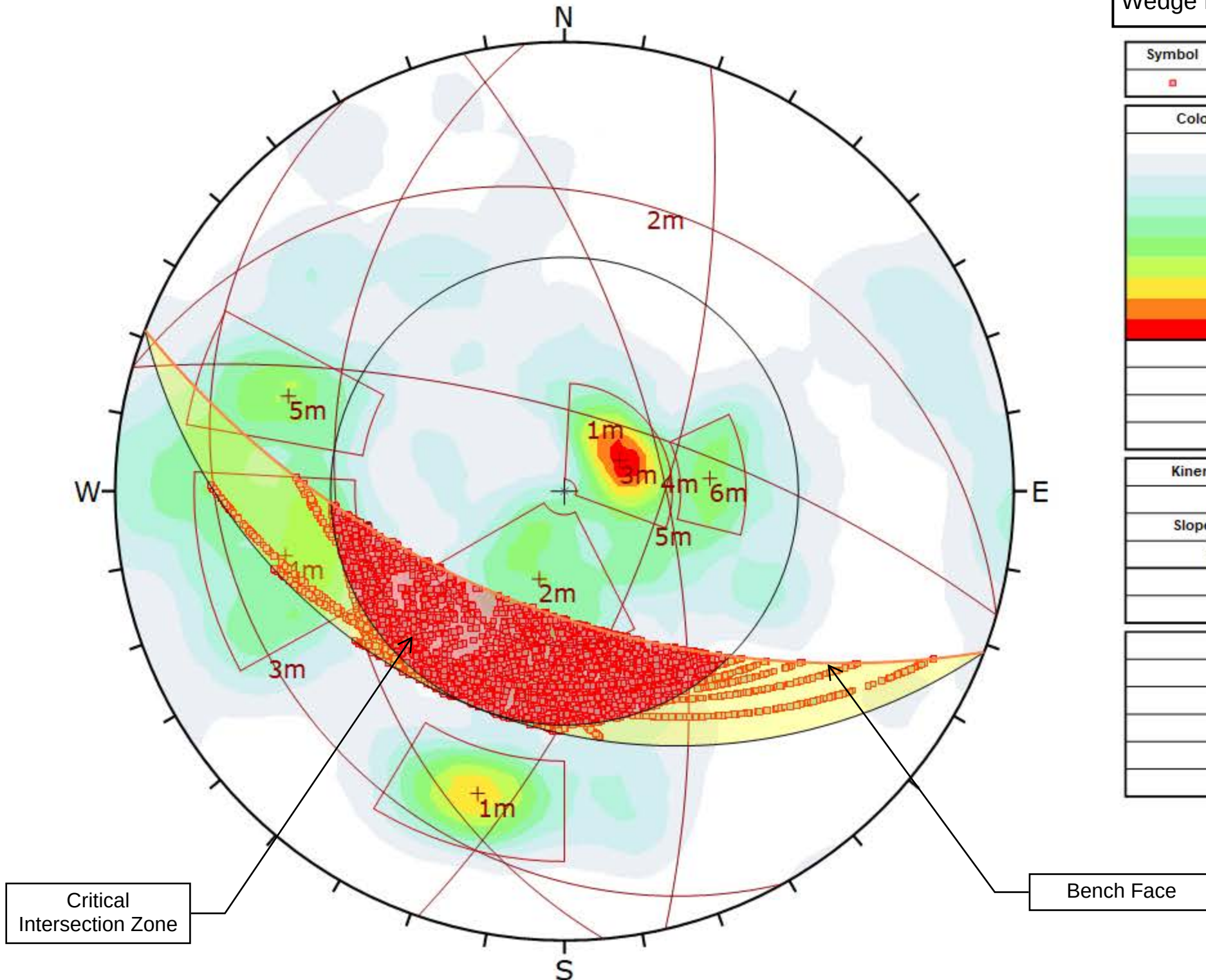
Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Direct Toppling		
Slope Dip	60		
Slope Dip Direction	201		
Friction Angle	35°		
Lateral Limits	30°		
	Critical	Total	%
Direct Toppling (Intersection)	15086	161596	9.34%
Oblique Toppling (Intersection)	7650	161596	4.73%
Base Plane (All)	98	569	17.22%
Base Plane (Set 3)	55	55	100.00%
Base Plane (Set 6)	6	24	25.00%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Wedge Failure - Point M Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

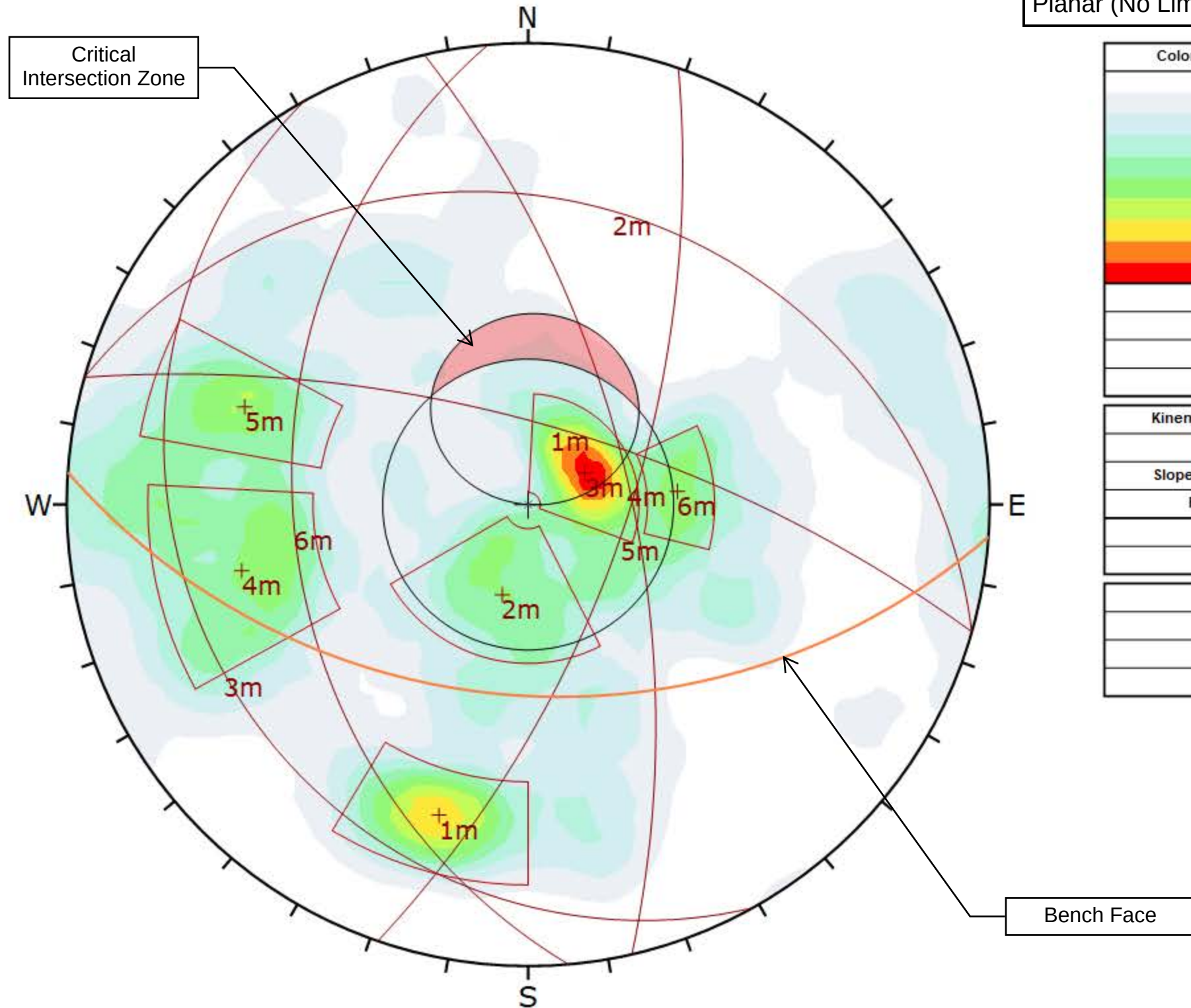
Kinematic Analysis	Wedge Sliding		
Slope Dip	60		
Slope Dip Direction	201		
Friction Angle	35°		
	Critical	Total	%
Wedge Sliding	6827	161596	4.22%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

RILEY

Drury Quarry - Sutton Block Extension

Planar (No Limits) Failure - Point N Waipapa Greywacke



Color	Density Concentrations	
	0.00	- 0.45
	0.45	- 0.90
	0.90	- 1.35
	1.35	- 1.80
	1.80	- 2.25
	2.25	- 2.70
	2.70	- 3.15
	3.15	- 3.60
	3.60	- 4.05
	4.05	- 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

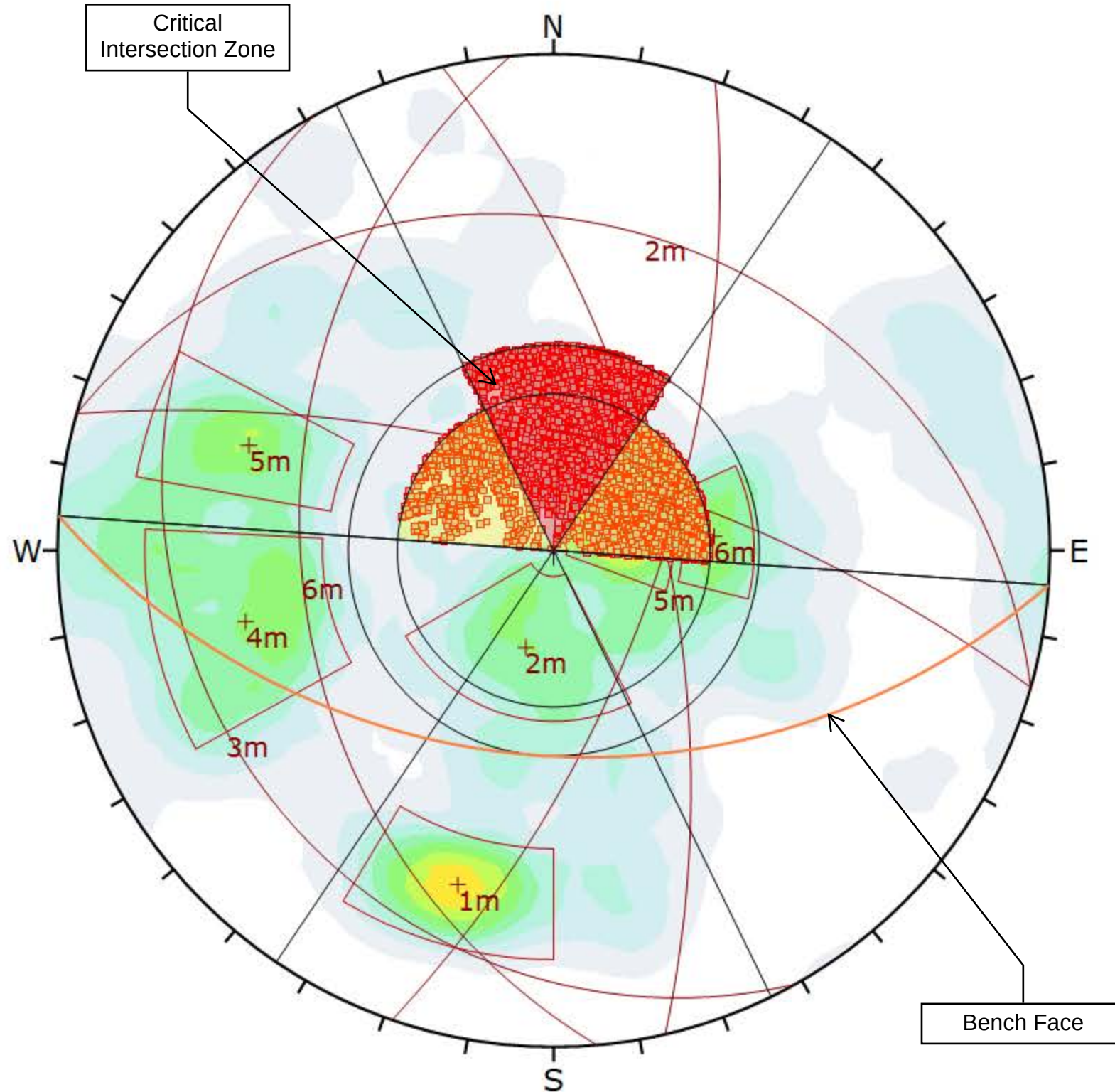
Kinematic Analysis	Planar Sliding		
Slope Dip	45		
Slope Dip Direction	184		
Friction Angle	35°		
	Critical	Total	%
Planar Sliding (All)	7	569	1.23%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Hemisphere	Lower
Projection	Equal Angle

RILEY

Drury Quarry - Sutton Block Extension

Topples Failure - Point N Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

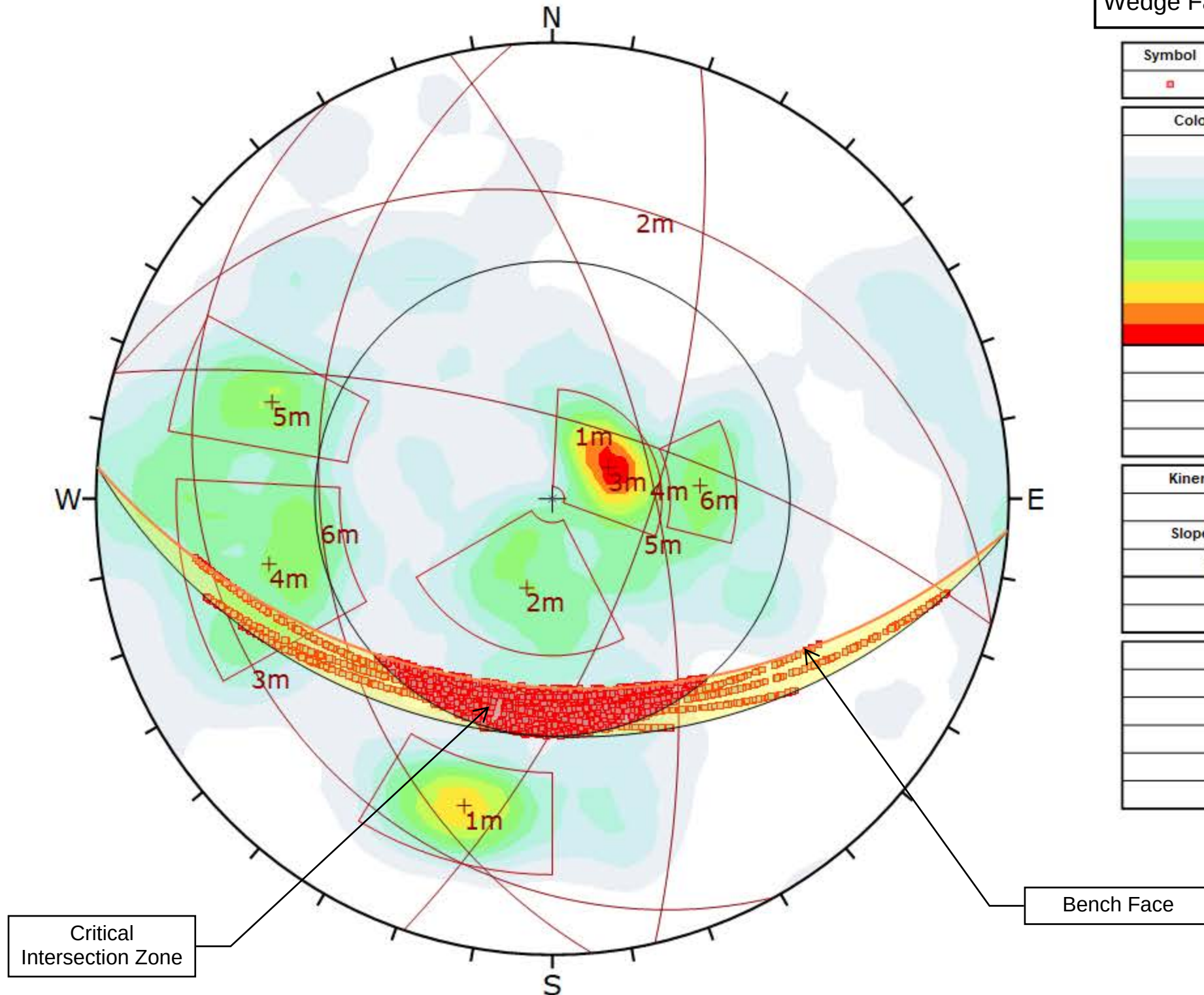
Kinematic Analysis	Direct Toppling
Slope Dip	45
Slope Dip Direction	184
Friction Angle	35°
Lateral Limits	30°

	Critical	Total	%
Direct Toppling (Intersection)	6685	161596	4.14%
Oblique Toppling (Intersection)	7956	161596	4.92%
Base Plane (All)	88	569	15.47%
Base Plane (Set 3)	46	55	83.64%
Base Plane (Set 6)	3	24	12.50%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Wedge Failure - Point N Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding
Slope Dip	45
Slope Dip Direction	184
Friction Angle	35°

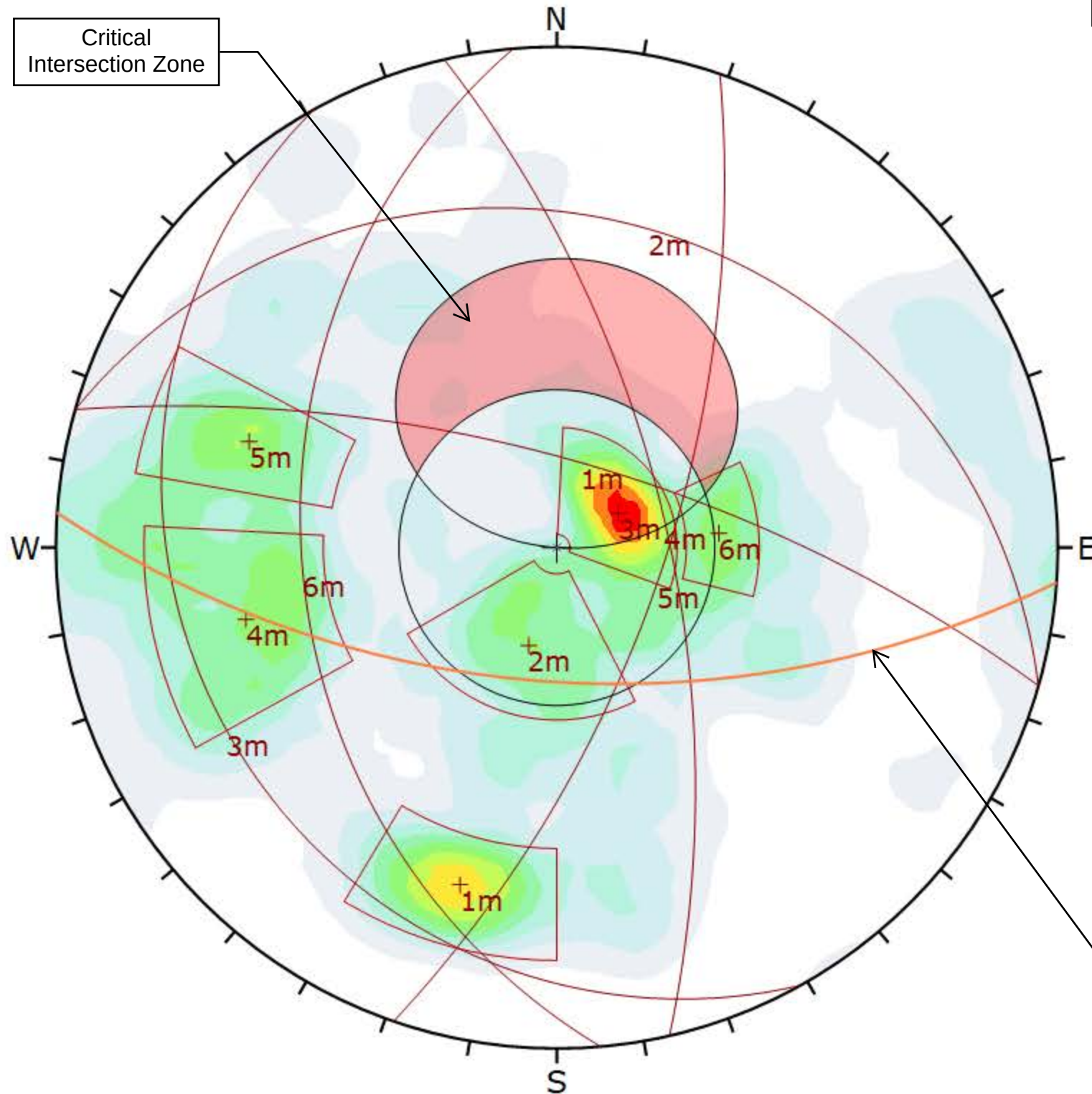
	Critical	Total	%
Wedge Sliding	3332	161596	2.06%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

RILEY

Drury Quarry - Sutton Block Extension

Planar (No Limits) Failure - Point O Waipapa Greywacke



Color	Density Concentrations	
	0.00	- 0.45
	0.45	- 0.90
	0.90	- 1.35
	1.35	- 1.80
	1.80	- 2.25
	2.25	- 2.70
	2.70	- 3.15
	3.15	- 3.60
	3.60	- 4.05
	4.05	- 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

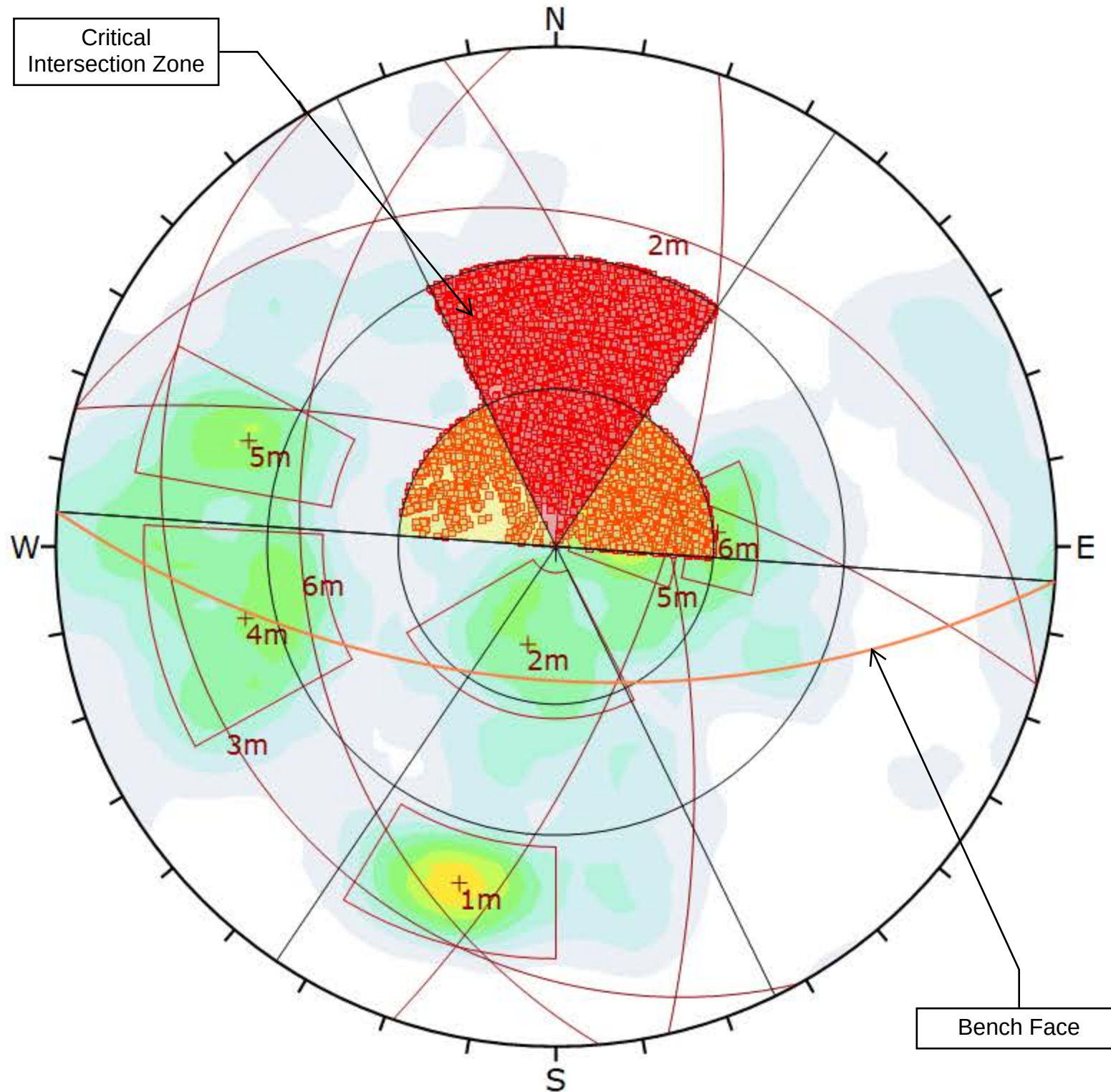
Kinematic Analysis	Planar Sliding		
Slope Dip	60		
Slope Dip Direction	184		
Friction Angle	35°		
	Critical	Total	%
Planar Sliding (All)	20	569	3.51%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Hemisphere	Lower
Projection	Equal Angle

RILEY

Drury Quarry - Sutton Block Extension

Topple Failure - Point O Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

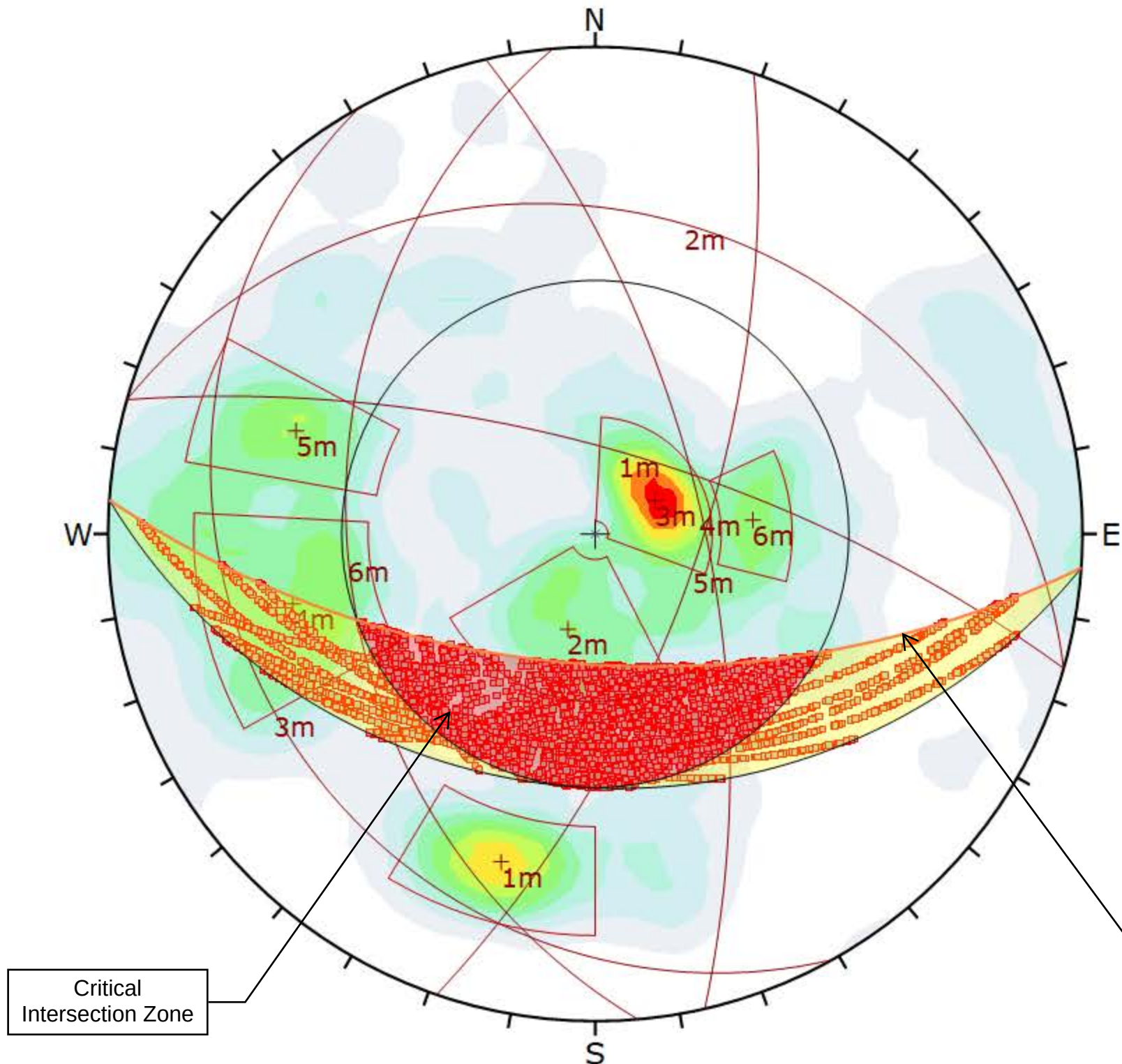
Kinematic Analysis	Direct Toppling
Slope Dip	60
Slope Dip Direction	184
Friction Angle	35°
Lateral Limits	30°

	Critical	Total	%
Direct Toppling (Intersection)	13443	161596	8.32%
Oblique Toppling (Intersection)	7956	161596	4.92%
Base Plane (All)	93	569	16.34%
Base Plane (Set 3)	46	55	83.64%
Base Plane (Set 6)	3	24	12.50%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

Drury Quarry - Sutton Block Extension

Wedge Failure - Point O Waipapa Greywacke



Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 0.45
	0.45 - 0.90
	0.90 - 1.35
	1.35 - 1.80
	1.80 - 2.25
	2.25 - 2.70
	2.70 - 3.15
	3.15 - 3.60
	3.60 - 4.05
	4.05 - 4.50

Contour Data	Pole Vectors
Maximum Density	4.29%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding		
Slope Dip	60		
Slope Dip Direction	184		
Friction Angle	35°		
	Critical	Total	%
Wedge Sliding	8136	161596	5.03%

Plot Mode	Pole Vectors
Vector Count	569 (569 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	161596
Hemisphere	Lower
Projection	Equal Angle

RILEY

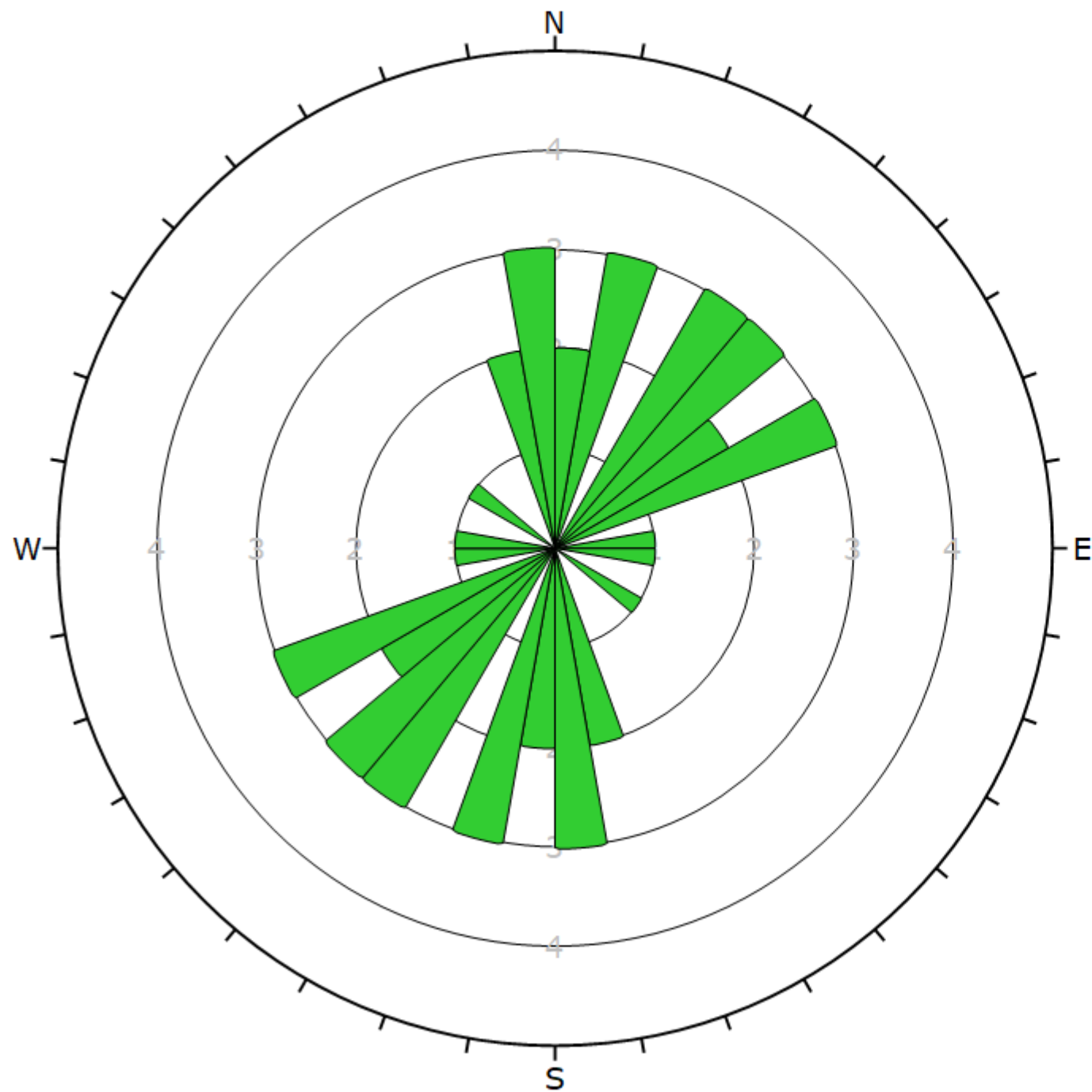
Drury Quarry - Sutton Block Extension

Kinematic Analysis Results - Waipapa Greywacke			
Location	Type	Lateral Limits	%
A	Planar	N/A	8.08
	Wedge	N/A	7.95
	Topple	30°	17.22
B	Planar	N/A	9.14
	Wedge	N/A	9.92
	Topple	30°	18.63
C	Planar	N/A	10.9
	Wedge	N/A	8.52
	Topple	30°	25.31
D	Planar	N/A	8.61
	Wedge	N/A	10.47
	Topple	30°	27.37
E	Planar	N/A	8.44
	Wedge	N/A	10.23
	Topple	30°	18.63
F	Planar	N/A	8.61
	Wedge	N/A	10.06
	Topple	30°	18.8
G	Planar	N/A	8.61
	Wedge	N/A	10.26
	Topple	30°	23.9
H	Planar	N/A	3.87
	Wedge	N/A	2.69
	Topple	30°	23.3

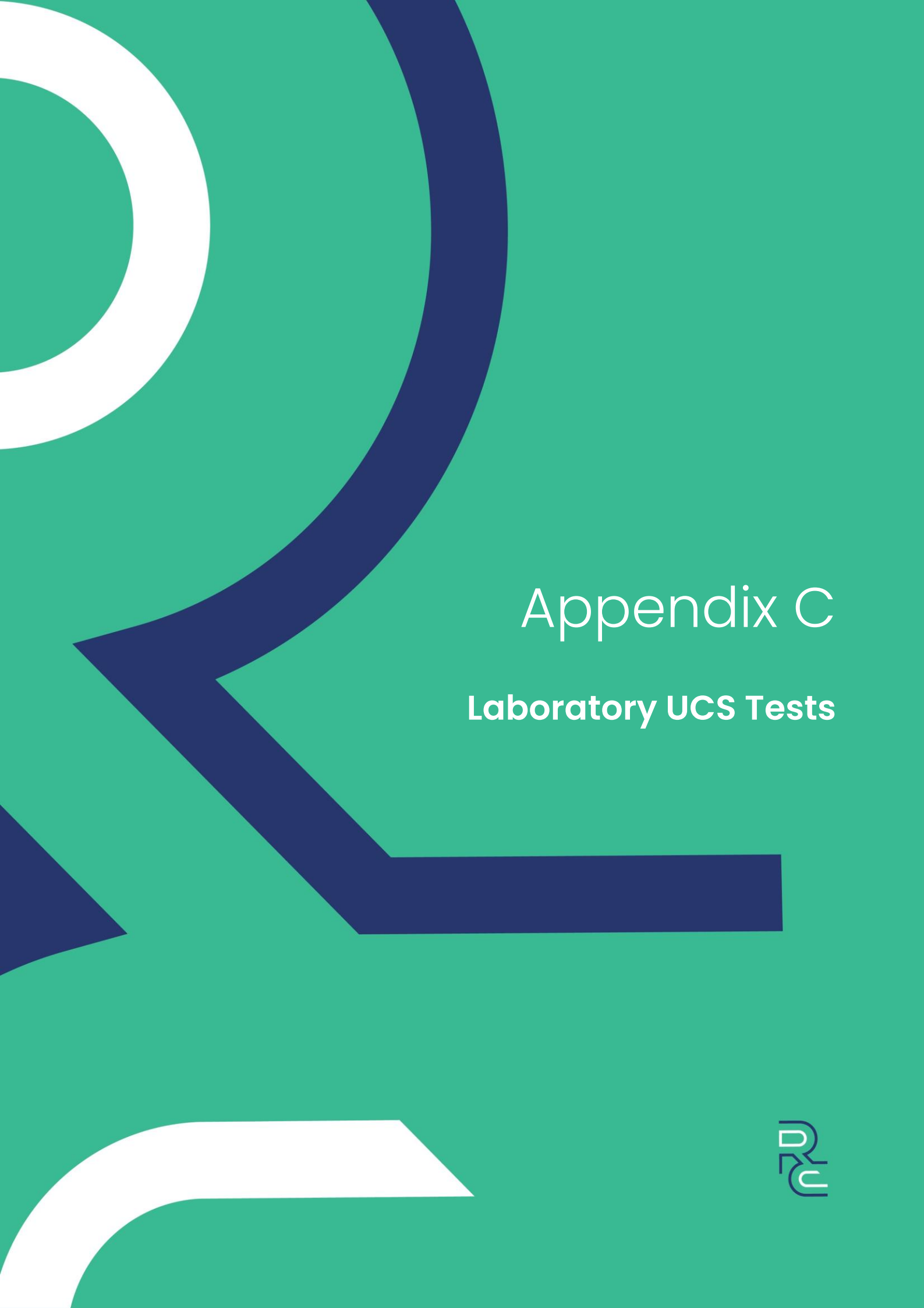
Kinematic Analysis Results - Waipapa Greywacke			
Location	Type	Lateral Limits	%
I	Planar	N/A	10.37
	Wedge	N/A	7.92
	Topple	30°	27.24
J	Planar	N/A	2.81
	Wedge	N/A	2.51
	Topple	30°	22.32
K	Planar	N/A	10.72
	Wedge	N/A	8.3
	Topple	30°	25.66
L	Planar	N/A	1.05
	Wedge	N/A	1.63
	Topple	30°	16.87
M	Planar	N/A	5.1
	Wedge	N/A	4.22
	Topple	30°	17.22
N	Planar	N/A	1.23
	Wedge	N/A	2.06
	Topple	30°	15.47
O	Planar	N/A	3.51
	Wedge	N/A	5.03
	Topple	30°	16.34

Drury Quarry - Sutton Block Extension

Orientation of RDCL Bedding Plane Defects Within Waikato Coal Measures



Plot Mode	Rosette
Plot Data	Apparent Strike
Face Normal Trend	0.0
Face Normal Plunge	90.0
Bin Size	10°
Outer Circle	5 planes per arc
Planes Plotted	24
Minimum Angle To Plot	0.0°
Maximum Angle To Plot	90.0°



Appendix C

Laboratory UCS Tests



Test Number: 230285

Report Number: 45801T

Date of Issue: 23rd January 2023

Page 1 of 3 Pages

FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs. Jo Young

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **Sandy MST – DH104 UCS1**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

B T BUCKLAND
KEY TECHNICAL PERSONNEL



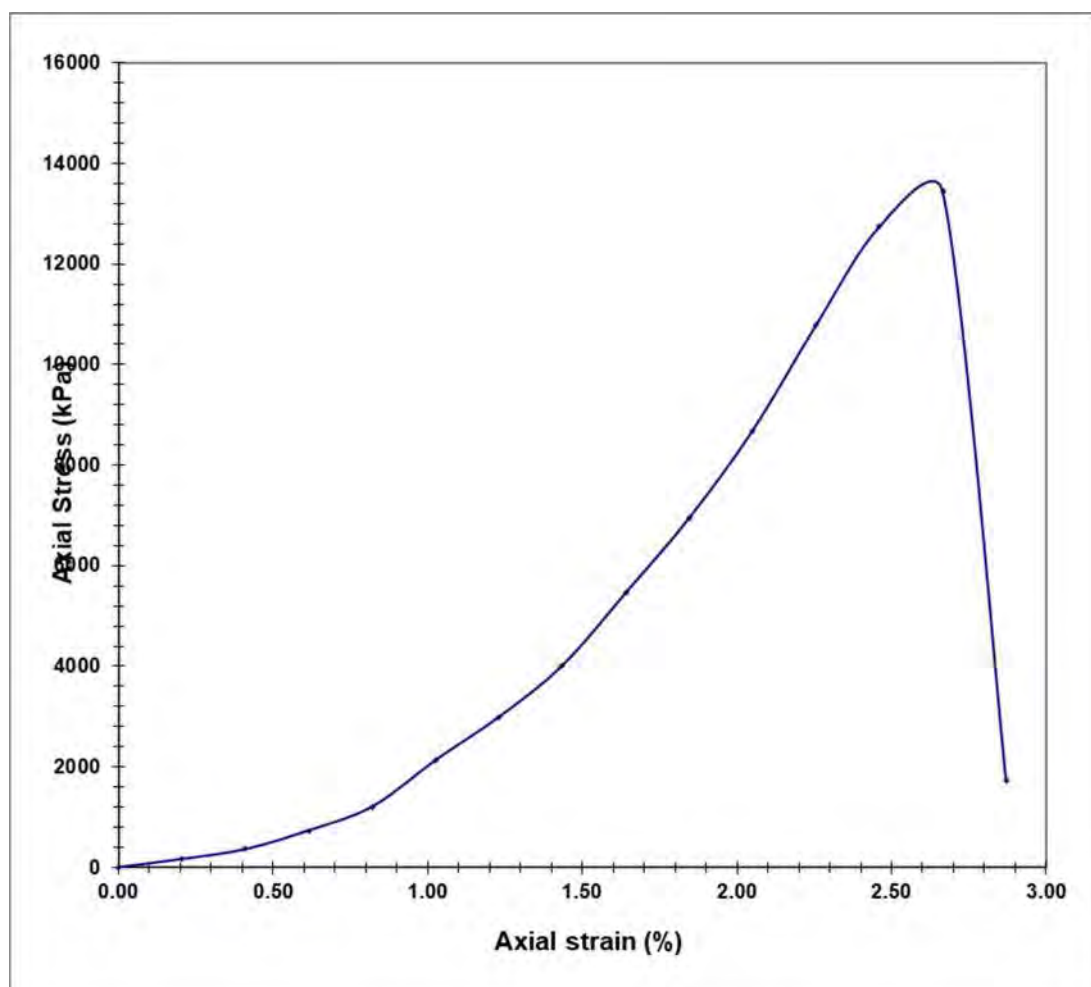
All tests reported
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TEST RESULTS

Material:	Sandy MST – DH104 UCS1	Test No.:	230285
Source:	23.3m-23.55m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample		Sandy MST, DH104
Sample Number		UCS1
Sample Depth	(m)	23.3-23.55
Sample Diameter	(mm)	59.7
Sample Height	(mm)	48.8
Wet Density	(t/m ³)	2.21
Water Content	(%)	3.4
Dry Density	(t/m ³)	2.15
Unconfined compressive strength	(kPa)	13000
Strain at failure	(%)	2.7
Rate of Axial Compression used	(mm/min)	0.2
Mode of failure		Brittle



Note: Sample was unable to be trimmed to 2:1 Ratio

TEST RESULTS

Material:	Sandy MST – DH104 UCS1	Test No.:	230285
Source:	23.3m-23.55m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-



Test Number: 230286

Report Number: 45802T

Date of Issue: 23rd January 2023

Page 1 of 3 Pages

FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs. Jo Young

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **Conglomerate – DH104 UCS2**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

B T BUCKLAND
KEY TECHNICAL PERSONNEL



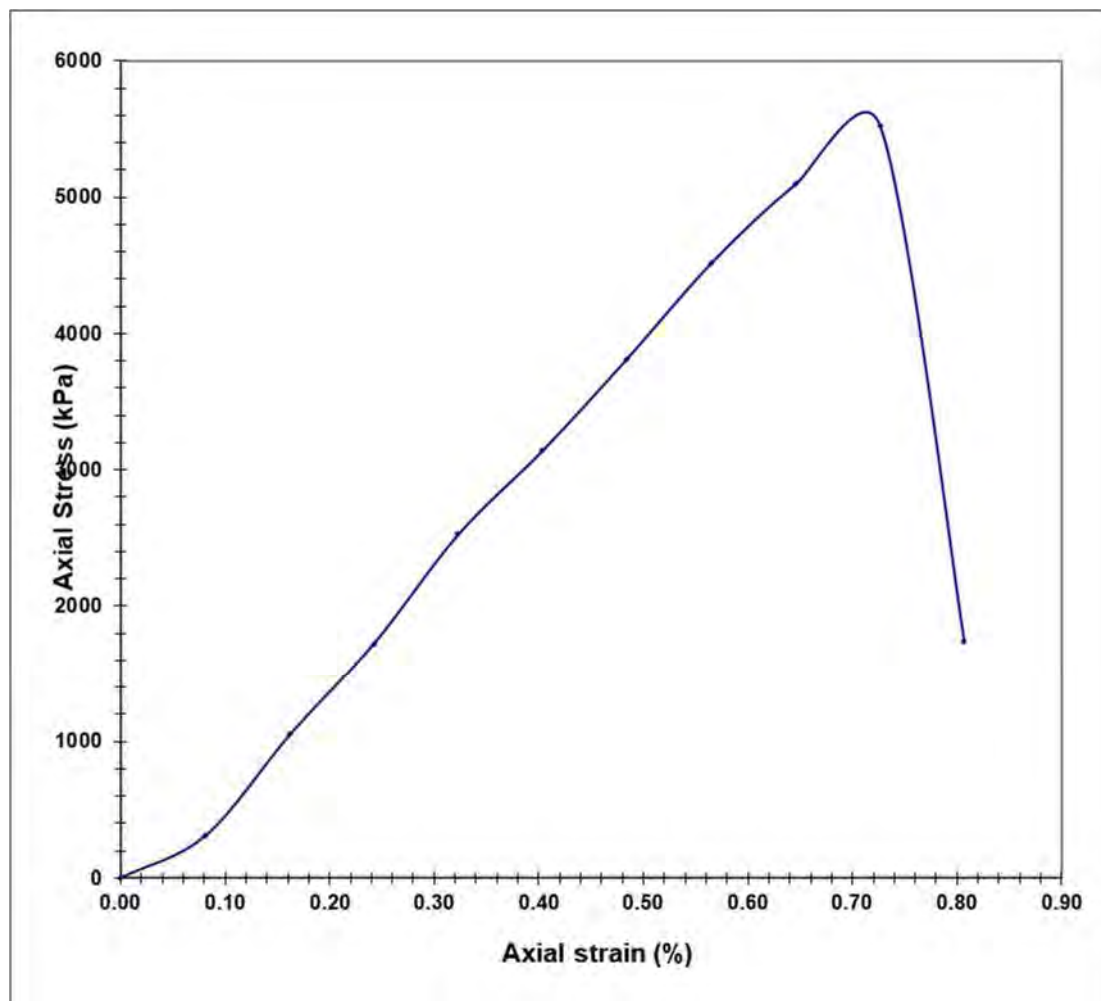
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TEST RESULTS

Material:	Conglomerate – DH104 UCS2	Test No.:	230286
Source:	28.2m-28.5m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample		Conglomerate – DH104
Sample Number		UCS2
Sample Depth (m)		28.2-28.5
Sample Diameter (mm)		60.3
Sample Height (mm)		123.9
Wet Density (t/m ³)		2.07
Water Content (%)		4.6
Dry Density (t/m ³)		2.00
Unconfined compressive strength (kPa)		5500
Strain at failure (%)		0.7
Rate of Axial Compression used (mm/min)		0.2
Mode of failure		Brittle



TEST RESULTS

Material:	Conglomerate – DH104 UCS2	Test No.:	230286
Source:	28.2m-28.5m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-



Test Number: 230287

Report Number: 45803T

Date of Issue: 23rd January 2023

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FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs Jo Young.

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **Silty MST – DH104 UCS3**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

B T BUCKLAND
KEY TECHNICAL PERSONNEL



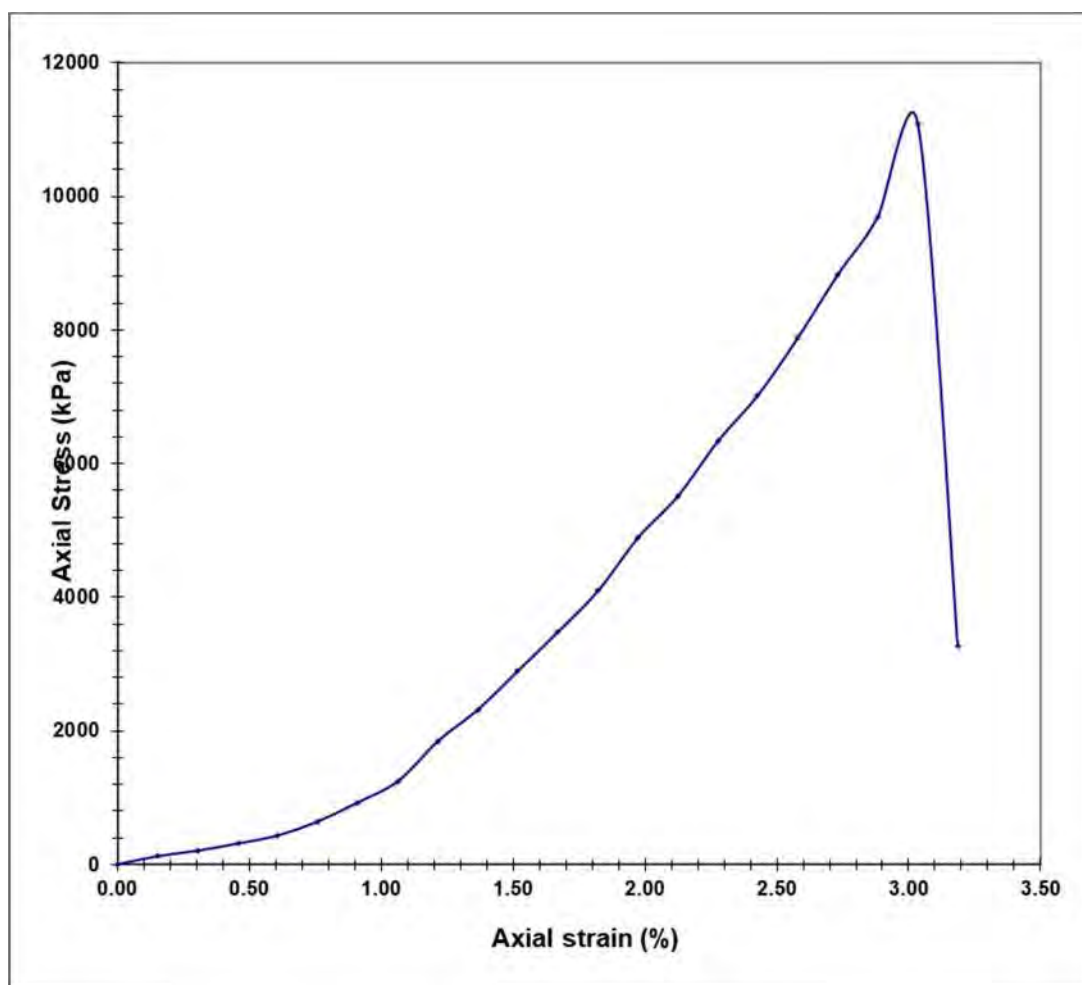
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scope of accreditation

TEST RESULTS

Material:	Silty MST – DH104 UCS3	Test No.:	230287
Source:	12.5m-12.35m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample Number		Silty MST – DH104
Sample Number		UCS3
Sample Depth (m)		12.5-12.35
Sample Diameter (mm)		60.1
Sample Height (mm)		65.9
Wet Density (t/m ³)		2.14
Water Content (%)		4.3
Dry Density (t/m ³)		2.05
Unconfined compressive strength (kPa)		11000
Strain at failure (%)		3.0
Rate of Axial Compression used (mm/min)		0.2
Mode of failure		Brittle



Note: Sample was unable to be trimmed to 2:1 Ratio

TEST RESULTS

Material:	Silty MST – DH104 UCS3	Test No.:	230287
Source:	12.5m-12.35m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-



Test Number: 230288

Report Number: 45804T

Date of Issue: 23rd January 2023

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FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs. Jo Young

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **Greywacke – DH104 UCS4**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

B T BUCKLAND
KEY TECHNICAL PERSONNEL



All tests reported
herein have been
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scope of accreditation

TEST RESULTS

Material:	Greywacke – DH104 UCS4	Test No.:	230288
Source:	38.3m-38.5m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample	Greywacke – DH104
Sample Number	UCS4
Sample Depth (m)	38.3-38.5
Sample Diameter (mm)	60.8
Sample Height (mm)	119.2
Wet Density (t/m ³)	2.68
Water Content (%)	0.5
Dry Density (t/m ³)	2.65
Unconfined compressive strength (kPa)	20000
Rate of Axial Compression used (N/s)	200
Mode of failure	Brittle

- Notes:
- i. Sample exceeded testing capabilities of CBR machine (50kN).
 - ii. Sample tested in concrete compression machine, which only provides a peak strength, and does not measure compression displacement.
 - iii. Rate of compression measured in N/s as concrete compression machine does not measure displacement.
 - iv. Strain unable to be calculated as displacement is not measured.

TEST RESULTS

Material:	Greywacke – DH104 UCS4	Test No.:	230288
Source:	38.3m-38.5m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-



Test Number: 230289

Report Number: 45805T

Date of Issue: 23rd January 2023

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FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs. Jo Young

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **Greywacke – DH104 UCS5**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

B T BUCKLAND
KEY TECHNICAL PERSONNEL



All tests reported
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scope of accreditation

TEST RESULTS

Material:	Greywacke – DH104 UCS5	Test No.:	230289
Source:	33.7m-33.85	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample	Greywacke – DH104
Sample Number	UCS5
Sample Depth (m)	33.7-33.85
Sample Diameter (mm)	60.8
Sample Height (mm)	120.8
Wet Density (t/m ³)	2.65
Water Content (%)	0.7
Dry Density (t/m ³)	2.63
Unconfined compressive strength (kPa)	23000
Rate of Axial Compression used (N/s)	200
Mode of failure	Brittle

- Notes:
- i. Sample exceeded testing capabilities of CBR machine (50kN).
 - ii. Sample tested in concrete compression machine, which only provides a peak strength, and does not measure compression displacement.
 - iii. Rate of compression measured in N/s as concrete compression machine does not measure displacement.
 - iv. Strain unable to be calculated as displacement is not measured.

TEST RESULTS

Material:	Greywacke – DH104 UCS5	Test No.:	230289
Source:	33.7m-33.85	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-



Test Number: 230290

Report Number: 45806T

Date of Issue: 23rd January 2023

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FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs. Jo Young

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **Conglomerate – DH104 UCS6**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

B T BUCKLAND
KEY TECHNICAL PERSONNEL



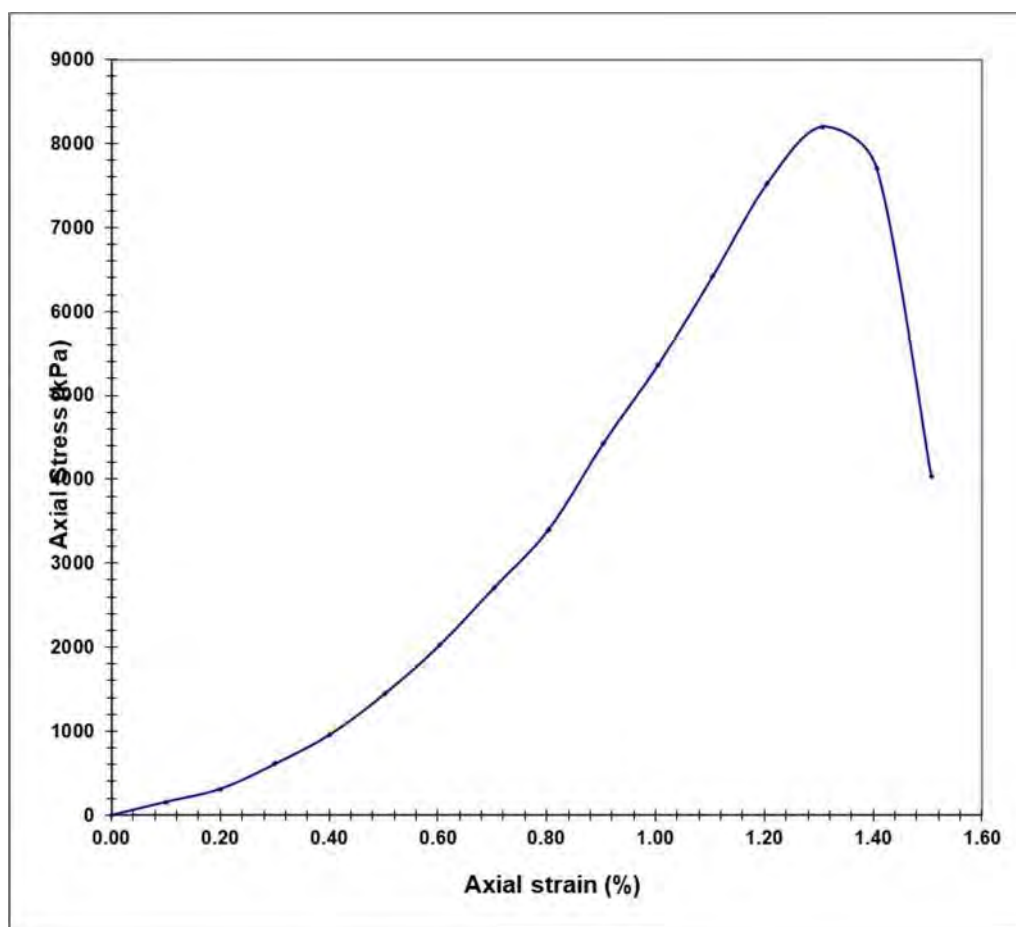
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TEST RESULTS

Material:	Conglomerate – DH104 UCS6	Test No.:	230290
Source:	29.1m-29.3m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample	Conglomerate – DH104	
Sample Number	UCS6	
Sample Depth (m)	29.1-29.3	
Sample Diameter (mm)	60.3	
Sample Height (mm)	99.5	
Wet Density (t/m ³)	2.05	
Water Content (%)	4.2	
Dry Density (t/m ³)	1.95	
Unconfined compressive strength (kPa)	8200	
Strain at failure (%)	1.3	
Rate of Axial Compression used (mm/min)	0.2	
Mode of failure	Brittle	



Note: Sample was unable to be trimmed to 2:1 Ratio

TEST RESULTS

Material:	Conglomerate – DH104 UCS6	Test No.:	230290
Source:	29.1m-29.3m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-



Test Number: 230291

Report Number: 45807T

Date of Issue: 23rd January 2023

Page 1 of 3 Pages

FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs. Jo Young

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **Conglomerate – DH104 UCS7**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

A handwritten signature in blue ink, appearing to read "B T Buckland".

B T BUCKLAND
KEY TECHNICAL PERSONNEL



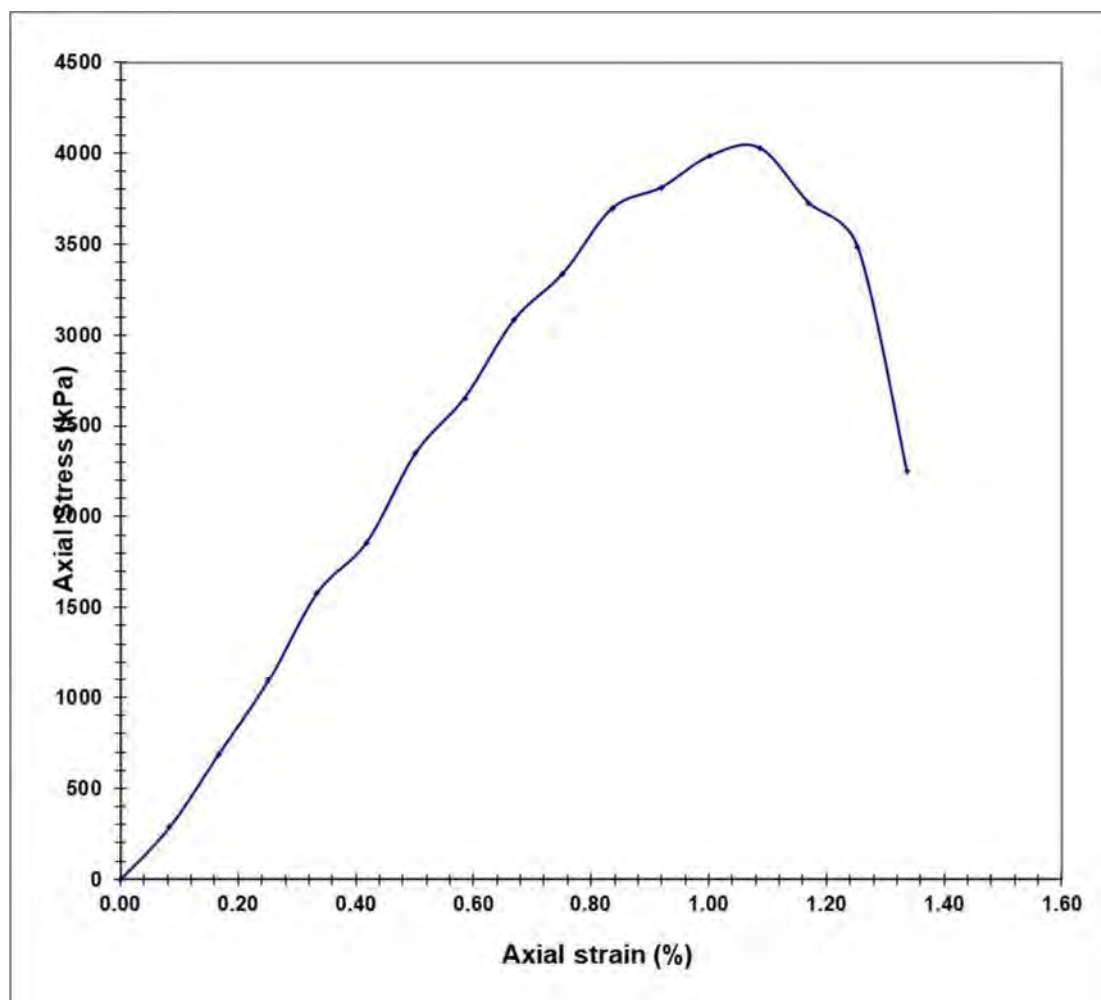
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TEST RESULTS

Material:	Conglomerate – DH104 UCS7	Test No.:	230291
Source:	26.5-26.7	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample		Conglomerate – DH104
Sample Number		UCS7
Sample Depth (m)		26.5-26.7
Sample Diameter (mm)		60.4
Sample Height (mm)		119.7
Wet Density (t/m ³)		2.08
Water Content (%)		5.6
Dry Density (t/m ³)		1.95
Unconfined compressive strength (kPa)		4000
Strain at failure (%)		1.1
Rate of Axial Compression used (mm/min)		0.2
Mode of failure		Brittle



TEST RESULTS

Material:	Conglomerate – DH104 UCS7	Test No.:	230291
Source:	26.5-26.7	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-



Test Number: 230292

Report Number: 45808T

Date of Issue: 23rd January 2023

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FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs. Jo Young

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **Greywacke – DH101 UCS8**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

B T BUCKLAND
KEY TECHNICAL PERSONNEL



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TEST RESULTS

Material:	Greywacke – DH101 UCS8	Test No.:	230292
Source:	50.35m-50.60m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample	Greywacke – DH101
Sample Number	UCS8
Sample Depth (m)	50.35-50.6
Sample Diameter (mm)	60.8
Sample Height (mm)	120.0
Wet Density (t/m ³)	2.69
Water Content (%)	0.4
Dry Density (t/m ³)	2.70
Unconfined compressive strength (kPa)	54000
Rate of Axial Compression used (N/s)	500
Mode of failure	Brittle

- Notes:
- i. Sample exceeded testing capabilities of CBR machine (50kN).
 - ii. Sample tested in concrete compression machine, which only provides a peak strength, and does not measure compression displacement.
 - iii. Rate of compression measured in N/s as concrete compression machine does not measure displacement.
 - iv. Strain unable to be calculated as displacement is not measured.

TEST RESULTS

Material:	Greywacke – DH101 UCS8	Test No.:	230292
Source:	50.35m-50.60m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-



Test Number: 230293

Report Number: 45809T

Date of Issue: 23rd January 2023

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FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs. Jo Young

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **MST – DH101 UCS11**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

B T BUCKLAND
KEY TECHNICAL PERSONNEL



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TEST RESULTS

Material:	MST – DH101 UCS11	Test No.:	230293
Source:	16.05m-16.35m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample	MST - DH101
Sample Number	UCS11
Sample Depth (m)	16.05-16.35
Sample Diameter (mm)	60.9
Sample Height (mm)	N/A
Mode of failure	Brittle

Notes: i. Sample broke during preparation of test. No core able to be tested.



Test Number: 230294

Report Number: 45810T

Date of Issue: 23rd January 2023

Page 1 of 3 Pages

FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs. Jo Young

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **Greywacke – DH101 UCS12**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

B T BUCKLAND
KEY TECHNICAL PERSONNEL



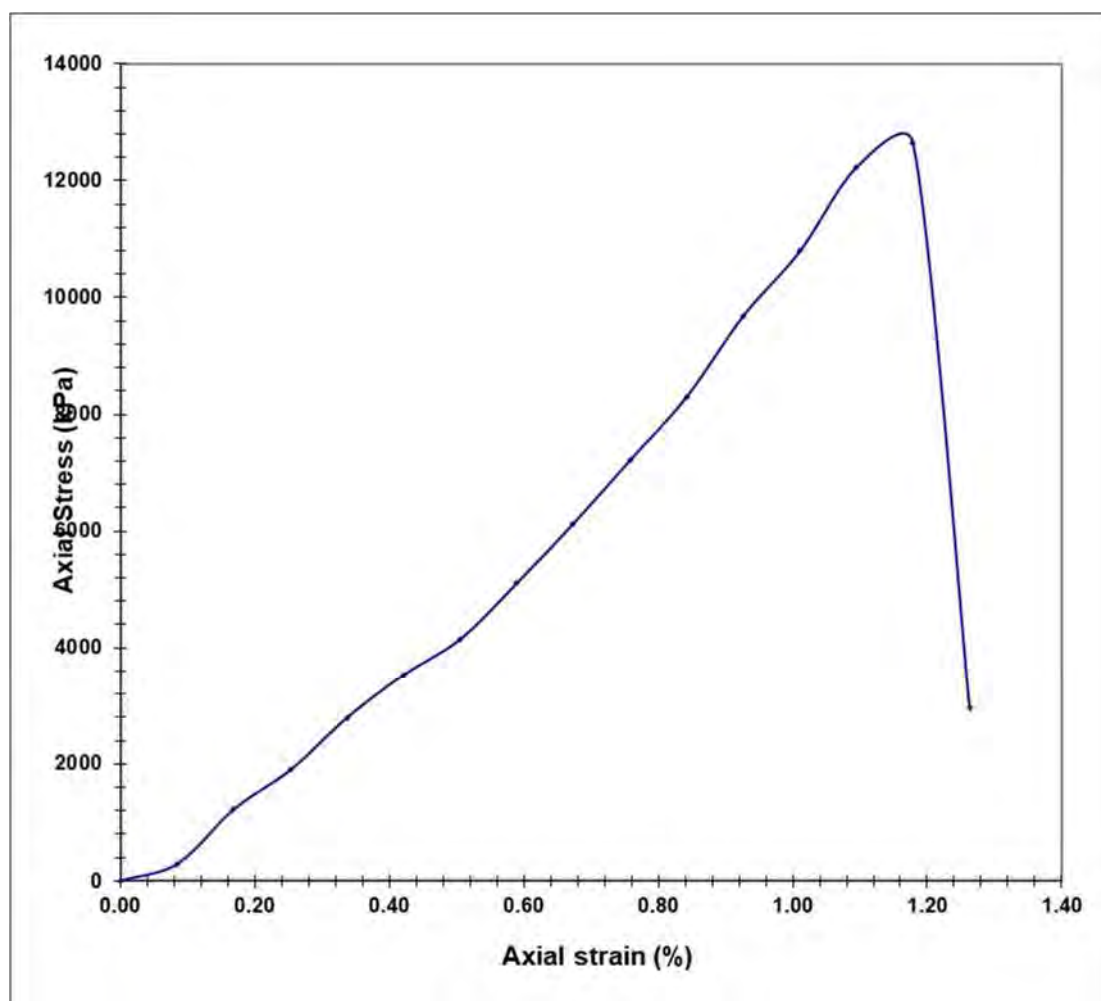
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TEST RESULTS

Material:	Greywacke – DH101 UCS12	Test No.:	230294
Source:	38.1m-38.7m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample		Greywacke – DH101
Sample Number		UCS12
Sample Depth	(m)	38.1-38.7
Sample Diameter	(mm)	60.6
Sample Height	(mm)	118.8
Wet Density	(t/m ³)	2.21
Water Content	(%)	4.4
Dry Density	(t/m ³)	2.10
Unconfined compressive strength	(kPa)	13000
Strain at failure	(%)	1.2
Rate of Axial Compression used	(mm/min)	0.2
Mode of failure		Brittle



TEST RESULTS

Material:	Greywacke – DH101 UCS12	Test No.:	230294
Source:	38.1m-38.7m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-



Test Number: 230295

Report Number: 45811T

Date of Issue: 23rd January 2023

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FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs. Jo Young

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **Greywacke – DH103 UCS13**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

B T BUCKLAND
KEY TECHNICAL PERSONNEL



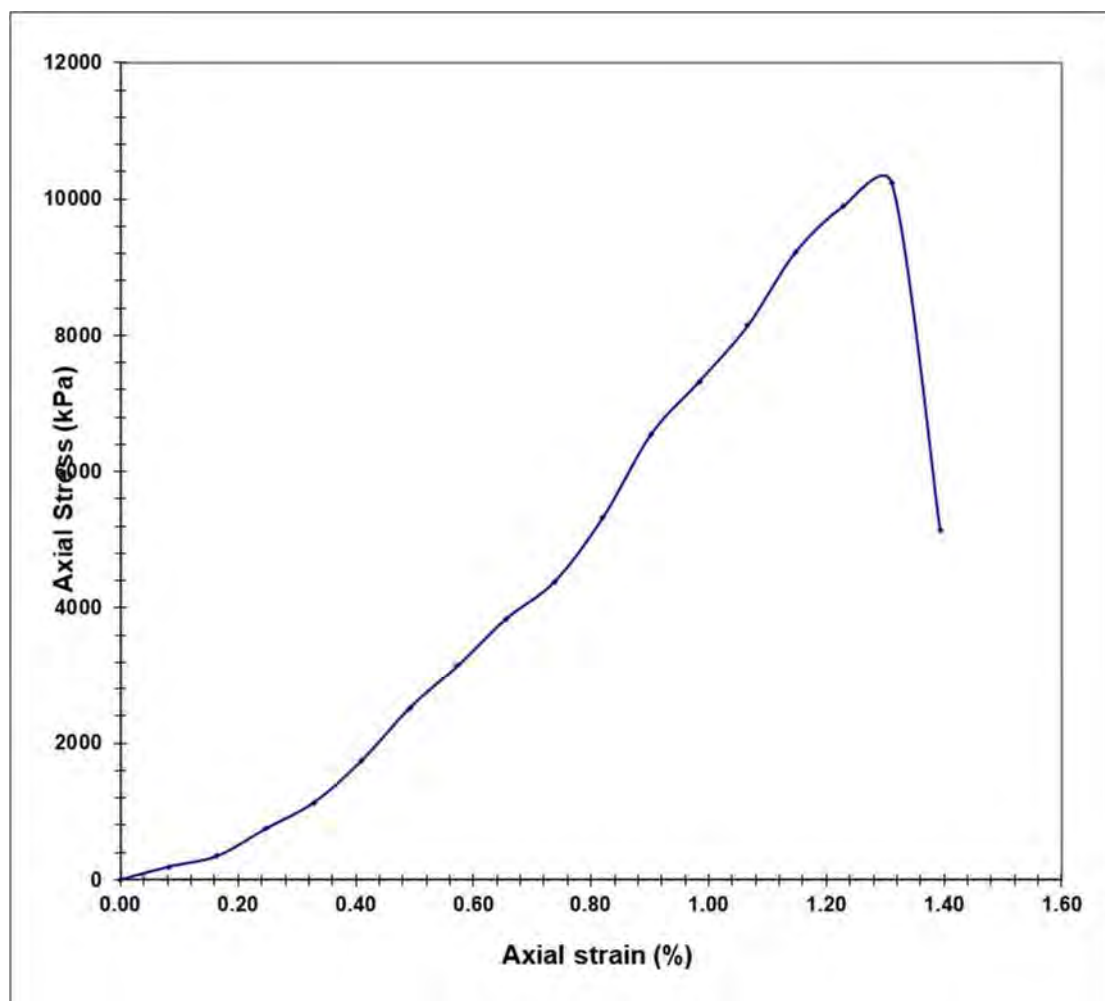
All tests reported
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with the laboratory's
scope of accreditation

TEST RESULTS

Material:	Greywacke – DH103 UCS13	Test No.:	230295
Source:	76.5m-76.7m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample	Greywacke – DH103
Sample Number	UCS13
Sample Depth (m)	76.5-76.7
Sample Diameter (mm)	59.4
Sample Height (mm)	122.0
Wet Density (t/m ³)	2.00
Water Content (%)	4.9
Dry Density (t/m ³)	1.90
Unconfined compressive strength (kPa)	10000
Strain at failure (%)	1.3
Rate of Axial Compression used (mm/min)	0.3
Mode of failure	Brittle



TEST RESULTS

Material:	Greywacke – DH103 UCS13	Test No.:	230295
Source:	76.5m-76.7m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-



Test Number: 230296

Report Number: 45812T

Date of Issue: 23rd January 2023

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FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs. Jo Young

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **Greywacke – DH103 UCS14**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

B T BUCKLAND
KEY TECHNICAL PERSONNEL



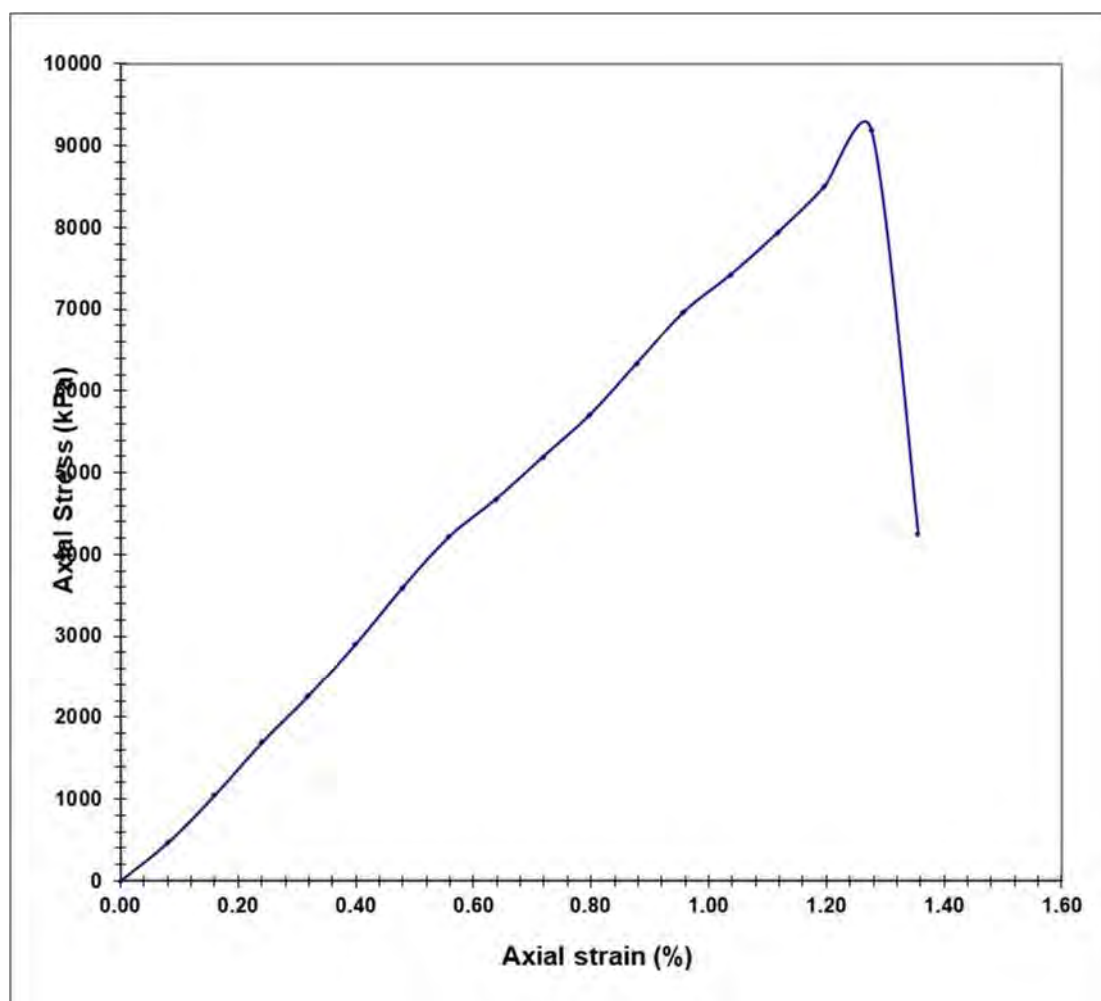
All tests reported
herein have been
performed in accordance
with the laboratory's
scope of accreditation

TEST RESULTS

Material:	Greywacke – DH103 UCS14	Test No.:	230296
Source:	76.95m-77.15m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample		Greywacke – DH103
Sample Number		UCS14
Sample Depth	(m)	76.95-77.15
Sample Diameter	(mm)	60.0
Sample Height	(mm)	125.4
Wet Density	(t/m ³)	2.13
Water Content	(%)	4.4
Dry Density	(t/m ³)	2.05
Unconfined compressive strength	(kPa)	9100
Strain at failure	(%)	1.3
Rate of Axial Compression used	(mm/min)	0.2
Mode of failure		Brittle



TEST RESULTS

Material:	Greywacke – DH103 UCS14	Test No.:	230296
Source:	76.95m-77.15m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-



Test Number: 230297

Report Number: 45813T

Date of Issue: 23rd January 2023

Page 1 of 3 Pages

FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs. Jo Young

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **MST – DH103 UCS15**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

B T BUCKLAND
KEY TECHNICAL PERSONNEL



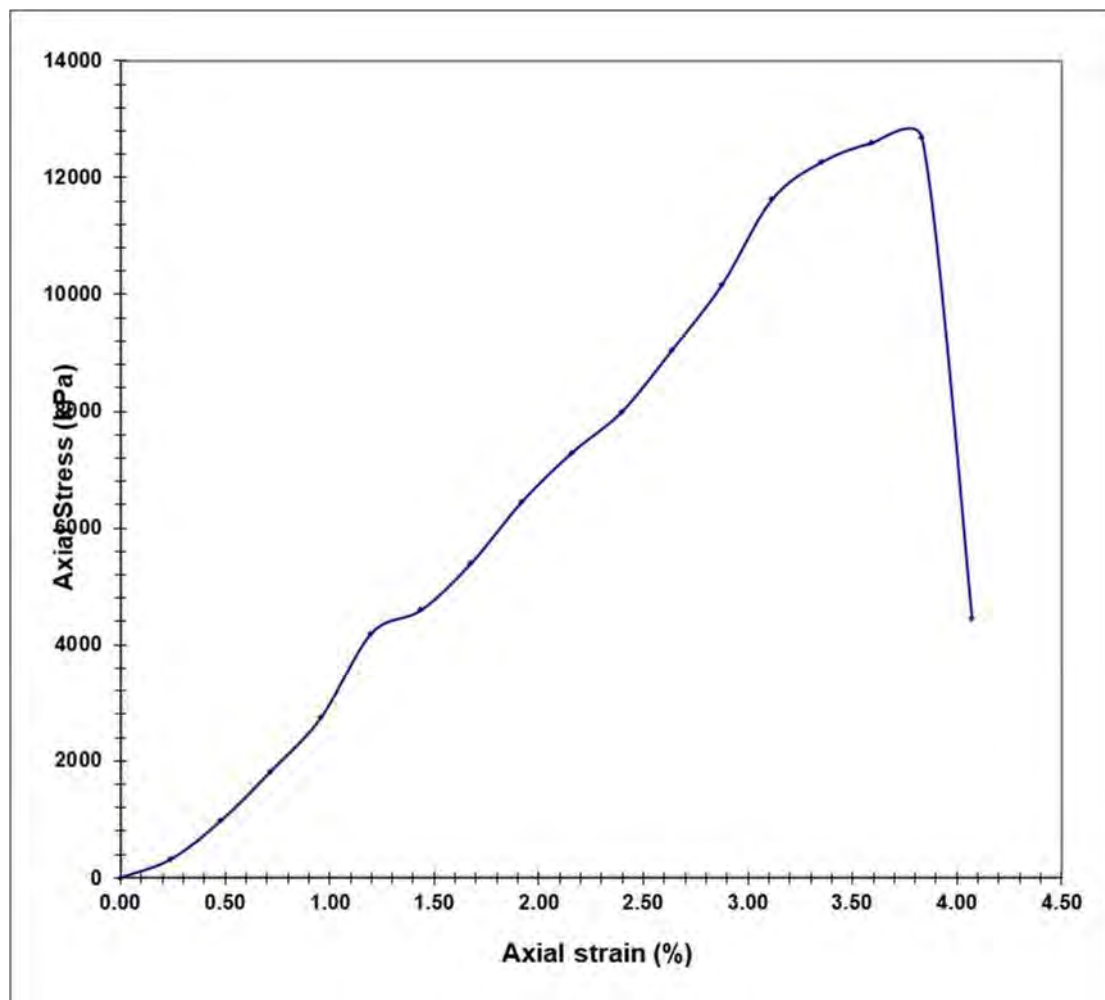
All tests reported
herein have been
performed in accordance
with the laboratory's
scope of accreditation

TEST RESULTS

Material:	MST – DH103 UCS15	Test No.:	230297
Source:	39.3m-39.55m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample	MST-DH103	
Sample Number	UCS15	
Sample Depth (m)	39.3-39.55	
Sample Diameter (mm)	58.0	
Sample Height (mm)	41.8	
Wet Density (t/m ³)	2.06	
Water Content (%)	6.9	
Dry Density (t/m ³)	1.95	
Unconfined compressive strength (kPa)	13000	
Strain at failure (%)	3.8	
Rate of Axial Compression used (mm/min)	0.2	
Mode of failure	Brittle	



Note: Sample was unable to be trimmed to 2:1 Ratio

TEST RESULTS

Material:	MST – DH103 UCS15	Test No.:	230297
Source:	39.3m-39.55m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-



Test Number: 230298

Report Number: 45814T

Date of Issue: 23rd January 2023

Page 1 of 2 Pages

FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs. Jo Young

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **MST – DH103 UCS16**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

B T BUCKLAND
KEY TECHNICAL PERSONNEL



All tests reported
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TEST RESULTS

Material:	MST – DH103 UCS16	Test No.:	230298
Source:	18.35m-18.5m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample	MST-DH103
Sample Number	UCS16
Sample Depth (m)	18.35-18.5
Sample Diameter (mm)	58.2
Sample Height (mm)	N/A
Mode of failure	Brittle

Notes: i. Note: Sample broke during preparation of test. No core able to be tested.



Test Number: 230299

Report Number: 45815T

Date of Issue: 23rd January 2023

Page 1 of 3 Pages

FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs. Jo Young

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **MST – DH103 UCS20**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

B T BUCKLAND
KEY TECHNICAL PERSONNEL



All tests reported
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TEST RESULTS

Material:	MST – DH103 UCS20	Test No.:	230299
Source:	71.15m-71.3m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample Number	MST- DH103
Sample Number	UCS20
Sample Depth (m)	71.15-71.3
Sample Diameter (mm)	58.6
Sample Height (mm)	50.2
Wet Density (t/m ³)	2.08
Water Content (%)	5.6
Dry Density (t/m ³)	1.95
Unconfined compressive strength (kPa)	24000
Rate of Axial Compression used (N/s)	200
Mode of failure	Brittle

- Notes:
- i. Sample was unable to be trimmed to 2:1 Ratio
 - ii. Sample exceeded testing capabilities of CBR machine (50kN).
 - iii. Sample tested in concrete compression machine, which only provides a peak strength, and does not measure compression displacement.
 - iv. Rate of compression measured in N/s as concrete compression machine does not measure displacement.
 - v. Strain unable to be calculated as displacement is not measured.

TEST RESULTS

Material:	MST – DH103 UCS20	Test No.:	230299
Source:	71.15m-71.3m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-



Test Number: 230300

Report Number: 45816T

Date of Issue: 23rd January 2023

Page 1 of 2 Pages

FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs. Jo Young

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **Greywacke – DH102 UCS21**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

B T BUCKLAND
KEY TECHNICAL PERSONNEL



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TEST RESULTS

Material:	Greywacke – DH102 UCS21	Test No.:	230300
Source:	39.95m-40.35m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample		Greywacke – DH102
Sample Number		UCS21
Sample Depth	(m)	39.95-40.35
Sample Diameter	(mm)	60.7
Sample Height	(mm)	120.1
Wet Density	(t/m ³)	2.68
Water Content	(%)	0.3
Dry Density	(t/m ³)	2.70
Unconfined compressive strength	(kPa)	62000
Rate of Axial Compression used	(N/s)	500
Mode of failure		Brittle

- Notes:
- i. Sample exceeded testing capabilities of CBR machine (50kN).
 - ii. Sample tested in concrete compression machine, which only provides a peak strength, and does not measure compression displacement.
 - iii. Rate of compression measured in N/s as concrete compression machine does not measure displacement.
 - iv. Strain unable to be calculated as displacement is not measured.



Test Number: 230302

Report Number: 45818T

Date of Issue: 23rd January 2023

Page 1 of 2 Pages

FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs. Jo Young

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **Greywacke – DH102 UCS24**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

B T BUCKLAND
KEY TECHNICAL PERSONNEL



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scope of accreditation

TEST RESULTS

Material:	Greywacke – DH102 UCS24	Test No.:	230302
Source:	43.3m-43.5m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample	Greywacke – DH102
Sample Number	UCS24
Sample Depth (m)	43.3-43.5
Sample Diameter (mm)	60.8
Sample Height (mm)	N/A
Mode of failure	Brittle

Notes: i. Sample broke during preparation of test. No core able to be tested.



Test Number: 230303

Report Number: 45819T

Date of Issue: 24th January 2023

Page 1 of 2 Pages

FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs. Jo Young

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **MST – DH102 UCS26**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

A handwritten signature in blue ink, appearing to read "B T Buckland".

B T BUCKLAND
KEY TECHNICAL PERSONNEL



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scope of accreditation

TEST RESULTS

Material:	MST – DH102 UCS26	Test No.:	230303
Source:	15.65m-15.85m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample	MST – DH102
Sample Number	UCS26
Sample Depth (m)	15.65-15.85
Sample Diameter (mm)	60.8
Sample Height (mm)	N/A
Mode of failure	Brittle

Notes: i. Sample broke during preparation of test. No core able to be tested.



Test Number: 230304

Report Number: 45820T

Date of Issue: 24th January 2023

Page 1 of 2 Pages

FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs. Jo Young

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **Greywacke – DH102 UCS27**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

B T BUCKLAND
KEY TECHNICAL PERSONNEL



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TEST RESULTS

Material:	Greywacke – DH102 UCS27	Test No.:	230304
Source:	49.5m-49.65m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample		Greywacke – DH102
Sample Number		UCS27
Sample Depth	(m)	49.5-49.65
Sample Diameter	(mm)	60.6
Sample Height	(mm)	119.4
Wet Density	(t/m ³)	2.65
Water Content	(%)	0.4
Dry Density	(t/m ³)	2.65
Unconfined compressive strength	(kPa)	20000
Rate of Axial Compression used	(N/s)	200
Mode of failure		Brittle

- Notes:
- i. Sample exceeded testing capabilities of CBR machine (50kN).
 - ii. Sample tested in concrete compression machine, which only provides a peak strength, and does not measure compression displacement.
 - iii. Rate of compression measured in N/s as concrete compression machine does not measure displacement.
 - iv. Strain unable to be calculated as displacement is not measured.



Test Number: 230305

Report Number: 45821T

Date of Issue: 24th January 2023

Page 1 of 2 Pages

FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs. Jo Young

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **Greywacke – DH102 UCS28**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

B T BUCKLAND
KEY TECHNICAL PERSONNEL



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TEST RESULTS

Material:	Greywacke – DH102 UCS28	Test No.:	230305
Source:	49.85m-50.05m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample		Greywacke – DH102
Sample Number		UCS28
Sample Depth	(m)	49.85-50.05
Sample Diameter	(mm)	60.7
Sample Height	(mm)	119.2
Wet Density	(t/m ³)	2.64
Water Content	(%)	0.4
Dry Density	(t/m ³)	2.65
Unconfined compressive strength	(kPa)	24000
Rate of Axial Compression used	(N/s)	200
Mode of failure		Brittle

- Notes:
- Sample exceeded testing capabilities of CBR machine (50kN).
 - Sample tested in concrete compression machine, which only provides a peak strength, and does not measure compression displacement.
 - Rate of compression measured in N/s as concrete compression machine does not measure displacement.
 - Strain unable to be calculated as displacement is not measured.



Test Number: 230306

Report Number: 45822T

Date of Issue: 24th January 2023

Page 1 of 2 Pages

FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs. Jo Young

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **Greywacke – DH105 UCS29**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

A handwritten signature in blue ink, appearing to read "B T Buckland".

B T BUCKLAND
KEY TECHNICAL PERSONNEL



All tests reported
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scope of accreditation

TEST RESULTS

Material:	Greywacke – DH105 UCS29	Test No.:	230306
Source:	29.0m-29.30m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample		Greywacke – DH105
Sample Number		UCS29
Sample Depth	(m)	29.0-29.3
Sample Diameter	(mm)	60.9
Sample Height	(mm)	119.4
Wet Density	(t/m ³)	2.67
Water Content	(%)	2.6
Dry Density	(t/m ³)	2.60
Unconfined compressive strength	(kPa)	87000
Rate of Axial Compression used	(N/s)	700
Mode of failure		Brittle

- Notes:
- Sample exceeded testing capabilities of CBR machine (50kN).
 - Sample tested in concrete compression machine, which only provides a peak strength, and does not measure compression displacement.
 - Rate of compression measured in N/s as concrete compression machine does not measure displacement.
 - Strain unable to be calculated as displacement is not measured.



Test Number: 230307

Report Number: 45823T

Date of Issue: 24th January 2023

Page 1 of 2 Pages

FINAL REPORT FOR STEVENSON AGGREGATES LTD - DRURY QUARRY

Clients Address: Quarry Road
DRURY

Attention: Mrs. Jo Young

Reference: Project Number 220245

Subject: **AGGREGATE TESTING**

Clients Instructions: Carry out testing as detailed below on core samples received.

Test Methods: 1. NZS4402: 1986: Tests
2.1: Determination of the Water Content
6.3.1: Determination of the Unconfined Compressive Strength (UCS) of a Cohesive Soil.

Date Sampled: 10th January 2023

Date Received: 18th January 2023

Date of Test: January 2023

Description of Sample: **Greywacke – DH105 UCS30**

Source: Drury Quarry Sutton Block

Notes: i. Field core sample retrieved in its natural state.
ii. Sampling of cores and product information is not covered by this report.
iii. Test results apply to sample received.

for STEVENSON AGGREGATES LTD

A handwritten signature in blue ink, appearing to read "B T Buckland".

B T BUCKLAND
KEY TECHNICAL PERSONNEL



All tests reported
herein have been
performed in accordance
with the laboratory's
scope of accreditation

TEST RESULTS

Material:	Greywacke – DH105 UCS30	Test No.:	230307
Source:	45.4m-45.75m	Date Sampled:	10 th January 2023
Job:	Project Number 220245	Reference No.:	-

UNCONFINED COMPRESSIVE STRENGTH (UCS)

Sample		Greywacke – DH105
Sample Number		UCS30
Sample Depth	(m)	45.4-45.75
Sample Diameter	(mm)	60.9
Sample Height	(mm)	118.9
Wet Density	(t/m ³)	2.67
Water Content	(%)	0.1
Dry Density	(t/m ³)	2.65
Unconfined compressive strength	(kPa)	135000
Rate of Axial Compression used	(N/s)	700
Mode of failure		Brittle

- Notes:
- i. Sample exceeded testing capabilities of CBR machine (50kN).
 - ii. Sample tested in concrete compression machine, which only provides a peak strength, and does not measure compression displacement.
 - iii. Rate of compression measured in N/s as concrete compression machine does not measure displacement.
 - iv. Strain unable to be calculated as displacement is not measured.



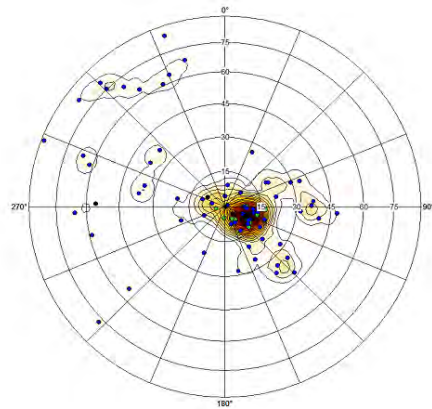


Appendix D

RDCL Borelog Plots

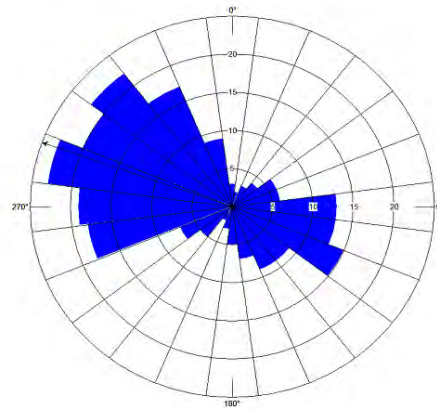


Stereoplot - Polar Projection Dip



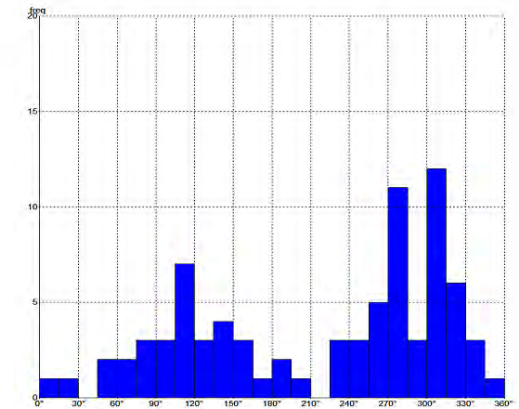
Schmidt Plot - Lower (Southern) Hemisphere - Structures - Mudstone
Depth: 4.60 m to 37.60 m

Rose Diagram - Azimuth



Depth: 4.60 m to 37.60 m

Histogram - Azimuth

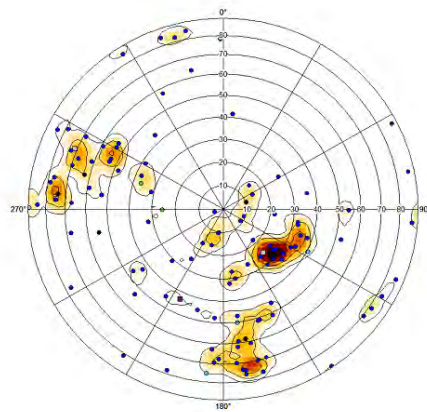


Depth: 4.60 m to 37.60 m



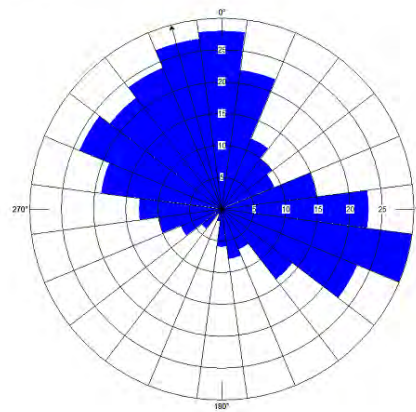
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PROJECT	Drury Stevenson Quarry	DRAWN BY	AC	DATE	26/01/23	FIG	
CLIENT	Drillforce Ltd.	CHECKED BY	KK	DATE	26/01/23	01	

Stereoplot - Polar Projection Dip



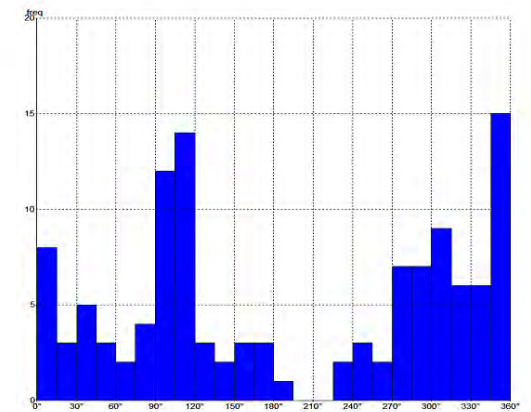
Schmidt Plot - Lower (Southern) Hemisphere - Structures - Greywacke
Depth: 37.60 m to 66.67 m

Rose Diagram - Azimuth



Depth: 37.60 m to 66.67 m

Histogram - Azimuth

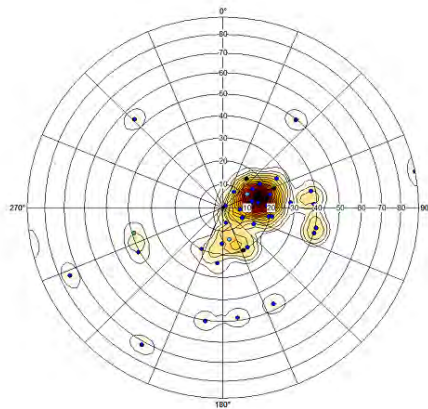


Depth: 37.60 m to 66.67 m



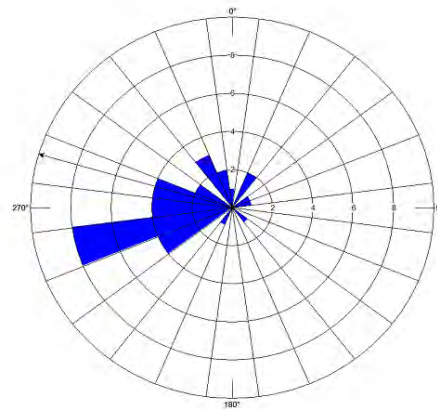
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PROJECT	Drury Stevenson Quarry	DRAWN BY	AC	DATE	26/01/23	FIG	
CLIENT	Drillforce Ltd.	CHECKED BY	KK	DATE	26/01/23	01	

Stereoplot - Polar Projection Dip



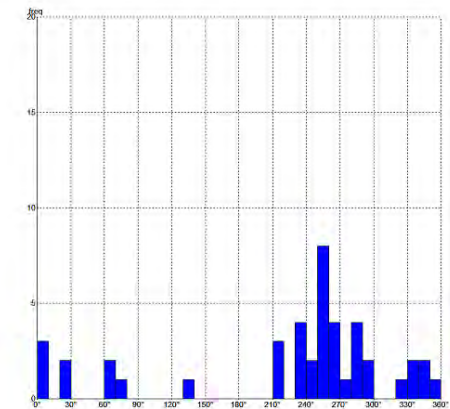
Schmidt Plot - Lower (Southern) Hemisphere - Structures - Mudstone
Depth: 2.90 m to 34.30 m

Rose Diagram - Azimuth



Depth: 2.90 m to 34.30 m

Histogram - Azimuth

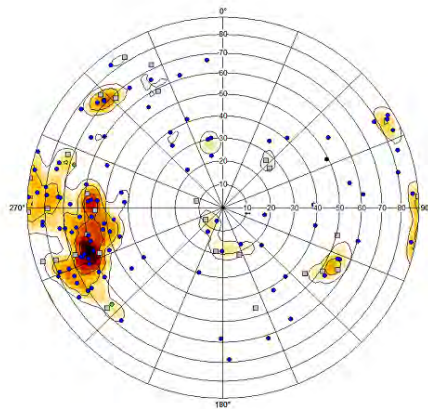


Depth: 2.90 m to 34.30 m



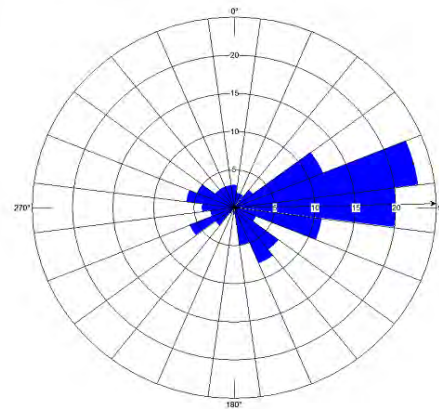
TITLE	BH102-Mudstone Structures	PROJECT	220770				
PROJECT	Drury Stevenson Quarry	DRAWN BY	AC	DATE	26/01/23	FIG	
CLIENT	Drillforce Ltd.	CHECKED BY	KK	DATE	26/01/23	01	

Stereoplot - Polar Projection Dip



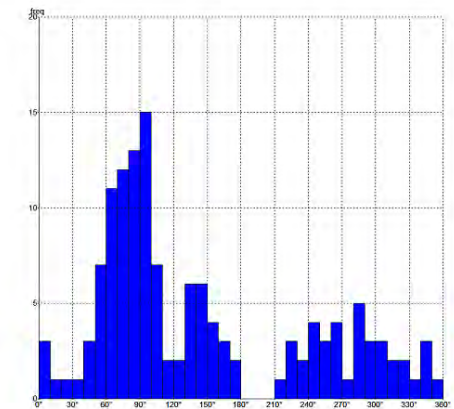
Schmidt Plot - Lower (Southern) Hemisphere - Structures - Greywacke
Depth: 34.30 m to 60.0 m

Rose Diagram - Azimuth



Depth: 34.30 m to 60.0 m

Histogram - Azimuth



Depth: 34.30 m to 60.0 m



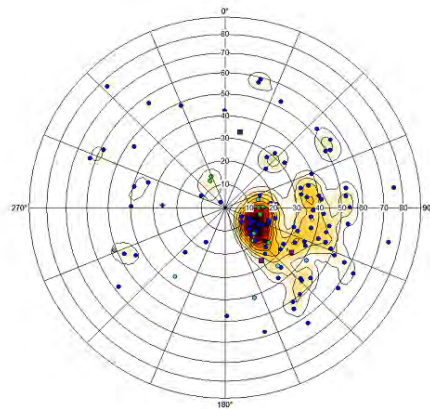
TITLE
PROJECT
CLIENT

BH102-Greywacke Structures
Drury Stevenson Quarry
Drillforce Ltd.

PROJECT
DRAWN BY
CHECKED BY

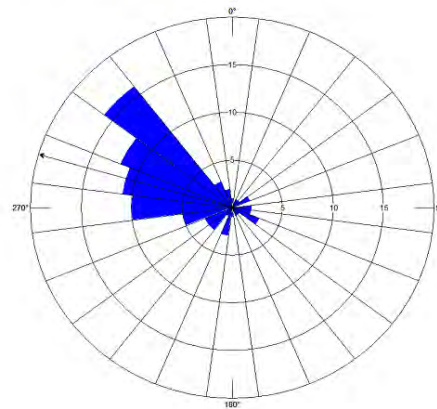
220770			
AC	DATE	26/01/23	FIG
KK	DATE	26/01/23	01

Stereoplot - Polar Projection Dip



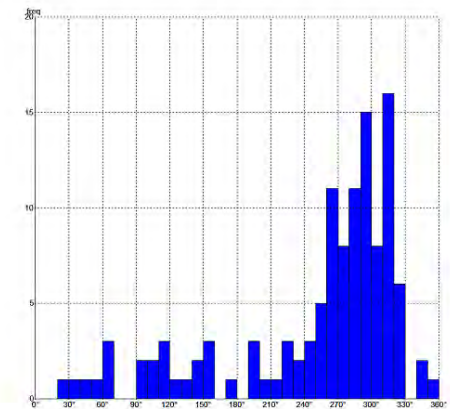
Schmidt Plot - Lower (Southern) Hemisphere - Structures - Mudstone
Depth: 8.15 m to 73.0 m

Rose Diagram - Azimuth



Depth: 8.15 m to 73.0 m

Histogram - Azimuth

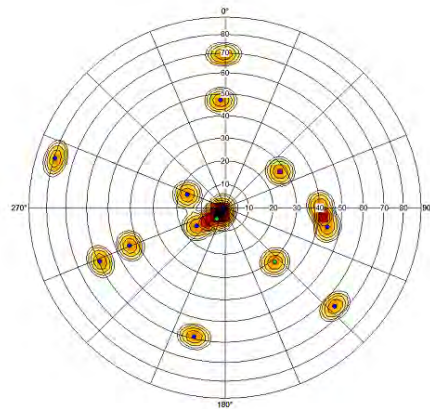


Depth: 8.15 m to 73.0 m



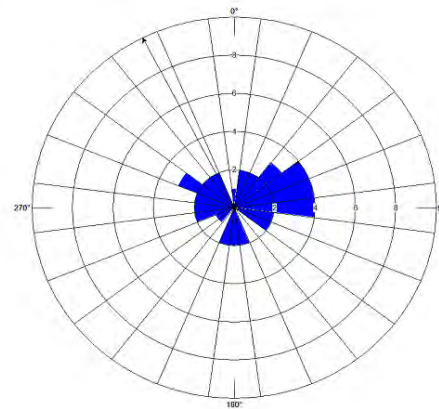
TITLE	BH103-Mudstone Structures	PROJECT	220770				
PROJECT	Drury Stevenson Quarry	DRAWN BY	AC	DATE	26/01/23	FIG	
CLIENT	Drillforce Ltd.	CHECKED BY	KK	DATE	26/01/23	01	

Stereoplot - Polar Projection Dip



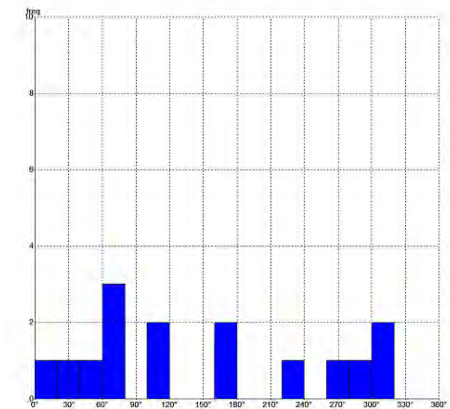
Schmidt Plot - Lower (Southern) Hemisphere - Structures - Greywacke
Depth: 72.80 m to 78.0 m

Rose Diagram - Azimuth



Depth: 72.80 m to 78.00 m

Histogram - Azimuth

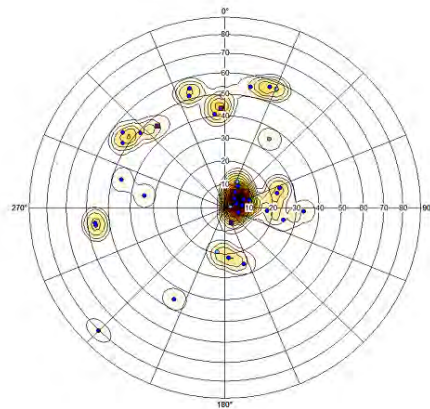


Depth: 72.80 m to 78.00 m



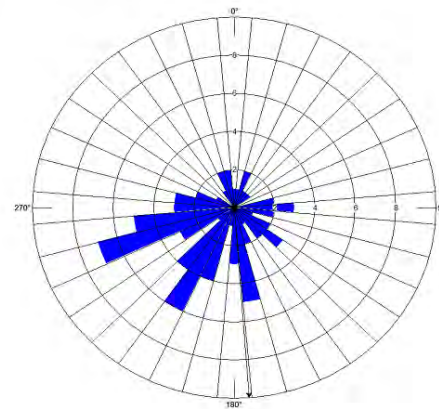
TITLE	BH103-Greywacke Structures	PROJECT	220770				
PROJECT	Drury Stevenson Quarry	DRAWN BY	AC	DATE	26/01/23	FIG	
CLIENT	Drillforce Ltd.	CHECKED BY	KK	DATE	26/01/23	01	

Stereoplot - Polar Projection Dip



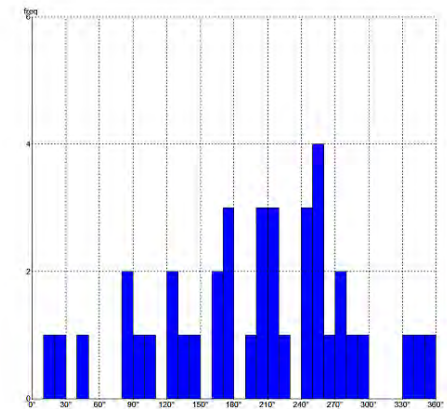
Schmidt Plot - Lower (Southern) Hemisphere - Structures - Mudstone
Depth: 5.5 m to 24.8 m

Rose Diagram - Azimuth



Depth: 5.5 m to 24.80 m

Histogram - Azimuth

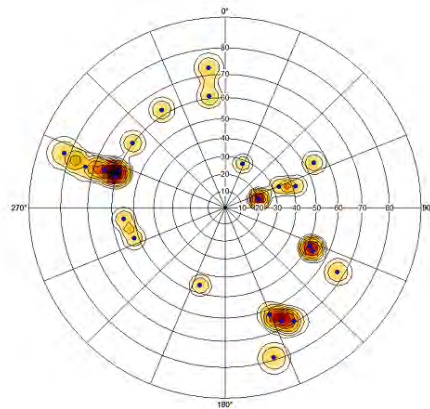


Depth: 5.5 m to 24.80 m



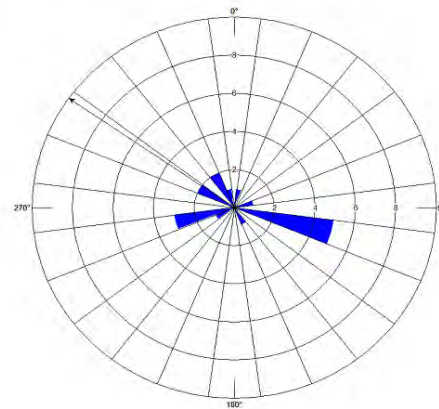
TITLE	BH104-Mudstone Structures	PROJECT	220770				
PROJECT	Drury Stevenson Quarry	DRAWN BY	AC	DATE	26/01/23	FIG	
CLIENT	Drillforce Ltd.	CHECKED BY	KK	DATE	26/01/23	01	

Stereoplot - Polar Projection Dip



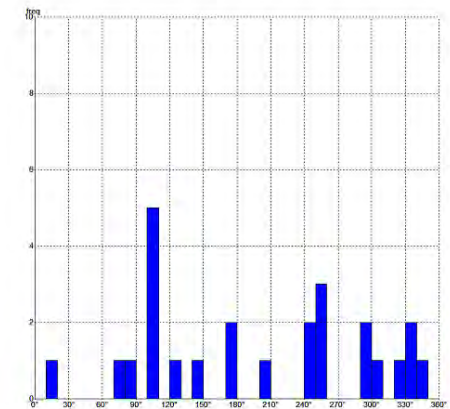
Schmidt Plot - Lower (Southern) Hemisphere - Structures - Greywacke
Depth: 30.9 m to 40.5 m

Rose Diagram - Azimuth



Depth: 30.90 m to 40.5 m

Histogram - Azimuth

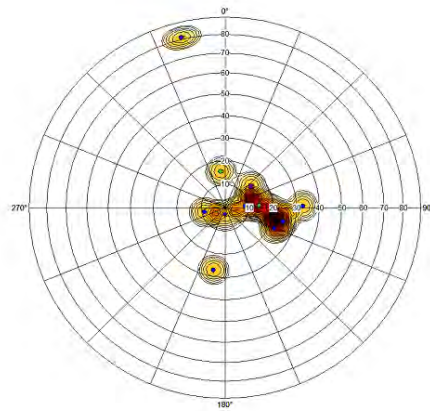


Depth: 30.90 m to 40.5 m



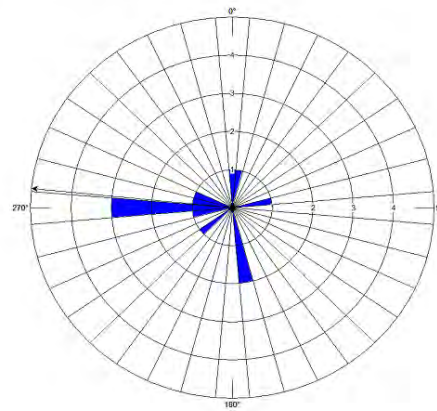
TITLE	BH104-Greywacke Structures	PROJECT	220770				
PROJECT	Drury Stevenson Quarry	DRAWN BY	AC	DATE	26/01/23	FIG	
CLIENT	Drillforce Ltd.	CHECKED BY	KK	DATE	26/01/23	01	

Stereoplot - Polar Projection Dip



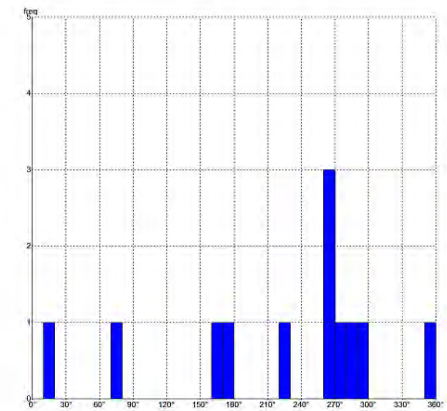
Schmidt Plot - Lower (Southern) Hemisphere - Structures - Conglomerate
Depth: 24.80 m to 30.90 m

Rose Diagram - Azimuth



Depth: 24.80 m to 30.90 m

Histogram - Azimuth

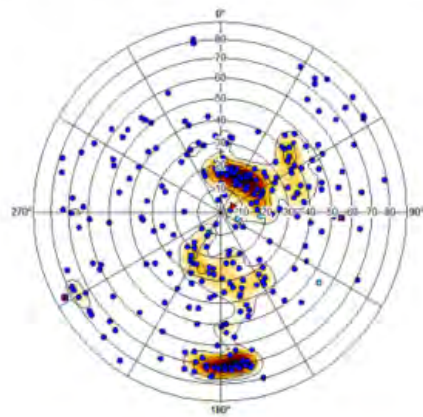


Depth: 24.80 m to 30.90 m



TITLE	BH104-Conglomerate Structures	PROJECT	220770				
PROJECT	Drury Stevenson Quarry	DRAWN BY	AC	DATE	26/01/23	FIG	
CLIENT	Drillforce Ltd.	CHECKED BY	KK	DATE	26/01/23	01	

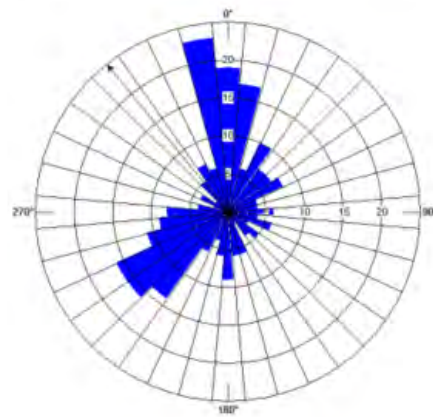
Stereoplot - Polar Projection Dip



Schmidt Plot - Lower (Southern) Hemisphere - Structures - True

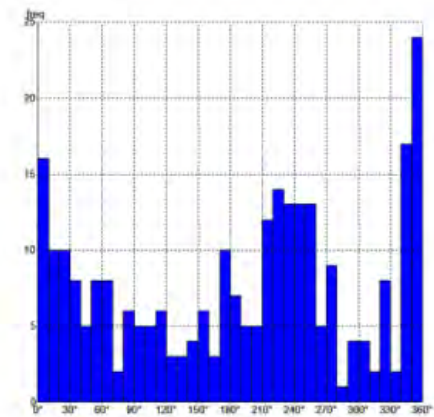
Depth: 3.50 m to 59.72 m

Rose Diagram - Azimuth



Depth: 3.50 m to 59.72 m

Histogram - Azimuth



Depth: 3.50 m to 59.72 m



TITLE
PROJECT
CLIENT

BH105-Greywacke Structures
Drury Stevenson Quarry
Drillforce Ltd.

PROJECT
DRAWN BY
CHECKED BY

220770
AC
KK
DATE
26/01/23
FIG
01