Attachment 30

Geotechnical Assessment

White Rock Quarry

Geotechnical Review and Response to DEM

Prepared for: Hanson Construction Materials

Date: December 2022

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Cover Page : Looking west toward the western extremities of the quarry

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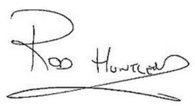
Important Note Regarding this Report

All information in this report relating to the Geotechnical Assessment is based on, and accurately reflects, information provided by Hanson and compiled by Groundwork Plus. Groundwork Plus, however, provides no warranty as to the accuracy of the information provided by Hanson.

The Geological and Geotechnical information was logged, compiled by Rod Huntley, Principal Geotechnical Engineer of Groundwork Plus.

Name: Rod Huntley



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Executive Summary

Groundwork Plus was commissioned by Hanson Construction Materials to prepare a response to the geotechnical items raised by the Department for Energy and Mining, (DEM), regarding Geohazards at White Rock Quarry. All points raised by DEM are discussed sequentially in a question/answer style format however, the key issues and changes to the initial rehabilitation design are discussed and illustrated below. All design works have been completed in accordance with :

- Cunning and Hawley. Guidelines for Mine Waste Dump and Stockpile Design CSIRO Publishing 2017.
- Read and Stacey. Guidelines for Open Pit Slope Design CSIRO Publishing 2009.
- Martin and Stacey. Guidelines for Open Pit Slope Design in Weak Rocks CSIRO Publishing 2018.
- Read and Beale. Guidelines for Evaluating Water in Pit Slope Stability CSIRO Publishing 2013.
- Slope Design Guidelines Eurocode 7.
- National Mines Safety Framework – Draft Code of Practice for Open Pit Mines.
- Assessment of Geotechnical Risks in Mines and Quarries.
- AS/NZS ISO 31000:2009 Risk Management - Principles and Guidelines.
- AS1726_2017 Geotechnical Site Investigations.
- National Mines Safety Framework – Draft Code of Practice for Open Pit Mines, and
- Geotechnical Engineering for Mine Waste Storage Facilities, CRC Press 2010.

Key Amendments

While there are no material changes to the quarry design several key amendments are proposed to the rehabilitation design to ensure long term stability of the rehabilitation profile. The final rehabilitated compacted fill slopes are in the majority, proposed to be benched on a maximum lift height of ten metres for access and stability purposes and to lower the overall total slope angle. The revised total slope angles are more conservative than a conventional compacted fill batter design and have the following benefits:

- Reducing the weights acting on the slope and the subsequent forces driving any potential failure.
- The Factors of Safety, (FoS), are >2 denoting long term stability, while Probabilities of Failure, (PoF), are negligible and slope Reliability Indexes, (RI), are suitably high.
- The revised design is more aligned to contemporary design standards pursuant to CSIRO design methodology

- The gentler batters are from experience expected to produce a greater propagation rate of endemic species on the gentler slope profiles.
- Access will be retained to the structure to allow for ongoing vegetation management and maintenance to occur, along with slope remediation if needed.
- The compacted fill is designed at a batter angle slightly shallower than the very commonly used 1V:2H batter profiles used in both civil and mining engineering applications. The proposed fill batter profile is a very conventional and standardised geometry regarding construction methodology for stable fill profiles.
- The western portion of the quarry will not be buttressed in fill and will remain as benches which will be rehabilitated with topsoil and suitable endemic species. This area is not being backfilled as it is not as visually apparent to the majority of stakeholders. Prior to the rehabilitation works being completed the areas will be stabilised trimmed and otherwise made stable to ensure that rehabilitation works can commence safely and practicably.

Plates 1 to 6 shows evolution of the quarry with selected stages of development and rehabilitation shows to illustrate the concepts involved.

Key Recommendations

- When finalised the rehabilitation works should be annually inspected to review stability and design compliance. A suitably detailed topographic survey should also be completed of the main fill areas, while the efficacy of the western abandonment bund should also be reviewed.
- When the fill/bench areas are finalised a set of static survey prisms should be installed on the structure and surveyed bi-annually to ensure movement rates are non-critical. Technology at this time is likely to allow for high resolution scanning or equivalent topographic comparisons to be completed so this will likely be a better option.
- Diversion drains, where needed, should be installed to limit any stormwater from entering the finalised bench areas or fill areas apart from the direct rainfall. No water should be channelled into the finalised areas.
- Buffer blasting, or equivalent, should be used approaching all final wall areas to limit vibrational impacts on the rock mass. A 20 metre wide geotechnical buffer zone should be implemented near final walls so that modified blasts are used as the final walls are approached.
- The final buttress fill structures should be independently audited and assessed during construction to ensure compliance with design.

- A small crest bund 200-300mm high should be used on the fill profile bench crests to limit water scouring across the batter face.
- A crest bund of approximately 1000mm height should be used on the rehabilitated quarry bench crests to limit water scouring across the batter face, as well as aiding with potential rockfall management and edge protection.
- The remaining non buttressed quarry faces should be scaled, and trimmed and have crest bunds implemented as needed before rehabilitation works are commenced.
- The proposed abandonment bund should be constructed as per design being 20 metres out from the toe of the slope being 4 metres high with batters of 1V:2H. It should also be revegetated with endemic species.

Key Plans

The key plans which have been provided to illustrate the concepts involved are :

- Quarry Development and Rehabilitation Plan - Stage 1 Drawing 1901_105R1
- Quarry Development and Rehabilitation Plan - Stage 2 Drawing 1901_106R1
- Quarry Development and Rehabilitation Plan - Stage 3 Drawing 1901_107R1
- Quarry Development and Rehabilitation Plan - Stage 3A1 Drawing 1901_110
- Quarry Development and Rehabilitation Plan - Stage 3A2 Drawing 1901_111
- Rehabilitation and Overburden Stockpile Cross Section Location Plan Drawing 1901_113
- Slope Cross Sections A-A'to E-E' Drawing 1901_113A
- Slope Cross Sections G-G' to S-S' Drawing 1901_113B
- Quarry Rehabilitation Detail Drawing No. 1901.DRG.114
- Drillhole Location Plan Drawing No. 1901.DRG.115
- Regional Geology Drawing No. 1901.DRG.023

These plans should be considered in conjunction with the terminology provided in this report.

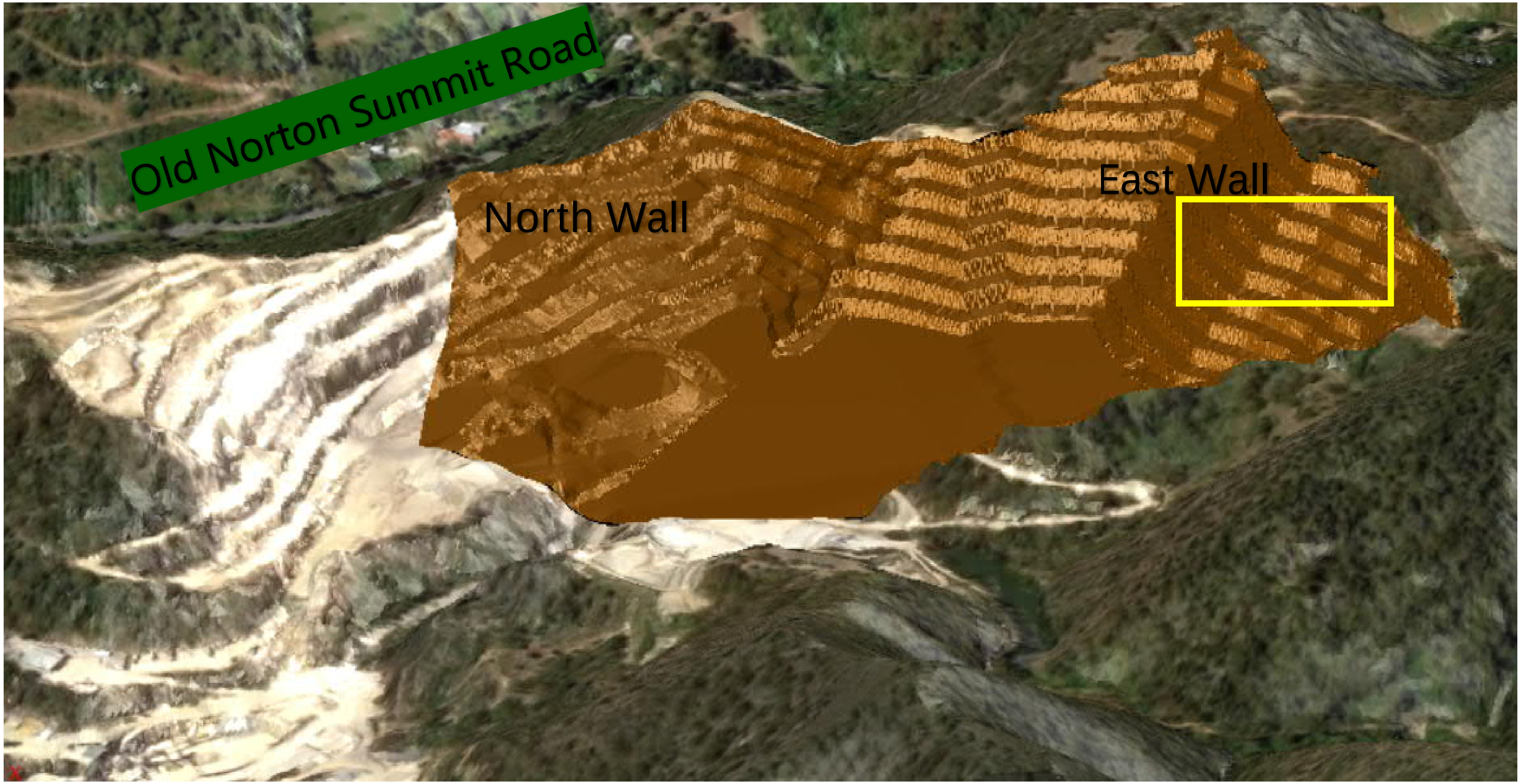


Plate 1: Stage 1 of quarry development (brown surface) which focuses largely on the eastern and north eastern sectors of the quarry. Importantly in this image the overburden to be recovered in the eastern highwall sits in the quarry pit area and cannot leave site as it will not roll up hill. The approximate location of the overburden is shown by the yellow boxed area. Stage 1 of rehabilitation is all temporary internal storage of overburden material which will be placed using a very conventional 1V : 2H compacted fill profile. This temporarily stored material will then be used in the east wall buttress in Stage 2 rehabilitation works, refer Plate 3. Old Norton Summit road is visible to the left of page paralleling the gully line.

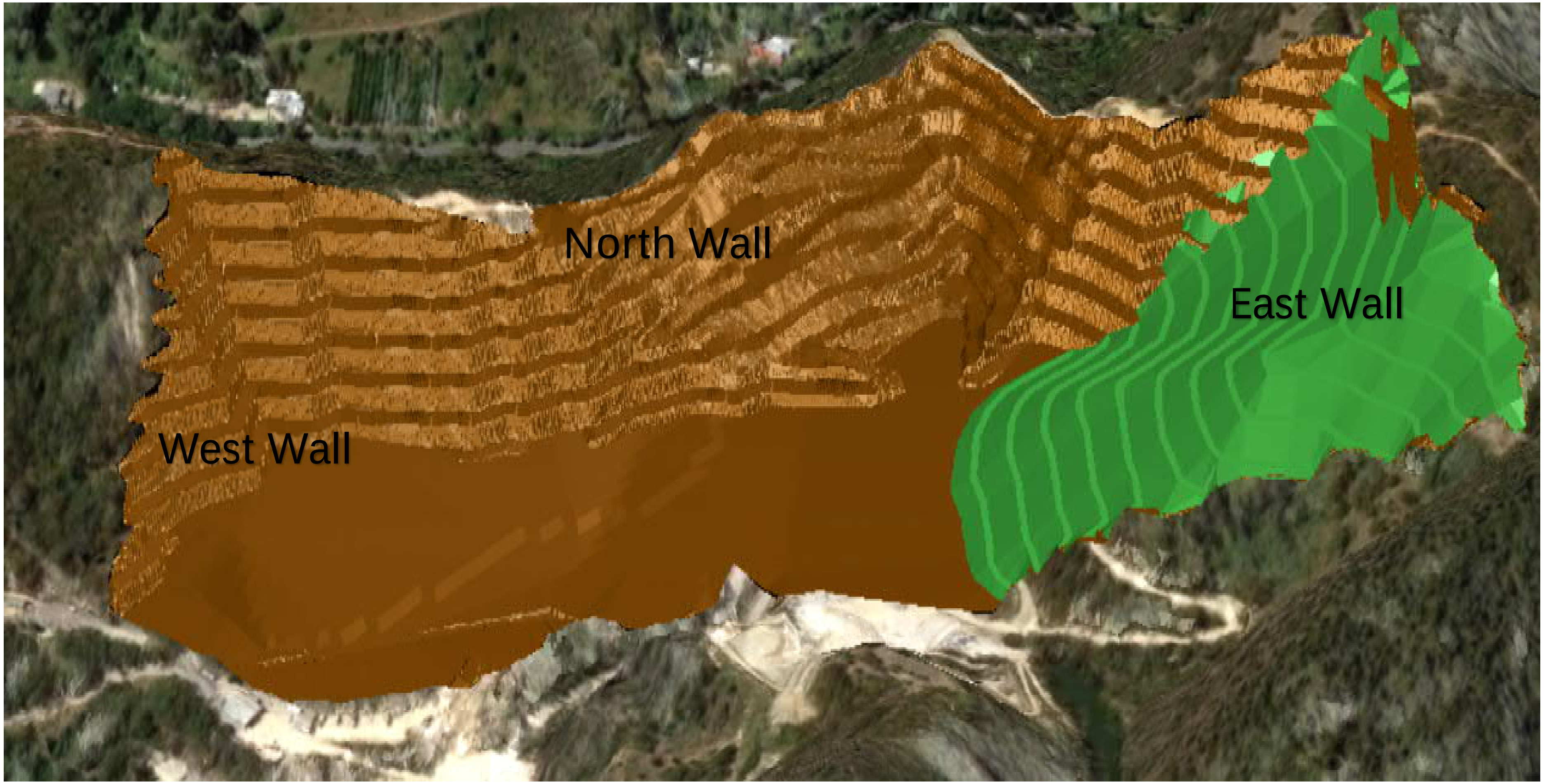


Plate 2: Stage 2 of quarry development with a sectional view of the east wall showing rehabilitation stage 2 as the green surface partially buttressing the eastern highwall. The east wall is visually the most prominent part of the quarry which is why it will be rehabilitated early. The green surface shown will be planted with endemic species pursuant to the rehabilitation plan. The total slope angle of the green surface is 22^0 which is suitably conservative and proportionally shallow for a compacted fill structure built in 10 metre high lifts, which will be compacted on the standard 500mm thick interval heights. Note the northern crest line of the ridge has been retained to limit direct impacts to Old Norton Summit Road.

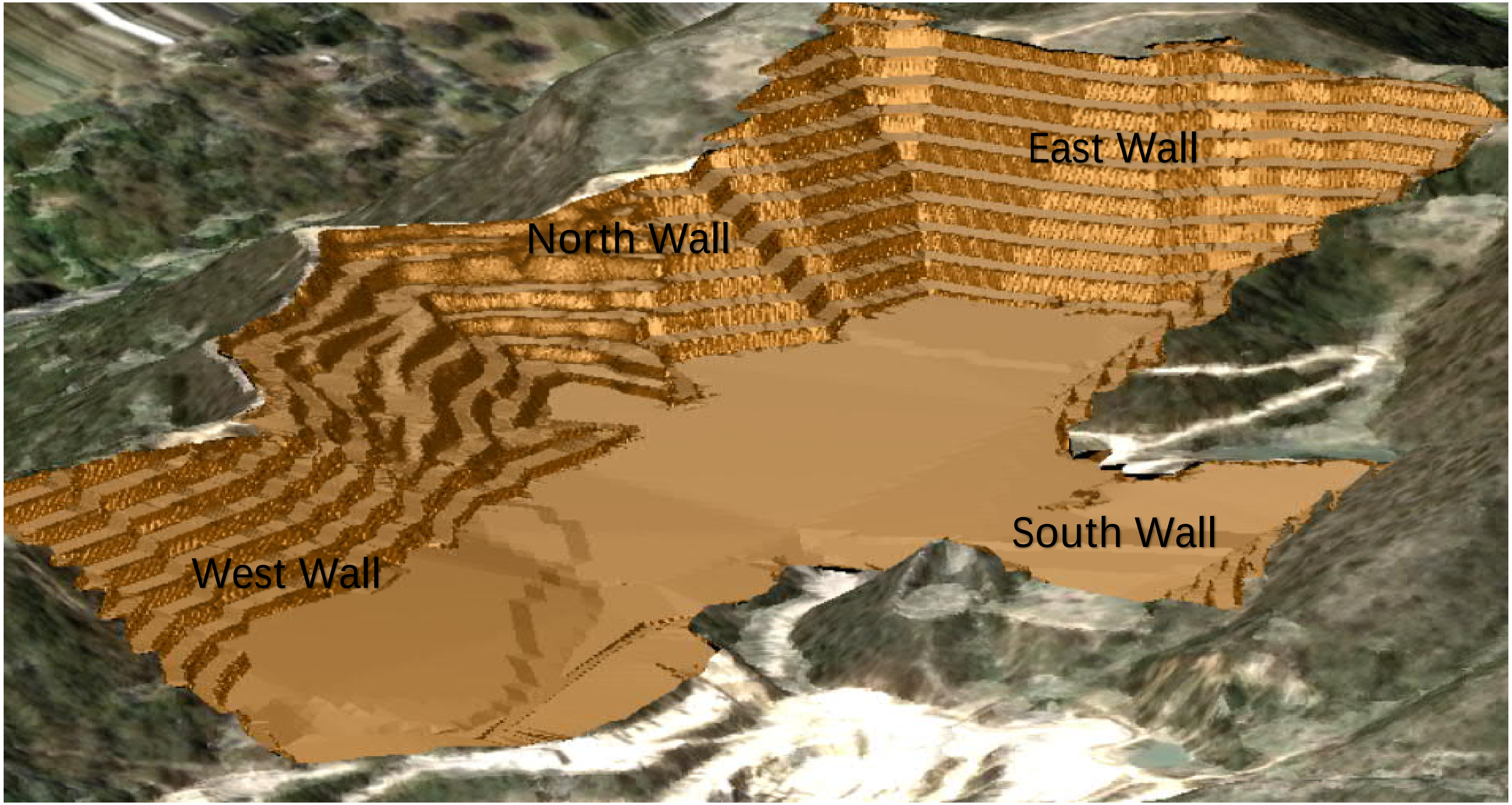


Plate 3: Stage 3 of quarry development which mainly extracts from the west and south wall areas.

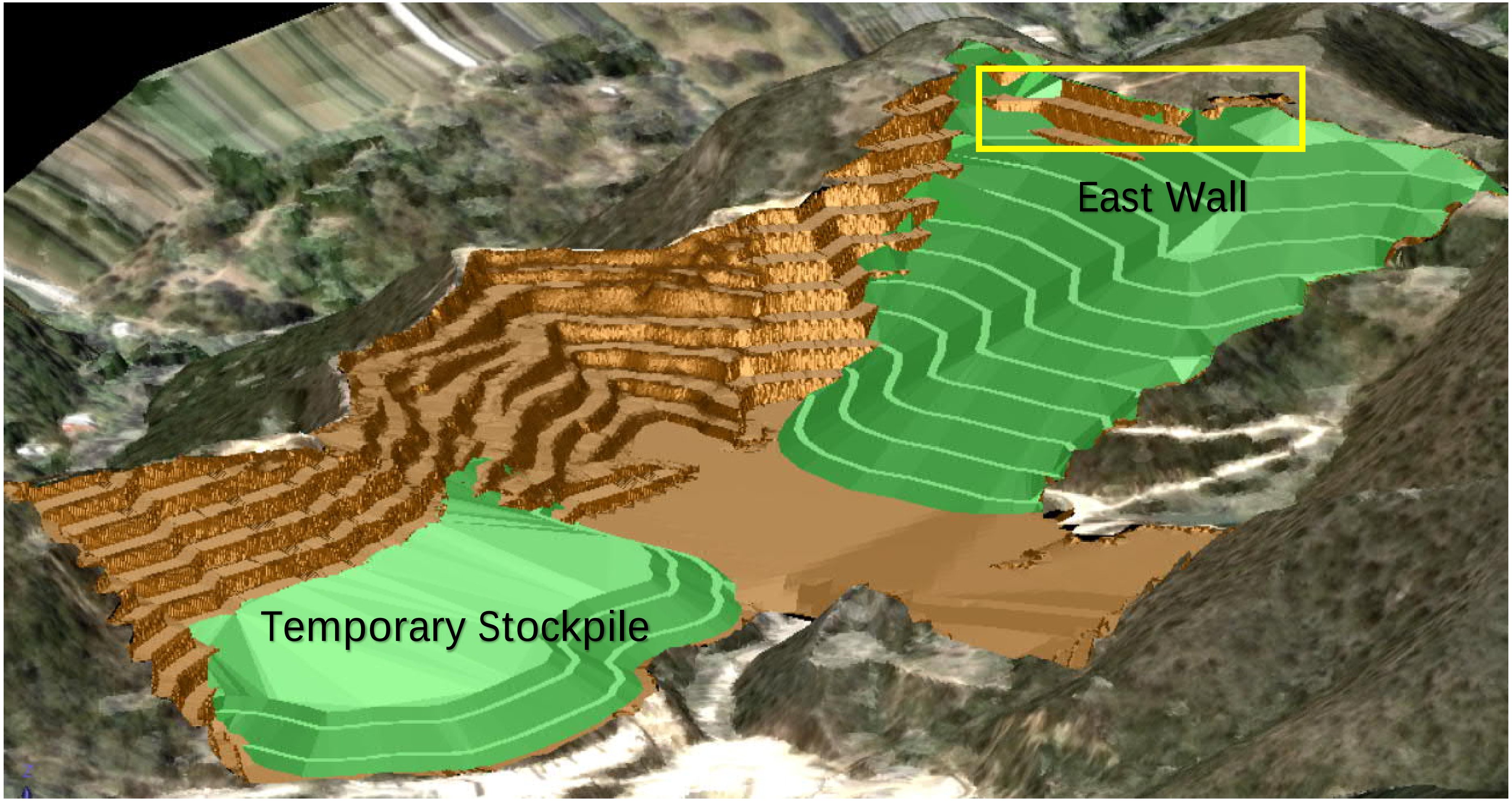


Plate 4: Stage 3 rehabilitation works shown in green with a temporary stockpile shown on the floor in the west pit. The eastern highwall cannot be added to as it would constrain extraction of the central and southern portions of the resource area. Temporary rehabilitation and plantings will be used in the highwall to limit visual amenity issues in the brown bench areas (yellow boxed area) which cannot yet be added to considering the bottom up compaction methodology used for the fill.

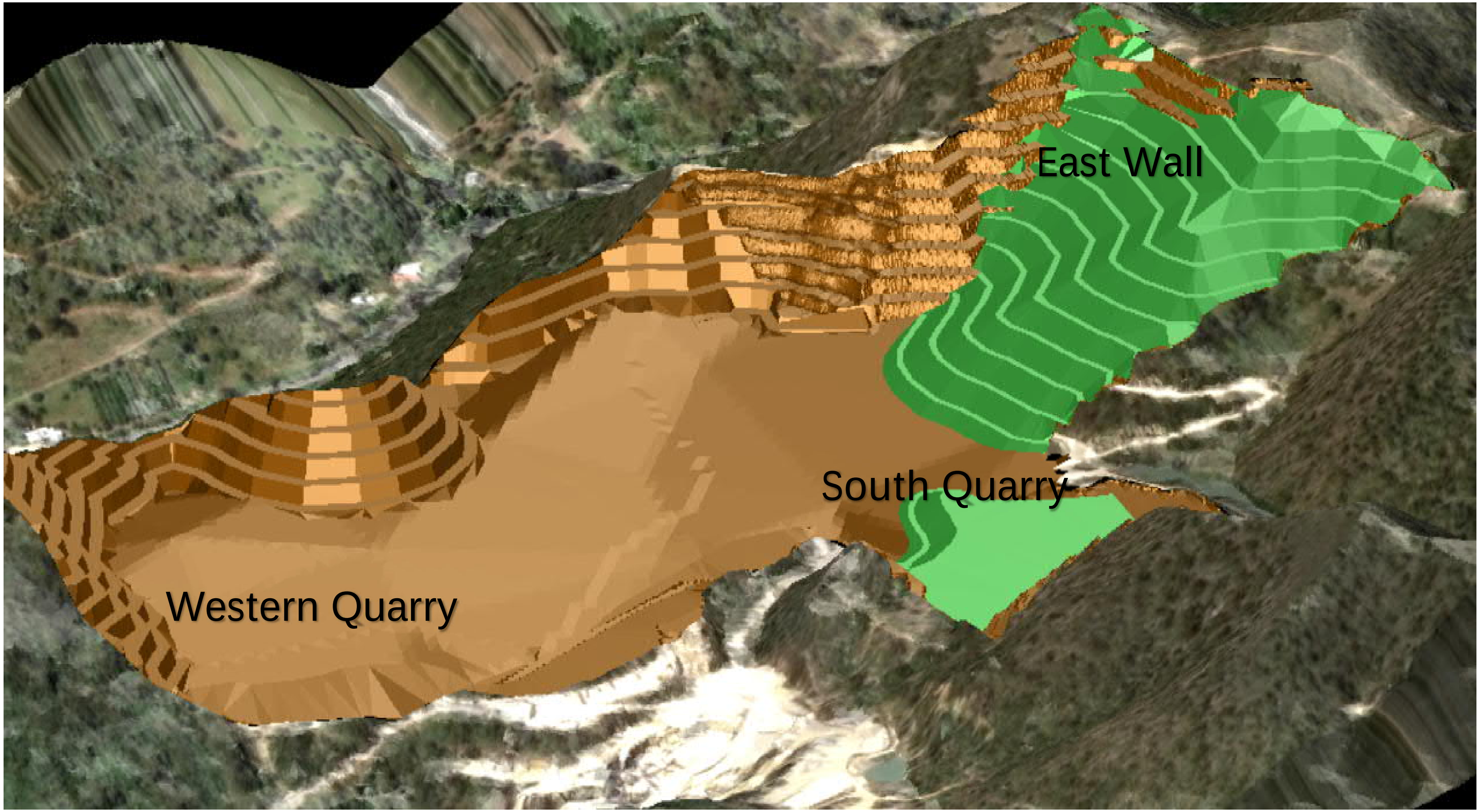


Plate 5: Showing the proposed final quarry landform as the brown benched surface prior to rehabilitation. The highest point on site is the eastern highwall which will be the first area to be fully rehabilitated. Old Norton Summit Road is visible to the left of page paralleling the gully line. Note this image is shown with rehabilitation to illustrate the proposed maximum extent of the quarry. The green surfaces are the rehabilitated areas.

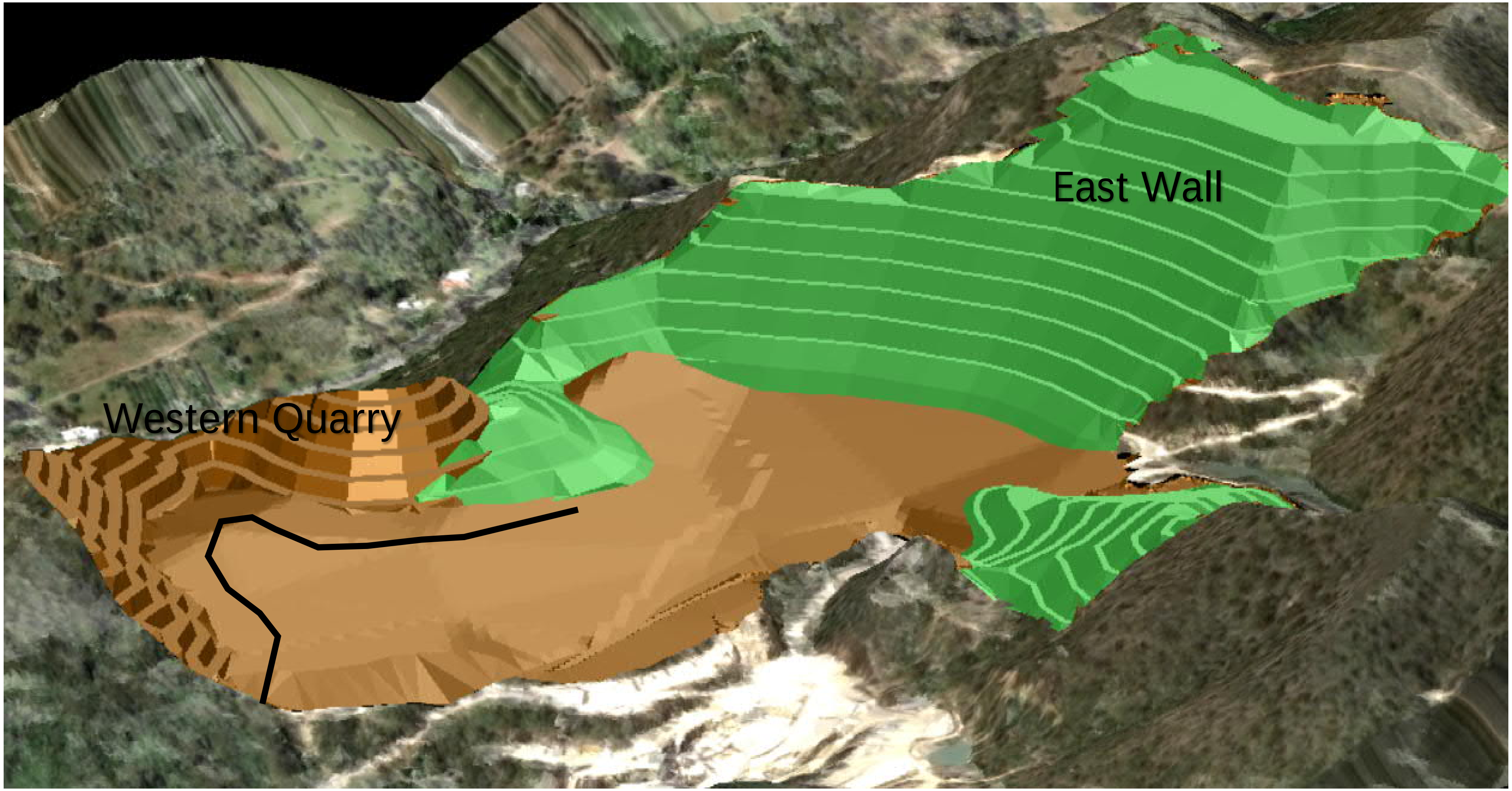


Plate 6: Showing the proposed full rehabilitation areas of the site with the raised floor level (groundwater issue) and the areas which will be retained as rehabilitated quarry benches shown in the west of site. An abandonment bund (black line) is proposed for the western quarry area for isolation purposes. Diversion drains, where needed, will be implemented around the crest of the area post extraction to divert clean water away from the quarry rehabilitation area. Because the quarry has retained the crest in many areas diversion drains will not be needed around large portions of the site.

1 Introduction

The general philosophy and rationale used by this document is pursuant to the outline proposed in the CSIRO Guidelines for Open Pit Slope Design 2009, as illustrated below in DIAGRAM 1 – FLOW CHART OF THE GEOTECHNICAL PIT DESIGN PROCESS. The overburden design has been prepared pursuant to the outline proposed in DIAGRAM 2 – OVERBURDEN GEOTECHNICAL DESIGN CONSIDERATIONS derived from the CSIRO Guidelines for Mine Waste Dump and Stockpile Design CSIRO Publishing 2017.

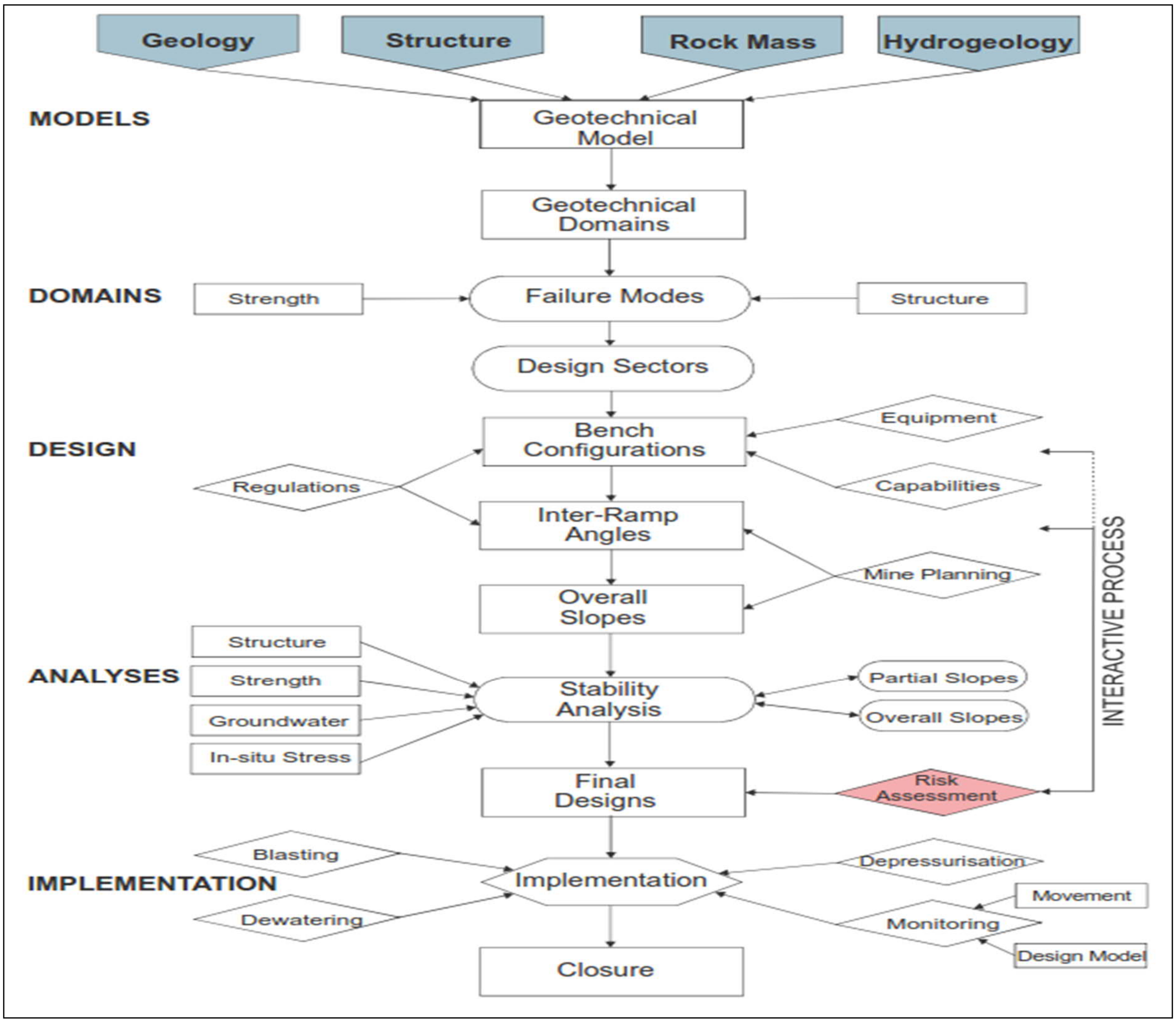


Diagram 1 – Geotechnical Pit Design Process (after Read and Stacey 2009 CSIRO)

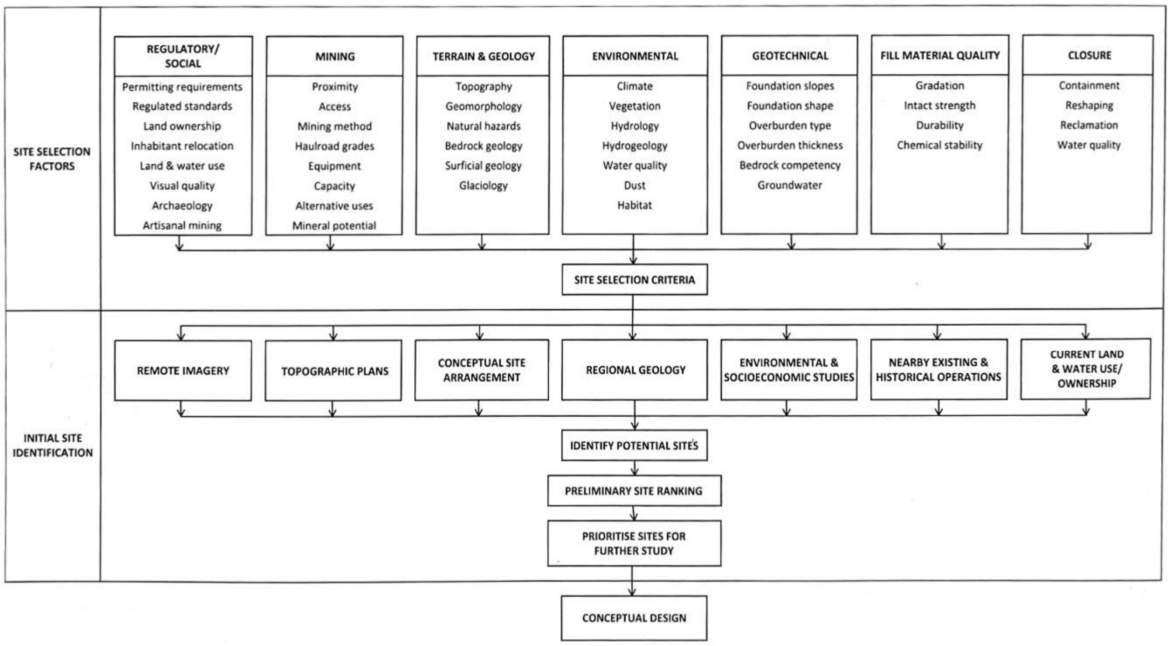


Diagram 2 – Overburden Geotechnical Design Considerations (after Cunning and Hawley 2017 CSIRO)

1.1 Scope

The scope of work is to answer in full the items raised by DEM as outlined in the Description of Matters, Identified Alterations Requested and Specific Alterations Identified.

1.2 Legislation

Pursuant to the Work Health and Safety Regulations 2012, regulation 627 the principal hazards must be identified on site and risk assessed for a quarry. Systematic investigations must be completed in regard to the hazard, which are listed in Regulation 628 and Schedule 19. Specifically for this project the following ground or strata instability criteria as listed have been considered in the design process.

Ground or strata instability.

The following matters must be considered in developing the control measures to manage the risks of ground or strata instability:

(a) the local geological structure;

(b) the local hydrogeological environment, including surface and ground water;

(c) the geotechnical characteristics of the rocks and soil, including the effects of time, oxidation and water on rock support and stability;

(d) any natural or induced seismic activity;

(e) the location and loadings from existing or proposed mine infrastructure such as waste dumps, tailings storage, haul roads and mine facilities;

(f) any previously excavated or abandoned workings;

(g) the proposed and existing mining operations, including the nature and number of excavations, the number and size of permanent or temporary voids or openings, backfilling of mined areas and stopes, abutments, periodic weighting, and windblast; and

(h) the proposed blasting activities, including airblast.

Cognisant of these requirements the design of the rehabilitation structure was completed in consideration of Regulation 628 and Schedule 19, of the Work Health Safety Regulations and also in consideration of Chapter 10 – Work, Health & Safety Regulations 2012

Principle Quarrying Hazards can, if not adequately controlled, result in multiple deaths on a site or result on serious ongoing incidents. Unfortunately, incidents involving Principal Quarrying Hazards can contain the threat of serious injury up to and including death. A Principal Quarrying Hazard plan must be designed for each of the individual hazards on the site.

Regarding geotechnical risks and slope stability analysis for the quarry design a large body of geotechnical work is completed early in the design phase to ensure that the initial plans provided to DEM are achievable and more importantly will be stable in the long term. Slope design works for both the quarry and rehabilitation profile are informed, by amongst other documents, the following guidelines:

- Read and Stacey. Guidelines for Open Pit Slope Design CSIRO Publishing 2009.
- Martin and Stacey. Guidelines for Open Pit Slope Design in Weak Rocks CSIRO Publishing 2018.
- Read and Beale. Guidelines for Evaluating Water in Pit Slope Stability CSIRO Publishing 2013.
- Cunning and Hawley. Guidelines for Mine Waste Dump and Stockpile Design CSIRO Publishing 2017.
- Slope Design Guidelines Eurocode 7
- National Mines Safety Framework – Draft Code of Practice for Open Pit Mines.
- Assessment of Geotechnical Risks in Mines and Quarries;
- Geotechnical guideline for terminal and rehabilitated slopes Extractive industry projects September 2020. Victorian Guidelines
- AS/NZS ISO 31000:2009 Risk Management - Principles and Guidelines;
- AS1726_2017 Geotechnical Site Investigations

- National Mines Safety Framework – Draft Code of Practice for Open Pit Mines, and
- Geotechnical Engineering for Mine Waste Storage Facilities, CRC Press 2010.

Various state based guidance material has also been considered in design of the structures.

1.3 Description of Matters

1. Quarry designs presented are high level, and the MOP Review does not include any information about geotechnical risks and slope stability analysis and how they have been considered in the design of the proposed extraction plans and rehabilitation strategies.
2. The MOP Review must demonstrate how the operational and terminal faces of the quarry have been designed to ensure achievement of public safety objectives, third party property objectives and visual amenity objectives.
3. Face heights, bench widths and wall angles are not described in section 3.4. DEM notes there is no change to bench heights in the drawing sets pertaining to rehabilitation, which appears inconsistent with the rehabilitation strategy.
4. The final rehabilitation strategy presented in drawing no. DRG.083AR1 shows a number of faces remaining in the landscape post closure which are to be located on the eastern and western boundaries of the quarry pit.
5. Section 3.4 of the MOP Review must provide details of the following matters:
    a. remaining face heights and wall angles;
    b. discussion of the long-term stability of the remaining faces, and
    c. an assessment of requirements for safety / abandonment bunds.
6. Stage 1 proposes extraction of overburden material which was previously placed above the east wall. The stability of the overburden material is not known. The MOP Review does not provide an analysis of the stability of the overburden or how geotechnical considerations have been used to inform the designs that mine through the overburden material.

1.4 Identified Alterations Requested

7. The MOP Review must provide sufficient evidence to demonstrate the quarry plan can be effectively executed.
8. Provide an analysis that demonstrates that geotechnical/slope stability of quarry landforms (including pit slopes and waste rock dumps/overburden) ensure protection of third- party property, public safety, and suitability of rehabilitation strategies (including visual amenity).
9. Undertake a risk assessment using the information from the geotechnical analysis. If risk is identified, revise the impact profile provided in section 6 (note the relevance to the following

impact assessments; section 6.10, section 6.13, section 6.14, section 7). Provide appropriate management strategies and an evaluation of residual risk.

10. Provide details of the following in relation to the base case landform rehabilitation strategy:
    a. remaining face heights and wall angles;
    b. discussion of the long-term stability of the remaining faces;
    c. appropriate management strategies, and
    d. an assessment of any requirement for safety bunds / abandonment bunds.
11. Review and make any necessary changes to the quarry planning, design and rehabilitation resulting from the geotechnical assessment.

1.5 Specific Alterations Identified

12. Describe how geotechnical parameters of the site have informed the design of the pit shells / OB stockpiles / rehabilitation batters.

Geotechnical parameters are summarised in Table 1

13. Section 3.4 – describe the pit design parameters including the face heights, bench widths and wall angles
14. Section 3.4 – discussion of long term stability of the rehabilitation
15. Section 3.4 – discuss the need for bunds post closure
16. Geotechnical considerations to be detailed for the extraction of the existing overburden material
    a. Base case landform details to include the following:
    b. remaining face heights and wall angles;
    c. discussion of the long-term stability of the remaining faces;
    d. appropriate management strategies, and

an assessment of any requirement for safety bunds / abandonment bunds

1.6 General Proposal Intent to Address Alteration

17. Rehabilitation strategy is hinged on visual amenity

2 Design Philosophy

2.1 Non Technical Quarry Design Considerations (Modifying Factors)

Initially when a site layout is being considered an understanding of all relevant impacts on stakeholders is initially considered and a design then proposed which should be generally achievable provided standard environmental controls are implemented. The quarry design is never an ideal technical rock mechanics, operational or resource design as firstly and foremostly and design must comply with relevant guidelines and legislation and additionally, and as equally important, try and coexist in so far as is practicable with all sensitive receptors and stakeholders. These criteria, or the requirement for the social licence to operate, are of paramount importance in any design philosophy, and rightly so overarch the technical design criteria which are studied once the societal impacts are firstly considered, and compliance can be demonstrated. Diagrams 1 and 2. provided previously, flow chart this design philosophy.

Clearly getting the right design is a difficult exercise and commonly technical designs undergo a large iterative process with multiple revisions in an attempt to achieve a balanced outcome between all competing issues. These issues are commonly described in mining parlance as the modifying factors under the Joint Ore Reserves Committee Guidelines (JORC) 2012 jointly prepared by the Minerals Council of Australia the Australian Institute of Mining and Metallurgy and the Australian Institute of Geoscientists.

2.2 The Technical Quarry Design Process

For this site at a practical, operational and design level, the quarry is a large working quarry which allows for a high degree of technical assessment to occur which subsequently provides a high level of confidence in the technical criteria assessed. Initially the geotechnical characteristics of the site rock mass is examined in detail to assess the relevant design criteria in both the current and future development areas. Assessment of the rock mass occurs by completing detailed geotechnical mapping of the exposed benches, batters, and all other relevant working areas, then developing a set of composite domains for the rock mass. Importantly the number of exposed faces and history of the quarry operation provides a very large data set in which to examine extant geotechnical conditions.

This quarry has been operational for 40^+ years and the rock mass is well understood. Several other quarries operate in the same geological rock mass with the nearby Stonyfell Quarry understood to also be an example, of how geotechnical conditions develop over time in this type of rock mass. Core drill results and the drill hole database, along with the materials testing database, topographic surveys and other relevant information is also then incorporated into this assessment. For this site I note that the levels of structural and geological homogeneity are high which is why a high degree of confidence exists in the geological and geotechnical model. Simply put these rocks are sub horizontally bedded which is clearly visible in the large amounts of rock exposure in the quarry and is also visible in core drill holes drilled in the future expansion area. As an example specific stratigraphic beds are traceable in the quarry which can be readily linked to the same beds encountered in the core drilling. Given the proportionally straight forward structural setting encountered on site this degree of homogeneity is not considered either unusual or unexpected.

Composite domains are then developed in preference to purely structural domains, as it is submitted that composite domains more accurately reflect site geotechnical characteristics and provide a more useful tool for management of the site, in contrast to structural domains which are of limited use to most people. Importantly the structural domains and kinematic assessment are an integral part of developing the composite domains however, also included in the composite domaining process are the following geotechnical elements:

- Degree of weathering, pursuant to AS1726_2017;
- Relevant engineering parameters (i.e. durability and rock strength), completed to NATA standards;
- Bench orientations, and slope-bench-batter design criteria;
- Slope Height and Total Slope Angle ;
- Ground/surface water impacts;
- History of performance and failure type/s if any;
- The field assessment of potential failure mechanisms for both slope and rockfall risk;
- Seismicity and proximity of Neotectonic structures;
- Adjacent sensitive receptors and other relevant infrastructure; and
- Benchmarking the slope design against criteria provided in relevant guidelines.

In more specific detail, geotechnical risks for the current workings and final landform consider the potential failure mechanisms and then implement design measures to adequately mitigate these risks. For the designs provided this includes ensuring that the final landform, prior to rehabilitation is safe and stable, with additional works completed, if needed, to ensure that slope is ready for large scale rehabilitation works. This practical phase of the works could include bench trimming, reprofiling additional buffer or presplit blasting, batter scaling and buttressing as needed.

Also at this stage of the design, assessment relevant failure mechanisms are assessed and managed, prior to rehabilitation works being commenced. When rehabilitation works are commenced initially the designs are ground truthed, with volume estimates completed on the earth works package to determine viability. The design is then modelled in Slide 2D to assess relevant Factor of Safety for the final proposed slopes. The slopes are also benchmarked against known slopes constructed in similar material. The kinematic analysis and Ground Control Management Plan are also reviewed with salient data captured from these documents and incorporated into the final proposed design. Table 1 Slope Risk Assessment tabulates risks and mitigation measures to be considered, while a Slope Stability Analyses provides the modelling data from the Limit Equilibrium Assessment. As part of the Limit Equilibrium slope assessment works, the designs are also considered in a Finite Element Slope Model, (RS2), to validate the data sets and slope stability outcomes. Plate 7 provides some relevant images of the current and other relevant quarry workings which display relevant characteristics of the operation considered at the design phase of works. Table 2 Geotechnical Considerations summarises relevant rock mechanics data which is assessed during the design process.

Plate 7: The eastern highwall in section is a bedded moderate strength metamorphosed rock mass which while jointed perform well in service as is clearly evident in this image. Bedding is sub horizontal and the rock mass is not folded to any significant degree. Minor warping of the bedding planes and small scale fault displacements are also recognised in this wall.

Table 1 – Slope Risk Assessment

Geotechnical Issue	Comments	Data Source	Risk Mitigation	Risk
Limited geotechnical information (e.g. greenfield site)	The rock mass weathering is variable while the structural setting is reasonably straight forward. Site conditions will always be slightly different to those expected.	Previous site development, drilling and outcrop. Site conditions will always be slightly different to those expected.	Conservative slope design in extremely mod-high strength rock	Low
Limited testing of rock mass properties (unrepresentative values)	Significant outcrop the historical workings and drill results have all returned very similar results. The rock is of moderate to high strength.	Hanson NAAT certified Lab with 40 years plus of data	Compliance testing will continue with production testing completed to further validate current test results	Low
Limited knowledge on ground control management	Management operates multiple quarries	Previous site development, drilling and outcrop. Site conditions will always be slightly different to those expected.	Geotechnical training and support provided as needed	Low
Unverified failure mechanisms	Not currently recognised	Previous site development, drilling and outcrop.	Bench/batter designs are conservative and could be amended further if needed	Low
Limited ability (financially or otherwise) to suitably manage ground movements	Hanson is a well-funded public company	DAX German Stock Exchange	Adequate width working areas with low bench heights	Very Low
Potential for sudden falls of ground causing harm to sensitive receptors	There are no sensitive receptors adjacent to or near the quarry that could be impacted by slope instability or rockfall risk	Site Layout Plan Quarry Plan	Adequate buffer zones have been retained	Very Low
Significantly variable ground conditions	Possible although all drilling, development areas and drilling demonstrates homogeneity	Previous site development, drilling and outcrop. Site conditions will always be slightly different to those expected.	Geotechnical Model and GCMP information will be updated routinely	Low
Important infrastructure in close proximity.	Occurs on other side of ridgeline	Site Layout Plan	Blast Mgmt design and implementing quarry design	Low

Table 2 – Geotechnical Considerations

Issue	Considerations
Slope status	Terminal or rehabilitated
Slope geometry	Overall slope height, overall slope angle, batter angle, bench height, berm width
Engineering characteristics	Rock or soil, structurally controlled, alteration materials present, material strength, discontinuity shear strength
Proximity of existing infrastructure	Property or services adjacent to crest or toe of slope, located externally or on site
Surcharge loading	Top-loading of slope by e.g., Stockpile, dumps, or dams.
Proximity of dams, dumps, and voids	Potential for adjacent structures to be impacted by slope failure, or potential for the excavation to be impacted by a dam failure or dump wall failure
Proximity of public	Proximity of public access, roads, footpaths, walkways
History of failure	History of instability, rock falls, unexpected slope movement
Slope condition	Active failure (visible signs of failure: rockfalls, bulging, tension cracks), stabilised, stable
Failure mechanism	Planar, wedge, toppling, rotational, liquefaction, toe bulge, crest damage, complex
Size of failure	Minor, significant (requires stabilisation), major (impacts on sensitive receptors)
Speed of failure	Rapid (flows, rockfall), slow (rotational), very slow (rotational)
Design acceptance criteria	Acceptability of failure based on consequence or probability of failure and the inherent uncertainty of the design data
Surface water	Control of surface water and detrimental effects on slope stability (e.g., erosion)
Groundwater	Visible signs of seepage or discharge, pore pressures
Frequency and size of rockfall	The size of the rockfall and ejection distance
Blast impacts	Blast performance and the damage induced into the rock mass (back break, crest damage)
Dispersive soils and clays	Soils rapidly erode due to water
Time	Effect of time on engineering characteristics of the soil and rock mass and degradation of ground support, and factor of safety over the life of the slope
Existing remedial measures	Reorientation, regrading, dewatering, buttresses, trenches, reprofiling, exclusion zones
Monitoring	Extensometers, piezometers, closure meters, EDM targets, radar, UAV, pin, and prism survey, etc.
Seismic history	Whether the region is seismically active or subject to significant crustal stress
Land end uses	End-use considerations on design acceptance criteria, terminal and rehabilitated slope designs, slope monitoring, and slope stabilisation

2.3 The Technical Rehabilitation Design Process

For design of the rehabilitation landforms a similar process is followed along with the most useful guidelines for this part of the process being:

- Cunning and Hawley. Guidelines for Mine Waste Dump and Stockpile Design CSIRO Publishing 2017.
- Blight. Geotechnical Engineering for Mine Waste Storage Facilities, CRC Press 2010.

Additionally the majority of the states have various legislation regarding rehabilitation and stability of final landforms with four of these being instructive:

- Geotechnical guideline for terminal and rehabilitated slopes Extractive industry projects September 2020 from Victoria
- Mine Closure Plan Guidance from Western Australia.
- Mine Closure Leading Practice Sustainable Development Program for the Mining Industry, and:
- Safety Bund Walls Around Abandoned Open Pit Mines from Western Australia.

Principally as a fundamental design outcome the rehabilitation structure/s that have been designed have had a “negligible” failure hazard classification assigned to the structure/s as its principal design philosophy, pursuant to the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Guidelines 2017. This will ensure, in so far as is practicable, the long term stability of the structure. These guidelines and their precursors provide clarity on design criteria and suggest that structures like the final proposed landform for White Rock Quarry should be benched to improve slope stability outcomes.

Importantly when assessing the stability of structures like the White Rock Quarry Rehabilitation Plan, a host of issues have been concisely distilled into tabular format by the CSIRO, refer Tables 3 and 4. These tables provide a useful high-level framework in which to assess stability conditions of structures like the Rehabilitation Plan and the amount of engineering investigation or information required to achieve a certain failure hazard level. They assess eleven relevant criteria, all of which have been considered in design of the structures. The failure hazard level of “negligible” was used and is recommended to be implemented. Additionally a “negligible” failure hazard level was deemed appropriate because of the sensitivity of the site and the proposed post extraction land uses considered.

Pursuant to these CSIRO Guidelines, and in consideration of other relevant issues, notably the design life requirement of >100 years, a suitable failure hazard classification suitable for the design was determined to be "negligible" i.e. a very low risk structure. Rehabilitation Structure Stability Rating

The stability rating system establishes a numerical index based on consideration of 11 factors with point ranges assigned to each factor weighted according to the authors perception of their overall performance. The sum of the individual point ratings is defined as the "stability rating".

2.4 Rehabilitation Stability Classes

When assessed Table 3 of this report the "stability rating" is further divided into four "stability classes". Each "stability class" is then assigned a relative failure or instability hazard descriptor. It is important to note that each stability class" was never intended as a standalone risk assessment tool, and it does not include any explicit reference to exposure or consequence of failure. The usefulness of the tables is that they provide a frame of reference for investigation and recognise that many factors contribute to stability conditions of a structure. Importantly when assessed against the CSIRO Dump Stability Rating criteria the rehabilitation plan returns a value less than 300 which is considered of negligible risk, refer Table 4, which provides the stability rating assessment for the engineering criteria.

Practically this structure is designed to be conservative and putting this slope design in context is that many sand mines have rehabilitation criteria of 18.5 degrees or a 1:3 slope. This slope in the compacted fill batter area is in part shallower than this angle at 16^0 which again very fundamentally and practically shows how suitably conservative this design is, refer Plates 8 and 9. It is noted that the profile does increase up to a total slope angle of 22^0 in some areas. More commonly hard rock quarry sites if left as benches have total slope angles of between 40 to 50 degrees depending upon rock mass conditions, which is illustrated in the benchmarking shown in Plates 47 to 51.

Section E, refer Plate 12 cut through the southern compacted overburden storage area is actually shallower than 1V: 3H. The rehabilitation batter design can be conservative in this instance as significant volumes of fill will require storage and resultantly, they have been incorporated into the rehabilitation works.

Table 3.1 – Rehabilitation Stability Class*

Dump stability classes and recommended level of effort			
Dump stability rating (DSR)	Dump stability class (DSC)	Failure Hazard	Recommended level of effort for investigation, design, and construction
< 300	I	Negligible	Basic site reconnaissance, baseline documentation; minimal laboratory testing; routine check of stability, possibly using charts; minimal restrictions on construction; visual monitoring only
300-600	II	Low	Thorough site investigation; test pits, sampling may be required; limited laboratory index testing; stability may or may not influence design; basic stability analysis required; limited restrictions on construction; routine visual and instrument monitoring
600-1200	III	Moderate	Detailed, phased site investigation; test pits required, drilling or other subsurface investigations may be required; undisturbed sampling may be required; detailed laboratory testing, including index properties, shear strength and durability testing likely required; stability influences and may control, design; detailed stability analysis, possibly including parametric studies, required; Stage II detailed design report may be required for approval/permitting; moderate restrictions on construction (e.g. limiting loading rate, lift thickness, material quality); detailed instrument monitoring required to confirm design, document behaviour and establish loading limits
> 1200	IV	High	Detailed, phased site investigation; test pits, and possibly trenches, required; drilling and possible other subsurface investigations probably required; undisturbed sampling probably required; detailed laboratory testing, including index properties, shear strength and durability testing probably required; stability considerations paramount; detailed stability analysis, probably including parametric studies and full evaluation of alternatives probably required; Stage II detailed design report probably required for approval/permitting; severe restrictions on construction (e.g. limiting loading rate, lift thickness, material quality); detailed instrument monitoring required to confirm design, document behaviour and establish loading limits

*Provided courtesy of the CSIRO. Table 3.2 Pg 31Guidelines for Mine Waste Dump and Stockpile Design CSIRO Publishing 2017.

Table 3.2 – Stability Rating Criteria for Rehabilitation Design after CSIRO 2017

Dump Stability Rating (DSR)			
Key factors		Range of conditions-description (one score chosen from each dark box)	rating
Dump height	Low	< 50m	0
	Moderate	50-100 m	50
	High	100-200 m	100
	Very High	> 200 m	200
Dump volume	Small	< 1 x 10^6 BCM (bank cubic metres)	0
	Medium	< 1 x 10^6 -5 x 10^7 BCM	50
	Large	> 5 x 10^7 BCM	100
Dump slope	Flat	< 26°	0
	Moderate	26-35°	50
	Steep	> 35°	100
Foundation slope	Flat	< 10°	0
	Moderate	10-25°	
	Steep	25-35°	100
	Extreme	> 32°	200
Degree of confinement	Confined	Concave in plan/section, valley or cross-valley fill, toe buttressed against opposite valley wall; incised gullies that can be used to limit slope during development	0
	Moderately Confined	Natural benches or terraces on slope; even slopes, limited natural topographic diversity; heaped, sidehill or broad valley or cross valley fills	50
	Unconfined	Convex slope in plan or section; sidehill or ridge crest fill with no toe confinement; no gullies or benches to assist development	100
Foundation type	Competent	Foundation materials as strong or stronger than dump materials; not subject to adverse pore pressure; no adverse geologic structure	0
	Intermediate	Intermediate between competent and weak; soils gain strength with consolidation; adverse pore pressures dissipate if loading rate controlled	100
	Weak	Limited bearing capacity, soft soils; subject to adverse pore pressure; adverse groundwater, springs; strength sensitive to shear strain, potentially liquefiable	200
Dump material quality	High	Strong, durable; less than ~10% fines	0
	Moderate	Moderately strong, variable durability; 10-20% fines	100
	Poor	Predominantly weak rocks of low durability; greater than ~25% fines	200
Method of construction	Favourable	Thin lifts (< 25 m thick), wide platforms; dumping along contours; ascending construction; wraparounds or terraces	0
	Mixed	Moderately thick lifts (25-50 m); mixed construction methods	100
	Unfavourable	Thick lifts (>50 m), narrow platforms (silver fills); dumping down the fall line	200
Piezometric and climactic conditions	Favourable	Low piezometric pressures, no seepage; development of phreatic surface within dump unlikely; limited precipitation; minimal infiltration into dump; no snow/ice	0
	Intermediate	Moderate piezometric pressures, some seeps in foundation; limited development of phreatic surface within dump possible; moderate precipitation; high infiltration into dump; discontinuous snow or ice lenses in dump or foundation	100
	Unfavourable	High piezometric pressures, springs in foundation; high precipitation; significant potential for development of phreatic surface or perched water tables in dump;	200
Dumping rate	Slow	< 25 BCM/m of crest/d; crest advancement rate < 0.1 m/d	0
	Moderate	25-200 BCM/m of crest/d; crest advancement rate 0.1 - 1.0 m/d	100
	High	> 200 BCM/m of crest/d; crest advancement > 1.0 m/d	200
Seismicity	Low	Seismic Risk Zones	0
	Moderate	Seismic Risk Zones	50
	High	Seismic Risk Zones	100
Total		*Seismic Zones are based of Canadian/American Standard Building Codes.	250

2.5 Waste Dump and Stockpile Stability rating System

A second method of assessing the stability of the rehabilitation structures at White Rock Quarry is the waste dump and stockpile stability rating and hazard classification system, (WSRHC) also discussed at length by CSIRO *et.al*. This system uses 11 more input criteria than the dump stability classes and is considered a more contemporary version of the Dump Stability Class Rating system. Relevant inputs in this assessment of stockpiles and overburden dump stability assessments are listed in Tables 3.3 to 3.10 which are reproduced courtesy of CSIRO publishing 2017, as outlined in Figure 3.1.

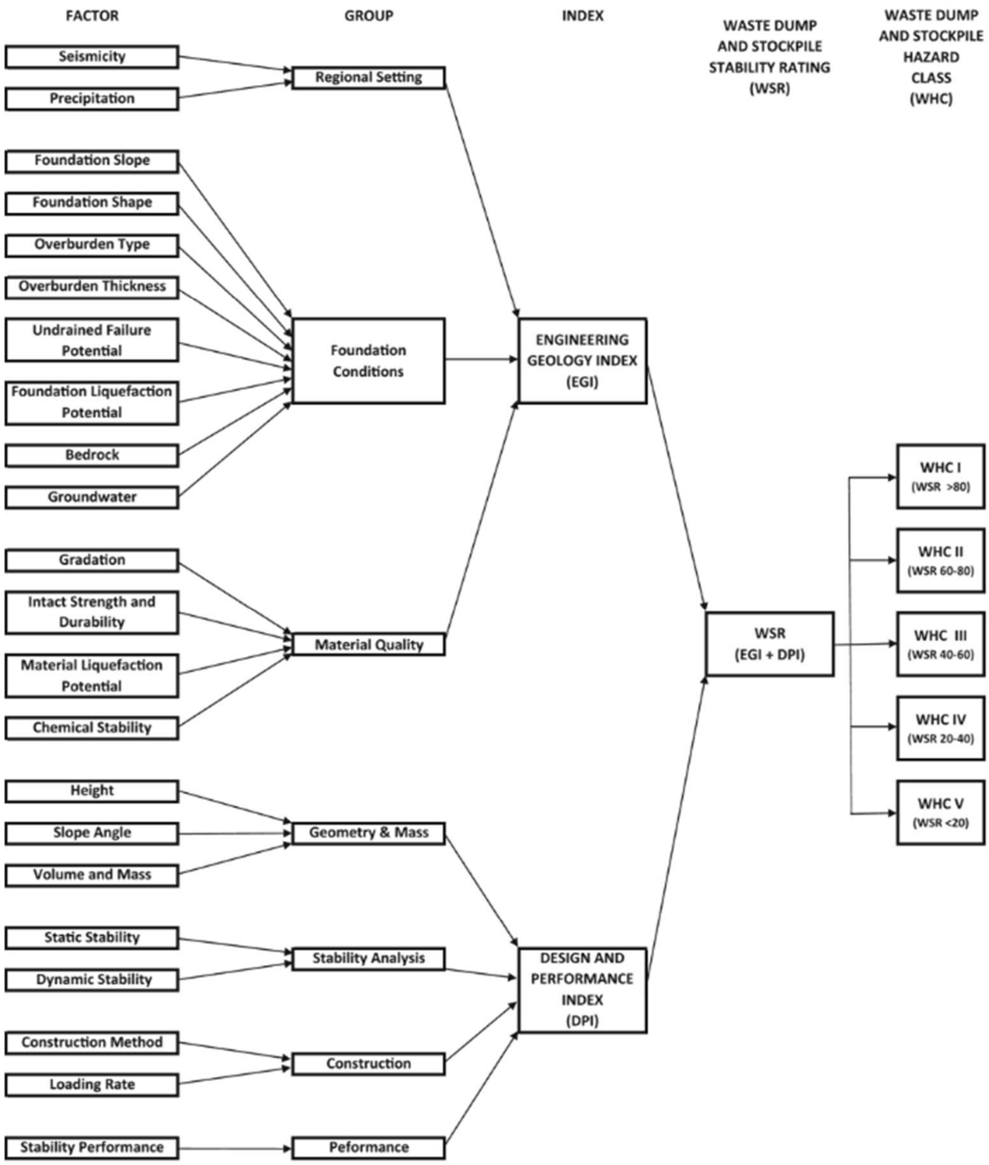


Figure 3.1: Structure of the waste dump and stockpile stability rating and hazard classification (WSRHC) system

In assessing the stability of the rehabilitation design concept the criteria used in Tables 3.3 to 3.10 have been assessed and highlighted so that the reader can review the input categories into this assessment.

For each factor of inputs they have been highlighted and then added to evaluate the likely performance rating then a stability rating summary, which are illustrated on Table 3.11 and Figures 3.4 and 3.5.

Table 3.3 – Regional Setting Factors and Ratings

Table 3.3: Regional setting factors and ratings

Factors[1]	Ratings				
Seismicity	Very High	High	Moderate	Low	Very low
Expected peak ground acceleration (g): based on 1:475 year return period event/ 10% probability of exceedance in 50 years	> 0.4	0.2–0.4	0.1–0.2	0.05–0.1	< 0.05
Expected peak ground acceleration (g): based on maximum credible earthquake (MCE)	> 0.6	0.4–0.6	0.2–0.4	0.1–0.2	< 0.1
Rating	0	0.5	1	1.5	2
Precipitation	Very High	High	Moderate	Low	Very low
Average annual precipitation: rainfall (mm)	> 2000	1000–2000	350–1000	100–350	< 100
Average annual precipitation: snowfall (cm)	> 200	100–200	35–100	10–35	< 10
Total annual precipitation: equivalent rainfall (mm)	> 2000	1000–2000	350–1000	100–350	< 100
Rating[2]	0	2	4	6	8
Regional Setting rating[3]				Maximum possible rating:	10

Notes:
1. Select a rating for each factor. Where more than one criteria is shown for a given factor, or you cannot decide between two ratings, select an average or intermediate rating.
2. For sites that experience intense seasonal rainfall or rapid runoff events, decrease the rating value by 1 point.
3. The sum of the ratings for the individual factors is the Regional Setting rating.

Table 3.4 – Foundation Conditions Factors and Ratings

Table 3.4: Foundation conditions factors and ratings

Factor[1]	Ratings				
Foundation Slope	Very Steep	Steep	Moderate	Gentle	Flat; benched bedrock slope; pit backfills
Average overall foundation slope angle (°)	> 32	25–32	15–25	5–15	< 5
Rating	0	1	2.5	4	5
Foundation Shape[2]					
Section Shape	Convex on Steep to Very Steep slopes	Convex on Moderate slopes; Concave or Planar on Steep to Very Steep slopes	Convex on Gentle slopes; Planar or Concave on Moderate slopes	Planar or Concave on Gentle slopes	Planar or Concave on Flat or very irregular slopes
Plan Shape	Slopes with a pronounced convex plan shape ('nose')	Large radius convex slopes	Planar slopes with no lateral confinement	Concave slopes and wide valleys that provide limited natural confinement	Narrow valleys or gullies that provide substantial natural confinement
Rating	0	0.5	1	1.5	2
Overburden Type	Type I	Type II	Type III	Type IV	Type V
Description	Highly organic soils; very soft to soft silts and clays; very sensitive clays; other very weak soils	Soft to firm, weak or sensitive fine grained soils (e.g. lacustrine deposits, silts and clays, fine-grained residual soils)	Alluvial deposits; loose to moderately dense sands and gravels; mixed-grained colluvial deposits; sandy residual soils; stiff fine-grained soils	Highly weathered but coherent bedrock; competent talus deposits; moderately dense to dense, coarse-grained soils; moderately dense, mixed-grained moraine (glacial till)	Very dense, mixed-grained moraine (glacial till) and other very competent or hard soils; perpetually frozen soils with negligible potential for creep due to embankment loading; competent bedrock
Rating	0	1	2	3	4
Overburden Thickness (m)	> 5	3–5	1–3	0.3–1	< 0.3
Rating	0	0.5	1	1.5	2
Undrained Failure Potential[3]	Very High[5]	High[6]	Moderate	Low	Negligible
Description	Saturated, normally or underconsolidated, compressible Type I or II soils that have very low hydraulic conductivity and behave as low-strength S_u (frictionless) materials; very high potential for generation of excess pore pressures when loaded rapidly	Saturated, normally or slightly overconsolidated, compressible Type I or II soils that have low hydraulic conductivity and behave as Mohr-Coulomb (c-ϕ) materials; high potential for generation of excess pore pressures when loaded rapidly	Saturated, normally consolidated, mixed or fine-grained Type III or IV soils with low to moderate hydraulic conductivity and moderate potential for generation of excess pore pressures when loaded rapidly; unknown potential for undrained failure	Unsaturated, normally or overconsolidated, mixed or fine-grained Type III or IV soils with moderate hydraulic conductivity and low potential for generation of excess pore pressures when loaded rapidly; low potential for undrained failure but cannot be fully discounted	Heavily overconsolidated Type III, IV or V mixed-grained soils or competent bedrock or granular Type III or IV soils with high hydraulic conductivity, high strength and negligible potential for generation of excess pore pressures when loaded rapidly
Rating	–20	–10	–5	–2.5	0

(Continued)

Table 3.4: (Continued)

Factor[1]	Ratings				
Foundation Liquefaction Potential[4]	Very High[5]	High[6]	Moderate	Low	Negligible
Description	Very uniform; very loose; minimal plastic fines; open, clast supported structure; high void ratio; rounded clasts; saturated	Extra-sensitive clays and extremely weak soils	Moderate (or unknown) liquefaction potential	Low liquefaction potential but cannot be fully discounted	Well graded; dense; high content of plastic fines; matrix supported structure; low void ratio; angular clasts; dry
Rating	–20	–10	–5	–2.5	0
Bedrock	Type A	Type B	Type C	Type D	Type E
Competency[7]	Very weak and/or highly clay altered, sheared or highly fractured rocks; laminated, highly carbonaceous coal measures; phyllite; flysch; GSI/RMR < 20; Q < 1	Fine-grained sedimentary rocks; moderately weathered or altered rocks; moderately to intensely fractured; GSI/RMR 20–40; Q 1–4	Moderately competent; moderately fractured; slightly weathered/altered; GSI/RMR 40–60; Q 4–10	Competent, hard, unweathered/unaltered, blocky; GSI/RMR 60–80; Q 10–40	Very competent, unweathered, unaltered, hard, massive; GSI/RMR > 80; Q > 40
Structure	Adversely oriented faults or shear zones; potential for structurally controlled foundation failure	Adversely oriented, continuous joints; potential for foundation failure on well-developed fabric anisotropy	Limited (or unknown) potential for foundation failure on major structure or moderately developed fabric anisotropy	Negligible potential for foundation failure on major structure or poorly developed fabric anisotropy	No adverse structure or fabric
Rating	0	1	2	3	[illegible]
Groundwater	High		Moderate		Low
Expected Groundwater Conditions	Groundwater table at surface; active discharge or seepage; strong upward gradients; potential for generation of high pore pressures in foundation due to embankment loading		Groundwater table > 5 m below ground surface; limited potential for development of adverse pore pressures in foundation due to embankment loading		Groundwater table at great depth; negligible potential for adverse pore pressures in foundation
Rating	0		1.5		3
Foundation Conditions rating[8]				Maximum possible rating:	20

Table 3.5 – Material Quality Factors and Ratings

Table 3.5: Material quality factors and ratings

Factors[1]	Ratings				
Gradation	Very Fine Grained		Mixed Grained		Very Coarse Grained
% Fines (passing # 200 Sieve; < 0.075 mm)	> 50%	25–50%	10–25%	5–10%	< 5%
% Greater than 75 mm	< 10%	10–25%	25–50%	50–75%	> 75%
Plasticity[2]	Highly plastic fines; LL > 50; PI > 20	Moderately plastic fines; LL 35–50; PI 10–20	Low plasticity fines; LL < 35; PI < 10	N/A	N/A
Rating	0	2	3.5	5	7
Intact Strength and Durability	Type 1	Type 2	Type 3	Type 4	Type 5
Intact Strength	Extremely weak to very weak rocks, R0-1 (UCS < 5 Mpa); Type A bedrock; Types I and II overburden	Weak rocks, R2 (UCS 5–25 Mpa); Type B bedrock; Types III, IV and most Type V overburden	Medium strong rocks, R3 (UCS 25–50 Mpa); most Type C bedrock; coarse grained alluvium and talus derived from hard rocks	Strong to very strong rocks, R4 (UCS 50–100 Mpa); most Type D bedrock	Very strong to extremely strong rocks R5–6 (UCS >100 Mpa); most Type E bedrock
Durability[3]	Material subject to breakdown during placement, time dependent degradation due to slaking or freeze–thaw, or crushing under anticipated static loading		Material subject to limited breakdown during placement, time dependent degradation due to slaking or freeze–thaw, or crushing under anticipated static loading		Material not subject to breakdown during placement, time dependent degradation due to slaking or freeze–thaw, or crushing under anticipated static loading
Permafrost[4]		Perpetually frozen Type 1 materials	Perpetually frozen Type 2 materials	Perpetually frozen Type 3 materials	Perpetually frozen Types 4 and 5 materials
Rating	0	2	4	6	8

(Continued)

Table 3.5: (Continued)

Factors[1]	Ratings				
Material Liquefaction Potential[5]	Very High[6]	High[7]	Moderate or Unknown	Low	Negligible
Description	Very uniformly graded; very loose; minimal plastic fines; open, clast supported structure; high void ratio; rounded clasts; saturated		Moderate (or unknown) liquefaction potential	Low liquefaction potential but cannot be fully discounted	Well graded; dense; high content of plastic fines; matrix supported structure; low void ratio; angular clasts; dry
Rating	−20	−10	−5	−2.5	0
Chemical Stability	Highly Reactive		Moderately Reactive		Neutral
ARD Potential	High potential for chemical breakdown/ oxidation/generation of ARD		Moderate (or unknown) potential for chemical breakdown/oxidation/ generation of ARD		Very chemically stable material with negligible content of reactive minerals
Impact of Precipitates	High potential for precipitates to fill voids, decrease hydraulic conductivity, and increase pore pressures over time		Limited (or unknown) potential for precipitates to fill voids, decrease hydraulic conductivity, and increase pore pressures over time		Negligible precipitates, or precipitates result in cementation and increase shear strength over time without adversly affecting pore pressures
Rating	−5	−2.5	0	2.5	5
Material Quality rating[8]				Maximum possible rating:	20

Notes:
1. Select a rating for each factor. Where more than one criteria is shown for a given factor, or you cannot decide between two ratings, select an average or intermediate rating.
2. LL = Liquid Limit; PI = Plasticity Index. These criteria apply only to cases where the fines content is > 10%.
3. Under expected ambient climatic conditions.
4. If material is perpetually frozen, select the next highest category to account for expected increased durability and strength.
5. Evaluation of liquefaction potential of waste dump and stockpile materials may require detailed investigations. If unknown, use a default value of −5 and consult a geotechnical specialist.
6. If the Material Liquefaction Potential is judged to be Very High, the waste dump or stockpile should be classified as WHC V (Very High Hazard), regardless of the WSR.
7. If the Material Liquefaction Potential is judged to be High, the waste dump or stockpile should be classified as WHC IV (High Hazard), unless the WSR is ≤ 20, in which case it should be classified as WHC V (Very High Hazard).
8. The sum of the ratings for the individual factors is the Material Quality rating.

Table 3.6 – Geometry and Mass Factor Ratings

Table 3.6: Geometry and Mass factors and ratings

Factors[1]			Ratings		
Height	Very High	High	Moderate	Low	Very Low
Overall Height (m)	> 500	250–500	100–250	50–100	< 50
Maximum Vertical Thickness (m)	> 500	250–500	100–250	50–100	< 50
Maximum Individual Lift Height (m)	> 200	100–200	50–100	25–50	< 25
Rating	0	1	2	3	4
Slope	Very Steep	Steep	Moderate	Flat	Very Flat
Overall Fill Slope Angle (°)[2]	> 35	30–35	25–30	15–25	< 15
Rating	0	1	2	3	4
Volume and Mass	Very Large	Large	Medium	Small	Very Small
Volume (m^3)	> 1×10^9	1×10^8–1×10^9	1×10^7–1×10^8	1×10^6–1×10^7	< 1×10^6
Mass (t)	> 2×10^9	2×10^8–2×10^9	2×10^7–2×10^8	2×10^6–2×10^7	< 2×10^6
Rating	0	0.5	1	1.5	2
Geometry and Mass rating[3]				Maximum possible rating:	10

Notes:
1. Select a rating for each factor. Where more than one criterion is shown for a given factor, or you cannot decide between two ratings, select an average or intermediate rating.
2. Overall fill slope angle is measured from toe to crest. Where the overall slope height is less than 50 m, use a minimum default rating of 2. Where the overall slope height is between 50 and 100 m, use a minimum default rating value of 1.
3. The sum of the ratings for the individual factors is the Geometry and Mass rating.

Table 3.7 – Stability Analysis Factors and Ratings

Table 3.7: Stability analysis factors and ratings

Factors[1]			Ratings		
Static Stability[2]					
Factor of Safety (FoS) or Strength Reduction Factor (SRF)[3]	< 1.1	1.1–1.2	1.2–1.3	1.3–1.5	> 1.5
Probability of Failure (PoF)	> 20%	10–20%	5–10%	1–5%	< 1%
Other criteria[4,5]	Non-convergent Numerical Model	No Supporting Stability Analysis	Convergent numerical model		
Rating	0	2	3.5	5	7
Dynamic Stability[2,6]					
Factor of Safety (FoS) or Strength Reduction Factor (SRF)[2]	< 1.0	1.0–1.05	1.05–1.10	1.10–1.15	> 1.15
Other criteria[7,8]	Non-convergent numerical model	No supporting stability analysis	Convergent numerical model		
Rating	0	1	1.5	2	3
Stability Analysis rating[9]				Maximum possible rating:	10

Notes:
1. Select a rating for each factor. Where more than one criterion is shown for a given factor, or you cannot decide between two ratings, select an average or intermediate rating.
2. It is assumed that there is at least a moderate level of confidence in the input parameters and that the analysis results are credible and reasonable.
3. Stability index values shown are based on FoS. If the stability analysis results are presented in terms of SRF, the user must decide whether SRF is equivalent to FoS based on the specifics of the analysis and is advised to consult with a geotechnical specialist to make this determination.
4. If numerical analyses indicates convergent behaviour, a minimum default rating of 3.5 should be assigned. If numerical analyses indicated non-convergent behaviour, a default rating of zero (0) should be used.
5. If no supporting stability analyses are available, a default value of 2 should be assigned.
6. If pseudostatic analyses are used to evaluate dynamic stability, an appropriate reduction in the design peak horizontal acceleration should be applied.
7. If numerical analyses indicate convergent behaviour, a minimum default rating of 1.5 should be assigned. If numerical analyses indicate non-convergent behaviour, a default rating of zero (0) should be used.
8. If no supporting stability analyses are available, a default value of 1 should be assigned.
9. The sum of the ratings for the individual factors is the Stability Analysis rating.

Table 3.8 – Construction Factors and Ratings

Table 3.8: Construction factors and ratings

Factors[1]	Ratings				
Construction method[2]	Method I	Method II	Method III	Method IV	Method V
Description[3]	Descending sequence with single or multiple (wrap-around), very high lifts constructed on very steep terrain; lift heights > 200 m; overall foundation slopes > 32°	Descending sequence with single or multiple (wrap-around) lifts constructed on steep terrain; lift heights < 200 m; overall foundation slopes 25–32°	Hybrid (combination of descending and ascending) sequence designed to avoid founding lift toes on steep or very steep terrain; lift heights < 200 m; overall foundation slopes > 25°	Ascending sequence with multiple lifts constructed on moderate terrain; lift heights < 100 m; overall foundation slopes 15–25°	Descending or ascending sequence on gentle or flat terrain; lift heights < 50 m; overall foundation slopes < 15°
Rating	0	2	4	6	8
Loading Rate	Very High	High	Moderate	Low	Very Low
Volumetric Loading Rate[4] ($m^3/d/m$)	> 500	150–500	50–150	15–50	< 15
Mass Loading Rate[5] (t/d/m)	> 250	75–250	25–75	7.5–25	< 7.5
Crest Advancement Rate[6] (m^2/d)	> 500	150–500	50–150	15–50	< 15
Rating	0	2	3.5	5	7
Construction Rating[7]				Maximum possible rating:	15

Notes:
1. Select a rating for each factor. Where more than one criterion is shown for a given factor, or you cannot decide between two ratings, select an average or intermediate rating.
2. Select the method that best describes the development sequence. Where the construction sequence includes attributes of more than one method, choose an intermediate rating.
3. Descending sequence refers to embankments that are constructed from the top down using wrap-around lifts; ascending sequence refers to embankments that are constructed in lifts from the bottom up.
4. Volumetric Loading Rate = average daily loose volume (m^3/d) ÷ average active crest length (m). Includes bulking factor.
5. Mass Loading Rate = average daily mass of fill consigned to the waste dump or stockpile (t/d) ÷ average active crest length (m). Assumes a nominal bulk density of 2.0 t/m^3; adjust as necessary.
6. Crest Advancement Rate = average daily rate of crest advancement (m/d) × average lift height (m).
7. The sum of the ratings for the individual factors is the Construction rating.

Table 3.9 – Performance Ratings

Table 3.9: Performance ratings

Factors[1]	Ratings				
Stability Performance	Very Poor[2]	Poor[3]	Fair	Good	Very Good
Description	Unstable; substantial long-term closures or major remedial work required; large-scale (> 1 × 10^6 t) instability; major impact on operations	Metastable to unstable; frequent short-term closures; frequent sliver/crest failures and/or local foundation failures, but no large-scale (> 1 × 10^6 t) instabilities; moderate impact on operations	Metastable to stable; occasional closures due to deformation/settlement; occasional small sliver failures (< 1 × 10^5 t); limited impact on operations; waste dumps and stockpiles with no performance history	Stable; minor deformation and/or settlement; rare closures; rare small failures; negligible impact on operations	Very stable; negligible deformation/settlement; no closures; no failures; no impact on operations
Rating	–15	–7.5	0	7.5	15
Performance Rating[4]				Maximum possible rating:	15

Notes:
1. Select a rating for each factor. Where more than one criterion is shown for a given factor, or you cannot decide between two ratings, select an average or intermediate rating.
2. If the Stability Performance is judged to be Very Poor, the waste dump or stockpile should be classified as WHC V (Very High Hazard), regardless of the calculated WSR.
3. If the Stability Performance is judged to be Poor, the waste dump or stockpile should be classified as WHC IV (High Hazard), unless the WSR is ± 20, in which case it should be classified as WHC V (Very High Hazard).
4. The sum of the ratings for the individual factors is the Performance Rating.

Table 3.10 – Rating Summary

Table 3.10: Waste dump and stockpile stability rating summary

Engineering Geology Index (EGI)	Regional Setting	Description	Very Adverse	Adverse	Neutral	Favourable	Very Favourable
		Rating	0	2.5	5	7.5	10
	Foundation Conditions	Description	Very Poor	Poor	Fair	Good	Very Good
		Rating	≤ 0	5	10	15	20
	Material Quality	Description	Very Poor	Poor	Fair	Good	Very Good
		Rating	≤ 0	5	10	15	20
Design and Performance Index (DPI)	Geometry and Mass	Description	Very Large	Large	Medium	Small	Very Small
		Rating	0	2.5	5	7.5	10
	Construction	Description	Very Unfavourable	Unfavourable	Intermediate	Favourable	Very Favourable
		Rating	0	5	7.5	10	15
	Performance	Description	Very Poor	Poor	Fair	Good	Very Good
		Rating	≤ 0	5	7.5	10	15
	Engineering Geology Index (EGI)			Design and Performance Index (DPI)			WSR

Table 3.11 – Performance Ratings

Table 3.11: Summary of waste dump and stockpile stability ratings, hazard classes and relative instability hazard

WSR	WHC	Instability Hazard
80–100	I	Very Low Hazard
60–80	II	Low Hazard
40–60	III	Moderate Hazard
20–40	IV	High Hazard
< 20	V	Very High Hazard

Using this stability assessment method and evaluating Tables 3.3 to 3.10 the performance rating of the rehabilitation structure returns a very low stability hazard rating classification. Using these criteria for Figures 3.4 and 3.5 plots the data has been plotted on both figures for reference purposes.

Figure 3.4 WHSRC Assessment Chart

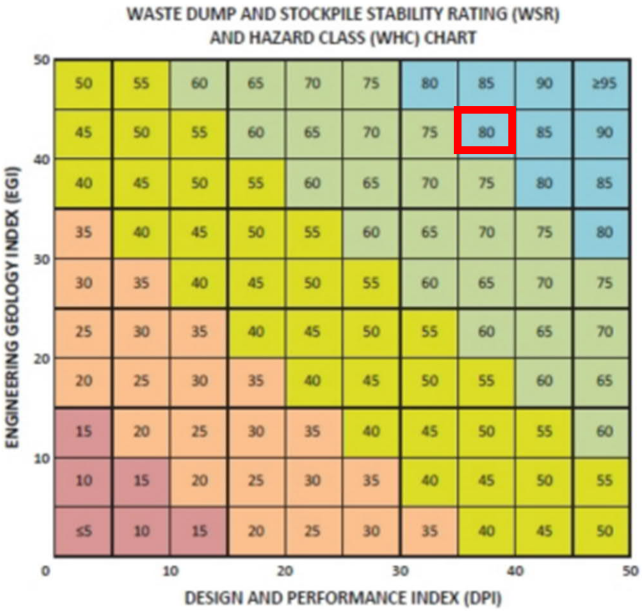


Figure 3.4: Waste dump and stockpile stability rating and hazard class chart

Figure 3.5 WHSRC Assessment Chart Historical Data

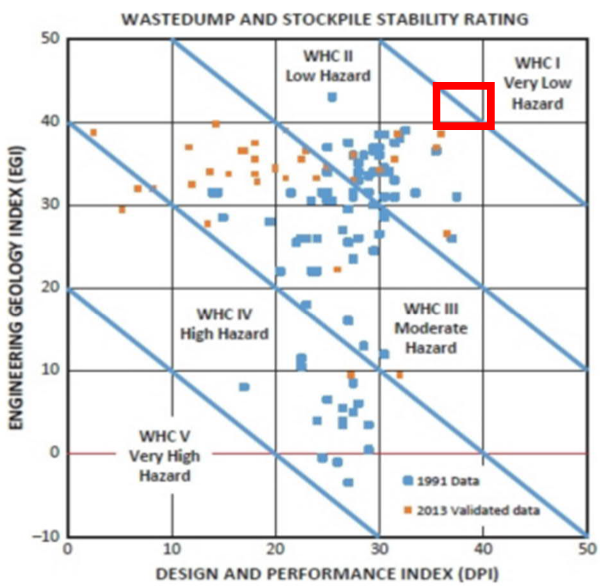


Figure 3.5: Waste dump and stockpile stability and hazard chart illustrating the results of the 1991 and 2013 surveys

Plate 8: The White Rock Quarry is already a significant operation which has a current total slope height of 120 metres in the east wall which will not materially change resultant of this proposal in the final bench heights. That is the slope heights which currently exist will not significantly change and the driving and gravitational forces which are currently managed by the slope design are expected to be similarly managed by the future design which largely uses the same design criteria. The overburden (yellow circle) is also partly visible in this image, which is treated as an extension of the quarry, although several areas of overburden exist.

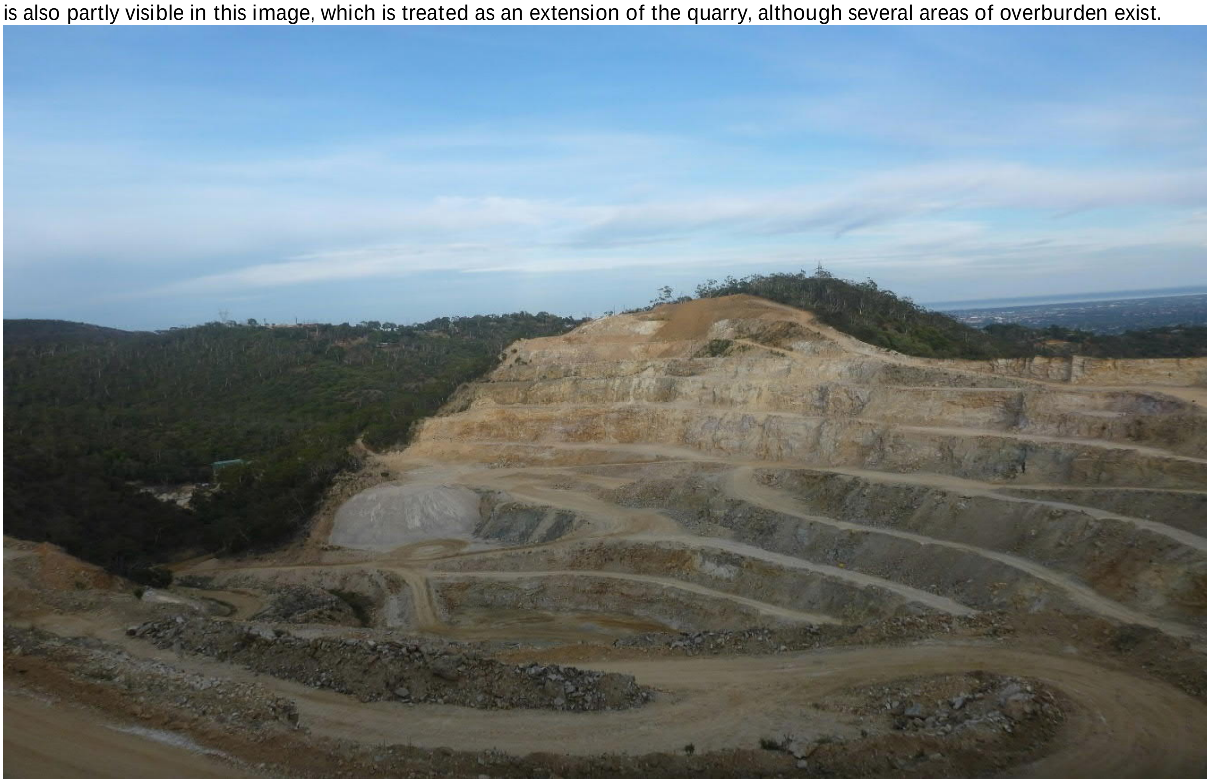


Plate 9: The west wall of White Rock Quarry is similarly already a very significant slope which shows no material signs or vectors denoting slope instability.

Plate 10: A portion of the east wall waste dumps which are proposed to be reclaimed as part of the project. Clearly for this part of the overburden area it will be a very straight forward earth moving exercise.

Plate 11: A further view of the White Rock overburden areas which are not steep or of any perceived difficult regarding reclamation activities.

Plate 12: A view of the ongoing rehabilitation at nearby quarry , provided courtesy of Quarry Magazine August 2012. This rehabilitation strategy would be similar to what is proposed for the western portion of the quarry.

Plate 13: A view of the ongoing rehabilitation at another quarry with rehabilitation completed in the right and moving slowly to the left of page.

Plate 14: A closer view of the ongoing rehabilitation at another quarry using a bench profile as rehabilitation, provided Courtesy of Quarry Magazine August 2012.

Plate 15: A closer view from the top of the overburden stockpile areas at White Rock, showing the very gentle nature of the material to be reclaimed.

3 Geotechnical Model and Assessment

3.1 Regional Geology

The regional surface geology surrounding of the site is dominated by four main units, refer Drawing 1901_023 being :

- T unit - Undifferentiated Tertiary sediments
- Nds unit (Saddleworth Formation) – Mudstone; siltstone; shale, partly carbonaceous
- Ndt unit (Stonyfell Quartzite) – Quartzite, feldspathic, with shale interbeds; silty sandstone in part schistose and calcareous.
- Ndw Woolshed Flat Shale, Shale, black; dolomitic siltstone; dolomite; grey laminated siltstone.

The Saddleworth Formation and the Stonyfell Quartzite are both Neoproterozoic in age and are part of the Adelaide Geosyncline. The Saddleworth Formation sediments are believed to have been deposited during renewed transgression of the sea level and has undergone subsequent lithification. The Stonyfell Quartzite is thought to have been deposited during deltaic progradation and undergone subsequent lithification and metamorphism (Drexel & Preiss 1995). The undifferentiated Tertiary sediments in the general area are comprised for sands, silts, and clays, all of which are targeted for construction materials. These Tertiary sediments were deposited in a fluvio-lacustrine environment and lie within the Golden Grove Embayment, located on the eastern flank of the St Vincent Basin. The undifferentiated tertiary sediments are underlain by the weathered shale of the Saddleworth Formation (McCallum 1988).

3.2 Local Geology

The surface geology at the Site is dominated by undifferentiated tertiary sediments in the south-western half of the Site and by the Saddleworth Formation in the north-eastern half of the Site. The main material of interest for Hanson in PM 188 is the quartzite of the Saddleworth Formation. Regional geology mapping suggests that a small outcrop of Stonyfell Quartzite exists in the eastern most corner of the Site. The shale onsite typically becomes less weathered at depth and hence also becomes harder. It was also noted that the overburden above the shale as well as some parts of the upper profile of the shale are calcareous. This calcareous material is not of interest to Hanson.

3.3 Geotechnical Model

The geotechnical model for the site is based on multiple composite domains which are delineated on characteristics which make up a typical rock mass model. They are not classical structural domains. Each relevant characteristic or element within the domain is then reviewed and its relevant impacts upon stability then assessed. To further optimise development of a domain, each domain is further broken into three (3) subsets being major, intermediate, and minor domain influences which can then be weighted and if necessary krigged into a geotechnical block model. A composite domain is defined by an area which has the same general geotechnical characteristics. Relevant characteristics of the domains are based on the general stability conditions at different locations. Composite domains are developed in preference to purely structural domains as it is submitted that composite domains more accurately reflect site geotechnical characteristics and provide a more useful tool for management of the site, in contrast to structural domains which are of limited use to non-technical people. Importantly the structural domains and kinematic assessment are an integral part of developing the composite domains however, also included in the composite domaining process are:

- Degree of weathering, pursuant to AS1726_2017;
- Relevant engineering parameters (i.e. durability and rock strength), completed to NATA standards;
- Bench orientations, and design criteria;
- Slope Height;
- Ground/surface water impacts;
- History of performance and failure type/s if any;
- Potential failure mechanism for both slope and rockfall risk;
- Seismicity and proximity of Neotectonic structures; and
- Adjacent sensitive receptors and other relevant infrastructure;
- Bedding
- Faulting and the shear zones
- Degree of Weathering
- Hydraulic draw down on the shear planes
- Jointing and the persistence of joint sets
- Rock type
- Dimensions, and geometry of blocks
- Physical properties including density, estimates of unconfined compressive strength and weathering effects
- Characteristics of potential failure planes, specifically
- Estimated frictional properties in terms of the Joint Roughness Coefficient, JRC (Barton & Choubey 1977)
- Estimated strength of the wall of the discontinuity or Joint Wall Compressive Strength, JCS
- Area of contact.

While Composite Domain Features include:

- Rock Mass Rating Number
- Intensity of Jointing, the nature of Jointing, and joint conditions
- Interaction and degree of intersection of jointing
- Total Slope Angle
- Frequency of access
- Discontinuity Persistence
- Aperture Infill, and small scale roughness criterion
- Stormwater impacts, and Seismicity.

3.4 Engineering Parameters of White Rock Meta-Sediments

Engineering parameters of the rock mass used for assessment and modelling purposes are provided in Table 4 and ae based off information provided by the Hanson NAATA accredited laboratory, refer Attachment 3.

Table 4 – Engineering Parameters of White Rock Meta-Sediments

Rock Mass Property and Conditions	Values and Comments
Rock Type	Quartzite, Meta Sandstone and Meta Siltstone
Density	Measured 2.7 t/m^3
Mohr Coulomb Friction Angle	Estimated at 38^0
Mohr Coulomb Cohesion kPa	Measured 150+
UCS	Correlated from Point Load 90-110 MPa Strong Rock
Youngs Modulus Estimated	Estimated 80GPa
Poisson's Ratio	Estimated 0.2
Groundwater Level	Measured Below pit floor
Number of Joints	Measured 6 + bedding and cross cut shear zone
Major Structures	Estimated One sub vertical shears zone which cross cuts the pit however intersects the wall at a nearly perpendicular orientation.
Rock mass model	Assumed Continuous homogeneous isotropic linear elastic
Buffer Zones	Ridgeline + 190 metre minimum to nearest receptor. The closest cluster of receptors are all on Old Norton summit Road, ranging between approximately 190-350 metres distance.
Seismicity K level	Design considerate of AS1170.4-2007.
Seismic Loading applied	Estimated Pseudo-static earthquake loading has been considered in the limit equilibrium analysis. maximum). The earthquake acceleration as a fraction of the acceleration due to gravity used a range of values between 0.1 to 0.3.
Bench heights	Variable in upper benches increasing to 11 metre high benches in the lower areas
Terminal Batters	70 to 75 degrees in unweathered rock 45 in weathered upper bench.
Residual Soil Thickness	Measured 1000-3000mm thickening away from ridgeline crest
Weathering Depth	Measured Highly variable up to 60 metres in some areas. Weathering surfaces have bene prepared for the geotechnical model in Surpac Mining software
Discontinuity Shear Strength Estimated	Estimated Peak 38^0
Infill-Veining	Minor quartz stockworking and veining in evident on site
Alteration	Silica and carbonate alteration via regional metamorphism is ubiquitous
Deg Factor Range	Measured 55-65%
Dispersiveness	Estimated Soils Emerson Class >4 nondispersive

3.5 Kinematic Analysis

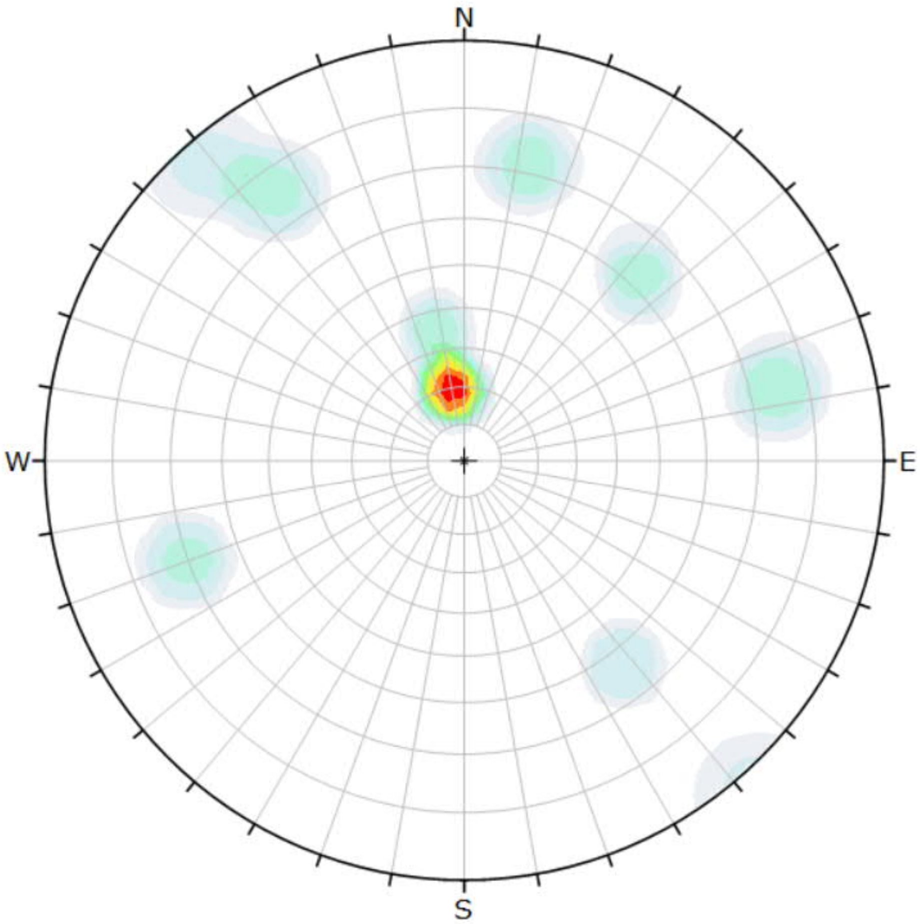
Table 5 – Joint Set Characteristics

Structure	Av Dip	Av Dip Dirn	JRC (1m)	Defect Spacing	Aperture Spacing	RMR	Infill
Bedding	18	175	11	Medium	Very Narrow	Good	Goethite Coating
Xcut Shear	88	140	0	N/A	Very Wide	Poor	Clay/Goethite
J_1	75	147	9	Medium	Very Narrow	Good	Goethite Coating
J_2	35	170	9	Medium	Very Narrow	Good	Goethite Coating
J_3	65	220	9	Medium	Very Narrow	Good	Goethite Coating
J_4	72	195	4	Medium	Very Narrow	Good	Clay/Goethite Coating
J_5	76	255	4	Medium	Very Narrow	Good	Clay/Goethite Coating
J_6	76	14	4	Medium	Very Narrow	Good	Clay/Goethite Coating

To complete the kinematic analysis structural data was recorded and then assessed in Rocscience Dips for Planar, Wedge and Topple potential. Resultant of the kinematic assessment it is clear that minor topple, wedge and planar potential will remain in the majority of bench areas. Importantly shallowing the benches increases planar risk but reduces wedge potential so when balancing all the competing issues of batter design a 70-80 degree batter angle is considered a realistic and pragmatic outcome. Based on the kinematic assessment the following potential failure methods are provided for each wall, refer Plates 19 to 30 while the main structures are illustrated on Plates 16 to 18.

Plate 16: This image shows a few of the main structures on site which have been considered as part of the geotechnical assessment.

Plate 17: A further image which shows the comparatively small block size the intensity of the jointing and the degree of weathering encountered on site in the upper benches.

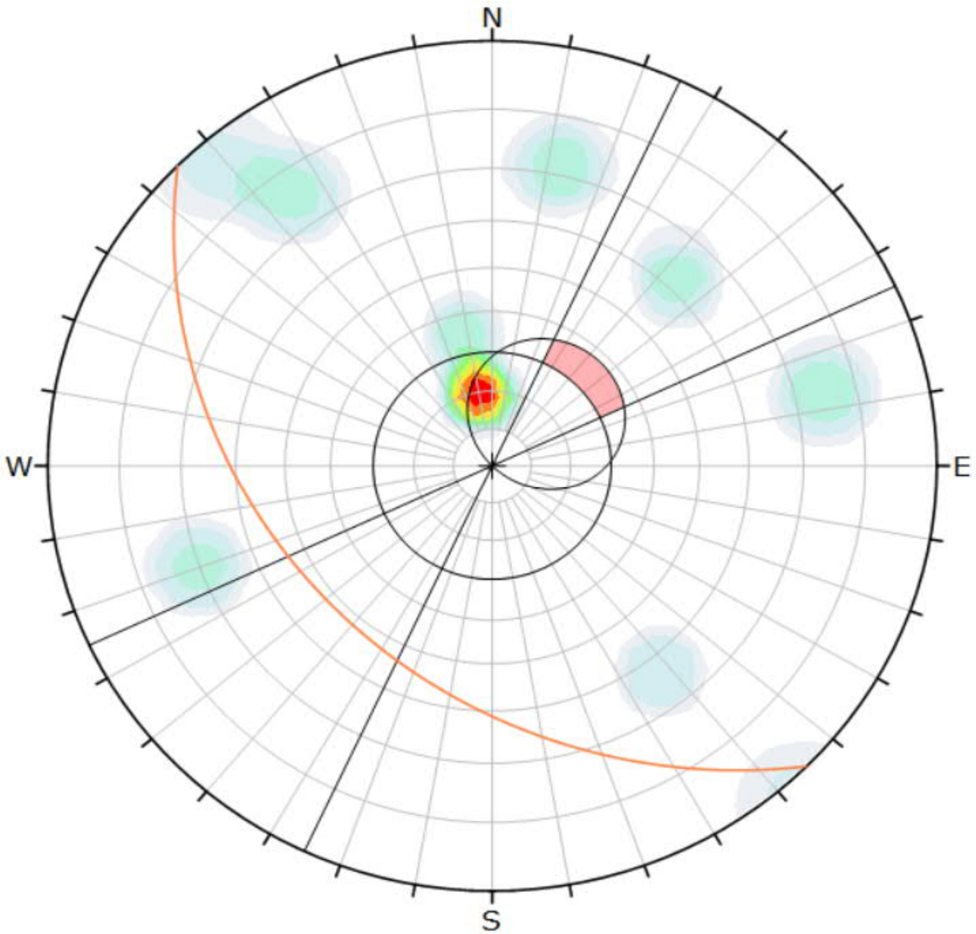


Color	Density Concentrations
	0.00 - 2.70
	2.70 - 5.40
	5.40 - 8.10
	8.10 - 10.80
	10.80 - 13.50
	13.50 - 16.20
	16.20 - 18.90
	18.90 - 21.60
	21.60 - 24.30
	24.30 - 27.00

Contour Data	Pole Vectors
Maximum Density	26.05%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	211 (211 Entries)
Hemisphere	Lower
Projection	Equal Angle

Plate 18: A simplified stereonet summary of the main structures encountered on site.



Color	Density Concentrations
	0.00 - 2.70
	2.70 - 5.40
	5.40 - 8.10
	8.10 - 10.80
	10.80 - 13.50
	13.50 - 16.20
	16.20 - 18.90
	18.90 - 21.60
	21.60 - 24.30
	24.30 - 27.00
Contour Data	Pole Vectors
Maximum Density	26.05%
Contour Distribution	Fisher
Counting Circle Size	1.0%

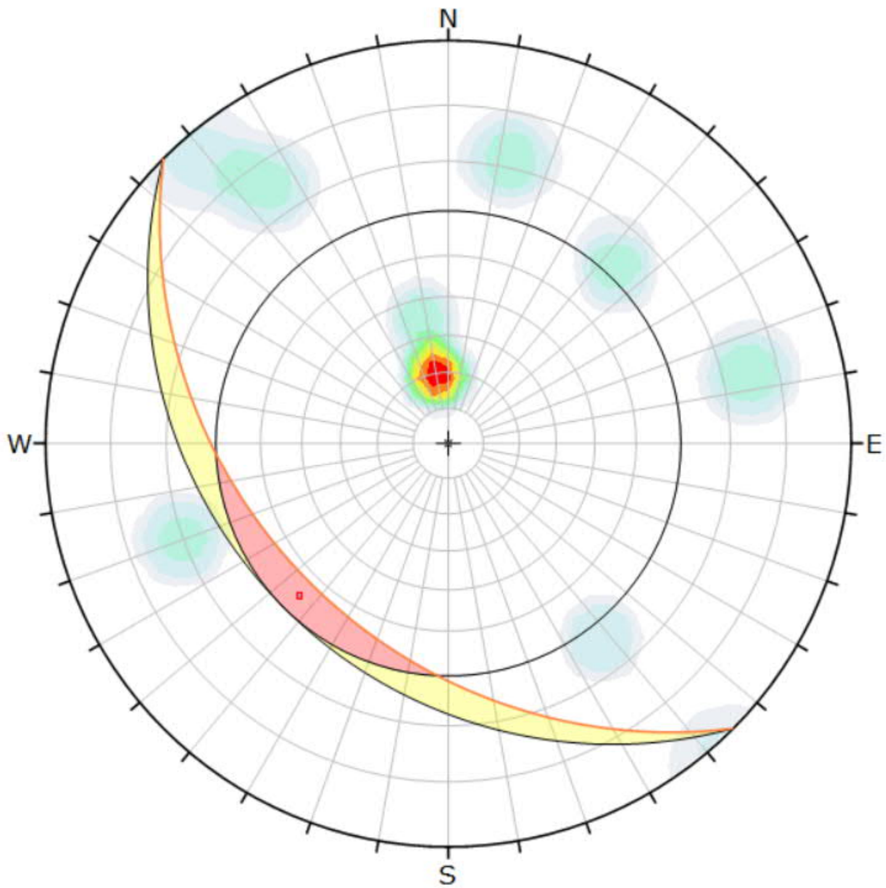
Kinematic Analysis	Planar Sliding
Slope Dip	38
Slope Dip Direction	225
Friction Angle	30°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	0	211	0.00%

Plot Mode	Pole Vectors
Vector Count	211 (211 Entries)
Hemisphere	Lower
Projection	Equal Angle

Plate 19: Kinematic assessment of planar failure potential for the east wall.

GROUNDWORK plus



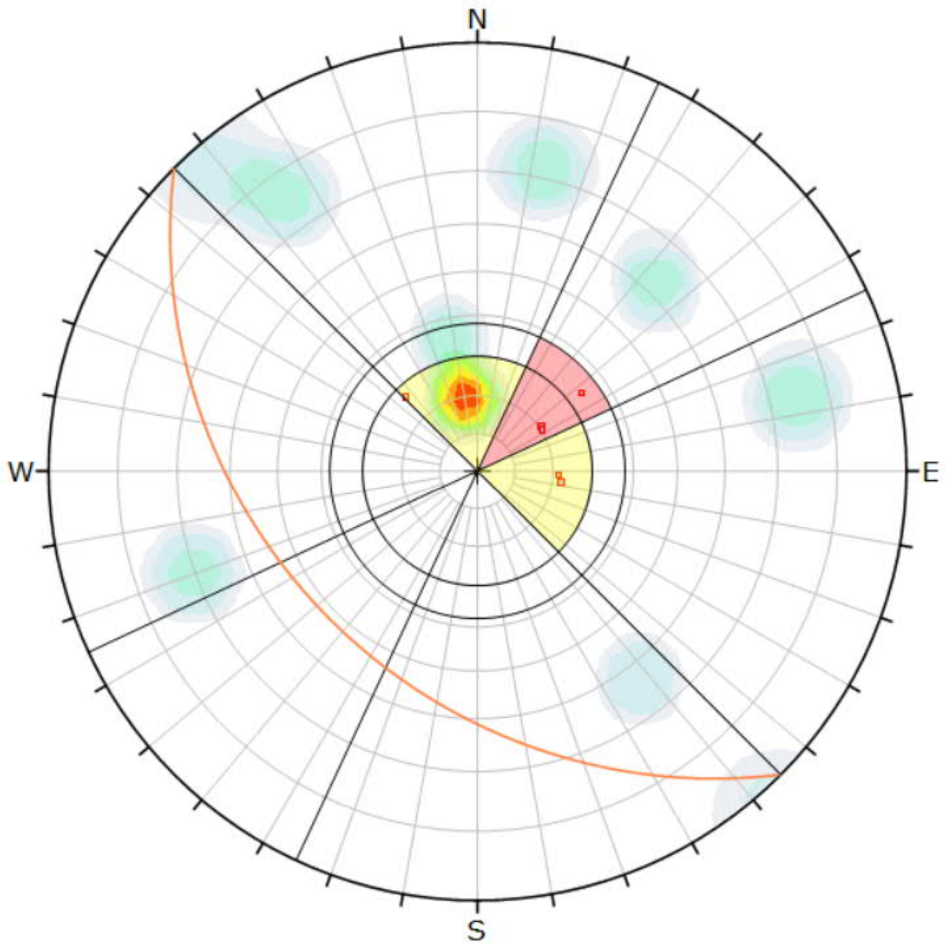
Symbol	Feature
▫	Critical Intersection

Color	Density Concentrations
	0.00 - 2.70
	2.70 - 5.40
	5.40 - 8.10
	8.10 - 10.80
	10.80 - 13.50
	13.50 - 16.20
	16.20 - 18.90
	18.90 - 21.60
	21.60 - 24.30
	24.30 - 27.00
Contour Data	Pole Vectors
Maximum Density	26.05%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding		
Slope Dip	38		
Slope Dip Direction	225		
Friction Angle	30°		
	Critical	Total	%
Wedge Sliding	72	20359	0.35%

Plot Mode	Pole Vectors
Vector Count	211 (211 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	20359
Hemisphere	Lower
Projection	Equal Angle

Plate 20: Kinematic assessment of wedge failure potential for the east wall.



Symbol	Feature
▫	Critical Intersection

Color	Density Concentrations
	0.00 - 2.70
	2.70 - 5.40
	5.40 - 8.10
	8.10 - 10.80
	10.80 - 13.50
	13.50 - 16.20
	16.20 - 18.90
	18.90 - 21.60
	21.60 - 24.30
	24.30 - 27.00

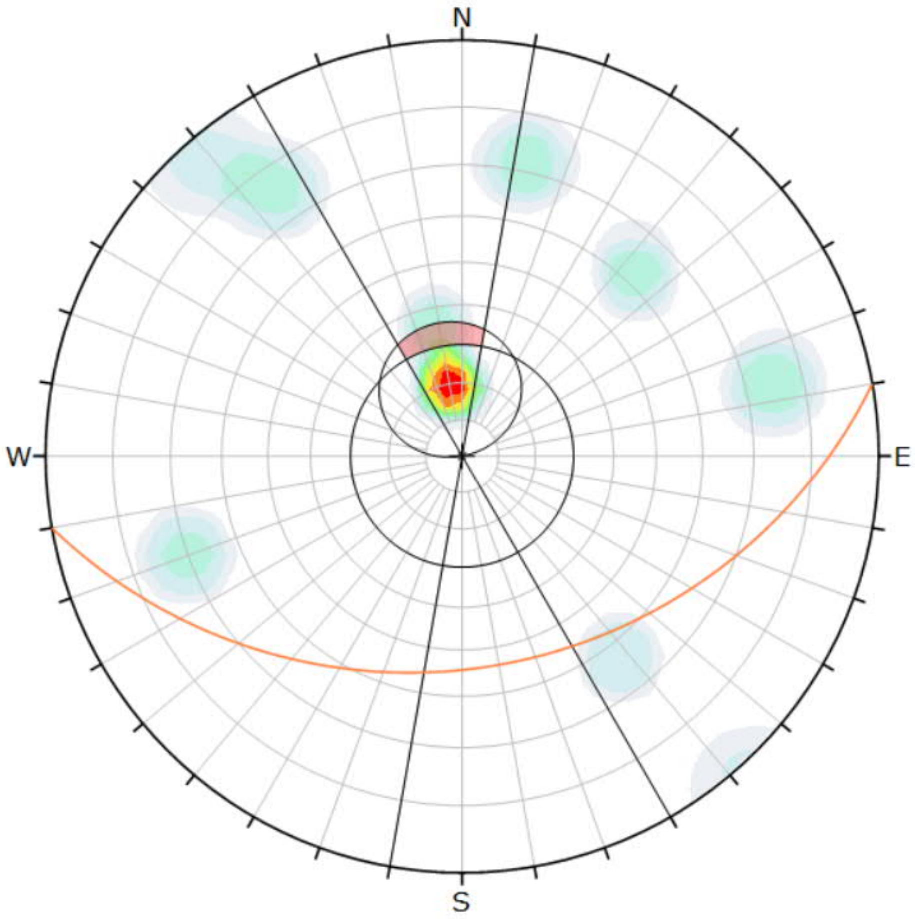
Contour Data	Pole Vectors
Maximum Density	26.05%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Direct Toppling
Slope Dip	38
Slope Dip Direction	225
Friction Angle	30°
Lateral Limits	20°

	Critical	Total	%
Direct Toppling (Intersection)	289	20359	1.42%
Oblique Toppling (Intersection)	480	20359	2.36%
Base Plane (All)	56	211	26.54%

Plot Mode	Pole Vectors
Vector Count	211 (211 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	20359
Hemisphere	Lower
Projection	Equal Angle

Plate 21: Kinematic assessment of topple failure potential for the east wall.



Color	Density Concentrations
	0.00 - 2.70
	2.70 - 5.40
	5.40 - 8.10
	8.10 - 10.80
	10.80 - 13.50
	13.50 - 16.20
	16.20 - 18.90
	18.90 - 21.60
	21.60 - 24.30
	24.30 - 27.00

Contour Data	Pole Vectors
Maximum Density	26.05%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Planar Sliding
Slope Dip	36
Slope Dip Direction	170
Friction Angle	30°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	15	211	7.11%

Plot Mode	Pole Vectors
Vector Count	211 (211 Entries)
Hemisphere	Lower
Projection	Equal Angle

Plate 22: Kinematic assessment of planar failure potential for the north wall.

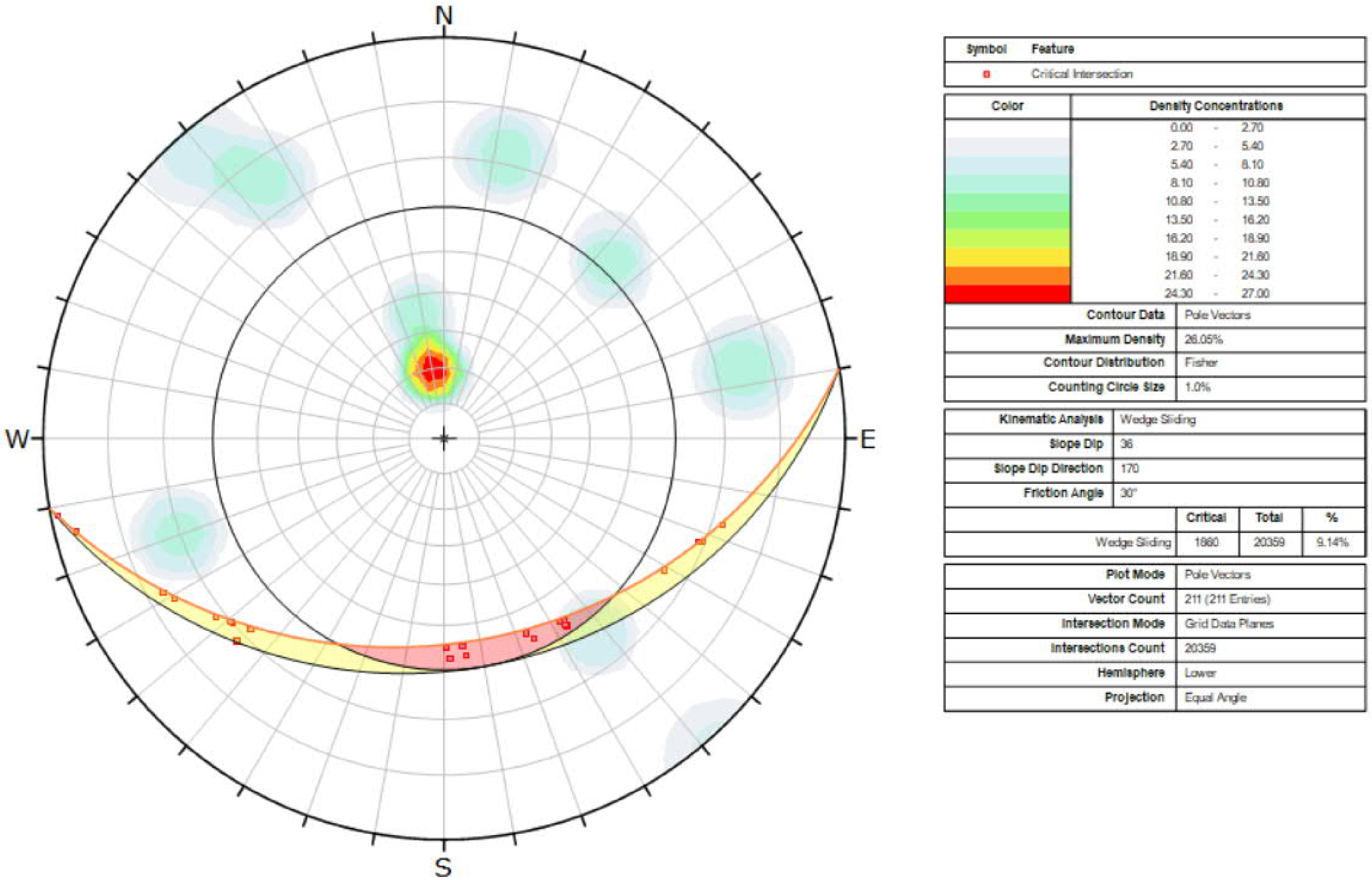
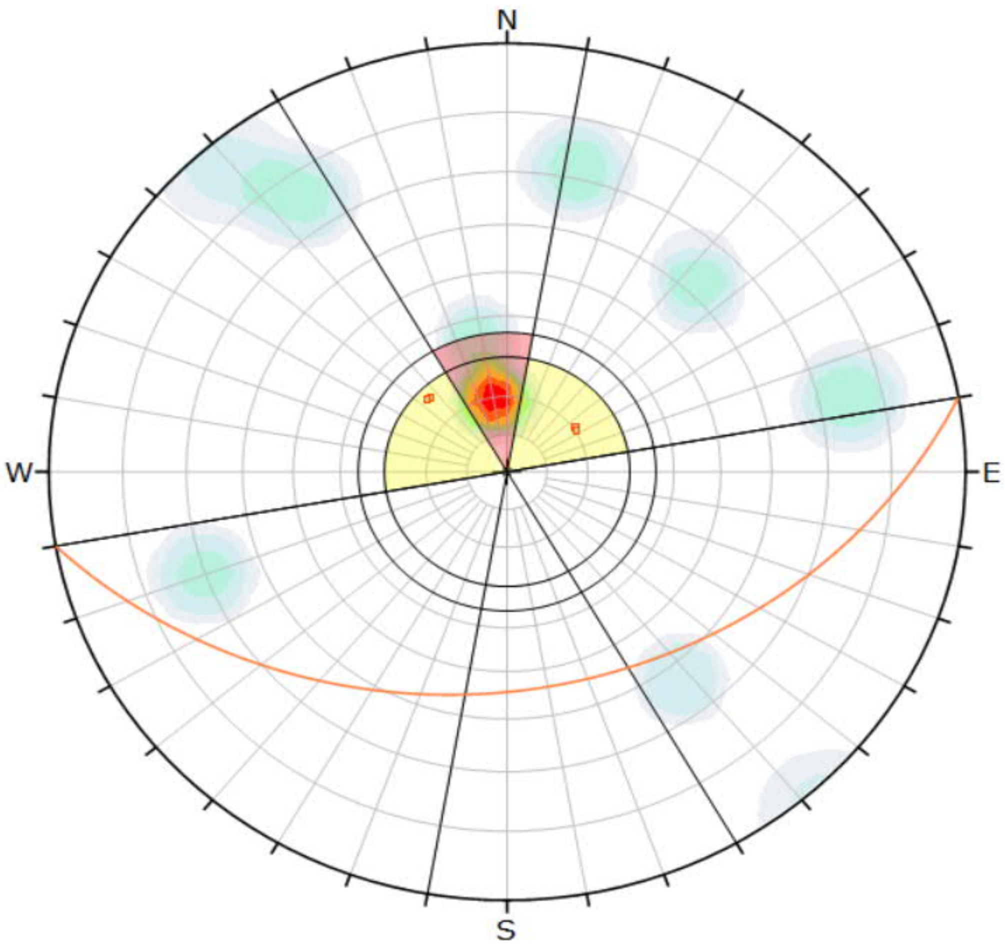


Plate 23: Kinematic assessment of wedge failure potential for the north wall.



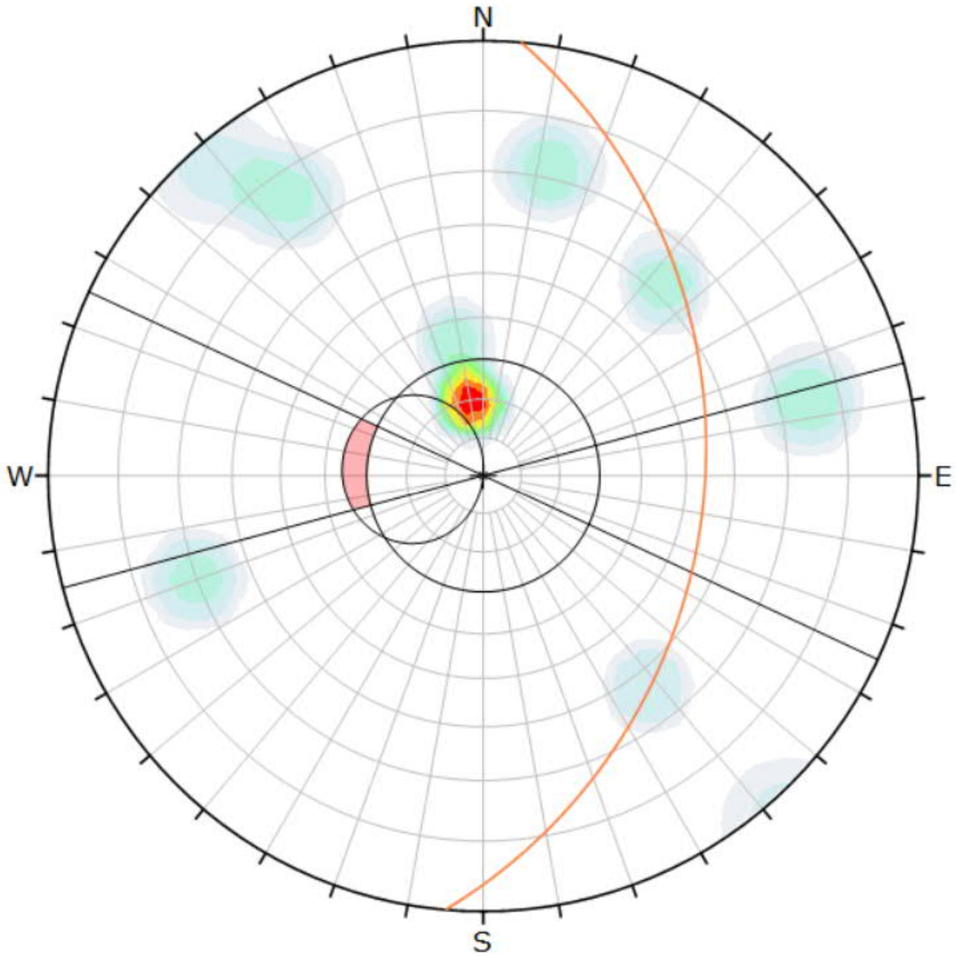
Symbol	Feature
■	Critical Intersection

Color	Density Concentrations
	0.00 - 2.70
	2.70 - 5.40
	5.40 - 8.10
	8.10 - 10.80
	10.80 - 13.50
	13.50 - 16.20
	16.20 - 18.90
	18.90 - 21.60
	21.60 - 24.30
	24.30 - 27.00
Contour Data	Pole Vectors
Maximum Density	26.05%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Direct Toppling		
Slope Dip	36		
Slope Dip Direction	170		
Friction Angle	30°		
Lateral Limits	20°		
	Critical	**Total**	**%**
Direct Toppling (Intersection)	0	20359	0.00%
Oblique Toppling (Intersection)	604	20359	2.97%
Base Plane (All)	71	211	33.65%

Plot Mode	Pole Vectors
Vector Count	211 (211 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	20359
Hemisphere	Lower
Projection	Equal Angle

Plate 24: Kinematic assessment of topple failure potential for the north wall.



Color	Density Concentrations
	0.00 - 2.70
	2.70 - 5.40
	5.40 - 8.10
	8.10 - 10.80
	10.80 - 13.50
	13.50 - 16.20
	16.20 - 18.90
	18.90 - 21.60
	21.60 - 24.30
	24.30 - 27.00

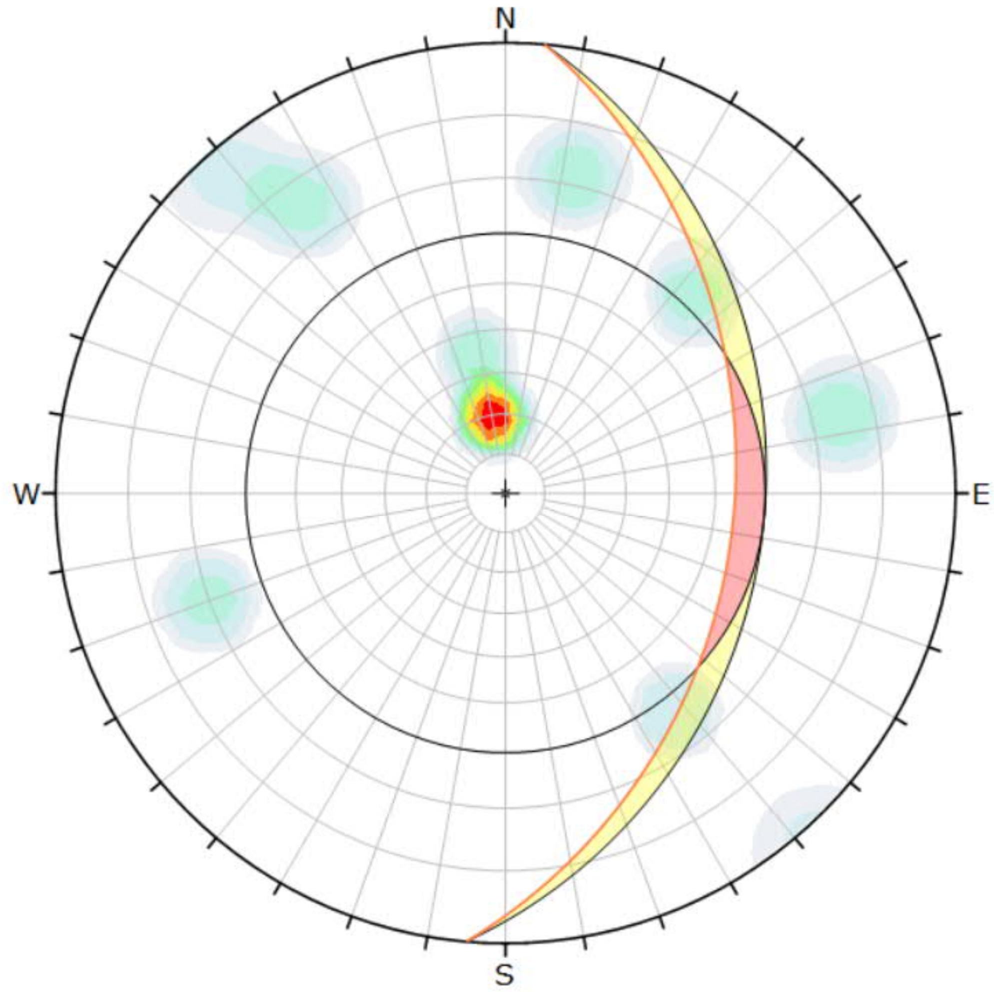
Contour Data	Pole Vectors
Maximum Density	26.05%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Planar Sliding
Slope Dip	36
Slope Dip Direction	95
Friction Angle	30°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	0	211	0.00%

Plot Mode	Pole Vectors
Vector Count	211 (211 Entries)
Hemisphere	Lower
Projection	Equal Angle

Plate 25: Kinematic assessment of planar failure potential for the west wall.



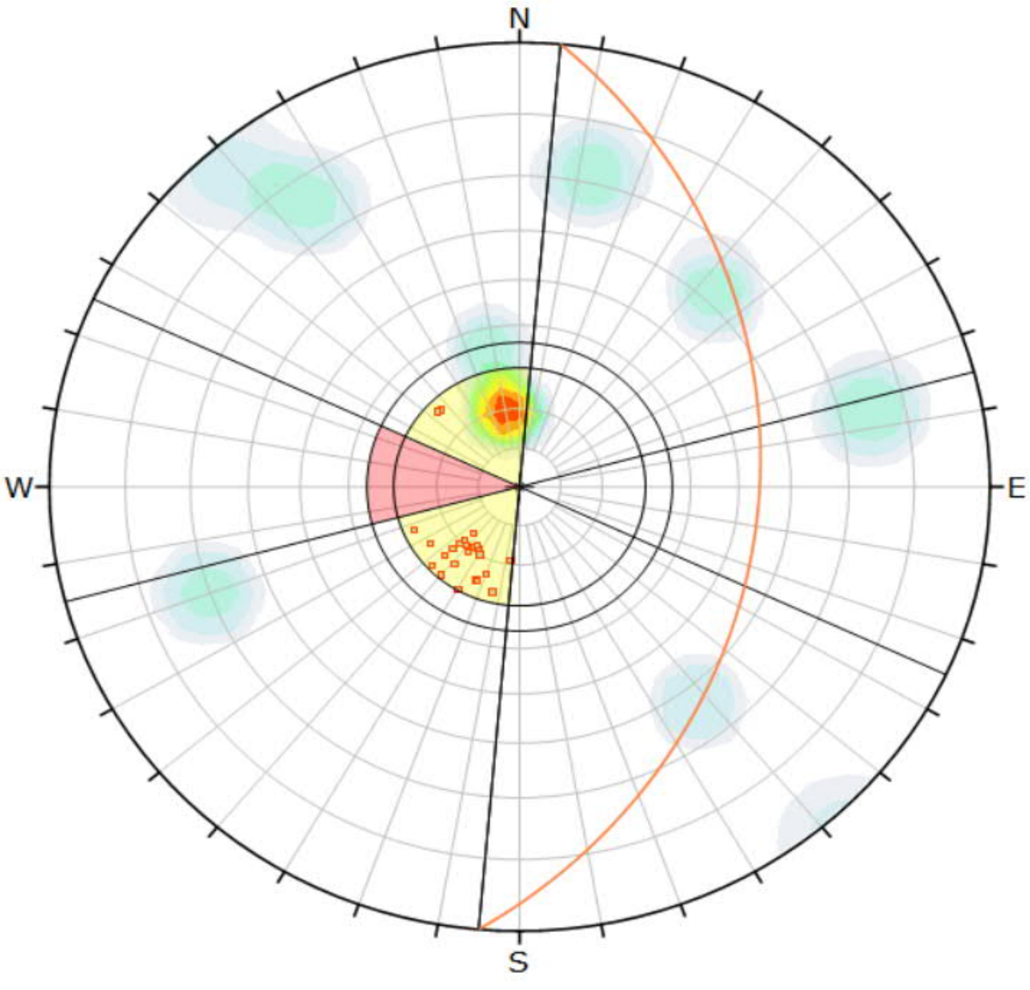
Symbol	Feature
◘	Critical Intersection

Color	Density Concentrations
	0.00 - 2.70
	2.70 - 5.40
	5.40 - 8.10
	8.10 - 10.80
	10.80 - 13.50
	13.50 - 16.20
	16.20 - 18.90
	18.90 - 21.60
	21.60 - 24.30
	24.30 - 27.00
Contour Data	Pole Vectors
Maximum Density	26.05%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding		
Slope Dip	36		
Slope Dip Direction	95		
Friction Angle	30°		
	Critical	Total	%
Wedge Sliding	0	20359	0.00%

Plot Mode	Pole Vectors
Vector Count	211 (211 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	20359
Hemisphere	Lower
Projection	Equal Angle

Plate 26: Kinematic assessment of wedge failure potential for the west wall.



Symbol	Feature
▫	Critical Intersection

Color	Density Concentrations
	0.00 - 2.70
	2.70 - 5.40
	5.40 - 8.10
	8.10 - 10.80
	10.80 - 13.50
	13.50 - 16.20
	16.20 - 18.90
	18.90 - 21.60
	21.60 - 24.30
	24.30 - 27.00
Contour Data	Pole Vectors
Maximum Density	26.05%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Direct Toppling		
Slope Dip	36		
Slope Dip Direction	95		
Friction Angle	30°		
Lateral Limits	20°		
	Critical	Total	%
Direct Toppling (Intersection)	0	20359	0.00%
Oblique Toppling (Intersection)	2911	20359	14.30%
Base Plane (All)	56	211	26.54%

Plot Mode	Pole Vectors
Vector Count	211 (211 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	20359
Hemisphere	Lower
Projection	Equal Angle

Plate 27: Kinematic assessment of topple failure potential for the north wall.

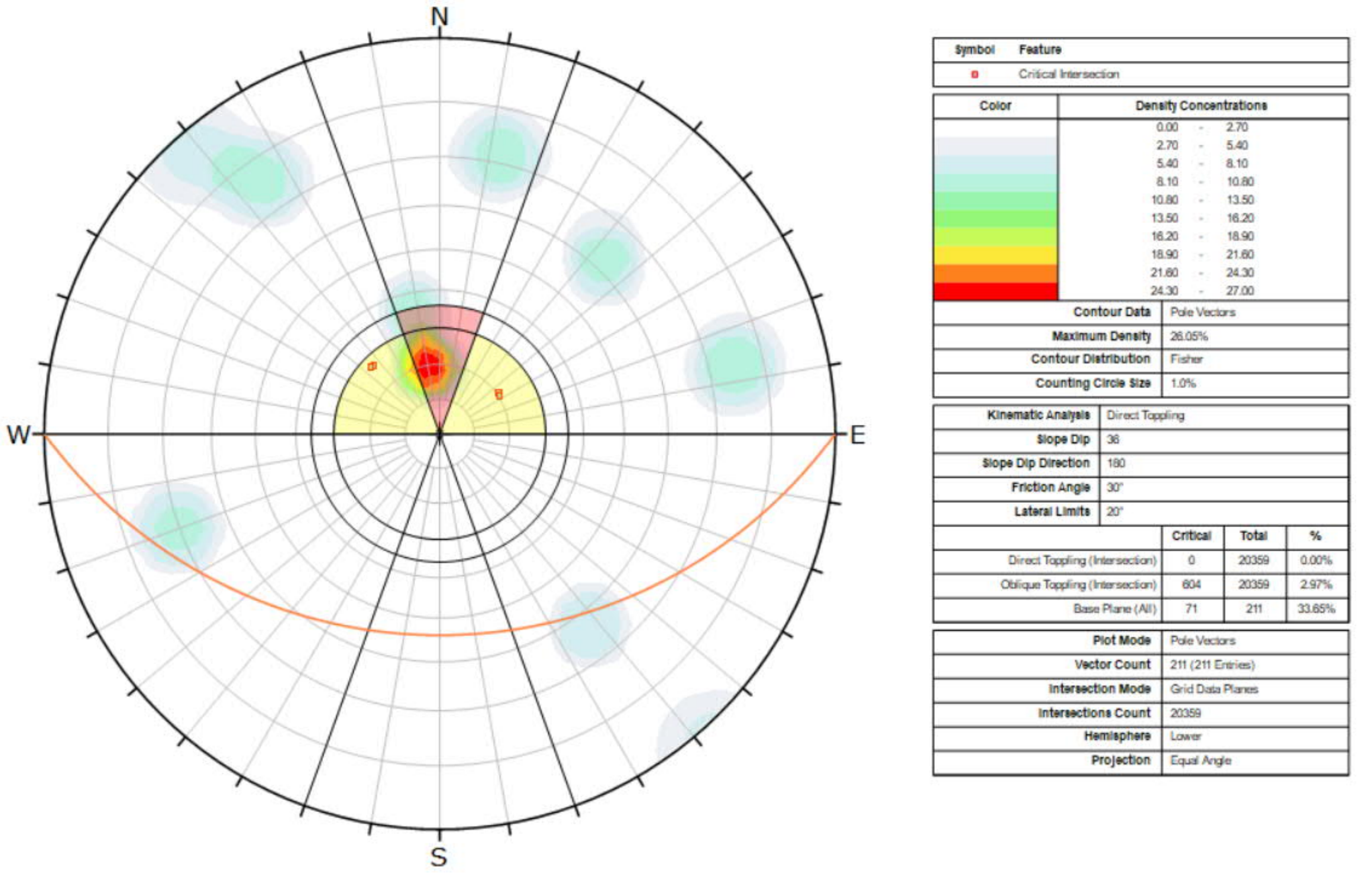
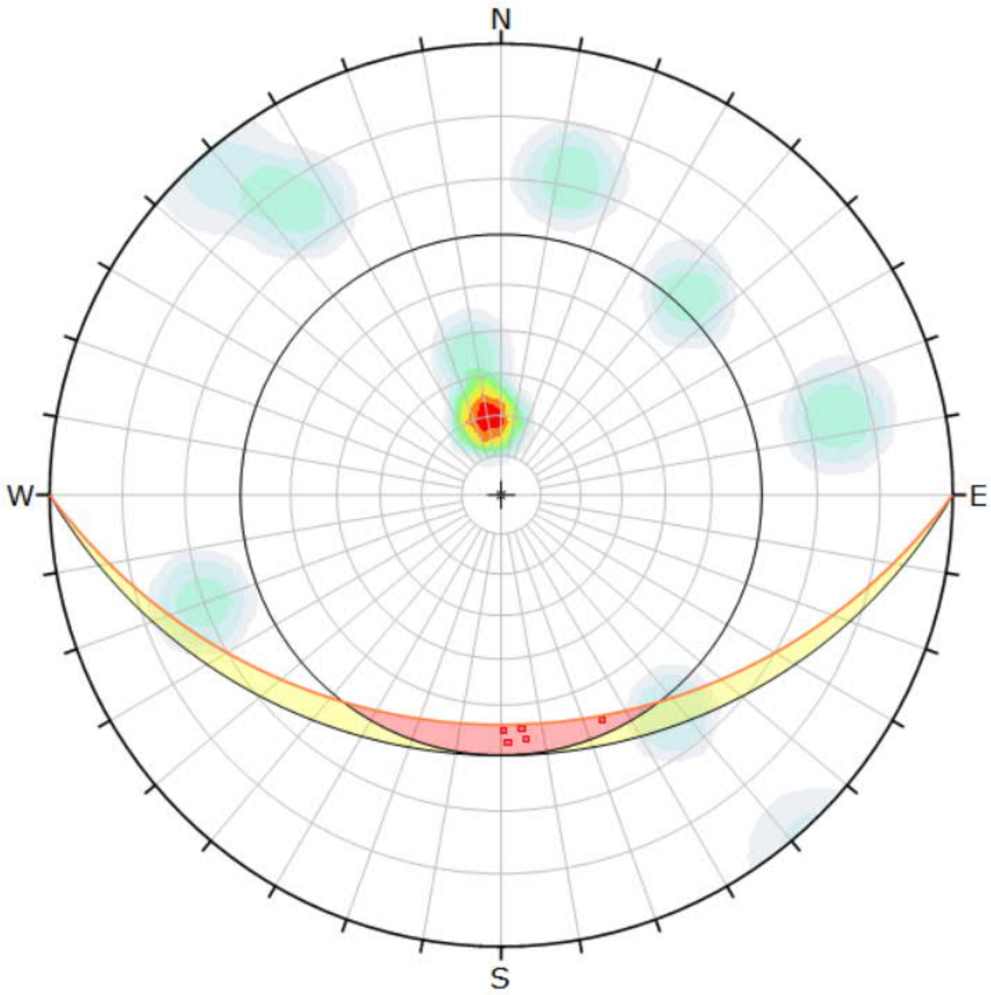


Plate 28: Kinematic assessment of planar failure potential for the south wall.



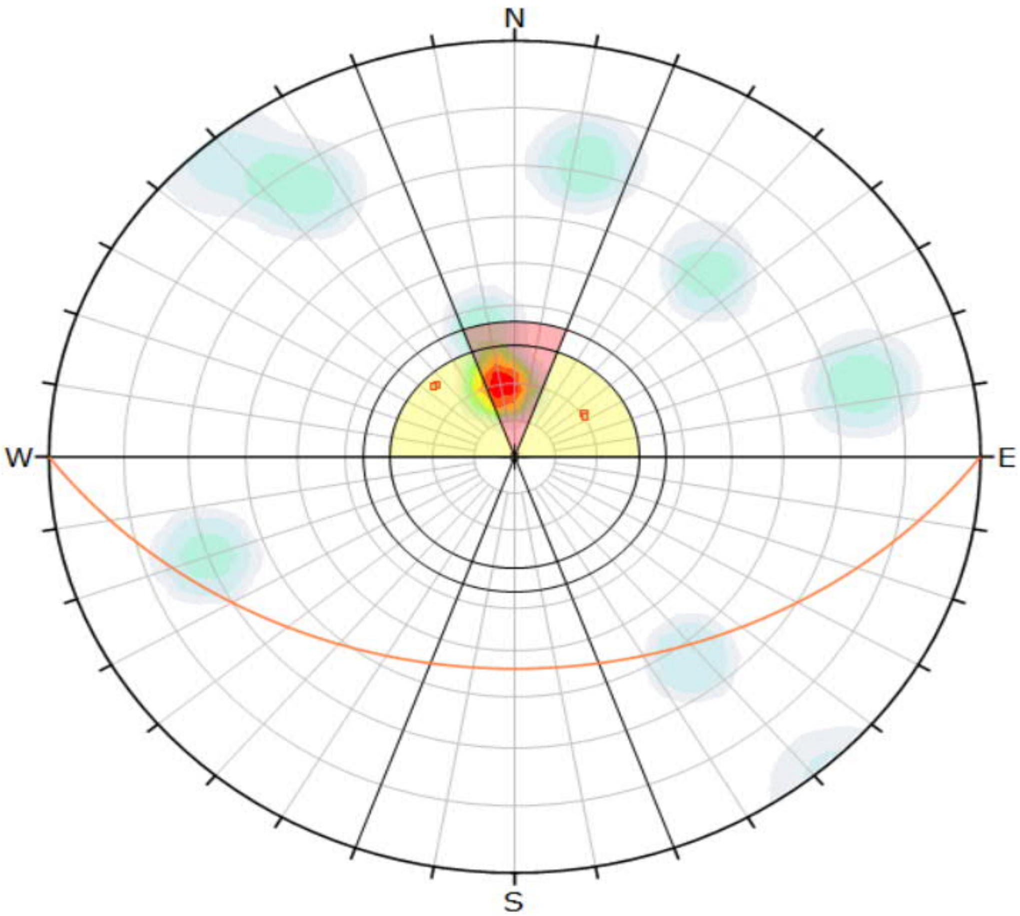
Symbol	Feature
▫	Critical Intersection

Color	Density Concentrations
	0.00 - 2.70
	2.70 - 5.40
	5.40 - 8.10
	8.10 - 10.80
	10.80 - 13.50
	13.50 - 16.20
	16.20 - 18.90
	18.90 - 21.60
	21.60 - 24.30
	24.30 - 27.00
Contour Data	Pole Vectors
Maximum Density	26.05%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding		
Slope Dip	36		
Slope Dip Direction	180		
Friction Angle	30°		
	Critical	Total	%
Wedge Sliding	435	20359	2.14%

Plot Mode	Pole Vectors
Vector Count	211 (211 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	20359
Hemisphere	Lower
Projection	Equal Angle

Plate 29: Kinematic assessment of wedge failure potential for the south wall.



Symbol	Feature
▫	Critical Intersection

Color	Density Concentrations
	0.00 - 2.70
	2.70 - 5.40
	5.40 - 8.10
	8.10 - 10.80
	10.80 - 13.50
	13.50 - 16.20
	16.20 - 18.90
	18.90 - 21.60
	21.60 - 24.30
	24.30 - 27.00
Contour Data	Pole Vectors
Maximum Density	26.05%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Direct Toppling		
Slope Dip	36		
Slope Dip Direction	180		
Friction Angle	30°		
Lateral Limits	20°		
	Critical	**Total**	**%**
Direct Toppling (Intersection)	0	20359	0.00%
Oblique Toppling (Intersection)	604	20359	2.97%
Base Plane (All)	71	211	33.65%

Plot Mode	Pole Vectors
Vector Count	211 (211 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	20359
Hemisphere	Lower
Projection	Equal Angle

Plate 30: Kinematic assessment of topple failure potential for the south wall.

3.6 Joint Conditions

Given that discontinuities within the rock mass will largely control stability in the deposit, particular attention was paid to the nature and orientation of the main joint sets, shears, bedding, veins, stock works and micro faults, if recognised. Essentially, any or all of these features have the potential to deleteriously impact upon stability if the appropriate conditions arise. In classifying the joint sets and other structures encountered on site, the terminology of Brown (1981), and Barton-Bandis (1990) et.al was used. This terminology classifies each potential discontinuity with a Joint Roughness Coefficient number, (JRC), refer TABLE 3 SMALL SCALE ROUGHNESS CRITERION, Jr, which can then be used in estimating Rock Mass Rating (RMR) values and also slope stability modelling. Further information on joint logging and appropriate methodologies can be found in the CSIRO Guidelines for Open Pit Slope Design 2009 (Read et.al).

Table 6 – Small Scale Roughness Criterion, Jr

Description	Profile	Jr	JRC 200 mm	JRC 1 m
Rough Smooth Slickensided Stepped		4 3 2	20 14 11	11 9 8
Rough Smooth Slickensided Undulating		3 2 1.5	14 11 7	9 8 6
Rough Smooth Slickensided Planar		1.5 1 0.5	2.5 1.5 0.5	2.3 0.9 0.4

Source: Read, J and Stacey, P. (Eds.), 2009: Guidelines for Open Pit Slope Design, CSIRO Publishing.

3.7 Rock Mass Rating (Bieniawski)

Resultant of the geological and geotechnical mapping completed on site, a rock mass rating (RMR) estimate was completed and then integrated in the geotechnical risk rating map prepared for the site. RMR calculations synthesize and distil a number of relevant geotechnical parameters into a numerical form which can then be incorporated into resultant geotechnical models, refer TABLE 7 RMR CALIBRATED AGAINST ROCK MASS QUALITY and TABLE 8 BIENIAWSKI 1976 RMR PARAMETER RATINGS. The parameters used in calculating the RMR include Rock Strength as UCS, Rock Quality Designation (RQD), groundwater conditions and the spacing and condition of joint sets and other structures. Adjustment factors for degree of weathering, structure, orientation and blasting technique are then integrated into the RMR to calculate a Quarrying Rock Mass Rating value which ranges from 0-100, with 100 being excellent quality material. Resultant of this rock mass quality estimate, it can be said that the majority of rock on site, when unweathered, has modest RMR values which generally range from fair to good. Interestingly, the RMR values also readily identify the lower quality areas, because RQD is a relevant factor in the estimate, as is the degree of weathering and the nature and size of the joint infill, refer TABLE 4 DEFECT SPACING TERMINOLOGY and TABLE 5 APPERTURE SPACING.

Table 7 – RMR Calibrated Against Rock Mass Quality

RMR rating	Description
81-100	Very good rock
61-80	Good rock
41-60	Fair rock
40-21	Poor rock
<21	Very poor rock
Source: Read, J and Stacey, P. (Eds.), 2009: Guidelines for Open Pit Slope Design, CSIRO Publishing.	

Table 8 – Bieniawski 1976 RMR Parameter Ratings

Parameter			Range of values						
1	Strength of intact rock material	Point-load strength index	>8 MPa	4-8 MPa	2-4 MPa	1-2 MPa	For this low range uniaxial compression test is preferred		
		Uniaxial compression strength	>200	100-200 MPa	50-100 MPa	25-50 MPa	10-25 MPa	3-10 MPa	1-3 MPa
	Rating		15	12	7	4	2	1	0
2	Drill core quality RQD		90-100%	75-90%	50-75%	25-50%	<25%		
	Rating		20	17	13	8	3		
3	Spacing of joints		>3 m	1-3 m	0.3-1 m	50-300 mm	<50 mm		
	Rating		30	25	20	10	5		

4	Condition of joints	Very rough surfaces Not continuous No separation Hard joint wall contact	Slightly rough surfaces Separation <1 mm Hard joint wall contact	Slightly rough surfaces Separation <1 mm Soft joint wall contact	Slickensided surfaces OR Gouge <5 mm thick Joints open 1-5 mm Continuous joints	Soft gouge >5 mm thick OR Joints open >5 mm Continuous joints
	Rating	25	20	12	6	0

Source: Read, J and Stacey, P. (Eds.), 2009: Guidelines for Open Pit Slope Design, CSIRO Publishing.

Table 9 – Defect Spacing Terminology

Term	Spacing (mm)
Extremely Close	<20
Very close	20-60
Close	60-200
Medium	200-600
Wide	600-2000
Very wide	>2000

Table 10 – Aperture Spacing

Term	Aperture (mm)
Tight	0
Very narrow	0-6
Narrow	6-20
Moderately narrow	20-60
Moderately wide	60-200
Wide	200-600
Very wide	600-2000
Cavernous	>2000

3.8 Rock Properties

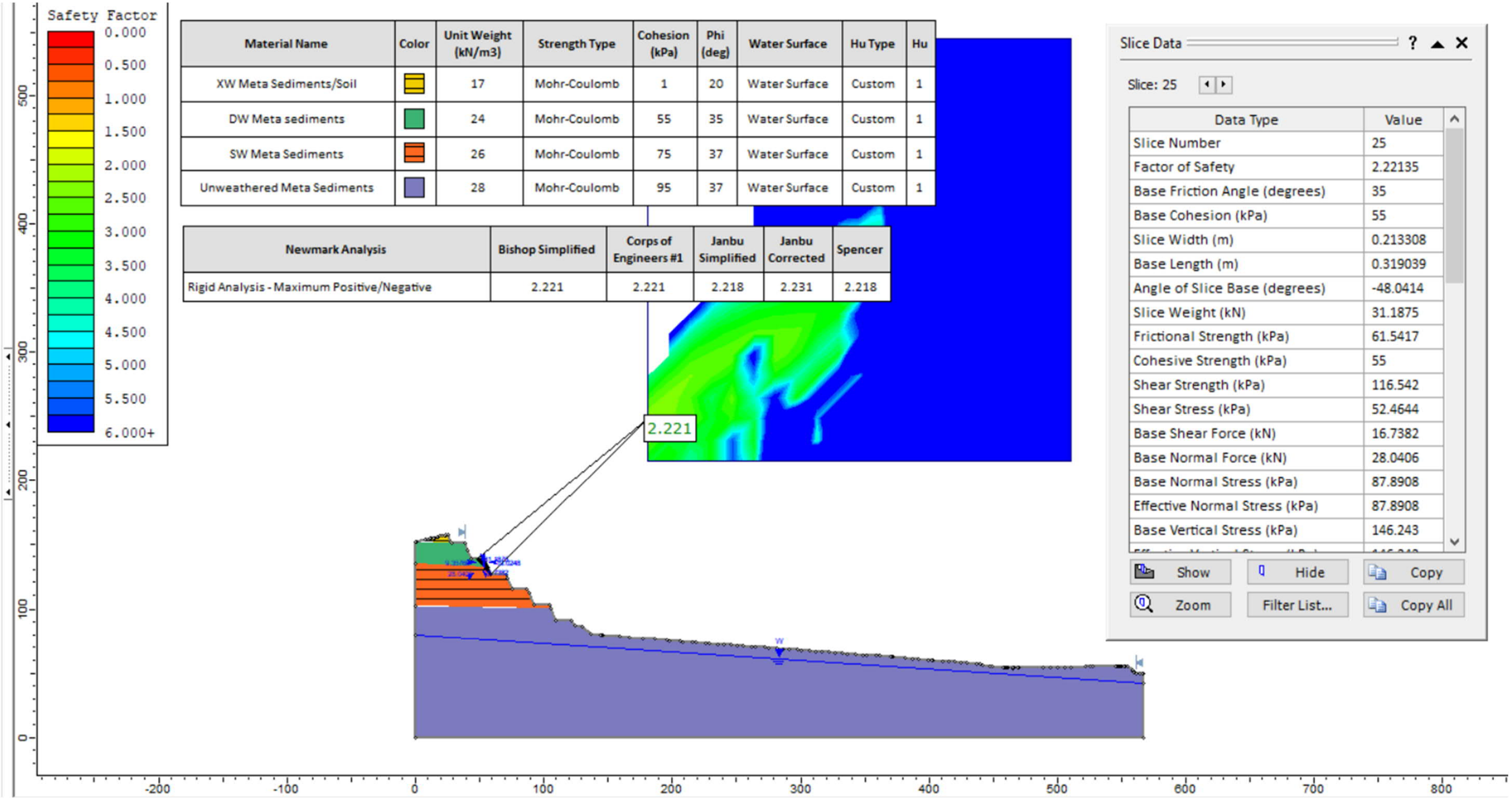
Rock properties used for modelling purposes are provided in TABLE 11.

Table 11 – Summary of Rock Properties

Rock Type	Apparent Particle Density (t/m^3)	UCS (MPa) Adjusted from kN	Tensile Strength(MPa) Adjusted from kN	Young's Modulus (GPa)	Poisson's Ratio
Meta-Sediments	2.7	50-90	26	50	0.2 to 0.35

3.9 Limit Equilibrium Modelling

To determine the insitu Factors of Safety (FOS) the slope was sectioned and imported into Slide V6.3 for slope stability modelling. Slide is a two dimensional slope stability program for evaluating the safety factor or probability of failure (POF), of circular or non-circular failure surfaces in soil or rock slopes. Slide analyses the stability of slip surfaces using vertical slice limit equilibrium methods. Individual slip surfaces sections are analysed to locate the critical slip surface for each section. Deterministic (FOS) analyses are then performed on the nominated criteria. Modelling one key section for each wall was completed, refer Plates 31 to 46 which demonstrate varying levels of FoS all of which demonstrate suitable levels of stability and a very low risk of slope failure, using the designed batter, bench, and slope configuration. Using these results, the following slope design guidelines are recommended to be used for the quarry, refer TABLE 12.



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
XW Meta Sediments/Soil		17	Mohr-Coulomb	1	20	Water Surface	Custom	1
DW Meta sediments		24	Mohr-Coulomb	55	35	Water Surface	Custom	1
SW Meta Sediments		26	Mohr-Coulomb	75	37	Water Surface	Custom	1
Unweathered Meta Sediments		28	Mohr-Coulomb	95	37	Water Surface	Custom	1

Newmark Analysis	Bishop Simplified	Corps of Engineers #1	Janbu Simplified	Janbu Corrected	Spencer
Rigid Analysis - Maximum Positive/Negative	2.221	2.221	2.218	2.231	2.218

Data Type	Value
Slice Number	25
Factor of Safety	2.22135
Base Friction Angle (degrees)	35
Base Cohesion (kPa)	55
Slice Width (m)	0.213308
Base Length (m)	0.319039
Angle of Slice Base (degrees)	-48.0414
Slice Weight (kN)	31.1875
Frictional Strength (kPa)	61.5417
Cohesive Strength (kPa)	55
Shear Strength (kPa)	116.542
Shear Stress (kPa)	52.4644
Base Shear Force (kN)	16.7382
Base Normal Force (kN)	28.0406
Base Normal Stress (kPa)	87.8908
Effective Normal Stress (kPa)	87.8908
Base Vertical Stress (kPa)	146.243

Plate 31: Section A west wall limit equilibrium assessment was completed to assess slope stability issues and FoS levels. FoS levels are high denoting stability, over the long term with the minimum slip circle shown. For the bulk of the slope the FOS is greater than 2.5. Engineering parameters are based of test data supplied by the Hanson NATA accredited laboratory. This rock is a class D rock or a moderately strong rock. Four different slope assessment methods have been used which all provide slightly different results for the Factors of Safety.

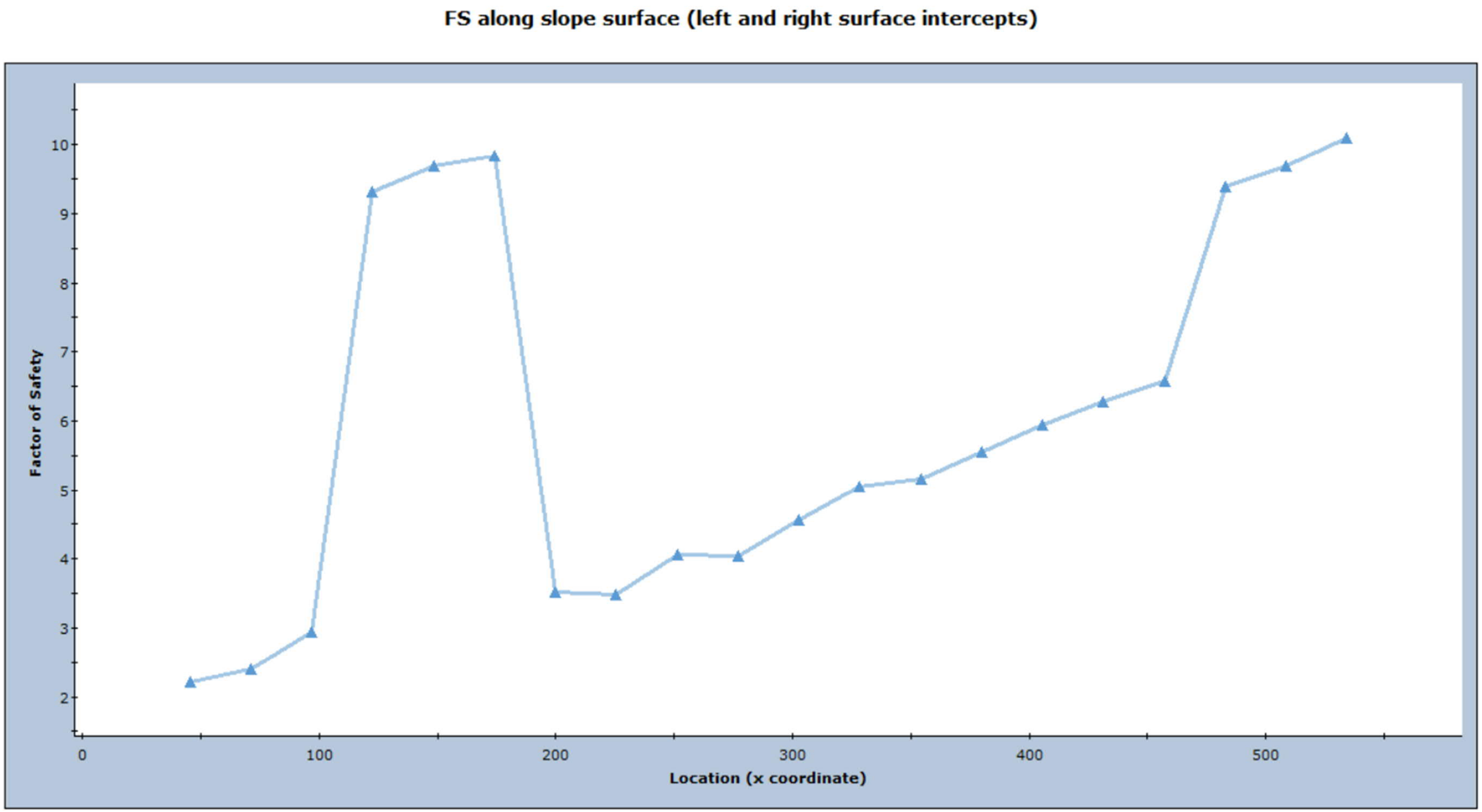


Plate 32: A graph of FOS along Section A, west wall with the minimum FOS encountered at the base of the distinctly weathered material. Critically several small failures have developed like this, so this model calibrates well with site conditions.

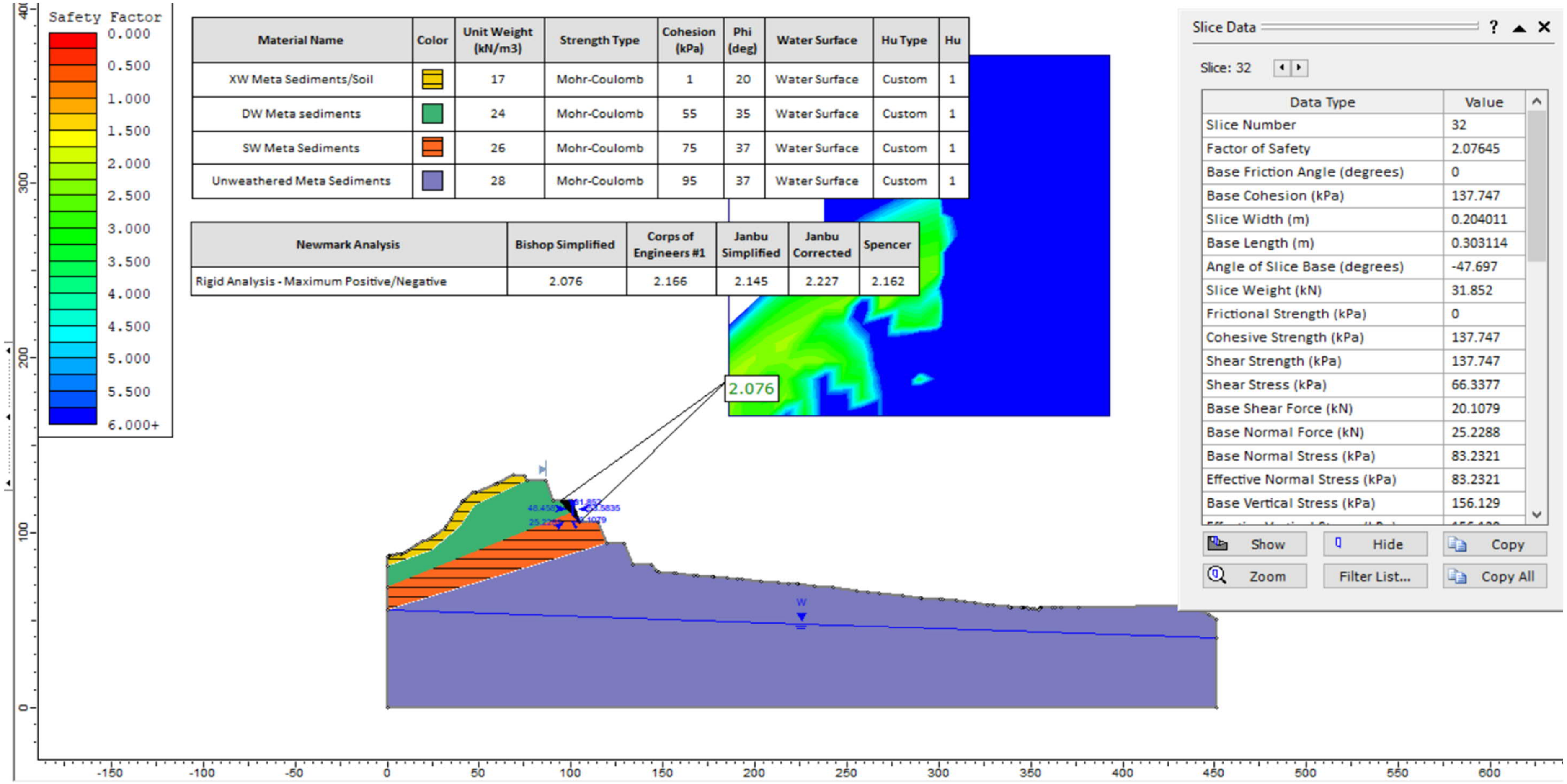


Plate 33: Section B north wall limit equilibrium assessment was completed to assess slope stability issues and FoS levels. FoS levels are suitable and denote stability, over the long term with the minimum slip circle shown. For the bulk of the slope the FOS is greater than 2.5.

GROUNDWORK plus

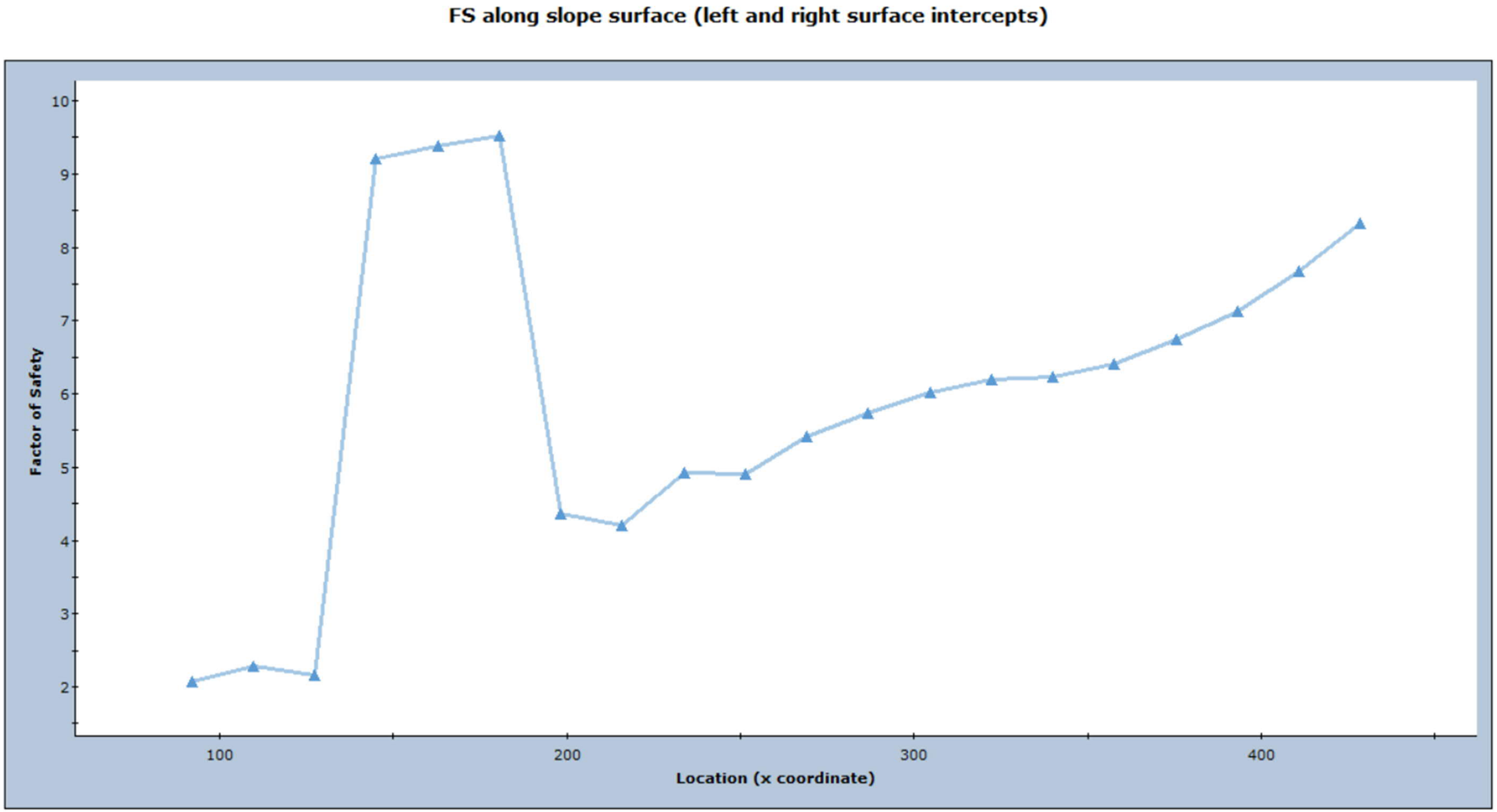


Plate 34: A graph of FOS along Section B, north wall with the minimum FOS encountered at the base of the distinctly weathered material. Critically several small failures have developed like this, so this model calibrates well with site conditions. The lower FoS in this instance are associated with the lower strength materials weathered encountered at the tope of the ridgeline.

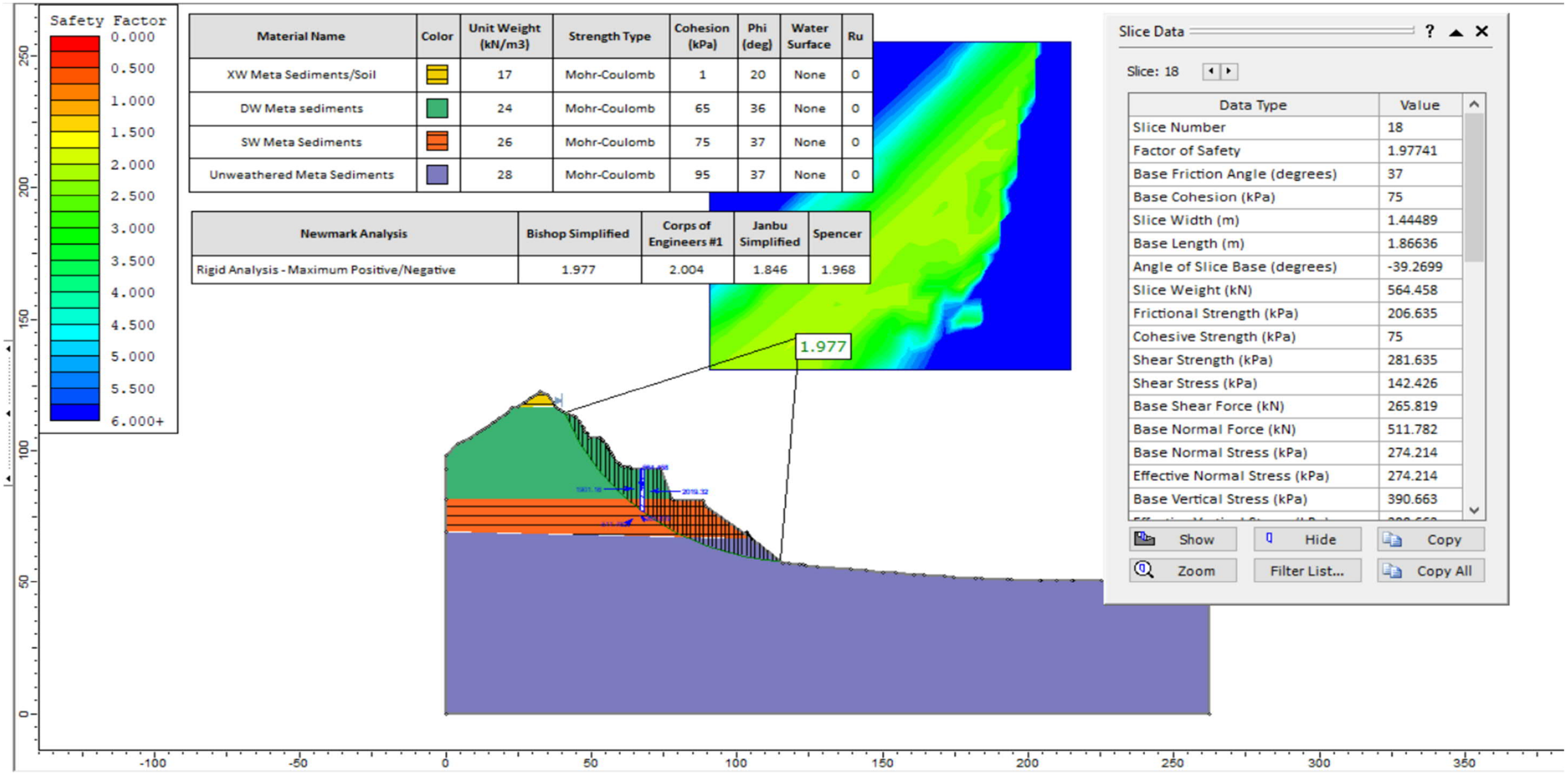


Plate 35: Section C north wall limit equilibrium assessment was completed to assess slope stability issues and FoS levels. FoS levels approximate 2 which is stable and suitable over the long term with the minimum slip circle shown. This slope has a different failure mechanism to the other sections in that it demonstrates that slope heights and weights are starting to impact slope performance.

GROUNDWORK plus

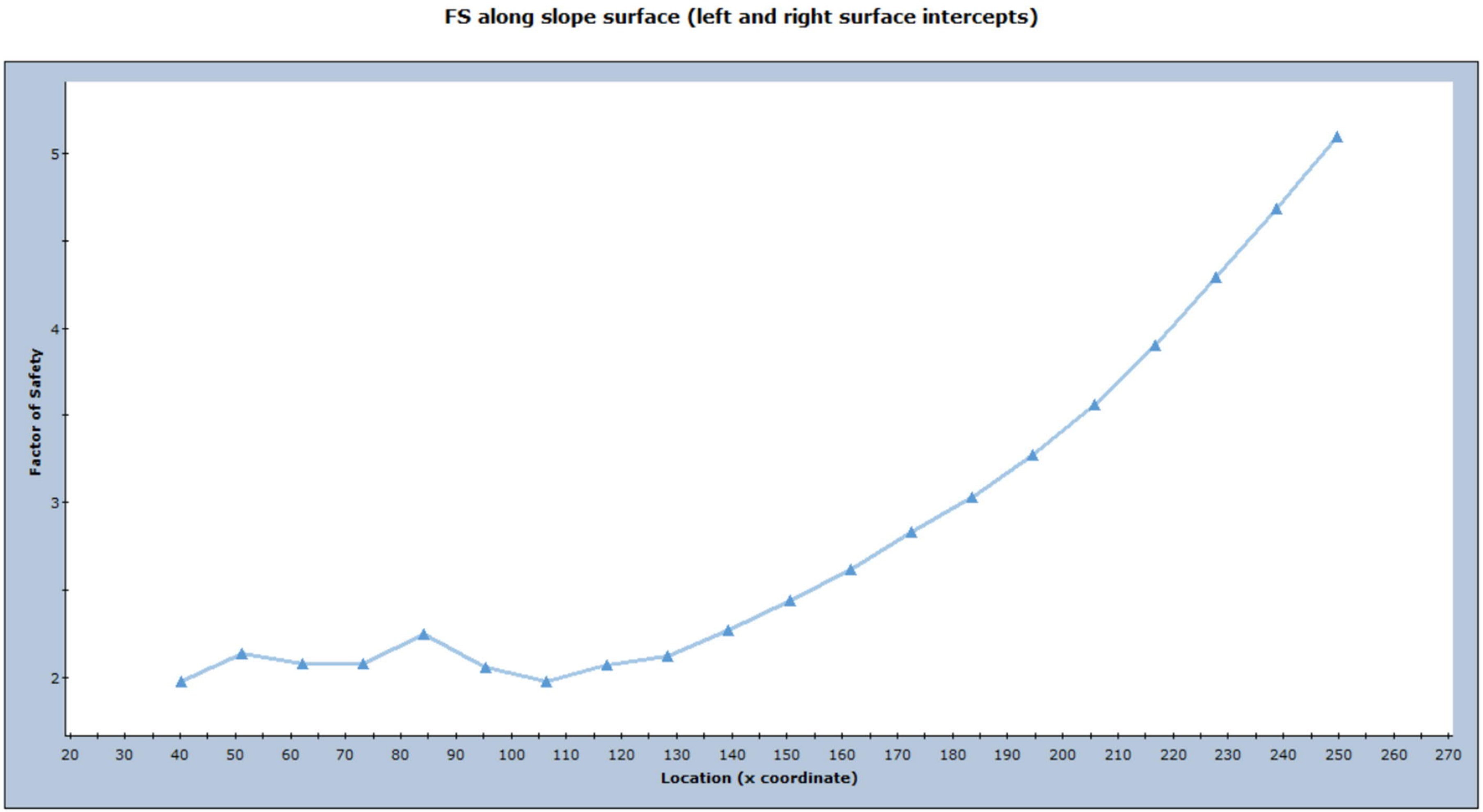


Plate 36: A graph of FOS along Section C, north wall with the minimum FOS encountered at the base of the slope denoting slope weight starts to impact overall slope performance.

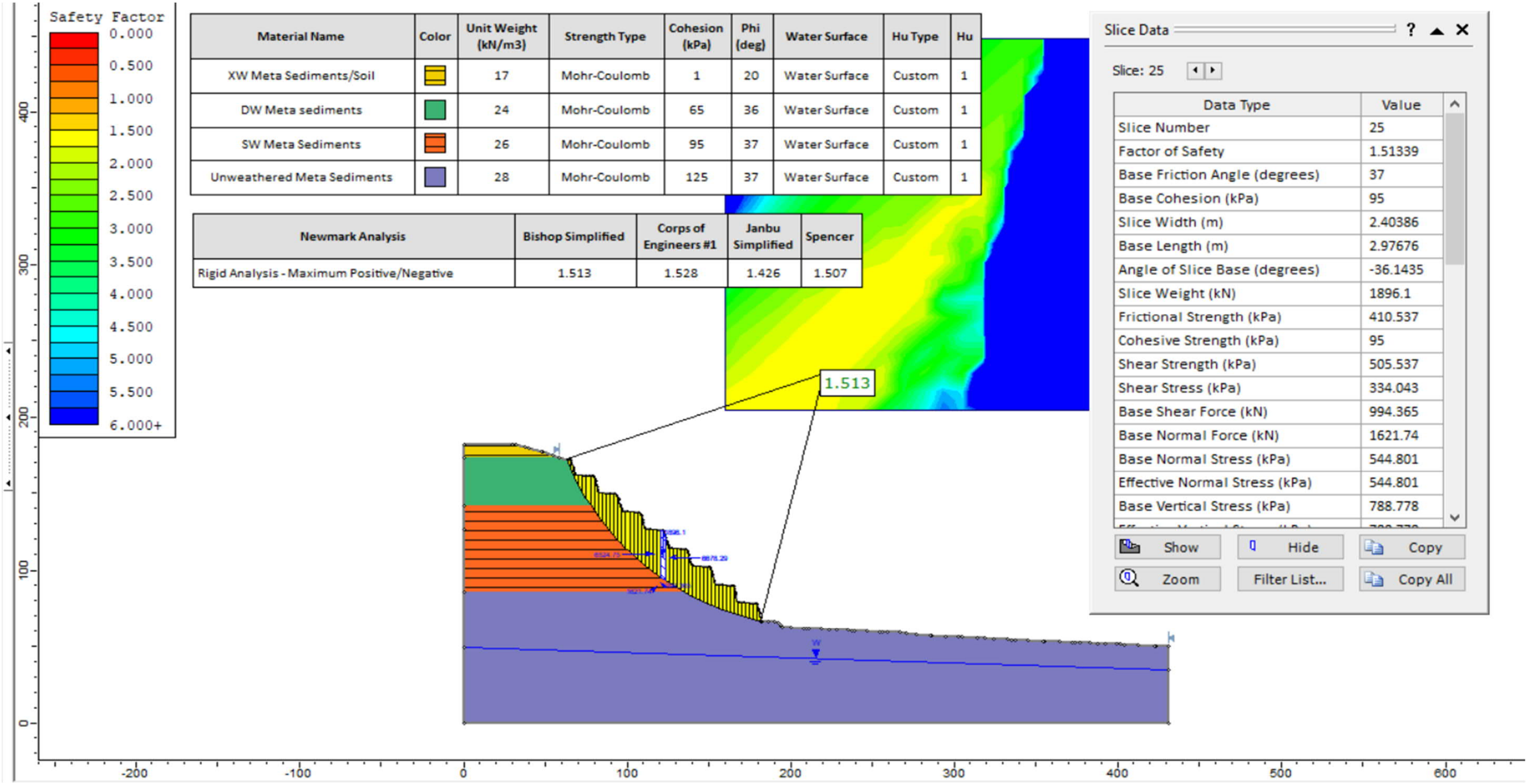


Plate 37: Section D east wall limit equilibrium assessment was completed to assess slope stability issues and FoS levels. FoS levels approximate 1.5 which is stable with the minimum slip circle shown. This slope has a similar failure mechanism to the section C in that it demonstrates that slope heights are starting to impact slope performance. This is why this slope has been buttressed along with the eastern part of the north wall to improve the long term FoS. When buttressed this slope increases the FoS to > 2. A FoS of 1.5 is suitable for operational slopes.

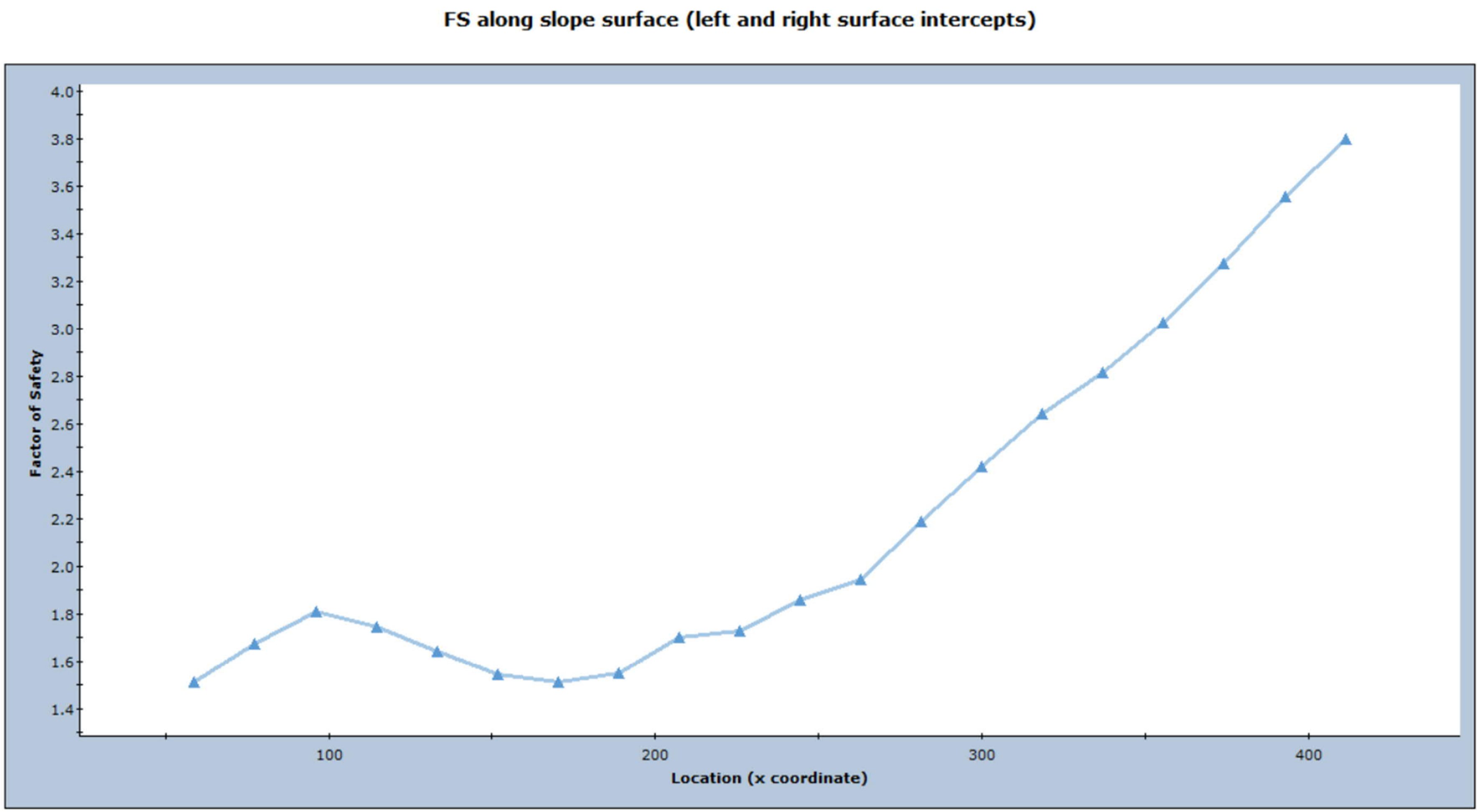


Plate 38: A graph of FOS along Section D, east wall with the minimum FOS encountered at the base of the distinctly weathered material.

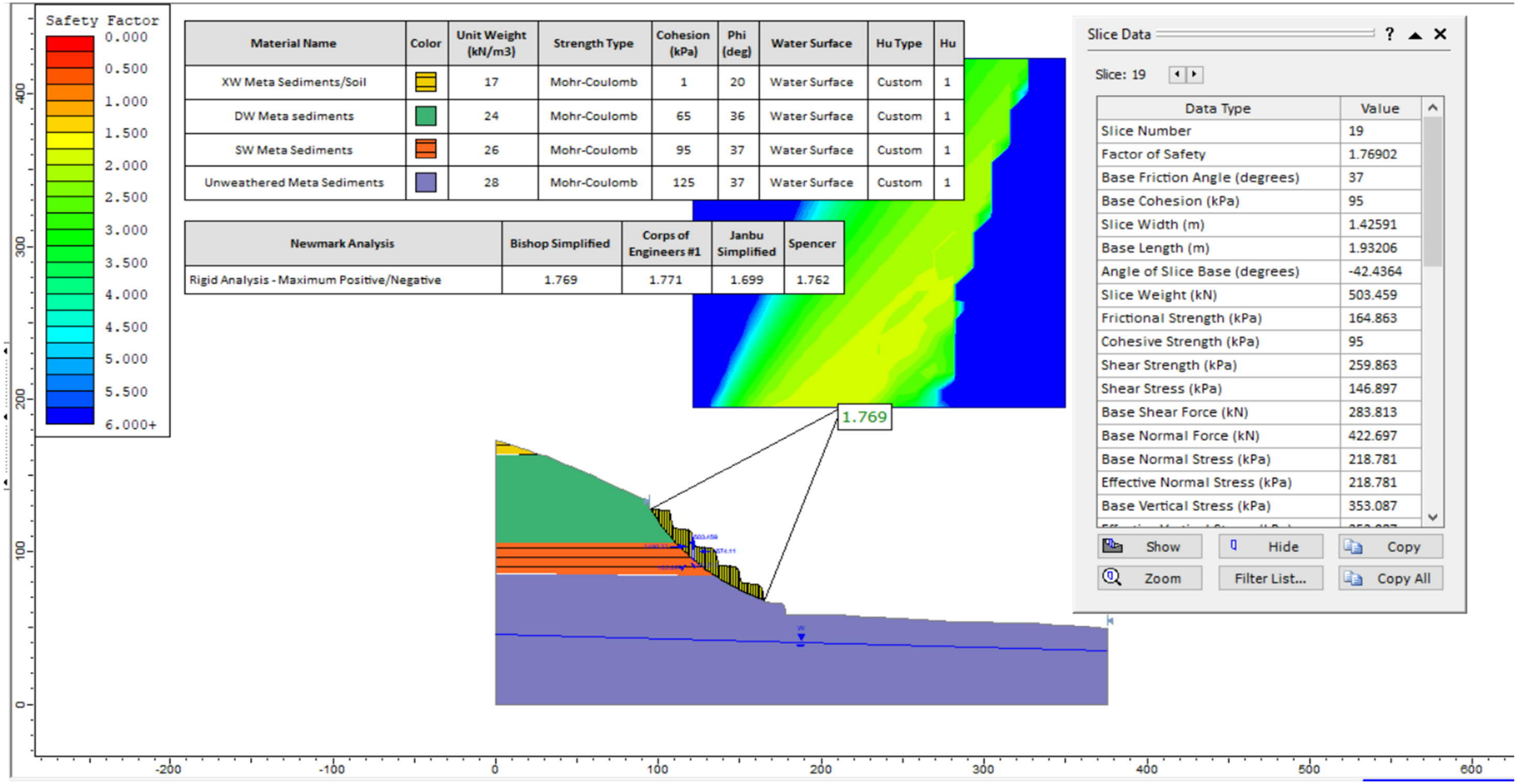


Plate 39: Section E south wall limit equilibrium assessment was completed to assess slope stability issues and FoS levels. FoS levels approximate 1.7 which is stable with the minimum slip circle shown. This slope has a similar failure mechanism to the section C in that it demonstrates that slope heights are starting to impact slope performance as is the weight of the slope above the cutting . This is why this slope has been buttressed along with the eastern part of the north wall to improve the long term FoS. When buttressed this slope increases the FoS to > 2. A FoS of 1.5 is suitable for operational slopes.

GROUNDWORK plus

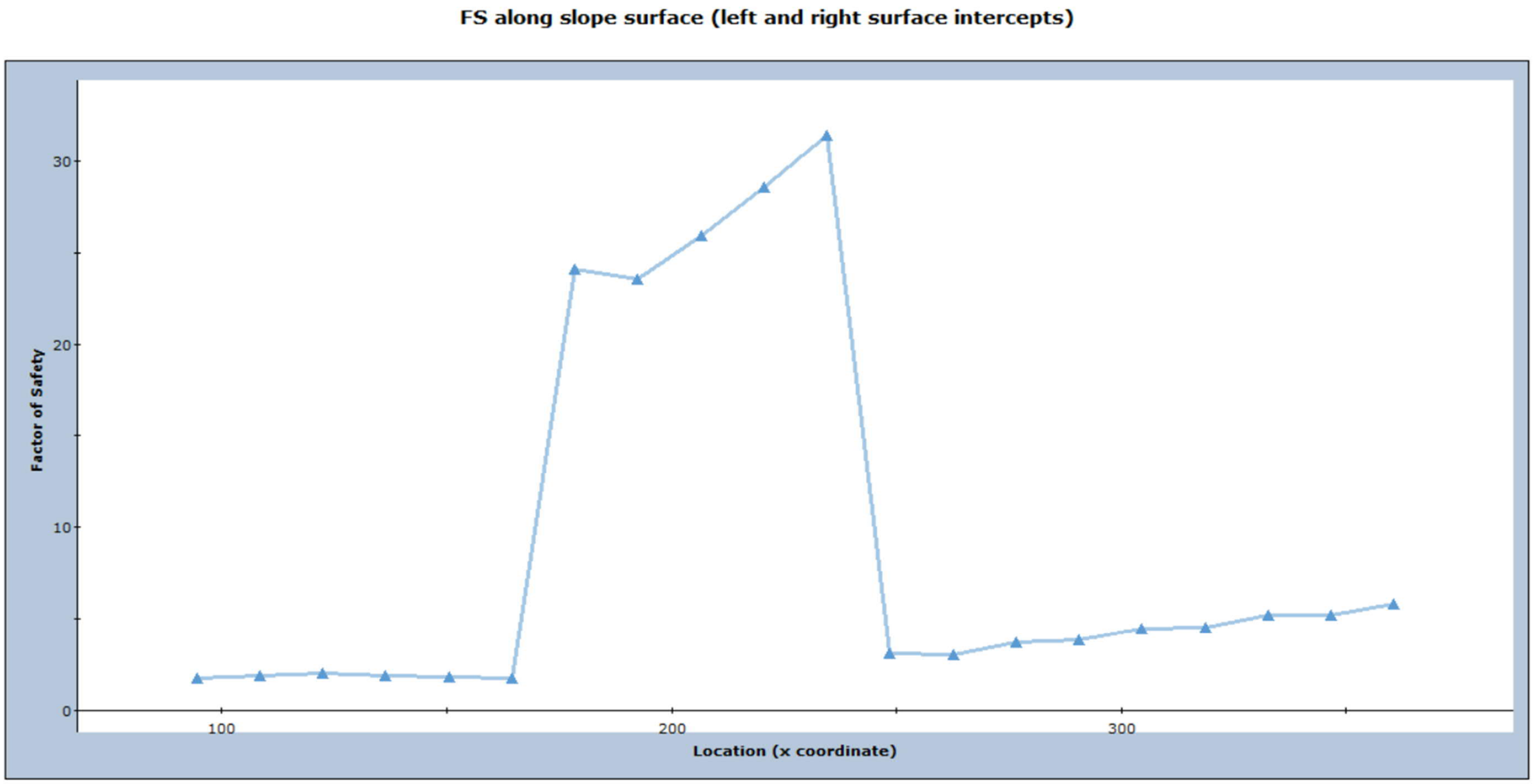


Plate 40: A graph of FOS along Section E, south wall with the minimum FOS encountered at the base of the slope.

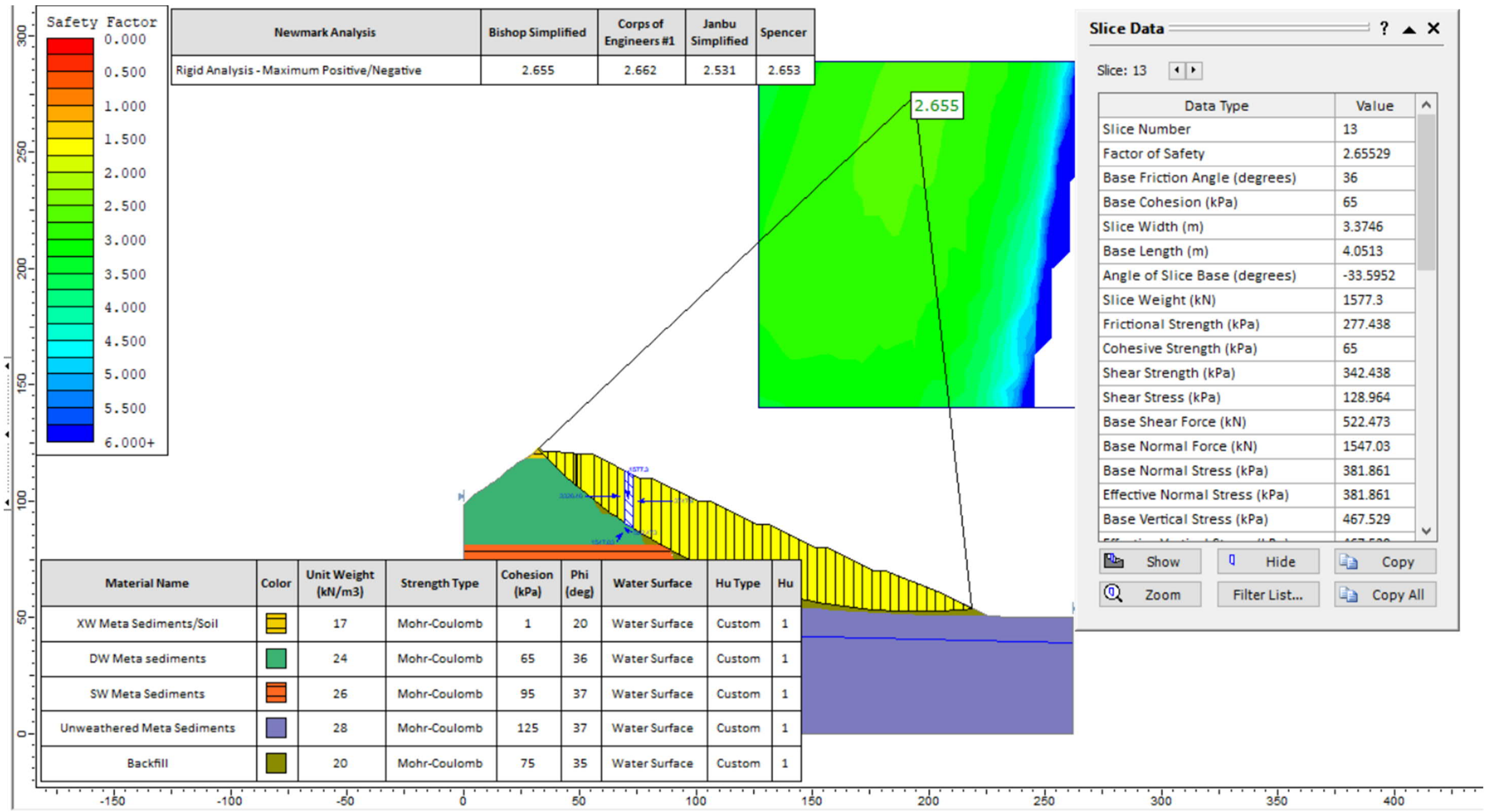


Plate 41: Section C buttressed, and rehabilitated north wall limit equilibrium assessment was completed to assess slope stability issues and FoS levels. FoS levels are>2 which is stable suitable over the long term with the minimum slip circle shown.

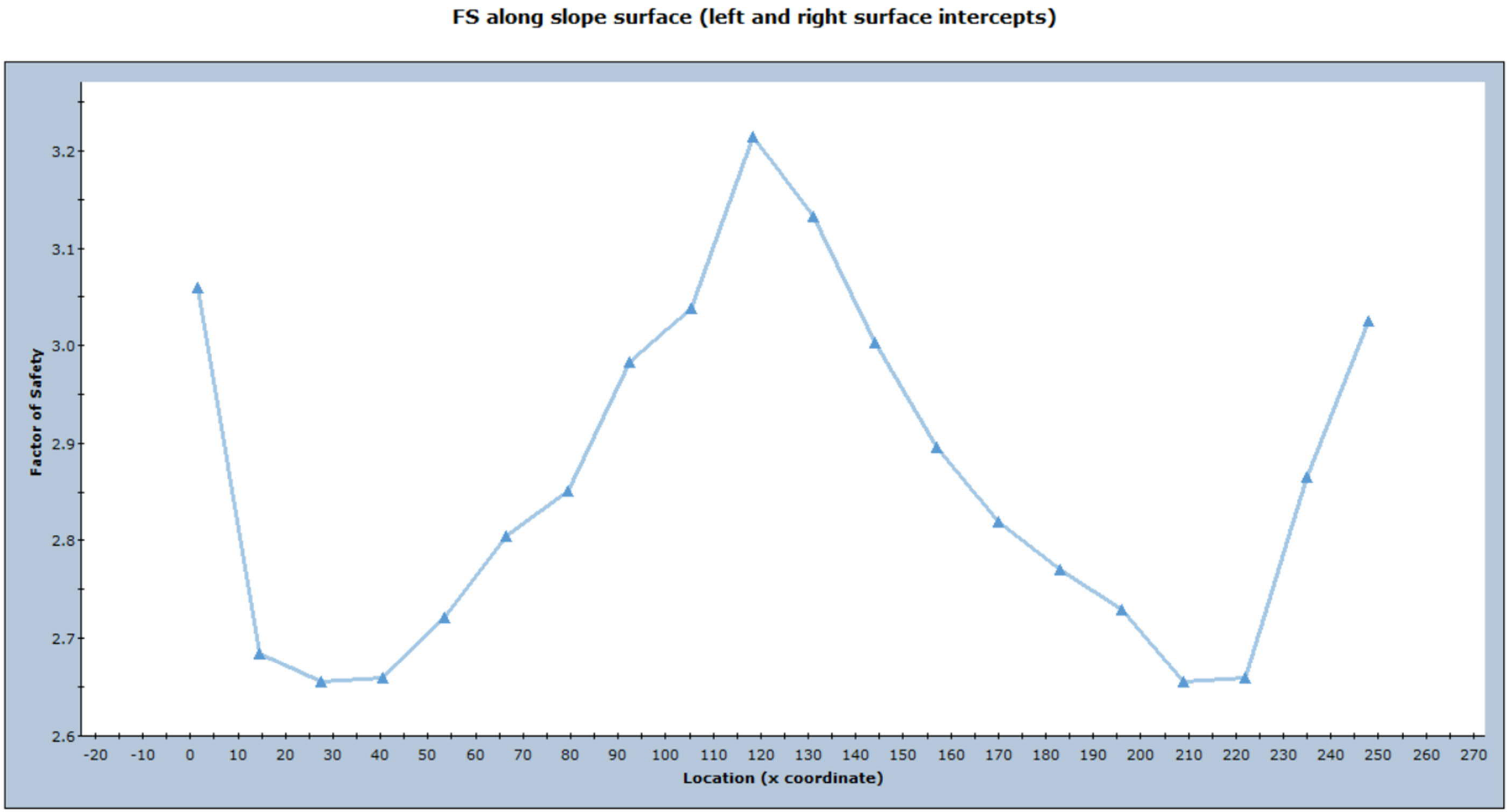
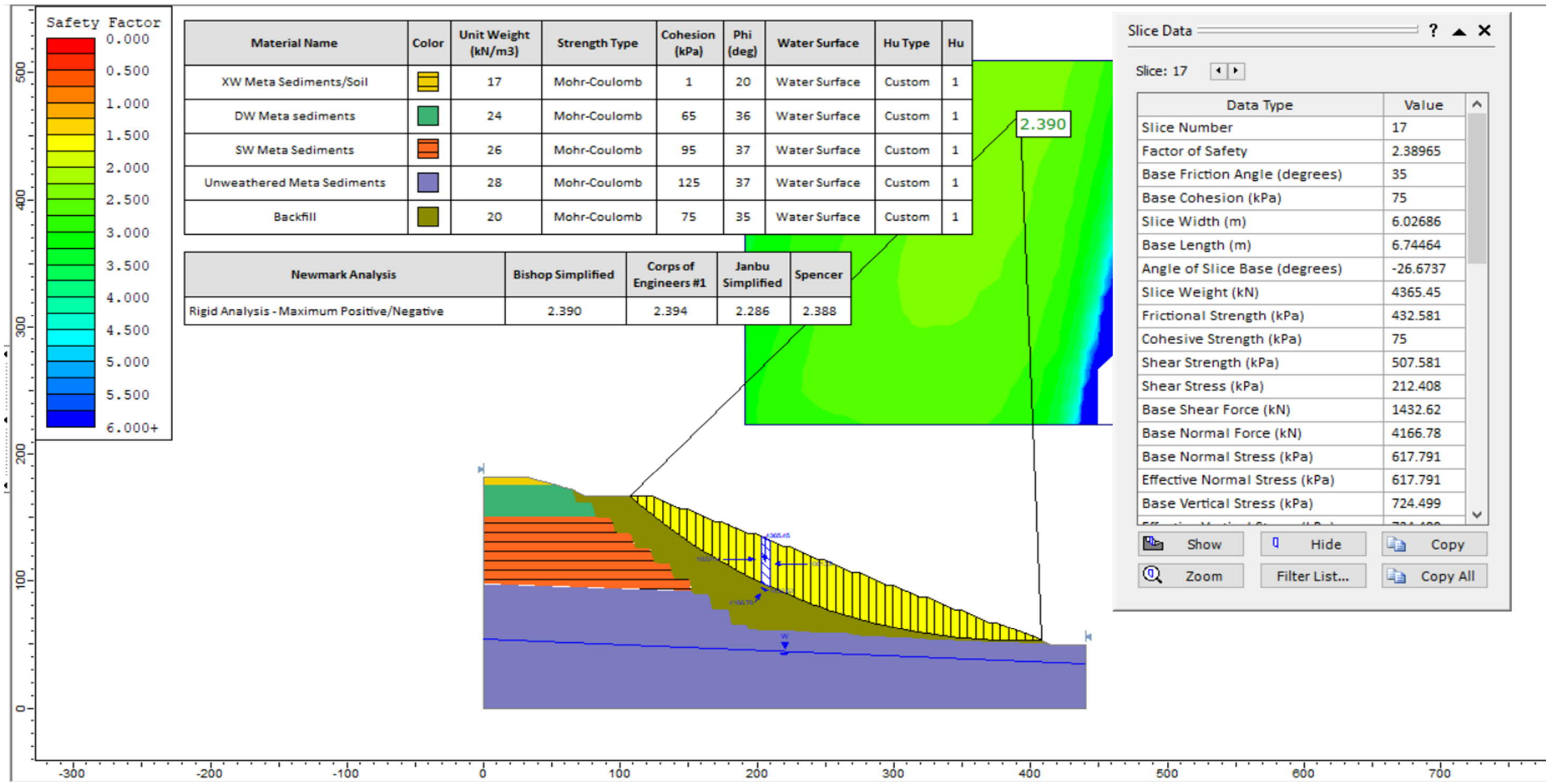


Plate 42: A graph of FoS along the buttressed and backfilled Section C, north wall. The modelled FoS are suitable for this slope.

GROUNDWORK plus



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
XW Meta Sediments/Soil		17	Mohr-Coulomb	1	20	Water Surface	Custom	1
DW Meta sediments		24	Mohr-Coulomb	65	36	Water Surface	Custom	1
SW Meta Sediments		26	Mohr-Coulomb	95	37	Water Surface	Custom	1
Unweathered Meta Sediments		28	Mohr-Coulomb	125	37	Water Surface	Custom	1
Backfill		20	Mohr-Coulomb	75	35	Water Surface	Custom	1

Newmark Analysis	Bishop Simplified	Corps of Engineers #1	Janbu Simplified	Spencer
Rigid Analysis - Maximum Positive/Negative	2.390	2.394	2.286	2.388

Data Type	Value
Slice Number	17
Factor of Safety	2.38965
Base Friction Angle (degrees)	35
Base Cohesion (kPa)	75
Slice Width (m)	6.02686
Base Length (m)	6.74464
Angle of Slice Base (degrees)	-26.6737
Slice Weight (kN)	4365.45
Frictional Strength (kPa)	432.581
Cohesive Strength (kPa)	75
Shear Strength (kPa)	507.581
Shear Stress (kPa)	212.408
Base Shear Force (kN)	1432.62
Base Normal Force (kN)	4166.78
Base Normal Stress (kPa)	617.791
Effective Normal Stress (kPa)	617.791
Base Vertical Stress (kPa)	724.499

Plate 43: Section D buttressed and rehabilitated east wall limit equilibrium assessment was completed to assess slope stability issues and FoS levels. FoS levels are>2 which is stable suitable over the long term with the minimum slip circle shown.

GROUNDWORK plus

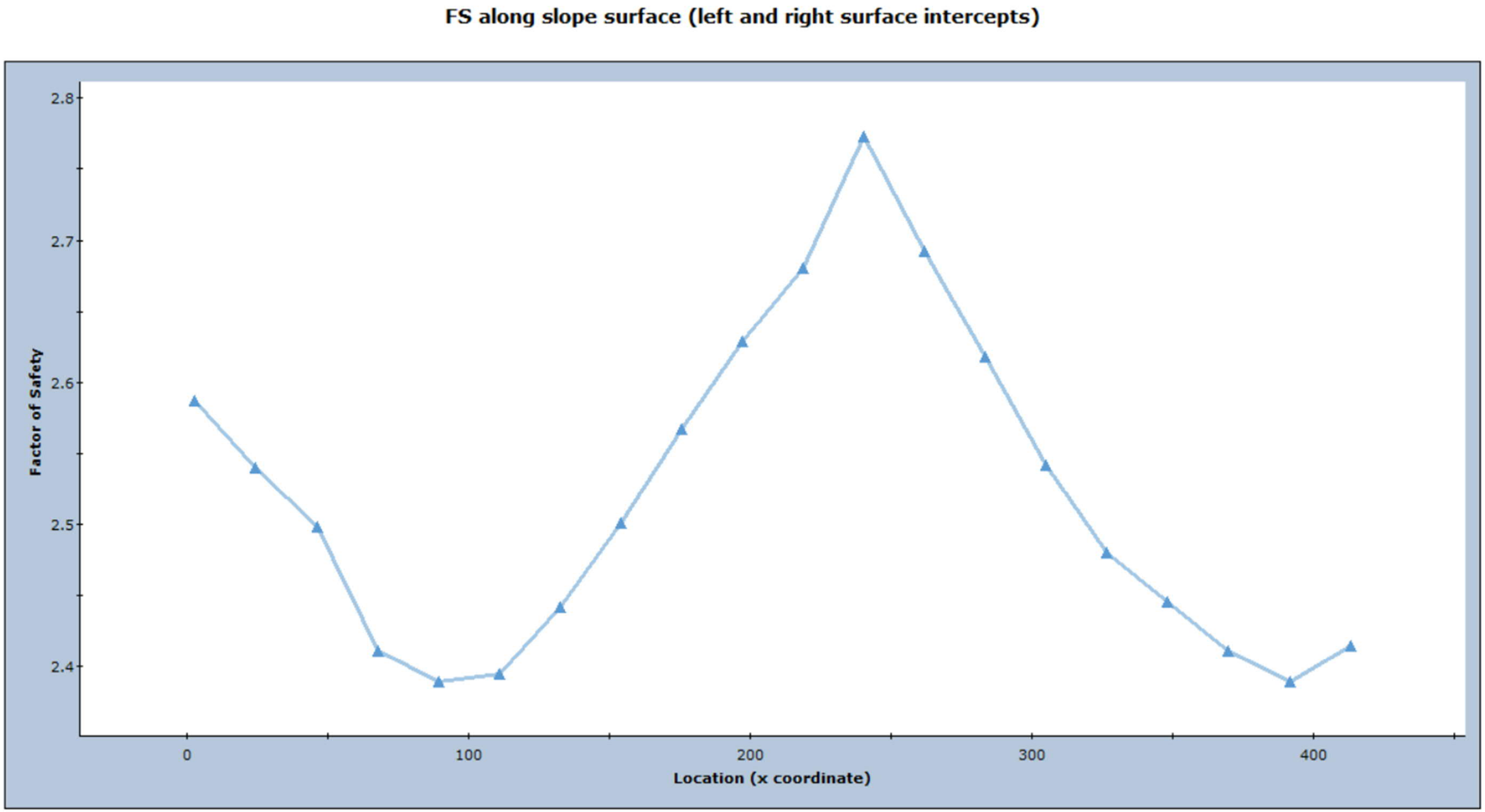


Plate 44: A graph of FOS along Section D, east wall. The modelled FoS are suitable for this slope.

GROUNDWORK plus

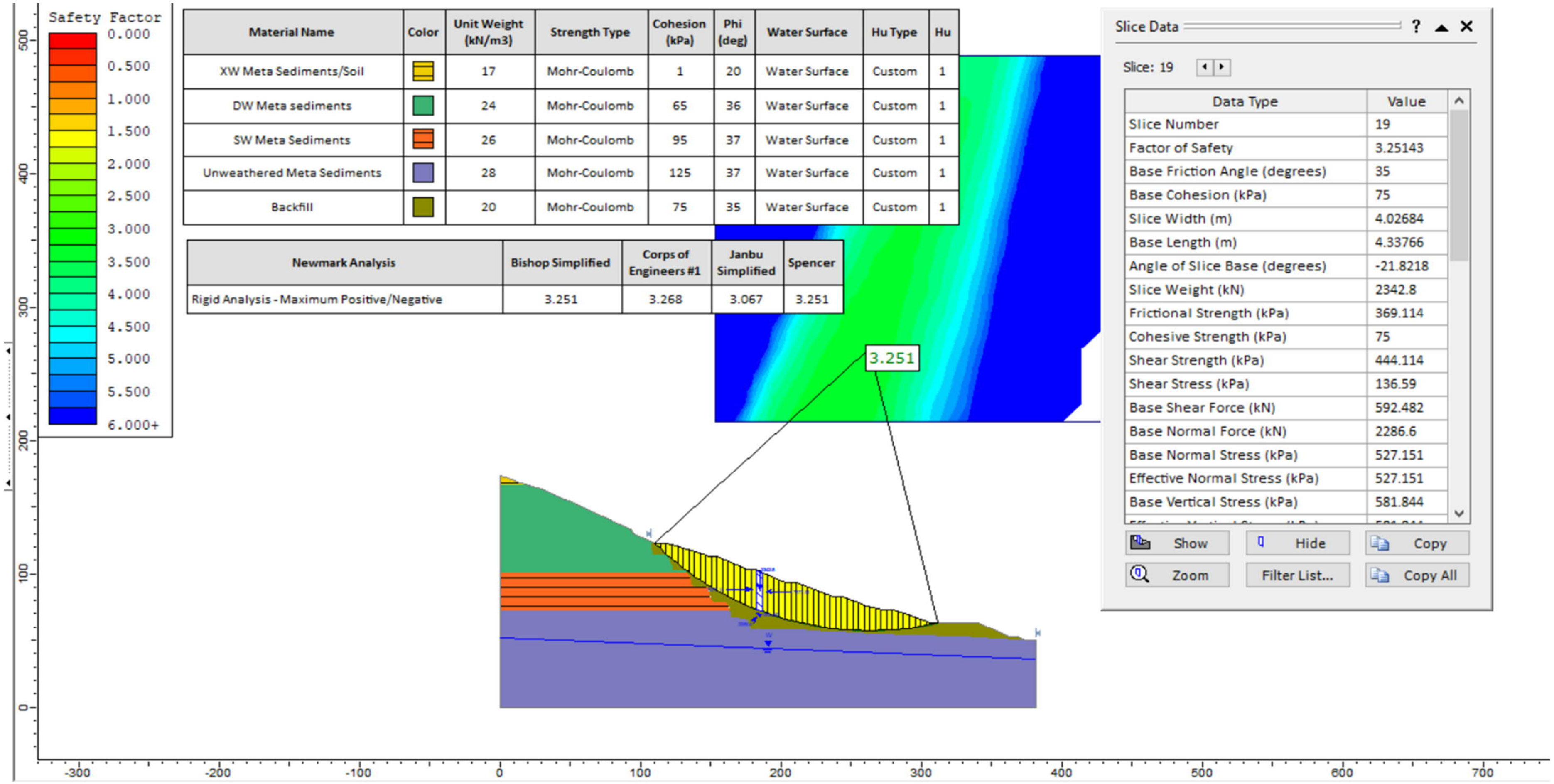


Plate 45: Section E buttressed, and rehabilitated east wall limit equilibrium assessment was completed to assess slope stability issues and FoS levels. FoS levels are>3 which is stable suitable over the long term with the minimum slip circle shown.

GROUNDWORK plus

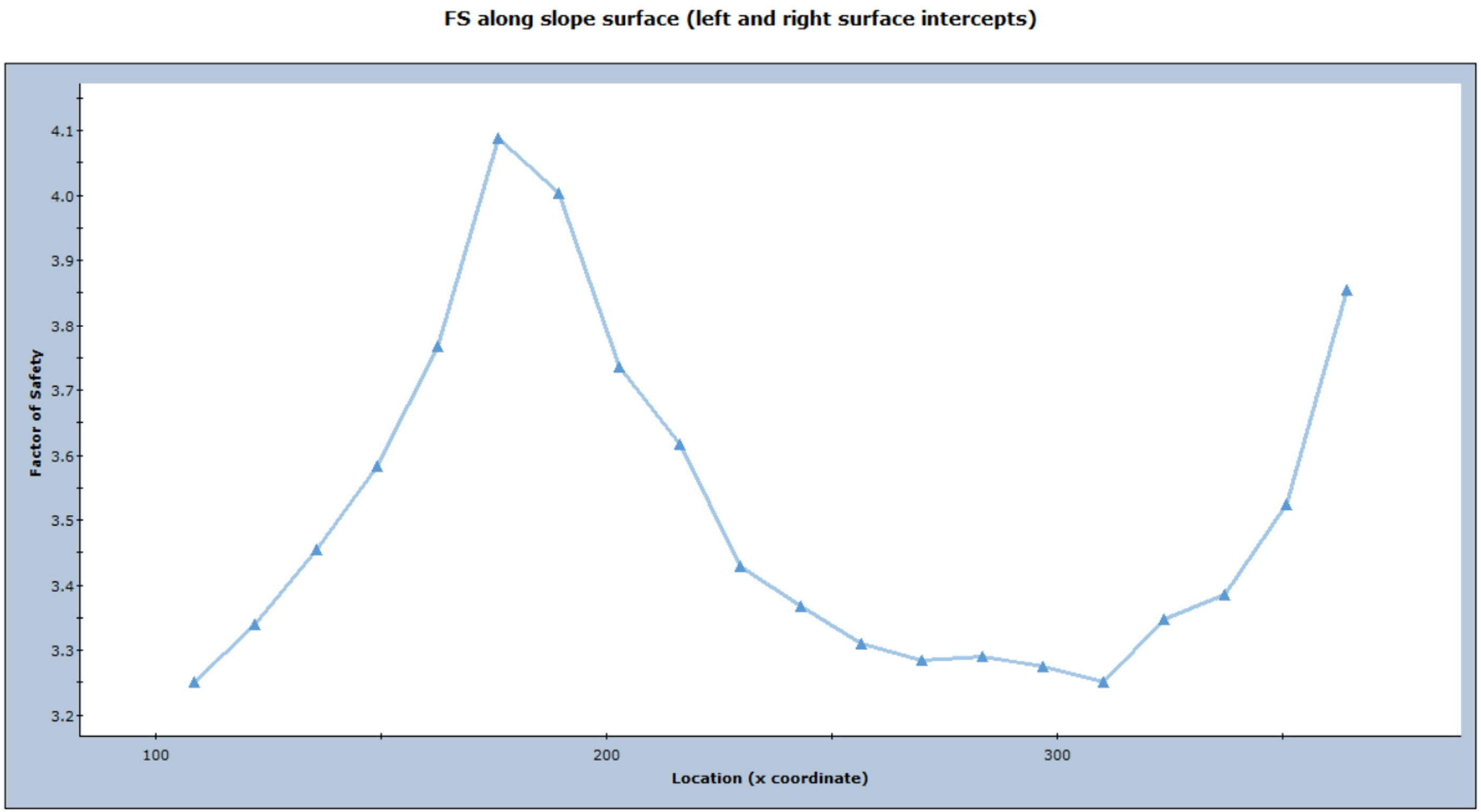


Plate 46: A graph of FOS along Section E, south wall. The modelled FoS are suitable for this slope.

Table 12 – Recommended Slope Design Guidelines Final Benches

Residual soils, extremely to highly weathered rock clays, and overburden dumps.	Maximum batter angle	26
	Maximum bench height	11
	Minimum bench width	10
Distinctly to Slightly weathered rock upper bench areas.	Maximum batter angle	60
	Maximum bench height	11
	Minimum bench width	10 & preferably 25 metres
Slightly weathered to fresh rock (Generally most areas of the Quarry.	Maximum batter angle	70-85
	Maximum bench height	11
	Minimum bench width	10

3.10 Geotechnical Benchmarking Quarry Design

To consider the actual quarry slope design and proposed design versus other slopes a high level benchmarking exercise was completed for the quarry which use documentation provided from the Guidelines for Open Pit design 2009. This work is illustrated in Plates 47 to 52.

Plate 46B: Looking toward the southern extraction area in this distance which has already been partially extracted.

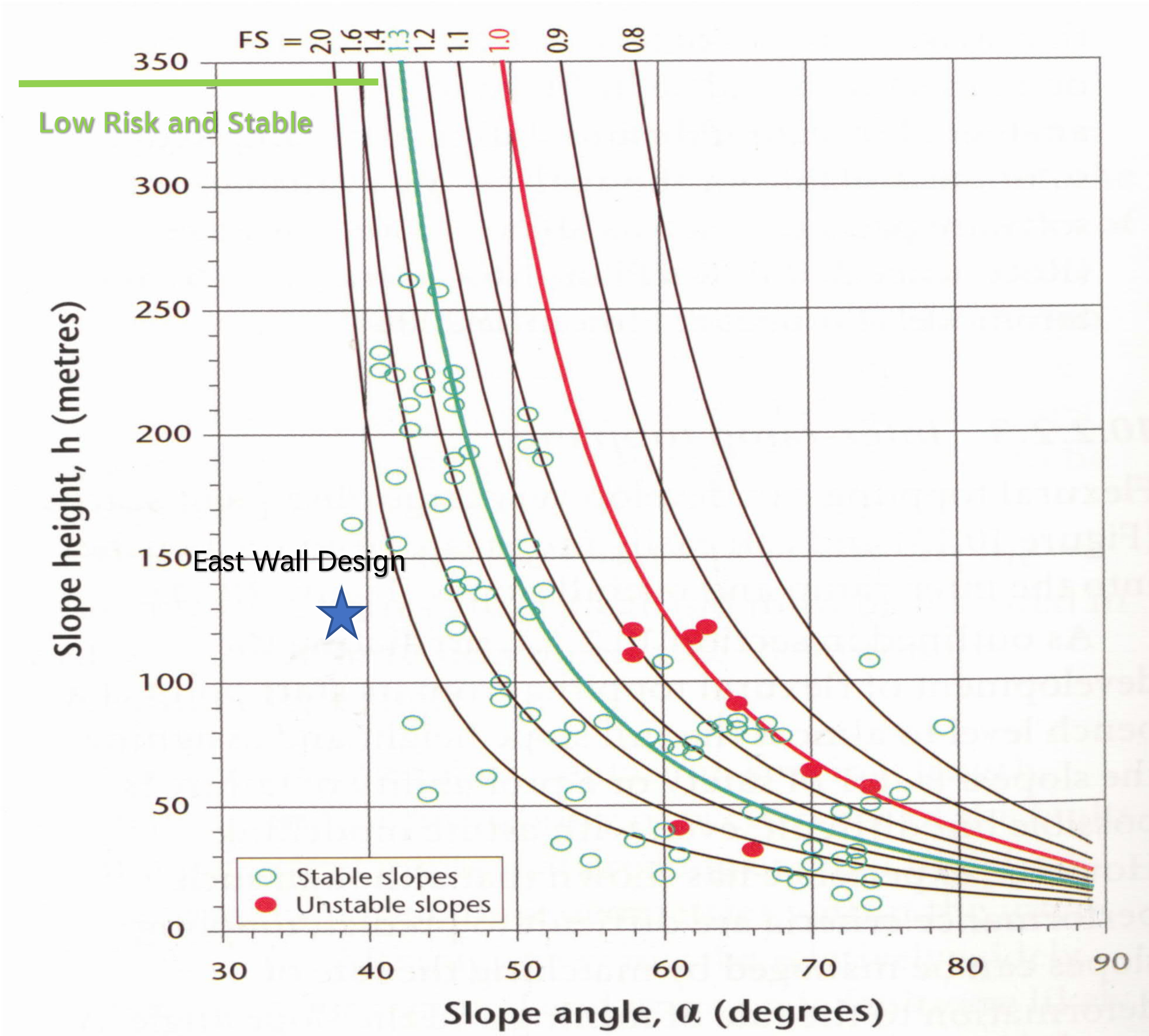


Plate 47: Benchmarking the east wall slope of the quarry versus other slopes Rock Slope Success (after Sjoberg 2004). To test the validity of the design, the slope is benchmarked.

Consequence of failure	Examples	Acceptable values: Mean Fos	Acceptable values: Minimum P[Fos<1.0]	Acceptable values: Maximum P [Fos<1.5]
Not serious	Individual benches; small (<50m), temporary slopes, not adjacent to haulage roads	1.3	10%	20%
Moderately serious	Any slope of a permanent or semi-permanent nature	1.6	1%	10%
Very serious	Medium-sized (50-100m) and high slopes (>150m) carrying major haulage roads or underlying permanent mine installations	2.0	0.30%	5%

Source: Priest & Brown (1983)

Plate 48: Acceptable values for a Factor of Safety. (After Priest et.al).

Material Type	Conditions	Acceptance level (static)	Reference
Soil earthworks	Normal loads and service conditions	1.5	Meyerhof (1984)
	Maximum loads and worst environmental conditions	1.3	
Earth retaining structures and excavation	Normal loads and service conditions	2	
	Maximum loads and worst environmental conditions	1.5	
Slopes	Cohesionless soil	1.3	
	Cohesive soils	1.5	
	Based on field vane tests corrected for strain rate and anisoropic effects	1.3	Bjerrum (1973)
		1.25	Bowled (1979)
	Highest value serious consequence of failure or high uncertainty	1.25-1.5	Gedney & Weber (1978)
		1.5	Hansen (1967)
		1.3-1.5	Meyerhof (1970)
		1.3-1.4	Sowers (1979)
	Lower values for temporary loading	1.5	Terzaghi (1943)
		1.25-1.3	
	Permanent or sustained conditions	1.5	US Navy Department (1962)
	Temporary	1.25	SAICE COP (1989)
	Permanent	1.5	SAICE COP (1989)
Dams	End of construction, no reservoir loading, pore pressure at end of construction estimates with undissipated pore pressure in foundations	1.3	Hoek (1991)
	Full reservoir, steady state seepage with undissipated pore pressure in foundation	1.3	
	Full reservoir with steady state flow and dissipated pore pressure	1.5	
	Flood level with steady state flow	1.2	
	Rapid drawdown pore pressure in dam with no reservoir loading	1.3	

Plate 49: Tolerance of risk versus a static Factor of Safety, (after Priest et.al).

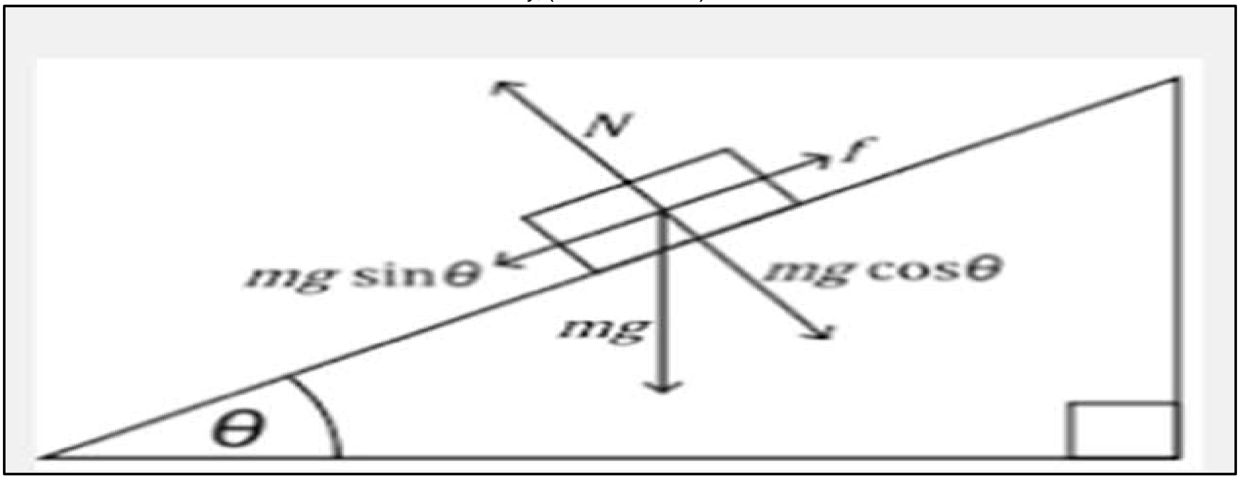


Plate 50: The physics of a sliding block down a slope. As slope angles increase the force acting on the block increases rapidly. For example, a one tonne block at 30 degrees has 0.5 tonnes of the block acting down slope. At 45 degrees these changes to 0.77 tonne, and at 60 degrees this increase to 0.86 tonnes.

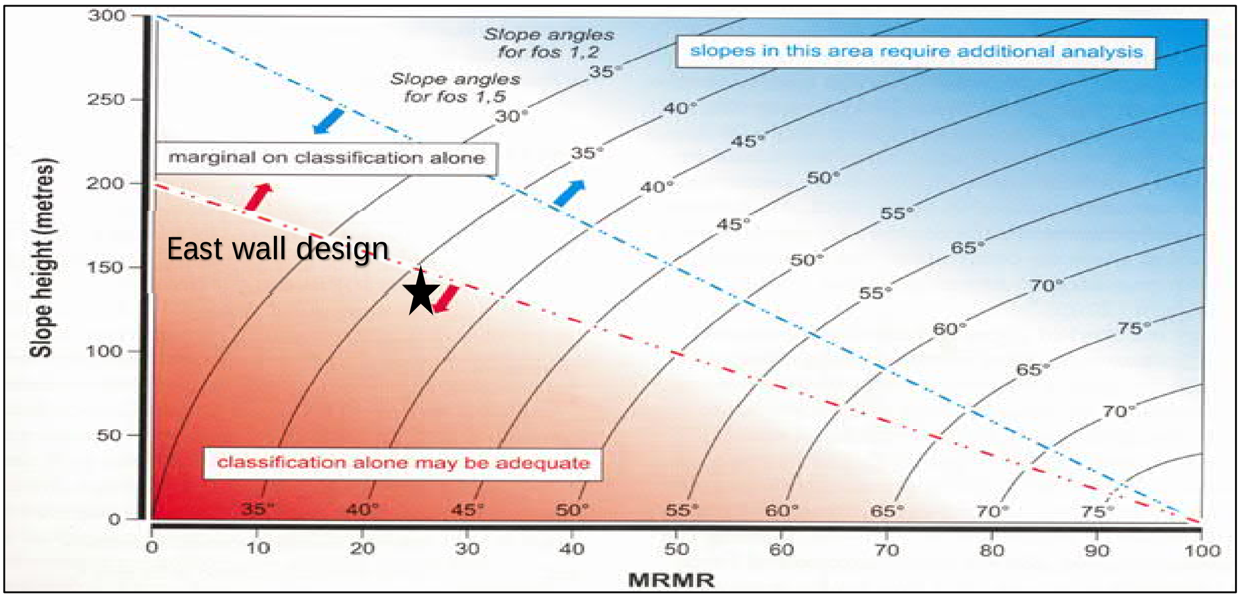


Plate 51: A black star denotes the highest slope section on site and when bench marked the degree of risk attached to the site. After Haines and Terbrugge Modified Rock Mass Rating Classification chart.

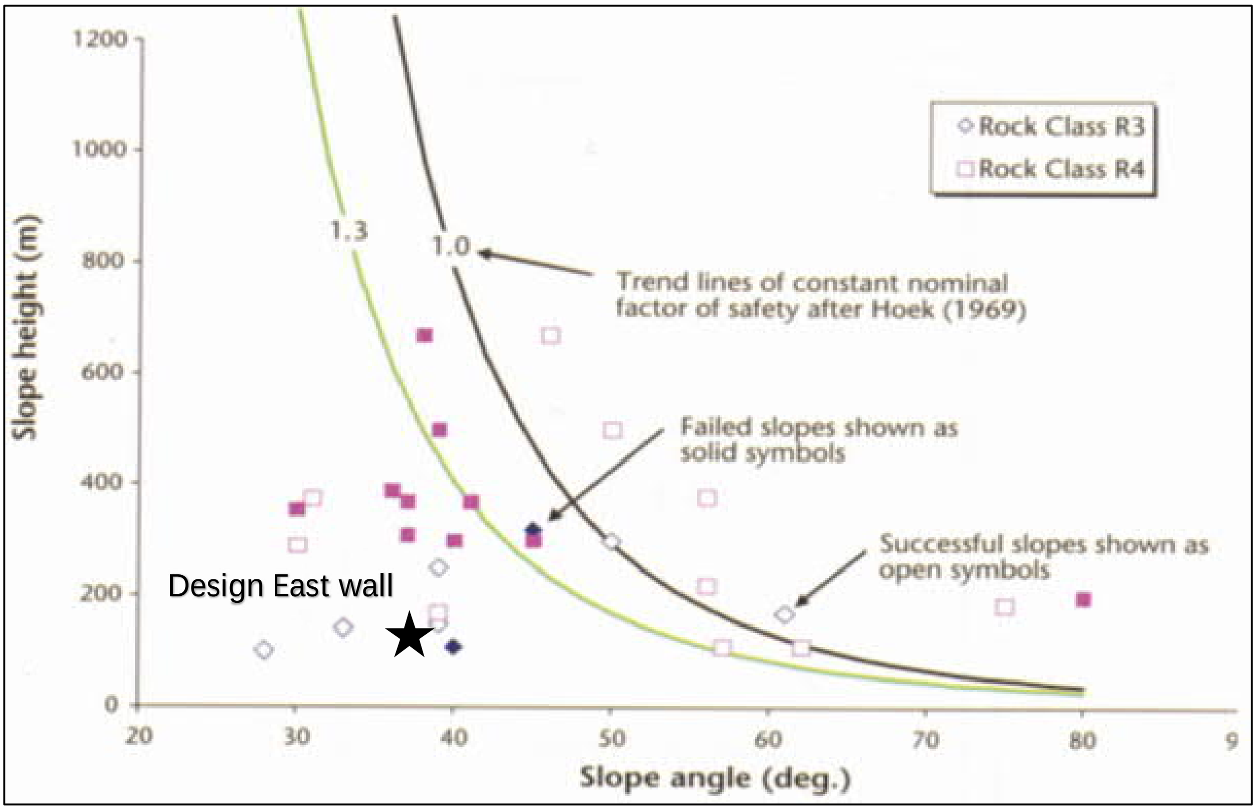


Plate 52: A black stars denote the highest slope sections on site.

3.11 Surface Water

Surface water runoff is currently well managed on site by appropriately designed and suitable capacity drainage features. As the quarry advances, sheet flow should not be allowed to occur across the surface of any slope, as this will reduce the cohesive properties of the rock mass and propagate localised instability. Surface water (sheet flow) is currently managed on site by providing suitable stormwater diversion devices, and it is planned that this trend will continue in both the short term and long term.

After large rain fall events problematic structures and all high frequency travel ways or work areas within the quarry are generally assessed for stability. This inspection should also consider all other areas which will be used directly after large rain fall events. The practical impact of large rain fall events is that it reduces the effective stress or cohesive strengths of joint surfaces which can increase the probability of localised or major rock fall events occurring.

Where practicable clean water should be diverted away from the quarry workings.

3.12 Hydrology

Groundwater is not encountered on site and is reportedly encountered well below the floor of the current quarry.

3.13 Surcharge Loading

Regarding surcharge there are no dams, or infrastructure proposed for the slopes, while the overburden storage areas will be adequately drained.

3.14 History of Failure

There are signs of soil and overburden rotational failure in the lower strength upper profile materials, while multiple small volumes failure mechanisms occur elsewhere on site. These failures are typically minor planar topple or wedge style failures. Minor time related deterioration of the overall rock mass will occur resultant of seepage into joint planes however the resultant loss of effective stress of these upper joint planes is not considered material.

3.15 Slope Stabilisation

Slope stabilisation excluding works are not currently needed on site. Like all slope issues if developed a specific plan will be implemented to reimplement stability and safety for the failure area

3.16 Scaling

Scaling will be required, and ongoing internal audits identify and remove or otherwise make safe isolated areas of batter and crest damage. A site SOP exists for scaling.

3.17 Design Seismicity

According to the 'Atlas of Seismic Hazard Maps of Australia' 2013, Adelaide and surrounding areas have among the highest Peak Ground Acceleration (PGA) compared to the rest of the nation which internationally is still considered very low. Pursuant to relevant guidelines slope design should consider seismic acceleration as part of the design process. The Spectral Acceleration (SA) hazard value at 500-year return period is PGA 0.042 g. Stability assessments have been done in accordance with the CSIRO (2009) guidelines. According to Hynes-Griffin and Franklin (1984), a seismic coefficient equal to half of the PGA should be used in pseudo-static seismic analysis, and therefore a PGA of 0.021 g was adopted for this assessment.

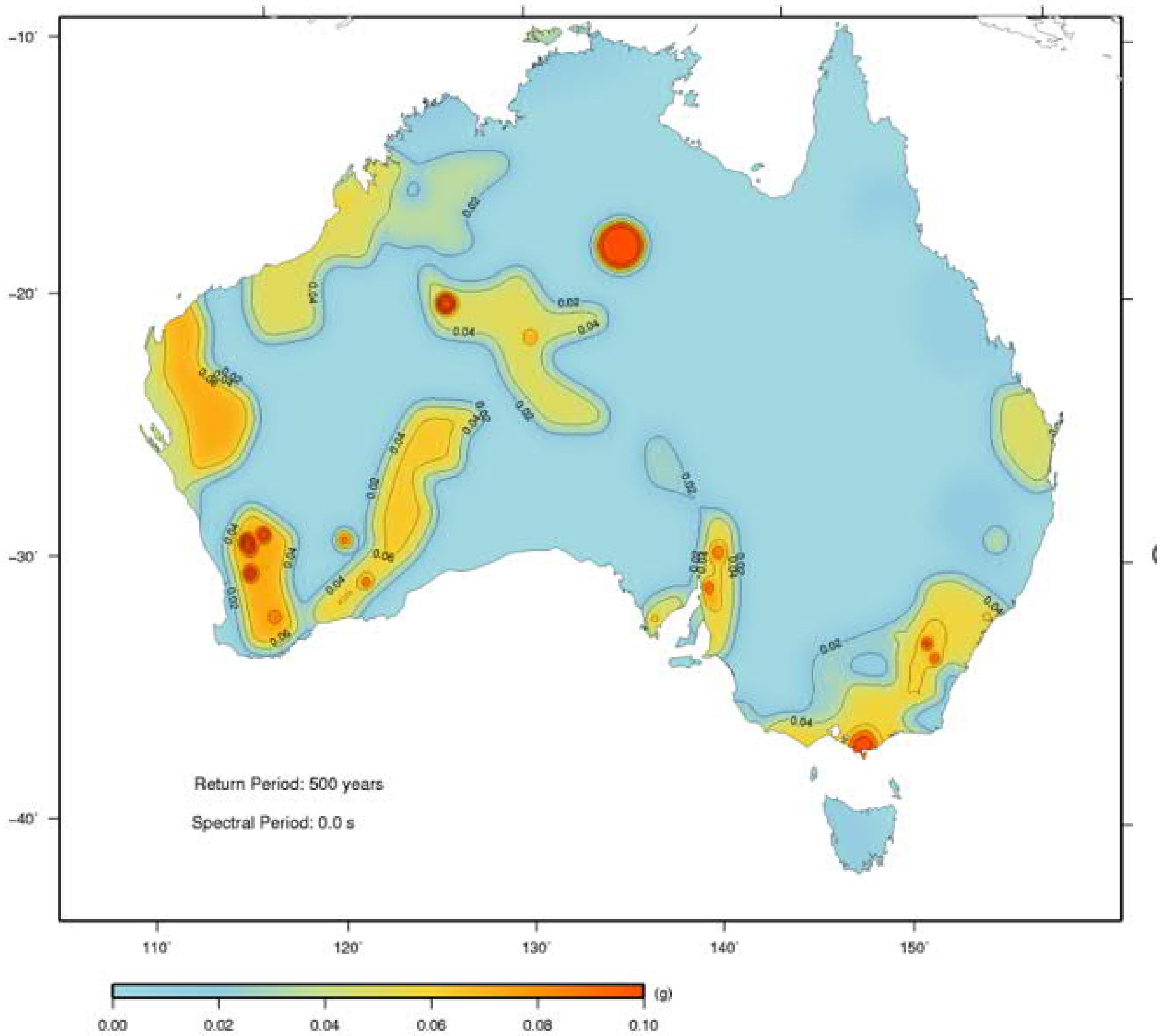


Plate 53: The national hazard map with an annual probability of exceedance of 1:500 at an RSA of 0.0 (PGA). Provided courtesy of Burbridge 2012.

The results of the seismic analyses indicate the following:

- A minimum FoS of above 2 is achieved for an overall (global) scale failure for a 1 in 500-year seismic event.
- The achieved FoS is contingent upon the adopted fill material strengths being achieved.
- Accordingly, large scale (overall) instability is not expected for a 1 in 500-year seismic event.

3.18 Active Seismicity

A link to the Geoscience database is http://www.ga.gov.au/earthquakes. Regarding induced seismicity impacts, the area is understood to be in a non-induced seismic area as fracking of wells and, or large underground operations do not currently occur or exist in the area. In regard to seismicity the Geoscience Australia database was searched, and one events was reported in this area since 1955, refer Plate 54.

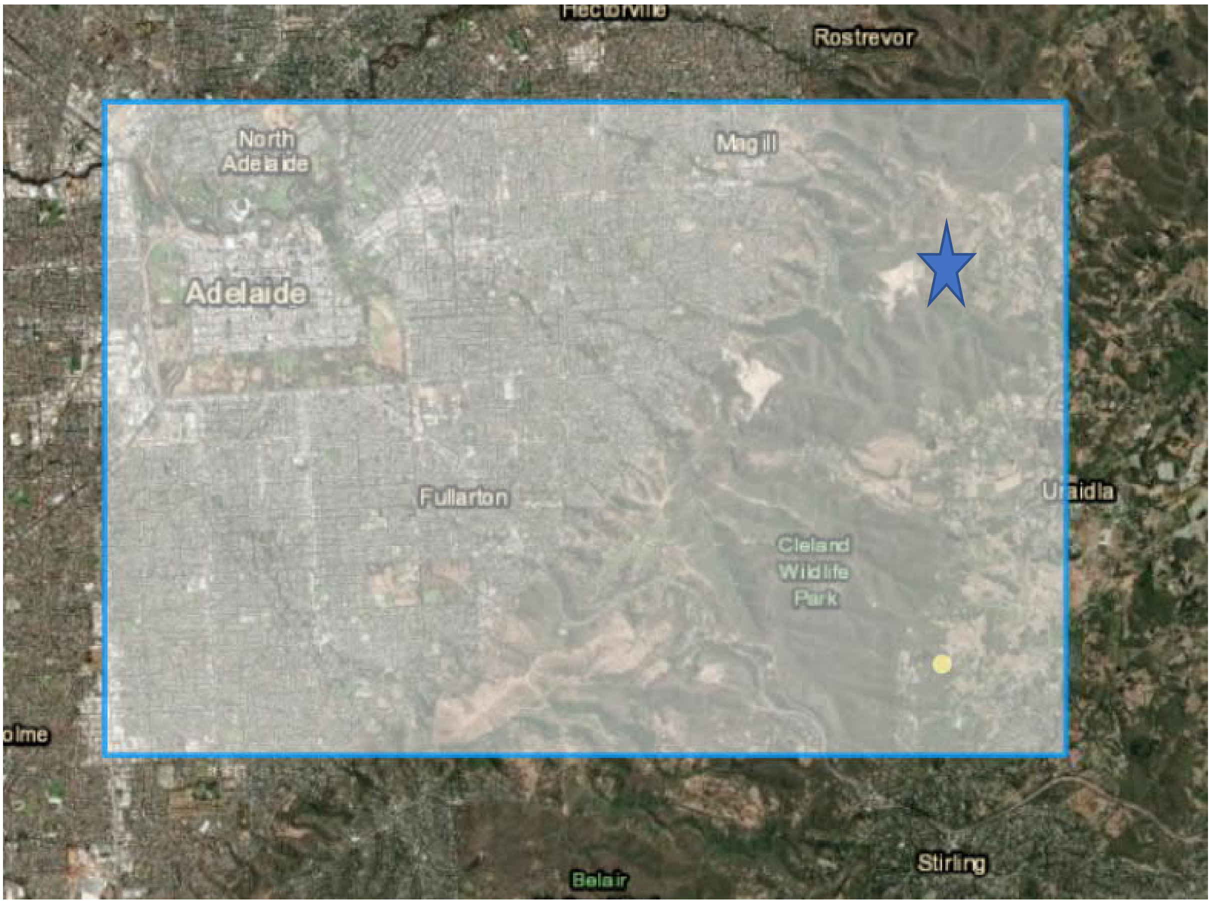


Plate 54: One seismic related event occurred in the area since reporting began in 1955. The location of the site is shown by the blue star.

1 results (Page 1 of 1)

Magnitude	UTC ^	Latitude	Longitude	Depth(Km)	Location
1.8	16/04/2017 05:39:23	-34.98	138.71	10	Near Stirling, SA. (Reported felt).

Plate 55: One seismic event (yellow dot) was recorded in 2017. Importantly the database was searched several times as this area was thought to be slightly more active.

3.19 Crustal Stress

Residual stress tensors (both differential and static) appear low in this pit and do not appear to currently have a significant or material impact on stability. That said major fault structures occur in this area, not in the pit albeit and as the pit develops the impact of these structures when recognisable, may need to be further assessed. These structures if intersected could be problematic and will impact significantly upon material quality as well as geotechnical stability. Reference to the crustal stress map of Australia suggests that crustal stress in this rock type in this area will be low, refer Plate 56.

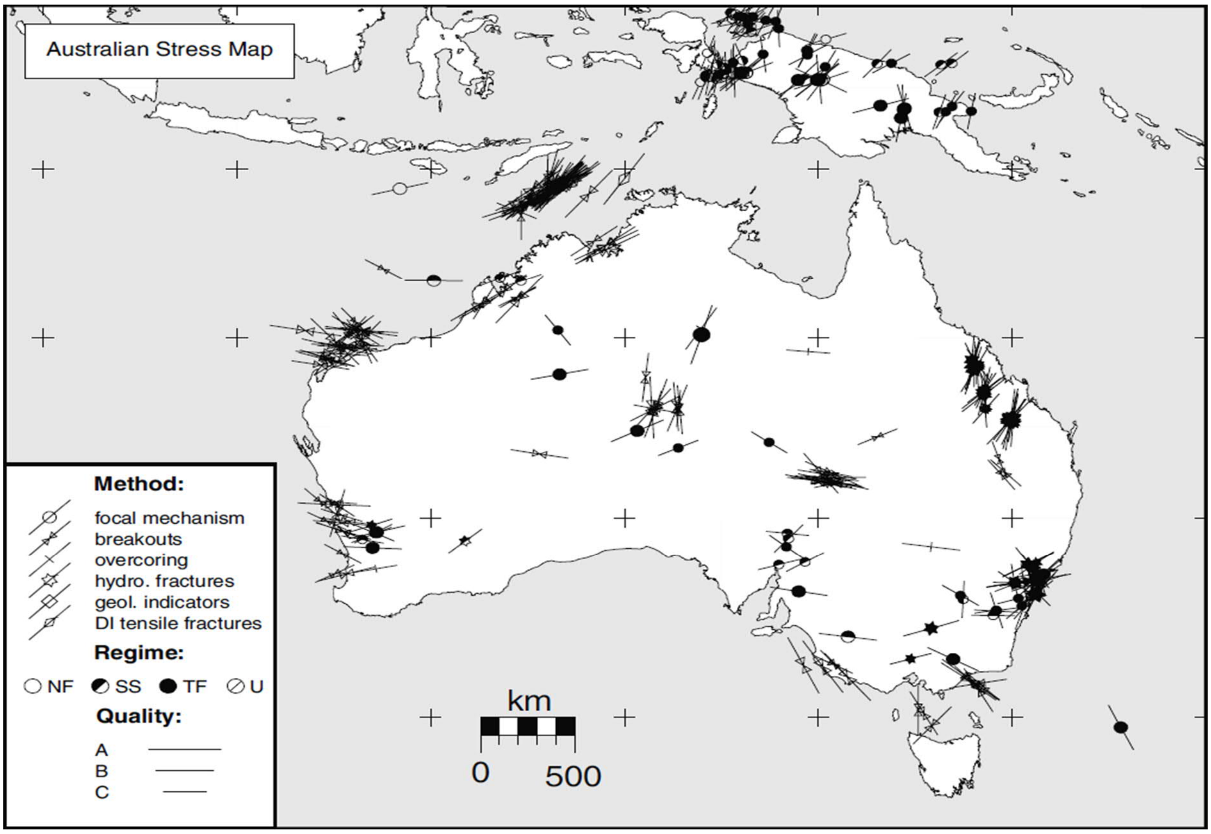


Plate 56: The crustal stress map of Australia suggests that insitu stress will be low in this area. Courtesy of Hillis and Reynolds.

3.20 Neotectonic Structures

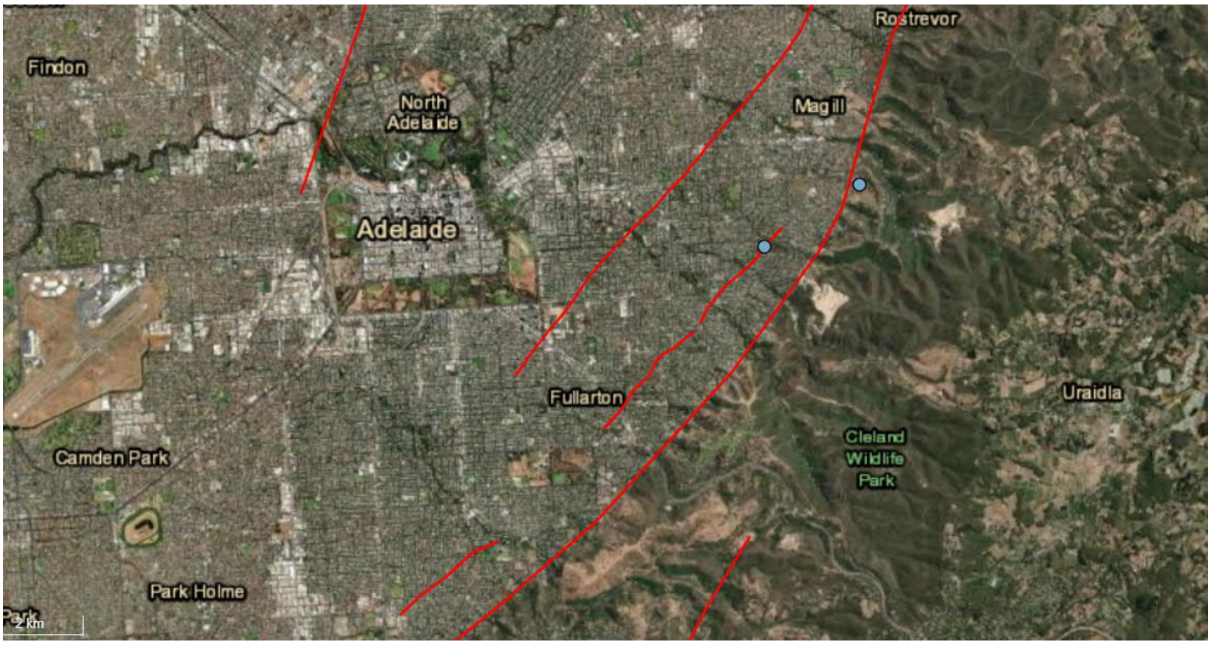


Plate 57: The Neotectonic structures of the White Rock area provided courtesy of Geoscience Australia. These structures are not expected to impact quarry stability although in dealing with structures of this size three is a degree of uncertainty attached to very large seismic events

3.21 Geotechnical Design Methods and Acceptance Criteria

Groundwork was not involved in the geotechnical design for the site however, the criteria used are typical industry standards and demonstrably suitable as the site is clearly working well operationally and has done so for many years with a minimum of risk. The acceptance criteria for the pit become evident when the pit design is considered versus the as-built pit. Similarly, the bench and batter profiles are very close when considered against design.

3.22 Design Implementation and Quality Control

The pit design is updated and audited by Hanson Technical Services as needed. In this process completed via survey the extent of the pit versus design is reviewed and amended or altered as needed. This is understood to occur as needed and is an internal Hanson QA/QC process

3.23 Monitoring Methods and Data Review

Pit inspections are routinely completed by site management while the Hanson Technical Team provide help and assistance as needed. The only monitoring completed on site is the annual survey review which remotely assesses extant conditions on site. At the time of review internal feedback is provided to the site manager as needed.

3.24 Managing Unstable Ground

Unstable ground is managed as it relates to specific issues as they are encountered. Unstable ground excluding crest damage has not been a big issue for the quarry.

3.25 Communication Training and Supervision

Hanson has internal SWMS for completing these tasks.

3.26 Emergency Response

Hanson has developed an applicable EMRP for the site.

3.27 Slope Stability Issues

Ground conditions at site vary considerably across the site both laterally and with depth. Lithological variations, weathering, material strength, discontinuity location, discontinuity orientation and discontinuity shear strength, surface water runoff, erosion and groundwater infiltration pressure are the principal issues influencing ground stability. These structural features have the potential to cause localised instability and also radically alter pore pressures and groundwater movements in the bench areas. Environmental factors such as saturation of the potential failure planes can lead to a reduction in the factor of safety. Saturation of a joint plane can occur after any rain event and, following heavy rain events, a temporary head of water can build up in joints to create excess pore water pressures. The effects of saturation by itself were not modelled, however stability has, at its base, the rate of physical erosion together with the rate of chemical weathering reducing the strength on joint planes. Blasting, extraction, and slope design factors also impact on overall stability.

Geotechnical information was collected from the site during the field investigation, however, to further develop the geotechnical model a number of assumptions have been used based on the common properties of Meta-Sediments and a conservative approach to design. Cohesive strength and Uniaxial Compressive Strength (UCS) have been estimated based on site specific observations and industry standard values.

The geological structure varies noticeably around the site, and this variation largely controls the style and frequency of potential failure mechanisms. As a rock, the majority of the unweathered rocks are of modest strength, relatively undeformed, possesses apparently modest to high cohesive strength and currently present little in the way of geotechnical risk to the operation.

Because of the multiple failure mechanisms recognised on site the most practical way to deal with these features is by having an appropriately design, as any one particular feature cannot be designed around, and in doing so would ignore the presence of the other features. Accordingly, the value of having suitably wide benches working areas cannot be underestimated.

4 Risk Analysis

4.1 Overview of Risk Management

A large number of terms are associated with risk management and the processes it involves. The following definitions of key terms are based on those of the International Organisation for Standardisation's (2002) ISO/IEC Guide 73 on risk management vocabulary, and the Australian and New Zealand Standard on Risk Management, AS/NZS 4360: 2004 (Standards Australia 2004):

Consequence:	The outcome or impact of an event.
Hazard:	A source of potential harm; a potential occurrence or condition that could lead to injury, damage to the environment, delay, or economic loss.
Likelihood:	The probability or frequency of occurrence of an event, described in qualitative or quantitative terms.
Risk:	The chance of something happening that will have an impact on objectives.
Risk Analysis:	A systematic process to understand the nature of and deduce the level of risk.
Risk Assessment:	The overall process of risk identification, risk analysis and risk evaluation.
Risk Criteria:	The terms of reference by which the significance of risk is assessed.
Risk Evaluation:	The process of comparing the level of risk against risk criteria.
Risk Identification:	The process of determine what, where, when, why and how something could happen.
Risk Management:	The culture, processes and structures directed towards realising potential opportunities while managing adverse effects.
Risk Treatment:	The process of selecting and implementing measures to modify risk.

4.2 General Risk Management Process

The general risk management process to be developed and applied is that used in AS/NZ 4360: 2004 (Standards Australia 2004), illustrated in DIAGRAM 2 SLOPE DESIGN PROCESS. Other risk management processes, such as that developed by the Institute of Risk Management in the UK (Institute of Risk Management 2002) are similar but not necessarily identical to that used here.

As shown in DIAGRAM 2 SLOPE DESIGN PROCESS, the process follows a number of clearly defined and inter-related steps:

Establish the context:	Establish the external, internal and risk management contexts in which the rest of the process will take place. Establish the criteria against which risk will be evaluated and define the structure of the analysis.
Identify the risks:	Identify where, when, why and how events could prevent, degrade, delay, or enhance achievement of the objectives.
Analyse the risks:	Identify and evaluate the existing controls. Determine the consequences and likelihoods of particular occurrences and therefore the associated levels of risk, considering the range of potential consequences and how these could occur. Generally, the risk is quantified as the product of the likelihood and consequence of the particular occurrence.
Evaluate the risks:	Compare estimated levels of risk against the pre-established criteria and consider the balance between potential benefits and adverse outcomes. This enables decisions to be made about the extent and nature of treatments required and their priorities.
Treat the risks:	Develop and implement specific cost-effective strategies and action plans for increasing potential benefits and reducing potential costs or adverse effects.
Monitor and review:	It is necessary to monitor and review progress and the effectiveness of all steps in the risk management process to ensure continuous improvement and that the risk management plan is implemented effectively and remains relevant.

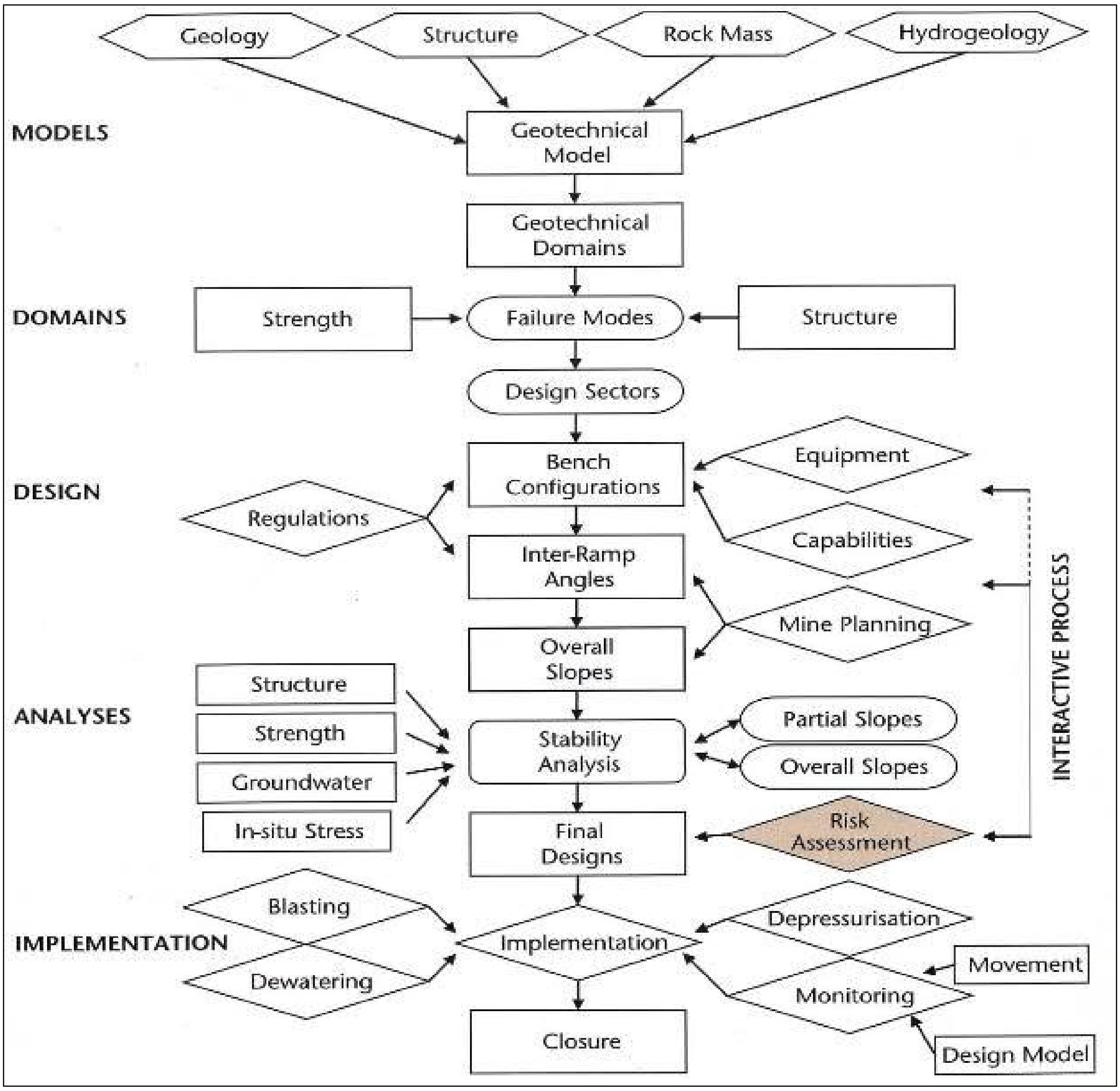


Diagram 2 – Slope Design Process

The first three steps are regarded as comprising risk analysis, while risk assessment involves those steps plus risk evaluation. DIAGRAM 3 RISK MANAGEMENT PROCESS AFTER STANDARDS AUSTRALIA shows that communication and consultation is required at every stage in the process, and that monitoring, and review create feedback loops that may require modifications to earlier results. It will be necessary to adapt this general procedure to take account of the special features and factors involved in a particular risk management exercise. For example, DIAGRAM 4 LANDSLIDE RISK MANAGEMENT illustrates the adaptation of the general process to the risk management of landslides. Full details of the landslide risk management concepts and guidelines developed are given by the Australian Geomechanics Society (AGS) Subcommittee on Landslide Risk Management (2000).

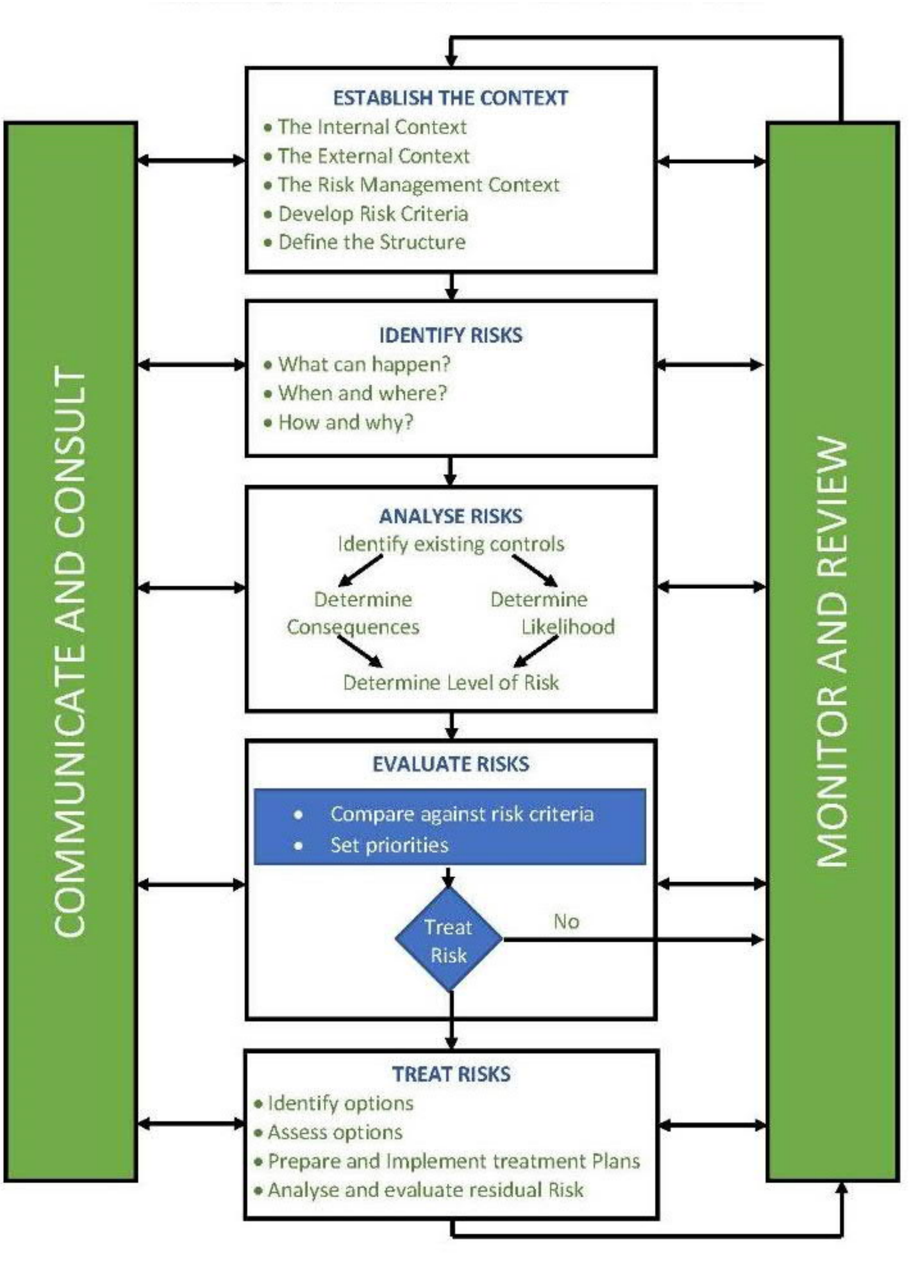


Diagram 3 – Risk Management Process after Standards Australia

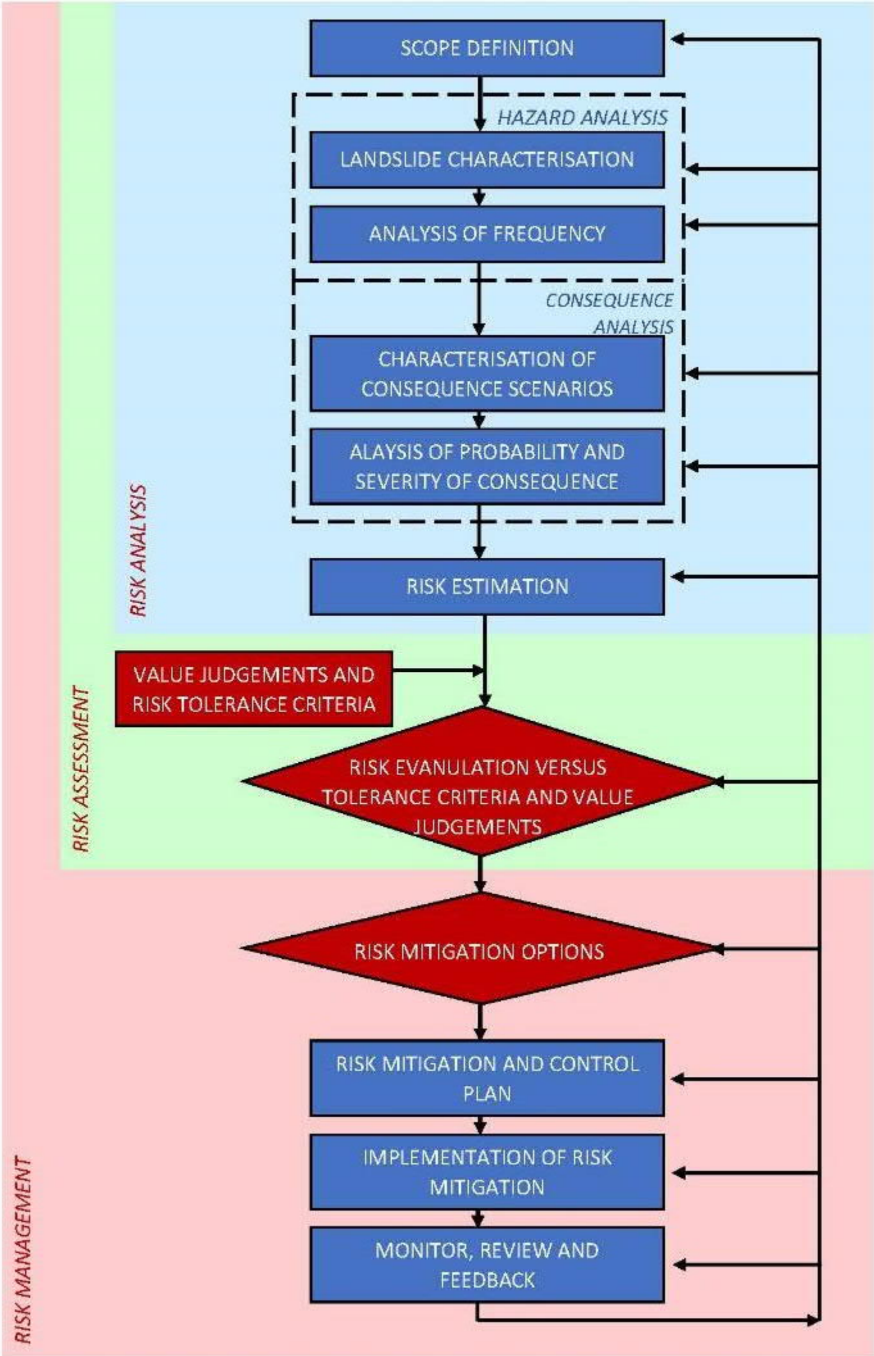


Diagram 4 – Landslide Risk Management

4.3 Risk Management in Extractive Industry

Throughout its long history, the quarrying industry has been plagued by the economic failure of quarrying ventures through various causes and by damage to infrastructure, and injury to and loss of life, arising from hazards such as truck roll overs, mechanical failures, rockfalls etc. Safety issues associated with the use mechanical equipment has long been of concern. Resultant is that the international quarrying industry is now using formal and systematic risk assessment and management procedures in business and operational applications.

The Australian National Minerals Industry Safety and Health Risk Assessment Guidelines (Joy & Griffiths 2005) was developed partly as a result of this perception. Earlier, in New South Wales a Risk Management Handbook for the Quarrying Industry was developed by the NSW Department of Mineral Resources (1997).

The Minerals industry risk management maturity chart shown in DIAGRAM 5 MINERALS INDUSTRY RISK CHART illustrates how a company's risk culture can improve and mature by increasing employees' awareness of risk and introducing risk assessment and management procedures.

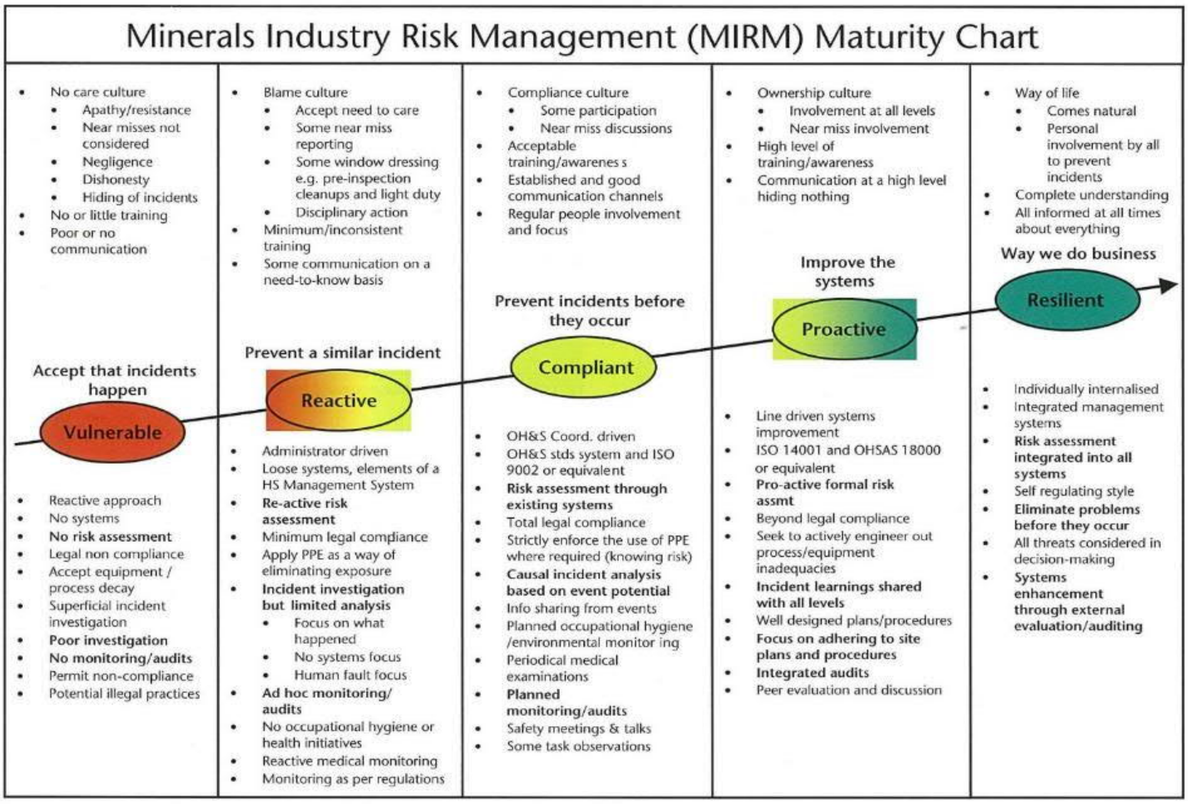


Diagram 5 – Minerals Industry Risk Chart

4.4 Risk Assessment Findings

Resultant of this work and the risk assessment completed on geotechnical conditions and stability, the risk is currently considered to be of low risk.

5 Terminology

The terminology used in this report is provided in PLATES A and B.

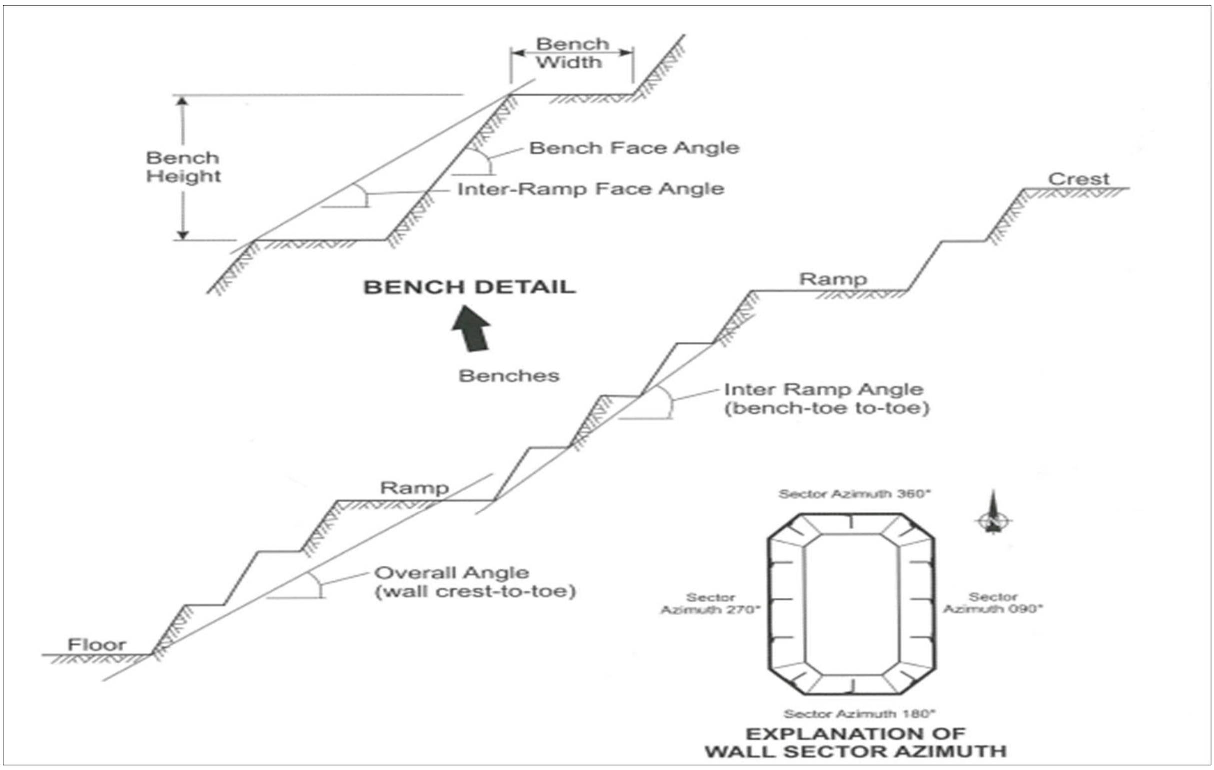


Plate A: Batters and Bench Design Terminology.

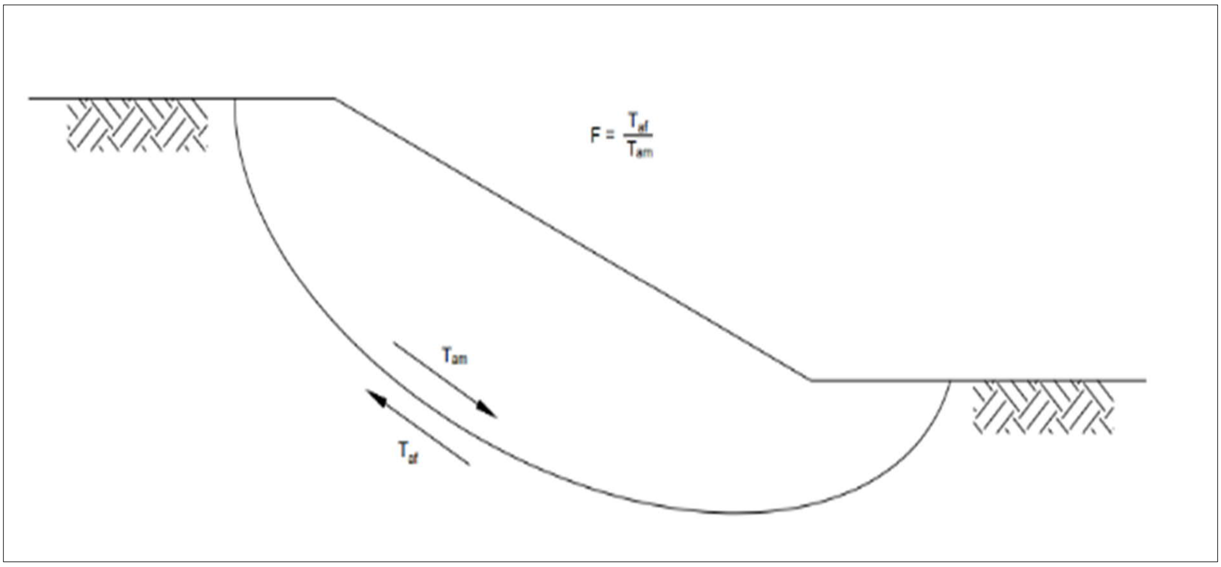


Plate B: Factor of Safety, (FOS), Definition: There are two aspects to slope stability: the safety against failure (ultimate limit state) and the movement under normal conditions (serviceability limit state). The movement under normal conditions is not often an issue and thus is rarely calculated. The main issue is safety against failure; therefore, slope stability analysis consists of calculating the factor of safety F. In the general case, (circular failure surface), the factor of safety F is defined as where τ= af is the average shear strength of the rock on the plane of failure and τ= am is the average shear stress mobilised on the plane of failure to keep the slope in equilibrium. The factor of safety defined above is also given in this case by the ratio of the maximum resisting moment over the driving moment around the centre of the circle: The Probability of Failure, (POF), the Probability of Failure is the number of analyses which result in a safety factor less than 1, divided by the total Number of Samples. Similarly, the Reliability Index is calculated using the same equations.

6 Risk Categories and Definitions

Risk Category	Risk Assessment Impacts
Very Low/Incidental	Health: Illness or effect with limited or no impact on ability to function and treatment is not necessary.
	Safety: Injury such as First Aid, usually dealt with in-house.
	Environment: No discernible impact or measurable impairment on habitat, species, or natural environment (air, water, land).
	Regulatory: No risk of punitive actions and any intervention limited to an observation.
	Community/Reputation: Isolated complaint from a local individual.
Low/Minor	Health: Mild illness or health effect which requires some treatment and/or has some functional impairment but is usually easily medically manageable.
	Safety: One or more injuries which require treatment by a medical professional or as a hospital outpatient but are not serious (e.g. no time lost).
	Environment: Localised and measurable short-term impact on habitat, species, or natural environment.
	Regulatory: Risk of punitive action unlikely and any intervention limited to field report (or similar).
	Community/Reputation: Clustering of complaints and risk of local media interest.
Modest/Moderate	Health: Illness or significant adverse health effect needing a high level of medical treatment or management.
	Safety: One or more injuries which are serious enough to result in lost time, non-permanent disabling injuries, or overnight hospitalisation as an inpatient.
	Environment: Localised and measurable medium-term impact on habitat, species, or natural environment.
	Regulatory: Formal intervention, typically issuing of an Improvement Notice at a site and unlikely to escalate if complied with. Fine up to AUD 100K (or equivalent) without criminal proceedings.
	Community/Reputation: Coordinated community concern at a local level and limited local media coverage.
High/Major	Health: Illness or chronic exposure resulting in significant life impacting effects
	Safety: Minor permanent disabling injury e.g. loss of fingers) or extended temporary impairment and/or hospitalisation.
	Environment: Extensive and measurable medium-term impact on habitat, species, or natural environment.
	Regulatory: Formal, high level intervention (e.g. prohibition notice) at a site, and risk of further interventions at other sites. Significant fine or penalty likely for Corporate (greater than AUD 100K or equivalent).
	Community/Reputation: Community alarm at a regional level and adverse and longer running local/regional media coverage.
Extreme/Severe	Health: Serious illness or chronic exposure resulting in fatality or significant life shortening effects.
	Safety: Death or significant permanently disabling injury e.g. blindness, loss of hand(s), quadriplegia.
	Environment: Destruction of important populations of habitat, species, or natural environment.
	Regulatory: Significant prosecution action, including risk to Company Officers.
	Community/Reputation: Widespread community unrest and/or adverse national/international media coverage.

7 Glossary of Terms

Competence:	Defined and demonstrated skills, knowledge, and behaviours within any given task.
Ground Control:	A combination of planning, drilling, controlled blasting, scaling, and ground support to influence the rock mass and provide a safe working environment.
Ground Support:	Elements applied to the interior of rock mass or the perimeter of an excavation to limit movement of the rock mass, eg. rock bolts, cable bolts, steel sets, timber props and shotcrete.
Practicable:	Technically feasible, economically justifiable and contributing to the reduction of risk.
Rockfall:	An uncontrolled displacement (due to gravity or stress) of rock from the surface of the excavation.
Scaling:	The action of removing loose rocks from the batters, benches, and haul roads of an excavation.
Serviceability:	Fit for purpose for the required life.
Shall:	A mandatory requirement i.e. a requirement that is to be met at all times. For new equipment processes and systems, this requirement must be met. For existing equipment, processes and systems, the requirement must be addressed in an implementation plan approved by the Quarry Manager. There must be evidence of progressive implementation according to this plan.
Should:	An advisory requirement i.e. a requirement that is to be met where practicable. Where the requirement is not implemented, the justification for non-adoption and evidence of an alternative solution shall be provided.
May:	A discretionary requirement i.e. the person authorised to make a judgment is to use their discretion.

8 Important Information

Your attention is drawn to the document - "Important Information about your Geotechnical Engineering Report", the statements presented in this document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimise the risks associated with the geotechnical criteria for this project. The document is not intended to reduce the level of responsibility accepted by Groundwork Plus, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing. We would be pleased to answer any questions about this important information from the reader of this report. Further information on UNDERSTANDING YOUR GEOTECHNICAL REPORT is presented in ATTACHMENT 2.

9 References

ANCOLD 2012 Guidelines on Tailing Dams Planning, Design, Construction and Closure.

Atlas of Seismic Hazard Maps of Australia 2013

Australian Geomechanics Society Modified Landslide Risk Management Concepts and Guidelines.

Assessment of Geotechnical Risks in Mines and Quarries;

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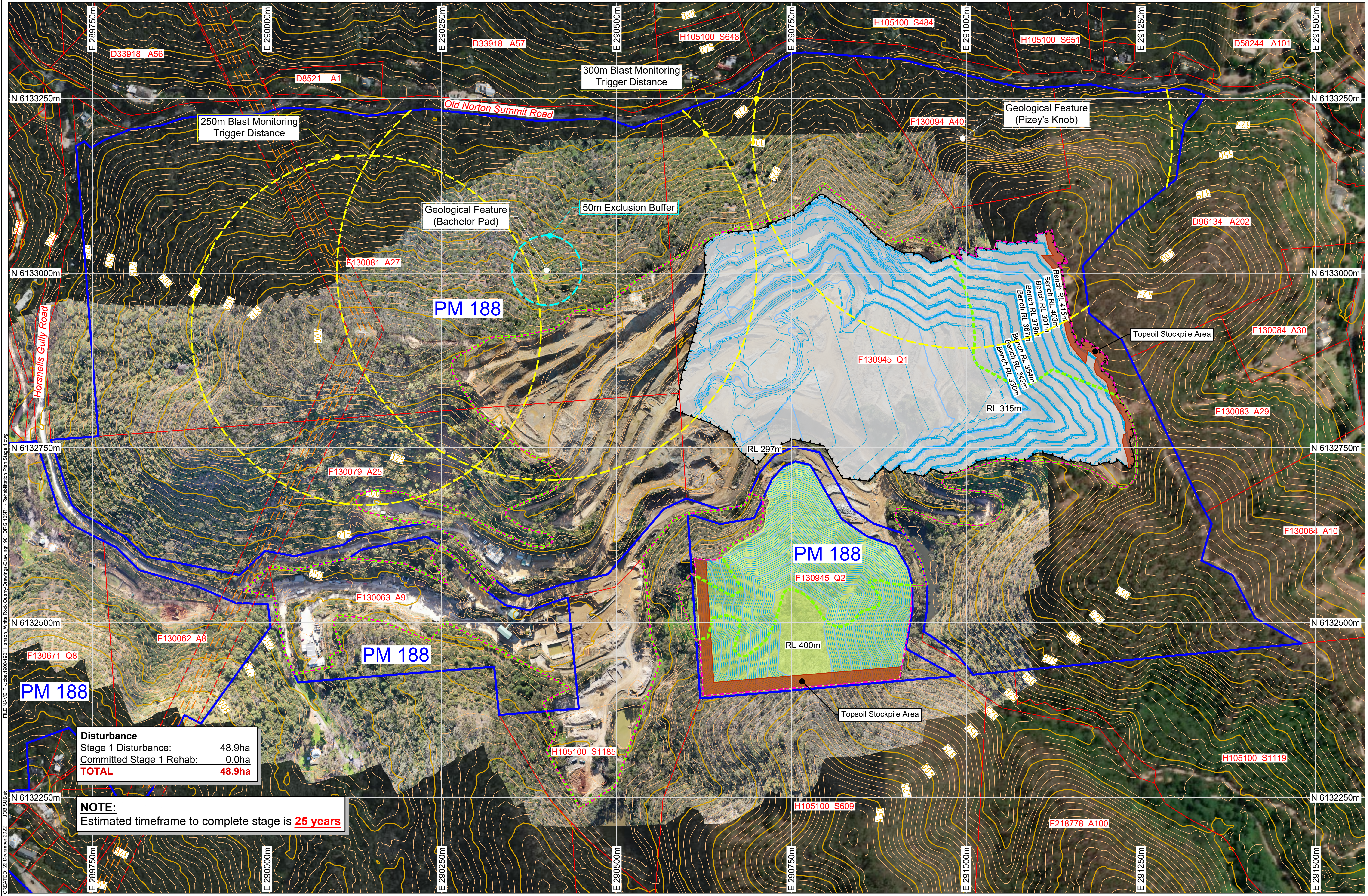
FIGURES



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Cadastre: © The Government of South Australia (DIT) 2022
Ecosystem:
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Legend:
- Cadastral Boundary
- Private Mine
- High VoltageTransmission Cable
- Existing Site Disturbance (42.58 Ha)
- Easement Boundary
- Stage 1 Disturbance (48.88 Ha)
- Extraction Area
- Overburden Stockpile Area
- Topsoil Stockpile Area

N

PROJECT: White Rock Quarry

CLIENT: Hanson Construction Materials

TITLE: Quarry Development and Rehabilitation Plan - Stage 1

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SCALE:	DRAWING NUMBER:	REVISION:
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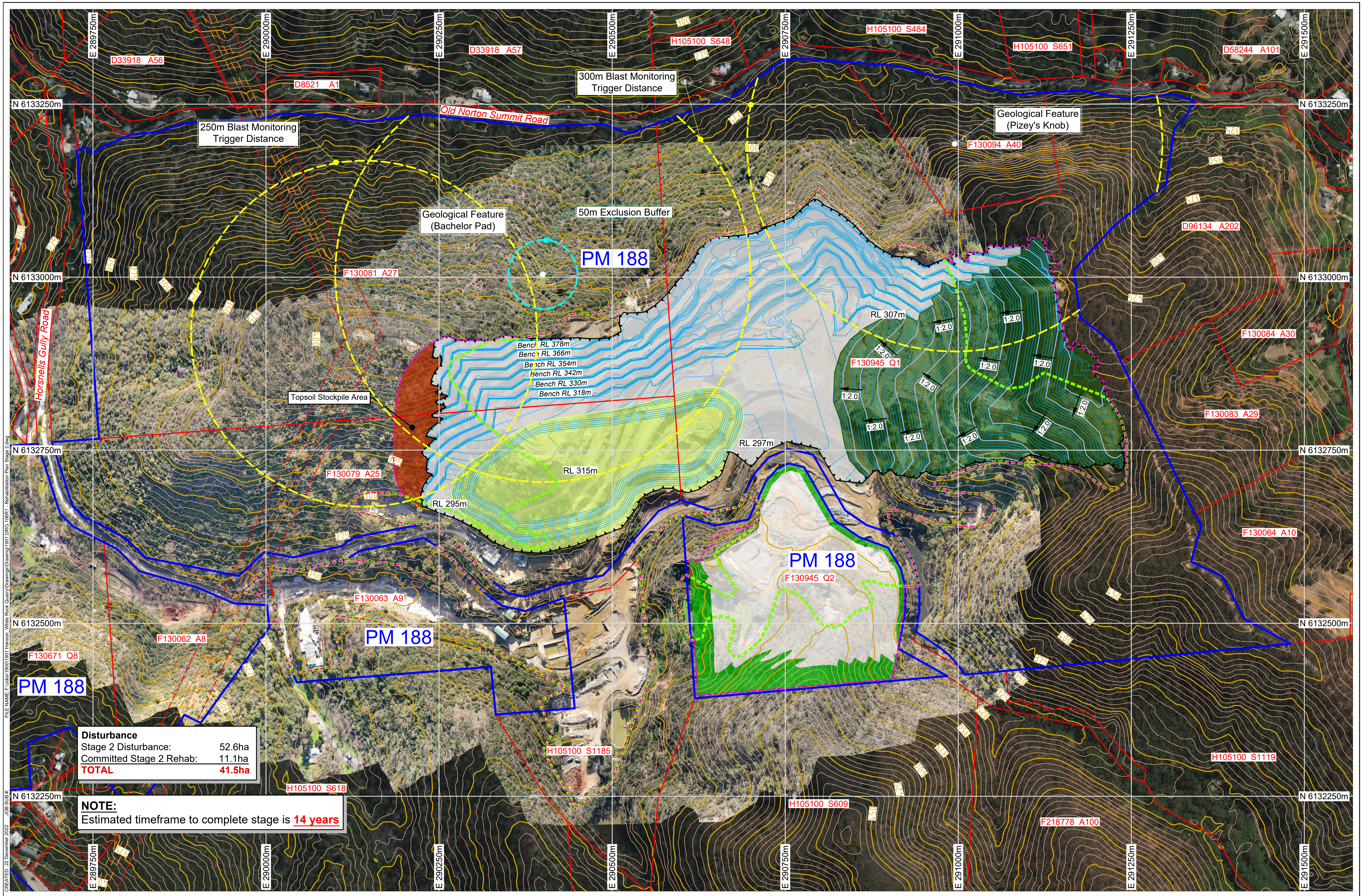

Disturbance

Stage 2 Disturbance:	52.6ha
Committed Stage 2 Rehab:	11.1ha
TOTAL	**41.5ha**

NOTE:
Estimated timeframe to complete stage is **14 years**

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Ecosystem:
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Legend:
- Cadastral Boundary
- Private Mine
- High VoltageTransmission Cable
- Existing Site Disturbance (42.58 Ha)
- Stage 2 Disturbance (52.64 Ha)
- Easement Boundary
- Topsoil Stockpile Area
- Extraction Area
- Overburden Stockpile Area
- Rehabilitation Area
- Overburden Stockpile Rehabilitation Area
- Future Extraction Area

PROJECT: White Rock Quarry

TITLE: Quarry Development and Rehabilitation Plan - Stage 2

CLIENT: Hanson Construction Materials

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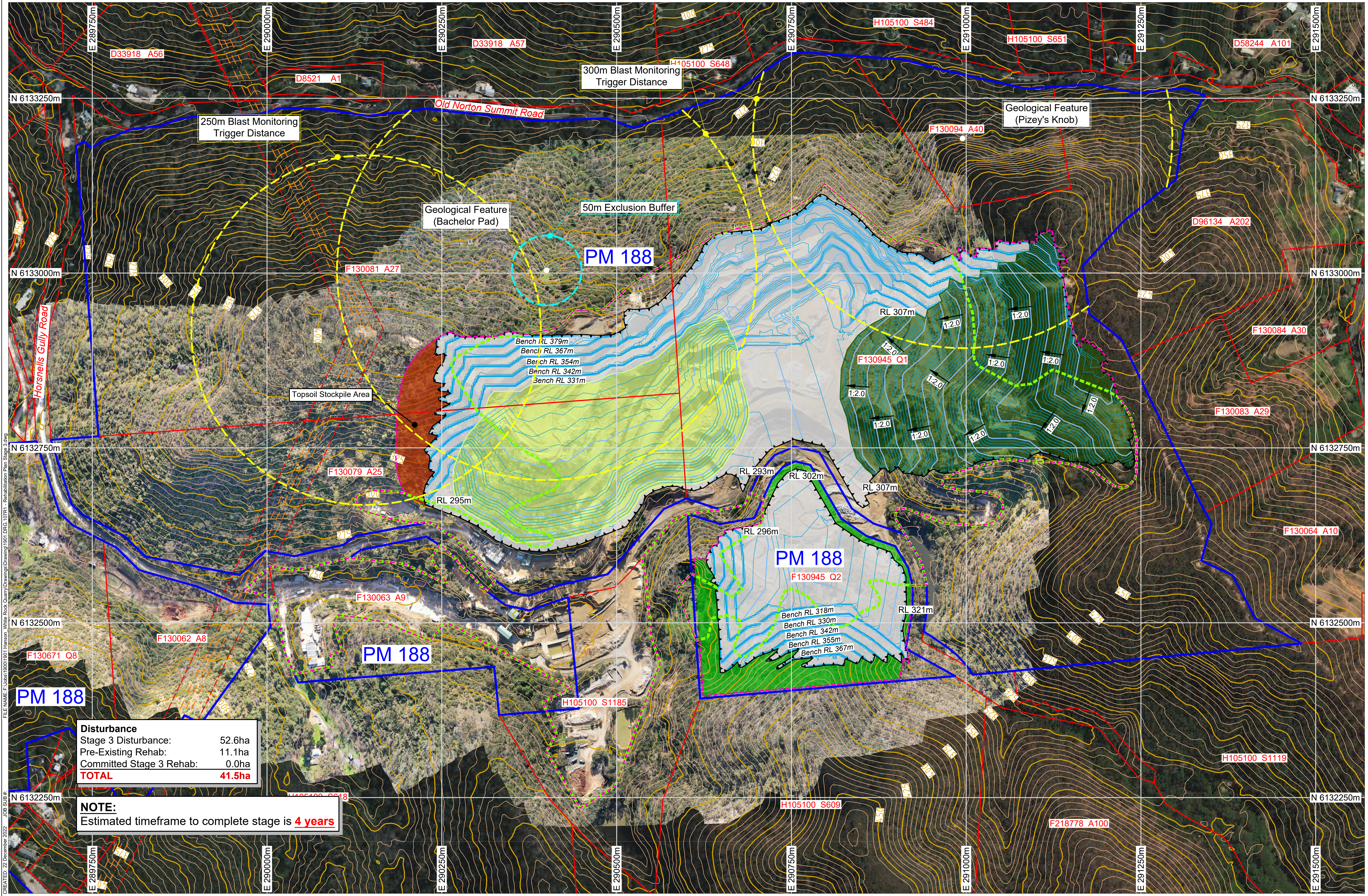

Disturbance	
Stage 3 Disturbance:	52.6ha
Pre-Existing Rehab:	11.1ha
Committed Stage 3 Rehab:	0.0ha
TOTAL	41.5ha

NOTE:
Estimated timeframe to complete stage is **4 years**

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Ecosystem:
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Legend:
- Cadastral Boundary
- Private Mine
- High VoltageTransmission Cable
- Existing Site Disturbance (42.58 Ha)
- Stage 2 Disturbance (52.64 Ha)
- Easement Boundary
- Extraction Area
- Overburden Stockpile Area
- Rehabilitation Area
- Overburden Stockpile Rehabilitation Area
- Topsoil Stockpile Area

PROJECT: White Rock Quarry

TITLE: Quarry Development and Rehabilitation Plan - Stage 3

CLIENT: Hanson Construction Materials

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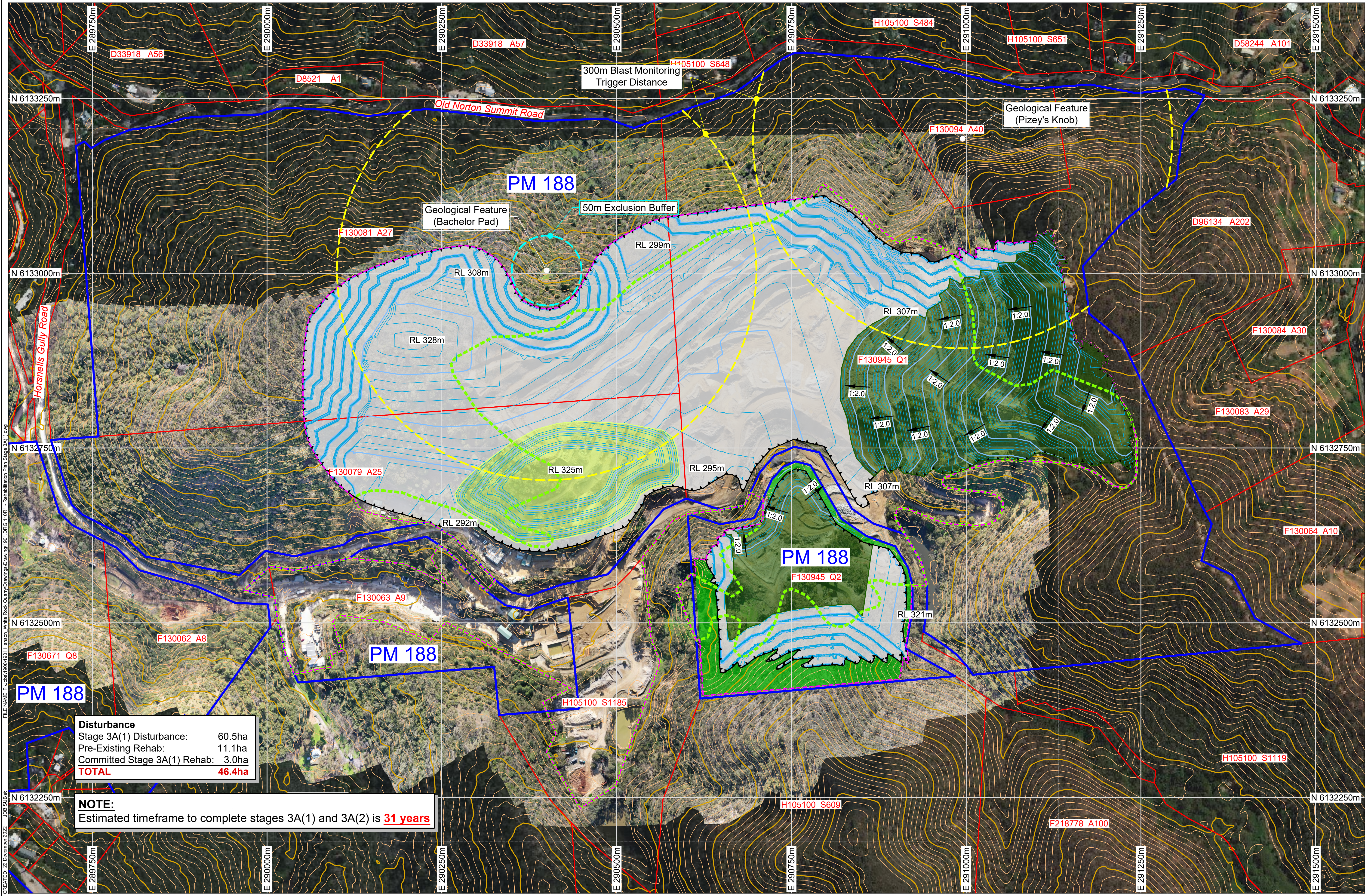

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Ecosystem:
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Legend:
- Cadastral
- Private Mine
- Existing Site Disturbance (42.58 Ha)
- Stage 4(1) Disturbance (60.46 Ha)
- Extraction Area
- Overburden Stockpile Area
- Rehabilitation Area
- Overburden Stockpile Rehabilitation Area

PROJECT: White Rock Quarry

CLIENT: Hanson Construction Materials

TITLE: Quarry Development and Rehabilitation Plan - Stage 3A(1)

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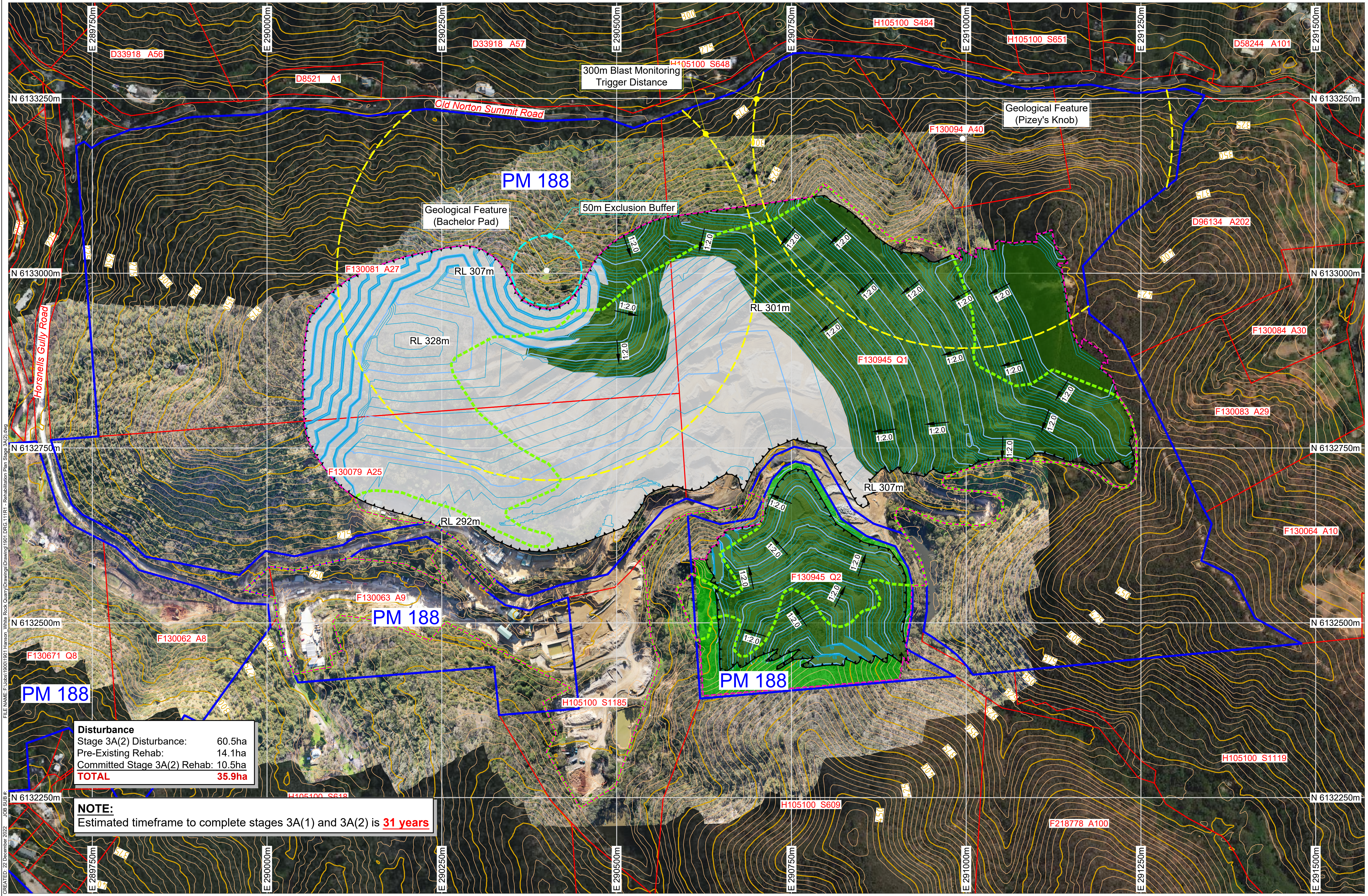

Disturbance

Stage 3A(2) Disturbance:	60.5ha
Pre-Existing Rehab:	14.1ha
Committed Stage 3A(2) Rehab:	10.5ha
TOTAL	**35.9ha**

NOTE:
Estimated timeframe to complete stages 3A(1) and 3A(2) is **31 years**

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Ecosystem:
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Legend:
- Cadastral
- Private Mine
- High voltage transmission cables
- Existing Site Disturbance (42.58 Ha)
- Stage 4(2) Disturbance (60.46 Ha)
- Extraction Area
- Rehabilitation Area
- Overburden Stockpile Rehabilitation Area

N

PROJECT: White Rock Quarry

TITLE: Quarry Development and Rehabilitation Plan - Stage 3A(2)

CLIENT: Hanson Construction Materials

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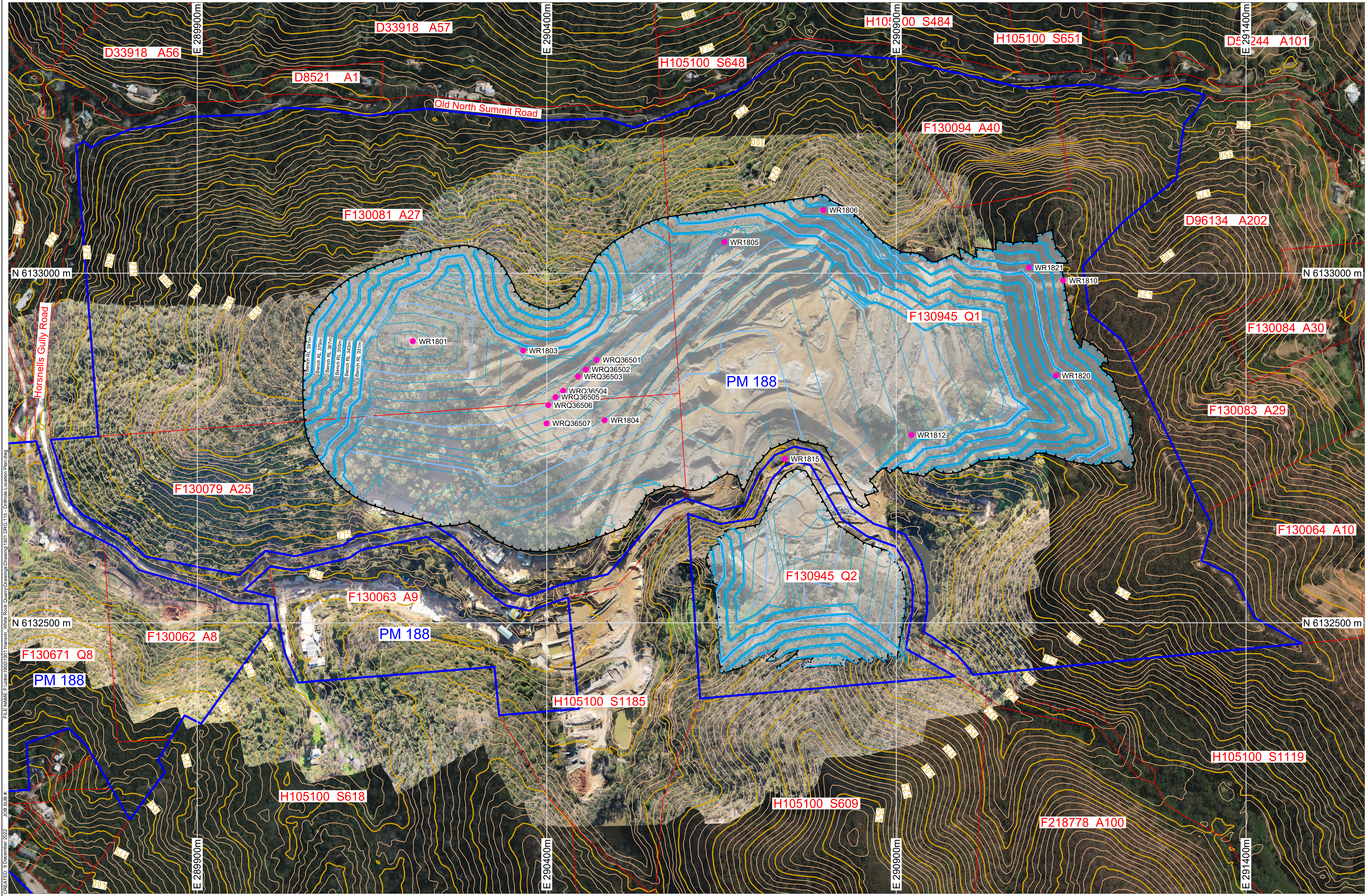

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Ecosystem:
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Legend:
- Private Mine
- Cadastral Boundary
- Drillhole Location

PROJECT: White Rock Quarry

CLIENT: Hanson Construction Materials

TITLE: Drillhole Location Plan

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REVISION:

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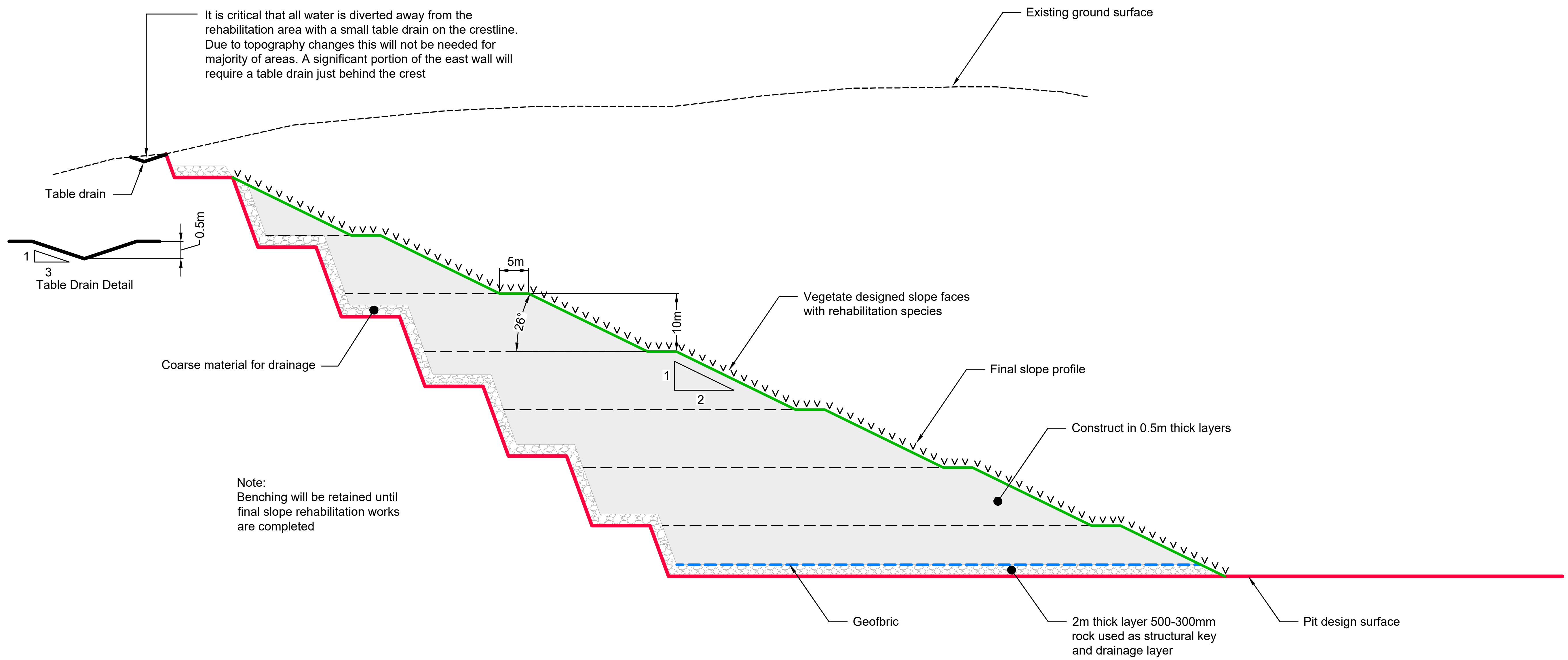
PRINTED: 9 December 2022
DRAWN: JVivash
CHECKED: RHuntley
DATUM: HORIZONTAL / VERTICAL / ZONE
MGA / AHD / 54

Fill Placement Criteria

- Fill shall be placed on dry ground and not submerged until the rehabilitated batter is complete.
- Fill shall be placed in line with geometry depicted an approved Rehabilitation Plan. The thickness of each compacted lift (layer) shall be no more than 500-700mm after compaction.
- Fill shall be compacted until the following criteria is achieved - 6 blows / 100 mm with a dynamic cone penetrometer (DCP).
- Testing of Fill Compaction Control (DCP) shall comply with procedure AS1289.6.3.2. A minimum of 2 DCP tests should be completed to a depth of 500 mm, for every 2500 m^2 of fill placed, to test compaction of each lift.
- DCP tests can be completed onsite by Hanson staff with a record of testing kept on file.
- If compaction cannot be achieved, Hanson should consult a suitably qualified geotechnical engineer to review the onsite compaction and testing regime.
- The client should undertake all excavation related activities in line with specific safe operating procedures (SOP's) to ensure slope stability is maintained during quarrying.
- Visual monitoring of the working batters conducted by suitably experienced site personnel, terminal and rehabilitated slopes conducted by suitably experienced site personnel should be at a maximum four-week interval and continue for at least six months following closure.
- If any visual signs of cracking, slumping, increased seepage, or other geotechnical issues are observed, a geotechnical engineer should be contacted in order to implement the necessary engineering controls (where required).
- Surficial erosion needs to be managed once the final landform concept is developed and should be assessed against appropriate industry guidelines.
- Surface water should be suitably managed (i.e., using suitable systems) to prevent uncontrolled water flows and minimise the potential for soil erosion.
- Management of surface water and groundwater is a key component of geotechnical risk management, as excess build-up of pore water pressures as a result of uncontrolled / excessive surface water ingress can trigger instability in otherwise stable batters. Where changes in ground and groundwater conditions are encountered, a geotechnical engineer should be contacted.



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Topography:
Cadastre:
Ecosystem:
LiDAR:

Legend:
- Existing Ground Surface
- Pit Design Surface
- Rehabilitation Surface
- Geofabric

PROJECT: White Rock Quarry

CLIENT: Hanson Construction Materials

TITLE: Typical Quarry Rehabilitation Detail

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PH: +61 7 3871 0411
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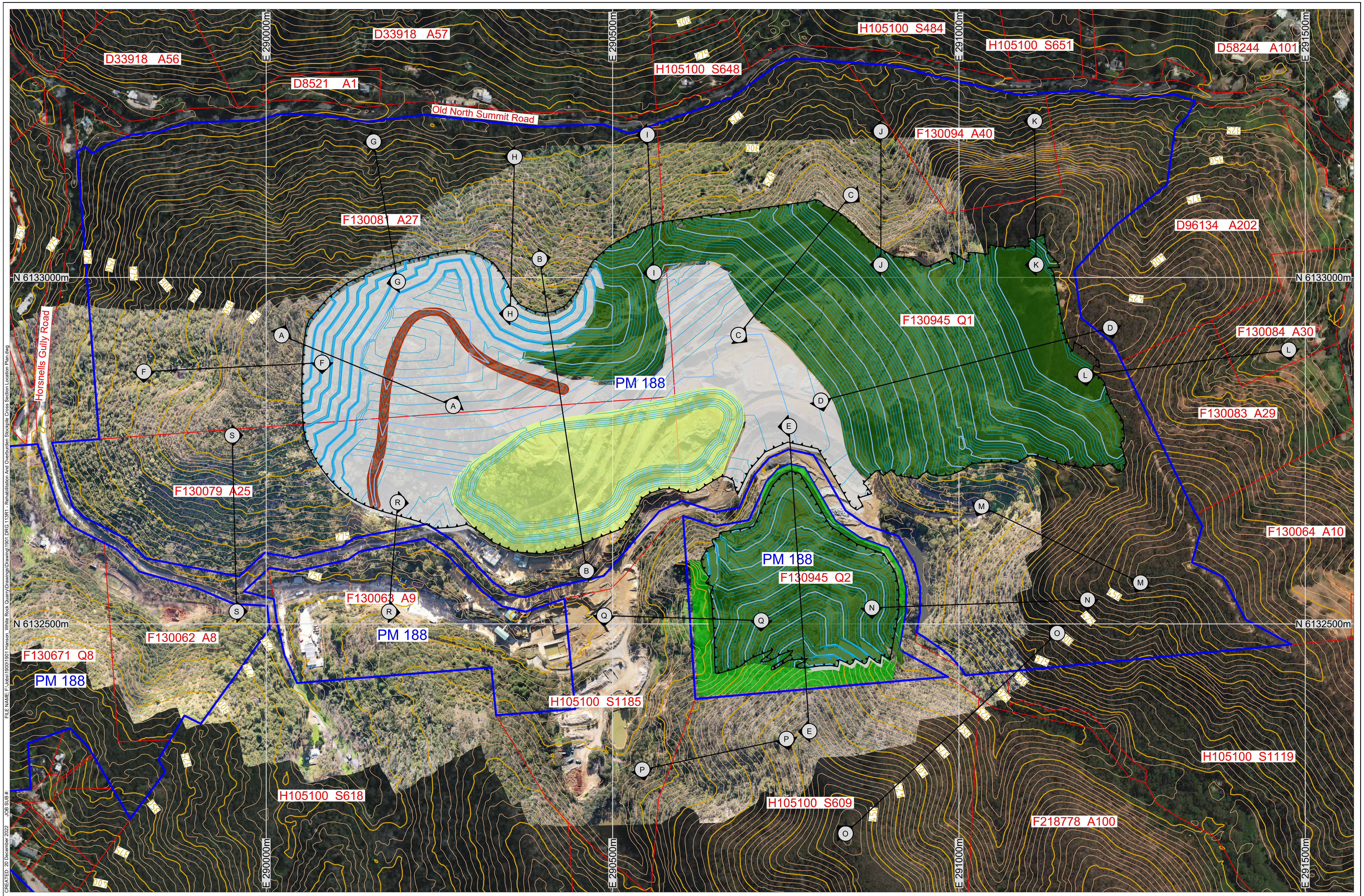
SCALE: 1:750 When Printed On A3 — 0 15m

DRAWING NUMBER: 1901.DRG.114 REVISION:

DATE: 13 December 2022 DRAWN: JHV

PRINTED: 14 December 2022 CHECKED: RH

DATUM: HORIZONTAL / VERTICAL / ZONE
GDA94 / MGA / AHD / 54



REV	DESCRIPTION	DATE	BY

Data Sources:
Photography: © Hanson UAV Survey, Captured 2022-07-06
Topography: © Commonwealth of Australia (Geoscience Australia) 2019-12-06, LiDAR 5m
Cadastre: © The Government of South Australia (DIT) 2022
Ecosystem:
Other: © 2022 Microsoft Corporation; © 2022 Maxar; © CNES (2022) Distribution Airbus DS

Legend:
- Cadastral
- Private Mine
- Abandonment Bund
- Extraction Area
- Overburden Stockpile Area
- Rehabilitation Area
- Overburden Stockpile Rehabilitation Area

PROJECT: White Rock Quarry

TITLE: Rehabilitation and Overburden Stockpile Cross Section Location Plan

CLIENT: Hanson Construction Materials

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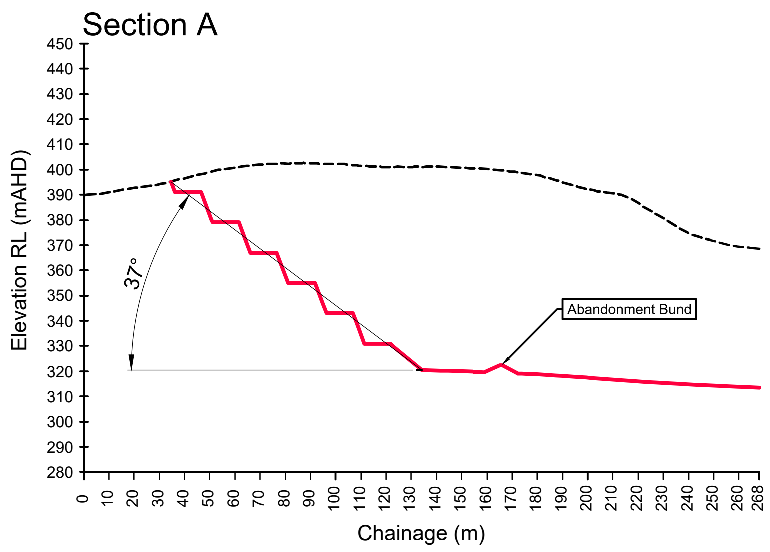
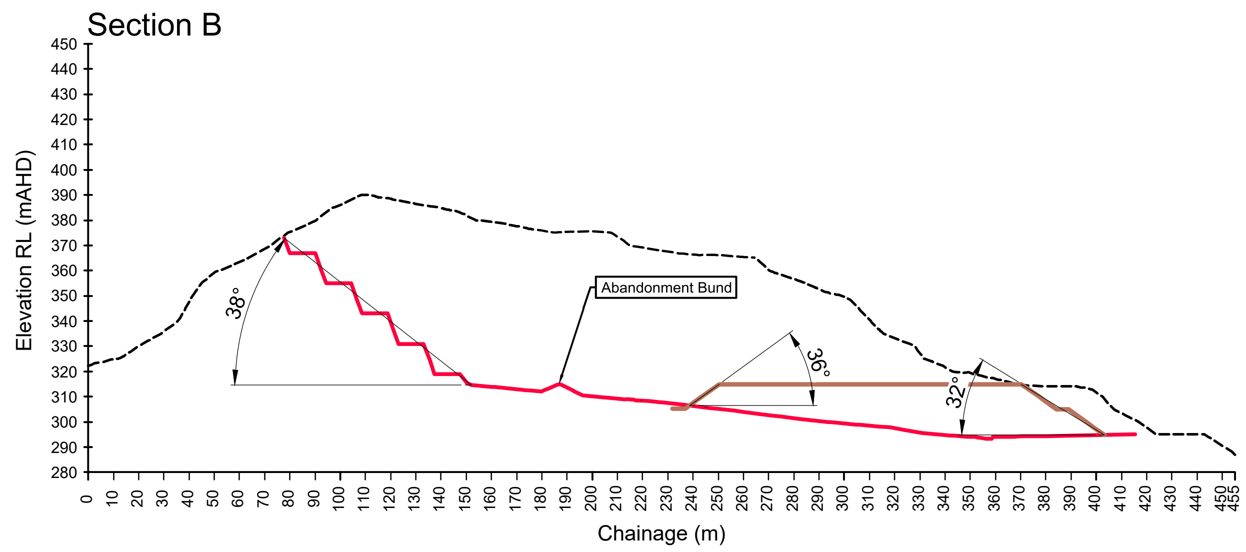
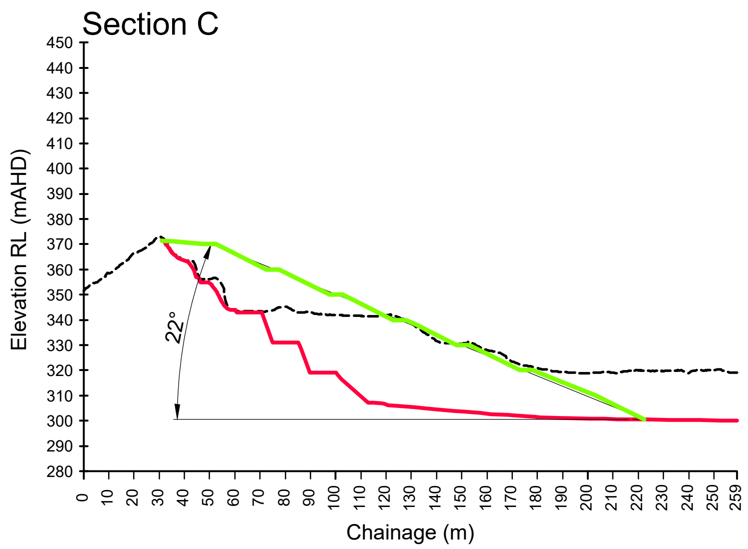
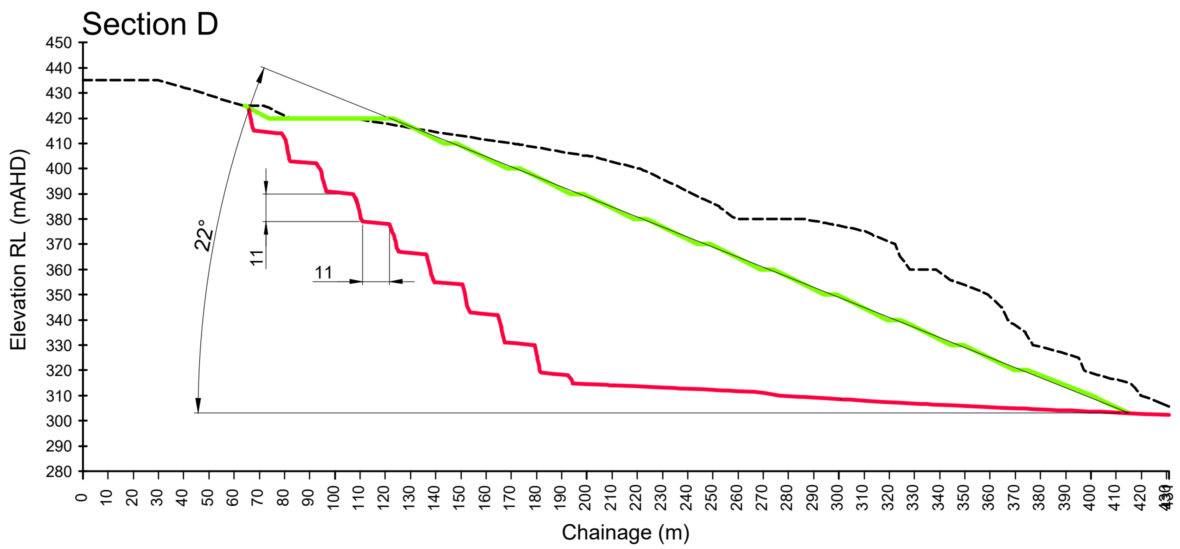
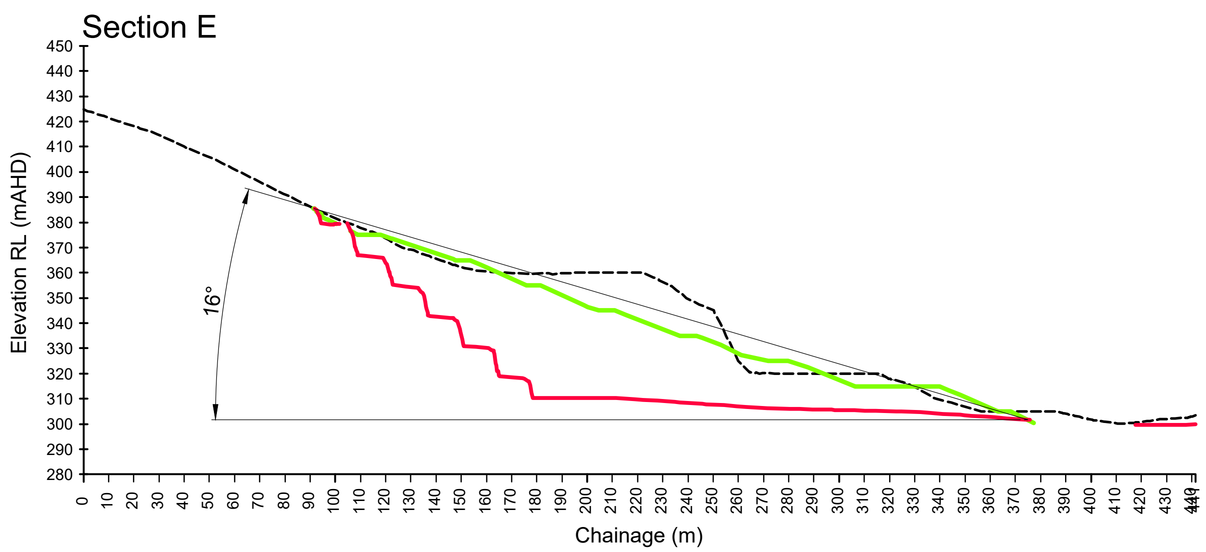
SCALE:	DRAWING NUMBER:	REVISION:
1:5,000 When Printed On A3 (0 – 100m)	1901.DRG.113	1
DATE: 20 December 2022	DRAWN: JVivash	DATUM: HORIZONTAL / VERTICAL / ZONE
PRINTED: 20 December 2022	CHECKED: RHuntley	MGA / AHD / 54











CREATED: 13 December 2022 JOB SUB #: FILE NAME: F:\Jobs\1900\1901 Hanson_White Rock Quarry\Drawings\Drawing\1901 DRG 113 - Rehabilitation And Overburden Stockpile Cross Section Location Plan.dwg

REV	DESCRIPTION	DATE	BY
1	Added Abandonment Bund	20/12/22	CP

Data Sources:
Photography: © Hanson UAV Survey, Captured 2022-07-06
Topography: © Commonwealth of Australia (Geoscience Australia) 2019-12-06, LiDAR 5m
Cadastre: © The Government of South Australia (DIT) 2022
Ecosystem:
Other: © 2022 Microsoft Corporation; © 2022 Maxar; © CNES (2022) Distribution Airbus DS

Legend:
- Ground Surface (2019 LiDAR)
- Pit Design
- Rehabilitation
- Overburden Structure

PROJECT: White Rock Quarry

CLIENT: Hanson Construction Materials

TITLE: Slope Cross Section A-A to E-E

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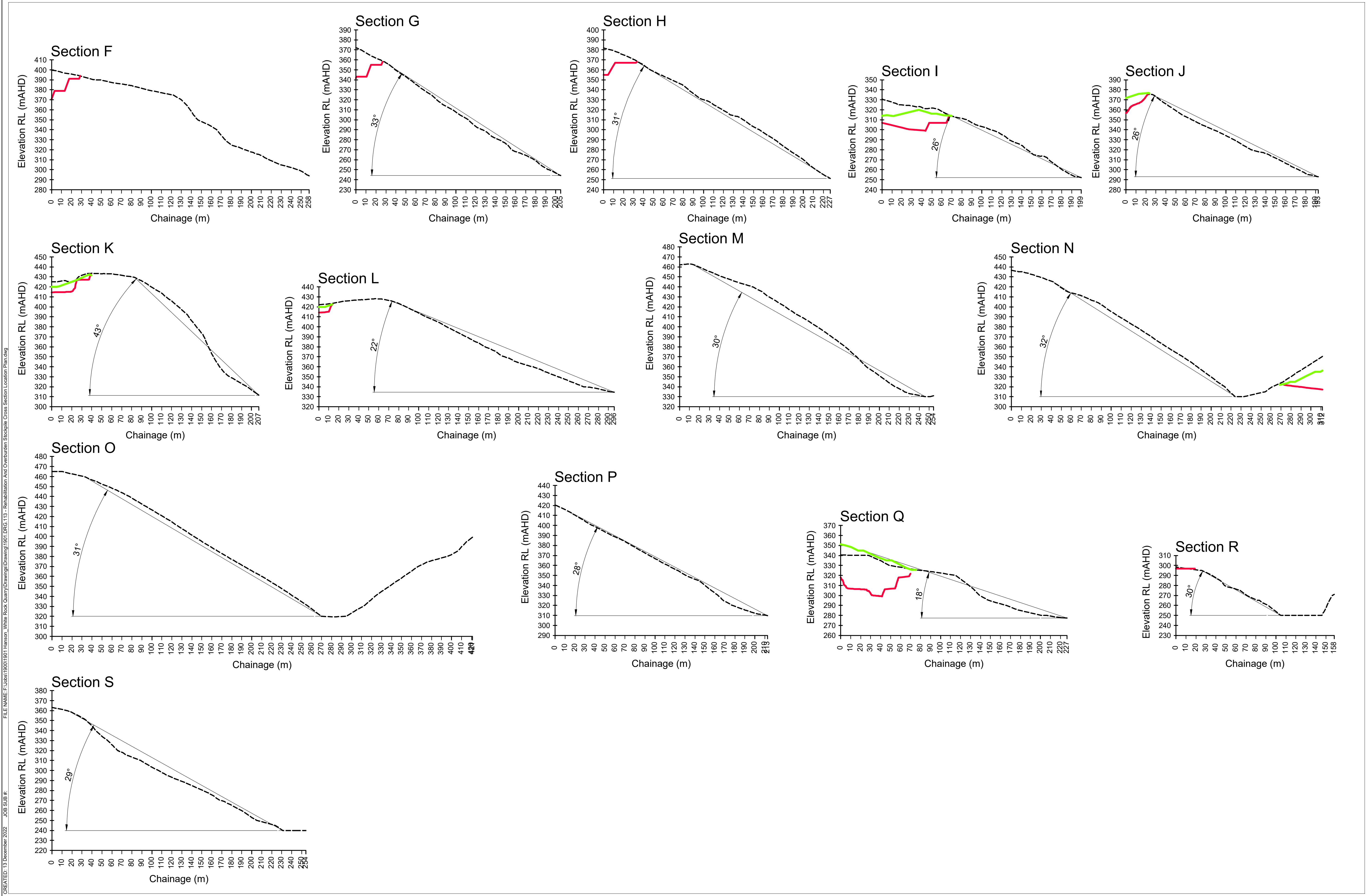
SCALE:	DRAWING NUMBER:	REVISION:
1:3,000 When Printed On A3 (0 – 60m)	1901.DRG.113A	1

DATE: 13 December 2022	DRAWN: CParham	DATUM: HORIZONTAL / VERTICAL / ZONE
PRINTED: 13 December 2022	CHECKED: MDupree	MGA / AHD / 54



CREATED: 13 December 2022 JOB SUB #: FILE NAME: F:\Jobs\1900\1901 Hanson_White Rock Quarry\Drawings\Drawing\1901 DRG 113 - Rehabilitation And Overburden Stockpile Cross Section Location Plan.dwg

REV	DESCRIPTION	DATE	BY

Data Sources:
Photography: © Hanson UAV Survey, Captured 2022-07-06
Topography: © Commonwealth of Australia (Geoscience Australia) 2019-12-06, LiDAR 5m
Cadastre: © The Government of South Australia (DIT) 2022
Ecosystem:
Other: © 2022 Microsoft Corporation; © 2022 Maxar; © CNES (2022) Distribution Airbus DS

Legend:
- Ground Surface (2019 LiDAR)
- Pit Design
- Rehabilitation

PROJECT: White Rock Quarry

CLIENT: Hanson Construction Materials

TITLE: Slope Cross Section F-F to S-S

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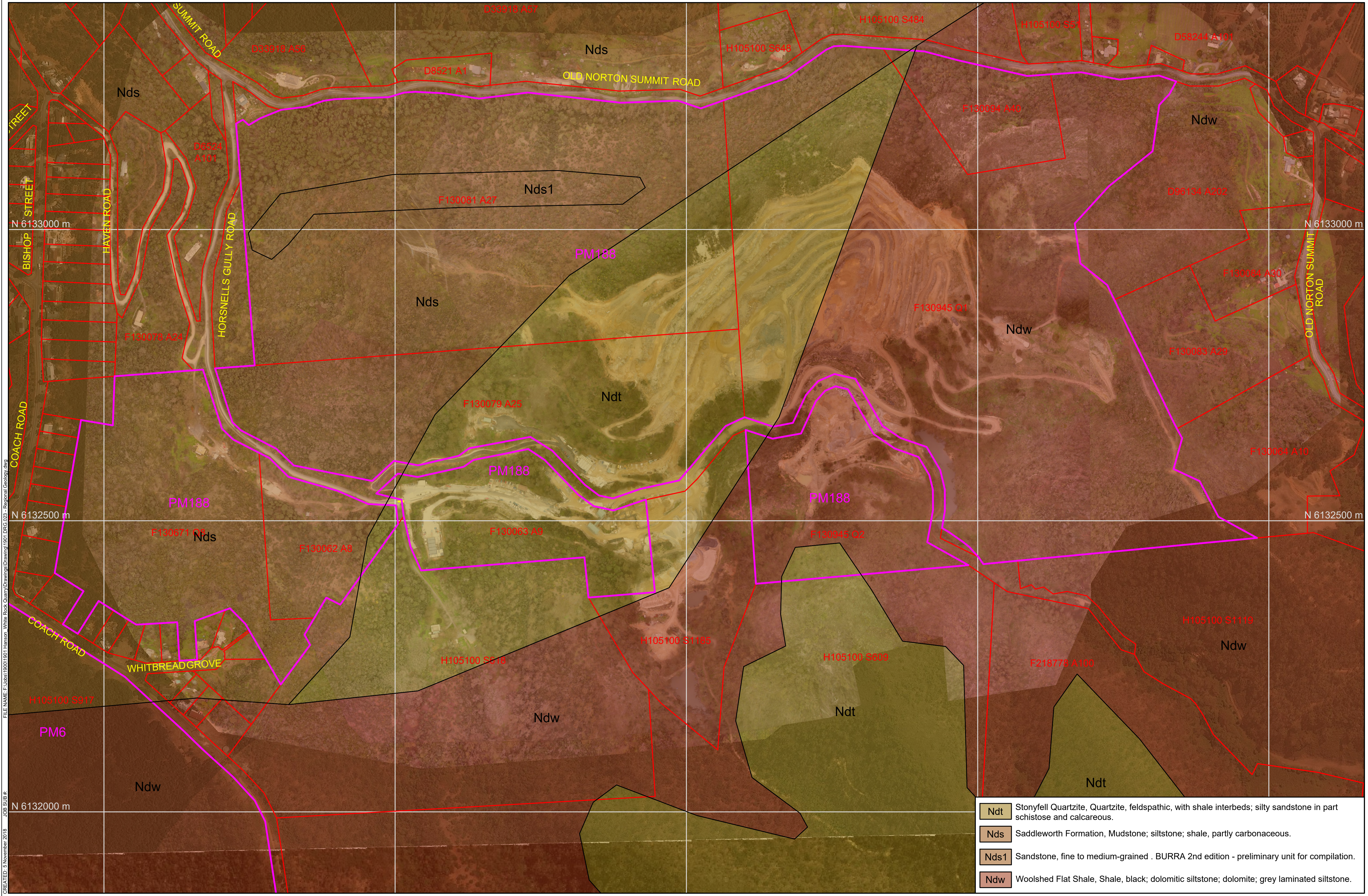
SCALE: 1:3,500 When Printed On A3 (0 – 70m)
DATE: 13 December 2022 DRAWN: CParham
PRINTED: 13 December 2022 CHECKED: MDupree
DRAWING NUMBER: 1901.DRG.113B REVISION:
DATUM: HORIZONTAL / VERTICAL / ZONE
MGA / AHD / 54



REV	DESCRIPTION	DATE	BY

Data Sources:
Photography: UAV Survey. Captured 28-08-2017.
Topography: UAV Survey. Captured 28-08-2017.
Cadastre: SA PLB
Ecosystem:
Other:

Legend:
- Private Mine Boundary
- Cadastral Boundary
- Road

PROJECT: White Rock Quarry

TITLE: Regional Geology

CLIENT: Hanson Construction Materials Pty Ltd

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SCALE: 1:6,000 When Printed On A3 — 0 120m

DRAWING NUMBER: 1901.DRG.023
REVISION:

DATE: 5 November 2018 | DRAWN: MR
PRINTED: 8 December 2020 | CHECKED: JR
DATUM: HORIZONTAL / VERTICAL / ZONE — MGA / AHD / 54

ATTACHMENTS

Attachment 1

Curriculum Vitae

Attachment 2

Understanding Your Geotechnical Report

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL REPORT

These notes have been collated by Groundwork Plus. They are designed to help you in the interpretation of your Report.

Geological studies are commissioned to gain information about environmental conditions on and beneath the surface of a site. The more comprehensive the study, the more reliable the assessment is likely to be, but remember, any such assessment is to a greater or lesser extent based on professional opinions about conditions that cannot be seen or tested. Accordingly, no matter how much data is accumulated, risks created by unanticipated conditions will always remain. Work with your geological consultant to manage known and unknown risks. Part of that process should already have been accomplished, through the risk allocation provisions you and your geological professional discussed and included in your contract's general terms and conditions. This document is intended to explain some of the concepts that may be included in your agreement and to pass along information and suggestions to help you manage your risk.

Beware Of Change; Keep Your Geological Professional Advised

The design of a geological study considers a variety of factors that are subject to change. Changes can undermine the applicability of a reports findings, conclusions, and recommendations. Advise your geological professional about any changes as you become aware of them. Geological professionals cannot accept responsibility or liability for problems that occur because a report fails to consider conditions that did not exist when the study was designed. Ask your geological professional about the types of changes you should be particularly alert to. Some of the most common include:

- modification of the proposed development or ownership group;
- sale or other property transfer;
- replacement of or additions to the financing entity;
- amendment of existing regulations or introduction of new ones; or
- changes in the use or condition of adjacent property.

Should you become aware of any change, do not rely on an existing geological report. Advise your geological professional immediately; follow the professional's advice.

Prepare To Deal with Unanticipated Conditions

The findings, recommendations, and conclusions of a report typically are based on a review of historical information, interviews, a site 'walkover' and other forms of non-invasive research. When site subsurface conditions are not sampled in any way, the risk of unanticipated conditions is higher than it would otherwise be.

While borings, installation of monitoring wells, and similar invasive test methods can help reduce the risk of unanticipated conditions, do not overvalue the effectiveness of testing. Testing provides information about actual conditions only at the precise locations where samples are taken and only when they are taken. Your geological professional has applied that specific information to develop a general opinion about environmental conditions. Actual conditions in areas not sampled may differ (sometimes sharply) from those predicted in a report. For example, a site may contain an unregistered underground storage tank that shows no surface trace of its existence. Even conditions in areas that were tested can change, sometimes suddenly, due to any number of events, not the least of which include occurrences at adjacent sites. Recognize too, that even some conditions in tested areas may go undiscovered, because the tests or analytical methods used were designed to detect only those conditions assumed to exist.

Manage your risks by retaining your geological professional to work with you as the project proceeds. Establish a contingency fund or other means to enable your geological professional to respond rapidly, in order to limit the impact of unforeseen conditions. To help prevent any misunderstanding, identify those empowered to authorize changes and the administrative procedures that should be followed.

Do Not Permit Any Other Party to Rely on the Report

Geological professionals design their studies and prepare their reports to meet the specific needs of the clients who retain them, in light of the risk management methods that the client and geological professionals agree to, and the statutory, regulatory, or other requirements that apply. The study designed for a developer may differ sharply from one designed for a lender, insurer, public agency or even another developer. Unless the report specifically states otherwise, it was developed for you and only you. Do not unilaterally permit any other party to rely on it. The report and the study underlying it may not be adequate for another party's needs and you could be held liable, for shortcomings your geological professional was powerless to prevent or anticipate. Inform your geological professional when you know or expect that someone else - a third-party will want to use or rely on the report. Do not permit third-party use or reliance until you first confer with the Geological professional who prepared the report. Additional testing, analysis, or study may be required and in any event, appropriate terms and conditions should be agreed to so both you and your geological professional are protected from third-party risks. Any party who relies on a geological report without the express written permission of the professional who prepared it and the client for whom it was prepared may be solely liable for any problems that arise.

Avoid Misinterpretation of the Report

Design professionals and other parties may want to rely on the report in developing plans and specifications. They need to be advised, in writing, that their needs may not have been considered when the study's scope was developed and even if their needs were considered, they might misinterpret geological findings, conclusions, and recommendations. Commission your geological professional to explain pertinent elements of the report to others who are permitted to rely on it and to review any plans, specifications or other instruments of professional service that incorporate any of the report's findings, conclusions, or recommendations. Your geological professional has the best understanding of the issues involved, including the fundamental assumptions that determined the study's scope.

Give Contractors Access to the Report

Reduce the risk of delays, claims, and disputes by giving contractors access to the full report, providing that it is accompanied by a letter of transmittal that can protect you by making it unquestionably clear that: I) the study was not conducted and the report was not prepared for purposes of bid development and 2) the findings, conclusions and recommendations included in the report are based on a variety of opinions, inferences, and assumptions and are subject to interpretation. Use the letter to also advise contractors to consult with your geological professional to obtain clarifications, interpretations, and guidance (a fee may be required for this service) and that-in any event, they should conduct additional studies to obtain the specific type and extent of information each prefers for preparing a bid or cost estimate. Providing access to the full report, with the appropriate caveats, helps prevent formation of adversarial attitudes and claims of concealed or differing conditions. If a contractor elects to ignore the warnings and advice in the letter of transmittal, it would do so at its own risk. Your geological professional should be able to help you prepare an effective letter.

Do Not Separate Documentation from the Report

Geological reports often include supplementary documentation, such as maps and copies of regulatory files, permits, registrations, citations, and correspondence with regulatory agencies. If subsurface explorations were performed, the report may contain final boring logs and copies of laboratory data. If remediation activities occurred on site, the report may include; copies of daily field reports, waste manifests and information about the disturbance of subsurface materials, the type and thickness of any fill placed on site and fill placement practices, among other types of documentation. Do not separate supplementary documentation from the report. Do not permit any other party to redraw or modify any of the supplementary documentation for incorporation into other professionals' instruments of service.

Realize That Recommendations May Not Be Final

The technical recommendations included in a geological report are based on assumptions about actual conditions and so are preliminary or tentative. Final recommendations can be prepared only by observing actual conditions as they are exposed. For that reason, you should retain your geological professional to observe construction and/or remediation activities on site, to permit rapid response to unanticipated conditions. The geological professional who prepared the report cannot assume responsibility or liability for the report's recommendations if that professional is not retained to observe relevant site operations.

Understand That Geotechnical Issues Have Not Been Addressed

Unless geotechnical engineering was specifically included in the scope of professional service, a report is not likely to relate any findings, conclusions, or recommendations about the suitability of subsurface materials for construction purposes, especially when site remediation has been accomplished through the removal, replacement, encapsulation, or chemical treatment of on- site soils. The equipment, techniques, and testing used by geotechnical engineers differ markedly from those used by Geological professionals; their education, training, and experience are also significantly different. If you plan to build on the subject site, but have not yet had a geotechnical engineering study conducted, your Geological professional should be able to provide guidance about the next steps you should take. The same firm may provide the services you need.

Read Responsibility Provisions Closely

Geological studies cannot be exact; they are based on professional judgement and opinion. Nonetheless, some clients, contractors, and others assume geological reports are, or certainly should be, unerringly precise. Such assumptions have created unrealistic expectations that have led to wholly unwarranted claims and disputes. To help prevent such problems, geological professionals have developed a number of report provisions and contract terms that explain who is responsible for what and how risks are to be allocated. Some people mistake these for 'exculpatory clauses', that is, provisions whose purpose is to transfer one party's rightful responsibilities and liabilities to someone else. Read the responsibility provisions included in a report and in the contract you and your Geological professional agreed to.

Attachment 3

Engineering Test Results

LABSA PTY LTD
Construction Materials Testing
ABN 12 113 330 073
30 HUDSON ROAD
MAWSON LAKES SA 5095
Tel: 08 8258 5594 | Fax: 08 8258 9919
WEB: www.labsa.com.au

CONSTRUCTION MATERIAL TESTING

Aggregate/Soil Test Report

Report No: MAT:PR-19/0090-26
Issue No: 1
This report replaces all previous issues of report no 'MAT:PR-19/0090-26'.

Client: SMS Geotechnical
PO Box 347
GREENWITH SA 5125

Project No.: PR-19/0090

Project: SMS Geotechnical Material Testing 2019

Lot No:

TRN:

Accredited for compliance with ISO/IEC 17025 - Testing

NATA Accredited Laboratory Number: 375

Approved Signatory: Lorena Villacis (Senior Laboratory Technician)

Date of Issue: 17/10/2019

Sample Details

Sample ID:	PR-19/0090-26
Lot No.:	
Client Sample ID:	1-1907429
Date Received:	4/10/2019
Date Sampled:	4/10/2019
Source:	On site
Material:	20mm Aggregate
Specification:	Aggregate Investigation Sample
Location:	
Sampling Method:	Sample submitted by client
Sampled From:	Stockpile

Other Test Results

Description	Method	Result	Limits
Nominal Sample Size (mm)	AS 1141.22	20	
Nature of Sample		Crushed Rock	
Agg Size and Crush Details		20mm Aggregate	
Fraction Size		-19.0 + 9.5 mm	
Wet Strength (kN)		58	
Dry Strength (kN)		149	
Wet/Dry Strength Variation (%)		61	
Breakdown Occurred		No	
Cylinder Size (diameter in mm)		150	

Particle Size Distribution

Chart

Comments

N/A

LABSA PTY LTD
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WEB: www.labsa.com.au

CONSTRUCTION MATERIAL TESTING

Aggregate/Soil Test Report

Report No: MAT:PR-19/0090-27
Issue No: 1
This report replaces all previous issues of report no 'MAT:PR-19/0090-27'.

Client: SMS Geotechnical
PO Box 347
GREENWITH SA 5125

Project No.: PR-19/0090

Project: SMS Geotechnical Material Testing 2019

Lot No: **TRN:**

Accredited for compliance with ISO/IEC 17025 - Testing

NATA Accredited Laboratory Number: 375

Approved Signatory: Lorena Villacis (Senior Laboratory Technician)

Date of Issue: 17/10/2019

Sample Details

Sample ID: PR-19/0090-27
Lot No.:
Client Sample ID: 1-1907430
Date Received: 4/10/2019
Date Sampled: 4/10/2019
Source: On site
Material: 20mm Aggregate
Specification: Aggregate Investigation Sample
Location:
Sampling Method: Sample submitted by client
Sampled From: Stockpile

Other Test Results

Description	Method	Result	Limits
Nominal Sample Size (mm)	AS 1141.22	20	
Nature of Sample		Crushed Rock	
Agg Size and Crush Details		20mm Aggregate	
Fraction Size		-19.0 + 9.5 mm	
Wet Strength (kN)		111	
Dry Strength (kN)		165	
Wet/Dry Strength Variation (%)		33	
Breakdown Occurred		No	
Cylinder Size (diameter in mm)		150	

Particle Size Distribution

Chart

Comments

Note 1: Sample for Wet/Dry Strength Variation, AS1141.22 was prepared by client, NATA Accreditation # 19225

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WEB: www.labsa.com.au

LABSA CONSTRUCTION MATERIAL TESTING

Aggregate/Soil Test Report

Report No: MAT:PR-19/0090-28
Issue No: 1
This report replaces all previous issues of report no 'MAT:PR-19/0090-28'.

Client: SMS Geotechnical
PO Box 347
GREENWITH SA 5125

Project No.: PR-19/0090

Project: SMS Geotechnical Material Testing 2019

Lot No:

TRN:

Accredited for compliance with ISO/IEC 17025 - Testing

NATA Accredited Laboratory Number: 375

Approved Signatory: Lorena Villacis (Senior Laboratory Technician)

Date of Issue: 17/10/2019

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Sample Details

Sample ID:	PR-19/0090-28
Lot No.:	
Client Sample ID:	1-1907431
Date Received:	4/10/2019
Date Sampled:	4/10/2019
Source:	On site
Material:	20mm Aggregate
Specification:	Aggregate Investigation Sample
Location:	
Sampling Method:	Sample submitted by client
Sampled From:	Stockpile

Other Test Results

Description	Method	Result	Limits
Nominal Sample Size (mm)	AS 1141.22	20	
Nature of Sample		Crushed Rock	
Agg Size and Crush Details		20mm Aggregate	
Fraction Size		-19.0 + 9.5 mm	
Wet Strength (kN)		71	
Dry Strength (kN)		129	
Wet/Dry Strength Variation (%)		45	
Breakdown Occurred		No	
Cylinder Size (diameter in mm)		150	

Particle Size Distribution

Chart

Comments

Note 1: Sample for Wet/Dry Strength Variation, AS1141.22 was prepared by client, NATA Accreditation # 19225

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CONSTRUCTION MATERIAL TESTING

Aggregate/Soil Test Report

Report No: MAT:PR-19/0090-29
Issue No: 1
This report replaces all previous issues of report no 'MAT:PR-19/0090-29'.

Client: SMS Geotechnical
PO Box 347
GREENWITH SA 5125

Project No.: PR-19/0090

Project: SMS Geotechnical Material Testing 2019

Lot No: **TRN:**

Accredited for compliance with ISO/IEC 17025 - Testing

NATA Accredited Laboratory Number: 375

Approved Signatory: Lorena Villacis (Senior Laboratory Technician)

Date of Issue: 17/10/2019

Sample Details

Sample ID: PR-19/0090-29
Lot No.:
Client Sample ID: 1-1907432
Date Received: 4/10/2019
Date Sampled: 4/10/2019
Source: On site
Material: 20mm Aggregate
Specification: Aggregate Investigation Sample
Location:
Sampling Method: Sample submitted by client
Sampled From: Stockpile

Other Test Results

Description	Method	Result	Limits
Nominal Sample Size (mm)	AS 1141.22	20	
Nature of Sample		Crushed Rock	
Agg Size and Crush Details		20mm Aggregate	
Fraction Size		-19.0 + 9.5 mm	
Wet Strength (kN)		116	
Dry Strength (kN)		148	
Wet/Dry Strength Variation (%)		22	
Breakdown Occurred		No	
Cylinder Size (diameter in mm)		150	

Particle Size Distribution

Chart

Comments

Note 1: Sample for Wet/Dry Strength Variation, AS1141.22 was prepared by client, NATA Accreditation # 19225

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LABSA CONSTRUCTION MATERIAL TESTING

Aggregate/Soil Test Report

Report No: MAT:PR-19/0090-30
Issue No: 1
This report replaces all previous issues of report no 'MAT:PR-19/0090-30'.

Client: SMS Geotechnical
PO Box 347
GREENWITH SA 5125

Project No.: PR-19/0090

Project: SMS Geotechnical Material Testing 2019

Lot No: **TRN:**

Accredited for compliance with ISO/IEC 17025 - Testing

NATA Accredited Laboratory Number: 375

Approved Signatory: Lorena Villacis (Senior Laboratory Technician)

Date of Issue: 21/10/2019

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Sample Details

Sample ID: PR-19/0090-30
Lot No.:
Client Sample ID: 1-1907433
Date Received: 4/10/2019
Date Sampled: 4/10/2019
Source: On site
Material: 20mm Aggregate
Specification: Aggregate Investigation Sample
Location:
Sampling Method: Sample submitted by client
Sampled From: Stockpile

Other Test Results

Description	Method	Result	Limits
Nominal Sample Size (mm)	AS 1141.22	20	
Nature of Sample		Crushed Rock	
Agg Size and Crush Details		20mm Aggregate	
Fraction Size		-19.0 + 9.5 mm	
Wet Strength (kN)		162	
Dry Strength (kN)		217	
Wet/Dry Strength Variation (%)		25	
Breakdown Occurred		No	
Cylinder Size (diameter in mm)		150	

Particle Size Distribution

Chart

Comments

Note 1: Sample for Wet/Dry Strength Variation, AS1141.22 was prepared by client, NATA Accreditation # 19225

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CONSTRUCTION MATERIAL TESTING

Aggregate/Soil Test Report

Report No: MAT:PR-19/0090-31
Issue No: 1
This report replaces all previous issues of report no 'MAT:PR-19/0090-31'.

Client: SMS Geotechnical
PO Box 347
GREENWITH SA 5125

Project No.: PR-19/0090

Project: SMS Geotechnical Material Testing 2019

Lot No: **TRN:**

Accredited for compliance with ISO/IEC 17025 - Testing

NATA Accredited Laboratory Number: 375

Approved Signatory: Lorena Villacis (Senior Laboratory Technician)

Date of Issue: 18/10/2019

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Sample Details

Sample ID:	PR-19/0090-31
Lot No.:	
Client Sample ID:	1-1907434
Date Received:	4/10/2019
Date Sampled:	4/10/2019
Source:	On site
Material:	20mm Aggregate
Specification:	Aggregate Investigation Sample
Location:	
Sampling Method:	Sample submitted by client
Sampled From:	Stockpile

Other Test Results

Description	Method	Result	Limits
Nominal Sample Size (mm)	AS 1141.22	20	
Nature of Sample		Crushed Rock	
Agg Size and Crush Details		20mm Aggregate	
Fraction Size		-19.0 + 9.5 mm	
Wet Strength (kN)		132	
Dry Strength (kN)		233	
Wet/Dry Strength Variation (%)		43	
Breakdown Occurred		No	
Cylinder Size (diameter in mm)		150	

Particle Size Distribution

Chart

Comments

Note 1: Sample for Wet/Dry Strength Variation, AS1141.22 was prepared by client, NATA Accreditation # 19225

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CONSTRUCTION MATERIAL TESTING

Aggregate/Soil Test Report

Report No: MAT:PR-19/0090-32
Issue No: 1
This report replaces all previous issues of report no 'MAT:PR-19/0090-32'.

Client: SMS Geotechnical
PO Box 347
GREENWITH SA 5125

Project No.: PR-19/0090

Project: SMS Geotechnical Material Testing 2019

Lot No:

TRN:

Accredited for compliance with ISO/IEC 17025 - Testing

NATA Accredited Laboratory Number: 375

Approved Signatory: Lorena Villacis (Senior Laboratory Technician)

Date of Issue: 18/10/2019

THIS DOCUMENT SHALL NOT BE REPRODUCED EXCEPT IN FULL

Sample Details

Sample ID:	PR-19/0090-32
Lot No.:	
Client Sample ID:	1-1907435
Date Received:	4/10/2019
Date Sampled:	4/10/2019
Source:	On site
Material:	20mm Aggregate
Specification:	Aggregate Investigation Sample
Location:	
Sampling Method:	Sample submitted by client
Sampled From:	Stockpile

Other Test Results

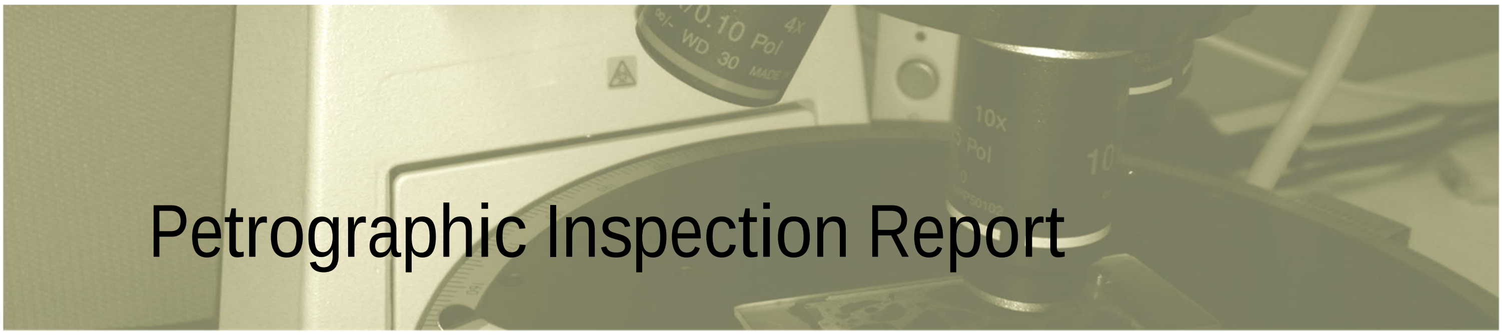
Description	Method	Result	Limits
Nominal Sample Size (mm)	AS 1141.22	20	
Nature of Sample		Crushed Rock	
Agg Size and Crush Details		20mm Aggregate	
Fraction Size		-19.0 + 9.5 mm	
Wet Strength (kN)		93	
Dry Strength (kN)		169	
Wet/Dry Strength Variation (%)		45	
Breakdown Occurred		No	
Cylinder Size (diameter in mm)		150	

Particle Size Distribution

Chart

Comments

Note 1: Sample for Wet/Dry Strength Variation, AS1141.22 was prepared by client, NATA Accreditation # 19225



Petrographic Inspection Report

Title:	Petrographic Inspection Report
Prepared for:	Hanson Construction Material Pty Ltd
Date Sampled:	19/02/2018
Sample Type:	Spall
Source:	White Rock Quarry – Adelaide Hills, South Australia
Sample ID:	White Rock
Date of Inspection:	22/03/2018
Report Issued:	04/04/2018
Project/ File Ref.:	P2018_0014_001v1

Author:

Luke Ryan (BGeo)
Geologist,
Groundwork Plus

Reviewer:

Rod Huntley (BSc, M.App.Sc, M.Eng)
Principal Resource Consultant,
Groundwork Plus

Rock Identity

Name: Quartzite

Lithology Metamorphic Rock

Introduction

This report provides the results of a general petrographic assessment of a spall sample which was submitted to the Groundwork Plus petrographic laboratory and describes the method and standards used to assess the sample. The thin section was prepared and analysed by Groundwork Plus with instructions from the client to conduct petrographic testing to ASTM C295 and recommend further testing if significant deleterious characteristics are identified pursuant to Clause 16.3 of this standard. The spall was sampled by the client and sectioned at the Groundwork Plus petrographic facility. The provided modal mineral percentages relate to the supplied sample which is understood to be representative of material on site. Assessment regarding the Alkali-Silica Reactivity (ASR) potential of the aggregate has been advised by AS1141.65-2008 and is communicated pursuant to Clause 9. Communication of findings are advised by AS 1726-1993 Geotechnical Site Investigations.

Method

The petrographic assessment of the slide was carried out using a Nikon polarising microscope equipped with a digital camera at the Groundwork Plus petrographic laboratory. A photograph of the hand specimen and thin section photomicrographs showing grain sizes and any particular aspects of the minerals were included as part of the report (Plates 1, 2, and 3). Modal analysis was conducted on the sample using JMicroVision image analysis software on 200 points (Table 2 – Modal Analysis of Minerals).

The petrology assessment was based on:

- ASTM C 295 Standard Guide for Petrographic Examination of Aggregates for Concrete.
- AS2758.1 – 1998 Aggregates and Rock for Engineering Purposes Part 1: Concrete Aggregates (Appendix B).
- AS1141 Standard Guide for the Method for Sampling and Testing Aggregates.
- Alkali Aggregate Reaction - Guidelines on Minimising the Risk of Damage to Concrete Structure in Australia - Cement and Concrete Association of Australia and Standards Australia (HB 79-2015).
- The accepted definition of free silica is set out in the Queensland Department of Transport and Main Roads Test Method Q188, and tested pursuant to the AS1141.65-2008 Methods for sampling and testing aggregates – Alkali aggregates reactivity – Qualitative petrological screening for potential alkali-silica reaction and AS1141.26 Secondary Mineral Content.

Interpretation

- The supplied rock sample is identified as Quartzite, a Metamorphic Rock.

- In hand sample the aggregate is described as white-brown, siliceous rock displaying sacharoidal fracture faces revealing tightly intergrown 0.2 to 0.5mm quartz and feldspar grains with no denuded cementitious material residual to the metamorphic process. Quartz filled veins are discontinuous, erratic and host fine opaques and isolated iron oxide staining. Characteristic among quartzites the sample is exceptionally hard, presenting a glassy sectioned face and is duly expected to be of extremely high strength and offer exceptional durability in service. Rare opaque and interstitial muscovite is detected as bright flakes measuring to 0.5mm. The rock is not appreciably magnetic and no sulfides are detected in hand sample.

- Petrographic analysis reveals the quartzite is comprised principally of robust recrystallised quartz crystals (74%), feldspar (21%), magnetite/ilmenite (1%) with subordinate inter-crystalline calcite (2%), muscovite (1%) and minor iron oxide. The rock is essentially unweathered and is non-porous.

- The sample contains 74% free silica in the form of heavily strained or finely annealed quartz. Duly, material represented by this sample is regarded as presenting risk significant Alkali-Silica Reactivity (ASR) in concrete.

- Pending material testing, the quartzite is regarded as suitable for use as Coarse Aggregate in Concrete (provided account is made in mix design for the stated potential for ASR) and Unbound Pavements. The rock may also be suitable as Cover Aggregate and Asphalt following bitumen affinity and Polished Aggregate Friction Value (PAFV) testing. The rock is also suitable for use as marine armour, gabion and revetment if large enough blocks can be recovered. Extensive crushing is expected to produce quality manufactured sand. The highly competent nature of the quartzite may result in increased wear on crushing and processing equipment.

- For engineering purposes the rock may be summarised as:

  – Quartzite, a metamorphic rock.
  – Essentially unweathered and non-porous.
  – Composed principally of robust and comprehensively consolidated grains with subordinate weak metamorphic or weathering products.
  – Very hard and of expected extremely high strength and superior durability.
  – Containing 74% free silica.
  – Presenting risk of significant ASR in concrete.
  – Exposure of ferruginous material to cement paste may result in staining.
  – Quartzite's such as this may present a risk of separation from cement paste if used as concrete aggregate due to heavy strain among constituent grains.

Table 1 – Risk Rating for Specific Applications and Source Rock Quality

Risk Rating for Application	Low	Mod	High	Comments (Pending material testing results and assuming the sample is indicative of overall source rock quality)
Coarse Aggregate in Concrete	✓			Composed principally of robust phases with relatively minor texturally isolated weak micas and calcite. Unlikely to be released in significant quantities with crushing
Unbound Pavements	✓			Suitable high strength, hard and durable material
Cover Aggregate	✓			Mechanically suitable with high strength. Hard and durable material
Graded Asphalt Aggregate	✓			Mechanically suitable with high strength. Hard and durable material
Rail Ballast	✓			Mechanically suitable high strength, hardness and durability
Manufactured Sand	✓			Weak secondary phases are rare and consolidated within the robust fabric of the rock. A proportion of these are expected to be released by extensive crushing but are very unlikely to constitute deleterious fines
Marine Armour	✓			Mechanically suitable provided adequately sized blocks can be recovered
Risk Rating Source Rock	**Low**	**Mod**	**High**	
Alkali Silica Reactivity			✓	Risk of significant ASR in concrete associated with heavily strained quartzites
Weak/secondary Mineral Impacts	✓			4% weak phases
Durability	✓			Suitable
Strength	✓			Suitable
Hardness	✓			Suitable
Voids	✓			No voids observed and duly regarded as non-porous rock
Fractures	✓			No significant fracturing or weakened planes observed
Bitumen affinity		✓		Coarsely grained siliceous rock can be associated with sub-optimal bitumen affinity. Bitumen affinity testing recommended prior to allocation to cover aggregate
Polishing		✓		Sacharoidal fracture faces likely to offset tendency of siliceous material to polish in service
Free Silica Content			✓	74% as quartz
Sulfides	✓			None observed
Light micaceous particles	✓			Subordinate fine texturally isolated muscovite

*Low risk means a low probability of causing source rock related issues in regard to material performance in any particular applications. Risk is recommended to be considered in conjunction with a sampling frequency protocol for production of any particular product.

Plate 1: Photograph displaying sectioned face of the quartzite including fine to medium grain size of constituent quartz and feldspar.

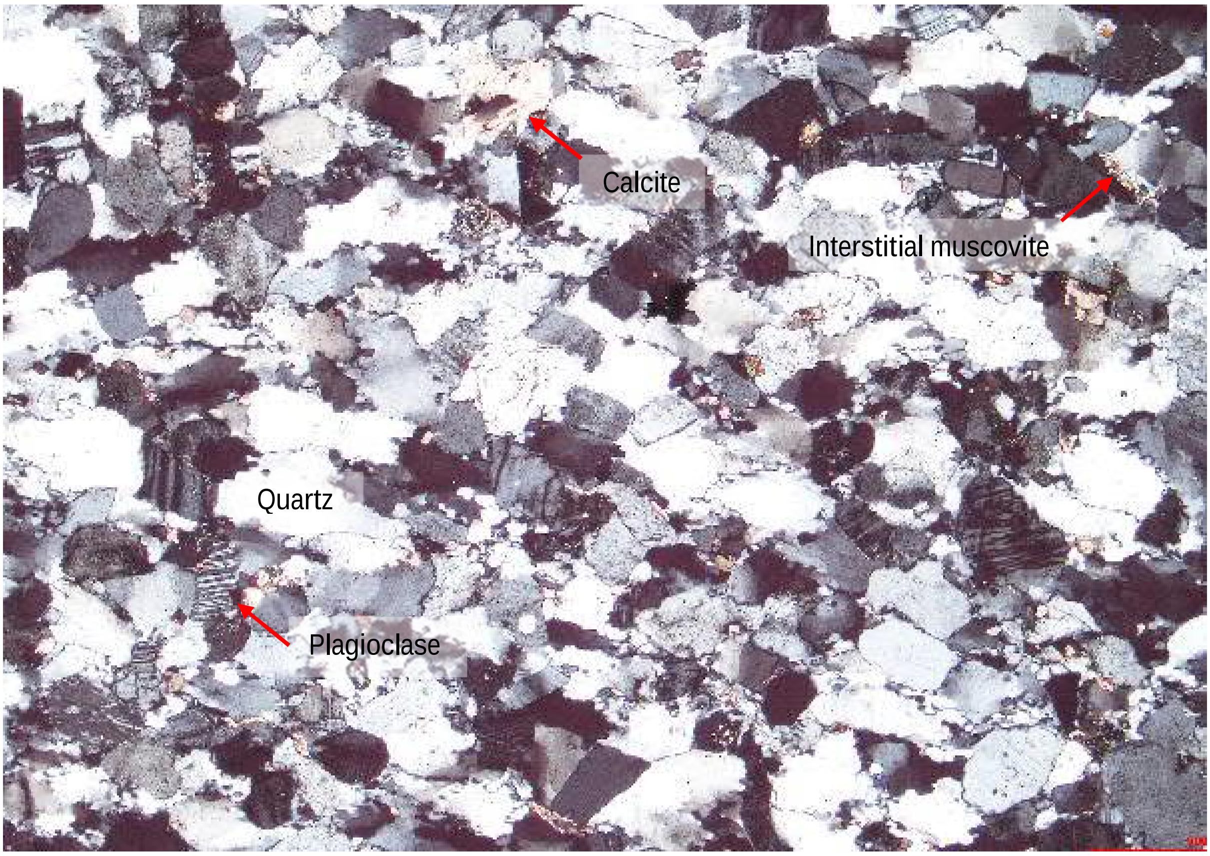


Plate 2: Microphotograph displaying representative mineral assembly and pressure solution textures which characterise the quartzite. Subordinate metamorphic muscovite is detected interstitial to otherwise sutured grains. Image shown in cross polarised light.

Plate 3: Microphotograph utilising plane polarised light to better distinguish dusty feldspar profiles from clear quartz and illustrate calcite, opaque and rare zircon distributions within the quartzite.

Thin Section Description

Petrographic analysis reveals that the spall represents a medium grain quartzite, the metamorphic product of an arkose sandstone protolith. Duly, the rock is comprised almost exclusively of 0.2 to 0.5mm quartz and feldspar grains with any interstitial argillic material metamorphosed to produce subordinate muscovite crystals which accommodate the compressed elongate boundaries of more competent quartz and feldspars. Fine magnetite/ilmenite crystals occur as 0.05mm opaques which frequently show alteration halos of rutile and leucoxene with associated emanative iron oxide staining. Additional accessary zircon crystals occur as persistent quartz inclusions as do fine filaments of apatite. 05 to 0.1mm euhedral calcite crystals are evenly distributed as euhedral crystals superimposed over quartz and feldspar mosaic fabric of the quartzite. These are likely the consolidation of fine carbonate sediments or shell fragments in the protolith.

Quartz crystals which account for the majority of the observed rock show universal heavy strain, elongate parallel crystal shapes and suturing at interfaces producing erratic boundaries between quartz grains. Finely annealed quartz crystals occur at boundaries with feldspar grains which include pristine plagioclase and microcline. These grains which composed the arkose sandstone protolith show mature development into a cohesive and highly competent quartzite with no observable voids or micaceous/argillic and consequently labile planes. Duly, aggregate derived from this rock is predicted to be well-suited to a broad range of engineering applications provided the stated high risk of ASR in concrete can be accommodated in mix design and appropriate measures can be taken in terms of dust suppression due to the high free silica content inherent to all quartzites. The highly competent nature of the rock is also likely to increase wear on crushing and processing equipment.

A mode based on a count of 200 widely spaced points is listed in Table 2- Modal Analysis of Minerals.

Table 2 – Modal Analysis of Minerals

STRONG MINERALS	MODE (per cent)	COMMENTS
Quartz	74	0.2 to 0.5mm sutured grains or finely annealed crystals
Feldspar	21	Including plagioclase and microcline variants
Opaques	1	Occurring as magnetite/ilmenite with progressive leucoxene alteration and associated sphene
Zircon	Trace	Rare quartz inclusions
Apatite	Trace	Fine filament inclusions
WEAK MINERALS		
Calcite	2	Occurring as euhedral crystals throughout the rock
Muscovite	1	As fine interstitial mica
Goethite	Minor	Fine 0.01mm sub-opaque botryoids associated with altered opaques
Iron oxide	Minor	Emanative ferruginous staining associated with opaques
TOTAL	100	Balance accounted for by minor and trace phases

Summary

Pending material testing, the quartzite is regarded as suitable for use as Coarse Aggregate in Concrete (provided account is made in mix design for the stated potential for ASR) and Unbound Pavements. The rock may also be suitable as Cover Aggregate and Asphalt following bitumen affinity and Polished Aggregate Friction Value (PAFV) testing. The rock is also suitable for use as marine armour, gabion and revetment if large enough blocks can be recovered. Extensive crushing is expected to produce quality manufactured sand. The highly competent nature of the quartzite may result in increased wear on crushing and processing equipment.

For engineering purposes the rock may be summarised as:

- Quartzite, a metamorphic rock.
- Essentially unweathered and non-porous.
- Composed principally of robust and comprehensively consolidated grains with subordinate weak metamorphic or weathering products.
- Very hard and of expected extremely high strength and superior durability.
- Containing 74% free silica.
- Presenting risk of significant ASR in concrete.
- Exposure of ferruginous material to cement paste may result in staining.
- Quartzite's such as this may present a risk of separation from cement paste if used as concrete aggregate due to heavy strain among constituent grains.

Free Silica Content

74% free silica content.

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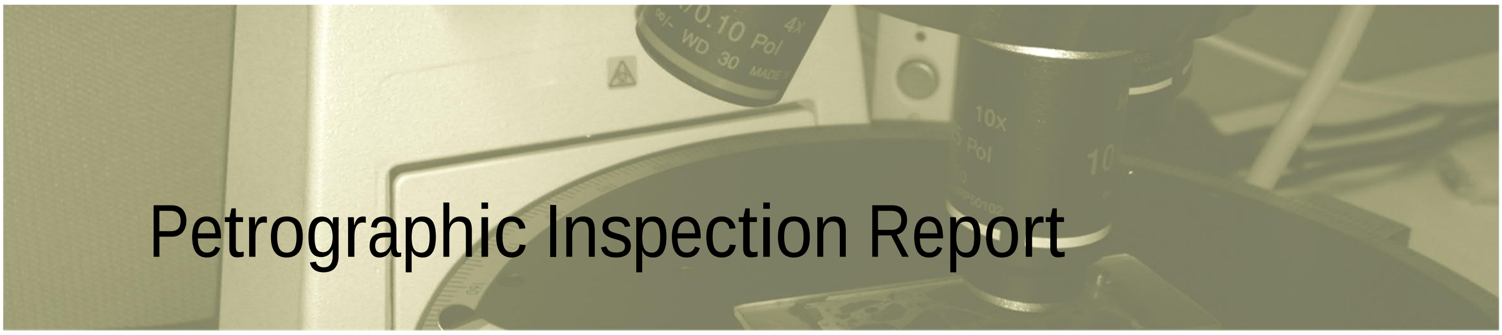
Enquiries regarding the content of this report should be directed to Groundwork Plus 07 3871 0411

Samples are disposed of after 3 months from the date of report. Thin sections will remain on site indefinitely.



Petrographic Inspection Report

Title:	Petrographic Inspection Report
Prepared for:	Hanson Construction Materials Pty Ltd
Date Sampled:	19/02/2018
Sample Type:	Spall
Source:	White Rock Quarry – Adelaide Hills, South Australia
Sample ID:	Cave
Date of Inspection:	22/03/2018
Report Issued:	04/04/2018
Project/ File Ref.:	P2018_0014_002v1

Author:

Luke Ryan (BGeo)
Geologist,
Groundwork Plus

Reviewer:

Rod Huntley (BSc, M.App.Sc, M.Eng)
Principal Resource Consultant,
Groundwork Plus

Rock Identity

Name: Quartzite

Lithology Metamorphic Rock

Introduction

This report provides the results of a general petrographic assessment of a spall sample which was submitted to the Groundwork Plus petrographic laboratory and describes the method and standards used to assess the sample. The thin section was prepared and analysed by Groundwork Plus with instructions from the client to conduct petrographic testing to ASTM C295 and recommend further testing if significant deleterious characteristics are identified pursuant to Clause 16.3 of this standard. The spall was sampled by the client and sectioned at the Groundwork Plus petrographic facility. The provided modal mineral percentages relate to the supplied sample which is understood to be representative of material on site. Assessment regarding the Alkali-Silica Reactivity (ASR) potential of the aggregate has been advised by AS1141.65-2008 and is communicated pursuant to Clause 9. Communication of findings are advised by AS 1726-1993 Geotechnical Site Investigations.

Method

The petrographic assessment of the slide was carried out using a Nikon polarising microscope equipped with a digital camera at the Groundwork Plus petrographic laboratory. A photograph of the hand specimen and thin section photomicrographs showing grain sizes and any particular aspects of the minerals were included as part of the report (Plates 1, 2, and 3). Modal analysis was conducted on the sample using JMicroVision image analysis software on 200 points (Table 2 – Modal Analysis of Minerals).

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Interpretation

- The supplied rock sample is identified as Quartzite, a Metamorphic Rock.

- In hand sample the spall is described as a brown, siliceous rock displaying coarsely sacharoidal fractures and distinctly voided sections with ubiquitous ferruginous staining. Quartz infills many fractures as combed white veining and haematitic veins are accompanied by muscovite and large voids. Weathered feldspar grains occur as white grains amid the quartzite's otherwise clear and brown intergrown quartzose matrix. While voided and displaying weathered ferruginous planes the sample represents essentially hard, strong and durable quartzite. Rare opaque and interstitial muscovite is detected as bright flakes measuring to 0.5mm. The rock is not appreciably magnetic and no sulfides are detected in hand sample.

- Petrographic analysis reveals the quartzite is comprised principally of robust recrystallised quartz crystals (69%), feldspar (19%), minor magnetite/ilmenite with accompanying interstitial muscovite (3%) goethite/haematitic staining along weathered fractures (3%) and argillic void infill or weathering of feldspars. While the rock shows slight to distinct weathering the bulk of the quartzite is unaffected as quartz. Inlcuding approximately 4% voids by volume.

- The sample contains 69% free silica in the form of heavily strained or finely annealed quartz. Duly, material represented by this sample is regarded as presenting risk significant Alkali-Silica Reactivity (ASR) in concrete.

- Pending material testing, the quartzite is regarded as suitable for use as Coarse Aggregate in Concrete (provided account is made in mix design for the stated potential for ASR) and Unbound Pavements. The rock may also be suitable as Cover Aggregate and Asphalt following bitumen affinity and Polished Aggregate Friction Value (PAFV) testing. Extensive crushing may liberate elevated weak phases including muscovite and ferruginous/argillic void infill. The highly competent nature of the quartzite may result in increased wear on crushing and processing equipment.

- For engineering purposes the rock may be summarised as:

  - Quartzite, a metamorphic rock.
  - Slightly to distinctly weathered and including approximately 4% voids by volume.
  - Composed principally of robust and comprehensively consolidated grains with subordinate weak metamorphic or weathering products.
  - Very hard and of expected extremely high strength and superior durability.
  - Containing 69% free silica as heavily strained quartz.
  - Presenting risk of significant ASR in concrete.
  - Exposure of ferruginous material to cement paste may result in staining.
  - Quartzite's such as this may present a risk of separation from cement paste if used as concrete aggregate due to heavy strain among constituent grains.

Table 1 – Risk Rating for Specific Applications and Source Rock Quality

Risk Rating for Application	Low	Mod	High	Comments (Pending material testing results and assuming the sample is indicative of overall source rock quality)
Coarse Aggregate in Concrete		✓		Composed principally of robust phases but ferruginous material and micas may be released with crushing which may have a cosmetic implications for concrete finishes. Universal heavy strain among quartz grains can result in separation of aggregate from cement paste
Unbound Pavements	✓			Suitable high strength, hard and durable material provided weak ferruginous/micaceous planes are fully exploited by crushing
Cover Aggregate		✓		Mechanically suitable provided weak ferruginous/micaceous panes are fully exploited by crushing
Graded Asphalt Aggregate		✓		Mechanically suitable provided weak ferruginous/micaceous panes are fully exploited by crushing
Manufactured Sand		✓		Increased weak ferruginous and micaceous phases may be liberated by extensive crushing
Risk Rating Source Rock	**Low**	**Mod**	**High**	
Alkali Silica Reactivity			✓	Risk of significant ASR in concrete associated with heavily strained quartzites
Weak/secondary Mineral Impacts	✓			7% weak phases generally texturally isolated by competent siliceous grains
Durability		✓		Suitable provided weak ferruginous/micaceous panes are fully exploited by crushing
Strength		✓		Suitable provided weak ferruginous/micaceous panes are fully exploited by crushing
Hardness	✓			Suitable
Voids		✓		Common voids associated with weak ferruginous and micaceous phases
Fractures		✓		Ferruginous and micaceous phases occupy weakened fracture planes. Exposure of ferruginous phases to cement paste may result in staining
Bitumen affinity		✓		Coarsely grained siliceous rock can be associated with sub-optimal bitumen affinity. Bitumen affinity testing recommended prior to allocation to cover aggregate
Polishing		✓		Sacharoidal fracture faces likely to offset tendency of siliceous material to polish in service
Free Silica Content			✓	69% as quartz
Sulfides	✓			None observed
Light micaceous particles	✓			Subordinate fine texturally isolated muscovite

*Low risk means a low probability of causing source rock related issues in regard to material performance in any particular applications. Risk is recommended to be considered in conjunction with a sampling frequency protocol for production of any particular product.

Plate 1: Photograph displaying sectioned face of the quartzite including medium and coarse grain size of constituent quartz and feldspar as well as a pervasive network of ferruginous veins and associated weathered voids.

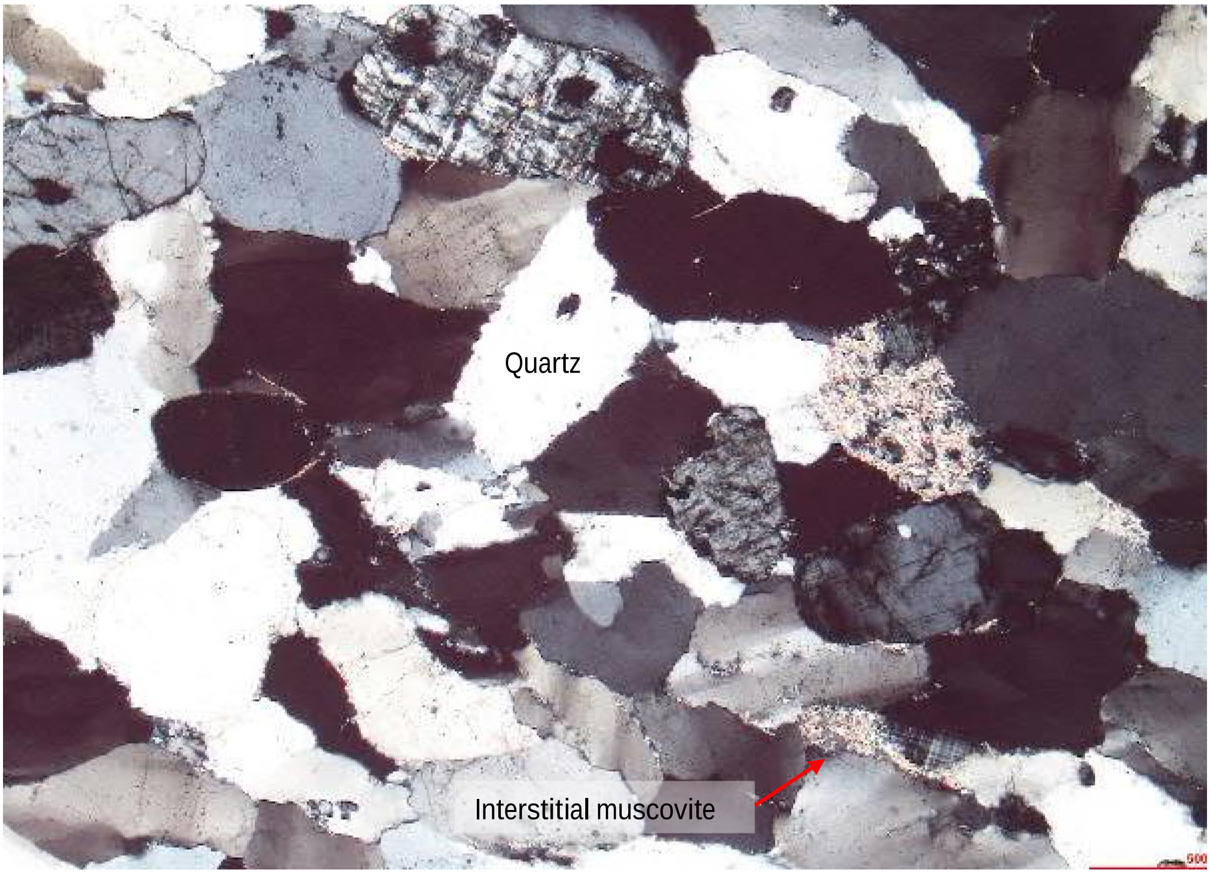

Plate 2: Microphotograph displaying representative mineral assembly of the quartzite including abundant quartz and subordinate feldspar grains with interstitial metamorphic muscovite. Image shown in cross polarised light.

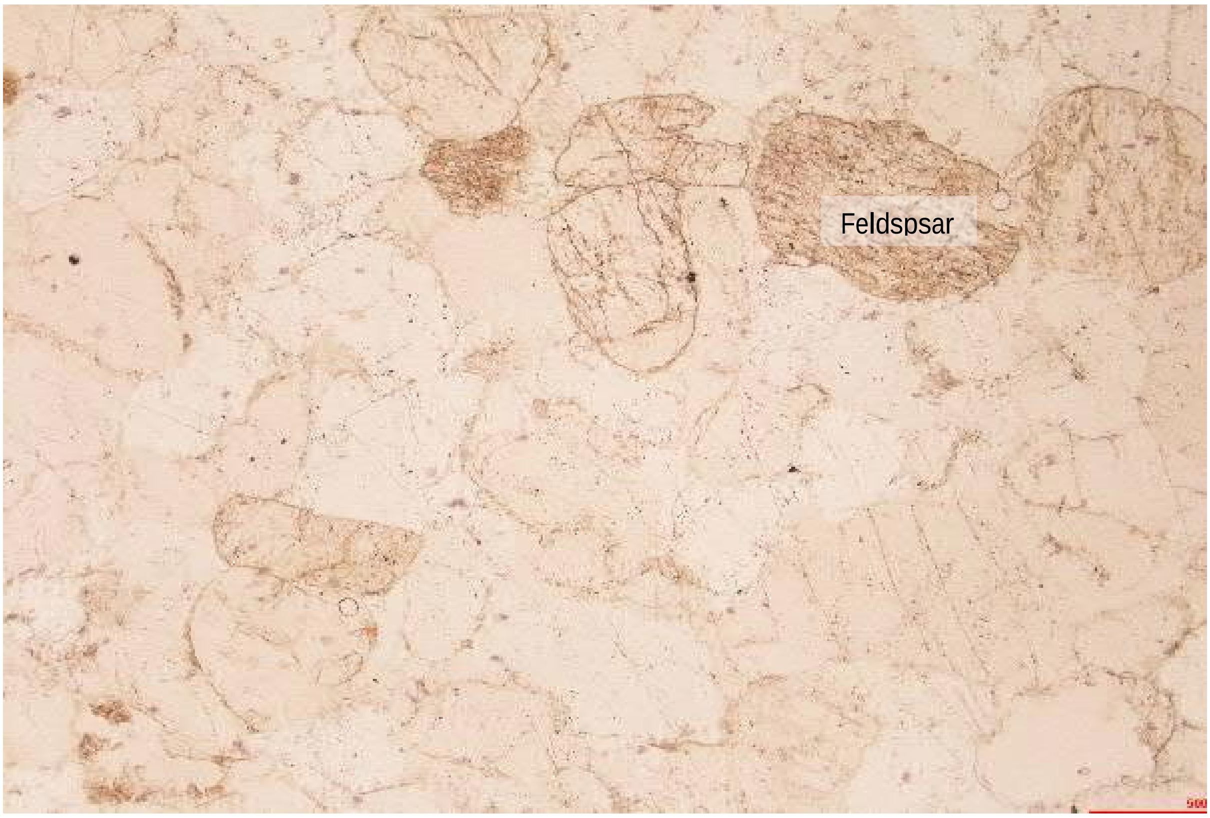

Plate 3: Microphotograph utilising plane polarised light to better distinguish dusty feldspar profiles from clear quartz and illustrate calcite, opaque and rare zircon distributions within the quartzite.

Thin Section Description

Petrographic analysis reveals that the spall represents a medium to coarsely grained quartzite, being the comprehensively metamorphosed equivalent of an arkose sandstone. Duly, the rock is comprised almost exclusively of 0.5 to 1.0mm quartz and feldspar grains with subordinate interstitial muscovite and fine 0.05mm magnetite/ilmenite opaques generally associated with emanative iron oxide staining, goethite and haematitic staining along weathered fracture planes and voids. Zircon and apatite inclusions are common among quartz grains. Weathered voids host earthy limonitic linings. Feldspar grains adjacent these weathered voids and fracture planes display more advanced argillisation and consequently are more prone to pocking out and abrasion with associated fine mica and ferruginous cements.

Quartz crystals which account for the majority of the observed rock show universal heavy strain, elongate parallel crystal shapes and suturing at interfaces producing erratic boundaries between quartz grains. Finely annealed quartz crystals occur at boundaries with feldspar grains which include pristine plagioclase and microcline varieties. These grains which composed the arkose sandstone protolith show mature development into a cohesive and highly competent quartzite with no labile micaceous planes. However, the network of ferruginous veins/fractures and weathered voids are likely to be exploited by crushing. Duly. aggregate derived from this rock is predicted to be well-suited to a broad range of engineering applications provided the stated high risk of ASR in concrete can be accommodated in mix design and appropriate measures can be taken in terms of dust suppression due to the high free silica content inherent to all quartzites. The highly competent nature of the rock is also likely to increase wear on crushing and processing equipment. While mechanical suitable for use as aggregate in concrete quartzite's may be prone to separation from cement paste due to the heavy strain contained within constituent quartz crystals.

A mode based on a count of 200 widely spaced points is listed in Table 2- Modal Analysis of Minerals.

Table 2 – Modal Analysis of Minerals

STRONG MINERALS	MODE (per cent)	COMMENTS
Quartz	69	0.5 to 1.0mm sutured grains with finely annealed crystals
Feldspar	19	Including plagioclase and microcline variants
Opaques	Minor	Occurring as magnetite/ilmenite with associated emanative ferruginous staining
Zircon	Trace	Rare quartz inclusions
Apatite	Trace	Fine filament inclusions
WEAK MINERALS		
Muscovite	3	As fine interstitial mica
Goethite/hematite	3	Fine 0.01mm sub-opaque botryoids associated with altered opaques
Argillic material	1	Weathered feldspars and loose material accompanying ferruginous material in fractures and voids
Calcite	Minor	Rare carbonate crystals inhabiting veins
Iron oxide	Minor	Emanative ferruginous staining associated with opaques
Voids	4	Barren or lined with argillic and ferruginous weathering products
TOTAL	100	Balance accounted for by minor and trace phases

Summary

Pending material testing, the quartzite is regarded as suitable for use as Coarse Aggregate in Concrete (provided account is made in mix design for the stated potential for ASR) and Unbound Pavements. The rock may also be suitable as Cover Aggregate and Asphalt following bitumen affinity and Polished Aggregate Friction Value (PAFV) testing. Extensive crushing may liberate elevated weak phases including muscovite and ferruginous/argillic void infill. The highly competent nature of the quartzite may result in increased wear on crushing and processing equipment.

For engineering purposes the rock may be summarised as:

- Quartzite, a metamorphic rock.
- Slightly to distinctly weathered and including approximately 4% voids by volume.
- Composed principally of robust and comprehensively consolidated grains with subordinate weak metamorphic or weathering products.
- Very hard and of expected extremely high strength and superior durability.
- Containing 69% free silica as heavily strained quartz.
- Presenting risk of significant ASR in concrete.
- Exposure of ferruginous material to cement paste may result in staining.
- Quartzite's such as this may present a risk of separation from cement paste if used as concrete aggregate due to heavy strain among constituent grains.

Free Silica Content

69% free silica content.

Groundwork Plus ABN: 13 609 422 791

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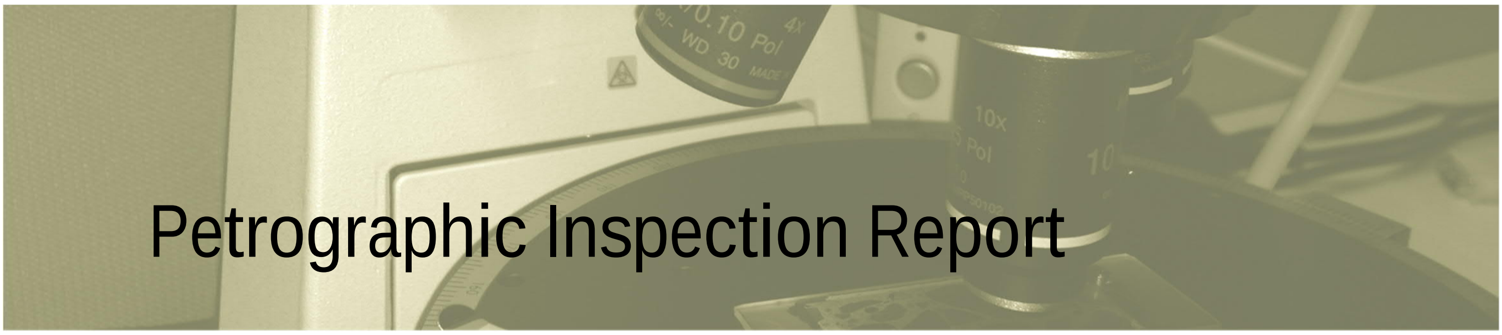

Petrographic Inspection Report

Title:	Petrographic Inspection Report
Prepared for:	Hanson Construction Materials Pty Ltd
Date Sampled:	19/02/2018
Sample Type:	Spall
Source:	White Rock Quarry – Adelaide Hills, South Australia
Sample ID:	Bottom Quarry
Date of Inspection:	22/03/2018
Report Issued:	04/04/2018
Project/ File Ref.:	P2018_0014_003v1

Author:

Luke Ryan (BGeo)
Geologist,
Groundwork Plus

Reviewer:

Rod Huntley (BSc, M.App.Sc, M.Eng)
Principal Resource Consultant,
Groundwork Plus

Rock Identity

Name:	Weathered Quartzite
Lithology	Metamorphic Rock

Introduction

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Method

The petrographic assessment of the slide was carried out using a Nikon polarising microscope equipped with a digital camera at the Groundwork Plus petrographic laboratory. A photograph of the hand specimen and thin section photomicrographs showing grain sizes and any particular aspects of the minerals were included as part of the report (Plates 1, 2, and 3). Modal analysis was conducted on the sample using JMicroVision image analysis software on 200 points (Table 2 – Modal Analysis of Minerals).

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Interpretation

- The supplied rock sample is identified as Quartzite, a Metamorphic Rock.

- In hand sample the spall is described as a coarsely grained, brown, siliceous rock displaying sacharoidal and distinctly voided sectioned and fractured faces with ubiquitous ferruginous staining and common fine interstitial muscovite. Thick quartz veins are common and are associated with weathered ferruginous infill and haematitic staining. Weathered feldspar grains occur occasionally as white grains amid the quartzite's otherwise clear and brown intergrown quartzose matrix. Fractured faces frequently show an earthy disaggregative nature with individual quartz and feldspar grains abrading easily. While much of the supplied rock appears hard, strong and durable the sample is highly variable and susceptible to crystal denudement and disaggregation in zones with a high incidence of interstitial muscovite and weathered ferruginous staining. The rock is not appreciably magnetic and no sulfides are detected in hand sample.

- Petrographic analysis reveals the quartzite is comprised principally of robust recrystallised quartz crystals (67%), feldspar (15%), minor remnant magnetite/ilmenite with accompanying interstitial muscovite (5%) goethite/haematitic staining along weathered fractures (4%), argillic void infill or weathering of feldspars (2%) and emanative to diffuse iron oxide staining. Including approximately 5% voids by volume.

- The sample contains 67% free silica in the form of heavily strained or finely annealed quartz. Duly, material represented by this sample is regarded as presenting risk significant Alkali-Silica Reactivity (ASR) in concrete.

- Pending material testing, the quartzite represented by this sample is regarded as suitable for use as Unbound Pavements but may be prohibitively variable in terms of its voids and mica content/distribution to produce aggregate in concrete. Extensive crushing is expected to liberate elevated weak phases including muscovite and ferruginous/argillic void infill. Weathered, voided and ferruginous rock is expected to facilitate crushing with commensurate liberation to fines of weak secondary phases.

- For engineering purposes the rock may be summarised as:

  - Quartzite, a metamorphic rock.
  - Distinctly weathered and including approximately 5% voids by volume.
  - Composed of robust quartz and feldspar grains but these are often isolated by weak micaceous and ferruginous cements (13%) which may facilitate crystal denudement and disaggregation.
  - Hard, of moderate overall strength and moderate durability.
  - Containing 67% free silica as heavily strained quartz.
  - Presenting risk of significant ASR in concrete.
  - Exposure of ferruginous material to cement paste may result in staining.
  - Quartzite's such as this may present a risk of separation from cement paste if used as concrete aggregate due to heavy strain among constituent grains as well as isolation of robust crystals by fine micas.

Table 1 – Risk Rating for Specific Applications and Source Rock Quality

Risk Rating for Application	Low	Mod	High	Comments (Pending material testing results and assuming the sample is indicative of overall source rock quality)
Coarse Aggregate in Concrete		✓		Robust quartz and feldspar frequently isolated by fine micas and ferruginous cements. Weak weathered planes abrade easily and present risk of disaggregation
Unbound Pavements	✓			Suitable high strength, hard and durable material provided weak ferruginous/micaceous planes are fully exploited by crushing
Manufactured Sand			✓	Increased weak ferruginous and micaceous phases may be liberated by extensive crushing
Risk Rating Source Rock	**Low**	**Mod**	**High**	
Alkali Silica Reactivity			✓	Risk of significant ASR in concrete associated with heavily strained quartzites
Weak/secondary Mineral Impacts	✓			13% weak phases generally texturally isolated by competent siliceous grains
Durability		✓		Suitable provided weak ferruginous/micaceous panes are fully exploited by crushing
Strength		✓		Suitable provided weak ferruginous/micaceous panes are fully exploited by crushing
Hardness	✓			Suitable
Voids		✓		Common voids 5% associated with weak ferruginous and micaceous phases
Fractures		✓		Ferruginous and micaceous phases occupy weakened fracture planes. Exposure of ferruginous phases to cement paste may result in staining
Free Silica Content			✓	67% as quartz
Sulfides	✓			None observed
Light micaceous particles		✓		Common fine isolating micas

*Low risk means a low probability of causing source rock related issues in regard to material performance in any particular applications. Risk is recommended to be considered in conjunction with a sampling frequency protocol for production of any particular product.

Plate 1: Photograph displaying sectioned and fractured face of the quartzite both of which exhibit the ferruginous and voided vein network characterises much of the rock. Constituent grains are generally coarse and recrystallised quartz account for much of the sample's veins.

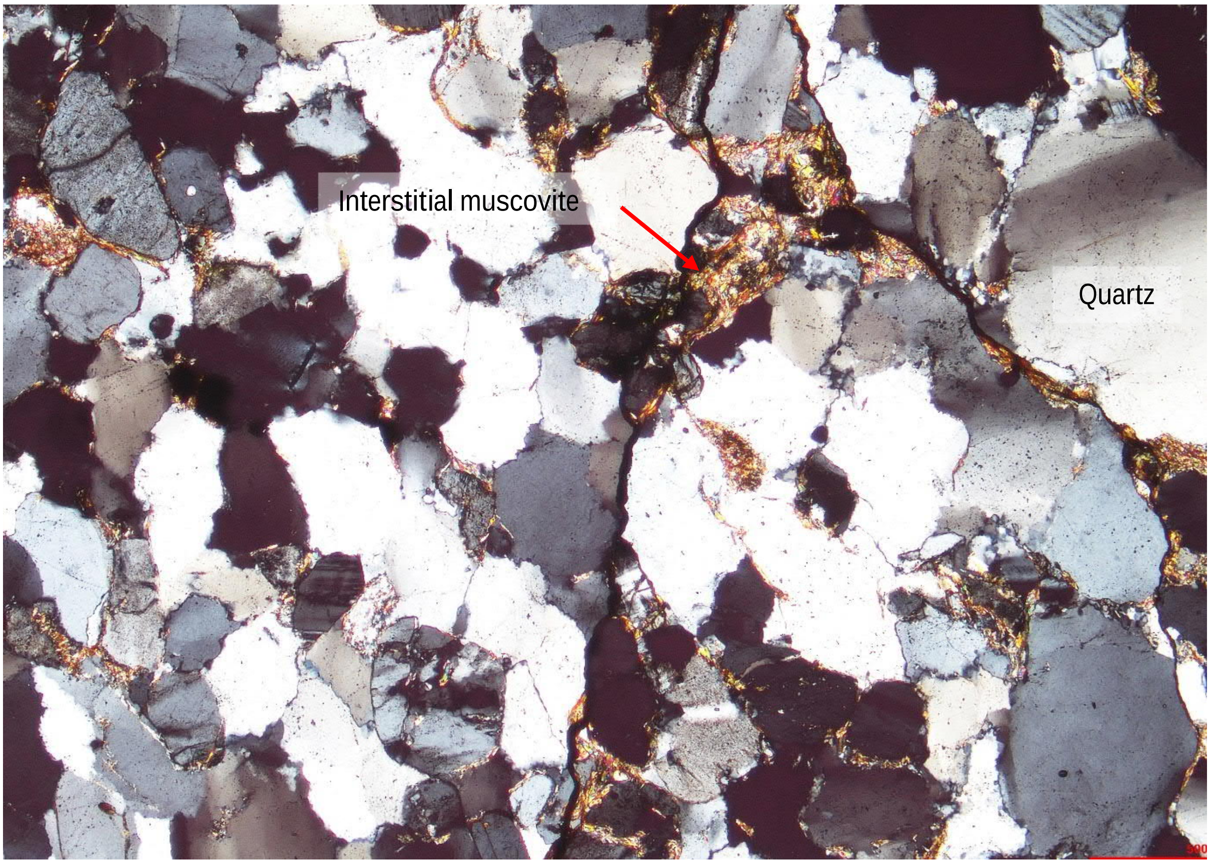

Plate 2: Microphotograph displaying representative mineral assembly of the quartzite being composed principally of heavily strained quarzt and feldspar grains and common interstitial muscovite and weathered ferruginous cements which also form vein networks. Image shown in cross polarised light.

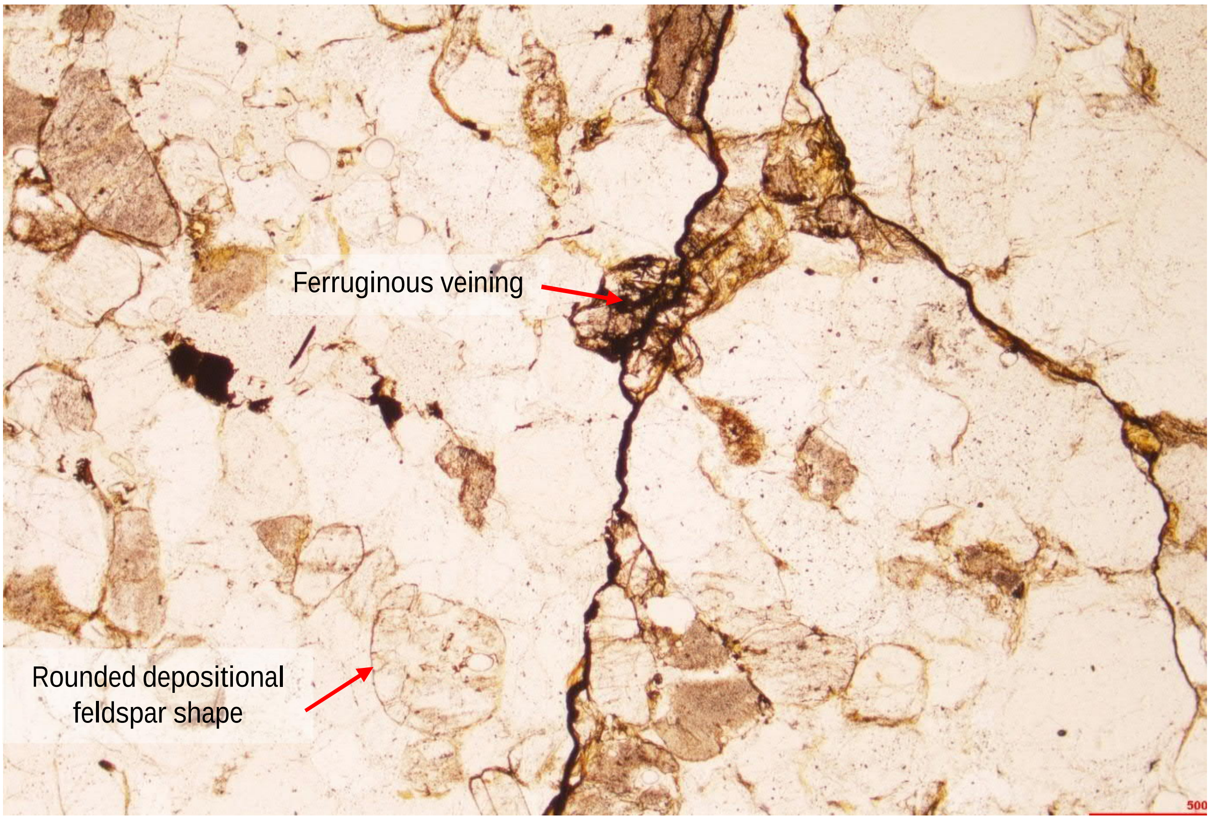

Plate 3: Microphotograph utilising plane polarised light to illustrate opaque particles and weathered ferruginous infill of fractures. Due to common accommodating interstitial micas feldspar grains frequently maintain depositional grain shapes which would otherwise be better consolidated into the fabric of the quartzite.

Thin Section Description

Petrographic analysis reveals that the spall represents a medium to coarsely grained quartzite, being the metamorphosed equivalent of an arkose sandstone. Duly, the rock comprises abundant 0.5 to 1.5mm quartz and feldspar grains with argillic cements metamorphosed to produce fine muscovite and fine remnant opaques as magnetite and goethite. While much of the rock's quartz and feldspar grains display cohesion through annealment and suturing metamorphic muscovite and weathered ferruginous material frequently isolate constituent grains and account for the hand sample's susceptibility to crystal denudement and disaggregation. This is particularly true of distinctly weathered rock indicated by increased void incidence/size and ferruginous staining. Sub-opaque ferruginous phases as goethite and hematite inhabit an erratic network of veins which is associated with the permeation of iron oxide, increased weathering among feldspars and argillic infill of associated voids.

Quartz crystals which account for the majority of the observed rock show universal heavy strain, elongate parallel crystal shapes and suturing at crystal interfaces. Finely annealed quartz crystals occur at boundaries with feldspar grains which include pristine plagioclase and microcline varieties. While these grains show mature development into a cohesive and essentially competent quartzite throughout much of the sampled rock, significant micaceous and ferruginous segregations and weathered voids represent weak porous material and are likely to be exploited by crushing and abrade easily. Duly. aggregate derived from this rock is predicted to be well-suited Unbound Pavements with separated fines augmenting binder in the product but may be too variable and porous to produce aggregate in concrete.

A mode based on a count of 200 widely spaced points is listed in Table 2- Modal Analysis of Minerals.

Table 2 – Modal Analysis of Minerals

STRONG MINERALS	MODE (per cent)	COMMENTS
Quartz	67	0.5 to 1.5mm sutured grains with finely annealed crystals
Feldspar	15	Including plagioclase and microcline variants
Opaques	Minor	Largely weathered and occurring as magnetite/ilmenite with associated secondary phases and staining
Zircon	Trace	Rare quartz inclusions
Apatite	Trace	Fine filament inclusions
WEAK MINERALS		
Muscovite	5	As finely composed interstitial mica commonly isolating quartz and feldspar grains
Goethite/hematite	4	Common vein infill with associated iron oxide staining
Argillic material	2	Weathered feldspars and loose material accompanying ferruginous material in fractures and voids
Iron oxide	1	Emanative and diffused ferruginous staining associated with and goethite
Calcite	Minor	Rare carbonate crystals inhabiting veins
Voids	5	Barren or lined with argillic and ferruginous weathering products
TOTAL	100	Balance accounted for by minor and trace phases

Summary

Pending material testing, the quartzite represented by this sample is regarded as suitable for use as Unbound Pavements but may be prohibitively variable in terms of its voids and mica content/distribution to produce aggregate in concrete. Extensive crushing is expected to liberate elevated weak phases including muscovite and ferruginous/argillic void infill. Weathered, voided and ferruginous rock is expected to facilitate crushing with commensurate liberation to fines of weak secondary phases.

For engineering purposes the rock may be summarised as:

- Quartzite, a metamorphic rock.
- Distinctly weathered and including approximately 5% voids by volume.
- Composed of robust quartz and feldspar grains but these are often isolated by weak micaceous and ferruginous cements (13%) which may facilitate crystal denudement and disaggregation.
- Hard, of moderate overall strength and moderate durability.
- Containing 67% free silica as heavily strained quartz.
- Presenting risk of significant ASR in concrete.
- Exposure of ferruginous material to cement paste may result in staining.
- Quartzite's such as this may present a risk of separation from cement paste if used as concrete aggregate due to heavy strain among constituent grains as well as isolation of robust crystals by fine micas.

Free Silica Content

67% free silica content.

Groundwork Plus ABN: 13 609 422 791

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Enquiries regarding the content of this report should be directed to Groundwork Plus 07 3871 0411

Samples are disposed of after 3 months from the date of report. Thin sections will remain on site indefinitely.

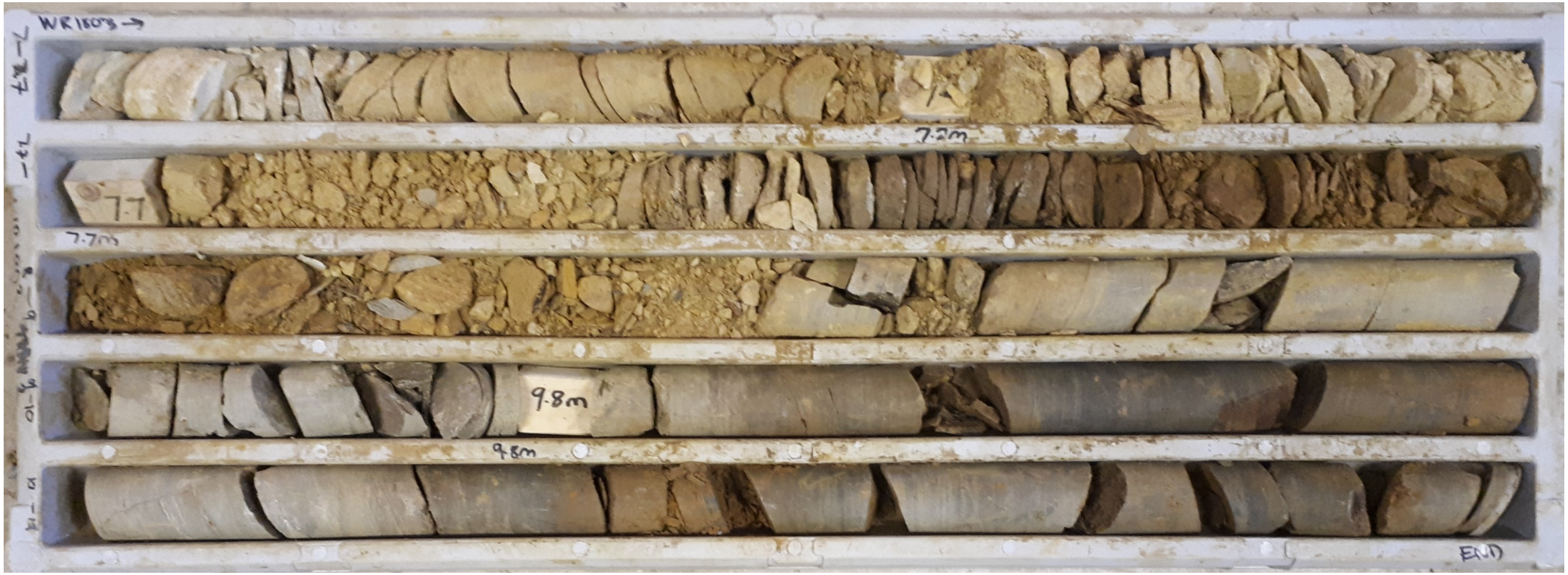
Attachment 4

Drill Core Photos

WR1803 290369E 6132891N

WR1803 0 to 7m

WR1803 290369E 6132891N



WR1803 7 to 11.2m

WR1803 290369E 6132891N

WR1803 11.2 to 16m

WR1803 **290369E 6132891N**

WR1803 **17 to 20m**

WR1803 290369E 6132891N

WR1803 20 to 24.2m

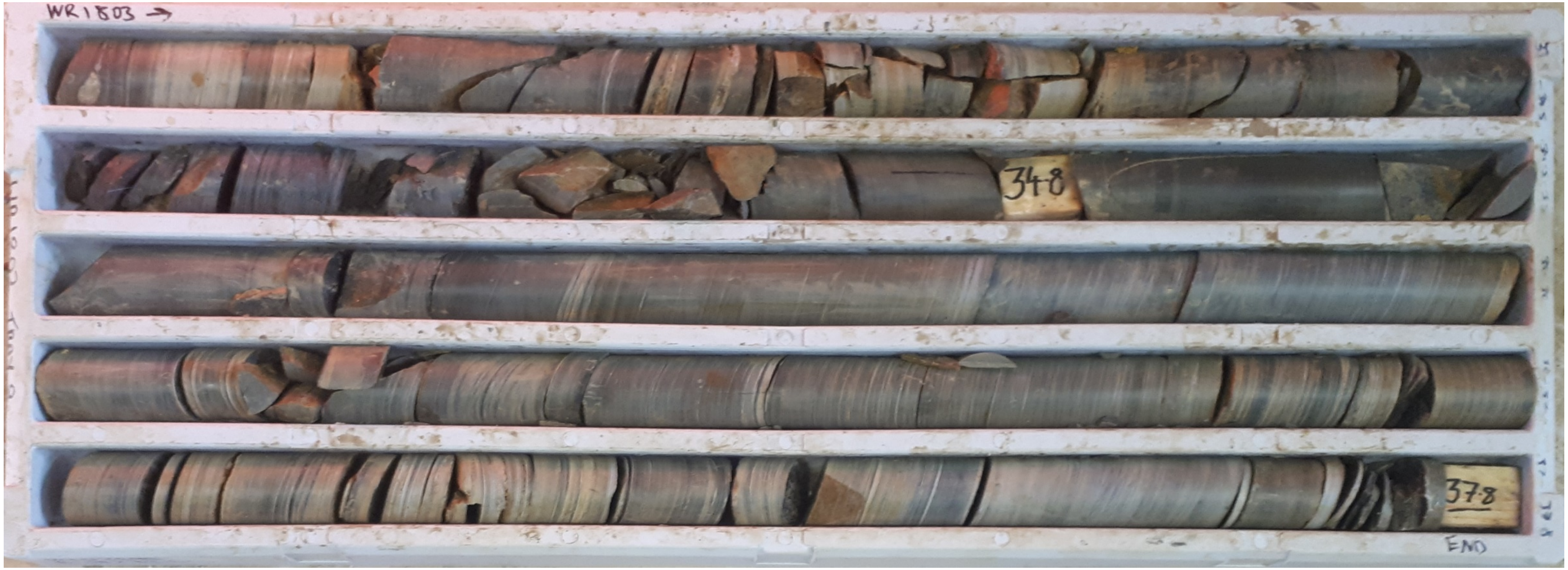
WR1803 290369E 6132891N

WR1803 24.2 to 29m

WR1803 290369E 6132891N

WR1803 29 to 33.5m

WR1803 290369E 6132891N



WR1803 33.5 to 37.8m

WR1803 290369E 6132891N

WR1803 37.8 to 42.5m

WR1803 290369E 6132891N

WR1803 42.5 to 47m

WR1803 290369E 6132891N

WR1803 47 to 51.2m

WR1803 290369E 6132891N

WR1803 51.2 to 56m

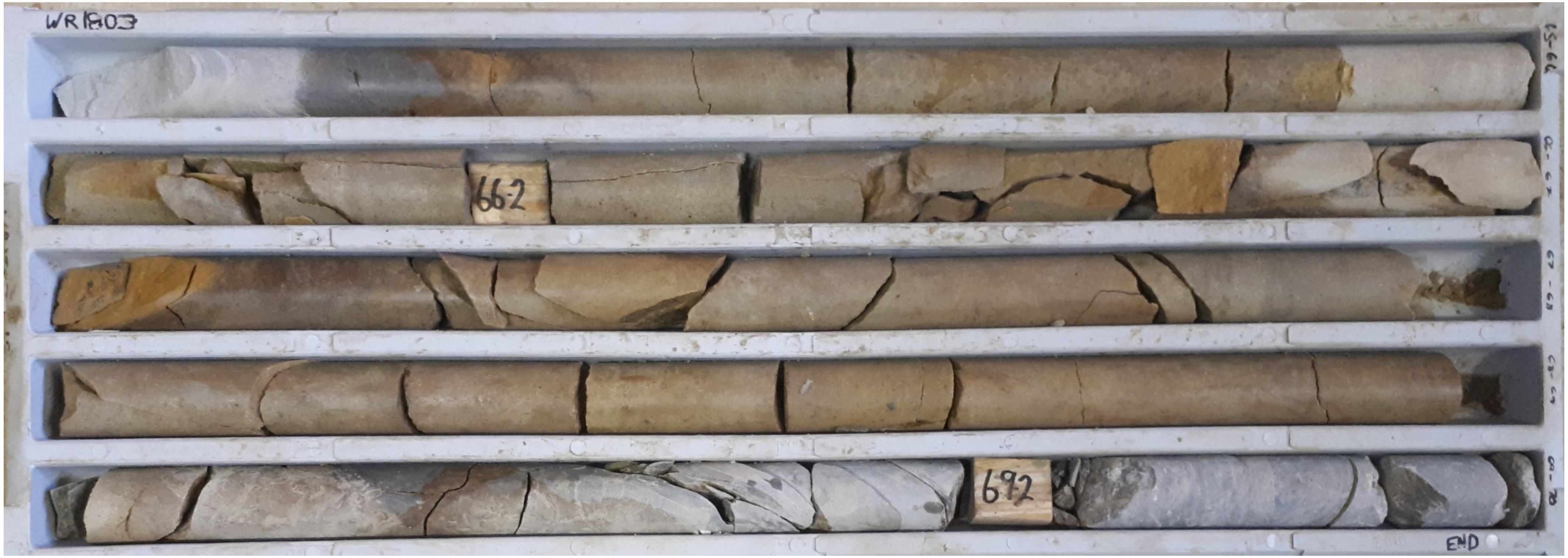
WR1803 290369E 6132891N

WR1803 56 to 60.4m

WR1803 290369E 6132891N

WR1803 60. 4to 65m

WR1803 290369E 6132891N



WR1803 65 to 69.5m

WR1803 290369E 6132891N

WR1803 69.5 to 74m

WR1803 290369E 6132891N

WR1803 74 to 78.5m

WR1803 **290369E 6132891N**

WR1803 **78.5 to 83m**

WR1803 290369E 6132891N

WR1803 83 to 87m

WR1803 290369E 6132891N

WR1803 87 to 91.5m

WR1803 290369E 6132891N

WR1803 91.5 to 96m

WR1803 290369E 6132891N

WR1803 96 to 101m

WR1803 290369E 6132891N

WR1803 101 to 105m

WR1803 **290369E 6132891N**

WR1803 **105 to 109.5m**

WR1803 290369E 6132891N

WR1803 109.5 to 113.8m

WR1803 290369E 6132891N

WR1803 113.8 to 118.5m

WR1803 290369E 6132891N

WR1803 118.5 to 123m

WR1803 290369E 6132891N

WR1803 123 to 127.5m

WR1803 290369E 6132891N

WR1803 127.5 to 132m

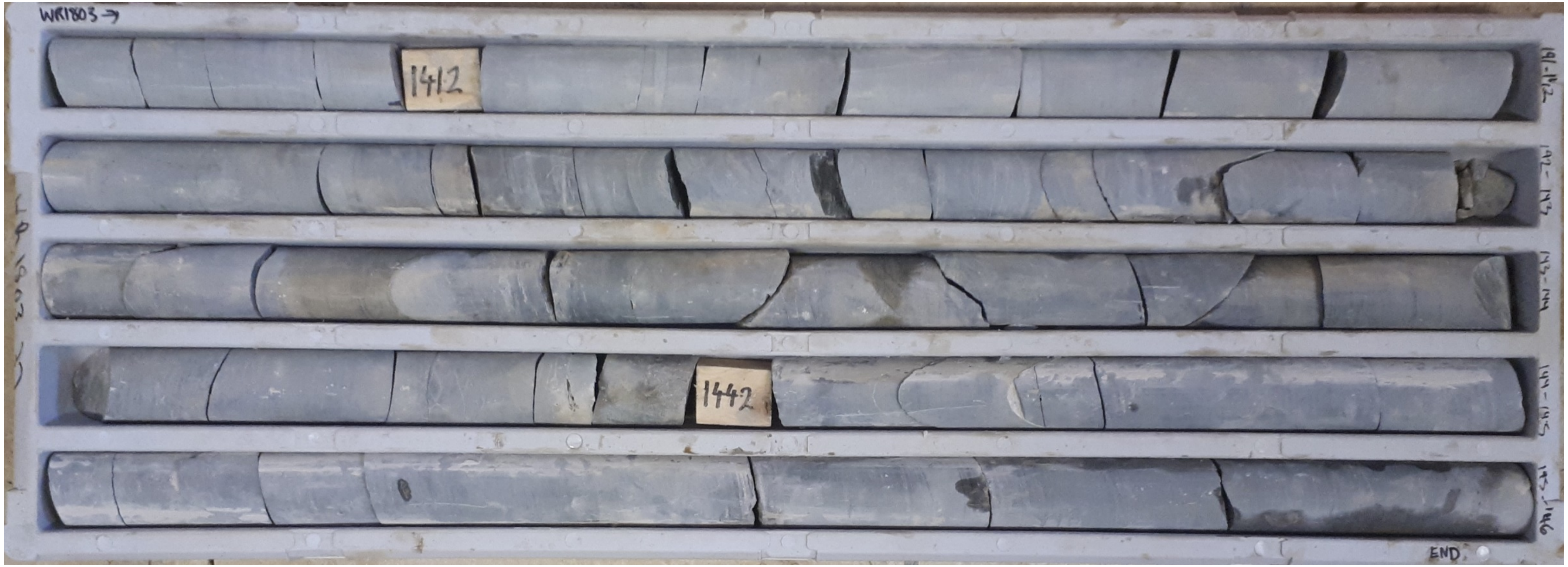
WR1803 290369E 6132891N

WR1803 132 to 136.5m

WR1803 290369E 6132891N

WR1803 136.5 to 141m

WR1803 290369E 6132891N



WR1803 141 to 146m

WR1803 **290369E 6132891N**

WR1803 **146 to 150m**

WR1805 290544E, 6132941N

WR1805 2 to 6m

WR1805 **290544E, 6132941N**

WR1805 **6 to 9.5m**

WR1805 290544E, 6132941N

WR1805 9.5 to 12.3 m

WR1805 290544E, 6132941N

WR1805 12.3 to 16m

WR1805 290544E, 6132941N

WR1805 16 to 19.1m

WR1805 **290544E, 6132941N**

WR1805 **19.1 to 22.4m**

WR1805 290544E, 6132941N

WR1805 22.4 to 28m

WR1805 290544E, 6132941N

WR1805 28 to 35m

WR1805 290544E, 6132941N

WR1805 35 to 40m

WR1805 290544E, 6132941N

WR1805 40 to 45.5m

WR1805 290544E, 6132941N

WR1805 45.5 to 53m

WR1805 290544E, 6132941N

WR1805 53 to 57.5m

WR1805 290544E, 6132941N

WR1805 57.5 to 61.8m

WR1805 290544E, 6132941N

WR1805 61.8 to 66.5m

WR1805 290544E, 6132941N

WR1805 66.5 to 70.9m

WR1805 290544E, 6132941N

WR1805 70.9 to 75.5m

WR1805 290544E, 6132941N

WR1805 75.5 to 79.5m

WR1805 290544E, 6132941N

WR1805 79.5 to 84m

WR1805 290544E, 6132941N

WR1805 84 to 88.5m

WR1805 290544E, 6132941N

WR1805 88.5 to 93.1m

WR1805 290544E, 6132941N

WR1805 93.1 to 98m

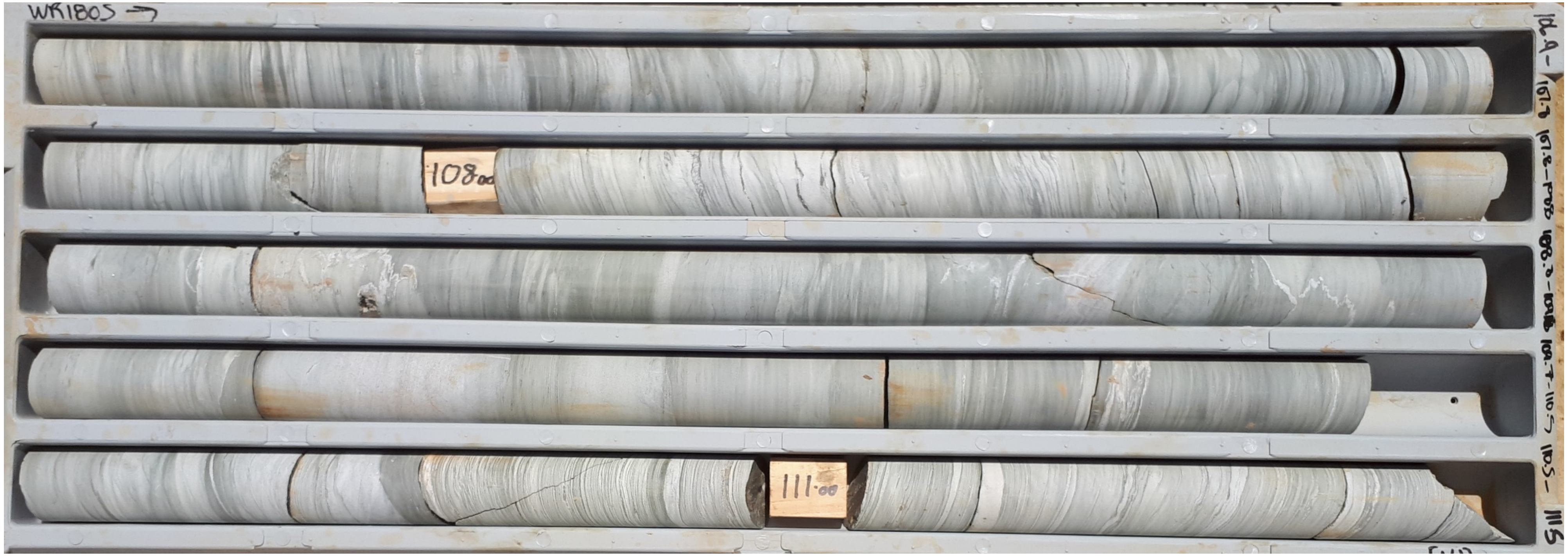
WR1805 290544E, 6132941N

WR1805 98 to 102.5m

WR1805 290544E, 6132941N

WR1805 102.5 to 106.9m

WR1805 **290544E, 6132941N**



WR1805 **106.9 to 111.5m**

WR1805 290544E, 6132941N

WR1805 111.5 to 116m

WR1805 290544E, 6132941N

WR1805 116 to 120.5m

WR1805 290544E, 6132941N

WR1805 120.5 to 125.2m

WR1805 290544E, 6132941N

WR1805 125.2 to 130m

WR1805 290544E, 6132941N

WR1805 130 to 134.8m

WR1805 290544E, 6132941N

WR1805 134.8 to 139.4m

WR1805 290544E, 6132941N

WR1805 139.4 to 143.8m

WR1805 290544E, 6132941N

WR1805 143.8 to 148.5m

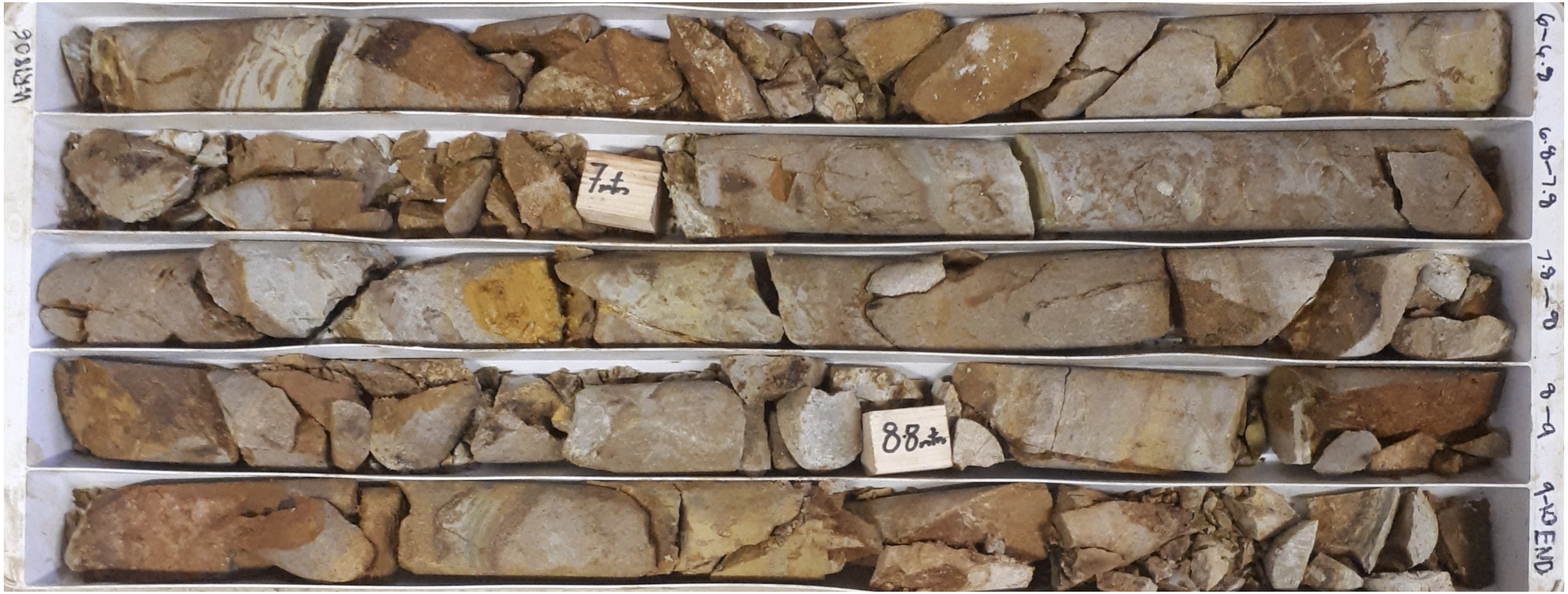
WR1805 290544E, 6132941N

WR1805 148.5 to 150m

WR1806 290797E 6133095N

WR1806 0 to 6m

WR1806 290797E 6133095N



WR1806 6 to 10m

WR1806 290797E 6133095N

WR1806 10 to 14m

WR1806 290797E 6133095N

WR1806 14 to 18m

WR1806 290797E 6133095N

WR1806 18 to 22m

WR1806 290797E 6133095N

WR1806 22 to 26m

WR1806 290797E 6133095N

WR1806 26 to 32.5m

WR1806 290797E 6133095N

WR1806 32.5 to 38.5m

WR1806 290797E 6133095N

WR1806 38.5 to 45.5m

WR1806 290797E 6133095N

WR1806 45.5 to 50.2m

WR1806 290797E 6133095N

WR1806 50.2 to 55m

WR1806 290797E 6133095N

WR1806 55 to 59m

WR1806 290797E 6133095N

WR1806 59 to 63m

WR1806 290797E 6133095N

WR1806 63 to 67.8m

WR1806 290797E 6133095N

WR1806 67.8 to 72m

WR1806 290797E 6133095N

WR1806 72 to 76.3m

WR1806 290797E 6133095N

WR1806 76.3 to 80.7m

WR1806 290797E 6133095N

WR1806 80.7 to 84.6m

WR1806 290797E 6133095N

WR1806 84.6 to 88.9m

WR1806 290797E 6133095N

WR1806 88.9 to 94.5m

WR1806 290797E 6133095N

WR1806 94.5 to 100m

WR1806 290797E 6133095N

WR1806 100 to 104m

WR1806 **290797E 6133095N**

WR1806 **104 to 108.5m**

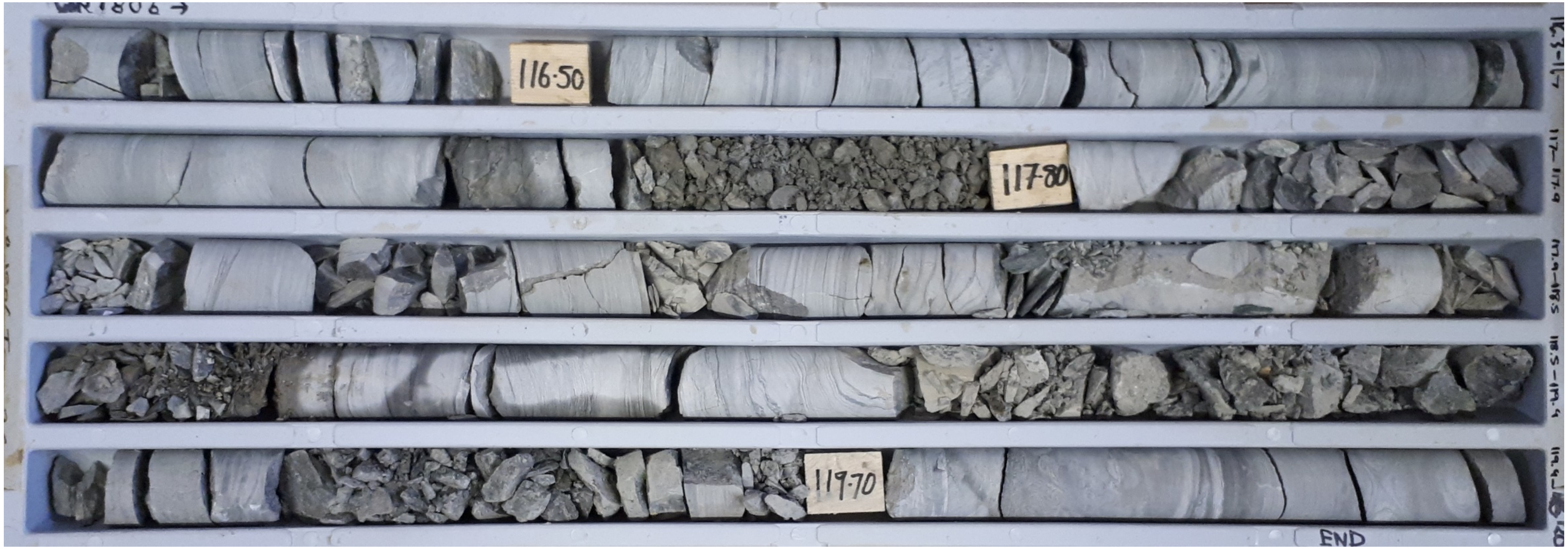
WR1806 290797E 6133095N

WR1806 108.5 to 112.5m

WR1806 290797E 6133095N

WR1806 112.5 to 116.3m

WR1806 290797E 6133095N



WR1806 116.3 to 120m

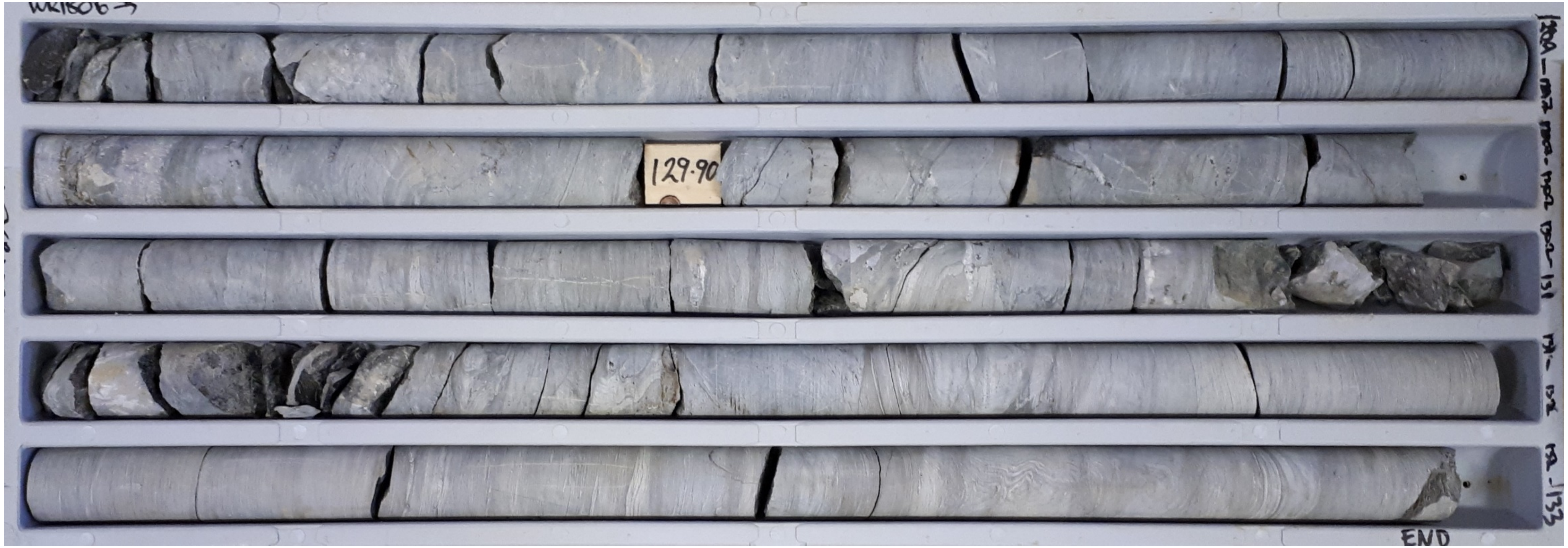
WR1806 290797E 6133095N

WR1806 120 to 123.5m

WR1806 290797E 6133095N

WR1806 123.5 to 128m

WR1806 290797E 6133095N



WR1806 128 to 133m

WR1806 290797E 6133095N

WR1806 133 to 141m

WR1806 290797E 6133095N

WR1806 141 to 144.6m

WR1806 290797E 6133095N

WR1806 144.6 to 149.8m

WR1806 290797E 6133095N

WR1806 149.8 to 150m

Attachment 5

JORC 2012 Commentary

JORC 2012 Summary

Geological Modelling Methodology

Introduction

As the basis to complete a resource estimate the geology of the site is interpreted and a digital model is generated of these interpreted conditions. This model includes the estimated thickness of overburden, the mapped changes in rock type and the continuity of the meta-sedimentary resource. The model also includes relevant geological criteria to aid in estimating what the yields of various materials in the resource estimate will be. Resultantly and based on all of the available geological and engineering information, suitable lithology and weathering boundaries have been interpreted and wireframes constructed. Review and edit of the lithological and grade domains were carried out using the interactive modelling facilities in the Surpac mining software package. All modelling work was completed in the GDA 94 coordinate system .

Lithological Boundaries

Lithological or geological boundaries occur on site and mark the change between the various rock types at White Rock. The geology model used for the interpolation process is relatively simple in that the marble/Meta-Sedimentary is known to be relatively homogenous and consistent both vertically and laterally, dipping to the south at approximately 11^0.

A thin layer of variable thickness topsoil generally overlies most of the Meta-Sedimentary units with the thickness of this material increasing both to the east and west as well as significantly to the north.

A transitional zone exists between the top of the Meta-Sedimentary and the unweathered material this layer has been modelled as a separate domain. It is of variable thickness and was modelled using a combination of lithological logging and weathering constraints.

These above units make up the separate domains that have been modelled and used as separate constraining blocks in Surpac for resource calculation purposes.

Surface Topography

The surface topography model used to constrain the block model is based on data from aerial photography acquired in July 2022. The images were orthorectified using Inpho Orthomaster software and correlated DEM surface. Accuracy is reported at 0.25m in the horizontal plane and 0.22m in the vertical plane.

Resource Estimation

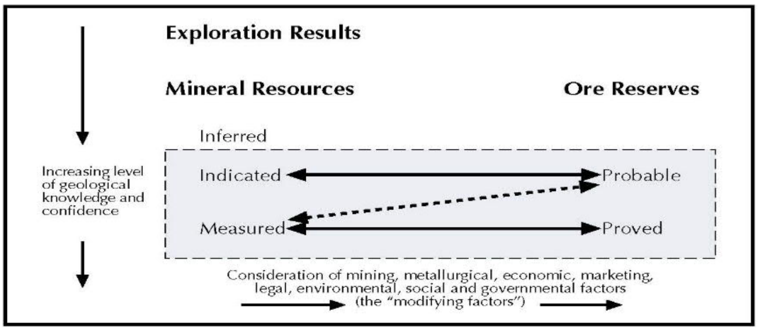
To estimate the various volumes and tonnages of material in the various pit designs considered in this report the following design criteria were used.

Criteria Used

- Measured Bulk Density of pit area Meta-Sedimentary units in situ 2.7 t/m^3;
- Estimated Bulk Density of distinctly weathered Meta-Sedimentary in situ 2.4 t/m^3;
- Estimated Bulk Density of overburden in situ 1.8 t/m^3;
- Maximum Pit Slope angle 38º; and
- Topography based on the Aerial survey completed by Hanson July 2022.

Resultant of the completed work is that the resource can be categorised under JORC 2012 as being a combination of *Measured Indicated and Inferred Resources*. Following is the classification system as set out in the JORC 2012 which is the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves.

Table 2: JORC 2012 Resource Diagram



The resource estimate is based on in-situ volumes. The actual product yield will depend on a number of factors including, (but not limited to), final pit design, geotechnical conditions, unsaleable product, and losses due to mining, sales mix, plant configuration, haul road location and other diluting factors.

Geological mapping and drilling campaigns have assisted in defining the nature and extent of rock resources at the site and from this work an adequate appreciation of rock resources was obtained.

The estimates of exploitable rock resources at the site are based primarily on available geological data, all borehole data, and a considered final development plan for the quarry taking potential constraints which may affect the project into consideration.

It should be noted that lithological, structural, and weathering characteristics of rock deposits such as those which occur at this site are variable and may change over relatively short distances both laterally and with depth. Data interpretation has required certain assumptions to be made and development planning has required adoption of certain operational parameters which could be subject to change as quarrying progresses.

Geological Modelling

To determine the volume of aggerate quality material available the weathering profile of the resource has been modelled in three dimensions, using Surpac mining software, based on pit exposures and drill hole information. To simplify the modelling process, the weathering classifications have been grouped into the following classes based on similar physical properties:

- fresh to slightly weathered;
- distinctly weathered; and
- extremely weathered to residual soil.

Block Model Construction

A 3D block model was constructed for the resource for the purposes of defining volumetric totals for each weathering class within the defined development plan. Block model development was completed using Surpac Mining Software.

A series of variables were incorporated into the block model for recording attributes assigned throughout development of the block model. The coding was assigned on the basis of the topographical, weathering class, and development plan wireframes.

Assumptions and Parameters

The resource estimate provided assumes that:

- the limits of quarrying are in keeping with the area currently gazetted for extraction;

- the resource has acceptable lithological uniformity and general weathering characteristics as indicated by exposure and drilling results;
- the engineering properties of the various source rock types quarried are adequately reflected by the materials testing results;
- the lowest extraction elevations for the quarry at this point in time are as per the MOP approved long term pit, although some material which is currently not included in the resource inventory does exist below the currently modelled pit; and
- the development as proposed meets development approval and other statutory requirements and is carried out in accordance with accepted quarry practice.

Resource Classification

Following is the classification system as set out in the JORC 2012 which is the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves.

A 'Measured Mineral Resource' is that part of a Mineral Resource for which tonnage, densities, shape, physical characteristics, grade, and mineral content can be estimated with a high level of confidence. It is based on detailed and reliable exploration, sampling and testing information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings, and drill holes. The locations are spaced closely enough to confirm geological and/or grade continuity.

Measured Resources are estimated from geological mapping combined with borehole data and topographic data.

An 'Indicated Mineral Resource' is that part of a Mineral Resource for which tonnage, densities, shape, physical characteristics, grade, and mineral content can be estimated with a reasonable level of confidence. It is based on exploration, sampling and testing information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings, and drill holes. The locations are too widely or inappropriately spaced to confirm geological and/or grade continuity but are spaced closely enough for continuity to be assumed.

The resource confidence assigned to each unit is at the discretion of the Competent Person to determine what is the most robust category to define the resource and in considering all other salient factors that may influence the resource.

An 'Inferred Mineral Resource' is that part of a Mineral Resource for which tonnage, grade and mineral content can be estimated with a low level of confidence. It is inferred from geological evidence and assumed but not verified geological and/or grade continuity. It is based on information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings, and drill holes which may be limited or of uncertain quality and reliability.

An Inferred Resource is estimated from widely spaced surface drilling and surface geological mapping. An 'Ore Reserve' is the economically mineable part of a Measured or Indicated Mineral Resource. It includes diluting materials and allowances for losses which may occur when the material is mined. Appropriate assessments which may include feasibility studies, have been carried out and include consideration of and modification by realistically assumed mining, metallurgical, economic, marketing, legal, environmental, social, and governmental factors. These assessments demonstrate at the time of reporting that extraction could reasonably be justified.

Ore Reserves are sub-divided in order of increasing confidence into Probable Ore Reserves and Proven Ore Reserves. A 'Proven Ore Reserve' is the economically mineable part of a Measured Mineral Resource. It includes diluting materials and allowances for losses which may occur when the material is mined. Appropriate assessments, which may include feasibility studies, have been carried out, and include consideration of and modification by realistically assumed mining, metallurgical, economic, marketing, legal, environmental, social, and governmental factors. These assessments demonstrate at the time of reporting that extraction could reasonably be justified.

A Probable Ore Reserve has a lower level of confidence than a Proven Ore Reserve. A 'Probable Ore Reserve' is the economically mineable part of an Indicated and in some circumstances Measured Mineral Resource. It includes diluting materials and allowances for losses which may occur when the material is mined. Appropriate assessments which may include feasibility studies, have been carried out and include consideration of and modification by realistically assumed mining, metallurgical, economic, marketing, legal, environmental, social, and governmental factors. These assessments demonstrate at the time of reporting that extraction could reasonably be justified.

Measured Resources are examined in 3D to determine the bench height, workable faces, and infrastructure costs. Bench ore blocks are designed which include dilution if this is deemed necessary. The resultant tabulation of reserves is termed Probable Ore Reserves. Due to the uncertainty which may attach to some Inferred Mineral Resources, it cannot be assumed that all or part of an Inferred Mineral Resource will be upgraded to an Indicated or Measured Mineral Resource as a result of continued exploration and development. Confidence in the estimate is usually not sufficient to allow the appropriate application of technical and economic parameters or to enable an evaluation of economic viability.

The measured resource estimate is based on in-situ volumes. The actual product yield will depend on a number of factors including (but not limited to) the variation in weathering and rock quality, site geology and variances in the block model, useable product, and losses due to mining, blasting method, extraction method, processing and plant configuration and location, basement elevation variations, haul road location and other diluting factors.

At the time of writing the Resource Estimate for the site is in the process of being updated however as described in the MOP significant volumes of material is potentially available for extraction. The final volume will depend upon what iteration of the pit has been used at the cessation of extraction.

Database Validation

As part of the resource estimation procedure, the database project was audited. As part of the process the original data, where available, was revisited for accuracy.   The resource categorisation has been based on the robustness of the various data sources available, including:

- geological knowledge and interpretation;
- confidence in sampling and materials testing data; and
- drilling density.

Attachment 31

Concrete Returns and Washout Resource Management Plan

White Rock Quarry

Concrete Returns & Washout Resource Management Plan

Issue	*Description*	*Date*	*Author*	*Reviewer*
0	White Rock Quarry - Concrete Returns & Washout Resource Management Plan	31 July 2022	A. Garzon	S. Seal

Prepared by Hanson Construction Materials Pty Ltd

31 July 2022

Table of Contents

1. Referenced Documentation / Information

Licensee	Hanson Construction Materials Pty Ltd
EPA Licence	12714
DEM Mine Operations Plan	MOP PM188
Site to which this plan applies	CT5549/847 F130081 A27 CT5549/844 F130079 A25 CT5258/251 F130945 Q1 CT5258/251 F130945 Q2 CT5806/61 F130062 A8 CT5718/699 F130063 A9 CT5258/250 F130671 Q8 CT5258/250 F130671 Q9 CR6028/50 H105100 S1185
EPA Environmental Improvement Programme - Stormwater Management Under the terms of the Environment Protection Authority (EPA) Licence number 12714 issued 1 December 2016 Hanson is required to prepare an Environmental Improvement Programme EIP through systematic analysis (risk assessment) addressing Stormwater Management in accordance with Conditions 3.5.1, 3.5.2 (a) to (e) and 3.5.3 of the licence.	First issue: 30 April 2017 Last issue (Current): 01 November 2021 For further information refer to the document: Environment Improvement Program (EIP) – Stormwater Management
Location	98 Horsnells Gully Rd, Horsnell Gully SA 5141
Contact Personnel	Steve Seal Supply Chain Manager - Aggregates

2. General Information

2.1 Introduction

Hanson Construction Materials Pty Ltd (Hanson) operate concrete batching plants; hard rock quarries and sand quarries throughout South Australia. Among the hard rock quarries operated by Hanson is White Rock Quarry, located at Horsnells Gully Road, Hornsells Gully. White Rock Quarry maintains an approval (EPA Licence No. 12714) for the receipt of waste concrete (the resource) from concrete plants that are operated by Hanson.

As per the sites EPA licence, Hanson have approval for the reprocessing of concrete returns and concrete washout (the resource) produced from concrete batch plants. The resource is recycled and used for the manufacturing of aggregates, sand and road base products. The re-use of these resources is consistent with Hanson's Corporate Environmental Policy, Sustainability targets and is considered industry leading practice.

Concrete return and washout is generated for a number of reasons. The key factors in generating this material are:

- Concrete customers regularly over order resulting in excess concrete at conclusion of a pour that must be dealt with.
- The short shelf life of concrete in a plastic state can lead to concrete loads that may be rejected by a customer due to real or perceived quality issues, or, site based interruptions resulting in concrete going past its useable life and can no longer be placed.
- Cleaning of concrete agitator bowls at the end of the day produces a washout material than can either be sent to landfill, or reprocessed.

Reprocessing this resource into a saleable product prevents it otherwise going into landfill and reduces the potential for waste in Hanson's concrete supply chain.

2.2 Objectives

This Resource Management Plan (RMP) intends to document how the resource will be received, handled, stored, and used on-site to prevent environmental harm from occurring and to ensure compliance with all of the conditions of the EPA licence 12714.

3. Resource Management

The following steps detail how the resource is managed on site.

3.1 Receiving

The resource is of known chemical and physical quality and source as it is produced and received from Hanson concrete batching plants via the following methods;

- Produced by Hanson's concrete batch plants
- Delivered and returned by Hanson concrete agitators
- Transported to WRQ by Hanson truck and trailers or semi-tippers

The concrete returned to the site from concrete agitators is documented in the Concrete Returns Register by the concrete plant supervisor or delegate.

The concrete wash out is transported from Hanson concrete plants by truck and trailers, or semi-tippers and is received at the quarry with a shipping docket. The truck passes over the weighbridge upon entering the quarry and a record of the material receipt is produced and maintained at the site for tracking purposes.

3.2 Handling

Once the trucks arrive at the quarry, drivers are provided with instruction on where to unload the resource. The material will be transported to a stockpile located within a controlled area where it is unloaded by the truck.

3.3 Storage

The material is stored within the controlled area until it is required for re-processing. The nominated controlled area is a dedicated area maintained with a bund to prevent release of contaminated water to the stormwater drainage system.

Currently, the defined controlled area for the concrete returns and concrete washout (the resource) is designated within the quarry (Old Quarry), coordinates (-34° 55' 37", 138° 42' 37") as per image 1 below.

Image 1. Concrete returns area

The resource is allowed to dry out and then re-crushed to saleable specification. The material is then sold as a recycled concrete product (Aggregate or road base) for re-entry into the South Australian Infrastructure Sector or general construction market.

3.4 Transportation of Resource

The resource is transported to the quarry from concrete batching plants in road going haul trucks as mentioned in section 3.1, which are designed to prevent any spills during transport. Trucks are only filled to a safe level depending on the consistency of the material. Any spillages from the transport of the resource (either within or outside of the quarry) must be contained and cleaned up as soon as practicable after becoming aware of the spill. Such loss or releases must not be cleaned up by hosing, sweeping or otherwise releasing contaminants into any stormwater drainage system, roadside gutter, or waters.

The trucks shall be effectively cleaned by cleaning the draw bars and washing the truck body/trailer after carting the resource. Washing of vehicles shall be carried out within the designated controlled area to prevent release of materials onto any roadway or adjacent stormwater drainage system.

3.5 Recording

Hanson must maintain the following records for each load of resource transported to the quarry;

- Origin of the resource;
- Destination of the resource;
- Date of pickup of the resource; and
- Quantity of the resource.

3.6 Management Strategy

3.6.1 Sustainable Product Development

Hanson are committed to continuously increase the substitution rate of natural raw materials by using by-products or recycled materials. The Sustainability Commitments 2030 made by Hanson's parent company Heidelberg Materials and which apply to Hanson locally in Australia are in line with international standards and in accordance with the UN Sustainable Development Goals. One of our key focus areas of sustainability is enabling the Circular Economy. Setting clear targets will drive us to continually improve as we contribute to building a sustainable world for 2030 and beyond.

Hanson's recycling strategy includes reusing all of our concrete returns, reprocessing the resource, producing a recycled aggregate and introducing the recycled product back to the market through our concrete products. This eliminates waste from the concrete production process.

Hanson have set a short term target to incorporate a minimum of 10% recycled aggregates within our concrete production. Longer term, the target is to increase recycled aggregate use to 30% of our concrete products by 2030.

White Rock Quarry has successfully undertaken crushing campaigns of recycled materials utlilsing the current mobile crushing plant located within the pit. In future concrete returns will be reprocessed in the same manner during broader aggregate crushing campaigns.

Image 2. Recycle aggregate from White Rock Quarry

3.6.2 Resource volumes

The table 1 below includes a description of annual estimate resource volumes managed at the site.

Table 1. Description of annual estimate resource volumes

Resource	Concrete Returns (m3)	Concrete Washout (m3)
Received	2700 in 2021	6380 m3 2021 2529 m3 2022 (July)
Stored	2700 in 2021	6380 m3
Processed	1200m3 processed in July 2022 campaign crushing producing recycle concrete aggregates	2238m3 processed in July 2022 campaign crushing producing pavement materials

The current storage volumes are included in table 2 below.

Table 2. Current stockpiles (July 2022)

Resource	Volume (m3)	Production Time & Market Demand
Concrete Return	13000	Reprocessed time is 32.5 days. Laboratory work including mix designs have been finalised. Currently tendering on future projects for recycled aggregate concrete materials. Current campaign crushing stocks have been allocated to tendered work.

Concrete Washout	24400	Currently tendering on future projects for recycled pavement materials. Current campaign crushing stocks have been allocated to tendered work.

3.6.3 Resource specification

Concrete aggregates are manufactured, sampled, and tested according to Hanson Construction Materials internal aggregate standards and as per Australian Standard 2758.1 *Aggregates and rock for engineering purposes Concrete aggregates*.

Recycled pavement materials are produced, sampled, and tested to the Department for Infrastructure and Transport specifications RD-PV-S1. The tables below are taken from the Pavement Material Specification – List of Products[1] provided by the Department for Infrastructure and Transport.

[1]Roads, Master Specifications, Department for infrastructure and Transport, August 2020. https://dit.sa.gov.au/__data/assets/pdf_file/0005/553253/MASTER_SPECIFICATION_-_PART_RD-PV-S1_-_SUPPLY_OF_PAVEMENT_MATERIALS.DOCX.pdf

Identification No.	Source	Mix Design	Product
SPALLS			
SP300	Quarry	No	300 mm Spalls
ROAD BALLAST			
RB100	Quarry	No	100 mm Road Ballast
RB65	Quarry	No	65 mm Road Ballast
RAIL BALLAST			
RAIL50	Quarry	No	50 mm Rail Ballast
RAIL60	Quarry	No	60 mm Rail Ballast
RAIL60S	Quarry	No	60 mm Rail Ballast (steel sleepers)
CLASS 3 RECYCLED PAVEMENT MATERIALS			
PM3/20RG	Recycled	No	20 mm Class 3 Recycled Pavement Material [Grading Based]
PM3/40RG	Recycled	No	40 mm Class 3 Recycled Pavement Material [Grading Based]
PM3/55RG	Recycled	No	55 mm Class 3 Recycled Pavement Material [Grading Based]
PM3/75RG	Recycled	No	75 mm Class 3 Recycled Pavement Material [Grading Based]
CLASS 3 QUARRIED PAVEMENT MATERIALS			
PM3/20QG	Quarry	No	20 mm Class 3 Quarried Pavement Material [Grading Based]
PM3/40QG	Quarry	No	40 mm Class 3 Quarried Pavement Material [Grading Based]
PM3/55QG	Quarry	No	55 mm Class 3 Quarried Pavement Material [Grading Based]
PM3/75QG	Quarry	No	75 mm Class 3 Quarried Pavement Material [Grading Based]
CLASS 2 RECYCLED PAVEMENT MATERIALS			
PM2/20RG	Recycled	No	20 mm Class 2 Recycled Pavement Material [Grading Based]
PM2/30RG	Recycled	No	30 mm Class 2 Recycled Pavement Material [Grading Based]
PM2/40RG	Recycled	No	40 mm Class 2 Recycled Pavement Material [Grading Based]
PM2/20RM	Recycled	Yes	20 mm Class 2 Recycled Pavement Material [Performance Based]
PM2/30RM	Recycled	Yes	30 mm Class 2 Recycled Pavement Material [Performance Based]
CLASS 2 QUARRIED PAVEMENT MATERIALS			
PM2/20QG	Quarry	No	20 mm Class 2 Quarried Pavement Material [Grading Based]
PM2/30QG	Quarry	No	30 mm Class 2 Quarried Pavement Material [Grading Based]
PM2/40QG	Quarry	No	40 mm Class 2 Quarried Pavement Material [Grading Based]
PM2/20QM	Quarry	Yes	20 mm Class 2 Quarried Pavement Material [Performance Based]
PM2/30QM	Quarry	Yes	30 mm Class 2 Quarried Pavement Material [Performance Based]
CLASS 1 RECYCLED PAVEMENT MATERIALS			

Identification No.	Source	Mix Design	Product
PM1/20RG	Recycled	No	20 mm Class 1 Recycled Pavement Material [Grading Based]
PM1/30RG	Recycled	No	30 mm Class 1 Recycled Pavement Material [Grading Based]
PM1/40RG	Recycled	No	40 mm Class 1 Recycled Pavement Material [Grading Based]
PM1/20RM	Recycled	Yes	20 mm Class 1 Recycled Pavement Material [Performance Based]
PM1/30RM	Recycled	Yes	30 mm Class 1 Recycled Pavement Material [Performance Based]
CLASS 1 QUARRIED PAVEMENT MATERIALS			
PM1/20QG	Quarry	No	20 mm Class 1 Quarried Pavement Material [Grading Based]
PM1A/20QG	Quarry	No	20 mm Class 1 Heavy Duty Quarried Pavement Material
PM1B/20QG	Quarry	No	20 mm Class 1 Heavy Duty Quarried Pavement Material
PM1/30QG	Quarry	No	30 mm Class 1 Quarried Pavement Material [Grading Based]
PM1/40QG	Quarry	No	40 mm Class 1 Quarried Pavement Material [Grading Based]
PM1/20QM	Quarry	Yes	20 mm Class 1 Quarried Pavement Material [Performance Based]
PM1/30QM	Quarry	Yes	30 mm Class 1 Quarried Pavement Material [Performance Based]
STABILISED PAVEMENT MATERIAL			
Refer Clause 8 “General” for examples of nomenclature for this class of pavement material.			
SEALING AGGREGATE			
SA20-14	Quarry	No	20/14 mm Sealing Aggregate
SA16-10	Quarry	No	16/10 mm Sealing Aggregate
SA14-10	Quarry	No	14/10 mm Sealing Aggregate
SA10-7	Quarry	No	10/7 mm Sealing Aggregate
SA7-5	Quarry	No	7/5 mm Sealing Aggregate
SA5-2	Quarry	No	5/2 mm Sealing Aggregate
SAND			
Sa – A	Quarry/ Pit	No	Type A Sand
Sa – B	Quarry/ Pit	No	Type B Sand
Sa – C	Quarry/ Pit	No	Type C Sand
Sa – D	Quarry/ Pit	No	Type D Sand
ASPHALT AGGREGATE			
Refer to the relevant Product Information Sheet for requirements of Source Materials and Product Quality Control.			
MINERAL FILLER FOR ASPHALT, OTHER THAN HYDRATED LIME			
Refer to the relevant Product Information Sheet for requirements of Product Quality Control.			
ADDITIONAL REQUIREMENTS FOR BASIC IGNEOUS SOURCE ROCK			
ARRESTOR BED MATERIAL			

Class 3 Recycled Pavement Material [Grading Based]

Source Materials

13.4 Source materials may be quarried material, reclaimed concrete or any combination of them. Supplementary source materials may comprise brick, tile and asphalt. Asbestos or asbestos fibre must not be incorporated into the product under any circumstances. No more than 20% by mass of supplementary materials may be incorporated and the constituent proportions must remain unchanged during production.

Product Quality Control

Table RD-PV-S1 13-5 Class 3 Recycled Pavement Material [Grading Based] Quality Control Tests

Test Procedure	Manufacturing Tolerance				
Quality Control Tests					
	Product	20 mm Class 3 PM 3/20RG	40 mm Class 3 PM 3/40RG	55 mm Class 3 PM 3/55RG	75 mm Class 3 PM 3/75RG
Particle Size Distribution TP134	Sieve Size (mm)	Percent Passing			
	75				100
	53		100	100	75 – 95
	37.5		90 – 100	75 – 95	
	26.5	100			50 – 75
	19	90 – 100	60 – 85	50 – 75	
	13.2				
	4.75	40 – 65	25 - 50	20 – 45	20 – 40
	0.075	5 – 15	3 - 11	3 - 11	3 - 11
AS 1289.3.1.2	Liquid Limit	Maximum 35%			
AS 1289.3.3.1	Plasticity Index	Maximum 15%			
AS 1289.3.4.1	Linear Shrinkage	Maximum 8%			
RMS T276	Type II Foreign Materials	Maximum 1%			
RMS T276	Type III Foreign materials excluding bitumen	Maximum 0.5%			
AS/NZS 2891.3.3	Bitumen Content	Maximum 1%			
AS 1141.23	LA Abrasion Grading 'A'	N/A	Maximum 45%		
AS 1141.23	LA Abrasion Grading 'B'	Max 45%	N/A		

13.5

Class 2 Recycled Pavement Material [Grading Based]

Source Materials

13.7 Source materials may be quarried material, reclaimed concrete or any combination of them. Supplementary source materials may comprise brick, tile and asphalt. Asbestos or asbestos fibre must not be incorporated into the product under any circumstances. No more than 20% by mass of supplementary materials may be incorporated and the constituent proportions must remain unchanged during production.

Product Quality Control

Table RD-PV-S1 13-7 Class 2 Recycled Pavement Material [Grading Based] Quality Control Tests

Test Procedure	Manufacturing Tolerance			
Quality Control Tests				
	Product	20 mm Class 2 PM 2/20RG	30 mm Class 2 PM 2/30RG	40 mm Class 2 PM 2/40RG
	Sieve Size (mm)	Percent Passing		
Particle Size Distribution TP134	53			100
	37.5		100	90 – 100
	26.5	100	90 – 100	74 – 96
	19	90 – 100	77 – 95	62 – 86
	13.2	74 – 96		
	9.5	61 – 85	51 – 75	42 – 66
	4.75	42 – 66	35 – 57	28 – 50
	2.36	28 – 50	24 – 44	20 – 39
	0.425	11 – 27	9 – 22	8 – 21
	0.075	4 – 14	4 – 12	3 - 11
AS 1289.3.1.2	Liquid Limit	Maximum 28%		
AS 1289.3.3.1	Plasticity Index	Minimum 1% - Maximum 8%		
AS 1289.3.4.1	Linear Shrinkage	Maximum 4%		
RMS T276	Type II Foreign Materials	Maximum 1%		
RMS T276	Type III Foreign materials excluding bitumen	Maximum 0.5%		
AS/NZS 2891.3.3	Bitumen Content	Maximum 1%		
AS 1141.23	LA Abrasion Grading 'A'	N/A	N/A	Maximum 45%
AS 1141.23	LA Abrasion Grading 'B'	Maximum 45%	Maximum 45%	N/A

Class 2 Recycled Pavement Material [Performance Based]

Source Materials

13.8 Source materials may be quarried material, reclaimed concrete or any combination of them. Supplementary source materials may comprise brick, tile and asphalt. Asbestos or asbestos fibre must not be incorporated into the product under any circumstances. No more than 20% by mass of supplementary materials may be incorporated and the constituent proportions must remain unchanged during production.

Nominated Mix Design Parameters

Table RD-PV-S1 13-8 Class 2 Recycled Pavement Material [Performance Based] Quality Control Tests – Mix Design Limits

Test Procedure	Mix Design Limits		
Quality Control Tests			
Particle Size Distribution TP134	Product	20 mm Class 2 PM 2/20RM	30 mm Class 2 PM 2/30RM
	Sieve Size (mm)	Percent Passing	
	37.5		100
	26.5	100	90 – 100
	19	90 – 100	80 – 95
	2.36	30 – 60	25 – 55
	0.075	5 – 20	5 – 20
AS 1289.3.1.2	Liquid Limit	Maximum 30%	
AS 1289.3.3.1	Plasticity Index	Minimum 1% - Maximum 10%	
AS 1289.3.4.1	Linear Shrinkage	Maximum 5%	
TP183	Resilient Modulus	Minimum 250 MPa	
TP183	Deformation	Maximum 10-7	
AS 1141.23	LA Abrasion Grading 'B'	Contractor Nominated Value	
TP184	Triaxial Compression	Cohesion Max 250 kPa, Friction Angle Min 400	
RMS T276	Type II Foreign Materials	Maximum 1%	
RMS T276	Type III Foreign Materials excluding bitumen	Maximum 0.5%	
AS/NZS 2891.3.3	Bitumen Content	Maximum 1%	

Product Quality Control

Table RD-PV-S1 13-9 Class 2 Recycled Pavement Material [Performance Based] Quality Control Tests

Test Procedure	Manufacturing Tolerance	
Particle Size Distribution TP134	Sieve Size (mm)	Percent Passing
	37.5	0
	26.5	0 (PM2/20), +/-6 (PM2/30)
	19	+/-6
	9.5	+/-9
	2.36	+/-8
	0.075	+/-3
AS 1289.3.1.2	Liquid Limit	+3
AS 1289.3.3.1	Plasticity Index	+2
AS 1289.3.4.1	Linear Shrinkage	+1
AS 1141.23	LA Abrasion Grading 'B'	+3

Class 1 Recycled Pavement Material [Grading based]

Source Materials

13.11 Source materials may be quarried material, reclaimed concrete or any combination of them. Supplementary source materials may comprise brick, tile and asphalt. Asbestos or asbestos fibre must not be incorporated into the product under any circumstances. No more than 20% by mass of supplementary materials may be incorporated and the constituent proportions must remain unchanged during production.

Product Quality Control

Table RD-PV-S1 13-13 Class 1 Recycled Pavement Material [Grading based] Quality Control Tests

Test Procedure	**Manufacturing Tolerance**			
Quality Control Tests				
	Product	20 mm Class 1 PM 1/20RG	30 mm Class 1 PM 1/30RG	40 mm Class 1 PM 1/40RG
	Sieve Size (mm)	Percent Passing		
	53			100
	37.5		100	95 – 100
Particle Size Distribution TP134	26.5	100	95 – 100	79 – 91
	19	95 – 100	79 – 93	65 – 83
	13.2	77 – 93		
	9.5	63 – 83	53 – 73	44 – 64
	4.75	44 – 64	36 – 56	29 – 49
	2.36	29 – 49	25 – 43	20 – 38
	0.425	13 – 23	10 – 21	8 – 18
	0.075	5 – 11	4 - 10	3 – 9
AS 1289.3.1.2	Liquid Limit	Maximum 25%		
AS 1289.3.3.1	Plasticity Index	Minimum 1% - Maximum 6%		
AS 1289.3.4.1	Linear Shrinkage	Maximum 3%		
AS 1141.23	LA Abrasion Grading 'A'	N/A.	N/A	Maximum 30%
AS 1141.23	LA Abrasion Grading 'B'	Maximum 30%	Maximum 30%	N/A
RMS T276	Type II Foreign Materials	Maximum 1%		
RMS T276	Type III Foreign Materials excluding bitumen	Maximum 0.5%		
AS/NZS 2891.3.3	Bitumen Content	Maximum 1%		

Note: The recycled pavement material must have a uniform grading and must not be graded from the coarse limit of the grading envelope to the fine limit of the grading envelope, or vice versa.

Class 1 Recycled Pavement Material [Performance Based]

Source Materials

13.12 Source materials may be quarried material, reclaimed concrete or any combination of them. Supplementary source materials may comprise brick, tile and asphalt. Asbestos or asbestos fibre must not be incorporated into the product under any circumstances. No more than 20% by mass of supplementary materials may be incorporated and the constituent proportions must remain unchanged during production.

Nominated Mix Design Parameters

Table RD-PV-S1 13-14 Class 1 Recycled Pavement Material [Performance Based] Quality Control Tests – Mix Design Limits

Test Procedure	Mix Design Limits		
Quality Control Tests			
	Product	20 mm Class 1 PM 1/20RM	30 mm Class 1 PM 1/30RM
	Sieve Size (mm)	Percent Passing	
Particle Size Distribution TP134	37.5		100
	26.5	100	
	19	95 – 100	80 – 95
	9.5	65 – 85	50 – 75
	2.36	30 – 50	25 – 45
	0.075	5 – 15	5 – 15
AS 1289.3.1.2	Liquid Limit	Maximum 25%	
AS 1289.3.3.1	Plasticity Index	Minimum 1% - Maximum 6%	
AS 1289.3.4.1	Linear Shrinkage	Maximum 3%	
TP183	Resilient Modulus	Minimum 300 MPa	
TP183	Deformation	Maximum 10-8	
AS 1141.23	LA Abrasion Grading 'B'	Contractor Nominated Value	
TP184	Triaxial Compression	Cohesion Max 150 kPa, Friction Angle Min 450	
RMS T276	Type II Foreign Materials	Maximum 1%	
RMS T276	Type III Foreign Materials excluding bitumen	Maximum 0.5%	
AS/NZS 2891.3.3	Bitumen Content	Maximum 1%	

Product Quality Control

Table RD-PV-S1 13-15 Class 1 Recycled Pavement Material [Performance Based] Quality Control Tests

Test Procedure	Manufacturing Tolerance	
	Sieve Size (mm)	Percent Passing
Particle Size Distribution TP134	37.5	0
	26.5	0 (PM1/20), +/-6 (PM1/30)
	19	+/-6
	9.5	+/-9
	2.36	+/-8
	0.075	+/-3
AS 1289.3.1.2	Liquid Limit	+3
AS 1289.3.3.1	Plasticity Index	+2
AS 1289.3.4.1	Linear Shrinkage	+1
AS 1141.23	LA Abrasion Grading 'B'	+3

Note: Refer to the Contractor's current Mix Design certificate to assess compliance.

Stabilised Pavement Material [Binder Control]

Source Materials

13.16 Source materials must be natural quarried material or, where approved, recycled materials.

Raw Feed Product Quality Control

Table RD-PV-S1 13-21 Stabilised Pavement Material [Binder Control] Quality Control Tests

Test Procedure	Manufacturing Tolerance [Grading Based]			
Quality Control Tests				
	Product	20 mm Class 2 PM 2/20*	30 mm Class 2 PM 2/30*	40 mm Class 2 PM 2/40*
	Percent Passing		Percent Retained	
	Sieve Size (mm)	%	Size Range (mm)	%
	53			100
	37.5		100	90 – 100
Particle Size Distribution TP134	26.5	100	90 – 100	74 – 96
	19	90 – 100	77 – 95	62 – 86
	13.2	74 – 96		
	9.5	61 – 85	51 – 75	42 – 66
	4.75	42 – 66	35 – 57	28 – 50
	2.36	28 – 50	24 – 44	20 – 39
	0.425	11 – 27	9 – 22	8 – 21
	0.075	4 – 14	4 – 12	3 – 11
AS 1289.3.1.2	Liquid Limit	Maximum 28%		
AS 1289.3.3.1	Plasticity Index	Minimum 1% - Maximum 8%		
AS 1289.3.4.1	Linear Shrinkage	Maximum 4%		
AS 1141.23	LA Abrasion Grading ‘A’	N/A	N/A	Maximum 45%
AS 1141.23	LA Abrasion Grading ‘B’	Maximum 45%	Maximum 45%	N/A

Stabilised Product Quality Control

Table RD-PV-S1 13-22 Stabilised Pavement Material [Binder Control] – Product Quality Control

Test	Product	Refer Clause 8 for nomenclature
Contractor Quality Plan	Target Binder Content (% dry mass)	Within the tolerance specified in Clause 8 “Additive Content Determination” of the binder content specified in the material description in accordance with Clause 8 “General”.
AS 1141.51	Unconfined Compressive Strength (96% MDD - 7 days curing)	Reported Value
AS 1141.51	Unconfined Compressive Strength (96% MDD - 28 days curing)	Strength must not be less than the value specified in the material description in accordance with Clause 8 under “General”.

Note:

- *Raw feed material must be: PM2/20QG, PM2/30QG, PM2/40QG, OR, with prior approval, PM2/20RG, PM2/30RG or PM2/40RG.
- The Principal may specify Class 1 Quarried, Recycled or Performance Based materials as an alternative to Class 2 Pavement Material (Grading Based). When Class 1 materials are specified, Product Quality Control criteria for the appropriate Class 1 Pavement Material must apply.

Stabilised Pavement Material [Strength Control]

Source Materials

13.17 Source materials must be natural quarried material or, where approved, recycled materials.

Raw Feed Product Quality Control

Table RD-PV-S1 13-23 Stabilised Pavement Material [Strength Control] Quality Control Tests

Test Procedure	Manufacturing Tolerance [Grading Based]			
Quality Control Tests				
	Product	20 mm Class 2 PM 2/20*	30 mm Class 2 PM 2/30*	40 mm Class 2 PM 2/40*
	Percent Passing		Percent Retained	
	Sieve Size (mm)	%	Size Range (mm)	%
Particle Size Distribution TP134	53			100
	37.5		100	90 – 100
	26.5	100	90 – 100	74 – 96
	19	90 – 100	77 – 95	62 – 86
	13.2	74 – 96		
	9.5	61 – 85	51 – 75	42 – 66
	4.75	42 – 66	35 – 57	28 – 50
	2.36	28 – 50	24 – 44	20 – 39
	0.425	11 – 27	9 – 22	8 – 21
	0.075	4 – 14	4 – 12	3 – 11
AS 1289.3.1.2	Liquid Limit	Maximum 28%		
AS 1289.3.3.1	Plasticity Index	Minimum 1% - Maximum 8%		
AS 1289.3.4.1	Linear Shrinkage	Maximum 4%		
AS 1141.23	LA Abrasion Grading 'A'	N/A	N/A	Maximum 45%
AS 1141.23	LA Abrasion Grading 'B'	Maximum 45%	Maximum 45%	N/A

Stabilised Product Quality Control

Table RD-PV-S1 13-24 Stabilised Pavement Material [Strength Control] Product Quality Control

Test	Product	Refer Clause 8 for nomenclature
Contractor Quality Plan	Target Binder Content (% dry mass)	Within the tolerance specified in Clause 8 "Additive Content Determination" of the binder content specified in the material description in accordance with Clause 8 "General".
AS 1141.51	Unconfined Compressive Strength (96% MDD - 7 days curing)	Reported Value
AS 1141.51	Unconfined Compressive Strength (96% MDD - 28 days curing)	Strength must not be less than the value specified in the material description in accordance with Clause 8 "General".

NOTE:

- *Raw feed material must be: PM2/20QG, PM2/30QG, PM2/40QG, OR, with prior approval, PM2/20RG, PM2/30RG or PM2/40RG.
- The Principal may specify Class 1 Quarried, Recycled or Performance Based materials as an alternative to Class 2 Pavement Material (Grading Based). When Class 1 materials are specified, Product Quality Control criteria for the appropriate Class 1 Pavement Material must apply.

Additional Requirements for Basic Igneous Source Rock

13.24 This clause applies where basic igneous source rock (as defined in AS 2758) is used for the production of a Pavement Material complying with this Part. The presence of Secondary Minerals must not have a deleterious effect of the Pavement Material's intended performance.

13.25 The Source Rock must be classified in accordance with the following:

Table RD-PV-S1 13-30 Basic Igneous Source Rock Classifications

Rock Classification	Secondary Mineral Content (%) AS1142.6	Accelerated Soundness Index AS 1141.29
Sound Rock	< 25	> 94
Marginal Rock	26-30	90-93
Unsound Rock	> 30	< 90

13.26 Unsound and marginal rock in that fraction of the product retained on a 4.75 mm AS sieve must not exceed the percentages specified below:

Table RD-PV-S1 13-31 Basic Igneous Source Rock Marginal and Unsound Rock Percentages

Material Class	Total of Marginal and Unsound Rock % (max)	Unsound Rock % (max)
PM 1	10	5
PM 2	10	7
PM 3	20	10
Sealing and Asphalt Aggregate	10	3

4. Environmental Risk Assessment

The environmental risk assessment identifies the preliminary risk level of the identified aspect without taking into consideration any design, controls and management strategies used by Hanson to mitigate the associated risks.

The assessment was performed in accordance with leading practice, and considering all operational stages (e.g., traffic movement, stockpiles, etc). Identification of potential impacts is based on current activities, similar industrial operations, and key concerns from stakeholders.

The environmental risk assessment has considered the hierarchy of controls and control strategies that are technically and economically feasible. The residual risk evaluation score is then applied to each potential impact identified following the implementation of environmental management strategies and controls at the Site.

Hanson is committed to minimise negative environmental impact, adopting best practice quarrying and environmental management approaches.

The preliminary risk level and the residual risk evaluation have adopted a qualitative risk-based approach, designed to assess risk, based on:

- the likelihood / probability of the impact or event occurring over the time (Table 3)
- the consequences/severity outcomes of the impact or event occurring (Table 4)
- the risk based on the combination of the likelihood and consequence of the impact or event occurring (Table 5)

Table 3. Definitions of likelihood

Description	Definitions
Rare	May occur only in exceptional circumstances
Unlikely	Could occur but doubtful
Possible	Might occur at some time in the future
Likely	Will probably occur
Almost Certain	Is expected to occur in most circumstances

Table 4. Definitions of consequence

Consequence Description	Definition of Significant Environmental Risk		
	Environmental	**Legislative**	**Social**
Negligible	- The event does not breach site boundaries nor causes nuisance to the public. - The environment impact is minimal, controlling the event take 30 minutes or less.	- There have been no breaches of limits prescribed by operating conditions	- No complaints
Minor	- The event has potentially breached site boundaries but does not cause nuisance to the public - The environment impact is minor and easily rectifiable without escalating severity. Controlling the event takes more than 30 minutes but less than 1 hour	- A single breach of prescribed operating conditions - Issue of caution and/or show cause Notice from administering authority	- Any community complaint directly received from the public regarding the site operations.
Moderate	- The event has breached site boundaries with potential to cause nuisance to the public - The environment impact of the event is significant but rectifiable, controlling the event without escalating severity, taking more than 1 but less than 6 hours	- Multiple breaches of prescribed operating conditions - Issue of writing warning from administering authority	- Any community complaint directly received from the public associated with an existing incident or event - Any community complaint directed to administering authorities and relayed to the business
Major	- The event has breached site boundaries and cause reportable nuisance to the public - Long-term consequences	- Multiple breaches of prescribed operating conditions - Issue of penalty Infringement Notice from administering authority	- Multiple community complaints with potential to cause negative and damage media coverage
Catastrophic	- Any event resulting in catastrophic impact to the environment, where damage is irreversible and/or controls would be of a magnitude that may impact on company profitability and reputation - The event has breached site boundaries and caused overwhelming nuisance to the public	- Multiple breaches of prescribed operating conditions with orders from administering authority to rectify issues immediately - Issue of authority order (e.g. Environmental protection order) - Prosecution by administering authorities - Order to stop operations	- Multiple sustained community complaints directed to administering authorities and relayed to the business, with significant negative and damaging media coverage

Table 5 below illustrates the final risk level assigned, determined by the product of the likelihood and consequence scores, which equals the magnitude of the impacts. The higher the risk score, the higher the priority is for management.

Table 5. Risk Assessment Matrix

		Consequence				
		Negligible 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
Likelihood	Almost Certain 5	Medium 5	High 10	High 15	Extreme 20	Extreme 25
	Likely 4	Low 4	Medium 8	High 12	High 16	Extreme 20
	Possible 3	Low 3	Medium 6	Medium 9	High 12	High 15
	Unlikely 2	Low 2	Low 4	Medium 6	Medium 8	High 10
	Rare 1	Low 1	Low 2	Low 3	Low 4	Medium 5

4.1 Controls and residual risk level assessment

When a risk has been identified and assessed, controls need to be developed to reduce the risk to an acceptable level. Hanson must always take into consideration the Hierarchy of Controls to ensure that the most effective controls possible are implemented.

When determining the right controls to manage the risks (impacts to nearby receptors), the following must be considered:

Table 6. Hierarchy of Controls

Hierarchy of Controls	
Eliminate	Remove the risk activity/equipment/work practice from the site
Substitute	Replace the risk activity/equipment/work practice with a less impacting one
Isolate	Separate risk activity/equipment/work practice from people involved in the work or people in the surrounding areas
Engineering controls	Modify tools or equipment, automating processes, providing guarding to machinery or equipment or any other engineering measure that is practicable to implement
Administrative	Document work practices that reduce the risk, training the appropriate people in all aspects of these documents
PPE	Equipment or clothing to provide protection

The Hierarchy of Controls is a preferred order of control measures which range from the most effective control method being elimination of the risk, to the least preference control methods being the administration/procedural controls and physical barrier.

4.2 Environmental Impact Assessment

The following potential environmental impacts have been identified and risk assessed to ensure best practice management controls and strategies are implemented in the concrete returns resource management.

- **Soil contamination** Contaminated land/waterways resulting from incidental spillage
- **Surface water contamination** Reduction in downstream water quality
- **Noise** generated by on-site activities resulting in noise nuisance at nearby sensitive receptors
- **Air quality** Dust generated from onsite activities causing dust nuisance and health impacts at sensitive receptors
- **Waste** No market demand causing excess material stockpiling/ waste disposal must not occur
- **Weeds, Pests and Plant Pathogens** Effect of weeds /pest on site

4.3 Controls and residual risk level

Table 7 outlines practicable controls identified, using the hierarchy of controls, for each of the potential environmental impacts and the assessment of the residual risk level. All employees have the responsibility to take action; report, manage and follow up potential environmental impacts. Table 7 also includes person responsible to ensure controls and strategies are in place

- Supply Chain Manager (OM)
- Quarry Manager (QM)
- Quarry Supervisor (QS)
- Employee (E) (e.g. Weighbridge operator, HME operator, truck drivers, contractors, concrete manager (CM), concrete supervisor (CS), etc.)

The site has a topographic barrier that minimise potential environmental impacts. Preventative measures include daily checks and assessment of meteorological forecast to implement controls and strategies accordingly.

Table 7. Residual risk after hierarchy of controls.

Environmental Impact	Impact/Risk	Consequence	Likelihood	Risk Rating	Control (Engineering/Procedural)	Consequence	Likelihood	Risk Rating
Soil contamination	Contamination of land and waterways	3	4	H	• Spill kits available on site, employees trained to use them (E-Campus) (QM, QS, E) • Maintenance of vehicles to be done in the designated area away from concrete returns area • Fuelling to occur in dedicated areas (QM, QS, E) • Resource to be stored in a dedicated area (QM, QS) • Any spillage of the resource during handling will be cleaned up as quickly as practicable to prevent release to stormwater drainage systems. (QM, QS, E) • Storage area will be bunded to prevent release to the stormwater drainage system. (QM, QS)	3	2	M
Surface water	Reduction in downstream water quality	3	4	H	• All relevant personnel trained and inducted, competent knowledge of their roles and responsibilities in water management of the site (QM, QS, E) • Maintain clean stormwater diversion (QM, QS, E) • Divert surface water from disturbed areas to sediment basins (QM, QS) • Check stockpile during rain events to ensure potential flows are directed into the sediment basins (QM, QS) • Daily checks to inspect effectiveness of perimeter bunds, diversion banks or drains, containment of recycling products/resources (QM, QS) • Maintain and stabilise permanent bunds.	3	3	M
Noise	Potential for noise nuisance at nearby sensitive receptors from concrete resource reprocessing	3	3	H	• Equipment is to be maintained in accordance with the original equipment manufacturer's specifications. • Equipment is to be shut down when not in use. • Mobile crushing plant located within the pit. • Fit broadband reversing alarms, rather than audible sirens or beepers, on mobile equipment. • Complaints from neighbouring residents to be recorded, investigated, and responded to in a timely manner.	2	2	L
Air quality/dust	Dust generated from onsite activities causing dust nuisance and health impacts at sensitive receptors.	3	4	H	• Sprinklers used in operational areas (e.g. crusher: conveyor, transfer points) (QM, QS, E) • Sprays are used before plant is started to minimise dust before crushing commences (QM, QS, E) • Adjust the rate of crushing to respond to the meteorological conditions (TARP) (QM, QS) • Material to be conveyed is wetted if dust is visible (QM, QS) • Fines collected under the plant and conveyors will be removed by personnel with appropriate equipment (QM, QS) • Wetting down of haul roads and operational areas by water truck where fixed sprays cannot be implemented (QM, QS, E) • Water truck to wet down operational areas prior to plant start-up during level 1 TARP conditions (QM, QS, E) • Continually monitor and assess effectiveness of dust suppression systems, controls and strategies, during crushing and screening (QM, QS, E) • Trucks will not be overloaded (E) • Tipping of finer aggregates to occur slowly and in stages (E) • Speed limit reductions to minimise dust generation or even stop operation in accordance with the TARP (QM) • All personnel shall observe onsite vehicle speed limits to reduce dust lift-off from unsealed roads (E) • Speed limit reductions to minimize dust generation or even stop operation as per TARP trigger level (QM) • Locate stockpiles in shielded areas (QM) • Implement the actions associated with the TARP (QM)	2	2	L
Waste	Market demand below planned	3	4	H	• Concrete returns volumes to be documented (CS) • Undertake regular inspections of storage areas (QM, QS) • Blend materials/resources into existing or/and new processes/products (OM, QM) • The Site will only receive the resource from plants that are operated by Hanson Construction Materials Pty Ltd as per EPA Licence No. 12714 conditions. • Monthly sales production planning meetings to review market conditions and stocks.	3	3	M
Weeds, Pests and Plant Pathogens	Effect of weeds /pest on site	3	4	H	• Weed maintenance program using an external contractor (QM) • Established roads and tracks are to be used whenever possible to control the potential spread of weeds and plant pathogens. Weed-infested areas are to be avoided (E) • Schedule pest control as required (QM, QS, E)	2	2	L