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To:	Terry Woods	**From:**	Troy Lowien
Address:	Via email	**Date:**	26/08/2019
		File Ref.:	2289_200_001
Re:	Meppem Quarry – Suitability of Resource for Supply to Inland Rail Project.		

The NSW Department of Planning, Industry & Environment – Division of Resources & Geoscience, Geological Survey of New South Wales has responded to the Moree Plains Shire Council's request to comment on the Environmental Impact Statement for the proposed Meppem Quarry. The response includes the following statement:

"*The proponent should confirm the suitability of the material for its intended purposes, including demonstrating they meet ARTC specifications*."

I provide the following comments on the suitability of the Resource at the site to supply the Inland Rail Project:

The EIS appendices included a report (Inland Rail Project: Preliminary Resource Investigation – Meppem Property, August 2018) that concluded the Resource is a high-quality basalt deposit, predicted to be suitable for uses including Rail Ballast CT147. The report's findings took into consideration the results from petrographic analyses, a percussion drilling program, as well as site inspection by an experienced geologist. The report also stated the risk of non-compliance in respect to material specifications for intended use is low.

In order to be able to confirm material specifications by test work, a bulk sample of basalt would need to be extracted. However, this would require an approval for quarrying activities. It is also not usual practice to commence a quarry operation with an exhaustive suite of tests having already been undertaken.

It is my opinion, having inspected numerous quarries with similar rock type and quality, that the proposed Meppem Quarry will be capable of providing material with requisite specifications for the Inland Rail Project.

Regards,

Troy Lowien.
Principal Resource Consultant

GROUNDWORK plus

Resources, Environment, Land Use Planning

Inland Rail Project: Preliminary Resource Investigation – Meppem Property

Prepared for:
Quarry Solutions

Date:
August 2018

File Ref: 2033_220_009

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Document Control

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Principal Author:	Troy Lowien
Client:	Quarry Solutions

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	V1	V2	V3	V4	V5	V6	V7	V8	V9
Terry Woods	1E								

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Executive Summary

As part of a preliminary resource investigation conducted in central NSW following the proposed Inland Rail route from Narromine to Inglewood, preliminary drilling and field mapping has identified key sites hosting modest sized resources of commercial interest. These resources include basalt, such as that occurring on the property owned by John Meppem, approximately 10km north east of the town of Bellata. The total basalt resource available on the property is shown below in **Table 1- Inferred Resources**.

Table 1 – Inferred Basalt Resources – Meppem Property

Description	Basalt Volume (m^3) (*in situ*)	Comments and calculation constraints
Total Basalt	4,213,000	Based on drilling data and local LIDAR derived topographic data. Constrained to within 50m buffer of property boundary. Inclusive of material within pit design.
Conceptual Quarry Plan	1,038,000	Based on drilling data and local LIDAR derived topographic data. Constrained to within conceptual pit design only.

Key Findings

- Drilling and field mapping have identified that the site consists of a significant high-quality basalt resource which forms a prominent hill, locally known as Black Hill. The hill is interpreted to be a remnant basalt flow, potentially up to 50m thick, and extending for about 1,000m long by 800m wide. Approximately two-thirds of the basalt on Black Hill occurs on the Meppem property.
- The basalt is predicted to be well-suited to a broad range of industrial applications including Unbound Pavements, Cover Aggregate, Aggregate for Concrete, Rail Ballast CT147, Manufactured Sand and Gabion/Revetment.
- This resource estimate is preliminary as additional resources, should they be required may be proven with further exploration.

Key Recommendations

- It is recommended to collect a bulk sample from Black Hill for materials testing to confirm preliminary geological observations. Whilst the risk of geological non-compliance is considered low in the target material, completing this work would confirm the suitability of the material for the production of specification materials.

1. Introduction

Groundwork Plus was commissioned by Quarry Solutions to conduct a collaborative investigation to gather sufficient information to recommend key sites of interest to service the material needs of the anticipated Inland Rail Project. Drilling was completed over one day on the 19th of July 2018 and was jointly supervised by Terry Woods of Quarry Solutions and Troy Lowien of Groundwork Plus. A total of eighteen (18) percussion drill holes were completed over the site by an air track top hammer rig during this time with samples retrieved at each site for further analysis and digitisation into logs. Brief reconnaissance style geological mapping of the site was also completed to inform hole locations and confirm the broad nature and distribution of the rock types on site.

2. Key Site Details

Locations:	Lot 10 DP751753. Situated 10km north east of Bellata via Berrigal Road.
Land Use:	The site is currently used for agricultural activities.
Landform:	Hilly rise to 360m AHD surrounded by gently undulating agricultural plains
Site Geology:	Residual basalt flow overlying sandstone to argillite sedimentary rock.
Vegetation:	Patches of remnant vegetation on hills.

Plate 1 – View looking south from base of Black Hill. Residual basaltic soil in foreground, remnant basaltic flows forming hills in background.

3. Investigations

The results of this report relate to recent investigative drilling conducted in central NSW with the object to identify potential quarry resources and nominate sites to service the anticipated Inland Rail Project. The Inland Rail Project requires a broad range of quarry materials including significant fill, pavement, sealing and ballast products to be sourced along the breadth of the proposed line which is not yet finalised. Accordingly, sites were chosen following a desktop review conducted by Groundwork Plus in consultation with Quarry Solutions and accessed opportunistically with the permission and co-operation of the land owner. Final determination of the site, subsequent drill hole locations and resource sampling and logging was conducted by a suitably qualified geologist (Troy Lowien – Groundwork Plus) and overseen from an operational perspective by a representative of Quarry Solutions (Terry Woods).

Investigation of the basalt resource on Meppem's Property was conducted over an isolated hill, locally known as Black Hill, rising approximately 70m above the surrounding plain. The hill shows surficial distinctly to slightly weathered basalt cobbles but little in situ outcrop available to mark geological contacts.

Recent investigative drilling consisted of eighteen (18) percussion holes with material retrieved at one (1) metre intervals to be stored in chip trays for later logging. All drill collars were surveyed using a hand-held GPS unit, refer **Figure 1 - DRILLHOLE LOCATION.**

The details of the drilling are listed below:

Contractor: Ron Sothern Drilling
Holes Drilled: 1 Percussion Holes (MR01 to MR18)
Total Meters Drilled: 200m
Drill Hole Inclination: Linear holes drilled at -90°
Drilling Date: July 2018
Hole Size: 89mm
Drilling Style: Top hole hammer

Drilling commenced around the base of the main hill, then traversed up the hill along the property boundary, across the top of the hill and back down the side of the hill towards the starting position, refer **Figure 1 – Drillhole Location Plan**. The aim was to delineate the contact between the good quality basalt of the main hill with the lower quality weathered basalt and sedimentary rocks at its base.

The results of the investigation are discussed in Section 4 and the percussion drill-hole logs are attached in **APPENDIX 1 – PERCUSSION DRILL HOLE PHOTOGRAPHS AND LOGS**.

Figure 1 – Drillhole Location Plan

4. Results of Investigations

The resource estimates are based on the results of the very preliminary site inspections combined with the information returned from all percussion drill-holes completed in this investigation. The material encountered was geologically logged pursuant to Australian Standard AS1726-1993: Geotechnical Site Investigations. Estimated material strength, degree of weathering, degree of alteration, rock structure, foliation intensity, and general rock type were recorded. The percussion drill-hole logs are attached in **APPENDIX 1 – PERCUSSION DRILL HOLE PHOTOGRAPHS AND LOGS**.

In general the drilling conditions encountered across the site were good. Drill penetration rates in the fresh basalt were consistent with a high quality, high strength material. This suggests that the target rock has high potential for use as high quality quarried products.

4.1 Results

The geology of the site is dominated by a remnant basaltic flow which overlies older sedimentary rocks (gravels, sandstone, siltstone), refer **Figure 2 – Site Geology**.

The relatively unweathered basalt on Meppem's property forms a prominent hill, approximately 1,000m long by 800m wide, which rises to about 70m above the surrounding plain. Recent drilling was focussed on delineating the peripheral extents of the basalt on the south-east corner of the hill and testing the basalt at depth on the top of the hill.

Holes MR01 to MR03 drilled at the base of the hill intersected 6m of residual soil and extremely weathered basalt before being terminated. Logs of two registered water bores (GW005969 and GW029476) located nearby indicate the weathered basalt extends to a depth of around 20m, where it overlies sandstone, shale and gravel.

Holes MR04 to MR08 were drilled on a section line, approximately 100m apart, on the flank of the hill. Hole MR06 intersected 4m of slightly weathered basalt before hitting the highly weathered zone, while good quality fresh basalt was intersected in MR07 to end of hole at 21m depth, inferring the contact between high and low quality basalt is just downhill of MR06, or at around 325mRL. This was confirmed with drillholes MR16 to MR18 which were drilled 400m to the east at a similar elevation.

Along the top of the hill, holes MR07 to MR14 were drilled in an approximate 100m by 100m grid to test the basalt to a depth of 15- 20m in the footprint of the proposed quarry site. All these holes intersected high quality basalt to end of hole (refer **Plate 2**).

Overburden on the hill consists of a very thin veneer of residual basaltic soil (<500mm) and cobbles.

Figure 2 – Site Geology

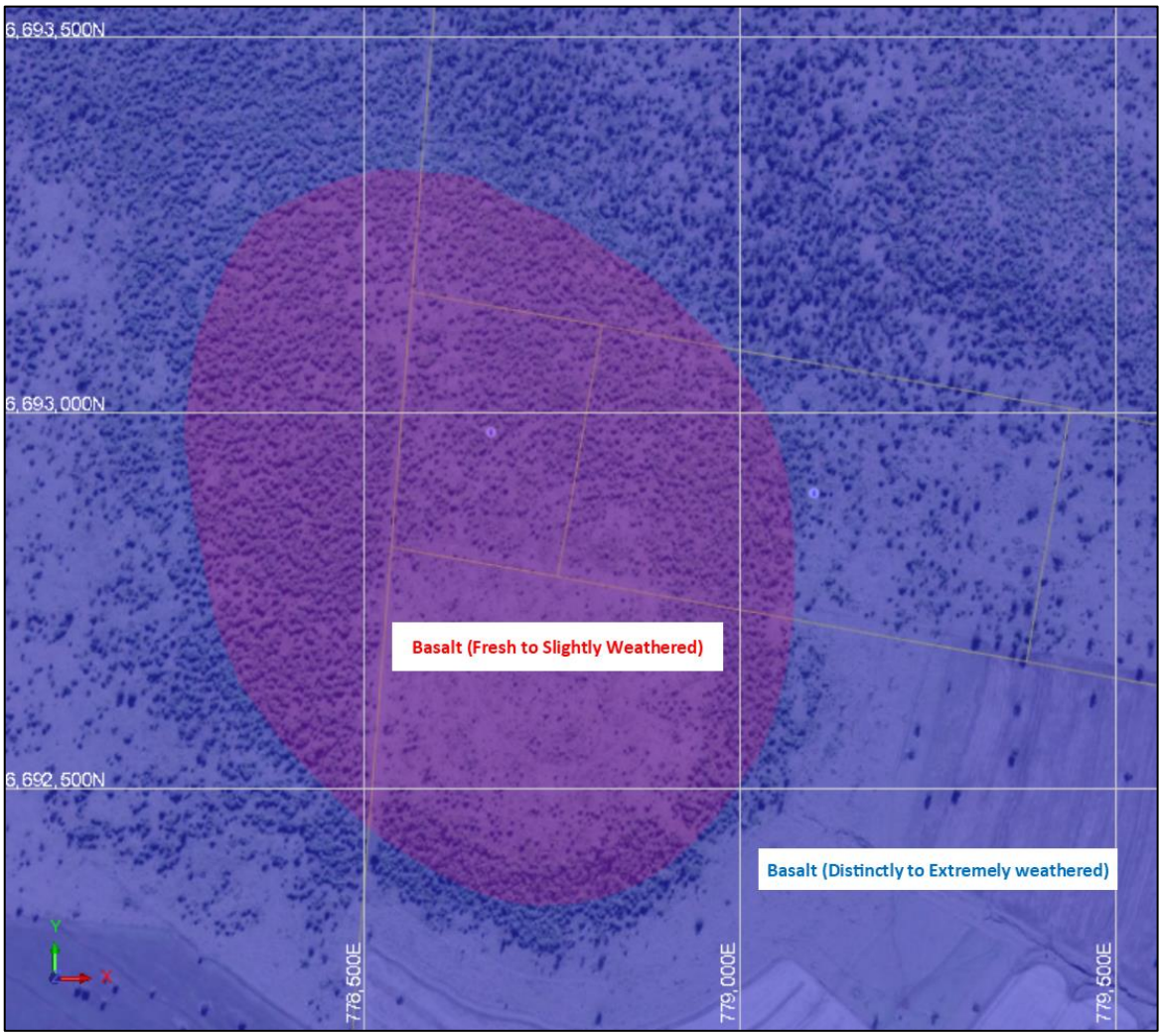


Plate 2 – High Quality Basalt intersected in hole MR014

The basalt is a black, fine grained, sparsely vesicular basic igneous rock, displaying a basaltic mineral assembly consisting of abundant plagioclase laths and ubiquitous ferromagnesian phases including pyroxene, olivine and magnetite. Olivine crystals form 0.2 to rare 0.5mm green or weathered brown phenocrysts. The rock displays slight weathering as ferruginous staining and occasional argillic infill of sparse vesicles. The basalt displays otherwise competent, granular broken faces and is likely to produce well-shaped aggregate with crushing. The rock is regarded as hard, and is of predicted high strength and durability, well suited to a broad range of engineering products. The basalt is highly magnetic. Trace sulfides as pyrite is observed.

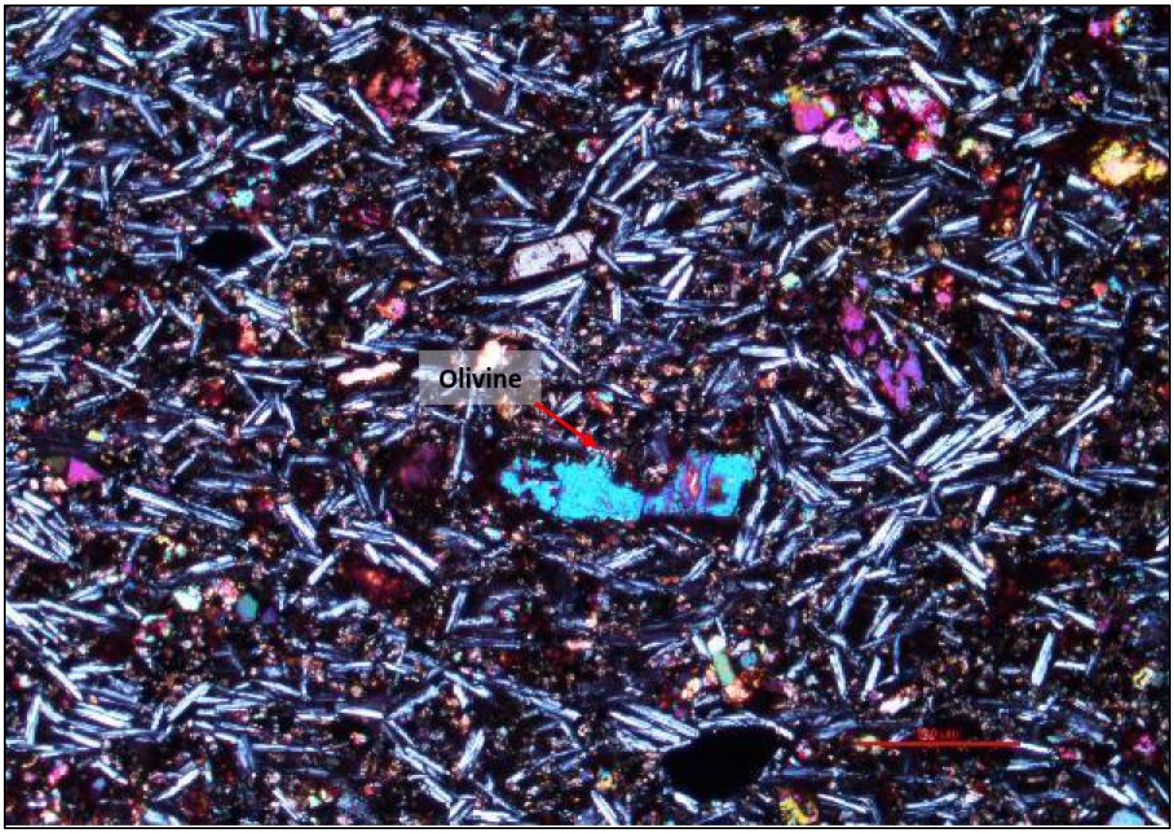
Plate 3 – Basaltic rubble on side of main hill.

4.2 Petrology

A sample of basalt was collected from the largest available boulder on the hill as representative of the site's geology and used for petrographic analysis to determine salient mineralogical and textural features as well as determine if deleterious secondary minerals are present which may constrain the utility of the rock. The Petrographic Inspection Report can be found in **APPENDIX 2 – PETROGRAPHIC REPORT**. An excerpt with associated microphotograph is provided below.

Pending material testing, the examined basalt is predicted to be well-suited to a broad range of industrial applications including Unbound Pavements, Cover Aggregate, Aggregate for Concrete, Rail Ballast CT147, Manufactured Sand and Gabion/Revetment. Allocation of this aggregate to Asphalt Aggregate should be preceded by polished aggregate friction value (PAFV) testing given observed moderate flow alignment and fine crystal sizes.

Plate 4 – Microphotograph displaying representative mineral assembly of the basalt including abundant plagioclase, fine tabular pyroxene and plagioclase with finely disseminated magnetite. Image shown in cross polarised light.



For engineering purposes, the rock may be summarised as:

- Olivine Basalt, a Basic Igneous Rock.
- Essentially unweathered to slightly weathered with generally texturally isolated weak-secondary phases (9%) and minor vesicular smectite.
- Hard, of high strength and regarded as durable.
- Non-porous with minor residual vesicular voids and no heir-line fractures.
- Containing 2% free silica as remnant ferromagnesian volcanic glass. On this basis the basalt is considered innocuous in relation to ASR in concrete provided significantly more glassy material is not encountered.

4.3 Volumes

The base of fresh basalt was modelled in 3D using geological modelling software with the basal contact with the more weathered basalt based upon the indicative 325mRL elevation as mentioned in section 4.1. A conceptual pit design was created that avoids disturbing the remnant vegetation on the sides of the hill and encompasses the grid of holes drilled on the crest of the hill (**Figures 3 and 4**). The pit was designed using a batter angle of 80° and and maximum bench height of 15m. The volumes of basalt within the pit design, as well as within the property boundary, are shown in **Table 3**.

Table 2 – Meppem Property Basalt - Conceptual Pit Volume

Description	Basalt Volume (m3)
Conceptual Quarry Plan	1,038,000
Total Basalt (inclusive of quarry)	4,213,000

Figure 3 – Meppem Property – Drill hole locations and conceptual pit design.

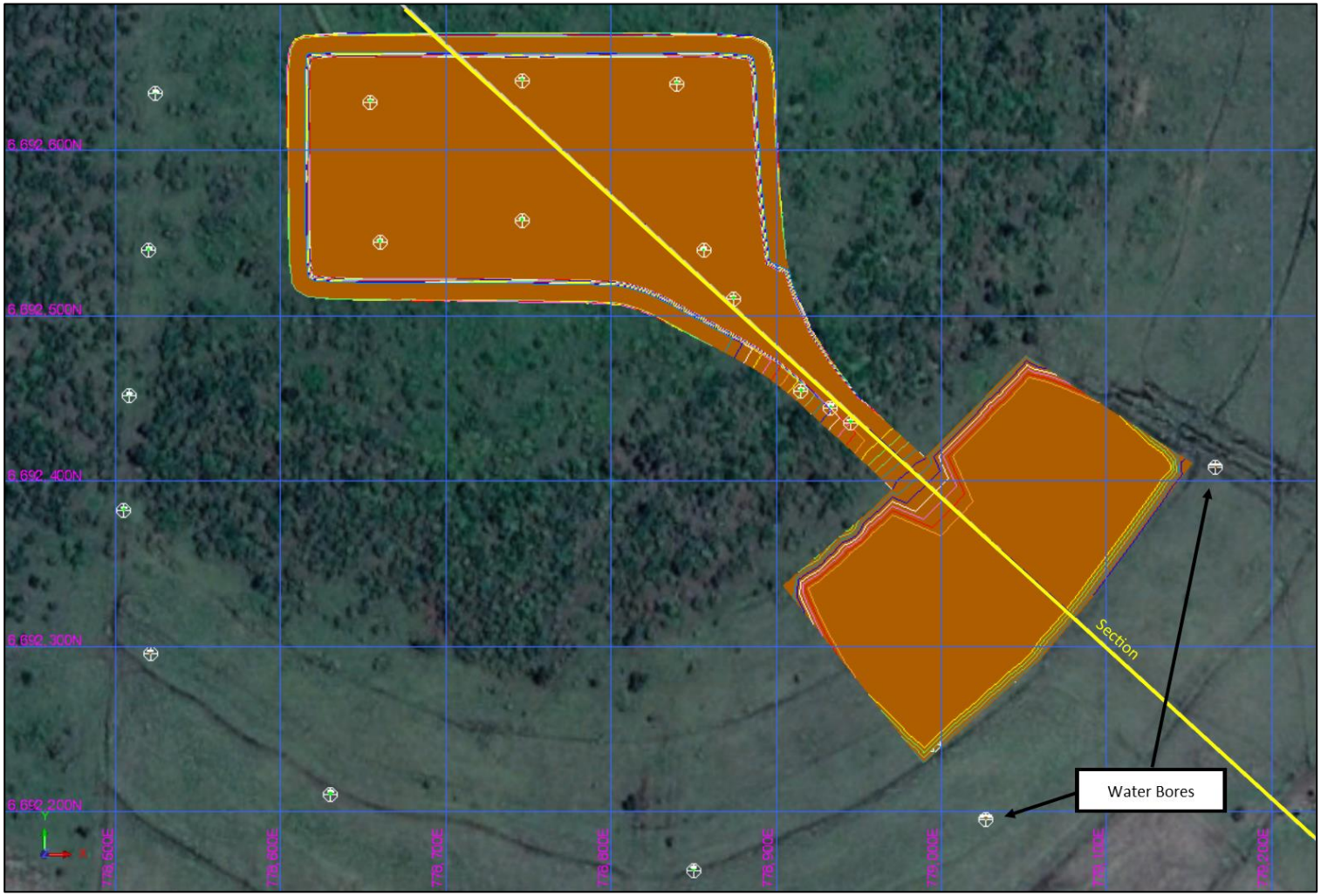
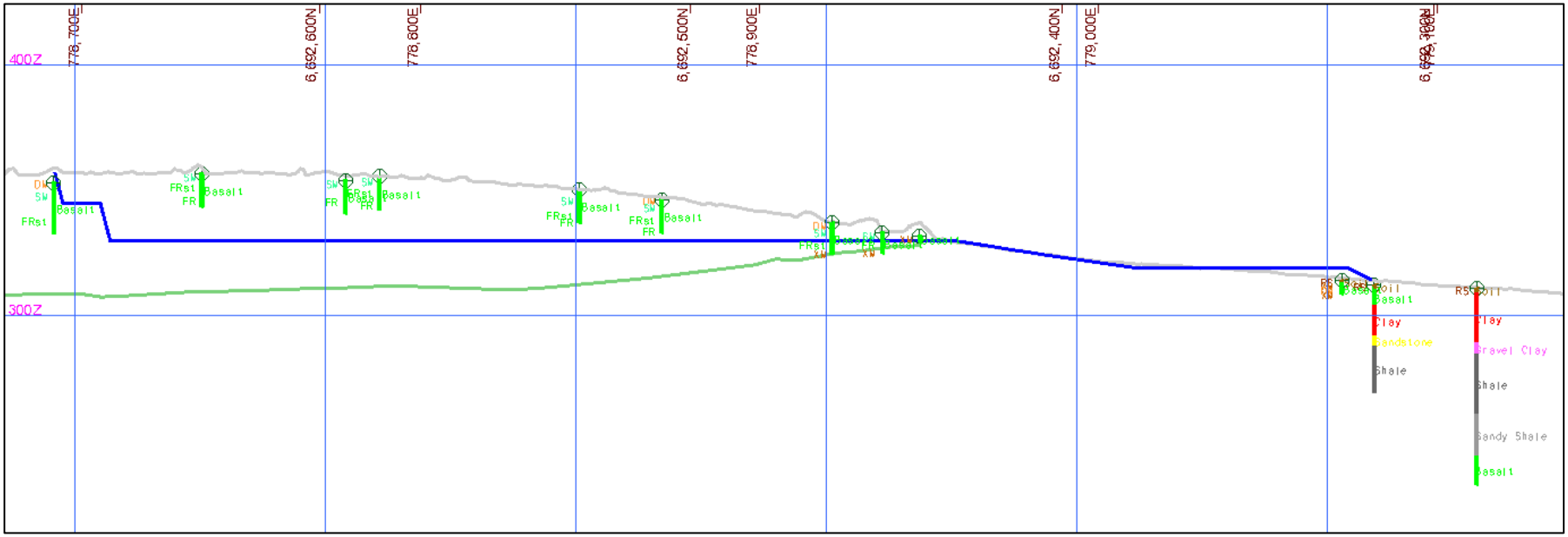


Figure 4 – Meppem Property – Section displaying drill holes (incl water bores) and pit design.



6. Recommendations

While data suggests that the quality of the basalt resource is high at the Meppem Property site, it is recommended to collect a bulk sample for materials testing to confirm preliminary geological observations. Whilst the risk of geological non-compliance is considered low in the target material, completing this work would confirm the suitability of the material for the production of material complying with ARTC specifications.

7. Important Information

Your attention is drawn to the document – 'Important Information about your 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 REPORT** is presented in **APPENDIX 2**.

appendices

Appendix 1

PERCUSSION DRILL HOLE PHOTOGRAPHS AND LOGS

CHIP TRAY PHOTOGRAPHY

Client: Quarry Solutions
Drill Type: Percussion
Project: Narrabri to Inglewood
Date: 17 July 2018
Logged by: Troy Lowien
Job: 2033_220

GROUNDWORK plus
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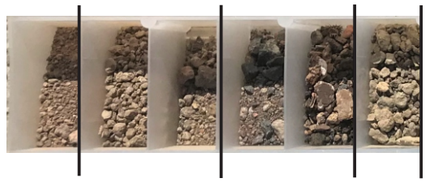
Hole Numbers:

MR01



0.0 - 1.0m
Residual basaltic soil.

1.0 - 3.0m
Extremely weathered basalt.

3.0 - 5.0m
Distinctly weathered basalt. Low strength. Ferruginous staining.

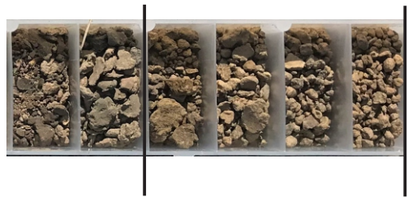
5.0 - 6.0m
Extremely weathered basalt.

MR02

0.0 - 2.0m
Extremely weathered basalt and soil.

2.0 - 6.0m
Distinctly weathered basalt. Low strength. Ferruginous staining.

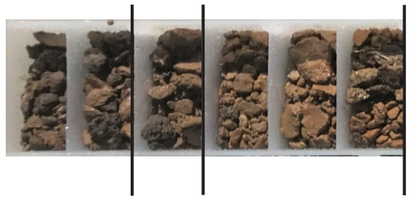
MR03



0.0 - 2.0m
Extremely weathered basalt and soil.

2.0 - 6.0m
Distinctly weathered basalt. Low strength. Ferruginous staining.

MR04

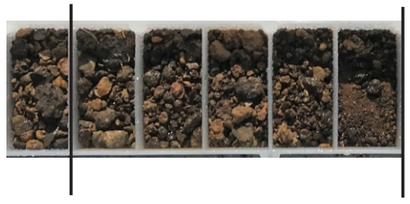


0.0 - 2.0m
Residual basaltic soil.

2.0 - 3.0m
Extremely weathered basalt.

3.0 - 6.0m
Distinctly weathered basalt. Ferruginous staining.

MR05

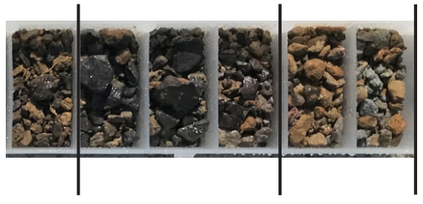


0.0 - 1.0m
Extremely to distinctly weathered basalt.

1.0 - 6.0m
Distinctly weathered basalt. Ferruginous staining.

2.0 - 9.0m
Slightly weathered to fresh basalt with ferruginous staining. Higher strength.

MR06



0.0 - 1.0m
Distinctly weathered basalt. Ferruginous staining.

1.0 - 4.0m
Slightly weathered basalt. Ferruginous staining. Higher strength.

4.0 - 6.0m
Distinctly weathered basalt. Ferruginous staining. Lower strength.

CHIP TRAY PHOTOGRAPHY

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Hole Numbers:

MR07

0.0 - 1.0m
Distinctly weathered basalt. Ferruginous staining. Lower strength.

1.0 - 8.0m
Slightly weathered basalt. Ferruginous staining. Higher strength.

8.0 - 21.0m
Fresh basalt. High strength.

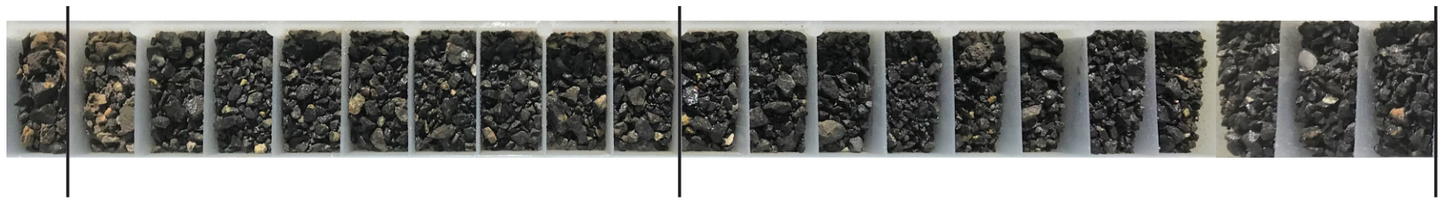
MR08

0.0 - 1.0m
Slightly to distinctly weathered basalt. Ferruginous staining. Lower strength.

1.0 - 6.0m
Slightly weathered basalt. Ferruginous staining.

6.0 - 21.0m
Fresh basalt. High strength.

MR09



0.0 - 1.0m
Distinctly weathered basalt. Ferruginous staining. Lower strength.

1.0 - 10.0m
Slightly weathered basalt. Ferruginous staining.

10.0 - 21.0m
Fresh basalt with ferruginous staining on joint surfaces. High strength.

CHIP TRAY PHOTOGRAPHY

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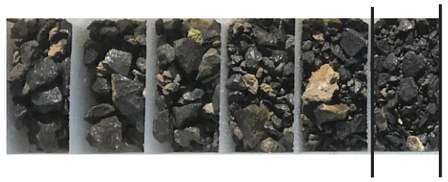
Hole Numbers:

MR10



0.0 - 5.0m
Slightly weathered basalt. Ferruginous staining.

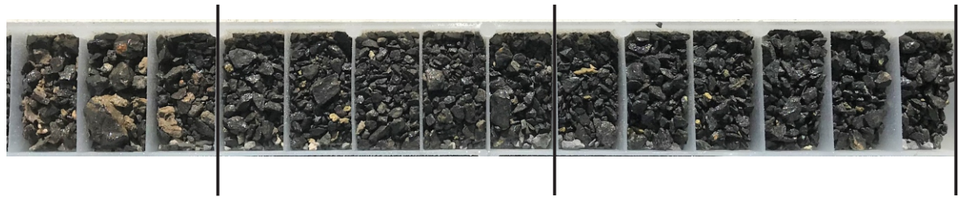
5.0 - 6.0m
Fresh basalt with ferruginous staining on joint surfaces. High strength.

MR11

0.0 - 3.0m
Slightly weathered basalt. Ferruginous staining.

3.0 - 14.0m
Fresh basalt. High strength.

MR12



0.0 - 3.0m
Slightly weathered basalt. Ferruginous staining.

3.0 - 8.0m
Fresh basalt with ferruginous staining on joint surfaces. High strength.

8.0 - 14.0m
Fresh basalt. High strength.

MR13

0.0 - 4.0m
Slightly weathered basalt. Ferruginous staining.

4.0 - 9.0m
Fresh basalt with ferruginous staining on joint surfaces. High strength.

9.0 - 14.0m
Fresh basalt. High strength.

MR14

0.0 - 9.0m
Slightly weathered basalt. Ferruginous staining.

9.0 - 12.0m
Fresh basalt with ferruginous staining on joint surfaces. High strength.

12.0 - 14.0m
Fresh basalt. High strength.

MR15

0.0 - 1.0m
Distinctly weathered basalt. Ferruginous staining. Lower strength.

1.0 - 5.0m
Slightly weathered basalt. Ferruginous staining.

5.0 - 11.0m
Fresh basalt with ferruginous staining on joint surfaces. High strength.

11.0 - 14.0m
Fresh basalt. High strength.

CHIP TRAY PHOTOGRAPHY

Client: Quarry Solutions
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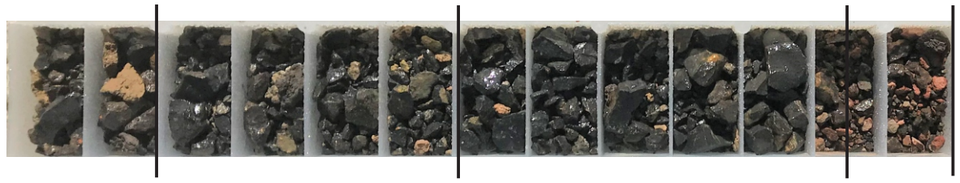
Hole Numbers:

MR16



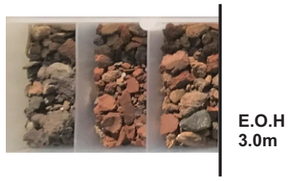
0.0 - 2.0m
Distinctly weathered basalt. Ferruginous staining. Lower strength.

2.0 - 6.0m
Slightly weathered basalt. Ferruginous staining.

6.0 - 11.5m
Fresh basalt with ferruginous staining on joint surfaces. High strength.

11.5 - 13.0m
Distinctly to extremely weathered basalt. Ferruginous.

MR17



0.0 - 3.0m
Extremely weatrhered basalt and ferruginous clay.

MR18

0.0 - 3.0m
Slightly weathered basalt. Ferruginous staining.

3.0 - 7.5m
Fresh basalt. High strength.

7.5 - 9.0m
Distinctly weathered basalt. Ferruginous staining. Lower strength.

Appendix 2

PETROGRAPHIC REPORT

Petrographic Inspection Report

Title:	Petrographic Inspection Report: Olivine Basalt Spall
Prepared for:	Quarry Solutions
Date Sampled:	03/05/2018
Sample Type:	Spall
Source:	Meppem Station, NSW
Sample ID:	P2018.0077.001
Date of Inspection:	03/08/2018
Report Issued:	03/08/2018
Project/ File Ref.:	P2018_0077_001

Author:

Luke Ryan (BGeo)
Geologist,
Groundwork Plus

Reviewer:

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

Rock Identity

Name: Olivine Basalt

Lithology Basic Igneous Rock

Introduction

The results of this report relate to a recent geological investigation conducted on the Meppen Station, NSW and provides the results of a targeted petrographic assessment of spall retrieved on site. The thin section was prepared and analysed by Groundwork Plus by suitably qualified personnel 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 rock was selected to broadly represent the mineralogical and textural characteristics of the target source rock. Accordingly, it is accepted that the provided modal mineral percentages relate to this material specifically and that structural analysis of the site should determine the extent and nature of any variation. 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

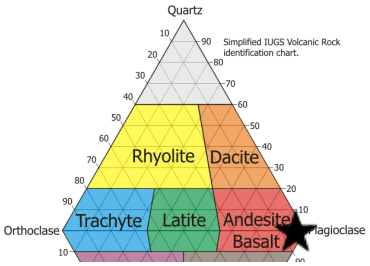
The petrographic assessment of the slide was carried out using a Nikon polarising microscope equipped with a digital camera at the Groundwork Plus petrographic laboratory. A photograph of the hand specimen and thin section photomicrographs showing grain sizes and any particular aspects of the minerals 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 600 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 aggregate is identified as an **Olivine Basalt**, an extrusive to hypabyssal **Basic Igneous Rock**.
- In hand sample, the spall is described as a black, fine grain, sparsely vesicular basic igneous rock displaying a basaltic mineral assembly consisting of abundant plagioclase laths and ubiquitous ferromagnesian phases including pyroxene, olivine and magnetite. Olivine crystals form 0.2 to rare 0.5mm green or weathered brown phenocrysts. The rock displays slight weathering as ferruginous staining and occasional argillic infill of sparse vesicles. The basalt displays otherwise competent, granular broken faces and is likely to produce well-shaped aggregate with crushing. The rock is regarded as hard, and is of predicted high strength and durability, well suited to a broad range of engineering products. The basalt is highly magnetic. Trace sulfides as pyrite is observed.



QAPF Diagram after Streckeisen, A. L., 1978 QAPF diagram is a double triangle diagram which is used to classify igneous rocks based on mineralogical composition. The acronym, QAPF, stands for "Quartz, Alkali feldspar, Plagioclase, Feldspathoid". Black star indicates bulk mineral composition of the rock.

- Petrographic analysis confirms that the aggregate represents an **Olivine Basalt,** a **Basic Igneous Rock,** comprising abundant well-formed and moderately flow aligned plagioclase laths (38%), pyroxene (29%), olivine crystals (10%), magnetite (11%) and residual volcanic glass (2%) accompanied by weak secondary smectite-chlorite (3%), iddingsite (2%), and goethite (2%) with associated zeolite and iron oxide staining. Minor secondary quartz occurs as vesicular rims.
- The basalt is composed primarily of robust silicate and opaque phases (91%) with texturally isolated secondary alteration and weathering products (9%). Heir-line fractures are not observed. While sparse voids are observed the basalt is essentially non-porous.
- The rock is regarded as innocuous in relation to Alkali-Silica Reactivity (ASR) in concrete given ferromagnesian character of residual volcanic glass and rare secondary quartz does not include chalcedonic varieties.
- Pending material testing, the examined basalt is predicted to be well-suited to a broad range of industrial applications including Unbound Pavements, Cover Aggregate, Aggregate for Concrete, Rail Ballast CT147, Manufactured Sand and Gabion/Revetment. Allocation of this aggregate to Asphalt Aggregate should be preceded by polished aggregate friction value (PAFV) testing given observed moderate flow alignment and fine crystal sizes.
- For engineering purposes, the rock may be summarised as:
  - Olivine Basalt, a Basic Igneous Rock.
  - Essentially unweathered to slightly weathered with generally texturally isolated weak-secondary phases (9%) and minor vesicular smectite.
  - Hard, of high strength and regarded as durable.
  - Non-porous with minor residual vesicular voids and no heir-line fractures.
  - Containing 2% free silica as remnant ferromagnesian volcanic glass. On this basis the basalt is considered innocuous in relation to ASR in concrete provided significantly more glassy material is not encountered.

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

Risk Rating for Application	Low	Mod	High	Comments (pending material testing and assuming the sample is indicative of overall source rock quality)
Coarse Aggregate in Concrete	✓			Expected to produce well-shaped, durable aggregate with competent crushed faces. Secondary phases sufficiently isolated to prevent liberation of significant fines with crushing
Unbound Pavements	✓			Suitable hardness, strength and durability
Cover Aggregate	✓			Suitable hardness, strength and durability
Rail Ballast	✓			Suitably durable, high density and low free silica as quartz
Asphalt Aggregate	✓			Suitable hardness, strength and durability, pending PAFV results
Manufactured Sand	✓			Liberated secondary fines should be manageable with standard processing strategies
Gabion and Revetment	✓			Suitable
Risk Rating Source Rock	**Low**	**Mod**	**High**	
Alkali Silica Reactivity	✓			Innocuous
Secondary Mineral Impacts	✓			9% texturally isolated secondary phases. Minor smectite infilling of vesicles
Durability	✓			Suitable
Strength	✓			Suitable
Hardness	✓			Suitable
Free Silica Content	✓			Minor quartz but 2% residual ferromagnesian volcanic glass
Sulfides	✓			Trace sulfides visible in hand specimen
Light particles	✓			No light micaceous particles detected
Voids	✓			Minor voids as residual vesicles
Bitumen Affinity	✓			Basic igneous rock associated with adequate bitumen affinity.
Polishing		✓		Polishing potential likely to be off-set by the tightly inter-grown crystal matrix and robust mineralogy of the basalt. PAFV testing recommended to precede allocation to asphalt
Heir-line fractures	✓			No heir-line fracturing observed

*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 weathered rind common among surficial spalls on-site. Vesicles in the basalt resulting from entrained gas bubbles remain as partially filled voids in the rock measuring to 0.5mm in diameter and hosting secondary quartz and ferruginous/argillic material.

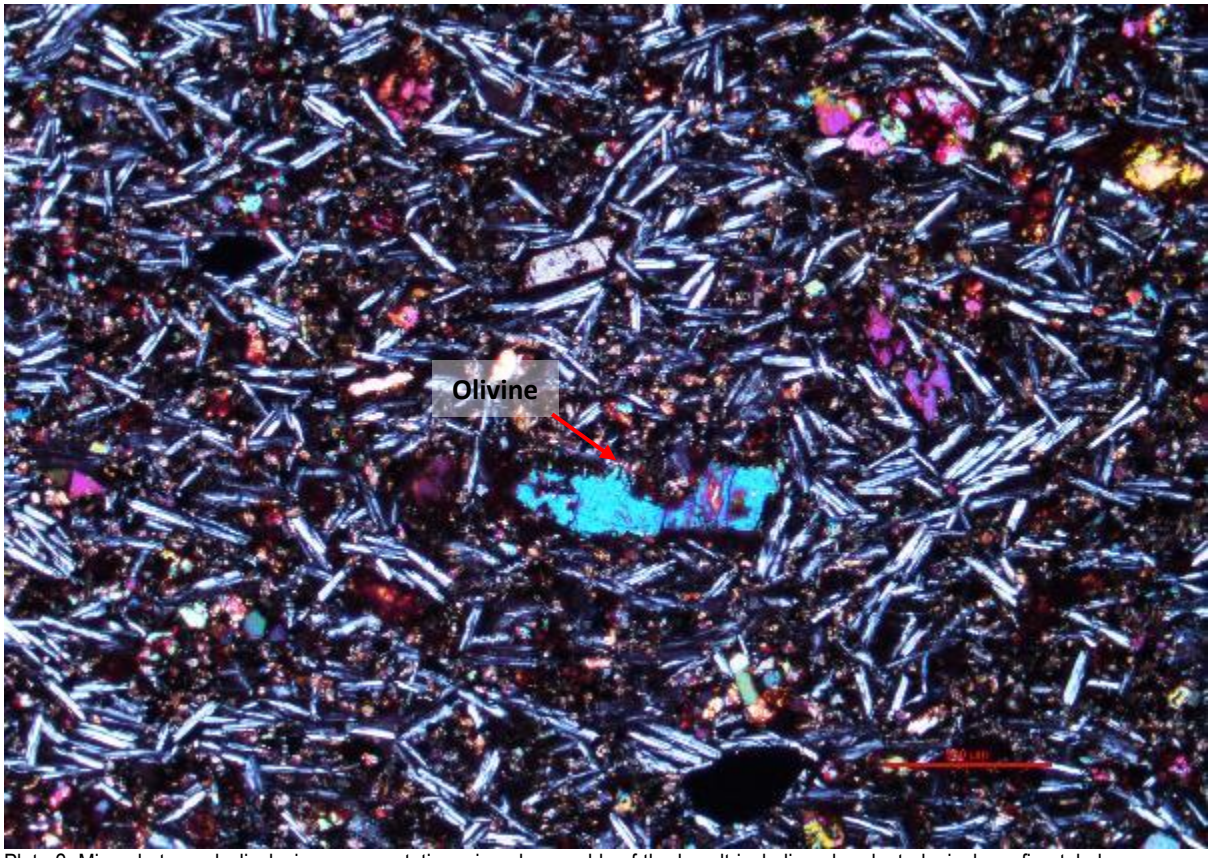


Plate 2: Microphotograph displaying representative mineral assembly of the basalt including abundant plagioclase, fine tabular pyroxene and plagioclase with finely disseminated magnetite. Image shown in cross polarised light.

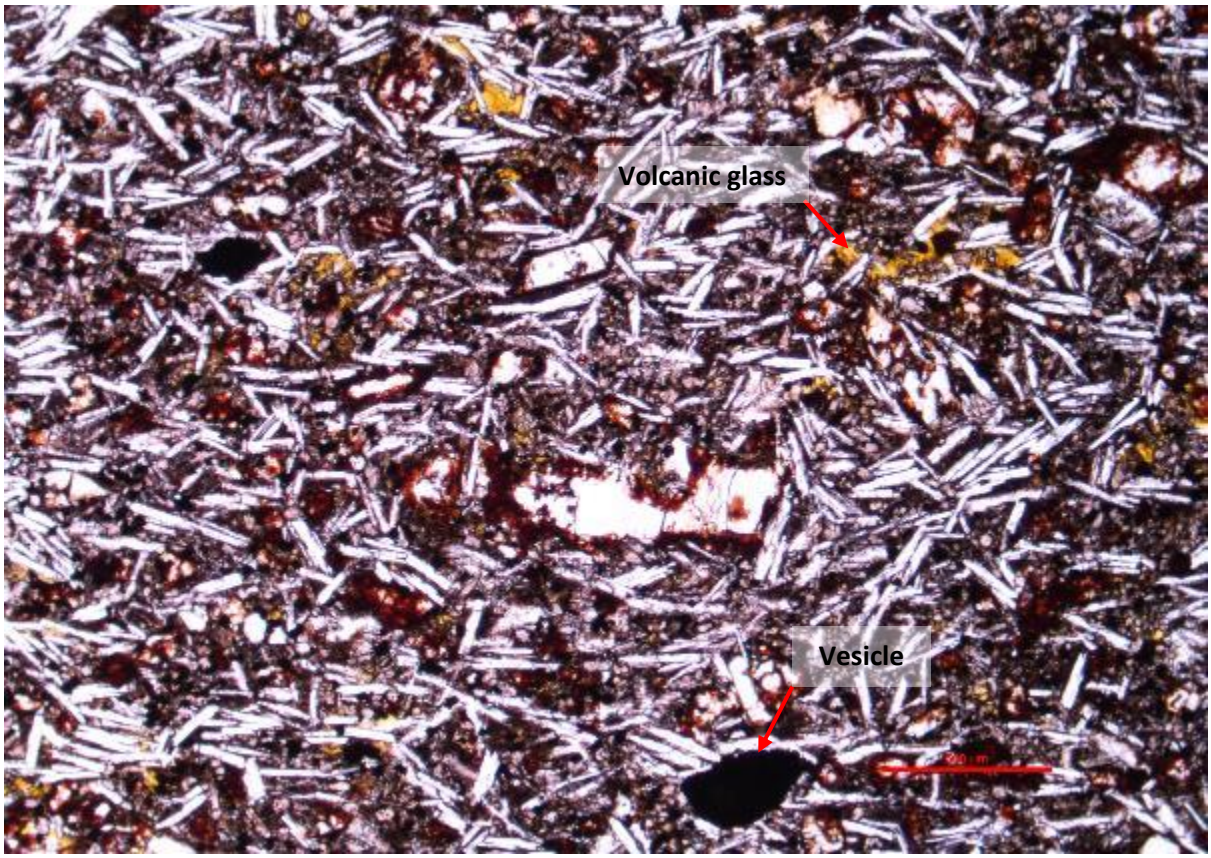


Plate 3: Microphotograph shown using plane polarised light to distinguish iddingsite alteration among olivine crystals, residual partially devitrified volcanic glass and opaques.

Thin Section Description

The basalt displays a fine phaneritic to porphyritic, hypidiomorphic, sparsely vesicular and originally hypo-crystalline texture. Slight weathering is indicated by trivial ferruginous staining and partial replacement of olivine crystals following mild alteration by smectite-chlorite. The bulk of the rock consists of pristine plagioclase laths displaying characteristic swallow tail terminations and mild flow alignment interrupted by coarse olivine crystals. Fine tabular and generally pristine to mildly altered pyroxene crystals occupy the interstitial space with finely disseminated magnetite. Altered crystals display goethite ingress and associated emanative ferruginous staining. Olivine phenocrysts occur as 0.2 to 0.5mm euhedral prisms with isolated 2mm examples accompanied by agglomeritic pyroxene and opaques or associated opaque clots. Iddingsite alteration is under-developed and alteration to goethite is generally limited to surficial sub-opaque examples. Resolution with weathering to smectite-chlorite occurs in association with the spall's weathered rind, infilled vesicles and devitrified glass. Sparse vesicles host partial infill of composite goethite, smectite-chlorite, calcite and rare quartz with zeolite. Residual glass is observed in masses associated with vesicle occurrence and occurs as a brown ferromagnesian mesostasis with partial devitrification to obscured allumino-silicate phases, zeolite and minor smectite clays with associated emanative ferruginous staining. Fractures within the rock are observed but are barren and therefore regarded as occurring with sample reduction rather than heir-line fracture textures. Scrutiny of this feature is recommended in aggregate produced from this source.

Due to the low incidence of voids as partially filled rare vesilces the basalt is regarded as essentially non-porous, with low risk of amygdaloidal textures and significant associated deleterious clays including montmarillonite. This has positive implications for the overall strength and durability of the basalt as well as the capacity of the source rock to produce a broad range of engineering products. Basic igneous rock, particularly those displaying mild to well-developed flow lineations among plagioclase laths can be associated with polishing in service as asphalt aggregate. The extent to which this potential is off-set by the basalt's robust tightly inter-grown mineral assembly should be assessed by PAFV testing prior to utility in these roles. A mode based on a count of 600 widely spaced points is listed in **Table 2** - **Modal Analysis of Minerals**.

Table 2 - Modal Analysis of Minerals

PRIMARY MINERALS	MODE (%)	COMMENTS
Plagioclase	38	Pristine with mild flow lineations 0.2mm
Pyroxene	29	Mildly altered fine tabular crystals 0.05 to 0.1mm
Olivine	10	Occurring as subhedral pristine to slightly altered crystals 0.2-0.5mm
Magnetite	11	Finely disseminated cubic opaques with clots associated with olivine
Volcanic glass	2	Residual vitric mesostasis. Brown glass
Apatite	Minor	Common needle-like intrusions in plagioclase and pyroxene crystals
Volcanic glass	Trace	Rare residual glass mesostasis
SECONDARY MINERALS		
Iddingsite	3	Alteration product of olivine
Smectite/chlorite	2	Weathered iddingsite in association with goethite and rare vesicle infill
Goethite/iron oxide	2	Alteration product and associated emanative staining
Zeolite	2	Alumino-silicate devitrification product
Quartz	Minor	Partial vesicular infill
Sericite	Trace	Alteration product of plagioclase
Calcite	Trace	Rare devitrification product
Voids	Minor	Barren or partially infilled residual vesicles
Total	**100**	***Balance accounted for minor and trace minerals***

Summary

Pending material testing, the examined basalt is predicted to be well-suited to a broad range of industrial applications including Unbound Pavements, Cover Aggregate, Aggregate for Concrete, Rail Ballast CT147, Manufactured Sand and Gabion/Revetment. Allocation of this aggregate to Asphalt Aggregate should be preceded by polished aggregate friction value (PAFV) testing given observed moderate flow alignment and fine crystal sizes.

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Free Silica Content

Minor free silica as quartz but 2% remnant ferromagnesian glass.

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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.

Appendix 3

UNDERSTANDING YOUR 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.