University of Southern Queensland

Faculty of Engineering and Surveying

Impact of Pavement Material for Flood Resistance on Rural Roads

A dissertation submitted by

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In fulfilment of the requirements of

Bachelor of Civil Engineering (Honours)

November 2024

ABSTRACT

This dissertation analyses and develops the idea that there is a lack of understanding between which granular road base materials are best suited for the construction of rural flood-affected roads, in terms of quality and cost.

The Queensland road network is approximately 226,000 km long of which 80% can be classified as rural roads. A lack of road maintenance and upgrade services in rural areas ultimately results in a failing transport system, which leads to rising costs and significant financial impacts to the local economy and population. Specifically, insufficient road maintenance leads to reduced service delivery and decreased safety on the roads. Consequently, the importance of maintenance needs to be recognized by government to ensure these issues can be avoided.

The ultimate goal for this project is to determine the most cost-effective way to repair and restore rural unsealed granular, flood affected roads when there is a shortage of quality materials. To determine the best option, various tests were conducted including testing road subgrade strength using both Dynamic Cone Penetration (DCP) testing and California Bearing Ratio (CBR) testing. This testing took place on Normanton – Burketown Road in Carpentaria Shire, Queensland.

DCP testing yielded an average CBR value for existing poorer quality material along Normanton – Burketown Road of 36%. According to MRTS05 this would most likely be a Type 2.4 material. CBR test results from gravel of higher quality from Well's Quarry yielded a CBR result of 100%. According to MRTS05 this would most likely be a Type 2.1 material.

For this specific example, it is predicted that **flooding will occur** each year on Normanton – Burketown Road, in which case the preferred option for this scenario is the **Type 2.4** material. It has been determined that the Type 2.1 material will not perform better under flooded/soaked conditions then the Type 2.4 material will, and due to the Type 2.4 material being cheaper and more easily accessible throughout the entire shire, this is ultimately the preferred option. With flooding of the road each year being extremely likely, it is proposed that the Type 2.4 material option will be required.

Table 1 – Estimated Total 5 Yearly Maintenance Costs when Flooding Occurs

	Type 2.4 Material	Type 2.1 Material
Total	$51,290,925.00	$52,028,505.00

With the ultimate goal of this report to determine which road base material is best suited for the construction of rural roads when flooding occurs, the **Type 2.4** material is the recommended option.

DISCLAIMER

CANDIDATES CERTIFICATION

I certify that the ideas, designs and experimental work, results, analyses and conclusions set out in this dissertation are entirely my own effort, except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

M. Gambin
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09/09/2024

ACKNOWLEDGMENTS

This research was carried out under the principal supervision of Dr. Hannah Seligmann.

Appreciation is due to the course coordinator Associate Professor Belal Yousif.

Appreciation is also due to John Martin of ERSCON Consulting Engineers for allowing the use of the company's DCP equipment to perform testing, as well as access any historical test data and other information within Carpentaria Shire.

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NOMENCLATURE AND ACRONYMS

CBR	**California Bearing Ratio.**
DCP	**Dynamic Cone Penetration**
OMC	**Optimum Moisture Content.**
RV	**Recommended Value.**
TMR	**Transport and Main Road.**
QRA	**Queensland Reconstruction Authority.**
MTM	**Materials Testing Manual (TMR)**

CHAPTER 1
Introduction

1.1 Background

The Queensland road network is approximately 226,000 km long of which 80% can be classified as rural roads. Rural roads typically carry low volumes of traffic. While they are essential for connecting communities, particularly in remote areas, rural roads are not normally well funded in comparison with major roads in high population centres. Many are unsealed and often traverse harsh terrain and may become impassable in wet weather. An example of such roads can be found in Carpentaria Shire, in Western Queensland. The region is continuously hit each year with severe weather events causing immense flooding. This flooding then causes, damage to the roads and the surrounding environment, loss of cattle and crops, and roads become inaccessible, meaning farmers, residents and truck drivers cannot access certain areas, resulting in loss of profits.

While there have been advances with the use of innovative methods and materials for the development and management of these roads, their ongoing development and management continue to present significant challenges. This is in part due to a lack of funding available for ongoing maintenance or upgrade of these roads, higher transport costs for materials, the isolation of communities due to flooding and the need for non-standard pavement materials for road construction, due to scarcity of standard materials in rural areas.

Fortunately, the Queensland Government offers a range of funding schemes to help tackle these issues and restore or upgrade these roads. This is done through the Queensland Reconstruction Authority (QRA). Their role consists of managing and coordinating Queensland’s program of recovery and reconstruction funding within disaster-impacted communities. (Queensland Government, 2023).

As of October 2019, the government has approved an average of $44 million worth of funding each year to Carpentaria Shire, to aid in the recovery from flooding events. (Queensland Government, p 12, 2019). Since this date, an average of 8 significant flood events have been recorded each year around Queensland. (Queensland Government, 2024).

Ultimately, the selection of pavement materials is a critical element in the design, construction and maintenance of pavements if performance is to be optimised and whole of life costs minimised. The selection process relies on the evaluation of a number of criteria, some of which may be in conflict. This evaluation process relies on materials testing, evaluation of environmental impact, financial considerations, legacy issues, past performance and engineering judgement. (Austroads, p 5, 2007).

1.2 The Problem

A lack of road maintenance and upgrade services in rural areas ultimately results in a failing transport system, which leads to rising costs and significant financial impacts to the local economy and population. Specifically, insufficient road maintenance leads to reduced service delivery and decreased safety on the roads. Consequently, the importance of maintenance needs to be recognized by government to ensure these issues can be avoided.

It would appear that there is a lack of understanding between which road base materials are best suited for the construction of these rural flood-affected roads, specifically unsealed granular pavements. An analysis between the quality (strength) of the material used and the amount of times the road is subjected to flooding needs to occur to find an appropriate balance between durability and cost.

1.3 Research Objectives

The objective of this report is to research the current flooding factors that affect the structural integrity of rural roads in Western Queensland, and the current government funding schemes and legislations in place to upgrade or restore these roads following these weather events. After analysing all the current data, a gap in the existing knowledge can be found and a solution can be proposed. The methodology of this solution will then be explored. This will include discussing the proposed scope of works, aims and objectives, as well as required project resources, materials and schedule. Following this, a risk assessment will be performed on the proposed solution to evaluate any hazards and the likelihood of them occurring, and if necessary, remove the hazard or minimize its level of risk by putting control measures in place. Following this, any conclusions and recommendations will be made.

Summary:

- Analyse historical flood modelling within rural areas.
- Analyse various pavement materials within Australia and Carpentaria Shire, and how these relate to flood immunity.
- Perform unsealed granular pavement tests along Normanton – Burketown Road and compare existing material to imported material of better quality.
- Draw conclusions on preferred option and make any recommendations.

1.4 Conclusions

The purpose of developing this report is to raise the issue that is prevalent within our rural road infrastructure sector – the lack of quality pavement material available in rural areas. This project involves conducting various tests in attempts to compare the cost and durability benefits, or limitations of using either existing poor-quality pavement materials at a lower cost, or importing good quality materials at a higher cost, particularly when a road is subject to flooding. It is hoped that following this analysis an appropriate balance between durability and cost can be found and implemented for future projects.

Considering low volume rural roads are not funded as well as major roads, it would seem logical to choose the most cost-effective option. The expected outcomes of this project will be that the poor-quality material will prove to be more cost effective, however, it will not have the same strength and durability of the good quality pavement material. Seeing as these roads are subjected to extreme flooding each year, it is important that the material used, is of high strength. On the contrary, flooding will damage the road, no matter how strong and durable its materials are, so perhaps, it is simply better to implement cost saving measures and utilize the poorer quality gravel. If anything would improve the flood resistance of a road, it would be by sealing it, however, this is outside the scope of this report.

Benefits of this project include cost savings, leading to governments being more willing to spend money to help repair Carpentaria Shire's rural roads. This in turn has benefits for local community members, farmers, transport workers, and travelers.

CHAPTER 2
Literature Review

2.1 Introduction

This literature review focuses its analysis on Queensland's consistent flooding events that cause damage to its rural roads and environment, and the funding schemes that are in place to mitigate help this issue, with a focus on roads within Carpentaria Shire. Additional information was researched regarding legislation, guidelines, and policies within Queensland. Examples of Council's response following an extreme weather event is also explored for Toowoomba Regional Council, Carpentaria Shire Council, Brisbane City Council and Hinchinbrook Shire Council. Pavement design, materials and rehabilitation options within Queensland are also analysed. This literature review also has a focus on the knowledge gap that is present within this information.

2.2 Rural Queensland Flood Events

The Flood Mitigation Cycle forms the basis for the development of strategies for flood protection and flood responses. Councils will typically use this system or something similar to prepare themselves for a disaster. The flood mitigation cycle can be considered as three stages, by considering the Project Report strategies that affect the system's response, relative to the timing of the flood. The strategies can be considered as those which:

- Aim at improving the system's readiness and preparedness prior to a flood event
- Aim at improving the system's response during a flood event
- Aim at improving the system's recovery following a flood event

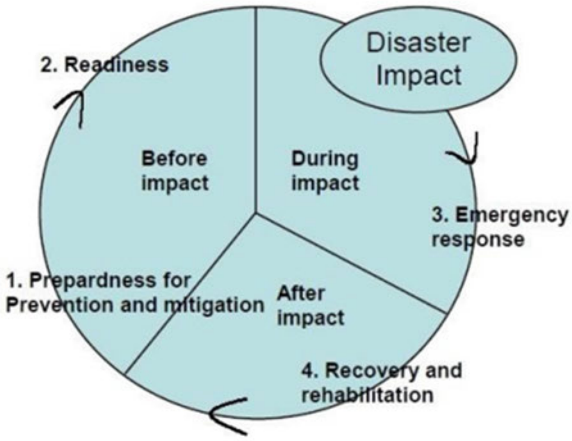

Figure 1 – Flood Mitigation Cycle (Mark and Djordjevic, 2006)

According to the Queensland Government, "North-West Queensland experienced one of its worst flooding event in 2019 from a slow-moving Monsoonal trough which developed to the north of Australia and intensified as it moved over Cape York Peninsula towards Townsville and then inland towards Mt Isa. Once this trough was to the west of Cloncurry, it became almost stationary. The resulting rainfall totals were the highest on record over much of this area (Figure 2), extended for a week to 10 days, and led to extensive flooding across the region." (Queensland Government, 2019, pp. 3).

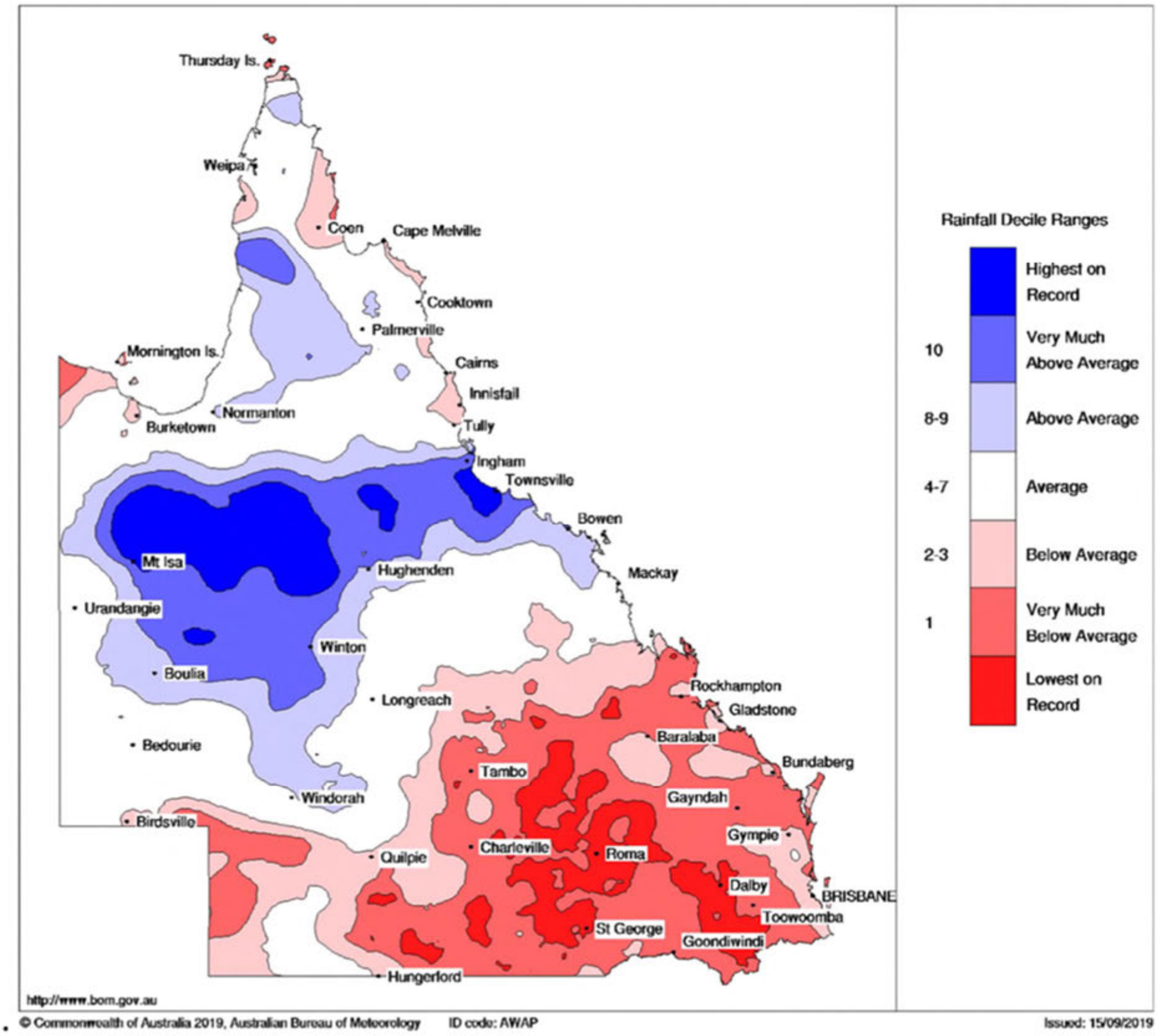

Figure 2 – (Queensland Government, 2019, pp. 4)

The Queensland Government states that "Shires of the Burke, Carpentaria, Cloncurry, Flinders, McKinlay, Richmond and Winton were disaster declared to ensure people isolated by the flooding were safe, to provide assistance to deliver food to surviving livestock. The damage to infrastructure was immense, with approximately 10,200 km of fencing destroyed and over 29,300 km of roads destroyed." (Queensland Government, 2019, pp. 9).

2.3 Funding Schemes

There are many funding schemes offered in Queensland that are administered by the Queensland Reconstruction Authority (QRA), with the hopes of improving communities' resilience to extreme weather events, such as the 2019 flooding event in North-West Queensland investigated above. QRA currently administers the following disaster relief and recovery funding arrangements:

- **Disaster Recovery Funding Arrangements (DRFA) –** "which is an agreed Australian Government and state government cost sharing arrangement that may be activated following an eligible disaster to aid impacted community members, small businesses, not-for-profit organizations, primary producers, local governments, and state government agencies." (Queensland Government, 2022).

- **State Disaster Relief Arrangements (SDRA**) – “which is a wholly state funded program that may be activated for all hazards and aids where personal hardship and distress is experienced following the impact of a disaster event.” (Queensland Government, 2022).
- **Resilience Funding** – “QRA administers disaster resilience funding on behalf of the State of Queensland. 2021-22 Queensland Resilience and Risk Reduction Fund (QRRRF) has spent $19.1 million in helping eligible communities, mitigate and manage the risks associated with natural disasters. North Queensland Natural Disasters Mitigation Program aims to help councils in North and Far North Queensland reduce their disaster risk and assist in reducing the growth of insurance costs for residents, businesses and the community.” (Queensland Government, 2022).
- **“Get Ready Queensland funding for councils”** – “This funding scheme is about building our resilience to deal with the extreme weather and natural disasters that are part of living in our state. Its aim is to make Queensland the nation’s most disaster resilient state. The program provides a total of $2 million in Queensland Government funding to help local governments improve their communities’ resilience.” (Queensland Government, 2022).
- **Queensland Betterment Funds** – “Queensland Betterment Funds are jointly funded by the Australian and Queensland Governments and enables the reconstruction of public assets to a more disaster resilient standard. Queensland leads the nation in delivering betterment programs that demonstrate how upfront investment in stronger, more resilient assets, saves money for all levels of government in future disasters. Since 2013 when the first betterment fund was established by QRA, more than 520 projects across 70 local government areas in Queensland – with a betterment value of more than $263 million – have been approved to helped create stronger, more resilient Queensland communities.” (Queensland Government, 2022).
- **Exceptional Circumstances Assistance** – “This funding offers two categories of exceptional circumstances in which assistance will be provided for severely affected communities following disaster events. Category C provides assistance for severely affected communities, regions or sectors includes clean-up and recovery grants for small businesses and primary producers and/or the establishment of a Community Recovery Fund. Category D assistance is generally considered once the impact of the disaster has been assessed and specific recovery gaps identified that cannot be covered in any other category.” (Queensland Government, 2022).

Several legislations have also been put in place by the Australian Government to deal with disaster management throughout Australia. These include:

- **Local Government Act 2009** – “This provides the legislative framework for local government to operate during normal time. Section 59 to 75 of the Act deals with roads and other infrastructure. Section 60 gives authority to local government to control all roads within the local government area.” (Local Government Act 2009).
- **Disaster Management Act 2003** – “This is a state legislation that governs Local Government responsibilities in a disaster and gives authority for local government to act during a disaster. Sections 57 directs local government to prepare a plan for disaster management in the local government area. Section 59 directs local government to review and renew the local disaster management plan and review its effectiveness at least once a year. Section 76 provides direction regarding general powers of local government during a disaster. These powers include ensuring public safety and order,

prevention of loss of life, prevention of loss or damage to property and directions to respond to the disaster." (Disaster Management Act, 2003).

2.4 Local Council Disaster Management Response

Two councils in Queensland have been analyzed in regard to their disaster management response involving surrounding roads, following an extreme weather event. These two have been chosen to help gain a better understanding of Council response to natural disasters within Queensland.

2.4.1 Toowoomba Regional Council

A report analysing Toowoomba City's Disaster Management stated the following:
"On 10 January 2011 two storm cells passed over south-east Queensland as one intense thunderstorm. The rainfall that fell into the Toowoomba City catchment area caused massive and severe flash flooding in Toowoomba City. On Tuesday, January 11, 2011, the Premier of Queensland, Anna Bligh, declared three quarters of Queensland a disaster zone. In Toowoomba city the surging water washed away bridges, damaged road and railway lines and flooded the central part of the CBD. The narrow watercourses caused the water to flow at a high velocity, with great depth and carrying away all in its path." (Olm, 2011, pp.25).

"The Disaster Management Act 2003 is the main legislative instrument which provides the authority and directions under which Councils are to act in a disaster event. Local councils have a legislated responsibility to manage and prepare for the possibility of a disaster event which is defined as an event that will have a profound and adverse effect on the safety of life and property within their area. This responsibility includes investigating and planning for disaster mitigation, prevention, preparedness, response, and recovery from an event. The local governing body in to ensure a "response capability" to an event which means that their planning is to include preparedness to provide personnel and resources sufficient to deal with the emergency, a disaster plan and disaster management group to manage an event and the council must provide and maintain a facility and equipment to be used as a coordination centre in the event of a 28 disaster." (Olm, 2011, pp. 27).

Acting on this legislation, Toowoomba Regional Council imposed Emergency works and Restoration works to their roads under the QRA Natural Disaster Relief and Recovery Arrangement (NDRRA) scheme.

"The emergency response began by the council closing unsafe roads to public access with the assistance of Police and erecting appropriate warning signage where needed. The council also issued safety warnings regarding unsafe roads via local radio and other media and asked residents to refrain from travel if possible. The council website publicised road and safety conditions and other information to keep the public informed of the situation. Emergent work performed immediately after the disaster focused on preserving public health and safety and restoring the road system to reopen road network systems for citizens to resume normal communications. Therefore, immediate repair work entailed inspections, removal of debris, performing road closures by erecting appropriate signage and barriers, traffic control, pavement repair, road patching, mill and fill, and backfill. Where the damage was not easily repaired to restore the road to a safe and trafficable condition, road barriers and road closures were performed to wait for further assessments and reconstruction works. Emergent works were then completed within 60 days of the activation date as per the NDRRA Guidelines." (Olm, 2011, pp. 36-37).

"Once the initial disaster phase was over Toowoomba entered the recovery and restorative phase when reconstruction of the community could begin. Restoration works and submissions are to be completed within 2 years of the activation date. Reconstruction works included removal of debris, replacement of road furniture, scour protection, resurfacing and repair of bridge structure and unsealed shoulders." (Olm, 2011, pp. 37-39).

Toowoomba Regional Council organised and authored the appropriate disaster management system that ultimately restored the regions roads and helped the system cope with the 2011 weather event.

2.4.2 Carpentaria Shire Council

The 2019 flood that had ravaged the North-West of Queensland is recorded as one of the worst in recent years. The council of Carpentaria Shire had a similar disaster response to Toowoomba Regional Council for their 2011 event. Their response included 3 stages:

- Stage 1 – Immediate Recover
- Stage 2 – Short to Medium Term Recovery
- Stage 3 – Long Term Recovery

"Stage 1 aims to address and support the immediate needs of individuals, businesses and the community affected by an event. This phase of recovery is challenging as it often coincides simultaneously with response operations. It is the period after a disaster when initial "relief" services are offered to the affected community whilst the full recovery framework is established. It is also the period when detailed recovery planning, including damage and needs analysis is undertaken. Some examples included restoration of power, water and communication commenced, emergency shelter, clothing and food distribution, roads re-open and personal support provided." (CSC, 2021, pp. 19).

"Stage 2 continues the coordinated process of supporting affected communities in the reconstruction of physical infrastructure, re-establishment of the economy and rehabilitation of the environment. During this phase, support for the emotional, social, and physical wellbeing of those affected continues. The recovery activities at this stage will assist the affected community to return to a state of normality, although the community may experience significant change resulting from the event." (CSC, 2021, pp. 20). Examples of this from the 2019 event included assessments on impacts and needs, repairing roads, community support and development and supply chains returning to normal.

"Stage 3 is characterised by the ongoing restoration and rebuilding of physical infrastructure, restoration of the economy and of the environment, and reshaping to support sustainability of recovery measures in the longer term. During the transition phase, specialist recovery workers leave affected communities and systems start to wind down as normal community development and business as usual processes return. Long term recovery may last many months and in some cases many years after the event." (CSC, 2021, pp. 20). Examples following the 2019 event included restoring asses to their original state or improving them. This included sealing of certain sections of road and upgrading causeway crossings to be more flood resistant. Exit strategies can also be implemented, including completion reports of this work.

2.5 QRA Treatment Types

A treatment guide is prepared by QRA to provide a common set of treatments for the scoping of road reconstruction works following damage by natural disasters. The following treatment types are used to restore and rehabilitate unsealed roads within Queensland to their original structure. (QRA, 2021).

Light Formation Grading

"Light Formation Grading is often undertaken during the emergency works period to restore rideability prior to restoration works. Where the road is formed only (not gravelled), and loss of shape and material is minor only, a Light Formation Grading may be appropriate for restoration works to restore shape." (QRA, 2021). Works involve light trimming by a grader of the roadway to fill any holes and depressions. No imported gravel is required.

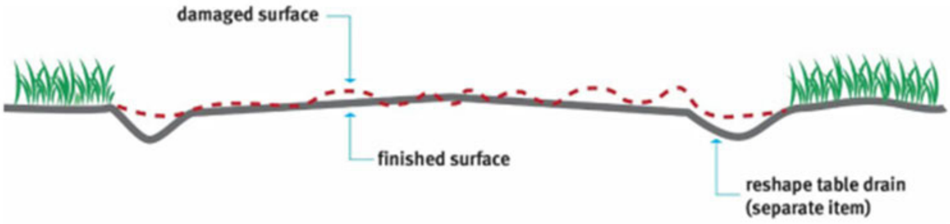

Figure 3 – Light Formation Grading (QRA, 2021)

Medium Formation Grading

Medium Formation Grading involves "grading to restore the road surface to pre-disaster profile and condition. Includes roughening of up to 50mm of roadway top (by grader), clearing and grubbing to remove light vegetation and grass, recovery of suitable material from table drains (by grader), incorporation of water and compaction." (QRA, 2021). No imported gravel is required.

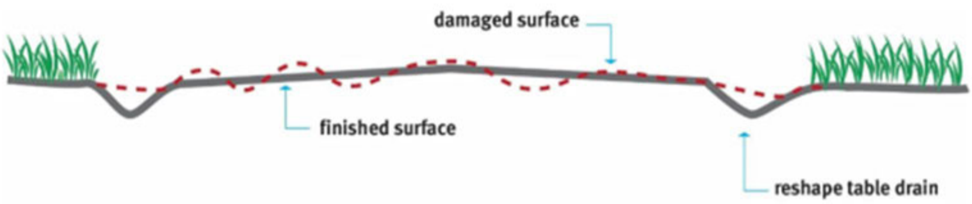

Figure 4 – Medium Formation Grading (QRA, 2021)

Heavy Formation Grading

Heavy Formation Grading involves "clearing and grubbing and recovery of suitable material from table drains (by grader), tyne <100mm depth (150mm if supported by depth of rutting), incorporation of additional gravel/material (excluding Heavy Formation Grading), trimming, and compaction." (QRA, 2021).
Heavy Formation Grading including 50mm gravel supply and Heavy Formation Grading including 75mm gravel supply are the available gravel/material supply options.

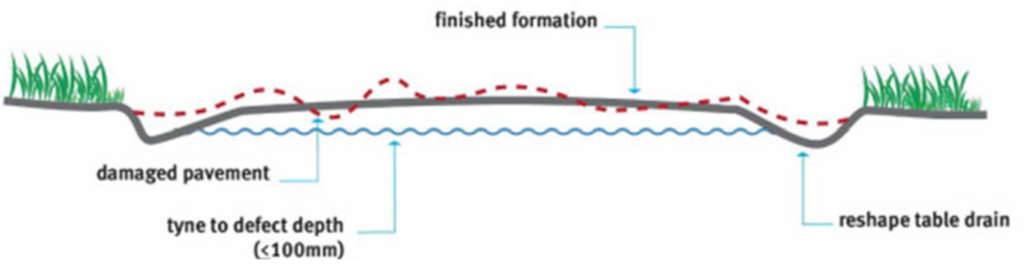

Figure 5 – Heavy Formation Grading (QRA, 2021)

Gravel Resheeting

“Preparation of the formation through Heavy Formation Grading. Supply and spreading of imported gravel/material. Imported material should be consistent with material in-place pre-disaster or material which the asset owner currently uses for maintenance in the area.” (QRA, 2021).

Gravel Resheeting including 100mm gravel supply and Gravel Resheeting including 150mm gravel supply are the available gravel/material supply options. Gravel Resheeting excluding gravel/material supply is also available, with the option to add gravel/material supply separately.

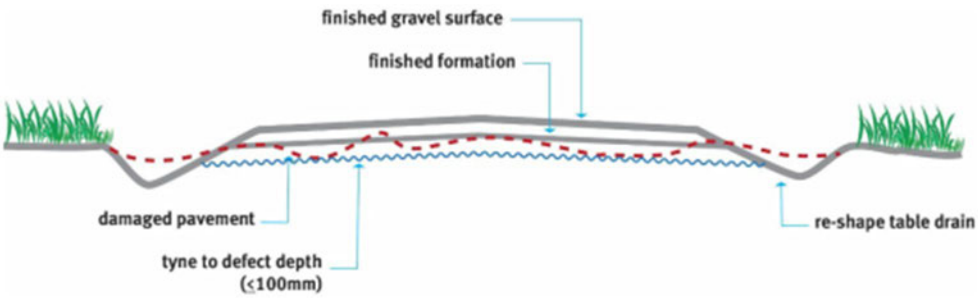

Figure 6 – Gravel Resheeting (QRA, 2021)

The treatment types required to repair a road are determined by engineers assessing the road damage and assigning treatment options, based on the extent of the damage. This then must be approved by QRA.

2.6 Flood Affected Pavements

Two studies by Griffith University have been analysed, in relation to flood affected pavements caused by the 2011 Brisbane Floods. “A Study of the Flood Affected Flexible Pavements in Australia” and “A Review of the Structural Performance of Flooded Pavements” both present findings on the functional and structural performance of flood affected roads, comparing data from flooded and non-flooded roads, with the hopes of creating more resilient road networks.

A Study of the Flood Affected Flexible Pavements in Australia

“This study commenced in early 2013 and was funded by Austroads and the ARRB Group in a collaborative research arrangement between the ARRB and Griffith University. The study examines the structural and functional performance of flood affected flexible pavements using the Falling Weight Deflectometer (FWD) and surface condition data sourced from the Brisbane City Council (BCC) and the Roads and Maritime Services of New South Wales (RMS, NSW). The research aims to advance

the knowledge on the effect of extreme weather events such a flooding or frequent heavy rainfall events, on pavement deterioration and to address the long-term impact of flooding on the sealed local roads. An extensive and long-term monitoring of flood affected roads is very significant to assess the rapid deterioration phase of pavement after flooding. Hence, it is necessary to implement a systematic program to investigate the deterioration of flood affected roads." (Sultana, 2015, pp. 2).
The report states that the total damage to public infrastructure across Queensland during the 2011 Brisbane floods was approximately $5-$6 billion. Road sections that were provided with flood data are in Brisbane and include Luxford Street in Chelmer, Haig Road in Milton and Aldersgate Street in Oxley.
From the data analysis, the following key information can be gathered:

Table 2 – Flexible Pavement Data Analysis

Structural Strength	• The flood-affected pavements experienced a decrease in structural strength immediately after the flooding. • The reduction in modified structural numbers (SNC) ranged from 1.5% to 50% in different pavement sections. • Two years after the flood, some pavement sections showed a gain in structural strength due to post-flooding rehabilitation works and subsequent dry weather periods. • However, four years after the flood, some pavement sections showed a further reduction in structural strength, indicating ongoing damage to the subgrade.
Subgrade Strength	• The subgrade CBR values (California Bearing Ratio) decreased significantly during the flooding. • The loss of subgrade strength ranged from 7% to 67% at different chainages. • Report does not state whether the original CBR tests were soaked or dry.
Surface Conditions	• Marginal increases in roughness, rutting, and cracking were observed in some parts of the flood-affected pavements. • The increase in roughness was measured using the NAASRA Roughness Meter (NRM) in counts/km. • Rutting and cracking were measured in millimetres.
Statistics	• Mean maximum deflection values were higher immediately after the flood for some pavement sections.

	• Two years post-flooding, mean deflection values improved in some pavement sections due to post-flooding rehabilitation work. • Four years post-flooding, some pavement sections showed a further reduction in mean deflection values. • The coefficient of variation (CVAR) was calculated to assess the variation in deflection values.

Overall, the data analysis indicates that flood affected pavements experience a faster deterioration in structural strength and surface condition. "It can be concluded from the analysis and discussion that both resurfacing/rehabilitation and subsequent dry weather period following flood and heavy rainfall events contributed to the strength gain of the pavements." (Sultana, 2015, pp. 10).

2.7 Flood Affected Pavements within Carpentaria Shire

Roads within Carpentaria Shire are consistently affected by extreme flooding each year, often resulting in major damage to their surfacing and/or structural integrity. Moreover, the pavement material currently being used to rehabilitate these roads are of a poorer quality, as importing high quality material is generally too costly. This further compounds the amount of damage that occurs to the roads. Normanton – Burketown Road will be the primary example of this analysis.

2.7.1 Normanton – Burketown Road

Normanton – Burketown Road is approximately 141km long and connects Normanton to Burketown up until the Carpentaria and Burke Shire boundary. The road is 8m wide and as of 2024 has approximately 76.3km of seal from the start of the road (64.7km is unsealed).

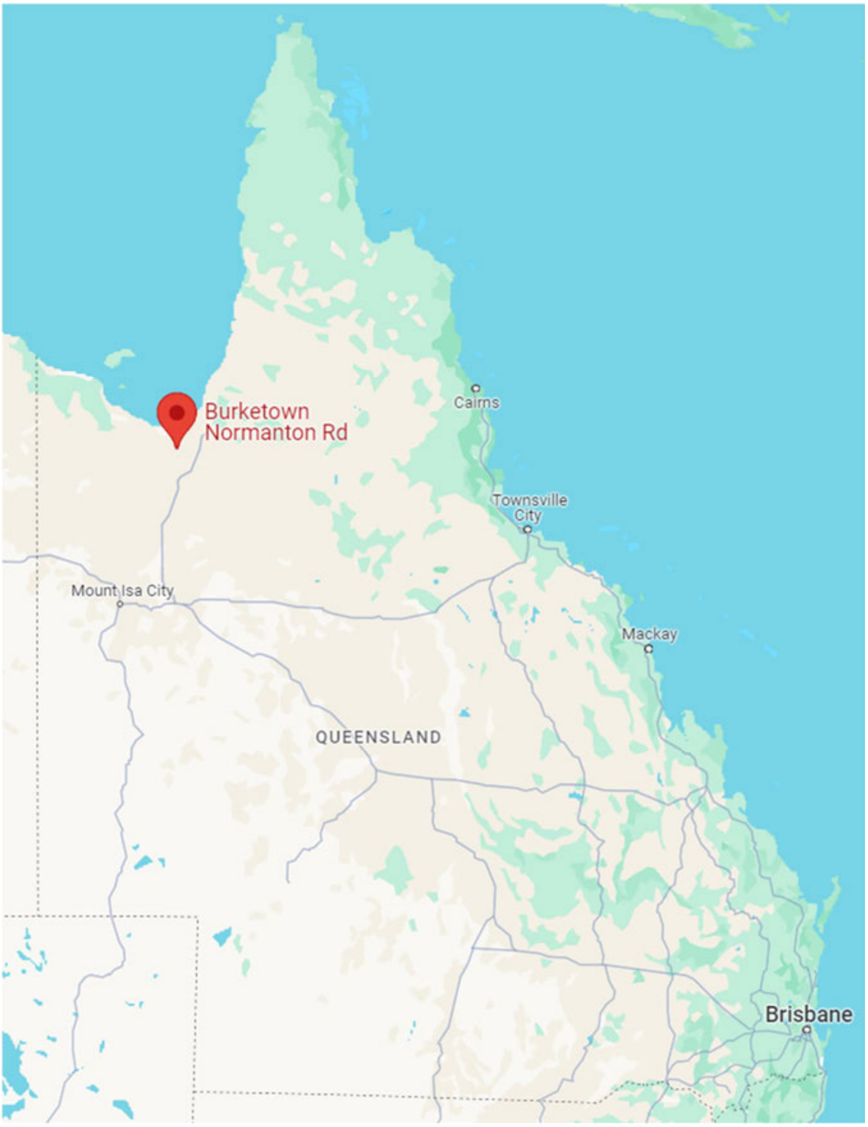

Figure 7 – Normanton – Burketown Road Locality.

This road is a Principal Road within Carpentaria Shire and has been a high priority for improvements with significant betterment funding expended in recent years for the upgrade of causeways and sealing.
Normanton to Burketown Road forms part of the Savannah Way (Cairns to Broome) and has been identified for the Roads of Strategic Importance Fund (ROSI) funded by the Australian Government. It is a key link in the Savannah Way and improvements are programmed progressively between now and 2030. Normanton to Burketown Road falls within the Cairns to Northern Territory Corridor.

The road is currently an even combination of station, construction, and tourism traffic throughout the year. Traffic count data from the beginning of road shows an AADT of 89.4 combined light and heavy vehicles. Full traffic counts from 2019 are provided in **Appendix A**. It is expected that there will be approximately 2% p.a. growth in tourism traffic volumes and 1% p.a. growth in general traffic (Cummings, 2019) giving an approximate AADT of 102.8 in 2024.

2.7.1.1 Associated Yearly Costs

Recent upgrade projects include:

- 2015 Bynoe/Little Bynoe/Flinders River Causeways – Total value approx. $6 million
- 2020/21 Sealing - Total value approx. $4.1 million
- 2018 M Creek Causeway – Total value approx. $5 million
- 2023 Armstrong Creek Causeways – Total value approx. $2.4 million
- 2023 Inverleigh West Causeway – Total value approx. $500k
- 2023 Sealing - Total value approx. $5 million
- 2024 Sealing - Total value approx. $5 million
- 2024 Boredrain Creek Causeway - Total value approx. $982k

Normanton – Burketown Road is subject to extensive flooding each wet season, resulting in prolonged road closures and extreme damage to the road's structure. As a result, the Queensland Government expenses millions of dollars each year to restore and rehabilitate the road. Table 3 shows the yearly costs as of 2016. These costs were established using the QRA treatment methods discussed in Section 2.5.

Table 3 – Restoration and Rehabilitation RV Costs on Normanton – Burketown Road (Excl. GST)

Year	Cost
2016	$7,135,838.00
2017	$2,135,172.00
2018	$600,885.00
2019	$7,225,068.50
2020	$1,868,783.51
2021	$3,384,537.60
2022	$162,302.51
2023	$1,740,803.60
2024	$3,834,517.39
Total	**$34,087,728.11**
Average	**$3,787,525.35**

2.7.1.2 Strength Test Results

Table 4 below shows test results conducted in 2022 to determine the strength of the road. Test results are taken following construction of the road, to help ensure proper compaction. Test results show that compaction of the road is not always up to standard. This may be due to the poor material used and/or poor construction by the crew. Density ratios are put into 3 categories:

- 100% and above – Good Compaction
- 97% - 99.99% - Average Compaction
- 97% and below – Poor Compaction

Table 4 – 2022 Normanton – Burketown Road Geotechnical Test Results

Test No.	Chainage (m)	Density Ratio	OMC	Sample Location	Date Sampled
2021 – G1	75645	99.9	9.3	0.5-1m LHS	08/06/2022
2021 – G3	77634	99.2	10.9	0.5-1.5m LHS	08/06/2022
2021 – G4	78391	98.8	11.1	0.5-1m RHS	08/06/2022
2021 – G15	93199	98.6	9.4	0.5-1m LHS	08/08/2022
2021 – G16	94420	103.5	10.8	0.5-1m RHS	08/06/2022
2021 – G19	100120	100.3	10.9	0.5-1m LHS	08/08/2022

2021 – G20	102927	99.7	10.1	0.5-1m RHS	08/06/2022
2020 – G12	79861	96.9	9.9	0.5-1.5m RHS	24/04/2022
2020 – G13	81553	100.0	10.3	0.5-1m RHS	24/04/2022
2020 – G14	82791	100.9	8.3	0.5-1.5m LHS	24/04/2022
2020 – G15	85305	97.3	11.4	0.5-1.5m LHS	24/04/2022
2020 – G16	86510	97.4	10.8	0.5-1m RHS	24/04/2022

Results show that 8 out of 12 test results are of average compaction or below, meaning only 33% of tests have met strength requirements.

See **Appendix C** for individual test result spreadsheets and **Appendix B** for locality sketches to see location of each test along Normanton – Burketown Road.

2.7.1.3 Failure Mechanisms

Typical failure mechanisms on the unsealed sections of Normanton – Burketown Road include deformation, cracking and potholing.

Deformation

Common types of deformation that occurs are rutting, shoving and depressions. Rutting is longitudinal deformation in a wheelpath and is caused by water entering through the pavement surface or road edges and into the base and subgrade and inadequate quality of pavement materials.
Shoving is the bulging and horizontal deformation of the road surface. This typically occurs due to swelling of moisture-suseptible pavement material caused by flooding, poor pavement materials and inadequate compaction of the surface or base.
Lastly, depressions are irregular and may also produce bulges. This occurs when water enters the pavement and causes moisture movements in the subgrade. Inadequate drainage and compaction may also be a key cause. (Austroads, 2011, pp. 134-136).

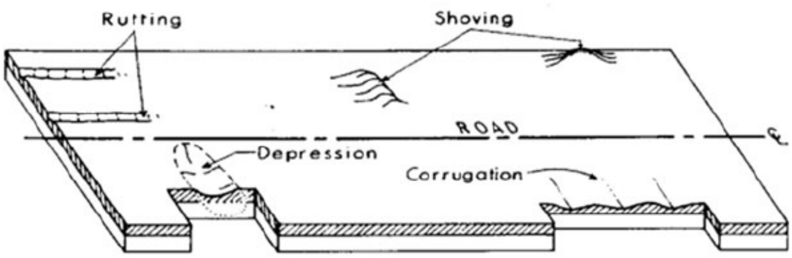

Figure 8 – Deformation Defects (Austroads, 2011, pp. 133)

Cracking

Common types of cracking is block, crocodile, transverse, diagonal, meandering, longitudinal and crescent shaped cracking. All of these types of cracking are typically formed due to fatigue to the road structure and moisture from flooding, resulting in softening of the base layers. (Austroads, 2011, pp. 138-144).

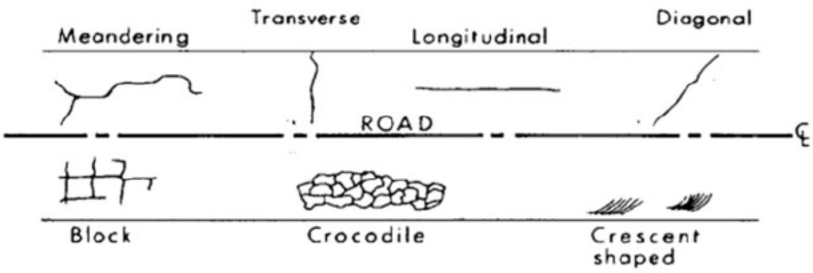

Figure 9 – Cracking Defects (Austroads, 2011, pp. 133)

Potholing

Potholing is described as "a steep-sided or bowl-shaped cavity extending into layers below the wearing course." (Austroads, 2011, pp. 153). This is quite a common issue for sealed and unsealed roads and is generally caused by a loss of surface material due to ravelling, stripping, cracking and/or delamination and from moisture entering base layers of the road through cracking, resulting in softening of these layers. Poor quality pavement materials are also a common cause.

Figure 10 – Potholing Defects (Austroads, 2009, pp. 54)

Figure 11 shows Normanton – Burketown Road following the 2023 Tropical Cyclone Jasper (taken 31/03/2023) and Figure 12 shows the rectification of that area (taken 12/07/24). The damage photo shows transverse scouring/depression caused by flood waters flowing across the road.

	
Figure 11 – 2023 Damage Photo (CH 88585)	**Figure 12 – 2023 Rectification Photo (CH 88585)**

2.8 Pavement Material Types

Unbound granular pavement materials can be broken down into 4 types within Queensland. MRTS05 Unbound Pavement Technical Specification is the standard used throughout Queensland and details the following information on the 4 pavement types.

- Type 1 – High Standard Granular (HSG)
- Type 2 – Standard Material
- Type 3 – Standard Material
- Type 4 – Non-Standard Material

Type 1 – High Standard Granular

Type 1 material is a premium unbound granular pavement material, used in the base course of heavy-duty unbound granular pavements to produce a durable, hard and uniform material that enables a dense and uniform pavement to be constructed, that is typically covered with a sprayed bituminous treatment or thin asphalt layer.

The pavement materials must not be subject to traffic without the bituminous or asphalt surfacing. No direct strength test (CBR) is specified to determine this type and due to the extensive range of properties chosen to specify this material, Type 1 materials provide the greatest probability of achieving a consistently high-quality pavement material. (MRTS05, 2022).

Type 2 – Standard Material

Type 2 material is a high quality unbound granular pavement material, used in base, subbase and lower pavement layers and is generally used in wet environments, hence soaked CBR testing and more rigorous durability requirements (compared to Type 3 materials), are required. Moreover, Type 2 pavement material is produced from either quarried, natural or recycled materials. (MRTS05, 2022).

Table 5 below, from MRTS05 shows the CBR requirements for Type 2 materials. For example, material with a CBR result of >60 will likely be Type 2.2 material.

Table 5 – California Bearing Ratio Requirements – Type 2 (MRTS05, 2022)

Property	Subtype						
	2.1		2.2		2.3	2.4	2.5
Compaction standard (refer Clause 8.4.3)	Modified	Standard	Modified	Standard	Standard	Standard	Standard
CBR (4 day soaked)	Not specified	≥ 80	Not specified	≥ 60	≥ 45	≥ 35	≥ 15

Type 3 – Standard Material

Characteristics of Type 3 material is the same as per Type 2, except it is intended for use in relatively dry environments, where the pavement moisture content is low, therefore, unsoaked CBR testing is required. “Similarly, only the wet strength and the flakiness index properties for the coarse component are specified and the fines standards are less stringent than the values specified for Type 2 materials.” (MRTS05, 2022). Type 3 pavement material is also produced from either quarried, natural or recycled materials.

Table 6 below, from MRTS05 shows the CBR requirements for Type 3 materials. For example, material with a CBR result of >60 will likely be Type 3.2 material.

Table 6 - California Bearing Ratio Requirements – Type 3 (MRTS05, 2022)

Property	Subtype						
	3.1		3.2		3.3	3.4	3.5
Compaction standard (refer Clause 8.4.3)	Modified	Standard	Modified	Standard	Standard	Standard	Standard
CBR (unsoaked)	Not specified	≥ 80	Not specified	≥ 60	≥ 45	≥ 35	≥ 15

Type 4 – Non-Standard Material

Type 4 pavement material "relies mainly on cohesion but may also utilise the mobilisation of internal frictional forces to resist the applied load." (MRTS05, 2022). In order to utilise Type 4 materials, the designer must develop the relevant standards and requirements.

Table 7 below, from MRTS05 shows the CBR requirements for Type 4 materials. For example, material with a CBR result of >60 will likely be Type 4.2 material.

Table 7 - California Bearing Ratio Requirements – Type 4 (MRTS05, 2022)

Property	Subtype				
	4.1	4.2	4.3	4.4	4.5
Compaction standard	Standard	Standard	Standard	Standard	Standard
CBR (unsoaked)	≥ 80	≥ 60	≥ 45	≥ 35	≥ 15

2.9 Alternative Pavement Materials

2.9.1 Pavement Requirements

According to Austroads Guide to Pavement Design, "The selection of pavement materials is a critical element in the design, construction and maintenance of pavements if performance is to be optimised and whole of life costs minimised. The selection process relies on the evaluation of a number of criteria, some of which may be in conflict. This evaluation process relies on materials testing, evaluation of environmental impact, financial considerations, legacy issues, past performance and engineering judgement." (Austroads, p 5, 2007).

"Pavement materials are categorised in terms of their position. This includes the subgrade, subbase, base and potentially wearing surface. Some materials are more appropriate in certain layers of the pavement structure than others."

Sustainable pavements should have the following characteristics:

- Good quality construction to minimize future maintenance and rehabilitation needs and associated disruptions to traffic (Austroads, p 17, 2007).
- Smooth, quiet wearing surface to minimize energy consumption by traffic and environmental impacts (Austroads, p 17, 2007).
- Be constructed using sustainable materials wherever possible. (Austroads, p 17, 2007).

There may be a need for alternative pavement materials when standards materials are not available. This can occur particularly in rural areas, hence it is important to study the alternative pavement materials used around the world, to help gain knowledge of the different options and subsequent cost benefits.

2.9.2 Cement Stabilisation

Stabilisation using a cementitious binder is a common material used in a road basecourse to increase pavement stiffness to provide tensile resistance. (Austroads, 2009, pp. 34). This type of stabilisation has previously been used in Carpentaria Shire on both Normanton – Burketown Road and Dunbar – Kowanyama Road, prior to sealing.

"In addition to lime stabilisation of unsealed roads, cementitious binders have been successfully used on unsealed low volume roads and as localised treatments, such as floodways, bends, intersections, etc. Circumstances where the use of cementitious binders may be considered include, improving the subgrade strength to significantly reduce pavement depth or where saturated subgrades are encountered, modifying poor materials to make them suitable as a pavement layer and enhancing wear resistance and/or reduce dust emissions from the wearing course." (Austroads, 2009, pp. 42).

"It is unlikely that traditional subgrade stabilisation would be linked to unsealed road construction unless it formed part of a staged construction approach in which the road was intended to be sealed in the short term. Stabilisation of unsealed road wearing surfaces is generally limited to granular stabilisation. However, modified stabilisation (particularly lime and chemical binders) may be used to enhance surface wear characteristics, slow down the rate of deterioration – mainly manifested as the generation of dust and loose, gravelly surfaces which may lead to potholes and corrugations – and reduce subsequent asset management costs. The possible use of stabilisation for improving wearing course attributes cannot be assessed quantitatively in a laboratory." (Austroads, 2009, pp. 42).

2.9.3 TMR Triple Blend

The process of combining hydrated lime, GP cement and fly ash (or triple blend) to form a stabilised subbase layer is popular with the Department of Transport and Main Road (TMR) for road pavements in Queensland.

"The triple blend stabilised subbase layer is typically not sealed with a bituminous surfacing and not exposed to public trafficking. An overlying pavement layer or layers is typically placed on the triple blend stabilised layer. The thickness of the triple blend stabilised subbase layer, is typically between 300 mm to 350 mm. At this depth, subgrade materials may be incorporated into the insitu stabilised layer. This is quite common and, provided there has been adequate material sampling and laboratory testing, incorporating subgrade materials should not be purposely avoided." (TMR, 2022, pp. 1).

In accordance with MRTS115, the construction process for Triple Blend stabilisation should be as follows:

1. Each section of the Works with a unique combination of stabilising agent type, stabilising agent spread rate, material(s) to be stabilised and depths, shall be identified as a separate area for construction.
2. A trial section shall be constructed for each separate area for construction.
3. The compaction of each trial section shall be tested and checked for compliance with the relevant clauses.

4. “If the minimum characteristic value of the relative compaction results for the trial section is not less than the value specified, no further compaction testing shall be carried out for the balance of the area for construction that is represented by that trial section, provided that the same construction plant, processes and methodology is used to construct the remaining area as that used for the construction of the trial section.” (TMR, 2022, pp. 11).
5. “If the minimum characteristic value of the relative compaction results for the trial section is less than the value specified, the trial section shall be rectified so that it complies with this Technical Specification and an additional trial section shall be constructed and assessed.” (TMR, 2022, pp. 11).
6. Remove and dispose of unsuitable material for stabilisation, for example, concrete, cement treated patches and asphalt patches.
7. The three materials to be stabilised will be pulverised. “One pass of a reclaimer / stabiliser hooked-up to a fully laden water truck, shall be undertaken to pulverise the materials to be stabilised. The pulverisation pass shall be undertaken to a depth that is 50 mm less than the design depth.” (TMR, 2022, pp. 12).
8. Compaction and trimming of the surface will need to take place prior to the stabilising agent being spread.
9. Spread the stabilising agent at the required spread rate determined in this Technical Specification.
10. “The maximum amount of hydrated lime to be spread in one pass, shall be 10 kg/m^2 to avoid wastage. The number of passes shall be calculated to comply with these requirements.” (TMR, 2022, pp. 15).
11. “Traffic shall be stopped during spreading of stabilising agent, if wind direction is such that airborne cementitious blends are impeding through traffic.” (TMR, 2022, pp. 15).
12. If required, additional material to correct the pavement shape shall be pulverised and spread onto the pavement surface.
13. Relevant compliance testing is to be undertaken following the construction process.

The relative moisture ratio (RMR) during the final wet incorporation pass, shall comply with the requirements specified in Table 8.7.3 of MRTS115.

Table 8 – Relative moisture ratio requirements (TMR, 2022, pp. 30, table 8.7.3)

Property	Minimum value (%)	Maximum value (%)
Relative moisture ratio during the final wet incorporation pass	90	105

The minimum characteristic value of the relative compaction results for the full thickness of the stabilised layer, shall comply with the requirements specified in Table 8.7.4 of MRTS115.

Table 9 – Compaction requirements (TMR, 2022, pp. 30, table 8.7.4)

Layer	Minimum relative compaction value
Triple blend stabilised layer	100% (standard compaction)

2.9.4 Pedogenic Materials

A report discussing the use of naturally occurring materials for road pavements in Western Australia has been analysed. It begins by stating:

“Naturally occurring granular materials are an important source for basecourse or as subbase courses in the construction of flexible pavements in Western Australia (WA). They include fine-grained materials such as well graded silty and clayey sands (sand-clay), coarse and medium-grained materials such as natural gravels and materials produced by ripping and rolling rock which breaks down.” (Cocks, 2015, pp.43).

These materials are often used, but are not limited to, roads with low to medium traffic (<5000 vpd) and surfaced with sprayed seals. However, when correctly applied their use on much more heavily trafficked roads have been successful.” (Cocks, 2015, pp.43).

Natural materials have been used for runway construction on some of these airports where aircraft movements are less than about 10 per day and maximum aircraft size is about 100 seats. The term "natural material" is used here to mean a gravelly material occurring in nature as such, or which can be produced with only minimal crushing. Some processing to remove or breakdown oversize may still be necessary.” (Cocks, 2015, pp.43).

However, a distinction is made between these "natural materials" and material produced by crushing hard rock and referred to as “crushed rock base”. The performance of a material as a basecourse or subbase is largely dependent upon its strength and stiffness. For conventional materials, strength comes mainly from mechanical interlock and may be reasonably inferred from simple tests such as particle size distribution and plasticity index. Conventional criteria based on classification tests are generally adequate to exclude almost all unsatisfactory materials. However, they have the disadvantage of also excluding some materials capable of giving satisfactory performance.” (Cocks, 2015, pp.43).

The WA road network includes more than 18,000 km of highways and main roads and about 170,000 km of secondary and local roads. With such a vast road network and small population, a strong commitment to low-cost road construction is necessary.” (Cocks, 2015, pp.43).
The report discusses conventional specifications for road basecourse, using tests such as particle size distribution, particle durability and fines plasticity.

The study is ultimately centred around comparing these conventional basecourse materials to “Pedogenic Materials”. Table 10 of the report compares various properties of both material types.

Table 10 – Difference between Conventional and Pedogenic Materials (Netterberg, 1985)

Property	*Conventional (crushed rock base, river gravels, glacial outwash)*	*Pedogenic (Laterite, Calcrete, Silcrete)*
Composition	Natural or crushed aggregate with fines	Varies from clay to rock
Aggregate	Solid, strong rock	Sometimes porous, weakly cemented fines
Clay minerals	Mostly illite or montmorillonite	Wide variety, e.g. halloysite, attapulgite
Cement	None (usually)	Iron oxides, aluminium hydroxide, calcium carbonate, etc
Hydration	None	Variable
Chemical Reactivity	Inert	Reactive
Solubility	Insoluble	May be soluble
Weathering	Weathering or stable	Forming or weathering
Consistency Limits	Stable	Sensitive to drying and mixing
Grading	Stable	Sensitive to drying and working
Salinity	Non-saline	May be saline
Self-stabilisation	Non self-stabilising	May be self-stabilising
Stabilisation (cement)	Increases strength and stiffness	Usually increases strength and stiffness
Stabilisation (lime)	Decreases plasticity	Usually decreases plasticity and/or increases strength and stiffness
Variability	Homogeneous	Extremely variable

Consistency limits, such as plastic limit, liquid limit, plasticity index, and linear shrinkage, are related to the type and amount of clay in a material. It was found that these limits can affect the stability and performance of a basecourse material. (Cocks, 2015).

Pedogenic materials, such as laterite, ferricrete, bauxite, silcrete, and calcrete, behave differently from conventional materials commonly used as basecourse, as they may exhibit self-stabilization and have different composition, cementation, and weathering characteristics, to conventional materials. The selection criteria for pedogenic materials and other natural gravels in Western Australia have been adapted based on local experience, cost considerations, climate, axle loads, traffic volumes, and construction skills. (Cocks, 2015).

This report did not clearly state whether Pedogenic pavement materials are preferred over conventional materials, it was simply comparing the two. (Cocks, 2015).

2.10 Knowledge Gap

It has become apparent through an extensive literature review that there is a gap in the knowledge when it comes to understanding what pavement material, such as gravel, is best suited in rural, flood prone areas such as North-Western Queensland. It is evident that standard, good quality pavement gravel is scarce in these rural areas, meaning this material will need to be imported to site, producing greater costs to repair a flood damaged road. It leads to the question, is it worth spending this amount of money on a rural road when it is likely to be flood ravaged again the following wet season, and yet again, more gravel needs to be imported to repair the road?

Alternatively, there may be cost benefits of using existing gravel from the surrounding site, rather than importing it. This, however, would lead to the gravel being of poorer quality than that that is imported, which may affect the overall strength and durability of the road, and due to the lesser strength and durability, the road is affected far greater from flooding.

It is clear that various tests and analyses will need to be done to help determine which option is more viable, particularly in terms of cost. Is it worth importing better quality gravel that is more expensive, or is it better to use poorer quality gravel that is cheaper, seeing as though the road is subjected to flooding each year?

CHAPTER 3
Research Design and Methodology

3.1 Project Development

3.1.1 Project Feasibility Analysis

There have been several studies that have examined the strength and durability of pavement materials and there are also studies showing how rural roads are affected during severe weather events, as discussed in Chapter 2 of this report. No existing study could be found that attempted to compare the cost and durability benefits, or limitations of using either existing poor-quality materials or importing good quality materials, particularly when a road is subject to flooding. This presents a gap in the current body of knowledge that would be ideal to fill to ensure that rural roads are properly maintained.

The study will build upon the previous studies analysed in the Literature Review and will adopt similar methodologies. Access to materials and equipment, standards and other data will not be an issue as they can be accessed through USQ or my current place of work. The staff at USQ will however, need to be informed in order to liaise with them. Sound planning of the project will be undertaken in the ensuing sections, along with a risk assessment to ensure the project is safe and achievable. The project idea is deemed feasible based on the defined scope and availability of resources. Further planning of the project is set out in the following sections.

3.1.2 Scope

The ultimate goal for this project is to determine the most cost-effective way to repair and restore rural, flood affected roads when there is a shortage of quality materials. To determine the best option, various tests will need to be conducted. This will include testing road subgrade strength using both Dynamic Cone Penetration (DCP) testing and California Bearing Ratio (CBR) testing. This project will ultimately take place on a rural, low volume road in Carpentaria Shire, Queensland.

Normanton – Burketown Road would most likely produce the best outcome and provide the most relevant information for these tests, as it is a commonly used rural that connects Normanton to Burketown, that is consistently subjected to extreme flooding, as discussed in Section 2.2.1. As part of this comparison, imported gravel material of higher quality will also be tested to help determine the most suitable option.

3.1.3 Onsite Investigation

The onsite investigation will consist of Dynamic Cone Penetration (DCP) testing. The purpose of performing a DCP test is to measure the subgrades resistance to penetration, which ultimately gives a measure of strength for the in-situ soil. The road has previously been constructed with poorer quality materials, so this test will provide a good basis on how this material is performing.

Ten tests will be conducted along a 1 km section of Normanton – Burketown Road, at 100m intervals. These intervals are in line with Standard AS 1289.

The following figure and table show the location and chainage along Normanton – Burketown Road in which the DCP tests will be done. This location was chosen due to it being a straight section of road, as corners can pose a safety risk with oncoming traffic. Moreover, the road is fully sealed up until the point, hence, DCP testing cannot be performed prior to this section.

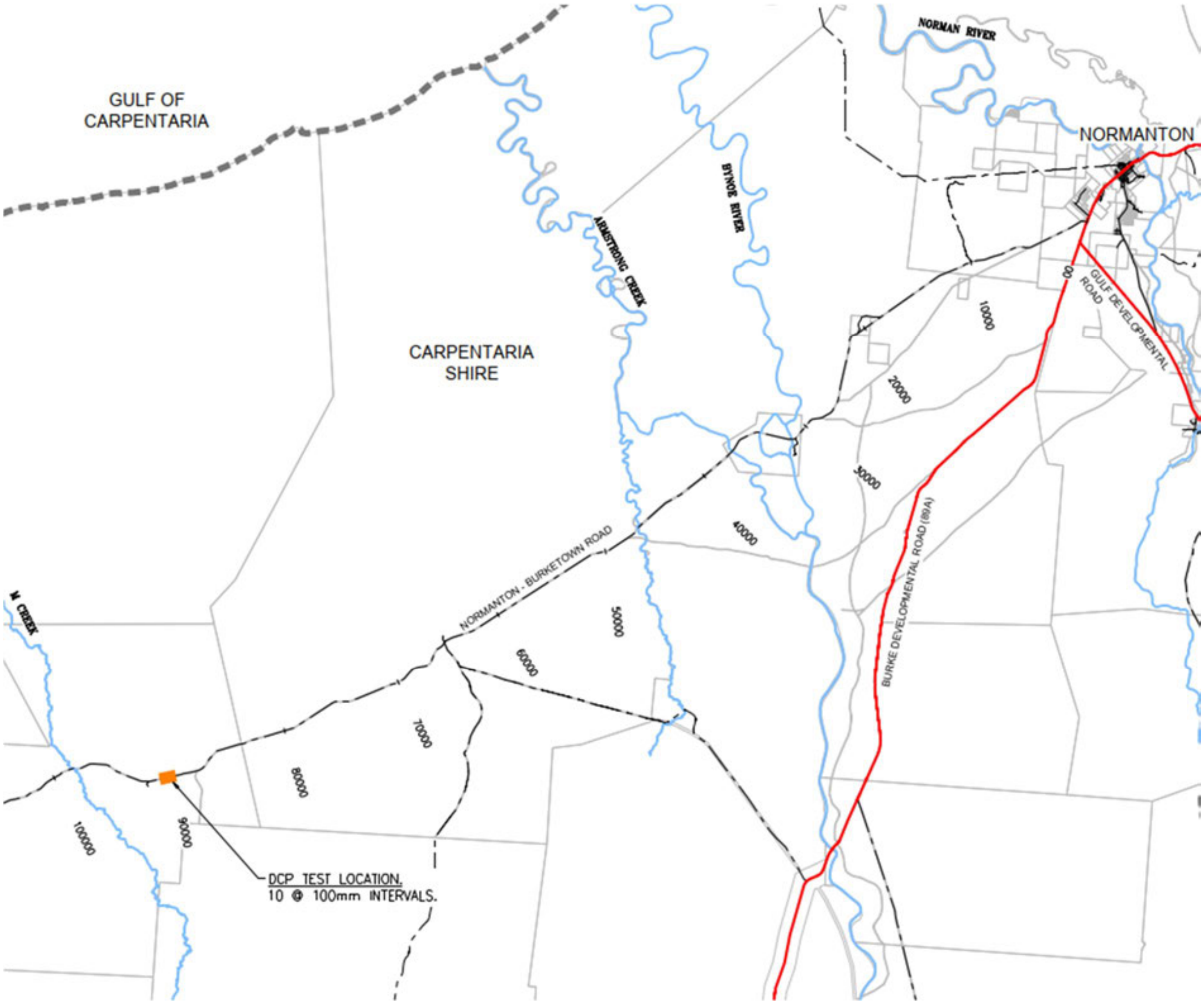

Figure 13 – DCP Test Location along Normanton – Burketown Road

Table 11 – DCP Test Chainages along Normanton – Burketown Road

Site	Chainage (m)
1	90950
2	90850
3	90750
4	90350
5	90250
6	90150
7	89950
8	89850
9	89750
10	89650

Equipment required:

i. Dynamic Cone Penetration Device
ii. PPE, including boots, hi-vis, hat, ear plugs, etc.
iii. Data sheets (for recording data)
iv. GPS Camera

Test procedure for DCP test is as follows, in accordance with Standard AS 1289 and the TMR Materials Testing Manual (MTM):

i. Obtain adequate clearance on road from moving vehicles. Corners may be dangerous.
ii. Assemble the DCP correctly, while using caution not to pinch fingers between the hammer and anvil.
iii. A crew of two people are to operate the DCP and record data manually.
iv. Record test location and any project information on data sheet.
v. A hole must be drilled if testing soil layers below pavement material, however, it is unlikely that this will be necessary for this project due to the tests taking place on a predominantly graded road.
vi. Set the DCP on the test surface, or insert in the hole, making sure the shaft is plumb.
vii. Lift the hammer and drop from a partial height until the cone is below the surface. This will become the reference reading and can be recorded as “Blow 0”.
viii. Lift the hammer again to its upper limit and let the hammer fall freely onto the anvil. Use caution not to force the hammer down as this will influence the result. Record the reading and blow count by reading the shaft to the closest millimetre. Record this as “Blow 1”.
ix. Continue this until the cone is driven either the full depth of 100mm and record the results. Total penetration is 1m if possible. Refusal is 30 blows/100mm.
x. Following this test, the DCP can be removed from the hole and safely packed away.
xi. During this process, crew members should attempt to take photos or have a third crew take photos for them.
xii. Process the results in Excel by converting to CBR values. This will allow the results to be compared with the Laboratory Investigation and any previous results.

3.1.4 Laboratory Investigation

The laboratory investigation will consist of California Bearing Ratio (CBR) Testing. A CBR test measures the pressure required to penetrate the subgrade sample using test equipment. It should prove particularly useful for this experiment as we can test various subgrade samples, rather than in-situ samples, such as with the DCP. A test sample of granular material from Well’s Quarry have previously been tested and will be used for this investigation. The type of CBR testing will be 4-day soaked, as this will better help mimic adverse moisture conditions from potential rainfall and flooding.

Equipment required:

i. CBR test machine
ii. PPE, including boots, hi-vis, hat, etc.
iii. Data sheets (for recording data)
iv. Camera

Test procedure for CBR test is as follows, in accordance with Standard AS 1289 and the TMR Materials Testing Manual (MTM):

i. After the samples are obtained, the weight of the mold will need to be determined and the compaction tool assembled.
ii. Then the sample will need to be placed into the mold in three layers.

iii. Next the sample needs to be compacted with 25 well-distributed blows with the hammer.
iv. Following this, the weight of mold and soil need to be weighed and oven dried for 4 days (which will determine moisture content).
v. This test will ultimately provide data on the maximum dry density and optimal moisture content of the samples, helping to show quality and which sample is optimal to use as pavement material.
vi. Record results in the data sheets. The moisture content and maximum dry density data sheets that will be used, can be seen in Appendix B. Along with this, an example of the spreadsheet that the data sheets will be input to, is included. This spreadsheet will show a moisture vs dry density chart and ultimately the CBR value.
vii. Following these tests, a rough cost analysis can be conducted comparing the cost of all the samples along with their expected lifespan. From this, an options analysis can be prepared.

3.1.5 Test Analysis

Following the compilation of all test results in CBR form, an analysis comparing the existing pavement material on Normanton – Burketown Road to the imported pavement material from Wells Quarry can be conducted. Quality and costs of each material will be analysed to gain an understanding of which material is better suited for the construction of rural flood affected roads within Carpentaria Shire. The data examined in the Literature Review will also form part of this discussion.

3.2 Project Planning

3.2.1 Project Requirements

Materials required for this project include granular samples of a better-quality subgrade material from Well's Quarry (taken March 2022), to use for the CBR testing. DCP tests will simply be conducted on location and do not require samples. General equipment such as PPE and datasheets will be required during the testing process. Microsoft Excel will be needed convert DCP tests to CBR results and to complete a cost analysis and comparisons.

3.2.2 Risk Assessments

A risk assessment on this project showed that there were two types of potential risks that may occur. The first being a safety risk when undertaking the required tests and the other being risks to the project outcome.
A standard risk probability versus consequence matrix was used to determine the severity of these risks, which can be seen in **Appendix D**.

The potential safety risks can be seen in Table 12 below.

Table 12 – Potential Safety Risks

Hazard	Risk	Minimization/Mitigation	Risk After Mitigation is Implemented
Heat stroke when exacting gravel samples	Extreme	Ensure sun protecting PPE is worn and person performing test is staying hydrated and taking the required breaks.	Moderate

Injury when conducting DCP testing	Moderate	Ensure correct PPE is worn.	Low
Dehydration when conducting DCP testing	High	Ensure sun protecting PPE is worn and person performing test is staying hydrated and taking the required breaks.	Moderate

The potential project risks can be seen in Table 13 below.

Table 13 – Potential Project Risks

Hazard	Risk	Minimization/Mitigation	Risk After Mitigation is Implemented
Inaccurate data	High	Ensure care is taken when performing tests and check over work. A qualified Geotechnical Officer will be aiding with the CBR and DCP tests.	Low
Issue collecting data and progressing to next stage of project	High	Depending on what test, previous data may be able to be used, such as for the flood and traffic study.	Low

For further details on risk assessment see **Appendix D**.

CHAPTER 4
Results and Discussion

4.1 Test Results

This Chapter presents and discusses the test results achieved using the methodology in Chapter 3 for both the onsite and laboratory investigations. From this, a comparison between the two options is examined, with a focus on the quality of the material and how this translates to current and future costs.

4.1.1 Onsite Investigation

10 DCP tests were successfully performed at approximately 100m intervals along Normanton – Burketown Road from chainage 89650 to 90950. Figure 14 - Figure 17 demonstrate some of the testing in action, including hitting the cone into the ground by dropping the weight and removing the cone once it has been imbedded 1m.

Figure 14 – DCP4 Test

Figure 15 – DCP5 Test

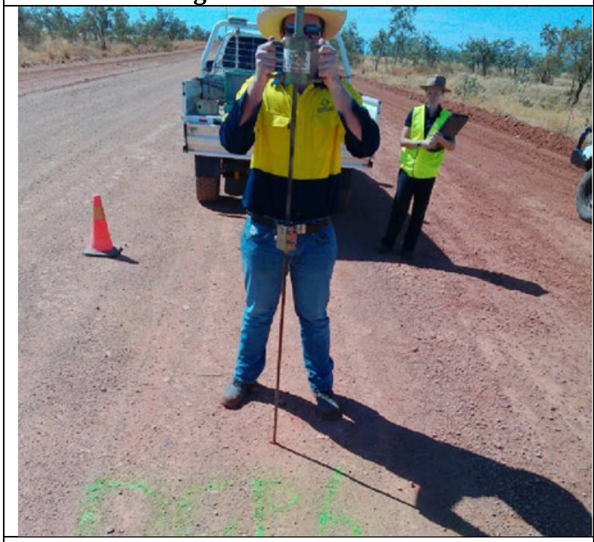

Figure 16 – DCP6 Test

Figure 17 – DCP2 Removal

Although most of the tests proved to give accurate results up to 1m deep, some could not penetrate past 100mm deep, due to rocks being below the test site. These tests include 1, 4, 5, 7, 8, 9. Figure 18 below displays the average blows/100mm based off the 10 DCP tests and gives the corresponding CBR results.

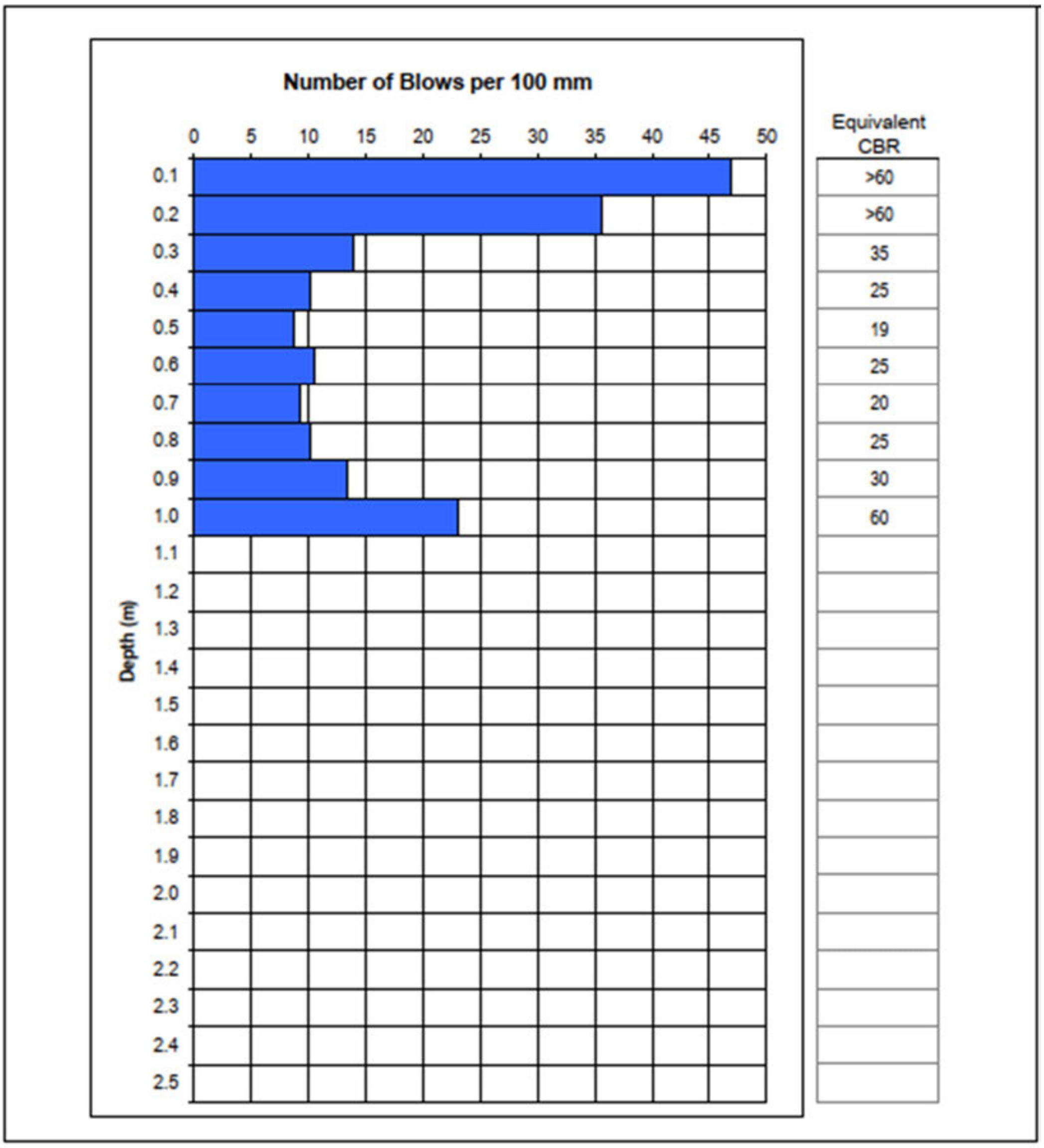

Figure 18 – Average results from DCP Testing

Appendix E shows all 10 individual DCP tests with equivalent CBR results used to calculate the average results in Figure 18.

These results show that the first 200mm is quite well compacted with CBR at >60. Below this, CBR's range from 19-60. This appears to meet expectations, as approximately the top 200mm would be compacted pavement material and below this is clayey subgrade material. Comparing these results to the pavement types discussed in Section 2.8, the existing pavement materials along Normanton – Burketown Road appears to match a Type 2.4 gravel, as Type 2.4 is typically used in wet environments and has more stringent durability requirements compared to Type 3 materials, and has also been produced from either natural, quarried materials. Moreover, after assessing the average CBR results from the field investigation, the total average CBR comes to 35.9 or 36. Assessing this against Table 14 below of MRTS05, the pavement material is >35, but not >45, hence fits into the Type 2.4 category.

Table 14 – California Bearing Ratio Requirements – Type 2 (MRTS05, 2022)

Property	Subtype						
	2.1		2.2		2.3	2.4	2.5
Compaction standard (refer Clause 8.4.3)	Modified	Standard	Modified	Standard	Standard	Standard	Standard
CBR (4 day soaked)	Not specified	≥ 80	Not specified	≥ 60	≥ 45	≥ 35	≥ 15

4.1.2 Laboratory Investigation

CBR tests were conducted in March of 2022 on pavement material from Wells Quarry, located in Croydon Shire, QLD. Results of these tests can be seen below, ultimately with the CBR Value equalling 100%.

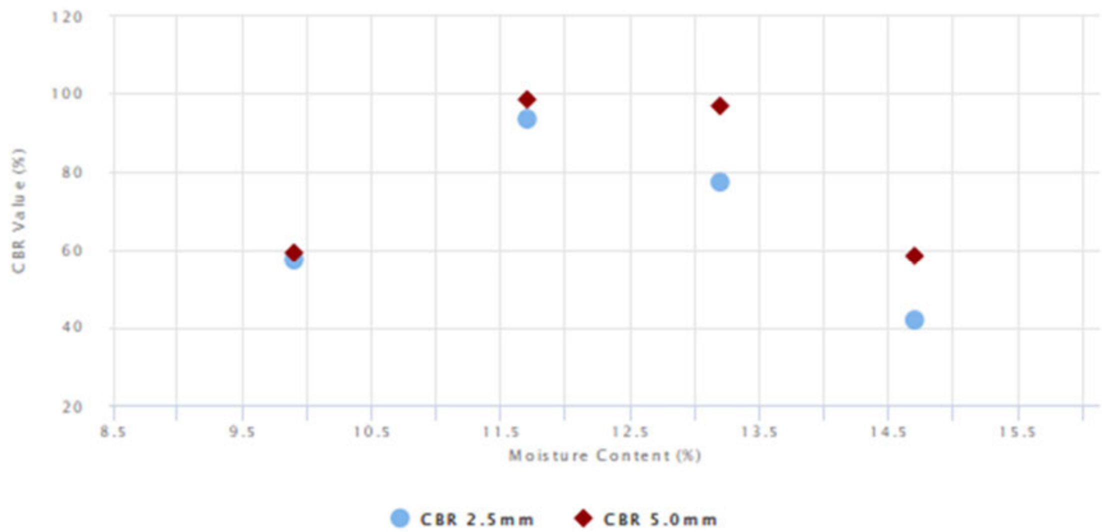

Figure 19 – Wells Quarry CBR Results

Method:	Q113A			
Sample Location:	Onsite Stockpile			
Sample Description:	(GM) Silty GRAVEL - Brown			
Curing Time (hrs):	2			
Curing Determination:	Q104A			
Soaking Period (days):	4			
Surcharge (kg):	4.5			
Initial Moisture Content (%):	13.2	14.7	11.7	9.9
Compacted Dry Density (t/m3):	1.826	1.805	1.788	1.734
CBR 2.5mm (%):	80	40	90	60
CBR 5.0mm (%):	100	60	100	60
CBR MDD (t/m3):	1.83			
CBR OMC (%):	13.5			
CBR 2.5mm (%):	80			

CBR 5.0mm (%):	100
CBR Value (%):	**100**

Refer **Appendix F** for CBR and Atterberg Limit Test Certificates of Wells/Shady Lagoon Quarry sample.

Comparing these results to the pavement types discussed in Section 2.8, this pavement material along Normanton – Burketown Road appears to match a Type 2.1 gravel, as Type 2.1 is typically used in wet environments and has more stringent durability requirements compared to Type 3 materials, and has also been produced from either natural, quarried materials. Moreover, the CBR value equal 100%, therefore, assessing it against Table 15 below of MRTS05, the pavement material is >80, hence fits into the Type 2.1 category.

Table 15 – California Bearing Ratio Requirements – Type 2 (MRTS05, 2022)

Property	Subtype						
	2.1		2.2		2.3	2.4	2.5
Compaction standard (refer Clause 8.4.3)	Modified	Standard	Modified	Standard	Standard	Standard	Standard
CBR (4 day soaked)	Not specified	≥ 80	Not specified	≥ 60	≥ 45	≥ 35	≥ 15

4.2 Quality and Cost Analysis

A comparison between the Field Investigation (Type 2.4 material) and the Laboratory Investigation (Type 2.1 material) is undertaken with the objective of finding which material is the most durable and cost effective for the construction of Normanton – Burketown Road. Ultimately, the outcome of these results is hoped to be used for other roads within the Shire.

4.2.1 Type 2.4 Material

The Type 2.4 pavement material is currently being used on Normanton – Burketown Road and although results from the DCP testing shows it has quite strong surface and basecourse layers, the subgrade layers have low compaction strength. This is likely a key contributor to why the road fails following a flood event. As discussed in Section 2.7.1.3, this is also a likely contributor to other fail mechanisms common on the road, including deformation, cracking and potholing.

It is evident that if this current Type 2.4 material is continued to be used, the structural integrity of the road will continually be affected following flood events and need additional material imported for rehabilitation each year, similar to the discussion in Section 2.7.1.1. It is predicted, based off previous construction years, that 100mm Gravel Resheeting will be necessary to return Normanton – Burketown Road to its original state.

Gravel Resheet (100mm)	= $158.55/m3 (Based off the 2024 rate by QRA)
Length of unsealed road	= 64700
Total	= $10,258,185.00

4.2.2 Type 2.1 Material

CBR strength of the Well's Quarry Type 2.1 material, as shown in Section 4.1.2, is more than double the strength of the existing Type 2.4 material, hence it is expected to have twice the lifespan. It is predicted, based off previous construction years of using Wells Quarry in combination with Gravel Resheeting excluding material, on other roads within the Shire, the following rate will apply.

Wells Quarry imported gravel + Resheet	= \$160.83/m3 (100mm QRA rate)
Length of unsealed road	= 64700
Total	= \$10,405,701.00

4.2.3 Cost Comparison

This cost comparison will analyse approximate construction costs over the next 5 years to help determine which pavement material type will prove the most cost effective. Two scenarios will be analysed, one where no flooding is to occur on the road, and one where flooding occurs. This way an investigation can be conducted on how costs may change when flooding is involved and how this may affect the final decision.

4.2.3.1 No Flooding Occurs

It can be assumed that if using the Type 2.4 material, similar to previous years, the structural integrity of Normanton – Burketown Road will continue to be severally affected. Thus, it can be assumed the **\$10,258,185.00** amount for 100mm Gravel Resheeting will be required each year (typically the entire unsealed section would not be assessed as 100mm Gravel Resheeting, however, for simplicity, it is assumed).

Alternatively, the Type 2.1 material is predicted to have close to double the strength properties compared to the Type 2.4 material. As a result, it is predicted that using the Type 2.1 pavement material will mean gravel top-ups on the road will only necessary every 2 years, rather than every year. On the years where no extra imported material is required, Heavy Formation Grading will be required to help improve the formation of the road.

On the years requiring 100mm Gravel Resheeting, costs to rehabilitate the unsealed section of road using Type 2.1 material is **\$10,405,701.00** and years requiring Heavy Formation Grading will cost **\$2,470,246.00** (\$38.18/m^3). The summation of these costs over the next 5 years can be seen below.

Table 16 – Estimated Yearly Maintenance Costs

	Type 2.4 Material	**Type 2.1 Material**
Year 1	\$10,258,185.00	\$10,405,701.00
Year 2	\$10,258,185.00	\$2,470,246.00
Year 3	\$10,258,185.00	\$10,405,701.00
Year 4	\$10,258,185.00	\$2,470,246.00
Year 5	\$10,258,185.00	\$10,405,701.00
Total	**\$51,290,925.00**	**\$36,157,595.00**

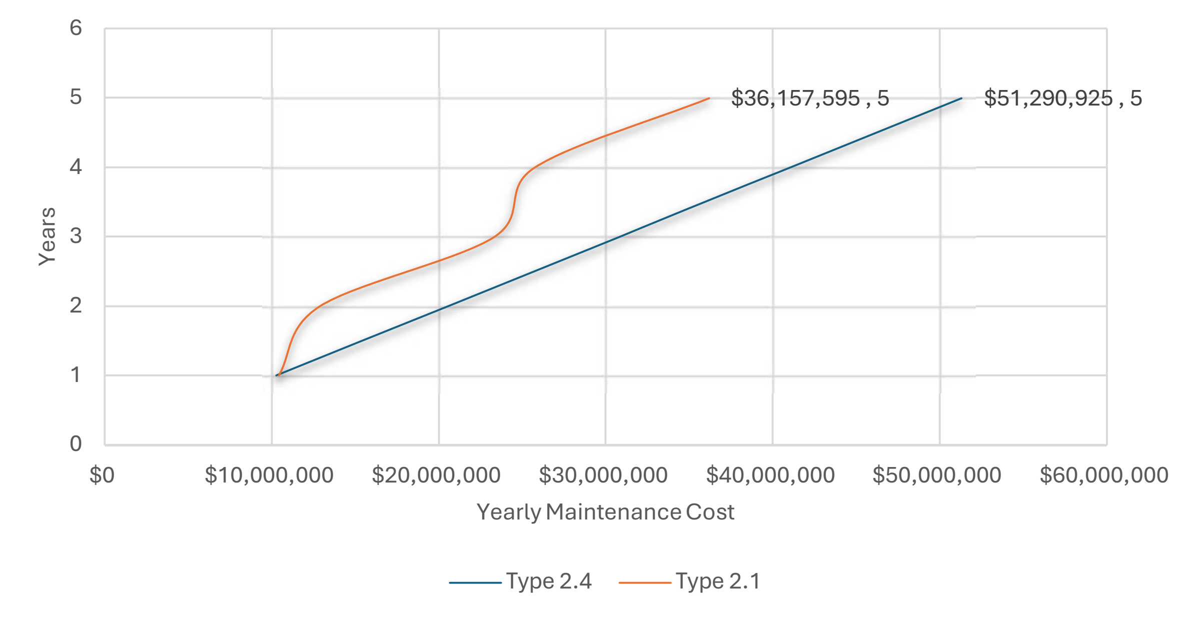

Figure 20 – Estimated Yearly Maintenance Costs

4.2.3.2 Flooding Occurs

If flooding was to occur, completely soaking the road and washing away surface materials, it can be assumed that both the Type 2.4 and Type 2.1 material will continue to need 100mm of Gravel Resheeting applied to the road, as it is predicted to either completely wash away (**$10,258,185.00** each year for Type 2.4 and **$10,405,701.00** each year for Type 2.1 material). This is due to the fact that the road pavement will be completely soaked for approximately 4 months during the flood event and surface material will then be washed away as flood waters recede. This extreme event is predicted to severely impact the structural integrity of the road and cause almost complete loss of surface and base materials. The cost summation of these repairs over the next 5 years can be seen below.

Table 17 – Estimated Yearly Maintenance Costs

	Type 2.4 Material	**Type 2.1 Material**
Year 1	$10,258,185.00	$10,405,701.00
Year 2	$10,258,185.00	$10,405,701.00
Year 3	$10,258,185.00	$10,405,701.00
Year 4	$10,258,185.00	$10,405,701.00
Year 5	$10,258,185.00	$10,405,701.00
Total	**$51,290,925.00**	**$52,028,505.00**

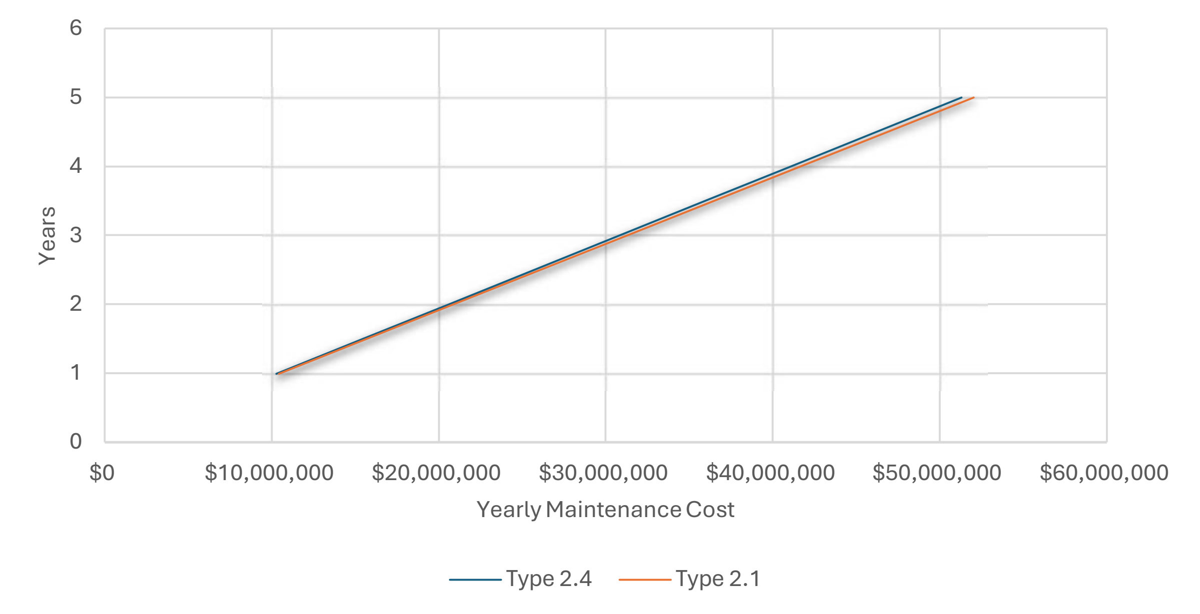

Figure 21 – Estimated Yearly Maintenance Costs

4.3 Discussion

When analysing the two material types when little to no flooding occurs, it is clear that the Type 2.1 material has a higher initial cost, however, proves to be more cost effective in the long run, compared to the Type 2.4 material. Although cost/m³ is slightly cheaper than the Type 2.1 material, long term costs end up more being 30% more expensive, as seen in Table 16.

While this would seem to be quite a simple solution, when extreme long-term flooding is added into the equation, it becomes quite complicated, as it is projected that majority of the road pavement will be damaged and/or washed away, requiring a full 100mm Gravel Resheet each year for both the Type 2.4 and Type 2.1 materials. In this circumstance, repair costs using the Type 2.1 material ends up costing 1.4% more each year. Although this amount may not seem significant, over say a 10-year period, this would equate to more than $7 million in variation.

In conclusion, although CBR results of the Type 2.4 material show it is still of fairly good quality, it is not of a high standard compared to Type 2.1, however, when the road is completely flood affected, this appears to not make much difference to the longevity of the road. The Type 2.1 material is still severely affected by moisture from the long exposure to flooding and gets washed away similar to the Type 2.4 material.

CHAPTER 5
Conclusions

5.1 Introduction

The final Chapter of the report will draw upon the test results and cost analysis from Chapter 4 and make a final decision on which pavement material will be best suited for the construction of rural flood affected roads within Carpentaria Shire, to maximize flood resistance and cost efficiency.

Suggestions for additional research that will help further develop the analysis of pavement material for flood resistance on rural roads will also be made.

5.2 Conclusions

Upon final investigation of the two pavement material types, the **Type 2.1** material has been chosen as the preferred option in terms of quality and costs, **if flooding was not to occur**. Restoration cost using the Type 2.4 material is anticipated to cost $51,290,925.00 over the next 5 years, compared to the Type 2.1 material that is expected to cost $36,157,595.00, which is a saving of approximately 30%.

Table 18 – Estimated Total 5 Yearly Maintenance Costs when No Flooding Occurs

	Type 2.4 Material	Type 2.1 Material
Total	**$51,290,925.00**	**$36,157,595.00**

Alternatively, and for this specific example, it is predicted that **flooding will occur** each year on Normanton – Burketown Road, in which case the preferred option is the **Type 2.4** material. It has been determined that the Type 2.1 material will not perform better under flooded/soaked conditions than the Type 2.4 material will, and due to the Type 2.4 material being cheaper and more easily accessible throughout the entire shire, this is ultimately the preferred option. With flooding of the road each year being extremely likely, it is proposed that the Type 2.4 material option will be required.

Table 19 – Estimated Total 5 Yearly Maintenance Costs when Flooding Occurs

	Type 2.4 Material	Type 2.1 Material
Total	**$51,290,925.00**	**$52,028,505.00**

With the ultimate goal of this report to determine which road base material is best suited for the construction of rural roads when flooding occurs, the **Type 2.4** material is the recommended option.

It is hoped that with the conclusions made, this report will act as a basis for all unsealed road designs within Carpentaria Shire and can be further developed to expand on the knowledge and perfect the design of rural flood affected roads.

5.3 Further Research and Recommendations

Although Carpentaria Shire is the focus of this investigation, the surrounding Shires of Burke, Cloncurry, Croydon, McKinley & Kowanyama Aboriginal Shire are also exposed to similar flooding events and may also benefit from the information and conclusions made in this report.

To further develop this thesis, the following research ideas are suggested.

- **Independent CBR tests on Wells Quarry material –** There may be bias involved with the CBR test results conducted on the Wells Quarry materials due to the testing being done internally. It may be found that the results are not as high quality as found. TMR has a facility in Brisbane that may be ideal to send some samples to. If results vary from what has been previously determined, it may change the outcome of this report.

- **Analysis of how the Type 2.1 material performs –** An analysis of how the Type 2.1/Wells Quarry material actually performs over the next 2-5 years would be ideal to either confirm or reject this report. If it does not perform as well as expected, then further analysis on the strength and cost breakdown will need to be completed.

- **Analysis of a Type 1.3 material –** It may prove useful to analyse a Type 1.3 material or something similar. Investigate the quality of the material and how it will perform during flood events and complete a cost analysis, comparing it to the Type 2 materials.

- **Analysis and comparison of Stabilised Cement pavements** – Analysing and comparing stabilised cement additive as a third option to the Type 2.4 and Type 2.1 pavement material comparison. It would seem likely that stabilised cement would create an even stronger road pavement than the Type 2.4 and Type 2.1 materials, however, be far more expensive, therefore, an analysis and comparison between quality and cost would need to be conducted.

- **Analysis and comparison of sealing the road –** Sealing of these rural roads is also an option that could be explored, as this immensely improves the strength of the road and comfortability for the driver. This would ultimately be the most expensive option as the road pavement is generally stabilised and then spray sealed, so costs for both would be incurred. Sealing does still incur flood damage due to moisture getting trapped in the underlying materials, so repairs to the road are still quite common.

- **Environmental Analysis –** An environmental analysis may be useful to help better understand the flooding that occurs in the area. Carpentaria Shire is basically one big flood plain, so waters typically rise rapidly and have nowhere to disperse. An environmental analysis or flood study would prove useful to help find the worst affected areas which may potentially need better road maintenance or upgrades.

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APPENDIX A – 2019 TRAFFIC DATA

AADT SEGMENT ANALYSIS REPORT

SITE : NORMANTON - BURKETOWN ROAD CH 10.198
TRAFFIC YEAR 2019 - DATA COLLECTION YEAR 2019

		G		A		B	
All Vehicles		46.3	100%	43.2	100%	89.4	100%
Light Vehicles		35.0	75.7%	37.3	86.5%	72.4	80.9%
Heavy Vehicles		11.3	24.3%	5.8	13.5%	17.1	19.1%
Short Vehicles		35.0	75.7%	37.3	86.5%	72.4	80.9%
Trucks & Buses		7.3	15.7%	2.9	6.7%	10.2	11.3%
Articulated Vehicle		2.7	5.8%	1.5	3.6%	4.2	4.7%
Road Trains		1.3	2.8%	1.4	3.3%	2.7	3.0%
Class 1	Short 2 Axle Vehicles	26.4	57.1%	26.6	61.7%	53.1	59.4%
Class 2	Short Vehicles Towing	8.6	18.55%	10.7	24.76%	19.3	21.55%
Class 3	2 Axle Trucks & Buses	5.9	12.85%	2.4	5.59%	8.4	9.35%
Class 4	3 Axle Truck & Bus	1.0	2.20%	0.2	0.51%	1.2	1.39%
Class 5	4 Axle Truck	0.3	0.63%	0.3	0.59%	0.5	0.61%
Class 6	3 Axle Articulated	0.9	2.03%	0.3	0.75%	1.3	1.41%
Class 7	4 Axle Articulated	1.0	2.23%	0.6	1.38%	1.6	1.82%
Class 8	5 Axle Articulated	0.2	0.46%	0.0	0.09%	0.3	0.28%
Class 9	6 Axle Articulated	0.5	1.09%	0.6	1.33%	1.1	1.21%
Class 10	B Double	0.1	0.17%	0.1	0.19%	0.2	0.18%
Class 11	Double Road Train	0.3	0.57%	0.3	0.73%	0.6	0.64%
Class 12	Triple Road Train	1.0	2.07%	1.0	2.34%	2.0	2.20%

THIS REPORT SHOWS ANNUAL AVERAGE DAILY TRAFFIC VALUES (AADT's).

AADT SEGMENT REPORT

PROVIDES AADT SEGMENT DETAILS FOR A ROAD SECTION TOGETHER WITH THE TRAFFIC FLOW DATA COLLECTED AT THE RELATED SITE. THE ROAD SEGMENTS ARE REPRESENTED DIAGRAMMATICALLY WITH AADT DATA INCLUDING:

AADT BY DIRECTION OF TRAFFIC FLOW
%VC PERCENTAGE VEHICLE CLASS AS PER THE AUSTROADS VEHICLE CLASSIFICATION SCHEME

ANNUAL AVERAGE DAILY TRAFFIC (AADT)

ANNUAL AVERAGE DAILY TRAFFIC (AADT) IS THE NUMBER OF VEHICLES PASSING A POINT ON A ROAD IN A 24 HOUR PERIOD, AVERAGED OVER A CALENDAR YEAR.

DATA YEAR

THE MOST RECENT YEAR THE TRAFFIC DATA WAS COLLECTED FOR THIS AADT SEGMENT.

GAZETTAL DIRECTION

THE GAZETTAL DIRECTION IS THE DIRECTION OF THE TRAFFIC FLOW EG. NORMANTON – BURKETOWN ROAD: STAT CHAINAGE 0.00 TO END CHAINAGE 148.920.

G TRAFFIC FLOWING IN GAZETTAL DIRECTION
A TRAFFIC FLOWING AGAINST GAZETTAL DIRECTION
B THE COMBINED TRAFFIC FLOW IN BOTH DIRECTIONS

SITE

THE PHYSICAL LOCATION OF A TRAFFIC COUNTING DEVICE. SITES ARE LOCATED AT A SPECIFIED THROUGH DISTANCE ALONG A ROAD SECTION.

FOR INFORMATION ONLY

PLOT DATE 9/09/2019 10:29:37 AM
FILE LOCATION D:\ERSCON Dropbox\ERSCON\101 Carp SC\101 General\Carpentaria Traffic Counters\2019\4_ Normanton to Burketown\4_Drawings\101-101-SK803 Normanton - Burketown (Lilyvale).dwg

REVISIONS

NO.	DATE	DESCRIPTION	DESIGN	APPROVED
1	09/09/19	INITIAL ISSUE		

ERSCON CONSULTING ENGINEERS

CLIENT: CARPENTARIA SHIRE — Outback by the Sea

SCALE: NTS

ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE

DRAWN: RH
DESIGNED: RH
DRAWN APPROVED: -
DESIGN APPROVED: -
CIVIL SIGNOFF APPROVAL
DATE: RPEQ:

PROJECT REF: CARPENTARIA SHIRE TRAFFIC COUNT
DRAWING REF: NORMANTON - BURKETOWN ROAD 2019 TRAFFIC COUNT : CH 10.198
DRAWING NO: 101-101-SK803
SIZE: A4
REVISION: 1

AADT SEGMENT ANALYSIS REPORT

SITE : NORMANTON - BURKETOWN ROAD CH 64.958
TRAFFIC YEAR 2019 - DATA COLLECTION YEAR 2019

All Vehicles

G	37.1	100%
A	32.3	100%
B	69.4	100%

Light Vehicles

G	28.5	76.8%
A	24.4	75.6%
B	52.9	76.2%

Heavy Vehicles

G	8.6	23.2%
A	7.9	24.4%
B	16.5	23.8%

Short Vehicles

G	28.5	76.8%
A	24.4	75.6%
B	52.9	76.2%

Trucks & Buses

G	5.4	14.7%
A	4.2	13.1%
B	9.7	14.0%

Articulated Vehicle

G	2.0	5.4%
A	2.4	7.4%
B	4.4	6.4%

Road Trains

G	1.2	3.1%
A	1.2	3.8%
B	2.4	3.4%

Class 1 – Short 2 Axle Vehicles

G	21.2	57.1%
A	16.4	50.7%
B	37.5	54.1%

Class 2 – Short Vehicles Towing

G	7.3	19.71%
A	8.1	24.93%
B	15.4	22.14%

Class 3 – 2 Axle Trucks & Buses

G	3.2	8.64%
A	3.5	10.82%
B	6.7	9.66%

Class 4 – 3 Axle Truck & Bus

G	1.8	4.77%
A	0.5	1.53%
B	2.3	3.26%

Class 5 – 4 Axle Truck

G	0.5	1.28%
A	0.3	0.78%
B	0.7	1.05%

Class 6 – 3 Axle Articulated

G	0.5	1.47%
A	1.0	2.97%
B	1.5	2.17%

Class 7 – 4 Axle Articulated

G	0.9	2.34%
A	1.0	3.22%
B	1.9	2.75%

Class 8 – 5 Axle Articulated

G	0.2	0.65%
A	0.1	0.22%
B	0.3	0.45%

Class 9 – 6 Axle Articulated

G	0.4	0.95%
A	0.3	1.03%
B	0.7	0.99%

Class 10 – B Double

G	0.3	0.68%
A	0.2	0.59%
B	0.4	0.64%

Class 11 – Double Road Train

G	0.3	0.68%
A	0.3	1.00%
B	0.6	0.83%

Class 12 – Triple Road Train

G	0.6	1.74%
A	0.7	2.19%
B	1.4	1.95%

THIS REPORT SHOWS ANNUAL AVERAGE DAILY TRAFFIC VALUES (AADT's).

AADT SEGMENT REPORT

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G TRAFFIC FLOWING IN GAZETTAL DIRECTION
A TRAFFIC FLOWING AGAINST GAZETTAL DIRECTION
B THE COMBINED TRAFFIC FLOW IN BOTH DIRECTIONS

SITE

THE PHYSICAL LOCATION OF A TRAFFIC COUNTING DEVICE. SITES ARE LOCATED AT A SPECIFIED THROUGH DISTANCE ALONG A ROAD SECTION.

FOR INFORMATION ONLY

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NO.	DATE	DESCRIPTION	DESIGN	APPROVED
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ERSCON CONSULTING ENGINEERS

CLIENT: CARPENTARIA SHIRE – Outback by the Sea

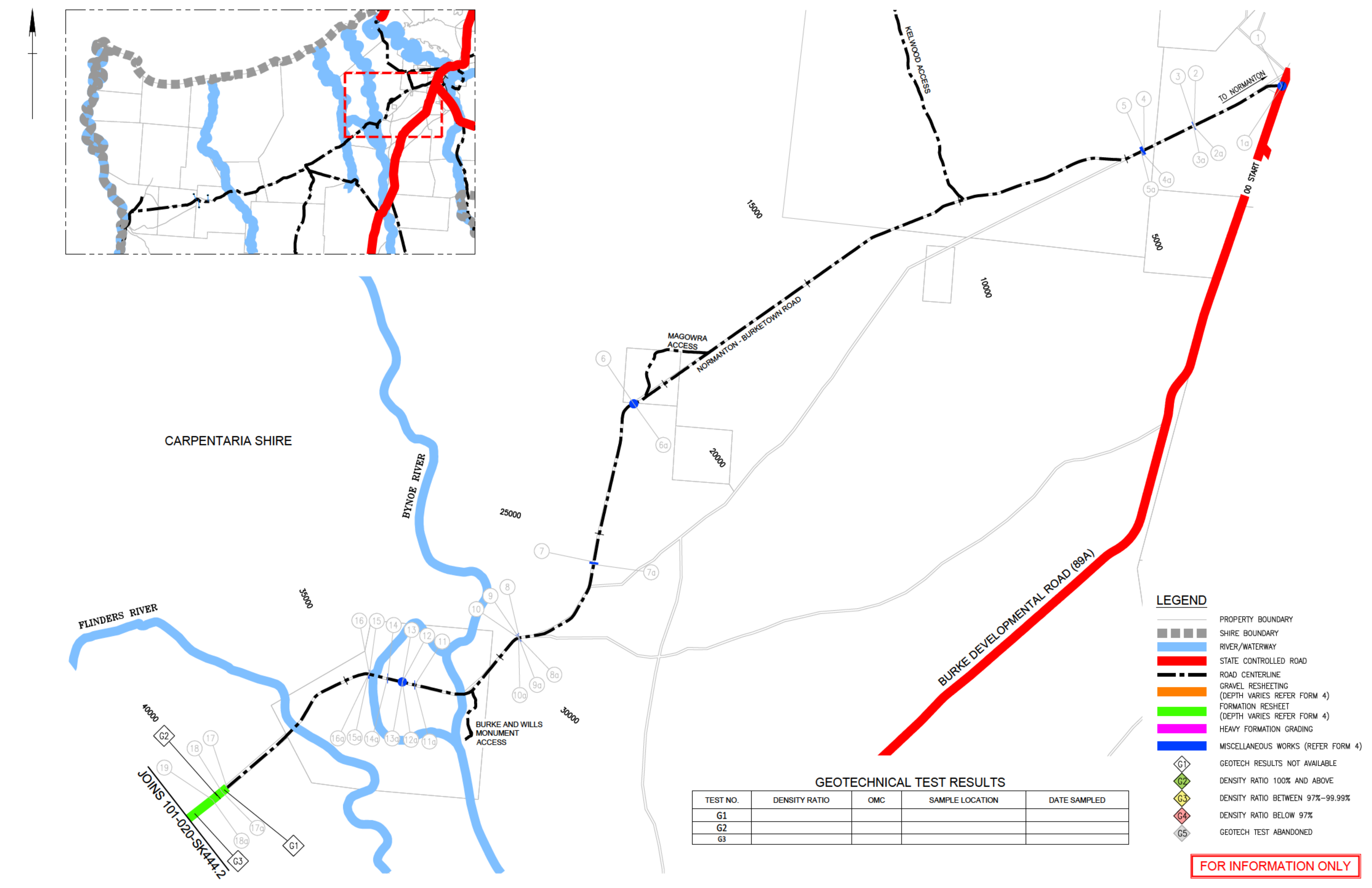
SCALE: NTS

ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE

DRAWN: BB
DESIGNED: BB
DRAWN APPROVED: -
DESIGN APPROVED: -
CIVIL SIGNOFF APPROVAL
DATE:
RPEQ:

PROJECT REF: CARPENTARIA SHIRE TRAFFIC COUNT
DRAWING REF: NORMANTON - BURKETOWN ROAD 2019 TRAFFIC COUNT : CH 64.958
DRAWING NO: 101-101-SK804
SIZE: A4
REVISION: 1

APPENDIX B – 2022 NORMANTON – BURKETOWN ROAD TEST LOCALITY SKETCHES



LEGEND

- PROPERTY BOUNDARY
- SHIRE BOUNDARY
- RIVER/WATERWAY
- STATE CONTROLLED ROAD
- ROAD CENTERLINE
- GRAVEL RESHEETING (DEPTH VARIES REFER FORM 4)
- FORMATION RESHEET (DEPTH VARIES REFER FORM 4)
- HEAVY FORMATION GRADING
- MISCELLANEOUS WORKS (REFER FORM 4)
- G1 GEOTECH RESULTS NOT AVAILABLE
- G2 DENSITY RATIO 100% AND ABOVE
- G3 DENSITY RATIO BETWEEN 97%-99.99%
- G4 DENSITY RATIO BELOW 97%
- G5 GEOTECH TEST ABANDONED

GEOTECHNICAL TEST RESULTS

TEST NO.	DENSITY RATIO	OMC	SAMPLE LOCATION	DATE SAMPLED
G1				
G2				
G3				

FOR INFORMATION ONLY

NO.	DATE	DESCRIPTION	DESIGN	APPROVED
5	02/06/22	TEST RESULTS UPDATED	AB	
4	19/05/22	TEST RESULTS UPDATED	AB	
3	27/05/21	REVISED FROM SEAL WORKS	BCB	
2	24/02/21	TEST POINTS REVISED	MG	
1	09/10/20	INITIAL ISSUE		

REVISIONS

ERSCON CONSULTING ENGINEERS

CLIENT: CARPENTARIA SHIRE Outback by the Sea

SCALE 1:100,000 A3 (0 1000 2000 3000)

ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE

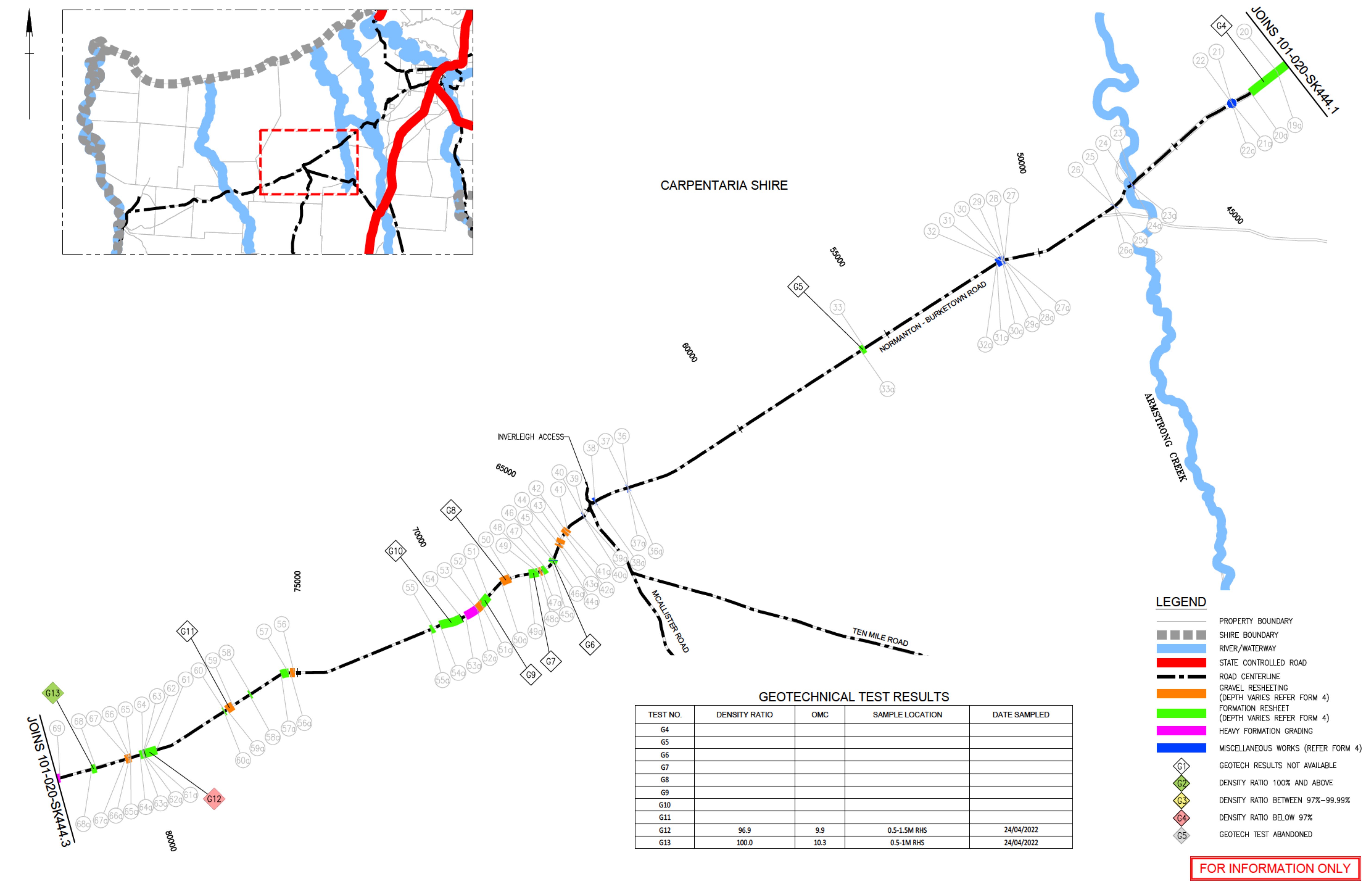
DRAWN BCB
DESIGNED
DRAWN APPROVED
DESIGN APPROVED
CIVIL SIGNOFF APPROVAL
DATE: RPEQ:

PROJECT REF: DRFA 2020 CARPENTARIA SHIRE ROADS RESTORATION

DRAWING REF: NORMANTON - BURKETOWN ROAD (ROAD 1025)
2020 GEOTECHNICAL TEST RESULTS (SHEET 1 OF 4)

DRAWING NO: 101-020-SK444.1 | SIZE: A3 | REVISION: 5

PLOT DATE 2/06/2022 2:36:25 PM
FILE LOCATION D:\ERSCON Dropbox\ERSCON\101 Carp SC\020 2020 Restoration_4 Scope_2 Drawings\GEOTECHNICAL SKETCHES (400 SERIES)\101-020-SK444 NORMANTON - BURKETOWN ROAD.dwg



LEGEND

- PROPERTY BOUNDARY
- SHIRE BOUNDARY
- RIVER/WATERWAY
- STATE CONTROLLED ROAD
- ROAD CENTERLINE
- GRAVEL RESHEETING (DEPTH VARIES REFER FORM 4)
- FORMATION RESHEET (DEPTH VARIES REFER FORM 4)
- HEAVY FORMATION GRADING
- MISCELLANEOUS WORKS (REFER FORM 4)
- G1 GEOTECH RESULTS NOT AVAILABLE
- G2 DENSITY RATIO 100% AND ABOVE
- G3 DENSITY RATIO BETWEEN 97%-99.99%
- G4 DENSITY RATIO BELOW 97%
- G5 GEOTECH TEST ABANDONED

GEOTECHNICAL TEST RESULTS

TEST NO.	DENSITY RATIO	OMC	SAMPLE LOCATION	DATE SAMPLED
G4				
G5				
G6				
G7				
G8				
G9				
G10				
G11				
G12	96.9	9.9	0.5-1.5M RHS	24/04/2022
G13	100.0	10.3	0.5-1M RHS	24/04/2022

FOR INFORMATION ONLY

NO.	DATE	DESCRIPTION	DESIGN	APPROVED
5	02/06/22	TEST RESULT UPDATED	AB	
4	19/05/22	TEST RESULT UPDATED	AB	
3	27/05/21	REVISED FROM SEAL WORKS	BCB	
2	24/02/21	TEST POINTS REVISED	MG	
1	09/10/20	INITIAL ISSUE		

REVISIONS

ERSCON CONSULTING ENGINEERS

CLIENT: CARPENTARIA SHIRE *Outback by the Sea*

SCALE 1:100,000 0 1000 2000 3000 A3

ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE

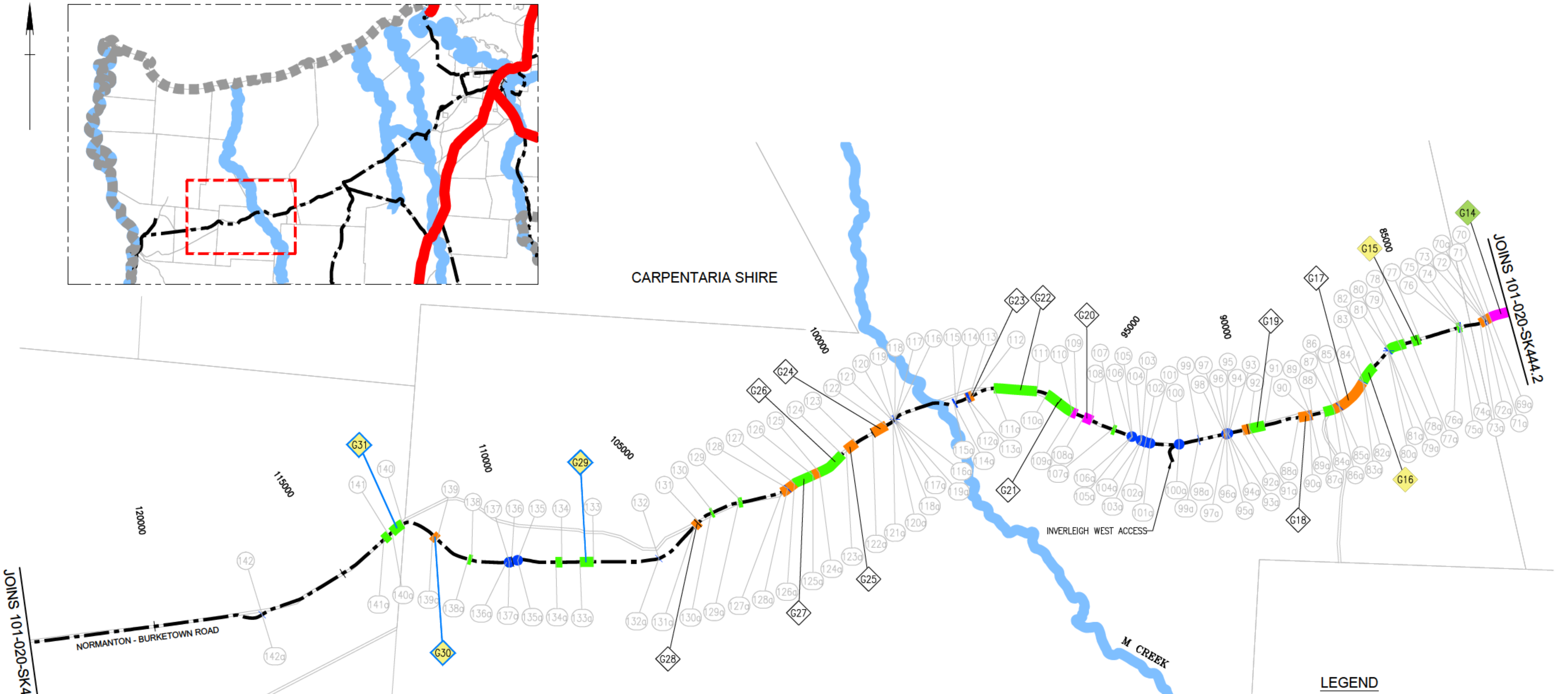
DRAWN: BCB
DESIGNED:
DRAWN APPROVED:
DESIGN APPROVED:
CIVIL SIGNOFF APPROVAL:
DATE: RPEQ:

PROJECT REF: DRFA 2020 CARPENTARIA SHIRE ROADS RESTORATION

DRAWING REF: NORMANTON - BURKETOWN ROAD (ROAD 1025) 2020 GEOTECHNICAL TEST RESULTS (SHEET 2 OF 4)

DRAWING NO: 101-020-SK444.2 | SIZE: A3 | REVISION: 5

PLOT DATE 2/06/2022 2:36:55 PM



GEOTECHNICAL TEST RESULTS

TEST NO.	DENSITY RATIO	OMC	SAMPLE LOCATION	DATE SAMPLED
G14	100.9	8.3	0.5-1.5M LHS	24/04/2022
G15	97.3	11.4	0.5-1.5M LHS	24/04/2022
G16	97.4	10.8	0.5-1M RHS	24/04/2022
G17				
G18				
G19				
G20				
G21				
G22				
G23				
G24				
G25				
G26				
G27				
G28				
G29	97.2	12.2	0.5-1.5M LHS	18/05/2022
G30	99.0	10.5	0.5-1.5M RHS	18/05/2022
G31	98.9	11.9	0.5-1.5M RHS	18/05/2022

LEGEND

- PROPERTY BOUNDARY
- SHIRE BOUNDARY
- RIVER/WATERWAY
- STATE CONTROLLED ROAD
- ROAD CENTERLINE
- GRAVEL RESHEETING (DEPTH VARIES REFER FORM 4)
- FORMATION RESHEET (DEPTH VARIES REFER FORM 4)
- HEAVY FORMATION GRADING
- MISCELLANEOUS WORKS (REFER FORM 4)
- G1 GEOTECH RESULTS NOT AVAILABLE
- G2 DENSITY RATIO 100% AND ABOVE
- G3 DENSITY RATIO BETWEEN 97%-99.99%
- G4 DENSITY RATIO BELOW 97%
- G5 GEOTECH TEST ABANDONED

FOR INFORMATION ONLY

PLOT DATE 2/06/2022 2:37:19 PM
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REVISIONS

NO.	DATE	DESCRIPTION	DESIGN	APPROVED
5	02/06/22	TEST RESULTS UPDATED	AB	
4	19/05/22	TEST RESULTS UPDATED	AB	
3	27/05/21	REVISED FROM SEAL WORKS	BCB	
2	24/02/21	TEST POINTS REVISED	MG	
1	09/10/20	INITIAL ISSUE		

ERSCON CONSULTING ENGINEERS

CLIENT: CARPENTARIA SHIRE — Outback by the Sea

SCALE 1:100,000 — 0 1000 2000 3000 — A3

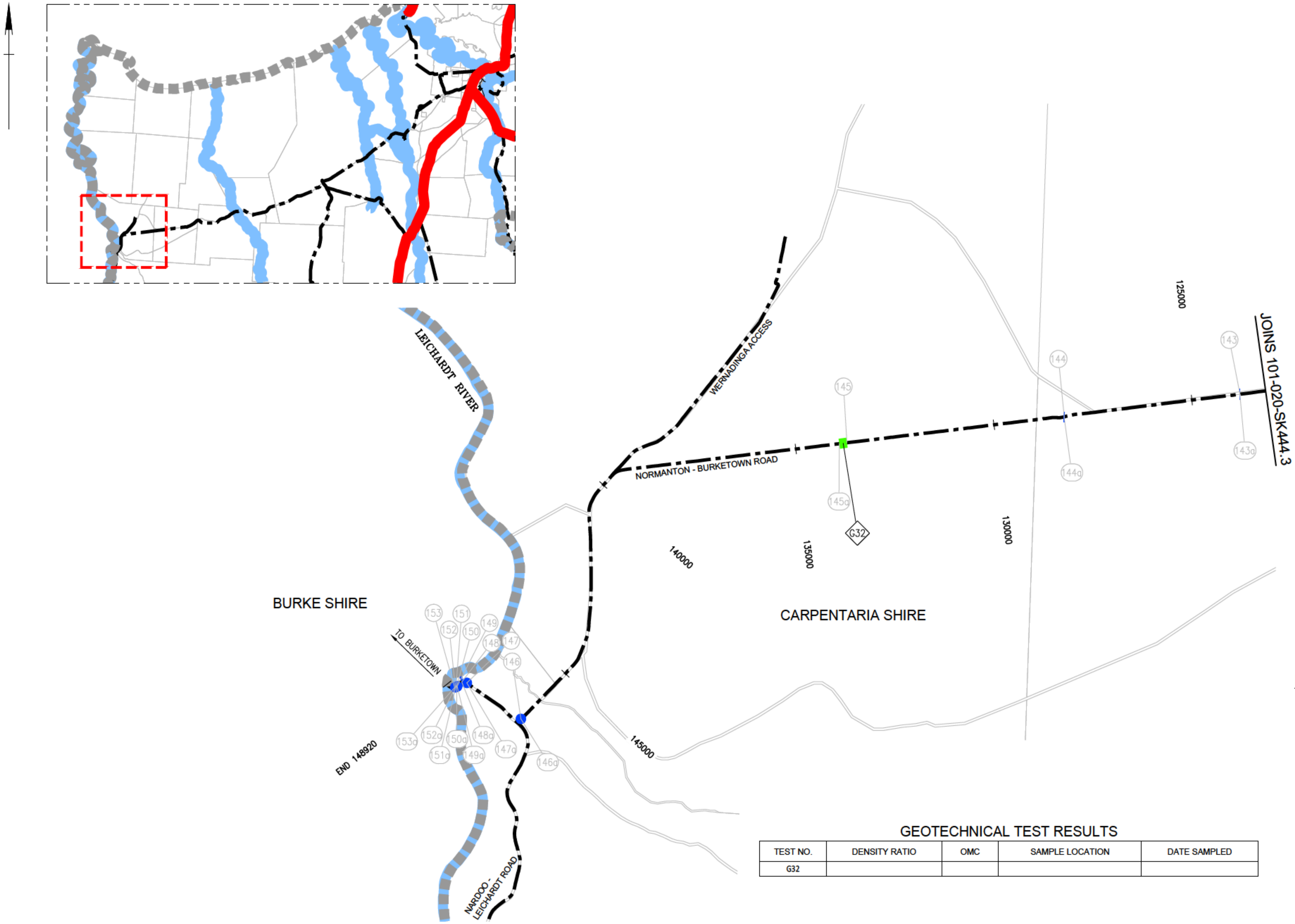
ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE

DRAWN: BCB
DESIGNED:
DRAWN APPROVED:
DESIGN APPROVED:
CIVIL SIGNOFF APPROVAL:
DATE:
RPEQ:

PROJECT REF: DRFA 2020 CARPENTARIA SHIRE ROADS RESTORATION

DRAWING REF: NORMANTON - BURKETOWN ROAD (ROAD 1025)
2020 GEOTECHNICAL TEST RESULTS (SHEET 3 OF 4)

DRAWING NO: 101-020-SK444.3 — SIZE: A3 — REVISION: 5



GEOTECHNICAL TEST RESULTS

TEST NO.	DENSITY RATIO	OMC	SAMPLE LOCATION	DATE SAMPLED
G32				

LEGEND

- PROPERTY BOUNDARY
- SHIRE BOUNDARY
- RIVER/WATERWAY
- STATE CONTROLLED ROAD
- ROAD CENTERLINE
- GRAVEL RESHEETING (DEPTH VARIES REFER FORM 4)
- FORMATION RESHEET (DEPTH VARIES REFER FORM 4)
- HEAVY FORMATION GRADING
- MISCELLANEOUS WORKS (REFER FORM 4)
- G1 GEOTECH RESULTS NOT AVAILABLE
- G2 DENSITY RATIO 100% AND ABOVE
- G3 DENSITY RATIO BETWEEN 97%-99.99%
- G4 DENSITY RATIO BELOW 97%
- G5 GEOTECH TEST ABANDONED

FOR INFORMATION ONLY

PLOT DATE 2/06/2022 2:37:33 PM
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REVISIONS

NO.	DATE	DESCRIPTION	DESIGN	APPROVED
5	02/06/22	TEST RESULTS UPDATED	AB	
4	19/05/22	TEST RESULTS UPDATED	AB	
3	27/05/21	REVISED FROM SEAL WORKS	BCB	
2	24/02/21	TEST POINTS REVISED	MG	
1	09/10/20	INITIAL ISSUE		

ERSCON CONSULTING ENGINEERS

CLIENT: CARPENTARIA SHIRE — Outback by the Sea

SCALE 1:100,000 — 0 1000 2000 3000 — A3

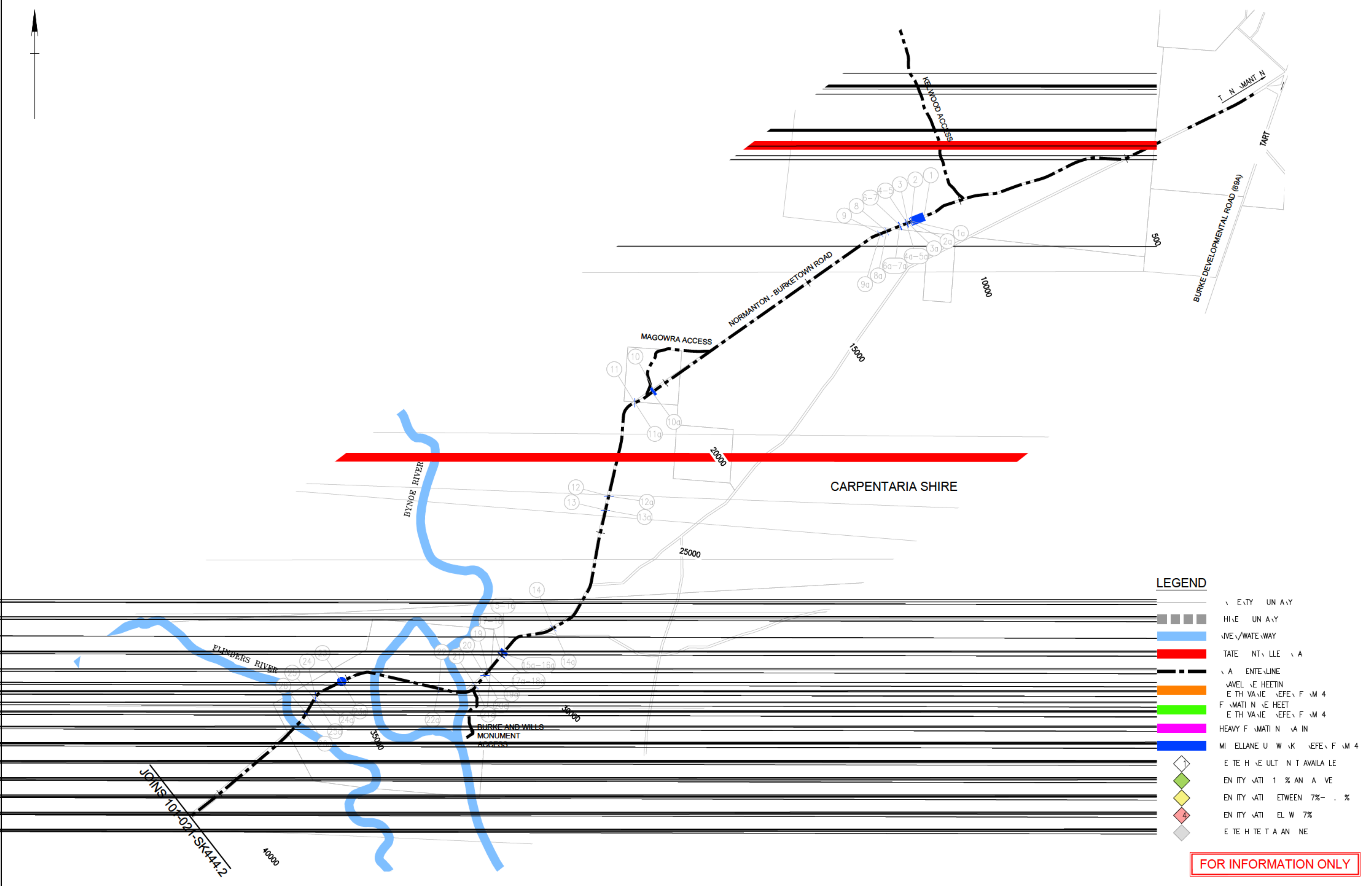
ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE

DRAWN: BCB
DRAWN APPROVED
DESIGNED
DESIGN APPROVED
CIVIL SIGNOFF APPROVAL
DATE: RPEQ:

PROJECT REF: DRFA 2020 CARPENTARIA SHIRE ROADS RESTORATION

DRAWING REF: NORMANTON - BURKETOWN ROAD (ROAD 1025) 2020 GEOTECHNICAL TEST RESULTS (SHEET 4 OF 4)

DRAWING NO: 101-020-SK444.4 | SIZE: A3 | REVISION: 4



NO.	DATE	DESCRIPTION	DESIGN	APPROVED
4	25/08/22	TEST RESULTS UPDATED	AB	
3	16/06/22	TEST RESULTS UPDATED	AB	
2	06/06/22	APPROVED SCOPE & TEST POINTS	BCB	
1	22/10/21	INITIAL ISSUE		

REVISIONS

PLOT DATE 25/08/2022 10:17:45 AM

ERSCON CONSULTING ENGINEERS

CLIENT: CARPENTARIA SHIRE — Outback by the Sea

SCALE 1:100,000 (0, 1000, 2000, 3000) A3

ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE

DRAWN: MG — DESIGNED: MG

DRAWN APPROVED — DESIGN APPROVED — CIVIL SIGNOFF APPROVAL

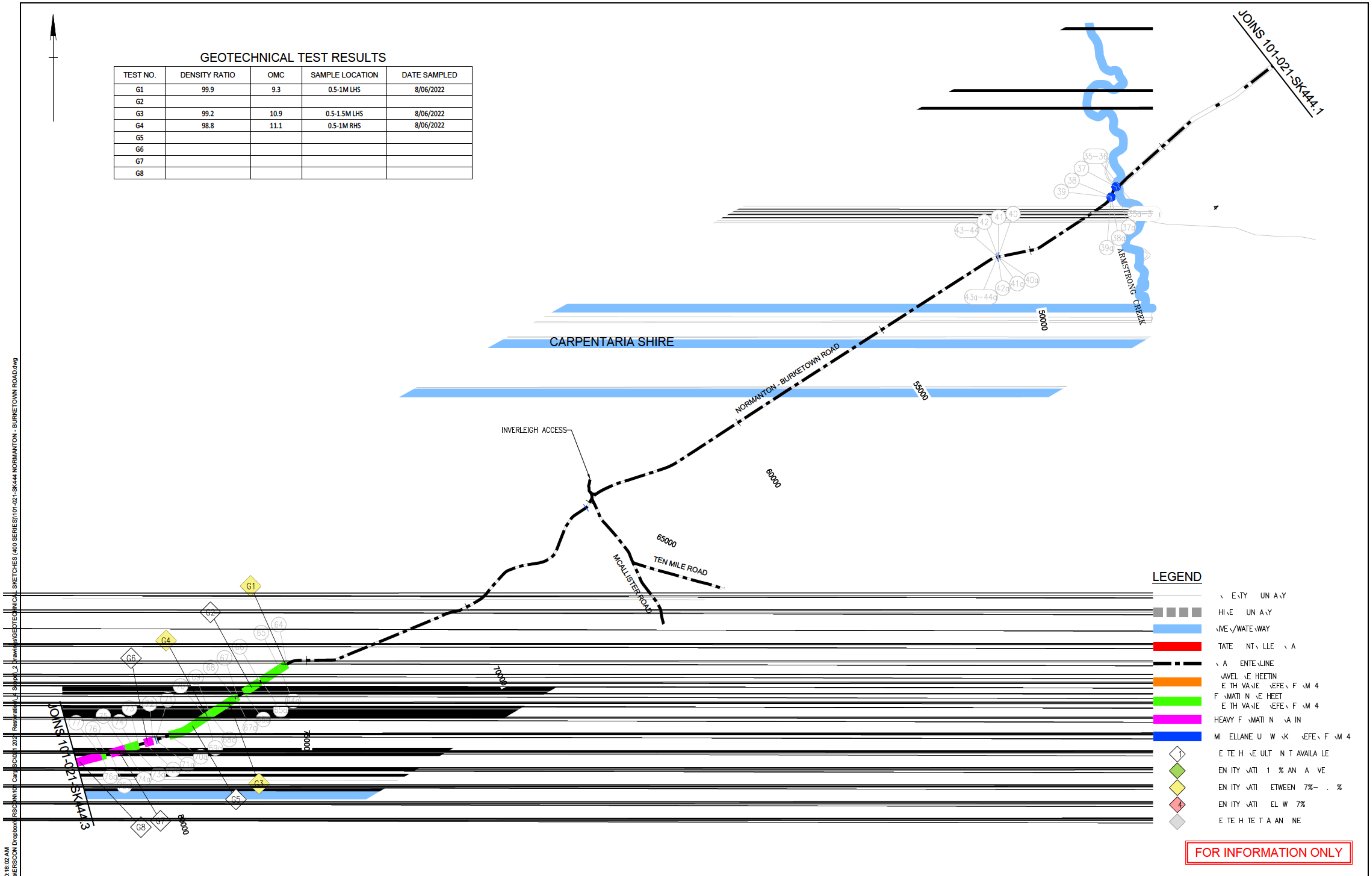
PROJECT REF: DRFA 2021 CARPENTARIA SHIRE ROADS RESTORATION

DRAWING REF: NORMANTON - BURKETOWN ROAD (ROAD 1025)
2021 GEOTECHNICAL TEST RESULTS (SHEET 1 OF 4)

DRAWING NO: 101-021-SK444.1 — SIZE: A3 — REVISION: 4

GEOTECHNICAL TEST RESULTS

TEST NO.	DENSITY RATIO	OMC	SAMPLE LOCATION	DATE SAMPLED
G1	99.9	9.3	0.5-1M LHS	8/06/2022
G2				
G3	99.2	10.9	0.5-1.5M LHS	8/06/2022
G4	98.8	11.1	0.5-1M RHS	8/06/2022
G5				
G6				
G7				
G8				



REVISIONS				
NO.	DATE	DESCRIPTION	DESIGN	APPROVED
4	25/08/22	TEST RESULTS UPDATED	AB	
3	16/06/22	TEST RESULTS UPDATED	AB	
2	06/06/22	APPROVED SCOPE & TEST POINTS	BCB	
1	22/10/21	INITIAL ISSUE		

ERSCON CONSULTING ENGINEERS

CLIENT: CARPENTARIA SHIRE — Outback by the Sea

SCALE 1:100,000 (0, 1000, 2000, 3000) A3

ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE

DRAWN: MG — DESIGNED: MG

DRAWN APPROVED — DESIGN APPROVED — CIVIL SIGNOFF APPROVAL

DATE: — RPEQ:

PROJECT REF: DRFA 2021 CARPENTARIA SHIRE ROADS RESTORATION

DRAWING REF: NORMANTON - BURKETOWN ROAD (ROAD 1025) 2021 GEOTECHNICAL TEST RESULTS (SHEET 2 OF 4)

DRAWING NO: 101-021-SK444.2 — SIZE: A3 — REVISION: 4

PLOT DATE 25/08/2022 10:18:02 AM
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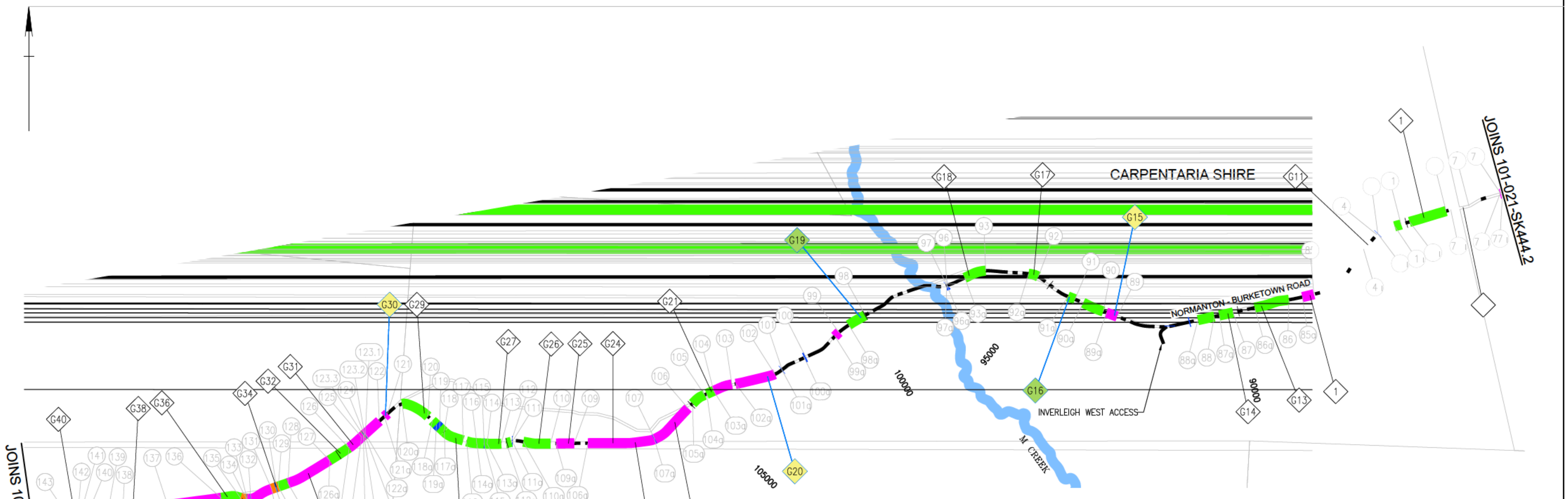

GEOTECHNICAL TEST RESULTS

TEST NO.	DENSITY RATIO	OMC	SAMPLE LOCATION	DATE SAMPLED
G9				
G10				
G11				
G12				
G13				
G14				
G15	98.6	9.4	0.5-1M LHS	8/08/2022
G16	103.5	10.8	0.5-1M RHS	8/08/2022
G17				
G18				
G19	100.3	10.9	0.5-1M LHS	8/08/2022
G20	99.7	10.1	0.5-1M RHS	8/08/2022
G21				
G22				
G23				
G24				
G25				
G26				
G27				
G28				
G29				
G30	98.1	12	1M RHS	22/08/2022
G31				
G32				
G33				
G34				
G35				
G36				
G37				
G38				
G39				
G40				
G41				

LEGEND

- E TY UN A Y
- HI E UN A Y
- IVE /WATE WAY
- TATE NT LLE A
- A ENTE LINE
- AVEL E HEETIN E TH VA IE EFE F M 4
- F MATI N E HEET E TH VA IE EFE F M 4
- HEAVY F MATI N A IN
- MI ELLANE U W K EFE F M 4
- E TE H E ULT N T AVAILA LE
- EN ITY ATI 1 % AN A VE
- EN ITY ATI ETWEEN 7%- . %
- EN ITY ATI EL W 7%
- E TE H TE T A AN NE

FOR INFORMATION ONLY

NO.	DATE	DESCRIPTION	DESIGN	APPROVED
4	25/08/22	TEST RESULTS UPDATED	AB	
3	16/06/22	TEST RESULTS UPDATED	AB	
2	06/06/22	APPROVED SCOPE & TEST POINTS	BCB	
1	22/10/21	INITIAL ISSUE		

REVISIONS

ERSCON CONSULTING ENGINEERS

CLIENT: CARPENTARIA SHIRE — Outback by the Sea

SCALE 1:100,000 — 0 1000 2000 3000 — A3

ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE

DRAWN: MG
DESIGNED: MG
DRAWN APPROVED
DESIGN APPROVED
CIVIL SIGNOFF APPROVAL
DATE: RPEQ:

PROJECT REF: DRFA 2021 CARPENTARIA SHIRE ROADS RESTORATION

DRAWING REF: NORMANTON - BURKETOWN ROAD (ROAD 1025) 2021 GEOTECHNICAL TEST RESULTS (SHEET 3 OF 4)

DRAWING NO. 101-021-SK444.3 | SIZE A3 | REVISION 4

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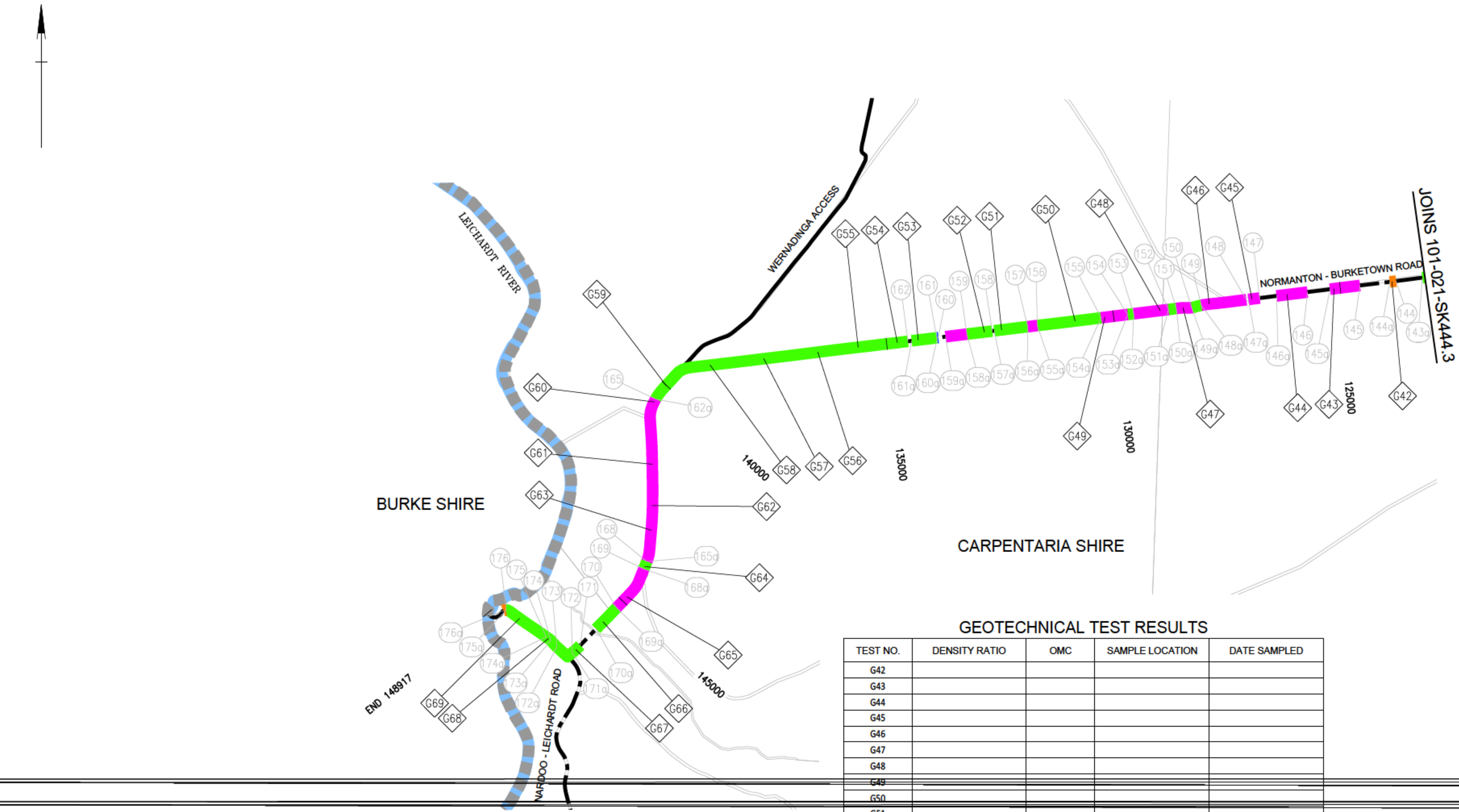

GEOTECHNICAL TEST RESULTS

TEST NO.	DENSITY RATIO	OMC	SAMPLE LOCATION	DATE SAMPLED
G42				
G43				
G44				
G45				
G46				
G47				
G48				
G49				
G50				
G51				
G52				
G53				
G54				
G55				
G56				
G57				
G58				
G59				
G60				
G61				
G62				
G63				
G64				
G65				
G66				
G67				
G68				
G69				

LEGEND

- E TY UN A Y
- HI E UN A Y
- IVE /WATE WAY
- TATE NT LLE A
- A ENTE LINE
- AVEL E HEETIN E TH VA IE EFE F M 4
- F MATI N E HEET E TH VA IE EFE F M 4
- HEAVY F MATI N A IN
- MI ELLANE U W K EFE F M 4
- E TE H E ULT N T AVAILA LE
- EN ITY ATI 1 % AN A VE
- EN ITY ATI ETWEEN 7%– . %
- EN ITY ATI EL W 7%
- E TE H TE T A AN NE

FOR INFORMATION ONLY

NO.	DATE	DESCRIPTION	DESIGN	APPROVED
4	25/08/22	TEST RESULTS UPDATED	AB	
3	16/06/22	TEST RESULTS UPDATED	AB	
2	06/06/22	APPROVED SCOPE & TEST POINTS	BCB	
1	22/10/21	INITIAL ISSUE		

REVISIONS

ERSCON CONSULTING ENGINEERS

CLIENT: CARPENTARIA SHIRE — Outback by the Sea

SCALE 1:100,000 — 0 1000 2000 3000 — A3

ALL DIMENSIONS IN METRES UNLESS NOTED OTHERWISE

DRAWN: MG — DESIGNED: MG

DRAWN APPROVED — DESIGN APPROVED — CIVIL SIGNOFF APPROVAL — DATE: — RPEQ:

PROJECT REF: DRFA 2021 CARPENTARIA SHIRE ROADS RESTORATION

DRAWING REF: NORMANTON - BURKETOWN ROAD (ROAD 1025) 2021 GEOTECHNICAL TEST RESULTS (SHEET 4 OF 4)

DRAWING NO: 101-021-SK444.4 — SIZE: A3 — REVISION: 4

PLOT DATE 25/08/2022 10:18:41 AM
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APPENDIX C – 2022 NORMANTON – BURKETOWN ROAD TEST RESULTS

FIELD DENSITY NOTES DATA ENTRY

CLIENT	Carpentaria Shire Council		
PROJECT NO	101-020		
PROJECT			
TEST REQUEST NO			
MATERIAL SOURCE	HFG-Natural		
LOT NO			
SAMPLE DESCRIPTION	Red Brown Gravel		
DATE TESTED			
COMPACTION STD	100%		
TESTED BY			
NUC GAUGE NO	30823		
DS			
MS			
SAMPLE ID			
TEST LOCATION			
ORIENTATION	0	90	
PROBE DEPTH /			
LAYER DEPTH (mm)			
TIME SETTING (min)			
TIME OF TEST			Average
DENSITY COUNT			#DIV/0!
MOISTURE COUNT			#DIV/0!
GAUGE FIELD WET DENSITY (t/m3)			#DIV/0!
GAUGE FIELD DRY DENSITY (t/m3)			#DIV/0!
GAUGE MOISTURE CONTENT (%)			#DIV/0!
GAUGE MOISTURE CONTENT (kg)			#DIV/0!

Dry Density Variation Check (<0.075 t/m3)
0

SAND REPLACEMENT DATA ENTRY

	ORIGINAL WEIGHT (g)	FINAL WEIGHT (g)	SAND WEIGHT (g)
SAND CALIBRATION (SC)	2000	606	1394
SAND REPLACEMENT (SR)	6000	3311	2689

SAND IN HOLE (SR-SC) (g)	1295
DENSITY OF SAND (t/m3)	1.445
VOLUME OF HOLE (m3)	0.000896194
MASS OF CONTAINER (g)	411
MASS OF CONTAINER AND WET SOIL (g)	2464
DENSITY OF HOLE MATERIAL (t/m3)	2.290799228
DRY DENSITY (t/m3)	2.166942085
DENSITY RATIO	96.9

LAB MOISTURE CONTENT DATA ENTRY

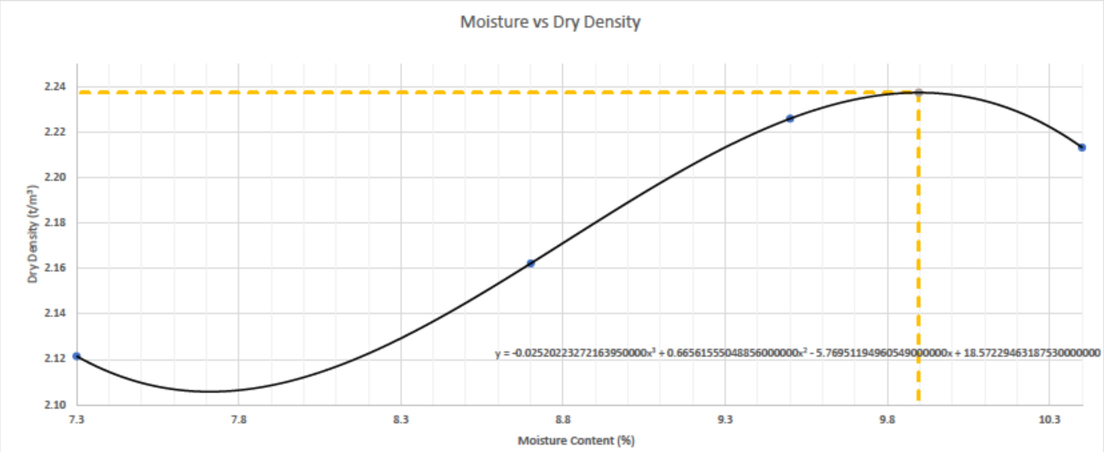
					STARTING MOISTURE CONTENT
SAMPLE ID	1025-G12				
DATE LAB TESTED	24/04/2022				
LAB WORK PERFORMED BY	TR				
CONTAINER NUMBER	18	16	19	20	21
INITIAL TIME OF TEST					
MASS OF CONTAINER (m1)	413	283	421	407	411
MASS OF CONTAINER AND WET SOIL (m2) (g)	1413	1283	1421	1407	2464
FIRST WEIGH (g)					
SECOND WEIGH (g)					
THIRD WEIGH (g)					
FOURTH WEIGH (g)					
FIFTH WEIGH (g)					
FINAL WEIGH (g)					
TIME OF FINAL WEIGH					
MASS OF CONTAINER AND DRY SOIL (m3) (g)	1333	1196	1327	1339	2353
MOISTURE CONTENT (w) (%)	8.7	9.5	10.4	7.3	5.7
Mass of Dry Soil	2365.2	2365.2	2365.2	2365.2	
Total mass of water	209.8	234.8	259.8	184.8	
Moisture Content Check (%)	8.9	9.9	11	7.8	

LAB DRY DENSITY/MOISTURE CONTENT ENTRY

SAMPLE ID	1025-G12			
DATE TESTED	24/04/2022			
TIME OF COMPACTION				
TESTED BY	TR			
BALANCE NO				
RAMMER NO				
MOULD NO	A			
MOULD VOLUME	999			
MASS OF MOULD	4231			
MASS OF SOIL	2500	2500	2500	2500
VOLUME WATER ADDED (mL)	75	100	125	50
MASS OF MOULD & WET SOIL (g)	6579	6666	6672	6505
WET DENSITY (t/m3)	2.35	2.44	2.44	2.28

CALCULATIONS

Final Moisture Content (%)	8.7	9.5	10.4	7.3
Wet density of material (ρ_w)(t/m^3)	2.35	2.44	2.44	2.28
Dry density of material (ρ_d)(t/m^3)	2.162	2.226	2.213	2.121



y = -0.0252022327216395000x3 + 0.665615550488560000x2 - 5.76951194960549000000x + 18.5722946318753000000		*Inset Formula*
a	-0.025202233	
b	0.66561555	
c	-5.76951195	
d	18.57229463	

Derivative

a	-0.075606698
b	1.331231101
c	-5.76951195

Turning Point (Derivative = 0)

Answer 1	7.710558189
Answer 2	9.896758798

Copy answer which corresponds to maxium dry density on curve (highest point) and paste value below

OMC	9.9
MDD	2.237

SITE MOISTURE BIAS CALCULATIONS

	Orientation 1	Orientation 2	Average
Field moisture content at site (w_{dn})(%)	5.7	5.7	5.7
Field wet density at site (ρ_n)(t/m3)	0	0	#DIV/0!
Field water content W_{dn} (t/m3)	0.000	0.000	#DIV/0!
Unadjusted field water content displayed by gauge (w_{vn})(%)	0.0	0.0	#DIV/0!
Unadjusted field water content displayed by gauge (W_{vn})(t/m3)	0.000	0.000	#DIV/0!
Individual site moisture bias (B_{mn})(t/m3)	0.000	0.000	#DIV/0!

ADJUSTED FIELD MOISTURE CONTENT & DRY DENSITY CALCULATIONS

Field Wet Density (t/m³)	0.000	0.000	#DIV/0!
Field Dry Density (t/m³)	0	0	#DIV/0!
Field Moisture Conent	0	0	#DIV/0!
Adjusted Field Dry Density (t/m³)	0.000	0.000	#DIV/0!
Adjusted Field Moisture Content (%)	5.7	5.7	5.7
Nuclear Gauge - Density Ratio (%)	0.0	0.0	#DIV/0!
Sand Replacement - Density Ratio (%)			96.9

FIELD DENSITY NOTES DATA ENTRY

CLIENT	Carpentaria Shire Council			
PROJECT NO	101-020			
PROJECT				
TEST REQUEST NO				
MATERIAL SOURCE	HFG-Natural			
LOT NO				
SAMPLE DESCRIPTION	Red Brown Gravel			
DATE TESTED				
COMPACTION STD	100%			
TESTED BY				
NUC GAUGE NO	30823			
DS				
MS				
SAMPLE ID				
TEST LOCATION				
ORIENTATION	0	90		
PROBE DEPTH /				
LAYER DEPTH (mm)				
TIME SETTING (min)				
TIME OF TEST			Average	
DENSITY COUNT			#DIV/0!	
MOISTURE COUNT			#DIV/0!	Dry Density Variation Check (<0.075 t/m3)
GAUGE FIELD WET DENSITY (t/m3)			#DIV/0!	
GAUGE FIELD DRY DENSITY (t/m3)			#DIV/0!	0
GAUGE MOISTURE CONTENT (%)			#DIV/0!	
GAUGE MOISTURE CONTENT (kg)			#DIV/0!	

SAND REPLACEMENT DATA ENTRY

	ORIGINAL WEIGHT (g)	FINAL WEIGHT (g)	SAND WEIGHT (g)
SAND CALIBRATION (SC)	2000	605	1395
SAND REPLACEMENT (SR)	6000	3058	2942

SAND IN HOLE (SR-SC) (g)	1547
DENSITY OF SAND (t/m3)	1.445
VOLUME OF HOLE (m3)	0.001070588
MASS OF CONTAINER (g)	418
MASS OF CONTAINER AND WET SOIL (g)	2854
DENSITY OF HOLE MATERIAL (t/m3)	2.275384615
DRY DENSITY (t/m3)	2.172637363
DENSITY RATIO	100.0

LAB MOISTURE CONTENT DATA ENTRY

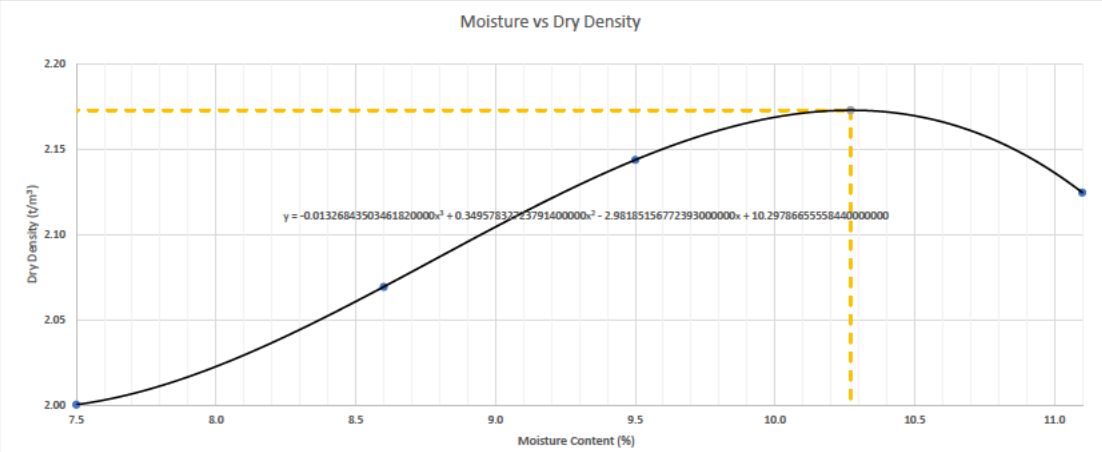
					STARTING MOISTURE CONTENT
SAMPLE ID	1025-G13				
DATE LAB TESTED	24/04/2022				
LAB WORK PERFORMED BY	TR				
CONTAINER NUMBER	31	32	33	34	35
INITIAL TIME OF TEST					
MASS OF CONTAINER (m1)	412	420	416	413	418
MASS OF CONTAINER AND WET SOIL (m2) (g)	1412	1420	1416	1413	2854
FIRST WEIGH (g)					
SECOND WEIGH (g)					
THIRD WEIGH (g)					
FOURTH WEIGH (g)					
FIFTH WEIGH (g)					
FINAL WEIGH (g)					
TIME OF FINAL WEIGH					
MASS OF CONTAINER AND DRY SOIL (m3) (g)	1342	1341	1329	1313	2744
MOISTURE CONTENT (w) (%)	7.5	8.6	9.5	11.1	4.7
Mass of Dry Soil	2387.8	2387.8	2387.8	2387.8	
Total mass of water	187.2	212.2	237.2	270.2	
Moisture Content Check (%)	7.8	8.9	9.9	11.3	

LAB DRY DENSITY/MOISTURE CONTENT ENTRY

SAMPLE ID	1025-G13			
DATE TESTED	24/04/2022			
TIME OF COMPACTION				
TESTED BY	TR			
BALANCE NO				
RAMMER NO				
MOULD NO	A			
MOULD VOLUME	999			
MASS OF MOULD	4263			
MASS OF SOIL	2500	2500	2500	2500
VOLUME WATER ADDED (mL)	75	100	125	158
MASS OF MOULD & WET SOIL (g)	6411	6508	6608	6621
WET DENSITY (t/m3)	2.15	2.25	2.35	2.36

CALCULATIONS

Final Moisture Content (%)	7.5	8.6	9.5	11.1
Wet density of material (ρ_w)(t/m^3)	2.15	2.25	2.35	2.36
Dry density of material (ρ_d)(t/m^3)	2.000	2.069	2.144	2.125



y = -0.0132684350346182000x3 + 0.3495783272379140000x2 - 2.9818515677239300000x + 10.2978665555844000000		*Inset Formula*
a	-0.013268435	
b	0.349578327	
c	-2.981851568	
d	10.29786656	

Derivative

a	-0.039805305
b	0.699156654
c	-2.981851568

Turning Point (Derivative = 0)

Answer 1	7.293511607
Answer 2	10.27089727

Copy answer which corresponds to maxium dry density on curve (highest point) and paste value below

OMC	10.3
MDD	2.173

SITE MOISTURE BIAS CALCULATIONS

	Orientation 1	Orientation 2	Average
Field moisture content at site (w_{dn})(%)	4.7	4.7	4.7
Field wet density at site (ρ_n)(t/m3)	0	0	#DIV/0!
Field water content W_{dn} (t/m3)	0.000	0.000	#DIV/0!
Unadjusted field water content displayed by gauge (w_{vn})(%)	0.0	0.0	#DIV/0!
Unadjusted field water content displayed by gauge (W_{vn})(t/m3)	0.000	0.000	#DIV/0!
Individual site moisture bias (B_{mn})(t/m3)	0.000	0.000	#DIV/0!

ADJUSTED FIELD MOISTURE CONTENT & DRY DENSITY CALCULATIONS

Field Wet Density (t/m³)	0.000	0.000	#DIV/0!
Field Dry Density (t/m³)	0	0	#DIV/0!
Field Moisture Conent	0	0	#DIV/0!
Adjusted Field Dry Density (t/m³)	0.000	0.000	#DIV/0!
Adjusted Field Moisture Content (%)	4.7	4.7	4.7
Nuclear Gauge - Density Ratio (%)	0.0	0.0	#DIV/0!
Sand Replacement - Density Ratio (%)			100.0

FIELD DENSITY NOTES DATA ENTRY

CLIENT	Carpentaria Shire Council			
PROJECT NO	101-020			
PROJECT				
TEST REQUEST NO				
MATERIAL SOURCE	HFG-Natural			
LOT NO				
SAMPLE DESCRIPTION	Red Brown Gravel			
DATE TESTED				
COMPACTION STD	100%			
TESTED BY				
NUC GAUGE NO	30823			
DS				
MS				
SAMPLE ID				
TEST LOCATION				
ORIENTATION	0	90		
PROBE DEPTH /				
LAYER DEPTH (mm)				
TIME SETTING (min)				
TIME OF TEST			Average	
DENSITY COUNT			#DIV/0!	
MOISTURE COUNT			#DIV/0!	Dry Density Variation Check (<0.075 t/m3)
GAUGE FIELD WET DENSITY (t/m3)			#DIV/0!	
GAUGE FIELD DRY DENSITY (t/m3)			#DIV/0!	0
GAUGE MOISTURE CONTENT (%)			#DIV/0!	
GAUGE MOISTURE CONTENT (kg)			#DIV/0!	

SAND REPLACEMENT DATA ENTRY

	ORIGINAL WEIGHT (g)	FINAL WEIGHT (g)	SAND WEIGHT (g)
SAND CALIBRATION (SC)	2000	588	1412
SAND REPLACEMENT (SR)	6000	3329	2671

SAND IN HOLE (SR-SC) (g)	1259
DENSITY OF SAND (t/m3)	1.445
VOLUME OF HOLE (m3)	0.00087128
MASS OF CONTAINER (g)	280
MASS OF CONTAINER AND WET SOIL (g)	2410
DENSITY OF HOLE MATERIAL (t/m3)	2.444678316
DRY DENSITY (t/m3)	2.358598094
DENSITY RATIO	100.9

LAB MOISTURE CONTENT DATA ENTRY

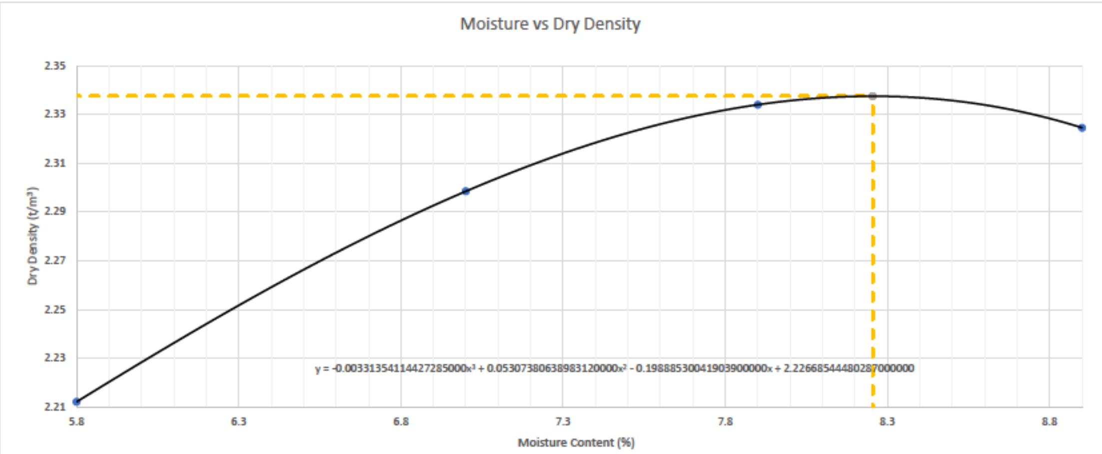
SAMPLE ID	1025-G14				
DATE LAB TESTED	24/04/2022				
LAB WORK PERFORMED BY	TR				STARTING MOISTURE CONTENT
CONTAINER NUMBER	1	2	3	4	5
INITIAL TIME OF TEST					
MASS OF CONTAINER (m1)	276	279	275	278	280
MASS OF CONTAINER AND WET SOIL (m2) (g)	1276	1279	1275	1278	2410
FIRST WEIGH (g)					
SECOND WEIGH (g)					
THIRD WEIGH (g)					
FOURTH WEIGH (g)					
FIFTH WEIGH (g)					
FINAL WEIGH (g)					
TIME OF FINAL WEIGH					
MASS OF CONTAINER AND DRY SOIL (m3) (g)	1203	1197	1210	1223	2335
MOISTURE CONTENT (w) (%)	7.9	8.9	7	5.8	3.6
Mass of Dry Soil	2413.1	2413.1	2413.1	2413.1	
Total mass of water	186.9	211.9	161.9	136.9	
Moisture Content Check (%)	7.7	8.8	6.7	5.7	

LAB DRY DENSITY/MOISTURE CONTENT ENTRY

SAMPLE ID	1025-G14			
DATE TESTED	24/04/2022			
TIME OF COMPACTION				
TESTED BY	TR			
BALANCE NO				
RAMMER NO				
MOULD NO	A			
MOULD VOLUME	999			
MASS OF MOULD	4231			
MASS OF SOIL	2500	2500	2500	2500
VOLUME WATER ADDED (mL)	100	125	75	50
MASS OF MOULD & WET SOIL (g)	6747	6760	6688	6569
WET DENSITY (t/m3)	2.52	2.53	2.46	2.34

CALCULATIONS

Final Moisture Content (%)	7.9	8.9	7.0	5.8
Wet density of material (ρ_w)(t/m^3)	2.52	2.53	2.46	2.34
Dry density of material (ρ_d)(t/m^3)	2.334	2.325	2.299	2.212



y = -0.0033135411442728500x3 + 0.0530738063898312000x2 - 0.1988853004190390000x + 2.2266854448028700000		*Inset Formula*
a	-0.003313541	
b	0.053073806	
c	-0.1988853	
d	2.226685445	

Derivative

a	-0.009940623
b	0.106147613
c	-0.1988853

Turning Point (Derivative = 0)

Answer 1	2.42386824
Answer 2	8.254296313

Copy answer which corresponds to maxium dry density on curve (highest point) and paste value below

OMC	8.3
MDD	2.338

SITE MOISTURE BIAS CALCULATIONS

	Orientation 1	Orientation 2	Average
Field moisture content at site (w_{dn})(%)	3.6	3.6	3.6
Field wet density at site (ρ_n)(t/m3)	0	0	#DIV/0!
Field water content W_{dn} (t/m3)	0.000	0.000	#DIV/0!
Unadjusted field water content displayed by gauge (w_{vn})(%)	0.0	0.0	#DIV/0!
Unadjusted field water content displayed by gauge (W_{vn})(t/m3)	0.000	0.000	#DIV/0!
Individual site moisture bias (B_{mn})(t/m3)	0.000	0.000	#DIV/0!

ADJUSTED FIELD MOISTURE CONTENT & DRY DENSITY CALCULATIONS

Field Wet Density (t/m³)	0.000	0.000	#DIV/0!
Field Dry Density (t/m³)	0	0	#DIV/0!
Field Moisture Conent	0	0	#DIV/0!
Adjusted Field Dry Density (t/m³)	0.000	0.000	#DIV/0!
Adjusted Field Moisture Content (%)	3.6	3.6	3.6
Nuclear Gauge - Density Ratio (%)	0.0	0.0	#DIV/0!
Sand Replacement - Density Ratio (%)			100.9

FIELD DENSITY NOTES DATA ENTRY

CLIENT	Carpentaria Shire Council			
PROJECT NO	101-020			
PROJECT				
TEST REQUEST NO				
MATERIAL SOURCE	HFG-Natural			
LOT NO				
SAMPLE DESCRIPTION	Red Brown Gravel			
DATE TESTED				
COMPACTION STD	100%			
TESTED BY				
NUC GAUGE NO	30823			
DS				
MS				
SAMPLE ID				
TEST LOCATION				
ORIENTATION	0	90		
PROBE DEPTH /				
LAYER DEPTH (mm)				
TIME SETTING (min)				
TIME OF TEST			Average	
DENSITY COUNT			#DIV/0!	
MOISTURE COUNT			#DIV/0!	Dry Density Variation Check (<0.075 t/m3)
GAUGE FIELD WET DENSITY (t/m3)			#DIV/0!	
GAUGE FIELD DRY DENSITY (t/m3)			#DIV/0!	0
GAUGE MOISTURE CONTENT (%)			#DIV/0!	
GAUGE MOISTURE CONTENT (kg)			#DIV/0!	

SAND REPLACEMENT DATA ENTRY

	ORIGINAL WEIGHT (g)	FINAL WEIGHT (g)	SAND WEIGHT (g)
SAND CALIBRATION (SC)	2000	646	1354
SAND REPLACEMENT (SR)	6000	3379	2621

SAND IN HOLE (SR-SC) (g)	1267
DENSITY OF SAND (t/m3)	1.445
VOLUME OF HOLE (m3)	0.000876817
MASS OF CONTAINER (g)	273
MASS OF CONTAINER AND WET SOIL (g)	2172
DENSITY OF HOLE MATERIAL (t/m3)	2.165789266
DRY DENSITY (t/m3)	2.05402131
DENSITY RATIO	97.3

LAB MOISTURE CONTENT DATA ENTRY

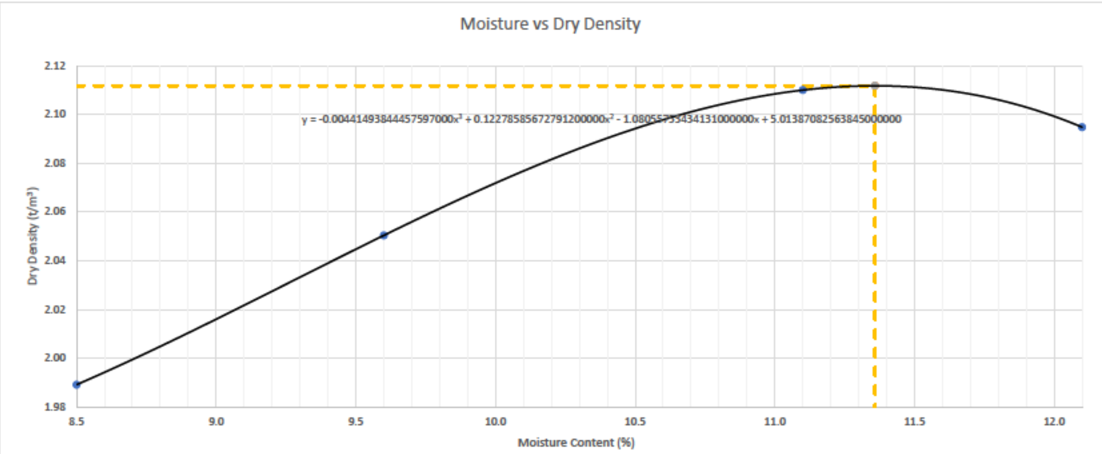
					STARTING MOISTURE CONTENT
SAMPLE ID	1025-G15				
DATE LAB TESTED	24/04/2022				
LAB WORK PERFORMED BY	TR				
CONTAINER NUMBER	11	12	13	14	15
INITIAL TIME OF TEST					
MASS OF CONTAINER (m1)	280	275	276	275	273
MASS OF CONTAINER AND WET SOIL (m2) (g)	1280	1275	1276	1275	2172
FIRST WEIGH (g)					
SECOND WEIGH (g)					
THIRD WEIGH (g)					
FOURTH WEIGH (g)					
FIFTH WEIGH (g)					
FINAL WEIGH (g)					
TIME OF FINAL WEIGH					
MASS OF CONTAINER AND DRY SOIL (m3) (g)	1202	1187	1176	1167	2074
MOISTURE CONTENT (w) (%)	8.5	9.6	11.1	12.1	5.4
Mass of Dry Soil	2371.9	2371.9	2371.9	2371.9	
Total mass of water	203.1	228.1	263.1	288.1	
Moisture Content Check (%)	8.6	9.6	11.1	12.1	

LAB DRY DENSITY/MOISTURE CONTENT ENTRY

SAMPLE ID	1025-G15			
DATE TESTED	24/04/2022			
TIME OF COMPACTION				
TESTED BY	TR			
BALANCE NO				
RAMMER NO				
MOULD NO	A			
MOULD VOLUME	999			
MASS OF MOULD	4231			
MASS OF SOIL	2500	2500	2500	2500
VOLUME WATER ADDED (mL)	75	100	135	160
MASS OF MOULD & WET SOIL (g)	6387	6476	6573	6577
WET DENSITY (t/m3)	2.16	2.25	2.34	2.35

CALCULATIONS

Final Moisture Content (%)	8.5	9.6	11.1	12.1
Wet density of material $(\rho_w)(t/m^3)$	2.16	2.25	2.34	2.35
Dry density of material $(\rho_d)(t/m^3)$	1.989	2.050	2.110	2.095



y = -0.00441493844457597000x3 + 0.12278585672791200000x2 - 1.08055753434131000000x + 5.01387082563845000000		*Inset Formula*
a	-0.004414938	
b	0.122785857	
c	-1.080557534	
d	5.013870826	

Derivative

a	-0.013244815
b	0.245571713
c	-1.080557534

Turning Point (Derivative = 0)

Answer 1	7.182794581
Answer 2	11.35817464

Copy answer which corresponds to maxium dry density on curve (highest point) and paste value below

OMC	11.4
MDD	2.112

SITE MOISTURE BIAS CALCULATIONS

	Orientation 1	Orientation 2	Average
Field moisture content at site (w_{dn})(%)	5.4	5.4	5.4
Field wet density at site (ρ_{fi})(t/m3)	0	0	#DIV/0!
Field water content W_{dn} (t/m3)	0.000	0.000	#DIV/0!
Unadjusted field water content displayed by gauge (w_{vn})(%)	0.0	0.0	#DIV/0!
Unadjusted field water content displayed by gauge (W_{vn})(t/m3)	0.000	0.000	#DIV/0!
Individual site moisture bias (B_{mn})(t/m3)	0.000	0.000	#DIV/0!

ADJUSTED FIELD MOISTURE CONTENT & DRY DENSITY CALCULATIONS

Field Wet Density (t/m^3)	0.000	0.000	#DIV/0!
Field Dry Density (t/m^3)	0	0	#DIV/0!
Field Moisture Conent	0	0	#DIV/0!
Adjusted Field Dry Density (t/m^3)	0.000	0.000	#DIV/0!
Adjusted Field Moisture Content (%)	5.4	5.4	5.4
Nuclear Gauge - Density Ratio (%)	0.0	0.0	#DIV/0!
Sand Replacement - Density Ratio (%)			97.3

FIELD DENSITY NOTES DATA ENTRY

CLIENT	Carpentaria Shire Council			
PROJECT NO	101-020			
PROJECT				
TEST REQUEST NO				
MATERIAL SOURCE	HFG-Natural			
LOT NO				
SAMPLE DESCRIPTION	Red Brown Gravel			
DATE TESTED				
COMPACTION STD	100%			
TESTED BY				
NUC GAUGE NO	30823			
DS				
MS				
SAMPLE ID				
TEST LOCATION				
ORIENTATION	0	90		
PROBE DEPTH /				
LAYER DEPTH (mm)				
TIME SETTING (min)				
TIME OF TEST			Average	
DENSITY COUNT			#DIV/0!	
MOISTURE COUNT			#DIV/0!	Dry Density Variation Check (<0.075 t/m3)
GAUGE FIELD WET DENSITY (t/m3)			#DIV/0!	
GAUGE FIELD DRY DENSITY (t/m3)			#DIV/0!	0
GAUGE MOISTURE CONTENT (%)			#DIV/0!	
GAUGE MOISTURE CONTENT (kg)			#DIV/0!	

SAND REPLACEMENT DATA ENTRY

	ORIGINAL WEIGHT (g)	FINAL WEIGHT (g)	SAND WEIGHT (g)
SAND CALIBRATION (SC)	2000	653	1347
SAND REPLACEMENT (SR)	6000	3388	2612

SAND IN HOLE (SR-SC) (g)	1265
DENSITY OF SAND (t/m3)	1.445
VOLUME OF HOLE (m3)	0.000875433
MASS OF CONTAINER (g)	278
MASS OF CONTAINER AND WET SOIL (g)	2189
DENSITY OF HOLE MATERIAL (t/m3)	2.182920949
DRY DENSITY (t/m3)	2.076687747
DENSITY RATIO	97.4

LAB MOISTURE CONTENT DATA ENTRY

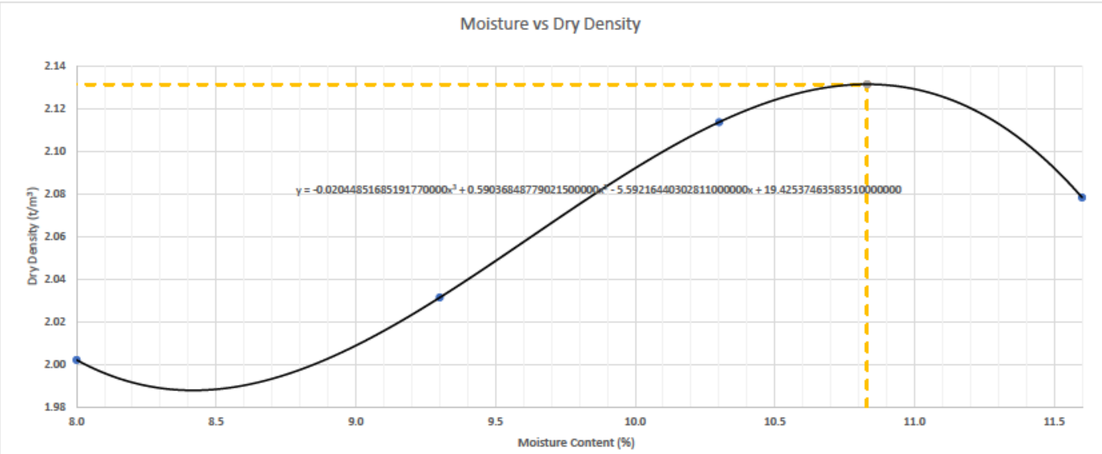
					STARTING MOISTURE CONTENT
SAMPLE ID	1025-G16				
DATE LAB TESTED	24/04/2022				
LAB WORK PERFORMED BY	TR				
CONTAINER NUMBER	6	7	8	9	10
INITIAL TIME OF TEST					
MASS OF CONTAINER (m1)	269	276	287	284	278
MASS OF CONTAINER AND WET SOIL (m2) (g)	1269	1276	1287	1284	2189
FIRST WEIGH (g)					
SECOND WEIGH (g)					
THIRD WEIGH (g)					
FOURTH WEIGH (g)					
FIFTH WEIGH (g)					
FINAL WEIGH (g)					
TIME OF FINAL WEIGH					
MASS OF CONTAINER AND DRY SOIL (m3) (g)	1195	1191	1194	1180	2096
MOISTURE CONTENT (w) (%)	8	9.3	10.3	11.6	5.1
Mass of Dry Soil	2378.7	2378.7	2378.7	2378.7	
Total mass of water	196.3	221.3	246.3	271.3	
Moisture Content Check (%)	8.3	9.3	10.4	11.4	

LAB DRY DENSITY/MOISTURE CONTENT ENTRY

SAMPLE ID	1025-G16			
DATE TESTED	24/04/2022			
TIME OF COMPACTION				
TESTED BY	TR			
BALANCE NO				
RAMMER NO				
MOULD NO	A			
MOULD VOLUME	999			
MASS OF MOULD	4231			
MASS OF SOIL	2500	2500	2500	2500
VOLUME WATER ADDED (mL)	75	100	125	150
MASS OF MOULD & WET SOIL (g)	6391	6449	6560	6548
WET DENSITY (t/m3)	2.16	2.22	2.33	2.32

CALCULATIONS

Final Moisture Content (%)	8.0	9.3	10.3	11.6
Wet density of material (ρ_w)(t/m^3)	2.16	2.22	2.33	2.32
Dry density of material (ρ_d)(t/m^3)	2.002	2.031	2.114	2.078



y = -0.020448516851917700000x3 + 0.590368487790215000000x2 - 5.592164403028110000000x + 19.425374635835100000000		*Inset Formula*
a	-0.020448517	
b	0.590368488	
c	-5.592164403	
d	19.42537464	

Derivative

a	-0.061345551
b	1.180736976
c	-5.592164403

Turning Point (Derivative = 0)

Answer 1	8.416873998
Answer 2	10.8304384

Copy answer which corresponds to maxium dry density on curve (highest point) and paste value below

OMC	10.8
MDD	2.131

SITE MOISTURE BIAS CALCULATIONS

	Orientation 1	Orientation 2	Average
Field moisture content at site (w_{dn})(%)	5.1	5.1	5.1
Field wet density at site (ρ_n)(t/m3)	0	0	#DIV/0!
Field water content W_{dn} (t/m3)	0.000	0.000	#DIV/0!
Unadjusted field water content displayed by gauge (w_{vn})(%)	0.0	0.0	#DIV/0!
Unadjusted field water content displayed by gauge (W_{vn})(t/m3)	0.000	0.000	#DIV/0!
Individual site moisture bias (B_{mn})(t/m3)	0.000	0.000	#DIV/0!

ADJUSTED FIELD MOISTURE CONTENT & DRY DENSITY CALCULATIONS

Field Wet Density (t/m³)	0.000	0.000	#DIV/0!
Field Dry Density (t/m³)	0	0	#DIV/0!
Field Moisture Conent	0	0	#DIV/0!
Adjusted Field Dry Density (t/m³)	0.000	0.000	#DIV/0!
Adjusted Field Moisture Content (%)	5.1	5.1	5.1
Nuclear Gauge - Density Ratio (%)	0.0	0.0	#DIV/0!
Sand Replacement - Density Ratio (%)			97.4

FIELD DENSITY NOTES DATA ENTRY

CLIENT	Carpentaria Shire Council		
PROJECT NO	101-021		
PROJECT			
TEST REQUEST NO			
MATERIAL SOURCE	HFG-Natural		
LOT NO			
SAMPLE DESCRIPTION	Red Brown Gravel		
DATE TESTED			
COMPACTION STD	100%		
TESTED BY			
NUC GAUGE NO	30823		
DS			
MS			
SAMPLE ID			
TEST LOCATION			
ORIENTATION	0	90	
PROBE DEPTH /			
LAYER DEPTH (mm)			
TIME SETTING (min)			
TIME OF TEST			Average
DENSITY COUNT			#DIV/0!
MOISTURE COUNT			#DIV/0!
GAUGE FIELD WET DENSITY (t/m3)			#DIV/0!
GAUGE FIELD DRY DENSITY (t/m3)			#DIV/0!
GAUGE MOISTURE CONTENT (%)			#DIV/0!
GAUGE MOISTURE CONTENT (kg)			#DIV/0!

Dry Density Variation Check (<0.075 t/m3)
0

SAND REPLACEMENT DATA ENTRY

	ORIGINAL WEIGHT (g)	FINAL WEIGHT (g)	SAND WEIGHT (g)
SAND CALIBRATION (SC)	2000	649	1351
SAND REPLACEMENT (SR)	6000	3094	2906

SAND IN HOLE (SR-SC) (g)	1555
DENSITY OF SAND (t/m3)	1.445
VOLUME OF HOLE (m3)	0.001076125
MASS OF CONTAINER (g)	278
MASS OF CONTAINER AND WET SOIL (g)	2810
DENSITY OF HOLE MATERIAL (t/m3)	2.35288746
DRY DENSITY (t/m3)	2.244163987
DENSITY RATIO	99.9

LAB MOISTURE CONTENT DATA ENTRY

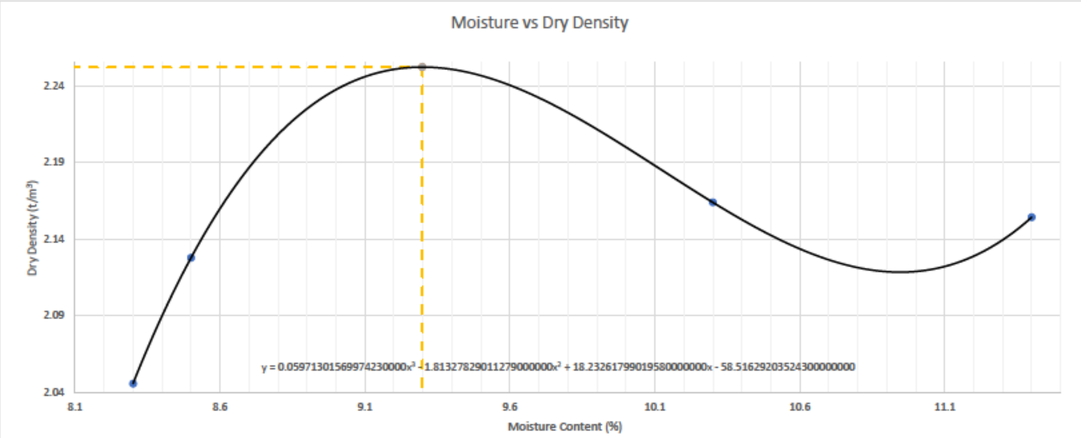
SAMPLE ID	1025-G1				
DATE LAB TESTED	9/06/2022				
LAB WORK PERFORMED BY	JL				STARTING MOISTURE CONTENT
CONTAINER NUMBER	7	8	9	11	10
INITIAL TIME OF TEST					
MASS OF CONTAINER (m1)	276	287	285	280	278
MASS OF CONTAINER AND WET SOIL (m2) (g)	1276	1278	1285	1280	2810
FIRST WEIGH (g)					
SECOND WEIGH (g)					
THIRD WEIGH (g)					
FOURTH WEIGH (g)					
FIFTH WEIGH (g)					
FINAL WEIGH (g)					
TIME OF FINAL WEIGH					
MASS OF CONTAINER AND DRY SOIL (m3) (g)	1199	1200	1192	1178	2693
MOISTURE CONTENT (w) (%)	8.3	8.5	10.3	11.4	4.8
Mass of Dry Soil	2385.5	2385.5	2385.5	2385.5	
Total mass of water	214.5	239.5	264.5	289.5	
Moisture Content Check (%)	9	10	11.1	12.1	

LAB DRY DENSITY/MOISTURE CONTENT ENTRY

SAMPLE ID	1025-G1			
DATE TESTED	9/06/2022			
TIME OF COMPACTION				
TESTED BY	JL			
BALANCE NO				
RAMMER NO				
MOULD NO	A			
MOULD VOLUME	999			
MASS OF MOULD	4231			
MASS OF SOIL	2500	2500	2500	2500
VOLUME WATER ADDED (mL)	100	125	150	175
MASS OF MOULD & WET SOIL (g)	6439	6532	6610	6623
WET DENSITY (t/m3)	2.21	2.30	2.38	2.39

CALCULATIONS

Final Moisture Content (%)	8.3	8.5	10.3	11.4
Wet density of material (ρ_w)(t/m^3)	2.21	2.30	2.38	2.39
Dry density of material (ρ_d)(t/m^3)	2.041	2.123	2.159	2.149



y = 0.0597130156997423000x3 - 1.8132782901127900000x2 + 18.2326179901958000000x - 58.5162920352430000000		*Inset Formula*
a	0.059713016	
b	-1.81327829	
c	18.23261799	
d	-58.51629204	

Derivative

a	0.179139047
b	-3.62655658
c	18.23261799

Turning Point (Derivative = 0)

Answer 1	10.94647574
Answer 2	9.297891079

Copy answer which corresponds to maxium dry density on curve (highest point) and paste value below

OMC	9.3
MDD	2.247

SITE MOISTURE BIAS CALCULATIONS

	Orientation 1	Orientation 2	Average
Field moisture content at site (w_{dn})(%)	4.8	4.8	4.8
Field wet density at site (ρ_n)(t/m3)	0	0	#DIV/0!
Field water content W_{dn} (t/m3)	0.000	0.000	#DIV/0!
Unadjusted field water content displayed by gauge (w_{vn})(%)	0.0	0.0	#DIV/0!
Unadjusted field water content displayed by gauge (W_{vn})(t/m3)	0.000	0.000	#DIV/0!
Individual site moisture bias (B_{mn})(t/m3)	0.000	0.000	#DIV/0!

ADJUSTED FIELD MOISTURE CONTENT & DRY DENSITY CALCULATIONS

Field Wet Density (t/m³)	0.000	0.000	#DIV/0!
Field Dry Density (t/m³)	0	0	#DIV/0!
Field Moisture Conent	0	0	#DIV/0!
Adjusted Field Dry Density (t/m³)	0.000	0.000	#DIV/0!
Adjusted Field Moisture Content (%)	4.8	4.8	4.8
Nuclear Gauge - Density Ratio (%)	0.0	0.0	#DIV/0!
Sand Replacement - Density Ratio (%)			99.9

FIELD DENSITY NOTES DATA ENTRY

CLIENT	Carpentaria Shire Council			
PROJECT NO	101-021			
PROJECT				
TEST REQUEST NO				
MATERIAL SOURCE	HFG-Natural			
LOT NO				
SAMPLE DESCRIPTION	Red Brown Gravel			
DATE TESTED				
COMPACTION STD	100%			
TESTED BY				
NUC GAUGE NO	30823			
DS				
MS				
SAMPLE ID				
TEST LOCATION				
ORIENTATION	0	90		
PROBE DEPTH /				
LAYER DEPTH (mm)				
TIME SETTING (min)				
TIME OF TEST			Average	
DENSITY COUNT			#DIV/0!	
MOISTURE COUNT			#DIV/0!	Dry Density Variation Check (<0.075 t/m3)
GAUGE FIELD WET DENSITY (t/m3)			#DIV/0!	
GAUGE FIELD DRY DENSITY (t/m3)			#DIV/0!	0
GAUGE MOISTURE CONTENT (%)			#DIV/0!	
GAUGE MOISTURE CONTENT (kg)			#DIV/0!	

SAND REPLACEMENT DATA ENTRY

	ORIGINAL WEIGHT (g)	FINAL WEIGHT (g)	SAND WEIGHT (g)
SAND CALIBRATION (SC)	2000	649	1351
SAND REPLACEMENT (SR)	6000	3062	2938

SAND IN HOLE (SR-SC) (g)	1587
DENSITY OF SAND (t/m3)	1.445
VOLUME OF HOLE (m3)	0.00109827
MASS OF CONTAINER (g)	283
MASS OF CONTAINER AND WET SOIL (g)	2770
DENSITY OF HOLE MATERIAL (t/m3)	2.264470699
DRY DENSITY (t/m3)	2.153386894
DENSITY RATIO	99.2

LAB MOISTURE CONTENT DATA ENTRY

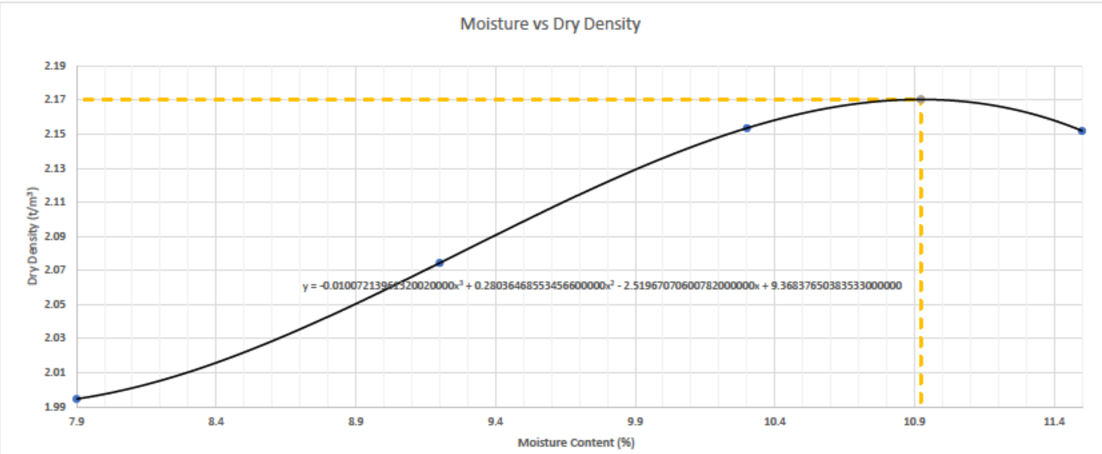
					STARTING MOISTURE CONTENT
SAMPLE ID	1025-G3				
DATE LAB TESTED	9/06/2022				
LAB WORK PERFORMED BY	JL				
CONTAINER NUMBER	12	13	14	15	16
INITIAL TIME OF TEST					
MASS OF CONTAINER (m1)	276	276	275	273	283
MASS OF CONTAINER AND WET SOIL (m2) (g)	1276	1276	1275	1273	2770
FIRST WEIGH (g)					
SECOND WEIGH (g)					
THIRD WEIGH (g)					
FOURTH WEIGH (g)					
FIFTH WEIGH (g)					
FINAL WEIGH (g)					
TIME OF FINAL WEIGH					
MASS OF CONTAINER AND DRY SOIL (m3) (g)	1192	1183	1172	1200	2648
MOISTURE CONTENT (w) (%)	9.2	10.3	11.5	7.9	5.2
Mass of Dry Soil	2376.4	2376.4	2376.4	2376.4	
Total mass of water	223.6	248.6	273.6	198.6	
Moisture Content Check (%)	9.4	10.5	11.5	8.4	

LAB DRY DENSITY/MOISTURE CONTENT ENTRY

SAMPLE ID	1025-G3			
DATE TESTED	9/06/2022			
TIME OF COMPACTION				
TESTED BY	JL			
BALANCE NO				
RAMMER NO				
MOULD NO	A			
MOULD VOLUME	999			
MASS OF MOULD	4231			
MASS OF SOIL	2500	2500	2500	2500
VOLUME WATER ADDED (mL)	100	125	150	75
MASS OF MOULD & WET SOIL (g)	6494	6604	6628	6381
WET DENSITY (t/m3)	2.27	2.38	2.40	2.15

CALCULATIONS

Final Moisture Content (%)	9.2	10.3	11.5	7.9
Wet density of material (ρ_w)(t/m^3)	2.27	2.38	2.40	2.15
Dry density of material (ρ_d)(t/m^3)	2.074	2.154	2.152	1.995



y = -0.0100721396132002000x3 + 0.28036468553456600000x2 - 2.5196707060078200000x + 9.3683765038353300000		*Inset Formula*
a	-0.01007214	
b	0.280364686	
c	-2.519670706	
d	9.368376504	

Derivative

a	-0.030216419
b	0.560729371
c	-2.519670706

Turning Point (Derivative = 0)

Answer 1	7.634139009
Answer 2	10.92296976

Copy answer which corresponds to maxium dry density on curve (highest point) and paste value below

OMC	10.9
MDD	2.170

SITE MOISTURE BIAS CALCULATIONS

	Orientation 1	Orientation 2	Average
Field moisture content at site (w_{dn})(%)	5.2	5.2	5.2
Field wet density at site (ρ_{fi})(t/m3)	0	0	#DIV/0!
Field water content W_{dn} (t/m3)	0.000	0.000	#DIV/0!
Unadjusted field water content displayed by gauge (w_{vn})(%)	0.0	0.0	#DIV/0!
Unadjusted field water content displayed by gauge (W_{vn})(t/m3)	0.000	0.000	#DIV/0!
Individual site moisture bias (B_{mn})(t/m3)	0.000	0.000	#DIV/0!

ADJUSTED FIELD MOISTURE CONTENT & DRY DENSITY CALCULATIONS

Field Wet Density (t/m³)	0.000	0.000	#DIV/0!
Field Dry Density (t/m³)	0	0	#DIV/0!
Field Moisture Conent	0	0	#DIV/0!
Adjusted Field Dry Density (t/m³)	0.000	0.000	#DIV/0!
Adjusted Field Moisture Content (%)	5.2	5.2	5.2
Nuclear Gauge - Density Ratio (%)	0.0	0.0	#DIV/0!
Sand Replacement - Density Ratio (%)			99.2

FIELD DENSITY NOTES DATA ENTRY

CLIENT	Carpentaria Shire Council		
PROJECT NO	101-021		
PROJECT			
TEST REQUEST NO			
MATERIAL SOURCE	HFG-Natural		
LOT NO			
SAMPLE DESCRIPTION	Red Brown Gravel		
DATE TESTED			
COMPACTION STD	100%		
TESTED BY			
NUC GAUGE NO	30823		
DS			
MS			
SAMPLE ID			
TEST LOCATION			
ORIENTATION	0	90	
PROBE DEPTH /			
LAYER DEPTH (mm)			
TIME SETTING (min)			
TIME OF TEST			Average
DENSITY COUNT			#DIV/0!
MOISTURE COUNT			#DIV/0!
GAUGE FIELD WET DENSITY (t/m3)			#DIV/0!
GAUGE FIELD DRY DENSITY (t/m3)			#DIV/0!
GAUGE MOISTURE CONTENT (%)			#DIV/0!
GAUGE MOISTURE CONTENT (kg)			#DIV/0!

Dry Density Variation Check (<0.075 t/m3)
0

SAND REPLACEMENT DATA ENTRY

	ORIGINAL WEIGHT (g)	FINAL WEIGHT (g)	SAND WEIGHT (g)
SAND CALIBRATION (SC)	2000	642	1358
SAND REPLACEMENT (SR)	6000	3144	2856

SAND IN HOLE (SR-SC) (g)	1498
DENSITY OF SAND (t/m3)	1.445
VOLUME OF HOLE (m3)	0.001036678
MASS OF CONTAINER (g)	280
MASS OF CONTAINER AND WET SOIL (g)	2627
DENSITY OF HOLE MATERIAL (t/m3)	2.263961949
DRY DENSITY (t/m3)	2.141455274
DENSITY RATIO	98.8

LAB MOISTURE CONTENT DATA ENTRY

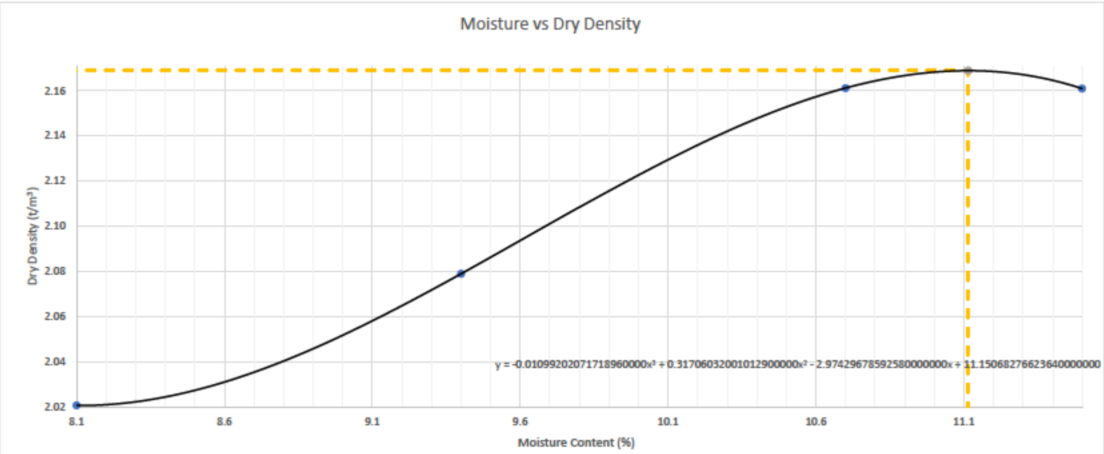
					STARTING MOISTURE CONTENT
SAMPLE ID	1025-G29				
DATE LAB TESTED	22/05/2022				
LAB WORK PERFORMED BY	TR				
CONTAINER NUMBER	1	2	3	4	5
INITIAL TIME OF TEST					
MASS OF CONTAINER (m1)	276	279	275	278	280
MASS OF CONTAINER AND WET SOIL (m2) (g)	1276	1279	1275	1278	2627
FIRST WEIGH (g)					
SECOND WEIGH (g)					
THIRD WEIGH (g)					
FOURTH WEIGH (g)					
FIFTH WEIGH (g)					
FINAL WEIGH (g)					
TIME OF FINAL WEIGH					
MASS OF CONTAINER AND DRY SOIL (m3) (g)	1201	1193	1178	1175	2500
MOISTURE CONTENT (w) (%)	8.1	9.4	10.7	11.5	5.7
Mass of Dry Soil	2365.2	2365.2	2365.2	2365.2	
Total mass of water	209.8	234.8	259.8	284.8	
Moisture Content Check (%)	8.9	9.9	11	12	

LAB DRY DENSITY/MOISTURE CONTENT ENTRY

SAMPLE ID	1025-G29			
DATE TESTED	22/05/2022			
TIME OF COMPACTION				
TESTED BY	TR			
BALANCE NO				
RAMMER NO				
MOULD NO	A			
MOULD VOLUME	999			
MASS OF MOULD	4231			
MASS OF SOIL	2500	2500	2500	2500
VOLUME WATER ADDED (mL)	75	100	125	150
MASS OF MOULD & WET SOIL (g)	6412	6502	6620	6637
WET DENSITY (t/m3)	2.18	2.27	2.39	2.41

CALCULATIONS

Final Moisture Content (%)	8.1	9.4	10.7	11.5
Wet density of material (ρ_w)(t/m^3)	2.18	2.27	2.39	2.41
Dry density of material (ρ_d)(t/m^3)	2.020	2.078	2.160	2.160



y = -0.010992020717189600000x3 + 0.317060320010129000000x2 - 2.974296785925800000000x + 11.150682766236400000000		*Inset Formula*
a	-0.010992021	
b	0.31706032	
c	-2.974296786	
d	11.15068277	

Derivative

a	-0.032976062
b	0.63412064
c	-2.974296786

Turning Point (Derivative = 0)

Answer 1	8.114877002
Answer 2	11.11484901

Copy answer which corresponds to maxium dry density on curve (highest point) and paste value below

OMC	11.1
MDD	2.168

SITE MOISTURE BIAS CALCULATIONS

	Orientation 1	Orientation 2	Average
Field moisture content at site (w_{dn})(%)	5.7	5.7	5.7
Field wet density at site (ρ_n)(t/m3)	0	0	#DIV/0!
Field water content W_{dn} (t/m3)	0.000	0.000	#DIV/0!
Unadjusted field water content displayed by gauge (w_{vn})(%)	0.0	0.0	#DIV/0!
Unadjusted field water content displayed by gauge (W_{vn})(t/m3)	0.000	0.000	#DIV/0!
Individual site moisture bias (B_{mn})(t/m3)	0.000	0.000	#DIV/0!

ADJUSTED FIELD MOISTURE CONTENT & DRY DENSITY CALCULATIONS

Field Wet Density (t/m³)	0.000	0.000	#DIV/0!
Field Dry Density (t/m³)	0	0	#DIV/0!
Field Moisture Conent	0	0	#DIV/0!
Adjusted Field Dry Density (t/m³)	0.000	0.000	#DIV/0!
Adjusted Field Moisture Content (%)	5.7	5.7	5.7
Nuclear Gauge - Density Ratio (%)	0.0	0.0	#DIV/0!
Sand Replacement - Density Ratio (%)			98.8

FIELD DENSITY NOTES DATA ENTRY

CLIENT	Carpentaria Shire Council			
PROJECT NO	101-021			
PROJECT				
TEST REQUEST NO				
MATERIAL SOURCE	HFG-Natural			
LOT NO				
SAMPLE DESCRIPTION	Red Brown Gravel			
DATE TESTED				
COMPACTION STD	100%			
TESTED BY				
NUC GAUGE NO	30823			
DS				
MS				
SAMPLE ID				
TEST LOCATION				
ORIENTATION	0	90		
PROBE DEPTH /				
LAYER DEPTH (mm)				
TIME SETTING (min)				
TIME OF TEST			Average	
DENSITY COUNT			#DIV/0!	
MOISTURE COUNT			#DIV/0!	Dry Density Variation Check (<0.075 t/m3)
GAUGE FIELD WET DENSITY (t/m3)			#DIV/0!	
GAUGE FIELD DRY DENSITY (t/m3)			#DIV/0!	0
GAUGE MOISTURE CONTENT (%)			#DIV/0!	
GAUGE MOISTURE CONTENT (kg)			#DIV/0!	

SAND REPLACEMENT DATA ENTRY

	ORIGINAL WEIGHT (g)	FINAL WEIGHT (g)	SAND WEIGHT (g)
SAND CALIBRATION (SC)	2000	664	1336
SAND REPLACEMENT (SR)	6000	3081	2919

SAND IN HOLE (SR-SC) (g)	1583
DENSITY OF SAND (t/m3)	1.445
VOLUME OF HOLE (m3)	0.001095502
MASS OF CONTAINER (g)	411
MASS OF CONTAINER AND WET SOIL (g)	2895
DENSITY OF HOLE MATERIAL (t/m3)	2.267454201
DRY DENSITY (t/m3)	2.173433354
DENSITY RATIO	98.6

LAB MOISTURE CONTENT DATA ENTRY

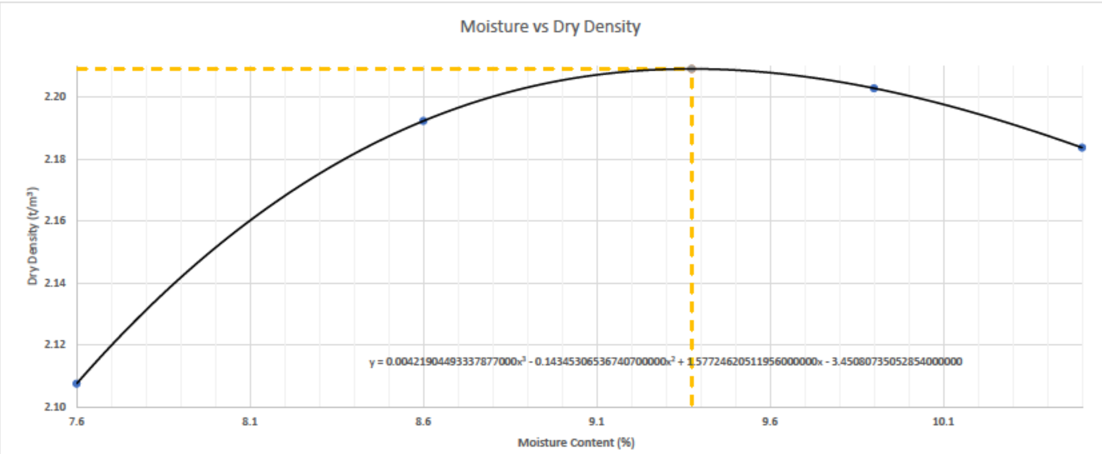
					STARTING MOISTURE CONTENT
SAMPLE ID	1025-G15				
DATE LAB TESTED	8/08/2022				
LAB WORK PERFORMED BY	TR				
CONTAINER NUMBER	17	18	19	20	21
INITIAL TIME OF TEST					
MASS OF CONTAINER (m1)	415	413	421	407	411
MASS OF CONTAINER AND WET SOIL (m2) (g)	1415	1413	1421	1407	2895
FIRST WEIGH (g)					
SECOND WEIGH (g)					
THIRD WEIGH (g)					
FOURTH WEIGH (g)					
FIFTH WEIGH (g)					
FINAL WEIGH (g)					
TIME OF FINAL WEIGH					
MASS OF CONTAINER AND DRY SOIL (m3) (g)	1344	1334	1331	1312	2792
MOISTURE CONTENT (w) (%)	7.6	8.6	9.9	10.5	4.3
Mass of Dry Soil	2396.9	2396.9	2396.9	2396.9	
Total mass of water	203.1	228.1	259.1	278.1	
Moisture Content Check (%)	8.5	9.5	10.8	11.6	

LAB DRY DENSITY/MOISTURE CONTENT ENTRY

SAMPLE ID	1025-G15			
DATE TESTED	8/08/2022			
TIME OF COMPACTION				
TESTED BY	TR			
BALANCE NO				
RAMMER NO				
MOULD NO	A			
MOULD VOLUME	999			
MASS OF MOULD	4231			
MASS OF SOIL	2500	2500	2500	2500
VOLUME WATER ADDED (mL)	100	125	156	175
MASS OF MOULD & WET SOIL (g)	6491	6604	6644	6636
WET DENSITY (t/m3)	2.26	2.38	2.42	2.41

CALCULATIONS

Final Moisture Content (%)	7.6	8.6	9.9	10.5
Wet density of material (ρ_w)(t/m^3)	2.26	2.38	2.42	2.41
Dry density of material (ρ_d)(t/m^3)	2.102	2.187	2.198	2.179



y = 0.00421904493337877000x3 - 0.14345306536740700000x2 + 1.57724620511956000000x - 3.45080735052854000000		*Inset Formula*
a	0.004219045	
b	-0.143453065	
c	1.577246205	
d	-3.450807351	

Derivative

a	0.012657135
b	-0.286906131
c	1.577246205

Turning Point (Derivative = 0)

Answer 1	13.29365627
Answer 2	9.373885416

Copy answer which corresponds to maxium dry density on curve (highest point) and paste value below

OMC	9.4
MDD	2.204

SITE MOISTURE BIAS CALCULATIONS

	Orientation 1	Orientation 2	Average
Field moisture content at site (w_{dn})(%)	4.3	4.3	4.3
Field wet density at site (ρ_n)(t/m3)	0	0	#DIV/0!
Field water content W_{dn} (t/m3)	0.000	0.000	#DIV/0!
Unadjusted field water content displayed by gauge (w_{vn})(%)	0.0	0.0	#DIV/0!
Unadjusted field water content displayed by gauge (W_{vn})(t/m3)	0.000	0.000	#DIV/0!
Individual site moisture bias (B_{mn})(t/m3)	0.000	0.000	#DIV/0!

ADJUSTED FIELD MOISTURE CONTENT & DRY DENSITY CALCULATIONS

Field Wet Density (t/m³)	0.000	0.000	#DIV/0!
Field Dry Density (t/m³)	0	0	#DIV/0!
Field Moisture Conent	0	0	#DIV/0!
Adjusted Field Dry Density (t/m³)	0.000	0.000	#DIV/0!
Adjusted Field Moisture Content (%)	4.3	4.3	4.3
Nuclear Gauge - Density Ratio (%)	0.0	0.0	#DIV/0!
Sand Replacement - Density Ratio (%)			98.6

FIELD DENSITY NOTES DATA ENTRY

CLIENT	Carpentaria Shire Council		
PROJECT NO	101-021		
PROJECT			
TEST REQUEST NO			
MATERIAL SOURCE	HFG-Natural		
LOT NO			
SAMPLE DESCRIPTION	Red Brown Gravel		
DATE TESTED			
COMPACTION STD	100%		
TESTED BY			
NUC GAUGE NO	30823		
DS			
MS			
SAMPLE ID			
TEST LOCATION			
ORIENTATION	0	90	
PROBE DEPTH /			
LAYER DEPTH (mm)			
TIME SETTING (min)			
TIME OF TEST			Average
DENSITY COUNT			#DIV/0!
MOISTURE COUNT			#DIV/0!
GAUGE FIELD WET DENSITY (t/m3)			#DIV/0!
GAUGE FIELD DRY DENSITY (t/m3)			#DIV/0!
GAUGE MOISTURE CONTENT (%)			#DIV/0!
GAUGE MOISTURE CONTENT (kg)			#DIV/0!

Dry Density Variation Check (<0.075 t/m3)

0

SAND REPLACEMENT DATA ENTRY

	ORIGINAL WEIGHT (g)	FINAL WEIGHT (g)	SAND WEIGHT (g)
SAND CALIBRATION (SC)	2000	637	1363
SAND REPLACEMENT (SR)	6000	3145	2855

SAND IN HOLE (SR-SC) (g)	1492
DENSITY OF SAND (t/m3)	1.445
VOLUME OF HOLE (m3)	0.001032526
MASS OF CONTAINER (g)	273
MASS OF CONTAINER AND WET SOIL (g)	2689
DENSITY OF HOLE MATERIAL (t/m3)	2.339892761
DRY DENSITY (t/m3)	2.218830429
DENSITY RATIO	103.5

LAB MOISTURE CONTENT DATA ENTRY

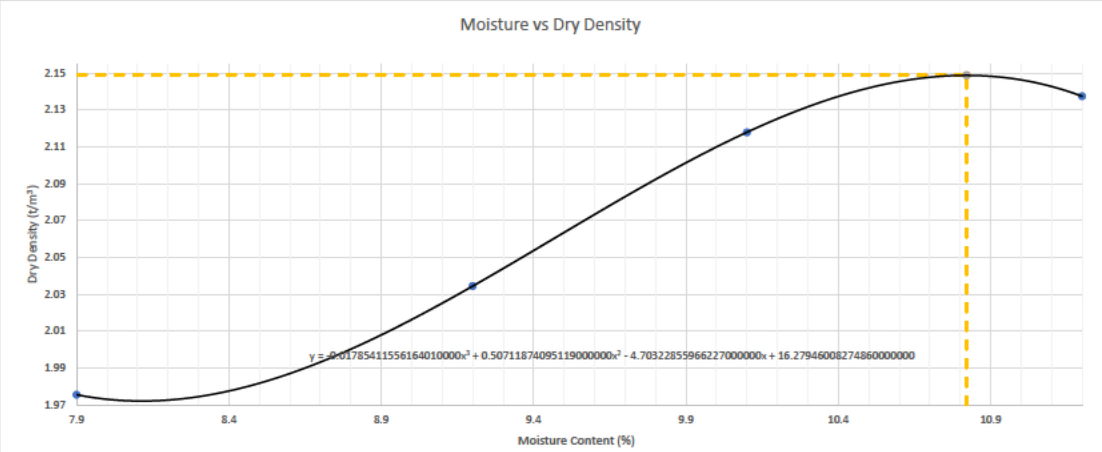
					STARTING MOISTURE CONTENT
SAMPLE ID	1025-G16				
DATE LAB TESTED	8/08/2022				
LAB WORK PERFORMED BY	TR				
CONTAINER NUMBER	11	12	13	14	15
INITIAL TIME OF TEST					
MASS OF CONTAINER (m1)	280	275	276	275	273
MASS OF CONTAINER AND WET SOIL (m2) (g)	1280	1275	1276	1275	2689
FIRST WEIGH (g)					
SECOND WEIGH (g)					
THIRD WEIGH (g)					
FOURTH WEIGH (g)					
FIFTH WEIGH (g)					
FINAL WEIGH (g)					
TIME OF FINAL WEIGH					
MASS OF CONTAINER AND DRY SOIL (m3) (g)	1207	1191	1184	1174	2564
MOISTURE CONTENT (w) (%)	7.9	9.2	10.1	11.2	5.5
Mass of Dry Soil	2369.7	2369.7	2369.7	2369.7	
Total mass of water	205.3	230.3	255.3	283.3	
Moisture Content Check (%)	8.7	9.7	10.8	12	

LAB DRY DENSITY/MOISTURE CONTENT ENTRY

SAMPLE ID	1025-G16			
DATE TESTED	8/08/2022			
TIME OF COMPACTION				
TESTED BY	TR			
BALANCE NO				
RAMMER NO				
MOULD NO	A			
MOULD VOLUME	999			
MASS OF MOULD	4231			
MASS OF SOIL	2500	2500	2500	2500
VOLUME WATER ADDED (mL)	75	100	125	153
MASS OF MOULD & WET SOIL (g)	6355	6445	6555	6600
WET DENSITY (t/m3)	2.13	2.22	2.33	2.37

CALCULATIONS

Final Moisture Content (%)	7.9	9.2	10.1	11.2
Wet density of material (ρ_w)(t/m^3)	2.13	2.22	2.33	2.37
Dry density of material (ρ_d)(t/m^3)	1.970	2.030	2.113	2.133



y = -0.0178541155616401000x3 + 0.507118740951190000x2 - 4.70322855966227000000x + 16.2794600827486000000		*Inset Formula*
a	-0.017854116	
b	0.507118741	
c	-4.70322856	
d	16.27946008	

Derivative

a	-0.053562347
b	1.014237482
c	-4.70322856

Turning Point (Derivative = 0)

Answer 1	8.114618202
Answer 2	10.82102493

Copy answer which corresponds to maxium dry density on curve (highest point) and paste value below

OMC	10.8
MDD	2.144

SITE MOISTURE BIAS CALCULATIONS

	Orientation 1	Orientation 2	Average
Field moisture content at site (w_{dn})(%)	5.5	5.5	5.5
Field wet density at site (ρ_n)(t/m3)	0	0	#DIV/0!
Field water content W_{dn} (t/m3)	0.000	0.000	#DIV/0!
Unadjusted field water content displayed by gauge (w_{vn})(%)	0.0	0.0	#DIV/0!
Unadjusted field water content displayed by gauge (W_{vn})(t/m3)	0.000	0.000	#DIV/0!
Individual site moisture bias (B_{mn})(t/m3)	0.000	0.000	#DIV/0!

ADJUSTED FIELD MOISTURE CONTENT & DRY DENSITY CALCULATIONS

Field Wet Density (t/m³)	0.000	0.000	#DIV/0!
Field Dry Density (t/m³)	0	0	#DIV/0!
Field Moisture Conent	0	0	#DIV/0!
Adjusted Field Dry Density (t/m³)	0.000	0.000	#DIV/0!
Adjusted Field Moisture Content (%)	5.5	5.5	5.5
Nuclear Gauge - Density Ratio (%)	0.0	0.0	#DIV/0!
Sand Replacement - Density Ratio (%)			103.5

FIELD DENSITY NOTES DATA ENTRY

CLIENT	Carpentaria Shire Council		
PROJECT NO	101-021		
PROJECT			
TEST REQUEST NO			
MATERIAL SOURCE	HFG-Natural		
LOT NO			
SAMPLE DESCRIPTION	Red Brown Gravel		
DATE TESTED			
COMPACTION STD	100%		
TESTED BY			
NUC GAUGE NO	30823		
DS			
MS			
SAMPLE ID			
TEST LOCATION			
ORIENTATION	0	90	
PROBE DEPTH /			
LAYER DEPTH (mm)			
TIME SETTING (min)			
TIME OF TEST			Average
DENSITY COUNT			#DIV/0!
MOISTURE COUNT			#DIV/0!
GAUGE FIELD WET DENSITY (t/m3)			#DIV/0!
GAUGE FIELD DRY DENSITY (t/m3)			#DIV/0!
GAUGE MOISTURE CONTENT (%)			#DIV/0!
GAUGE MOISTURE CONTENT (kg)			#DIV/0!

Dry Density Variation Check (<0.075 t/m3)
0

SAND REPLACEMENT DATA ENTRY

	ORIGINAL WEIGHT (g)	FINAL WEIGHT (g)	SAND WEIGHT (g)
SAND CALIBRATION (SC)	2000	654	1346
SAND REPLACEMENT (SR)	6000	3136	2864

SAND IN HOLE (SR-SC) (g)	1518
DENSITY OF SAND (t/m3)	1.445
VOLUME OF HOLE (m3)	0.001050519
MASS OF CONTAINER (g)	278
MASS OF CONTAINER AND WET SOIL (g)	2615
DENSITY OF HOLE MATERIAL (t/m3)	2.224614625
DRY DENSITY (t/m3)	2.103722003
DENSITY RATIO	100.3

LAB MOISTURE CONTENT DATA ENTRY

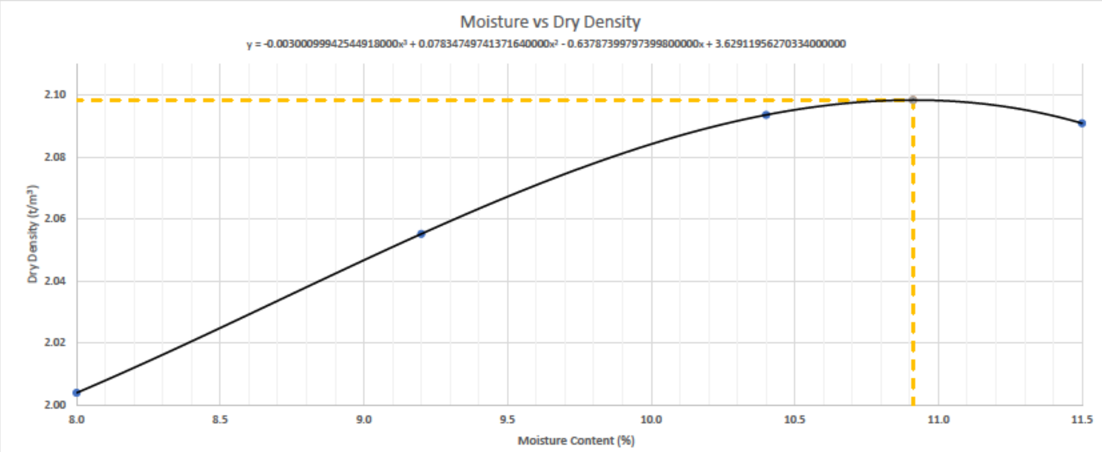
SAMPLE ID	1025-G19				
DATE LAB TESTED	8/08/2022				
LAB WORK PERFORMED BY	TR				STARTING MOISTURE CONTENT
CONTAINER NUMBER	6	7	8	9	10
INITIAL TIME OF TEST					
MASS OF CONTAINER (m1)	269	276	286	284	278
MASS OF CONTAINER AND WET SOIL (m2) (g)	1269	1276	1286	1284	2615
FIRST WEIGH (g)					
SECOND WEIGH (g)					
THIRD WEIGH (g)					
FOURTH WEIGH (g)					
FIFTH WEIGH (g)					
FINAL WEIGH (g)					
TIME OF FINAL WEIGH					
MASS OF CONTAINER AND DRY SOIL (m3) (g)	1195	1192	1192	1181	2488
MOISTURE CONTENT (w) (%)	8	9.2	10.4	11.5	5.7
Mass of Dry Soil	2365.2	2365.2	2365.2	2365.2	
Total mass of water	209.8	234.8	259.8	290.8	
Moisture Content Check (%)	8.9	9.9	11	12.3	

LAB DRY DENSITY/MOISTURE CONTENT ENTRY

SAMPLE ID	1025-G19			
DATE TESTED	8/08/2022			
TIME OF COMPACTION				
TESTED BY	TR			
BALANCE NO				
RAMMER NO				
MOULD NO	A			
MOULD VOLUME	999			
MASS OF MOULD	4231			
MASS OF SOIL	2500	2500	2500	2500
VOLUME WATER ADDED (mL)	75	100	125	156
MASS OF MOULD & WET SOIL (g)	6393	6473	6540	6560
WET DENSITY (t/m3)	2.16	2.24	2.31	2.33

CALCULATIONS

Final Moisture Content (%)	8.0	9.2	10.4	11.5
Wet density of material (ρ_w)(t/m^3)	2.16	2.24	2.31	2.33
Dry density of material (ρ_d)(t/m^3)	2.004	2.055	2.094	2.091



y = -0.0030009994254491800x3 + 0.0783474974137164000x2 - 0.6378739979739980000x + 3.62911956270334000000	*Inset Formula*

a	-0.003000999
b	0.078347497
c	-0.637873998
d	3.629119563

Derivative

a	-0.009002998
b	0.156694995
c	-0.637873998

Turning Point (Derivative = 0)

Answer 1	6.493282609
Answer 2	10.91147412

Copy answer which corresponds to maxium dry density on curve (highest point) and paste value below

OMC	10.9
MDD	2.098

SITE MOISTURE BIAS CALCULATIONS

	Orientation 1	Orientation 2	Average
Field moisture content at site (w_{dn})(%)	5.7	5.7	5.7
Field wet density at site (ρ_n)(t/m3)	0	0	#DIV/0!
Field water content W_{dn} (t/m3)	0.000	0.000	#DIV/0!
Unadjusted field water content displayed by gauge (w_{vn})(%)	0.0	0.0	#DIV/0!
Unadjusted field water content displayed by gauge (W_{vn})(t/m3)	0.000	0.000	#DIV/0!
Individual site moisture bias (B_{mn})(t/m3)	0.000	0.000	#DIV/0!

ADJUSTED FIELD MOISTURE CONTENT & DRY DENSITY CALCULATIONS

Field Wet Density (t/m³)	0.000	0.000	#DIV/0!
Field Dry Density (t/m³)	0	0	#DIV/0!
Field Moisture Conent	0	0	#DIV/0!
Adjusted Field Dry Density (t/m³)	0.000	0.000	#DIV/0!
Adjusted Field Moisture Content (%)	5.7	5.7	5.7
Nuclear Gauge - Density Ratio (%)	0.0	0.0	#DIV/0!
Sand Replacement - Density Ratio (%)			100.3

FIELD DENSITY NOTES DATA ENTRY

CLIENT	Carpentaria Shire Council			
PROJECT NO	101-021			
PROJECT				
TEST REQUEST NO				
MATERIAL SOURCE	HFG-Natural			
LOT NO				
SAMPLE DESCRIPTION	Red Brown Gravel			
DATE TESTED				
COMPACTION STD	100%			
TESTED BY				
NUC GAUGE NO	30823			
DS				
MS				
SAMPLE ID				
TEST LOCATION				
ORIENTATION	0	90		
PROBE DEPTH /				
LAYER DEPTH (mm)				
TIME SETTING (min)				
TIME OF TEST			Average	
DENSITY COUNT			#DIV/0!	
MOISTURE COUNT			#DIV/0!	Dry Density Variation Check (<0.075 t/m3)
GAUGE FIELD WET DENSITY (t/m3)			#DIV/0!	
GAUGE FIELD DRY DENSITY (t/m3)			#DIV/0!	0
GAUGE MOISTURE CONTENT (%)			#DIV/0!	
GAUGE MOISTURE CONTENT (kg)			#DIV/0!	

SAND REPLACEMENT DATA ENTRY

	ORIGINAL WEIGHT (g)	FINAL WEIGHT (g)	SAND WEIGHT (g)
SAND CALIBRATION (SC)	2000	658	1342
SAND REPLACEMENT (SR)	6000	3155	2845

SAND IN HOLE (SR-SC) (g)	1503
DENSITY OF SAND (t/m3)	1.445
VOLUME OF HOLE (m3)	0.001040138
MASS OF CONTAINER (g)	280
MASS OF CONTAINER AND WET SOIL (g)	2690
DENSITY OF HOLE MATERIAL (t/m3)	2.316999335
DRY DENSITY (t/m3)	2.1949002
DENSITY RATIO	99.7

LAB MOISTURE CONTENT DATA ENTRY

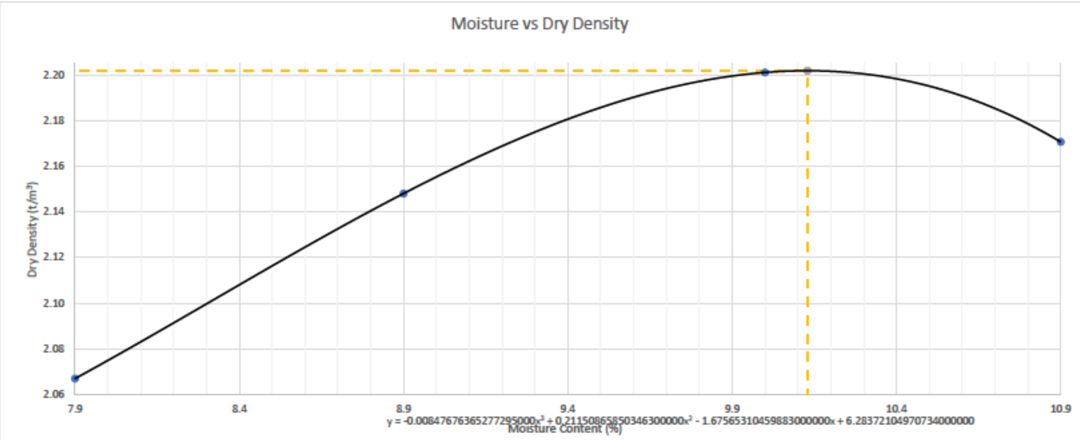
SAMPLE ID	1025-G20				
DATE LAB TESTED	8/08/2022				
LAB WORK PERFORMED BY	TR				STARTING MOISTURE CONTENT
CONTAINER NUMBER	1	2	3	4	5
INITIAL TIME OF TEST					
MASS OF CONTAINER (m1)	276	278	274	278	280
MASS OF CONTAINER AND WET SOIL (m2) (g)	1276	1278	1274	1278	2690
FIRST WEIGH (g)					
SECOND WEIGH (g)					
THIRD WEIGH (g)					
FOURTH WEIGH (g)					
FIFTH WEIGH (g)					
FINAL WEIGH (g)					
TIME OF FINAL WEIGH					
MASS OF CONTAINER AND DRY SOIL (m3) (g)	1203	1196	1183	1180	2563
MOISTURE CONTENT (w) (%)	7.9	8.9	10	10.9	5.6
Mass of Dry Soil	2367.4	2367.4	2367.4	2367.4	
Total mass of water	207.6	232.6	257.6	282.6	
Moisture Content Check (%)	8.8	9.8	10.9	11.9	

LAB DRY DENSITY/MOISTURE CONTENT ENTRY

SAMPLE ID	1025-G20			
DATE TESTED	8/08/2022			
TIME OF COMPACTION				
TESTED BY	TR			
BALANCE NO				
RAMMER NO				
MOULD NO	A			
MOULD VOLUME	999			
MASS OF MOULD	4231			
MASS OF SOIL	2500	2500	2500	2500
VOLUME WATER ADDED (mL)	75	100	125	150
MASS OF MOULD & WET SOIL (g)	6459	6568	6650	6636
WET DENSITY (t/m3)	2.23	2.34	2.42	2.41

CALCULATIONS

Final Moisture Content (%)	7.9	8.9	10.0	10.9
Wet density of material (ρ_w)(t/m^3)	2.23	2.34	2.42	2.41
Dry density of material (ρ_d)(t/m^3)	2.067	2.148	2.201	2.171



y = -0.00847676365277295000x3 + 0.21150865850346300000x2 - 1.67565310459883000000x + 6.28372104970734000000		*Inset Formula*
a	-0.008476764	
b	0.211508659	
c	-1.675653105	
d	6.28372105	

Derivative

a	-0.025430291
b	0.423017317
c	-1.675653105

Turning Point (Derivative = 0)

Answer 1	6.505096077
Answer 2	10.12929154

Copy answer which corresponds to maxium dry density on curve (highest point) and paste value below

OMC	10.1
MDD	2.202

SITE MOISTURE BIAS CALCULATIONS

	Orientation 1	Orientation 2	Average
Field moisture content at site (w_{dn})(%)	5.6	5.6	5.6
Field wet density at site (ρ_n)(t/m3)	0	0	#DIV/0!
Field water content W_{dn} (t/m3)	0.000	0.000	#DIV/0!
Unadjusted field water content displayed by gauge (w_{vn})(%)	0.0	0.0	#DIV/0!
Unadjusted field water content displayed by gauge (W_{vn})(t/m3)	0.000	0.000	#DIV/0!
Individual site moisture bias (B_{mn})(t/m3)	0.000	0.000	#DIV/0!

ADJUSTED FIELD MOISTURE CONTENT & DRY DENSITY CALCULATIONS

Field Wet Density (t/m³)	0.000	0.000	#DIV/0!
Field Dry Density (t/m³)	0	0	#DIV/0!
Field Moisture Conent	0	0	#DIV/0!
Adjusted Field Dry Density (t/m³)	0.000	0.000	#DIV/0!
Adjusted Field Moisture Content (%)	5.6	5.6	5.6
Nuclear Gauge - Density Ratio (%)	0.0	0.0	#DIV/0!
Sand Replacement - Density Ratio (%)			99.7

APPENDIX D – RISK REGISTER

University of Southern Queensland **Offline Version**

USQ Safety Risk Management System

Note: This is the offline version of the Safety Risk Management System (SRMS) Risk Management Plan (RMP) and is only to be used for planning and drafting sessions, and when working in remote areas or on field activities. It must be transferred to the online SRMS at the first opportunity.

Safety Risk Management Plan – Offline Version

Assessment Title:	Impact of Pavement Material for Flood Resistance on Rural Roads	Assessment Date:	09/07/2024
Workplace (Division/Faculty/Section):	Engineering Faculty	Review Date:(5 Years Max)	09/09/2024

Context

Description:

What is the task/event/purchase/project/procedure?	Project that involves various tests onducted on rural roads		
Why is it being conducted?	Determine best cost options for restoring rural roads		
Where is it being conducted?	Normanton - Burketown Road, Carpentaria Shire		
Course code (if applicable)	ENP4111	Chemical name (if applicable)	

What other nominal conditions?

Personnel involved	Monique Gambin
Equipment	Ipad, Excel, DCP test equipment, PPE, spatial data
Environment	Rural road and geotech lab
Other	
Briefly explain the procedure/process	Perform DCP test at 100m intervals, complete cost anaylsis

Assessment Team - who is conducting the assessment?

Assessor(s)	Monique Gambin
Others consulted:	USQ Engineering faculty

Eg 1. Enter Consequence

Eg 2. Enter Probability

Eg 3. Find Action

Probability	Consequence				
	Insignificant No Injury 0-$5K	**Minor** First Aid $5K-$50K	**Moderate** Med Treatment $50K-$100K	**Major** Serious Injuries $100K-$250K	**Catastrophic** Death More than $250K
Almost Certain 1 in 2	M	H	E	E	E
Likely 1 in 100	M	H	H	E	E
Possible 1 in 1000	L	M	H	H	H
Unlikely 1 in 10 000	L	L	M	M	M
Rare 1 in 1 000 000	L	L	L	L	L

Recommended Action Guide

E=Extreme Risk – Task ***MUST NOT*** proceed

H=High Risk – Special Procedures Required (See USQSafe)

M=Moderate Risk – Risk Management Plan/Work Method Statement Required

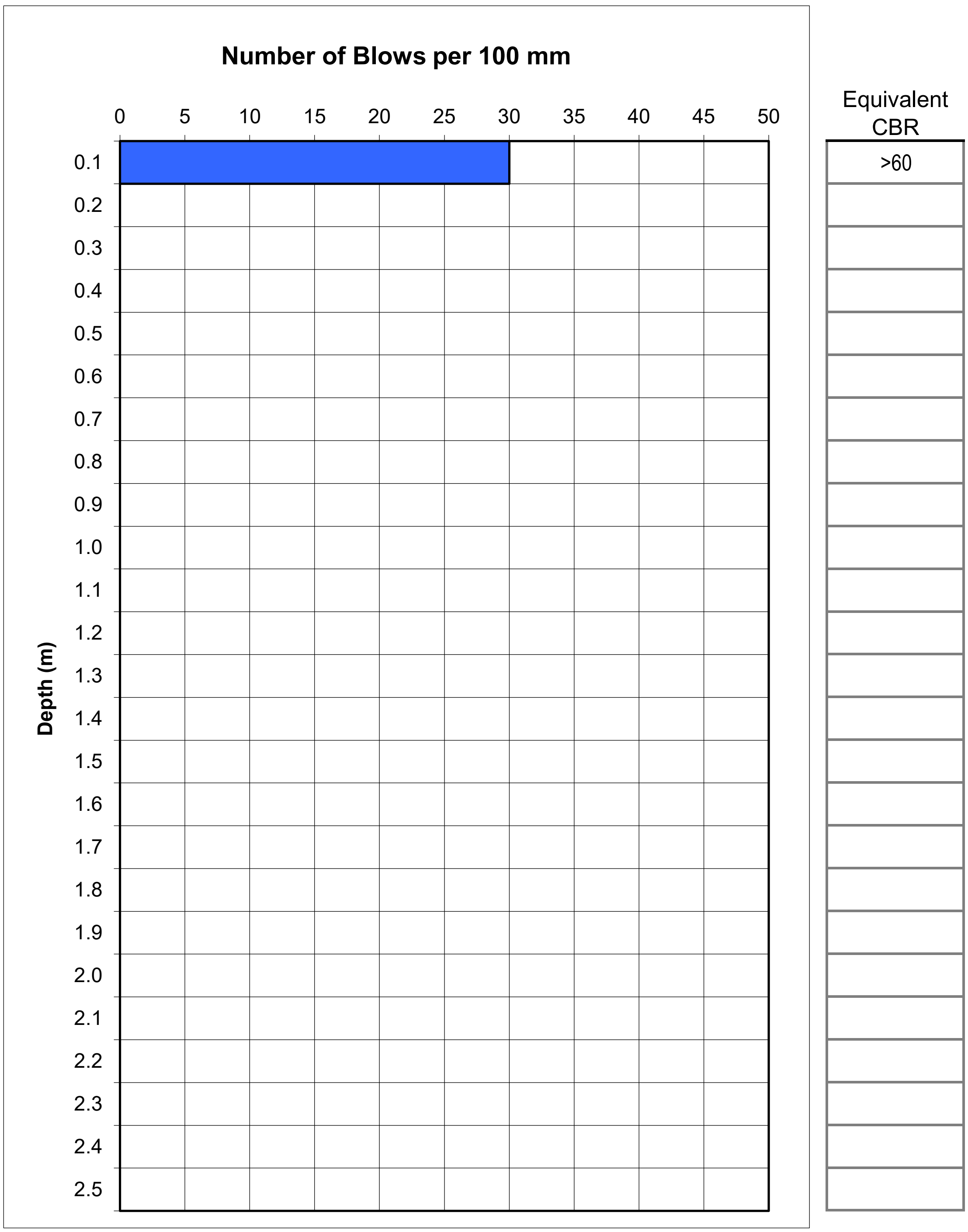
L=Low Risk – Use Routine Procedures

Step 1 (cont)	Step 2	Step 2a	Step 2b	Step 3			Step 4				
***Hazards**:* From step 1 or more if identified	***The Risk:*** What can happen if exposed to the hazard without existing controls in place?	***Consequence:*** What is the harm that can be caused by the hazard without existing controls in place?	***Existing Controls:*** What are the existing controls that are already in place?	***Risk Assessment:*** Consequence x Probability = Risk Level			***Additional controls:*** Enter additional controls if required to reduce the risk level	***Risk assessment with additional controls:***			
				Probability	**Risk Level**	**ALARP? Yes/no**		**Consequence**	**Probability**	**Risk Level**	**ALARP? Yes/no**
Example											
Working in temperatures over 35⁰ C	Heat stress/heat stroke/exhaustion leading to serious personal injury/death	catastrophic	Regular breaks, chilled water available, loose clothing, fatigue management policy.	possible	high	No	temporary shade shelters, essential tasks only, close supervision, buddy system	catastrophic	unlikely	mod	Yes
Working in high temperatures when etracting gravel samples	Heat stress/heat stroke leading to injury or death	Major	Sun protecting PPE, lots of water, lots of breaks	Possible	High	No	Not working alone, shade provided	Major	Unlikely	Moderate	Yes
Injury when conducting DCP test	Serious personal injury or death	Moderate	Regular breaks, PPE worn at all times, first aid available on site	Unlikely	Moderate	No	Not working alone, being correctly trained on how to perform proctor test, close supervision	Moderate	Rare	Low	Yes
Dehydration when conducting tests	Heat stress, exhaustion leading to injury or death	Major	Sun protecting PPE, lots of water, lots of breaks	Possible	High	No	Not working alone, shade provided, essential task only	Major	Unlikely	Moderate	Yes

APPENDIX E – NORMANTON – BURKETOWN ROAD DCP TEST RESULTS

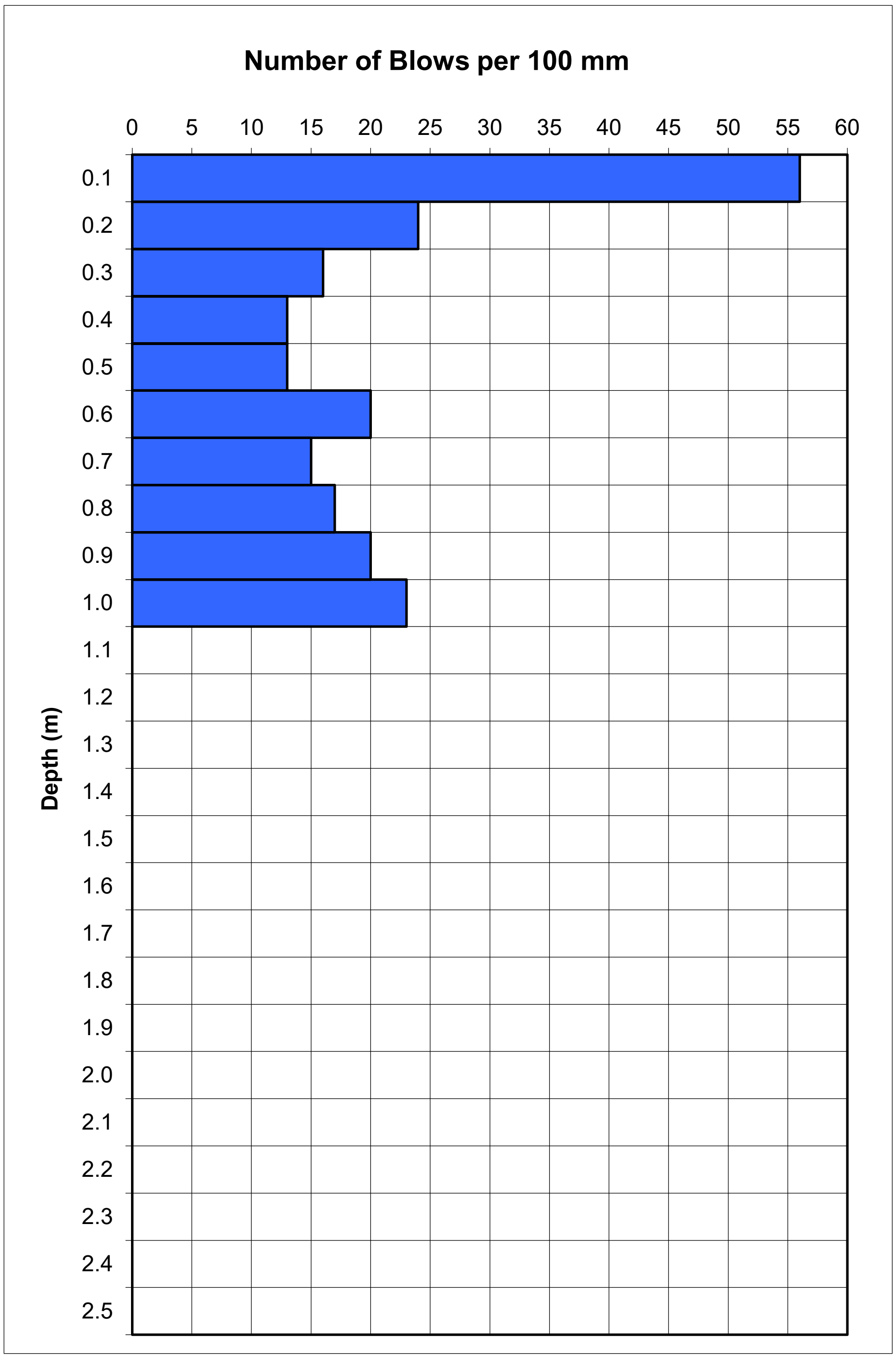
Dynamic Cone Penetrometer Test

Test No.	*DCP1*		
Sheet	*1* of *10*		
Client	***Carpentaria Shire Council***	Job No.	***101-100***
Principal	***ERSCON***	Date	***5/08/2024***
Project	***2024 Normanton - Burketown Road Betterment***	Tested By	***ERSCON***
Location	***Normanton - Burketown Road***	Checked By	***NL***
Location Ref.			
Test Method	***AS 1289.6.3.2 Determination of the Penetration Resistance of a Soil using a 9 kg Dynamic Cone Penetrometer***		
Hammer mass	***9kg***	Hammer Drop	***510mm***
Tip Type	***Conical***		



Dynamic Cone Penetrometer Test

Test No.	*DCP2*		
Sheet	*2* of *10*		
Client	***Carpentaria Shire Council***	Job No.	***101-100***
Principal	***ERSCON***	Date	***5/08/2024***
Project	***2024 Normanton - Burketown Road Betterment***	Tested By	***ERSCON***
Location	***Normanton - Burketown Road***	Checked By	***NL***
Location Ref.			
Test Method	***AS 1289.6.3.2 Determination of the Penetration Resistance of a Soil using a 9 kg Dynamic Cone Penetrometer***		
Hammer mass	***9kg***	Hammer Drop	***510mm***
Tip Type	***Conical***		

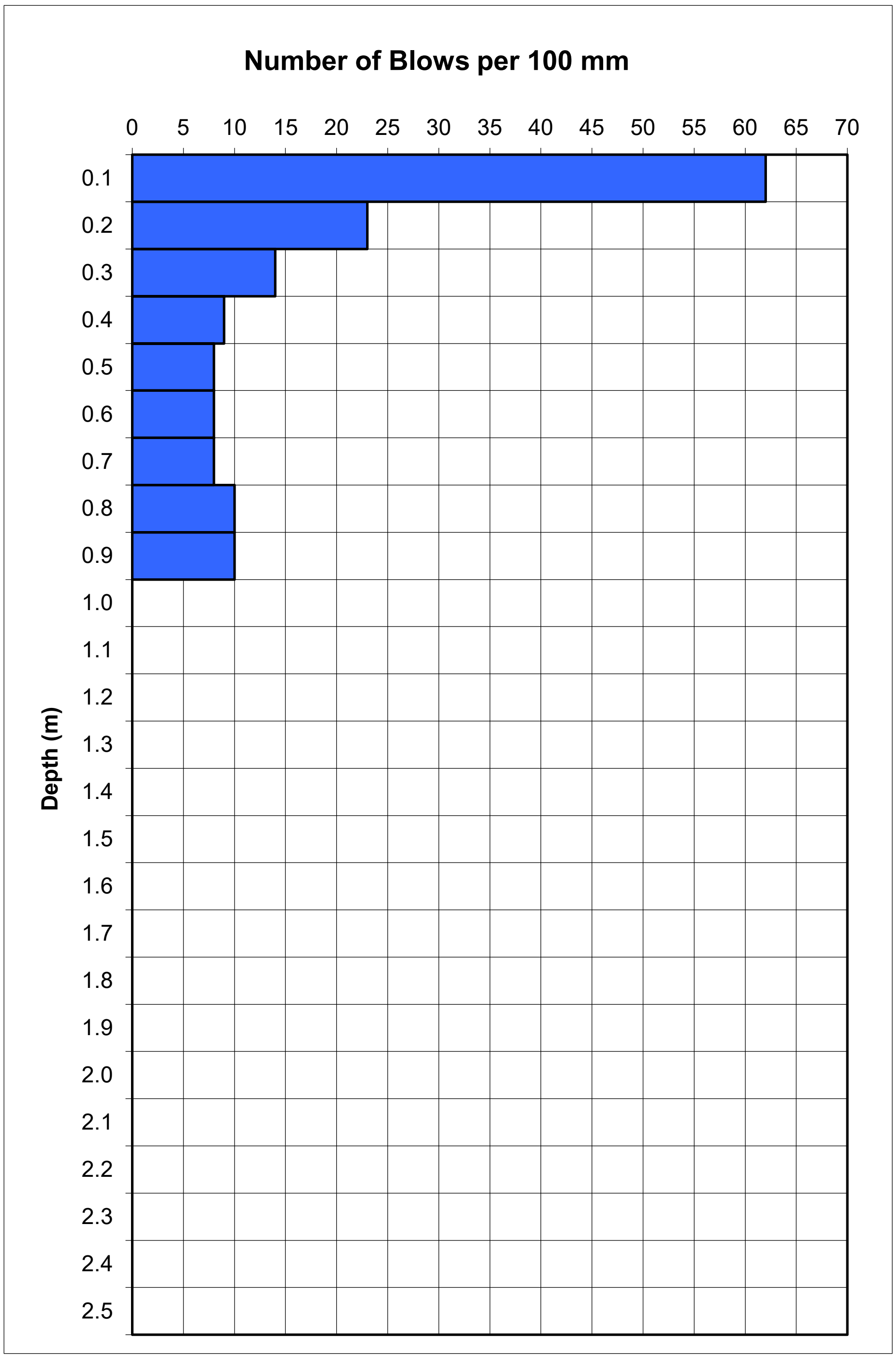


Equivalent CBR
>60
>60
40
30
30
50
35
40
50
60

Dynamic Cone Penetrometer Test

Test No.	DCP3
Sheet	3 of 10

Client	***Carpentaria Shire Council***	Job No.	***101-100***
Principal	***ERSCON***	Date	***5/08/2024***
Project	***2024 Normanton - Burketown Road Betterment***	Tested By	***ERSCON***
Location	***Normanton - Burketown Road***	Checked By	***NL***
Location Ref.			
Test Method	***AS 1289.6.3.2 Determination of the Penetration Resistance of a Soil using a 9 kg Dynamic Cone Penetrometer***		
Hammer mass	***9kg***	Hammer Drop	***510mm***
Tip Type	***Conical***		



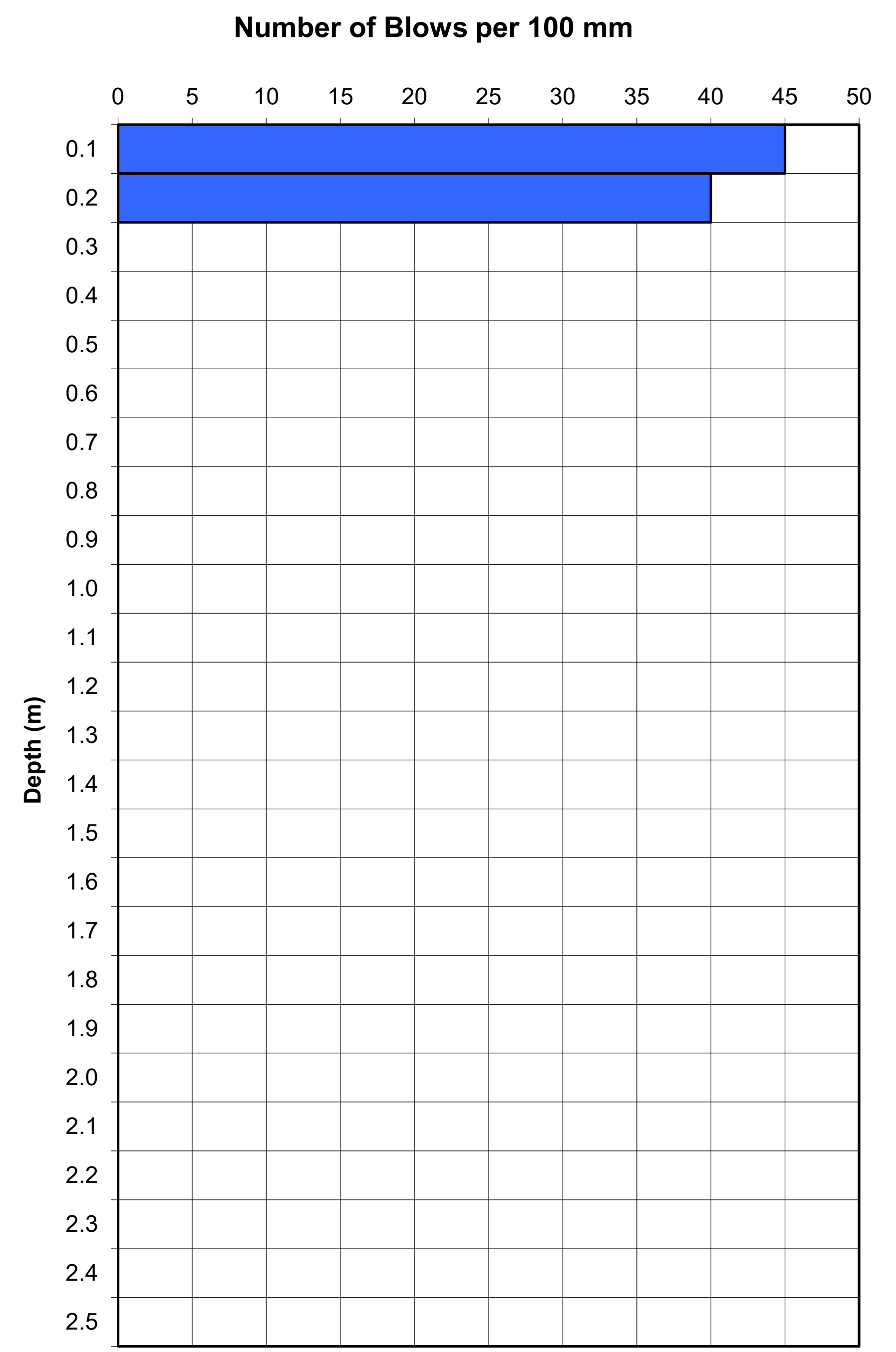
Depth (m)	Equivalent CBR
0.1	>60
0.2	60
0.3	35
0.4	19
0.5	17
0.6	17
0.7	17
0.8	20
0.9	20
1.0	
1.1	
1.2	
1.3	
1.4	
1.5	
1.6	
1.7	
1.8	
1.9	
2.0	
2.1	
2.2	
2.3	
2.4	
2.5	

ERSCON CONSULTING ENGINEERS

Dynamic Cone Penetrometer Test

Test No.	***DCP4***
Sheet	***4*** of ***10***

Client	***Carpentaria Shire Council***	Job No.	***101-100***
Principal	***ERSCON***	Date	***5/08/2024***
Project	***2024 Normanton - Burketown Road Betterment***	Tested By	***ERSCON***
Location	***Normanton - Burketown Road***	Checked By	***NL***
Location Ref.			
Test Method	***AS 1289.6.3.2 Determination of the Penetration Resistance of a Soil using a 9 kg Dynamic Cone Penetrometer***		
Hammer mass ***9kg***	Hammer Drop ***510mm***	Tip Type	***Conical***

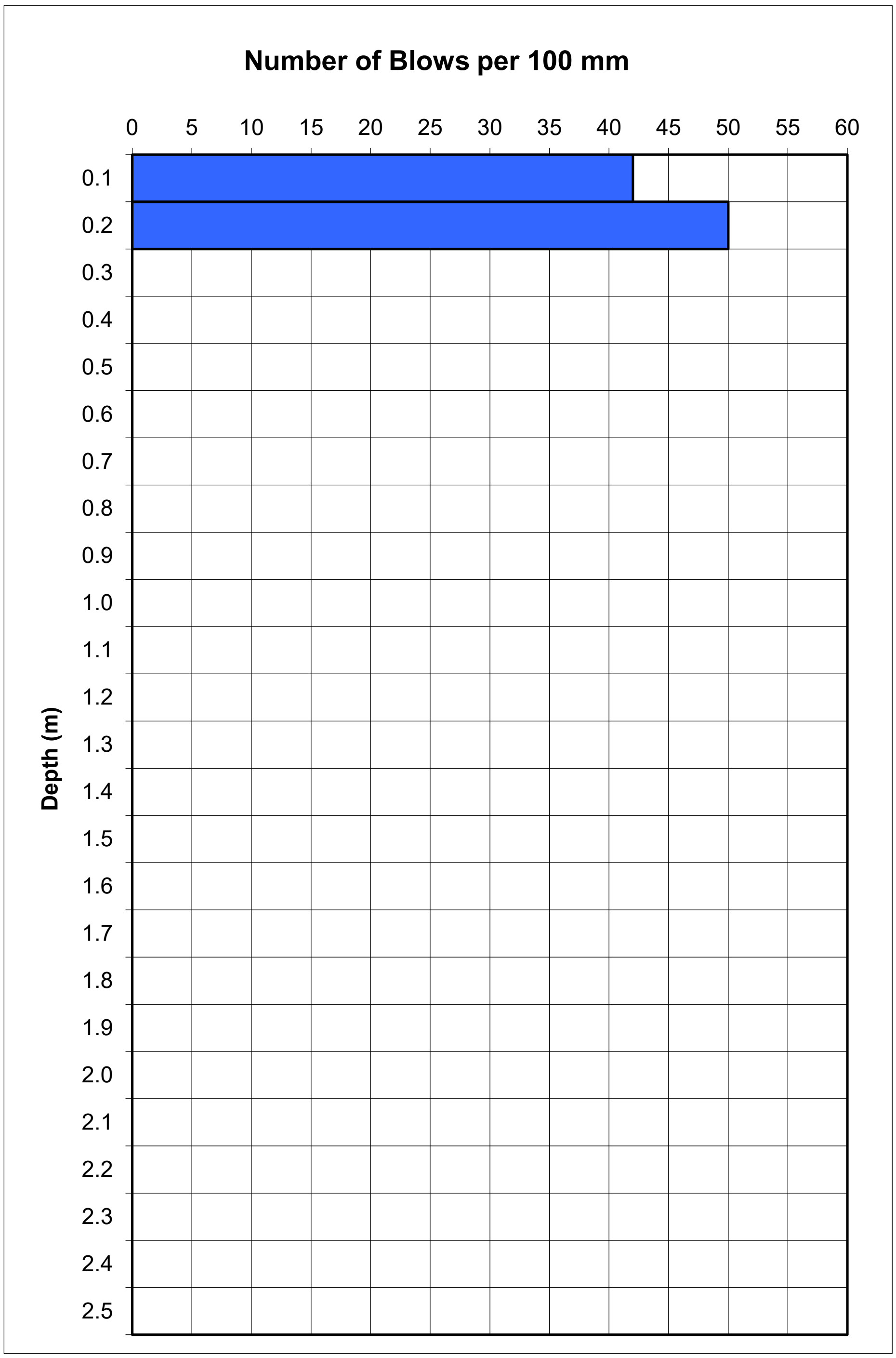


Equivalent CBR
>60
>60

Dynamic Cone Penetrometer Test

Test No.	***DCP5***
Sheet	***5*** of ***10***

Client	***Carpentaria Shire Council***	Job No.	***101-100***
Principal	***ERSCON***	Date	***5/08/2024***
Project	***2024 Normanton - Burketown Road Betterment***	Tested By	***ERSCON***
Location	***Normanton - Burketown Road***	Checked By	***NL***
Location Ref.			
Test Method	***AS 1289.6.3.2 Determination of the Penetration Resistance of a Soil using a 9 kg Dynamic Cone Penetrometer***		
Hammer mass ***9kg***	Hammer Drop ***510mm***	Tip Type	***Conical***

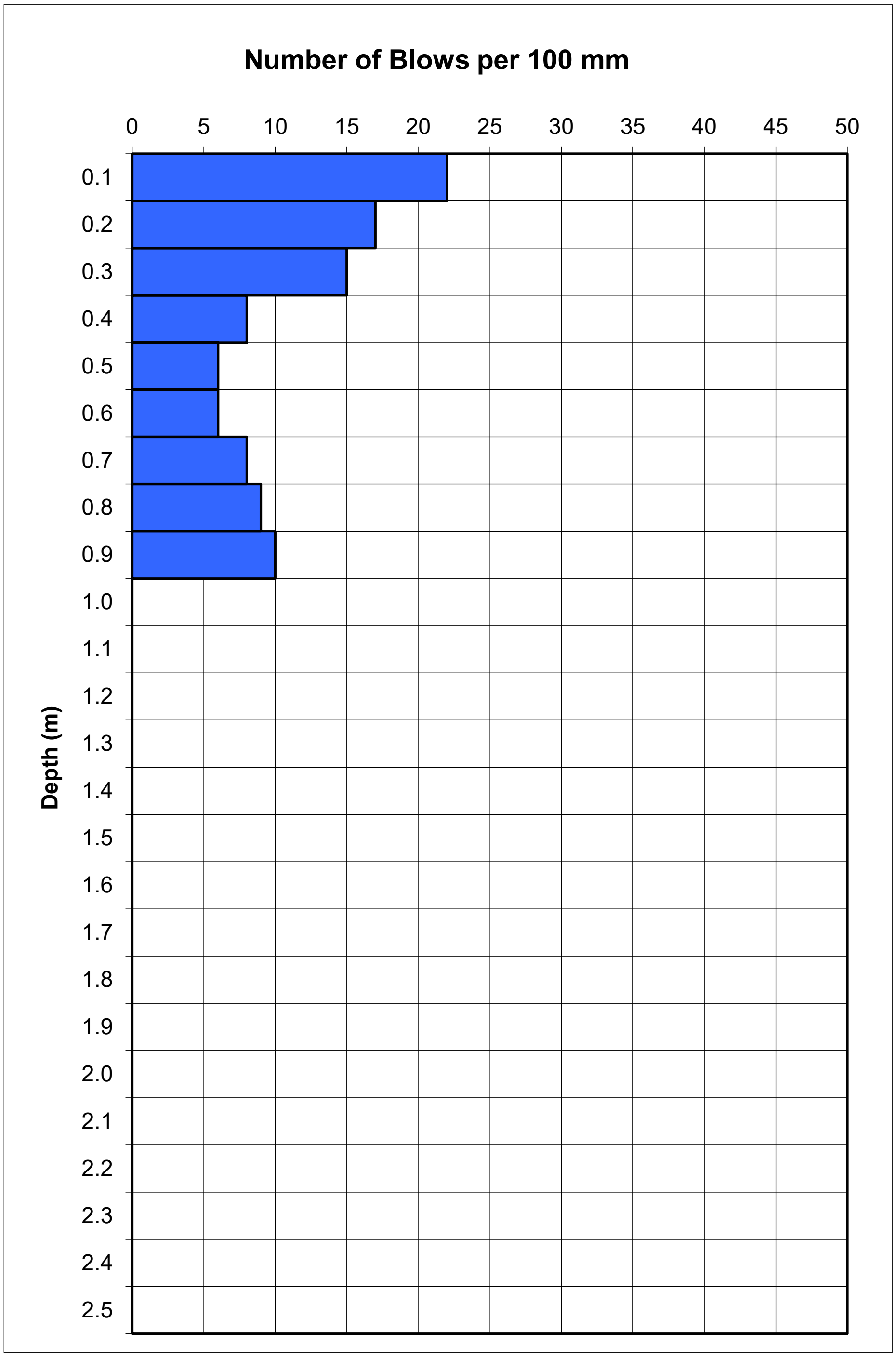


Depth (m)	Equivalent CBR
0.1	>60
0.2	>60
0.3	
0.4	
0.5	
0.6	
0.7	
0.8	
0.9	
1.0	
1.1	
1.2	
1.3	
1.4	
1.5	
1.6	
1.7	
1.8	
1.9	
2.0	
2.1	
2.2	
2.3	
2.4	
2.5	

Dynamic Cone Penetrometer Test

Test No.	***DCP6***		
Sheet	***6***	of	***10***

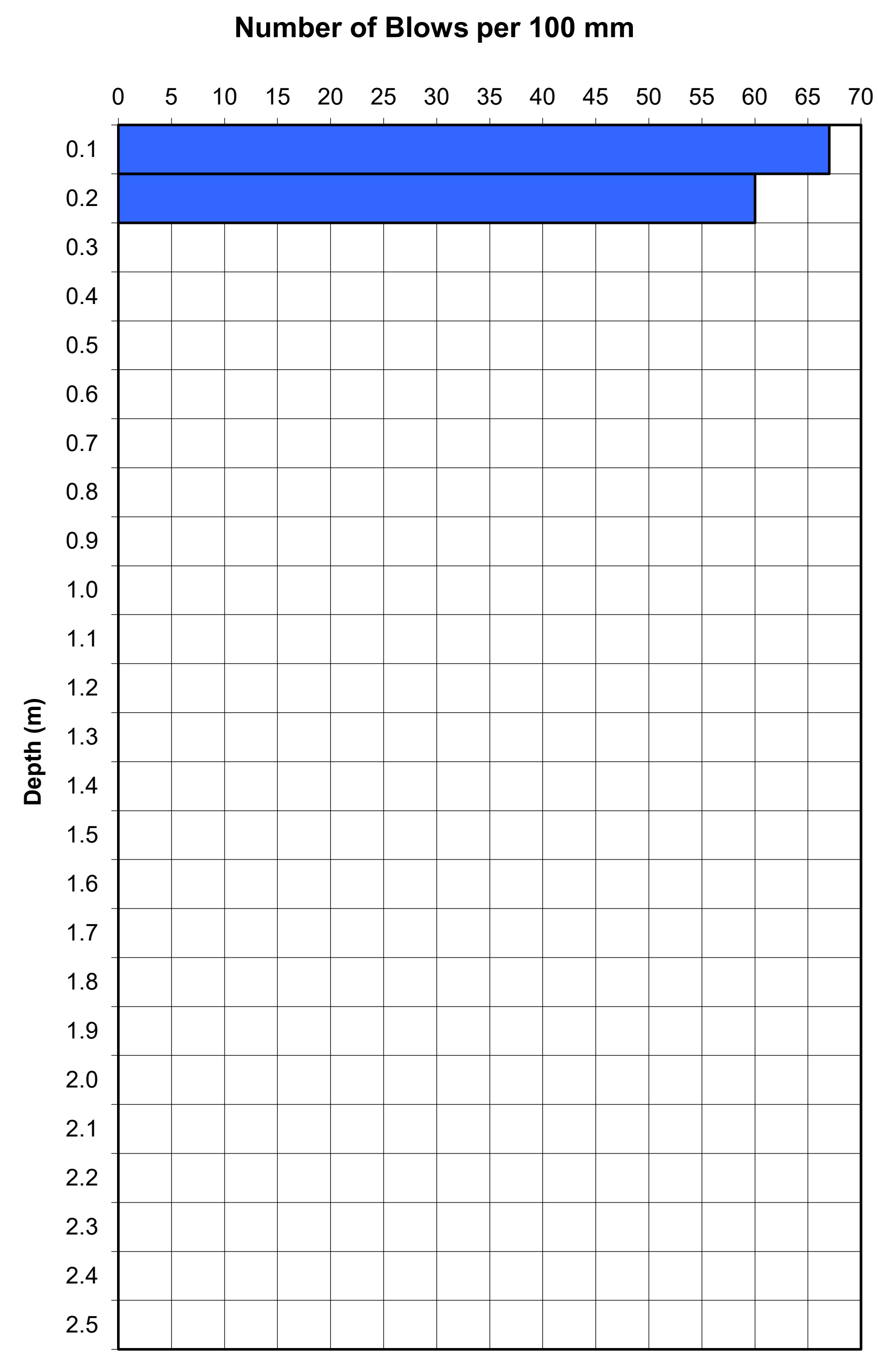
Client	***Carpentaria Shire Council***	Job No.	***101-100***
Principal	***ERSCON***	Date	***5/08/2024***
Project	***2024 Normanton - Burketown Road Betterment***	Tested By	***ERSCON***
Location	***Normanton - Burketown Road***	Checked By	***NL***
Location Ref.			
Test Method	***AS 1289.6.3.2 Determination of the Penetration Resistance of a Soil using a 9 kg Dynamic Cone Penetrometer***		
Hammer mass ***9kg***	Hammer Drop ***510mm***	Tip Type	***Conical***



Equivalent CBR
50
40
35
17
12
12
17
19
20

Dynamic Cone Penetrometer Test

Test No.	***DCP7***		
Sheet	***7*** of ***10***		
Client	***Carpentaria Shire Council***	Job No.	***101-100***
Principal	***ERSCON***	Date	***5/08/2024***
Project	***2024 Normanton - Burketown Road Betterment***	Tested By	***ERSCON***
Location	***Normanton - Burketown Road***	Checked By	***NL***
Location Ref.			
Test Method	***AS 1289.6.3.2 Determination of the Penetration Resistance of a Soil using a 9 kg Dynamic Cone Penetrometer***		
Hammer mass	***9kg***	Hammer Drop ***510mm***	Tip Type ***Conical***

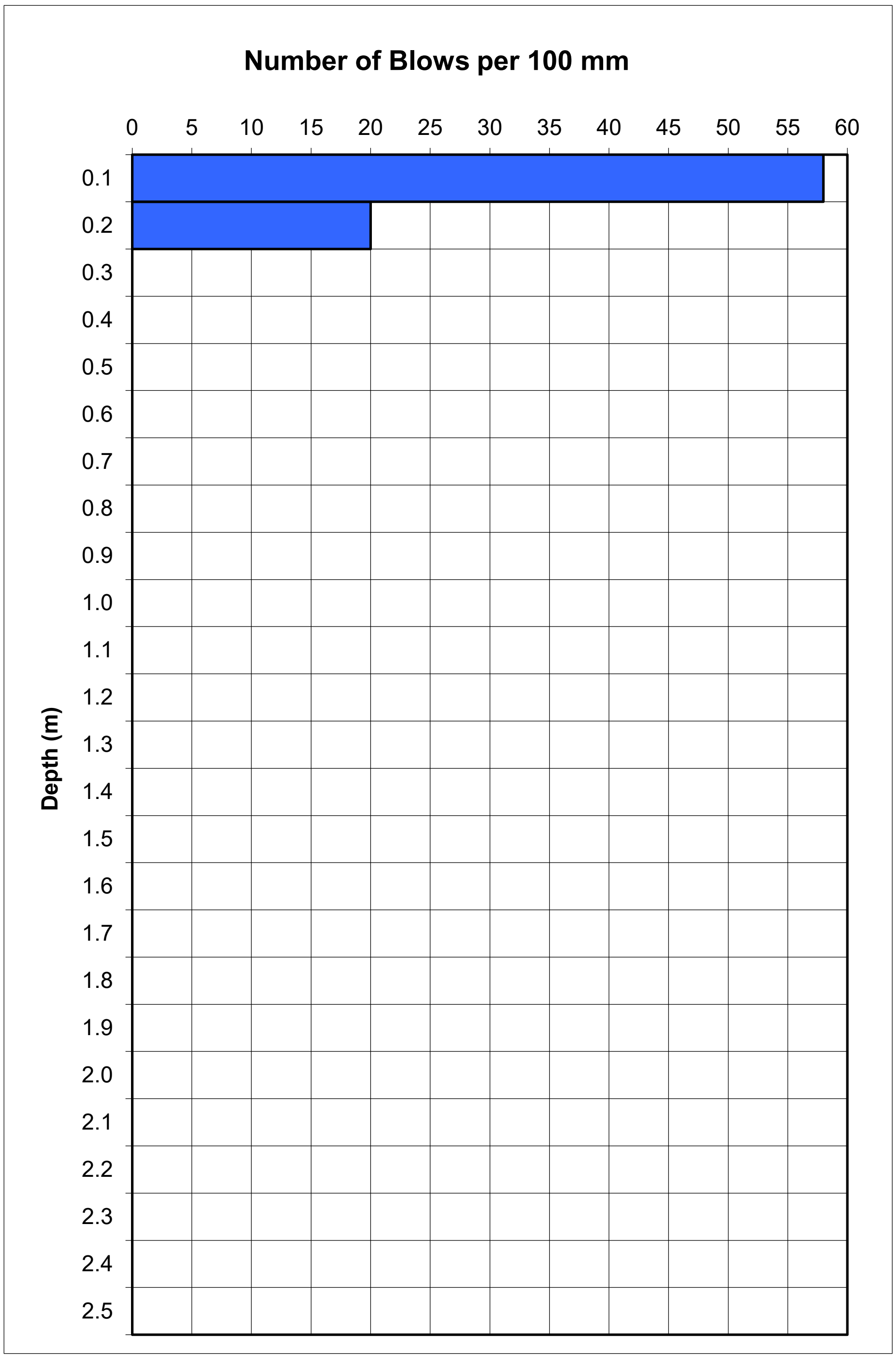


Depth (m)	Equivalent CBR
0.1	>60
0.2	>60
0.3	
0.4	
0.5	
0.6	
0.7	
0.8	
0.9	
1.0	
1.1	
1.2	
1.3	
1.4	
1.5	
1.6	
1.7	
1.8	
1.9	
2.0	
2.1	
2.2	
2.3	
2.4	
2.5	

Dynamic Cone Penetrometer Test

Test No.	*DCP8*
Sheet	*8* of *10*

Client	***Carpentaria Shire Council***	Job No.	***101-100***
Principal	***ERSCON***	Date	***5/08/2024***
Project	***2024 Normanton - Burketown Road Betterment***	Tested By	***ERSCON***
Location	***Normanton - Burketown Road***	Checked By	***NL***
Location Ref.			
Test Method	***AS 1289.6.3.2 Determination of the Penetration Resistance of a Soil using a 9 kg Dynamic Cone Penetrometer***		
Hammer mass	***9kg***	Hammer Drop ***510mm***	Tip Type ***Conical***

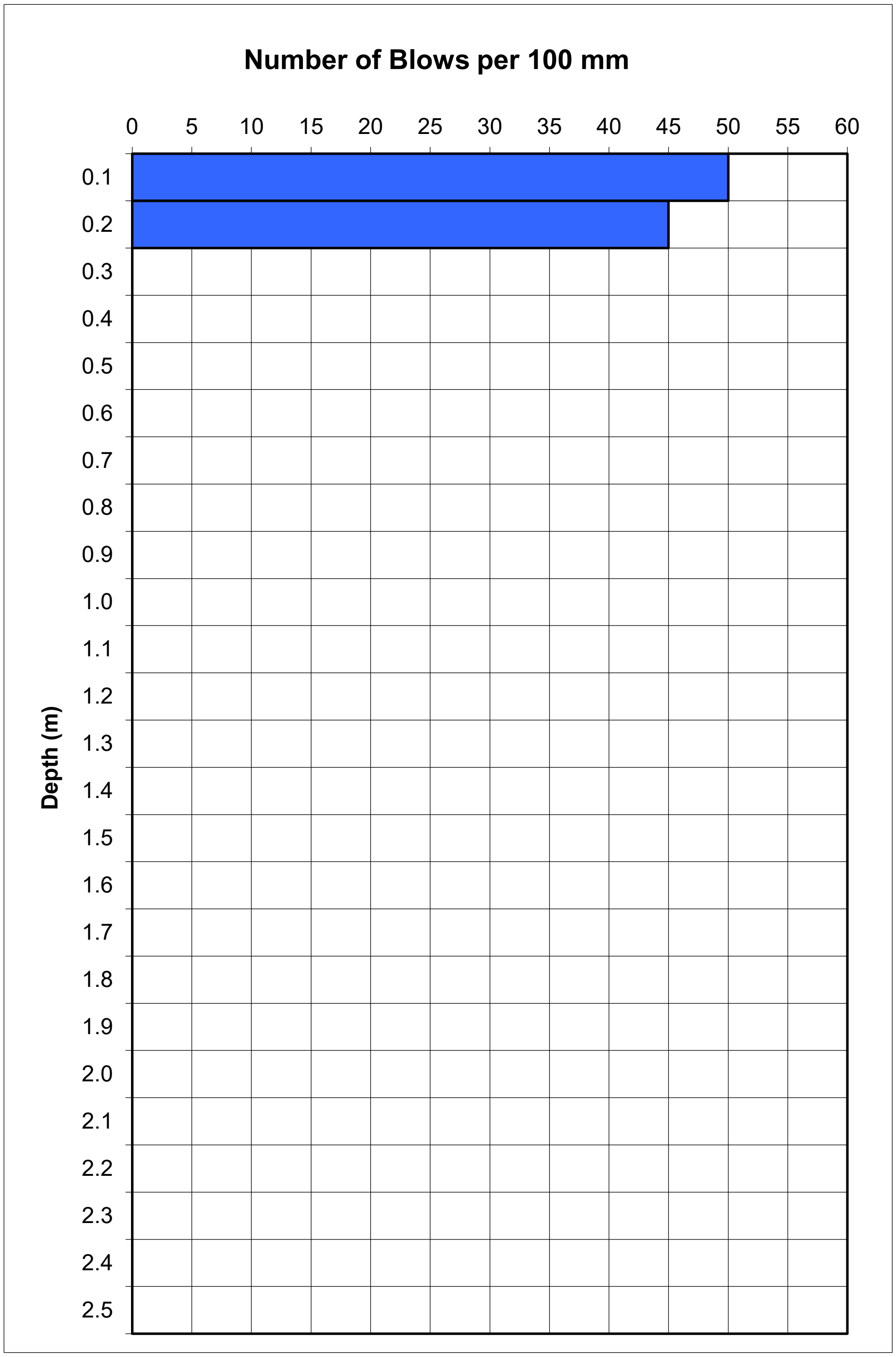


Equivalent CBR
>60
50

Dynamic Cone Penetrometer Test

Test No.	**DCP9**		
Sheet	**9**	of	**10**

Client	***Carpentaria Shire Council***	Job No.	***101-100***
Principal	***ERSCON***	Date	***5/08/2024***
Project	***2024 Normanton - Burketown Road Betterment***	Tested By	***ERSCON***
Location	***Normanton - Burketown Road***	Checked By	***NL***
Location Ref.			
Test Method	***AS 1289.6.3.2 Determination of the Penetration Resistance of a Soil using a 9 kg Dynamic Cone Penetrometer***		
Hammer mass ***9kg***	Hammer Drop ***510mm***	Tip Type	***Conical***

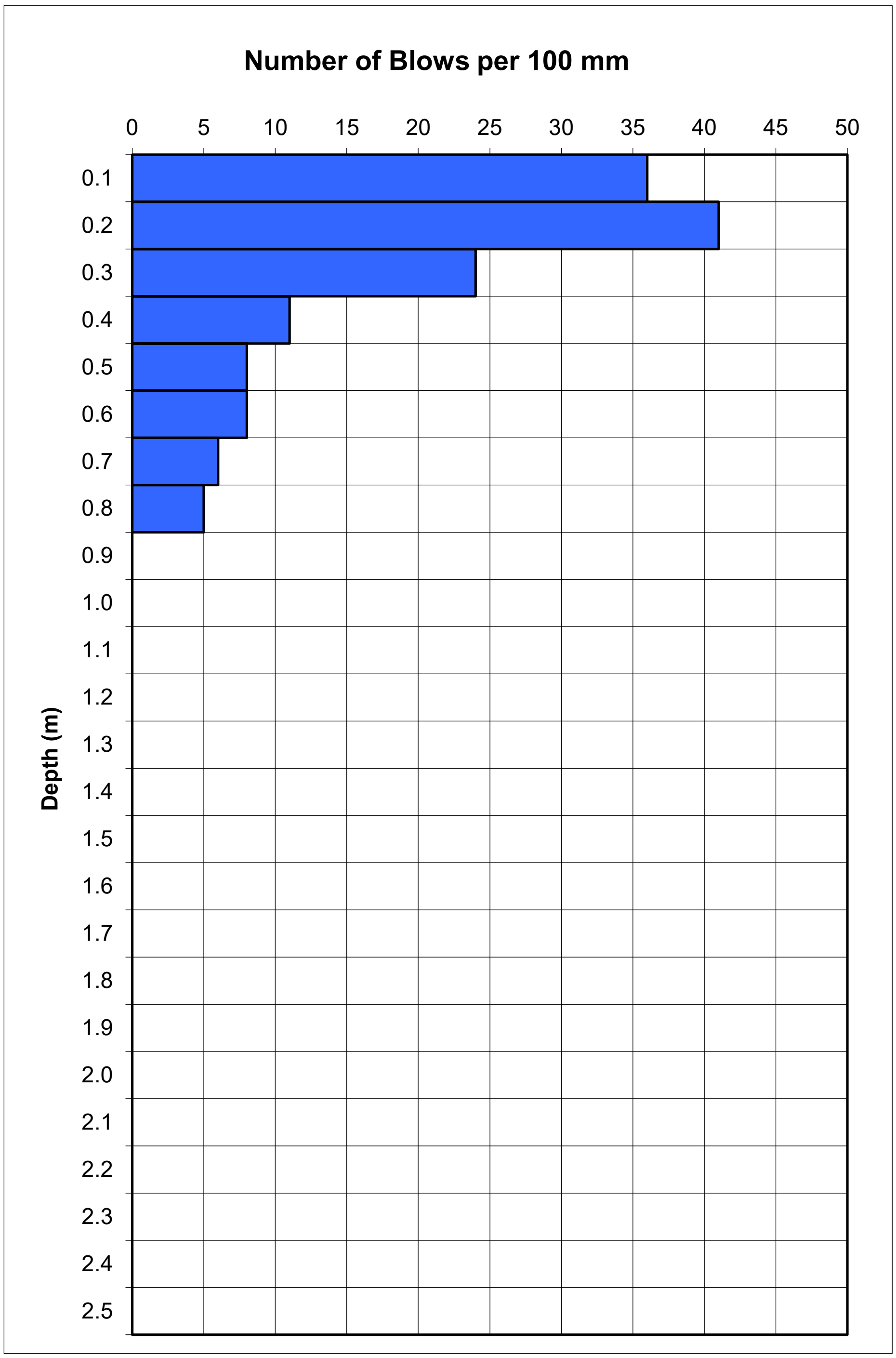


Equivalent CBR
>60
>60

Dynamic Cone Penetrometer Test

Test No.	*DCP10*
Sheet	***10*** of ***10***

Client	***Carpentaria Shire Council***	Job No.	***101-100***
Principal	***ERSCON***	Date	***5/08/2024***
Project	***2024 Normanton - Burketown Road Betterment***	Tested By	***ERSCON***
Location	***Normanton - Burketown Road***	Checked By	***NL***
Location Ref.			
Test Method	***AS 1289.6.3.2 Determination of the Penetration Resistance of a Soil using a 9 kg Dynamic Cone Penetrometer***		
Hammer mass ***9kg***	Hammer Drop ***510mm***	Tip Type	***Conical***



Equivalent CBR
>60
>60
>60
25
17
17
12
10

APPENDIX F – WELLS QUARRY TEST RESULTS

GROUNDWORK plus

TEST CERTIFICATE

Groundwork Plus
78 / 109 Leitchs Road, Brendale, QLD
4500 Australia

Client:	Wells Plant Hire	Lot No:	Stockpile	Job No:	000755
Address:	125 Yappar St, Karumba QLD 4891	Material Source:	Shady Lagoon Quarry	Sample ID:	00002602
Site:	Shady Lagoon	Material Type:	Unbound Pavements - Natural Gravel & Quarried Materials	Client Sample ID:	Type 2.3
Order No:	March 2022	Description:	Type 2 - Standard Material Type 2.3	Sample Method:	Sampled by Client
Order Name:	Compliance Testing	Lithology:	-	Sampled Date:	7/03/2022

California Bearing Ratio

Method:	Q113A
Sample Location:	Onsite Stockpile
Sample Description:	(GM) Silty GRAVEL - Brown
Curing Time (hrs):	2
Curing Determination:	Q104A
Soaking Period (days):	4
Surcharge (kg):	4.5

Initial Moisture Content (%):	13.2	14.7	11.7	9.9
Compacted Dry Density (t/m^3):	1.826	1.805	1.788	1.734
CBR 2.5mm (%):	80	40	90	60
CBR 5.0mm (%):	100	60	100	60

CBR MDD (t/m^3):	1.83
CBR OMC (%):	13.5
CBR 2.5mm (%):	80
CBR 5.0mm (%):	100
CBR Value (%):	**100**

Approved Signatory [redacted] (Dave Gregson, Business Manager - Laboratories) Date: 16/03/2022

NATA

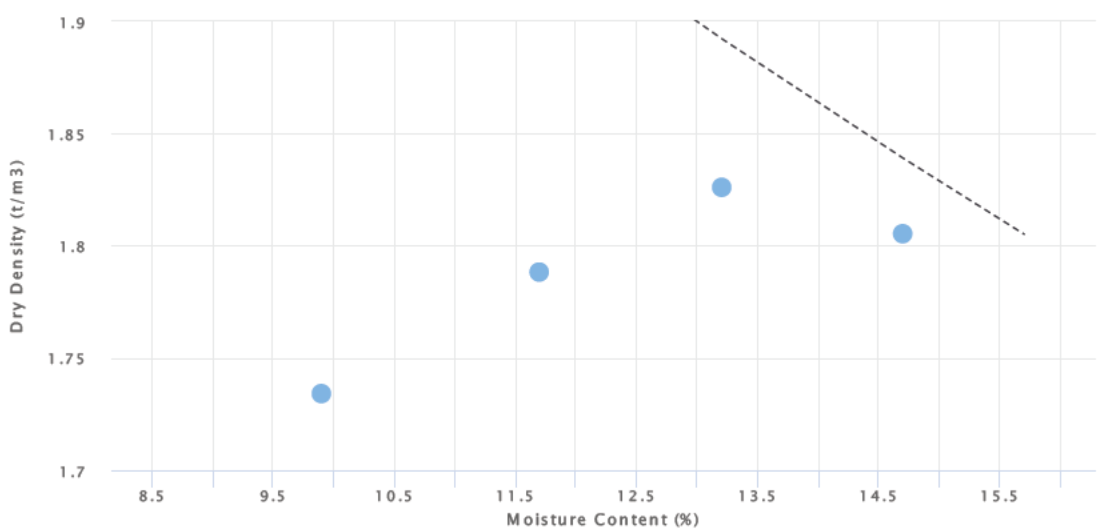
Accreditation No.: 20630
Accredited for compliance with ISO / IEC 17025 - Testing

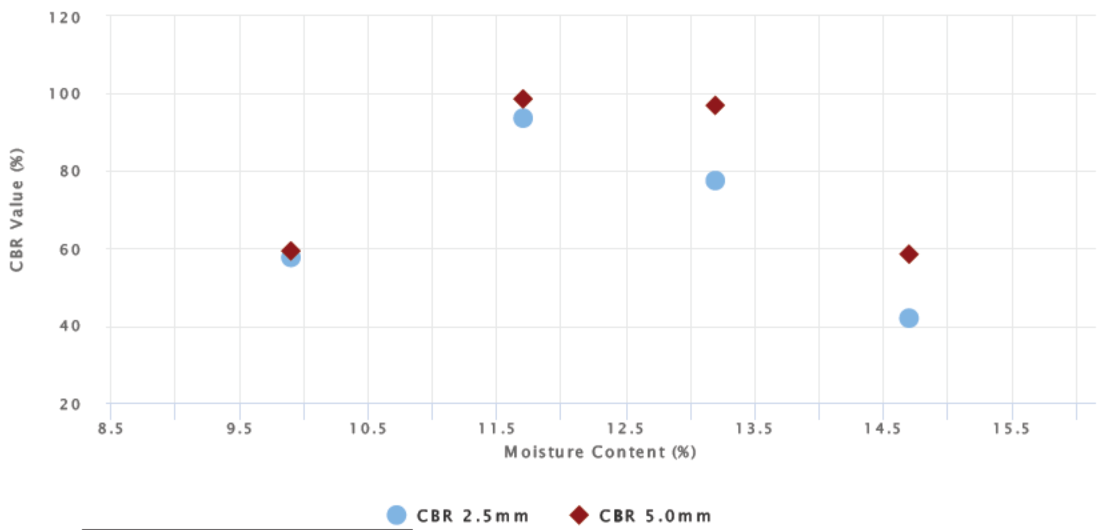
Site No.: 24729
Cert No.: 066-00002602A
Form No.: GWB-FMR-066 v.1.0 15.08.2019

TEST CERTIFICATE

Groundwork Plus
78 / 109 Leitchs Road, Brendale, QLD
4500 Australia

Client:	Wells Plant Hire	Lot No:	Stockpile	Job No:	000755
Address:	125 Yappar St, Karumba QLD 4891	Material Source:	Shady Lagoon Quarry	Sample ID:	00002602
		Material Type:	Unbound Pavements - Natural Gravel & Quarried Materials	Client Sample ID:	Type 2.3
Site:	Shady Lagoon			Sample Method:	Sampled by Client
Order No:	March 2022	Description:	Type 2 - Standard Material Type 2.3	Sampled Date:	7/03/2022
Order Name:	Compliance Testing	Lithology:	-		





Approved Signatory: [redacted] (Dave Gregson, Business Manager - Laboratories) Date: 16/03/2022

Accreditation No.: 20630
Accredited for compliance with ISO / IEC 17025 - Testing

Site No.: 24729
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