,

TRANS-CALEDON TUNNEL AUTHORITY

CONSULTING SERVICES FOR THE BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT No. TCTA 21-041

ACCESS ROADS - CONCEPT DESIGN

18 MARCH 2022

AMANZI ENTABA JOINT VENTURE

Report No: 1A-R-211-07 (Rev B)

CONSULTING SERVICES FOR THE BERG RIVER VOELVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT NO. TCTA 21-041

DOCUMENT CONTROL SHEET

Report No : **1A-R-211-07 (Rev B)**

Title : **ACCESS ROADS - CONCEPT DESIGN**

Rev No	Date of Issue	Originator		Checked		Approved		Description
		Initials	Signature	Initials	Signature	Initials	Signature	
A	22 Feb 2022	JPG		FLR		CJM		Issued for comments
B	18 Mar 2022	JPG		FLR		CJM		Final, comments from TCTA included

CONSULTING SERVICES FOR THE BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

CONTRACT NO. TCTA 21-041

ACCESS ROADS - CONCEPT DESIGN

TABLE OF CONTENTS

List of Annexures

Annexure A: BRVAS – Access Road Feasibility Study, Sturgeon Consulting, Draft Report dated May 2018

Annexure B: Conceptual Design Drawings

Annexure C: Specific Dust Suppression Measures

LIST OF TABLES AND FIGURES

Figures

Tables

CONSULTING SERVICES FOR THE BERG RIVER-VOËLVLEI AUGMENTATION SCHEME (BRVAS)

ACCESS ROADS - CONCEPT DESIGN

ABBREVIATIONS AND ACRONYMS

AEJV	Amanzi Entaba Joint Venture
BRVAS	Berg River Voëlvlei Augmentation Scheme
CCT	City of Cape Town
dia	diameter
DN	Nominal Diameter
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
h	hours
JV	Joint Venture
km	kilometre
m	meter
m asl	meter above sea level
m^3/s	cubic meters per second
m/s	metre per second
$ℓ/m^2$	litre per square meter
km/h	kilometre per hour
NDU	Natural Drainage Unit
OMC	Optimum Moisture Content
NME	Nano-Modified Emulsions
DCP	Dynamic Cone Penetrometer
O&M	Operation and Maintenance
PDBC	Plant and Design Build Contract
RID	Record of Implementation Decision
TCTA	Trans-Caledon Tunnel Authority
WCWSS	Western Cape Water Supply System
DT&PW	Western Cape Department of Transport & Public Works
DRE	District Roads Engineer

1. INTRODUCTION

1.1. Scope

During the development of the tender documentation the need to further investigate access to the abstraction works on both banks of the Berg River was identified. The following access requirements were identified for further investigation:

- Access for construction vehicles to the pumping station and weir on the left bank of the river.
- Access for construction vehicles to the weir and the earth-fill embankment on the right bank of the river.
- Permanent access to the pumping station for operational and maintenance vehicles on the left bank of the river.

This report addresses the abovementioned aspects with specific focus on the following:

- Assessment of the current condition of the minor roads to be affected by construction vehicles during the construction of the abstraction works (inclusive of the weir, pumping station and earth-fill embankment) and pipeline.
- Assessment of improvements (geometric alignment, drainage and pavement strength) to be implemented by the contractor; prior, during and at the end of the project.
- Develop a concept design for the permanent access road to the pumping station located on private land.
- Formulate options for the temporary access road required to provide access for construction vehicles to the earth embankment area on the right bank of the river as discussed between TCTA and AEJV representatives during a site visit held on the 14th of February 2022.

1.2. Background and Relevant Documentation

The Department of Water and Sanitation identified the need for augmentation of the Western Cape Water Supply System some years ago and proceeded with pre-feasibility and feasibility studies into potential surface water development options, which led to the identification of the BRVAS as the preferred option. As part of the previous studies an Access Road Feasibility Study was conducted by Messrs Sturgeon Consulting and completed in mid-2018. For ease of reference the report is attached as Annexure A to this report. The study assessed the wider road network in and around the project area and the proclaimed provincial road network servicing the area is indicated in Figure 1 below.

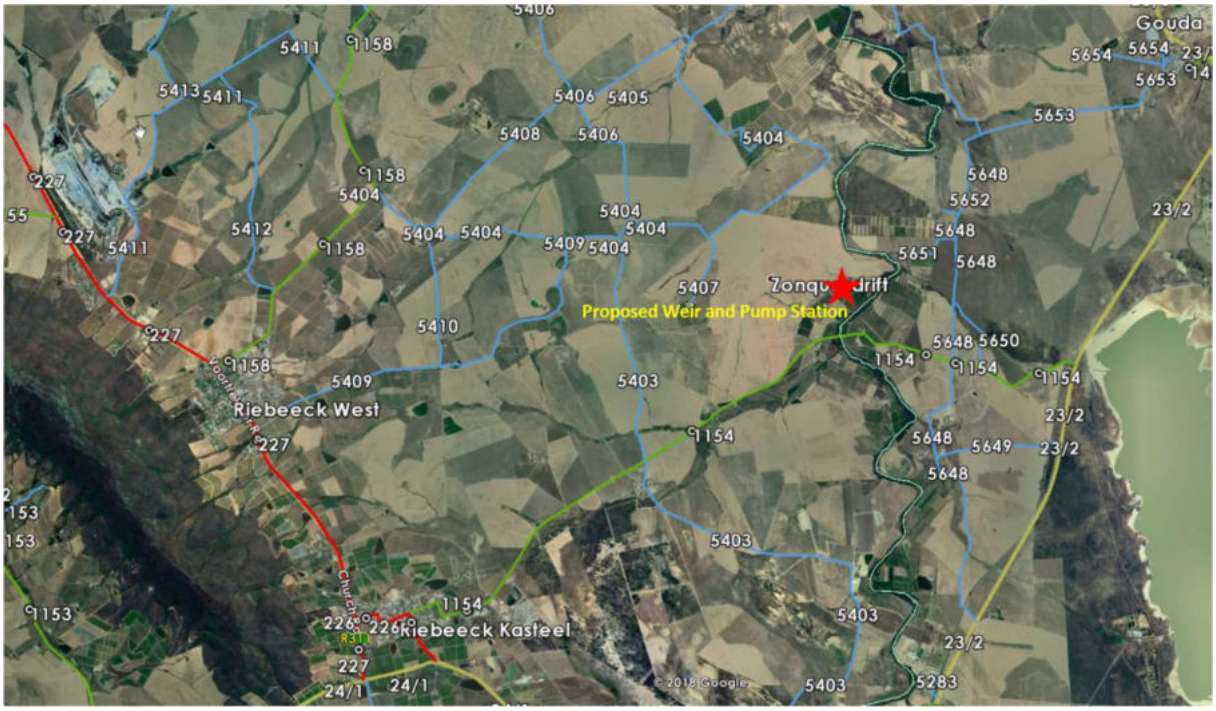


Figure 1: Proclaimed Provincial Road Network (Public Road Right of Way)

The feasibility study addressed among other the following traffic engineering aspects:

- Site observations;
- Engagement with relevant Provincial Roads Departments;
- Traffic counts at the following intersections;
  - TR2302/DR1154 (Voëlvlei Dam - R46) (Pieter Cruythoff Avenue/R46)
  - MR226/DR1154 (Riebeek Kasteel) (Retief Street/Hermon Street)
- Analysis of traffic impact during construction and operational phases;
- Confirmation of upgrade standards from Provincial Roads Design Branch; and
- Conceptual Cost Estimate for possible road upgrades and maintenance thereof.

The consolidated recommendations of the abovementioned feasibility study are listed below:

- That the existing Proclaimed Public Road Network (OP5403 and OP5404; also referred to as 'Minor Roads') be used as the preferred access to the Site during both the Construction Phase (±10 months) and Operational Phase (5 to 6 months in the Winter).
- A 40 km/h speed limit be implemented on the proposed access road with the approval of the Western Cape Department of Transport and Public Works (DT&PW).
- As this is not a change in land use application, access via OP5403 and OP5404 is legal for the construction of the weir and pump station. However, it is unlikely that the Department of Transport and Public Works will contribute towards the upgrade of the road. The District Roads Engineer (DRE) in Ceres may assist with grading the road during the construction period.
- The necessary dust suppression measures be implemented.

During the initial stages of the development of the contract documentation and concept designs for the BRVAS project a few aspects were identified that required amendments to the abovementioned feasibility study.

These aspects are the following:

- The utilisation of OP5403 was discarded for the following reasons;
  - Horizontal geometric alignment that included more sharp bends than OP5404, and
  - Numerous gates installed by farmers to control livestock movement and improve security.
- Inclusion of access via OP5648 to the area for construction of the earth-fill embankment on the right bank of the river.

1.3. Location of Roads

Following initial investigations, the roads to be included in this report for assessment and concept design (in the case of the permanent access road to the pumping station) were finalised and are shown in Figure 2 below.

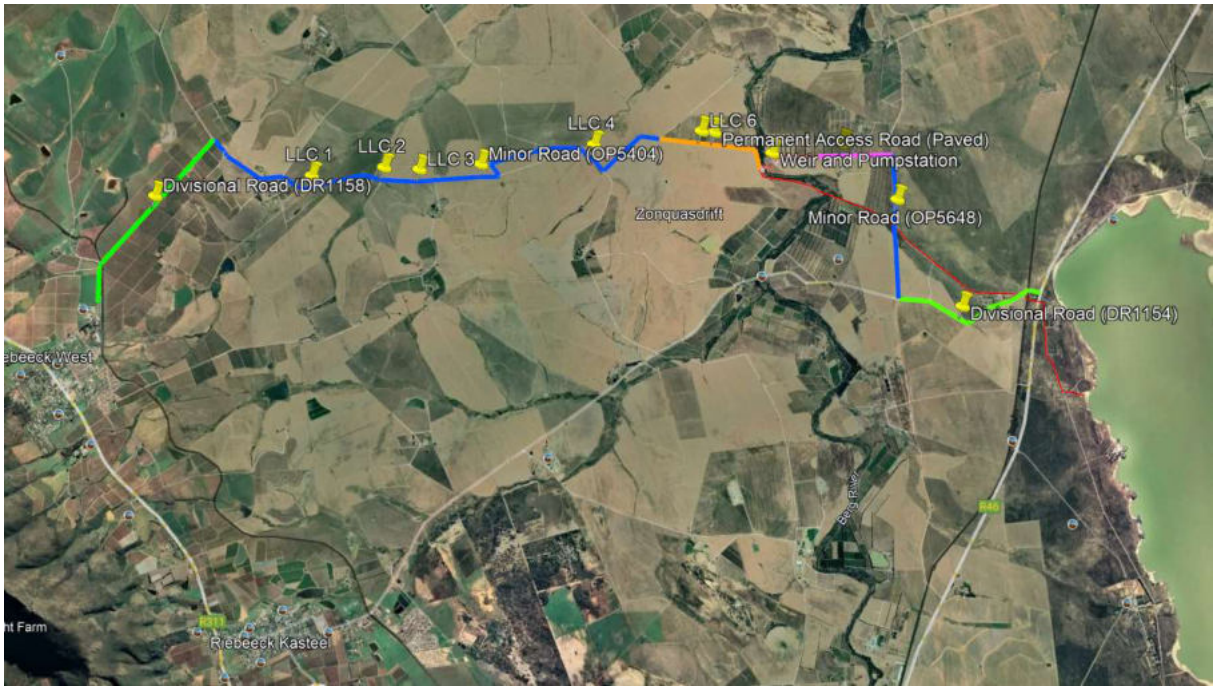


Figure 2: Roads providing access to the Site

2. DESIGN CRITERIA / CONSIDERATIONS

This section highlights the following:

- Design considerations to be considered by the contractor in the taking over, maintaining and handing back of provincial roads (unpaved Divisional Roads and Minor Roads) to the DT&PW.
- Design criteria / considerations in the design of the permanent access road to the proposed pumping station.

2.1. Provincial Roads

a) General

i) Divisional Roads

Divisional Roads are mostly paved and where access is assumed via paved roads no further investigations were carried out in line with discussion with the DT&PW. However, where Divisional Roads are not paved the Dynamic Cone Penetrometer (DPC) testing was carried out.

ii) Minor Roads

Minor Roads are not paved and where access is assumed, Dynamic Cone Penetrometer (DPC) testing was carried out along the centre lines of these roads.

The abovementioned approach was followed to determine the basic condition of the gravel roads and to assess their suitability to accommodate construction vehicle traffic. The results enabled the AEJV to recommend preventative measures, routine maintenance measures and close-out measures to ensure that the roads will be handed back to the DT&PW at the end of construction in a condition similar or better than at the start of construction activities.

b) Road Signage and Traffic Management

i) Road Signage

All road traffic signs are to be designed and installed as per the South African Road Traffic Signs Manual – Revision 2015.

ii) Traffic Management & Safety

The contractor shall compile a holistic site wide Traffic Management Plan that will be submitted to the DT&PW and the Engineer for approval and acceptance. The contractor shall introduce the following:

- Ensure that the speed limit as prescribed in the Design Considerations is adhered to.
- Fit all road going construction vehicles with a satellite tracking system that will record all traffic movement in real time.
- Data recorded will be assessed for transgressions and handed over to the client on a monthly supported by a report highlighting transgressions and remedial steps taken to rectify behaviour of drivers/operators.

2.2. Permanent Access Road

a) Geometric Design

The geometric design standards should follow the TRH17 guidelines. A summary of the recommended Design Criteria for the permanent access road is included in Table 1 below.

Table 1: Summary of Design Standards for the Access Road

Description		Value
General	Design vehicle: Geometry	WB-12 Truck
General	Design vehicle: Stop sight distance	Passenger car
General	Design Speed: General areas	30 km/h
General	Design Speed: Intersections and 90º bends	< 15 km/h
HOR	Road width	4.0 m
HOR	Lane width	N/A
HOR	Minimum Radius: General areas	60 m
HOR	Minimum Radius: Intersections and 90º bends	25 m
HOR	Stop sight distance	50 m
HOR	Eye height	1 080 mm
HOR	Object Height	600 mm
Cross-fall	General cross fall slope	2%
Cross-fall	Maximum Super elevation	N/A
Cross-fall	Runoff Length Total	N/A
Cross-fall	Runoff Length on straight	N/A
Cross-fall	Runoff Length on curve	N/A
VER	Maximum grade: Flat areas	6%
VER	Min K-value: Crest	12
VER	Min K-value: Sag	12
VER	Minimum Curve Length	60 m

b) Pavement Design

i) Standards and Codes

The following standard specifications and codes of practice are relevant to the design of the internal and access roads:

- Structural Design of Flexible Pavements for Interurban and Rural Roads: TRH4; 1996.
- Traffic Loading for Pavement and Rehabilitation Design: TRH 16; 1991.
- Standard Specification of Road and Bridge Works for State Road Authorities: COLTO; 1998
- All road traffic signs are to be designed and installed as per the South African Road Traffic Signs Manual – Revision 2015.
- South African Pavement Engineering Manual (SAPEM): Chapter 10: Pavement Design; 2013.
- Design of Segmental Block Pavements for South Africa: UTG2 ;1987.
- Human Settlement Planning and Design Volume 2: ISBN 0-7988-5498-7

ii) Design Parameters

The following general parameters were utilized to define the functional requirements of the road pavement and the environmental conditions under which they must perform:

- Base year for analysis: 2022
- Pavement Design Life: 20+ years
- Road Category: UC
- Design Confidence Limit: 80%
- Required subgrade cover: 800mm
- Pavement Type (s): Semi -rigid

iii) Traffic Analysis

The permanent road will only be used when maintenance is required. An UC street category is considered feasible for this project. It is required that a **design class of ES1** is considered for this road.

c) Drainage Design

The design criteria for storm water are summarised in Table 2 below:

Table 2: Design Criteria for Drainage Structures

Description	Value
Flood return period	1:5 years
Minimum time of concentration or storm duration	To be determined
Runoff coefficient: for Rational Method	To be determined
Design method	Rational method
Minimum Pipe Diameter	600 mm ND class 100D external, to SANS 10677
Minimum pipe gradient	0.67% - 1:150
Low-level crossings	As per the details of DRAWING NO. 021.001-A-C6-200

d) Fencing

The road shall be fenced off by means of a seven-strand barbed wire cattle fence and provided with a lockable vehicle gate at the junction with Minor Road OP5404.

2.3. Temporary Access Roads

a) General

A summary of the Design Criteria for the temporary access roads Table 3 below.

Table 3: Design Criteria for Temporary Access Roads

Description		Value
General	Design vehicle: Geometry	WB-15 Truck
General	Design vehicle: Stop sight distance	Passenger car
General	Design Speed: General areas	30 km/h
General	Design Speed: Intersections and 90º bends	< 15 km/h
General	Lane separation to be applied by means of a safety earth-fill berm to separate construction vehicles	Earth-fill berm to be a minimum height of half the design vehicle wheel diameter
HOR	Road width	5.0 m
HOR	Lane width	N/A
HOR	Minimum Radius: General areas	60 m
HOR	Minimum Radius: Intersections and 90º bends	25 m
HOR	Stop sight distance	50 m
HOR	Eye height	1 080 mm
HOR	Object Height	600 mm
Cross-fall	General cross fall slope	3%
Cross-fall	Maximum Super elevation	N/A
Cross-fall	Runoff Length Total	N/A
Cross-fall	Runoff Length on straight	N/A
Cross-fall	Runoff Length on curve	N/A
VER	Maximum grade: Flat areas	6%
VER	Min K-value: Crest	12
VER	Min K-value: Sag	12
VER	Minimum Curve Length	60 m

b) Fencing

The roads shall be fenced off by means of a seven-strand barbed wire cattle fence and provided with a lockable vehicle gates at the junction with Minor Roads OP5404 and OP5648.

3. DESIGN

3.1. Provincial Roads

a) General

The gravel roads were evaluated in terms of the DCPs that were conducted on the centreline of the road. The DCP in general indicated, fair bearing capacity when compared to a traffic curve of 20 to 60 heavy vehicles per day.

The upper 200 mm of the road must be ripped, reworked, shaped and compacted to ensure a camber shaped base with 3% crossfall. The road shall be ripped and reshaped every 6 months to ensure no corrugation. If treated with Nano-Modified Emulsions (NME) or similar approved these processes can be delayed depending on the performance.

b) Dust Suppression

Treatment of gravel roads to protect the gravel layer and reduce dust.

All preparations of the NME materials and construction processes and testing as per normal construction and rehabilitation of roads shall be included in a project specification. The surface of the wearing course should receive additional treated as follows:

- Providing a temporary wearing course

Immediately after completion of the compaction described in subsection (l), Nano-Silane Nano-Polymer prime shall be applied to the finished surface using a water truck (or by hand sprayer) at a pray rate of 1 ℓ/m². The spray rate may be adjusted by the Engineer following a trial section of not less than 100 m.

As alternative, a 50:50 diluted anionic NME may be sprayed onto the layer and compacted using a steel wheeled roller with a mass of not less than 12 tons each, and/or with pneumatic rollers.

The following process is to be followed:

1. Immediately after compaction, slushing of the surface will commence: Spray 1 ℓ/m² of the diluted NME onto the surface followed immediately with further compaction by means of a 13-ton vibratory roller which must follow directly behind the water cart. A 22-ton pneumatic tyre roller (PTR) must then follow directly behind the vibratory roller.
2. Turn around and on the same strip have the water cart first drenching the surface with a further 1 ℓ/m² diluted NME. This time the pneumatic tyre roller follows directly behind the water cart and the vibratory roller follows closely behind the PTR. It is important that the water cart and roller must always work in close tandem; to prevent any pick-up of the material onto the drum of the vibratory roller (although unusual with nano-modified emulsion).
3. Continue points 1 and 2 until the total area to be worked is completed.
4. The area treated then is to be kept closed to traffic for it to properly set (until the top 50 mm of the layer has dried out) with the moisture content of OMC < 50%. The time of required closure is dependent on the prevailing weather and may be as short as 1 hour. Due to the addition of the silane modification a hydrophobic material surface is created, and water is effectively repelled from the layer. Hence, stabilised layers constructed using an anionic NME stabilising agent normally dries much quicker than pavement layers treated using traditional emulsion stabilisation processes which depend only on evaporation as a method of drying. In dry and hot conditions, a pavement layer can sufficiently dry within a period of less than 24 hours to reach 50% of OMC.

The final surface should be smooth, tightly knit, and free of undulations, corrugations, holes, bumps or loose material.

The application of an applicable compatible prime (i.e. a recommended compatible Nano-silane Nano-Polymer based prime) when the base has reached a moisture content of 50% of OMC should prevent most damage under conditions of light trafficking in urban areas. Heavy brushing with soft bristles is recommended prior to the application of the prime to remove any dust or loose materials on the surface, not disturbing the surface itself. The instructions of the supplier should apply - the risk remains with the contractor to achieve an acceptable required base condition after application of the prime. Experience has shown that an applicable Nano-silane Nano-Polymer modified prime will dry within an hour. In cases where the surfacing is applied immediately, the prime may be substituted by an appropriate specified tack-coat. However, this is only applicable to cases where the contractor can ensure that the surfacing material and equipment is available for immediate application.

Additional protection of the surface can be provided by the application of a Nano-Silane Nano-Polymer “clear seal”. The clear seal is applied as per product specifications using a diluted compatible nano-silane modified nano-polymer (applied at 1.6 ℓ to 2 ℓ/m^2) clear surfacing similar to a traditional prime, but with an extended expected duration, especially on fine graded materials.

Details regarding the recommended material specifications for the treatment of wearing courses of gravel roads treated / stabilised with anionic NME are provided in Table 4 below.

Table 4: Recommended Material Specifications for the Treatment of Wearing Courses of Gravel roads treated / stabilised with anionic NME

Test or Indicator	Material[1]	Material classification NME4- WC
Minimum material requirements before stabilisation and/or treatment (Natural materials)		
Material spec.(minimum) Unstabilised material: Soaked CBR (%)(Mod AASHTO)	NG/GS/SSSG (CS)	> 7 (93%)
Sieve analysis % passing the 0.075 mm sieve ($P_{0.075}$)		< 50 %
XRD scans: - Total sample - 0.075 mm fraction	ALL ALL	√ √
The greater of: Identified % Silt and Clay, or % Material passing 2 µm ($P_{0.002}$) (e.g. Clay & Mica & Talc), with Talc <10%) (XRD-scans of the material passing the 0.075 mm sieve is recommended for use to determine the % clay, mica and talc in the material).	NME with emulsion particle size > 2 µm	
	ALL	< 15 %
	NME containing micro-scale as well as nano-scale particles (adjusted according to material grading)	
	ALL	< 35%
	NME with emulsion containing nano-scale and pico-scale particles (grading adjustments) together with technologies addressing workability of materials on site	
	ALL	> 35%
Material specifications after stabilisation and/or treatment		
In-situ density to be required after stabilisation and compaction (mod AASHTO) (%) (minimum)	Base-layer	> 97 %
DCP DN (mm/blow) – Adjusted for Climate (C_f)[2] (stabilised and compacted) (Quality control)	Top of base	< 3.5 / (C_f)
Mod AASHTO density (%) (for laboratory testing)		> 100%
*UCS_{wet} (kPa) (150 mm Φ Sample)	**Design[3]**	**> 750**
	Construction[4]	**> 450**
Retained Compressive Strength (RCS): (UCS_{wet}/UCS_{dry}) (%)		> 75
RCS in relation to minimum $UCS_{wet\ (criteria)}$ ($RCS_{effective}$): (RCS x ($UCS_{wet}/UCS_{wet\ (criteria)}$)) (%)		> 100
*ITS_{wet} (kPa) (150 mm Φ Sample)	**Design[3]**	**> 100**
	Construction[4]	**> 80**
Retained Tensile strength (RTS): ITS_{wet}/ITS_{dry} (%)		> 60
RTS in relation to minimum $ITS_{wet\ (criteria)}$ ($RTS_{effective}$) ((RTS x ($ITS_{wet}/ITS_{wet\ (criteria)}$)) (%)		> 100

[1]CS–Crushed Stone; NG – Natural Gravel; GS – Gravel Soil, and SSSC – Sand, Silty sand, Silt, Clay. UCS_{dry}; ITS_{dry} = testing after rapid curing; UCS_{wet}; ITS_{wet} = testing after rapid curing + 4 hours in water;

[2]Climatic factor (C_f) (Jordaan and Steyn, 2019) for required DCP-DN

Design[3] = Minimum criteria to be met in the laboratory during the design phase

Construction[4] = Minimum criteria to be met during construction as part of quality control

c) Geometric Design

No amendments are proposed to the geometric design of the provincial roads.

d) Drainage Design

Road drainage improvements are recommended at the locations along the OP5404 as indicated on DRAWING NO. 021.001-A-C3-206 (included in Annexure B). These improvements are aimed at providing save crossing of minor water courses during the rainy season. As a minimum these improvements shall include the following:

- Providing low-level crossing structures as indicated on DRAWING NO. 021.001-A-C6-200 (included in Annexure B), suitable to accommodate construction traffic.
- Providing side drains as required, leading up to these crossings.
- All low-level crossing structures must be designed to accommodate a flood with a 1 in 5-year recurrence interval.
- Maximum water depth during the abovementioned flood event must be limited to 150 mm across the base of the low-level crossing structures.

e) Road Traffic Signs

Appropriate road traffic signs must be erected at the following points:

- **Information signs:** At entry points onto the Minor Road system that will be used by construction traffic. To be approved by the DT&PW and the Engineer.
- **Warning signs:** At regular intervals indicating the speed limit as per the Design Criteria.
- **Warning signs:** At railway crossings and low-level water crossings.
- **Warning signs:** At points before sharp bends indicating prompting drivers to reduce speed. The signs must also highlight the reduced speed limit through these sections as per the Design Criteria.

3.2. Permanent Access Road

a) Geometric Design

The geometric design of the permanent access road must conform to the Design Criteria and be guided by the design as included on the following conceptual design drawings (included in Annexure B):

- DRAWING NO. 021.001-A-C3-201
- DRAWING NO. 021.001-A-C3-202
- DRAWING NO. 021.001-A-C3-203
- DRAWING NO. 021.001-A-C3-204
- DRAWING NO. 021.001-A-C3-205

b) Pavement Design

The parameters that were used for the pavement structure are as follows:

- Typical vehicle Heavy deliveries and Farm vehicles
- Road Category UC

It is anticipated that light vehicles (including taxes and short heavy vehicles) will make use of the access road. Provision should be made in the design for this possibility.

Based on the above Table 5 below includes a concept pavement design for the permanent access road.

Table 5: Proposed Pavement Structure based on Human Settlements Guide

Thickness (mm)	Layer	Type of Layer	Description
80	Base	Interlocking paving blocks (type S-A)	Laid in herringbone bond
20	Bedding Sand	Sand (SND)	Commercial clean river sand, grading as per COLTO 7302 (a)
150	Sub-base	Stabilised Natural gravel (C4), Imported Material	Min. UCS of 1.5 MPa at 100% Mod. AASHTO, min ITS of 250 kPa at 100% Mod. AASHTO compacted to 97% MDD
150	Upper Selected /Fill	Natural gravel (G7), Imported Material	Compacted to 95% Mod. AASHTO density, min. CBR of 15% at density specified for the layer, Max PI of 12 or 2(GM)+10. Compacted in 150 mm layer lifts.
Semi-infinite	In-situ	In situ	Rip and recompact 300 mm in place. Apply three roller pass treatment to the roadbed using a vibrating roller or padfoot roller and finished off with a single axle pneumatic roller. If stable, compact the roadbed to at least 93% of MDD.

c) Drainage Design

Drainage must conform to the Design Criteria and be guided by the design as highlighted in DRAWING NO. 021.001-A-C6-200 (included in Annexure B).

As a minimum the drainage infrastructure shall include the following:

- Providing low-level crossing structures as indicated on the abovementioned drawings.
- Providing trapezoidal side drains as required, leading up to these crossings.
- All low-level crossing structures and trapezoidal side drains must be designed to accommodate a flood with a 1 in 5-year recurrence interval.
- Maximum water depth during the abovementioned flood event must be limited to 150 mm across the base of the low-level crossing structures.

d) Road Traffic Signs

Warning signs: At points before sharp bends indicating prompting drivers to reduce speed. The signs must also highlight the reduced speed limit through these sections as per the Design Criteria.

3.3. Temporary Access Roads

The designs by the contractor shall conform to the Design Criteria proposed in Section 2.3 of the report and shall be submitted to the Engineer for acceptance.

In his design the contractor shall ensure the following:

- The roadbed preparation and pavement design are in accordance with the requirements of the proposed construction vehicles.

- Drainage is of such a nature to minimise erosion and mitigate any negative impact on adjacent land.
- Dust suppression is carried out in accordance with the Design Criteria.
- Upon completion of the project all temporary access roadworks is to be removed and the areas used for the temporary roads must be rehabilitated to their former condition.

4. CONCLUSION

The objective of this report is to give guidance to the contractor/designer regarding important aspects to be considered in the design of the access roads. It further provides details regarding Design Criteria / Considerations that are included in the Employer's Requirements and that will have to be met by the contractor in his design of the roads.

ANNEXURE A

Access Road Feasibility Study, Draft Report dated May 2018

No 5 Kleinmelkbos, George Mellet Crescent, Melkbosstrand, 7441
Postnet Suite #347, Private Bag x1, Melkbosstrand, 7437
t: 021 553 4167 f: 086 559 5327

BERG RIVER-VOËLVLEI AUGMENTATION SCHEME (BRVAS)

ACCESS ROAD FEASIBILITY STUDY

Project No.: STUR0219

DRAFT REPORT
May 2018

PREPARED BY:
STURGEON CONSULTING (PTY) LTD
Postnet Suite 347
P/Bag x1
Melkbosstrand
7437

CONTACT PERSON:
Barend du Preez
Tel no: +27 (0)83 701 2299

PREPARED FOR:
NEMAI CONSULTING
PO Box 1673
Sunninghill
2157

CONTACT PERSON:
Ms S Gerber
Tel no: +27 (0)11 781 1730

DOCUMENT CONTROL SHEET

DATE	REPORT STATUS	AUTHORED BY:	APPROVED BY:
14 May 2018	Draft for comment	NAME Sarah Larratt, Pr. Tech Eng	NAME Barend du Preez, Pr. Eng
		SIGNATURE 	SIGNATURE 
		NAME	NAME
		SIGNATURE	SIGNATURE

TITLE:

BERG RIVER-VOËLVLEI AUGMENTATION SCHEME (BRVAS)

ACCESS ROAD FEASIBILITY STUDY

CARRIED OUT BY:
Sturgeon Consulting
Postnet Suite #347
Private Bag x1
Melkbosstrand
7437

Tel: +27 21 553 4167
Fax: +27 86 559 5327
Email: barend@sturgeonsa.co.za

COMMISSIONED BY:
NEMAI CONSULTING
PO Box 1673
Sunninghill
2157

Ms S Gerber

Email: SamanthaG@nemai.co.za

SYNOPSIS:
The primary purpose of this report is to evaluate the feasibility of the proposed access roads for the construction and operation of the weir and pump station on Portion 1 of Farm Sonquas Doordrift 648.

TABLE OF CONTENTS

FIGURES

TABLES

ACRONYMS

BRVAS - Berg River-Voëlvlei Augmentation Scheme
EIA - Environmental Impact Assessment
TIA – Transport Impact Assessment
WTW - Water Treatment Works
WCG – Western Cape Government
NMT – Non-Motorised Transport
vph – Vehicles per Hour
COTO – Committee of Transport Officials
AMP – Access Management Plan
LOS – Level of Service
GLA – Gross Leasable Area
IPTN – Integrated Public Transport Network
AM – Morning
PM – Afternoon
d – Delay in Seconds

1. INTRODUCTION

1.1 APPOINTMENT AND BACKGROUND

Nemai Consulting has appointed Sturgeon Consulting to undertake a feasibility study for the alternative access roads to the proposed weir and pump station for construction and future maintenance of the Berg River-Voëlvlei Augmentation Scheme (BRVAS) as part of the Environmental Impact Assessment (EIA) for the Proposed Surface Water Developments for Augmentation of the Western Cape Water Supply System.

Department of Water and Sanitation identified the need for augmentation of the Western Cape Water Supply System by 2019 and proceeded with pre-feasibility and feasibility studies into potential surface water development options. Initially six options were assessed at a pre-feasibility level of detail. These options were then prioritized to identify the two most viable options. These were:

- Berg River-Voëlvlei Augmentation Scheme (also known as the First Phase Augmentation of Voëlvlei Dam); and
- Breede-Berg Transfer Scheme (also known as the Michell's Pass Diversion Scheme).

Ultimately, the Feasibility Study found that the BRVAS option was the most favourable surface water intervention and as such the Department of Water and Sanitation proposes to implement this scheme which involves the transfer of approximately 23 million m3 per annum from the Berg River to the existing Voëlvlei Dam (i.e. the yield of the dam would be 23 million m3 per annum more than it is currently).

The proposed project is situated in Western Cape in the Drakenstein Local Municipality of the Cape Winelands District as well as the Swartland Local Municipality of the West Coast District.

The proposed developments fall within the Berg River Catchment of the Berg–Olifants Water Management Area. Both Voëlvlei Dam and the Lorelei abstraction site are located in quaternary catchment G10F of the Berg River Catchment.

The project components include the following:

- A low-level weir, abstraction works and 4 m3/s raw water pump station on the Berg River;
- A rising main pipeline from the Berg River to Voëlvlei Dam; and
- A potential new summer release connection at the existing Swartland Water Treatment Works (WTW) to facilitate summer releases into the Berg River for environmental requirements thus eliminating the need to utilize the existing canal from which water losses occur.

All the infrastructure and activities that require environmental authorisation need to be assessed as part of the Environmental Impact Assessment. In this regard, the following associated infrastructure was identified:

- Abstraction works;
- Rising main pipeline and pump station;
- Diversion weir;

- Access roads during construction;
- Access roads during operation; and
- Construction camp (footprint).

1.2 SCOPE OF THIS REPORT

The primary purpose of this report is to evaluate the feasibility of the proposed access roads for the construction and operation of the weir and pump station on Portion 1 of Farm Sonquas Doordrift 648.

The scope of work for this feasibility study includes following traffic engineering aspects:

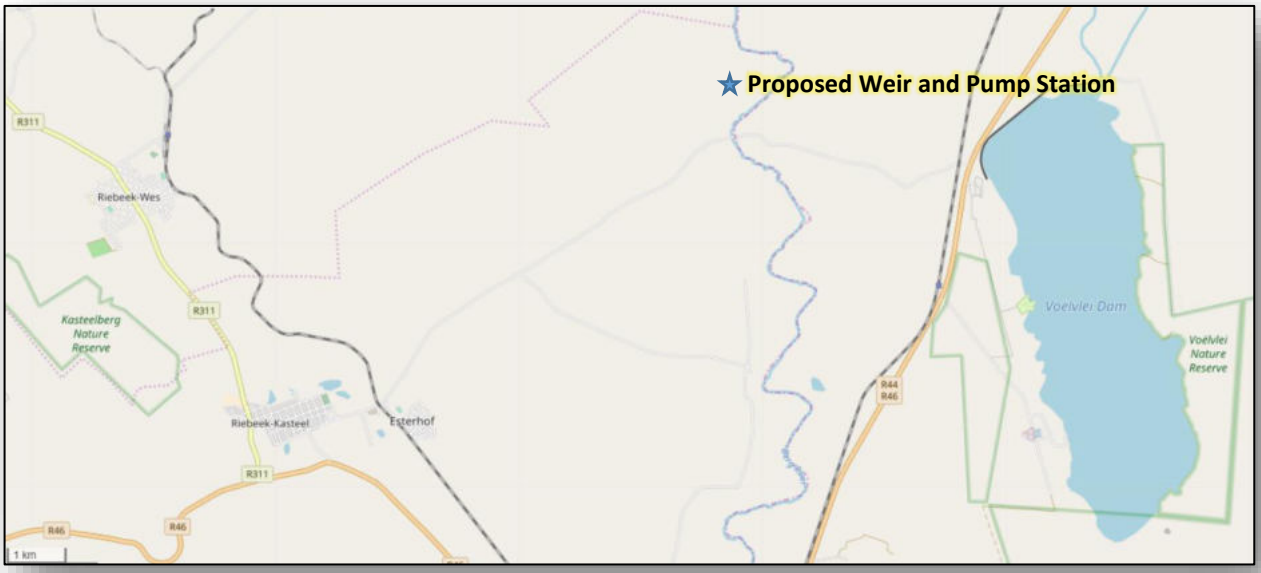
- Site observations
- Engagement with relevant Provincial Roads Departments
- Traffic counts at the following intersections:
    - TR2302/DR1154 (Voelvlei Dam - R46) (Pieter Cruythoff Avenue/R46)
    - MR226/DR1154 (Riebeeck Kasteel) (Retief Street/Hermon Street)
- Analysis of traffic impact during construction and operational phases
- Confirmation of upgrade standards from Provincial Roads Design Branch
- Conceptual Cost Estimate for possible road upgrades and maintenance thereof

2. SITE LOCATION

The proposed weir and pump station (hereafter called the Site) for the BRVAS are located in Berg River in the Zonquasdrift area halfway between Riebeeck West and Gouda as shown in **Figure 2.1** below.

Figure 2.1 – Site Location (Weir and Pump Station)

Source: Google Maps



Source: OpenStreetMap

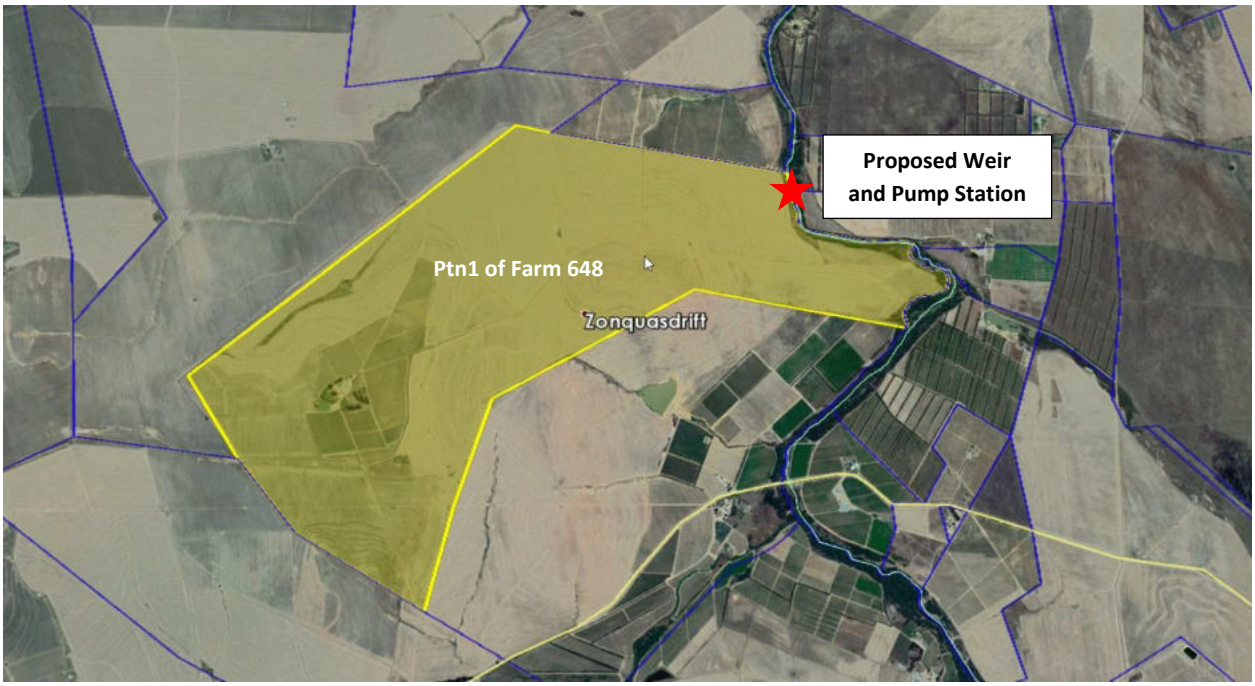
The different components of the proposed BRVAS project are illustrated in **Figure 2.3** and include the following:

- A low-level weir, abstraction works and 4 m^3/s raw water pump station on the Berg River;
- A rising main pipeline from the Berg River to Voëlvlei Dam; and
- A potential new summer release connection at the existing Swartland Water Treatment Works (WTW) to facilitate summer releases into the Berg River for environmental requirements thus eliminating the need to utilize the existing canal from which water losses occur.

The following infrastructure and activities requires environmental authorisation as part of the EIA. This included the following associated infrastructure:

- Abstraction works;
- Rising main pipeline and pump station;
- Diversion weir;
- **Access roads during construction;**
- **Access roads during operation**; and
- Construction camp (footprint).

Figure 2.2 – Close-up Aerial View of Location of proposed Weir and Pump Station



During the EIA process 2 access road routes were identified over Portion 2 of Farm 648 and Portion 1 of Farm 648 as indicated in **Figure 2.3**. Access Road 1 was identified as the preferred route as indicated in **Figure 2.4**. The preferred access road is approximately 6.6km long and runs along the western and northern boundary of the 2 farms. Possible access via public roads were not considered.

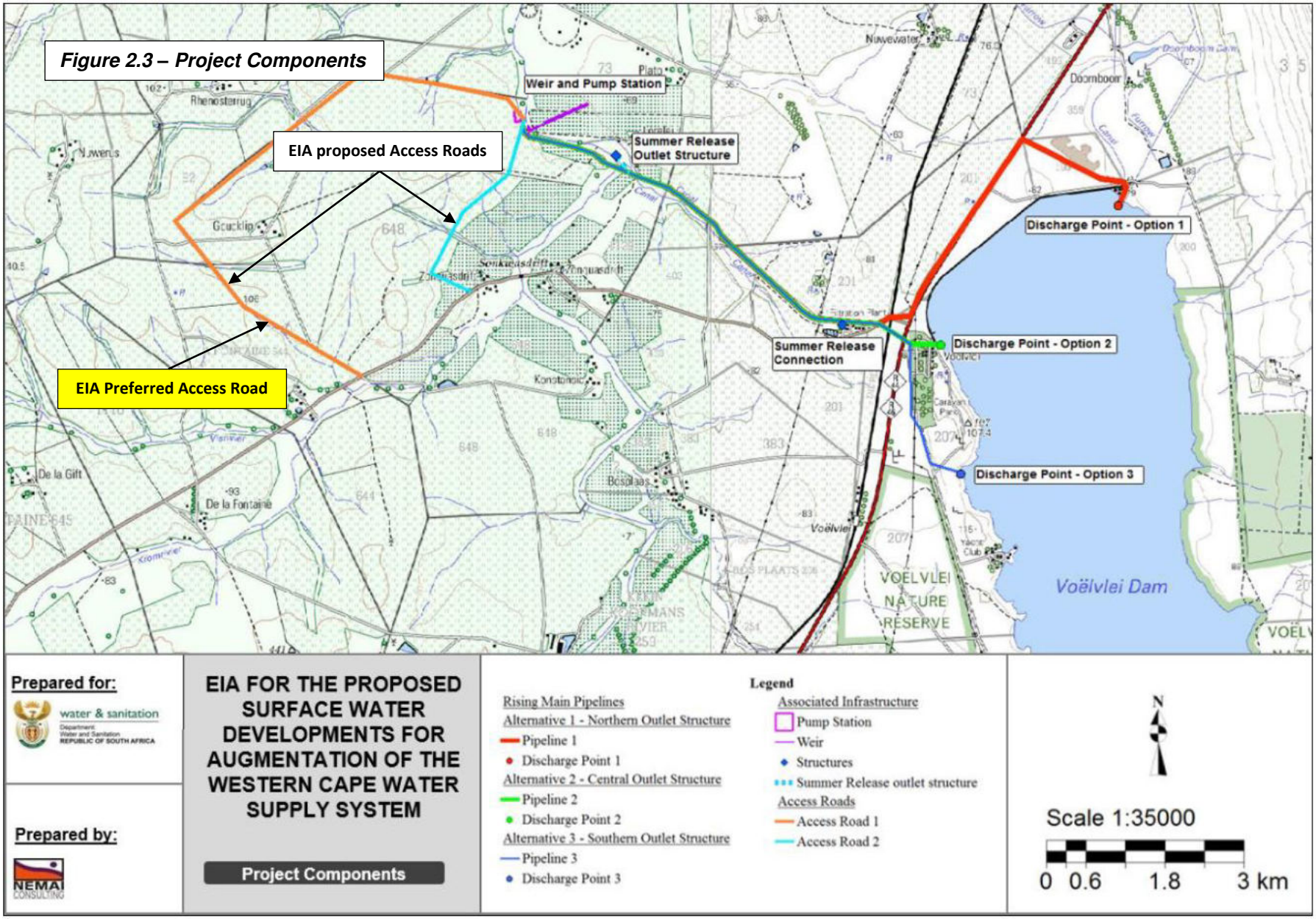
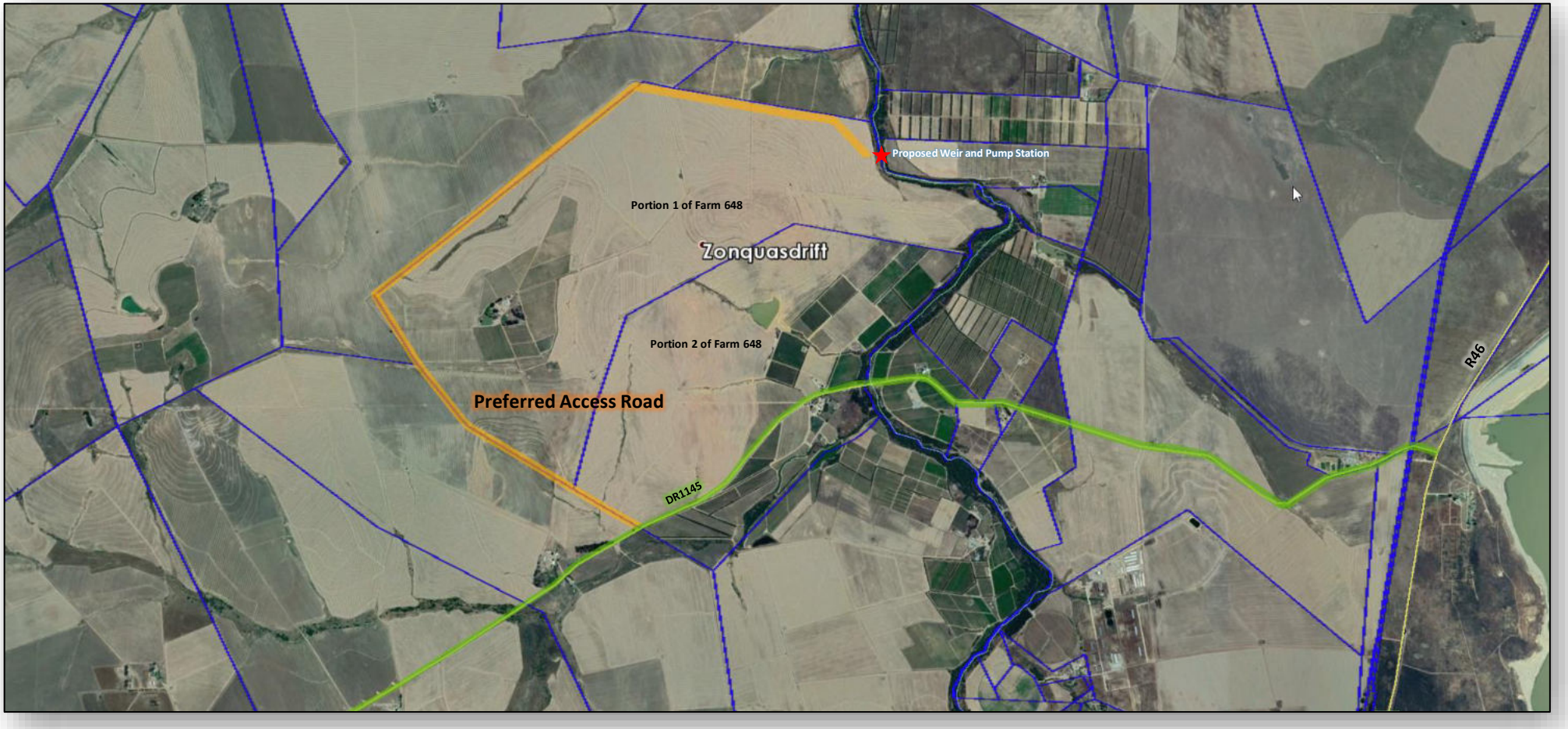


Figure 2.3 – Project Components
Weir and Pump Station
Summer Release Outlet Structure
EIA proposed Access Roads
EIA Preferred Access Road
Summer Release Connection
Discharge Point - Option 1
Discharge Point - Option 2
Discharge Point - Option 3
Voëlvlei Dam
VOELVLEI NATURE RESERVE
Prepared for:
water & sanitation
Prepared by:
NEMAI CONSULTING
EIA FOR THE PROPOSED SURFACE WATER DEVELOPMENTS FOR AUGMENTATION OF THE WESTERN CAPE WATER SUPPLY SYSTEM
Project Components
Legend
Rising Main Pipelines
Alternative 1 - Northern Outlet Structure
Pipeline 1
Discharge Point 1
Alternative 2 - Central Outlet Structure
Pipeline 2
Discharge Point 2
Alternative 3 - Southern Outlet Structure
Pipeline 3
Discharge Point 3
Associated Infrastructure
Pump Station
Weir
Structures
Summer Release outlet structure
Access Roads
Access Road 1
Access Road 2
N
Scale 1:35000
0 0.6 1.8 3 km

Figure 2.5: EIA Preferred Access Road



3. EXISTING ROAD INFRASTRUCTURE AND TRAFFIC DEMAND

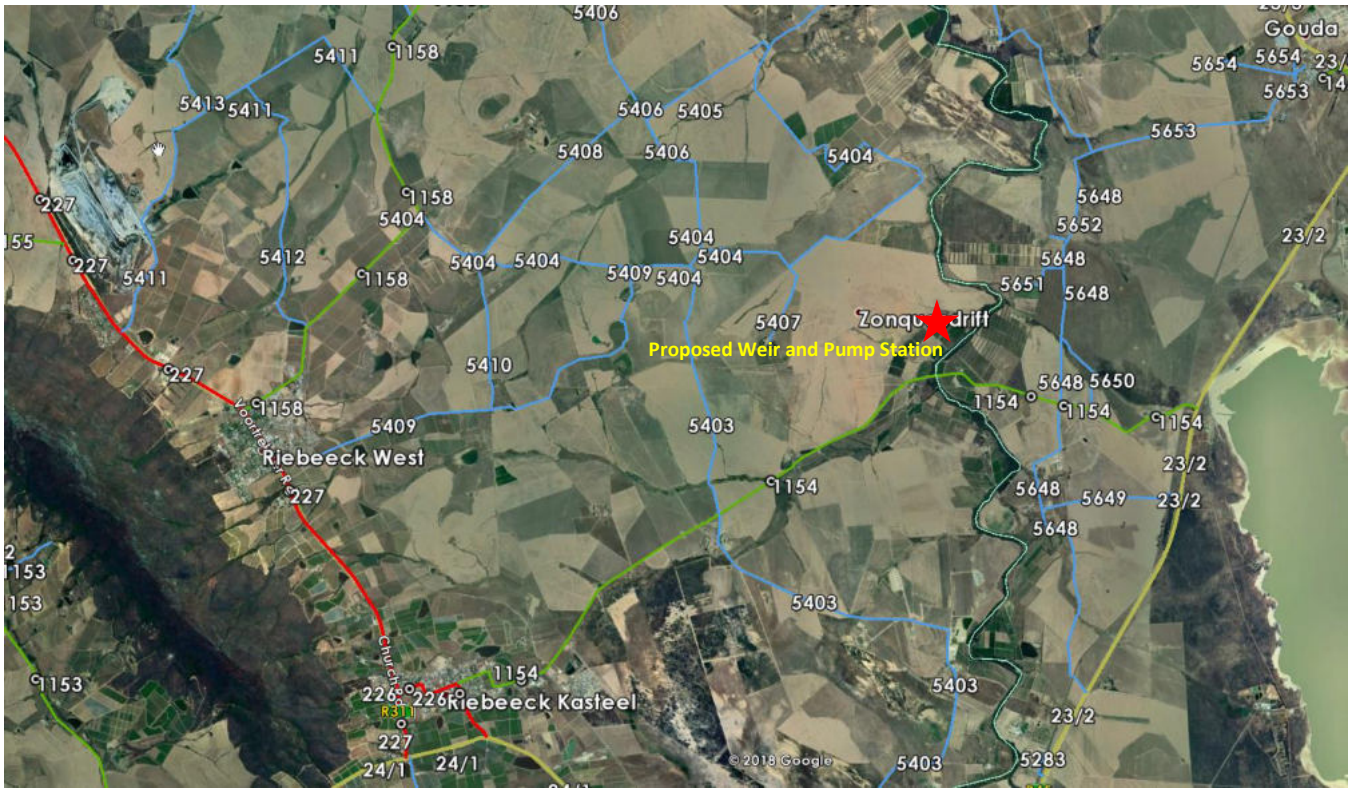
3.1 EXISTING ROAD INFRASTRUCTURE

The surrounding proclaimed public road network consists of the following roads as shown in **Figure 3.1**.

The main roads that could provide access to the project are:

- Main Road 227 (MR227) (R311) which provides regional access from Trunk Road 24 Section 1 (TR24/1) (R46) via Riebeeck Kasteel;
- MR226 through Riebeeck Kasteel providing a link between MR227 and TR24/1;
- Trunk Road 23 Section 2 (TR23/2) (R44) which connects Paarl/Wellington with Gouda and Tulbagh;
- Divisional Road 1154 (DR1154) which provides an east-west link between Riebeeck Kasteel and TR23/2; and
- Several Minor Roads provide access to the different farms in the vicinity of the project:
  - Minor Road 5403 (OP5403) which links DR1154 with OP5404; and
  - OP5404 which links DR1158 with OP5405;

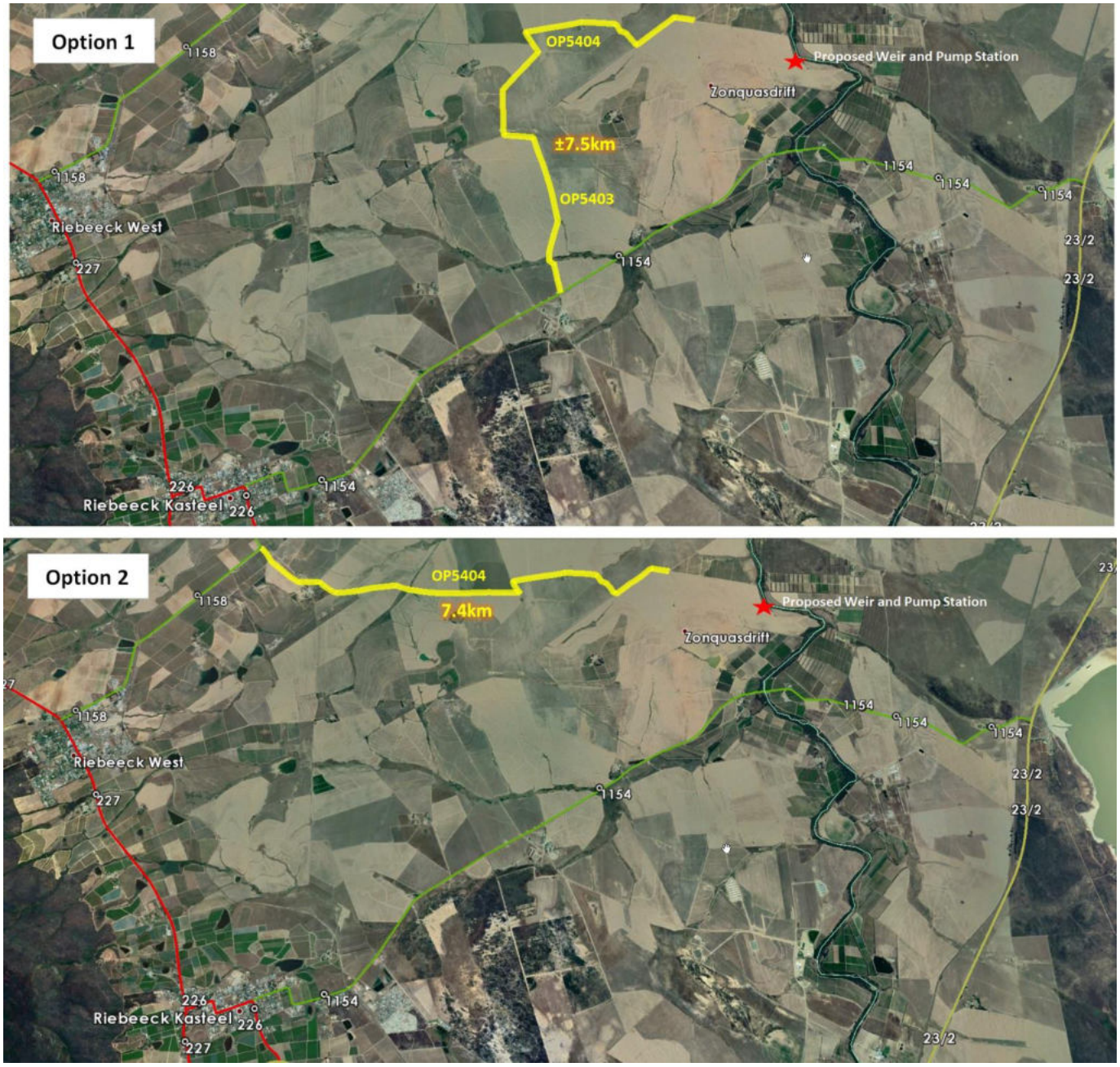
Figure 3.1 – Proclaimed Provincial Road Network (Public Road Right of Way)



3.2 POSSIBLE MINOR ROAD ACCESS ROUTES TO THE SITE

Several Proclaimed Minor Roads (OP) can provide public access to the Site. The first option, also the option on which this feasibility study is focussed, are OP5403 and OP5404 which is approximately 7.5km long. However, and alternative exists via OP5404 from the west (Riebeeck West) which is approximately 7.4km long as illustrated in **Figure 3.2**. Both these roads connect different farms with the major road network and has a public road right of way.

Figure 3.2 – Two Possible Proclaimed Minor Road (OP) Access Options



Option 1 can be accessed via DR1154 from Riebeeck Kasteel in the west and the R44 in the east adjacent to Voëlvlei dam.

Option 2 provides access from Riebeeck west via DR1158.

3.3 TRAFFIC DEMAND

The main access route to the Site is via DR1154 (Pieter Cruythoff Avenue) from either Riebeeck Kasteel or Voëlvlei Dam (R44). Depending on the choice of route to the Site the existing traffic demand along DR1154 were determined via 12-hour classified traffic counts that were conducted on 6 March 2018 at the following intersections as indicated in **Figure 3.3**:

- MR226 (Piet Retief Street/Hermon Street) – the main intersection providing access to DR1154 (4-way stop)
- DR1154 (Pieter Cruythoff Avenue)/TR23/2 (R46) – the T junction on the R46 (Stop control on DR1154)

The Road Network Information System operated by Western Cape Department of Transport and Public Works contains a Traffic Counting System (TCS) which serves the Western Cape Provincial Network and has been around since 1999. The main emphasis of the system is on Trunk, Main and Divisional roads - currently only Minor Roads (OPs) that intersect with more important roads are on the system. The TCS comprises of two "types" of counts namely: - Short Term and Permanent Counts. No Permanent counts are located close to the Site.

There are 3 TCS stations along DR1154 for which counts were recently conducted and indicated **Figure 3.3**:

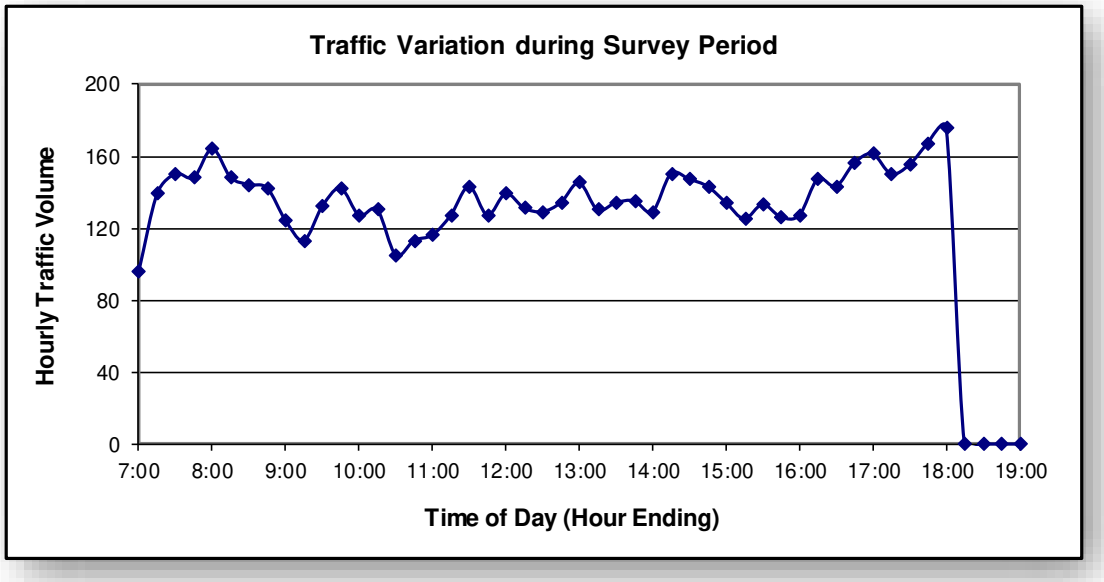
- Station No 0304 (MR226 (Piet Retief Street/Hermon Street)) (2 December 2015);
- Station No 0515 (18 June 2015); and
- Station No 0194 (Pieter Cruythoff Avenue/TR23/2 (R46)) (25 January 2016).

On DR1158 (Station Road) TCS Station No 0696 (DR1158) provides a vehicle count conducted on 17 June 2015.

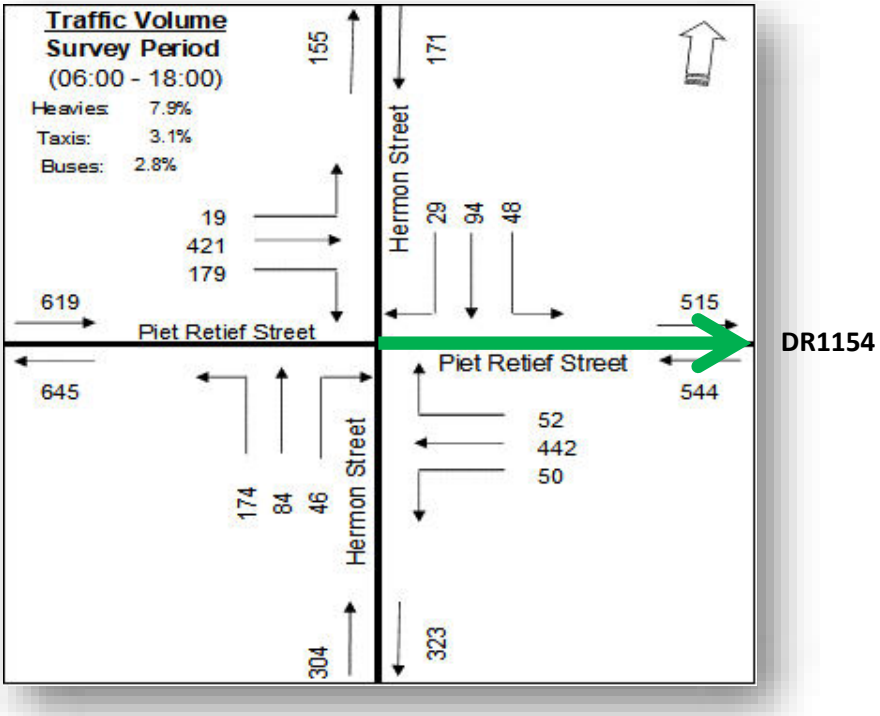
Figure 3.3 – Classified Traffic Count Locations

- **MR226 (Piet Retief Street)/Hermon Street (Station No 0304) Intersection**

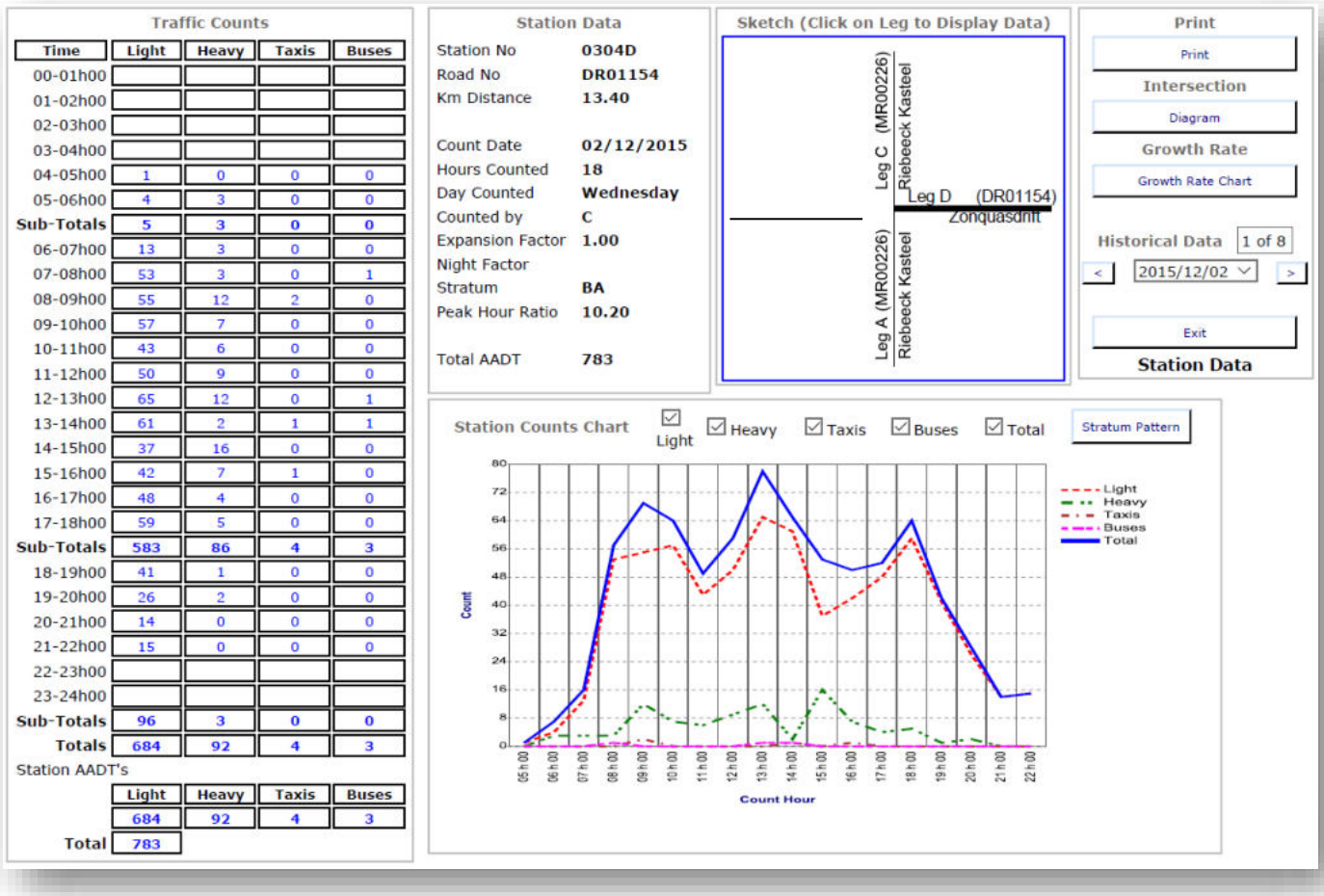
During the traffic count conducted on 6 March 2018, the intersection carried an average of approximately 130 vehicles per hour which is very low (<200) as indicated in the traffic variation graph below.



The total traffic on each leg of the intersection between 7:00 and 18:00 was:



The highest volumes occurred on Piet Retief Street (>1 000vpd 2-way). The intersection carries approximately 8% heavy vehicles. Piet Retief Street (DR1154) to the east carries approximately 1 060 vehicles (2-way) with almost 11% heavy vehicles.



Traffic Counts

Time	Light	Heavy	Taxis	Buses
00-01h00				
01-02h00				
02-03h00				
03-04h00				
04-05h00	1	0	0	0
05-06h00	4	3	0	0
Sub-Totals	**5**	**3**	**0**	**0**
06-07h00	13	3	0	0
07-08h00	53	3	0	1
08-09h00	55	12	2	0
09-10h00	57	7	0	0
10-11h00	43	6	0	0
11-12h00	50	9	0	0
12-13h00	65	12	0	1
13-14h00	61	2	1	1
14-15h00	37	16	0	0
15-16h00	42	7	1	0
16-17h00	48	4	0	0
17-18h00	59	5	0	0
Sub-Totals	**583**	**86**	**4**	**3**
18-19h00	41	1	0	0
19-20h00	26	2	0	0
20-21h00	14	0	0	0
21-22h00	15	0	0	0
22-23h00				
23-24h00				
Sub-Totals	**96**	**3**	**0**	**0**
Totals	**684**	**92**	**4**	**3**

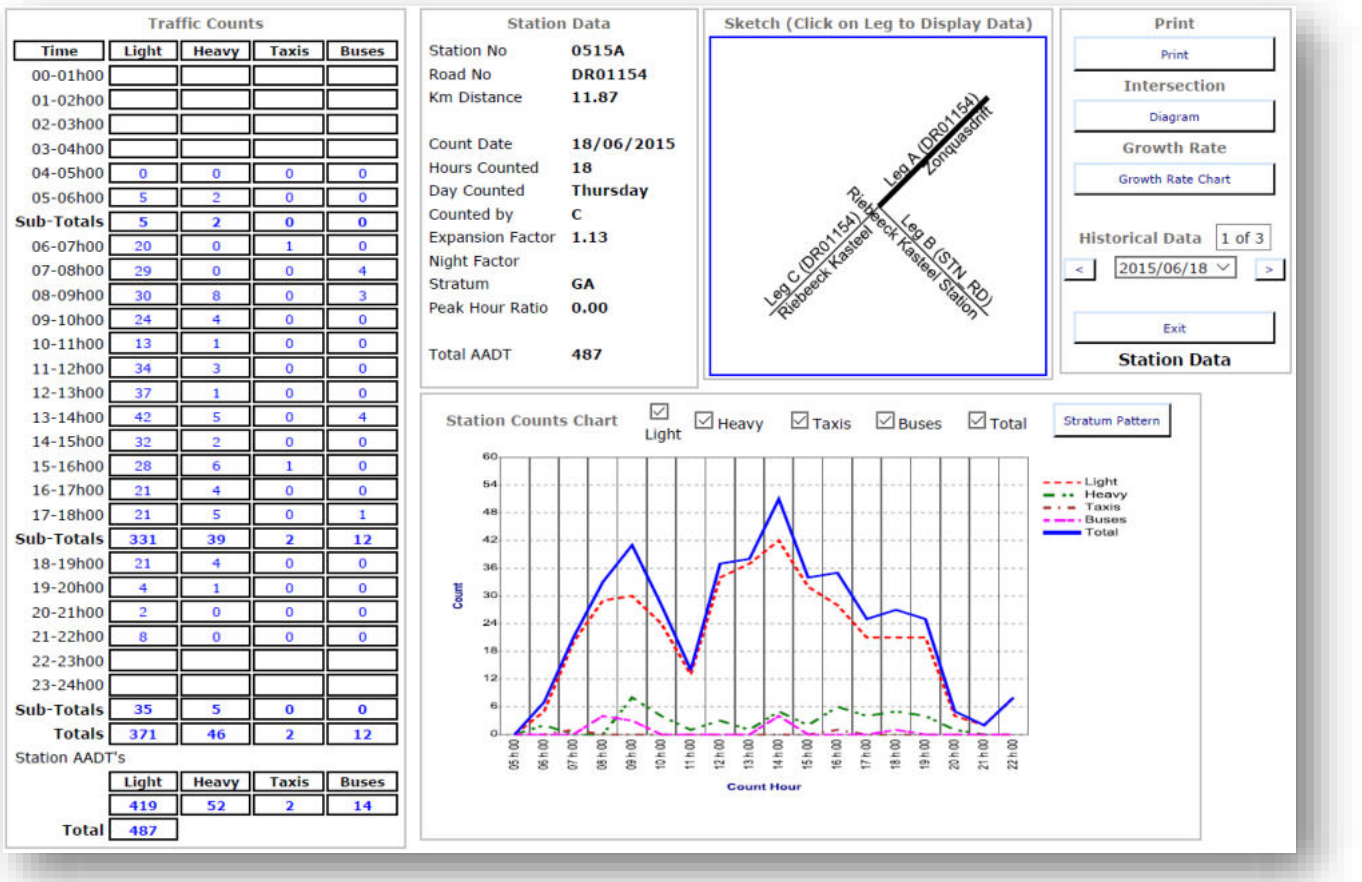
Station AADT's

	Light	Heavy	Taxis	Buses
	684	92	4	3
Total	783			

In December 2015 DR1154 had an Annual Average Daily Traffic (AADT) of almost 800 vpd (2-way) with approximately 12% heavy vehicles. However, the number of heavy vehicles were very low at less than 20 vph.

- **DR1154 (Pieter Cruythoff Avenue)/Station Road (Station No 0515) Intersection**

A TCS traffic count conducted on 18 June 2015 indicated a 2-way AADT of close to 500 vpd with approximate 14% heavies on DR1154 to the east. The extent of heavy vehicles per hour were very low (<10 vph).



Traffic Counts

Time	Light	Heavy	Taxis	Buses
00-01h00				
01-02h00				
02-03h00				
03-04h00				
04-05h00	0	0	0	0
05-06h00	5	2	0	0
Sub-Totals	**5**	**2**	**0**	**0**
06-07h00	20	0	1	0
07-08h00	29	0	0	4
08-09h00	30	8	0	3
09-10h00	24	4	0	0
10-11h00	13	1	0	0
11-12h00	34	3	0	0
12-13h00	37	1	0	0
13-14h00	42	5	0	4
14-15h00	32	2	0	0
15-16h00	28	6	1	0
16-17h00	21	4	0	0
17-18h00	21	5	0	1
Sub-Totals	**331**	**39**	**2**	**12**
18-19h00	21	4	0	0
19-20h00	4	1	0	0
20-21h00	2	0	0	0
21-22h00	8	0	0	0
22-23h00				
23-24h00				
Sub-Totals	**35**	**5**	**0**	**0**
Totals	**371**	**46**	**2**	**12**

Station AADT's

Light	Heavy	Taxis	Buses
419	52	2	14

Total 487

Station Data

Station No	0515A
Road No	DR01154
Km Distance	11.87
Count Date	18/06/2015
Hours Counted	18
Day Counted	Thursday
Counted by	C
Expansion Factor	1.13
Night Factor	
Stratum	GA
Peak Hour Ratio	0.00
Total AADT	487

Sketch (Click on Leg to Display Data)

Print

Print

Intersection

Diagram

Growth Rate

Growth Rate Chart

Historical Data 1 of 3

< 2015/06/18 >

Exit

Station Data

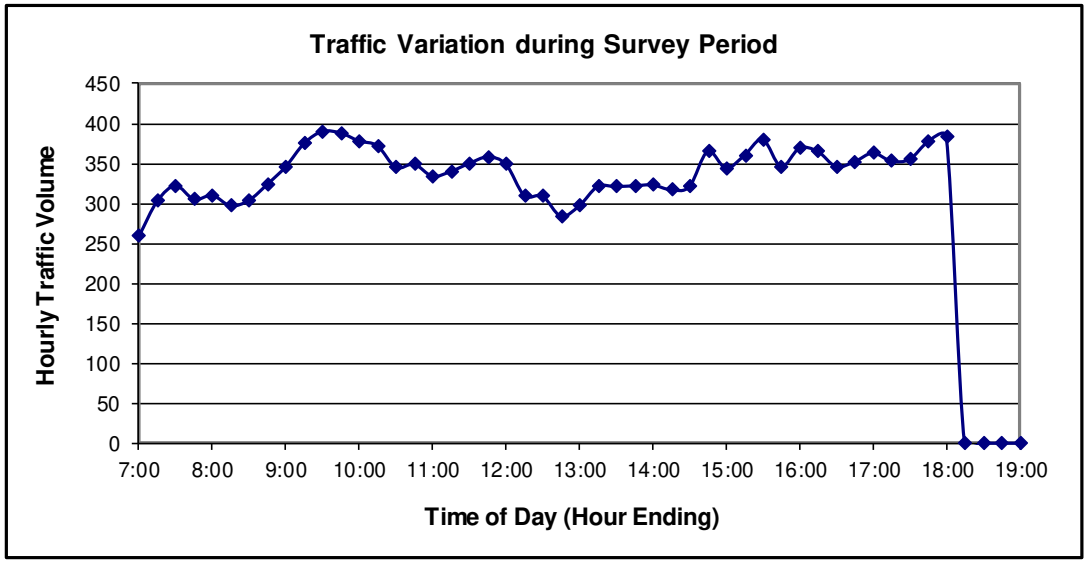
Station Counts Chart

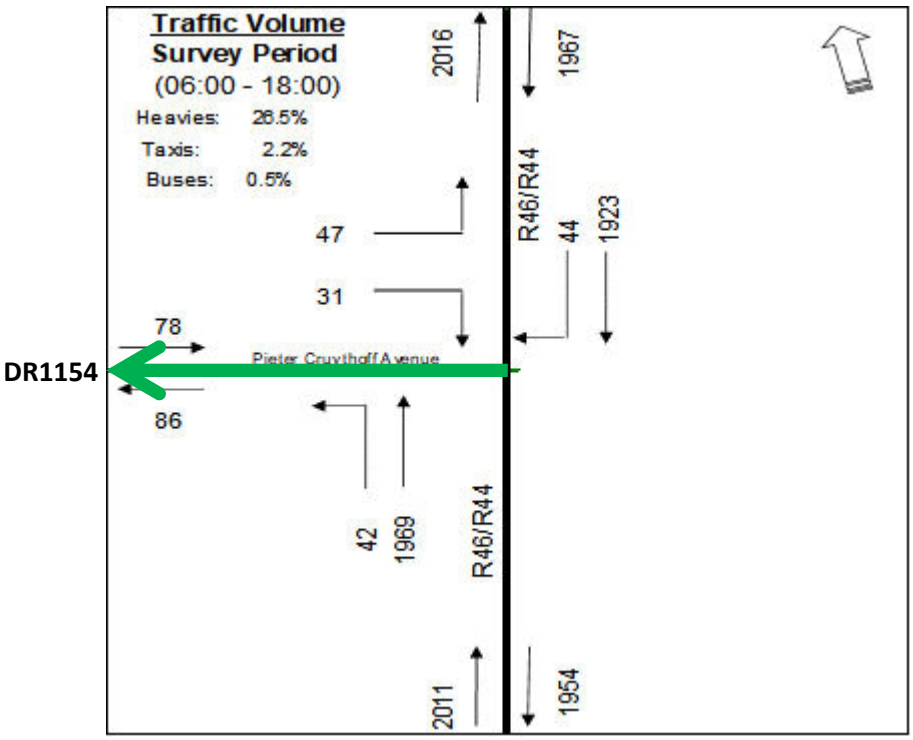
Light Heavy Taxis Buses Total

Stratum Pattern

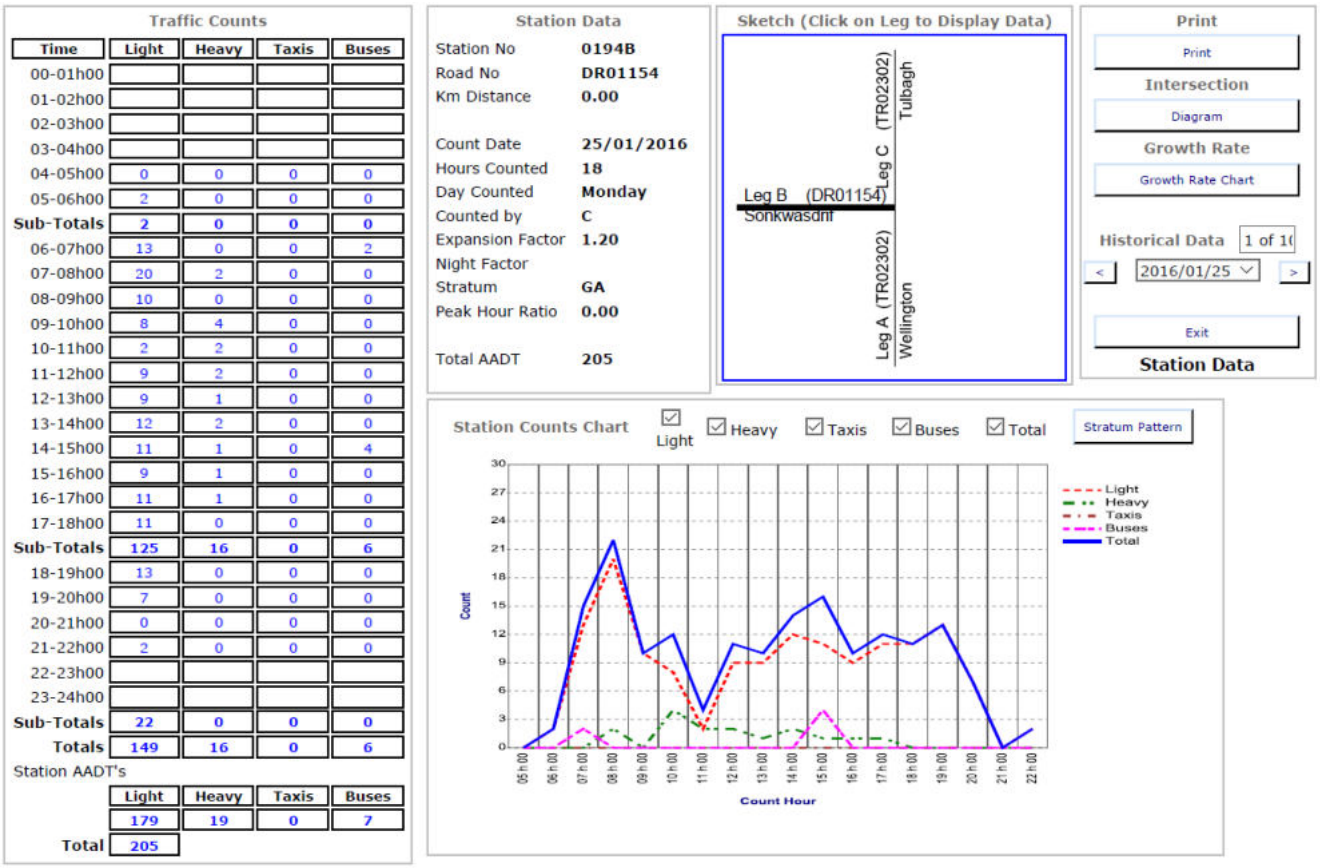
- **DR1154 (Pieter Cruythoff Avenue)/TR23/2 (R46) (Station No 0194) Intersection**

The intersection carried an average of approximately 350 vehicles per hour which is low (<500) as indicated in the traffic variation graph below.





On this eastern side of the intersection, DR1154 only carries approximately 170 vehicles per day which is low (<200 vpd). The intersection carries approximately 27% heavy vehicles with DR1154 only caring around 4% heavies. The R46 therefore carries the bulk of the heavy vehicles.



Traffic Counts

Time	Light	Heavy	Taxis	Buses
00-01h00				
01-02h00				
02-03h00				
03-04h00				
04-05h00	0	0	0	0
05-06h00	2	0	0	0
Sub-Totals	**2**	**0**	**0**	**0**
06-07h00	13	0	0	2
07-08h00	20	2	0	0
08-09h00	10	0	0	0
09-10h00	8	4	0	0
10-11h00	2	2	0	0
11-12h00	9	2	0	0
12-13h00	9	1	0	0
13-14h00	12	2	0	0
14-15h00	11	1	0	4
15-16h00	9	1	0	0
16-17h00	11	1	0	0
17-18h00	11	0	0	0
Sub-Totals	**125**	**16**	**0**	**6**
18-19h00	13	0	0	0
19-20h00	7	0	0	0
20-21h00	0	0	0	0
21-22h00	2	0	0	0
22-23h00				
23-24h00				
Sub-Totals	**22**	**0**	**0**	**0**
Totals	**149**	**16**	**0**	**6**

Station AADT's

	Light	Heavy	Taxis	Buses
	179	19	0	7
Total	205			

Station Data

Station No	0194B
Road No	DR01154
Km Distance	0.00
Count Date	25/01/2016
Hours Counted	18
Day Counted	Monday
Counted by	C
Expansion Factor	1.20
Night Factor	
Stratum	GA
Peak Hour Ratio	0.00
Total AADT	205

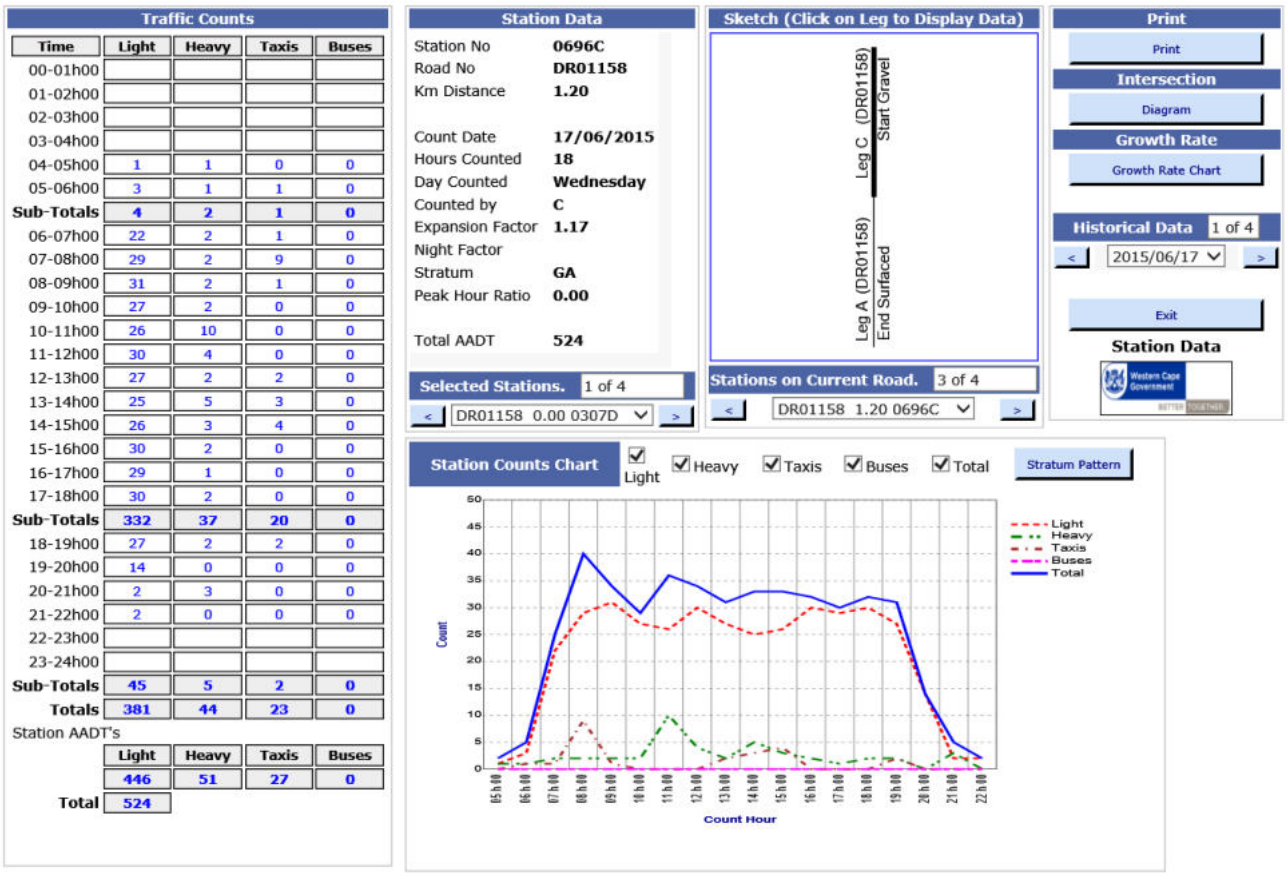
Sketch (Click on Leg to Display Data)

Print
Print
Intersection
Diagram
Growth Rate
Growth Rate Chart
Historical Data 1 of 1(
< 2016/01/25 >
Exit
Station Data

Station Counts Chart
Light Heavy Taxis Buses Total
Stratum Pattern

- **DR1158 (Station Street)**

In 2015 DR1158 carried approximately 10% heavy vehicles or 50 per day. Unfortunately, no traffic count information is available for the DR1158/OP5404 intersection. However, it is estimated that the volumes of traffic are very low (<50vpd) with an even lower heavy vehicle component.



- **OP5403 and OP5404**

Both these roads currently carry very low traffic volumes (<10vpd) and is only use by the local farmers. Once the flood damage repairs have been completed the road will be open to the public.

3.4 CONDITION OF ROADS

During the site visits a drive through observation of the condition of the different roads were conducted. The results of these are listed below:

- **DR1154 (20m Proclaimed Road Reserve)**

DR1154 starts at the TR23/2 (R46) and ends at MR226 (Piet Retief Street), totalling a distance of 13.4km. **Table 3.1** provides a summary of the different sections of the road as well as the observed condition.

Table 3.1 – Summary of Road and Road Condition

Start KM	End KM	Distance (m)	Surface Type	Road Width (m)	Condition
0.00	0.79	790	Surfaced	6.0	Very Poor
0.79	3.85	3 060	Gravel	6.0	Very Poor
3.85	3.91	60	Surfaced	5.0	Very Good
3.91	4.57	660	Gravel	6.0	Poor
4.57	4.79	220	Surfaced	5.0	Very Good
4.79	11.86	7 070	Gravel	6.8	Very Good
11.86	13.40	1 540	Surfaced	6.0	Poor

TR23/2 (R46) – Start of DR1154

Intersection in very poor condition

Level Railway Line Crossing

1st Surfaced Section in very poor condition

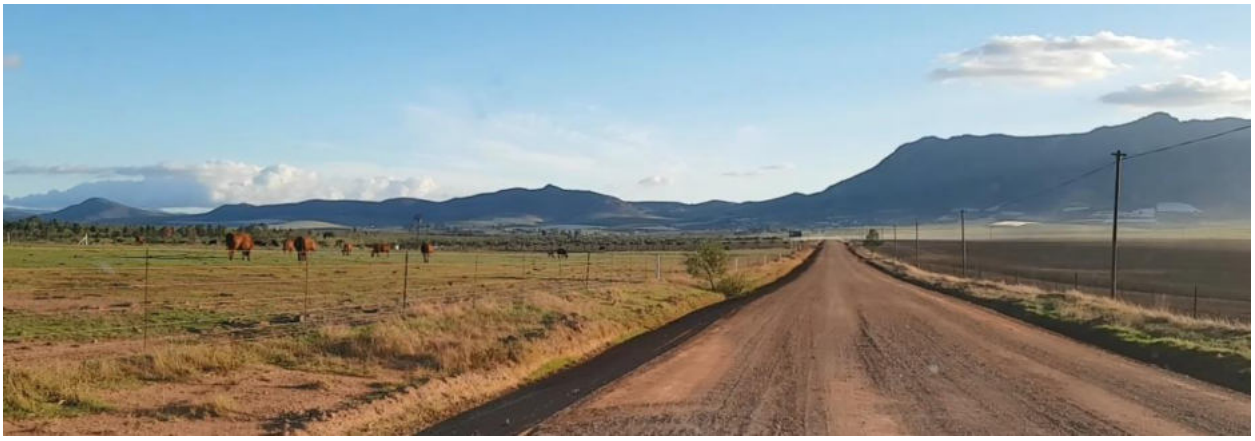
Start of 1st Gravel Section

Gravel Road in very poor condition

Gravel Section in very poor condition

Section before crossing the Berg River

Gravel Road in very good condition



Start of street network and level railway crossing

Piet Retief Street in very poor condition

- **OP5403 (20m Proclaimed Road Reserve)**

Start KM	End KM	Distance (m)	Surface Type	Road Width (m)	Condition
11.67	15.58	3 910	Gravel	3.0	**Flood damage and maintenance required**

Road Closed at km11.67 due to flood damage

Section between DR1154 and the river – northbound

Road in good condition

Flood Damage

Farm Gate Locked due to flood damage

3.5 TRIP GENERATION DURING CONSTRUCTION AND OPERATION PHASES

Construction Phase:

It is estimated that the construction of the weir and pump station will take approximately 10 months.

Although there will be light motor vehicles, the main consideration should be for the heavy vehicles ranging from short (<12m) to long (>17m). This will require the access road to be designed to accommodate the turning circles of these vehicles. Furthermore, the main pumps and other electrical equipment for the pump station will probably be delivered (more or less 10 trips to the site) on long heavy vehicles with low ground clearance i.e. lowboy trailer. The access road must be able to accommodate these trucks.

During construction approximately 4 000m^3 of commercial concrete will be required per day which would equate to around 5 truck deliveries. Should concrete be batched on-site, the figures will obviously be much less.

There will be other trucks and light motor vehicles, but this should not result in significant numbers e.g. rebar, bricks, valves, gravels, staff and labour, etc.

It is assumed that spoil material will be discarded on site and not at a commercial landfill. However, there could be a few heavy loads per month that would need to travel away from the Site, but these will have an insignificant impact on the access road/s.

For the construction of the 6.3km pipeline, 332 pipes (19m each) will be delivered to the site along the pipeline servitude. It is estimated that 2 pipes will be delivered per heavy vehicle due to the size of the pipes. At a production rate of 50m per day, approximately 4 trucks will deliver pipes per day over a period of 5 months. These deliveries will occur on the opposite side of the river connecting the new pump station and weir with Voëlvlei Dam. A few of these pipes may be delivered at the construction site for the pump station and weir.

Maintenance of the access road/s will be required, and the frequency and extent will depend on the trip generation. Regular monitoring of the road surface will trigger ad hoc maintenance that may be required.

Operational Phase:

During the operational phase, which would predominantly be during the 5 to 6 winter months, operating and maintenance staff will access the Site via light motor vehicles with the odd heavy vehicle.

The impact of vehicles during the operational phase on the access road/s will be insignificant.

3.6 COMPARISON OF ACCESS ROUTES

This study focuses on determining the feasibility of utilising the existing Proclaimed Road Network to access the Site.

Currently only the first approximately 575m over Portion 2 of Farm 648 of the preferred access road is an existing farm gravel road. The remainder of the proposed access road does not exist and would need to be constructed **(Refer to Figure 2.4)**.

An alternative to Access Road 1 is using the existing Proclaimed Minor Road network as indicated in **Figure 3.4.** The route consists of a section of OP5403 (±4.4km) plus a section of OP5404 (±3km) and a Farm Access Road (±1.6km) totalling ±9km.

See below the different distances between Riebeeck Kasteel and Access Road 1 and OP5403 as well as between the R44 and Access Road 1 and OP5403 via DR1154.

For Access Road 1 the following distances apply:

- Riebeeck Kasteel to Site: 8.2km + 6.7km = 14.9km
- R44 to Site: 6.2km + 6.7km = 12.9

For OP5403 the following distances apply:

- Riebeeck Kasteel to Site: 6.2km + 9.0km = 15.2km
- R44 to Site: 8.2km + 9.0km = 17.2

Access via OP5403 is 300m longer from Riebeeck Kasteel while it is 4.3km longer from the R44. However, it should be noted that the opening and closing of farm gates along OP5403 and OP5404 could impact on travel time.

Taking into account the difference in distance and the condition of DR1154 east of Access Road 1 and OP5403 it is recommended that plant and materials destined for the Site be delivered from Riebeeck Kasteel. Access to Riebeeck Kasteel from the N7 via Mooreesburg and Malmesbury is also closer than Paarl via the R44.

The PPC Cement quarry is also locate north-west of Riebeeck Kasteel. Concrete can easily be transported to the Site from the cement plant.

Figure 3.4 – Alternative Access Road via Proclaimed Road Network

Please note that die Provincial RNIS in places show a different alignment to the actual alignment for OP5403 and OP5404 as indicated above

Distance between Riebeeck Kasteel to Access Road 1

Distance between R44 and Access Road 1

Distance between R44 and OP5403

Distance between Riebeeck West and OP5403

4. COST ESTIMATES

To construct, repair and maintain the alternative access roads depends on the existing alignment and condition of the road. The estimated costs for each of the access road options are listed below:

EIA Preferred Access Road:

The proposed access road over Portion 1 and 2 of Farm 648 will be a private road that would not attract other public traffic in the area. Currently only the 1st 560m of the access road over Portion 2 of Farm 648 exists. The remaining 6.15km road will have to be constructed. The road will not have to comply with all the public road design standards as it will only be used for the construction and operation of the weir and pump station. It is estimated that a 6m wide gravel road will cost approximately R2 million per km. The total cost for the construction of the access road is therefore **R12.3 million**. Narrowing the road could have a significant impact on the construction cost.

Maintenance of the road will be approximately R80 000.00 per month consisting of Re-Cutting & Cleaning of Side-Drains and Pipes and Grading & Shaping as well as Dust Suppression.

OP5403 plus section of OP5404

The proclaimed section is ±7.46km long and will require some upgrading. The road is only wide enough to accommodate 1 vehicle per direction. It is recommended that passing embayments be constructed strategically (line of sight) to allow for vehicles to wait and pass each other. It is estimated that it will cost R500 000 per km to upgrade OP5403 and OP5404 (A detail inspection of the road will be required). The upgrading will therefore cost approximately R3.7 million.

The last 1.5km of the access road will have to be constructed over Portion 1 of Farm 648. This section could cost around R1.5 million depending on the width of the road. The total cost for the alternative access road is therefore **R5.2 million**.

The client can also approach the District Roads Engineer in Ceres to assist in grading the road frequently. Without their assistance it is estimated that the Re-Cutting & Cleaning of Side-Drains and Pipes and Grading & Shaping as well as Dust Suppression will be approximately R50 000.00 per month.

5. RECOMMENDATIONS

It is recommended that the existing Proclaimed Public Road Network (OP5403 and OP5404) be used as the preferred access to the Site during both the Construction Phase (±10 months) and Operational Phase (5 to 6 months in the Winter).

Other recommendations:

- A 40km/h speed limit be implemented on the proposed access road with the approval of the DRE in Ceres;
- As this is not a change in land use application, access via OP5403 and OP5404 is legal for the construction of the weir and pump station. However, it is unlikely that the Department of Transport and Public Works will contribute towards the upgrade of the road. The DRE in Ceres may assist with scarping the road during the construction period; and
- The necessary dust suppression measures be implemented.

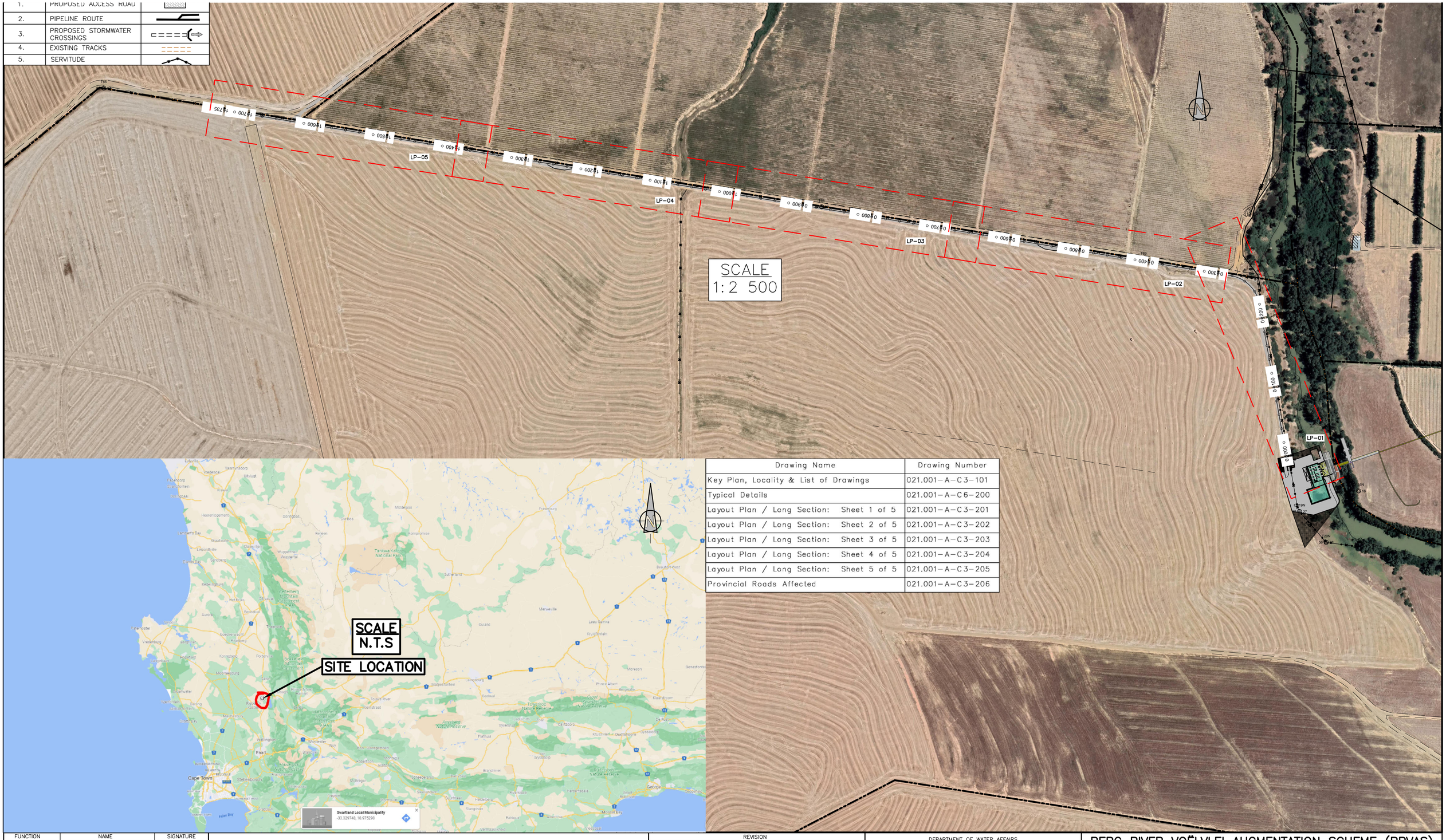
6. REFERENCES

1. City of Cape Town, *Guidelines for the Public Transport Component of Transport Impact Assessments, Draft*, December 2001.
2. Committee of Transport Officials, *South African Road Classification and Access Management Manual, TMH 26*, August 2012
3. Committee of Transport Officials, *South African Trip Data Manual, TMH 17*, September 2013.
4. Committee of Transport Officials, *South African Traffic Impact and Site Traffic Assessment Manual*, *TMH 16 Volume 1*, August 2012.
5. Committee of Transport Officials, *South African Traffic Impact and Site Traffic Assessment Manual Standards and Requirements Manual, TMH 16 Volume 2*, August 2012.
6. Department of Transport, Geometric Design of Rural Roads, TRH 17, Pretoria, 1988.
7. Department of Transport, *Guidelines for Traffic Impact Studies, Report No. PR 93/645*, Pretoria, 1995.
8. Department of Transport, *Pedestrian Facility Guidelines, RR 92/126*, 1993.
9. Department of Transport, *Pedestrian and Bicycle Facility Guidelines, Draft 1.0*, August 2003.
10. Department of Transport, *South African Trip Generation Rates, Report No. RR 92/228*, Pretoria, 1995.
11. PGWC Department of Economic Affairs, Agriculture & Tourism: Transport Branch, *Road Access Guidelines, Second Edition and Second Print*, September 2002.

ANNEXURE B

Conceptual Design Drawings

1.	PROPOSED ACCESS ROAD	
2.	PIPELINE ROUTE	
3.	PROPOSED STORMWATER CROSSINGS	
4.	EXISTING TRACKS	
5.	SERVITUDE	



Drawing Name	Drawing Number
Key Plan, Locality & List of Drawings	021.001–A–C3–101
Typical Details	021.001–A–C6–200
Layout Plan / Long Section: Sheet 1 of 5	021.001–A–C3–201
Layout Plan / Long Section: Sheet 2 of 5	021.001–A–C3–202
Layout Plan / Long Section: Sheet 3 of 5	021.001–A–C3–203
Layout Plan / Long Section: Sheet 4 of 5	021.001–A–C3–204
Layout Plan / Long Section: Sheet 5 of 5	021.001–A–C3–205
Provincial Roads Affected	021.001–A–C3–206

FUNCTION	NAME	SIGNATURE
DESIGNED	S MALOPE	
DRAWN	Z SHOYOSA	
DESIGN CHECKED	F LE ROUX	
DRAWING CHECKED	P GROBLER	

APPROVAL – CONSULTANT

NAME: P GROBLER REG. No. 950304

SIGNATURE: DATE:

JV DRAWING NUMBER

021.001–A–C3–101

IMPLEMENTING AGENT: TCTA A new word for water

CONSULTING ENGINEER: Amanzi Entaba JV

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWA

FOR TENDER

DEPARTMENT OF WATER AFFAIRS
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
CIVIL DESIGN
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336–7500

CHECKED: DATE: DESIGN:

ENGINEER: DATE: DRAWN:

CHIEF ENGINEER / APP (Pr. Eng): DATE: EXTERNAL APPROVAL: DATE:

DIRECTOR (Pr. Eng): DATE:

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

GENERAL

KEY PLAN,LOCALITY AND LIST OF DRAWINGS

PROVINCE: WESTERN CAPE | DISTRICT: DRAKENSTEIN/SWARTLAND | KEYCODES: | OTHER NUMBER

LOCALITY No. XXX | TENDER/ CONTRACT No. XXX | SHEET 01 OF 01 | REG. No. | REV. A

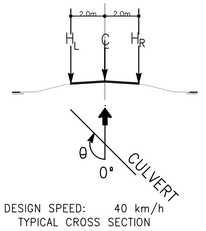
CALC. FILE. XXX

REF. NO	ITEM	SYMBOL
1.	PROPOSED ACCESS ROAD	
2.	PIPELINE ROUTE	
3.	PROPOSED STORMWATER CROSSINGS	
4.	EXISTING TRACKS	
5.	SERVITUDE	

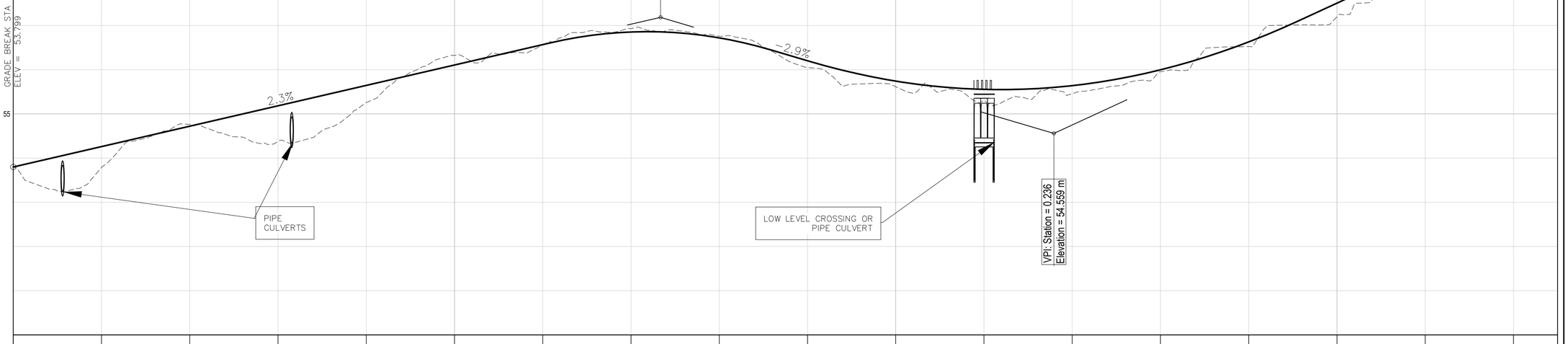
1. TERRAIN AROUND LOW SPOTS ALONG THE ALIGNMENT TO BE SHAPED TO ALLOW DRAINAGE TO CLOSEST T CULVERT.
2. SIDE DRAIN TO DRAIN TO NEAREST CULVERT.
3. ROAD LEVELS ARE ON TOP OF GRAVEL.
4. FOR TYPICAL CROSS SECTION AND PAVEMENT DESIGN REFER TO DRAWING 021-A-C6-200.

CURVE DATA			
Radius	Length	Tc	Delta
50.000m	61.675m	35.451m	70°40'29"
CO-ORDINATE WGS 84 Lo 29			
Point	Y-COORD	X-COORD	
BCC	1943.391	3688892.054	
ECC	1984.526	3688851.393	
CCC	1992.632	3688900.732	
PI	1949.544	3688857.141	

Notes:
1. Drainage structures are indicative only
2. Drainage design in accordance with the Employer's requirement

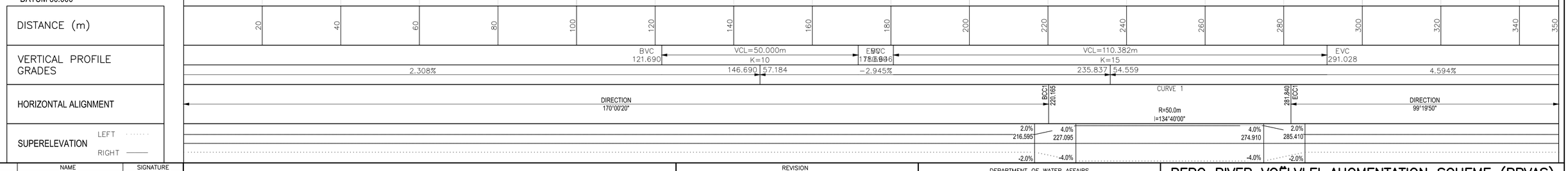


DESIGN SPEED: 40 km/h
TYPICAL CROSS SECTION



SCALES:
Horizontal 1:500
Vertical 1:50

DATUM 50.000



FUNCTION	NAME	SIGNATURE
DESIGNED	S MALOPE	
DRAWN	Z SHOYOSA	
DESIGN CHECKED	F LE ROUX	
DRAWING CHECKED	P GROBLER	

APPROVAL – CONSULTANT
NAME: P GROBLER REG. No. 950304
SIGNATURE: DATE:

JV DRAWING NUMBER
021.001-A-C3-201

IMPLEMENTING AGENT: TCTA A new word for water
CONSULTING ENGINEER: Amanzi Entaba JV

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWA

FOR TENDER

DEPARTMENT OF WATER AFFAIRS
REPUBLIC OF SOUTH AFRICA
HEAD OFFICE
CIVIL DESIGN
PRIVATE BAG X313
PRETORIA 0001
SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: DATE: DESIGN:
DRAWN:
ENGINEER: DATE: EXTERNAL APPROVAL: DATE:
CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

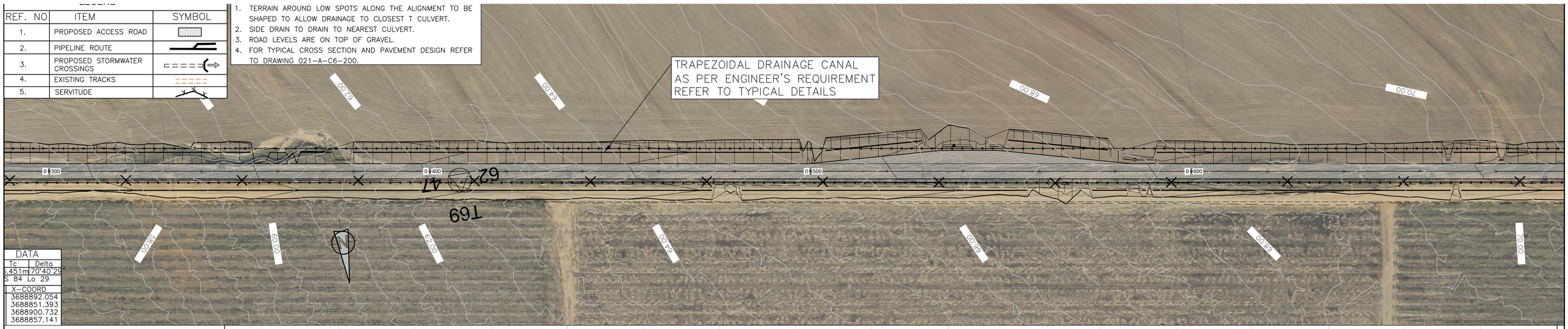
GENERAL

LAYOUT PLAN/LONG SECTION
SHEET 1 OF 5

PROVINCE: WESTERN CAPE | DISTRICT: DRAKENSTEIN/SWARTLAND | KEYCODES: | OTHER NUMBER
LOCALITY No. XXX | TENDER/ CONTRACT No. XXX | SHEET 01 OF 05 | REG. No. | REV. A
CALC. FILE. XXX

REF. NO	ITEM	SYMBOL
1.	PROPOSED ACCESS ROAD	
2.	PIPELINE ROUTE	
3.	PROPOSED STORMWATER CROSSINGS	
4.	EXISTING TRACKS	
5.	SERVITUDE	

1. TERRAIN AROUND LOW SPOTS ALONG THE ALIGNMENT TO BE SHAPED TO ALLOW DRAINAGE TO CLOSEST T CULVERT.
2. SIDE DRAIN TO DRAIN TO NEAREST CULVERT.
3. ROAD LEVELS ARE ON TOP OF GRAVEL.
4. FOR TYPICAL CROSS SECTION AND PAVEMENT DESIGN REFER TO DRAWING 021-A-C6-200.



DATA

Tc	Delta
0.451m	76°40'29"
S 84 Lo 29	

X-COORD
3688892.054
3688851.393
3688900.732
3688857.141

Notes:
1. Drainage structures are indicative only
2. Drainage design in accordance with the Employer's requirement

DESIGN SPEED: 40 km/h
TYPICAL CROSS SECTION

SCALES:
Horizontal 1:500
Vertical 1:50

DATUM 58.000

FUNCTION	NAME	SIGNATURE
DESIGNED	S MALOPE	
DRAWN	Z SHOYOSA	
DESIGN CHECKED	F LE ROUX	
DRAWING CHECKED	P GROBLER	

APPROVAL – CONSULTANT

NAME: P GROBLER REG. No. 950304

SIGNATURE: DATE:

JV DRAWING NUMBER

021.001-A-C3-202

IMPLEMENTING AGENT: TCTA – A new word for water

CONSULTING ENGINEER: Amanzi Entaba JV

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWA

FOR TENDER

DEPARTMENT OF WATER AFFAIRS
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
CIVIL DESIGN
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: DATE: DESIGN:

ENGINEER: DATE: DRAWN:

CHIEF ENGINEER / APP (Pr. Eng): DATE: EXTERNAL APPROVAL: DATE:

DIRECTOR (Pr. Eng): DATE:

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

GENERAL

LAYOUT PLAN/LONG SECTION
SHEET 2 OF 5

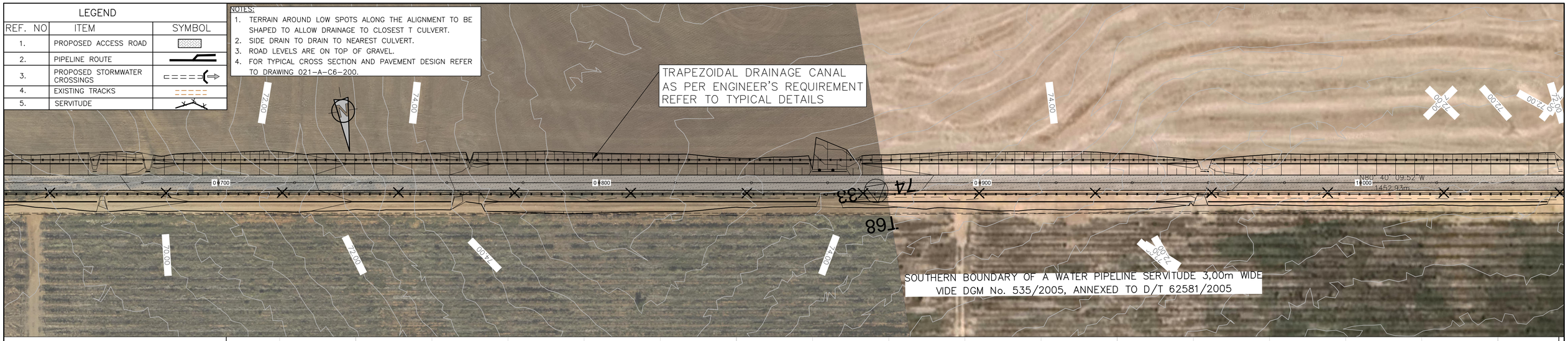
PROVINCE: WESTERN CAPE | DISTRICT: DRAKENSTEIN/SWARTLAND | KEYCODES: | OTHER NUMBER

LOCALITY No. XXX | TENDER/ CONTRACT No. XXX | SHEET 02 OF 05 | REG. No. | REV. A

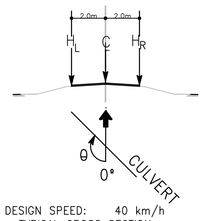
CALC. FILE. XXX

LEGEND		
REF. NO	ITEM	SYMBOL
1.	PROPOSED ACCESS ROAD	
2.	PIPELINE ROUTE	
3.	PROPOSED STORMWATER CROSSINGS	
4.	EXISTING TRACKS	
5.	SERVITUDE	

NOTES:
1. TERRAIN AROUND LOW SPOTS ALONG THE ALIGNMENT TO BE SHAPED TO ALLOW DRAINAGE TO CLOSEST T CULVERT.
2. SIDE DRAIN TO DRAIN TO NEAREST CULVERT.
3. ROAD LEVELS ARE ON TOP OF GRAVEL.
4. FOR TYPICAL CROSS SECTION AND PAVEMENT DESIGN REFER TO DRAWING 021-A-C6-200.



Notes:
1. Drainage structures are indicative only
2. Drainage design in accordance with the Employer's requirement



DESIGN SPEED: 40 km/h
TYPICAL CROSS SECTION

SCALES:
Horizontal 1:500
Vertical 1:50

DATUM 65.000

FUNCTION	NAME	SIGNATURE
DESIGNED	S MALOPE	
DRAWN	Z SHOYOSA	
DESIGN CHECKED	F LE ROUX	
DRAWING CHECKED	P GROBLER	

APPROVAL – CONSULTANT
NAME: P GROBLER REG. No. 950304
SIGNATURE: DATE:

JV DRAWING NUMBER
021.001-A-C3-203

IMPLEMENTING AGENT: TCTA A new word for water
CONSULTING ENGINEER: Amanzi Entaba JV

REVISION				
MOD No.	DATE	DESCRIPTION	FOR	DWA

FOR TENDER

DEPARTMENT OF WATER AFFAIRS
REPUBLIC OF SOUTH AFRICA
HEAD OFFICE
CIVIL DESIGN
PRIVATE BAG X313
PRETORIA 0001
SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: DATE: DESIGN:
ENGINEER: DATE: DRAWN:
CHIEF ENGINEER / APP (Pr. Eng): DATE: EXTERNAL APPROVAL: DATE:
DIRECTOR (Pr. Eng): DATE:

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

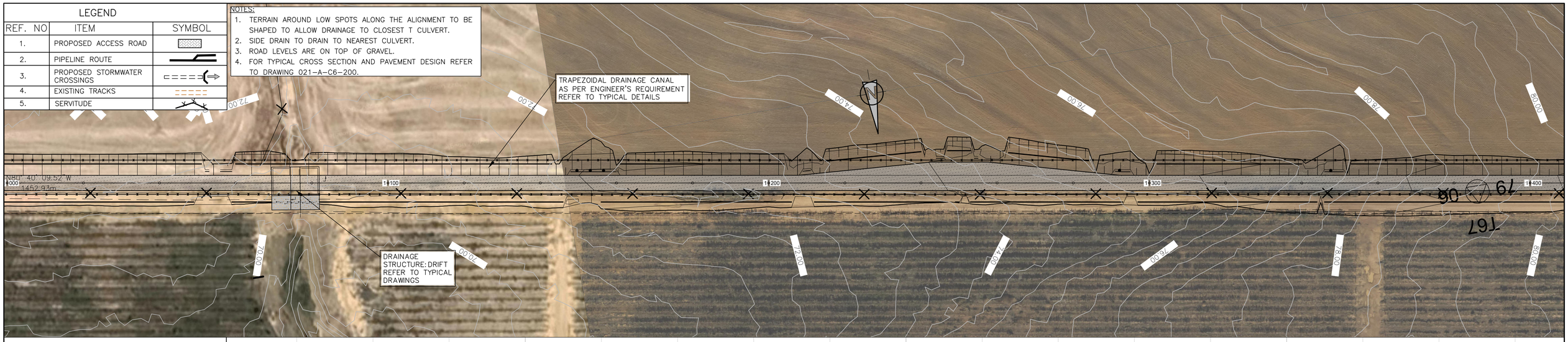
GENERAL

LAYOUT PLAN/LONG SECTION
SHEET 3 OF 5

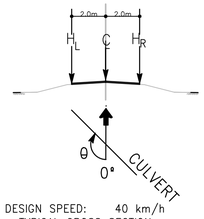
PROVINCE: WESTERN CAPE | DISTRICT: DRAKENSTEIN/SWARTLAND | KEYCODES: | OTHER NUMBER
LOCALITY No. XXX | TENDER/ CONTRACT No. XXX | SHEET 03 OF 05 | REG. No. | REV. A
CALC. FILE. XXX

LEGEND		
REF. NO	ITEM	SYMBOL
1.	PROPOSED ACCESS ROAD	
2.	PIPELINE ROUTE	
3.	PROPOSED STORMWATER CROSSINGS	
4.	EXISTING TRACKS	
5.	SERVITUDE	

NOTES:
1. TERRAIN AROUND LOW SPOTS ALONG THE ALIGNMENT TO BE SHAPED TO ALLOW DRAINAGE TO CLOSEST T CULVERT.
2. SIDE DRAIN TO DRAIN TO NEAREST CULVERT.
3. ROAD LEVELS ARE ON TOP OF GRAVEL.
4. FOR TYPICAL CROSS SECTION AND PAVEMENT DESIGN REFER TO DRAWING 021-A-C6-200.



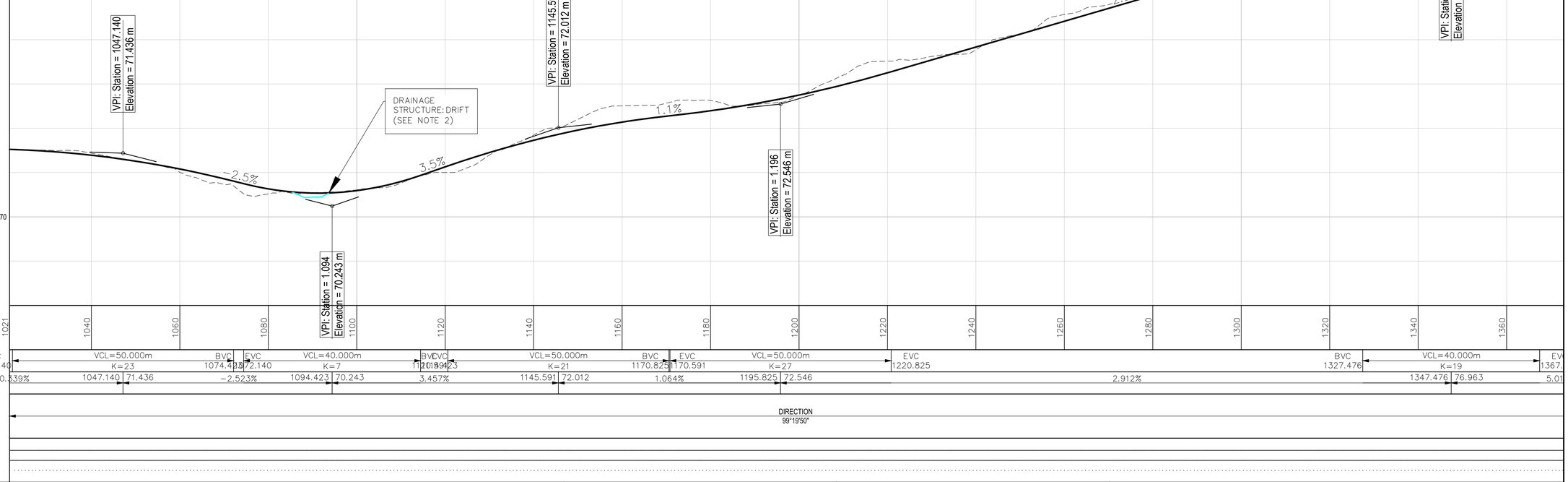
Notes:
1. Drainage structures are indicative only
2. Drainage design in accordance with the Employer's requirement



DESIGN SPEED: 40 km/h
TYPICAL CROSS SECTION

SCALES:
Horizontal 1:500
Vertical 1:50

DATUM 68.000



FUNCTION	NAME	SIGNATURE
DESIGNED	S MALOPE	
DRAWN	Z SHOYOSA	
DESIGN CHECKED	F LE ROUX	
DRAWING CHECKED	P GROBLER	

APPROVAL – CONSULTANT
NAME: P GROBLER REG. No. 950304
SIGNATURE: DATE:

JV DRAWING NUMBER
021.001-A-C3-204

IMPLEMENTING AGENT: TCTA A new word for water
CONSULTING ENGINEER: Amanzi Entaba JV

REVISION				
MOD No.	DATE	DESCRIPTION	FOR	DWA

FOR TENDER

DEPARTMENT OF WATER AFFAIRS
REPUBLIC OF SOUTH AFRICA
HEAD OFFICE
CIVIL DESIGN
PRIVATE BAG X313
PRETORIA 0001
SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: DATE: DESIGN:
ENGINEER: DATE: DRAWN:
CHIEF ENGINEER / APP (Pr. Eng): DATE: EXTERNAL APPROVAL: DATE:
DIRECTOR (Pr. Eng): DATE:

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

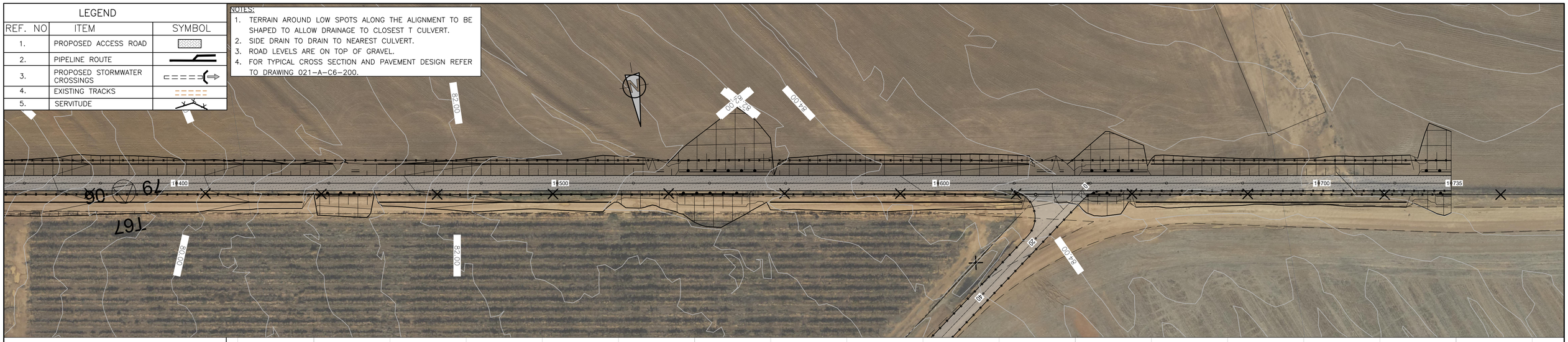
GENERAL

LAYOUT PLAN/LONG SECTION
SHEET 4 OF 5

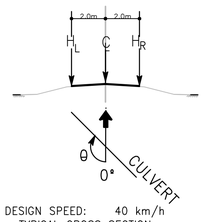
PROVINCE: WESTERN CAPE | DISTRICT: DRAKENSTEIN/SWARTLAND | KEYCODES: | OTHER NUMBER
LOCALITY No. XXX | TENDER/ CONTRACT No. XXX | SHEET 04 OF 05 | REG. No.
CALC. FILE. XXX | REV. A

LEGEND		
REF. NO	ITEM	SYMBOL
1.	PROPOSED ACCESS ROAD	
2.	PIPELINE ROUTE	
3.	PROPOSED STORMWATER CROSSINGS	
4.	EXISTING TRACKS	
5.	SERVITUDE	

NOTES:
1. TERRAIN AROUND LOW SPOTS ALONG THE ALIGNMENT TO BE SHAPED TO ALLOW DRAINAGE TO CLOSEST T CULVERT.
2. SIDE DRAIN TO DRAIN TO NEAREST CULVERT.
3. ROAD LEVELS ARE ON TOP OF GRAVEL.
4. FOR TYPICAL CROSS SECTION AND PAVEMENT DESIGN REFER TO DRAWING 021-A-C6-200.



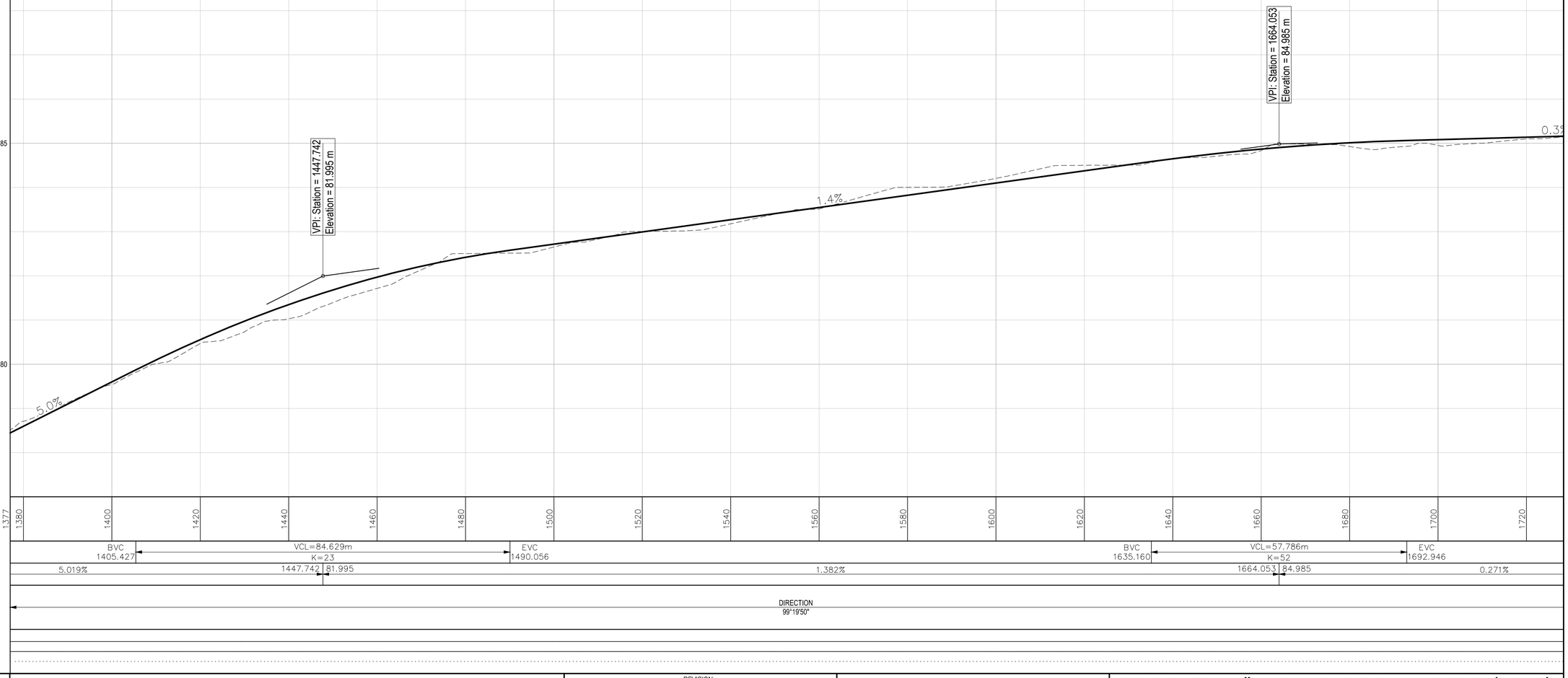
Notes:
1. Drainage structures are indicative only
2. Drainage design in accordance with the Employer's requirement



DESIGN SPEED: 40 km/h
TYPICAL CROSS SECTION

SCALES:
Horizontal 1:500
Vertical 1:50

DATUM 77.000



FUNCTION	NAME	SIGNATURE
DESIGNED	S MALOPE	
DRAWN	Z SHOYOSA	
DESIGN CHECKED	F LE ROUX	
DRAWING CHECKED	P GROBLER	
APPROVAL – CONSULTANT		
NAME: P GROBLER	REG. No. 950304	
SIGNATURE:	DATE:	

JV DRAWING NUMBER

021.001-A-C3-205

IMPLEMENTING AGENT: TCTA A new word for water
CONSULTING ENGINEER: Amanzi Entaba JV

REVISION				
MOD No.	DATE	DESCRIPTION	FOR	DWA

FOR TENDER

DEPARTMENT OF WATER AFFAIRS
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
CIVIL DESIGN
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: DATE:	DESIGN:
ENGINEER: DATE:	DRAWN:
CHIEF ENGINEER / APP (Pr. Eng): DATE:	EXTERNAL APPROVAL: DATE:
	DIRECTOR (Pr. Eng): DATE:

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

GENERAL

LAYOUT PLAN/LONG SECTION
SHEET 5 OF 5

PROVINCE: WESTERN CAPE	DISTRICT: DRAKENSTEIN/SWARTLAND	KEYCODES:	OTHER NUMBER
LOCALITY No. XXX	TENDER/ CONTRACT No. XXX	SHEET 05 OF 05	REG. No.
CALC. FILE. XXX			REV. A

FUNCTION	NAME	SIGNATURE
DESIGNED	S MALOPE	
DRAWN	Z SHOYOSA	
DESIGN CHECKED	F LE ROUX	
DRAWING CHECKED	P GROBLER	

APPROVAL – CONSULTANT

NAME: P GROBLER REG. No. 950304

SIGNATURE: DATE:

JV DRAWING NUMBER

021.001–A–C3–301

IMPLEMENTING AGENT: TCTA A new word for water

CONSULTING ENGINEER: Amanzi Eintaba JV

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWA

FOR TENDER

DEPARTMENT OF WATER AFFAIRS
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
CIVIL DESIGN
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336-7500

CHECKED: DATE: DESIGN:

ENGINEER: DATE: DRAWN:

CHIEF ENGINEER / APP (Pr. Eng): DATE: EXTERNAL APPROVAL: DATE:

DIRECTOR (Pr. Eng): DATE:

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

GENERAL

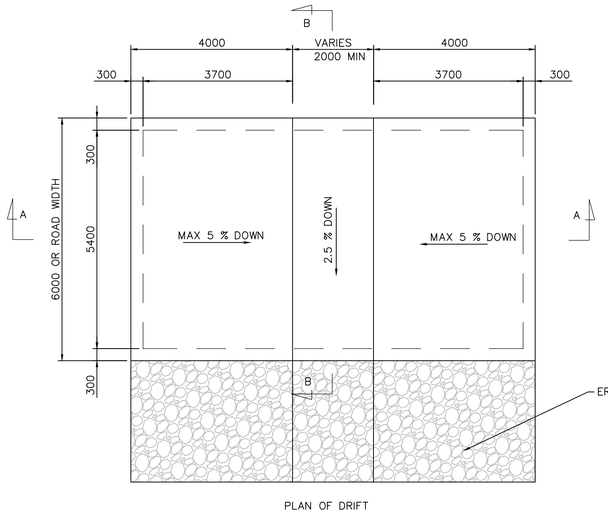
PROVINCIAL ROADS AFFECTED

PROVINCE: WESTERN CAPE | DISTRICT: DRAKENSTEIN/SWARTLAND | KEYCODES: | OTHER NUMBER

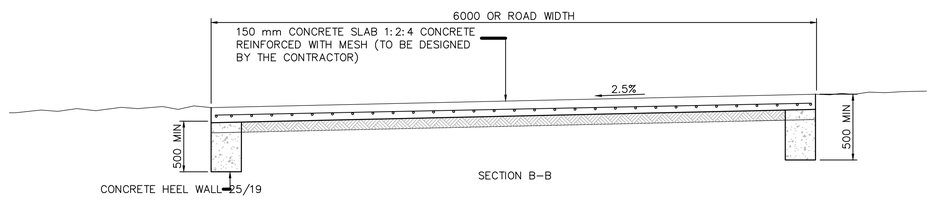
LOCALITY No. XXX | TENDER/ CONTRACT No. XXX | SHEET 01 OF 01 | REG. No.

CALC. FILE. XXX

REV. A

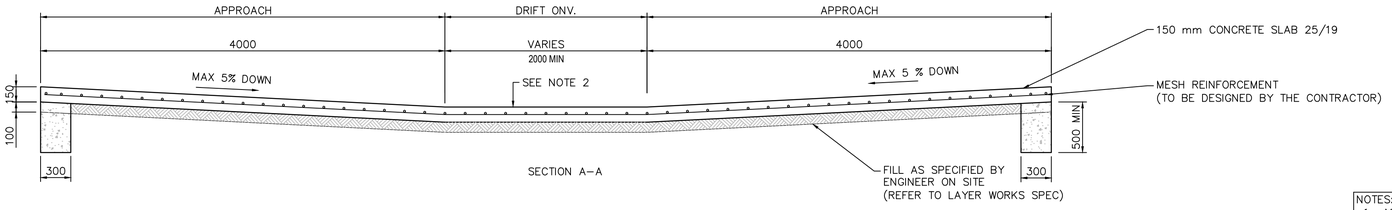


PLAN OF DRIFT



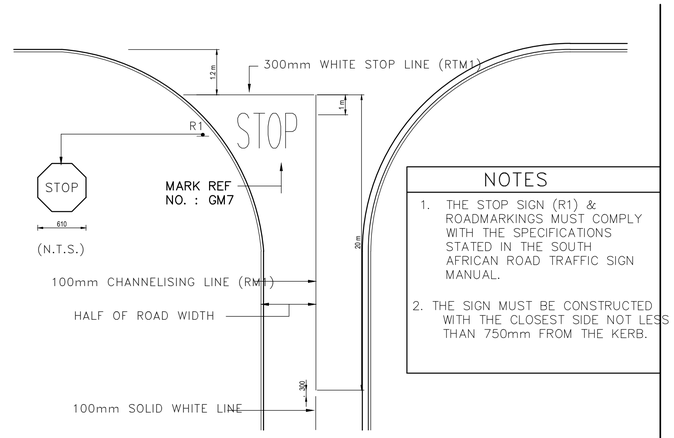
SECTION B–B

TYPICAL DRIFT



SECTION A–A

NOTES:
1. MIN COVER TO STEEL = 50mm
2. DRIFT INVERT LEVEL TO TIE UP WITH SIDE DRAIN INVERT AT. UPSTREAM SIDE
3. DRAINAGE DETAILS ARE INDICATIVE ONLY
4. DRAINAGE DESIGN IN ACCORDANCE WITH THE EMPLOYER'S REQUIREMENT

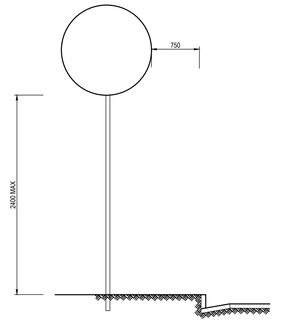


NOTES

1. THE STOP SIGN (R1) & ROADMARKINGS MUST COMPLY WITH THE SPECIFICATIONS STATED IN THE SOUTH AFRICAN ROAD TRAFFIC SIGN MANUAL.
2. THE SIGN MUST BE CONSTRUCTED WITH THE CLOSEST SIDE NOT LESS THAN 750mm FROM THE KERB.

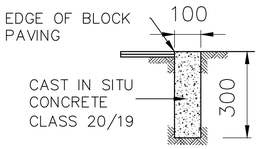
TYPICAL STOP INTERSECTION

N.T.S.



POSITION OF ROADSIGNS

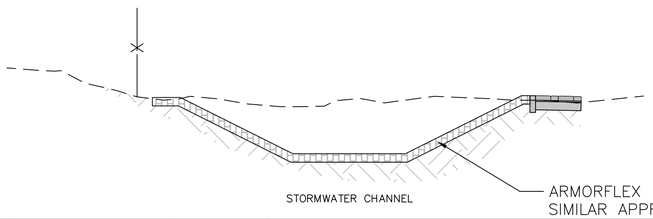
N.T.S.

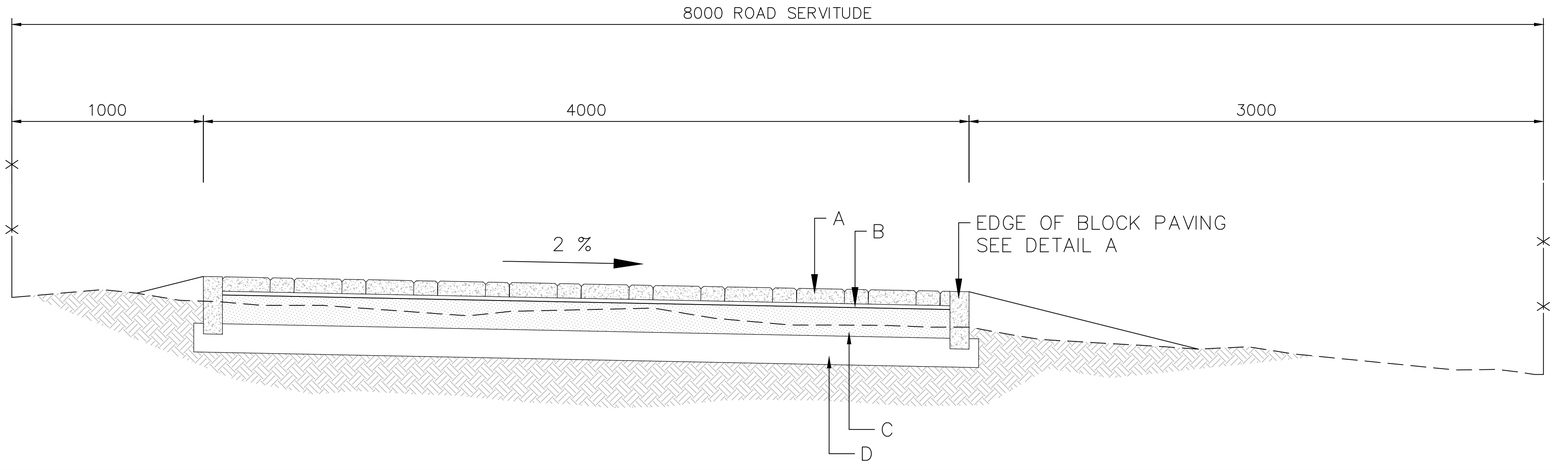


DETAIL A: EDGE RESTRAIN OF BEAM

Table : Proposed Pavement Structure

No.	Thickness (mm)	Layer	Type of Layer	Description
A	80	Base	Interlocking paving blocks (type S–A)	Laid in herringbone bond, as per COLTO 73.01 (a)
B	20	Bedding Sand	Sand (SND)	Commercial clean river sand, grading as per COLTO 7302 (a)
C	200	Sub–base	Stabilised Natural gravel (C4), Imported Material	Min. UCS of 1.5 MPa at 100% Mod. AASHTO, min ITS of 250 kPa at 100% Mod. AASHTO compacted to 97% MDD
D	150	Upper Selected/Fill	Natural gravel (G7), Imported Material	Compacted to 95% Mod. AASHTO density, min. CBR of 15% at density specified for the layer, Max PI of 12 or 2(GM)+10. Compacted in 150mm layer lifts.
E	150	In–situ	In situ	Rip and recompact 300mm in place. Apply three roller pass treatment to the roadbed using a vibrating roller or padfoot roller and finished off with a single axle pneumatic roller. If stable, compact the roadbed to at least 93% of MDD.





FUNCTION	NAME	SIGNATURE
DESIGNED	S MALOPE	
DRAWN	Z SHOYOSA	
DESIGN CHECKED	F LE ROUX	
DRAWING CHECKED	P GROBLER	

APPROVAL – CONSULTANT

NAME: P GROBLER REG. No. 950304

SIGNATURE: DATE:

JV DRAWING NUMBER

021.001–A–C6–200

IMPLEMENTING AGENT: TCTA A new word for water

CONSULTING ENGINEER: Amanzi Entaba JV

REVISION

MOD No.	DATE	DESCRIPTION	FOR	DWA

FOR TENDER

DEPARTMENT OF WATER AFFAIRS
REPUBLIC OF SOUTH AFRICA

HEAD OFFICE
CIVIL DESIGN
PRIVATE BAG X313
PRETORIA 0001

SEDIBENG BUILDING
185 FRANCIS BAARD STREET
PRETORIA
(012) 336–7500

CHECKED: DATE: DESIGN: DRAWN:

ENGINEER: DATE: EXTERNAL APPROVAL: DATE:

CHIEF ENGINEER / APP (Pr. Eng): DATE: DIRECTOR (Pr. Eng): DATE:

BERG RIVER VOËLVLEI AUGMENTATION SCHEME (BRVAS)

GENERAL

TYPICAL DETAILS

PROVINCE: WESTERN CAPE | DISTRICT: DRAKENSTEIN/SWARTLAND | KEYCODES: | OTHER NUMBER

LOCALITY No. XXX | TENDER/ CONTRACT No. XXX | SHEET 01 OF 01 | REG. No. | REV. A

CALC. FILE. XXX

ANNEXURE C:

Specific Dust Suppression Measures

ANNEXURE C:

RECOMMENDED PROJECT SECIFICATIONS ADJUSTED WITH SPECIFIC REFERENCE TO THE USE OF ANIONIC NEW-AGE MODIFIED EMULSIONS (NME) FOR THE STABILISATION OF NATURALLY AVAILABLE MATERIALS

PROJECT SPECIFICATION FOR THE APPLICATION OF A STABILISING AGENT (END PRODUCT SPECIFICATIONS) TO BE USED TO IMPROVE THE PERFORMANCE CHARACTERISTICS OF ANY MATERIALS (ROCK / AGGREGATE / SOIL) USED IN THE CONSTRUCTION OF ROAD PAVEMENT LAYERS

NEW-AGE MODIFIED EMULSION (NME) OR SIMILAR (New-age = post 2000) where an emulsion = any additive in the form of a solution, including any additive added to the construction water, including (but not limited to):

- Bitumen emulsions with / without a modified emulsifying agent (e.g. an aggregate adhesive, water repellent agents (e.g. organo-functional-silanes) and / or with the addition of polymers (micro- and or nano-polymers);
- Material compatible polymers (micro- and/or nano-polymers), or
- Any rock/aggregate/soil stabilising agent.

In the context of this document NME may be considered as an abbreviation covering the use of any or all of the above-mentioned stabilising or material improvement additives (emulsions = any additive in the form of a solution, e.g. modified bitumen emulsions). Numerous modifiers have been in use since the 1970s. These modifiers have improved considerably since the ability have been developed in the 1990s to see and observe (with the development of electron microscopes), the impact of these modifiers in terms of engineering characteristics, unless specifically otherwise identified or separately specified. However, the engineering requirements in terms of strength criteria, sample preparation and test protocol as contained in this document must be met in all cases.

The **END PRODUCT SPECIFICATIONS** require a NME to be verified prior to usage and the use thereof **AND GUARANTEED** by the contractor through his supplier. **It is important to note that the anionic NME stabilising agent (or equivalent) is costed in terms of cubic metre of the material that is being stabilised and NOT by quantity of the stabilising agent.** The cost of a stabilising agent depends on theend result and not by the quantity added to the material.

PROJECT SPECIFICATIONS

PART C COLD IN-SITU STABILISATION WITH A NEW-AGE MODIFIED EMULSION (NME) STABILISING AGENT

CONTENTS

C1001 SCOPE

This section covers work required for construction of new roads or for the rehabilitation of the upper pavement layers (base and sub-base) using the cold in- situ recycling process with (a) conventional equipment, (b) recycler and (c) central mixing plant. The construction of new pavement layers, using an appropriate silicon- based New-age Modified Emulsion (NME) stabilising agent or alternative stabilising additive in an emulsified state, is aimed at the use of naturally available materials (often in-situ) from the area of the road that can cost-effectively be utilised in the upper pavement layers.

The rehabilitation of existing roads are aimed at the optimum use of damaged or weathered in-situ materials in a cold in-situ recycling process, which may include a pre-stabilisation process of the breaking-up of existing pavement layers and mixing of the materials, with or without the addition of new materials to achieve a uniformly mixed material with no materials exceeding the least maximum size of 63 mm or a third of the total thickness of the layer that is being recycled. After a homogeneous mix has been achieved, the material is in-situ stabilised with the applicable NME stabilising agent or alternative stabilising additive/product to produce a homogenous mixture, which is spread, cut to level and compacted to the required specification. This section also covers the use of an applicable prime, as a temporary surface for early trafficking.

C1002 MATERIALS

The use of an appropriate NME stabilising agent or alternative stabilising additive / product aims to optimally use naturally available material (new or in-situ) in the upper pavement layers of a road meeting the minimum design requirements as specified in Table C1002/1 (applicable during construction for quality control and for use during the detailed material design in the laboratory as detailed). The aim is to cost-effectively utilise naturally available materials as an alternative to newly crushed- stone materials in both the design and construction of new roads as well as the rehabilitation of existing pavements, through the improvement (through neutralisation

of the effect and possible negative impact of secondary minerals formed during weathering as a result of chemical decomposition) of available materials normally considered to be “non-standard”, “marginal”, “low-cost”, or even “sub-standard” in terms of the standard material indicator tests.

Materials from existing pavement layers shall be classified as follows for excavation and processing purposes:

(i) Existing bituminous material

Bituminous material shall be an asphalt surfacing or a bituminous seal from an existing layers. Where the asphalt surfacing and bituminous seal are recycled together with the underlying layers, the mixture will **not** be classified as bituminous material.

(ii) Granular material

The base and sub-base pavement layers in the existing pavement shall be classified as granular materials.

Granular material shall include crushed stone, gravel soil and natural gravel and can consist of cemented or non-cemented material. Crushed stone obtained from existing pavements and processed as gravel material will be paid for as gravel material and not as crushed stone.

The mixture of bituminous material (RA) and base and sub-base material shall be classified as granular material.

(iii) Extra material

Extra material as specified consists of:

(a) Naturally available materials (and (if cost-effective) crushed stone materials)

The pavement layers will be designed based on the requirements of the design traffic loadings and the material specifications required for the various pavement layers as designed, complying with Table C1002/1.

(b) Crusher dust.

No crusher dust is to be used with anionic NME stabilising agents.

(c) Gravel.

The gravel material shall be of a minimum quality as per table C1002/1. (Higher quality will normally require less of the modifier, depending on the inherent mineralogy.) Payment for the addition of extra material shall be made under Pay Item C10.10.

(iv) Material stabilisation / improvement products / additives

(a) Stabilising Agent: Silicon-based anionic New-age Modified Emulsions (NME) with or without polymer combinations.

During the Detailed Design Phase of the project the Design Engineer must have tested and proved (as contained in the Detailed Design Report) the availability of New-age Modified Emulsions (NME) that meets the criteria as specified as contained in the following details:

The specified cold-mix silicon-based Modified Emulsion will consist of an **anionic SS60 bitumen emulsion** with an emulsifying agent ("soap" or surfactant) consisting of a Sodium Hydroxide basic molecule with an alkyl(organo-functional) group consisting of a $CH_3(CH_2)_n$, carbon-chain where n >
18. The supplier/contractor will take full responsibility for using an emulsifying agent resulting in inferior test results and/or stability.

The specified emulsion must be modified with a compatible (as tested with the XRD-determined mineralogy of the materials) New-age (Nano) (silicon-based) Modified (alkyl alkoxy or organo-functional siloxane) Emulsion (NME) with the basic formula of "R" – $Si(OH)^3$ resulting in a stabilised mix meeting the minimum requirements as specified in Table C1002/1 **(take note that different specifications are applicable for the design in the laboratory and for and quality control during construction to allow for laboratory versus site**

TABLE C1002/1: STANDARD SPECIFICATIONS FOR NANO-MODIFIED EMULSION (NME) STABILISING MATERIALS

	Material[1]	Material classification			
		NME1	NME2	NME3	NME4
Minimum material requirements before stabilisation and/or treatment (Natural materials)					
Material spec.(minimum) Unestablished material: Soaked CBR[2] (%) (Mod AASHTO)	NG /(CS)	> 45[2] (95%) ACV < 30%	> 25[2] (95%)	> 10[2] (93%)	> 7[2] (93%)
Grading Modulus (GM)	NG	> 1.8	> 1.5	-	-
Sieve analysis: % < 0.075 mm ($P_{0.075}$)	ALL	< 20 %	< 25 %	< 35 %	< 50 %
XRD scans: - Total sample - 0.075 mm fraction ($P_{0.075}$)	 ALL ALL	 √ √	 √ √	 √ √	 √ √
% Material passing 2 µm ($P_{0.002}$) (e.g. Clay & Mica & Talc) as a % of Material (with Talc <10%) (XRD-scans of the material passing the 0.075 mm sieve is used to determine the % clay, mica and talc in the material – In this case $P_{0.002} = P_{0.075}$ x ($P_{clay, etc.}$ in $P_{0.075}$), or % Silt and Clay	NME stabilisation with micro-meter (µm) emulsion particle sizes				
	ALL	< 15 %	< 15 %	< 15 %	< 15 %
	NME stabilisation with emulsion containing micro-scale as well as nano-scale particles (adjusted according to material grading)				
	ALL	NA	< 35 %	< 35 %	< 35 %
	NME stabilisation with emulsion containing nano-scale and pico-scale particles (grading adjustments) together with technologies addressing workability of materials on site				
	ALL	NA	NA	> 35 %	> 35%
Material specifications after stabilisation and/or treatment					
In-situ density to be required after stabilisation and compaction (mod AASHTO) (%) (minimum)	Base	> 100 %	> 100 %	> 98 %	> 97 %
	Sub-base	NA	> 98 %	> 97 %	> 95 %
DCP(DN mm/blow)(Quality control) (stabilised and compacted)		NA	NA	< 2.6	< 3.5
Mod AASHTO density (%) (for laboratory testing)		> 100 %	> 100 %	> 100 %	> 100 %
*UCS_{wet} (kPa) (150 mm Φ Sample)	**Design[3]**	**> 2 500**	**> 1 500**	**> 1 000**	**> 750**
	Construction[4]	**> 2 200**	**> 1 200[4]**	**> 700[4]**	**> 450[4]**
Retained Compressive Strength (RCS): (UCS_{wet}/UCS_{dry}) (%)		> 85	> 75	> 70	> 65
RCS in relation to minimum $UCS_{wet(criteria)}$ ($RCS_{effective}$) (%)		>100	>100	>100	> 100
*ITS_{wet} (kPa) (150 mm Φ Sample)	**Design[3]**	**> 240**	**> 200**	**> 160**	**> 120**
	Construction[4]	**> 220**	**> 180[4]**	**> 140[4]**	**> 100[4]**
Retained Tensile strength (RTS): ITS_{wet}/ITS_{dry} (%)		> 85	> 75	> 70	> 65
RTS in relation to minimum $ITS_{wet(criteria)}$ ($RTS_{effective}$) (%)		>100	>100	>100	> 100

[1]CS – crushed stone; NG – natural gravel; GS – gravel soil, and SSSC – sand, silty sand, silt, clay.\
[2]CBR only used as reference to traditionally used test procedures as a broad first indicator
*Definitions:(UCS = Unconfined Compressive Strength) (ITS = Indirect Tensile Strength)
UCS_{dry}; ITS_{dry} = testing after rapid curing; UCS_{wet}; ITS_{wet} = testing after rapid curing and 4 hours in water;
($RCS_{effective}$) = (RCS x ($UCS_{wet}/UCS_{wet(criteria)}$)); ($RTS_{effective}$) = ((RTS x ($ITS_{wet}/ITS_{wet(criteria)}$))
Design[4] = Minimum criteria to be met in the laboratory during the design phase
Construction[5] = Minimum criteria to be met during construction as part of quality control
[4]Criateria based on TG2 (Asphalt Academy, 2009)

variations and conditions), using the prescribed test procedures as detailed in Clause C1013.

The NME stabilising agent must be environmentally stable and produce/release NO adverse negative substances during the process of hydrolysis (i.e. when mixed with the construction water) and condensation (i.e. when attachment to the material/soil occurs). A Safety Sheet to this effect must be produced by the supplier.

The NME stabilising agent must have a guaranteed minimum on-site storage stability exceeding **4 (four)** months and a workable Viscosity during all seasons of the year without pre-heating, allowing for the in-situ cold recycling of the available materials, taking into account storage at high temperatures during summer months and possible cold temperatures during winter months. The supplier/contractor **will take full responsibility for maintaining the stabilising agent on-site to ensure that it will remain stable during storagewith no visible separation and without an increase in viscosity during storage. The NME must meet the following minimum specifications proven by the supplier/contractor:**

i. A guaranteed shelf-life on-site (e.g. in flow bins if applicable) **exceeding 4 (four) months**. (The shelf life can normally be increased to at least 6 to 9 months through circulation of the NME mix once a week using a normal circulation pump.)

ii. Laboratory test results using the prescribed rapid curing test procedure on available materials from site testing the UCS (dry and wet) and ITS (dry and wet) and meeting the required Retained Compression Strengths (RCS) (UCS_{wet}/UCS_{dry} in percentage) and Retained Tensile Strengths (RTS) (ITS_{wet}/ITS_{dry} in percentage) as well as the required Effective Retained Compressive Strength ($RCS_{effective}$ = RCS x ($UCS_{wet}/UCS_{wet(criteria)}$)) and Effective Retained Tensile Strengths ($RTS_{effective}$=RTSx($ITS_{wet}/ITS_{wet(criteria)}$)). The average values of at least 3 tests shall be used to obtain the laboratory results. The laboratory results should meet the criteria for the design phase

as contained in Table C1002/1 (the higher design criteria take into account variations between laboratory and on-site conditions).

iii. Additional test samples shall be prepared and cured at 25 - 30°C for 28 days and retested. The test results should either show similar (± 5%) or higher results as tested after the initial rapid curing process as contained in Table C1002/1 to ensure that no negative mineral and or stabilising agent interaction or degeneration of polymers (where applicable) occur.

The prepared NME on site must be ready for immediately dispersion within the construction water (using a standard circulation pump) ready for stabilisation. It is important to note that all containers and water tankers must be thoroughly cleaned before the NME is added. Unclean (contaminated) equipment willresult in the activating of any residual bituminous mix left in the container or water tanker when the NME is added, resulting in an unusable sticky substance, such as balls or strings of bitumen. **Any losses occurred during construction due to the use of contaminated equipment will be to the costof the contractor.**

(b) Additives for granular material stabilisation / treatment alternatives other than defined in Item (a).

The material stabilisation / treatment additive must have a guaranteed on-site stability exceeding 4 (four) months taking into account storage at high temperatures during summer months and possible cold temperatures during winter months**. The supplier/contractor will take full responsibility for maintaining the stabilising additive / product on site to ensure that during storage, before application, the additive /product will remain stable with no visible separation of particles and without any change in measurable properties during storage (e.g. an increase in viscosity). The stabilised mix must meet the following minimum specifications proven be the supplier/contractor:**

i. A guaranteed shelf-life on-site (e.g. in flow bins if applicable) exceeding 4 (four) months. (The shelf-life can normally be increased to at least 6 to 9

months by through maintaining the additive / product on a regular basis as required by the supplier.)

ii. Laboratory test results using the prescribed rapid curing test procedure on available materials from site testing the UCS (dry and wet) and ITS (dry and wet) and meeting the required Retained Compression Strengths (RCS) (UCS_{wet}/UCS_{dry} in percentage) and Retained Tensile Strengths (RTS) (ITS_{wet}/ITS_{dry} in percentage) as well as the required Effective Retained Compressive Strength ($RCS_{effective}$ = RCS x ($UCS_{wet}/UCS_{wet(criteria)}$)) and Effective Retained Tensile Strengths ($RTS_{effective}$=RTSx($ITS_{wet}/ITS_{wet(criteria)}$)). The average values of at least 3 tests shall be used to obtain the laboratory results. The laboratory results should meet the criteria for the design phase as contained in Table C1002/1 (the higher design criteria takes into account variations between laboratory and on-site conditions)

iii. Additional test samples shall be prepared and cured at 25 - 30°C for 28 days and retested. The test results should either show similar (± 10%) or higher results as tested after the initial rapid curing process as contained in Table C1002/1 to ensure that no negative mineral and or stabilising additive/product interaction or degeneration of the additive/product (where applicable) occurs as an indication of durability.

The prepared stabilising additive / product on-site must be ready for immediate dispersion within the construction water (using a standard circulation pump) ready for stabilisation or the supplier must clearly specify the process of application during the construction process to ensure that a uniform mix with uniform qualities is achieved. The differences in methods of application will be to the cost of the contractor.

It is important to note that all containers and water tankers must be thoroughly cleaned before any stabilising additive/product is added. Unclean (contaminated) equipment could result in the activating of any residual mix leftin the container or water tanker when the stabilising additive/product is added, resulting in an unusable substance. **Any losses occurred during**

construction due to the use of contaminated equipment will be to the cost of the contractor.

c) Water.

Water used for diluting the stabilising additive/product shall be potable water (clean and free from any salts and contamination) that will cause the stabilising additive/product to be adversely affected by these chemical impurities. The stabilising additive / product will be tested for compatibility with the compaction water.

Water must be potable and the pH shall not exceed 7 (or as required for the use of the specific stabilising additive/product). Should local sources be considered, prior laboratory testing to ensure acceptability will be required.

The quality of the water must adhere to the specifications given inTable C2002/3. Any additional requirement for the construction water as required by the supplier of the stabilising additive/product will be to the cost of the contractor.

(v) Chemical modification of material

No additional chemical modification of the stabilised material will be allowed if not contained in the original specification. In all cases the requirements as given in Table C1002/1 in Item (iv) must be met

(vi) Stabilisation of sub-base

In the case of the rehabilitation of an existing road or the construction of a new road, the sub-base shall conform to requirements of the layer as per design. In all cases the possible consequences and compatibility of the layer characteristics, in terms of the expected behaviour of the pavement structure as a whole, needs to be assessed by the Engineer.

TABLE C1002/3: WATER CLASSIFICATION FOR CONSTRUCTION TESTING

		Water Quality Classification Code						
		H0	H1	H2	H3	H4	H5	
Property	Unit	Pure water (AR)	Clean water (Rain)	Treated water (Municipal)	Silty (muddy) water with low salt content	Highly mineralised chloride sulphate water (brackish)	Waste brack, sewage, marsh, sea, etc water	Method
PH*	-	7.0	5.7 – 7.9	4.5 – 6.5	4.5 – 8.5	9.0	-	SABS M113 SM 11 - 1990
Dissolved solids*	ppm	0	1000	1500	3000	-	-	SABS 213 SM213 - 1990
Total hardness*	-	None	None	Temporary	Temporary	Permanent	-	SABS 215 SM 215 - 1971
Suspended matter	ppm	0	2000	2000	5000	-	-	SABS 1049 SM 1049 - 1990
Electrical conductivity	mS/m	0	200	200	500	-	-	SABS 1057 SM 1057 – 1982
Sulphates (SO_4)	ppm	0	200	300	500	1000	-	SABS 212 SM 212 - 1971
Chlorides (Cl)	ppm	0	500	1000	3000	5000	-	SABS 202 SM 202 - 1983
Alkali Carbonates (CO_3) & Bicarbonates (HCO_3)	ppm	0	500	1000	1000	2000	-	SABS 241 - 999
Sugar	-	Negative	Negative	Negative	Negative	Negative	-	SABS 833
Quality of water required		Untreated layer works	✔	✔	✔	✔	Investigate the effect on the quality of the material	
		Chemically treated layer works	✔	✔	Investigate the effect on the quality of the stabilised material	Investigate the effect on the quality of the stabilised material		
		Concrete mass	✔	✔	✔	Investigate the effect on the quality of the material		
		Concrete prestressed	✔	✔	References: 1. Concrete Technology – Dr S Fulton (1989) 2. Materials Manual (PAWC)			
		Slurry & emulsion	✔	✔				
		Soil/gravel tests	✔	✔				
		Chemical or control tests	✔	✔				

C1003 COMPOSITION OF RECYCLED MIXES

During rehabilitation of existing pavement layers, the recycled material shall consistof the existing surfacing, granular material from existing pavement layers, additional material where required and an applicable stabilising agent/product. The actual composition of the mix shall be determined by the Engineer to comply with the testing requirements as specified in Table C2001/1.

Adjustments to the actual mix constituents are not normally required as it is already accounted for in the differences in specifications for the design versus in-field conditions during construction (some slight adjustments may be authorised by the Engineer, based on the results of the trail section taking into account additional factors such as equipment used, e.g. conventional equipment vs recycler vs central mixing plant and climatic conditions) – in all cases such adjustments must be authorised by the Engineer. The Engineer reserves the right to adjust the composition of the mix at any time should he deem it necessary. The Contractor and Supplier shall provide to the Engineer the proposed final mix proportions based on the required test results and the Engineer must approve the results, before any materials are ordered. The risk of alternative designs using any alternative additive/product not specified, remains with the Contractor as per documents applicable to the contract.

The average values for maximum dry densities shall be tested by the Contractor and confirmed by the Engineer prior to any work commencing on any specific day.

C1004 PLANT AND EQUIPMENT

The specified stabilising agent could be highly reactive and it is IMPERATIVE THAT ALL STORAGE TANKS, WATER TANKS, ETC., BE THOROUGHLY CLEANED, WITH NO RESIDUE FROM PREVIOUS MIXES PRESENT IN THESE TANKS. THE CONTRACTOR WILL ALLOW THE ENGINEER TO INSPECT THE EQUIPMENT BEFORE USE, TO ENSURE THAT THE EQUIPMENT IS SUITABLE FOR USE WITH THE SPECIFIED NME STABILISING AGENT OR ANY OTHER

ALTERNATIVE AS RECOMMENDED BY THE CONTRACTOR AND HIS SUPPLIER. IN ALL CASES THE SUPPLIER WILL ENSURE THAT THE STABILISING AGENT APPLICATION IS CLEARY SPECIFIED AND THE CONTRACTOR WILL TAKE FULL RESPONSIBILITY TO MEET THE SPECIFICATIONS OF THE SUPPLIER THAT MUST BE FREELY AVAILABLE TO THE ENGINEER FOR QUALITY CONTROL PURPOSES.

(a) Conventional Plant

A heavy-duty motor-grader is an essential item of plant for NME stabilisation, irrespective of the combination of any of the other plant items used. This grader is required to pre-shape the material prior to being treated, for processing the material and thereafter, to cut the layer to final levels. Processing by grader includes mixing the material prior to treatment and mixing in the additive and the diluted NME or alternative additive/product.

A milling machine will be required to break up a thick asphalt layer and/or high strength cemented material to produce a material suitable for the stabilisation or treatment. When in-situ material is to be augmented with imported material, a milling machine can also be effectively used to blend the two materials after the additional material has been levelled out on top of the in-situ material and pre-shaped with a grader.

Alternatively, layers that have developed high in-situ strength can be broken down using a “woodpecker-type” fitted to an excavator. The resulting chunks of pavement material can then be transported to a single-stage crusher to be crushed and transported back to the road for further processing.

(b) Recycling Equipment

The plant shall be so equipped that it will be able to recycle pavement layers to depths up to at least 300 mm in one operation. The plant shall be equipped so that the stabilising agent mixed in with the construction water as per calculations, can be added uniformly in a calibrated and controlled manner directly to the material being

recycled. Width reduction must be possible on the application nozzles when overlap recycling is done. The recycling depth shall be controlled electronically.

Pre-milling of the layer(s) to be stabilised with the surfacing (when specified) will be done to ensure that a uniformly mixed layer is present before stabilisation with the recycler is to be done.

The direction and speed of the recycling machine and the speed of rotation of the scarifying drum shall be adjusted so as to obtain the required grading and sufficient mixing of all the components of the recycled material. The machine shall be capable of making a neat vertical cut at the outer edges when recycling the layer.

The recycler should, as a minimum, be equipped with:

- Self-cleansing nozzles, and
- Be equipped with a micro-computer, able to adjust the application of the stabilising agent according to the speed of the recycler – the proper working of this equipment is essential to ensure that and mix be applied to specification. The Contractor shall ensure that equipment operators receive the necessary training to operate the equipment to enable the required specifications to be met.

The recycler will be pre-tested using clean water to ensure that all systems, as per specification, are in proper working order, that operators are fully trained and that the stabilising agent will be added as adjusted by the speed of the recycler.

(c) Water Tanker

Self-propelled water tankers, with a 15 000-litre capacity, are essential plant items for the successful construction of a stabilised layer. In addition to supplying the stabilising agent/additive/product for mixing, water tankers are required to ensure proper finishing of the treated layer of material after the initial mixing and processing stage has been completed **(AT NO STAGE SHOULD WATER WITHOUT THESTABILISING AGENT BE ADDED TO THE LAYER)**.

Sufficient construction water mixed with the stabilising agent must be added to the mix to account for loss of moisture during processing, taking into account the equipment to be used and climatic conditions to ensure that compaction starts with the layer preferably at approximately OMC. (Results from detailed testing under actual as well as research conditions indicate that the OMC of the material is reduced by approximately 10% and that the moisture / density relationship may not be as critical compared to that of stabilisation without anionic NME stabilising agents.Experience has shown that the best results are usually obtained when final compaction is achieved at a moisture level of 0.5% to 1.0% below OMC (taking into account the total fluid content and not only the water content of the stabilising agent).Sufficient water tankers must be provided to ensure that the processing of the material is a continuous procedure with no stopping to wait for a water tanker.

Where applicable, water tankers involved with the treatment and distribution of a stabilising agent, should be earmarked only for the transportation of the stabilising agent in various stages of dilution as dictated by the in-situ moisture content of the material to be stabilised. In the case of anionic NME stabilisation, it is recommended that a small percentage of the anionic NME mixture be retained in the tanker in the cases of the use of conventional equipment to treat a “dry” surface before or during compaction when the moisture loss is deemed to be excessive for one or another reason that may occur in practice due to numerous unforeseen (e.g. weather) conditions. A surface is visually considered to be to dry when fine cracks appear directly behind the rollers. It is essential that supervision personnel be on site during stabilisation operations to visually note any changes that may occur during the stabilisation process.

Due to material variations, some sections along a road may also contain excessive moisture. In these cases a small “wave” will form in-front of the compaction equipment. When this phenomenon is observed, the section should be ripped and allowed to expel some moisture before been recompacted. This operation should notexceed a time period to end of compaction of 6 hours.

All water tankers used for anionic NME treatment must be equipped with a circulating pump system to circulate the diluted anionic NME after standing for an extended period of time and for circulating during the dilution process. Water tankers must not be fitted with a conventional spray-bar but with valves (such as a clam-lock valve) which will not easily clog. The application of the diluted anionic NME is a coldprocess and the addition of the nano-silane agent considerably reduces the possibility of blockages of the nozzles. However, it is the responsibility of the Contractor to ensure that no blockages occur during the stabilisation process, resulting in the uneven distribution of the stabilising agent. In cases where such blockages do occur, the Engineer will require the layer to be remixed using conventional equipment. Tankers must be properly flushed should they need to standempty for extended periods (e.g. overnight).

(d) Rollers

The equipment to be used for the conventional breaking-up and excavation of existing pavement layers will be determined by the size and depth of the pavement section to be processed or excavated, taking into consideration the fact that workmay have to be carried out in restricted areas.

One heavy duty grid roller and an adequately powered pneumatic tyre tractor which will pull the grid roller when fully loaded, or an equivalent self-propelled sheep foot roller, may be required in the case of very course material during the initial stages of compaction. The use of a sheep-foot roller should be used not to affect the final visual condition of the layer.

The compaction of a stabilised base layer is normally adequately achieved with a vibratory smooth drum roller in combination with a pneumatic wheel roller to achieve a surfacing finishing, meeting the required specifications of the layer in terms of density as well a finishing. It is the responsibility of the Contractor to ensure that operators of the compacting equipment are fully trained on the importance and effect of amplitude and frequency when compaction is done using vibratory rollers.

(e) General

Static tanks should be provided to store sufficient quantities of the stabilising agent for the needs of the project. Normally such tanks will have a capacity of between 30 000 and 120 000 litres. Static tanks must be fitted with a circulating pump system which will enable the stored stabilising agent to be properly circulated from time to time in the static tank, especially if the stabilising agent has been standing for a period of 2 to 3 consecutive days. These tanks must be fitted with a flowmeter to ensure that the required percentage of the stabilising agent is carefully measured and added to the construction water.

C1005 SETTING-OUT AND CONTROL OF THE WORK

The Contractor shall establish his own reference and level beacons for the setting- out and control of the works.

The Contractor shall indicate his own reference and control beacons to the Engineer at least one week before the work is programmed to commence. The Engineer will take control measurements to determine the accuracy and adequacy of the reference / control beacons and may instruct the Contractor to correct any faulty work and to take and provide such additional measurements and details as may be deemed necessary. This survey work will not be measured and paid for directly and compensation for any work involved in staking or setting out will be deemed to be covered by the rates tendered and paid for the various items of work included in this contract.

No payment will be made for any inconvenience or delay caused by compliance with these requirements.

C1006 CONSTRUCTION

(a) Removal of grass and weeds

Prior to commencing in-situ recycling, all grass, weeds, etc., encroaching into or onto the road surface or growing between the edge of the existing surfacing and kerbs, channels, etc., shall be removed.

(b) Preparing the pavement surface

Before cold in-situ recycling may commence, the pavement surface shall be clean and free from any material that could be harmful to the execution of the works and affecting the quality thereof.

For the conventional method any asphaltic surface with granular sub-layers and/or cemented-layers will be pre-milled prior to the preparation of the layer.

Extra material shall be spread to the thickness and width as specified. The area to be recycled shall be properly demarcated. No payment will be made for cold, in-situ recycling beyond the required width.

Before cold in-situ recycling may commence, the moisture content of the granular material shall be determined in an approved manner so as to determine the amount of water required to reach optimum moisture content. In the case of the measured moisture content exceeding optimum by more than 0.5% with the addition of the diluted stabilising agent, the layer shall be ripped and left to dry until the moisture content has reached an acceptable level by applying the stabilising agent and reaching the required moisture conditions..

(c) Construction in confined areas

In such an event where any rehabilitation or reconstruction work as specified in this section has to be executed in an area where the width of which is less than 1.0 m or the length of which is less than 50 m and the area is less than 50 m^2,it shall be classified as work in restricted areas.

(d) Recovery of bituminous material

If so required by the design, existing bituminous material shall be milled out as indicated by the design. The recovery material shall be transported and stockpiled as specified in Section 3800.

The limits of milling shall be demarcated clearly and these limits shall not be exceeded by more than 100 mm. Areas milled outside the specified limits shall be repaired by the Contractor at his own cost and to the satisfaction of the Engineer.

(e) Spreading of extra material on a layer prior to recycling

Where the existing pavement layer or surfacing level is too low, or existing material has to be spoiled due to unsuitability and where specified or instructed by theEngineer, suitable pavement material shall be added to the layer to make up the short-fall prior to the recycling the layer. Suitable pavement material for addition to make up a layer short-fall shall consist of naturally available materials as specified or directed by the Engineer.

The extra pavement material, including reclaimed asphalt (RA), shall be spread uniformly over the full area of the underlying short-fall layer by means of an approved type of mechanical spreader to such thickness as to comply with the requirements specified in Clause C1010 after the final compaction. Segregation of the materials shall be avoided and the additional material shall be placed free from pockets of course and fine materials. Extra material shall only be spread on the section to be recycled and only immediately prior to the recycling operation.

(f) Application of stabilising agent diluted with water

At no time whatsoever should an undiluted stabilising agent (such as an anionic NME) be applied to the layer of material that is being processed. The anionic NME must be added to the construction water (taking into account the total fluid content of the anionic NME (a water repellent silicon-based modified emulsion effectively reduces the OMC of the material). Hence, not only the water percentage within the emulsion needs to be taken into account but the total fluid content, to ensure that the

mix is properly distributed throughout the layer. The supplied anionic NME need to be diluted by a factor of between 1:4 (1-part anionic NME and three parts water) and 1:1 (50-50) to ensure proper distribution of the stabilising agent. A high percentage offine material (in the order of more than 20 – 25 per cent passing the 0.075 mm sieve size), will normally require higher rates of dilution to ensure that a thorough distribution of the stabilising agent is achieved.

Coating of all the granular particles within the layer will not take place when the anionic NME is added separately to the construction water (as is possible with modern recycling equipment). Any “wetting” of material before stabilisation will be detrimental to the material adhesion to be achieved with the nano-silane modificationadded to the binder. As a consequence, the in-situ moisture content of the untreated layer must never be so high that it cannot accommodate the anionic NME that has been diluted with the construction water.

(g) Pre-treating of the exposed base layer

A material compatible designed anionic NME stabilising agent will not require the pre-treatment of materials to account for “problem” minerals such as Smectites, Muscovite (Mica), etc. The anionic NME must be tested to automatically address the presence of such minerals during the detailed design phase and must be specifically designed to neutralise the effect of these minerals. In cases with high contents of specifically identified minerals, a pre-treatment may be prescribed using an appropriate proven co-product prior to the stabilisation process. The identification of the need for pre-treatment shall be done as part of the detailed design process through the detailed testing of the mineral composition of available materials (using XRD-scans), to be used in the construction / rehabilitation of a road pavement.

(h) Breaking down of material using conventional methods

During rehabilitation works, the existing pavement material shall be broken down to the specified depth and processed in place.

The ripped material shall then be broken down in-situ with a fully loaded grid roller hauled by an adequately powered tractor. During the process of grid rolling and breaking the material, the material shall be windrowed constantly and any oversize material shall be removed.

Unsuitable material for sub-base and base shall, as directed by the Engineer, be removed and spoiled and will be paid under pay Item 10.13.

Where sub-base layers need to be constructed, the base material shall be windrowed to the side and the sub-base layer should be inspected first. After inspection by the Engineer the demarcated sub-base area should be re-worked and re-stabilised if so required by the Engineer.

(i) Adding diluted anionic NME

The emulsion tanker supplying the diluted anionic NME (containing the mix of the anionic NME and the required construction water as measured and calculated) shall be equipped with an approved measuring device (e.g. dipstick) to enable the site staff to take control calibrated depth measurements at intervals specified by the Engineer. The recycling operation will be cancelled / interrupted by the Engineer, until this required specification is met.

The method of introducing the various materials comprising the final mix shall be subject to the Engineer's approval. Care shall be taken to prevent excessive loss of moisture between the time when the materials are mixed and when it is compacted on the road.

(j) Spreading

The recycled mix shall be spread and levelled with a motor grader to the required width and to such thickness as to comply with the requirements specified in Clause C1010 after final compaction. Segregation of the materials shall be avoided and the layers shall be free of pockets of course or fine materials.

(i) Mixing Recycler

The recycled base / sub-base material, extra material, anionic NME stabilising agent diluted in the construction water, shall be thoroughly mixed by the recycling mixing process with plant as specified in Clause C1004.

The anionic NME diluted in the construction water, shall be measured by mass and quantities, calculated in accordance with the formulas given in Clause C1003. It shall be introduced continuously in a controlled manner into the material that is being stabilised, proportionally to the speed of the recycler, to ensure that the correct quantity of the stabilising is added to the full width of the section being recycled. Careshould be taken that all nozzles are fully operational during the recycling process. In cases where an uneven distribution of the stabilising agent is noticed, the layer willbe re-mixed using conventional blade-mixing with graders, at no extra costs.

(ii) Conventional Method

Blade-mixing by grader is undertaken by using the blade to move the material from side to side. This mixing process is often supplemented with the use of ploughs and/or rotavators. Where the width of the treatment restricts the horizontal movementof the material, extra use should also be made of the grader rippers with specially designed “shoes” welded onto the rippers. Such shoes are in the shape of a horizontal “V”, with the sharp end of the V pointing in the direction of travel of the grader. The rippers with their V-shaped shoes are lowered to the treated depth and the “fast forward” gear of the grader is used to plough through the layer. In this manner, the material is pushed aside, ensuring that proper mixing is achieved, even when working in confined widths.

The anionic NME must first be diluted with the compaction water to a residual anionic NME content of between a 1:1 to 1:4 dilution and applied in several applications onto the material. Water tankers are used to apply the anionic NME and the grader(s) must travel directly behind the water tanker, immediately covering the freshly sprayed anionic NME with material, thereby preventing excessive loss of moisture and the anionic NME from immediate breaking. The volume of diluted anionic NME

applied is determined by the designed percentage of the anionic NME, expressed as a percentage by mass of the layer that is being treated.

Should weather conditions be particularly hot or dry, adjustments to the construction water must be made to ensure that the compaction moisture content (containing the anionic NME stabilising agent) be achieved. This process is exactly the same as to the compaction of any granular layer, requiring the same care during construction to achieve the required densities.

Care should be taken to ensure that the diluted anionic NME is applied in such a way that no rivulets are formed and that the anionic NME does not run off the layer before it has been mixed into the layer.

During mixing, attention must be paid to the fluid content of the mix. The fluid content is the total quantity of fluid in the mix, including hygroscopic moisture, the diluted NME still in suspension and the water in the anionic NME.

The addition of the pre-mixed construction water (mixed with the anionic NME stabilising agent) should not be so high as to result in deformation of the surface under final compaction. (Observed as a “wave” forming in front of the compaction equipment.) The required total mixed construction water as determined in the laboratory prior to the start of the stabilisation process, may be amended based on on-site observations, allowing for the type of compaction equipment used.

Additional adjustments in the pre-mixed construction water may be required when working with porous materials. Such materials will absorb some water leading to a need for a higher percentage of pre-mixed water in order to achieve the required results. The design process as recommended should identify the presence of materials that will require higher than normal percentages of pre-mixed construction water. However, due to the limits to which pre-testing can be done, the Engineer on site should be aware of this possibility and require adjustments as recognised on site.

Where the existing asphalt surfacing or cemented base-layer is being recycled with the underlying gravel layer using conventional construction equipment, the asphalt layer must first be milled off and left in windrow on top of the granular base that is to be recycled. Once the asphalt layer has been milled off in this manner then the base-layer can be milled or ripped and broken down. Once the milled asphalt layer and the existing gravel base material have been thoroughly blended, then the additive must be mixed in immediately ahead of the introduction of the diluted anionic NME on the same day.

(k) Preparation before the stabilisation/treatment of the material

The following will need to be determined in advance for input into the Moisture Calculation Sheet:

- Length, width and depth of section to be stabilised; MOD, OMC and in-situ moisture content; Content of water tanker in litres; Water tanker volume will also need to be calibrated and marked out on a volume measuring gauge.

Preparation before stabilisation:

- Prior to applying the stabilising agent, the NME shall be mixed with water in the water tanker to form a diluted NME which, when applied to the material, will act as a carrier of the diluted NME to the soil fines.
- The Contractor shall determine the rate of dilution of the additive by means of the Moisture Calculation Sheet, which may range from 1 litre of anionic NME to between (5 litres and 40 litres) of water depending on the type of material/soil, in-situ moisture content and percentage of the anionic NME stabilisation required. This calculation sheet shall be submitted to the Engineer on a daily basis for approval, both before and after completion of each section to be stabilised. Experience has shown that anionic NME stabilised material / soil will reach optimum strength when final compaction is done at a moisture content of just below OMC taking into account the total fluid content (taking into consideration that a silicon-based modification will normally reduce the OMC by about 10%). In order to reach this target OMC, it may be necessary to apply 1,0 % to 2,0 % moisture above OMC (depending on climatic conditions which could result in the

drying and loss of moisture due to evaporation during very hot conditions and the mixing equipment used – e.g. conventional grader mixing will take longer and will allow more moisture to escape (evaporate) than mixing with a recycler). Compaction at moisture conditions which are too low, will lead to the formation of fine cracks (immediately visible after the roller) which will compromise the integrity of the top of the layer, resulting in the formation of a weak inter-layer at the top which may result in the failure of the seal by separation with the rest ofthe base-layer (the appearance of fine “cracking” when compaction commence can be addressed through a further application of some diluted anionic NME (kept in reserve in the water-tanker) which will increase the surface moisture to achieve the desired compaction densities and a uniform layer. Too high moistureconditions will be seen when the layer is moving in front of the roller (kneeing) – in these cases, the drying out of the layer may be required by ripping, drying and re-compaction (as per previous discussions and guidelines). Such operations should not exceed a time period of more than 6 hours.

- The diluted anionic NME may be sprayed onto the road surface by means of a spray bar fitted to the water tanker or by hand spraying in places with difficult access.
- Initial thorough and complete mixing of the NME with the construction water is essential. The anionic NME products using a double emulsification processusually result in small particles which distribute easily through the construction water without much additional effort. However, it is the Contractor’s responsibilityto ensure that the anionic NME is evenly distributed within the construction water. The cases where an anionic NME stabilising agent is used that require constant mixing, an electrical or petrol driven stirrer must be used. In such cases,the contractor must ensure that:
  1. The pump is of sufficient capacity to circulate the entire contents of the tank in 15 minutes;
  2. There are no internal baffles in the tank restricting circulation; and

3. Prior to commencement of spraying, the contents are circulated for at least 20 minutes.

(I) Compaction

The completed compacted layer shall have a minimum in-situ dry density as specified for the specific layer (as per requirement of the designed layer as per TableC1002/1). It shall be the responsibility of the Contractor to determine the maximum dry density and Optimum Moisture Content (OMC) of the material to be stabilised for purposes of quality control (compaction control). The Contractor may select any suitable compaction technique to achieve this required compaction, subject to the following conditions:

The initial compaction shall be carried out with plant, which achieves stability suitable for subsequent compaction, without causing undue displacement of the material or deformation of the layers. The rolling pattern shall be designed so as to retain the shape of the layers as far as possible.

The types and number of compaction equipment to be used and the amount of rolling to be done, shall be such as to ensure that specified densities are obtained without damage being done to lower layers or structures. During compaction the layer shall be maintained to the required shape and cross-section, and all holes, ruts and laminations shall be removed.

Compaction equipment shall be adequate for obtaining the specified density within the specified time limits.

The compaction equipment and techniques shall be capable of producing the specified surface finish and density without any interruption.

Not more than four (4) hours shall elapse between the time of starting the mixing process and that of starting to compact the material.

From the time when the diluted anionic NME is added and mixed, not more than six (6) hours shall elapse until the compaction has been finally completed.

It is important to note that when adding water to material **only diluted anionic NME should be used**.

The only time when the clean water can be used on its own is during the **pre-wetting of the completed layer prior to priming as per specification.**

At no time would it be allowed to "cutting back" materials, to achieve levels without remixing of the layer – materials added by "cutting back" material will result in "biscuit" layers and the disintegration (breaking up) of the top of the layer. Under such circumstances high penetration of the stone with associated bleeding within the wheel tracks will occur when a surfacing consisting of a seal is used. A ring and ball test performed on top of the base-course prior to sealing should normally expose this weakness and potential risks. The normal criteria used to evaluate ring and ball test are applicable.

(m) Rejected work

The Contractor shall note that should he fail to meet the specified requirements for the anionic NME stabilised layer place at ambient temperatures, he shall remove the unacceptable layer and replace it with approved material all at his own expense or as instructed by the Engineer.

Reworking of an existing layer may be allowed by the Engineer by ripping of the stabilised layer, adding 50% of the original anionic NME stabilising agent and compaction at the required OMC as per original process to achieve the required results. It should be noted that the OMC of the material may have changed due tothe first NME application. Such reworking of the layer will be at the risk of the Contractor who will not be paid extra for the reworking of rejected works.

(n) Providing a temporary wearing course

Immediately after completion of the compaction described in subsection (l), Nano-Silane Nano-Polymer prime shall be applied to the finished surface using a water truck (or by hand sprayer) at a pray rate of 1 litre / m^2. The spray rate may be adjusted by the Engineer following a trail section of not less than 100 m.

As alternative, a 50:50 diluted anionic NME mat be sprayed onto the layer and compacted using a steel wheeled roller with a mass of not less than 12 tons each, and/or with pneumatic rollers.

The following process is to be followed:

1. Immediately after compaction, slushing of the surface will commence: Spray 1 litre/m² of the diluted NME onto the surface followed immediately with further compaction by means of a 13-ton vibratory roller which must follow directly behind the water cart. A 22-ton pneumatic tyre roller (PTR) must then follow directly behind the vibratory roller.
2. Turn around and on the same strip have the water cart first drenching the surface with a further 1 litre/m² diluted NME. This time the pneumatic tyre roller follows directly behind the water cart and the vibratory roller follows closely behind the PTR. It is important that the water cart and roller must work in close tandem at all times; in order to prevent any pick-up of the material onto the drum of the vibratory roller (although unusual with nano-modified emulsion).
3. Continue points 1 and 2 until the total area to be worked is completed.
4. The area treated then is to be kept closed to traffic in order for it to properly set (until the top 50 mm of the layer has dried out) with the moisture content of OMC < 50%. The time of required closure is dependent on the prevailing weather and may be as short as 1 hour. Due to the addition of the silane modification a hydrophobic material surface is created and water is effectively repelled from the layer. Hence, stabilised layers constructed using an anionic NME stabilising agent normally dries much quicker than pavement layers treated using traditional emulsion stabilisation processes which depend only on evaporation as a method of drying. In dry and hot conditions, a pavement layer can sufficiently dry within a period of less than 24 hours to reach 50% of OMC. The final surface should be smooth, tightly knit and free of undulations, corrugations, holes, bumps or loose material.'

The application of an applicable compatible prime (i.e. a recommended compatible Nano-silane Nano-Polymer based prime) when the base has reached a moisture content of 50% of OMC should prevent most damage under conditions of light trafficking in urban areas. Heavy brushing with soft bristles is recommended prior to the application of the prime to remove any dust or loose materials on the surface, not disturbing the surface itself. The instructions of the supplier should apply - the risk remains with the contractor to achieve an acceptable required base condition after application of the prime. Experience has shown that an applicable Nano-silane Nano-Polymer modified prime will dry within an hour. In cases where the surfacing is applied immediately, the prime may be substituted by an appropriate specified tack- coat. However, this is only applicable to cases where the contractor can ensure that the surfacing material and equipment is available for immediate application.

(o) Disposal of surplus material

Recovered pavement material remains the property of the Employer.

Surplus materials, including waste or over-size material, bladed or skimmed off the road, shall be stockpiled at designated areas within a free-haul radius of 5 km as directed by the Engineer with approval from the Client.

Should the Employer decide not to use the surplus material, the Contractor shall then dispose of the material to the satisfaction of the Client within a free-haul distance of 5 km.

(p) Checking moisture content and surface condition prior to priming and/or surfacing

The mixing and placing of asphalt or seal will not be allowed if:

(i) free water is present on the working surface; or

(ii) the moisture content of the upper 50 mm of the recycled base exceeds 50% of the Optimum Moisture Content (OMC).

(iii) in cases where the base has been primed and exposed to trafficking, the surface needs to be cleaned of all loose material and any localised problem area repaired using a nano-modified emulsion slurry (the same anionic NME used for the stabilisation of the base layer should usually be good to prepare smallquantities of slurry and ensure excellent bonding with the existing base-layer).

C1007 WEATHER LIMITATIONS

No in-situ recycling shall commence if the threat of rain is present. The in-situmoisture condition should allow for the dilution of the anionic NME in the constructionwater as described.

C1008 OPERATIONAL LIMITATIONS

The Contractor shall arrange his in-situ recycling of existing pavement layer operations in such a manner as to minimise the disruption of public traffic. Everyeffort shall be made to ensure the safety of the travelling public on existing roads throughout the site of the works at all times. In-situ recycling operations shall be carefully planned and executed in accordance with the following limitations:

(a) Individual work areas shall be clearly demarcated with traffic signs, delineators and traffic control facilities as specified.

(b) The individual work areas shall be planned in such a manner that all recycled pavement layers are compacted as specified in Clause C1006 (l) for a day's production.

(c) No priming shall be done unless the recycled layers have been tested, inspected and accepted by the Engineer. In cases where access need to be given to the public, priming will be done on instruction of the Engineer.

(d) Within individual working areas, the Contractor shall make adequate provision for drainage of milled, excavated and/or asphalt overlay areas where water can pond or be contained against a difference in depth on the roadway. No separate payment will be made for the provision and use of standby pumps and

dewatering equipment of cutting of drainage slots and / or channels to effectively drain the roadway surface where instructed by the Engineer in the interests of safety for the travelling public. The Contractor shall make due allowance for this drainage in this tendered rates.

(e) Delineators shall be placed along each longitudinal step exceeding 30 mm between adjacent lanes of the roadway.

The maximum allowable step within a lane open to traffic shall be restricted to 40 mm. If, due to plant breakdown or other unforeseen circumstances, a longitudinal or transverse step higher than 20 mm occurs within a lane, the strip shall be feathered off by means of compacted asphalt over a distance of500 mm.

(f) If rain falls during the application process, the work must be stopped, the area must be sealed by means of a single roller pass and application of the anionic NME shall only recommence once the moisture content of the area has returned to the level it was at before it started raining.

C1009 PROTECTION AND MAINTENANCE

The Contractor shall protect the completed base-layer from all damage until the asphalt or seal work is complete. Any damage occurring to the completed base or any defects which may develop due to faulty workmanship, shall be made good by the Contractor at his own expense and to the satisfaction of the Engineer.

Repairs shall be made in a manner approved by the Engineer to ensure an even and uniform surface.

During working and construction of the base-layer, precautionary measures shall be taken to prevent kerbs and channelling and concrete works from being damaged or shifted. Care shall be taken to protect all pre-cast units from chipping and breakage. Concrete kerbing and channelling, as well as other structures adjacent to the road, shall be protected against staining, by the anionic NME product. Any work stained by the anionic NME shall be broken down and replaced, unless all such anionic NME is

completely removed so as not to show any stains. Painting over stained work will not be allowed.

Where the cold in-situ recycling process is to be carried out at existing structures, care shall be exercised to avoid damage to concrete elements, expansion joints, manholes, catch-pits, etc. Damage caused to any element forming part of the permanent works shall be repaired at the Contractor's cost.

Damaged caused by the Contractor through careless operations shall be repaired at his own costs. New construction shall be done in accordance with the drawings and the Specifications. The Contractor will be held responsible for the timely adjustment of all covers and frames in advance of surrounding construction, whether they are indicated on the drawings or by the Engineer or not. No claims for delays arising from the failure of the Contractor to affect the necessary adjustments in good time will be allowed.

The type of surfacing and selection of the binder or modified binder should allow for evaporation of moisture to continue (similar to any other layer that will continue to have a reduction in moisture content due to evaporation). It should be noted that some modified binders do not allow for any evaporation to take place, leading to the trapping of evaporation and concentration of moisture and formation of water below the surfacing which could result in early problems in terms of stripping of the surfacing and / or, in the case of chip-seals, punching of the surfacing into the base, resulting in severe bleeding of the surfacing and earl failure.

C1010 CONSTRUCTION TOLERANCES AND FINISH REQUIREMENTS

(a) Construction tolerances

The applicable construction tolerances are the relevant tolerances indicated in the construction documents as related to the Category of Road. Where the existing granular base abuts kerbs or channels or New-Jersey barriers, the new work shall extend to the edge of these facilities.

Unless otherwise specified, the recycled base shall be constructed to the existing levels, cross-section profile and cross-fall to allow for a surfacing layer.

(b) NME stabilising agents

The average rate of application of the diluted anionic NME as measured at operating temperature in the recycling plant and water tanker shall be within 5% of the specified rate of application.

(c) Uniformity of mix (chemical stabilisation)

No additional chemical stabilisation agent is required with the use of a material compatible anionic NME stabilising agent.

(d) Statistical judgement schemes

Routine inspections and tests will be carried out by the Engineer to determine the quality of the materials and workmanship for compliance with the requirements of this section.

The statistical judgement schemes to be used to determine whether the requirements specified are being complied with shall be those set out in prescribed contract documents.

C1011 TRIAL SECTIONS

Where ordered by the Engineer, the Contractor shall execute trial cold in-situ recycling on the various materials to be reprocessed. During the trail sections any adjustments in terms of addition of water and applicable OMC should be finalised. The latter is of importance especially if layers in excess of 150 mm are to be stabilised in one operation (not advised). The water released and repelled by the anionic NME will be pushed upwards towards the top part of the layer, requiring an adjustment in the pre-mixed construction water.

Trial sections shall be carried out at locations approved by the Engineer.

C1012 WORK OUTSIDE NORMAL WORKING HOURS

Any work carried out outside of normal working hours must be approved by the Engineer. The Contractor shall give the Engineer at least 48 hours' notice of his intention to do work outside the normal working hours. The closure of traffic lanes will only be permitted during these times. The provision and layout of lighting for the works and warning lights for the accommodation of traffic shall be approved by the Engineer. No additional payment will be made for the provision of additional warning lights for work done outside of normal working hours. The Contractor shall allow for the provision, erection and maintenance of additional items required in his tendered rates.

C1013 TESTING

(a) Testing

The Contractor shall give the Engineer at least 24 hours' notice of his intention to stabilise / recycle / rework, so that the actual process can be monitored and tested (quality control) by the Engineer. Unless otherwise agreed in advance, the Contractor shall only stabilise / recycle/ rework when the Engineer or his representative is present.

(b) Test Methods for determining UCS and ITS values – applicable during the design as well as quality control process. The number of tests done during construction as part of quality control will be done in accordance to the instruction of the engineer.

The following material test methods shall be used for the testing of NME stabilising agents (engineering properties in terms of UCS and ITS values):

- As an input into the testing of the UCS and ITS of the material, the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) are to be determined using as per normal prescribed test procedures;

- The testing of the Unconfined Compression Strength (UCS), and the Indirect Tensile Strength (ITS) of the stabilised materials shall be done according to the protocols pre-scribed in the following paragraphs.

In all the above test methods the +37.5 mm material must be screened off and discarded. The aggregate passing the 37.5 mm sieve and retain on the 19.0 mm sieve must not be crushed and must be used in the testing process. A pH test must be performed to determine the acidity / alkalinity levels of the material.

The curing and testing process of the 152 mm diameter samples (127 mm high) shall be as follows:

The anionic NME stabilising agent is mixed in with the construction water and the sample prepared at Optimum Moisture Content (OMC). For example, if the OMC is 8 per cent and 1 per cent of the anionic NME stabilising agent is added, the material should and the in-situ moisture content is 3 per cent, the addition of (8-3) 5 per cent moisture should be added to the material to achieve OMC. The 5 per cent to be added will consist of a mixture of 4 per cent construction water and 1 per cent anionicNME as per total requirement. (Accordingly, the total fluid content (i.e. the total percentage of the anionic NME) is added as part of the compaction water – not only the water percentage of the anionic NME.)

No cement or lime is added to anionic NME stabilised material. Hence, the samples are not placed in plastic bags to assist with the hydration of the cement (as per usual Bituminous Stabilised Materials (BSM) designs which contain cement as an additive and hence, the samples need to be placed in plastic bags in the oven to assist in the hydration of the cement in the mix):

1. The prepared 152 mm diameter by a 127 mm height samples are to be prepared as per TMH 1 (Method A14) with no plastic covering. (Plastic covering is required when cement is included in the mix to assist in the hydration of the cement). Samples are cured for 24 hours in an oven at 30°C before being subjected to a “rapid curing” process in an oven (for 48 hours at 40 - 45°C) (temperatures in the oven should NOT exceed 50°C).

2. After 48 hours the samples must be removed from the oven and allowed to cool off for twenty-four (24) hours. This is preferably to be done in the oven at 30°C for 24 hours).

3. Three (3) samples must be crushed to determine the ITS and UCS values. The values obtained are called the DRY ITS and the DRY UCS values.

4. Three (3) samples must be placed in a bath of water with a temperature of 22°C - 25°C for four (4) hours and thereafter removed from the bath and allowed to drain off excess water before determining the wet ITS and UCS values. The values obtained are called the WET ITS and the WET UCS values. (ITS andUCS soaked values are determined (not required as per Table C1002/1) by leaving the samples in the bath for 24 hours.)

5. If so approved by the Engineer, the “wet” tests (UCS and ITS) may suffice during the quality control during construction. For the lower-order roads (Category D and E), DCP tests done at randomly selected spots may be approved for quality control as approved by the Engineer.

6. During the design stage 3 samples each must be preserved outside the moulds for a period of 28 days. After 28 days the UCS (wet and dry) as well as the ITS (wet and dry) should be tested as per procedure described above. The results of the 28-day tests should not show a decrease of more than 5% in the values of the respective UCS and ITS tests as compared to that obtained after the rapid curing process.
7. **It is important to note that sample preparation must be done in strict compliance with the prescribed procedures and NO deviation will be allowed**, including:
    7.1 The moulds in which the samples are prepared are not to be treated with grease or and other lubricant to facilitate the easy removal of the sample

as this could influence the loss of moisture and hence, the measurements of UCS and ITS, and

7.2 No additional soaking of samples in any “covering” liquid or any other material will be allowed as this will make any comparison and application of test requirements invalid and not comparable to what is practically achievable during construction.

C1014 TREATMENT OF GRAVEL ROADS TO PROTECT THE GRAVEL LAYER AND REDUCE DUST

All preparations of the NME materials and construction processes and testing as per normal construction and rehabilitation of roads as discussed under items C1001 to C1013 also apply to the treatment of the top layer of the gravel roads. In the case of gravel roads Table C1002/1 is replaced by Table C1014/1.

The surface of the wearing course should receive additional treated as described under Item C1006 (n).

Additional protection of the surface can be provided by the application of a Nano-Silane Nano-Polymer “clear seal”. The clear seal is applied as per product specifications using a diluted compatible nano-silane modified nano-polymer (applied at 1.6l to 2l / m^2) clear surfacing similar to a traditional prime, but with an extended expected duration, especially on fine graded materials.

Table C1014/1: Recommended material specifications for the treatment of wearing courses of gravel roads treated / stabilised with anionic NME

Test or Indicator	Material[1]	Material classification
		NME4- WC
Minimum material requirements before stabilisation and/or treatment (Natural materials)		
Material spec.(minimum) Unstabilised material: Soaked CBR (%)(Mod AASHTO)	NG/GS/SSSG (CS)	> 7 (93%)
Sieve analysis % passing the 0.075 mm sieve ($P_{0.075}$)		< 50 %
XRD scans: - Total sample - 0.075 mm fraction	ALL ALL	√ √
The greater of: Identified % Silt and Clay, or % Material passing 2 µm ($P_{0.002}$) (e.g. Clay & Mica & Talc), with Talc <10%) (XRD-scans of the material passing the 0.075 mm sieve is recommended for use to determine the % clay, mica and talc in the material).	NME with emulsion particle size > 2 µm	
	ALL	< 15 %
	NME containing micro-scale as well as nano-scale particles (adjusted according to material grading)	
	ALL	< 35%
	NME with emulsion containing nano-scale and pico-scale particles (grading adjustments) together with technologies addressing workability of materials on site	
	ALL	> 35%
Material specifications after stabilisation and/or treatment		
In-situ density to be required after stabilisation and compaction (mod AASHTO) (%) (minimum)	Base-layer	> 97 %
DCP DN (mm/blow) – Adjusted for Climate (C_f)[2] (stabilised and compacted) (Quality control)	Top of base	< 3.5 / (C_f)
Mod AASHTO density (%) (for laboratory testing)		> 100%
*UCS_{wet} (kPa) (150 mm Φ Sample)	**Design[3]**	**> 750**
	Construction[4]	**> 450**
Retained Compressive Strength (RCS): (UCS_{wet}/UCS_{dry}) (%)		> 75
RCS in relation to minimum $UCS_{wet\ (criteria)}$ ($RCS_{effective}$): (RCS x ($UCS_{wet}/UCS_{wet\ (criteria)}$)) (%)		> 100
*ITS_{wet} (kPa) (150 mm Φ Sample)	**Design[3]**	**> 100**
	Construction[4]	**> 80**
Retained Tensile strength (RTS): ITS_{wet}/ITS_{dry} (%)		> 60
RTS in relation to minimum $ITS_{wet\ (criteria)}$ ($RTS_{effective}$) (RTS x ($ITS_{wet}/ITS_{wet\ (criteria)}$)) (%)		> 100

[1]CS–Crushed Stone; NG – Natural Gravel; GS – Gravel Soil, and SSSC – Sand, Silty sand, Silt, Clay. UCS_{dry}; ITS_{dry} = testing after rapid curing; UCS_{wet}; ITS_{wet} = testing after rapid curing + 4 hours in water;

[2]Climatic factor (C_f) (Jordaan and Steyn, 2019) for required DCP-DN

Design[3] = Minimum criteria to be met in the laboratory during the design phase

Construction[4] = Minimum criteria to be met during construction as part of quality control

C1014 MEASUREMENT AND PAYMENT

Item Unit

C10.01 ESTABLISHMENT OF PLANT

(a) Establishment of cold in-situ recycling

Equipment/plant on site ..... lump sum

(b) Establishment of Conventional equipment on site ..... lump sum

The tendered lump sum shall include full compensation for the provision of any number of recycling machine(s)/plant on the section of the site and the subsequent removal thereof, including additional plant required for carrying out cold in-situ recycling operations.

The lump sum will become payable after the cold in-situ recycling work has been completed and the equipment has been removed from the site.

Payment will not distinguish between the number of recycling machines or conventional units of equipment brought onto and/or removed from the site. No payment will be made for the replacement of defective plant.

Item **Unit**

C10.02 Cold in-situ recycled granular layer treated)

(a) Using a recycler

(i) Base-layer (depth to be specified) compacted to the specified density (Table C1002/1) using an anionic New-age Modified Emulsion (NME) or equivalent ..... cubic metre (m^3)

(ii) Sub-base (depth to be specified) compacted to design specification as per Table C1002/1) using a New-age Modified Emulsion (NME) or equivalent ..... cubic metre (m^3)

(b) Using conventional plant

(i) Base-layer (depth to be specified) compacted to the required density as per table C1002/1) using an anionic New-age Modified Emulsion (NME) or equivalent.....cubic metre (m^3)

(ii) Sub-base (depth to be specified) compacted to the specified density as per Table C1002/1) using an anionic New-age Modified Emulsion (NME)or equivalent .....cubic metre (m^3)

The unit of measurement shall be the cubic metre of pavement recycled to provide the recycled base and or sub-base layer as specified.

The rate tendered shall include full compensation for the provision of all plant, labour, materials and all other incidentals necessary to produce the finished layer as specified but excluding the provision of the anionic NME stabilising layer which shall be measured and paid for under item C10.03. The emulsion will consist of a SS60 anionic emulsion with an emulsifying agent ("soap" or surfactant) consisting of Sodium Hydroxide with an alkyl group $CH_3(CH_2)_n$ (where n>18) (Vinsol resin or equivalent – the Contractor will take responsibility for using an emulsifying agent resulting in inferior test results).

The tendered rate shall also include full compensation for the milling of existing pavement layers, blending of the materials in the nominal mix ratios specified, supply, diluting of the anionic NME in potable water and mixing of the diluted anionic NME, spreading and final blading of the recycled mix, compacting the material to the specified density and protecting and maintaining the work in accordance with the specifications.

The tendered rate shall also include full compensation for the cleaning of the surface and the referencing of lane and control survey markings as specified.

Where ordered by the Engineer for the recycling of pavement layers to depths other than specified, the payment will be made on a *pro rata* basis between the tendered rates for nominal depths scheduled.

All failures due to the use of contaminated equipment (not thoroughly cleaned) will be for the cost of the Contractor.

Item **Unit**

C10.03 ANIONIC NEW-AGE MODIFIED (BITUMEN) EMULSION (NME) OR EQUIVALENT ..... / cubic meter stabilised

The unit of measurement shall be per cubic metre of the material stabilised with the anionic NME to be supplied to meet all the required criteria as specified and as instructed by the Engineer.

The tendered rate shall include full compensation for providing, diluting, expansion and applying the stabilising agent, irrespective of the rate of application. The material compatible anionic NME will be provided to site by the supplier to meet the specifications. The Contractor will take full responsibility and liability for using a stabilising agent not meeting the END-PRODUCT specification. During the design phase, the Design Engineer should ensure that products are available that will meet the specifications with the given naturally available materials.

Item **Unit**

C10.04 Chemical additive

No chemical additives will be required with an anionic NME stabilising agent.

Item **Unit**

C10.05 Pre-treating the base layer with an anionic NME stabilising agent

No pre-treatment of lime, etc. will be required with an anionic NME stabilising agent. Some minerals may require pre-treatment with an appropriate / proven product. Payment is to be similar to Items C10.02 and 10.03.

Item **Unit**

C10.06 Blading of surplus material to windrow ..... cubic metre (m^3)

The unit of measurement shall be the cubic metre of surplus material bladed to windrow as specified by the Engineer.

The tendered rate shall include full compensation for all labour equipment and any other incidentals required for blading to windrow of surplus material with a motor grader.

Item **Unit**

C10.07 Removal from site of surplus material .....cubic metre (m^3)

The unit of measurement shall be the cubic metre of surplus material removed.

The volume shall be determined as prescribed by the Engineer and shall be theloose volume in stockpiles or its equivalent measured in hauling vehicles. Accurate load and haul sheets shall be kept on site and submitted to the Engineer. The tendered rate shall include full compensation for loading and transporting the surplus material to a designated spoil or stockpile site within a 5 km radius.

Item **Unit**

C10.08 Construction of a temporary wearing course.....square metre (m^2)

The unit of measurement shall be the square metre of recycled granular baseslushed in accordance with the requirements of section C1006 (n) of the Project Specification and the tendered rate shall include full compensation thereof..

Item **Unit**

C10.09 Trial sections were ordered (extra over item C10.02 and C10.03) ……..……..……..……square metre (m^2)

The unit of measurement shall be the square metre of recycled pavement layers as ordered.

The tendered rate shall include full compensation for the construction of the trial section of recycled pavement layers complete as specified.

Item **Unit**

C10.10 Extra over Item C10.02 for adding extra material to the layer

(a) Gravel Base (G2) .....cubic metre (m^3)

(b) Gravel sub-base (G5)..... cubic metre (m^3)

(c) RA .....cubic metre (m^3)

The unit of measurement shall be the cubic metre of material added on the instruction of the Engineer, which quantity shall be taken as 70% of the loose volumemeasured in trucks, unless instructed by the Engineer that the quantity be determined by way of cross-sections.

The tendered rate shall include full compensation for procuring and adding the specified material to the layer, for spreading the material, for all haul and other incidentals to add the material to the layer.

Item **Unit**

C10.11 Milling out existing bituminous material with an average milling depth:

(a) Not exceeding 30 mm ..... cubic metre (m^3)

(b) Exceeding 30 mm but not exceeding 60 mm.....cubic metre (m^3)

(c) Exceeding 60 mm..... cubic metre (m^3)

Measurement shall be as per pay item 38.02

Item **Unit**

C10.12 Providing the milling machine on the site (size indicated) .....number (No)

Measurement shall be as per pay item 38.14

C10.13 Break down of in-situ material ..... cubic metre (m^3)

The unit of measurement shall be the cubic meter of material measured after compaction. The quantity measured shall be computed by method of average end areas from levelled cross-sections prepared from the existing road surface before any ripping or breaking down of the existing surface and base-course has taken place.

All measurement shall be neat and material placed in excess of the authorized cross-section will not be paid for.

The tendered price shall include the ripping, breaking down, preparing, processing, shaping and watering the materials to the specified densities.

C10.14 Application of a prime or "clear seal"..... / m^2

Rates should include the provision of suitable distribution equipment able to apply the prim or specified "clear seal" to meet the required specifications and at the specified required rate.