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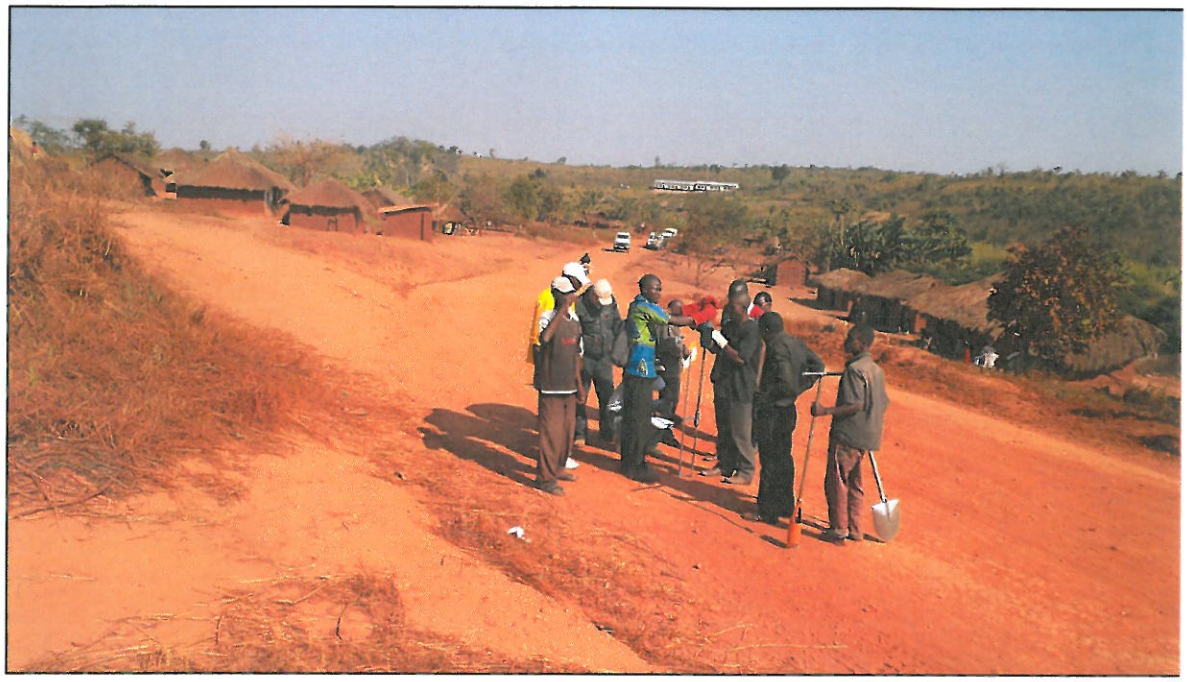

INCEPTION REPORT

AFCAP/DRC/107/A

Consultancy services for materials investigation, pavement design and identification of appropriate surfacing options – Phase IDRC Experimental Road

1 August 2013

aurecon

This project was funded by the Africa Community Access Programme (AFCAP) which promotes safe and sustainable access to markets, healthcare, education, employment and social and political networks for rural communities in Africa.

Launched in June 2008 and managed by Crown Agents, the five year-long, UK government (DFID) funded project, supports research and knowledge sharing between participating countries to enhance the uptake of low cost, proven solutions for rural access that maximise the use of local resources.

The programme is currently active in Ethiopia, Kenya, Ghana, Malawi, Mozambique, Tanzania, Zambia, South Africa, Democratic Republic of Congo and South Sudan and is developing relationships with a number of other countries and regional organisations across Africa.

This material has been funded by UKaid from the Department for International Development, however the views expressed do not necessarily reflect the department's or the managing agent's official policies.

For further information visit https://www.afcap.org

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Contents

1. Introduction and background 1
2. Assignment objectives 2
3. Approach and methodology 3
4. Design parameters 5
5. Work programme 6
6. Knowledge transfer 8
7. References 9

Index of Figures

Figure 1: DCP test device 3

Index of Tables

Table 1: Scoping visit itinerary 1
Table 2: Design parameters 5
Table 3: Summary of deliverables and dates 6
Table 4: Proposed programme 7

List of Appendixes

APPENDIX A: List of attendees
APPENDIX B: Materials investigation specification

1. Introduction and background

The Government of the Democratic Republic of Congo (GoDRC) has requested participation in the Africa Community Access Programme (AFCAP) in order to benefit from best practice guidelines for rural transport developed in other countries in the region. The DRC also offers the opportunity to carry out new research on the design and maintenance of rural roads in very high rainfall areas. This AFCAP research project is managed by Crown Agents that appointed Aurecon AMEI (Aurecon) in June 2013 to provide Consultancy Services for Materials Investigations, Pavement Design and Identification of Appropriate Surfacing Options for a 5km research road section in the DRC.
As part of the project inception, a scoping visit was organised in Kinshasa and on site in Kalemie during the week of 8 July 2013. This visit aimed to introduce all the parties involved in the project, finalise the selection of the research section in the Katanga Province on the Kalemie-Uvira Road and to provide training for the field teams that would be conducting the materials investigation. A detail schedule of the visit is presented in **Error! Reference source not found.** below, while a list of the attendees is provided in Annexure A.

Table 1: Scoping visit itinerary

Date	Place	Activity	Attendance
8 July	Kinshasa	Meeting: Introduction, presentation of different parties and overview of the project.	Crown Agents, Cellule Infrastructure, Office des Routes, Division de voies de dessertes Agricoles and Aurecon
9 July	Kinshasa	Security briefing at UK embassy and introduction to DFID.	DFID, Crown Agents and Aurecon
9 July	Kinshasa	Meeting: review of ToR, technical discussion on testing methods and design.	Crown Agents, Cellule Infrastructure, Office des Routes, Division de voies de dessertes Agricoles and Aurecon
10 July	Kinshasa	Visit to the Laboratoire National de Travaux Publics (LNTP).	Aurecon
11 July	Kalemie	Site visit and finalization of the research section selection.	Crown Agents, Office des Routes and Aurecon
12 July	Kalemie	Meeting: overview of testing methodology by Aurecon.	Cellule Infrastructure, Office des Routes, Division de voies de dessertes Agricoles and Aurecon
12-13 July	Kalemie	First site investigation (DCP and test pits).	Cellule Infrastructure, Office des Routes, Division de voies de dessertes Agricoles and Aurecon
13 July	Lubumbashi	Visit to the Laboratoire National de Travaux Publics (LNTP).	Crown Agents
14 July	Kalemie	Site investigation: (strip map data collection).	Aurecon

This inception report provides guidelines as to the work that will be undertaken, a programme of when activities and deliverables will be submitted and what the deliverables will entail.

2. Assignment objectives

The main project aims to provide research information for the development of specific design standards for low volume roads in the DRC. Research data will be generated through the construction and monitoring of specific research and demonstration road sections, approximately 5 km in length. This specific assignment involves the design of a 5km experimental road section and the compilation of tender documentation.

The experimental road is located in the Province of Katanga, specifically the Kalemie - Uvira road. The project will include the following:

- Materials investigations on the project road to provide input for the design of the experimental road. The investigations will include DCP measurements, test pitting and sampling and laboratory evaluation of the in-situ materials. A limited topographical survey will also be conducted to ensure that possible drainage problems are addressed.
- Design of the pavement layer works using the DCP pavement design method, developed by Kleyn and Van Heerden (1983) and recently updated under AFCAP for application under Malawian conditions (Pinard, 2011) and Kenia (IT Transport, 2013). The designs will be adjusted to take site specific material, drainage, safety etc. issues into consideration.
- Preparation of technical specifications and schedules of quantities for the inclusion in the tender documentation.
- Provision of in service training to GoDRC, Office des Routes and Cellule Infrastructures staff.

In terms of the overall project objectives we understand that country specific adjustments to the DCP design method will probably include modifications to the design DN numbers for the layer works. Accordingly detail characterisation of the local road building material will be required and thus be included in the research section test matrix. Additionally the test matrix would require scope for refinement of compaction requirements as well as the design cross section.

3. Approach and methodology

We have broken down our approach in different tasks as indicated in the Terms of reference programme.

Collect / Collate Available Data

Data of particular importance to be collected is:

- Similar AFCAP project reports in neighbouring countries,
- Available existing geotechnical and borrow pit data,
- Regional rainfall and climatic data,
- Any as-built data on the existing gravel roads.

Aurecon also has digital maps with contours on Globalmapper which will be used on this project to assist with the location selection, drainage and the general topography outside of possible surveyed areas.

Field Inspection and materials survey

Delegates from Office des Routes will perform the fieldwork sampling and testing. During the initial field inspection trip both Aurecon's project engineer and pavement expert visited the proposed sites. Possible materials sources were also visited including gravel borrow pits and stone quarries. The most appropriate location was selected and details of the materials investigation confirmed including DCP and test pit positions (see illustration below of DCP method usage below).

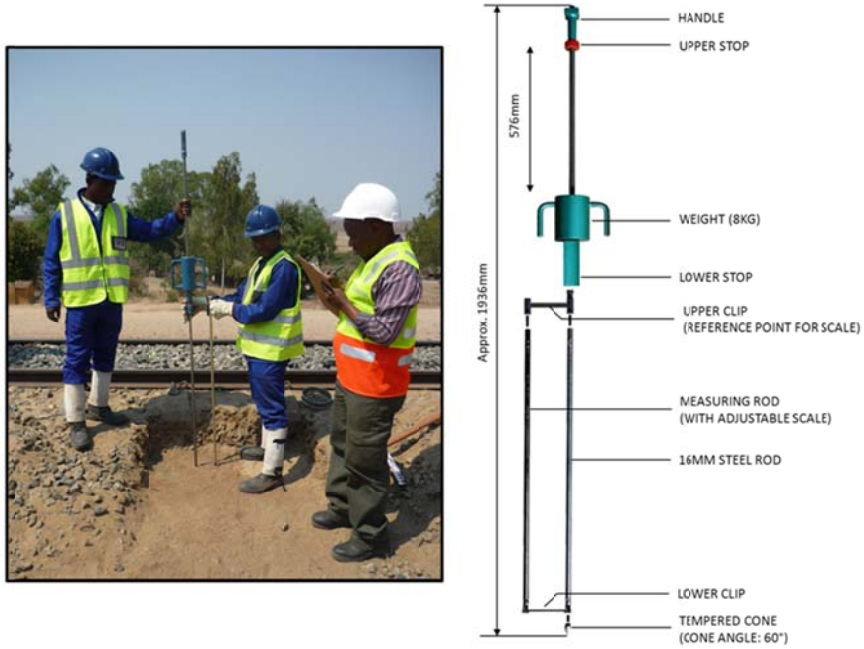


Figure 1: DCP test device

In addition, the personnel doing the fieldwork were briefed on any specific requirements regarding the material sampling and in-situ testing. A Field Investigation Specification, detailing the requirements of the field investigation and testing, has been attached in Annexure B.
A video logging of the proposed research section was also performed for reference purposes.

Environmental Impact Assessment

Although environmental issues will be considered during the selection of the research section locations, we assume that an Environment Impact Assessment (EIA) will not form part of the scope of works. Any environmental requirements that needs to be addressed for the opening of new borrow pit areas will not form part of the scope of works.

Topographical Survey

A topographical survey will be commissioned to be performed by Office des Routes and as a minimum include vertical alignment levels at 20m intervals. The final alignment will be fixed in conjunction with delegates from Office des Routes and Cellule.

Pavement design

The findings of the AFCAP LVSR design document developed for Kenia (IT Transport, 2013) will be used as a guide to the design process. Particular adjustments related to the in situ moisture regime will be required as saturated conditions will be expected in the DRC for a significant part of the year.
Based on the expected traffic volume suggested by Office des Routes, the design traffic loading for the experimental road will be determined. The DCP data received will be analysed and uniform pavement sections identified. The layer-strength diagrams for each uniform section will be determined and the required pavement strengthening calculated. It is proposed that for each uniform section, a 25% thinner and a 25% thicker covering layer be constructed.
Surfacing alternatives to be investigated will probably include slurries and otta seals due to the availability of seal stone and construction equipment. Aurecon has extensive experience in the design of all these thin surfacing's under varied conditions and we will provide typical design applications for the research sections. We would expect that each of the research sections be sealed with a selected variation of seals and probably application rates to be able to collect data on their performance and accordingly make adjustments to their application under local conditions.

Drainage design

The main cross drainage structures on the specific route are being upgraded under the current SynoHydro contract. Accordingly only nominal longitudinal drainage in the form of side drains and mitre drains will be provided.

Specifications and schedule of quantities

A technical specifications document will be compiled that will detail any special requirements regarding the earthworks, pavement layer works, surfacing, erosion protection and drainage. SATCC (2001) will be used as the standard specifications.

Additionally a separate Bill of Quantities, based on the above specifications will be developed. Consideration will be given to developing special pay items that would simplify the standard detail pay items into a combined item where appropriate. Special attention will be required to the detailing of quality control and testing requirements (SATCC Series 7000), where the use of the DCP to control relative compaction will be specified.

Monitoring of the research sections

The monitoring of the research section does not form part of this contract; however it is recommended that the final report elaborate on proposed monitoring actions required to verify the quality of construction as well as the long term performance of the sections and appropriateness of the design parameters and methodology. These would typically include:

- Construction quality control; density, compaction moisture, layer thickness.
- Long term performance monitoring; surface defects, rut depths, moisture ingress and rainfall.

4. Design parameters

The design parameters specified in Table 2 will apply.

Table 2: Design parameters

Description	Design criteria
Design traffic	100 vehicles per day for the whole section.
Typical cross section	6m carriageway with 1m shoulders on each side.
Side drain dimensions	Use the criteria set in IT Transport (2013). Maximum mitre drain length 20m.
Number of uniform sections	Maximum 8
Minimum uniform section length	300m
Base layer thickness variation	3 (25% upper, average, 25% lower) for 3 uniform sections with different subgrade conditions.

5. Work programme

Table 3 below provides a summary of the proposed deliverables and their dates. A Gant diagram of our proposed programme is shown in Table 4. Apart from the initial site visit, another visit to Kinshasa will take place during the submission of the final tender documents.

It is emphasised that the timely completion of the fieldwork, laboratory testing and the topographical survey by Office des Routes will be key to the completion of the project on the proposed delivery date.

Table 3: Summary of deliverables and dates

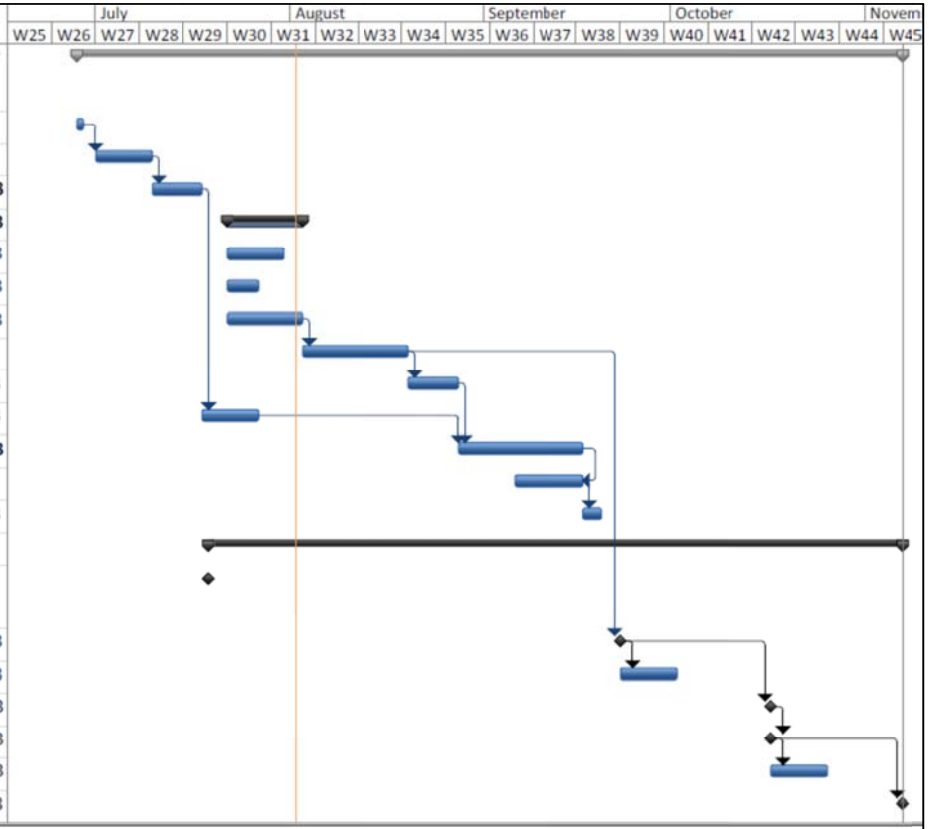
Phase	Deliverables	Completion Date
Site visit, project start	Inception report	7/31/2013
Design	Draft design report	9/23/2013
	Final design report	10/17/2013
Tender documentation	Draft Bill of Quantities, Specification and drawings	10/17/2013
	Final Bill of Quantities, Specification and drawings	11/6/2013

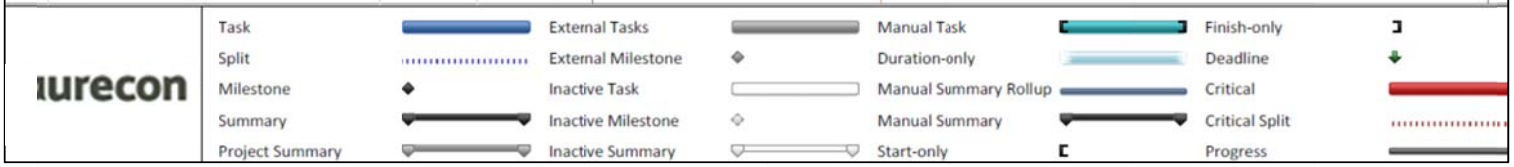
The drawings will include the following:

- Typical cross section.
- Typical drainage detail (mitre drain, side drain and drift structure details).
- Pavement design drawing.
- Borrow pit design drawing (depending on the quality of information received from the materials investigation).

Table 4: Proposed programme

WBS	Task Name	Duration	Start
0	***DRC Experimental Low Volume Surfaced Roads***	***94 days***	***Fri 6/28/13***
1	**Appointment**	**1 day**	**Fri 6/28/13**
2	**Data collection and background study**	**7 days**	**Mon 7/1/13**
3	**Site visit - Test site selection**	**7 days**	**Wed 7/10/13**
4	**Fieldwork**	**10 days**	**Mon 7/22/13**
4.1	Topograpical survey	7 days	Mon 7/22/13
4.2	DCP survey	5 days	Mon 7/22/13
4.3	Test Pitting	10 days	Mon 7/22/13
5	**Laboratory testing**	**14 days**	**Sat 8/3/13**
6	**Review lab and field data**	**7 days**	**Tue 8/20/13**
7	**Traffic loading determination**	**7 days**	**Thu 7/18/13**
8	**Pavement design**	**14 days**	**Wed 8/28/13**
9	**Drainage design**	**7 days**	**Fri 9/6/13**
10	**Cost estimate**	**3 days**	**Tue 9/17/13**
11	**Report Milestone Dates**	**79 days**	**Fri 7/19/13**
11.1	Materials investigation specification and Inception report	0 days	Fri 7/19/13
11.2	Draft design report	0 days	Mon 9/23/13
11.3	Peer review - design report	7 days	Mon 9/23/13
11.4	Final design report	0 days	Thu 10/17/13
11.5	Draft tender documents	0 days	Thu 10/17/13
11.6	Peer review - tender documents	7 days	Thu 10/17/13
11.7	Final tender documents	0 days	Wed 11/6/13





6. Knowledge transfer

We understand that capacity building and transfer of knowledge are key components of this assignment and will endeavour to work in close collaboration with the local partners i.e. GoDRC, Office des Routes and Cellule Infrastructure. To this end we propose that a group of 5 young engineers/counterparts be nominated to take part in the project training. During the initial site visit they accompanied the pavement design experts to site. It is proposed that they become involved in the actual materials investigation and witness the material sampling and laboratory testing. An additional full day design training workshop for these individuals is included in the scope of works with the delivery of the final tender documents in Kinshasa.

7. References

Kleyn, EG; Van Heerden, MJJ; 1983 *Using DCP soundings to optimise pavement rehabilitation.* Proceedings of the Annual Transportation Convention, Johannesburg, South Africa.

IT Transport; 2013 *A guide to pavement design of low volume sealed roads using the DCP design method*. Final Report, Kenyan Roads Authority.

Pinard, MI; 2011 *Performance review of design standards and technical specifications for low volume sealed roads in Malawi*. Final Report, African Community Access Programme Project MAL/016, Malawian Roads Authority.

SATCC (2001). *Standard Specifications for Road and Bridge Works.* Southern Africa Transport and Communications Commission.

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APPENDIX B: Materials investigation specification

DRAFT

MATERIALS INVESTIGATION SPECIFICATION

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INDEX

ABBREVIATIONS, TERMS AND UNITS OF MEASUREMENT 4
1. SCOPE OF THE INVESTIGATION 6
1.1 CENTRE LINE TEST PITTING AND TESTING 6
1.2 BORROWPIT TEST PITTING AND TESTING 6
2. SPECIFICATIONS FOR PROFILING 7
3. SPECIFICATIONS FOR TEST PITTING 8
3.1 TEST PIT DIMENSIONS 8
3.1.1 EXISTING ROAD (PAVEMENTS) AND SHOULDERS 8
3.1.2 BORROW PITS AND NEW ALIGNMENTS 8
3.2 SAMPLING AND TESTING INSTRUCTIONS 8
3.2.1 SAMPLING OF SEPARATE TEST PIT LAYERS 8
3.2.2 SAMPLE BAGGING AND LABELLING 8
3.3 TEST PIT AND DCP NUMBERING 9
3.4 LOGGING OF TEST PIT POSITIONS 9
3.5 BACKFILLING OF TEST PITS 9
3.6 PROVISION OF PHOTOGRAPHS 9
4. SPECIFICATIONS FOR BORROW PITTING 10
4.1 GENERAL 10
4.2 LOCATION OF POTENTIAL BORROW PITS 10
4.3 SAMPLING, RECORDINGS AND TESTING 10
5. SPECIFICATIONS FOR FIELD TESTING 12
5.1 DYNAMIC CONE PENETROMETER PROBINGS 12
6. LABORATORY TESTING SPECIFICATIONS 13
7. SPECIFICATIONS FOR REPORTING 15
ANNEXURE A: STANDARDISED TEST PIT PROFILE TEMPLATE 16
ANNEXURE B: TEST PIT PHOTOGRAPH TEMPLATE 17
ANNEXURE C: LABORATORY TESTING INSTRUCTION SHEET 18
ANNEXURE D: BORROW PIT DATA FIELD SHEET 19
ANNEXURE E: FACTUAL REPORT CONTENT 20
ANNEXURE F: TYPICAL BORROW PIT LAYOUT DRAWING 21
ANNEXURE G: TYPICAL BORROW PIT LAYOUT MAPS 22

LIST OF TABLES

Table 1: Unit of measurement 4
Table 2: Abbreviations and terms – Institutions and companies 5
Table 3: Material quantities required for construction (compacted) 10
Table 4: Borrow pit target area locations 10
Table 5: Details of laboratory testing 13

ABBREVIATIONS, TERMS AND UNITS OF MEASUREMENT

The following units of measurement and abbreviations and terms are applicable to this report:

Table 1: Unit of measurement

Unit	Name	Measures
%	percent	percentage
hr	hour	time
km	kilometre	length
m	metre	length
mm	millimeter	lenght
m^2	square metre	area
m^3	cubic metre	volume
kg	kilogram	mass
t	tonne	mass
kg/m^3	kilogram/cubic metre	density
kN	kilonewton	force
kPa	kilopascal	pressure
MPa	megapascal	pressure

Table 2: Abbreviations and terms – Institutions and companies

Abbreviation	Definition
AASHTO	American Association of State Highway and Transportation Officials
ACV	Aggregate Crushing Value
ADT	Average Daily Traffic
ASTM	American Society for Testing and Materials
COLTO	Committee of Land Transport Officials
CBR	California Bearing Ratio
CSRA	Committee of State Road Authorities
ESA	Equivalent 80kN Standard Axles
FACT	Fines Aggregate Crushing Test
FIND	Foundation Indicator
GM	Grading Modulus
GPS	Global Positioning System
GWC	Gravel Wearing Course
LL	Liquid Limit (Atterberg Limits)
LS	Linear Shrinkage (Atterberg Limits)
MDD	Maximum Dry Density
NP	Non plastic
OMC	Optimum Moisture Content
PI	Plasticity Index (Atterberg Limits)
RIND	Road Indicator
SANS	South African National Standards
TLB	Tractor-Loader-Backhoe
TMH	Technical Methods for Highways
TRH	Technical Recommendations for Highways
USCM	Unified Soil Classification Method

1. SCOPE OF THE INVESTIGATION

The objective of this document is to provide guidelines for a centre line and borrow pit materials investigations with the associated laboratory testing.

1.1 CENTRE LINE TEST PITTING AND TESTING

In order to complete the materials investigation and detail design, the following test pitting and testing is suggested :

- Number of test pits: 12 (every 400m)
- Number of DCP tests: 100 (every 50m)
- Sieve analysis testing: 24 (at least 2 per testpit)
- Atterburg limit testing: 24 (at least 2 per testpit)
- MDD and OMC testing: 12 (at least 1 per testpit)
- CBR testing: 12 (at least 1 per testpit)

1.2 BORROWPIT TEST PITTING AND TESTING

In order to complete the borrow pit materials investigation and detail design, the following test pitting and testing is suggested :

- Number of borrowpits: 3
- Number of test pits: 18 (6 per borrowpit)
- Sieve analysis testing: 18
- Atterburg limit testing: 18
- MDD and OMC testing: 12 (4 per borrowpit)
- CBR testing: 12 (4 per borrowpit)

The above relates to 3 borrow pits of approximately 1 hectare each (grid approximately 80m), with 6 test pits per borrow pit.

2. SPECIFICATIONS FOR PROFILING

Soil profiling of test pits for the materials investigations shall be done in accordance with *Jennings J.E., Brink A.B.A. and Williams A.A.B. 1973. Revised Guide to Soil Profiling for Civil Engineering Purposes in South Africa, and Standards South Africa. South African National Standard. Profiling, and Percussion and Core Borehole Logging in Southern Africa for Engineering Purposes. SANS 633:2009*. *Draft*. Only experienced engineering geologists, geotechnical engineers or senior materials technicians shall profile test pits..

Special notes on the log sheet shall include the following:

1. Depth at which the water table or seepage is encountered;
2. Refusal depth and the material the refusal occurred on;
3. Conceivable geological formations and considerations, etc.;
4. Type of samples taken and their corresponding depths;
5. Testing that will be required; and
6. All other information that may be required relating to the particular location with regards to:
    - graves, dwellings, agricultural activities, obstacles and obstructions, etc.
    - environmental sensitive areas.
    - rock outcrops encountered, possible rock hardness.
    - expected borrow pit excavation hardness and material oversize.
    - material quantity in general.
    - expected expansion possibilities in general.

The test pit profiles will be compiled as indicated in Annexure A: Standardised test pit profile template.

3. SPECIFICATIONS FOR TEST PITTING

3.1 TEST PIT DIMENSIONS

3.1.1 EXISTING ROAD (PAVEMENTS) AND SHOULDERS

The excavation of the testpit shall be 1.25 m x 0.70 m minimum in area, to the total depthof 800 mm. The excavation shall be carried out with due care, so that each layer/type of material encountered can be sampled separately (grouped). The excavation shall be carried out neatly, by hand, with the sides of the testpit being vertical.

3.1.2 BORROW PITS AND NEW ALIGNMENTS

The excavation depth shall be approximately 3m or refusal, but not less than 2m. In order to prove borrow pit viability, provision must be made for the use of a TLB if possible.

3.2 SAMPLING AND TESTING INSTRUCTIONS

3.2.1 SAMPLING OF SEPARATE TEST PIT LAYERS

The field logging engineering geologists /geotechnical engineers /senior materials technicians will identify horizons in the test pits where testing is desirable. Representative samples shall be taken from each layer/horizon, in accordance with TMH5 with specific reference to sampling method MC1. A sufficient quantity of material shall be sampled and labeled in order to conduct all the required test work:

• Road indicator (Atterberg limits and sieve analysis): 10 kg

• CBR (including MDD and OMC): 80 kg

3.2.2 SAMPLE BAGGING AND LABELLING

Samples of soils, gravel and rock shall be deposited in strong plastic sample bags and labeled with a tag attached to the bag with a cable-tie. An additional label shall be placed in a smaller plastic bag and placed with the material in the sample bag.

The following data shall be indicated on the sample tags:

- Project name: AFCAP EXPERIMENTAL ROAD PROJECT
- Test pit: e.g. TP-400
- Sample depth: e.g. 0.6 m
- Name of profiler/logger: e.g. Christian Nzungu
- Date sample taken: e.g. 14 July 2013
- Type of test: e.g. Road indicator /CBR

An instruction sheet, as indicated in the Laboratory testing instruction sheet in Annexure C: Laboratory testing instruction sheet, detailing the list of samples and the required tests to be performed on the samples, shall be compiled and submitted with the samples to the laboratory. In the case of Borrow pit investigation, a Borrow pit data field shall also be compilred as per Annexure D: Borrow pit data field sheet and submitted with the sample to the laboratory. Copies of the instruction sheet and the Borrow pit data shall be sent to the Client.

3.3 TEST PIT AND DCP NUMBERING

The test locations shall be named as indicated below:

Test name = **XXXYYYY- ZZ**, where

XXX = **BT** for Borrow pit Test pit, **CT** for Centre line Test pit and **DCP** for DCP test position;
YYYY = location of investigation e.g. 050 (at chainage 50); and
ZZ = Sequential Number, if more than one test is performed at a specific position.

3.4 LOGGING OF TEST PIT POSITIONS

The coordinates of the test pits and DCP test positions shall be logged by the engineering geologist /geotechnical engineer /senior materials technician with a handheld GPS (typically to within 8 m accuracy). It may be necessary to relocate some of the test pits to a more suitable location, due to the presence of structures, trees or crops or safety concerns, at the location originally chosen in the design /project office. Approval will be required to relocate test pits and borehole positions. The coordinates and elevations shall be indicated on the final test pit or borrow pit test pit log sheets and drawings when they are submitted.

3.5 BACKFILLING OF TEST PITS

On completion of a test pit the site shall be cleared, the test pit backfilled and the immediate surrounding area levelled. The test pit will be backfilled with the excavated material in the reverse sequence in which it was excavated, aiming to reinstate the test pit to its preceding situation. The material shall be compacted in 200 mm layers by means of hand tamping /machine to at least 93% of Modified AASHTO density. Any shortfall of materials, due to sampling, will be supplemented with materials of at least TRH 4 G7 quality. It is also required that photographs of each site be taken prior to excavation and after backfilling of each test pit. These photographs will be issued to the Client for record purposes.

3.6 PROVISION OF PHOTOGRAPHS

On completion of the excavation of testpits, a clear photograph of quality (minimum 4 mega picsel) will be taken which will include the following:

- The full depth of the profile showing no shadows.
- A board/clipboard indicating the road number, kilometer distance and position.
- Interface of layers marked by inserting nails and then connecting white string to the nails along each interface.
- A survey staff/scale inserted into the testpit and held in position against the face of the testpit.

On completion of the excavation of new alignment and Borrow pit testpits, a clear photograph of quality will be taken which will include the following:

- The full depth of the profile showing no shadows.
- A board/clipboard indicating the Borrow pit and testpit number.
- A survey staff/scale inserted into the testpit and held in position against the face of the testpit.

The use a flashlight is always encouraged in order to produce photographs of quality.

Annexure B: Test pit photograph template. depictes a Test Pit photograph.

4. SPECIFICATIONS FOR BORROW PITTING

4.1 GENERAL

A borrow pit survey (construction materials investigation) will be conducted and the focus will be on obtaining sufficient information to determine material utilization on a detail design level. All procedures for the materials investigations and testing shall be in accordance with the standards and requirements contained in TMH 5 and TMH 1.

4.2 LOCATION OF POTENTIAL BORROW PITS

In principle the haul distance from the borrow pit to the point of proposed use should be as short as possible. The spacing of borrow pits for earthworks and formation layer materials should typicallty not exceed 7 km. Sufficient quantities of materials for all works will be required and the quantities of materials shall exceed the total demand for each material type by at least 15%. Estimated material volumes are provided in *Table 3*.

Table 3: Material quantities required for construction (compacted)

Material Type	***Quantities***
Stone for seal	700 t
G5	10,000 m^3
G7	10,000 m^3
G9	10,000 m^3

The positions of the primary borrow pit target areas, as well as the prospecting areas are indicated in *Table 4* below.

Table 4: Borrow pit target area locations

BP number	***Km Chainage***	***Co-ordinates***	***Comments***
BP 01	Km 9.9	S5 52.611; E29 11.542	Currently used by SynoHydro; quartz pebbles
BP 02	Km 25.9	S5 46.069; E29 07.341	Old Safricas quarry; quartz rock and pebbles
BP 03	Km 29.3	S5 45.375; E29 04.655	Existing Office Des Routes pit; quartz pebbles

If the proposed target areas do not display the desired material characteristics and quantity, the field contractor shall expand the search geographically in the vicinity of the target and surrounding area. The field contractor shall communicate such decisions to the Client. The field contractor shall also obtain confirmation from the Client to proceed to a new target area after completion of a borrow pit.

Preference should be given to borrow pits located in positions where it is not visible from the completed road, and positioned to allow sufficient drainage. Borrow pits should ideally also not be on watercourses or ridges of hills where the skyline will be altered. An Environmental Management Plan and Environmental Impact Assessment (EIA) will be required for the borrow pits.

4.3 SAMPLING, RECORDINGS AND TESTING

The depth to which the investigation must be carried out is a function of the uniformity of the geology and soils in the relevant areas, and within that, the availability of materials for road construction. The test pitting will preferably be performed by means of a backhoe (TLB) to a depth of approximately 3 m, or refusal. Representative samples shall be taken for the purpose of laboratory testing over the full extent of the horizon if the material is considered to be usable. For each test pit at least one Indicator test and one CBR test will be required.

Adequate sampling and testing will be performed to prove the availability and quality of the material (viability of the borrow pit). Sample pits shall generally be spaced at no greater than 75 m centres. When an extensive source is investigated, it is not required to test more than 6 samples, provided the material quality remains consistent throughout the area. Only materials suitable for construction shall be sampled. “Small samples” are intended for indicator tests, and “large samples” for indicator and CBR tests. Large representative samples shall be taken from layers in excess of 0.3m to 0.4m thickness, etc. Similar layers can be combined at times when the quality of the material is of a similar nature. Where no samples are taken, an attempt will be made to refer to materials that appear to be similar at other test pit positions in the immediate area. The test instructions are completed on a Laboratory testing instruction sheet (Annexure D: Borrow pit data field sheet.

Additional information, such as the expected excavation hardness in relation to SANS 1200 classifications, alluvial, colluvium, maximum diameter of boulder and oversize percentage shall be recorded. The field contractor shall specifically pay attention to whether the borrow pit materials require additional grid rolling, crushing and /or screening. All features and aspects that may impact on material quantities, sourcing operations and environmental related issues shall be recorded. A schedule (Annexure D: Borrow pit data field sheet) indicating material quantity limiting factors, shall be completed for each borrow pit by the field contractor and forwarded to the Client. A clear photograph shall be taken showing the surrounding area, the soil and gravel horizons in detail to full depth, using a tape measure for scale, and all the relevant materials as typically shown in Annexure B: Test pit photograph template. The test pit number and coordinate will be indicated in neat and clear print on the photo next to the relevant soil /gravel profile or material sample.

5. SPECIFICATIONS FOR FIELD TESTING

5.1 DYNAMIC CONE PENETROMETER PROBINGS

The tests shall be carried out in accordance with draft TMH6 method ST6. The maximum depth of penetration of the DCP probe will be 800 mm. The field moisture content at each DCP test position shall be assessed by performing an auger excavation to a depth of approximately 500mm at that position. A description of the moisture content (as per Section 2 above) and the soil type shall be noted on the DCP measurement data sheet. A photogragh of the excavated material shall be taken upon completion.

6. LABORATORY TESTING SPECIFICATIONS

Table 5 summarises the testing specified by the Client. The applicable test methods and the approximate sizes of the material samples that will be required for the tests to be performed, are also shown.

Table 5: Details of laboratory testing

Item	Description of tests	Test method	Size of material required
1	Complete granulometry	TMH 1 A1 & A5	3 kg
	Atterberg limits	TMH 1 A2-A4	3 kg
	Determinantion of the maximum dry density and optimum moisture content	TMH 1 A7	50 kg
	California Bearing Index (5 points)*	TMH 1 A8	50 kg

*Note: For each CBR test specified a DCP CBR test is also required as detailed below.

For each CBR test specified a DCP CBR test will also be required that consists of the following:

- Perform a DCP test on a 100% modified AASHTO compacted sample inside the mould just after compaction at OMC as indicated in Figure 1. Penetration needs to be recorded after each blow on the top 100mm of the mould. Record the actual moisture content of the sample.

- Perform a DCP test on a 100% modified AASHTO compacted sample at OMC inside the mould after allowing the sample to air dry for 4 hours. Record the actual moisture content of the sample.

- Perform a DCP test on a CBR soaked sample just after CBR penetration by turning the sample so that the penetrated side are facing downwards. Record the actual moisture content of the sample.

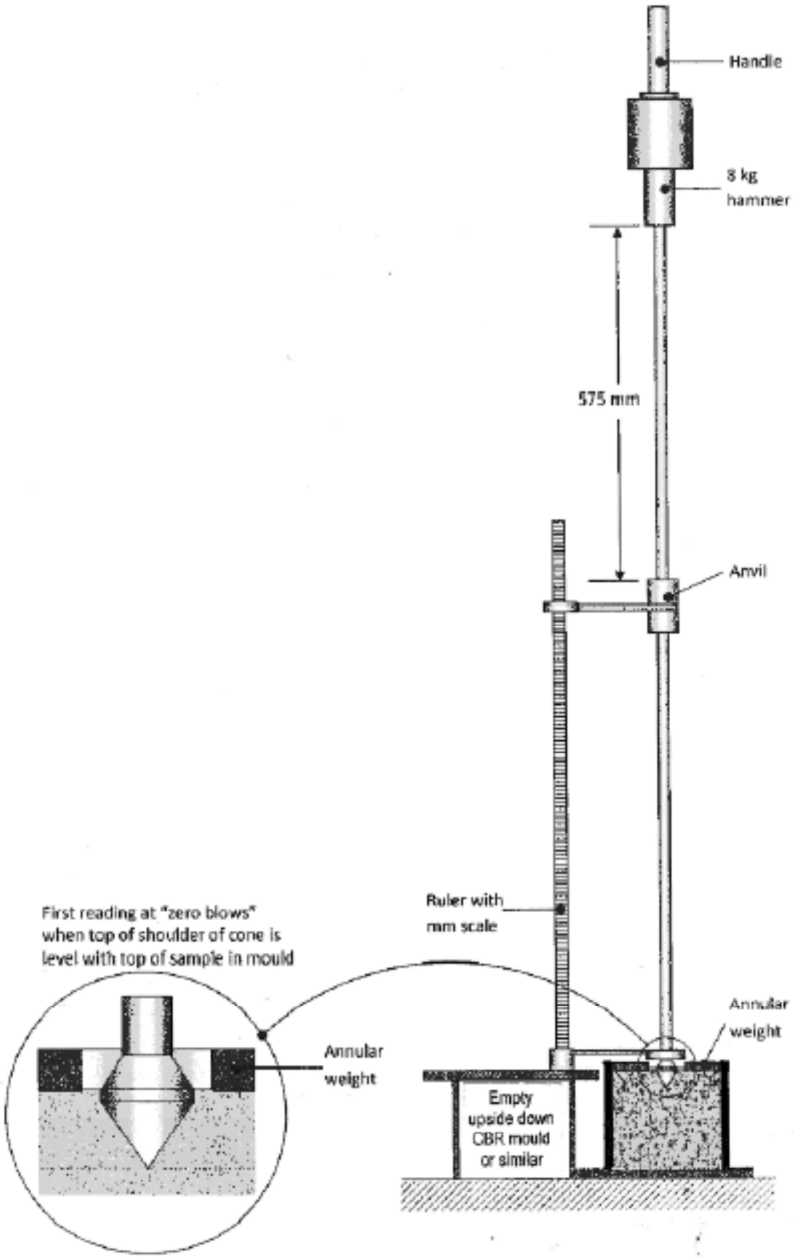


Figure 1: Determination of DCP CBR value (laboratory DN value)

7. SPECIFICATIONS FOR REPORTING

The field contractor shall present a factual report of the materials investigation addressing all the requirements listed in this document. Included in the report shall be the test pit profiles, summaries of laboratory test results presented in a sequential manner, DCP data sheets, the borrow pit field sheets, borrow pit location drawings and a photo report. The report should be submitted in digital format (.docx format) and all photographs, clearly referenced, in a separate folder in .jpg format. All data sheets can be submitted in .pdf format while GPS logs should be in .gdb format.

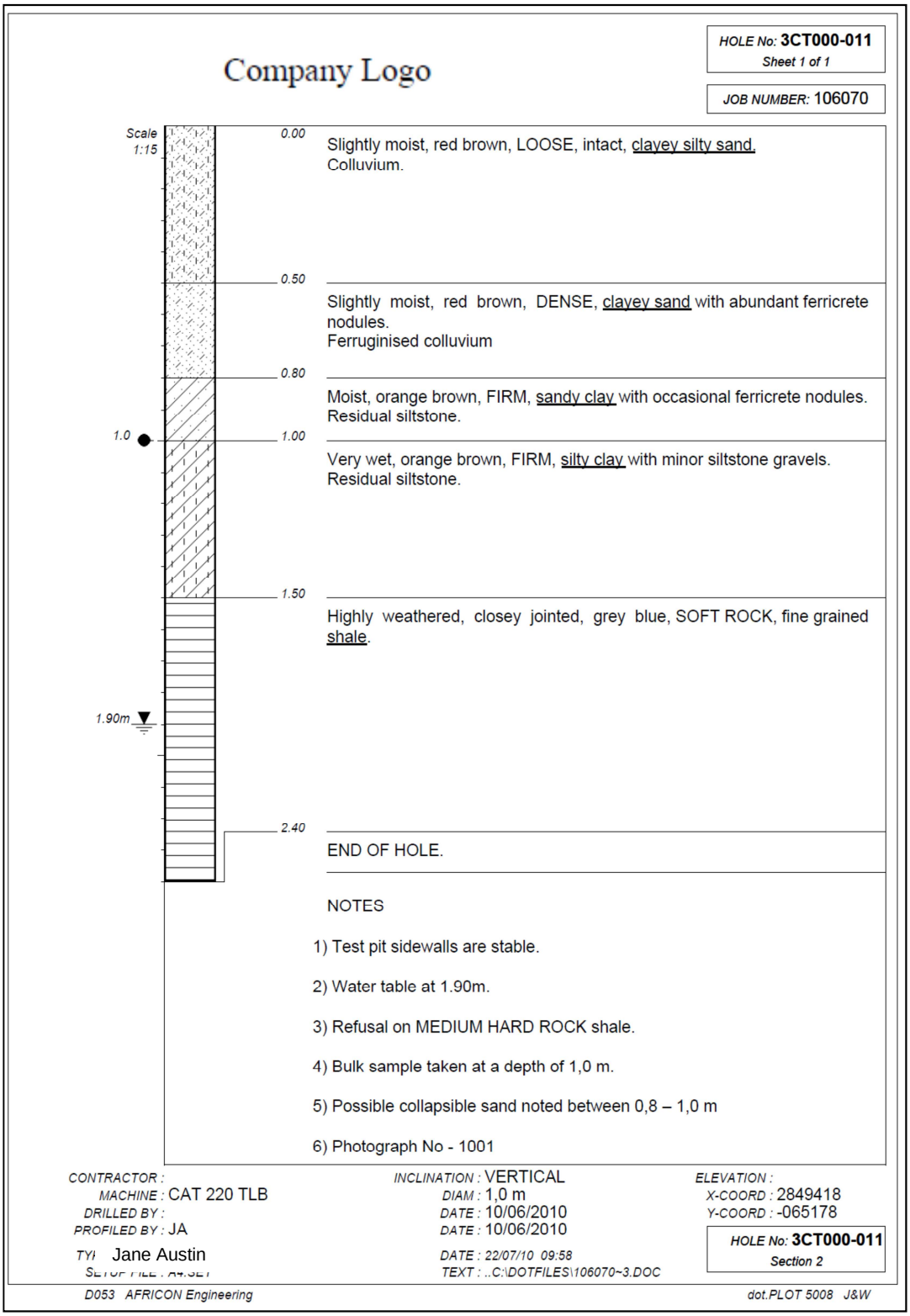
A layout of the contents required in the report is provided in Annexure E: Factual report content.

The borrow pit drawings shall include the following:

- A general layout drawing, at a minimum scale of 1:125,000, indicating the positions of the borrow pits that were investigated. The drawing shall have a table indicating the specific coordinates of the centre of each of the borrow pits. A typical general layout drawing (key plan) is provided in Annexure F: Typical borrow pit layout drawing.
- For each borrow pit, a layout map shall be included indicating the borrow pit's relative position to the construction works and how access will be attained, the layout of the test pits, other structures and possible expansions. A typical borrow pit layout map is indicated in Annexure G: Typical borrow pit .

ANNEXURE A: STANDARDISED TEST PIT PROFILE TEMPLATE

Test Pit Input Template File

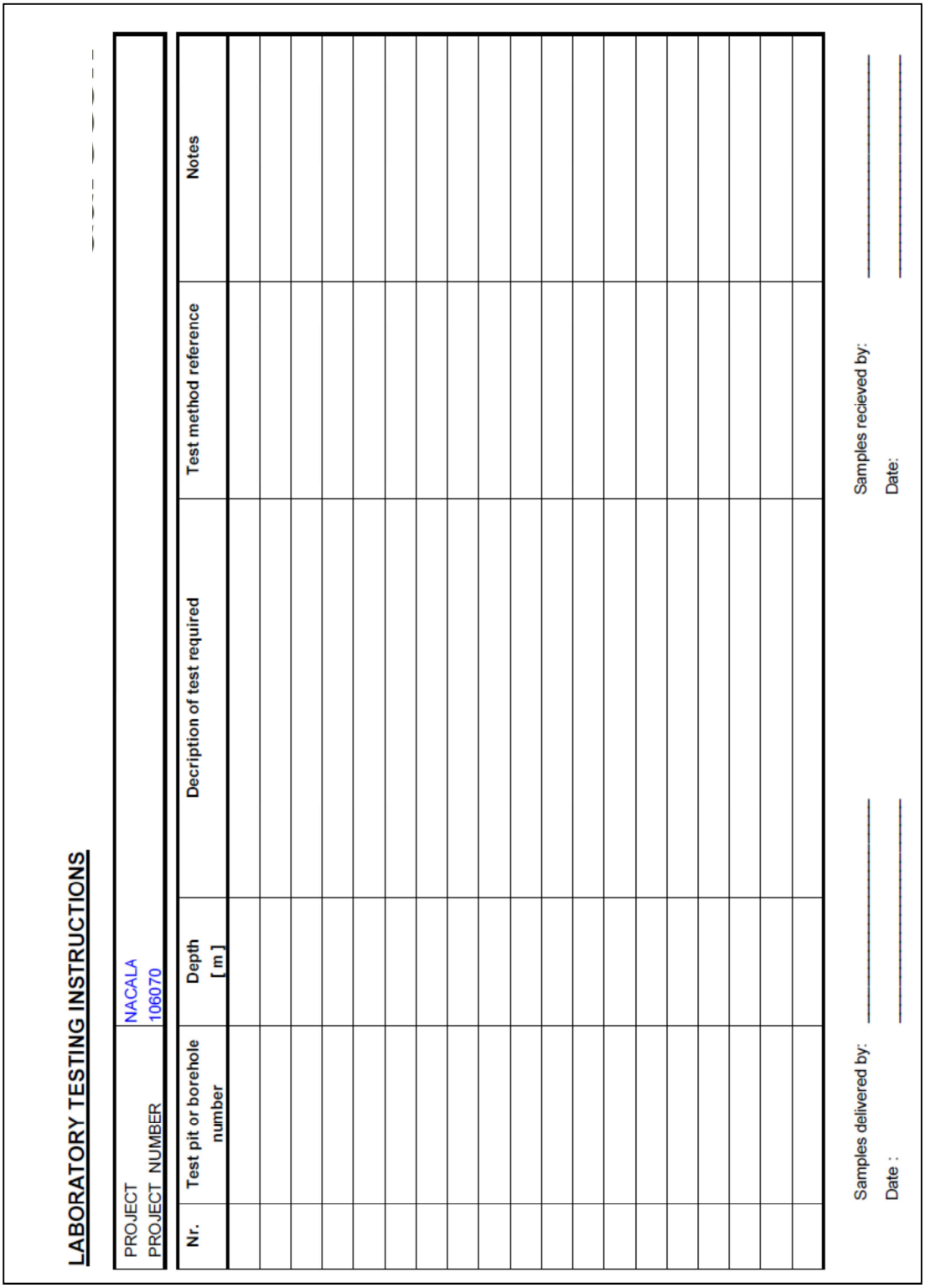


ANNEXURE B: TEST PIT PHOTOGRAPH TEMPLATE

Company Logo

PROJECT		SECTION	
DATE PROFILED		TEST PIT No.	
DEPTH (m)		CHAINAGE POSITION	

ANNEXURE C: LABORATORY TESTING INSTRUCTION SHEET



LABORATORY TESTING INSTRUCTIONS

PROJECT NACALA
PROJECT NUMBER 106070

Nr.	Test pit or borehole number	Depth [m]	Decription of test required	Test method reference	Notes

Samples delivered by: _____
Date : _____

Samples recieved by: _____
Date: _____

ANNEXURE D: BORROW PIT DATA FIELD SHEET

Borrow pit name:	**Date of investigation:**	**Investigator:**	
Position from centreline: **Coordinate:**	Total area (hec) : Dimensions (m) :	Overburden thickness (m): Quantity overburden:	Material thickness (m): Total quantity usable material /s:

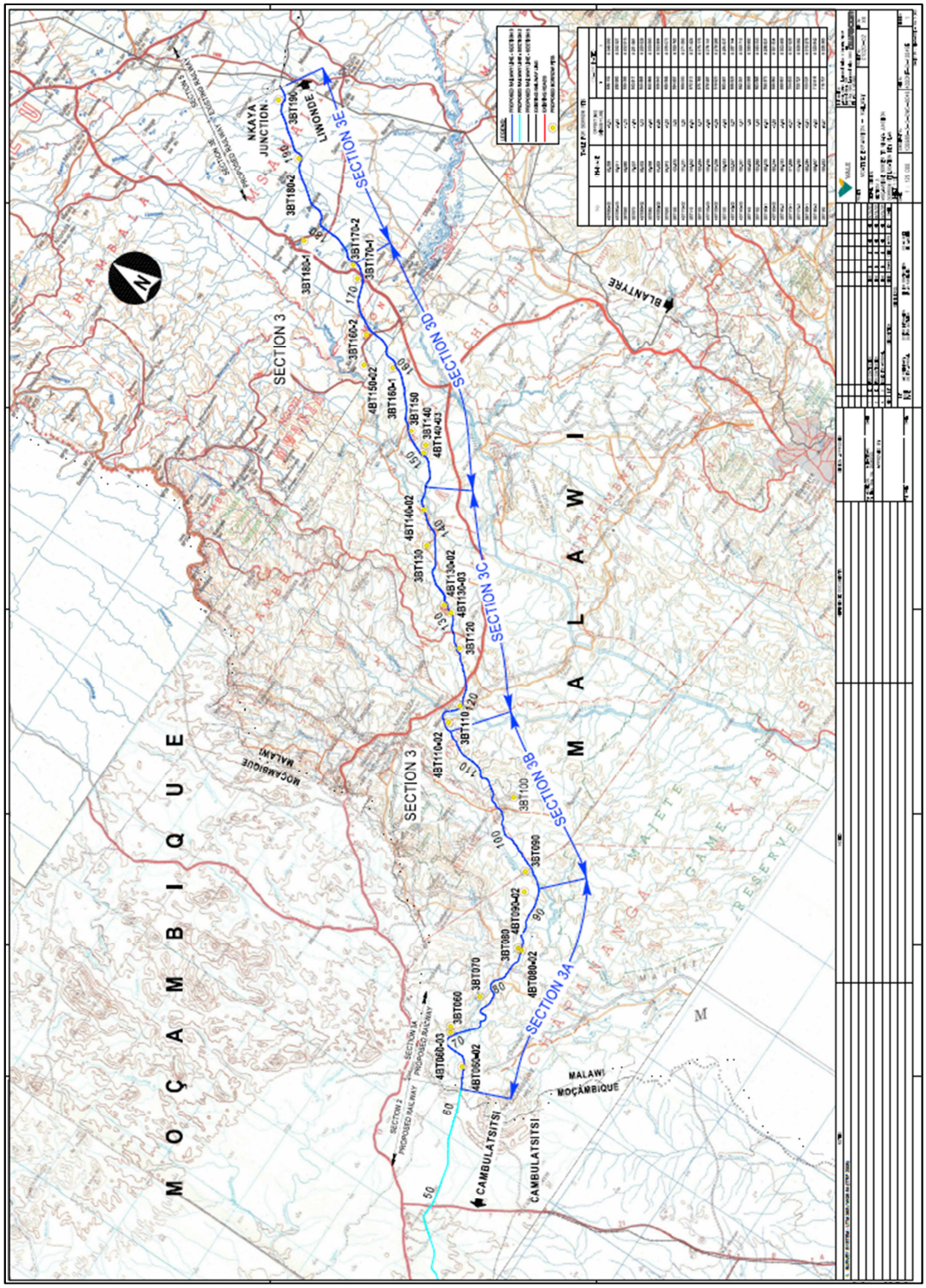
Quantity limiting factors and detail	**Yes / Min**	**No / Max**	**Remarks (detail measurements and recordings)**
1. Number of test pits, and type of material (fine /coarse granite /ferricrete)	Number:		Type:
2. Variability of overburden (min & max) measured in m			
3. Maximum oversize (m)			
4. Percentage oversize			
5. Excavation hardness (soft /intermediate /boulder /hard)			
6. Slope, extraction (number of refusals) and environmental problems			
7. Number of large trees			
8. Graves			
9. Power lines			
10. Dwellings			
11. Lands and fields			
12. Rocky outcrops			
13. Roads			
14. Other areas to be avoided			
15. Drainage problems and surface water			
16. Other factors that may impact on quantity calculations			
17. Obstacles and hazards			

Signature:	**Date:**	

ANNEXURE E: FACTUAL REPORT CONTENT

1. Introduction
2. DCP tests
   2.1 DCP data sheets
   2.2 DCP photographs
3. Centre line tests pits
   3.1 Test pit profiles
   3.2 Test pit photographs
   3.3 Laboratory test results
4. Potential borrow pits
   4.1 Locations of potential borrow pits
   4.2 Borrow pit test pit profiles
   4.3 Borrow pit photographs
   4.4 Individual borrow pit descriptions and summaries
      Access, location, land use, dwellings, material quality, variability, oversize & excavation hardness, expansion possibilities, drainage of area, summary of test results.
   4.5 Laboratory test results
   4.6 Borrow pit quantities and material deficits
   4.7 Layout drawings
5. References

ANNEXURE F: TYPICAL BORROW PIT LAYOUT DRAWING



ANNEXURE G: TYPICAL BORROW PIT LAYOUT MAPS