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REPORT ON THE ASSESSMENT OF TRENCHING INTHE ROAD RESERVE OF THE ROAD BETWEEN BEAUFORT WEST AND CARNAVON.

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1. INTRODUCTION AND BACKGROUND

CSIR, MERAKA (SANReN), approached CSIR Built Environment to carry out a physical and visual assessment of the route they intended using for the laying an underground fibre cable between Beaufort West and Carnarvon. This work was for the Square Kilometre Array (SKA) project.

The intention of SKA was to bury the cable within the road reserve of the road between Beaufort West and Loxton and from Loxton to Carnarvon.

This report contains the visual assessment of the route and also a limited number of soil tests. Also, recommendations are given on the trench digging and backfilling.

The visual assessment was done to determine the feasibility of digging the trench along the route, taking into consideration obstacles to digging such as bridges, culverts, watercourses, rocky outcrops, etc.

The limited soil investigation was done to determine the compactability of the soil along the route, as the trench to be dug to house the cable would have to be re-filled primarily with the excavated material and this material adequately compacted.

2. Visual Assessment of the route

Figure 1, gives an estimate of the road reserve that can easily be trenched. However, it must be emphasized that it is a visual survey and as such does not include what may occur below the surface. Figure 2 is a more detailed observation of the obstacles to trenching.

The study area is located in the Karoo Supergroup within the Beaufort group and Ecca group. Both groups comprises of sandstone, mudrock (siltstone, shale, clay) and the karoo dolerite. The sandstone is mainly jointed and fractured (Figure 3) and forms alternating layers with mudrock (Figure 4) in some areas. The dolerite is in a form of boulders (core stones) which are a result of spheroidal weathering (Figure 5). In some areas, secondary minerals such as kaolinite, chlorites etc are observed, which, are the end products of dolerite weathering. The compressive strength of these rocks is fundamental when constructing a trench. In general, sandstone has UCS strength of 20-170 MPa while mudrocks ranges between 5-100 MPa (shale) and 100-200 MPa (slate). Dolerite on the other hand has a compressive strength ranging between 200-300 MPa.

The road within the study area is 180.3 km and can be divided into two sections i.e. from Beaufort West to Loxton and Loxton to Carnarvon. The first section of the road (Beaufort West to Loxton) is quite mountainous (Figure 6) and dominated by dolerite. Between 6.6 km and 25km, the area is very rocky and mainly made of dolerite (Figure 7). From 25km to 40km, digging a trench is possible as the area is less rocky but has more trees. Between 40km and 43km, the area gets rocky again. After 43km, digging is again possible.

The path between Loxton and Carnarvon is less rocky but has quite a number of small cuttings (Figure 8 typical small cutting). Some of the cuttings are of dolerite in composition whilst some are of sandstone and mudrock. The sandstone is highly fractured compared to the dolerite. The jointing and fracturing of the sandstone as well as the weathering of dolerite has an influence on the strength of the rocks, respectively. Generally, jointing and weathering reduces the rock strength thus weakening the rock.

A number of man-made features (bridges and culverts) were observed. Details of these are given in Figure 2 and Table 1.

Figure1: Feasibility of Trenching along the Route

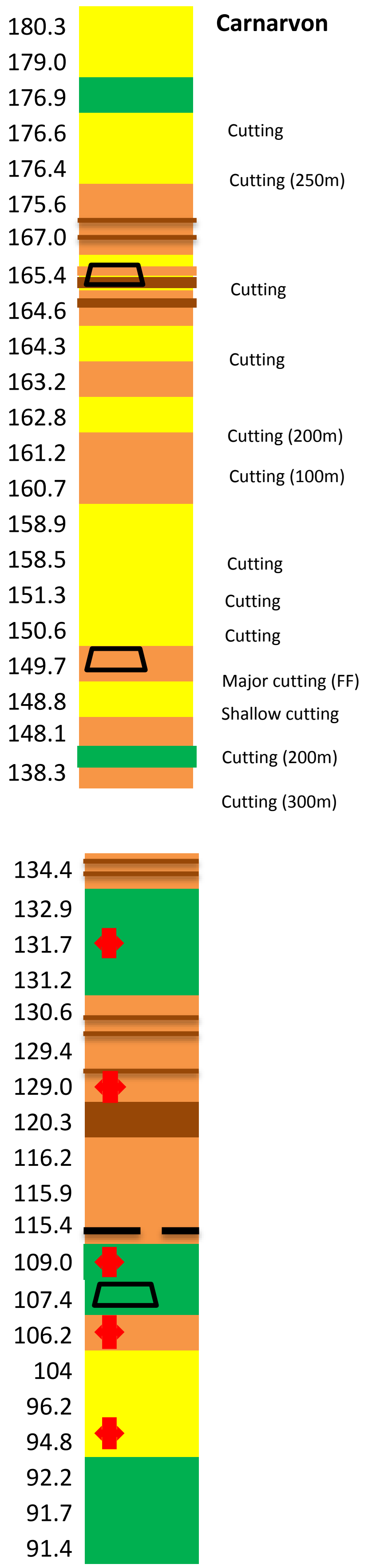


Figure 2: Details of obstacles to trenching

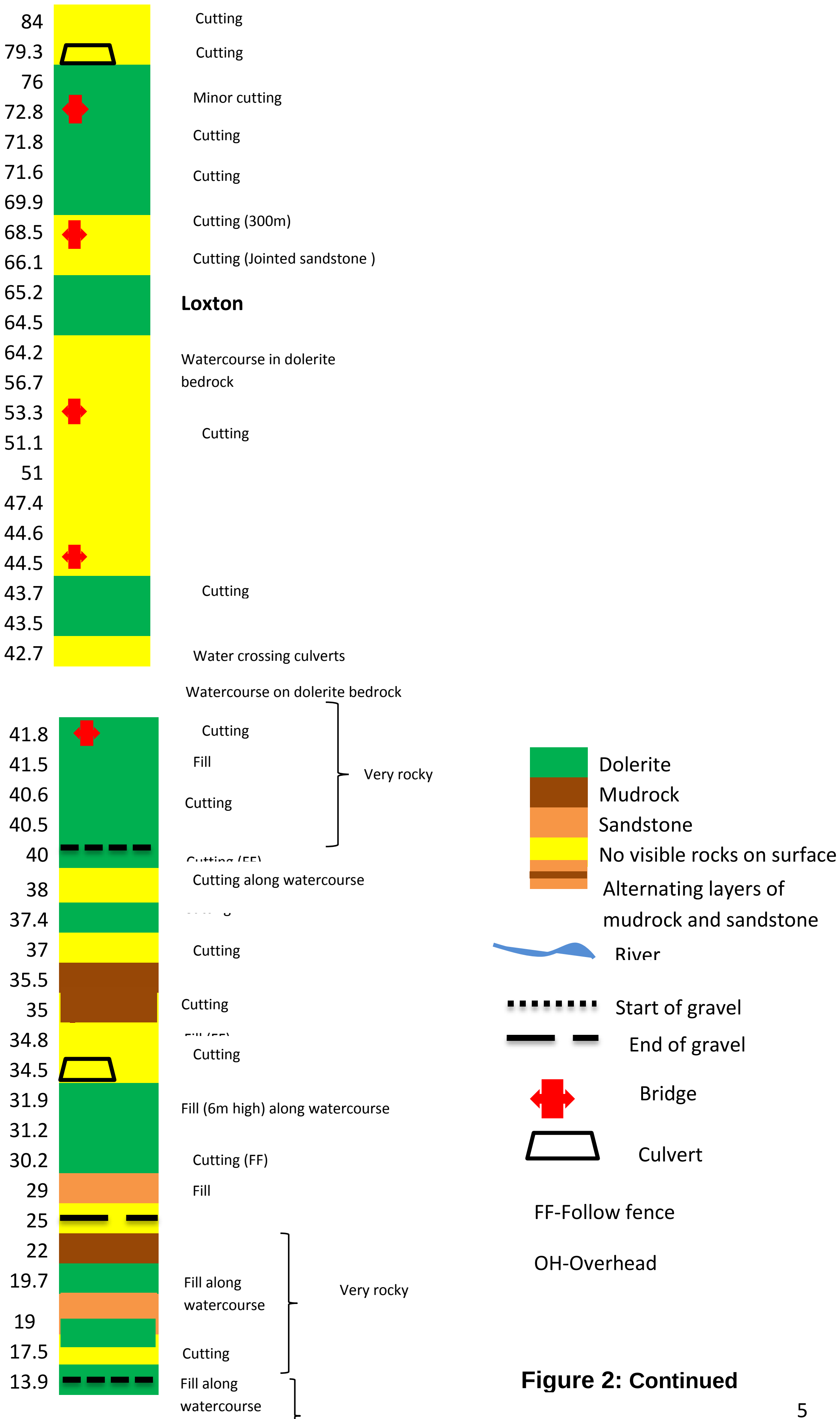


Figure 2: Continued

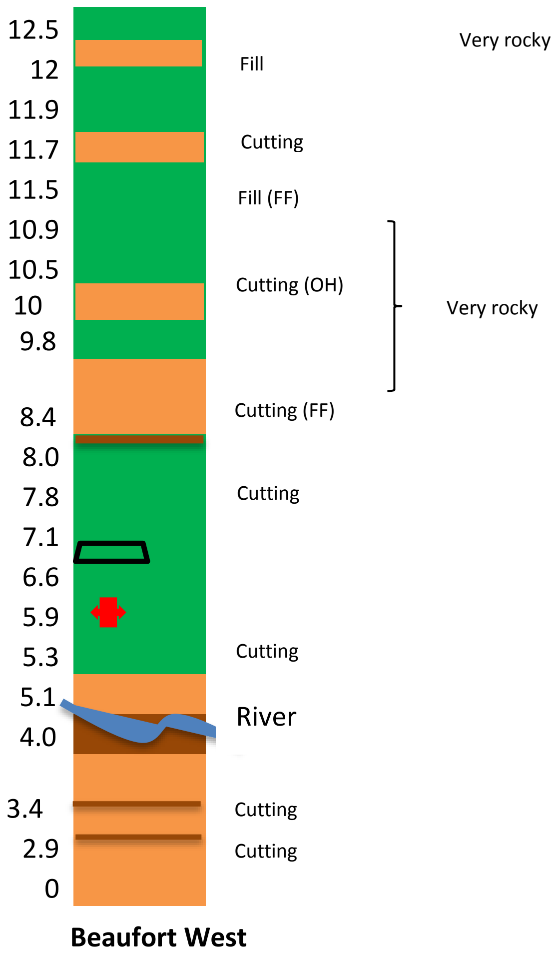


Figure 2: Continued

Table 1: Bridges and Culverts along the route

Province	Route No	Road No	Road Km	Structure_Type	Overall Length (m)	Overall Width (m)
W Cape	R381	TR05801	0.96	Major Culvert	12.9	10.9
W Cape	R381	TR05801	5.8	Bridge	30.0	11.3
W Cape	R381	TR05801	6.8	Major Culvert	3.2	13.6
W Cape	R381	TR05801	7.74	Major Culvert	5.3	23.0
W Cape	R381	TR05801	16.35	Major Culvert	7.0	20.5
W Cape	R381	TR05801	16.43	Major Culvert	7.7	12.7
W Cape	R381	TR05801	16.49	Major Culvert	8.1	11.5
W Cape	R381	TR05801	20.03	Major Culvert	3.9	14.7
W Cape	R381	TR05801	20.88	Major Culvert	5.4	11.0
W Cape	R381	TR05801	28.19	Major Culvert	94.0	17.4
W Cape	R381	TR05801	29.77	Major Culvert	8.9	16.2
W Cape	R381	TR05801	31.4	Major Culvert	3.5	17.7
W Cape	R381	TR05801	32.86	Major Culvert	11.9	16.3
W Cape	R381	TR05801	34.76	Major Culvert	4.0	13.0
W Cape	R381	TR05801	39.82	Bridge	58.3	4.3
W Cape	R381	TR05801	42.39	Bridge	57.4	4.4
W Cape	R381	TR05801	43.87	Major Culvert	3.4	13.6
W Cape	R381	TR05801	50.67	Major Culvert	41.5	7.4
W Cape	R381	TR05801	59.56	Major Culvert	12.5	9.1
W Cape	R381	TR05801	61.97	Major Culvert	3.6	9.5
W Cape	R381	TR05801	65.16	Major Culvert	25.3	9.3
W Cape	R381	TR05801	69.25	Major Culvert	14.8	9.2
W Cape	R381	TR05801	70.45	Major Culvert	3.7	10.2
W Cape	R381	TR05801	72.38	Major Culvert	5.6	10.2
W Cape	R381	TR05801	87.76	Major Culvert	11.8	9.9
W Cape	R381	TR05801	90.72	Major Culvert	44.2	7.2
W Cape	R381	TR05801	91.63	Bridge	11.9	7.4
N Cape	R381	TR05801	101.3	Bridge	18.6	9.6
N Cape	R381	TR05801	104	Bridge	60	7
N Cape	R63	TR01606	0.6	Bridge	6	13
N Cape	R63	TR01606	14.9	Bridge	27.5	12
N Cape	R63	TR01606	25.1	Bridge	28	12
N Cape	R63	TR01606	45.2	Bridge	71	7.5
Nn Cape	R63	TR01606	47.5	Bridge	45.5	9

Figure 3: Jointed sandstone

Figure 4: Alternating layers of sandstone and shale

Figure 3: weathered dolerite boulders

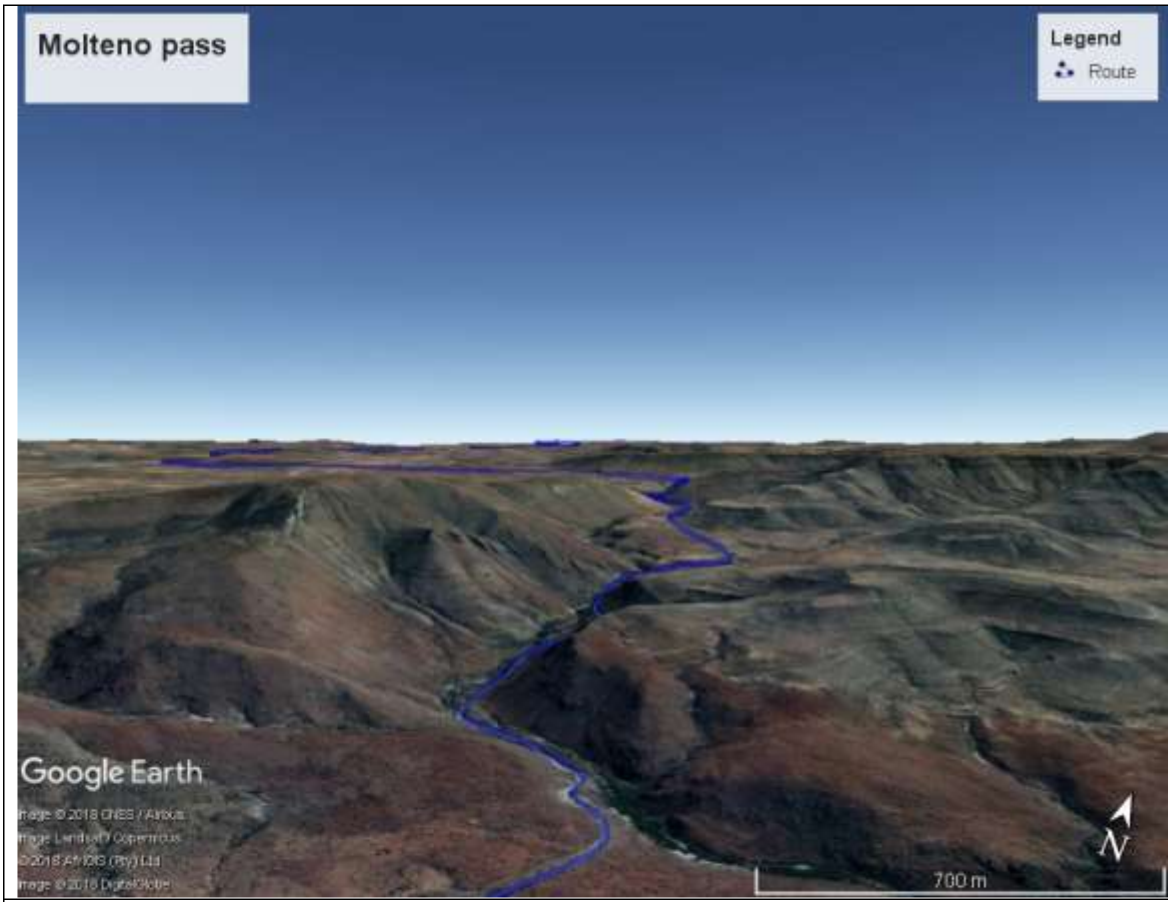


Figure 4: Molteno pass situated between Beaufort West and Loxton (Google Earth, 2018)

Figure 5: **An image showing dolerite dominating the first section of the road.**

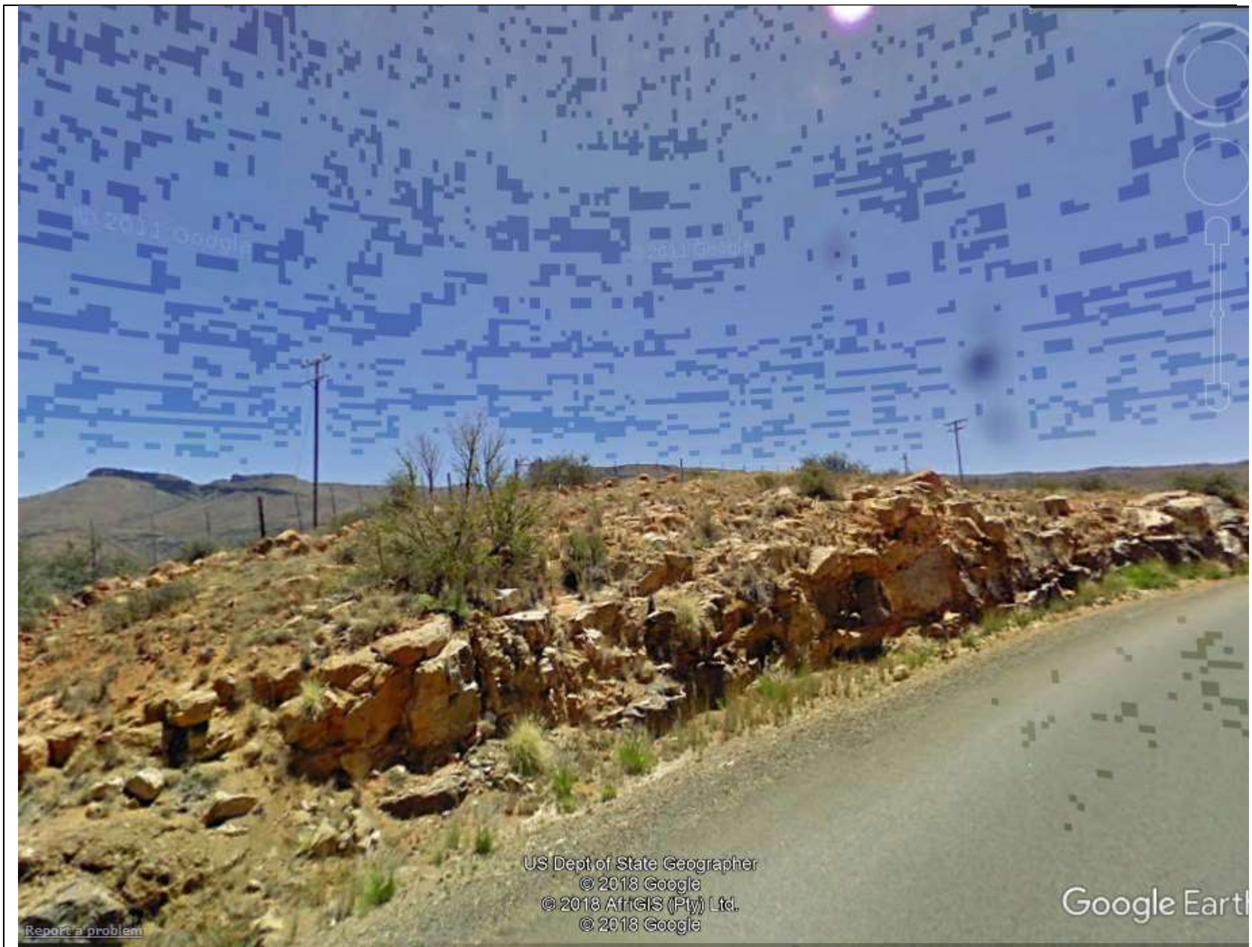


Figure 8: **Typical representation of many small cuttings**

3. Material Sampled along the route

Small samples of the gravel/sand material encountered along the route were sampled for laboratory testing.

Typical soil/gravel found along the route was sampled. Samples were taken where the soil was visually different, such that the samples taken gave a representative indication of the type of material that may be encountered. Six soil samples were taken at various points along the route for the laboratory tests.

3.1 Laboratory Testing

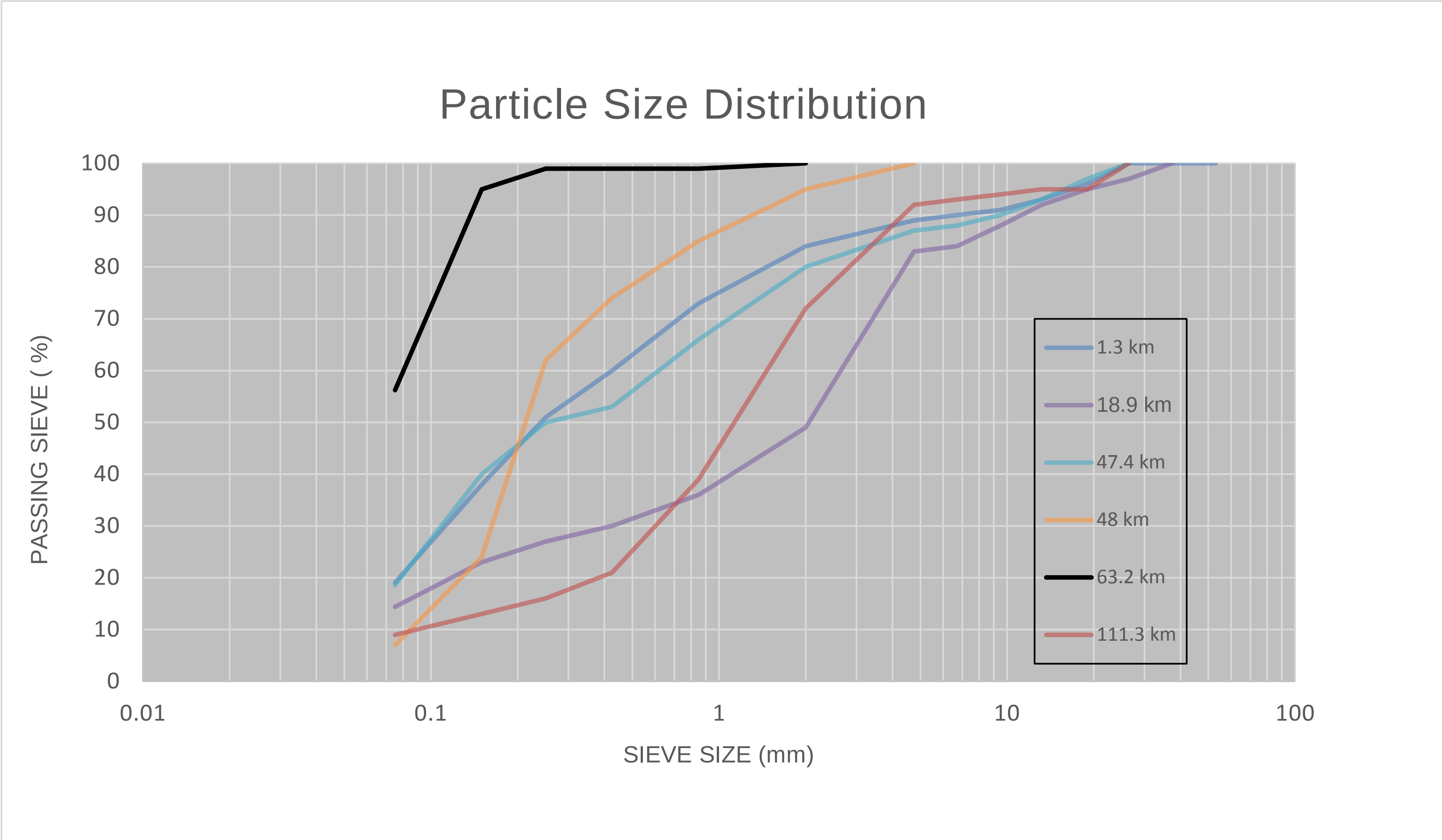
In the laboratory the following tests were carried out:

- *Particle size distribution*, which gives good indication of the material's compactability and strength, after compaction. Table 2 and Figure 9.
- *Atterberg Limits determination*s, which gives an indication of the clay content of the soil and how active the clay can be on wetting and drying.
- The compactability of the material under a relatively light compaction effort, such as would be applied by a light compacting device (possibly a plate compactor).
- The optimum moisture to be added to the soil in order to achieve maximum compaction for the compaction effort applied.
- The strength of the compacted material was also determined. This was to determine whether the compacted material has sufficient strength to carry vehicles coming off the road surface and traversing over the backfilled trench.

The test results are given in Table 2.

TABLE 2: Test results

SAMPLE DESCRIPTION						
Sample no	15971	15972	15973	15974	15975	15976
Distance from start (km)	1.3 Km	18.9 Km	47.4 Km	48 km	63.2 Km	111.3 Km
Grading Analysis						
75.0 mm						
53.0mm						
37.5 mm		100.0				
26.5 mm	100.0	96.9	100.0			100.0
19.0 mm	95.8	95.0	97.1			94.8
13.2 mm	92.7	92.2	93.2			94.8
9.5 mm	90.9	87.9	90.4	100.0		93.7
6.7 mm	89.7	84.4	88.3	99.9		92.5
4.75 mm	89.4	83.2	86.8	99.8	100.0	92.0
2.00 mm	83.5	49.2	79.8	94.7	99.7	72.4
0.850 mm	72.9	35.9	66.4	84.9	99.4	39.0
0.425 mm	60.2	30.4	53.2	74.1	99.2	21.0
0.250 mm	50.9	27.0	50.3	61.5	98.9	16.1
0.150 mm	38.2	22.6	39.8	23.6	95.0	13.1
0.075 mm	19.1	14.4	18.6	7.0	56.2	9.0
Atterberg Limits (Plasticity)						
Liquid Limit	17.0	17.4	Non Plastic	Non Plastic	24.5	21.9
Plasticity Limit	14.8	14.8	-	-	21.7	18.3
Plasticity Index	2.2	2.6	-	-	2.8	3.6
Linear Shrinkage (%)	1.3	2.0	-	-	1.0	1.7
Sample Compaction Values						
MDD (kg/m^3)			1696			
OMC			10.7			



Silt	Sand	Gravel

Figure 9: Grading Analysis of Sampled Materials

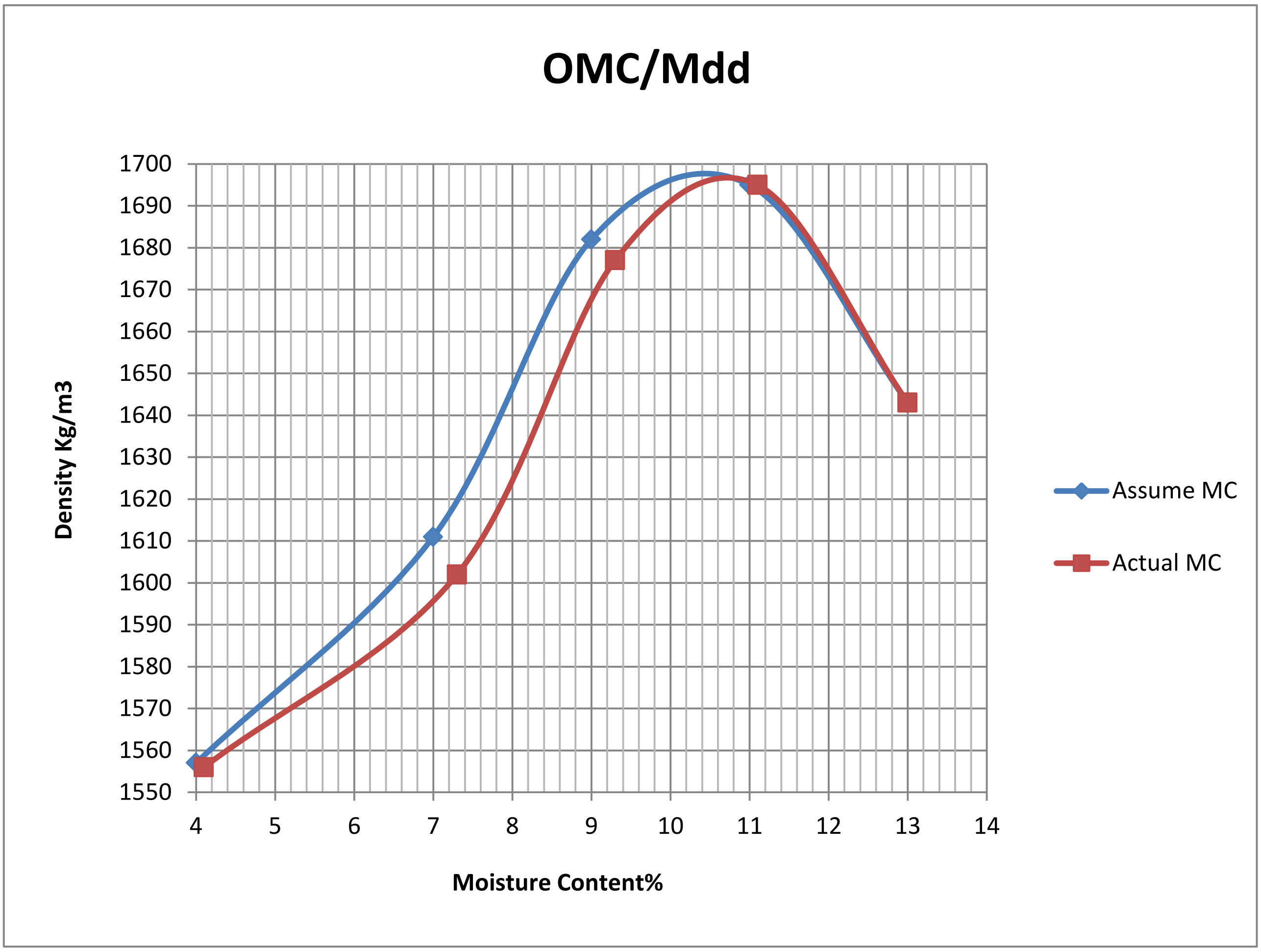


Figure 10: Optimum Moisture Content and Compactability Determination

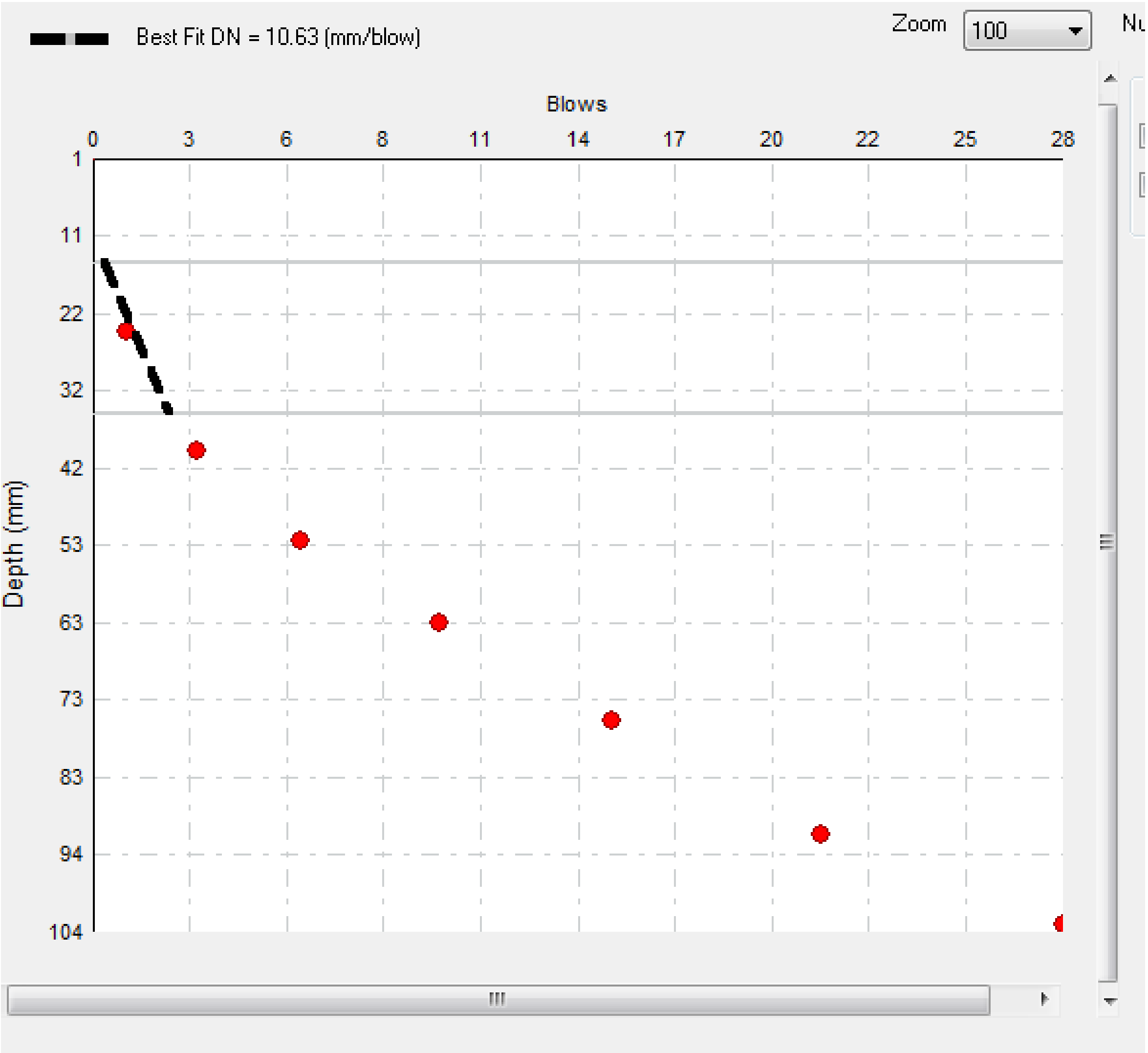


Figure 11: California Bearing Ratio (DCP) Determination

3.2 Test Results (Table 2)

Atterberg Limits (Plasticity – clay content)

The materials sampled did not have a high plasticity (active clay content). Highest plasticity Index was obtained for the sample from km 111.3 (PI = 3.6) and the lowest for the sample from km's 47.4 and 48, which were both non-plastic. The clay content should not be a factor when compacting.

Grading (Figure 9)

From the grading results it is evident that the materials from kilometres 1.3, 47.4, and 48 are mostly gap - graded sandy gravels with a fair amount of silt and may be somewhat difficult to compact. The sample from km 113 is a fairly well graded sand and should compact well. The material sampled at km 63.2 is considered a sandy silt and also can be problematic when compacting. However, as this is not a road layer being constructed, where compaction is very important, it should not present difficulties.

Optimum Moisture Content (OMC) of the material (Figure 10)

The optimum moisture content is a determination of the percentage of moisture required in a given soil, which will maximize the compacted density of that soil for a given compaction effort. Too much or too little water will result in a less than optimal compacted density.

It can be seen in Figure 10 that the maximum density obtained was 1696 kg/m3 when the moisture content was 10.7%. When the moisture content was above or below this level the densities obtained were lower.

Compacted strength - California Bearing Ratio (CBR) values (*Figure 11)*

The CBR value gives an indication of the bearing capacity of the gravel after compaction.

The material was compacted in a mould to determine its compacted strength. The compaction effort used was the lowest effort commonly used to compact road building materials.

When a light compaction effort was applied to the material, known as Proctor compaction effort, a strength value of CBR = 20.5 was achieved (see Figure 11). This should be more than sufficient to carry traffic that might ride over the compacted trench.

4. Suggested backfilling procedure

- Dig the trench approximately 850mm deep (Figure 12) and 200mm wide.
- Sieve out sufficient quantities of soil/sand passing a 2mm screen
- Place sufficient screened soil/sand at the bottom of the trench to compact a 100mm layer to a density of approximately 1700 kg/m^3. This can more easily be achieved by mixing in 10.5 percent water into the soil, by mass of the soil, before compaction.
- Place the cable on the compacted fine soil/gravel bed.

- Compact a layer of approximately of the screened soil/sand to a depth of 100mm above the cable. The fine material is used to ensure that the cable is not damaged when compaction takes place.
- The rest of the trench may now be compacted in layers, not exceeding 200 mm, with a mixture of sand, soil and gravel. The maximum size of the particles in these layers should not exceed 50mm, otherwise compaction becomes problematic. The compacted layers should be compacted to a density of approximately 1650 kg/m^3. The compaction will be facilitated by mixing in 10.5% water into the compacted soil (optimum moisture content) as suggested by the laboratory compaction testing. Water required per kilometre is approximately 32 000 litres. This quantity is dependent on the existing moisture content of the soil at the time.
- The density attained should be measured using a Hydrodensometer (Troxler). One measurement should be done every 100 metres. Alternately, use a Rapid Compaction Control Device (RCCD) (Figure 13), to determine that the correct strength for the material has been attained with compaction. A strength value of CBR equal to at least 15% is required. This may also be measured using a Dynamic Cone Penetrometer (DCP), where it is difficult to use the RCCD. However, where a DCP device is used, care must be taken not to damage the cable.

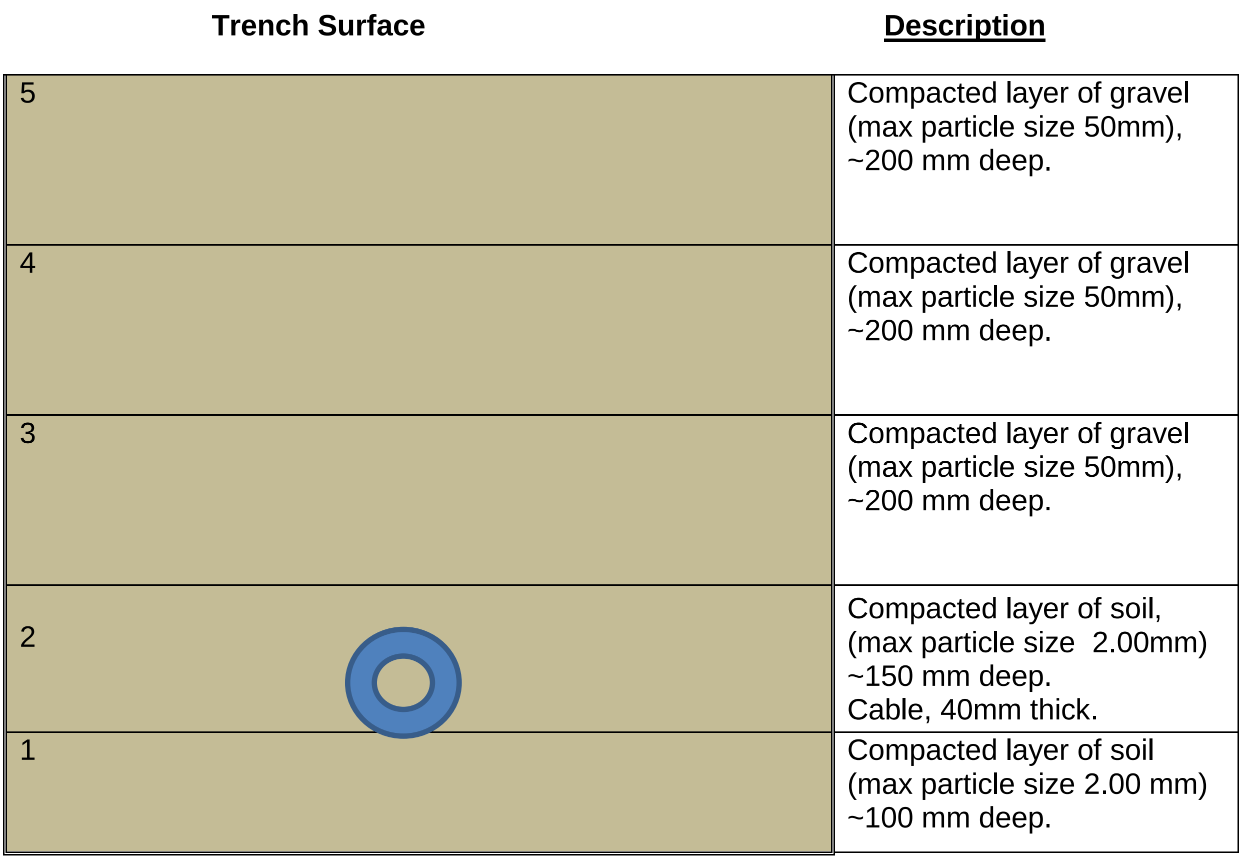


Figure 12: Schematic Diagram of Cable Trench (not to scale)

Figure 13: RCCD Device for indicating proper compaction

5. Conclusions and Recommendations

Most of the road reserve is suitable for trenching and backfilling. However, approximately 15 km are deemed to be unsuitable for trenching.

The areas considered unsuitable were where the road goes through the Molteno pass, which is very rocky and other areas that have extensive rocky outcrops (Figure 1). It may be prudent to consider alternatives to trenching in these areas. The possibility of digging in the road itself may be a viable alternative, if allowed by the Roads Authorities of the area. However, it is not known what may be encountered under the road (the depth to which there is soil)

The survey was mainly done by visual observation of the route and, thus it may be that below the visible surface there may be further rocky layers which will be difficult to dig through.

The materials sampled and tested in the laboratory suggest that trenching and backfilling should not present any difficulties and that a well compacted trench can be achieved, provided that good compaction practices are carried out.