WEST BANK LAND RESTITUTION TOWNSHIP: DISTRIBUTOR ROAD & SEWER PIPELINE GEOTECHNICAL REPORT

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FEBRUARY 2006

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EXECUTIVE SUMMARY

This report presents the findings of a geotechnical investigation for the proposed Distributor Road and Sewer Pipeline for bulk service provisions for the new West Bank Land Restitution Township in East London.

For the sewer pipeline investigations indicate easy excavation to about 1m – though there could be occasional near-surface rock – with pneumatic hammer excavation or blasting thereafter; perched water conditions with seepage during construction and minor post-construction pore water pressures; and a lack of bedding sand requiring sourcing from a commercial quarry.

No major foundation problems are envisaged for the distributor road though there may be some 'immediate' settlement on the western extremity of the site; foundations for the bridge comprise excellent quality sandstone; embankment slope batters should not exceed 34° and have toe subsoil drains; rock cuttings should be a minimum slope 1:1 with a 1,5m drop zone and with summit drainage; and the mudstone borrow pit on site can provide both gravel wearing course and G6 quality selected subgrade, though problems may arise with excavation hardness.

There are a few geotechnical and materials problems at the site, but these are by no means insurmountable, and can be minimised with judicious and relatively inexpensive design and construction as indicated.

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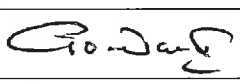
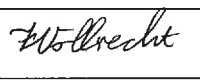
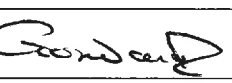
SIGNATURE			

CONTENTS

1. INTRODUCTION **4**
2. SITE DESCRIPTION **5**
3. METHOD OF INVESTIGATION **5**
4. GEOLOGY **5**
5. FIELD TESTING **8**
5.1 Sewer Pipeline ***8***
5.2 Distributor Road ***9***
6. LABORATORY TESTING **12**
7. GEOTECHNICAL APPRAISAL **13**
7.1 Sewer Pipeline ***13***
Excavatability 13
Perched groundwater 13
Bedding 13
7.2 Distributor Road ***14***
General 14
Bridge Foundations 14
Slope Stability 14
Materials 16
8. CONCLUSION **17**
APPENDIX 1: TRIAL HOLE PROFILES **18**
APPENDIX 2: LABORATORY RESULTS **19**

1. INTRODUCTION

This report presents the findings of a geotechnical investigation for the proposed Distributor Road and Sewer Pipeline for bulk service provisions for the new West Bank Land Restitution Township in East London; Eastern Cape Province . The investigation was initiated by Mr C Mitchell of Lukhozi Consulting Engineers (Pty) Ltd who after requesting geotechnical proposals and costs to undertake the work, appointed Terreco cc to undertake the work, with proposal as follows:

Roadworks

Centreline Investigation

Excavation of trial holes along the route with samples removed from trial holes for Foundation Indicator testing (Grading; Atterberg Limits; Hydrometer) plus MOD AASHTO density and California Bearing Ratio (CBR) testing to determine quality of subgrade material and possible usage as gravel wearing course. Both TRH 14 and TRH 20 would be used in determining quality and suitability of materials along the route.

Large culverts; causeways & bridges

Trial holes would initially be excavated at the Zaminyama Tributary crossing followed by Dynamic Cone Penetration tests if necessary. Terreco would also consider use of a deep sounding probe capable of 6m depth, depending on soil density or presence of boulders, for deeper probing. This initial investigation would then determine whether or not more expensive techniques such as refraction/ seismic surveys and drilling would be required. Geophysical investigations and drilling did not form part of the costs submitted.

Cutslope and sideslope stability

Samples would be removed for 2X MOD AASHTO and 2X Shear Box testing to determine the shear strength characteristics of the cutslope/ fill embankment materials. Joint surveys could be conducted on exposed rock if required. These investigations would be concentrated between Km 1,100 and 1,360.

Sewer Pipeline

Centreline

Trial excavations would be undertaken at 500m intervals and at direction change points as requested. Samples would only be removed from site for laboratory testing where potentially problematic materials had been identified on site by the geotechnical professional. Such tests were not costed since they would only become known once the investigation was under way. Trial hole information would be provided in DotPlot format and the geotechnical report would discuss excavatability of materials along the pipeline route.

General

The length of road to be investigated was estimated by Terreco as being 2 kilometres and the proposal presumed that the section of road beyond the "extent" boundary could not be investigated – this as later confirmed by Lukhozi. The 2 kilometres to be investigated would require approximately 7 trial holes for the centreline; 2 for the stream crossing and possibly more for specific requirements such as sampling for shear box testing.

The report outlines the investigation; analyzes the field and laboratory results; discusses the engineering geological findings; and provides a geotechnical assessment with recommendations for the project.

2. SITE DESCRIPTION

The distributor road and sewer pipeline are located on rolling hill type topography with relatively flat hilltops separated by narrow tree and bush covered valleys. The western area comprises a natural plain and contains an uninhabited farmhouse. Small thorntrees and grass vegetation dominate the landscape and an old borrow pit is located along the proposed road's centreline. Plate 1 over page provides a panorama of the site as viewed seawards from the north-eastern corner of the farm.

The site spans both sides of the Zaminyama Tributary which is deeply truncated into the surrounding topography. The surrounding valley has a relatively high proportion of thick tree copse and bush. Most trees are of the black wattle variety. Further west the surrounding hillslope comprises the site high point and is mostly covered with grass and sparse tree or bush cover. The study area abuts the western boundary of the East London Industrial Development Zone (EL IDZ) and has a new gravel road marking the boundary between the 2 sites.

3. METHOD OF INVESTIGATION

Field investigations comprised general engineering geological mapping of the area; excavation of 13 trial holes (see Figure 1 for trial hole positions) using a Tractor-Load-Backhoe (TLB); profiling; field testing and sampling. Disturbed samples were removed from the site for laboratory testing with all profiles recorded according to the method of Jennings, Brink and Williams as per the paper "Revised guide to soil profiling for civil engineering purposes in Southern Africa" as published in the Transactions of the South African Institution of Civil Engineers, vol 15, no.1, 1973, pp 3-12. Soil profiles have been interpreted and prepared for report presentation using the Dot Plot computer program. These have been included as Appendix 1.

Laboratory testing includes 3 Indicator Tests with Hydrometer testing; Atterberg Limits and Optimum Moisture tests; 3 grading tests; 3 MOD AASHTO/ CBR tests and 2 Shear Box tests to determine the shear strength characteristics Ø (Angle of Internal Friction) and C (Cohesion). Laboratory testing has been undertaken by ControLab of East London and the results included as Appendix 2.

Geotechnical appraisal has been undertaken of the field and laboratory information using computer aided techniques; specific analyses for items such as materials usage; soil activity; geological and soils interpretations: culminating in this geotechnical report.

4. GEOLOGY

The general area of the proposed new West Bank Township is underlain by argillaceous and arenaceous rocks of the Middleton Formation, Adelaide Subgroup, Beaufort Group, Karoo Sequence. The mudrocks comprise mostly yellow/ brown; maroon and grey mudstone, sometimes with a high silt component approaching siltstone classification. These alternate with sandstone units a few metres to tens of metres thick consisting of grey, fine grained, ultra-lithofeldspathic sandstone (approximately 20%) and mudstone (80%) as described. The

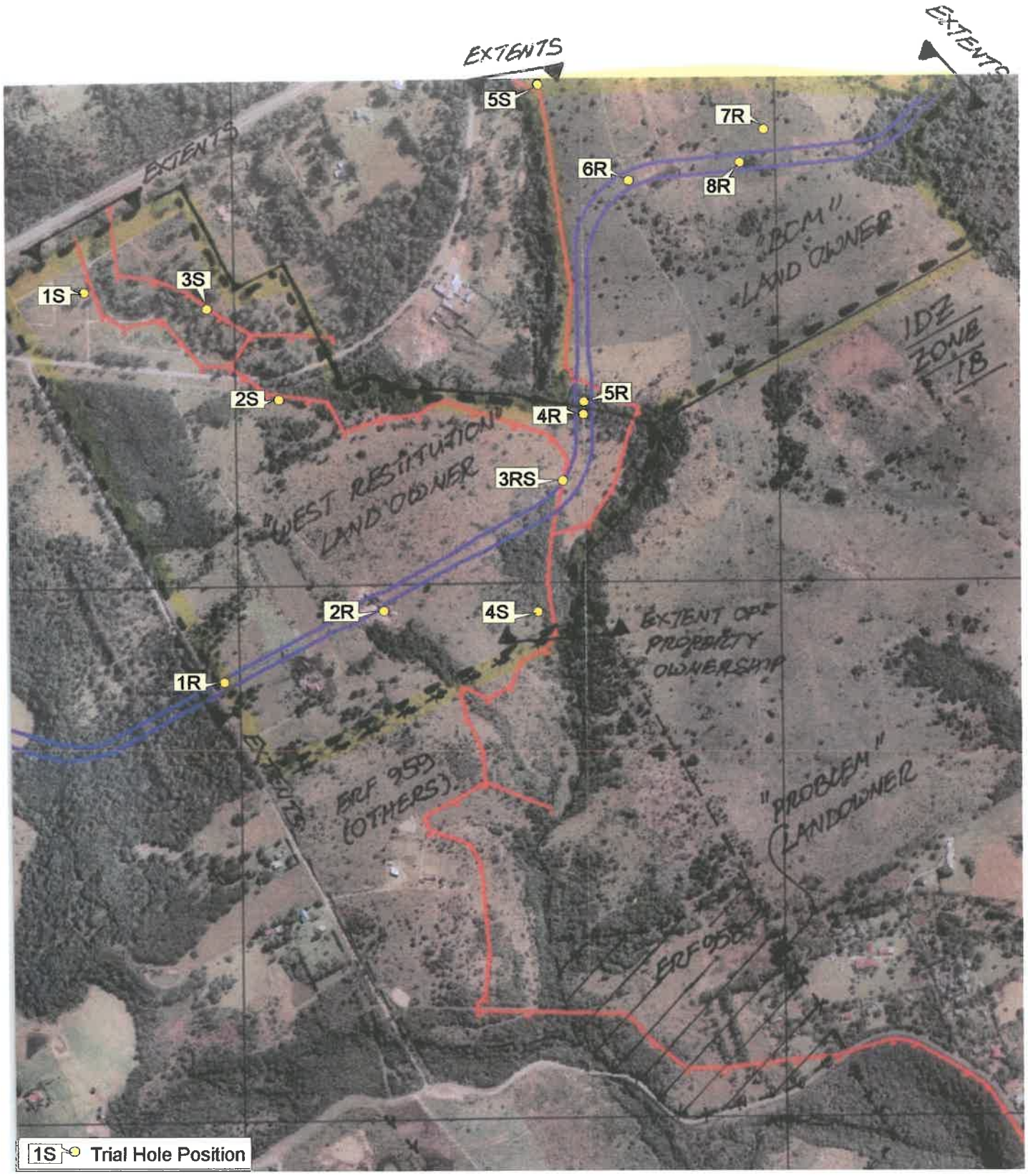


FIGURE 1

TRIAL HOLE POSITIONS

PROJECT: **West Bank Land Restitution Township:** **Distributor Road & Sewer Pipeline**	TERRECO cc Geotechnical, Environmental and Waste Management	Scale: Not to Scale Date: March 2006

sandstone displays flat-bedding, trough cross-bedding and micro-crosslamination, while the mudstone is poorly stratified or massive. Cut and fill structures within the mudstone are common. Near-surface mudrocks generally comprise relatively soft rock conditions, while that at depth is hard and difficult to excavate. Rapid refusal occurs in sandstone rich areas.

Hypabyssal igneous Post-Karoo dolerite has intruded the sedimentary rocks with regular monotony and occurs in the form of narrow dykes or large inclined sheets and sills. Emplacement took place during the Jurassic era largely subsequent to the extrusion of the Drakensberg lavas which form the top most unit of the Karoo Sequence. Dolerite though it occurs nearby does not outcrop in the study area.

Layers of colluvium and alluvium of variable depth blanket the site.

Plate 1: Seaward view of the West Bank Restitution Farm area

5. FIELD TESTING

5.1 Sewer Pipeline

Five trial holes were excavated along the proposed sewer line (See Figure 1) with another 2 at the intersection of the distributor road and the pipeline making seven in all. On the northern side of the property the pipeline splits along 3 separate directions with at least one trial hole excavated on each limb.

North-western Limb

Trial holes 1S and 2S excavated along the most north-western limb intersected a profile comprising colluvial clayey silt and gravel/ pebbles overlying either weathered mudstone or sandstone to a depth slightly more than 1m, overlying hard rock sandstone. A walkover survey suggests these conditions will persist but it is a known that in sandstone-rich areas hard rock can easily outcrop on surface, and though not obvious along the route, allowance should nonetheless be for near-surface or surface hard rock. This will require localised blasting or excavation using a pneumatic hammer fitted on an excavator boom, known colloquially as a 'rockpecker'. Excavations to 1,0m should generally be possible using a large track-mounted excavator.

Central northern limb

Trial hole 3S located alongside an old disused track comprises a thin layer of clayey silt and gravel overlying moderate to highly weathered sandstone to 1m, in turn underlain by hard rock sandstone. No watertable was intersected in the trial hole but the study area is renowned for perched water conditions as a result of a moderate to high rainfall; shallow soil cover and underlying relatively impervious rock.

North-eastern limb

This limb of the pipeline is aligned immediately east of the Zaminyama Tributary with deeper soils near the slope base. Trial holes 5S and 5R indicate a profile comprising relatively deep colluvial and alluvial clayey silt or silty sand to 1m overlying weathered rock or cobbles/ boulders and silt/ sand to between 1,3m and 1,9m. Hard slightly weathered sandstone is encountered beneath this depth. Again perched water conditions can be expected as encountered at 0,9m in Trial hole 5S, and there will be areas of shallow hard rock possibly less than 1m below surface.

Southern limb

The 3 sewer pipeline links coalesce into one in the southern part of the study area where trial holes 3RS and 4S indicate a relatively consistent profile of 0,5m colluvial silt overlying highly weathered sandstone to 1,2/ 1,4m in turn overlying hard rock sandstone. Perched groundwater seeps from trial hole 3RS at 0,6m.

Rock is generally approximately 1m below surface and if deep excavations are required blasting will be necessary in the hard underlying mostly sandstone rock. Table 1 provides a breakdown of the depth to refusal in rock for the 7 trial holes excavated.

Table 1: Depth to rock

TRIAL HOLE	DEPTH TO REFUSAL (m)	ROCK TYPE
1S	1,7	Sandstone
2S	1,2	Sandstone
3S	1,1	Sandstone
4S	1,5	Sandstone
5S	1,4	Sandstone
3RS	1,3	Sandstone
5R	1,9	Sandstone

The average depth to rock as encountered in these profiles is 1,4m but bear in mind that these are only point sources of information extracted from a long network of pipelines. Variation will therefore occur and must be expected.

Perched water seepage occurs in 2 trial holes namely 5S and 3RS. Perched water in areas of poor drainage on flat terrain will occur and may be problematic during construction and as excess pore water pressure after construction.

5.2 Distributor Road

The proposed distributor road (see Figure 1) forms, in plan, an 'S' shape from west to east. Eight trial holes have been excavated along the route with 3 on the west side of the Zaminyama Tributary; 2 within the confines of the stream and 3 on the east side.

Western section

This section of the road comprises a relatively flat plateau area. Trial hole 1R on the western extremity has 0,6m of loose colluvial sand overlying residual clayey sand to 1,7m, overlying hard sandstone to 1,8m. Trial hole 2R in an old disused borrow pit in the centre of this section consists of 1,5m of moderately weathered, medium hard mudstone overlying hard rock sandstone to 1,7m, and Trial hole 3RS further east has colluvium to 0,6m overlying soft rock sandstone to 1,2m in turn overlying hard sandstone to 1,3m. Perched water seeps at 0,6m from both Trial holes 1R and 3RS. Colluvial soils on the western extremity are loose to very loose and there may be some settlement of the road during, or immediately after, construction.

Central section

The road traverses the Zaminyama Tributary along this section. It comprises relatively steep slopes either side of the stream with rock close to surface as per generalised findings for the area. Natural profiles 4R and 5R indicate a profile, west and east of the streamline respectively, of approximately 1m of alluvial silty sand overlying 0,3m to 0,8m of silt, cobbles and boulders overlying slightly weathered hard rock sandstone. The river alluvial zone is approximately 30m wide with a 5m river section of slightly weathered, closely jointed, hard rock sandstone. Good quality foundations for the bridge structure are therefore available at surface or close to surface.

Eastern section

Trial holes 6R, 7R and 8R are located on the east side of the stream above an oval hill and relatively flat topped plateau area. These trial holes comprise 0,9m – 1,2m of loose, colluvial slightly clayey silt and sand. Colluvium underlies this with highly weathered mudstone or sandstone to 1,9m and 2,5m and a base of moderate or highly weathered sandstone.

Photographs of the trial holes are included in the pages following with individual profiles presented in DotPlot format in Appendix 1.

Plates 2-12: Trial hole photographs

Trail Hole 1S

Trial Hole 2S

Trail Hole 3S

Trial Hole 4S

Trial Hole 5S

Trail Hole 1R

Trial Hole 2R

Trail Hole 3R

Trial Hole 6R

Trail Hole 7R

Trial Hole 8R

6. LABORATORY TESTING

Laboratory testing has been undertaken on soils removed from the distributor road alignment. The main characteristics of the laboratory tests are presented in Table 2 with the complete set of test results detailed in Appendix 2.

Testing has been undertaken by ControLab of East London.

Table 2: Laboratory Results

TH	Dep. (m)	Description	Eq. PI	% Clay	LS	PI	MOD	C 90	B 93	R 95	'S 98	GM	HP
1R	1,0	Residual clayey sand	5	19	2,0	5							Low
2R	1,1	Olive weathered mudstone			6,0	12	2188	23	27	30	35	2,78	
3R S	1,1	Yellow weathered sandstone			0,5	SP	2118	8	15	23	42	2,34	
6R	1,4	Olive weathered mudstone			8,5	17	2085	4	5	6	8	2,47	
7R	0,4	Colluvial sandy silt	SP	8	0,5	SP							Low
8R	1,3	Residual sand clay	8	24	4,0	8							Low

Where:-

TH: Trial Hole
Dep: Depth
Eq. PI: Equivalent Plasticity Index
% Cl: Percentage clay
LS: Linear Shrinkage
MOD: MOD AASHTO density
CBR: California Bearing Ratio
GM: Grading Modulus
HP: Heave Potential
SP: Slightly Plastic

Results indicate a number of important geotechnical characteristics as follows:

- All clay rich elements of soil profiles indicate 'low' active clays as determined from the percentage clay content and 'equivalent' plasticity index
- Linear shrinkage values are low indicating no major problems in areas exposed to rapid drying
- Clay percentage is variable but not in excess of 25%
- Weathered rock materials are variable with a rapid lowering of CBR as rock weathering becomes more pronounced. Material values are discussed in more detail in sections following
- Grading modulii are all in excess of 2 thereby indicating well graded materials

These results suggest there are no major heave and shrinkage problems with respect to foundations for roads.

Calculation of the Shrinkage Product (Sp) and Grading Coefficient (Gc) as per TRH 20 requirements provides results as indicated in Table 3.

Table 3: Shrinkage Products & Grading Coefficients

Spl No	Dep. (m)	Description	Shrinkage Produce Sp	Grading Coefficient Gc	TRH 20 Category	TRH 14 Category
2R	1,1	Olive weathered mudstone	36	16	B	G6
3R S	1,1	Yellow weathered sandstone	13	11	B	G7
6R	1,4	Olive weathered mudstone	144	14	A	G10

Table 3 indicates the materials on site qualify as either Class B – road 'ravels and corrugates' after construction, or Class A – 'highly erodable' - as determined by TRH 20 classification. Of the three samples tested sample 2R provides the best material in terns of gravel wearing course and perhaps not surprisingly so since it derives from an old borrow pit as previously alluded to. The weathered sandstone from Trial hole 3RS has very low plasticity and would be difficult to work due to the presence of harder sandstone fragments, and the more weathered mudstone from Trial hole 6R has low strength and a too high plasticity index. TRH 14 'Standards for Road Construction Materials' classifies the borrow pit mudstone material as good quality G6; the weathered sandstone as G7 and the more weathered mudstone as low strength G10.

7. GEOTECHNICAL APPRAISAL

7.1 Sewer Pipeline

Excavatability

Trial hole investigations and walkover surveys suggest that excavations to 1m for installation of sewer piping will be relatively easy but beyond 1 – 1,5m from surface will require pneumatic hammers for excavation, or blasting. Sandstone appears to underlie most of the pipeline areas, and areas of low soil cover and even rock exposure on surface cannot be ruled out. Allowance must therefore also be made for near-surface hard excavation.

Perched groundwater

Conditions as encountered, viz. high rainfall over pervious soils underlain by relatively impermeable rock are all conducive to the formation of perched groundwater conditions. Some groundwater control may therefore be necessary during construction and the pipes designed to withstand any excess pore water pressures: bearing in mind that for a 1m excavation these will seldom exceed 10 kPa.

Bedding

Bedding sand will be required for the rough invert surface expected from sandstone rock excavations and it is recommended, since there are no obvious sand sources on site, that highly weathered dolerite 'sabunga' gravel or crusher sand be sourced from a commercial quarry.

7.2 Distributor Road

General

No major geotechnical problems are envisaged for construction of the distributor road. Some areas, such as the extreme west portion of the road require construction on loose to very loose silty materials and some settlement will therefore take place beneath the road in these areas. Perched water should be expected along the route with appropriate design requirements for subsurface and surface drainage.

Bridge Foundations

The 30m wide alluvial section demarcating the stream line and environs comprises approximately 1m of silty sand alluvium overlying 0,3 – 0,8m of silt cobbles and boulders; in turn overlying slightly weathered to unweathered, closely jointed, hard rock sandstone. The 5m wide stream channel has massive sandstone outcrop exposures with quality of rock more than capable as founding for the bridge structure. The stream is expected to have meandered across this alluvial area but the nature of the rock exposure, namely sandstone, and the near-horizontal dip of strata, makes it unlikely that alluvium is much deeper than the approximate 2m indicated in Trial holes 4R and 5R.

Safe allowable bearing capacity of the sandstone is expected to exceed 3500kPa. Plate 13 below indicates the good quality sandstone for bridge founding in the stream section of the road.

Plate 13: Stream foundation rock

Slope Stability

Cuttings

Investigations and on site inspection indicates that cuttings will comprise of a shallow cover of unconsolidated colluvium overlying mudstone or sandstone rock. The rock will require blasting in its slightly weathered or unweathered state and although experience shows that

sandstone can be excavated using a 'rock pecker' such excavation is tedious and extremely time-consuming.

Stability of any cuttings should not therefore be problematic. The colluvium should be cut back to a minimum of 34° (1V:1,5H) and a trench/ berm summit drain constructed to prevent stormwater eroding the exposed cutface. The rock is near-horizontal and therefore stable at slopes of 1:1. It is recommended a 1,5m wide toe drop zone be constructed to capture loose material eroding from the exposed faces.

There may be areas on the cutface where poorly orientated joints could give rise to local planar or wedge failure but such instances are expected to be small and isolated, and can in any case only be ascertained during construction. A further problem which might arise in deep cuttings is where sandstone overlies mudstone, and where the latter disintegrates on exposure causing cavitation beneath the sandstone with resultant large block sandstone failure onto the road. Damage would be minimised by the proposed drop zone but it may also be necessary to shotcrete the mudstone to prevent ongoing disintegration. Again this can only be ascertained when the cutslopes have been exposed during construction.

Embankment Fills

Samples of highly weathered sandstone and highly weathered mudstone were removed from site for shear box testing to determine their shear strength characteristics, since these are the materials most likely to be used in construction of a fill embankment and abutment fill for the bridge across the Zaminyama Tributary. Samples were compacted to 90% MOD AASHTO at OMC in order to simulate construction conditions. Results are indicated in Table 4 below.

Table 4: Shear box test results

Sample No	Dep. (m)	Description	Angle of Int. Friction Ø (°)	Cohesion C (kPa)
3RS	1,1	Yellow weathered sandstone	7,6	31,9
6R	1,4	Olive weathered mudstone	4,6	32,8

Stability analyses have been undertaken assuming a relatively high 7m embankment constructed of both weathered sandstone and weathered mudstone, overlying 2m of alluvial silt and boulders, in turn overlying hard rock sandstone. Conservative shear strength values have been used for the alluvium. A 'worst' condition of saturation was first assessed, mindful of the knowledge that total saturation is unlikely, especially seeing as measures will in any case be implemented to ensure the embankment remains dry. This worst condition does, however, set the stability benchmark. Slope stability analyses using Bisjan indicate Factor of Safety conditions as indicated in Table 5.

Table 5: Stability analyses

Fill material	**Factors of Safety**	
Highly weathered sandstone	**34° slope**	**45° slope**
Saturated	0,9	0,7
Dry	1,5	1,4
Highly weathered mudstone	**34° slope**	**45° slope**
Saturated	0,8	0,6
Dry	1,4	1,1

The minimum factor of safety (FOS) considered acceptable for cutslopes and embankments is 1,3. Results indicate that the embankment slopes are stable when **dry** for both the weathered mudstone and sandstone but unacceptable, even when dry, for a 1:1 weathered mudstone slope. Maximum batter to consider is therefore 1:1,5 which is in any case the maximum slope for revegetation.

The stability assessment also shows that the embankment *must be kept dry* and subsoil drainage is therefore recommended either side of the fill. Surface water must also not pond on the road surface or embankments, and the road shaped to rapidly shed stormwater along kerbs; and into chutes; channels and pipes to discharge away from the embankment.

The recommendation therefore is a minimum dry slope design of 1V:1,5H.

Materials

Field investigations and laboratory testing suggest that the borrow pit at Trial Hole 2R could possibly be reopened as a source of road material (see Plate 14).

Plate 14: Mudstone borrow pit

This material might ravel and corrugate when used as a gravel wearing course yet is capable of providing a reasonably good surface and being hard, is likely to last. As G6 quality it would also serve as selected subgrade in a surfaced road pavement. The highly weathered mudstone and sandstone do not have appeal as gravel wearing course for reasons as previously listed.

The weathered mudstone in the borrow pit is, however, hard, and will require large, and possibly specialised, construction plant for its excavation. There is already a large pit from which material was previously excavated so there is no doubt excavation is possible. Experience suggests, however, that contractors are loathe to commit machinery to hard excavation and such reluctance should therefore be expected during construction. Shallow blasting with single stage crushing may be considered since it would provide a superior quality gravel wearing course and omit contractual problems with hard excavation. It will cost more.

Either way the borrow area will require lateral enlargement since the weathered material is all near-surface hardening rapidly with depth to sandstone. An environmental management plan (EMP) report to the satisfaction of the Department of Minerals & Energy will be required prior to development of this borrow source.

8. CONCLUSION

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No major foundation problems are envisaged for the distributor road though there may be some 'immediate' settlement on the western extremity of the site; foundations for the bridge comprise excellent quality sandstone; embankment slope batters should not exceed 34° and have toe subsoil drains; rock cuttings should be a minimum 1:1 with a 1,5m drop zone and summit drainage; and the mudstone borrow pit on site can provide both gravel wearing course and G6 quality selected subgrade, though problems may arise with excavation hardness.

There are a few geotechnical and materials problems at the site, but these are by no means insurmountable, and can be minimised with judicious and relatively inexpensive design and construction as indicated.

Dr GV Price **TERRECO cc**

APPENDIX 1: TRIAL HOLE PROFILES

LUKHOZI CONSULTING ENGINEERS
WEST BANK RESTITUTION PROJECT

HOLE No: TH1S
Sheet 1 of 1

JOB NUMBER: GT113

Scale 1:10

0.00 Slightly moist, dark brown, loose, slightly shattered, CLAYEY SILT and GRAVEL.

0.50 Yellow brown, highly weathered, very closely jointed, soft rock, MUDSTONE.

1.50 Olive, moderate to slightly weathered, closely jointed, hard rock, SANDSTONE.

1.70

NOTES

1) End of hole.

2) No watertable.

3) Refusal at 1.7m.

CONTRACTOR :
MACHINE : CAT 416C
DRILLED BY :
PROFILED BY : GV PRICE
TYPE SET BY : CAJ
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : NOVEMBER 2005
DATE : 23/11/05 15:33
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ELEVATION :
X-COORD :
Y-COORD :

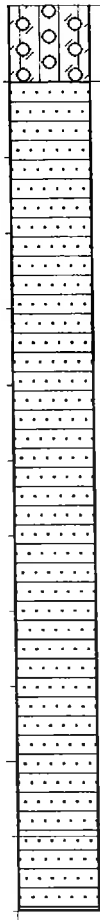
HOLE No: TH1S

LUKHOZI CONSULTING ENGINEERS
WEST BANK RESTITUTION PROJECT

HOLE No: TH2S
Sheet 1 of 1

JOB NUMBER: GT113

Scale 1:10



0.00 Slightly moist, dark brown, loose, slightly shattered, CLAYEY SILT with PEBBLES and GRAVEL.

0.10 Olive to yellow brown, moderate to highly weathered, closely jointed, medium hard, SANDSTONE.

1.10 Olive, moderate to slightly weathered, closely jointed, hard rock, SANDSTONE.

1.20

NOTES

1) End of hole.

2) No watertable.

3) Refusal at 1.2m.

CONTRACTOR :
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DRILLED BY :
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ELEVATION :
X-COORD :
Y-COORD :

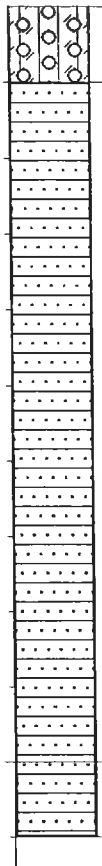
HOLE No: TH2S

LUKHOZI CONSULTING ENGINEERS
WEST BANK RESTITUTION PROJECT

HOLE No: TH3S
Sheet 1 of 1

JOB NUMBER: GT113

Scale 1:10



0.00 Slightly moist, dark brown, loose, slightly shattered, CLAYEY SILT and GRAVEL.

0.10 Olive to yellow brown, moderate to highly weathered, closely jointed, medium hard, SANDSTONE.

1.00 Olive, moderate to slightly weathered, closely jointed, hard rock, SANDSTONE.

1.10

NOTES

1) End of hole.

2) No watertable.

3) Refusal at 1.1m.

4) Trial hole excavated on an old forest road.

CONTRACTOR :
MACHINE : CAT 416C
DRILLED BY :
PROFILED BY : GV PRICE
TYPE SET BY : CAJ
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : NOVEMBER 2005
DATE : 23/11/05 16:01
TEXT : ..\SOILPR~1\TH3S.TXT

ELEVATION :
X-COORD :
Y-COORD :

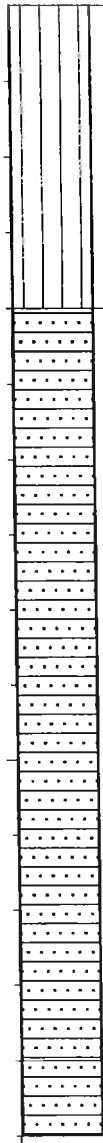
HOLE No: TH3S

LUKHOZI CONSULTING ENGINEERS
WEST BANK RESTITUTION PROJECT

HOLE No: TH4S
Sheet 1 of 1

JOB NUMBER: GT113

Scale 1:10



0.00 Slightly moist, grey brown, loose, intact, SILT: Colluvium.

0.40 Yellow/olive, highly weathered, closely jointed, soft rock SANDSTONE.

1.40 Olive, moderately weathered, closely jointed, hard rock, SANDSTONE.

1.50

NOTES

1) End of hole.

2) No watertable.

3) TLB struggles at 1.5m.

CONTRACTOR :
MACHINE : CAT 416C
DRILLED BY :
PROFILED BY : GV PRICE
TYPE SET BY : CAJ
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : NOVEMBER 2005
DATE : 23/11/05 15:36
TEXT : ..\SOILPR~1\TH4S.TXT

ELEVATION :
X-COORD :
Y-COORD :

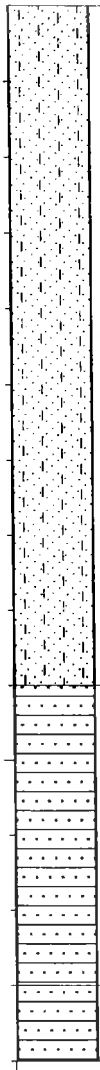
HOLE No: TH4S

LUKHOZI CONSULTING ENGINEERS
WEST BANK RESTITUTION PROJECT

HOLE No: TH5S
Sheet 1 of 1

JOB NUMBER: GT113

Scale 1:10



0.00 Moist, light brown, loose, intact, SILTY SAND: Colluvium.

0.90 Yellow brown, highly weathered, closely jointed, soft rock, SANDSTONE.

1.30 Olive, slightly weathered, closely jointed, hard rock, SANDSTONE.

1.40

NOTES

1) End of hole.

2) Perched water seeps from 0.9m.

3) Refusal at 1.4m.

CONTRACTOR :
MACHINE : CAT 416C
DRILLED BY :
PROFILED BY : GV PRICE
TYPE SET BY : CAJ
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : NOVEMBER 2005
DATE : 23/11/05 15:37
TEXT : ..\SOILPR~1\TH5S.TXT

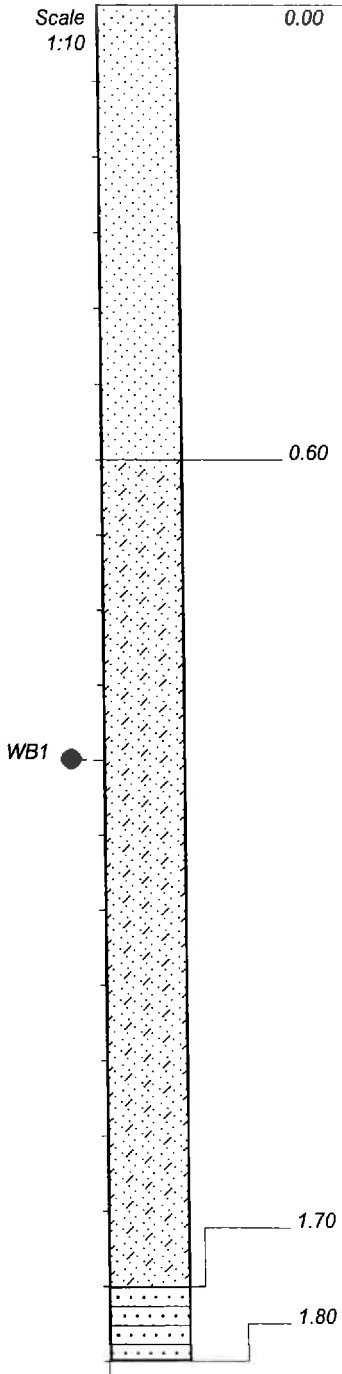
ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TH5S

LUKHOZI CONSULTING ENGINEERS
WEST BANK RESTITUTION PROJECT

HOLE No: TH1R
Sheet 1 of 1

JOB NUMBER: GT113



0.00 — Moist, dark brown, loose to very loose, intact, slightly organic, SAND: Colluvium.

0.60 — Moist, olive yellow, firm, intact, CLAYEY SAND: Residual.

1.70 — Olive, moderate to slightly weathered, closely jointed, hard rock, SANDSTONE.

1.80

NOTES

1) End of hole.

2) Slightly perched, see page at 0.6m.

3) Refusal at 1.8m.

4) Sample WB1 at 1.0m.

CONTRACTOR :
MACHINE : CAT 416C
DRILLED BY :
PROFILED BY : GV PRICE
TYPE SET BY : CAJ
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : NOVEMBER 2005
DATE : 23/11/05 15:40
TEXT : ..\SOILPR~1\TH1R.TXT

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TH1R

LUKHOZI CONSULTING ENGINEERS
WEST BANK RESTITUTION PROJECT

HOLE No: TH2R
Sheet 1 of 1

JOB NUMBER: GT113

Scale 1:10

0.00 Olive, moderate to highly weathered, very closely jointed, medium hard MUDSTONE.

1.50 Olive/grey, moderate to slightly weathered, closely jointed, hard rock, SANDSTONE.

1.70

NOTES

1) End of hole.

2) No watertable.

3) Refusal at 1.7m.

4) Trial hole in old borrow pit.

5) Sample WB2 at 1.1m (channel sample).

CONTRACTOR :
MACHINE : CAT 416C
DRILLED BY :
PROFILED BY : GV PRICE

TYPE SET BY : CAJ
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : NOVEMBER 2005

DATE : 23/11/05 15:35
TEXT : ..\SOILPR~1\TH2R.TXT

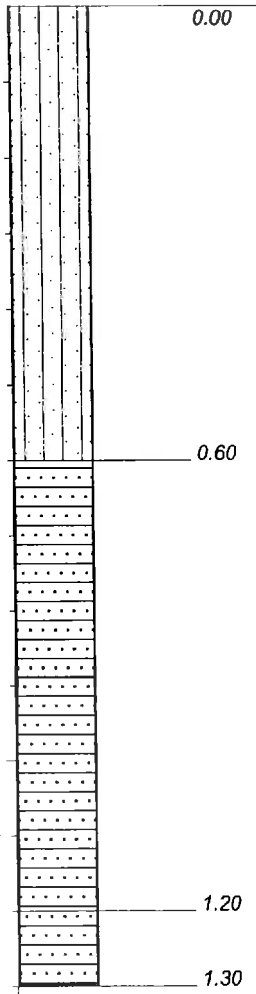
ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TH2R

LUKHOZI CONSULTING ENGINEERS
WEST BANK RESTITUTION PROJECT

HOLE No: TH3RS
Sheet 1 of 1

JOB NUMBER: GT113



0.00 Grey, slightly moist, medium dense, intact, SANDY SILT: Colluvium.

0.60 Yellow, olive, moderate to highly weathered, closely jointed, soft to medium hard rock, SANDSTONE.

1.20 Olive, slightly weathered, closely jointed, hard rock, SANDSTONE.

1.30

NOTES

1) End of hole.

2) Perched seepage at 0.6m.

3) Refusal at 1.3m.

4) Sample WB3 at 1.1m.

CONTRACTOR :
MACHINE : CAT 416C
DRILLED BY :
PROFILED BY : GV PRICE
TYPE SET BY : CAJ
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : NOVEMBER 2005
DATE : 23/11/05 15:36
TEXT : ..\SOILPR~1\TH3RS.TXT

ELEVATION :
X-COORD :
Y-COORD :

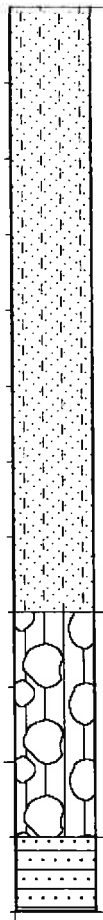
HOLE No: TH3RS

LUKHOZI CONSULTING ENGINEERS
WEST BANK RESTITUTION PROJECT

HOLE No: TH4R
Sheet 1 of 1

JOB NUMBER: GT113

Scale 1:10



0.00 Moist, grey, loose, intact, SILTY SAND: Alluvium.

0.80 Wet, grey, dense, intact, SILT, COBBLES and BOULDERS: Alluvium.

1.10 Olive grey, slightly weathered, closely jointed, hard rock SANDSTONE.

1.20

NOTES

1) End of natural profile.

2) S/W river bank.

3) Water flows in river.

4) In situ sandstone exposed in 4.5m wide river bed.

5) Survey peg A6 11m to the S/W.

CONTRACTOR :
MACHINE : CAT 416C
DRILLED BY :
PROFILED BY : GV PRICE

TYPE SET BY : CAJ
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : NOVEMBER 2005

DATE : 23/11/05 16:02
TEXT : ..\SOILPR~1\TH4R.TXT

ELEVATION :
X-COORD :
Y-COORD :

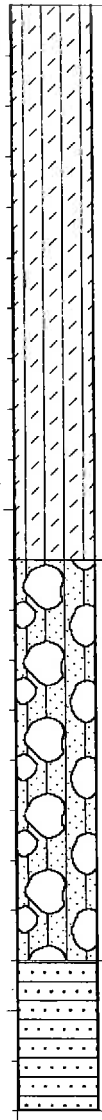
HOLE No: TH4R

LUKHOZI CONSULTING ENGINEERS
WEST BANK RESTITUTION PROJECT

HOLE No: TH5R
Sheet 1 of 1

JOB NUMBER: GT113

Scale 1:15



0.00 Slightly moist, grey/brown,medium dense, intact, slightly CLAYEY SILT: Alluvium.

1.10 Grey/brown, moist, medium dense, intact, SILT, SAND, COBBLES and BOULDERS: Alluvium.

1.90 Olive grey, slightly weathered, closely jointed, hard rock SANDSTONE.

2.20

NOTES

1) End of natural profile.

2) N/E river bank.

3) Profiled along survey cut.

4) Whole river plain is approximately 30m wide.

CONTRACTOR :
MACHINE : CAT 416C
DRILLED BY :
PROFILED BY : GV PRICE
TYPE SET BY : CAJ
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : NOVEMBER 2005
DATE : 23/11/05 16:04
TEXT : ..\SOILPR~1\TH5R.TXT

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TH5R

LUKHOZI CONSULTING ENGINEERS
WEST BANK RESTITUTION PROJECT

HOLE No: TH6R
Sheet 1 of 1

JOB NUMBER: GT113

Scale 1:10

0.00 Moist, brown, loose, intact, slightly CLAYEY SILT and SAND: Colluvium.

0.90 Olive grey, highly weathered, very closely jointed, soft rock, MUDSTONE.

2.00 Olive, moderately weathered, closely jointed, medium hard SANDSTONE.

2.10

NOTES

1) End of hole.

2) No watertable.

3) TLB struggles at 2.1m.

4) Sample WB4 at 1.4m.

CONTRACTOR :
MACHINE : CAT 416C
DRILLED BY :
PROFILED BY : GV PRICE

TYPE SET BY : CAJ
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : NOVEMBER 2005

DATE : 23/11/05 15:37
TEXT : ..\SOILPR~1\TH6R.TXT

ELEVATION :
X-COORD :
Y-COORD :

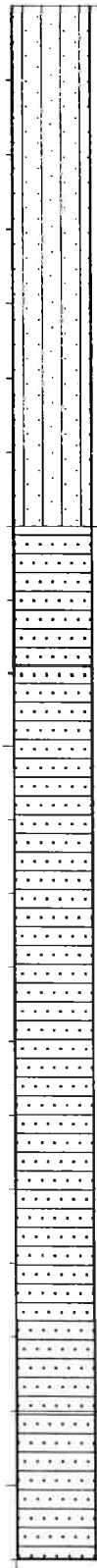
HOLE No: TH6R

LUKHOZI CONSULTING ENGINEERS
WEST BANK RESTITUTION PROJECT

HOLE No: TH7R
Sheet 1 of 1

JOB NUMBER: GT113

Scale 1:10



0.00 Moist, grey brown, loose, intact, SANDY SILT: Colluvium.

0.70 Olive/yellow, highly to completely weathered, closely jointed, soft rock, SANDSTONE.

1.90 Olive, moderately weathered, closely jointed, medium to hard SANDSTONE.

2.10

NOTES

1) End of hole.

2) No watertable.

3) TLB struggles at 2.1m.

4) Sample WB5 at 0.4m.

CONTRACTOR :
MACHINE : CAT 416C
DRILLED BY :
PROFILED BY : GV PRICE
TYPE SET BY : CAJ
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : NOVEMBER 2005
DATE : 23/11/05 15:37
TEXT : ..\SOILPR~1\TH7R.TXT

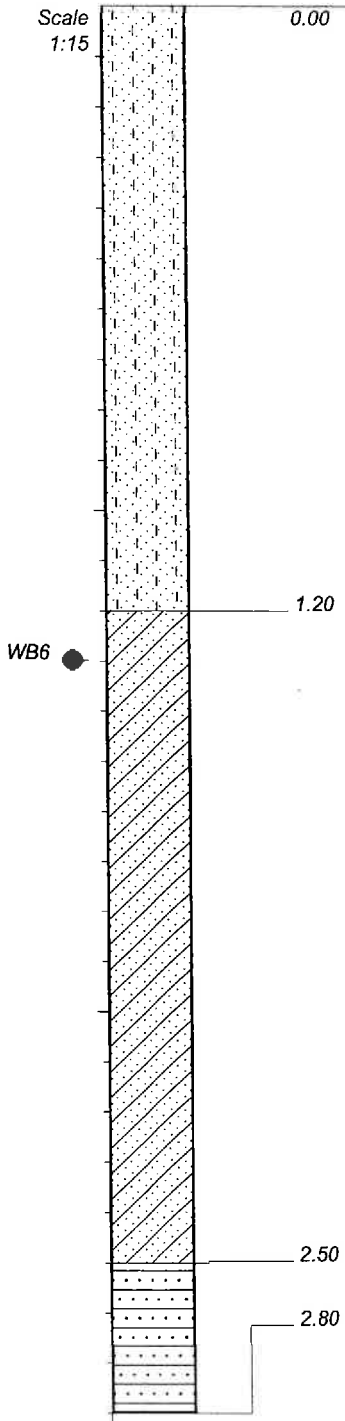
ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TH7R

LUKHOZI CONSULTING ENGINEERS
WEST BANK RESTITUTION PROJECT

HOLE No: TH8R
Sheet 1 of 1

JOB NUMBER: GT113



0.00 Moist, reddish/brown, loose, intact, SILTY SAND: Colluvium.

1.20 Moist, yellow brown, firm, SAND CLAY: Residual sandstone.

2.50 Olive yellow, highly weathered, closely jointed, soft rock, SANDSTONE.

2.80

NOTES

1) End of hole.

2) No watertable.

3) No refusal.

4) Sample WB6 at 1.3m.

CONTRACTOR :
MACHINE : CAT 416C
DRILLED BY :
PROFILED BY : GV PRICE
TYPE SET BY : CAJ
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : NOVEMBER 2005
DATE : 23/11/05 15:38
TEXT : ..\SOILPR~1\TH8R.TXT

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TH8R

HEAD OFFICE
10 St. Pauls Road
East London, 5201
P.O. Box 346
East London, 5200
Tel: (043) 722 8565 / 722 5420
Fax: (043) 743 9942

CONTROLAB cc

CK 90/12841/23

CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY

BRANCH OFFICES
Cape Town
Kokstad
Port Elizabeth
Umtata

CLIENT: Terreco cc
P O Box 1007
GONUBIE
5256

ATT : Dr G V Price

PROJECT: WEST BANK DISTRIBUTOR ROAD & SEWER

DATE: 06-12-2005

REF: 33563

FOUNDATION INDICATOR

SAMPLE NO	7496	7500	7501			
POSITION	WB1	WB5	WB6			
	1R	7R	8R			
DEPTH	1.0m	0.4m	1.3m			
DESCRIPTION	dk Y O	dk Br	dk Y O			
	sty s	sty s	sdy st			

SIEVE ANALYSIS % PASSING SIEVES: Method :TMH1 A1(a) & A5

% PASSING 75 mm						
37.5 mm						
19 mm						
9.5 mm						
4.75 mm			100			
2.36 mm			99			
1.18 mm			98			
0.600 mm	100	100	98			
0.425 mm	99	99	98			
0.300 mm	95	99	98			
0.150 mm	34	66	55			
0.075 mm	37.4	32.6	50.5			

HYDROMETER ANALYSIS: Method ASTM D422

0.06 mm	35	28	45			
0.02 mm	33	14	39			
0.006 mm	24	10	29			
0.002 mm	19	8	24			

ATTERBERG LIMITS SOIL CONSTANTS: Method: TMH1 A2 ; A3 & A4

LIQUID LIMIT	13	CBD	20			
PLASTICITY INDEX	5	SP	8			
LINEAR SHRINKAGE	2.0	0.5	4.0			

PREDICTION OF HEAVE: Van Der Merwe Method(3.4) TRH9

MOISTURE CONTENT %:						
PI WHOLE SAMPLE	5.0	0.0	8.0			
ACTIVITY	0.3	0	0.3			
POTENTIAL EXPANSIVENESS	LOW	LOW	LOW			

The above test results are pertinent to the samples received and tested only.
While the tests are carried out according to recognized standards Controlab shall not be liable for erroneous testing or reporting thereof. This report may not be reproduced except in full without prior consent of Controlab.

For Controlab: PLW

ConSR19

Remarks:

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East London, 5200
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CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY

BRANCH OFFICES
Cape Town
Kokstad
Port Elizabeth
Umtata

CLIENT: Terreco cc
P O Box 1007
GONUBIE
5256
ATT: Dr G V Price

PROJECT: WEST BANK DISTRIBUTOR ROAD & SEWER

DATE: 06-12-2005
REF: 33563

INDICATOR / CBR RESULT SUMMARY

SAMPLE NO:	7497	7498	7499			
POSITION / CHAINAGE	WB2 2R	WB3 3RS	WB4 6R			
DEPTH	1.1m	1.1m	1.4m			
DESCRIPTION:	dk Ol	lt Br	dk Ol			
	Sh + cly s	Sh + sty s	Sh + cly s			

SIEVE ANALYSIS % PASSING SIEVES: Method :TMH1 A1(a) & A5

PASSING 75 mm	99	89	92			
63 mm	91	81	88			
53 mm	86	79	86			
37.5 mm	82	74	82			
26.5 mm	70	61	67			
19 mm	61	54	59			
13.2 mm	52	48	48			
4.75 mm	28	36	31			
2.00 mm	12	30	23			
0.425 mm	6	25	17			
0.075 mm	4.0	11.5	13.3			

SOIL MORTAR ANALYSIS: Method: TMH1 A5

COURSE SAND	50	17	26			
FINE SAND	17	45	16			
SILT / CLAY	33	38	58			
GRADING MODULUS	2.78	2.34	2.47			

ATTERBERG LIMITS SOIL CONSTANTS: Method: TMH1 A2 ; A3 & A4

LIQUID LIMIT	24	CBD	34			
PLASTICITY INDEX	12	SP	17			
LINEAR SHRINKAGE	6.0	0.5	8.5			

MOD AASHTO ; C.B.R. : Method: TMH1 A7 & A8

MOD AASHTO (Kg/m3)	2188	2118	2085			
O.M.C. (%)	7.7	8.7	10.8			
C.B.R. @ 100% COMPACTION	39	64	10			
C.B.R. @ 98 % COMPACTION	35	42	8			
C.B.R. @ 95 % COMPACTION	30	23	6			
C.B.R. @ 93 % COMPACTION	27	15	5			
C.B.R. @ 90 % COMPACTION	23	8	4			
SWELL (max) %	0.00	0.40	2.10			

The above test results are pertinent to the samples received and tested only.
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Remarks:

For Controlab: PLW

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BRANCH OFFICES
Cape Town
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Port Elizabeth
Umtata

CLIENT: Terreco c.c.
P O Box 1007
GONUBIE
5256
ATT : Dr G V Price

PROJECT: WEST BANK DISTRIBUTOR ROAD & SEWER
DATE: 09-12-2005
REF: 33563

DIRECT SHEAR TEST

Sample Number	7499 WB4	Test type	Consolidated drained
Sample Type	<2mm remoulded	Depth (m)	
Description	Olive Grey weathered Mudstone		

Length (mm)	60.00	Specific Gravity	2.65
Breadth (mm)	60.00	Displacement mm/min	0.0480

RESULTS AT START OF TEST

Void Ratio	0.42	0.45	0.44
Moisture Content %	11.62	11.08	10.77

RESULTS AT END OF TEST

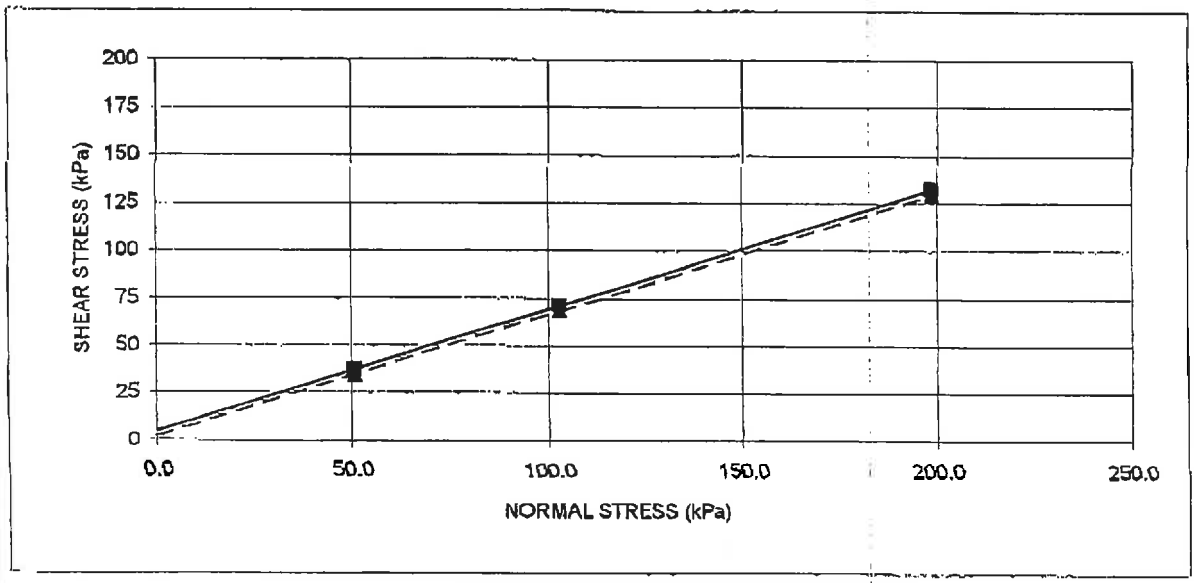
Void Ratio	0.42	0.41	0.33
Moisture Content %	18.40	18.13	17.46
Bulk Density kg/m³			
Dry Density kg/m³	1870	1827	1838

PEAK SHEAR STRENGTH

Shear Stress kPa	37.03	71.12	132.44
Normal Stress kPa	50.71	102.79	198.72

RESIDUAL SHEAR STRENGTH

Shear Stress kPa	34.22	68.71	129.62
Normal Stress kPa	50.71	102.79	198.72



	C kPa	Degrees
Peak	4.6	32.8
Residual	2.0	32.8

Apparent angle of internal shearing resistance given by regression (°)	32.8
Apparent cohesion given by regression (kPa)	4.6