

KOREA RURAL COMMUNITY CORPORATION
IN JOINT VENTURE WITH
DASAN CONSULTANTS CO. LTD.,
ISAN CORPORATION
AND
EMD CONSULTING ENGINEERING

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CHAPTER 1. GEOTECHNICAL SURVEY

1.1. Introduction

The geotechnical investigation was carried out in order to facilitate the detailed design of the SVTP-1 (Shire Valley Transformation Program-1) by supply the basic information about subsurface conditions and geotechnical properties.

The spatial extent of investigation centered on the proposed MC3 and Secondary Canals/Pipelines route.

In the report, “BH” means the borehole drilled in Feasibility Study, and “DBH” means the borehole drilled in Detailed Design of MC1 and part of MC2 stage. DBH-64 and DBH-65 was done for f Main Canal 3. “SBH” means the borehole drilled in this task (2nd Detailed Designing of 1st Stage).

The duties of a geotechnical expert in the detailed design are as follows:

- Review of existing data
- Execution of geotechnical investigation
- Writing activity report
- Provide the geotechnical investigation result for detailed design

1.2. Review of Previous Geotechnical Investigation

1.2.1. Previous Tasks

During TFS, the geotechnical investigation was conducted from January 2016 to March 2016. For Detailed design of MC1 and part t of MC2, the Geotechnical investigation was carried out from November 2017 to January 2018. The work scope of D.D was on Main Canal 1 and Main Canal 2 considering the changes of canal route. The works include drilling works, soil sampling, in-situ test and laboratory test. The tasks are shown in Table 3.2-1.

[Table 1.2-1] Previous Geotechnical Investigations

Items	Unit	Quantity			Remarks
		TFS	D.D	Total	
1. Drilling Boreholes					BS 5903(1990)
1) Percussive drilling	No	19	11	30	
2) Auger boring	No	9	39	48	
3) Borrow Pit & Quarry Site	No	12	-	12	
2. Permeability Pits	No	20	7	27	
3. Ground surface survey	Ls	1	1	2	Including quarry survey
4. Laboratory Test					BS 1337(1991)



1) sieve analysis	No	89	58	147	ASTM D 422
2) Atterberg limits	No	89	58	147	ASTM D 4318
3) UU Tri-axial test	No	-	3	3	ASTM D 2850
4) Specific gravity	No	89	58	147	ASTM D 854
5) Natural moisture content	No	40	-	40	ASTM D 2216
6) Direct shear test	No	-	4	4	ASTM D 3080
7) Permeability Test	No	20	7	27	

* TFS: Technical Feasibility Study

* D.D: Detailed Design for Main Canal (MC-1, MC-2)

1.2.2. Summary of Results

The project area is partly within the Shire Highlands and mostly within the Lower Shire Valley Plains. From the intake site, soil characteristics reveal the existence of charnockitic suite: banded pyroxene granulites and gneisses, and hyperthene-granite of precambrian palaeozoic late origin. Alluvium of quaternary origin occurs from the foot of the escarpment to Kamuzu Bridge to Majete Bangula.

Rock layers were found at MC-1(BH-A, BH-4, BH-9, BH-13, BH-14, BH-15, DBH-4, DBH-5, DBH-6), situated 2-7m below the ground surface. The earth layer in each borehole is 2m thick from the surface and comprises sand, silt, and clay.

The soils excavated at project area fall within the group of Loess Loam, with coefficient of permeability in the range of 10⁻² to 10⁻⁴.

Based on TFS & D.D. data, Main Canal mainly comprises of sandy soils which will likely result in high seepage losses if an unlined canal is opted. Additionally, as another option, it was recommended to use concrete pipes buried in the ground to be used as a water conveyance system so as to reduce evaporation losses and to protect wild animals from drowning. Table 3.2-2 and 3.2-3 show the percussion drilling depth & layer for TFS and Detailed Design respectively.

[Table 1.2-2] Percussion Drilling Depth & Layer for TFS

Hole No.	BH-A	BH-1	BH-2	BH-3	BH-4 BH-5	BH-7a	BH-6 BH-7 BH-9	BH-12 BH-13 BH-14	BH-15 BH-16	BH-18	BH-22	BH-23 BH-24
Layer	2	6	6	3	1	3	1	1	1	6	1	1
Depth (m)	2.65	6.46	6.5	9.70	2.235	1.3	3.45	4.15	3.45	6.45	3.0	3.175

* Locations of BH-23, BH-24 are belongs to MC-3

[Table 1.2-3] Percussion Drilling Depth & Layer for D.D.

Hole No.	DBH-1	DBH-2	DBH-4	DBH-5	DBH-6	DBH-14	DBH-19	DBH-45	DBH-50	DBH-51	DBH-63



Layer	4	3	2	5	2	3	3	3	4	7	4
Depth (m)	10.10	2.06	4.95	7.60	1.61	2.30	3.28	3.85	1.72	10.02	6.46

1.3. Site Investigations

1.3.1. Investigation Criteria

The purpose of the geotechnical investigations is to determine the surface and subsurface conditions at specific points within the project area including the physical, mechanical properties of subsurface samples required for economical detailed design and construction.

The consultant selected 35 points (33 drilling, 2 test pit) along the canal for geotechnical investigations, covering MC3(DBH-64, DBH-65) and Secondary Canals.

One or two drilling holes were conducted on each of the proposed secondary canal route. This is enabled a comprehensive geotechnical investigation. The drilling location was considered around the site of the night storage reservoir and pumping station. The sedimentary reservoir site had a drilling depth of 4 m, while the pumping station site had a drilling depth of 7 m. Locations which were difficult to reach using a drilling rig, were replaced by Test Pit (SBH-27, SBH-28).

The investigation was based on international standards of ASTM or BS.

1.3.2. Implementation

A geotechnical expert was dispatched from February 6, 2021 to April 25, 2021 in Malawi. The details of tasks, such as drilling activities, in-situ test, laboratory tests, etc., shall be as follows:

[Table 1.3-1] Geotechnical Investigation Tasks

Items	Unit	Quantity	Remarks (Standard)
1. Drilling Boreholes			BS 5903(1990)
1) Percussive drilling	No (m)	33 (127.5)	
2) Rotary Drilling	No (m)	3 (11.5)	SBH-14(1.0-6.0m) SBH-19(3.5-7.0m) SBH-33(4.0-7.0m)
2. Test Pit	No (m)	2 (4)	SBH-27, SBH-28
3. Standard Penetration Test	LS	62	ASTM D 1586
4. Laboratory Test	-	-	BS 1337(1991)
1) sieve analysis	No	67	ASTM D 422
2) Natural Water Content	No	52	ASTM D 2216
3) Atterberg limits	No	67	ASTM D 4318
4) Specific gravity	No	67	ASTM D 854



5) Permeability Test	No	33	-
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* Total investigation points are 35 (drilling 33 holes, test pit 2 holes)

* 3 holes for Rotary drilling, and Percussion Drilling 33 holes (SBH-14, SBH-19, SBH-33).

(Percussive drilling: the upper soil layer, Rotary drilling: the lower bed rock layer).

* (127.5) = drilling depth

1.4. Boreholes Analysis

1.4.1. Site and Testing Overview

Field work was conducted using percussive drilling method to recover samples for testing as well as conducting SPT (Standard Penetration Test) tests. The following field equipment was used.

[Table 1.4-1] Field Test Equipment

Equipment	Specifications	Quantity	Remark
Drill Rig	Dando Terrier	1 device	Geotechnical Soil Sampling Rig
S.P.T Instrument	BS Standard	1 set	Hammer(63.5kg) Split Spoon Sampler
GPS	Garmin GPSMAP 64x	1 device	N/A

Each borehole was drilled to a predetermined depth, majority of which was 4m. Certain points under the areas marked for structures were drilled to 7m to investigate further subsurface material. For bore hole drilling, 12 were on the MC1 route, 13 on the MC2, and 7 on the MC3, a total of 32 drillings were performed.

Figure 3.4-1 shows the Dando Terrier (drilling rig) and sampling scene of SBH-1.



[Figure 1.4-1] Drilling Rig(left) & Disturbed Sample(right)

The below tests were carried out in each set location.

[Table 1.4-2] Sampling and Test Breakdown

Item	Remarks
Percussive & Rotary Drilling	<ul style="list-style-type: none"> - SPT (every 1.5m depth) - Specific Gravity - Sieve analysis



	<ul style="list-style-type: none"> - Permeability - Atterberg limit test
Trial Pits	<ul style="list-style-type: none"> - Specific Gravity - Sieve analysis - Atterberg limit test



[Figure 1.4-2] Laboratory facility & Test Equipment

1.4.2. Drilling Activities

As already stated, the geotechnical survey was mainly carried out using percussive drilling in order to retrieve soil samples from the subsurface. The percussive rig was also used in tandem with the standard penetration test. Where the strata showed presence of decomposed rock and percussive drilling could no longer penetrate, the rotary wash and bore method was used instead in order to reach the required depth for the SPT.

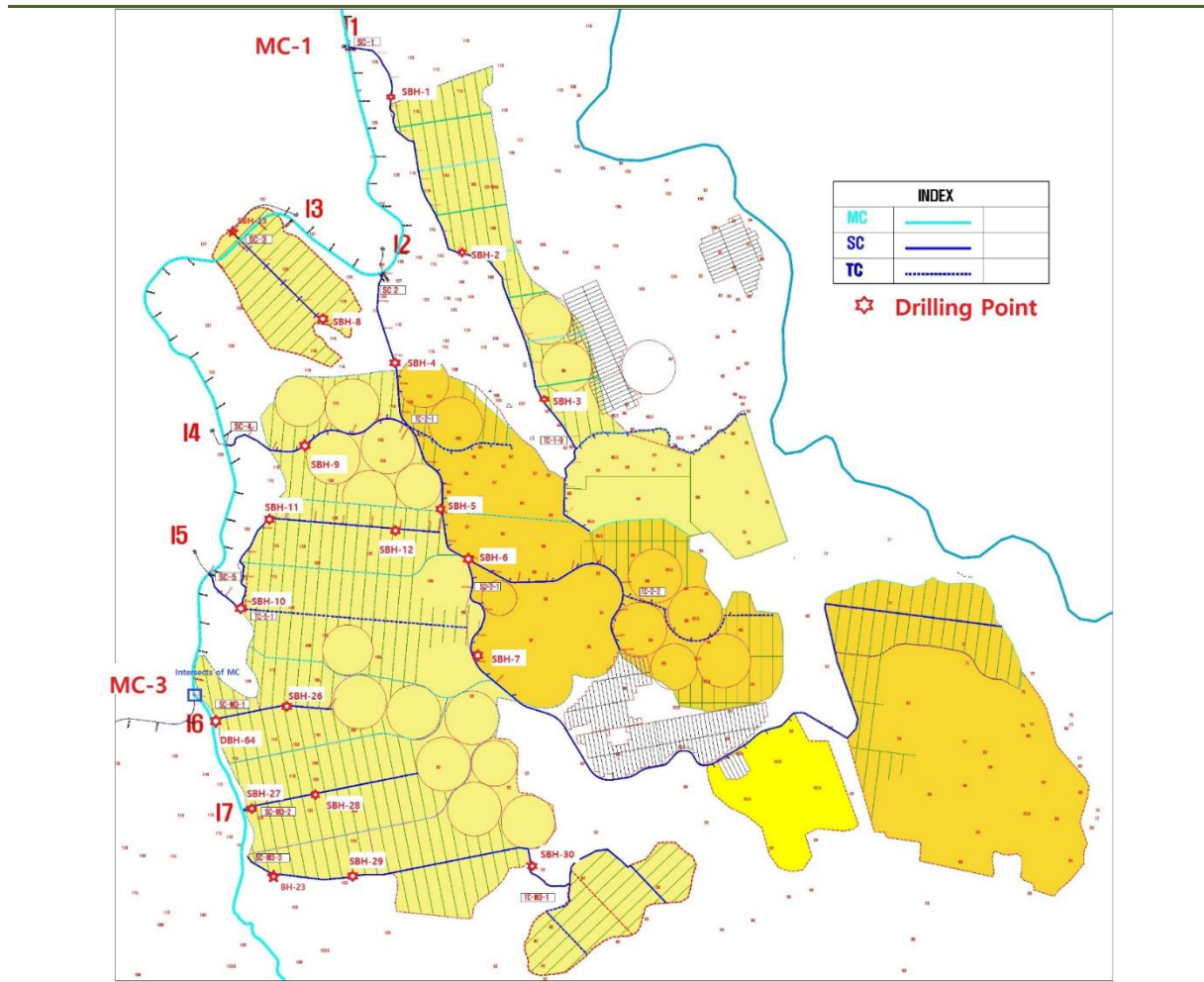
SPT testing was conducted according to ASTM (American Society for Testing and Materials) D 1586 at 1.5m and at 4m to allow for bearing capacity to be calculated at the two depths. This was carried out using a 63.5kg hammer to drive a hollow split spoon sampler into the soil. The number of blows for each run of 150mm was recorded for a total of 450mm. Total number of blows for the final 300mm are added together to give the SPT N number.

The drilling was carried out with a diameter of about NX, and a casing method was adopted to insert the casing to a solid layer without pore wall collapse.

For the topsoil section, the standard penetration test was performed to obtain the N value which is the index to grasp the degree of soil softening and compaction in the in situ. In addition, samples were taken using a Split Spoon Sampler.

Zone I-1

Five Secondary Canals/pipelines are getting water from MC1. A total of 13 bore holes were drilled for these SCs. Figure 3.4-3 shows the drilling points in Zone I-1, and Figure 3.4-4 shows the same drilling points with Division numbers which was named according to the name of the Secondary Canal. Table 3.4-1 shows the locations and drilling depths of boreholes in Zone I-1.



[Figure 1.4-3] Drilling Points in Zone I-1



[Figure 1.4-4] Drilling Points in Zone I-1 (SCs branched from MC1) (with Division Number)
 [Table 1.4-3] Locations and Drilling Depths of Boreholes in Zone I-1 (MC1)

Division Number	Drilling Point	Coordinates (Decimal Degrees)		Coordinates UTM (36K)		Drilling Depth
I1(SC1)						
SC1 POINT 1	SBH-1	-16.02429	34.766066	8,227,573	688,956	4.0
SC1 POINT 2	SBH-2	-16.04722	34.777099	8,225,025	690,115	4.0
SC1 POINT 3	SBH-3	-16.07005	34.791122	8,222,486	691,594	4.0
I2(SC2)						
SC2 POINT 1	SBH-4	-16.06521	34.767001	8,223,044	689,018	4.0
SC2 POINT 2	SBH-5	-16.08844	34.775082	8,220,466	689,860	4.0
SC2 POINT 3	SBH-6	-16.09572	34.779106	8,219,656	690,284	4.0
SC2-1						
SC2-1 POINT 1	SBH-7	-16.11217	34.78072	8,217,834	690,441	4.0
I3(SC3)						
SC3 POINT 1	SBH-33	-16.04135	34.75068	8,225,699	687,295	7.0
SC3 POINT 2	SBH-8	-16.05804	34.75492	8,223,862	687,758	4.0
I4(SC4)						
SC4 POINT 1	SBH-9	-16.07880	34.751247	8,221,554	687,319	4.0
I5(SC5)						
SC5 POINT 1	SBH-10	-16.10374	34.742208	8,218,802	686,329	4.0
SC5 POINT 2	SBH-11	-16.08935	34.746689	8,220,391	686,822	3.0
SC5 POINT 3	SBH-12	-16.09075	34.764742	8,220,219	688,752	4.0
Sum	13 holes					54.0

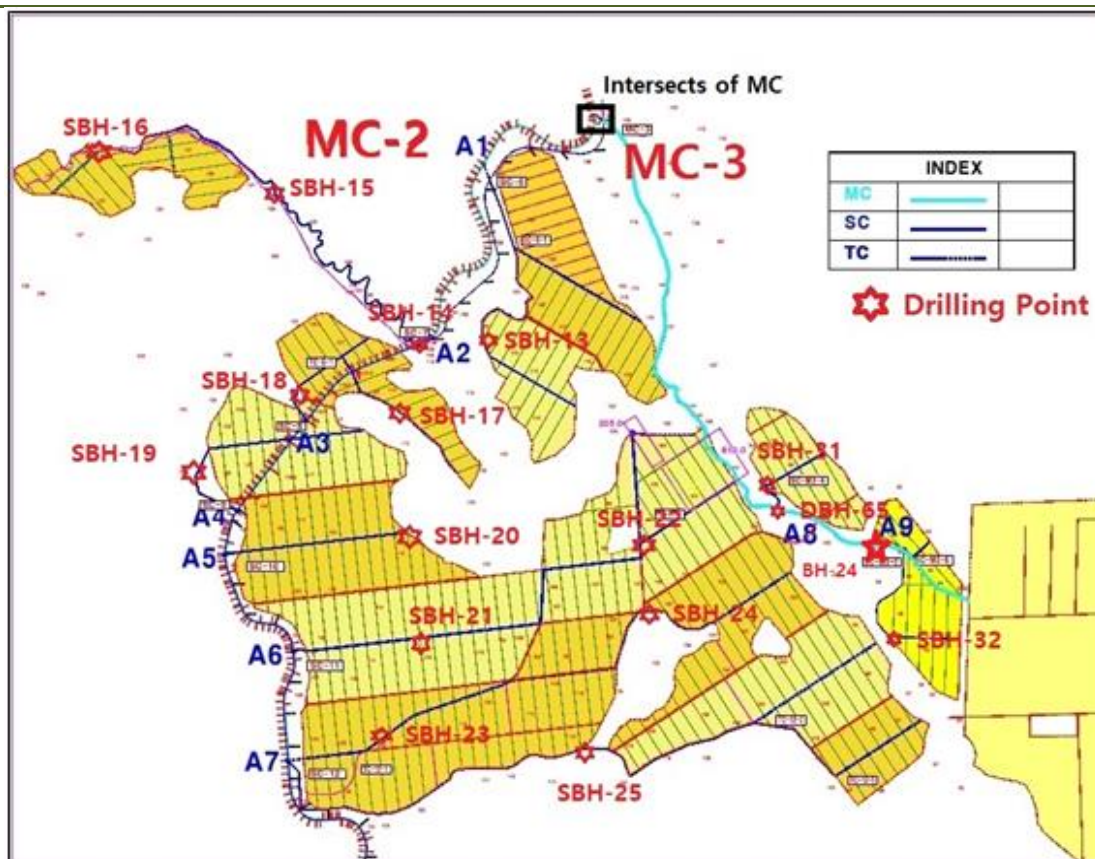


Generally, this area consists of alluvial soils. Among them, 4 holes (SBH-1, SBH-10, SBH-11, SBH-33) confirmed the presence outcrops and boulders on the surface. Interpreting data from the logging table, SBH-1 shows the presence of weathered rock subsurface from 0.4m to 4.0m. SBH-10 has boulder (clayey gravel) from 0.7 to 2.0m, and silty sand from 2.0m to 4.0m. SBH-11 has weathered rock from 0.7-3.0m. SBH-33 has boulders from 0.5 to 2.5m and also from 4.0 to 5.0m. It also has soft rock from 5.0 to 7.0m. In these strata, SPT N value is also 55. Because of the geological nature found on SBH 33 (boulder, weathered rock, soft rock), it was not possible to conduct SPT test.

Zone A

In this zone, Seven Secondary Canals/Pipelines are abstracting water from MC2. A total of 13 bore holes were drilled for these SCs. Still more, Five Secondary Canals are getting their water from MC3. A total of 7 bore holes were drilled for these SCs. In the feasibility study, two boreholes were drilled, (BH-23, BH-24) on Main Canal-3. During this study another two were drilled (DBH-64, DBH-65). Thus in total, the results of all these four boreholes were used in understanding the subsurface terrain of MC3. Figure 3.4-5 shows the drilling points in Zone A.

Figure 3.4-6 shows the drilling points on the SCs which are branching from MC2. The division numbers of holes were named according to the name of the Secondary Canal. Table 3.4-4 shows the locations of these points.



[Figure 1.4-5] Drilling Points in Zone A



[Figure 1.4-6] Drilling Points in Zone A (SCs branched from MC2) (with Division Number)

[Table 1.4-4] Locations and Drilling Depths of Boreholes in Zone A (MC2)

Division Number	Drilling Point	Coordinates (Decimal Degrees)		Coordinates UTM (36K)		Drilling Depth
A1(SC6)						
SC6 POINT 1	SBH-13	-16.14725	34.717964	8,214,010	683,695	4.00
A2(SC7)						
SC7 POINT 1	SBH-14	-16.14688	34.710271	8,214,057	682,873	6.00
SC7 POINT 2	SBH-15	-16.12834	34.687730	8,216,129	680,479	4.00
SC7 POINT 3	SBH-16	-16.12213	34.663174	8,216,837	677,858	4.00
A3(SC8)						
SC8 POINT 1	SBH-17	-16.15753	34.705613	8,212,883	682,365	4.00
SC8 POINT 2	SBH-18	-16.15563	34.691121	8,213,106	680,817	4.00
A4(SC9)						
SC9 POINT 1	SBH-19	-16.16660	34.677135	8,211,904	679,311	7.00
A5(SC10)						
SC10 POINT 1	SBH-20	-16.17434	34.706758	8,211,022	682,472	4.00
A6(SC11)						
SC11 POINT 1	SBH-21	-16.18931	34.707952	8,209,364	682,586	4.00
SC11 POINT 2	SBH-22	-16.17517	34.740319	8,210,900	686,060	4.00
A7(SC12)						
SC12 POINT 1	SBH-23	-16.20273	34.703575	8,207,883	682,106	4.00
SC12 POINT 2	SBH-24	-16.18480	34.741517	8,209,833	686,179	4.00



SC12 POINT 3	SBH-25	-16.20389	34.733279	8,207,728	685,281	4.00
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This area again consists of alluvial soils same as the previous zone. Results from analysis showed that borehole (SBH-14) has outcrops and boulders on the surface. 3 holes (SBH-13, SBH-15, SBH-19) come out with rock samples while drilling. by further interpreting logged data, SBH-13 showed the presence of weathered rock subsurface from 0.4m to 4.0m. Borehole SBH-14 has soft rock from 0.6 to 6.0m, while Borehole SBH-15 has weathered rock subsurface from 1.0m to 1.8m, and from 2.0 to 4.0m. SBH-19 has weathered rock from 3.0-3.5m, soft rock from 3.5-7.0m. In all these strata, SPT N value is also 55. Because of the geological nature found on SBH-14 (weathered rock, soft rock), it was not possible to conduct SPT test.

Figure 3.4-7 shows the drilling points on the SCs which emanates from MC3. The numbering code of these BH was based on the name of the Secondary Canal. Table 3.4-5 shows the locations of these points.



[Figure 1.4-7] Drilling Points in Zone A (SCs branched from MC3) (with Division Number)

[Table 1.4-5] Locations and Drilling Depths of Boreholes in Zone A (MC3)

Division Number	Drilling Point	Coordinates (Decimal Degrees)		Coordinates UTM (36K)		Drilling Depth
MC3	DBH-64	-16.1217	34.73813	8,216,811	685,877	3.00
MC3	(BH-23)	-	-	-	-	7
MC3	DBH-65	-16.17062	34.76036	8,211,386	688,209	3.00
MC3	(BH-24)	-	-	-	-	7



SC3-1						
SC3-1 POINT 1	SBH-26	-16.11912	34.749973	8,217,094	687,145	3.00
SC3-2						
SC3-2 POINT 1	SBH-27	-16.13496	34.743622	8,215,346	686,451	3.00
SC3-2 POINT 2	SBH-28	-16.13269	34.753829	8,215,588	687,545	3.00
SC3-3						
SC3-3 POINT 1	SBH-29	-16.14607	34.759109	8,214,103	688,097	4.00
SC3-3 POINT 2	SBH-30	-16.14594	34.791410	8,214,087	691,552	4.00
SC3-4						
SC3-4 POINT 1	SBH-31	-16.16760	34.758675	8,211,721	688,030	4.00
SC3-5						
SC3-5 POINT 1	SBH-32	-16.18828	34.776423	8,209,416	689,909	4.00

* The results of two holes (BH-23, BH-24) on the MC3 conducted in the FS, were also used.

Results of boreholes drilled in this area also shows the predominance of alluvial soils. two boreholes (BH-23, BH-24) were assessed during the feasibility study period and their results are incorporated in this report. Further to this two which were done during FS, additional two boreholes (DBH-64, DBH-65) were drilled on the MC3. Among them, 1 hole (DBH-64) showed the presence of outcrops on surface. Another borehole (BH-23) came out with rock samples while drilling. by carefully checking and analyzing logging samples, DBH-64 showed the presence of weathered rock subsurface from 0.5m to 4.0m while BH-23 has weathered rock from 0.88 to 2.81m. In all these strata, SPT N value is also 55++.

Two points (SBH-27, SBH-28) were excavated manually in the form of test pits due to access to local conditions which prevented the drilling rigs to access the area. However, percussion drilling which was conducted on 3 boreholes (SBH-26, SBH-28, SBH-31) confirmed the presence of outcrops and boulders on the surface. Interpreted data from logging samples shows that, SBH-26 has weathered rock subsurface from 0.8m to 4.0m. and SBH-27 has weathered rock from 1.0 to 2.0m. SBH-28 has weathered rock subsurface from 1.3m to 2.0m while SBH-31 has weathered rock from 0.6 to 4.0m. In all these strata, SPT N value is also 55++. The test pits (SBH-27, SBH-28) couldn't provide the SPT N value because as previously stated, they were manually excavated.

Three Survey points close to the Mwanza River were also drilled (SBH-29, 30 and 31). results of log data shows that SBH-29 has Sandy Silty Clay from 1 m below the surface to the drilling depth (4 m), and SBH-30 point, almost all the drilling depth (0-4 m) has Sand. The SPT values at these two points were 24 and 23, respectively, indicating that those bearing capacity are very weak. The SBH-31 point was identified as weathered rock from 0.6 m below the surface, and the bearing capacity was 55++, which was very good.

1.4.3. SPT (Standard Penetration Test)

SPT testing was conducted according to ASTM D 1586 at 1.5m and at 4m to allow for bearing capacity to be calculated at the two depths. This test was conducted to identify the relative density, consistency and composition of the strata, and also for the identification of constituents of the collected disturbed samples.



This test was carried out using a 63.5kg hammer to drive a hollow split spoon sampler into the soil. The number of blows for each run of 150mm was recorded for a total of 450mm. Total number of blows for the final 300mm are added together to give the SPT N number.

Bearing capacity was calculated using Bowles after Mayerhof 1976, whereas friction angles were calculated using Peck et al 1953.

Table 3.4-6 to 3.4-8 show the results of the SPT tests.

[Table 1.4-6] SPT N & Bearing Capacity & Friction Angle of Boreholes in Zone I-1 (MC1)

Division	Drilling Point	Bearing Capacity (kPa)		Friction Angle (Degrees)		SPT N	
		1.5m	4.0m	1.5m	4.0m	1.5m	4.0m
I1(SC1)							
SC1 POINT 1	SBH-1	1,919	2,022	32	32	55++	55++
SC1 POINT 2	SBH-2	256	384	29	29	14	19
SC1 POINT 3	SBH-3	461	512	29	29	24	25
I2(SC2)							
SC2 POINT 1	SBH-4	256	256	29	29	13	13
SC2 POINT 2	SBH-5	230	230	29	28	12	11
SC2 POINT 3	SBH-6	102	256	28	29	6	12
SC2-1							
SC2-1 POINT 1	SBH-7	230	333	29	29	12	16
I3(SC3)							
SC3 POINT 1	SBH-8	435	768	30	30	23	38
I4(SC4)							
SC4 POINT 1	SBH-9	256	742	28	30	13	37
I5(SC5)							
SC5 POINT 1	SBH-10	1,919	2,022	32	32	55++	55++
SC5 POINT 2	SBH-11	1,919	2,022	32	32	55++	55++
SC5 POINT 3	SBH-12	384	358	29	29	20	18

* SPT Test of SBH-11 was conducted 1.5m, 3.0m.

[Table 1.4-7] SPT N & Bearing Capacity & Friction Angle of Boreholes in Zone A (MC2)

Division	Drilling Point	Bearing Capacity (kPa)		Friction Angle(Degrees)		SPT N	
		1.5m	4.0m	1.5m	4.0m	1.5m	4.0m
A1(SC6)							
SC6 POINT 1	SBH-13	384	2,022	29	32	20	55++
A2(SC7)							
SC7 POINT 1	SBH-14	-	-	-	-	-	-
SC7 POINT 2	SBH-15	1,919	870	32	30	55++	43
SC7 POINT 3	SBH-16	358	256	29	29	18	13
A3(SC8)							



SC8 POINT 1	SBH-17	230	640	29	30	12	31
SC8 POINT 2	SBH-18	307	205	29	28	16	10
A4(SC9)							
SC9 POINT 1	SBH-19	281	1,663	29	31	15	55++
A5(SC10)							
SC10 POINT 1	SBH-20	230	256	29	29	12	13
A6(SC11)							
SC11 POINT 1	SBH-21	307	537	29	30	16	27
SC11 POINT 2	SBH-22	179	230	28	29	9	11
A7(SC12)							
SC12 POINT 1	SBH-23	358	409	29	29	18	20
SC12 POINT 2	SBH-24	102	307	28	29	6	15
SC12 POINT 3	SBH-25	128	154	28	28	7	7

* SPT Test of SBH-14 was not conducted for its geologic condition (soft rocks).

[Table 1.4-8] SPT N & Bearing Capacity & Friction Angle of Boreholes in Zone A (MC3)

Division Number	Drilling Point	Bearing Capacity (kPa)		Friction Angle(Degrees)		SPT N	
		1.5m	4.0m	1.5m	4.0m	1.5m	4.0m
Main Canal-3	DBH 64	1,919	2,022	32	32	55++	55++
	(BH-23)	-	-	-	-	7	55++
	DBH 65	205	128	28	28	11	6
	(BH-24)	-	-	-	-	7	7
SC3-1							
SC3-1 POINT 1	SBH-26	1,024	2,022	31	32	54	55++
SC3-2							
SC3-2 POINT 1	SBH-27	-	-	-	-	-	-
SC3-2 POINT 2	SBH-28	-	-	-	-	-	-
SC3-3							
SC3-3 POINT 1	SBH-29	512	486	29	29	26	24
SC3-3 POINT 2	SBH-30	77	461	27	29	4	23
SC3-4							
SC3-4 POINT 1	SBH-31	1,919	2,022	32	32	55++	55++
SC3-5							
SC3-5 POINT 1	SBH-32	102	128	28	28	6	6

* In the feasibility study, the results of the two holes (BH-23, BH-24) conducted on Main Canal-3 were used together.

1.4.4. Groundwater level measurement

Groundwater level was measured and recorded in each borehole to account for hydraulic pressure and effective overburden load due to groundwater level change.

Groundwater level measurement was performed first in the casing after completion of the drilling



operation, and after 24 hours after the completion of the drilling operation when the water level has stabilized. However, the measured groundwater level may vary depending on the season and meteorological phenomenon.

The standing water level (post 24h) will affect the bearing capacity values and thus need to be factored into the calculations.

Even though, the working period was in rainy season, it was only one site (SBH-6), that had stable water level measure at 2m below surface. Thus, it can be concluded with confidence that the permeability is very high in this area.



[Figure 1.4-8] Measure of Groundwater level (SBH-2, SBH-13)

1.5. Laboratory Activities

In order to understand the physical and mechanical properties of each stratum, the laboratory test was conducted for further information. Two samples were recovered from each borehole and were tested as described below:

1.5.1. Sieve Analysis

The classification method of soil was as follows. At the site survey, gentle classification method was used to classify strata. Laboratory test results were obtained by using the unified classification method. The United Standard classification system was developed by A. Casagrande as a method of engineering soil classification by soil size and consistency limits. This USCS is often used to classify soil engineering properties. The following table summarizes the USCS classification methods.



[Table 1.5-1] Unified Soil Classification System

Primary Divisions for Field and Laboratory Identification		Group Symbol	Typical Names
Gravel (More than 50% of coarse fraction larger than No.4 Sieve size)	Clean gravels (Less than 5% of material smaller than No.200 sieve size)	GW	Well graded gravels, gravel-sand mixtures, little or no fines*
		GP	Poorly graded gravels, gravel-sand mixtures, little or no fines*
	Gravels with fines (More than 12% of material smaller than No.200 sieve size)*	GM	Silty gravels, and gravel-sand-silt mixtures
		GC	Clayey gravels, and gravel-sand-clay mixtures
Sands (50% or more of coarse fraction smaller than No.4 sieve size)	Clean sands (Less than 5% of material smaller than No.200 sieve size)	SW	Well graded sands, gravelly sands, little or no fines*
		SP	Poorly graded sands and gravelly sands, little or no fines*
	Sands with fine (More than 12% of material smaller than No.200 sieve size)*	SM	Silty sands, sand-silt mixtures
		SC	Clayey sands, sand-clay mixtures
Fine grained soils (50% or More of material is smaller than No.200 sieve size)	Silts and clays (Liquid limit less than 50)	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands
		CL	Inorganic clays of low to medium plasticity, gravelly clays, silty clays, sandy clays, lean clays
		OL	Organic silts and organic silts-clays of low plasticity
	Silts and clays (Liquid limit greater than 50)	MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity
Highly organic soils	Pt	Peat, muck and other highly organic soils	

Sieve analysis gives an interpretation of the particle size distribution, which in turn allows us to determine the quantitative composition of the sample. The material passing the 0.075mm sieve size can be classified as silt or clay, so when a sample has 75% passing the 0.075mm sieve such as SBH25 at 0.3-1.2m it can be understood that 75% of the sample is silt or clay. The determination between silt and clay is then found from the Atterberg limits in the following section.

Table 3.5-2 to 3.5-4 show the results of sieve analysis for Secondary Pipelines of MC1, Mc2 and MC3 respectively.



[Table 1.5-2] Sieve Analysis for Secondary Lines of MC1

Borehole No.	Depth (m)	% Material Passing Sieve Size		
		2.36mm	0.425mm	0.075mm
SBH-1	0.5 - 1.5	92	78	60
SBH-2	3.5 - 4.0	85	54	21
SBH-3	0.3 - 1.8	98	70	21
SBH-3	2.4 - 3.0	98	30	11
SBH-4	0.5 - 1.6	100	82	33
SBH-4	2.8 - 4.0	96	61	18
SBH-5	0.1 - 2.1	100	90	52
SBH-5	2.4 - 3.4	96	90	59
SBH-6	0.3 - 1.1	100	86	50
SBH-6	2.0 - 4.0	94	80	48
SBH-7	0.3 - 1.3	99	86	50
SBH-7	2.3 - 3.5	99	86	42
SBH-33	0.4 - 1.2	72	50	30
SBH-33	1.2 - 3.0	89	64	31
SBH-8	0.6 - 1.2	100	84	38
SBH-8	2.2 - 3.3	95	69	27
SBH-9	0.5 - 1.0	99	82	32
SBH-9	2.6 - 3.4	80	63	31
SBH-10	0.7 - 1.0	60	42	20
SBH-10	2.0 - 3.0	99	64	21
SBH-11	0.0 - 0.9	83	63	38
SBH-11	0.9 - 4.0	100	60	19
SBH-12	0.2 - 1.2	100	78	43
SBH-12	2.0 - 3.0	96	86	49

[Table 1.5-3] Sieve Analysis for Secondary Lines of MC2

Borehole No.	Depth (m)	% Material Passing Sieve Size		
		2.36mm	0.425mm	0.075mm
SBH-13	0.0 - 0.4	92	85	54
SBH-13	0.4 - 0.3	90	67	39
SBH-14	0.6 - 1.1	46	32	8
SBH-14	2.0 - 3.0	95	67	33
SBH-15	0.4 - 1.0	96	74	32
SBH-15	1.0 - 1.8	85	67	26



SBH-16	0.9 - 1.3	100	71	44
SBH-16	2.5 - 3.4	97	61	21
SBH-17	0.0 - 0.8	99	53	15
SBH-17	0.8 - 3.7	97	46	3
SBH-18	1.2 - 2.3	100	91	36
SBH-18	2.3 - 4.0	100	40	14
SBH-19	0.2 - 1.1	100	69	61
SBH-19	2.0 - 3.0	92	74	45
SBH-20	0.5 - 1.8	99	52	4
SBH-20	1.8 - 4.0	98	40	5
SBH-21	0.3 - 1.4	100	78	62
SBH-21	2.3 - 3.8	95	46	10
SBH-22	0.9 - 2.5	100	97	41
SBH-22	2.5 - 4.0	99	56	14
SBH-23	0.3 - 1.3	100	76	44
SBH-23	2.5 - 3.8	95	47	10
SBH-24	0.4 - 1.3	100	44	23
SBH-24	1.3 - 4.0	99	23	4
SBH-25	0.3 - 1.2	100	94	75
SBH-25	1.2 - 4.0	99	45	8

[Table 1.5-4] Sieve Analysis for MC3, Secondary Lines of MC3

Borehole No.	Depth (m)	% Material Passing Sieve Size		
		2.36mm	0.425mm	0.075mm
SBH-26	0.3 - 0.8	52	34	20
SBH-26	0.8 - 2.0	90	55	26
SBH-27	0.4 - 1.0	78	55	37
SBH-27	1.0 - 2.0	95	69	7
SBH-28	0.9 - 1.2	95	80	50
SBH-28	1.2 - 2.0	83	52	30
SBH-29	0.4 - 1.0	100	87	67
SBH-29	1.0 - 3.0	98	84	54
SBH-30	0.2 - 1.0	99	38	4
SBH-30	2.0 - 3.0	99	41	5
SBH-31	0.6 - 1.0	79	47	18
SBH-31	2.0 - 3.0	100	76	17
SBH-32	0.1 - 1.1	100	90	67



SBH-32	2.9 - 4.0	99	91	54
DBH-64	0.5 - 1.0	88	51	27
(BH-23)	0.25 – 0.45	71	59	38
(BH-23)	1.95 – 2.35	65	17	6
DBH-65	0.3 - 1.7	100	95	44
DBH-65	2.0 - 3.2	100	93	60
(BH-24)	0.95 – 2.6	100	95	79
(BH-24)	2.6 – 3.0	99	94	55

* In the feasibility study, the results of BH-23 and BH-24 conducted on Main Canal-3 were used together.

1.5.2. Natural Moisture Content

Natural moisture content, is the ratio of the weight of water to the weight of the solids in each mass of soil. This ratio is usually expressed as percentage. When voids are filled with air, water content is equal to zero (dry soil). Soils are weighed in a container prior to be placed in a 100°C oven for 24h to allow to dry out completely. The weight of the soil is re-measured, and the difference is calculated as a percent.

Table 3.5-5 to 3.5-7 show the natural moisture contents for SCs of MC1, MC2 and MC3 respectively.

[Table 1.5-5] Natural Moisture Content for Secondary Lines of MC1

Borehole ID	Depth (m)	NMC %
SBH-1	2.0	4.8
SBH-2	2.0	6.6
SBH-3	2.0	1.2
SBH-4	2.0	5.4
SBH-5	2.0	23.4
SBH-5	4.0	16.2
SBH-6	2.0	17.0
SBH-6	4.0	22.3
SBH-7	2.0	10.2
SBH-7	4.0	15.1
SBH-33	2.0	2.8
SBH-33	4.0	16.7
SBH-8	2.0	6.1
SBH-8	4.0	9.0
SBH-9	2.0	7.2
SBH-9	4.0	5.6
SBH-10	2.0	8.6
SBH-10	4.0	9.4
SBH-11	2.0	2.0
SBH-12	2.0	12.8
SBH-12	4.0	9.6



NMC of 2nd Line of MC1 is 1.2 – 23.4%. The value of the sample taken at 2m is 1.2-23.4%. The value of the sample taken at 4m is 5.6-22.3%. (Table 3.5-5)

[Table 1.5-6] Natural Moisture Content for Secondary Lines of MC2

Borehole ID	Depth (m)	NMC %
SBH-13	2.0	7.0
SBH-13	4.0	7.8
SBH-15	2.0	3.7
SBH-15	4.0	4.0
SBH-16	2.0	14.5
SBH-16	4.0	22.9
SBH-17	4.0	4.7
SBH-18	2.0	3.4
SBH-18	4.0	10.5
SBH-19	2.0	14.1
SBH-19	4.0	7.3
SBH-20	2.0	15.8
SBH-20	4.0	11.6
SBH-21	2.0	4.0
SBH-21	4.0	7.5
SBH-22	2.0	8.1
SBH-23	2.0	8.8
SBH-23	4.0	1.6
SBH-24	2.0	2.2
SBH-24	4.0	3.1
SBH-25	2.0	2.6
SBH-25	4.0	4.1

NMC of 2nd Line of MC2 is 1.6 – 22.9%. The value of the sample taken at 2m is 2.2-15.8%. The value of the sample taken at 4m is 1.6-22.9%. (Table 3.5-6)

[Table 1.5-7] Natural Moisture Content for Secondary Lines of MC3

Borehole ID	Depth (m)	NMC %
DBH-64	2.0	6.5
DBH-65	2.0	4.2
DBH-65	4.0	19.5
SBH-26	2.0	6.7



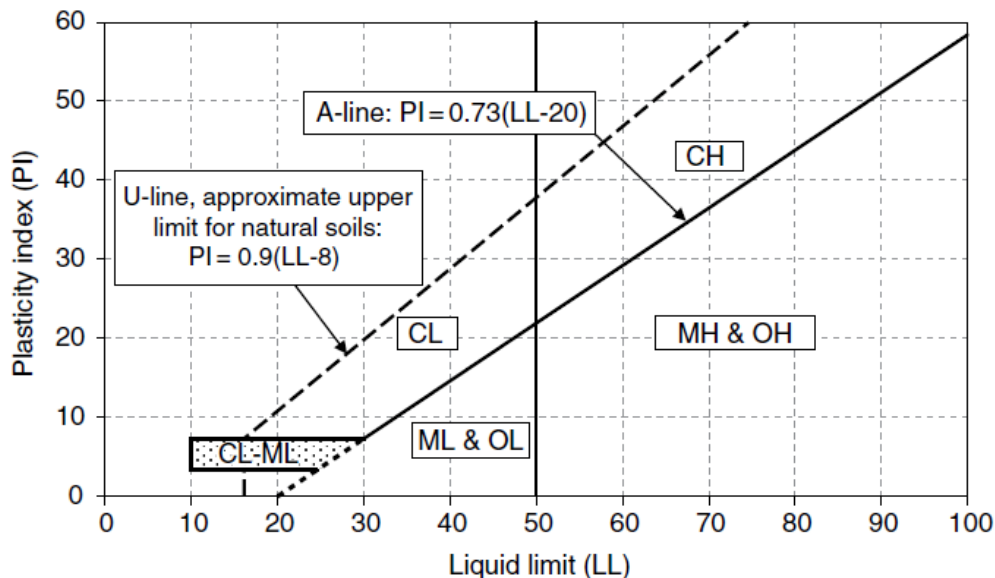
SBH-26	4.0	12.2
SBH-29	2.0	8.9
SBH-29	4.0	6.7
SBH-31	2.0	2.6
SBH-32	4.0	28.7

NMC of MC3 and 2nd Line of MC3 is 2.6 – 28.7%. The value of the sample taken at 2m is 2.6-8.9%. The value of the sample taken at 4m is 6.7-28.7%. (Table 3.5-7)

1.5.3. Atterberg Limits & Specific Gravity & Permeability Test

Atterberg Limit

Soil is placed into the Casagrande cup, and a groove is made down its center with a standardized tool of 2 mm (0.079 in) width. The cup is repeatedly dropped from a height of 10 mm onto a hard base at a rate of 120 blows per minute, during which the groove closes gradually as a result of the impact. The number of blows for the groove to close is recorded. The moisture content at which it takes 25 blows of the cup to cause the groove to close over a distance of 12.7 mm (0.50 in) is defined as the liquid limit. The test is normally run at several moisture contents, and the moisture content which requires 25 blows to close the groove is interpolated from the test results.



[Figure 1.5-1] Plasticity chart for the Unified/ASTM soil classification system

Using the plasticity index and the liquid limit we can classify the sample using the above chart. The symbols correspond to the unified soils classification system (USCS).

Samples with the classification NP (non-plastic) or SP (slightly plastic) are classified as non-cohesive soils and typically made up of sand and gravels.

Specific Gravity

Specific gravity was calculated using the Pycnometer method.



A clean dry pycnometer was weighted prior to having a determined mass of oven dried soil added to it, and then reweighed.

De-aired water is added to the pycnometer, the sample is shaken and left to rest to allow for any air to leave the sample. The weight is taken after the sample has been de-aired.

Once complete the sample is removed and the pycnometer is filled with water and reweighed. The below equation is used to determine the specific gravity of the sample.

$$G = \frac{M2 - M1}{(M2 - M1) - (M3 - M4)} \quad (3.1)$$

Specific gravity of the soils is used when calculating the density of the soil, this will help with structure design and embankment design as the loading on substructures will vary depending on the density.

The specific gravity also gives indications on the porosity of the material and the voids it may contain. Typically, soils range between 2.5-2.8 with the coarser grained soils having a lower specific gravity of 2.0-2.2.

Permeability

The falling head permeability test involves flow of water through a relatively short soil sample connected to a standpipe which provides the water head and also allows measuring the volume of water passing through the sample.

Before starting the flow measurements, the soil sample is saturated, and the standpipes are filled with de-aired water to a given level. The test then starts by allowing water to flow through the sample until the water in the standpipe reaches a given lower limit. The time required for the water in the standpipe to drop from the upper to the lower level is recorded. The standpipe is refilled, and the test is repeated three times.

The unit for the permeability test is given as $k = \text{cm/s}$.

[Table 1.5-8] Atterberg Limits & Specific Gravity & Permeability Test Result for Secondary Lines of MC1

Borehole ID	Depth (m)	Atterberg Limits			Specific Gravity	Permeability K(cm/s)
		LL %	PI	LS %		
SBH-1	0.5 - 1.5	NP	NP	0.0	3.215	3.99×10^{-6}
SBH-2	3.5 - 4.0	NP	NP	0.0	3.236	-
SBH-3	0.3 - 1.8	NP	NP	0.0	2.552	2.31×10^{-4}
SBH-3	2.4- 3.0	NP	NP	0.0	3.149	-
SBH-4	0.5 - 1.6	SP	S	0.7	2.780	-
SBH-4	2.8 - 4.0 (2.4 - 3.0)	NP	NP	0.0	2.989	6.43×10^{-5}
SBH-5	0.1 - 2.1 (0.5 - 1.6)	32	17	7.9	2.667	2.25×10^{-4}
SBH-5	2.4 - 3.4	31.8	14	7.9	2.633	
SBH-6	0.3 - 1.1	28.2	12	7.1	2.669	-
SBH-6	2.0 - 4.0	24	14	8.6	2.788	2.49×10^{-4}
SBH-7	0.3 - 1.3	30	13	7.1	2.152	-
SBH-7	2.3 - 3.5	29	15	7.1	2.981	1.67×10^{-4}



SBH-33	0.4 - 1.2	SP	SP	2.9	2.333	
SBH-33	1.2 - 3.0	SP	SP	0.7	2.298	3.31 X 10 ⁻⁴
SBH-8	0.6 - 1.2	29	11	5.7	2.169	-
SBH-8	2.2 - 3.3	SP	SP	2.9	2.493	1.19 x 10 ⁻⁵
SBH-9	0.5 - 1.0 (0.3 - 1.1)	SP	SP	2.1	2.018	7.77 X 10 ⁻⁶
SBH-9	2.6 - 3.4	28	14	5.7	2.519	-
SBH-10	0.7 - 1.0	SP	SP	2.9	2.965	-
SBH-10	2.0 - 3.0 (2.0 - 4.0)	SP	SP	1.4	3.044	4.18 X 10 ⁻⁵
SBH-11	0.0 - 0.9	41	20	12.1	1.975	
SBH-11	0.9 - 4.0 (0.3 - 1.3)	NP	NP	0.0	3.662	1.42 X 10 ⁻⁵
SBH-12	0.2 - 1.2	NP	NP	0.0	2.896	-
SBH-12	2.0 - 3.0 (2.3 - 3.5)	32	14	14.0	2.447	8.96 X 10 ⁻⁶

* () is the domain of the permeability test

[Table 1.5-9] Atterberg Limits & Specific Gravity & Permeability Test Result for Secondary Lines of MC2

Borehole ID	Depth (m)	Atterberg Limits			Specific Gravity	Permeability K(cm/s)
		LL %	PI	LS %		
SBH-13	0.0 - 0.4	32.6	21	7.1	2.384	-
SBH-13	0.4 - 3.0	SP	SP	1.4	2.475	8.96 X 10 ⁻⁶
SBH-14	0.6 - 1.1	NP	NP	0.0	2.927	-
SBH-14	2.0 - 3.0	NP	NP	0.0	3.614	8.89 X 10 ⁻⁵
SBH-15	0.4 - 1.0	NP	NP	0.0	2.462	-
SBH-15	1.0 - 1.8	SP	SP	1.4	2.447	3.16 X 10 ⁻⁴
SBH-16	0.9 - 1.3	31	15	7.1	2.243	-
SBH-16	2.5 - 3.4	NP	NP	0.0	2.367	2.49 X 10 ⁻⁴
SBH-17	0.0 - 0.8	NP	NP	0.0	2.571	-
SBH-17	0.8 - 3.7	NP	NP	0.0	3.174	2.70 X 10 ⁻⁴
SBH-18	1.2 - 2.3	NP	NP	0.0	2.221	-
SBH-18	2.3 - 4.0 (2.0 - 4.0)	NP	NP	0.0	2.195	4.92 X 10 ⁻⁴
SBH-19	0.2 - 1.1	NP	NP	0.0	1.992	-
SBH-19	2.0 - 3.0	30	14	7.7	2.310	1.21 X 10 ⁻⁵
SBH-20	0.5 - 1.8	NP	NP	0.0	2.320	-
SBH-20	1.8 - 4.0	NP	NP	0.0	3.165	2.58 X 10 ⁻³
SBH-21	0.3 - 1.4	NP	NP	0.0	2.268	-
SBH-21	2.3 - 3.8	NP	NP	0.0	2.602	2.58 X 10 ⁻³
SBH-22	0.9 - 2.5	NP	NP	0.0	2.622	-



SBH-22	2.5 - 4.0 (2.0 - 4.0)	NP	NP	0.0	2.249	6.13 X 10 ⁻⁴
SBH-23	0.3 - 1.3	NP	NP	0.0	2.916	-
SBH-23	2.5 - 3.8 (2.3 - 3.8)	26	9	4.5	2.863	2.58 X 10 ⁻³
SBH-24	0.4 - 1.3	NP	NP	0.0	2.521	-
SBH-24	1.3 - 4.0	NP	NP	0.0	2.491	3.32 X 10 ⁻³
SBH-25	0.3 - 1.2	32.6	21	7.1	3.558	-
SBH-25	1.2 - 4.0	SP	SP	1.4	2.305	3.31 X 10 ⁻³

* () is the domain of the permeability test

[Table 1.5-10] Atterberg Limits & Specific Gravity & Permeability Test Result for MC3, 2nd Line of MC3

Borehole ID	Depth (m)	Atterberg Limits			Specific Gravity	Permeability K(cm/s)
		LL %	PI	LS %		
SBH-26	0.3 - 0.8	30	13	7.1	2.472	-
SBH-26	0.8 - 2.0	NP	NP	0.0	2.426	4.56 X 10 ⁻⁶
SBH-27	0.4 - 1.0	41	22	10.7	2.223	-
SBH-27	1.0 - 2.0	SP	SP	2.9	2.931	2.10 X 10 ⁻⁷
SBH-28	0.9 - 1.2	33	18	10.7	2.417	-
SBH-28	1.2 - 2.0	NP	NP	0.0	2.185	2.35 X 10 ⁻⁴
SBH-29	0.4 - 1.0	41	19	10.7	2.319	-
SBH-29	1.0 - 3.0	SP	SP	4.3	2.326	1.84 X 10 ⁻⁵
SBH-30	0.2 - 1.0	36	17	7.1	2.711	-
SBH-30	2.0 - 3.0	41.8	21	10.7	2.099	2.96 X 10 ⁻³
SBH-31	0.6 - 1.0	NP	NP	0.0	2.147	-
SBH-31	2.0 - 3.0	NP	NP	0.0	2.171	1.22 X 10 ⁻⁴
SBH-32	0.1 - 1.1	NP	NP	0.0	2.171	-
SBH-32	2.9 - 4.0	47	23	7.9	2.447	1.05 X 10 ⁻³
DBH-64	0.5 - 1.0	SP	SP	1.4	2.320	-
(BH-23)	0.25 - 0.45	41	23	-	-	-
(BH-23)	1.95 - 2.35	NP	SP	-	-	-
DBH-65	0.3 - 1.7	SP	SP	2.1	2.353	-
DBH-65	2.0 - 3.2	NP	NP	0.0	2.056	-
(BH-24)	0.95 - 2.6	NP	SP	-	-	-
(BH-24)	2.6 - 3.0	34	18	-	-	-

* In the feasibility study, Geotechnical analysis of BH-23 and BH-24 were conducted during Feasibility study, and their results were used together with new BH on Main Canal-3.

The lab test results confirmed the geological data, in which alluvial sandy/silty deposits are the predominant materials found within the first 2m. This is shown through the non-plastic and slightly plastic material results which classify the samples as non-cohesive silts and sands, and the remainder



of the samples showed medium PI levels which would indicate presence of inorganic clays. Most of the samples have more than 50% (passing the 0.425mm sieve), further supporting the above statement of alluvial and colluvium deposits.

After the initial alluvial deposits, a competent decomposed weathered rock layer was typically found between 3 – 5m in depth. This gave good SPT and bearing capacity results as shown in above section.

Table 3.5-2 shows the synthesized classification of the permeability values based on the most applied standards.

	k=1	10 ⁻¹	10 ⁻²	10 ⁻³	10 ⁻⁴	10 ⁻⁵	10 ⁻⁶	10 ⁻⁷	10 ⁻⁸	10 ⁻⁹	10 ⁻¹⁰	10 ⁻¹¹	10 ⁻¹²
Drainage Characteristics	Good			Poor			Practically Impervious						
Permeability Classification	High		Medium		Low		Very Low		Practically Impermeable				
General Soil Type	Gravels	Clean Sands		Fissured and Weathered Very Fine or Silty Sands				Intact Clays					
Test Method	CH Cell 114 mm dia.	CH Cell 75 mm dia.		FH Cell				FH in Oedometer					
Standards	ASTM D2434-06 / BS 1377:5 BS EN ISO 17892-11 / AASHTO T215.				BS EN ISO 17892-11 ASTM D5856				BS EN ISO 17892-11				

[Figure 1.5-2] Permeability Values (Reference: <https://www.controls-group.com/usa/soil-permeability/>)

1.6. Borehole Data Analysis

Boreholes with low bearing capacity, below 150kPa, within the initial 1.5m are SBH-6, SBH-24, SBH-25, SBH-32 whereas SBH-30 showed bearing values of 77kPa. Care should be taken on these sections during construction phase.

When the bearing capacity of the ground is low, there are methods of stabilizing the ground such as chemical treatment, grouting, and soil mixing. In terms of cost, grouting is the highest, and chemical treatment is the lowest.

Since MC3 will be installed as a concrete box canal, it will generate more weight than any other SCs. The box canal has a scale of 2.5m×2.5m with the thickness of 25cm. When the water channel is filled with water, the weight per unit area does not exceed 5 tons/m². At SBH-6 and SBH-32, which are points on the MC3 route, the bearing capacity is much greater than this value, so special ground stabilization is not required.

The investigation period was rainy, so the permeability test was conducted in the laboratory. Thus, the K is lower than the field test. Most of the soils at boreholes are within the group of Loess Loam, with coefficient of permeability in the range of 10⁻³ to 10⁻⁴. Nevertheless, K in several samples is unusually low because the test domain is composed of weathered rock, silty sand, and clayey sand.

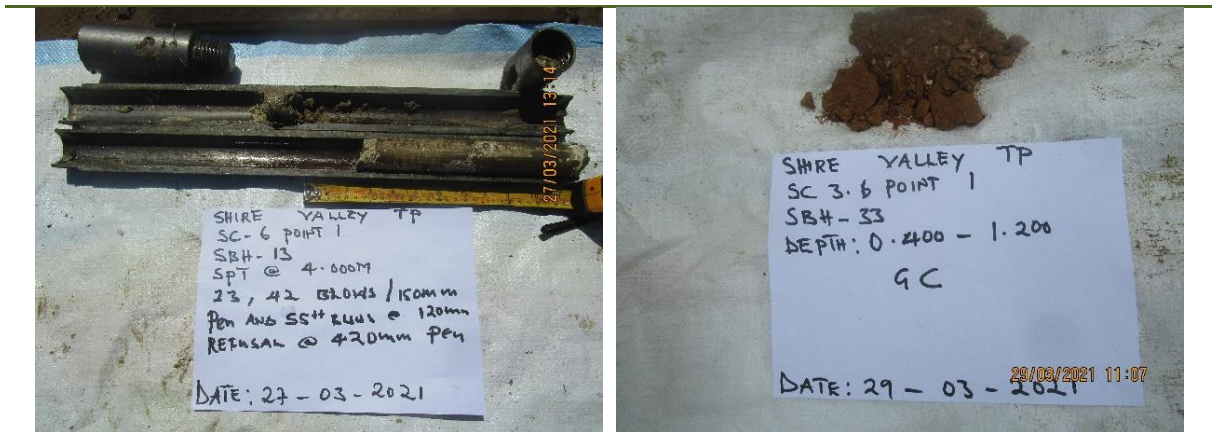
(Detailed borehole data is provided in the Appendix A.2)



1.7. Photos



[Figure 1.7-1] Drilling of Boreholes



[Figure 1.7-2] Disturbed Sample of drilling holes



[Figure 1.7-3] Cores Recovered from BH14 and BH33 Respectively



1.8. Conclusion

For Geotechnical investigation, the consultant selected 35 points (33 drilling, 2 test pit) along the canal, covering Main Canal-3(DBH-64, DBH-65), Secondary Canals of Main Canal-1, Main Canal-2, Main Canal-3.

Geography

The elevation of this investigation boundary is within 90- 150m. Most of the area is used as farmland, grassland. There are mountains and Mzimba River, Mwambezi River, Tributary of Mzimba River, around the project area as well as the Shire River. These mountains & rivers will play an important role in the balance of the area's water resources.

Surface Geotechnical Survey

Several types of rocks were identified in the investigation area. On the road from Blantyre to Chikwawa, there are outcrop of granite and gneiss. In addition, weathered zone and weathered rock based on granite and gneiss can be found at the construction site around intake. Most of the samples identified at the construction site were fresh and sturdy on the surface, but these are weathered rock that was easily crushed by geologic hammer or hand power.

Around SBH-1, SBH-10, SBH-11 of MC1's 2nd line, metamorphic and volcanic rock outcrops can be easily identified. Furthermore, rock boulders are widely spread around SBH-33. On the remaining borehole sites, the dominant composition was alluvium.

Around the bifurcation area where the Main Canal intersects (MC1, MC2, MC3), there is a wide distribution of metamorphic rock-based boulder and outcrops.

The Secondary Canal (Pipeline) route of MC2 is checked only around SBH-14, SBH-19, with outcrops or boulders based on metamorphic and igneous rocks. These 2 points are candidate sites for pumping station. Other drilling points are covered with alluvium.

The Secondary Canal (Pipeline) route of MC3 is identified only around SBH-26, SBH-28, SBH-31, DBH-64 with outcrops or boulders based on metamorphic rocks.

In this investigation area, metamorphic and igneous rock-based boulders and outcrops are identified in some points, but most of the surface is covered with alluvium. The outcrops and boulder are identified around the SBH-1 of SC1 line, SBH-33 of SC3 line, SBH-10 & SBH-11 of SC5 line, intersects of Main Canal, SBH-14 of SC7 line, DBH-64 of SC-MC3-1 line, SBH-28 of SC-MC3-2line. SBH-14, SBH-19, SBH-33 points are candidates for pumping stations.

Field Activities (Drilling)

Main Canal-1 has 5, 2nd line. The drilling holes are 13, has an elevation of 94-141m, most of which are alluvial. Among them, 4 holes (SBH-1, SBH-10, SBH-11, SBH-33) are confirmed the outcrops and boulders in surface. Compare these data to the logging, SBH-1 has weathered rock and soft rock in subsurface 0.4m-4.0m. SBH-10 has boulder (clayey gravel) in 0.7-2.0m, silty sand in 2.0m-4.0m. SBH-11 has weathered rock and soft rock in 0.7-4.0m. SBH-33 has boulder in 0.5-2.5m, 4.0-5.0m, weathered rock and soft rock in 5.0-7.0m. In these strata, SPT N value is also 55++.

For geologic condition (boulder, weathered rock, soft rock), SBH-33 couldn't do the SPT test.

Main Canal-2 has 7, 2nd line. The drilling holes are 13, has an elevation of 108-141m, most of which are alluvial. Among them, 1 hole (SBH-14) are confirmed the outcrops and boulders in surface. 3 holes (SBH-13, SBH-19) come out rock samples while drilling. Compare these data to the logging, SBH-13



has weathered rock in subsurface 0.4m-4.0m. SBH-14 has weathered rock and soft rock in 0.5-6.0m. SBH-15 has weathered rock in subsurface 1.0m-1.8m, 2.0-4.0m. SBH-19 has weathered rock in 3.0-3.5m, soft rock 3.5-7.0m. In these strata, SPT N value is also 55++. For geologic condition (weathered rock, soft rock), SBH-14 couldn't do the SPT test.

This task includes Main Canal-3. In the feasibility study, the results of the two holes (BH-23, BH-24) conducted on Main Canal-3 were used together. This investigation, additional two holes (DBH-64, DBH-65) were conducted on the MC3. The elevation of these holes are 96-126m. Among them, 1 hole (DBH-64) is confirmed the outcrops in surface. 1 hole (BH-23) come out rock samples while drilling. Compare these data to the logging, DBH-64 has weathered rock in subsurface 0.5m-4.0m. BH-23 has weathered rock in 0.88-2.81m. In these strata, SPT N value is also 55++.

Main Canal-3 has 5, 2nd line. The drilling holes are 7, has an elevation of 94-118m, most of which are alluvial. The two points (SBH-27, SBH-28) were excavated by hand in the form of test pits due to limited access. Among them, 3 holes (SBH-26, SBH-28, SBH-31) are confirmed the outcrops and boulders in surface. Compare these data to the logging, SBH-26 has weathered rock in subsurface 0.8m-4.0m. SBH-27 has weathered rock in 1.0-2.0m. SBH-28 has weathered rock in subsurface 1.3m-2.0m. SBH-31 has weathered rock in 0.6-4.0m. In these strata, SPT N value is also 55++(figure-13, figure-18, table-8, table-12). The test pits (SBH-27, SBH-28) couldn't do SPT.

Even though, the working period is rainy season, it is only one site checked (SBH-6), this was measured at 2m depth below surface. It can be estimated that the permeability is very high in this area.

Laboratory Test

Sieve analysis gives an interpretation of the particle size distribution, which in turn allows us to determine the quantitative composition of the sample. The material passing the 0.075mm sieve size can be classified as silt or clay, so when a sample has 75% passing the 0.075mm sieve such as SBH25 at 0.3-1.2m it can be understood that 75% of the sample is silt or clay. The determination between silt and clay is then found from the atterberg limits in the following section.

NMC of 2nd Line of MC1 is 1.2 – 23.4%. The value of the sample taken at 2m is 1.2-23.4%. The value of the sample taken at 4m is 5.6-22.3%.

NMC of 2nd Line of MC2 is 1.6 – 22.9%. The value of the sample taken at 2m is 2.2-15.8%. The value of the sample taken at 4m is 1.6-22.9%.

NMC of MC3 and 2nd Line of MC3 is 2.6 – 28.7%. The value of the sample taken at 2m is 2.6-8.9%. The value of the sample taken at 4m is 6.7-28.7%.

The test results confirm the geological data, in which alluvial sandy/silty deposits are the predominant materials found within the first 2m. This is shown through the non-plastic and slightly plastic material results which classify the samples as non-cohesive silts and sands, the remainder of the samples showed medium PI levels which would indicate presence of inorganic clays. Most of the samples have more than 50% (passing the 0.425mm sieve), further supporting the above statement of alluvial and colluvium deposits.

After the initial alluvial deposits, a competent decomposed weathered rock layer was typically found between 3 – 5m in depth. This gave good SPT and bearing capacity results as shown in above section.

Boreholes with low bearing capacity, below 150kPa (15 ton/m²), within the initial 1.5m are SBH-6, SBH-24, SBH-25, SBH-32 whereas SBH-30 showed bearing values of 77kPa (7.7 ton/m²). Although the bearing capacity of these points is relatively low, compared to other points, it has sufficient bearing capacity even for the MC3, which has the largest weight. Therefore, special ground stabilization is not



required.

The investigation period was rainy, so the permeability test was conducted in the laboratory. Thus, the K is lower than the field test. Most of the soils at boreholes are within the group of Loess Loam, with coefficient of permeability in the range of 10^{-3} to 10^{-4} . Nevertheless, K in several samples is unusually low because the test domain is composed of weathered rock, silty sand, and clayey sand.



A-3 Geotechnical Survey Data



Processed SPT Results

Bearing capacity was calculated using Bowles after Mayerhof 1976, whereas friction angles were calculated using Peck et al 1953. For reference, SPT test of SBH-11 was conducted at 1.5 m, 3.0 m.

[Table 0-1] MC1 Bearing & Friction Values

Division	Drilling Point	Bearing Capacity (kPa)		Friction Angle (Degrees)		SPT N	
		1.5m	4.0m	1.5m	4.0m	1.5m	4.0m
<u>I1(SC1)</u>							
SC1 POINT 1	SBH-1	1,919	2,022	32	32	55++	55++
SC1 POINT 2	SBH-2	256	384	29	29	14	19
SC1 POINT 3	SBH-3	461	512	29	29	24	25
<u>I2(SC2)</u>							
SC2 POINT 1	SBH-4	256	256	29	29	13	13
SC2 POINT 2	SBH-5	230	230	29	28	12	11
SC2 POINT 3	SBH-6	102	256	28	29	6	12
<u>SC2-1</u>							
SC2-1 POINT 1	SBH-7	230	333	29	29	12	16
<u>I3(SC3)</u>							
SC3 POINT 1	SBH-8	435	768	30	30	23	38
<u>I4(SC4)</u>							
SC4 POINT 1	SBH-9	256	742	28	30	13	37
<u>I5(SC5)</u>							
SC5 POINT 1	SBH-10	1,919	2,022	32	32	55++	55++
SC5 POINT 2	SBH-11	1,919	2,022	32	32	55++	55++
SC5 POINT 3	SBH-12	384	358	29	29	20	18

[Table 0-2] MC2 Bearing & Friction Values

Division	Drilling Point	Bearing Capacity (kPa)		Friction Angle (Degrees)		SPT N	
		1.5m	4.0m	1.5m	4.0m	1.5m	4.0m
<u>A1(SC6)</u>							
SC6 POINT 1	SBH-13	384	2,022	29	32	20	55++
<u>A2(SC7)</u>							
SC7 POINT 1	SBH-14	-	-	-	-	-	-
SC7 POINT 2	SBH-15	1,919	870	32	30	55++	43
SC7 POINT 3	SBH-16	358	256	29	29	18	13
<u>A3(SC8)</u>							
SC8 POINT 1	SBH-17	230	640	29	30	12	31
SC8 POINT 2	SBH-18	307	205	29	28	16	10
<u>A4(SC9)</u>							



SC9 POINT 1	SBH-19	281	1,663	29	31	15	82
A5(SC10)							
SC10 POINT 1	SBH-20	230	256	29	29	12	13
A6(SC11)							
SC11 POINT 1	SBH-21	307	537	29	30	16	27
SC11 POINT 2	SBH-22	179	230	28	29	9	11
A7(SC12)							
SC12 POINT 1	SBH-23	358	409	29	29	18	20
SC12 POINT 2	SBH-24	102	307	28	29	6	15
SC12 POINT 3	SBH-25	128	154	28	28	7	7

[Table A.2-3] MC3 Bearing & Friction Values

Division	Drilling Point	Bearing Capacity (kPa)		Friction Angle (Degrees)		SPT N	
		1.5m	4.0m	1.5m	4.0m	1.5m	4.0m
SC3-1							
SC3-1 POINT 1	SBH-26	1,024	2,022	31	32	54	55++
SC3-2							
SC3-2 POINT 1	SBH-27	-	-	-	-	-	-
SC3-2 POINT 2	SBH-28	-	-	-	-	-	-
SC3-3							
SC3-3 POINT 1	SBH-29	512	486	29	29	26	24
SC3-3 POINT 2	SBH-30	77	461	27	29	4	23
SC3-4							
SC3-4 POINT 1	SBH-31	1,919	2,022	32	32	55++	55++
SC3-5							
SC3-5 POINT 1	SBH-32	102	128	28	28	6	6



Sieve Analysis

[Table A.2-4] MC1 Sieve Analysis

Borehole ID	Depth (m)	% Material Passing Sieve Size		
		2.36mm	0.425mm	0.075mm
DBH64	0.3-1.7	100	95	44
DBH65	2.0-3.2	100	93	60
SBH1	0.5 - 1.5	92	78	60
SBH2	3.5 - 4.0	85	54	21
SBH3	0.3 - 1.8	98	70	21
SBH3	2.4 - 3.0	98	30	11
SBH4	0.5 - 1.6	100	82	33
SBH4	2.8 - 4.0	96	61	18
SBH5	0.1 - 2.1	100	90	52
SBH5	2.4 - 3.4	96	90	59
SBH6	0.3 - 1.1	100	86	50
SBH6	2.0 - 4.0	94	80	48
SBH7	0.3 - 1.3	99	86	50
SBH7	2.3 - 3.5	99	86	42
SBH8	0.6 - 1.2	100	84	38
SBH8	2.2 - 3.3	95	69	27
SBH9	0.5 - 1.0	99	82	32
SBH9	2.6 - 3.4	80	63	31
SBH10	0.7 - 1.0	60	42	20
SBH10	2.0 - 3.0	99	64	21
SBH11	0.0 - 0.9	83	63	38
SBH11	0.9 - 4.0	100	60	19
SBH12	0.2 - 1.2	100	78	43
SBH12	2.0 - 3.0	96	86	49

[Table A.2-5] MC2 Sieve Analysis

Borehole ID	Depth (m)	% Material Passing Sieve Size		
		2.36mm	0.425mm	0.075mm
SBH13	0.0 - 0.4	92	85	54
SBH13	0.4 - 0.3	90	67	39
SBH14	0.6 - 1.1	46	32	8
SBH14	2.0 - 3.0	95	67	33
SBH15	0.4 - 1.0	96	74	32
SBH15	1.0 - 1.8	85	67	26
SBH16	0.9 - 1.3	100	71	44
SBH16	2.5 - 3.4	97	61	21
SBH17	0.0 - 0.8	99	53	15
SBH17	0.8 - 3.7	97	46	3



SBH18	1.2 - 2.3	100	91	36
SBH18	2.3 - 4.0	100	40	14
SBH19	0.2 - 1.1	100	69	61
SBH19	2.0 - 3.0	92	74	45
SBH20	0.5 - 1.8	99	52	4
SBH20	1.8 - 4.0	98	40	5
SBH21	0.3 - 1.4	100	78	62
SBH21	2.3 - 3.8	95	46	10
SBH22	0.9 - 2.5	100	97	41
SBH22	2.5 - 4.0	99	56	14
SBH23	0.3 - 1.3	100	76	44
SBH23	2.5 - 3.8	95	47	10
SBH24	0.4 - 1.3	100	44	23
SBH24	1.3 - 4.0	99	23	4
SBH25	0.3 - 1.2	100	94	75
SBH25	1.2 - 4.0	99	45	8

[Table A.2-6] MC3 Sieve Analysis

Borehole ID	Depth (m)	% Material Passing Sieve Size		
		2.36mm	0.425mm	0.075mm
SBH26	0.3 - 0.8	52	34	20
SBH26	0.8 - 2.0	90	55	26
SBH27	0.4 - 1.0	78	55	37
SBH27	1.0 - 2.0	95	69	7
SBH28	0.9 - 1.2	95	80	50
SBH28	1.2 - 2.0	83	52	30
SBH29	0.4 - 1.0	100	87	67
SBH29	1.0 - 3.0	98	84	54
SBH30	0.2 - 1.0	99	38	4
SBH30	2.0 - 3.0	99	41	5
SBH31	0.6 - 1.0	79	47	18
SBH31	2.0 - 3.0	100	76	17
SBH32	0.1 - 1.1	100	90	67
SBH32	2.9 - 4.0	99	91	54
SBH33	0.4 - 1.2	72	50	30
SBH33	1.2 - 3.0	89	64	31
DBH64	0.5 - 1.0	88	51	27
DBH65	0.3 - 1.7	100	95	44
DBH65	2.0 - 3.2	100	93	60



Atterberg Limits

[Table A.2-7] MC1 Atterberg Limits

Borehole ID	Depth (m)	Atterberg Limits		
		LL %	PI	LS %
DBH64	0.3-1.7	SP	PS	1.4
DBH65	2.0-3.2	NP	NP	0.0
SBH1	0.5 - 1.5	NP	NP	0.0
SBH2	3.5 - 4.0	NP	NP	0.0
SBH3	0.3 - 1.8	NP	NP	0.0
SBH3	2.4 - 3.0	NP	NP	0.0
SBH4	0.5 - 1.6	SP	S	0.7
SBH4	2.8 - 4.0	NP	NP	0.0
SBH5	0.1 - 2.1	32	17	7.9
SBH5	2.4 - 3.4	31.8	14	7.9
SBH6	0.3 - 1.1	28.2	12	7.1
SBH6	2.0 - 4.0	24	14	8.6
SBH7	0.3 - 1.3	30	13	7.1
SBH7	2.3 - 3.5	29	15	7.1
SBH8	0.6 - 1.2	29	11	5.7
SBH8	2.2 - 3.3	SP	SP	2.9
SBH9	0.5 - 1.0	SP	SP	2.1
SBH9	2.6 - 3.4	28	14	5.7
SBH10	0.7 - 1.0	SP	SP	2.9
SBH10	2.0 - 3.0	SP	SP	1.4
SBH11	0.0 - 0.9	41	20	12.1
SBH11	0.9 - 4.0	NP	NP	0.0
SBH12	0.2 - 1.2	NP	NP	0.0
SBH12	2.0 - 3.0	32	14	14.0

[Table A.2-8] MC2 Atterberg Limits

Borehole ID	Depth (m)	Atterberg Limits		
		LL %	PI	LS %
SBH13	0.0 - 0.4	32.6	21	7.1
SBH13	0.4 - 0.3	SP	SP	1.4
SBH14	0.6 - 1.1	NP	NP	0.0
SBH14	2.0 - 3.0	NP	NP	0.0
SBH15	0.4 - 1.0	NP	NP	0.0
SBH15	1.0 - 1.8	SP	SP	1.4
SBH16	0.9 - 1.3	31	15	7.1
SBH16	2.5 - 3.4	NP	NP	0.0



SBH17	0.0 - 0.8	NP	NP	0.0
SBH17	0.8 - 3.7	NP	NP	0.0
SBH18	1.2 - 2.3	NP	NP	0.0
SBH18	2.3 - 4.0	NP	NP	0.0
SBH19	0.2 - 1.1	NP	NP	0.0
SBH19	2.0 - 3.0	30	14	7.7
SBH20	0.5 - 1.8	NP	NP	0.0
SBH20	1.8 - 4.0	NP	NP	0.0
SBH21	0.3 - 1.4	NP	NP	0.0
SBH21	2.3 - 3.8	NP	NP	0.0
SBH22	0.9 - 2.5	NP	NP	0.0
SBH22	2.5 - 4.0	NP	NP	0.0
SBH23	0.3 - 1.3	NP	NP	0.0
SBH23	2.5 - 3.8	26	9	4.5
SBH24	0.4 - 1.3	NP	NP	0.0
SBH24	1.3 - 4.0	NP	NP	0.0
SBH25	0.3 - 1.2	32.6	21	7.1
SBH25	1.2 - 4.0	SP	SP	1.4

[Table A.2-9] MC3 Atterberg Limits

Borehole ID	Depth (m)	Atterberg Limits		
		LL %	PI	LS %
SBH26	0.3 - 0.8	30	13	7.1
SBH26	0.8 - 2.0	NP	NP	0.0
SBH27	0.4 - 1.0	41	22	10.7
SBH27	1.0 - 2.0	SP	SP	2.9
SBH28	0.9 - 1.2	33	18	10.7
SBH28	1.2 - 2.0	NP	NP	0.0
SBH29	0.4 - 1.0	41	19	10.7
SBH29	1.0 - 3.0	SP	SP	4.3
SBH30	0.2 - 1.0	36	17	7.1
SBH30	2.0 - 3.0	41.8	21	10.7
SBH31	0.6 - 1.0	NP	NP	0.0
SBH31	2.0 - 3.0	NP	NP	0.0
SBH32	0.1 - 1.1	NP	NP	0.0
SBH32	2.9 - 4.0	47	23	7.9
SBH33	0.4 - 1.2	SP	SP	2.9
SBH33	1.2 - 3.0	SP	SP	0.7
DBH64	0.5 - 1.0	SP	SP	1.4
DBH65	0.3 - 1.7	SP	SP	2.1
DBH65	2.0 - 3.2	NP	NP	0.0



Specific Gravity

[Table A.2-10] MC1 Specific Gravity

Borehole ID	Depth (m)	Specific Gravity
DBH64	0.3-1.7	2.320
DBH65	2.0-3.2	2.056
SBH1	0.5 - 1.5	3.215
SBH2	3.5 - 4.0	3.236
SBH3	0.3 - 1.8	2.552
SBH3	2.4- 3.0	3.149
SBH4	0.5 - 1.6	2.780
SBH4	2.8 - 4.0	2.989
SBH5	0.1 - 2.1	2.667
SBH5	2.4 - 3.4	2.633
SBH6	0.3 - 1.1	2.669
SBH6	2.0 - 4.0	2.788
SBH7	0.3 - 1.3	2.152
SBH7	2.3 - 3.5	2.981
SBH8	0.6 - 1.2	2.169
SBH8	2.2 - 3.3	2.493
SBH9	0.5 - 1.0	2.018
SBH9	2.6 - 3.4	2.519
SBH10	0.7 - 1.0	2.965
SBH10	2.0 - 3.0	3.044
SBH11	0.0 - 0.9	1.975
SBH11	0.9 - 4.0	3.662
SBH12	0.2 - 1.2	2.896
SBH12	2.0 - 3.0	2.447

[Table A.2-11] MC2 Specific Gravity

Borehole ID	Depth (m)	Specific Gravity
SBH13	0.0 - 0.4	2.384
SBH13	0.4 - 0.3	2.475
SBH14	0.6 - 1.1	2.927
SBH14	2.0 - 3.0	3.614
SBH15	0.4 - 1.0	2.462
SBH15	1.0 - 1.8	2.447
SBH16	0.9 - 1.3	2.243
SBH16	2.5 - 3.4	2.367
SBH17	0.0 - 0.8	2.571
SBH17	0.8 - 3.7	3.174



SBH18	1.2 - 2.3	2.221
SBH18	2.3 - 4.0	2.195
SBH19	0.2 - 1.1	1.992
SBH19	2.0 - 3.0	2.310
SBH20	0.5 - 1.8	2.32
SBH20	1.8 - 4.0	3.165
SBH21	0.3 - 1.4	2.268
SBH21	2.3 - 3.8	2.602
SBH22	0.9 - 2.5	2.622
SBH22	2.5 - 4.0	2.249
SBH23	0.3 - 1.3	2.916
SBH23	2.5 - 3.8	2.863
SBH24	0.4 - 1.3	2.521
SBH24	1.3 - 4.0	2.491
SBH25	0.3 - 1.2	3.558
SBH25	1.2 - 4.0	2.305

[Table A.2-12] MC3 Specific Gravity

Borehole ID	Depth (m)	Specific Gravity
SBH26	0.3 - 0.8	2.472
SBH26	0.8 - 2.0	2.426
SBH27	0.4 - 1.0	2.223
SBH27	1.0 - 2.0	2.931
SBH28	0.9 - 1.2	2.417
SBH28	1.2 - 2.0	2.185
SBH29	0.4 - 1.0	2.319
SBH29	1.0 - 3.0	2.326
SBH30	0.2 - 1.0	2.711
SBH30	2.0 - 3.0	2.099
SBH31	0.6 - 1.0	2.147
SBH31	2.0 - 3.0	2.171
SBH32	0.1 - 1.1	2.171
SBH32	2.9 - 4.0	2.447
SBH33	0.4 - 1.2	2.333
SBH33	1.2 - 3.0	2.298
DBH64	0.5 - 1.0	2.320
DBH65	0.3 - 1.7	2.353
DBH65	2.0 - 3.2	2.056



Permeability

[Table A.2-13] MC1 Permeability

Borehole ID	Depth (m)	Permeability
SBH1	0.5 - 1.5	3.99×10^{-6}
SBH2	3.5 - 4.0	3.99×10^{-6}
SBH3	0.3 - 1.8	2.31×10^{-4}
SBH4	2.4- 3.0	6.43×10^{-5}
SBH5	0.5 - 1.6	2.25×10^{-4}
SBH6	2.0 - 4.0	2.49×10^{-4}
SBH7	2.3 - 3.5	1.67×10^{-4}
SBH8	2.2 - 3.3	1.19×10^{-5}
SBH9	0.3 - 1.1	7.77×10^{-6}
SBH10	2.0 - 4.0	4.18×10^{-5}
SBH11	0.3 - 1.3	1.42×10^{-5}
SBH12	2.3 - 3.5	8.96×10^{-6}

[Table A.2-14] MC2 Permeability

Borehole ID	Depth (m)	Permeability
SBH13	0.4 - 3.0	8.96×10^{-6}
SBH14	2.0 - 3.0	8.89×10^{-5}
SBH15	1.0 - 1.8	3.16×10^{-4}
SBH16	2.5- 3.4	2.49×10^{-4}
SBH17	0.8 – 3.7	2.70×10^{-4}
SBH18	2.0 - 4.0	4.92×10^{-4}
SBH19	2.0 - 3.0	1.21×10^{-5}
SBH20	1.8 - 4.0	2.58×10^{-3}
SBH21	2.3 - 3.8	2.58×10^{-3}
SBH22	2.0 - 4.0	6.13×10^{-4}
SBH23	2.3 - 3.8	2.58×10^{-3}
SBH24	1.3 - 4.0	3.32×10^{-3}
SBH25	1.2 - 4.0	3.31×10^{-3}

[Table A.2-15] MC3 Permeability

Borehole ID	Depth (m)	Permeability
SBH26	0.8 - 2.0	4.56×10^{-6}
SBH27	1.0 - 2.0	2.10×10^{-7}
SBH28	1.2 - 2.0	2.35×10^{-4}
SBH29	1.0 - 3.0	1.84×10^{-5}
SBH30	2.0 - 3.0	2.96×10^{-3}



SBH31	2.0 - 3.0	1.22×10^{-4}
SBH32	2.9 - 4.0	1.05×10^{-3}
SBH33	1.2 - 3.0	3.31×10^{-4}



BOREHOLE LOG SVTP - SBH01

GEOCONSULT

PROJECT NUMBER SBH01	DRILLING DATE 10-03-2021	COORDINATES 36K 0 688 975 , 8 227 467
PROJECT NAME SVTP	COMPLETION 10-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water present after 24h **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	ROD %	% Recovered	SPT	Water Level	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2		Top Soil
					0.4		CG - Clayey Gravel
ROTARY WASH AND BORE			55++ PEN 110mm		0.6		GM (Weathered Rock)
					0.8		
					1.0		
					1.2		
					1.4		
					1.6		
					1.8		
					2.0		
					2.2		
					2.4		
					2.6		
					2.8		
					3.0		
					3.2		
3.4							
3.6							
3.8							
			55++ PEN 50mm				Termination Depth at: 4.0 m



BOREHOLE LOG SVTP - SBH02

GEOCONSULT

PROJECT NUMBER SBH02	DRILLING DATE 10-03-2021	COORDINATES 36K 0 688 112 , 8 225 015
PROJECT NAME SVTP	COMPLETION 10-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: Water encountered at 4.0m. No water present after 24h
LOGGED BY G.K.
CHECKED BY M. Sabelli

Drilling Method	RQD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.0	[Cross-hatched pattern]	MC - Top Soil
					0.2	[Diagonal hatching]	SC - Clayey Sand
					0.4	[Diagonal hatching]	
					0.6	[Diagonal hatching]	
					0.8	[Diagonal hatching]	
					1.0	[Diagonal hatching]	
					1.2	[Diagonal hatching]	
					1.4	[Stippled pattern]	GM - Silty Gravel
					1.6	[Stippled pattern]	
					1.8	[Stippled pattern]	
					2.0	[Stippled pattern]	
					2.2	[Stippled pattern]	
					2.4	[Stippled pattern]	
					2.6	[Diagonal hatching]	MC - Silty Clay
					2.8	[Diagonal hatching]	
					3.0	[Diagonal hatching]	
					3.2	[Diagonal hatching]	
					3.4	[Diagonal hatching]	
					3.6	[Stippled pattern]	GM - Silty Gravel
					3.8	[Stippled pattern]	
					4.0	[Stippled pattern]	Termination Depth at: 4.0 m



BOREHOLE LOG SVTP - SBH03

GEOCONSULT

PROJECT NUMBER SBH03	DRILLING DATE 11-03-2021	COORDINATES 36K 0 691 598 , 8 222 487
PROJECT NAME SVTP	COMPLETION 11-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water encountered at 4.0m. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	ROD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2	[Cross-hatched pattern]	SM - Top Soil
					0.4	[Diagonal lines pattern]	SC - Clayey Sand
					0.6	[Diagonal lines pattern]	
					0.8	[Diagonal lines pattern]	
					1.0	[Diagonal lines pattern]	
					1.2	[Diagonal lines pattern]	
					1.4	[Diagonal lines pattern]	
					1.6	[Diagonal lines pattern]	
					1.8	[Diagonal lines pattern]	
					2.0	[Diagonal lines pattern]	
		15,12,12			2.0	[Wavy pattern]	GM - Silty Sand
					2.4	[Diagonal lines pattern]	MC - Clayey Sand
					3.0	[Wavy pattern]	GM - Silty Gravel
		15,10,15			4.0		Termination Depth at: 4.0 m



BOREHOLE LOG SVTP - SBH04

GEOCONSULT

PROJECT NUMBER SBH04	DRILLING DATE 12-03-2021	COORDINATES 36K 0 691 019 , 8 223 050
PROJECT NAME SVTP	COMPLETION 12-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water encountered at 4.0m. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	RQD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2		SM - Top Soil
					0.4		
					0.6		SC - Clayey Sand
					0.8		
					1.0		
					1.2		
					1.6		SM - Silty Sand
					1.8		
					2.0		
					2.2		
2.4		SC - Clayey Sand					
2.6							
2.8							
3.0							
3.2		SC - Clayey Sand					
3.4							
3.6							
3.8							
					4		Termination Depth at: 4.0 m



BOREHOLE LOG SVTP - SBH05

GEOCONSULT

PROJECT NUMBER SBH05	DRILLING DATE 19-03-2021	COORDINATES 36K 0 689 852 , 8 220 465
PROJECT NAME SVTP	COMPLETION 19-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: Water encountered at 2.0m. No water encountered after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

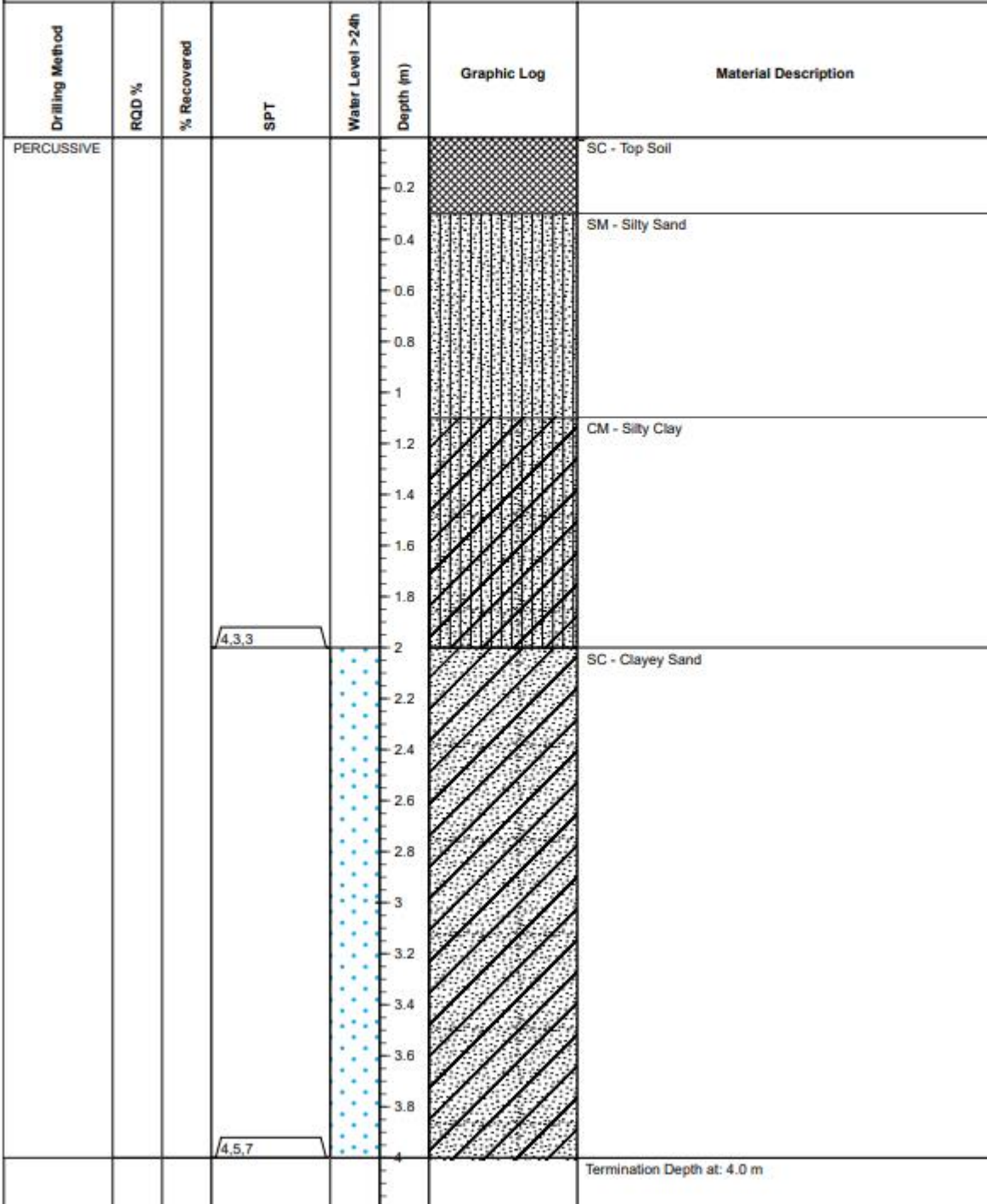
Drilling Method	RQD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2		SC - Top Soil
					0.4		CL - Clay
					0.6		
					0.8		
					1.0		
					1.2		
					1.4		
					1.6		
					1.8		
					2.0		
		4.5.7			2.2		ML - SilT
					2.4		SC - Clayey Sand
					2.6		
					2.8		
					3.0		
					3.2		
					3.4		MC - Silty Clay
					3.6		
					3.8		
		4.5.6			4.0		Termination Depth at: 4.0 m



BOREHOLE LOG SVTP - SBH06

PROJECT NUMBER SBH06	DRILLING DATE 19-03-2021	COORDINATES 36K 0 690 283 , 8 219 658
PROJECT NAME SVTP	COMPLETION 19-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: Water encountered at 2.5m. Water measured at 2.0m after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli





BOREHOLE LOG SVTP - SBH07

GEOCONSULT

PROJECT NUMBER SBH07	DRILLING DATE 19-03-2021	COORDINATES 36K 0 690 442 , 8 217 834
PROJECT NAME SVTP	COMPLETION 19-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water encountered after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	RQD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2		SC - Top Soil
					0.4		ML - Silty Clay
					0.6		
					0.8		
					1.0		
					1.2		
					1.4		
					1.6		
					1.8		
					2.0	8.6.6	
2.2							
2.4							
2.6							
2.8							
3.0							
3.2							
3.4							
3.6							
3.8							
4.0	8.8.8						
							Termination Depth at: 4.0 m



BOREHOLE LOG SVTP - SBH08

PROJECT NUMBER SBH08	DRILLING DATE 13-03-2021	COORDINATES 36K 0 687 758 , 8 223 862
PROJECT NAME SVTP	COMPLETION 13-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	ROD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2		CL - Top Soil
					0.4		
					0.6		ML - Silty Sand
					0.8		
					1.0		GM - Silty Gravel
1.2							
1.4							
1.6							
1.8	10,11,12						
2.0							
2.2					2.2		SM - Silty Sand
2.4							
2.6							
2.8							
3.0							
3.2					3.4		SC - Clayey Sand
3.6							
3.8							
			18,16,22		4		Termination Depth at: 4.0 m



BOREHOLE LOG SVTP - SBH09

GEOCONSULT

PROJECT NUMBER SBH09	DRILLING DATE 12-03-2021	COORDINATES 36K 0 687 302 , 8 221 555
PROJECT NAME SVTP	COMPLETION 12-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	RQD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2		SM - Top Soil
					0.4		
					0.6		SC - Clayey Sand
					0.8		
					1.0		SM - Silty Sand
					1.2		
					1.4		SC - Clayey Sand
				1.6			
		5.6.7			1.8		GC - Clayey Sand
				2.0			
				2.2			
				2.4			
				2.6			GC - Clayey Sand
				2.8			
				3.0			SC - Clayey Sand
				3.2			
				3.4			SC - Clayey Sand
				3.6			
				3.8			SC - Clayey Sand
				4.0			
		14, 15, 22					Termination Depth at: 4.0 m



BOREHOLE LOG SVTP - SBH10

GEOCONSULT

PROJECT NUMBER SBH10	DRILLING DATE 17-03-2021	COORDINATES 36K 0 686 231 , 8 218 896
PROJECT NAME SVTP	COMPLETION 17-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	RQD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2		SM - Top Soil
					0.4		GM - Silty Gravel
					0.8		GC - Clayey Gravel
Rotary Wash and Bore			38, 55++ PEN 120MM		1.8		GC - Clayey Gravel
					2.0		SM - Silty Sand
					2.2		SM - Silty Sand
					2.4		SM - Silty Sand
					2.6		SM - Silty Sand
					2.8		SM - Silty Sand
					3.0		SM - Silty Sand
					3.2		SM - Silty Sand
					3.4		SM - Silty Sand
					3.6		SM - Silty Sand
			14, 25++ PEN 120MM		3.8		SM - Silty Sand
					4.0		Termination Depth at: 4.0 m



BOREHOLE LOG SVTP - SBH11

GEOCONSULT

PROJECT NUMBER SBH11	DRILLING DATE 13-03-2021	COORDINATES 36K 0 686 821 , 8 220 393
PROJECT NAME SVTP	COMPLETION 13-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 3.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	RQD %	% Recovered	SPT	Water Level >2.4h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2		CL - Top Soil
					0.4		GM - Silty Gravel
Rotary Wash and Bore					0.6		GC - Weathered Rock
					0.8		
					1.0		
					1.2		
					1.4		
					1.6		
					1.8		
					2.0	36, 55++ PEN 130MM	
					2.2		
					2.4		
2.6							
2.8	39, 55++ PEN 110MM						
3.0							
					3.2		
					3.4		
					3.6		
					3.8		
					4.0		Termination Depth at: 3.0 m



BOREHOLE LOG SVTP - SBH12

GEOCONSULT

PROJECT NUMBER SBH12	DRILLING DATE 13-03-2021	COORDINATES 36K 0 688 753 , 8 220 220
PROJECT NAME SVTP	COMPLETION 13-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	ROD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.0	[Cross-hatched pattern]	SC - Top Soil
					0.2	[Vertical line pattern]	SM - Silty Sand
					0.4	[Vertical line pattern]	
					0.6	[Vertical line pattern]	
					0.8	[Vertical line pattern]	
					1.0	[Vertical line pattern]	
					1.2	[Vertical line pattern]	
					1.4	[Diagonal line pattern]	GM - Silty Gravel
					1.6	[Diagonal line pattern]	
					1.8	[Diagonal line pattern]	
2.0	[Diagonal line pattern]	MC - Clayey Silty					
2.2	[Diagonal line pattern]						
2.4	[Diagonal line pattern]						
2.6	[Diagonal line pattern]						
2.8	[Diagonal line pattern]						
3.0	[Diagonal line pattern]						
3.2	[Vertical line pattern]	SM - Silty sand					
3.4	[Vertical line pattern]						
3.6	[Vertical line pattern]						
3.8	[Vertical line pattern]						
					4.0	[Vertical line pattern]	Termination Depth at: 4.0 m

7.9.11

7.8.10



BOREHOLE LOG SVTP - SBH13

GEOCONSULT

PROJECT NUMBER SBH13	DRILLING DATE 27-03-2021	COORDINATES 36K 0 683 696 , 8 214 010
PROJECT NAME SVTP	COMPLETION 27-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	RQD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2		CM - Top Soil
					0.4		SM - Weathered Rock
Rotary Wash and Bore			10, 10, 10		0.6		SM - Weathered Rock
					0.8		
					1.0		
					1.2		
					1.4		
					1.6		
					1.8		
					2.0		
					2.2		
					2.4		
			23, 42, 55++ PEN 120MM		2.6		GC - Weathered Rock
					2.8		
					3.0		
					3.2		
					3.4		
					3.6		
					3.8		Termination Depth at: 4.0 m



BOREHOLE LOG SVTP - SBH14

GEOCONSULT

PROJECT NUMBER SBH14	DRILLING DATE 31-03-2021	COORDINATES 36K 0 682 873 , 8 214 057
PROJECT NAME SVTP	COMPLETION 01-04-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 6.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	RQD %	% Recovered	SPT	Water Level >2.4h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.0 - 0.5		CL - Top Soil
					0.5 - 0.8		GC - Clayey Gravel
					0.8 - 1.0		GC - Weathered Rock
ROTARY CORING	0%	77.8%			1.0 - 2.0		GC - Fractured Weathered Rock
	0%	35%			2.0 - 4.0		
WASH AND BORE					4.0 - 6.0		No Recovery
ROTARY CORING	0%	0%			6.0		Termination Depth at. 6.0 m



BOREHOLE LOG SVTP - SBH15

GEOCONSULT

PROJECT NUMBER SBH15	DRILLING DATE 15-03-2021	COORDINATES 36K 0 680 488 , 8 216 101
PROJECT NAME SVTP	COMPLETION 15-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	RQD %	% Recovered	SPT	Water Level >2.4h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2	[Cross-hatch pattern]	SC - Top Soil
					0.4	[Diagonal lines pattern]	CL - Clay
					0.6	[Diagonal lines pattern]	
					0.8	[Diagonal lines pattern]	
					1.0	[Diagonal lines pattern]	
					1.2	[Dotted pattern]	GC - Weathered Rock
					1.4	[Dotted pattern]	
					1.6	[Dotted pattern]	
					1.8	[Dotted pattern]	
					2.0	[Dotted pattern]	S - Sand
			30, 55++ PEN: 130MM				
						[Dotted pattern]	GC - Weathered Rock
					2.2	[Dotted pattern]	
					2.4	[Dotted pattern]	
					2.6	[Dotted pattern]	
					2.8	[Dotted pattern]	
					3.0	[Dotted pattern]	
					3.2	[Dotted pattern]	
					3.4	[Dotted pattern]	
					3.6	[Dotted pattern]	
					3.8	[Dotted pattern]	
			14, 18, 25		4.0	[Dotted pattern]	Termination Depth at: 4.0 m



BOREHOLE LOG SVTP - SBH16

GEOCONSULT

PROJECT NUMBER SBH16	DRILLING DATE 15-03-2021	COORDINATES 36K 0 677 858 , 8 216 838
PROJECT NAME SVTP	COMPLETION 15-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	ROD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2		SC - Top Soil
					0.4		MC - Silty Clay
					0.6		SC - Clayey Sand
					0.8		GC - Clayey Sand
					1.0		
					1.2		
					1.4		GM - Silty Gravel
					1.6		SC - Clayey Sand
					1.8		
					2.0		
2.2		MC - Silty Clay					
2.4		SC - Clayey Sand					
2.6							
2.8							
3.0		MC - Silty Clay					
3.2		SC - Clayey Sand					
3.4							
3.6							
3.8		MC - Silty Clay					
4.0		Termination Depth at: 4.0 m					



BOREHOLE LOG SVTP - SBH17

GEOCONSULT

PROJECT NUMBER SBH17	DRILLING DATE 21-03-2021	COORDINATES 36K 0 682 358 , 8 212 888
PROJECT NAME SVTP	COMPLETION 21-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	RQD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE			4, 6, 6		0.2		SC - Top Soil
					0.4		
					0.6		SW - Sand
					0.8		
1.0							
1.2							
1.4							
1.6							
1.8							
2.0							
2.2							
2.4							
2.6							
2.8							
3.0							
3.2							
3.4							
3.6							
3.8							
4.0							
			17, 18, 13				Termination Depth at: 4.0 m



BOREHOLE LOG SVTP - SBH18

PROJECT NUMBER SBH18	DRILLING DATE 21-03-2021	COORDINATES 36K 0 680 822 , 8 213 144
PROJECT NAME SVTP	COMPLETION 21-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	RQD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2		SC - Clayey Sand
					0.4		CL - Clay
					0.6		
					0.8		
					1.0		
					1.2		SM - Silty Sand
					1.4		
					1.6		
					1.8		
					2.0		
					2.2		
					2.4		SW - Sand
					2.6		
					2.8		
					3.0		
					3.2		
					3.4		
					3.6		
					3.8		
					4.0		Termination Depth at: 4.0 m



BOREHOLE LOG SVTP - SBH19

GEOCONSULT

PROJECT NUMBER SBH19	DRILLING DATE 25-03-2021	COORDINATES 36K 0 679 312 , 8 211 904
PROJECT NAME SVTP	COMPLETION 26-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 7.2m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	ROD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.0 - 0.5	SM - Top Soil	
					0.5 - 2.0	CL - Clay	
WASH AND BORE			5, 5, 10		2.0 - 3.0	GP - Silty Gravel	
					3.0 - 3.5	GP - Weathered Rock	
ROTARY CORING	0%	100%	23, 33, 49		3.5 - 4.5	GP - Fractured Rock	
	0%	70%			4.5 - 6.5	GP - Fractured Weathered Rock	
	0%	100%			6.5 - 7.0	GP - Soft to Hard Fractured Weathered Rock	
	13%	100%			7.0 - 7.2	Termination Depth at: 7.2m	

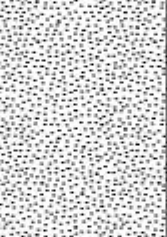
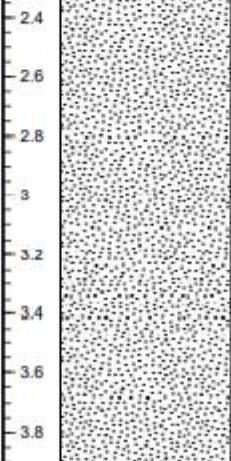


BOREHOLE LOG SVTP - SBH20

GEOCONSULT

PROJECT NUMBER SBH20	DRILLING DATE 24-03-2021	COORDINATES 36K 0 682 473 , 8 210 901
PROJECT NAME SVTP	COMPLETION 24-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	ROD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description	
PERCUSSIVE					0.2		SC - Clayey Sand	
					0.4			S - Sand
					0.6			
					0.8			
					1.0			
					1.2			
					1.4			
					1.6			
					1.8			
			5, 5, 7		2.0			
					2.2			
					2.4			
					2.6			
					2.8			
					3.0			
					3.2			
					3.4			
					3.6			
					3.8			
			5, 6, 7		4.0		Termination Depth at: 4.0m	



BOREHOLE LOG SVTP - SBH21

GEOCONSULT

PROJECT NUMBER SBH21	DRILLING DATE 25-03-2021	COORDINATES 36K 0 682 582 , 8 209 353
PROJECT NAME SVTP	COMPLETION 25-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	RDD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2		CL - Top Soil
					0.4		CM - Silty Clay
					0.6		
					0.8		
					1.0		
					1.2		
					1.4		SM - Silty Sand
				1.6			
				1.8			
			11, 8, 8		2.0		
					2.2		
					2.4		S - Sand
					2.6		
					2.8		
					3.0		
					3.2		
					3.4		
					3.6		
					3.8		GC - Clayey Gravel
			12, 13, 14		4.0		Termination Depth at: 4.0m



BOREHOLE LOG SVTP - SBH22

GEOCONSULT

PROJECT NUMBER SBH22	DRILLING DATE 20-03-2021	COORDINATES 36K 0 686 061 , 8 210 201
PROJECT NAME SVTP	COMPLETION 20-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: Water encountered at 4.0m. No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	ROD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2		CL - Clay
					0.4		
					0.6		
					0.8		
					1.0		
					1.2		
					1.4		
					1.6		
					1.8		
					2.0		
					2.2		
					2.4		
					2.6		
					2.8		
					3.0		
					3.2		
					3.4		
					3.6		
					3.8		
					4.0		Termination Depth at: 4.0m



BOREHOLE LOG SVTP - SBH23

GEOCONSULT

PROJECT NUMBER SBH23	DRILLING DATE 23-03-2021	COORDINATES 36K 0 685 281 , 8 207 728
PROJECT NAME SVTP	COMPLETION 23-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	RCD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2		CL - Clay
					0.4		SC - Clayey Sand
					0.6		
					0.8		
					1.0		
					1.2		
					1.4		
					1.6		
					1.8		
					2.0	13,11,7	
2.2							
2.4							
2.6							
2.8							
3.0							
3.2							
3.4							
3.6							
3.8							
			4,13,7			S - Sand	
Termination Depth at: 4.0m							



BOREHOLE LOG SVTP - SBH24

GEOCONSULT

PROJECT NUMBER SBH24	DRILLING DATE 23-03-2021	COORDINATES 36K 0 686 180 , 8 209 834
PROJECT NAME SVTP	COMPLETION 23-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	RCD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2		MC - Clay
					0.4		SC - Clayey Sand
					0.6		
					0.8		
					1.0		
					1.2		
					1.4		
					1.6		
					1.8		
					2.0		3, 3, 3
					2.2		
					2.4		
					2.6		
2.8							
3.0							
3.2							
3.4							
3.6							
3.8							
			5, 7, 8		4.0		Termination Depth at: 4.0m



BOREHOLE LOG SVTP - SBH25

GEOCONSULT

PROJECT NUMBER SBH25	DRILLING DATE 23-03-2021	COORDINATES 36K 0 685 281 , 8 207 728
PROJECT NAME SVTP	COMPLETION 23-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	RQD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2		CL - Top Soil
					0.4		CM - Silty Sand
					0.6		
					0.8		
					1.0		
					1.2		
					1.4		
					1.6		
					1.8		
					2.0	3, 3, 4	
2.2							
2.4							
2.6							
2.8							
3.0							
3.2							
3.4							
3.6							
3.8							
4.0	4, 4, 3						
						Termination Depth at 4.0m	



BOREHOLE LOG SVTP - DBH-64

GEOCONSULT

PROJECT NUMBER DBH64	DRILLING DATE 16-03-2021	COORDINATES 36K 0 685 877 , 8 216 811
PROJECT NAME SVTP	COMPLETION 16-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	RQD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description			
PERCUSSIVE					0.2		SC - Top Soil			
					0.4		GC - Reddish brown sandy silty CLAY with spots of decomposed rock			
ROTARY WASH AND BORE					0.6		GP - Moist mottled WEATHERED ROCK			
					0.8					
					1.0					
					1.2					
					1.4					
					1.6					
					1.8					
					19, 38, 55++ PEN: 120MM			2.0		
					2.2					
					2.4					
					2.6					
					2.8					
3.0										
3.2										
3.4										
3.6										
3.8										
55++ PEN: 70MM			4.0							
							Termination Depth at: 4.0m			



BOREHOLE LOG SVTP - DBH-65

GEOCONSULT

PROJECT NUMBER DBH65	DRILLING DATE 20-03-2021	COORDINATES 36K 0 688 209 , 8 211 386
PROJECT NAME SVTP	COMPLETION 20-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	RQD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2	[Cross-hatched pattern]	CL - Top Soil
					0.4	[Vertical line pattern]	SM - Silty SAND
					0.6	[Vertical line pattern]	
					0.8	[Vertical line pattern]	
					1.0	[Vertical line pattern]	
					1.2	[Vertical line pattern]	
					1.4	[Vertical line pattern]	
					1.6	[Vertical line pattern]	
					1.8	[Diagonal line pattern]	CL - Clay
					2.0	[Vertical line pattern]	SM- Silty SAND
2.2	[Vertical line pattern]						
2.4	[Vertical line pattern]						
2.6	[Vertical line pattern]						
2.8	[Vertical line pattern]						
3.0	[Diagonal line pattern]	MC - Clayey silty SAND					
3.2	[Diagonal line pattern]						
3.4	[Diagonal line pattern]						
3.6	[Diagonal line pattern]						
3.8	[Diagonal line pattern]						
					4	[Diagonal line pattern]	Termination Depth at: 4.0m



BOREHOLE LOG SVTP - SBH26


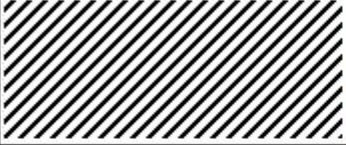
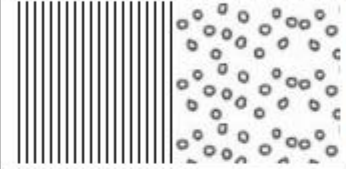
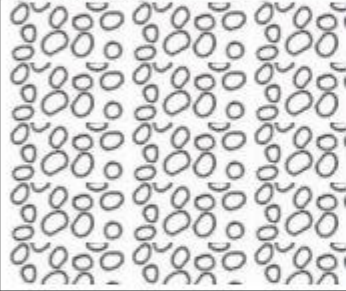
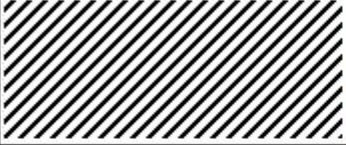
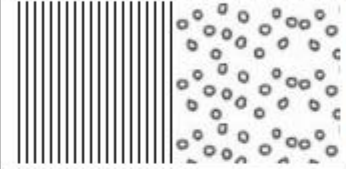
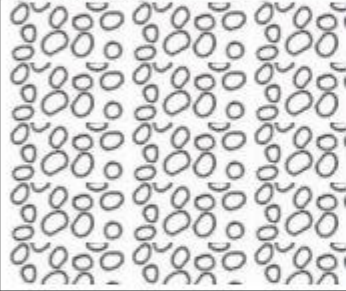
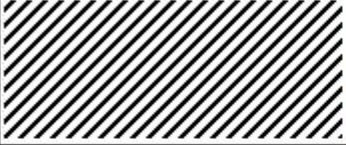
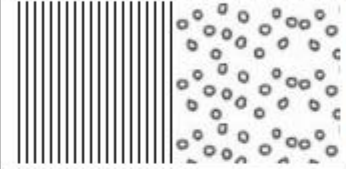
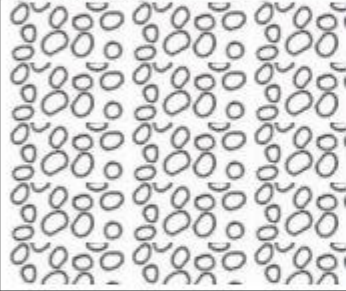

GEOCONSULT

PROJECT NUMBER SBH26	DRILLING DATE 16-03-2021	COORDINATES 36K 0 686 879 , 8 215 431
PROJECT NAME SVTP	COMPLETION 16-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	



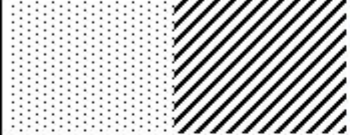

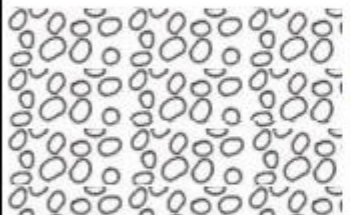

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	RQD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2		PT - Top Soil
					0.4		GC - Reddish Clayey Quartz Gravel
					0.8		GP - Moist Weathered Rock
WASH AND BORE			12,14,40		1.0		GP - Soft to Hard Moist Weathered Rock
					1.2		
					1.4		
					1.6		
					1.8		
					2.0		
					2.2		
					2.4		
					2.6		
					2.8		
			4,13,55++ PEN 130MM		3.8		Termination Depth at: 4.0m



 GEOCONSULT +265 0888 846 543 sabelli@geoconsult.cc	LAB REF No. GC1064 / 17MAR21 / 18:30		SAMPLE No. SVTP / SBH27 / 16MAR21											
	SAMPLED BY: GEOCONSULT LAB. TEAM		DATE: 16 - 03 - 2021	TIME: 13:00										
	LOCATION: 36L SBH27 - CHIKWAWA	EASTING 0 686 455	NORTHING 8 215 347	ELEVATION 0 103 (m)	DEPTH 2.000 (m)									
	TYPE OF MATERIAL: EXISTING NATURAL SOILS													
	TESTED BY: G. KONDE		DATE: 16 - 03 - 2021	TIME: 13:00										
	CHECKED BY: G. KACHIWALA		DATE: 16 - 03 - 2021	TIME: 14:00										
APPROVED BY: M. SABELLI		DATE: 08 - 04 - 2021	TIME: 15:00											
PROJECT: SHIRE VALLEY TRANSFORMATION PROJECT			CLIENT: KRC											
TRIAL PIT SOIL PROFILE STANDARD: ASTM D (2487)														
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%; text-align: center;">  </td> <td style="width: 5%; text-align: center;">0 100 200 300 400</td> <td style="width: 65%; text-align: center;">CL (CLAY TOP SOIL)</td> </tr> <tr> <td style="text-align: center;">  </td> <td style="text-align: center;">500 600 700 800 900 1000</td> <td style="text-align: center;">GM (SILTY GRAVEL)</td> </tr> <tr> <td style="text-align: center;">  </td> <td style="text-align: center;">1100 1200 1300 1400 1500 1600 1700 1800 1900 2000</td> <td style="text-align: center;">GW (WEATHERED ROCK)</td> </tr> </table>							0 100 200 300 400	CL (CLAY TOP SOIL)		500 600 700 800 900 1000	GM (SILTY GRAVEL)		1100 1200 1300 1400 1500 1600 1700 1800 1900 2000	GW (WEATHERED ROCK)
	0 100 200 300 400	CL (CLAY TOP SOIL)												
	500 600 700 800 900 1000	GM (SILTY GRAVEL)												
	1100 1200 1300 1400 1500 1600 1700 1800 1900 2000	GW (WEATHERED ROCK)												
PHOTOGRAPHIC REPORT														
														
REMARKS: TEST PIT ON SBH27 FOR SVTP IN CHIKWAWA														



 GEOCONSULT +265 0888 846 543 sabelli@geoconsult.cc	LAB REF No. GC1064 / 17MAR21 / 18:30		SAMPLE No. SVTP / SBH28 / 16MAR21			
	SAMPLED BY: GEOCONSULT LAB. TEAM		DATE: 16 - 03 - 2021	TIME: 12:45		
	LOCATION: 36L SBH28 - CHIKWAWA	EASTING 0 687 548	NORTHING 8 215 588	ELEVATION 0 102 (m)	DEPTH 2.000 (m)	
	TYPE OF MATERIAL: EXISTING NATURAL SOILS					
	TESTED BY: G. KONDE		DATE: 16 - 03 - 2021	TIME: 12:45		
	CHECKED BY: G. KACHIWALA		DATE: 16 - 03 - 2021	TIME: 14:00		
APPROVED BY: M. SABELLI		DATE: 08 - 04 - 2021	TIME: 15:00			
PROJECT: SHIRE VALLEY TRANSFORMATION PROJECT			CLIENT: KRC			
TRIAL PIT SOIL PROFILE STANDARD: ASTM D (2487)						
	0 100 200 300 400	CL (CLAY TOP SOIL)				
	500 600 700 800 900	SC (MOIST DARK BROWN SANDY CLAY)				
	1000 1100 1200	CL (CLAY)				
	1300 1400 1500 1600 1700 1800 1900 2000	GP (WEATHERED ROCK)				
PHOTOGRAPHIC REPORT						
						
REMARKS: TEST PIT ON SBH28 FOR SVTP IN CHIKWAWA						



BOREHOLE LOG SVTP - SBH29

GEOCONSULT

PROJECT NUMBER SBH29	DRILLING DATE 17-03-2021	COORDINATES 36K 0 688 097 , 8 214 104
PROJECT NAME SVTP	COMPLETION 17-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: Water encountered at 4.0m. No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	RQD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2		SC - Top Soil
					0.4		
					0.6		ML - Moist Clay
					0.8		
					1.0		
					1.2		MC - Moist Mottled Sandy Silty Clay
					1.4		
					1.6		
					1.8		
					2.0		
2.2							
2.4		GP - Moist Mottled Sandy Silty Clay with Decomposed Rock					
2.6							
2.8							
3.0							
3.2							
3.4							
3.6							
3.8							
4.0							
							Termination Depth at: 4.0m



BOREHOLE LOG SVTP - SBH30

GEOCONSULT

PROJECT NUMBER SBH30	DRILLING DATE 18-03-2021	COORDINATES 36K 0 691 553 , 8 214 088
PROJECT NAME SVTP	COMPLETION 18-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	ROD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2		SC - Silty Sand
					0.4		S - Sand
			3, 2, 2		0.6		
					0.8		
					1.0		
					1.2		
					1.4		
					1.6		
					1.8		
					2.0		
					2.2		
					2.4		
					2.6		
					2.8		
					3.0		
					3.2		
					3.4		
					3.6		
					3.8		
			9, 11, 12		4.0		Termination Depth at: 4.0m



BOREHOLE LOG SVTP - SBH31

GEOCONSULT

PROJECT NUMBER SBH31	DRILLING DATE 21-03-2021	COORDINATES 36K 0 688 031 , 8 214 722
PROJECT NAME SVTP	COMPLETION 22-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	RQD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.2		SC - Clayey Sand
					0.4		
					0.6		GC - Weathered Rock
					0.8		
					1.0		
					1.2		
					1.4		
					1.6		
					1.8		
					2.0		
					2.2		
					2.4		
					2.6		
2.8							
3.0							
3.2							
3.4							
3.6							
3.8							
4.0							Termination Depth at: 4.0m



BOREHOLE LOG SVTP - SBH32

GEOCONSULT

PROJECT NUMBER SBH32	DRILLING DATE 20-03-2021	COORDINATES 36K 0 689 909 , 8 209 416
PROJECT NAME SVTP	COMPLETION 20-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 4.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	RQD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.0		SM - Top Soil
					0.2		SC - Clayey Sand
					0.4		
					0.6		
					0.8		
					1.0		SM - Silty Sand
					1.2		
					1.4		
					1.6		
					1.8		
2.0							
2.2		SC - Clayey Sand					
2.4							
2.6							
2.8							
3.0							
3.2							
3.4							
					3.8		
					4.0		Termination Depth at: 4.0m



BOREHOLE LOG SVTP - SBH33

GEOCONSULT

PROJECT NUMBER SBH33	DRILLING DATE 29-03-2021	COORDINATES 36K 0 687 295 , 8 225 699
PROJECT NAME SVTP	COMPLETION 31-03-2021	COORD SYS UTM
CLIENT KRC - ISAN - DASAN	DIAMETER 150	TOTAL DEPTH 7.0m
	CASING Steel	

Comments: No water measured after 24h. **LOGGED BY** G.K.
CHECKED BY M. Sabelli

Drilling Method	ROD %	% Recovered	SPT	Water Level >24h	Depth (m)	Graphic Log	Material Description
PERCUSSIVE					0.0		CM - Top Soil
					0.5		GC - Clayey Gravel
					1.5		GM - Silty Gravel
WASH AND BORE					2.5		SC - Clayey Sand
					4.0		GC - Silty Gravel
					5.0		No Recovery
ROTARY CORING	0%	0%			6.0		GC - Weathered Rock Fragments
	0%	20%			7.0		Termination Depth at: 7.0m



Drilling Rig Set Up for SBH-1



Rod & Bit for Drilling



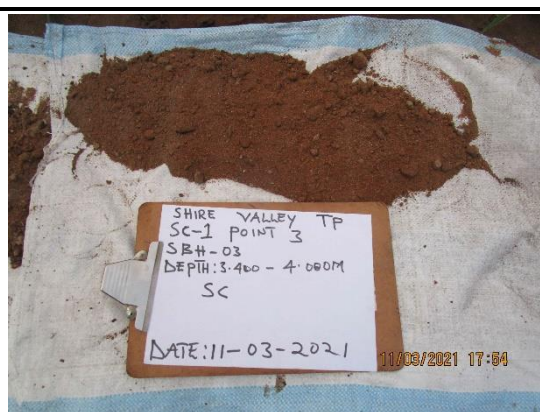
Drilling Rig Set Up for SBH-2



Disturbed Sample of SBH-2



Drilling Rig Set Up for SBH-3



Disturbed Sample of SBH-3



Drilling Rig Set Up for SBH-4



Disturbed Sample of SBH-4



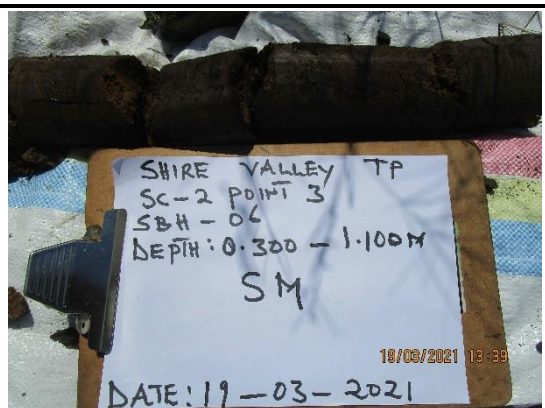
Site Scene for SBH-5



Disturbed Sample of SBH-5



Drilling Rig Set Up for SBH-6



Disturbed Sample of SBH-6



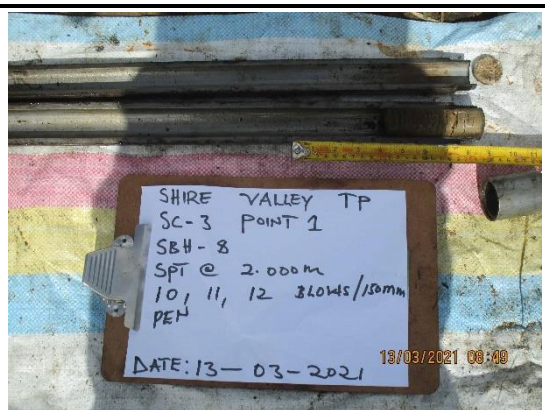
Drilling Rig Set Up for SBH-7



Disturbed Sample of SBH-7



Drilling Rig Set Up for SBH-8



Disturbed Sample of SBH-8



Drilling Rig Set Up for SBH-9



Disturbed Sample of SBH-9



Site Scene for SBH-10



Disturbed Sample of SBH-10



Drilling Rig Set Up for SBH-11



Disturbed Sample of SBH-11



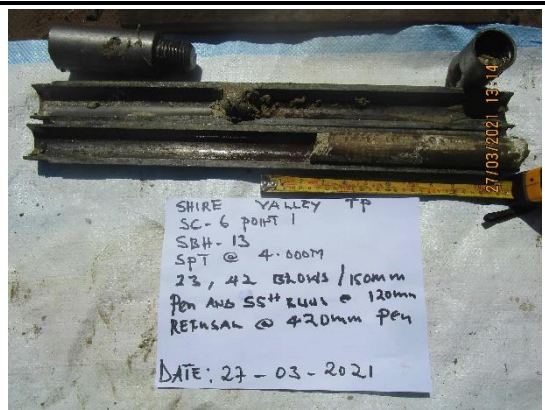
Drilling Rig Set Up for SBH-12



Disturbed Sample of SBH-12



Drilling Rig Set Up for SBH-13



Disturbed Sample of SBH-13



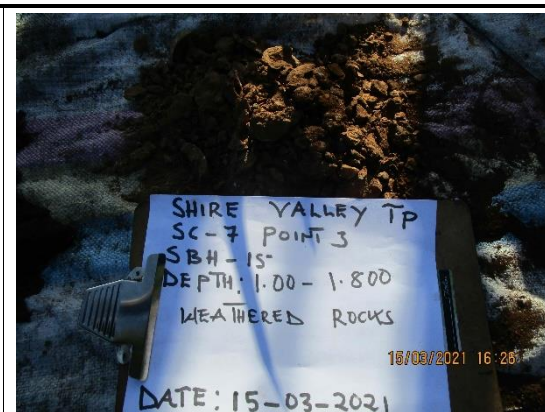
Disturbed Sample for SBH-14



Rock Sample of SBH-14



Drilling Rig Set Up for SBH-15



Disturbed Sample of SBH-15



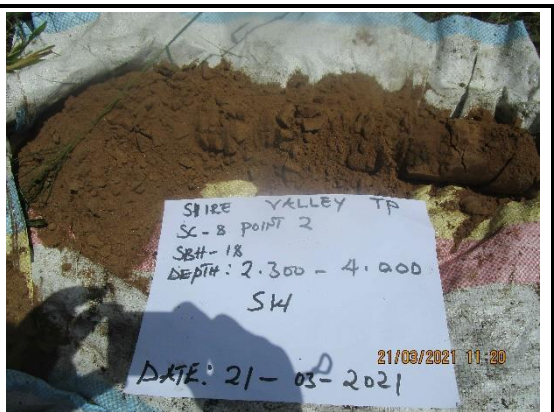
Drilling Rig Set Up for SBH-16



Disturbed Sample of SBH-16



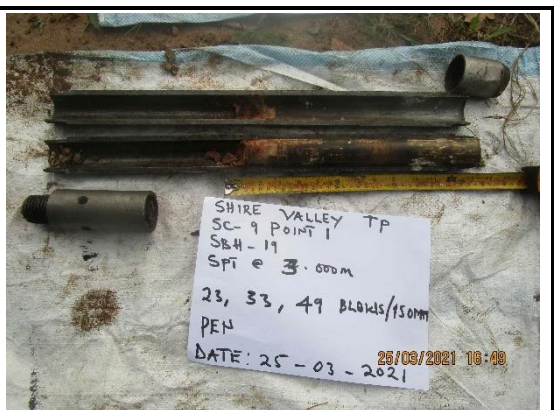
Drilling Rig Set Up for SBH-17



Disturbed Sample of SBH-17



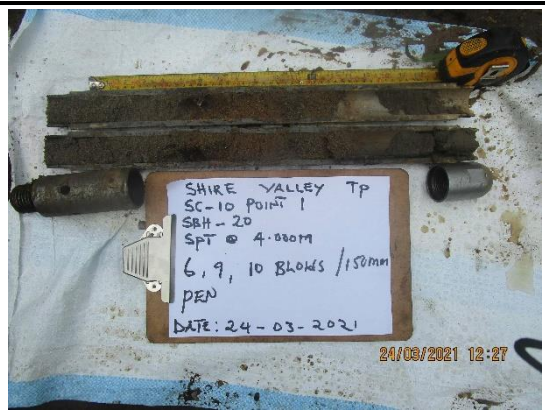
Drilling Rig Set Up for SBH-19



Disturbed Sample of SBH-19



Drilling Rig Set Up for SBH-20



Disturbed Sample of SBH-20



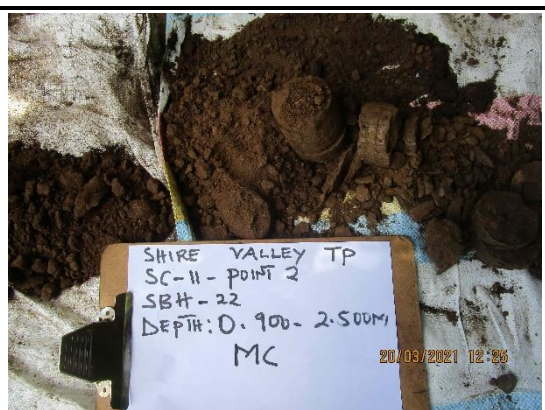
Drilling Rig Set Up for SBH-21



Disturbed Sample of SBH-21



Drilling Rig Set Up for SBH-22



Disturbed Sample of SBH-22



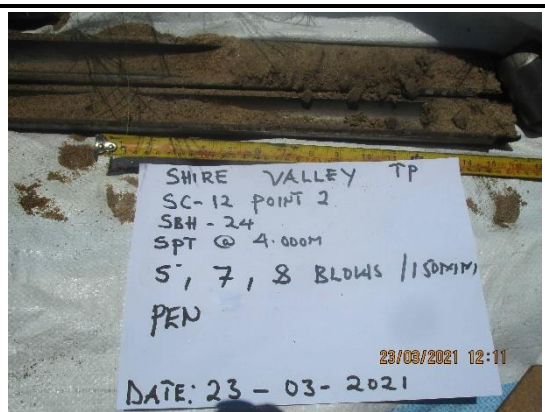
Drilling Rig Set Up for SBH-23



Disturbed Sample of SBH-23



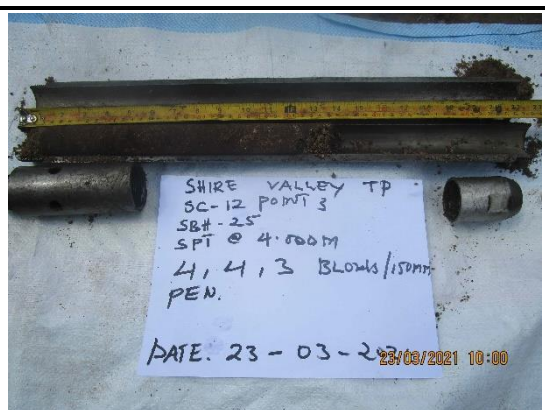
Drilling Rig Set Up for SBH-24



Disturbed Sample of SBH-24



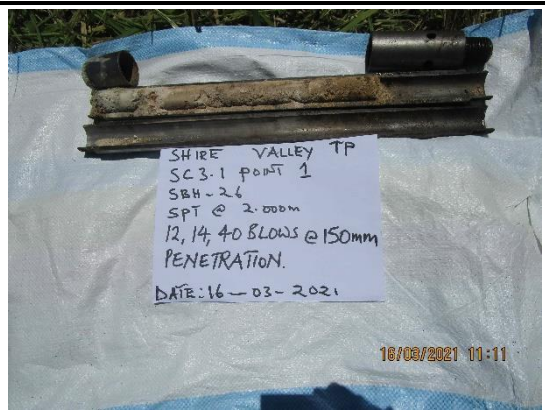
Drilling Rig Set Up for SBH-25



Disturbed Sample of SBH-25



Drilling Rig Set Up for SBH-26



Disturbed Sample of SBH-26



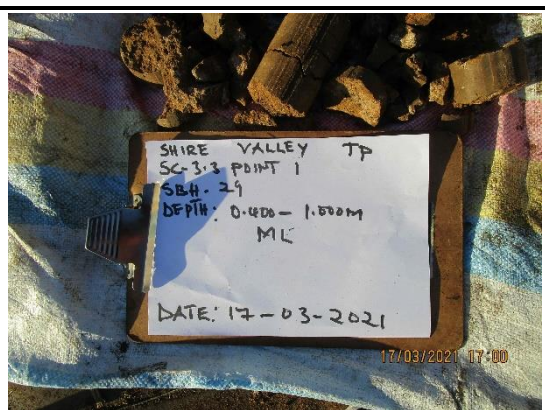
Digging Scene of SBH-27



Digging Scene of SBH-28



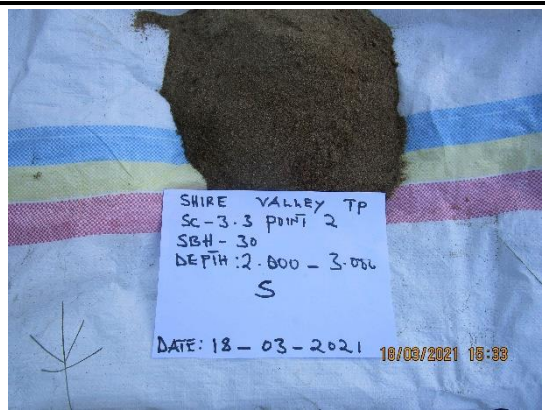
Site Scene of SBH-29



Disturbed Sample of SBH-29



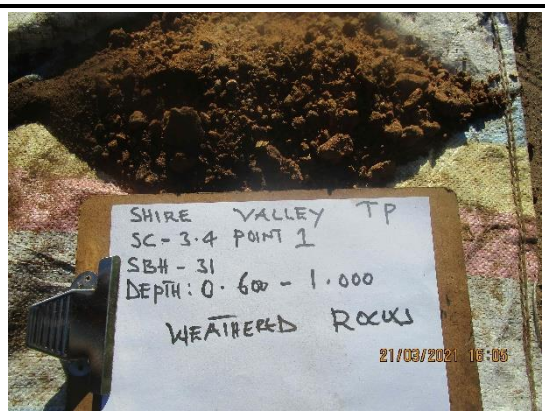
Drilling Rig Set Up for SBH-30



Disturbed Sample of SBH-30



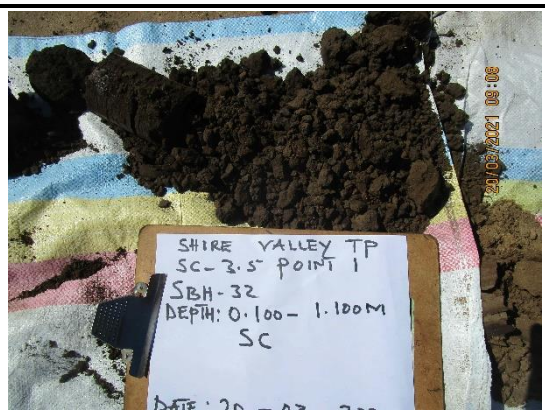
Disturbed Sample for SBH-31



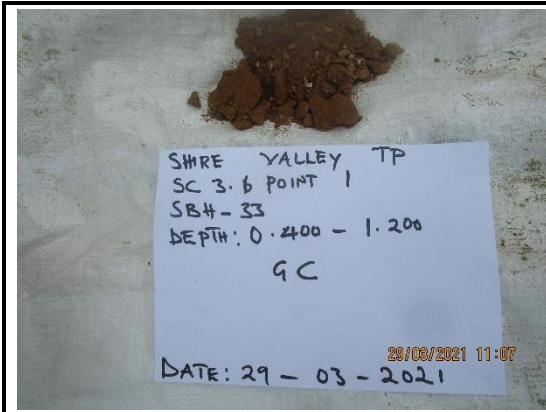
Disturbed Sample of SBH-31



Drilling Rig Set Up for SBH-32



Disturbed Sample of SBH-32



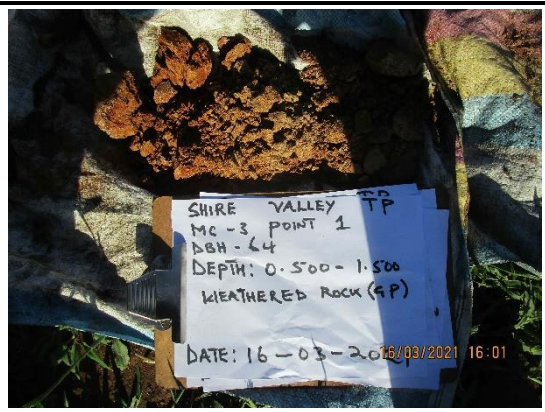
Disturbed Sample for SBH-33



Rock Sample of SBH-33



Disturbed Sample of DBH-64



Disturbed Sample of DBH-64



Drilling Rig Set Up of DBH-65



Disturbed Sample of DBH-65

