Hydrogeology, Environment and the Reserve of the

Polhena Gravel Deposit

Prepared by

Atula Senaratne, Ph.D.

Professor of Geology

Department of Geology

University of Peradeniya

May, 2017

HYDROGEOLOGY, ENVIRONMENT AND THE RESERVE OF THE POLHENA GRAVEL DEPOSIT

1.0 INTRODUCTION

1.1 Central Expressway

Journey from Colombo to Kandy had always been a nightmare for travellers . It usually took 3 hours in 1970s and gradually increased to a steady 4 hours and occasionally extended even to 5 hours on Fridays.

A less-than-two-hour connection to Kandy would have been a game-changer. The people of the Central Province have been pressing the government for several decades for improved A-01 highway. As a result the National Master Plan for 2007-2017 of Government of Sri Lanka (GOSL) has identified Central Expressway as a priority project to be implemented . Few sections of this expressway network have already started their operations such as Kottawa to Kadawatha section of the Outer Circular Highway (OCH).

Under the directives of Ministry of Highways, Road Development Authority (RDA) has initiated a study to find out a suitable road corridor to construct the expressway from Kadawatha to Dambulla via Kurunegala under Central Expressway Project (CEP) with a link to Kandy under the phase 1 of the project, considering present and future development options of the country. Under the phase 2 of the project, it is expected to extend the expressway to Northern and Eastern areas of the country. Under the phase 1, it is expected to start the Central Expressway at Kadawatha from Kadawatha – Kerawalapitiya section ,which is currently under construction. Subsequently the expressway will cross Gampaha, Meerigama, Kurunegala while ending at Dambulla. The Kandy link will branch off at Pothuhera and terminate at Galagedara which is about 10km away from Kandy City.

Financing, public protests, constraints in acquiring aggregates for filling and construction, natural hindrances such as topography, bedrock etc are the main factors govern the proceedings of the Central Expressway. The authorities have cleared almost all the obstacles which delayed the project sofar except for guaranteed aggregate supply.

The CEC has acquired a section of the highway and currently making preparations for the project . Gravel for filling is a major requirement of the project and CEC has identified a prospective land. The primary purpose of the study is to investigate the hydrogeological regime in and around the proposed gravel pit site and to make recommendations to establish an environmental friendly mining operation.

1.2 Property Description

1.2.1 Location and Access

The Property is located approximately 100 km by Colombo-Kurunegala highway and Kurunegala-Negombo highway, west of the city of Kurunegala and can be accessed by vehicle from Kurunegala in approximately 20 minutes.

The main Industry in the region is coconut plantation and allied industries. Aggregate mining is done in artisan scale and operated by small-time operators. The region is expected to be a good source of skilled personnel, support services, and mining equipment. Figure 1-1 shows the Project's regional location.

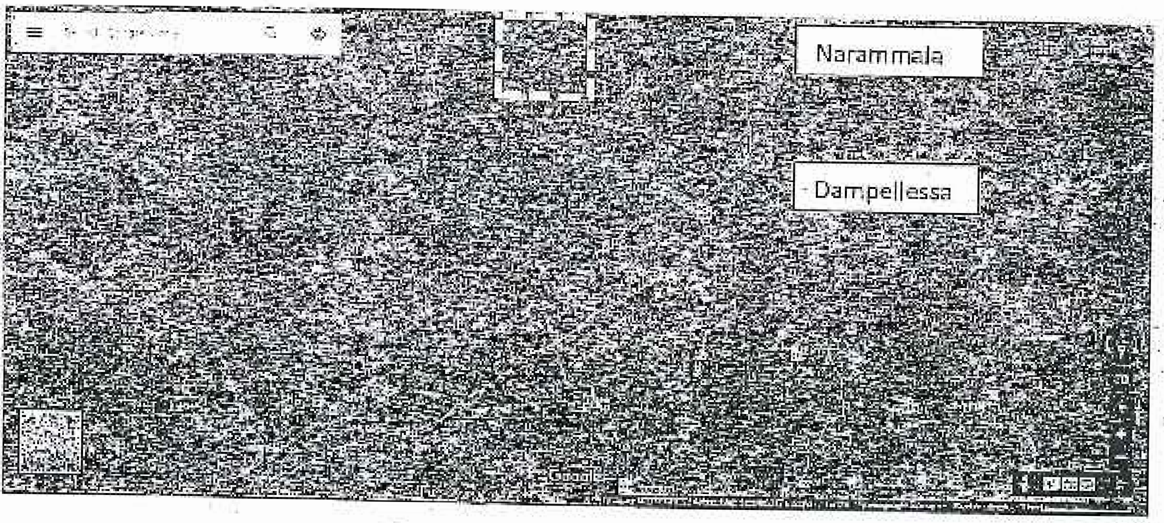


Figure 1-1: Project Location Map

The Property is situated 5 km away from the Dangolla junction along the Dangolla – Metiyagane road. On a closer view one can see the plot of land is located on the westerly dipping slope of a NS trending hillock. The average slope is about 11% while the highest point of the land measures approximately 140 M. MSL. The soil is very sandy in nature owing to the quartzite bedrock at depth. The coconut plantation shows evidence of malnourishment and mismanagement. The land has been abandoned too long and the neglected coconut palms show signs of weather beaten past.

Figure 1-1 illustrates the picturesque dendritic pattern of drainage as depicted by enveloping paddy fields. The trend lines of the ridges and valleys draws an arena like geological structure where the plot lies on the western limb of the Kivulgalla arena . The ridges are occasionally broken by crosscutting valleys formed along joints , fractures and lineaments on the bedrock. Most of these valleys are historically wetlands now occupied by paddy fields. Quartzite being the most prominent rock in the region makes highly porous sandy soils,which hardly retain any water after a rainy spell hence pushing groundwater quickly in to low lying wetland/paddy fields creating a very deep water table at foothills and no water table at all in elevated areas.

Grasses, small and thorny shrubs comprise the typical undergrowth in the plantation on the sloping hillsides with larger bushes and taller trees in the lower lying areas near paddy fields and streams. Nearby farmers produce beans and maize with groundwater sourced from thick gravel beds in the surrounding plains or via dry farming during the rainy season. The Property area has a semi-dry climate, with an annual average temperature of about 25°C and an average annual precipitation of about 1500 millimeters (mm), usually occurring between February and May. Mining activities can take place year round. The dominant wind direction is from southwest.

1.3 Geology

The Project is located on the western limb of the Kivulgalla (arena) double plunging antiform. The main quartzite band is about 500 meters in width and runs in full length round the Kivulgalla arena structure. This band is accompanied by crystalline limestone at northern and southern edges while granitic gneisses fill in to the core of the arena. The eastern limb of the antiform shows signs of multiple folding where the quartzite band appears as two parallel bands. In the inner band, the famous Dampelessa springs are located.

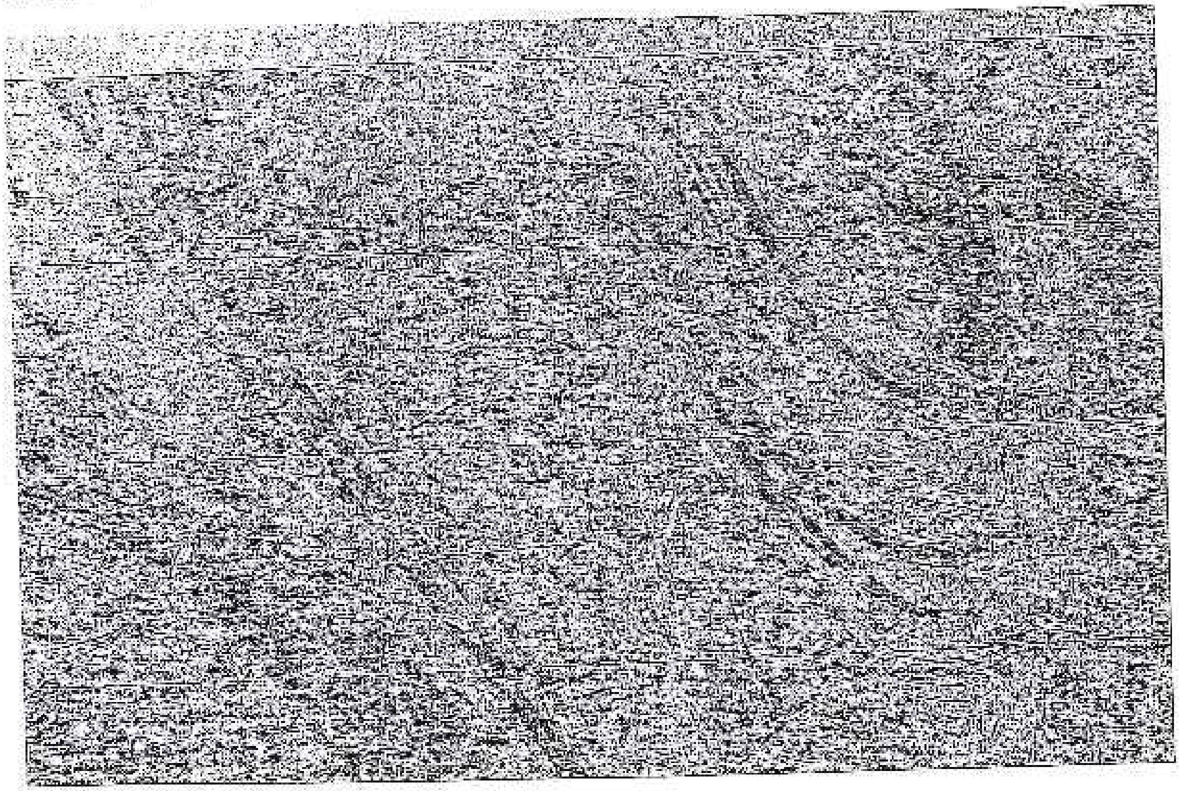


Figure 1-2. Geological map of the area around the project site

The valleys in the area are of two types. Valleys between ridges and those extend through the ridges crossing them at some points where the latter depicts fracture zones in the bedrock.

The valleys between ridges are usually shallow when compared with the fracture zone valleys. These fracture zones often penetrates through the geological formations for few kilometers to several hundreds of kilometers.

Being a very fragile rock, quartzite bands carry very closely arranged fracture zones laying parallel to the mega fracture zones run for several kilometers. These minor fracture zones in the quartzite band has divided the formation in to several hillocks where Polhena watta is one of them.

1.4 Hydrogeology of the Site

Polhena Estate has an aerial extension of about 67,000 sq.M. The area receives an annual rainfall of over 2000 mm. Based on these information, a groundwater budget for the site can be established as detailed below.

Annual rainfall 2000 mm

Catchment area 67,000 sq.M.

Total volume received by Polwattahena 67,000 x 2= 134,000 cu.M./annum

Considering the porous nature of the soil and the average slope of 11% a 10% of rain can be expected to infiltrate the surface to to contribute to the regional water table.

Contribution from Polwattahena to water table 13,400 cu.M./annum

Average daily contribution 13,400/365 = 36 cu.M/day

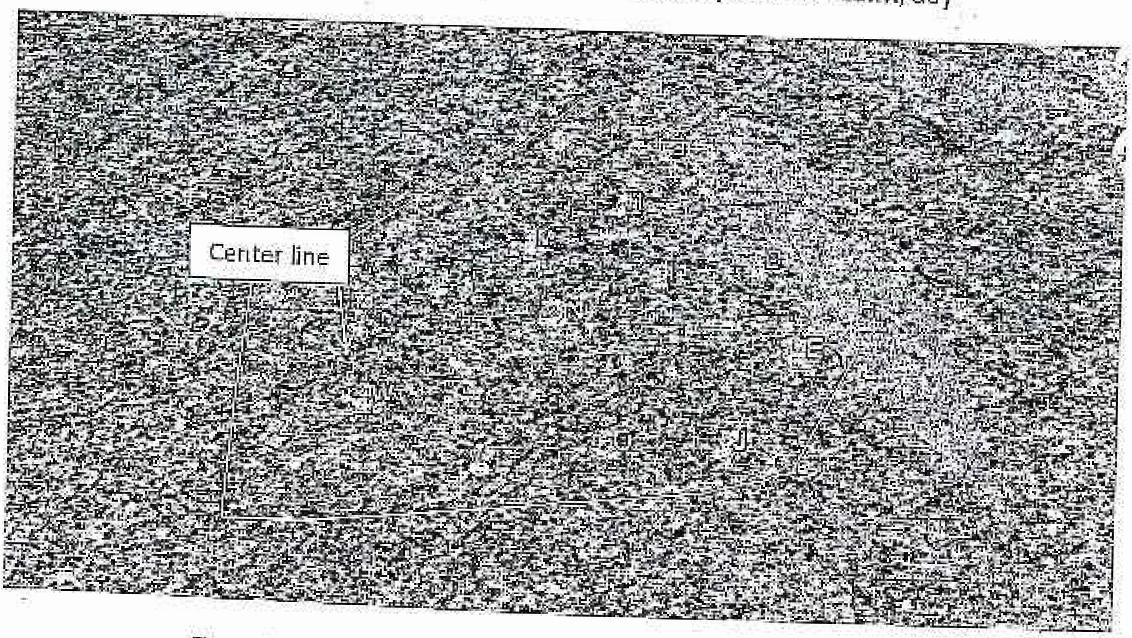


Figure1-3. Polwattahena land and its grid as marked on the ground

As per the above calculation, Polhena contributes about 36 cu.M. of water daily to the regional groundwater table. Although there was no water table within a most part of the land , water table was detected about 7.0 M. below the ground closer to the access road. After a rain, the surface runoff escapes the land within few minutes while the groundwater moves slowly through the sandy soil towards the wetlands/paddy fields joining the regional water table. The contribution from Polhena would have been more if the slope is lesser than as it is now. To assess the depth to water table and the bedrock, vertical electrical soundings were conducted at 6 points along the baseline (redline in fig.1-3).

2.0 GEOPHYSICAL INVESTIGATIONS

2.1.Resistivity Surveys

Vertical electrical sounding (VES) technique was used to measure resistivity of subsurface formations. This method is based on the estimation of the electrical conductivity or resistivity of the medium. The estimation is performed based on the measurement of voltage of electrical field induced by the distant 7 grounded electrodes (current electrodes). For the current study the Schlumberger Array of electrodes has been employed. The electrodes A and B are current electrodes which are connected to a current source; N and M are potential electrodes which are used for the voltage measurements. As source, direct current was used. The interpretation of the measurements can be performed based on the apparent resistivity values. The depth of investigation depends on the distance between the current electrodes. In order to obtain the apparent resistivity as the function of depth, the measurements for each position are performed with several different distances between current electrodes. The apparent resistivity is calculated and plotted against AB/2, which is assumed to be the probing depth. 6 locations were surveyed for subsurface resistivity values. They were marked here as Location C,H,M,R,V and Y . Among the 6 surveys 2 (C, and H) could not penetrate deep below 30 meters. All the VES plots have shown similar log-log curves indicating similar soil profiles at all the points tested. The values and the VES curves were separately interpreted in order to assess the thickness of the soil column and the depth to water table and the bedrock.

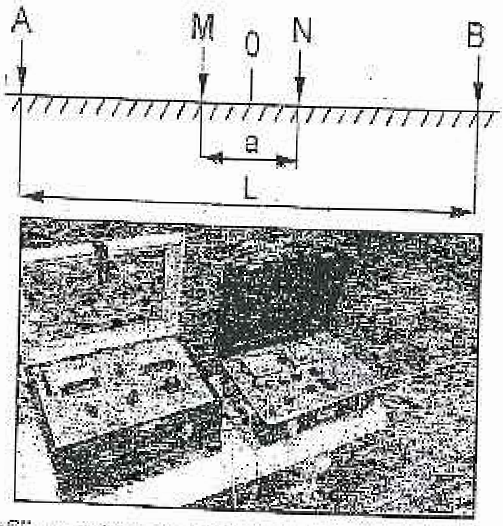


Figure 2-1. Electrical profiling using four-electrode probes in Schlumberger configuration (upper).Resistivity Meter, YEW, 3244 (Lower)

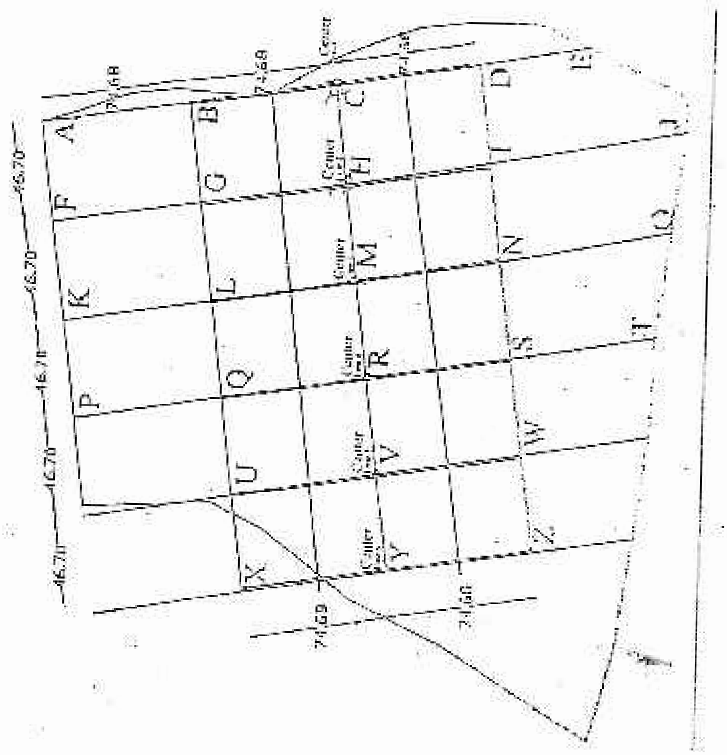
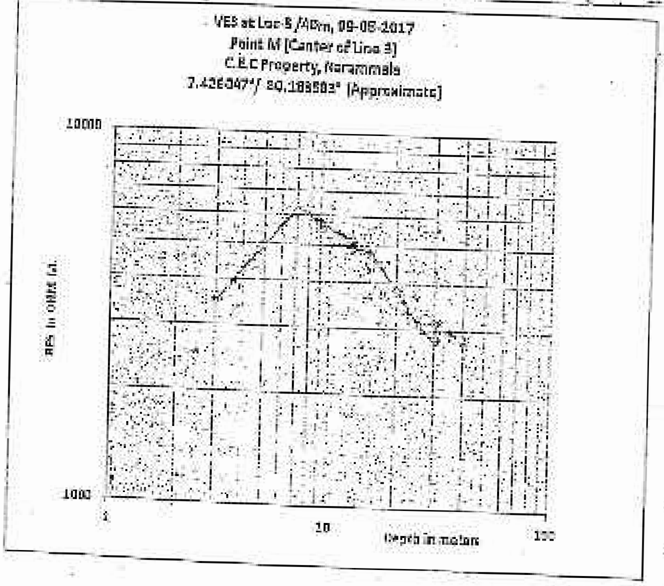
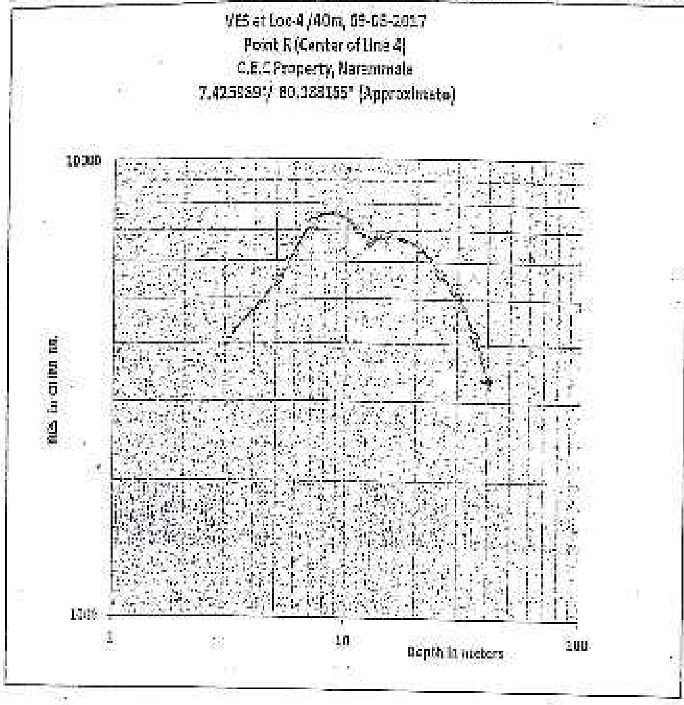


Figure 2-3 Survey plan



AB/2	MN/2	K	Rho	R	
1.5	0.5	6.28		0	Reading not possible
3	0.5	27.48	127	3489.33	
5	0.5	77.72	64	4973.76	
7	0.5	153.08	40	6123	
9	0.5	253.56	22.5	5704.99	
12.5	0.5	489.84	10.5	5143.32	
12.5	4	55.05	90	4954.33	
15	4	82.05	58	4757.69	
20	4	150.72	25.4	3828.29	
25	4	239.03	13	3107.42	
30	4	346.97	8.2	2845.15	
30	10	125.60	25	3140	
35	10	176.83	16.6	2931.98	
40	10	235.50	12.1	2849.55	

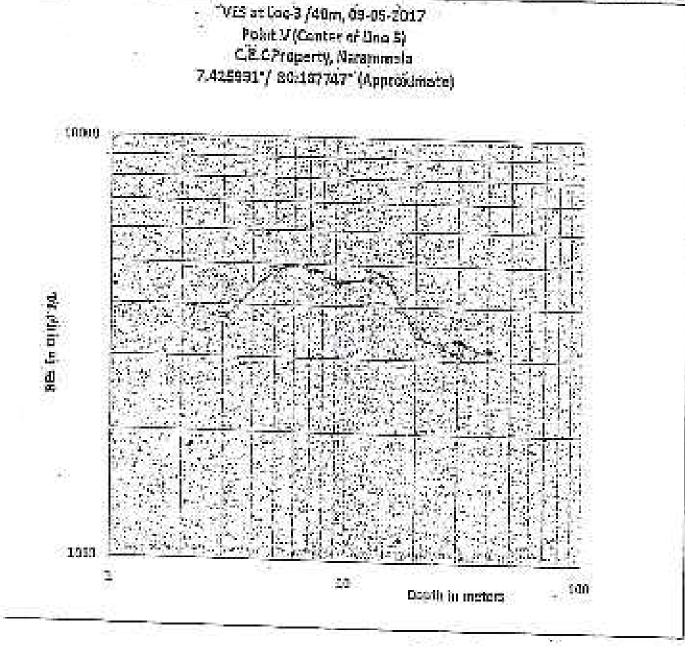
Figure 2-4 VES curve for Line 3



AB/2	MN/2	K	Rho	R
1.5	0.5	6.28		
3	0.5	27.48	147	4038.83
5	0.5	77.72	70	5440.05
7	0.5	153.08	47.5	7271.06
9	0.5	253.56	30	7606.65
12.5	0.5	489.84	13.5	6612.84
12.5	4	55.05	120	6605.78
15	4	82.05	82.5	6767.68
20	4	150.72	45	6180.96
25	4	239.03	23.6	5641.17
30	4	346.97	13.9	4822.88
30	10	125.60	40	5024
35	10	176.63	23.5	4150.69
40	10	235.50	14.1	3320.55

Reading not possible

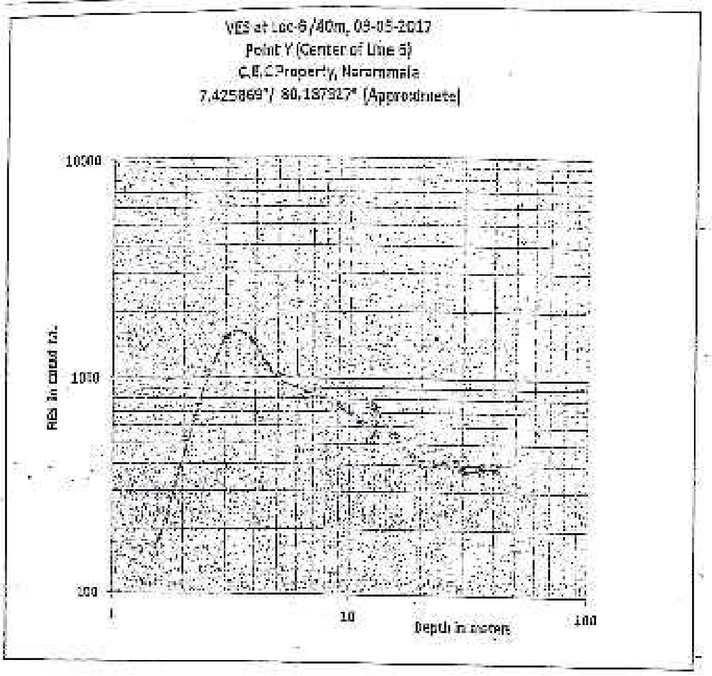
Figure 2-5 VES curve for Line 4



AB/2	MN/2	K	Rho	R
1.5	0.5	6.28		
3	0.5	27.48	135	3709.13
5	0.5	77.72	62	4818.33
7	0.5	153.08	32	4898.4
9	0.5	253.56	18	4563.99
12.5	0.5	489.84	9.5	4653.48
12.5	4	55.05	88	4844.24
15	4	82.05	56	4593.82
20	4	150.72	23	3466.56
25	4	239.03	13.5	3226.94
30	4	346.97	8.9	3088.03
30	10	125.60	26.5	3328.4
35	10	176.63	17.8	3143.99
40	10	235.50	13.5	3179.25

Reading not possible

Figure 2-6 VES curve for Line 5



AB/2	MN/2	K	Rho	R
1.50	0.50	6.28	24.50	153.86
3.00	0.50	27.48	55.00	1511.13
5.00	0.50	77.72	12.70	986.98
7.00	0.50	153.08	5.30	841.91
9.00	0.50	253.55	2.90	735.31
12.50	0.50	489.84	1.17	573.11
12.50	4.00	55.05	13.40	737.64
15.00	4.00	82.03	6.80	557.82
20.00	4.00	150.72	2.70	406.94
25.00	4.00	239.03	1.72	411.14
30.00	4.00	346.97	1.23	426.77
30.00	10.00	125.60	3.00	376.80
35.00	10.00	176.63	2.16	381.51
40.00	10.00	235.50	1.66	390.93

Figure 2-7 VES curve for Line 6

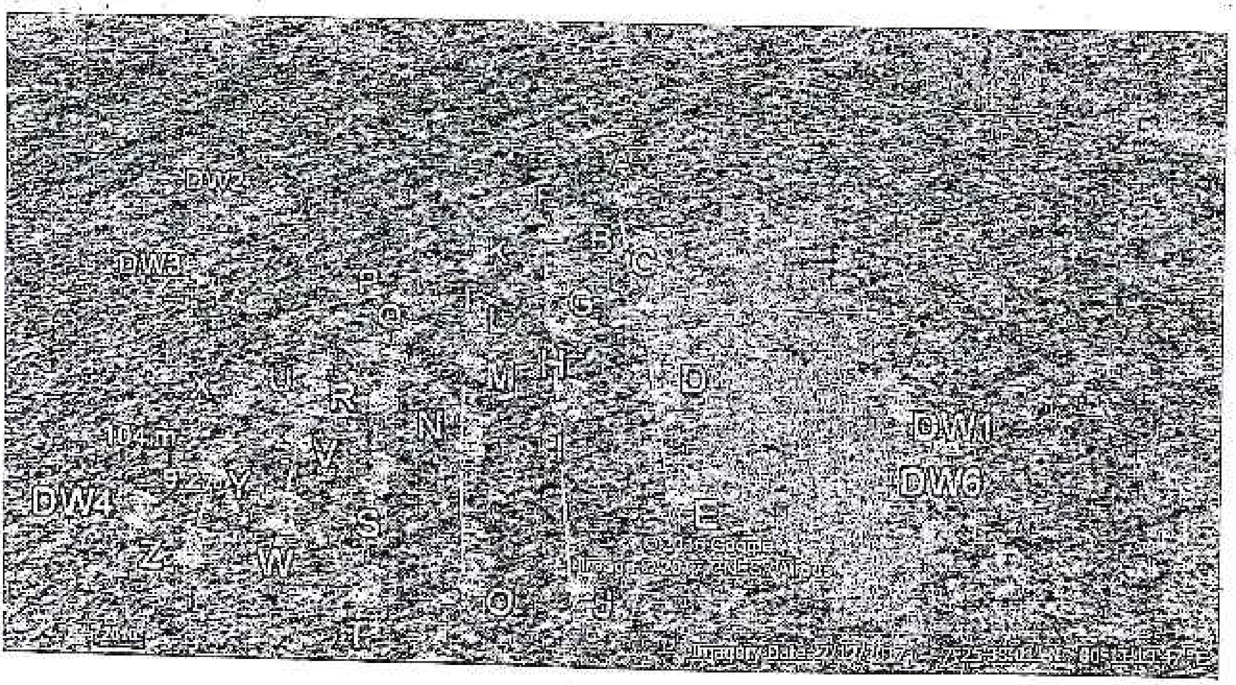


Figure 2-8 VES traverses

3.0 GRAVEL MINING

Sand and gravel mining refers to the process of removing sand or gravel from a place of its occurrence. These materials occur in a variety of natural settings and are commonly used in the construction industries worldwide. Sand and gravel occur on land, oceans, rivers, streams, flood plains or hills . An Increase in demand for sand and gravel for construction purposes has placed immense pressure on sand and gravel resources. Therefore, the extraction of these important construction aggregates is bound to have considerable negative effect on the place where they occur.

The mining of these aggregates anywhere can affect the water table and alter the land-use for agricultural purposes . The most common environmental impact is the alteration of land use, most likely from underdeveloped or natural land to excavations in the ground . Social pressures usually gather momentum with the news of impending issues associated with gravel mining such as accelerated soil erosion, effects on regional water table etc. The developers therefore must pay attention to those issues, reveal the impacts and identify remedies, educate the people involved and the population in the vicinity. The purpose of this work is to understand the anatomy of the deposit and to recommend best environment friendly mining methods.

3.1 Anatomy of the Polhena Gravel Deposit

The Polhena gravel deposit is an Insitu residual deposit formed on quartzite rock formation. The bed rock is not detected at most part of the land except for the lowermost point of the deposit. Next to the access road, bedrock was detected at 20.0 M. and the water table at a depth of about 7.0 M. below . These opbservations prove that the reserve can be utilized through a properly designed environmentaly sound mining plan. Figure 3-1 Illustrates a generalized profile of the deposit.

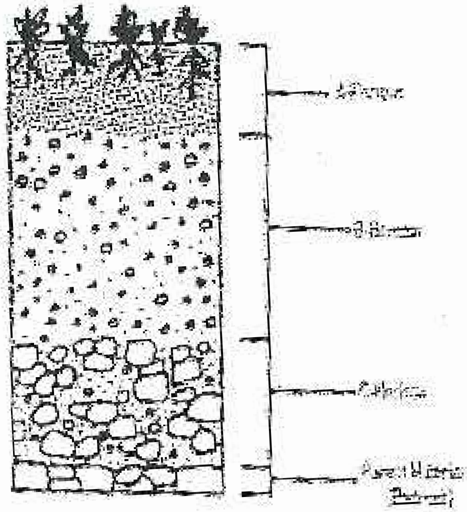


Figure 3-1 A generalized profile of the deposit

The thickness of the gravel bed vary across the land, thining at either sides. Similar deposits are found overlying the quartzite ring (refer to the geological map) running for over 40 km around the Kivulgaila antiform. There are numerous mining sites along the quartzite ridge, already excavated and blended back to the natural environment.

4.0 RECOMMENDATIONS

As stated above, the main issues probably would arise in gravel mining are,

1. Impacts on water table and
2. Soil erosion.

The developer therefore must pay attention to those issues and select the most suitable mining option where either impacts on water table can be minimized or improve the situation after mining. The problem of erosion however, would prevail only during mining operations and cease to occur once operations come to an end. Therefore all possible precautions must be taken to minimize unnecessary erosion within the mine and excessive siltation in waterways in the vicinity. Considering the above aspects the following actions can be proposed for a most environment friendly mining operation at Polhena.

1. Mining above the water table, causing no impact on regional hydrogeology.
2. Creating a dual purpose groundwater recharge and silt trap area within the mine to improve hydrogeology of the area
3. Keeping geotechnically favorable slopes in mine walls, close to natural slopes in the area
4. Blending back to nature after extraction of prescribed volume of gravel by planting indeginous tree species.

Keeping to above listed self controls, the project proponent can achieve an environment friendly gravel mine which can finally be an instrument improving groundwater setting in the area. Figure 3-2 illustrates the preliminary mining plan with all the prescribed remedial measures in place.

4.1 Reserve Calculation

As per the prescription in the above section, the reserve can be calculated as follows.
The total mineable volume is within the sections I,II and III in figure 2-3. The sectional areas are calculated as follows.

Section I:

1/2x89x30 = 1335 sq. M.

Section II:

1/2x137x30 = 2055sq.M.

Section III:

1/2x137x7 = 479.5 sq.M.

Total Sectional Area=3869.5 sq.M.

Based on the land survey data, the average width of the land is about 300 M.
Therefore the total volume mineable from the site keeping the environment free of impacts is 1,160,850 cu.M., which is in excess of 400,000 cubes.

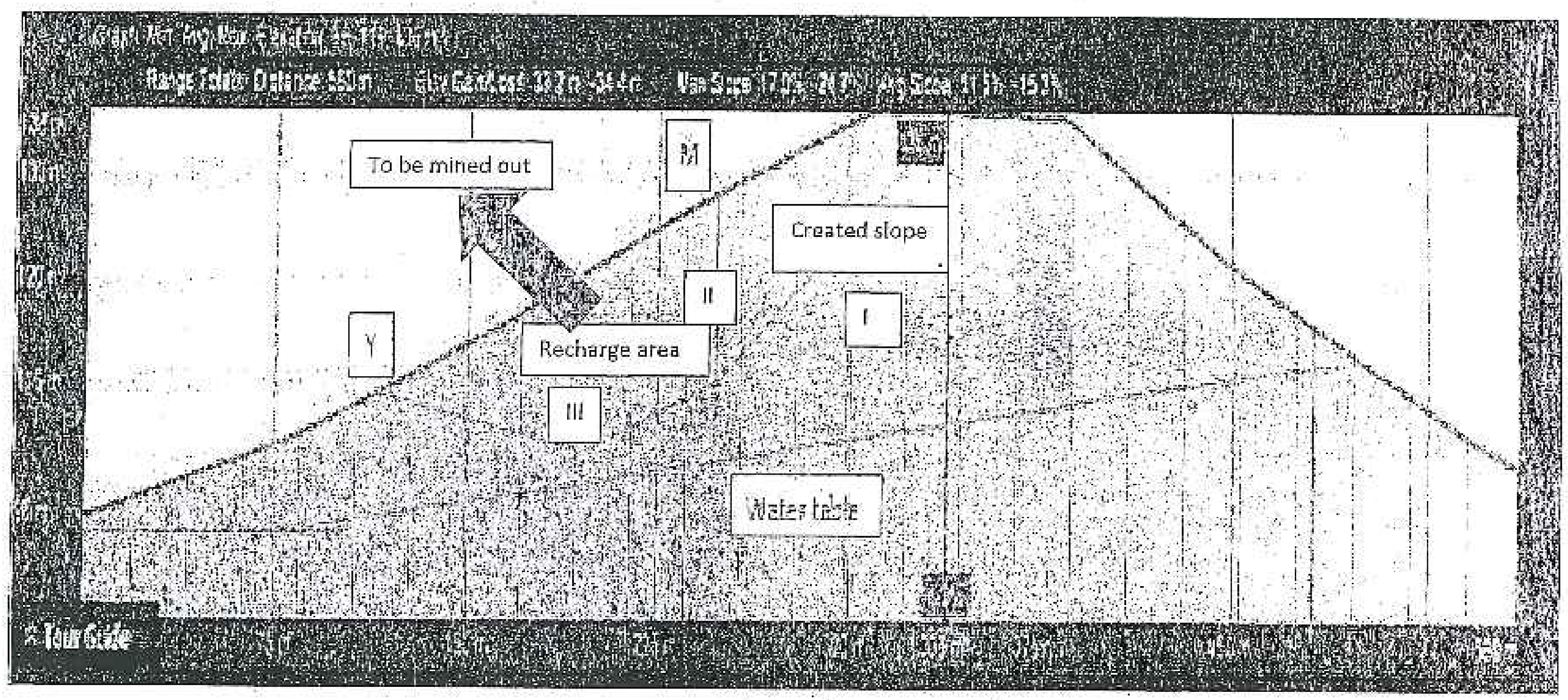


Figure 4-1 Tentative mining plan

18/05/2017

Prof. Atula Senaratne
Professor of Geology
Department of Geology
University of Peradeniya

Professor Atula Senaratne

Professor of Geology