

SBSjvw13684-08032022-ADC.docx

8th March 2022

Simon Davis
Arun District Council
Civic Centre,
Maltravers Road,
Littlehampton,
West Sussex
BN17 5LF

Dear Simon

LAND WEST OF BILSHAM ROAD (PLANNING REF: Y/3/22/OUT)

We refer to the Drainage Engineer's email response to the above planning application and provide the below response.

We confirm that winter groundwater monitoring is currently underway. Having received the groundwater monitoring data for the site over the period between 25th May 2021 and 17th January 2022 an interim summary of the groundwater levels is detailed as follows:

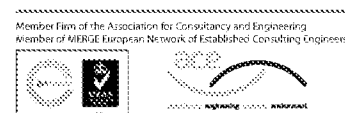
Each of the exploratory holes installed with groundwater monitoring equipment: WS01, WS02A, WS03 and WS04 recorded an increase in the groundwater level between 8th June 2021 and 12th October 2021. The location of the exploratory holes is shown on the attached layout drawing 13684-CRH-XX-XX-FG-G-7017-P5.

The groundwater level rose between 0.53m and 0.75m in WS01, WS02A and WS04 while the level within WS03 rose 1.19m. The greater increase in WS03 is likely due to the cohesive composition of the response zone (firm clay) within the hole, the lower permeability and hence the greater the build-up of water. The other installations have a response zone comprising sand which would account for the reduced increase in groundwater level as the water is able to drain away at a faster rate.

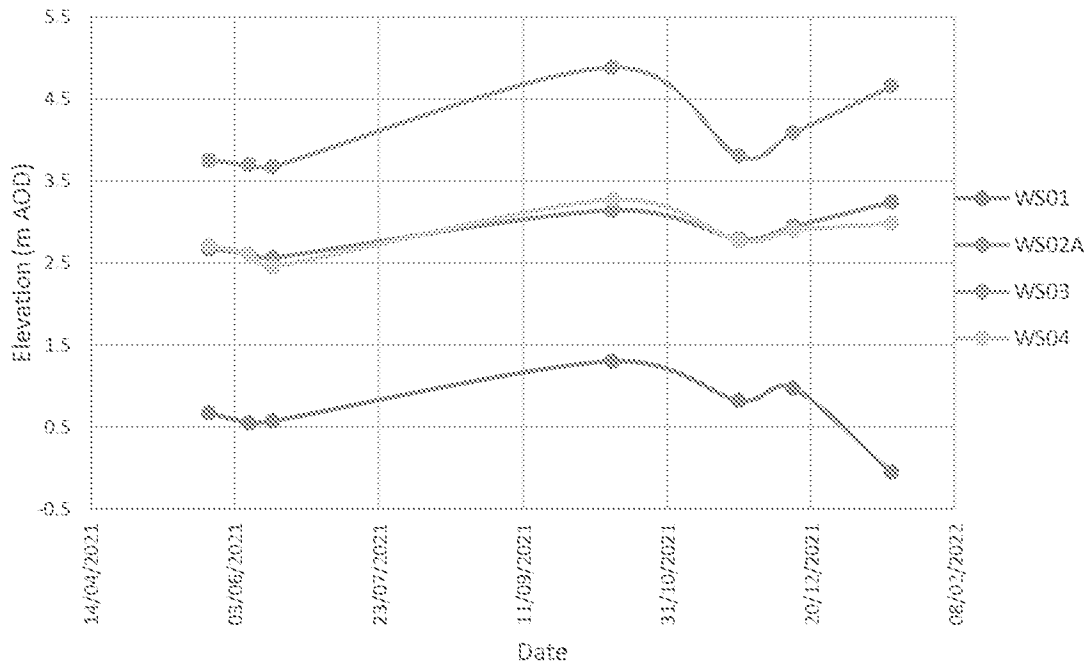
With the exception of WS01, following 12th October 2021 the groundwater levels reduced towards their initial level and then increased again into January 2022. WS01 however reduced in elevation after 14th December which is potentially due to a more granular material being present within the response zone. The borehole log records the material as "becoming loose" at 1.2m bgl (0.67m AOD) and "gravelly" from 2.0m bgl (-0.13m AOD), hence the material becomes more porous and the water is able to readily disperse within the granular material.

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The groundwater level varies between 0.57m bgl and 2.41m bgl across the site as shown in the chart below.



Groundwater monitoring will continue through to April 2022 to account for the winter variation and the updated groundwater monitoring results will be shared as soon as they are available. Available groundwater monitoring results to date are appended to this letter.

We further note your comment about infiltration test and would refer you to Land Quality Statement under reference 13684-CRH-XX-XX-RP-GE-0001-F2 dated December 2021. Relevant extracts from that report are attached at the end of this letter. Owing the cohesive nature of the soil on this site, infiltration test to BRE 365 have not yielded any results. Percolation tests were also undertaken with results of 5.19×10^{-6} m/s. Taking account of the very low results, winter testing will not yield any more advantage and not considered appropriate in this instance. Any consideration for shallow infiltration would require consideration of a factor of safety of 10 in accordance with CIRIA guidance and would result in a much lower effective percolation rate of 5.19×10^{-7} m/s, which is considered negligible for meeting half-drainage time requirement.

Taking account of the above, with regard to the wording of proposed condition PCENG2, we would request that you reconsider the use of that condition requesting for additional winter percolation testing would not generate any meaningful data.

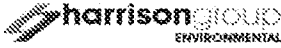
We trust that the additional information appended to this letter is of use in your consideration.

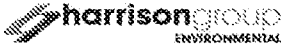
Yours sincerely

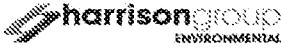
BAVA SATHAN

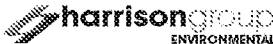
For and on behalf of **CAMPBELL REITH HILL LLP**

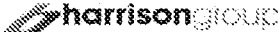
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				Groundwater Monitoring Results																										
Project ID: GL24212				Client: Landlink Estates Limited								Weather conditions: Cloudy and dry																		
Date: 25/05/2021				Location: Lamb's Field								Ground conditions: -																		
1 = All (m) depth measurements are recorded as meters from the top of the installation cover.												2 = I: Inertial, S: Submersible, B: Bailer, P: Peristaltic Pump.					3 = Purge volume standardisation: 50mm standpipe = 6 x water column, 35mm = 3.5 x water column, 19mm = 1 x water column.													
Field engineer(s): W. Atkins												Remarks:																		
Location ID	Monitoring Pipe and Diameter	Date Monitored	Time	Surface Elevation (maOD)	LNAPL Depth ¹ (mbgl)	LNAPL Depth (maOD)	Water Level ¹ (mbgl)	Water Level (maOD)	DNAPL Depth ¹ (mbgl)	DNAPL Depth (maOD)	Depth to base ¹ (mbgl)	Depth to base (maOD)	Readings:												Sampling Method ² (I, S, B, P)	Water Column (m)	Purged Volume ³ (L)	Sample Ref	Comments: (e.g. problems encountered, standpipe conditions, unusual odours, colour, turbidity, sheens)	
													Barometric Pressure (mB)	Air Temp (°C)	Downhole Temp (°C)	pH	Electrical Conductivity (µS/cm)	DO (%)	Redox Potential (mV)	Resistivity (Ohm-cm)	Salinity (psu)	Density (g/cm³)	TDS (ppt)	Water Pressure (psi)						
WS01	PIPE1 (50mm)	25/05/2021	11:07:00	1.87	N/E		1.20	0.67	N/E		2.68	-0.81														1.48			Interface meter recorded a solid beep from 1.88m, possibly due to increased turbidity.	
WS02A	PIPE1 (50mm)	25/05/2021	10:44:00	4.94	N/E		2.27	2.67	N/E		4.07	0.87														1.80			Interface meter recorded a solid beep from 2.95m, possibly due to increased turbidity.	
WS03	PIPE1 (50mm)	25/05/2021	10:30:00	6.08	N/E		2.33	3.75	N/E		5.05	1.03														2.72			Interface meter recorded a solid beep from 3.04m, possibly due to increased turbidity.	
WS04	PIPE1 (50mm)	25/05/2021	11:26:00	4.29	N/E		1.58	2.71	N/E		3.05	1.24														1.47			Interface meter recorded a solid beep from 2.27m, possibly due to increased turbidity.	

				Groundwater Monitoring Results																											
Project ID: GL24212				Client: Landlink Estates Limited								Weather conditions: Sunny and dry																			
Date: 06/06/2021				Location: Lambs Field								Ground conditions: -																			
¹ = All (m) depth measurements are recorded as meters from the top of the installation cover.												² = I: Inertial, S: Submersible, B: Bailer, P: Peristaltic Pump.						³ = Purge volume standardisation: 50mm standpipe = 6 x water column, 35mm = 3.5 x water column, 19mm = 1 x water column.													
Field engineer(s): J. Blyth												Remarks:																			
Location ID	Monitoring Pipe and Diameter	Date Monitored	Time	Surface Elevation (maOD)	LNAPL Depth¹ (mbgl)	LNAPL Depth (maOD)	Water Level¹ (mbgl)	Water Level (maOD)	DNAPL Depth¹ (mbgl)	DNAPL Depth (maOD)	Depth to base¹ (mbgl)	Depth to base (maOD)	Readings:										Sampling Method² (I, S, B, P)	Water Column (m)	Purged Volume¹ (L)	Sample Ref	Comments: (e.g. problems encountered, standpipe conditions, unusual odours, colour, turbidity, sheens)				
													Barometric Pressure (mB)	Air Temp (°C)	Downhole Temp (°C)	pH	Electrical Conductivity (µS/cm)	DO (%)	Redox Potential (mV)	Resistivity (Ohm-cm)	Salinity (psu)	Density (g/cm³)						TDS (ppt)	Water Pressure (psi)		
WS01	PIPE1 (50mm)	06/06/2021	11:10:00	1.87	N/E		1.32	0.55	N/E		2.80	-0.93													1.48						
WS02A	PIPE1 (50mm)	06/06/2021	10:30:00	4.94	N/E		2.33	2.61	N/E		4.12	0.82													1.79						
WS03	PIPE1 (50mm)	06/06/2021	10:00:00	6.08	N/E		2.39	3.69	N/E		5.01	1.07													2.62						
WS04	PIPE1 (50mm)	06/06/2021	10:50:00	4.29	N/E		1.68	2.61	N/E		3.23	1.06													1.55						

				Groundwater Monitoring Results																							
Project ID: GL24212				Client: Landlink Estates Limited								Weather conditions: Sunny and dry															
Date: 16/06/2021				Location: Lambs Field								Ground conditions: -															
¹ = All (m) depth measurements are recorded as meters from the top of the installation cover.										² = I: Inertial, S: Submersible, B: Bailer, P: Peristaltic Pump.				³ = Purge volume standardisation: 50mm standpipe = 6 x water column, 35mm = 3.5 x water column, 19mm = 1 x water column.													
Field engineer(s): J. Blyth										Remarks:																	
Location ID	Monitoring Pipe and Diameter	Date Monitored	Time	Surface Elevation (maOD)	LNAPL Depth¹ (mbgl)	LNAPL Depth (maOD)	Water Level¹ (mbgl)	Water Level (maOD)	DNAPL Depth¹ (mbgl)	DNAPL Depth (maOD)	Depth to base¹ (mbgl)	Depth to base (maOD)	Readings:										Sampling Method² (I, S, B, P)	Water Column (m)	Purged Volume³ (L)	Sample Ref	Comments: (e.g. problems encountered, standpipe conditions, unusual odours, colour, turbidity, sheens)
													Barometric Pressure (mB)	Air Temp (°C)	Downhole Temp (°C)	pH	Electrical Conductivity (µS/cm)	DO (%)	Redox Potential (mV)	Resistivity (Ohm-cm)	Salinity (psu)	Density (g/cm³)					
WS01	PIPE1 (50mm)	16/06/2021	11:30:00	1.87	N/E		1.30	0.57	N/E		2.70	-0.83											B	1.40		EW1-SP1	Slightly cloudy, white/orange.
WS02A	PIPE1 (50mm)	16/06/2021	11:00:00	4.94	N/E		2.38	2.56	N/E		4.11	0.83											B	1.73		EW1-SP1	Slightly cloudy, white/orange.
WS03	PIPE1 (50mm)	16/06/2021	10:30:00	6.08	N/E		2.41	3.67	N/E		5.06	1.02											B	2.65		EW1-SP1	Cloudy, light orangish brown.
WS04	PIPE1 (50mm)	16/06/2021	12:00:00	4.29	N/E		1.84	2.45	N/E		3.24	1.05											B	1.40		EW1-SP1	Cloudy, light orangish brown.

				Groundwater Monitoring Results																							
Project ID: GL24212				Client: Landlink Estates Limited								Weather conditions: Sunny and dry															
Date: 22/10/2021				Location: Lambs Field								Ground conditions: -															
1 = All (m) depth measurements are recorded as meters from the top of the installation cover.												2 = I: Inertial, S: Submersible, B: Bailer, P: Peristaltic Pump.				3 = Purge volume standardisation: 50mm standpipe = 6 x water column, 35mm = 3.5 x water column, 19mm = 1 x water column.											
Field engineer(s): J. Blyth				Remarks:																							
Location ID	Monitoring Pipe and Diameter	Date Monitored	Time	Surface Elevation (maOD)	LNAPL Depth ¹ (mbgl)	LNAPL Depth (maOD)	Water Level ¹ (mbgl)	Water Level (maOD)	DNAPL Depth ¹ (mbgl)	DNAPL Depth (maOD)	Depth to base ¹ (mbgl)	Depth to base (maOD)	Readings:										Sampling Method ² (I, S, B, P)	Water Column (m)	Purged Volume ³ (L)	Sample Ref	Comments: (e.g. problems encountered, standpipe conditions, unusual odours, colour, turbidity, sheens)
													Barometric Pressure (mB)	Air Temp (°C)	Downhole Temp (°C)	pH	Electrical Conductivity (µS/cm)	DO (%)	Redox Potential (mV)	Resistivity (Ohm-cm)	Salinity (psu)	Density (g/cm ³)					
WS01	PIPE1 (50mm)	22/10/2021	10:30:00	1.87	N/E		0.57	1.30	N/E		2.48	-0.61												1.91			
WS02A	PIPE1 (50mm)	22/10/2021	10:10:00	4.94	N/E		1.80	3.14	N/E		4.00	0.94												2.20			
WS03	PIPE1 (50mm)	22/10/2021	10:00:00	6.08	N/E		1.20	4.88	N/E		5.01	1.07												3.81			
WS04	PIPE1 (50mm)	22/10/2021	10:20:00	4.29	N/E		1.02	3.27	N/E		3.04	1.25												2.02			

				Groundwater Monitoring Results																									
Project ID: GL24212				Client: Landlink Estates Limited								Weather conditions: Cloudy and dry																	
Date: 25/11/2021				Location: Lambs Field								Ground conditions: -																	
¹ = All (m) depth measurements are recorded as meters from the top of the installation cover.										² = I: Inertial, S: Submersible, B: Bailer, P: Peristaltic Pump.						³ = Purge volume standardisation: 50mm standpipe = 6 x water column, 35mm = 3.5 x water column, 19mm = 1 x water column.													
Field engineer(s): L. Jeffery										Remarks:																			
Location ID	Monitoring Pipe and Diameter	Date Monitored	Time	Surface Elevation (maOD)	LNAPL Depth¹ (mbgl)	LNAPL Depth (maOD)	Water Level¹ (mbgl)	Water Level (maOD)	DNAPL Depth¹ (mbgl)	DNAPL Depth (maOD)	Depth to base¹ (mbgl)	Depth to base (maOD)	Readings:										Sampling Method² (I, S, B, P)	Water Column (m)	Purged Volume¹ (L)	Sample Ref	Comments: (e.g. problems encountered, standpipe conditions, unusual odours, colour, turbidity, sheens)		
													Barometric Pressure (mB)	Air Temp (°C)	Downhole Temp (°C)	pH	Electrical Conductivity (µS/cm)	DO (%)	Redox Potential (mV)	Resistivity (Ohm-cm)	Salinity (psu)	Density (g/cm³)						TDS (ppt)	Water Pressure (psi)
WS01	PIPE1 (50mm)	25/11/2021	14:10:00	1.87	N/E		1.05	0.82	N/E		2.43	-0.56													1.38				
WS02A	PIPE1 (50mm)	25/11/2021	13:48:00	4.94	N/E		2.15	2.79	N/E		4.00	0.94													1.85				
WS03	PIPE1 (50mm)	25/11/2021	13:43:00	6.08	N/E		2.28	3.80	N/E		5.02	1.06													2.74				
WS04	PIPE1 (50mm)	25/11/2021	13:57:00	4.29	N/E		1.52	2.77	N/E		3.06	1.23													1.54				

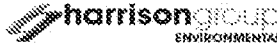
				Groundwater Monitoring Results																									
Project ID: GL24212				Client: Landlink Estates Limited								Weather conditions: Cloudy and dry																	
Date: 14/12/2021				Location: Lambs Field								Ground conditions: -																	
¹ = All (m) depth measurements are recorded as meters from the top of the installation cover.										² = I: Inertial, S: Submersible, B: Bailer, P: Peristaltic Pump.					³ = Purge volume standardisation: 50mm standpipe = 6 x water column, 35mm = 3.5 x water column, 19mm = 1 x water column.														
Field engineer(s): L. Jeffery										Remarks:																			
				Readings:																									
Location ID	Monitoring Pipe and Diameter	Date Monitored	Time	Surface Elevation (maOD)	LNAPL Depth ¹ (mbgl)	LNAPL Depth (maOD)	Water Level ¹ (mbgl)	Water Level (maOD)	DNAPL Depth ¹ (mbgl)	DNAPL Depth (maOD)	Depth to base ¹ (mbgl)	Depth to base (maOD)	Barometric Pressure (mBar)	Air Temp (°C)	Downhole Temp (°C)	pH	Electrical Conductivity (µS/cm)	DO (%)	Redox Potential (mV)	Resistivity (Ohm-cm)	Salinity (psu)	Density (g/cm³)	TDS (ppt)	Water Pressure (psf)	Sampling Method ² (I, S, B, P)	Water Column (m)	Purged Volume ³ (L)	Sample Ref	Comments: (e.g. problems encountered, standpipe conditions, unusual odours, colour, turbidity, sheens)
WS01	PIPE1 (50mm)	14/12/2021		1.87	N/E		0.90	0.97	N/E		2.50	-0.63														1.60			
WS02A	PIPE1 (50mm)	14/12/2021		4.94	N/E		2.00	2.94	N/E		4.02	0.92														2.02			
WS03	PIPE1 (50mm)	14/12/2021		6.08	N/E		2.00	4.08	N/E		5.00	1.08														3.00			
WS04	PIPE1 (50mm)	14/12/2021		4.29	N/E		1.40	2.89	N/E		3.03	1.26														1.63			

Table 6.2: Groundwater Observations

Exp. Hole	Standing Water Level During Monitoring							
	Struck		25/05/2021		08/06/2021		18/06/2021	
	m bgl	m ACD	m bgl	m ACD	m bgl	m ACD	m bgl	m ACD
WS01	2.00	-0.13	1.2	0.67	1.32	0.55	1.3	0.57
WS02A	3.50	1.44	2.27	2.67	2.33	2.61	2.38	2.56
WS03	1.90	4.18	2.33	3.75	2.39	3.69	2.41	3.67
WS04	1.60	2.69	1.58	2.71	1.68	2.61	1.84	2.45

6.2.4. The groundwater was struck within the superficial deposits in all locations (except WS02) and encountered at relatively shallow depths during the monitoring visits.

6.2.5. The details of installations, including response zones and return monitoring sheets are presented within the Factual Report included within Appendix C.

6.3. Soakaway Testing

6.3.1. One soakaway test was carried out in accordance with BRE Digest DG365:2016 [12]. The water depth did not change during the test indicating the site is not suitable for disposal of surface water runoff by infiltration drainage.

6.4. Percolation Testing

6.4.1. A single percolation test was undertaken in the south east corner of the site in accordance with BS 6297: 2007 + A1 2008. Due to the infiltration rate only two fills were undertaken. The results are included in Table 6.3.

Table 6.3: Percolation Test Results

Exploratory Hole	Elapsed time		Equivalent Infiltration Rate (m/s)
	Hrs/Mins/Secs	Seconds	
IT01	1 Hrs, 33 mins, 45 secs	5625	8.33 E -06
	2 Hrs, 36 mins, 48 secs	9408	5.19 E -06
	Average		6.76 E -06

6.5. Geotechnical Testing

8.4.3. Moisture content and Atterberg Limits

8.4.4. Two moisture content tests were undertaken on samples of the chalk recording 20% to 24%.

8.4.5. Two Atterberg Tests were undertaken due to the samples not being suitable for saturated moisture content and Intact Dry Density testing;

- Liquid Limit 22 - 27%
- Plastic Limit 16 - 23%
- Plasticity Index 4 - 6
- Passing 425µm 69 - 74%
- Classification Low plasticity Silt
- Modified PI 3 – 4% (low volume change potential [8])

8.4.6. Standard Penetration Tests (SPT)

8.4.7. Four SPT 'N' values were recorded in the chalk between 8 and 15 indicating a firm material.

8.5. Soakaway Tests

8.5.1. A single soakaway test was undertaken in the centre of the site. Due to the prominence of cohesive material no infiltration rate was recorded.

8.6. Percolation Tests

8.6.1. A single percolation test recorded an average infiltration rate of 6.76×10^{-6} m/s. Due to the low infiltration rate only two fills were undertaken.

8.7. Groundwater Conditions

8.7.1. Groundwater observations during the field and the subsequent monitoring are described in Section 7 and are summarised in Table 7.2.

8.7.2. During the May 2021 site investigation groundwater was struck in all locations except WS02. During the return monitoring visits standing water was recorded in all of the exploratory holes installed with monitoring wells at depths between 1.2m bgl to 2.4m bgl.

8.7.3. It should be noted that these readings were undertaken during the summer and shallower groundwater levels should be anticipated during the autumn and winter months.

8.7.4. The response zones (summarised in Table 7.1) included both the chalk and overlying superficial deposits in WS01 and WS03. The response zone in WS02A and WS04 was only within the overlying superficial deposits.

8.7.5. Minimal variation was recorded in the groundwater levels during the monitoring that was carried out between May and June 2021.

8.8. Buried Concrete

8.8.1. Two BRE Suite A tests were undertaken on cohesive samples of the superficial material recording 6mg/l and 5.5mg/l of water soluble SO₄ and pH values of 8.3 and 8.6 indicating a design sulphate class DS-1 and ACEC classification of AC-1 recommendation for concrete.

- 11.7.8. Groundwater ingress should be anticipated in areas of excavation and it is recommended that measures are put in place to mitigate against issues with instability such as piping, scour and slope failure caused by groundwater. Such measures could include the use of land drains as a long term solution.

11.8. Soakaway Drainage

- 11.8.1. Infiltration testing in accordance with BRE 365 was attempted however, no infiltration was recorded owing the fine grained cohesive nature of the superficial materials. A percolation test also indicated very low infiltration rates. The use of infiltration drainage devices on site is therefore considered unfeasible.
- 11.8.2. As per CIRIA 574 any soakaways should be kept a suitable distance away from any foundations (at least 20m where dissolution features are prevalent). Currently no dissolution features have been identified within the site however, due to the nature of chalk all soakaways should be at least 10m away from any foundations.
- 11.8.3. CIRIA C574 indicates the local authority and Environment Agency should be consulted when proposing soakaway installations in areas of chalk.

11.9. Floor slabs

- 11.9.1. Floor slabs will need to be suspended on the foundations owing to the variable thickness of the compressible material across the site.
- 11.9.2. The void dimensions to accommodate the occurrence of heave associated with any suspended floor slabs should be determined in accordance with chapter 4.2 of the NHBC Standards [8].

11.10. Road Pavements

- 11.10.1. Due to the thickness of firm to soft gravelly sandy clays across the majority of site and the low volume change potential for soils at the site, pavement surfaces should be constructed in flexible materials such as bituminous compounds or block paving which are more easily able to accommodate ground movement and can be more easily repaired. The formation level should be rolled and inspected for any soft or loose material. These materials should be removed and replaced with granular fill placed and compacted in accordance with suitable specification.
- 11.10.2. The clay dominant soils are considered to be frost susceptible.
- 11.10.3. Chalk should not be utilised as a capping layer unless good drainage is present.
- 11.10.4. Assuming excavation formation soils to comprise soft to firm clays and based on the formation preparation outlined above, a provisional CBR value of 2% is recommended. Testing is advised to validate this preliminary figure.
- 11.10.5. If road pavement are to be constructed on fill it is recommended that such fill is placed and compacted in accordance with a suitable specification based on the Specification for Highway Works. Pavement surfaces should be constructed in flexible materials such as bituminous compounds or block paving. The CBR value to be adopted would depend on nature of the fill specification adopted and the as built quality of the fill. Additional testing of the fill just prior to road construction is recommended, so as to confirm matters.