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Preliminary Geoenviromnmental Investigation

Whiterock Urban Extension, Paignton

WB03590 R2

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MULTIDISCIPLINARY ENGINEERING CONSULTANTS

Preliminary GeoEnvironmental Investigation

Report No.	Date.
WB03590 R2	November 2016

Project
Whiterock Urban Extension

Client Name
Deeley Freed Estates Limited

Issue Date/ Number	Status	Description of Amendments
30 Nov 2016	Final	-

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EXECUTIVE SUMMARY

Client	Deeley Freed Estates Limited
Site and Location	Land at White Rock, Goodrington, Paignton Approximate Grid Reference E288116, N57666.
Proposed Development	The proposed development comprises primarily housing, with associated infrastructure and green spaces.
History of Site and Surroundings	Currently the site comprises fields. The site has remained fields throughout its history with the Goodrington area to the north east becoming increasingly developed with housing. Former quarries lie just off of the site and one appears to lie on site. Fields (with some trees) bound the site to the west & south. The suggested tank on site appears to be a pond.
Ground Conditions	Investigation of the northern and southernmost fields was not possible due to crop and access constraints. Faults are suggested to exist on this site leading to: • Saltern Cove Formation – Mudstone, northern half of the site. • Brixham Limestone Formation – southern half of the site. No significant impacts from the faults have been found to date.
Hydrogeology & Hydrology	• A small historic pond exists in the east of the site, presently dry. Further ponds are suggested in the centre of the site, the centre of the west boundary, and the southwest. • The next nearest surface water is >1km away. • Groundwater was not encountered within 2.7m depth. • The strata under the site are Secondary 'A' and Principal Aquifers. • The site is not located within a Source Protection Zone. • A risk of Superficial Deposits Flooding has been highlighted within 50m of the wider site's boundary.
Geotechnical Considerations	**Excavations** • Should remain stable and dry in the short term. • Should be possible to >2m with conventional earthmoving plant. • Localised hard shallow bedrock may require breaking out. Reuse on site should be considered **Foundations & Ground Floor Slabs** • Shallow strip/pad foundations are likely to be suitable for the proposed development, but further investigation is recommended to confirm this. • Preliminary design wall loadings of 150kN/m run recommended for conventional foundations. Reinforcement required locally where foundations span different lithologies. • Suspended slabs likely to be required and will be required for the implementation of radon protection measures **Drainage** The soakaway results show that caution should be used when considering soakaway drainage. solutions, particularly within the Brixham Limestone Formation, due to a risk of solution features. These features are not always immediately visible or active during excavation, but appear to open due to the washout of fine materials during the course of the soakaways. Further testing should be completed, preferably at proposed locations based on the building layout. **Roads & Pavements & Slopes** A CBR of 3 % can be taken for preliminary design purposes. Depending on the soils/bedrock type, then slope angles could vary from 1:1 to 1:3
Environmental Considerations	**Soil Contamination** • No visual or olfactory indications of contamination have been found. Chemical testing remains to be undertaken. **Ground Gases and Radon** • Full radon protection is required. Gas risk has not currently been assessed. **Outline Strategy for Remediation & Risk Reduction** • Any topsoil and subsoil should be assessed for contamination prior to import.
Further Data and Investigation	Development specific investigation to delineate limestone and variation in ground conditions together with assessment of appropriate slope cutting angle for roads crossing the site. An invasive species survey should be considered.

1.0 INTRODUCTION

1.1 Instruction and Brief

Clarkebond (UK) Limited was commissioned by Deeley Freed Estates to undertake a Preliminary Geoenvironmental Investigation on a site known as White Rock Urban Extension, Paignton, Devon.

The proposed development comprises primarily housing, with associated infrastructure and green spaces.

1.2 Scope of Works

The main objectives of this preliminary investigation were to determine the sub-surface conditions in respect of:

- Assessment of the underlying geology
- Soakaway potential.

1.3 Limitations

This report is provided for the benefit only of the party to whom it is addressed and we do not accept responsibility to any third party for the whole or any part of the contents and we exercise no duty of care in relation to this report to any third party.

Subsoils are inherently variable and by their very nature are hidden from view such that no investigation can be exhaustive to the extent that all soil conditions are revealed. Conditions may therefore be present beneath the site that were not apparent from the data available for review. Similarly, this assessment has been based to some extent on third party data acquired and such data has been taken at face value and has not been subjected to any third party validation.

2.0 PHASE 1 ASSESSMENT

Clarkebond previously completed a Phase I Geoenvironmental Assessment of the site prior to the commencement of the intrusive site investigation works. The detailed findings of the assessment are included in:

- *Phase 1 Preliminary Risk Assessment, White Rock Urban Extension, for Deeley Freed Estates, October 2016, Ref WB03590.*

The main aspects are summarised in the following sections.

Site Location and Description
The site is located within 3.3km of the centre of the town of Paignton at approximate National Grid Reference E288116, N57666. A site location plan is presented as Figure 2.1.

The site comprises 6no. large pastoral and arable fields separated by hedges. The topography is gently undulating, with high points at the furthest north, furthest south and centre east of the site. The northern most field has been densely planted with mixed sapling trees which are to form a screen between this site and the adjacent development.

Some hedgerows contain mature trees. A small pond is present in the centre-far east of the site (between our trial pits TP5 and TP6) and at the time of visiting this was almost dry.

At the time of investigation full access to all the fields was not available due to access and crop issues. Further investigations are proposed in the southern area when crops have been harvested and in the northern field once access is permitted.

Geology
The northern end of the site is directly underlain by the Saltern Cove Formation (Mudstone and Limestone) of Devonian age. The southern half of the site is underlain by the Brixham Limestone Formation (Limestone) also of Devonian age. The maps show superficial Head deposits in the far southwest corner.

The geological maps sheets show the area to be heavily faulted. Two east-west trending thrust faults are shown between the Brixham Limestone and Saltern Cove Formation in the centre of the site. The Saltern Cove Formation is also faulted, with two north-south trending faults shown to be present beneath the western and eastern edges of the site.

Hydrology, Hydrogeology and Flood Risk
- A small pond is present in the east corner of the site. Further ponds are suggested in the centre of the site, the centre of the W boundary, and the SW corner.
- The underlying geologies are designated Secondary (A) and Principle aquifers.
- The nearest groundwater abstraction licence is 311m north and the site does not lie in or near any Source Protection Zone (SPZ).

Site History
The site has never undergone development through the map history. The surrounding area has localised areas of quarrying and lime kilns and there is a probable quarry pit in the south of the site. Residential expansion of the Goodrington area of Paignton begins in the 1930s.

Environmental Database
- An unspecified quarry (mapping suggests a coppice (near our pit TP3)) and unspecified tank are recorded to be present on site.
- Some former quarries lie just off the site.
- A gas governor is present on site.
- There is a Licenced Discharge Consent (sewage) at White Rock cottages on site.
- The surrounding area has numerous recorded sinkholes and solution pipes.
- Full Radon Protection is required for developments in this area.

3.0 PRELIMINARY CONCEPTUAL MODEL & RISK ASSESSMENT

The site characterisation identifies potential previous and existing site sources of contamination. The conceptual model links the identified sources likely to cause significant possibility of significant harm via pathways to identified critical receptors. It is therefore based on a number of identified source-pathway-receptor scenarios. For land to be classified as contaminated a significant pollutant linkage needs to be identified which will include each component of the conceptual model. The absence or removal of a source or interception of a pathway will 'break' the pollutant linkage. The conceptual model is characterised by identification of the following:

- **On-site** sources, which may impact **on-site** receptors via plausible pathways.
- **On-site** sources, which may impact **off-site** receptors via plausible pathways.
- **Off-site** sources, which may impact **on-site** receptors via plausible pathways.

In the event of a change of land use, the planning regime will require assessment of the new development layout within the context of the sources or risk and introducing new exposure pathways. The assessment is also used to determine if the site would class as contaminated land under the definition in Part 2A of the Environment Act 1990 as defined in the Environment Protection Act 1995. A preliminary conceptual model is indicated in Tables 3.1 and 3.2.

Table 3.1 On-Site to On-Site Source - Pathway - Receptor Model

Source		Pathway	Receptor	Probability	Consequence	Potential Risk?
General	**Hazard**					
Total soils concentrations (e.g. heavy metals and hydrocarbons as general impact from former site usage) Pesticides and Herbicides	Contamination of groundwater	Migration of leachate through unsaturated zone; Then Migration through saturated zone/groundwater	Groundwater and/or surface waters, and/or eco-system	Unlikely	Mild	Very Low
	Human health	Ingestion & dermal contact with soil & household dust; Inhalation of indoor & outdoor fugitive dust).	Human beings	Unlikely	Medium	Low
	Vegetation poisoning	Uptake by plant roots	Plants	Unlikely	Mild	Very Low
Natural limestone	Carbon Dioxide Asphyxiation	Preferential flow paths **into buildings** (drains, service runs, wall cavities, piles etc.); Inhalation of indoor gases	Human beings	Low Likelihood	Severe	Moderate
Radon Gas from natural soils/rocks (radionuclides)	Damage to lung tissue and/or Carcinogenic effects			Likely	Severe	High

Table 3.2 On-Site to Off-Site Source - Pathway - Receptor Model

Source		Pathway	Receptor	Probability	Consequence	Potential Risk
General	**Hazard**					
Total soils concentrations (e.g. heavy metals and hydrocarbons as general impact from former site usage) Pesticides and Herbicides	Contamination of groundwater	Migration of leachate through unsaturated zone; Migration through saturated zone/groundwater;	Groundwater and/or surface waters, and/or eco-system	Unlikely	Mild	Very Low
	Human health	Ingestion & dermal contact with soil & household dust; Inhalation of indoor & outdoor fugitive dust).	Human beings	Likely	Medium	Very Low
	Vegetation poisoning.	Uptake by plant roots	Plants	Unlikely	Mild	Very Low
Natural limestone	Carbon Dioxide Asphyxiation	Preferential flow paths **into buildings** (drains, service runs, wall cavities, piles etc.); Inhalation of indoor gases	Human beings	Low Likelihood	Severe	Moderate
Radon Gas from natural soils/rocks (radionuclides)	Damage to lung tissue and/or Carcinogenic effects			Likely	Severe	High

4.0 SITE INVESTIGATION

A preliminary intrusive site investigation, using trial pits, was carried out between 20th and 21st September 2016. The main focus for the investigation was soakaway testing to aid flood risk and preliminary drainage design for planning. The holes are summarised as follows:

Table 4.1 – Exploratory Hole Details

Exploratory Hole ID	Technique	Hole Depth (mBGL)	Comments & Reasons for Holes
TP1-TP9	Machine Excavated Trial Pit	1.1-2.7	For geological assessment and soakaway potential

A plan showing the exploratory hole and test locations is presented as Figure 3.1.

9nr trial pits, designated TP1 to TP9 inclusive, were excavated using a JCB-3CX type excavator. The trial pits were logged by an onsite engineer. On completion the pits were backfilled with excavated spoil and compacted.

Some fields are currently not accessible due to crop planting and further investigations will be completed in the spring.

Detailed log sheets of the trial pits are included in Appendix A. Photographs of the trial pits are included in Appendix B.

Soakaway tests were undertaken in TP1 to TP9 (TP7 was not undertaken due to time constraints) in general accordance with recommended practice given in BRE Digest 365.

Three fillings of the pits were not always undertaken due to slow infiltration rates, time constraints and instability of the pits. The results are contained in Appendix C.

5.0 GROUND CONDITIONS

5.1 General

The following tables provide a summary of the strata encountered and the depth to the base of each stratum in metres encountered in the exploratory holes.

Table 5.1 – Typical Strata: North of Site (TP1-TP4, TP6-TP8)

Strata	Depth Encountered (mBGL)		Typical Thickness (m)	Description & Comments
	Top	Bottom		
Topsoil	0.0	0.1-0.3	0.2	Red brown locally gravelly slightly SILT. 0.8m in TP8.
Saltern Cove Formation (Mudstone)	0.25	>1.10	Unknown	Weak slatey purplish grey MUDSTONE recovered as tabular slatey gravel, becoming more competent with depth
Saltern Cove Formation (Mudstone and Limestone)	0.1-0.3	>2.7m	Unknown	Firm to stiff red brown SILT/CLAY, with cobbles and boulders of hard sugary grey limestone. Locally pockets of ashy grey silt, soft black silt Grading to pinkish red stiff clay/weak waxy MUDSTONE.

Table 5.2 – Typical Strata: South of Site (TP5, TP9)

Strata	Depth Encountered (mBGL)		Typical Thickness (m)	Description & Comments
	Top	Bottom		
Topsoil	0.0	0.15	0.2	Red brown locally gravelly slightly silt. Absent in TP9.
Saltern Cove Formation (Mudstone and Limestone)	0.15	0.3, 1.6	-	Red brown silt, occasionally gravelly
Brixham Limestone Formation	0.3, 1.6	>1.1, >1.9	Unknown	Hard light grey sugary fractured LIMESTONE, recovered as polygonal gravel and cobbles, becoming more competent with depth. Or LIMESTONE boulders

Groundwater was not encountered during the investigation

5.2 Strata Encountered

Topsoil across the site was fairly consistent, being reddish orange brown silt with fine rootlets. This was variably gravelly; more where rock was at shallow depth, as in TP1 and TP9.

The Saltern Cove Formation is a mixed formation of mudstones, limestone and Tuff, often complexly interbedded. The limited trial pitting suggests that the central area is underlain by the Saltern, with the Brixham limestone only encountered in one trial pit to the south.

TP1 (furthest north) differed from the other pits within this Saltern unit, in that it recovered the Saltern as a weak silvery purple slatey mudstone rock at shallow depth, refusing in more competent rock at 1.1m depth.

TP2-TP8 predominantly encountered firm to stiff red brown silty clay, grading to a pinkish red weak waxy mudstones after around 1.0m depth, recovered as silty gravel and gravelly silt. The pits within this material refused in hard reddish purple mudstone at around 2.0-2.7m depth. Locally were bands and inclusions of boulders of hard sugary limestone.

TP3 encountered a layer of boulders of limestone between 1.3m and 2.2m depth. Amongst the boulders were highly variable pockets of soft black silt, orange silty clay and white ashy silt. TP8 encountered similarly variable materials between 1.6m to the final depth of 2.5m. The black material is likely to be umber (volcanic ash deposit) and it is this material that has been washed out between limestone horizons elsewhere in the Whiterock area.

The Brixham Limestone was only encountered in TP9 on the brow of the hill in the southern side of the site (TP5 was in a similar locality and elevation). The change in lithology could be seen in the increased cobbles and gravel scattered on the surface of the grass in this area. The limestone was encountered below 0.3m of very gravelly topsoil, and was light grey, sugary and recovered as polygonal angular gravel and cobbles. The unit became more competent with depth, refusing at 1.1m.

5.3 Contamination Indications

There were no visual or olfactory indications of contamination noted during the site works.

6.0 GEOTECHNICAL ASSESSMENT

6.1 Introduction

The current development proposals are primarily residential with associated infrastructure and greenspace. There are some areas of commercial development, likely to be 2-3 storey office type buildings.

According to the structural engineers, column loads for the commercial developments are likely to be in the order of 1500kN. For residential, for standard construction wall loading, 90-120kN/m run of wall for a 2-3 storey buildings respectively.

6.2 Earthworks

Any areas of particularly poor quality, i.e. wet, soft, loose etc, should be removed from beneath all proposed foundation and hardstanding areas, and the deficit made good with suitable compacted granular fill to an engineering specification. Excavations to 2.0m depth should be suitable with conventional soil excavating machinery, although pneumatic tools are likely to be required to break out shallow bedrock where encountered. Further investigation based on a development proposal should be completed to delineate particularly the areas of shallow depth limestone.

Surplus spoil resulting from excavations that could be reused as structural fill is as follows, otherwise it could be reused as general fill (e.g., landscape areas), or would require off-site disposal:

Soil/rock type	Reuse as engineered fill?
Firm silt/clay	Unlikely without treatment (e.g. drying or cement/lime stabilisation)
Stiff and very stiff silt/clay	Yes provided protected from significant rain prior to laying
Mudstone	Argillaceous material is crushable and if considered as an engineering fill will require special consideration and treatment. These materials will deteriorate when left exposed to rain, diminishing their suitability.
Limestone bedrock, limestone cobbles/boulders and limestone gravels, encountered at various depths in the SW half of the site	It may be possible to (crush and) grade and reuse as an engineered fill.

It is unlikely that shallow excavations will encounter significant groundwater.

Excavations below approximately 1m depth will require sheeting and shoring for personnel to enter safely. The stability of all excavations will deteriorate on wetting either from groundwater or surface water. Excavations should therefore be protected from rain and surface water runoff.

6.3 Foundation Assessment

Foundations should be seated into the Saltern Cove Formation or Brixham Limestone Formation that underlies the site. Taking account of the strata revealed by this investigation shallow strip foundations are likely to be suitable for much of the development area. The investigations have not encountered deep soft deposits yet, which have been found on nearby sites and which were related to faults. Faults are suggested to exist on this site

Further geotechnical assessment is recommended to confirm the bearing capacities of these units as well as mapping the areas of limestone, as these will be the areas that need additional assessment in terms of potential for voids in the limestone or solution features.

For preliminary guidance design wall loadings of 150kN/m run would be recommended. Localised reinforcement will be required where foundations span across formations of different settlement characteristics.

Foundations may need to be deepened if they lie in the within the influencing distance of either existing trees that are to be retained, or new ones that are to be planted.

All foundation formations should be inspected and approved by a suitably qualified geotechnical engineer. Any 'soft' spots where exposed should be excavated and replaced with suitably compacted engineering fill.

6.4 Floor Slabs

Suspended slabs likely to be required (due to site slope and likely volume change potential) and will be required for the implementation of radon protection measures.

6.5 Roads and Pavements

No DCP testing has been undertaken. Such should be carried out prior to construction or when formation level has been reached (which may increase the design CBR). The shallow depth formation does however appear to be relatively competent and a CBR of 3 % can be taken for preliminary design purposes.

The CBR values on limestone formation will be considerably higher.

Where the formation is mudstone and shale this will deteriorate when exposed to the weathered and will require protection with imported granular fill. Consideration should be given to reuse of site won limestone if this is encountered and likely to be excavated in enough volume.

6.6 Slope Stability

Some of the roads crossing the site are likely to be in cutting. The stability of excavated slopes will greatly depend on, and will vary with, the formation.

Where the cutting is in limestone, slope angles of 1:1 or greater should be achievable without remediation. Any steeper angles and there is a risk of block failures, or the requirement for stabilisation though bolting or netting.

For clay and mudstone slope angles are likely to be closer to 1:2 or 1:3. The mudstones and shales that have been encountered do not appear to be highly cleaved. The intersection of the cleavage and the cut slope would determine the angle of repose. If the cleavage is close to or parallel to the slope this can lead to progressive failure and ravelling of the slope, which means the base of the slope is taken further from the road with more land take as this will result in continued build-up of detritus at the base of the slope. Site specific investigations along the lines of cutting will determine the most effective angle of repose.

6.7 Drainage

Soakaway infiltration was undertaken in all trial pits apart from TP7. The results are contained in Appendix C and are summarised in the following table.

Time constraints did not allow a full test in TP7. A small amount of water was added and showed no infiltration in 30 minutes.

The values (factored in accordance CIRIA 156 (1996) Infiltration Drainage – Manual of Good Practice) may be used for design of soakaways in accordance with BRE Digest 365.

Table 6.1 – Soakaway Results

Trial Pit	Test Depth range (mbegl)	Corresponding Stratum	Soil Infiltration Rate (m/s)
TP1	0.38-1.1	Saltern Cove - Mudstone	3.38E-05
TP2	1.23-2.0	Saltern Cove - Mudstone	4.83E-05
TP3	1.17-2.2	Saltern Cove - Mudstone	3.26E-04*
TP4	1.03-2.0	Saltern Cove - Mudstone	1.09E-05
TP5	0.96-1.9	Saltern Cove - Mudstone	7.22E-06
TP6	1.58-2.7	Saltern Cove - Mudstone	6.44E-06
TP8	1.54-2.5	Saltern Cove - Mudstone	3.94E-05
TP9	0.38-1.1	Brixham Limestone	3.43E-05*

*The soakaways in TP3 and TP9 did not yield typical results due to the opening of fissures in the base of the pits. TP3 opened up during the course of the first fill. TP9 underwent two full standard soaks, however during the third fill a fissure opened in the base of the pit, causing a sudden emptying of the water. Photos of this fissure are shown on Plates 19 -20 in Appendix B.

The results suggest that conventional soakaway drainage may be feasible locally into the underlying Saltern Cove Formation

These results show that caution should be used when considering soakaway drainage solutions, particularly within the Brixham Limestone Formation, due to a risk of solution features. These features are not always immediately visible or active during excavation, but appear to open due to the washout of fine materials during the course of the soakaways. Further testing should be completed, preferably at proposed locations based on the building layout.

6.8 Radon Risk to Humans

The environmental data sheets state that **Full Radon protection** measures are required for new buildings or extensions on site.

6.9 Further Data and Investigation

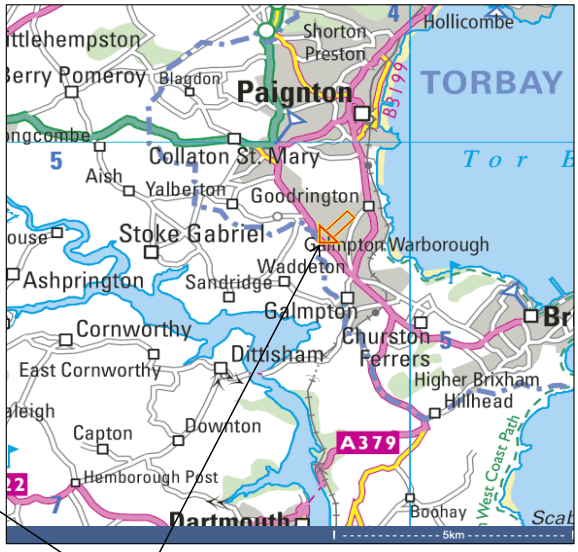
This investigation offers a preliminary assessment of likely ground conditions underlying the site and the potential for a soakaway drainage solution in future developments.

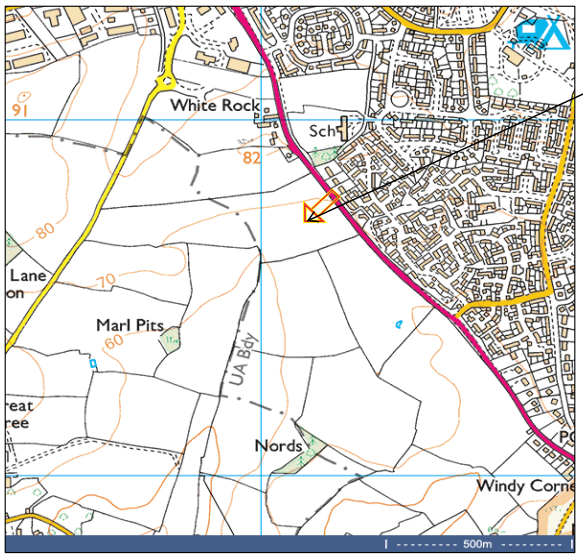
The ground conditions across this site are likely to be highly variable and it is recommended site-specific investigations are completed to determine the most appropriate foundation designs for the development.

Most notably further investigation should target:

- the nature of the soils around the historic pond and around the coppice/quarry.
- the nature of and any impacts from, the 4nr fault lines criss-crossing the site,
- the presence and implications of any voided zones under the site.

FIGURES





Site Centre (approximate):

OS X (Eastings) 288116
OS Y (Northings) 57666

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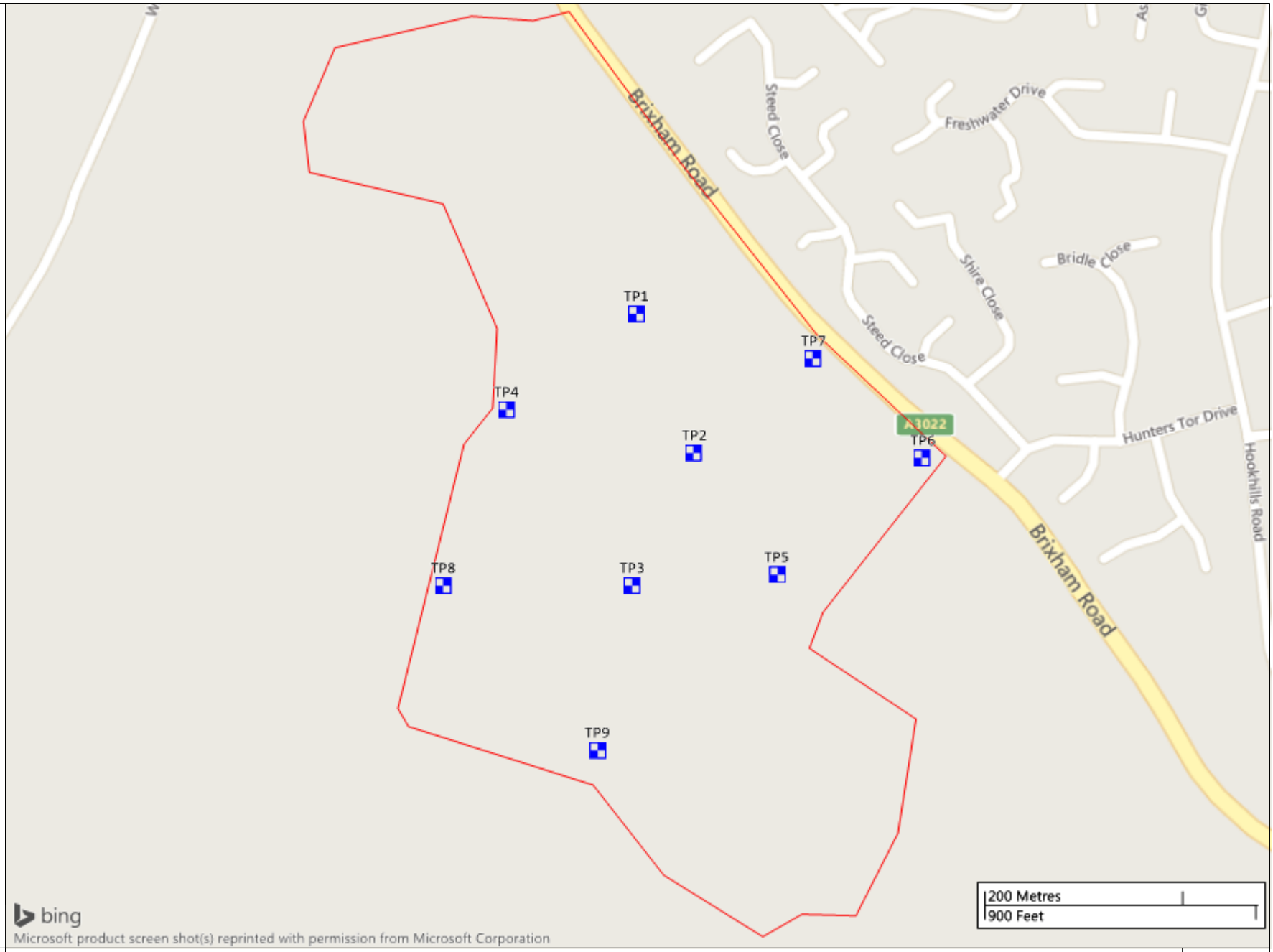
Project: White Rock Urban Extension Phase II Preliminary Geoenvironmental Investigation		Drawn: CS	Scale: NTS
		Checked: CW	Date: Oct-16
Title: Site Location Plan		Status: Final Issue	
		Figure No. WB03590/R1 Figure 2.1	Rev. 0

Legend Key

Locations By Type - TP

Project Bounds - Project…



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Exploratory Hole Location Plan

Project Number: WB03590

Project Name: White Rock Urban Extension

Figure: **4.1**

APPENDICES

A - Exploratory Hole Logs (9 A4 Sheets)
B - Trial Pit Photographs (5 A4 Sheets)
C - Soakaway Results (8 A4 Sheets)

A - Exploratory Hole Logs **(9 A4 Sheets)**

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Trial Pit Log

Trial Pit No.: **TP1**

Project Name:	White Rock Urban Extension	Co-Ordinates: 288142 E , 57622 N	Start: 20/09/2016
Project Number:	WB03590	Ground Level (m OD):	End: 20/09/2016

Samples and In Situ Testing			Depth (m)	Level (m OD)	Legend	Stratum Description	Water Strike	Well
Depth (m)	Type	Results						
			0.25			Brown very gravelly SAND. Gravel of fine to coarse tabular silvery purple mudstone TOPSOIL		
						Weak slatey purplish grey MUDSTONE recovered as fine to coarse tabular gravel and cobbles becoming increasingly competant with depth SALTERN COVE FORMATION		
			1.10			End of Borehole at 1.10m		

0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0

2.00

0.45

General Remarks:
Soakaway test attempted

Logged By: CS

Approved By: CW

Scale: 1:25

Stability:

Shoring: None

Method/Plant Used: JCB-3CX

Sheet 1 of 1

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Trial Pit Log

Trial Pit No.: **TP2**

Project Name:	White Rock Urban Extension	Co-Ordinates: 288198 E , 57480 N	Start: 20/09/2016
Project Number:	WB03590	Ground Level (m OD):	End: 20/09/2016

Samples and In Situ Testing			Depth (m)	Level (m OD)	Legend	Stratum Description	Water Strike	Well
Depth (m)	Type	Results						
			0.10			Dry orange brown SILT with fine rootlets TOPSOIL Dry firm to stiff orange brown SILT SALTERN COVE FORMATION		
			1.10			Stiff waxy shiney pinkish red SILT/CLAY with rare cobbles of hard grey limestone SALTERN COVE FORMATION		
			1.30			Pinkish red clayey BOULDERS of hard grey nodular limestone. SALTERN COVE FORMATION		
			2.20			End of Borehole at 2.20m		

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0

2.00

0.45

General Remarks:
Soakaway test attempted

Logged By: CS

Approved By: CW

Scale: 1:25

Stability:

Shoring: None

Method/Plant Used: JCB-3CX

Sheet 1 of 1

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Trial Pit Log

Trial Pit No.: **TP3**

Project Name:	White Rock Urban Extension	Co-Ordinates: 288132 E , 57347 N	Start: 20/09/2016
Project Number:	WB03590	Ground Level (m OD):	End: 20/09/2016

Samples and In Situ Testing			Depth (m)	Level (m OD)	Legend	Stratum Description	Water Strike	Well
Depth (m)	Type	Results						
			0.25			Dry orange brown SILT with fine rootlets TOPSOIL		
						Dry firm to stiff orange brown SILT. Locally brown, and locally pinkish with fine gravel of hard mudstone SALTERN COVE FORMATION		
			1.10			Light pinkish red slightly sandy SILT/CLAY with gravel and cobbles of red medium sandstone SALTERN COVE FORMATION		
			1.30			Clayey pinkish red BOULDERS of sugary nodular grey limestone with pockets of soft black silt and inclusions of white ashy silt and orange silty clay SALTERN COVE FORMATION		
			2.20			End of Borehole at 2.20m		

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0

2.20

0.45

General Remarks:
Soakaway test attempted. Fissure opened in the base of the pit after 1 soak. Further tests abandoned.

Logged By: CS

Approved By: CW

Scale: 1:25

Stability:

Shoring: None

Method/Plant Used: JCB-3CX

Sheet 1 of 1

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Trial Pit Log

Trial Pit No.: **TP4**

Project Name:	White Rock Urban Extension	Co-Ordinates: 288008 E , 57528 N	Start: 20/09/2016
Project Number:	WB03590	Ground Level (m OD):	End: 20/09/2016

Samples and In Situ Testing			Depth (m)	Level (m OD)	Legend	Stratum Description	Water Strike	Well
Depth (m)	Type	Results						
			0.20			Red brown SILT TOPSOIL		
			0.70			Red brown silty fine to medium subangular to subrounded GRAVEL of grey sugary limestone SALTERN COVE FORMATION		
			1.30			Waxy purple brown gravelly SILT. Gravel of fine to coarse mudstone. SALTERN COVE FORMATION		
			2.00			Weathered silvery purple MUDSTONE recovered as fine to coarse silty gravel SALTERN COVE FORMATION		
						End of Borehole at 2.00m		

Water Strike scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0

2.00

0.45

General Remarks:
Soakaway test attempted

Logged By: CS

Approved By: CW

Scale: 1:25

Stability:

Shoring: None

Method/Plant Used: JCB-3CX

Sheet 1 of 1

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Trial Pit Log

Trial Pit No.: **TP5**

Project Name:	White Rock Urban Extension	Co-Ordinates: 288279 E , 57355 N	Start: 20/09/2016
Project Number:	WB03590	Ground Level (m OD):	End: 20/09/2016

Samples and In Situ Testing			Depth (m)	Level (m OD)	Legend	Stratum Description	Water Strike	Well
Depth (m)	Type	Results						
			0.15			Grass over orange brown SILT with fine rootlets TOPSOIL		
						Orange brown locally light and darker orange SILT with rare fine limestone gravel SALTERN COVE FORMATION		
			0.90			Dark orange brown slightly gravelly waxy SILT. Gravel of fine to medium dark brown/black mudstone. Inclusions of white ash. SALTERN COVE FORMATION		
			1.60			Silty nodular BOULDERS of sugary grey/white limestone BRIXHAM LIMESTONE FORMATION		
			1.90			End of Borehole at 1.90m		

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0

2.00

0.45

General Remarks:
Soakaway test attempted

Logged By: CS

Approved By: CW

Scale: 1:25

Stability:

Shoring: None

Method/Plant Used: JCB-3CX

Sheet 1 of 1

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Trial Pit Log

Trial Pit No.: **TP6**

Project Name:	White Rock Urban Extension	Co-Ordinates: 288430 E , 57470 N	Start: 20/09/2016
Project Number:	WB03590	Ground Level (m OD):	End: 20/09/2016

Samples and In Situ Testing			Depth (m)	Level (m OD)	Legend	Stratum Description	Water Strike	Well
Depth (m)	Type	Results						
			0.20			Firm red brown slightly sandy SILT with rare fine limestone gravel TOPSOIL		
						Waxy purplish red brown completely weathered MUDSTONE recovered as fine to medium gravel and silt. SALTERN COVE FORMATION		
			2.50			Grey/black BOULDERS of sugary limestone SALTERN COVE FORMATION		
			2.60			Hard reddish purple MUDSTONE recovered as angular cobbles and gravel SALTERN COVE FORMATION		
			2.70			End of Borehole at 2.70m		

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0

2.10

0.45

General Remarks:
Soakaway test attempted

Logged By: CS

Approved By: CW

Scale: 1:25

Stability:

Shoring: None

Method/Plant Used: JCB-3CX

Sheet 1 of 1

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Trial Pit Log

Trial Pit No.: **TP7**

Project Name:	White Rock Urban Extension	Co-Ordinates: 288321 E , 57573 N	Start: 20/09/2016
Project Number:	WB03590	Ground Level (m OD):	End: 20/09/2016

Samples and In Situ Testing			Depth (m)	Level (m OD)	Legend	Stratum Description	Water Strike	Well
Depth (m)	Type	Results						
			0.15			Firm red brown slightly sandy SILT with rare fine limestone gravel TOPSOIL		
						Friable orange red brown waxy SILT SALTERN COVE FORMATION		
			1.10			Shiney pinkish red slightly gravelly waxy SILT. Gravel of very weak dark grey mudstone SALTERN COVE FORMATION		
						excavator teeth scraping into harder mudstone		
			2.50			End of Borehole at 2.50m		

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0

2.10

0.45

General Remarks:
No soakaway completed

Logged By: CS

Approved By: CW

Scale: 1:25

Stability:

Shoring: None

Method/Plant Used: JCB-3CX

Sheet 1 of 1

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Trial Pit Log

Trial Pit No.: **TP8**

Project Name:	White Rock Urban Extension	Co-Ordinates: 287940 E , 57351 N	Start: 21/09/2016
Project Number:	WB03590	Ground Level (m OD):	End: 21/09/2016

Samples and In Situ Testing			Depth (m)	Level (m OD)	Legend	Stratum Description	Water Strike	Well
Depth (m)	Type	Results						
						Red brown slightly sandy SILT TOPSOIL		
			0.80			Red brown silty BOULDERS of limestone SALTERN COVE FORMATION		
			1.00			Pinkish red very gravelly SILT. Gravel of fine to medium mudstone. Occasional cobbles and boulders of limestone SALTERN COVE FORMATION		
			1.60			Firm to stiff dark greyish brown slightly sandy slightly gravelly silty CLAY. Gravel of very weak mudstone. SALTERN COVE FORMATION *occasional boulders and cobbles of limestone* *inclusions of orange silty sand and pockets of soft black silty*		
			2.50			End of Borehole at 2.50m		

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0

2.30

0.45

General Remarks:
Soakaway test attempted

Logged By: CS

Approved By: CW

Scale: 1:25

Stability:

Shoring: None

Method/Plant Used: JCB-3CX

Sheet 1 of 1

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Trial Pit Log

Trial Pit No.: **TP9**

Project Name:	White Rock Urban Extension	Co-Ordinates: 288093 E , 57181 N	Start: 21/09/2016
Project Number:	WB03590	Ground Level (m OD):	End: 21/09/2016

Samples and In Situ Testing			Depth (m)	Level (m OD)	Legend	Stratum Description	Water Strike	Well
Depth (m)	Type	Results						
			0.30			Red brown very gravelly slightly sandy SILT SALTERN COVE FORMATION		
						Hard light grey sugary LIMESTONE recovered as polygonal angular gravel and cobbles BRIXHAM LIMESTONE FORMATION		
			1.10			End of Borehole at 1.10m		

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0

2.20

0.45

General Remarks:
Soakaway test attempted. Fissure opened in the base of the pit after 2 soaks.

Logged By: CS

Approved By: CW

Scale: 1:25

Stability:

Shoring: None

Method/Plant Used: JCB-3CX

Sheet 1 of 1

B - Trial Pit Photographs **(5 A4 Sheets)**

	
Plate 1 – TP1	***Plate 2 – TP1 Spoil***
	
Plate 3 – TP2	***Plate 4 – TP2 Spoil***

	
Plate 5 – TP3 showing the water running into a fissure in the bottom right hand corner	***Plate 6 – TP3 Spoil***

	
Plate 7 – TP4	***Plate 8 – TP4 Spoil***

	
Plate 9 - TP5	***Plate 10 – TP5 Spoil***

	
Plate 11 – TP6	***Plate 12 – TP6 Spoil***

	
Plate 13 – TP7	***Plate 14 – TP7 Spoil***

	
Plate 15 – TP8	***Plate 16 – TP8 Spoil***

	
Plate 17 – TP9	***Plate 18 – TP9 Spoil***
	
Plate 19 – TP9 showing the fissure in the base	***Plate 20 - TP9 showing the fissure in the base***

C - Soakaway Results **(8 A4 Sheets)**

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SOIL INFILTRATION RATE TEST

(B.R.E. Digest 365, 1991, Soakaway Design)

Site:	White Rock Urban Extensio
Job Number:	WB03590
Date of Test:	20/09/16

Trial Pit Number:	TP1
Length (m):	2.00
Width (m):	0.45
Depth (mbegl):	1.10
Groundwater Depth# (mbegl):	

#: not used in calculations but ensure > pit base

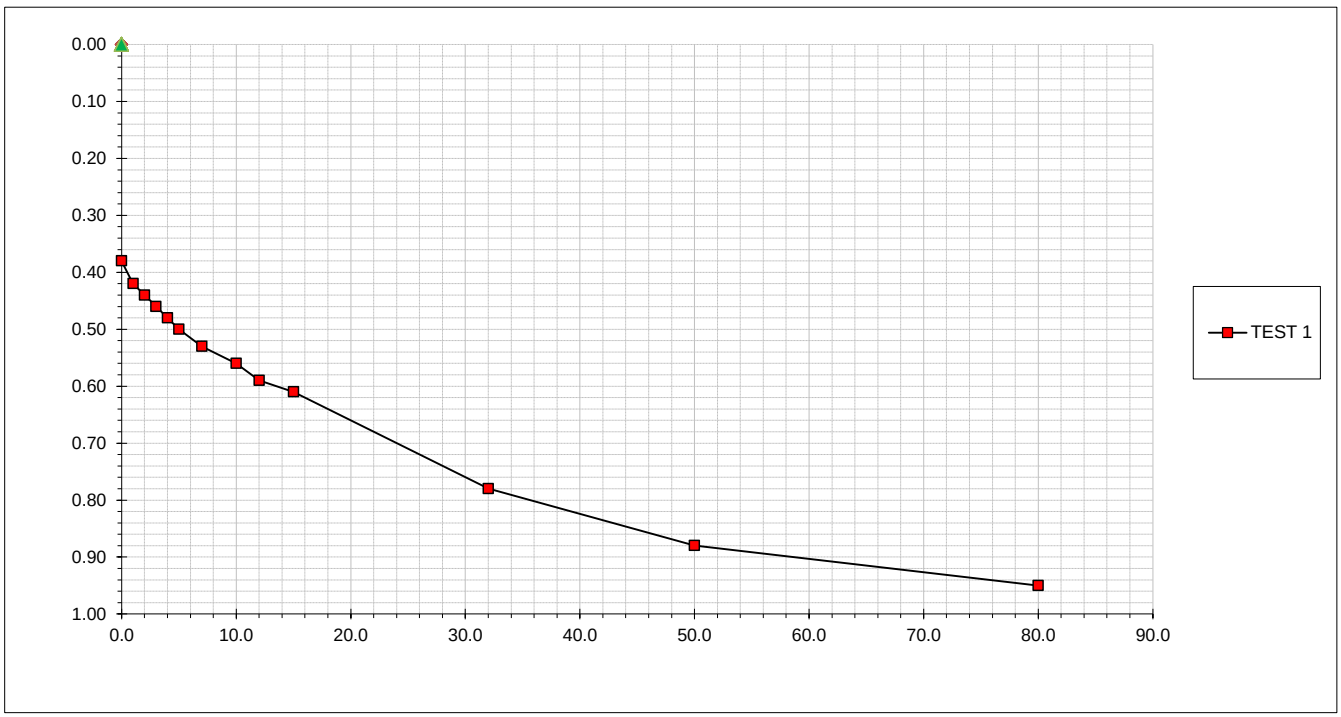
Remarks -

One fill only due to water and distance constraints

TEST 1		TEST 2		TEST 3	
Time(min)	Depth to Water (m)	Time(min)	Depth to Water (m)	Time(min)	Depth to Water (m)
0	0.38				
1	0.42				
2	0.44				
3	0.46				
4	0.48				
5	0.50				
7	0.53				
10	0.56				
12	0.59				
15	0.61				
32	0.78				
50	0.88				
80	0.95				

Effective Storage Depth	m	0.72			
75% Effective Storage Depth	m	0.54			
(i.e. depth below GL)	m	0.56			
25% Effective Storage Depth	m	0.18			
(i.e. depth below GL)	m	0.92			
Effective Storage Depth 75%-25%	m	0.36			
Time to fall to 75% effective depth	mins	10.00			
Time to fall to 25% effective depth	mins	70.00			
V (75%-25%)	m3	0.32			
a (50%)	m2	2.66			
t (75%-25%)	mins	60.00			
SOIL INFILTRATION RATE	m/s	**3.38E-05**			

DESIGN SOIL INFILTRATION RATE, f **3.38E-05 m/s**



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SOIL INFILTRATION RATE TEST

(B.R.E. Digest 365, 1991, Soakaway Design)

Site:	White Rock Urban Extensio
Job Number:	WB03590
Date of Test:	20/09/16

Trial Pit Number:	TP2
Length (m):	2.00
Width (m):	0.45
Depth (mbegl):	2.20
Groundwater Depth# (mbegl):	

#: not used in calculations but ensure > pit base

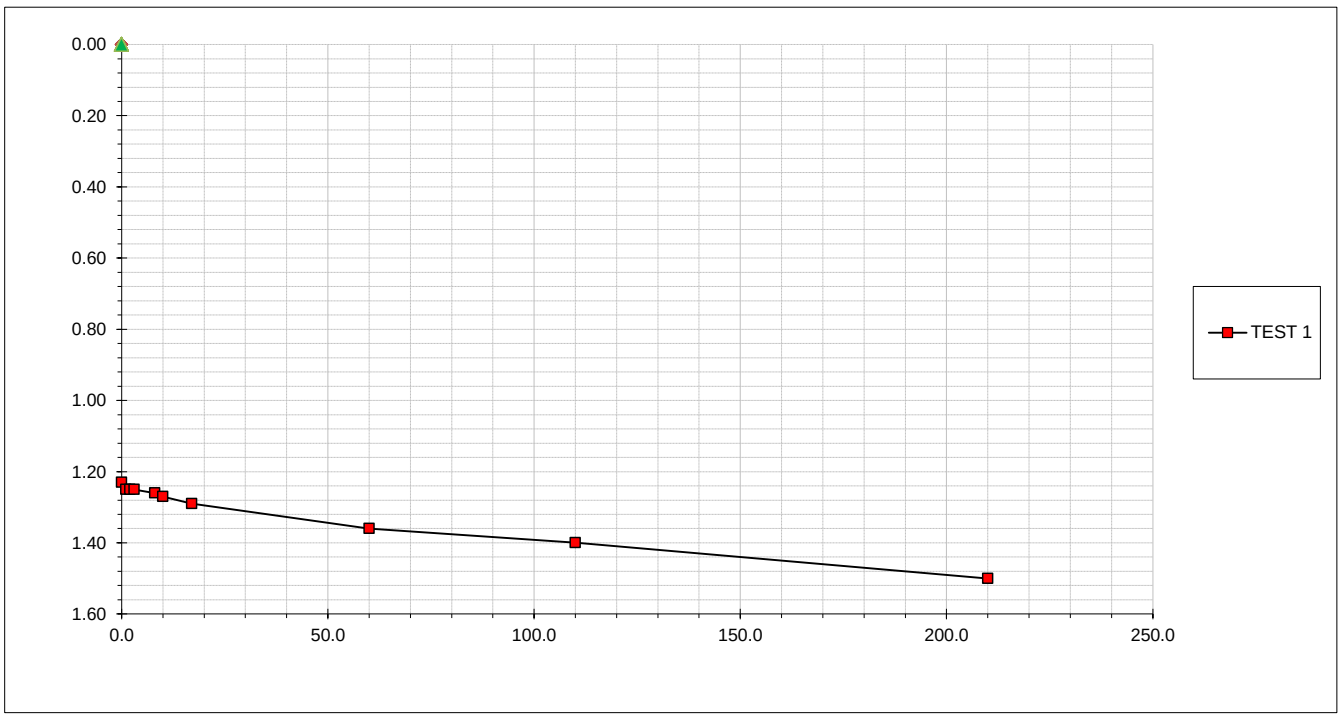
Remarks -

One fill only due to slow infiltration rates

TEST 1		TEST 2		TEST 3	
Time(min)	Depth to Water (m)	Time(min)	Depth to Water (m)	Time(min)	Depth to Water (m)
0	1.23				
1	1.25				
2	1.25				
3	1.25				
8	1.26				
10	1.27				
17	1.29				
60	1.36				
110	1.40				
210	1.50				

		TEST 1	TEST 2	TEST 3
Effective Storage Depth	m	0.97		
75% Effective Storage Depth	m	0.73		
(i.e. depth below GL)	m	1.47		
25% Effective Storage Depth	m	0.24		
(i.e. depth below GL)	m	1.96		
Effective Storage Depth 75%-25%	m	0.49		
Time to fall to 75% effective depth	mins	180.00		
Time to fall to 25% effective depth	mins	640.00		
V (75%-25%)	m3	0.44		
a (50%)	m2	3.28		
t (75%-25%)	mins	460.00		
SOIL INFILTRATION RATE	m/s	**4.83E-06**		

DESIGN SOIL INFILTRATION RATE, f **4.83E-06 m/s**



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SOIL INFILTRATION RATE TEST

(B.R.E. Digest 365, 1991, Soakaway Design)

Site:	White Rock Urban Extensio
Job Number:	WB03590
Date of Test:	20/09/16

Trial Pit Number:	TP3
Length (m):	2.20
Width (m):	0.45
Depth (mbegl):	2.20
Groundwater Depth# (mbegl):	

#: not used in calculations but ensure > pit base

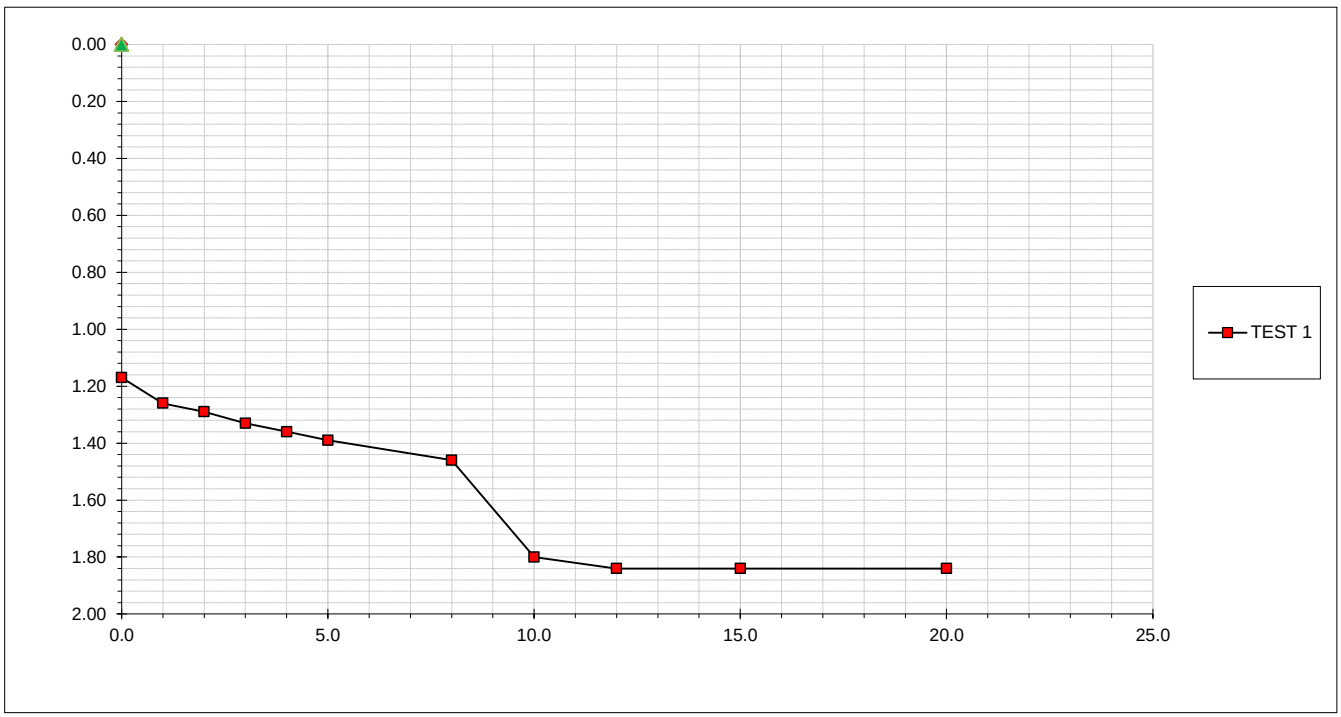
Remarks -

Fissure opened in the base of the pit. Further soakaway testing

TEST 1		TEST 2		TEST 3	
Time(min)	Depth to Water (m)	Time(min)	Depth to Water (m)	Time(min)	Depth to Water (m)
0	1.17				
1	1.26				
2	1.29				
3	1.33				
4	1.36				
5	1.39				
8	1.46				
10	1.80				
12	1.84				
15	1.84				
20	1.84				

		TEST 1	TEST 2	TEST 3
Effective Storage Depth	m	1.03		
75% Effective Storage Depth	m	0.77		
(i.e. depth below GL)	m	1.43		
25% Effective Storage Depth	m	0.26		
(i.e. depth below GL)	m	1.94		
Effective Storage Depth 75%-25%	m	0.52		
Time to fall to 75% effective depth	mins	7.00		
Time to fall to 25% effective depth	mins			
V (75%-25%)	m3	0.51		
a (50%)	m2	3.72		
t (75%-25%)	mins	-7.00		
SOIL INFILTRATION RATE	m/s	**-3.26E-04**		

DESIGN SOIL INFILTRATION RATE, f **-3.26E-04 m/s**



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SOIL INFILTRATION RATE TEST

(B.R.E. Digest 365, 1991, Soakaway Design)

Site:	White Rock Urban Extensio
Job Number:	WB03590
Date of Test:	20/09/16

Trial Pit Number:	TP4
Length (m):	2.00
Width (m):	0.45
Depth (mbegl):	2.00
Groundwater Depth# (mbegl):	

#: not used in calculations but ensure > pit base

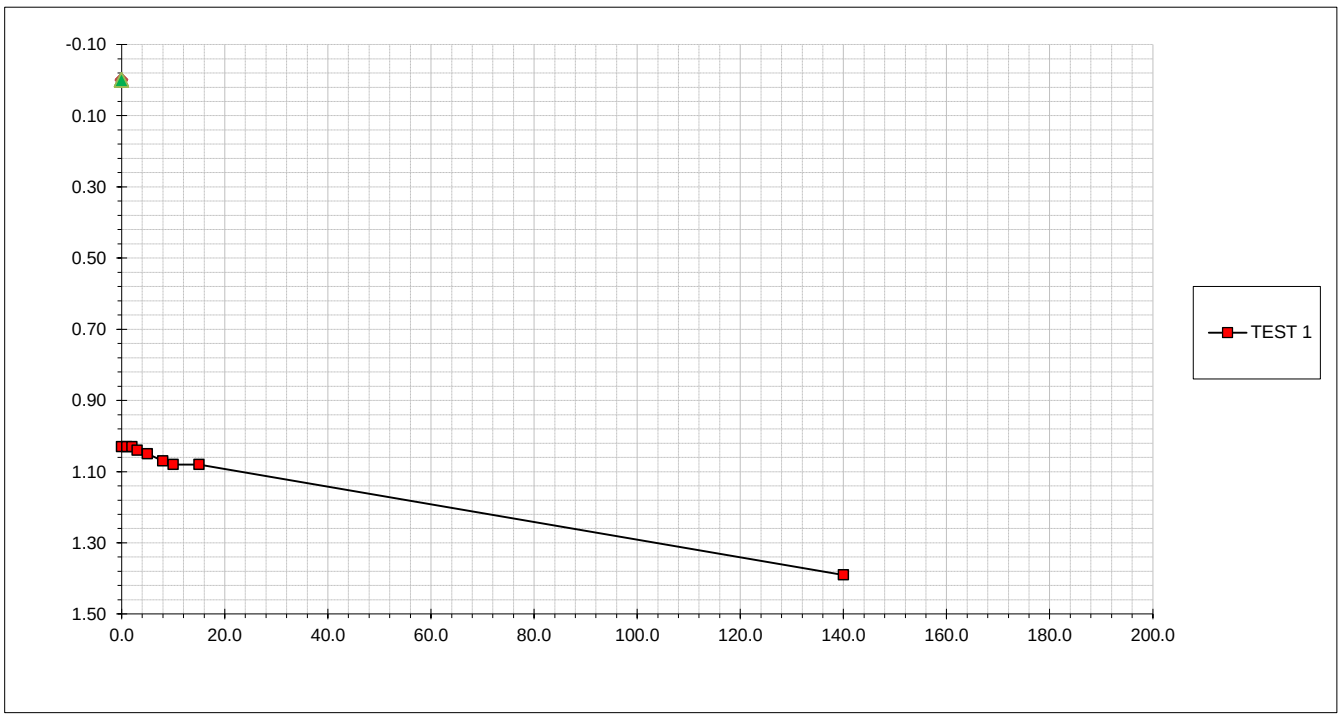
Remarks -

One fill only due to time constraints

TEST 1		TEST 2		TEST 3	
Time(min)	Depth to Water (m)	Time(min)	Depth to Water (m)	Time(min)	Depth to Water (m)
0	1.03				
1	1.03				
2	1.03				
3	1.04				
5	1.05				
8	1.07				
10	1.08				
15	1.08				
140	1.39				

Effective Storage Depth	m	0.97			
75% Effective Storage Depth	m	0.73			
(i.e. depth below GL)	m	1.27			
25% Effective Storage Depth	m	0.24			
(i.e. depth below GL)	m	1.76			
Effective Storage Depth 75%-25%	m	0.49			
Time to fall to 75% effective depth	mins	86.00			
Time to fall to 25% effective depth	mins	290.00			
V (75%-25%)	m3	0.44			
a (50%)	m2	3.28			
t (75%-25%)	mins	204.00			
SOIL INFILTRATION RATE	m/s	**1.09E-05**			

DESIGN SOIL INFILTRATION RATE, f **1.09E-05 m/s**



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SOIL INFILTRATION RATE TEST

(B.R.E. Digest 365, 1991, Soakaway Design)

Site:	White Rock Urban Extensio
Job Number:	WB03590
Date of Test:	20/09/16

Trial Pit Number:	TP5
Length (m):	2.00
Width (m):	0.45
Depth (mbegl):	1.90
Groundwater Depth# (mbegl):	

#: not used in calculations but ensure > pit base

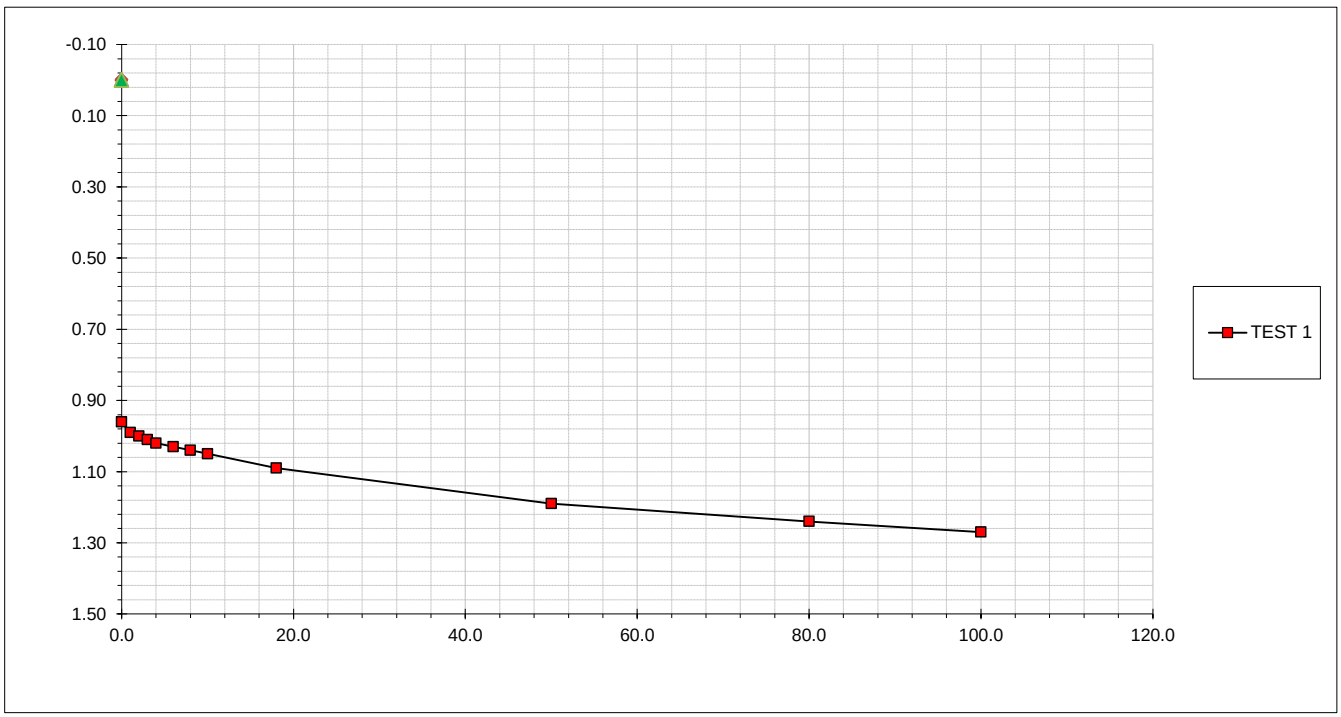
Remarks -

One fill only due to time contraints

TEST 1		TEST 2		TEST 3	
Time(min)	Depth to Water (m)	Time(min)	Depth to Water (m)	Time(min)	Depth to Water (m)
0	0.96				
1	0.99				
2	1.00				
3	1.01				
4	1.02				
6	1.03				
8	1.04				
10	1.05				
18	1.09				
50	1.19				
80	1.24				
100	1.27				

		TEST 1	TEST 2	TEST 3
Effective Storage Depth	m	0.94		
75% Effective Storage Depth	m	0.71		
(i.e. depth below GL)	m	1.20		
25% Effective Storage Depth	m	0.24		
(i.e. depth below GL)	m	1.67		
Effective Storage Depth 75%-25%	m	0.47		
Time to fall to 75% effective depth	mins	55.00		
Time to fall to 25% effective depth	mins	360.00		
V (75%-25%)	m3	0.42		
a (50%)	m2	3.20		
t (75%-25%)	mins	305.00		
SOIL INFILTRATION RATE	m/s	**7.22E-06**		

DESIGN SOIL INFILTRATION RATE, f **7.22E-06 m/s**



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SOIL INFILTRATION RATE TEST

(B.R.E. Digest 365, 1991, Soakaway Design)

Site:	White Rock Urban Extensio
Job Number:	WB03590
Date of Test:	20/09/16

Trial Pit Number:	TP6
Length (m):	2.00
Width (m):	0.45
Depth (mbegl):	2.70
Groundwater Depth# (mbegl):	

#: not used in calculations but ensure > pit base

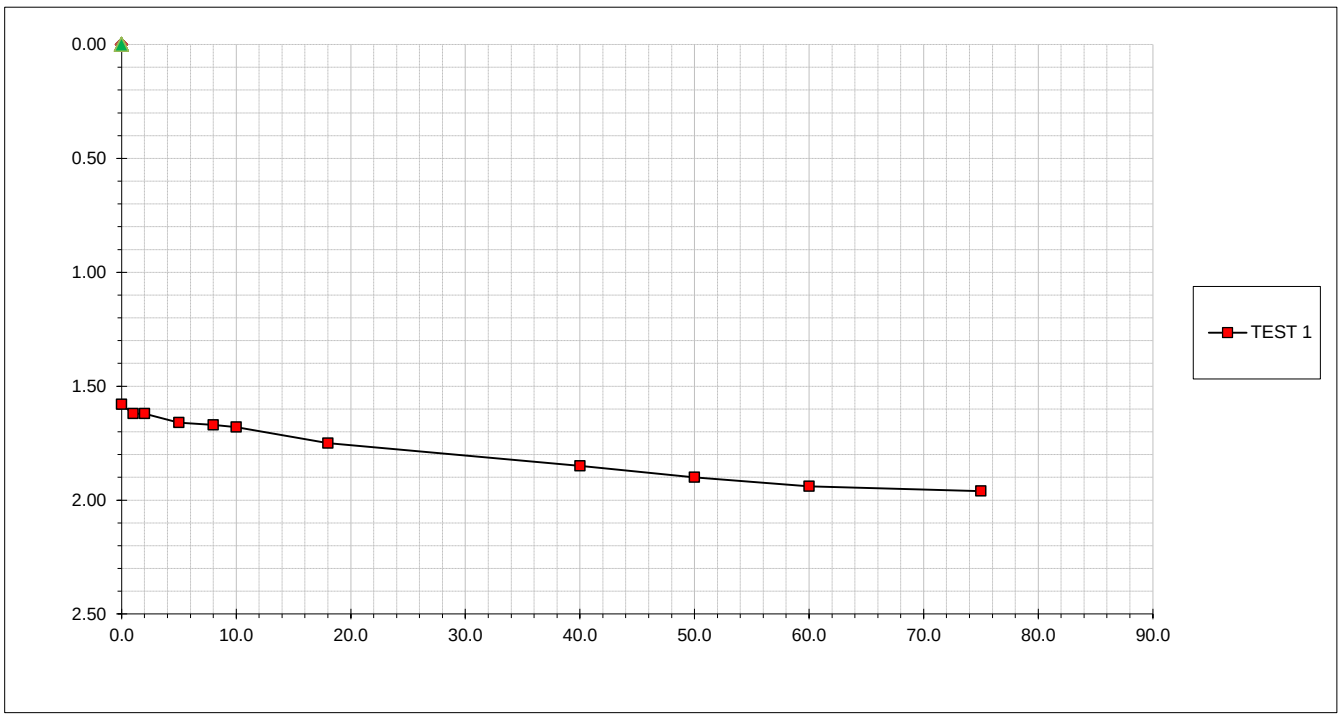
Remarks -

One fill only due to time constraints

TEST 1		TEST 2		TEST 3	
Time(min)	Depth to Water (m)	Time(min)	Depth to Water (m)	Time(min)	Depth to Water (m)
0	1.58				
1	1.62				
2	1.62				
5	1.66				
8	1.67				
10	1.68				
18	1.75				
40	1.85				
50	1.90				
60	1.94				
75	1.96				

Effective Storage Depth	m	1.12			
75% Effective Storage Depth	m	0.84			
(i.e. depth below GL)	m	1.86			
25% Effective Storage Depth	m	0.28			
(i.e. depth below GL)	m	2.42			
Effective Storage Depth 75%-25%	m	0.56			
Time to fall to 75% effective depth	mins	42.00			
Time to fall to 25% effective depth	mins	400.00			
V (75%-25%)	m3	0.50			
a (50%)	m2	3.64			
t (75%-25%)	mins	358.00			
SOIL INFILTRATION RATE	m/s	**6.44E-06**			

DESIGN SOIL INFILTRATION RATE, f **6.44E-06 m/s**



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SOIL INFILTRATION RATE TEST

(B.R.E. Digest 365, 1991, Soakaway Design)

Site:	White Rock Urban Extensio
Job Number:	WB03590
Date of Test:	20/09/16

Trial Pit Number:	TP8
Length (m):	2.30
Width (m):	0.45
Depth (mbegl):	2.50
Groundwater Depth# (mbegl):	

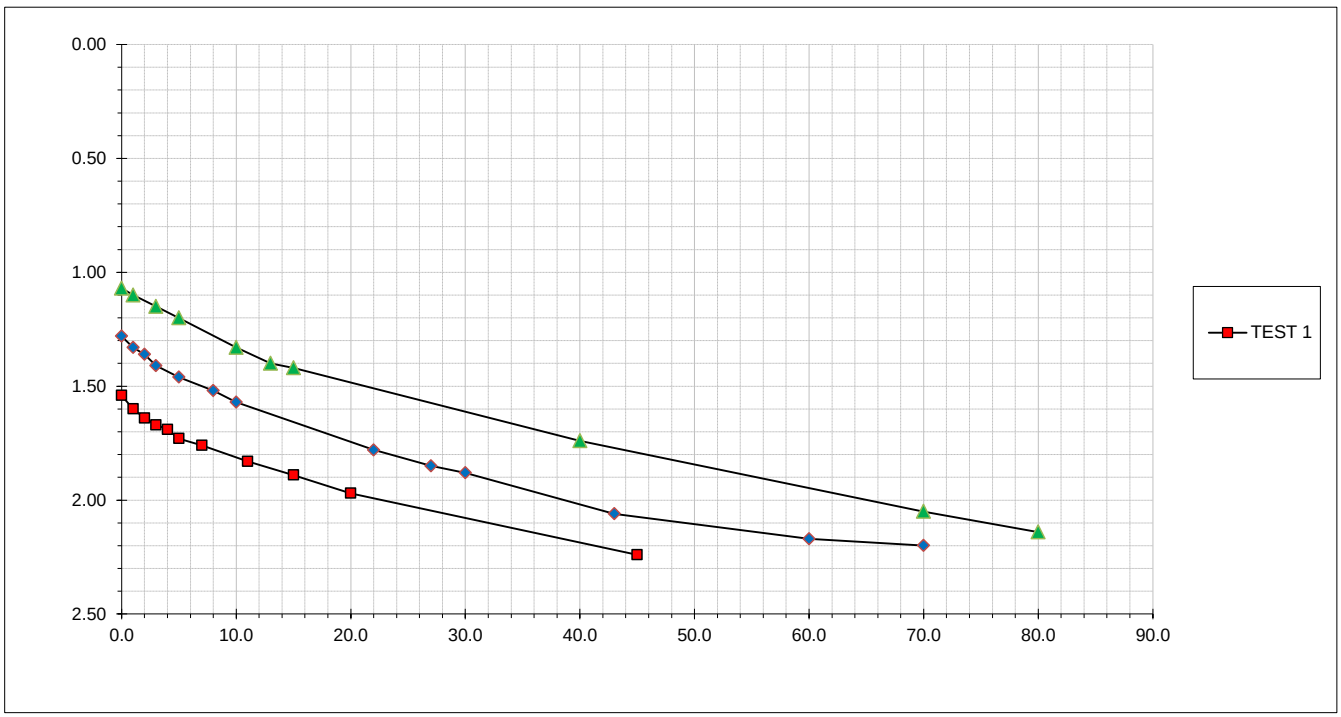
#: not used in calculations but ensure > pit base

Remarks -

TEST 1		TEST 2		TEST 3	
Time(min)	Depth to Water (m)	Time(min)	Depth to Water (m)	Time(min)	Depth to Water (m)
0	1.54	0	1.28	0	1.07
1	1.60	1	1.33	1	1.10
2	1.64	2	1.36	3	1.15
3	1.67	3	1.41	5	1.20
4	1.69	5	1.46	10	1.33
5	1.73	8	1.52	13	1.40
7	1.76	10	1.57	15	1.42
11	1.83	22	1.78	40	1.74
15	1.89	27	1.85	70	2.05
20	1.97	30	1.88	80	2.14
45	2.24	43	2.06		
		60	2.17		
		70	2.20		

		TEST 1	TEST 2	TEST 3
Effective Storage Depth	m	0.96	1.22	1.43
75% Effective Storage Depth	m	0.72	0.92	1.07
(i.e. depth below GL)	m	1.78	1.59	1.43
25% Effective Storage Depth	m	0.24	0.31	0.36
(i.e. depth below GL)	m	2.26	2.20	2.14
Effective Storage Depth 75%-25%	m	0.48	0.61	0.72
Time to fall to 75% effective depth	mins	9.00	12.00	17.00
Time to fall to 25% effective depth	mins	50.00	70.00	80.00
V (75%-25%)	m3	0.50	0.63	0.74
a (50%)	m2	3.68	4.39	4.97
t (75%-25%)	mins	41.00	58.00	63.00
SOIL INFILTRATION RATE	m/s	**5.50E-05**	**4.13E-05**	**3.94E-05**

DESIGN SOIL INFILTRATION RATE, f **3.94E-05 m/s**



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SOIL INFILTRATION RATE TEST

(B.R.E. Digest 365, 1991, Soakaway Design)

Site:	White Rock Urban Extensio
Job Number:	WB03590
Date of Test:	20/09/16

Trial Pit Number:	TP9
Length (m):	2.20
Width (m):	0.45
Depth (mbegl):	1.10
Groundwater Depth# (mbegl):	

#: not used in calculations but ensure > pit base

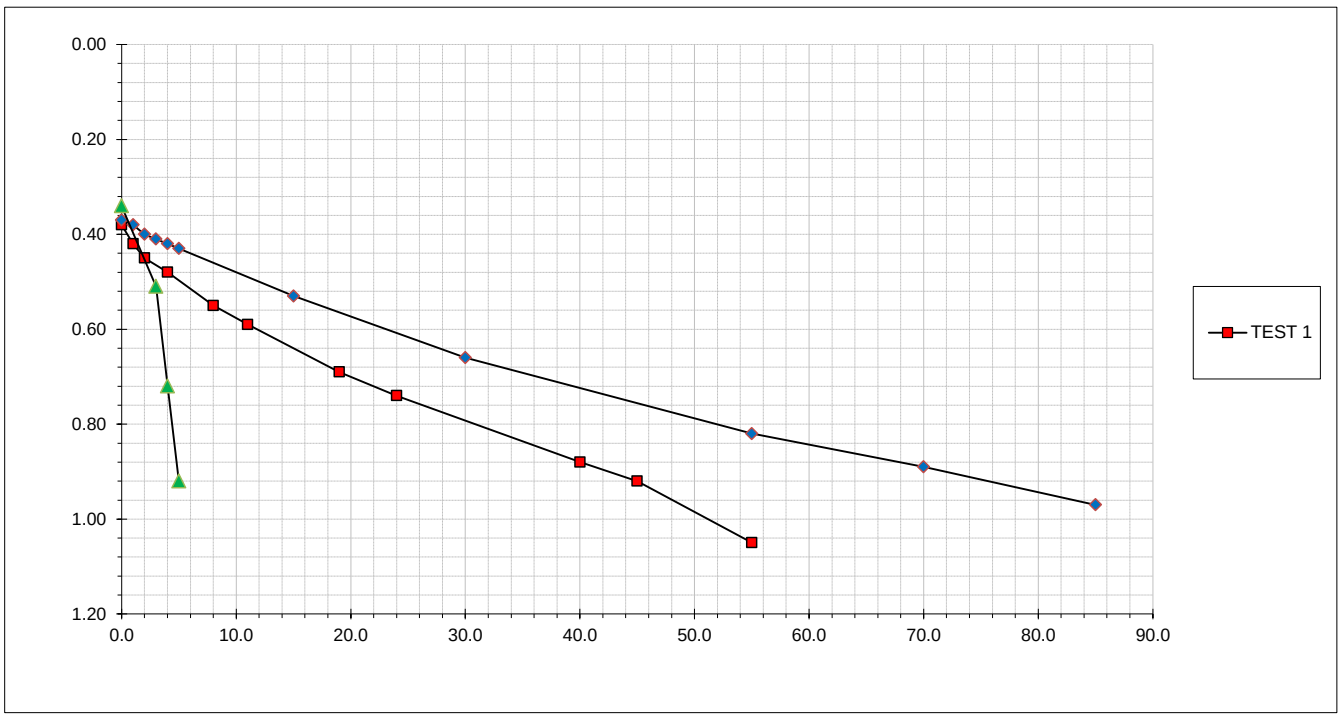
Remarks -

Fissure opened in the base of the pit in the 3rd fill

TEST 1		TEST 2		TEST 3	
Time(min)	Depth to Water (m)	Time(min)	Depth to Water (m)	Time(min)	Depth to Water (m)
0	0.38	0	0.37	0	0.34
1	0.42	1	0.38	3	0.51
2	0.45	2	0.40	4	0.72
4	0.48	3	0.41	5	0.92
8	0.55	4	0.42		
11	0.59	5	0.43		
19	0.69	15	0.53		
24	0.74	30	0.66		
40	0.88	55	0.82		
45	0.92	70	0.89		
55	1.05	85	0.97		

		TEST 1	TEST 2	TEST 3
Effective Storage Depth	m	0.72	0.73	0.76
75% Effective Storage Depth	m	0.54	0.55	0.57
(i.e. depth below GL)	m	0.56	0.55	0.53
25% Effective Storage Depth	m	0.18	0.18	0.19
(i.e. depth below GL)	m	0.92	0.92	0.91
Effective Storage Depth 75%-25%	m	0.36	0.37	0.38
Time to fall to 75% effective depth	mins	9.00	20.00	3.00
Time to fall to 25% effective depth	mins	45.00	80.00	5.00
V (75%-25%)	m3	0.36	0.36	0.38
a (50%)	m2	2.90	2.92	3.00
t (75%-25%)	mins	36.00	60.00	2.00
SOIL INFILTRATION RATE	m/s	**5.69E-05**	**3.43E-05**	**1.04E-03**

DESIGN SOIL INFILTRATION RATE, f **3.43E-05 m/s**



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