



Windroos Nursery, Littlehampton

Engineer's Report on Drainage

Stuart Lyons Haulage Ltd.

May 2016



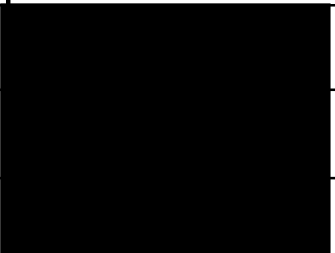
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**WINDROOS NURSERY,
LITTLEHAMPTON**

ENGINEER'S REPORT ON DRAINAGE

CONTROLLED DOCUMENT

<i>PB-Associates Document No:</i>		063.5001 ER1	
<i>Status:</i>	Final	<i>Copy No:</i>	1
	<i>Name</i>	<i>Signature</i>	<i>Date</i>
<i>Prepared by:</i>	Jon Burgess		May 2016
<i>Checked:</i>	Scott Webster		May 2016
<i>PBA Approved:</i>	Paul Basham		May 2016

Revision Record					
Rev.	Date	By	Summary of Changes	Chkd	Aprvd



Stuart Lyons Haulage Ltd.

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WINDROOS NURSERY, LITTLEHAMPTON

ENGINEER'S REPORT ON DRAINAGE

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- Appendix C – Windes Calculations
- Appendix D – Typical Infiltration Structures
- Appendix E – Location of Infiltration Structures

1. INTRODUCTION

1.1 Introduction:

This report is to accompany the reserved matters planning application to Arun District Council for the erection of 85 dwellings ranging from detached houses to apartments and their associated infrastructure. Prior to the submission of this report a conversation has been held with Arun District Council drainage engineers to understand the level of detail to accompany the application, and this report has been prepared accordingly.

1.2 Scope of the report:

Five main headings have been asked for in support of the Planning Application and these are as follows :-

- Infiltration test results across the site
- Ground water level monitoring
- Drainage calculations proving soakaway design for 1:100+cc
- Typical highway soakaway construction detail
- Typical infiltration detail for private areas

2. SITE CONTEXT

2.1 Infiltration Testing:

Six pits were excavated across the site where infiltration testing was undertaken in accordance with the methods described in BRE365. It was found that the site had higher values of infiltration towards the Southern end of the site.

The infiltration testing undertaken by Ground & Water Investigations was carried out between 30th March & 10th April this year. The results are included as **Appendix A**.

The lowest infiltration values were taken from each of the two groups of three and the average of these used to calculate the infiltration rate for both the Southern & Northern sections of the site. These rates were then used in the calculations to determine the best method & size of the preferred infiltration structure.

2.2 Soil Investigation:

A report was commissioned by Taylor Wimpey in June 2013 to ascertain the nature of the sub-soil this included ground water monitoring and is included in **Appendix B**.

3. SURFACE WATER DESIGN DEVELOPMENT

3.1 Highway Drainage:

Due to the variance in rates between the Northern & Southern sections of the site, it is proposed to take a larger run off area of highway to the Southern section and a reduction of area to the North.

3.2 Calculations:

Using MX (Windes) software, it was established that 9 concrete ring soakaways of 2.1m diameter are required and these can be sited within the large public open square in the middle of the development. It is proposed to space them about 10.0m apart so as to maximise their use and enable planting in between. The calculations show that during certain storm durations approximately 4.0cum of flood water will appear. Therefore, it is proposed to create a slight dish within the public open space to contain it, this will infiltrate away as the storm abates (see results).

At the Northern area the use of a 15.0 x 15.0 x 3.0m deep crate system is to be provided within the smaller open space. The volume available prevents any surface flooding but due to the lower infiltration rates, the system does not achieve the usual standard half drain down time, and additional volume has been provided to compensate.

3.3 Private Drainage:

One of the characteristics of the site is the proximity of the front of the dwellings with the footways/carriageways. Therefore, the drainage of the roof areas will be taken to the rear gardens and infiltration trenches provided. The size of these trenches is determined by the area to be drained. For this exercise, the largest impermeable area was used to determine the length of trench. This exercise was carried out for both North & South zones, again the trenches in the Northern area didn't achieve half drain down time but spare capacity will be made available.

Appendix C contains four sets of calculations, two for the highway drainage South & North and two for the private areas North and South. Appendix D are the details of both concrete ring and crate soakaways to be used for the disposal of run off from the highway and a trench type soakaway for the private areas within the rear gardens.

Appendix E is drawing 063.5001.107 which shown the likely location of the drainage features and the cut-off point between the Southern & Northern zones.

Windroos Nursery, Littlehampton
Engineer's Report on Drainage

Appendix A
Infiltration Testing

Paul Basham Associates Ltd
Report No. 063.5001 ER1

Soakaway Testing - Results

CLIENT	Stuart Lyons Haulage Ltd c/o Paul Basham Associates
SITE ADDRESS	Windroos, Worthing Road, Wick, Littlehampton, West Sussex BN17 6LY
REPORT REFERENCE	GWPR1624
ENGINEER	Roger Foord, Ground and Water Limited
INVESTIGATION LOCATIONS	Please see Figure 1 attached. Site works was undertaken between 30 th March 2016 and 10 th April 2016.

GROUND CONDITIONS ENCOUNTERED

Summary of Strata Encountered (TP1, TP2, TP3, TP5, TP6 & TP8)		
Strata	Depth Encountered (m bgl)	Thickness (m)
TOPSOIL (TP1, TP2, TP3, TP5 and TP8): Dark brown silty sand to dark brown slightly gravelly sandy, locally silty clay. Sand is fine to medium grained. Gravel is occasional, fine to coarse, sub-angular to sub-rounded flint.	GL	0.20 - 0.40
MADE GROUND (TP6): Dark brown gravelly sandy clay. Sand is fine to medium grained. Gravel is occasional to abundant, fine to coarse, sub-angular to sub-rounded flint and brick.	GL	0.80
AEOLIAN DEPOSITS: Brown to orange brown very silty CLAY, orange brown slightly sandy very silty CLAY to Orange brown slightly gravelly sandy very silty CLAY. Sand is fine to medium grained. Gravel is rare to occasional, fine, sub-angular to sub-rounded flint.	0.20 - 0.80	1.30 - 2.90
UNDIFFERENTIATED RIVER TERRACE DEPOSITS (TP2, TP3, TP5, TP6 and TP8): Orange brown slightly gravelly clayey SAND, orange brown slightly clayey SAND to pale brown and off white slightly clayey very gravelly SAND. Sand is fine to medium grained. Gravel is occasional, fine to coarse, sub-angular to sub-rounded flint and chalk in TP2. Deposits become more chalky with depth in TP2. An orange brown slightly gravelly very silty CLAY was encountered between 1.80-2.60m bgl in TP8. Sand is fine grained. Gravel is occasional, fine to medium, sub-angular to sub-rounded flint.	1.50 - 3.10	0.70 - >2.00
NEW CHALK FORMATION (TP1, TP3 and TP8): Structureless CHALK composed of off white to white slightly sandy gravelly clayey SILT with occasional sub-angular cobbles. Gravel and cobbles are medium dense, weak with occasional orange brown staining. Matrix is uncompact and off white. (CIRIA C574: Grade Dm).	2.00 - 3.30	>0.70 - >1.50

GROUNDWATER Groundwater was not encountered in the trial pits.

INFILTRATION RATE

Soakaway tests, in accordance with the principles of BRE365, were undertaken within each of the trial holes at 3.50m bgl within TP1 and TP2 and at 4.00m bgl within TP3, TP5, TP6 and TP8. The trial holes were bottomed out within the soils of the Undifferentiated River Terrace Deposits or the New Pit Chalk Formation. The infiltration rates recorded within the trial pits can be seen tabulated overpage.

The trial pits were then backfilled with coarse gravel and three soakaway tests were then conducted within the granular infill. The recorded infiltration rates have been corrected to account for the presence of granular infill using a void ratio of 0.40 for the gravel.

The infiltration rates are given below. The lowest recorded is in bold.

BRE 365 Test Results – Recorded Infiltration Rates m/s			
	Test 1	Test 2	Test 3
TP1 @ 3.50m bgl within New Pit Chalk Formation	6.11 x10⁻⁷ m/s	9.57 x10 ⁻⁷ m/s	1.09 x10 ⁻⁶ m/s
TP2 @ 3.50m bgl within River Terrace Deposits	4.16 x10 ⁻⁵ m/s	3.64 x10⁻⁵ m/s	5.55 x10 ⁻⁵ m/s
TP3 @ 4.00m bgl within New Pit Chalk Formation	1.02 x10 ⁻⁶ m/s	1.04 x10 ⁻⁶ m/s	7.13 x10⁻⁷ m/s
TP5 @ 4.00m bgl within River Terrace Deposits	1.56 x10 ⁻⁴ m/s	1.16 x10⁻⁴ m/s	1.38 x10 ⁻⁴ m/s
TP6 @ 4.00m bgl within River Terrace Deposits	9.72 x10⁻⁶ m/s	1.24 x10 ⁻⁵ m/s	1.34 x10 ⁻⁵ m/s
TP8 @ 4.20m bgl within New Pit Chalk Formation	5.63 x10 ⁻⁴ m/s	7.02 x10 ⁻⁴ m/s	5.03 x10⁻⁴ m/s

Soakaways constructed within the soils of the Undifferentiated River Terrace Deposits or the New Pit Chalk Formation are likely to perform to a satisfactory standard.

The site was located within a **Secondary A Aquifer** comprising the superficial deposits of the Undifferentiated River Terrace Deposits overlying a **Principal Aquifer** comprising the bedrock deposits of the New Pit Chalk Formation.

Examination of the Environment Agency records showed that the site **was not** located within a **Groundwater Source Protection Zone (SPZ)** as classified in the Policy and Practice for the Protection of Groundwater.

Consultation with the Environment Agency must be sought regarding any use that may have an impact on groundwater resources.

Please feel free to contact us should you have any queries regarding the information enclosed within this letter report.

Yours sincerely,



Roger Foord BA (Hons), MSc, DIC, FGS, MSoBRA
Senior Geotechnical Engineer
For and on behalf of Ground and Water Limited

Enc.

Figure 1

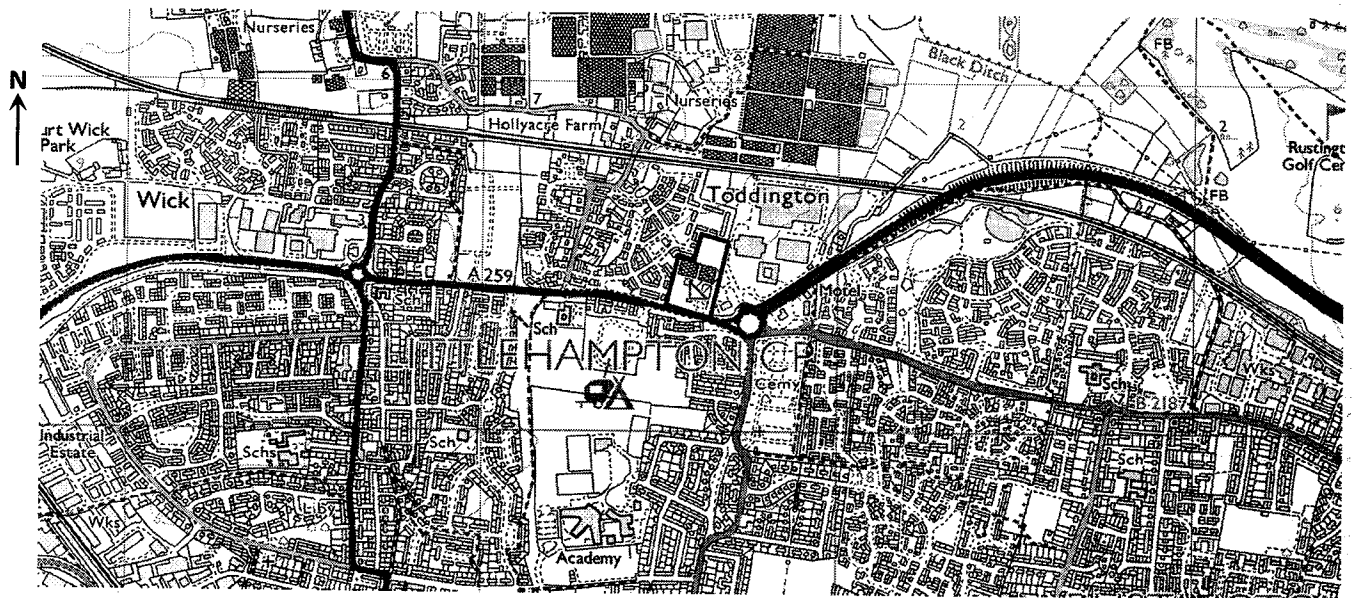
Site Location Plan

Figure 2

Trial Hole Location Plan

Appendix A

Trial Hole Logs



APPROXIMATE SITE BOUNDARY

NOT TO SCALE

Project:

Windroos, Worthing Road, Wick, Littlehampton, West Sussex BN17 6LY

Client:

Stuart Lyons Haulage Limited c/o Paul Basham Associates

Date:

April 2016

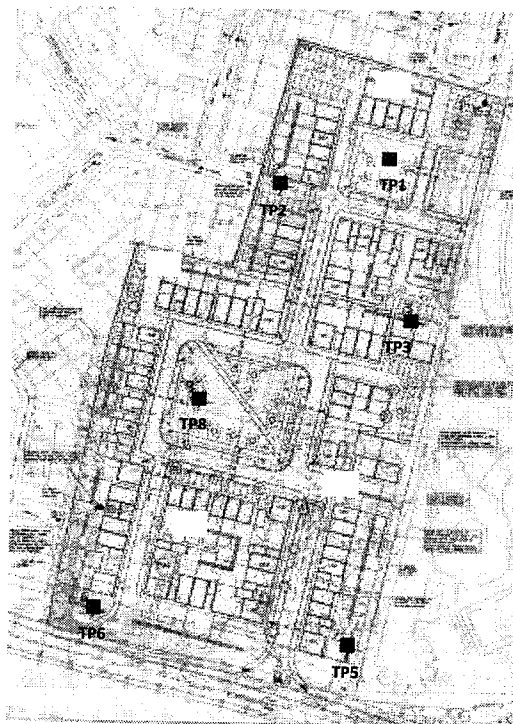
Site Location Plan

Ref:

GWPR1624

Figure 1

ground&water



APPROXIMATE SITE BOUNDARY

NOT TO SCALE

Project: Windroos, Worthing Road, Wick, Littlehampton, West Sussex BN17 6LY		Figure 2 ground&water
Client: Stuart Lyons Haulage Limited c/o Paul Basham Associates	Date: April 2016	
Trial Hole Location Plan	Ref: GWPR1624	

$$5 \quad 1.16 \times 10^{-4}$$

$$6 \quad 9.72 \times 10^{-6}$$

$$8 \quad 5.05 \times 10^{-4}$$

$$1 \quad 6.11 \times 10^{-7}$$

$$2 \quad 3.64 \times 10^{-5}$$

$$3 \quad 7.13 \times 10^{-7}$$

$$2.09 \times 10^{-4} \text{ m/s}$$

$$0.07524 \text{ m/hr}$$

$$1.26 \times 10^{-5} \text{ m/s}$$

$$0.004536 \text{ m/hr}$$

$$\times 360 = \text{m/hr}$$

NOT TO SCALE

Appendix A
Trial Hole Logs

Ground and Water Limited. Registered in England & Wales number 07032001. Registered Office: 15 Bow Street, Alton, Hampshire GU34 1NY.

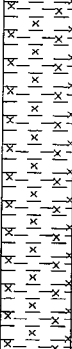
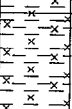
Project Name
WindroosProject No.
GWPR1624Co-ords: -
Level: -Date
30/03/2016Location: Worthing Road, Wick, Littlehampton, West Sussex
BN17 6LY

Dimensions:

Depth
3.50mScale
1:25

Client: Stuart Lyons Haulage Ltd

Logged By
RF

Samples & In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description	
Depth (m)	Type	Results					
1.00	D		0.30			TOPSOIL: Dark brown silty sand. Sand is fine grained.	
						AEOLIAN DEPOSITS: Brown very silty CLAY.	1
2.00	D		1.60			AEOLIAN DEPOSITS: Orange brown very silty CLAY.	
			2.00			NEW PIT CHALK FORMATION: Structureless CHALK composed of off white to white slightly sandy gravelly clayey SILT with occasional sub-angular cobbles. Gravel and cobbles are medium dense, weak with occasional orange brown staining. Matrix is uncompact and off white. (CIRIA C574: Grade Dm).	2
3.00	D						3
			3.50				
						Trialpit Complete at 3.50 m	4

Remarks: Roots noted to 0.30m bgl. Standpipe installed to 3.50m bgl. Trial pits back filled with gravel to 0.90m bgl.

Groundwater: No groundwater encountered.



Project Name
Windroos

Project No.
GWPR1624

Co-ords: -
Level: -

Date
30/03/2016

Location: Worthing Road, Wick, Littlehampton, West Sussex
BN17 6LY

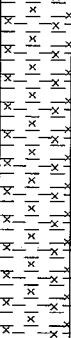
Dimensions: -

Scale
1:25

Client: Stuart Lyons Haulage Ltd

Depth
3.50m

Logged By
RF

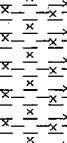
Samples & In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description	
Depth (m)	Type	Results					
0.20						TOPSOIL: Dark brown slightly gravelly sandy clay. Sand is fine to medium grained. Gravel is occasional, fine to coarse, sub-angular to sub-rounded flint.	
1.00	D					AEOLIAN DEPOSITS: Brown very silty CLAY.	1
1.50						UNDIFFERENTIATED RIVER TERRACE DEPOSITS: Orange brown slightly gravelly clayey SAND. Sand is fine to medium grained. Gravel is occasional, fine to coarse, sub-angular to sub-rounded flint.	
1.90						UNDIFFERENTIATED RIVER TERRACE DEPOSITS: Pale brown and off white slightly clayey very gravelly SAND. Sand is fine to coarse grained. Gravel is occasional, fine to cobble sized, sub-angular to sub-rounded flint and chalk; becomes more chalky with depth.	2
2.00	D						
3.00	D						3
3.50							
						Trialpit Complete at 3.50 m	4

Remarks: Roots noted to 1.10m bgl. Standpipe installed to 3.50m bgl. Trial pit back filled with gravel to 0.80m bgl.

Groundwater: No groundwater encountered.



Ground and Water Ltd							Trialpit No TP3 Sheet 1 of 1	
Project Name Windroos			Project No. GWPR1624		Co-ords: - Level: -		Date 30/03/2016	
Location: Worthing Road, Wick, Littlehampton, West Sussex BN17 6LY					Dimensions: - Depth 4.00m		Scale 1:25	
Client: Stuart Lyons Haulage Ltd							Logged By RF	

Samples & In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description
Depth (m)	Type	Results				
1.00	D		0.40			TOPSOIL: Dark brown slightly gravelly silty clay. Gravel is occasional, fine to coarse, sub-angular to sub-rounded flint.
						AEOLIAN DEPOSITS: Brown very silty CLAY.
2.00	D		2.75			AEOLIAN DEPOSITS: Orange brown slightly sandy very silty CLAY. Sand is fine to medium grained.
			3.30			NEW PIT CHALK FORMATION: Structureless CHALK composed of off white to white slightly sandy gravelly clayey SILT with occasional sub-angular cobbles. Gravel and cobbles are medium dense, weak with occasional orange brown staining. Matrix is uncompact and off white. (CIRIA C574: Grade Dm).
4.00	D		4.00		Trialpit Complete at 4.00 m	

Remarks:	Roots noted to 0.40m bgl. Standpipe installed to 4.00m bgl. Trial pit back filled with gravel to 1.20m bgl.
Groundwater:	No groundwater encountered.



Ground and Water Ltd						Trialpit No TP5 Sheet 1 of 1	
Project Name Windroos			Project No. GWPR1624		Co-ords: - Level: -		Date 30/03/2016
Location: Worthing Road, Wick, Littlehampton, West Sussex BN17 6LY					Dimensions: -		Scale 1:25
Client: Stuart Lyons Haulage Ltd					Depth 4.00m		Logged By RF

Samples & In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description	
Depth (m)	Type	Results					
1.00	D					TOPSOIL: Dark brown slightly gravelly sandy clay. Sand is fine to medium grained. Gravel is occasional, fine to coarse, sub-angular to sub-rounded flint.	1
2.00	D		2.00				AEOLIAN DEPOSITS: Brown slightly sandy very silty CLAY with pockets of orange silt with depth. Sand is fine grained.
3.00	D		3.10				UNDIFFERENTIATED RIVER TERRACE DEPOSITS: Orange brown clayey gravelly SAND. Sand is fine to medium grained. Gravel is occasional to abundant, fine to coarse, sub-angular to sub-rounded flint
4.00	D		3.90 4.00				UNDIFFERENTIATED RIVER TERRACE DEPOSITS: Orange brown clayey gravelly SAND. Sand is fine to medium grained. Gravel is occasional to abundant, fine to coarse, sub-angular to sub-rounded flint and chalk.
							Trialpit Complete at 4.00 m

Remarks:	Roots noted to 0.60m bgl. Standpipe installed to 4.00m bgl. Trial pit back filled with gravel to 1.20m bgl.
Groundwater:	No groundwater encountered.

Ground and Water Ltd						Trialpit No TP6 Sheet 1 of 1	
Project Name Windroos			Project No. GWPR1624		Co-ords: - Level: -		Date 30/03/2016
Location: Worthing Road, Wick, Littlehampton, West Sussex BN17 6LY					Dimensions: -		Scale 1:25
Client: Stuart Lyons Haulage Ltd					Depth 4.00m		Logged By RF

Samples & In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description	
Depth (m)	Type	Results					
1.00	D		0.80			MADE GROUND: Dark brown gravelly sandy clay. Sand is fine to medium grained. Gravel is occasional to abundant, fine to coarse, sub-angular to sub-rounded flint and brick.	
						AELIAN DEPOSITS: Brown very silty CLAY.	1
2.00	D		2.30				2
3.00	D					UNDIFFERENTIATED RIVER TERRACE DEPOSITS: Orange brown slightly clayey SAND. Sand is fine to medium grained.	3
4.00	D		4.00			Trialpit Complete at 4.00 m Trialpit Complete at 4.00 m	4

Remarks:	Roots noted to 2.10m bgl. Standpipe installed to 4.00m bgl. Trial pit back filled with gravel to 0.80m bgl.
Groundwater:	No groundwater encountered.

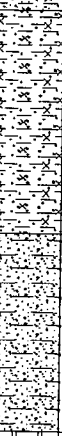
Project Name
WindroosProject No.
GWPR1624Co-ords: -
Level: -Date
30/03/2016Location: Worthing Road, Wick, Littlehampton, West Sussex
BN17 6LY

Dimensions:

Scale
1:25

Client: Stuart Lyons Haulage Ltd

Depth
4.20mLogged By
RF

Samples & In Situ Testing			Depth (m)	Level (m AOD)	Legend	Stratum Description
Depth (m)	Type	Results				
			0.30			TOPSOIL: Dark brown slightly gravelly silty clay. Gravel is occasional, fine to coarse, sub-angular to sub-rounded flint.
1.00	D					AEOLIAN DEPOSITS: Orange brown slightly gravelly sandy very silty CLAY. Sand is fine to medium grained. Gravel is rare to occasional, fine, sub-angular to sub-rounded flint.
2.00	D		1.80			
			2.60			UNDIFFERENTIATED RIVER TERRACE DEPOSITS: Orange brown slightly gravelly very silty CLAY. Sand is fine grained. Gravel is occasional, fine to medium, sub-angular to sub-rounded flint.
3.00	D					
			3.30			NEW PIT CHALK FORMATION: Structureless CHALK composed of off white to white slightly sandy gravelly clayey SILT with occasional sub-angular cobbles. Gravel and cobbles are medium dense, weak with occasional orange brown staining. Matrix is uncompact and off white. (CIRIA C574: Grade Dm).
4.00	D					
			4.20			
Trialpit Complete at 4.20 m						

Remarks: Roots noted to 0.45m bgl. Standpipe installed to 4.00m bgl. Trial pit back filled with gravel to 1.20m bgl.

Groundwater: No groundwater encountered.



Windroos Nursery, Littlehampton
Engineer's Report on Drainage

Appendix B
Soil Investigation

Paul Basham Associates Ltd
Report No. 063.5001 ER1

6.4 Natural Ground

The natural ground was found to generally comprise brown silty sand/clay, with occasional inclusions of flint gravel. It was encountered to depths of between 0.8 m and 3 m bgl and is likely to represent the River Terrace Deposits.

Below the River Terrace Deposits, orange brown slightly silty/clayey gravelly coarse grained sand with occasional flint and chalk gravel was encountered. This is likely to represent the Raised Beach Deposits.

Weathered chalk was encountered in six of the ten trial pits, and in five of the six window sample holes, at depths of between 2 m and 3.8 m bgl. This was recovered as weak gravel in a silty sand matrix in the upper layers, becoming stronger and more competent with depth. Refusal was obtained in the window sample holes in the chalk bedrock at depths of between 3 m and 4 m bgl.

6.5 Obstructions

Significant obstructions were not encountered in any of the exploratory holes.

6.6 Groundwater

Groundwater was not encountered in any of the trial pits or window sample holes.

6.7 Evidence of Contamination

Visual or olfactory evidence of possible significant contamination was not identified in any of the exploratory holes.

7.4 Roadworks

Due to the silty nature of the soils, CBR values of less than 2% may be recorded. The silty sand encountered below the topsoil across the site is likely to be frost susceptible and therefore a minimum construction thickness of 450 mm will apply.

You should allow a contingency for removing and infilling soft spots and we recommend that you arrange for in-situ CBR testing along the line of the roads just before construction commences, so that accurate values can be obtained to satisfy the Local Authority. A layer of terram at the base of the formation would also be prudent, during particularly wet periods, when the CBR values may be lower.

7.5 Superstructure Precautions

No specific precautions will be required in the superstructure of proposed buildings as a result of the ground conditions.

7.6 Problems Due to Past Development

The existing buildings will require demolition. Any below ground obstructions, such as the foundations and associated infrastructure, would need to be dealt with.

7.7 Excavation Problems

Excavation is expected to be fairly easy and pits in the natural ground were found to be relatively stable. Support will be required in accordance with current Health & Safety Regulations wherever access is required to trenches deeper than 1.2 m or less where there is risk of collapse.

Groundwater was not noted in any of the exploratory holes during the investigation. However, it should be noted that the groundwater levels may rise at wetter times of the year.

7.8 Surface Water Drainage

Four soakaway tests were undertaken. A copy of the results and calculation of the infiltrations rates is provided in Appendix 8 and these are summarised in the table overleaf.

Test	Depth (m bgl)	Strata	Comments	Infiltration Rate (x 10 ⁻⁰⁶ m/sec)
TP2	2.42 to 3.48	Very sandy SILT/CLAY (RTD) over slightly silty gravelly SAND (RBD)	Water level dropped 80 mm in 2.4 hours and then remained at this level for the next 2.6 hours	1.4
WS7	2.63 to 3.55	Slightly silty SAND (RBD) over CHALK	Water level dropped 160 mm in just over 1 hour	7.1
TP5	2.4 to 3.22	Slightly silty gravelly SAND (RBD) over CHALK	Water level dropped 380 mm in just over 2 hours	12
TP9	2.25 to 3.34	Very silty slightly clayey slightly gravelly SAND	Water level dropped 30 mm in 2.6 hours	0.48

The four 4 m deep monitoring wells were dry when dipped on 5 April 2013 and WS1, 2 and 10 were also dry on 17 June 2013.

Eastwood & Partners previously undertook soakaway testing at the site adjacent to the north and west of this site. Three tests were undertaken in the Raised Beach Deposits in late August/early September 2005, at the end of a fairly dry summer. The table below summarises the results of these.

Location	Depth (mbgl)	Infiltration Rate (x 10 ⁻⁰⁶ m/sec)
SAA (Around 270 m north-north-west of the site)	1.54 to 2.63	8.9
SAB (Around 300 m north-west of the site)	1.93 to 2.53	7.2
SAC (Around 15 m north of the site)	1.09 to 1.74	3

Four soakaway tests were also undertaken by Ashdown Site Investigation Ltd in 2004 (LW15295). Infiltration rates of 1.2, 6.9, 16 and 21 x 10⁻⁰⁶ m/sec were recorded. The lowest value was recorded in the River Terrace Deposits and the three higher results where Chalk was present at the base. The results of this previous testing are considered to be in line with the recent testing.

If soakaways are to be constructed in the Chalk consideration should be given to them being wholly constructed and cased into the undisturbed structured Chalk bedrock to minimize the risk of washing out of fine soils and accentuation of solution weathering that could eventually lead to subsidence. The Chalk is also a Principal Aquifer.

Groundwater monitoring was also undertaken for five positions to the north and west of this site. Initial water level readings were made on 30 August 2005. Groundwater level monitoring was then subsequently undertaken over a four month period starting in December 2005, with two visits per month. The groundwater depths ranged between 3.17 m and 5.35 m. There was relatively little variation in the groundwater level at each position and the depths in the closest well to the site, which is around 75 m to the north of the site, were recorded at 4 m to 4.51 m.

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Appendix C
MX (Windes) Calculations

Paul Basham Associates Ltd
Report No. 063.5001 ER1

Paul Basham Associates		Page 1
Lancaster Court 8 Barnes Wallis Road Fareham PO15 5TU	Windroos Littlehampton South Side	
Date May 2016	Designed by Jon Burgess	
File	Checked by	
XP Solutions		Source Control 2014.1

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 260 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	96.721	2.721	4.6	97.2	O K
30 min Summer	97.594	3.594	5.8	128.4	O K
60 min Summer	98.446	4.446	6.9	158.8	O K
120 min Summer	99.125	5.125	7.9	183.0	O K
180 min Summer	99.330	5.330	8.1	190.4	O K
240 min Summer	99.404	5.404	8.2	193.0	O K
360 min Summer	99.453	5.453	8.3	194.8	O K
480 min Summer	99.435	5.435	8.3	194.1	O K
600 min Summer	99.372	5.372	8.2	191.9	O K
720 min Summer	99.287	5.287	8.1	188.8	O K
960 min Summer	99.083	5.083	7.8	181.5	O K
1440 min Summer	98.658	4.658	7.2	166.4	O K
2160 min Summer	98.099	4.099	6.5	146.4	O K
15 min Winter	97.052	3.052	5.0	109.0	O K
30 min Winter	98.037	4.037	6.4	144.2	O K
60 min Winter	99.005	5.005	7.7	178.8	O K
120 min Winter	99.792	5.792	8.8	206.9	Flood Risk
180 min Winter	100.002	6.002	9.0	216.0	FLOOD
240 min Winter	100.004	6.004	9.0	217.8	FLOOD
360 min Winter	100.004	6.004	9.0	218.7	FLOOD

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	115.731	0.0	26
30 min Summer	77.804	0.0	39
60 min Summer	49.937	0.0	66
120 min Summer	30.956	0.0	122
180 min Summer	23.058	0.0	170
240 min Summer	18.577	0.0	198
360 min Summer	13.656	0.0	262
480 min Summer	10.974	0.0	330
600 min Summer	9.254	0.0	400
720 min Summer	8.046	0.0	468
960 min Summer	6.447	0.0	606
1440 min Summer	4.709	0.0	872
2160 min Summer	3.432	0.0	1260
15 min Winter	115.731	0.0	25
30 min Winter	77.804	0.0	39
60 min Winter	49.937	0.0	66
120 min Winter	30.956	0.0	122
180 min Winter	23.058	1.7	176
240 min Winter	18.577	3.5	210
360 min Winter	13.656	4.4	278

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Summary of Results for 100 year Return Period (+30%)

Half Drain Time exceeds 7 days.

Outflow is too low. Design is unsatisfactory.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m ³)	Status
15 min Summer	96.120	0.120	0.0	25.7	O K
30 min Summer	96.162	0.162	0.0	34.5	O K
60 min Summer	96.207	0.207	0.0	44.3	O K
120 min Summer	96.257	0.257	0.0	54.9	O K
180 min Summer	96.287	0.287	0.0	61.3	O K
240 min Summer	96.308	0.308	0.0	65.8	O K
360 min Summer	96.339	0.339	0.0	72.5	O K
480 min Summer	96.364	0.364	0.0	77.7	O K
600 min Summer	96.383	0.383	0.0	81.9	O K
720 min Summer	96.400	0.400	0.0	85.5	O K
960 min Summer	96.427	0.427	0.0	91.3	O K
1440 min Summer	96.468	0.468	0.0	100.0	O K
2160 min Summer	96.511	0.511	0.0	109.3	O K
2880 min Summer	96.544	0.544	0.0	116.3	O K
4320 min Summer	96.592	0.592	0.0	126.6	O K
5760 min Summer	96.629	0.629	0.0	134.4	O K
7200 min Summer	96.658	0.658	0.0	140.6	O K
8640 min Summer	96.683	0.683	0.0	146.1	O K
10080 min Summer	96.706	0.706	0.0	150.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m ³)	Time-Peak (mins)
15 min Summer	117.069	0.0	27
30 min Summer	78.692	0.0	42
60 min Summer	50.485	0.0	72
120 min Summer	31.269	0.0	132
180 min Summer	23.274	0.0	192
240 min Summer	18.738	0.0	252
360 min Summer	13.779	0.0	372
480 min Summer	11.072	0.0	492
600 min Summer	9.336	0.0	612
720 min Summer	8.117	0.0	732
960 min Summer	6.503	0.0	972
1440 min Summer	4.749	0.0	1452
2160 min Summer	3.461	0.0	2172
2880 min Summer	2.761	0.0	2892
4320 min Summer	2.005	0.0	4332
5760 min Summer	1.595	0.0	5776
7200 min Summer	1.335	0.0	7216
8640 min Summer	1.156	0.0	8656
10080 min Summer	1.023	0.0	10096

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<u>Summary of Results for 100 year Return Period (+30%)</u>					
Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Winter	96.135	0.135	0.0	28.8	O K
30 min Winter	96.181	0.181	0.0	38.7	O K
60 min Winter	96.232	0.232	0.0	49.6	O K
120 min Winter	96.288	0.288	0.0	61.5	O K
180 min Winter	96.321	0.321	0.0	68.6	O K
240 min Winter	96.345	0.345	0.0	73.7	O K
360 min Winter	96.380	0.380	0.0	81.3	O K
480 min Winter	96.407	0.407	0.0	87.0	O K
600 min Winter	96.429	0.429	0.0	91.7	O K
720 min Winter	96.448	0.448	0.0	95.7	O K
960 min Winter	96.478	0.478	0.0	102.3	O K
1440 min Winter	96.524	0.524	0.0	112.0	O K
2160 min Winter	96.573	0.573	0.0	122.4	O K
2880 min Winter	96.609	0.609	0.0	130.2	O K
4320 min Winter	96.664	0.664	0.0	141.8	O K
5760 min Winter	96.704	0.704	0.0	150.5	O K
7200 min Winter	96.737	0.737	0.0	157.5	O K
8640 min Winter	96.765	0.765	0.0	163.6	O K
10080 min Winter	96.791	0.791	0.0	169.0	O K
Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)		
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8640 min Winter	1.156	0.0	8656		
10080 min Winter	1.023	0.0	10096		
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Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	19.200	Shortest Storm (mins)	15
Ratio R	0.350	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time Area Diagram

Total Area (ha) 0.117

Time (mins)	Area	Time (mins)	Area	Time (mins)	Area
From: To:	(ha)	From: To:	(ha)	From: To:	(ha)
0 4	0.040	4 8	0.039	8 12	0.038

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Summary of Results for 100 year Return Period (+30%)

Half Drain Time exceeds 7 days.

Critical storm not identified, please run longer storm durations.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m ³)	Status
15 min Summer	97.268	0.268	0.0	9.2	O K
30 min Summer	97.360	0.360	0.0	12.3	O K
60 min Summer	97.462	0.462	0.0	15.8	O K
120 min Summer	97.573	0.573	0.0	19.6	O K
180 min Summer	97.640	0.640	0.0	21.9	O K
240 min Summer	97.687	0.687	0.0	23.5	O K
360 min Summer	97.758	0.758	0.0	25.9	O K
480 min Summer	97.812	0.812	0.0	27.8	O K
600 min Summer	97.856	0.856	0.0	29.3	O K
720 min Summer	97.893	0.893	0.0	30.5	O K
960 min Summer	97.954	0.954	0.0	32.6	O K
1440 min Summer	98.045	1.045	0.0	35.8	O K
2160 min Summer	98.143	1.143	0.0	39.1	O K
2880 min Summer	98.216	1.216	0.0	41.6	O K
4320 min Summer	98.324	1.324	0.0	45.3	O K
15 min Winter	97.300	0.300	0.0	10.3	O K
30 min Winter	97.404	0.404	0.0	13.8	O K
60 min Winter	97.518	0.518	0.0	17.7	O K
120 min Winter	97.642	0.642	0.0	22.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m ³)	Time-Peak (mins)
15 min Summer	116.400	0.0	23
30 min Summer	78.248	0.0	38
60 min Summer	50.211	0.0	68
120 min Summer	31.113	0.0	128
180 min Summer	23.167	0.0	188
240 min Summer	18.658	0.0	248
360 min Summer	13.718	0.0	368
480 min Summer	11.023	0.0	488
600 min Summer	9.295	0.0	608
720 min Summer	8.082	0.0	728
960 min Summer	6.475	0.0	968
1440 min Summer	4.729	0.0	1448
2160 min Summer	3.446	0.0	2168
2880 min Summer	2.750	0.0	2888
4320 min Summer	1.997	0.0	4328
15 min Winter	116.400	0.0	23
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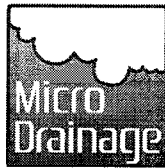
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180 min Summer	97.517	0.517	0.0	22.4	O K
240 min Summer	97.556	0.556	0.0	24.1	O K
360 min Summer	97.613	0.613	0.0	26.5	O K
480 min Summer	97.656	0.656	0.0	28.4	O K
600 min Summer	97.692	0.692	0.0	30.0	O K
720 min Summer	97.722	0.722	0.0	31.3	O K
960 min Summer	97.771	0.771	0.0	33.4	O K
1440 min Summer	97.845	0.845	0.0	36.6	O K
2160 min Summer	97.924	0.924	0.0	40.0	O K
2880 min Summer	97.983	0.983	0.0	42.6	O K
4320 min Summer	98.070	1.070	0.0	46.4	O K
15 min Winter	97.243	0.243	0.0	10.5	O K
30 min Winter	97.326	0.326	0.0	14.1	O K
60 min Winter	97.419	0.419	0.0	18.1	O K
120 min Winter	97.519	0.519	0.0	22.5	O K

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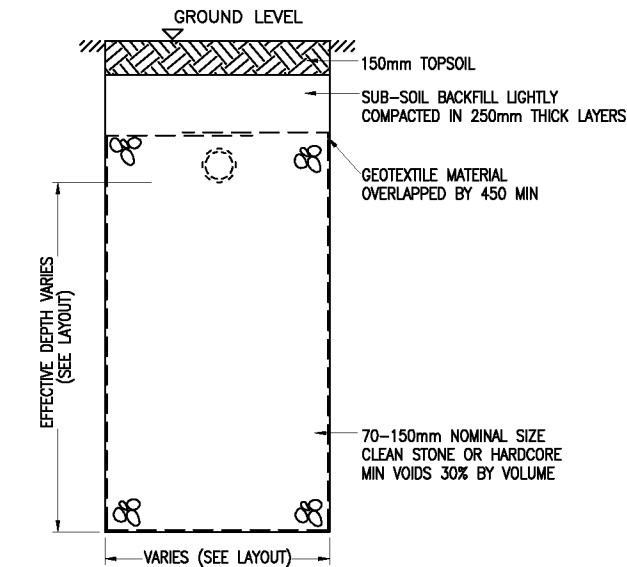
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<u>Model Details</u> Storage is Online Cover Level (m) 100.000 <u>Cellular Storage Structure</u> Invert Level (m) 97.000 Safety Factor 1.5 Infiltration Coefficient Base (m/hr) 0.07524 Porosity 0.95 Infiltration Coefficient Side (m/hr) 0.07524																																																																																						
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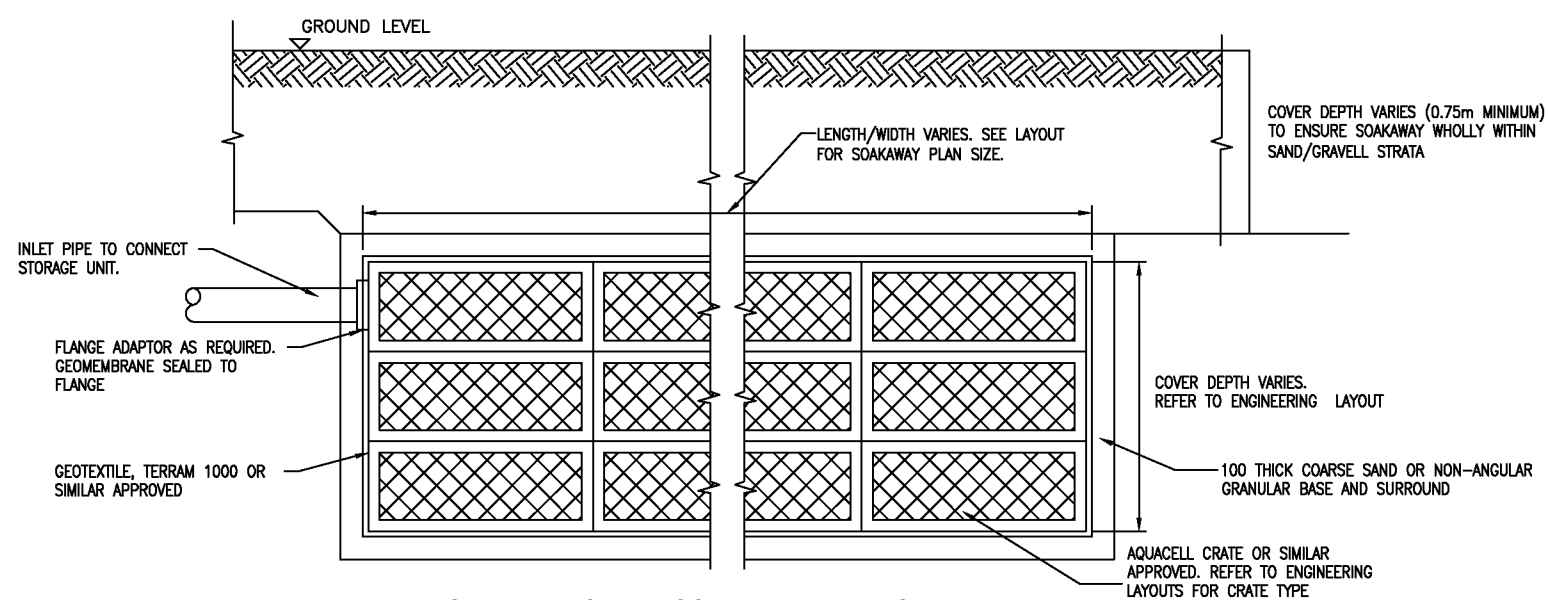
Appendix D
Typical Infiltration Details

Windroos Nursery, Littlehampton
Engineer's Report on Drainage

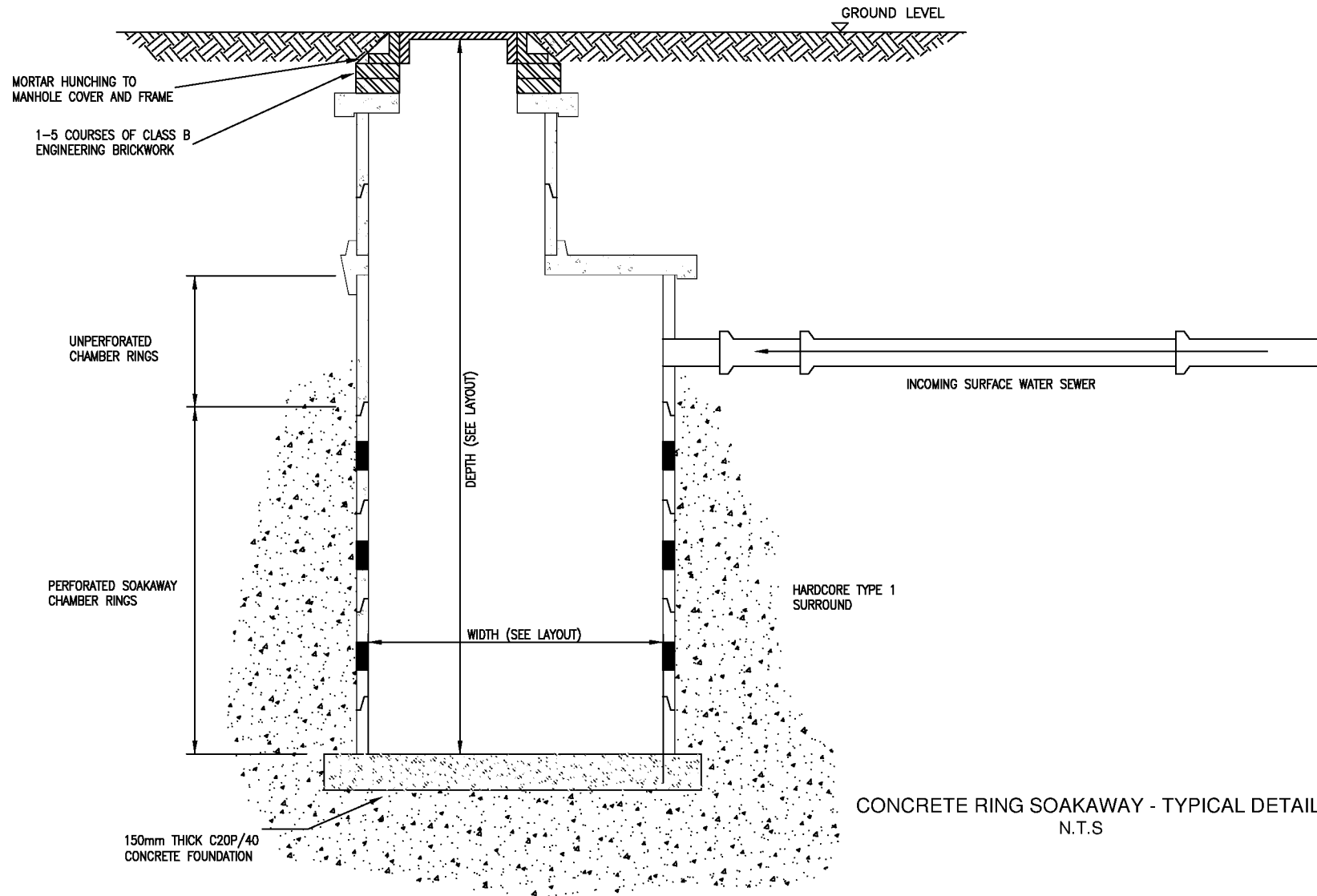
Paul Basham Associates Ltd
Report No. 063.5001 ER1



TRENCH SOAKAWAY - TYPICAL DETAIL
N.T.S



CELLULAR CRATE SOAKAWAY - TYPICAL DETAIL
N.T.S



CONCRETE RING SOAKAWAY - TYPICAL DETAIL
N.T.S

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None of the below is deemed to relieve any contractor of his obligations under all applicable health and safety legislation.

In preparing the design shown on this and related drawings Paul Basham Associates has considered and, where reasonably practicable, eliminated foreseeable risks.
Any further abnormal or unusual risks, which remain, are numbered below and identified thus  and should be given particular attention by all those carrying out construction or of future maintenance works.

- Abnormal or unusual risks
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Rev	Description	Date	By	Chk

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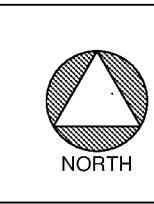
Project Name WINDROOS NURSARY, LITTLEHAMPTON	Title INFILTRATION STRUCTURES TYPICAL DETAILS	 Paul Basham Associates Ltd Lancaster Court 9 Barnes Wallis Road Poulsham, Havant PO15 6TU T: +44 (0) 1489 698134 E: info@paulbashamassociates.com W: www.paulbashamassociates.com	Client PRIVATE CLIENT	Checked By JB	Checked Date 23.05.16	Scale N.T.S.	Client Drawing No. -	PBA Drawing No. 063.5001.108	Revision -
Project Phase FOR INFORMATION				Drawn By BH	Drawn Date 23.05.16				

(AT A3 SIZE)

Appendix E
Infiltration Structures Location

Windroos Nursery, Littlehampton
Engineer's Report on Drainage

Paul Basham Associates Ltd
Report No. 063.5001 ER1



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- 1. Abnormal or unusual risks
- 2.
- 3.

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KEY:

- STORM WATER SEWER 150mm(U.N.O)
- TRENCH SOAK-AWAY
- ☐ CONCRETE RING SOAK-AWAY
- INFILTRATION CRATES STORAGE

A	UPDATE DRAINAGE NOTES	23.05.16	JBH	JB
P1	PLANNING ISSUE	19.05.16	JB	JB
Rev	Description	Date	By	Check



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Client

PRIVATE CLIENT

Project Name

WINDROOS NURSERY,
LITTLEHAMPTON

Title

INFILTRATION STRUCTURES

Project Phase

PRELIMINARY

Checked By	Checked Date	Drawn By	Drawn Date
JMB	19.05.16	JMB	19.05.16
Client Drawing No	Scale		
-	1:500		(AT A1 SIZE)
PBA Drawing No	Revision		
063.5001.107			A