Drainage Report
CATS Site
Leys Hill
Walford
HR9 5QU

Report date: 23 August 2016

Job number: 2504

Pennell Associates

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Author: Andrew Pennell
Date: 23 August 2016

Report Amendment Sheet

Revision	Amendment	Prepared By:	Date:
0	Initial Issue	AP	02.08.2016
1	Drainage items added	AP	10.08.2016
2	Confirmation of testing included and outline trench design for highway	AP	03.11.2016

1. INTRODUCTION

This report provides an overview of the drainage of the site for both foul and surface water along with the considerations for the provision of Sustainable Urban Drainage within the development.

This report has been prepared by Andrew Pennell, BEng MSc MSc CEng MIStructE CMIOSH, on behalf of Pennell Associates Limited.

This report is based on information provided by the property owner, with soakaways and drainage based upon percolation information provided.

2. SUSTAINABLE URBAN DRAINAGE

The overall role of Sustainable Urban Drainage (SuDS) is the use of drainage design to mitigate against the adverse effect of rainwater run off due to the impact of both new and existing developments.

Typical techniques for sustainable urban drainage include:

- Infiltration of stormwater into the ground.
- Storage of stormwater at a suitable location on site for later discharge post the peak of any storm.
- Use of permeable surfaces to allow stormwater to soak into the ground rather than run off site.
- Temporary trapping of water in vegetation for later natural evaporation (green roofs etc.).
- Control of stormwater at source.

The SuDS manual[1] confirms the role of Sustainable Urban Drainage as, "SuDS designs should aim to reduce runoff by integrating stormwater controls throughout the site in small, discrete units. Through effective control of runoff at source, the need for large flow attenuation and flow control structures should be minimised."

2.1. Ground Investigation

Checks with the British Geological Survey 'Geology of Britain viewer' indicate that the underlying bedrock geology is the "Tintern Sandstone Formation - Sandstone. Sedimentary Bedrock " There are no records of the superficial deposits in the area.

Records of the deeper geology suggest the regular usage of the wells in the area which draw water from the area and the continual water for the underlying Limestone Shales.

Percolation tests have been undertaken on the site (See Appendix A, Percolation Tests and soakaway design) which have shown that the upper level of soil is capable of being used for the purpose of construction of soakaways on the site.

Infiltration testing has been undertaken (5th, 6th, 7th August 2016) in accordance with the requirements of BRE Digest 365 (Soakaway Design), the results of which are included in Appendix A and used for the calculation of the soakaway sizes for plots 1-5 of the development.

2.2. Detention

Detention (local storage of water at ground level) of stormwater flows generally requires a suitable area of land to be available to store the water. As shown by the initial attenuation

[1] Woods Ballard, B., R. Kellagher, P. Martin, C. Jefferies, R. Bray, and P. Shaffer. "CIRIA C697. The SuDS Manual." *CIRIA, London* (2007).

calculations (Appendix B) a significant area of land would be required for the formation of a suitable detention basin on the site. The use of detention ponds is therefore uncommon in residential areas.

Detention areas present safety issues due to the occasional flooding of the area which needs to be mitigated by fencing etc. The close proximity of housing generally precludes this as a system which can be used on this project. It is therefore not considered a suitable approach for the site and individual soakaways are suggested as the most appropriate for the site based on the site layout .

2.3. Attenuation

Attenuation works in a similar manner to detention in that the flow out of a site is physically restricted by means of a limited size of opening where the pipes leave the site. The main difference is that waste is stored temporarily by means of the use of oversized drainage pipework or below ground storage areas. The soakaways have been provided with suitable internal storage to provide for the 1 in 10 year flows to be stored within the soakaways without the risk of the overflowing of the drainage system.

3. SITE DRAINAGE

3.1. Surface Water Sewage

It is proposed to construct a soakaway for each of the plots. Based on the percolation tests which have been provided for the site (design , soakaways have been provisionally sized in accordance with the BRE Digest 365 'Soakaway Design', published by the Building Research Establishment, Watford.

In line with general guidance the surface water has been designed to provide capacity for the 1 in 10 year storm event.

The surface water pipes have been sized in line with the maximum rainfall intensities of 107 mm/hour for the 1 in 10 year storm and 134 mm/hour for the 1 in 30 year storm. Using a nominal pipe gradient of 1 in 80 (for the initial drainage appraisal) a 150 mm pipe will not surcharge at either of the storm returns. Detailed design may allow for a smaller diameter pipe to be used for some of the drainage runs which do not to provide capacity for the entire roof of a dwelling.

The entire surface water drainage system will remain in private hands and not be offered up for adoption.

3.2. Attenuation Storage Sizing

Each individual surface water system and soakaway has been designed to accommodate flows from the connected property and as such no additional attenuation will be provided beyond the soakaways for the properties. The design of the soakaways is based upon test pits excavated on site in line with normal practice. As with all ground investigation the sample provided may not be representative of the site as a whole and as such additional investigations may be required relative to the plots should the ground conditions vary from those present at the locations tested. Pennell Associates has not undertaken any investigatory work in relation to the sub strata other than that indicated in this report within the geology section.

3.3. Highways Drainage

All new hard surfaces to the development will be formed in permeable paving to allow for the infiltration of water into the ground in line with SUDs recommendations for such areas.

Existing highway drains naturally to the side and soakaway by infiltration. If this is to be formalised calculations indicate that a trench 1.75 m deep by 1 m wide running parallel to a 5m wide carriageway should be sufficient to allow natural infiltration of any surface water which is generated on this surface.

3.4. Foul Water Sewage

The general outline of the foul water sewerage system has been indicated on the attached drawings. Each property will be provided with separate drainage runs and individual property sewage treatment plants. It is initially envisaged that these will be Klargester 'biodisc' units or similar. Outflow from the individual sewage treatment plants will flow to a communal sewage outflow area for percolation to the ground.

The information provided has indicated that the Vp for the site is 61 on the basis of this and the use of 900mm trench the following trench lengths will be required.

Plot	Bedrooms	Trench Length (m)
1	5	95
2	5	95
3	5	95
4	5	95
5	5	95

$$Trench\ length = (5+2) \times 61 \times 0.2 \times \frac{100(cm)}{90(cm)}$$

$$Trench\ length = No.\ People \times Vp \times sewage\ treatment\ area\ coefficient \times \frac{100(cm)}{Trench\ width(cm)}$$

It is recommended that 1m separation is provided between the sides of each trench.

The size of area required has been indicated on the drawings, however, final layout of pipework within this area will be subject to detailed design.

3.5. Flooding

As noted in the flood risk assessment, the general soil classification and percolation tests indicate that the ground is generally accepting of infiltration flows which will mitigate against excessive overland flows. However, in the event of exceptional infrequent intense rainfall water will, due to the slope gradients, have the potential for the generation of overland flows.

Excessive flooding from any source can bring about issues with inundation of the surface water drainage system, however, this source has the potential to produce the most unexpected of issues and may be coupled with flows from roofs and other areas resulting in early inundation of the surface water system and premature overtopping of the drainage system. To mitigate against this possibility no open gullies or similar will be provided to the exterior of the property. Roof drainage will enter into the surface water system by means of 'P traps' or similar to prevent unwanted surface water from inundating the drainage system.

4. CONCLUSION

The surface water drainage systems to the houses site will be provided by five independent surface water systems with independent soakaways, as the ground investigations have indicated that this is a viable option and as such requires no drainage off site. The use of an infiltration method is compliant with SuDS drainage principles.

The foul drainage system will be provided by use of individual sewage treatment plants for each of the new building plots with communal infiltration beds. No connection to the public foul sewer is envisaged.

Appendix A

Provisional Soakaway Sizing

ALTERNATIVE SOAKAWAY SIZES			
	trench soakaways		
width of trench *[mm]*:	450	600	900
required trench length *[m]*:	37.78	30.61	22.65
	ring soakaways		
diameter of ring *[mm]*:	1800	2400	2700
required pit diameter *[m]*:	5.33	4.84	4.52

** Based on effective depth and number of pits as in Soakaway Data table*

SUMMARY OF CALCULATIONS		
critical design rainfall duration 't_{crit}' =	360	*min*
required storage volume 'V_{req}' =	12.63	m^3
provided storage volume 'V_{prov}' =	13.23	m^3
utilisation factor =	**0.96**	***.OK***
required time to discharge 50% 't_{50}' =	13.51	*hours*
utilisation factor =	**0.56**	***.OK***

GENERAL DATA	
site location:	England and Wales
soakaway type:	perforated concrete ring
pit shape:	circular pit around ring
impermeable area drained to soakaway 'A' $[m^2]$ =	400
60 min rainfall depth of 5 year return period 'R' *[mm]* =	20
M5-60 to M5-2d rainfall ratio 'r' =	0.40
allowance for climate change:	No

SOAKAWAY DATA	
number of ring soakaways:	1
circular pit diameter 'D' [m] =	5.25
soakaway ring internal diameter 'D_{int}' *[mm]* =	2100
total depth from ground level 'D_b' *[m]* =	2.50
depth to drain invert level 'D_d' *[m]* =	1.00
soakaway effective depth 'D_{eff}' *[m]* =	1.50
free volume in infill aggregate *[%]* =	30

SOIL INFILTRATION DATA	
allowance for infiltration through soakaway base:	No
available on-site infiltration test results:	(●) Yes ( ) No
use soakage trial pit table below	
internal surface area of trial pit 'a_{p50}' $[m^2]$ =	3.24
storage volume between 75-25% 'V_p' $[m^3]$ =	0.56
time for water to fall from 75-25% 't_p' [min] =	262.11
soil infiltration rate 'f' [m/s] =	1.10E-05

SOAKAGE TRIAL PIT DATA	
soakage trial pit width 'W_t' *[m]* =	1.00
soakage trial pit length 'L_t' *[m]* =	1.00
total depth from ground level 'D_{tb}' *[m]* =	1.50
depth to pipe invert level 'D_{tp}' *[m]* =	0.38
soakage trial pit effective depth 'D_{teff}' *[m]* =	1.12
free volume in infill aggregate *[%]* =	100
NOTE: faces of excavation assumed to be vertical	

REQUIRED STORAGE CAPACITY PER RAINFALL DURATION

rainfall duration *[min]*	rainfall factor Z1	M5-D rainfalls *[mm]*	M10-D			ignore			ignore			outflow from soakaway $[m^3]$	required storage $[m^3]$
			Z2	rainfalls *[mm]*	inflow $[m^3]$	Z2	rainfalls *[mm]*	inflow $[m^3]$	Z2	rainfalls *[mm]*	inflow $[m^3]$		
5	0.37	7.47	1.20	9.00	3.60							0.04	3.56
10	0.52	10.47	1.22	12.79	5.12							0.08	5.03
15	0.63	12.67	1.23	15.59	6.24							0.12	6.11
30	0.80	16.07	1.24	19.92	7.97							0.24	7.72
60	1.00	20.00	1.24	24.80	9.92							0.49	9.43
120	1.21	24.13	1.24	29.93	11.97							0.98	10.99
240	1.45	28.93	1.22	35.42	14.17							1.96	12.21
360	1.60	32.07	1.21	38.92	15.57							2.94	**12.63**
600	1.79	35.87	1.20	43.13	17.25							4.89	12.36
1440	2.24	44.80	1.18	52.88	21.15							11.75	9.41

** Z2 is a growth factor from M5 rainfalls*

SOAKAGE TRIAL PIT INFILTRATION TEST RESULTS

	water level measurement N°:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Soakage Trial 1	time *[min]* =	0	183	355	535															
	depth to water *[m]* =	0.38	0.75	1.13	1.50															
Soakage Trial 2	time *[min]* =	0	180	348	531															
	depth to water *[m]* =	0.38	0.75	1.13	1.50															
Soakage Trial 3	time *[min]* =	0	180	352	532															
	depth to water *[m]* =	0.38	0.75	1.13	1.50															

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Land at CATS, Leys Hill Road, Walford, Ross-on-Wye, HR9 5QU		Revision	
Job No:	**2504**	Page:	**SW/02**
Prepared By:	**AP**	Date:	**10/08/2016**

Section: **Soakway based on CATS Hole 2**

ALTERNATIVE SOAKAWAY SIZES			
	trench soakaways		
width of trench *[mm]*:	**450**	**600**	**900**
required trench length *[m]*:	37.53	30.34	22.50
	ring soakaways		
diameter of ring *[mm]*:	1800	2400	2700
required pit diameter *[m]*:	5.31	4.82	4.50

** Based on effective depth and number of pits as in Soakaway Data table*

SUMMARY OF CALCULATIONS		
critical design rainfall duration 't_{crit}' =	360	*min*
required storage volume 'V_{req}' =	12.55	*m^3*
provided storage volume 'V_{prov}' =	13.23	*m^3*
utilisation factor =	**0.95**	***.OK***
required time to discharge 50% 't_{50}' =	13.13	*hours*
utilisation factor =	**0.55**	***.OK***

GENERAL DATA	
site location:	**England and Wales**
soakaway type:	**perforated concrete ring**
pit shape:	**circular pit around ring**
impermeable area drained to soakaway 'A' *[m^2]* =	**400**
60 min rainfall depth of 5 year return period 'R' *[mm]* =	**20**
M5-60 to M5-2d rainfall ratio 'r' =	**0.40**
allowance for climate change:	**No**

SOAKAWAY DATA	
number of ring soakaways:	**1**
circular pit diameter 'D' [m] =	**5.25**
soakaway ring internal diameter 'D_{int}' *[mm]* =	**2100**
total depth from ground level 'D_b' *[m]* =	**2.50**
depth to drain invert level 'D_d' *[m]* =	**1.00**
soakaway effective depth 'D_{eff}' *[m]* =	1.50
free volume in infill aggregate *[%]* =	**30**

SOIL INFILTRATION DATA	
allowance for infiltration through soakaway base:	**No**
available on-site infiltration test results:	◉ Yes ○ No
use soakage trial pit table below	
internal surface area of trial pit 'a_{p50}' [m^2] =	4.09
storage volume between 75-25% 'V_p' [m^3] =	0.78
time for water to fall from 75-25% 't_p' [min] =	282.59
soil infiltration rate 'f' [m/s] =	1.13E-05

SOAKAGE TRIAL PIT DATA	
soakage trial pit width 'W_t' *[m]* =	**1.00**
soakage trial pit length 'L_t' *[m]* =	**1.40**
total depth from ground level 'D_{tb}' *[m]* =	**1.50**
depth to pipe invert level 'D_{tp}' *[m]* =	**0.38**
soakage trial pit effective depth 'D_{teff}' *[m]* =	1.12
free volume in infill aggregate *[%]* =	**100**

NOTE: faces of excavation assumed to be vertical

REQUIRED STORAGE CAPACITY PER RAINFALL DURATION

rainfall duration *[min]*	rainfall factor Z1	**M5-D** rainfalls *[mm]*	**M10-D**			**ignore**			**ignore**			outflow from soakaway *[m^3]*	required storage *[m^3]*
			Z2	rainfalls *[mm]*	inflow *[m^3]*	Z2	rainfalls *[mm]*	inflow *[m^3]*	Z2	rainfalls *[mm]*	inflow *[m^3]*		
5	0.37	7.47	1.20	9.00	3.60							0.04	3.56
10	0.52	10.47	1.22	12.79	5.12							0.08	5.03
15	0.63	12.67	1.23	15.59	6.24							0.13	6.11
30	0.80	16.07	1.24	19.92	7.97							0.25	7.72
60	1.00	20.00	1.24	24.80	9.92							0.50	9.42
120	1.21	24.13	1.24	29.93	11.97							1.01	10.96
240	1.45	28.93	1.22	35.42	14.17							2.01	12.15
360	1.60	32.07	1.21	38.92	15.57							3.02	**12.55**
600	1.79	35.87	1.20	43.13	17.25							5.04	12.21
1440	2.24	44.80	1.18	52.88	21.15							12.09	9.06

** Z2 is a growth factor from M5 rainfalls*

SOAKAGE TRIAL PIT INFILTRATION TEST RESULTS

	water level measurement N^o:	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*
Soakage Trial 1	time *[min]* =	**0**	**187**	**363**	**550**															
	depth to water *[m]* =	**0.38**	**0.75**	**1.13**	**1.50**															
Soakage Trial 2	time *[min]* =	**0**	**195**	**382**	**580**															
	depth to water *[m]* =	**0.38**	**0.75**	**1.13**	**1.50**															
Soakage Trial 3	time *[min]* =	**0**	**187**	**367**	**558**															
	depth to water *[m]* =	**0.38**	**0.75**	**1.13**	**1.50**															

Appendix B

Initial Surface Water Pipe Sizing

Greenfield runoff estimation for sites

HR Wallingford
Working with water

Site name:	CATS
Site location:	Leys Hill Road, Walford, Ross-on-Wye, herefords

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the CIRIA SUDS Manual (2007). It is not to be used for detailed design of drainage systems. It is recommended that every drainage scheme uses hydraulic modelling software to finalise volume requirements and design details before drawings are produced.

Site coordinates

Latitude:	
Longitude:	
Reference:	000000000000 / 1.5
Date:	10 Aug 2016

Site characteristics

Total site area	1.5	ha
Significant public open space	0	ha
Area positively drained	1.5	ha

Methodology

Greenfield runoff method	IH124

Qbar estimation method	Calculate from SPR and SAAR
SPR estimation method	Calculate from SOIL type
SOIL type	2
HOST class	N/A
SPR	0.30

Hydrological characteristics

	Default	Edited	
SAAR	0	0	mm
M5-60 Rainfall Depth	20	14	mm
'r' Ratio M5-60/M5-2 day	0.4	0.2	
FEH/FSR conversion factor	0.97	0.97	
Hydrological region	1	1	
Growth curve factor: 1 year	0	0.85	
Growth curve factor: 10 year		1.45	
Growth curve factor: 30 year	0	1.95	
Growth curve factor: 100 year	0	2.48	

Greenfield runoff rates

	Default	Edited	
Qbar		0.00	l/s
1 in 1 year		0.00	l/s
1 in 30 years		0.00	l/s
1 in 100 years		0.00	l/s

Please note that a minimum flow of 5 l/s applies to any site

Greenfield runoff estimation for sites

HR Wallingford
Working with water

Site name:	CATS
Site location:	Leys Hill Road, Walford, Ross-on-Wye, herefords

This is an estimation of the greenfield runoff rate limits that are needed to meet normal best practice criteria in line with Environment Agency guidance "Preliminary rainfall runoff management for developments", W5-074/A/TR1/1 rev. E (2012) and the CIRIA SUDS Manual (2007). It is not to be used for detailed design of drainage systems. It is recommended that every drainage scheme uses hydraulic modelling software to finalise volume requirements and design details before drawings are produced.

Site coordinates

Latitude:	
Longitude:	
Reference:	000000000000 / 1.5
Date:	10 Aug 2016

Site characteristics

Total site area	1.5	ha
Significant public open space	0	ha
Area positively drained	1.5	ha

Methodology

Greenfield runoff method	FEH

Qmed estimation method	Calculate from BFI and SAAR	
BFI and SPR estimation method	Calculate from dominant HOST	
HOST class	N/A	
BFI / BFIHOST	0.00	
Qmed	N/A	l/s
Qbar / Qmed Conversion Factor	N/A	

Hydrological characteristics

	Default	Edited	
SAAR	0	0	mm
M5-60 Rainfall Depth	20	14	mm
'r' Ratio M5-60/M5-2 day	0.4	0.2	
FEH/FSR conversion factor	0.97	0.97	
Hydrological region	1	1	
Growth curve factor: 1 year	0	0.85	
Growth curve factor: 10 year		1.45	
Growth curve factor: 30 year	0	1.95	
Growth curve factor: 100 year	0	2.48	

Greenfield runoff rates

	Default	Edited	
Qbar	---	---	l/s
1 in 1 year	---	---	l/s
1 in 30 years	---	---	l/s
1 in 100 years	---	---	l/s

Please note that a minimum flow of 5 l/s applies to any site

Higham Hill Structures Ltd - Civil & Structural Engineers Applewood Grove, Cradley Heath. B64 6EW Tel: 0121 437 0407	**CATS, Leys Hill Road, Walford, Ross-on-Wye, herefordshire HR9 5QU**		Revision	
	Job No:	**2504**	Page:	**SW/03**
Section: **Max Flow Check**	Prepared By:	**AP**	Date:	**10/08/2016**

GENERAL DATA	
site location:	**England and Wales**
60 min rainfall depth of 5 year return period 'R' *[mm]* =	**20**
M5-60 to M5-2d rainfall ratio 'r' =	**0.40**
proposed discharge rate 'v_1' *[litre/s]* =	**12.00**
proposed discharge rate 'v_2' *[litre/s]* =	**15.00**
allowance for climate change:	**0%**

SUMMARY OF CALCULATIONS		
required storage volume for discharge rate 'v_1' =	**0.00**	m^3
required storage volume for discharge rate 'v_2' =	**0.00**	m^3

AREA DATA		impermeability *[%]*	effective area *[m^2]*
impermeable area 'A_1' *[m^2]* =	**400**	100.00	400
landscaping and/or green roof area 'A_2' *[m^2]* =	**0**	**80.00**	0
other partially permeable area 'A_3' *[m^2]* =	**0**	**20.00**	0
AREA DRAINED TO ATTENUATION TANK =			**400 m^2**

REQUIRED STORAGE VOLUME PER RAINFALL DURATION FOR DISCHARGE RATE v_1

rainfall duration *[min]*	rainfall factor Z1	**M5-D** rainfalls *[mm]*	**M1-D** Z2	M1-D rainfalls *[mm]*	M1-D inflow *[m^3]*	**M2-D** Z2	M2-D rainfalls *[mm]*	M2-D inflow *[m^3]*	**M10-D** Z2	M10-D rainfalls *[mm]*	M10-D inflow *[m^3]*	outflow from attenuation tank *[m^3]*	required storage *[m^3]*
5	0.37	7.47	0.62	4.59	1.84	0.79	5.90	2.36	1.20	9.00	3.60	3.60	**0.00**
10	0.52	10.47	0.61	6.39	2.56	0.79	8.28	3.31	1.22	12.79	5.12	7.20	**0.00**
15	0.63	12.67	0.62	7.79	3.12	0.80	10.07	4.03	1.23	15.59	6.24	10.80	**0.00**
30	0.80	16.07	0.62	10.03	4.01	0.80	12.89	5.16	1.24	19.92	7.97	21.60	**0.00**
60	1.00	20.00	0.64	12.80	5.12	0.81	16.20	6.48	1.24	24.80	9.92	43.20	**0.00**
120	1.21	24.13	0.66	15.84	6.34	0.82	19.75	7.90	1.24	29.93	11.97	86.40	**0.00**
240	1.45	28.93	0.68	19.55	7.82	0.83	23.95	9.58	1.22	35.42	14.17	172.80	**0.00**
360	1.60	32.07	0.68	21.94	8.78	0.83	26.68	10.67	1.21	38.92	15.57	259.20	**0.00**
600	1.79	35.87	0.69	24.81	9.92	0.84	29.98	11.99	1.20	43.13	17.25	432.00	**0.00**
1440	2.24	44.80	0.71	31.79	12.72	0.84	37.85	15.14	1.18	52.88	21.15	1036.80	**0.00**

** Z2 is a growth factor from M5 rainfalls*

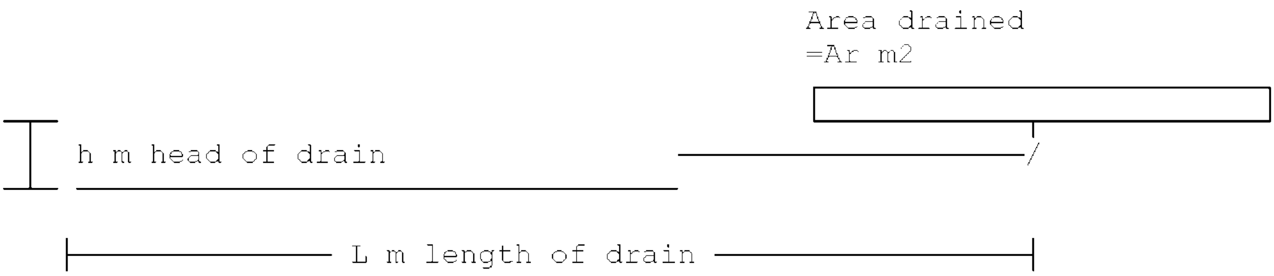
REQUIRED STORAGE VOLUME PER RAINFALL DURATION FOR DISCHARGE RATE v_2

rainfall duration *[min]*	rainfall factor Z1	**M5-D** rainfalls *[mm]*	**M30-D** Z2	M30-D rainfalls *[mm]*	M30-D inflow *[m^3]*	**ignore** Z2	ignore rainfalls *[mm]*	ignore inflow *[m^3]*	**ignore** Z2	ignore rainfalls *[mm]*	ignore inflow *[m^3]*	outflow from attenuation tank *[m^3]*	required storage *[m^3]*
5	0.37	7.47	1.46	10.89	4.35							4.50	**0.00**
10	0.52	10.47	1.49	15.63	6.25							9.00	**0.00**
15	0.63	12.67	1.51	19.12	7.65							13.50	**0.00**
30	0.80	16.07	1.53	24.59	9.83							27.00	**0.00**
60	1.00	20.00	1.54	30.87	12.35							54.00	**0.00**
120	1.21	24.13	1.54	37.05	14.82							108.00	**0.00**
240	1.45	28.93	1.52	43.91	17.56							216.00	**0.00**
360	1.60	32.07	1.50	48.22	19.29							324.00	**0.00**
600	1.79	35.87	1.49	53.30	21.32							540.00	**0.00**
1440	2.24	44.80	1.44	64.70	25.88							1296.00	**0.00**

** Z2 is a growth factor from M5 rainfalls*

Location: SURFACE WATER DESIGN - 1 IN 10 YEAR PIPE

Design of surface water sewer



Effective area to be drained   Ar=400 m^2
Impermeability factor   P=1
Rainfall intensity   R=107 mm/hour
Volume of water run off   Qs=(Ar*P*R/1000)/3600
=(400*1*107/1000)/3600
=0.011889 m3/s
Design flow in sewer   Q=Qs=0.011889 m3/s
Height of the drain (head)   h=0.375 m
Length of the drain   L=30 m
Inclination or fall   i=h/L=0.375/30=0.0125
Design pipe for flow of 1 times full bore.
Mean Hydraulic Depth factor   m=0.25

1. Using Chezy formula

Velocity = C(mDi)^0.5, where C is a constant usually taken as 56.
Diameter of drain required   D=1000*(Q^2/(0.785^2*56^2*m*i))^0.2
=1000*(0.011889^2/(0.785^2*56^2
*0.25*0.0125))^0.2
=118.54 mm
Diameter to be adopted   D=150 mm
According to Escritt for this size of pipe the minimum desirable gradient is 1 in 174.
Gradient greater than minimum recommended by Escritt, therefore OK.
Velocity   V=56*SQR(m*D/1000*i)
=56*SQR(0.25*150/1000*0.0125)
=1.2124 m/s

2. Using Escritt's formulae (see Drainage & Sewerage, published by the Clay Pipe Development Association)

Q = 0.00035D^2.62/(1/i)^0.5
V = 26.738D^0.62/(1/i)^0.5

To quote Escritt:
'The formulae approximate to the average of Hazen and William's formula for stoneware pipes, Barnes's formula for uncoated cast-iron pipes, Scobey's formula for rough-shuttered tunnel linings and Barnes's formula for brick conduits. They give fair accuracy for determining flows for

the smallest pipes used in domestic plumbing and in the largest sewers as yet constructed in Great Britain'.

Diameter of drain required D=(Q*1000*(1/i)^0.5/0.00035)^0.38168
=(0.011889*1000*(1/0.0125)^0.5
/0.00035)^0.38168
=123.77 mm
Diameter to be adopted D=150 mm
Velocity V=26.738*D^0.62/(SQR(1/i)*60)
=26.738*150^0.62/(SQR(1/0.0125)*60)
=1.1133 m/s

3. To check for drain running partially full; see hydraulic design of drains using Colebrook-White equation in Hydraulics Research Papers No 2 and No 4

Diameter of drain to be used D=150 mm
Surface roughness ks'=0.6 mm (linear measure)

(a) For pipe running part full:
Velocity V = -Ylog(ks/14.8m+1.225v/mY) for part full pipes where
v=viscosity Y=(32gmi)^0.5
Depth of flow as proportion of D x=0.55826
Velocity of flow V=1.1721 m/s

(b) For pipe running full using Colebrook-White:
Velocity V = -2Zlog(ks/3.7D+2.51v/DZ) for full pipes where
Z=(2gDi)^0.5 and v=viscosity
Velocity running full V=1.1227 m/s
Maximum discharge running full Q=0.01984 m3/s

DESIGN SUMMARY

Design discharge 0.011889 m3/s
Gradient of pipe 1 in 80 or 0.0125

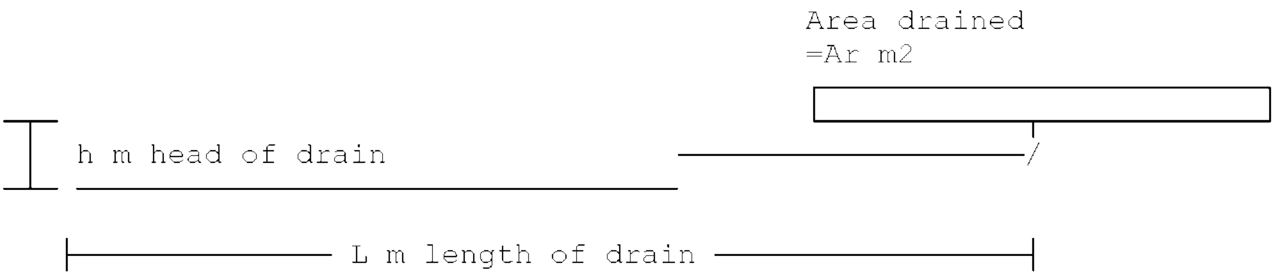
(a) Using Chezy formula:
Diameter of pipe 150 mm
Velocity of flow 1.2124 m/s

(b) Using Escritt's formulae:
Diameter of pipe 150 mm
Velocity of flow 1.1133 m/s

(c) Using Colebrook-White formula:
Diameter of pipe 150 mm
Velocity of flow 1.1721 m/s
Proportional depth 0.55826
Capacity of pipe 0.01984 m3/s
Velocity running full 1.1227 m/s

Location: SURFACE WATER DESIGN - 1 IN 30 YEAR PIPE

Design of surface water sewer



Effective area to be drained   Ar=400 m^2
Impermeability factor   P=1
Rainfall intensity   R=134 mm/hour
Volume of water run off   Qs=(Ar*P*R/1000)/3600
=(400*1*134/1000)/3600
=0.014889 m3/s
Design flow in sewer   Q=Qs=0.014889 m3/s
Height of the drain (head)   h=0.375 m
Length of the drain   L=30 m
Inclination or fall   i=h/L=0.375/30=0.0125
Design pipe for flow of 1 times full bore.
Mean Hydraulic Depth factor   m=0.25

1. Using Chezy formula

Velocity = C(mDi)^0.5, where C is a constant usually taken as 56.
Diameter of drain required   D=1000*(Q^2/(0.785^2*56^2*m*i))^0.2
=1000*(0.014889^2/(0.785^2*56^2
*0.25*0.0125))^0.2
=129.7 mm
Diameter to be adopted   D=150 mm
According to Escritt for this size of pipe the minimum desirable gradient is 1 in 174.
Gradient greater than minimum recommended by Escritt, therefore OK.
Velocity   V=56*SQR(m*D/1000*i)
=56*SQR(0.25*150/1000*0.0125)
=1.2124 m/s

2. Using Escritt's formulae (see Drainage & Sewerage, published by the Clay Pipe Development Association)

Q = 0.00035D^2.62/(1/i)^0.5
V = 26.738D^0.62/(1/i)^0.5

To quote Escritt:
'The formulae approximate to the average of Hazen and William's formula for stoneware pipes, Barnes's formula for uncoated cast-iron pipes, Scobey's formula for rough-shuttered tunnel linings and Barnes's formula for brick conduits. They give fair accuracy for determining flows for

the smallest pipes used in domestic plumbing and in the largest sewers as yet constructed in Great Britain'.

Diameter of drain required	D=(Q*1000*(1/i)^0.5/0.00035)^0.38168
	=(0.014889*1000*(1/0.0125)^0.5 /0.00035)^0.38168
	=134.87 mm
Diameter to be adopted	D=150 mm
Velocity	V=26.738*D^0.62/(SQR(1/i)*60)
	=26.738*150^0.62/(SQR(1/0.0125)*60)
	=1.1133 m/s

3. To check for drain running partially full; see hydraulic design of drains using Colebrook-White equation in Hydraulics Research Papers No 2 and No 4

Diameter of drain to be used	D=150 mm
Surface roughness	ks'=0.6 mm (linear measure)

(a) For pipe running part full:
Velocity V = -Ylog(ks/14.8m+1.225v/mY) for part full pipes where v=viscosity Y=(32gmi)^0.5

Depth of flow as proportion of D	x=0.64744
Velocity of flow	V=1.23 m/s

(b) For pipe running full using Colebrook-White:
Velocity V = -2Zlog(ks/3.7D+2.51v/DZ) for full pipes where Z=(2gDi)^0.5 and v=viscosity

Velocity running full	V=1.1227 m/s
Maximum discharge running full	Q=0.01984 m3/s

DESIGN SUMMARY

Design discharge	0.014889 m3/s
Gradient of pipe	1 in 80 or 0.0125

(a) Using Chezy formula:

Diameter of pipe	150 mm
Velocity of flow	1.2124 m/s

(b) Using Escritt's formulae:

Diameter of pipe	150 mm
Velocity of flow	1.1133 m/s

(c) Using Colebrook-White formula:

Diameter of pipe	150 mm
Velocity of flow	1.23 m/s
Proportional depth	0.64744
Capacity of pipe	0.01984 m3/s
Velocity running full	1.1227 m/s

Appendix C

Percolation Test Information for Infiltration

Percolation Test Results

Hole No	Test Date	Test No	Fill time			Start time			Finish time			Minutes	Seconds	Vp
1	10-Mar	1	11	19		11	45		13	28		103	6180	41.2
		2	14	52		16	15					166	9960	66.4
		3	9	27		12	50					406	24360	162.4
													Average	90
2	10-Mar	1	11	30		11	39		12	8		29	1740	11.6
		2	13	20		13	51		15	57		126	7560	50.4
	11-Mar	3	9	37		10	7		11	24		77	4620	30.8
													Average	30.93
													Average	60.47
Trench area														
	Area	No people	Vp	Treatment plant										
	604.667	50	60.47	0.2										

PLANNING

Notes
Do NOT scale off this drawing.

Check dimensions before use and notify the Architect of any discrepancies immediately.

Revisions

Job Title
CATS, Leys Hill, Walford
Residential Re-development

Drawing Title
Existing Site Plan

Drawn	Checked	Date	Scale
rh/ac		15/04/2016	1:500@A1

Graham Frecknall Architecture & Design
9 Agincourt Street Monmouth Monmouthshire NP25 3DZ
Tel 01600 716418 Fax 01600 714507 E-mail@gfarchitects.co.uk

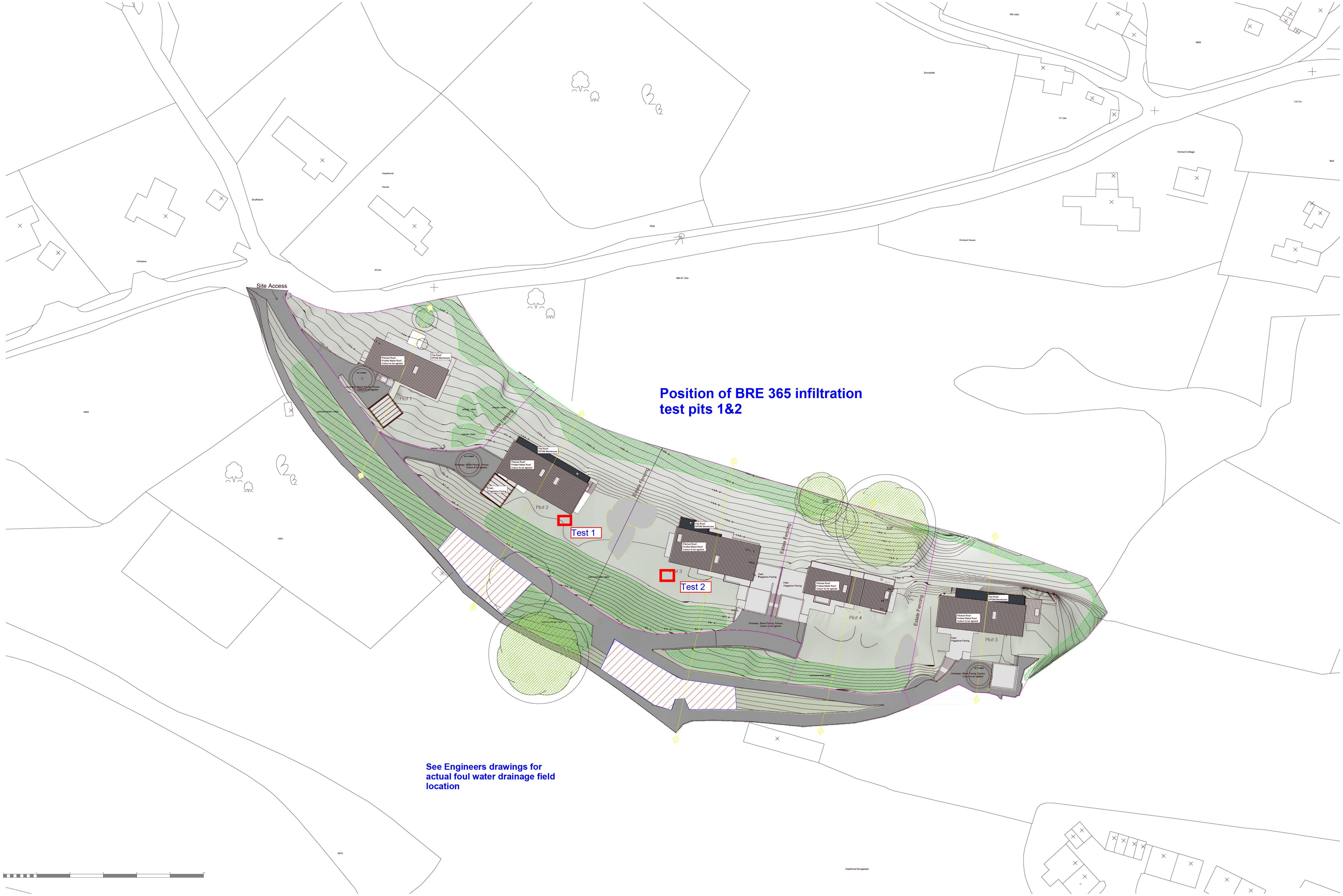
Job Number
1498.15

Work Stage

Drawing Number
AL.0.03

Rev.
-

Cats_Working Site Scheme_2016.02.02_24.mcd



Position of BRE 365 infiltration test pits 1&2
Site Access
Test 1
Test 2
Plot 2
Plot 4
Plot 5
See Engineers drawings for actual foul water drainage field location