ANTHONY-JOHNSON
Consulting Engineer Ltd

Site Address:

Building Plots to 4, 5 and 8,
Highstock lane
Gedney Hill.
PE12 0QG

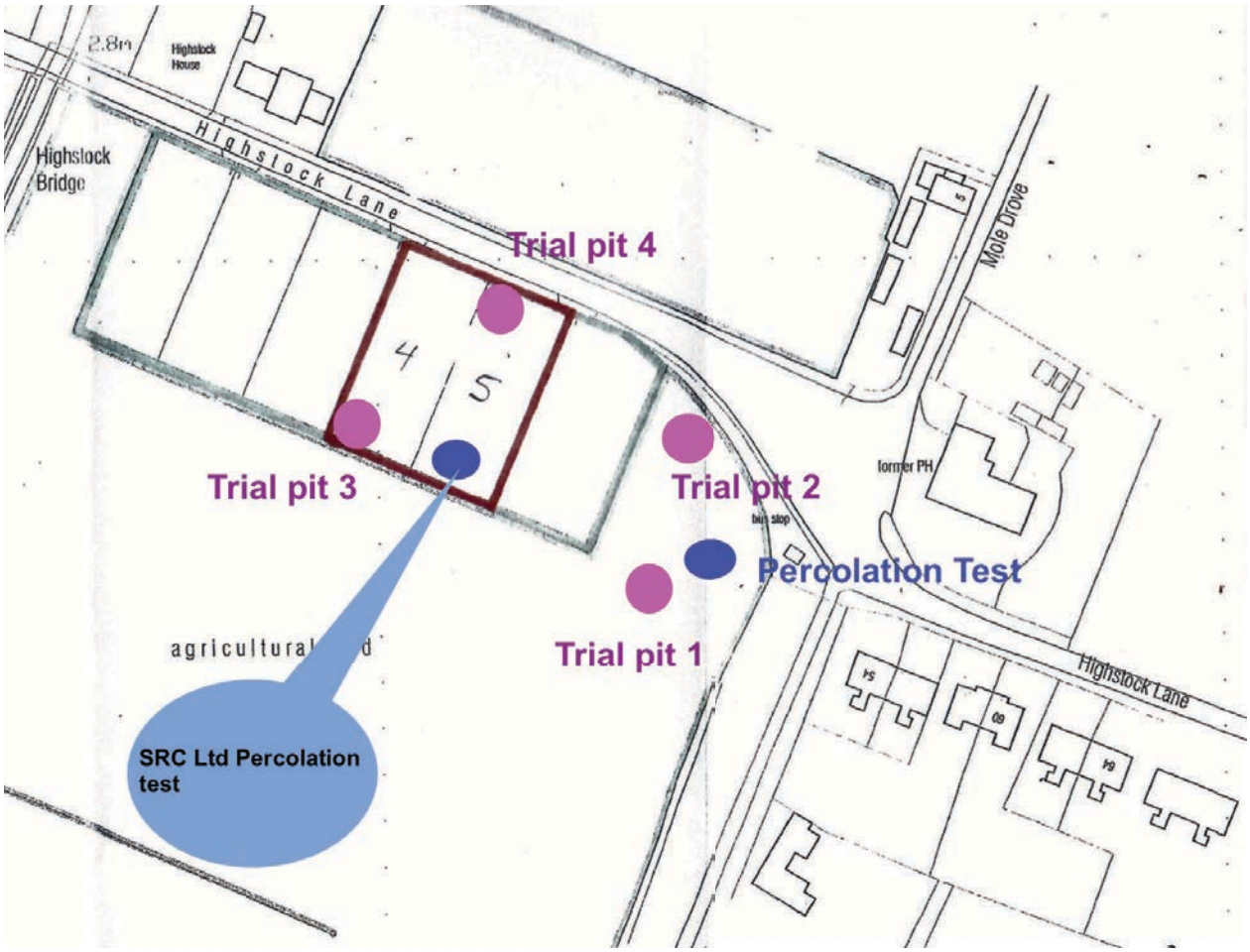
1.0 Overview:

A greenfield site, currently employed for arable farming and bounded on one side with trees, comprising sycamore Buddleia are and Silver Birch. It is proposed that residential properties be formed to the site.

The site is set, suitably removed from the adjacent highway, limiting the potential for existing services and disturbed/ made ground.

Former use of the land gives rise to the potential risk of drainage ditches and land drainage systems.

Grounds to Number 54 were noted as incorporating an area set aside for ground water/ surface water storage.



2.0 Goeotechnical Survey:

2.1 Trial Pit 1:

The first trial hole was set directly adjacent to the existing demise of plot 8.

The trial pit extended down through 400 mm of loamy topsoil With SILT clearly evident and some limited clay content.

The topsoil was found to be relatively friable with limited cohesion and limited moisture content.



Image 1.0: Trial pit with 400mm topsoil, set ot the head of a SILT bed.

At a depth of 400 mm a silty sand was encountered. Fine silt within the SAND was found to result in some limited cohesion within the geology and retention of moisture.

Mottling was noted within the SAND, indicative of some limited organic presence.



Image 2.0: SAND with SILT and mottling.

At 2.4 meters below ground level, extensive mottling was encountered within the geology and a sudden change from orange silty sand to grey silt was indicative of a total change in strata, similar in nature to the Barroway drove Beds, set to the underside of the Terrington Beds. The trial pit was terminated at 2.85 meters below ground level, with no further change in ground conditions.



Image 3.0: Grey mottled SAND and silt

2.2 Trial Pit 2:

The second trial pit was formed to the front of plot 8, 5 meters from the boundary line with the road. Ground level to this location was noted as being approximately 200 to 300 mm higher than at the location of the first trial pit. The trial pit extended down through 500 mm of dark loamy topsoil with some SILT and clay content. It was noted that some clumping of the extracted samples occurred.

At 500 mm below ground level SILTY sand was encountered and this was, as with trial pit one, noted as being mottled with some reddish inclusions.

At 1.5 meters below ground level, the sand started to change from a silver to an orange in colour.

Water started to enter the trial pit from a depth of 2.4 meters below ground level.

Walls to the trial pit starts to collapse from a depth of 2.6 m below ground level and on this basis it was considered prudent to terminate the trial pit at 2.7 m below ground level with no further change in ground conditions.



Image 4.0: Trial Pit 2.

2.3 Trial Pit 3:

A third trial pit was formed to the rear of plot four and this extended down through 400 mm of topsoil, comprising a dark loam with some roots present, some silt and very limited clay content. Remoulding of samples was attempted. However, these easily broke apart, indicating no- of little- cohesion, hence very low clay content.

At 400 mm below ground level, the topsoil gave way to a silt with sand present in the form of fine grained silica. This was noted as being mottled, with a discolouration throughout in the form of striations, likely representative of previous root inclusions/ decaying vegetation.



Image 5.0: Mottling of Silty SAND,

The orange silty SAND was found to continue to a depth of 2.8 m below ground level before giving way to a coarse grained grey SILT, reflective in nature of the Barroway Drove Beds.

Water content was found to enter the trial pit from 2.8 m below ground level with saturation of samples, resulting in liquefaction.



Image 6.0: View toward base of trial pit 3, with liquefaction of base due to ground water infiltration.

2.4 Trial pit 4:

A fourth trial pit was formed at the front of plot five and this extended down through 450 mm of topsoil before striking the head of the silty SAND bed.



Image 7.0: SAND and silt, extracted from trial pit 4

The SAND was found to be of limited cohesion, granular in nature, mottled, compact. This extended down to 2.6 m before striking the head of a grey SILT, mirroring findings to the first two trial pits.

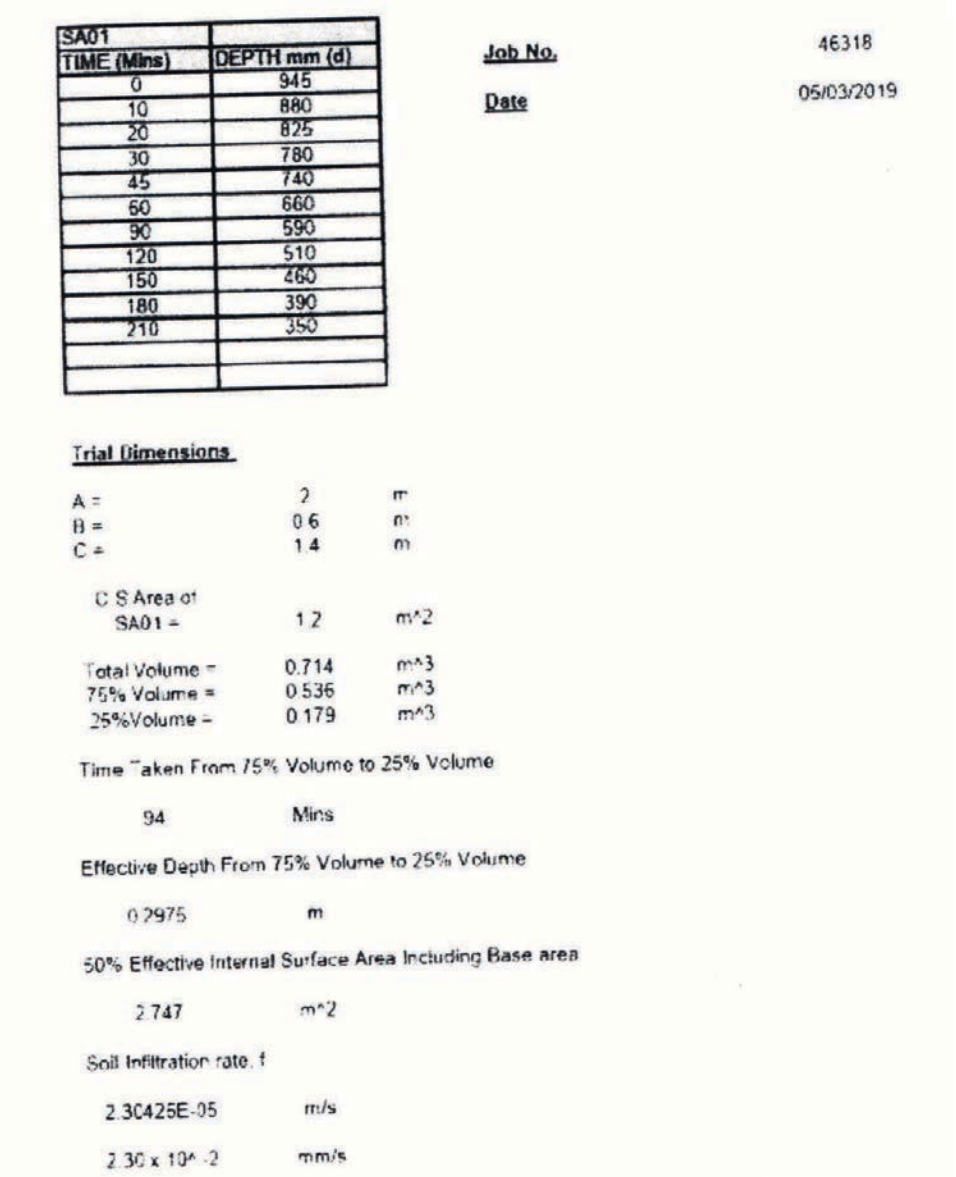


Image 8.0: View of trial pit 4

3.0: Percolation test:

Two sets of Percolation tests were performed on the site with the most recent being completed in March 2021 by this Engineer.

The first investigation comprised a single drainage test, performed by Sidebottom Richardson Cheng Ltd in March 2019, with results shown in image 10.0 below. A single run, which is noted as not allowing for attenuation within the surrounding ground, the results were found to mirror those obtained during the first of two sequential tests, potentially indicating limited variability year on year. Variability between tests was noted as being 0.1 x 10^-6 m/s, quantifying the results of tests as having been obtained with care.



SA01	
TIME (Mins)	DEPTH mm (d)
0	945
10	880
20	825
30	780
45	740
60	660
90	590
120	510
150	460
180	390
210	350

Job No. 46318

Date 05/03/2019

Trial Dimensions

A =	2	m
B =	0.6	m
C =	1.4	m
C S Area of SA01 =	1.2	m^2
Total Volume =	0.714	m^3
75% Volume =	0.536	m^3
25%Volume =	0.179	m^3

Time Taken From 75% Volume to 25% Volume

94 Mins

Effective Depth From 75% Volume to 25% Volume

0.2975 m

50% Effective Internal Surface Area Including Base area

2.747 m^2

Soil Infiltration rate, f

2.30425E-05 m/s

2.30 x 10^-2 mm/s

Image 9.0: Percolation test results obtained by Sidebottom Richardson Cheng Ltd in March 2019

Geotechnical analysis of the local geology, as detailed in the report above leads to the conclusion that local superficial geology is homogeneous in nature, formed of a granular upper strata, suitably free draining in nature, with a groundwater set at a depth greater

than 2.5 meters. Tidal flat deposits are noted as being set to the head of the Oxford Clay formation, as recorded by the BGS.

The tests carried out during March 2021 comprised a single trial pit, formed 1500mm long x 900mm wide x 1400mm deep. Topsoil was ignored, with the trial pit being sub-divided into equal 250mm vertical increments, each representing 25% volume.

The trial pit was filled and the time to discharge 50% of volume measured. The test was repeated, so as to allow for attenuation within the surrounding ground.

Percolation rates from the first test were found to be 2.4x10^-5 m/s. Attenuation within the ground resulted in this dropping significantly, so that the soil infiltration rate was found to drop to 1.43x10^-5 m/s.

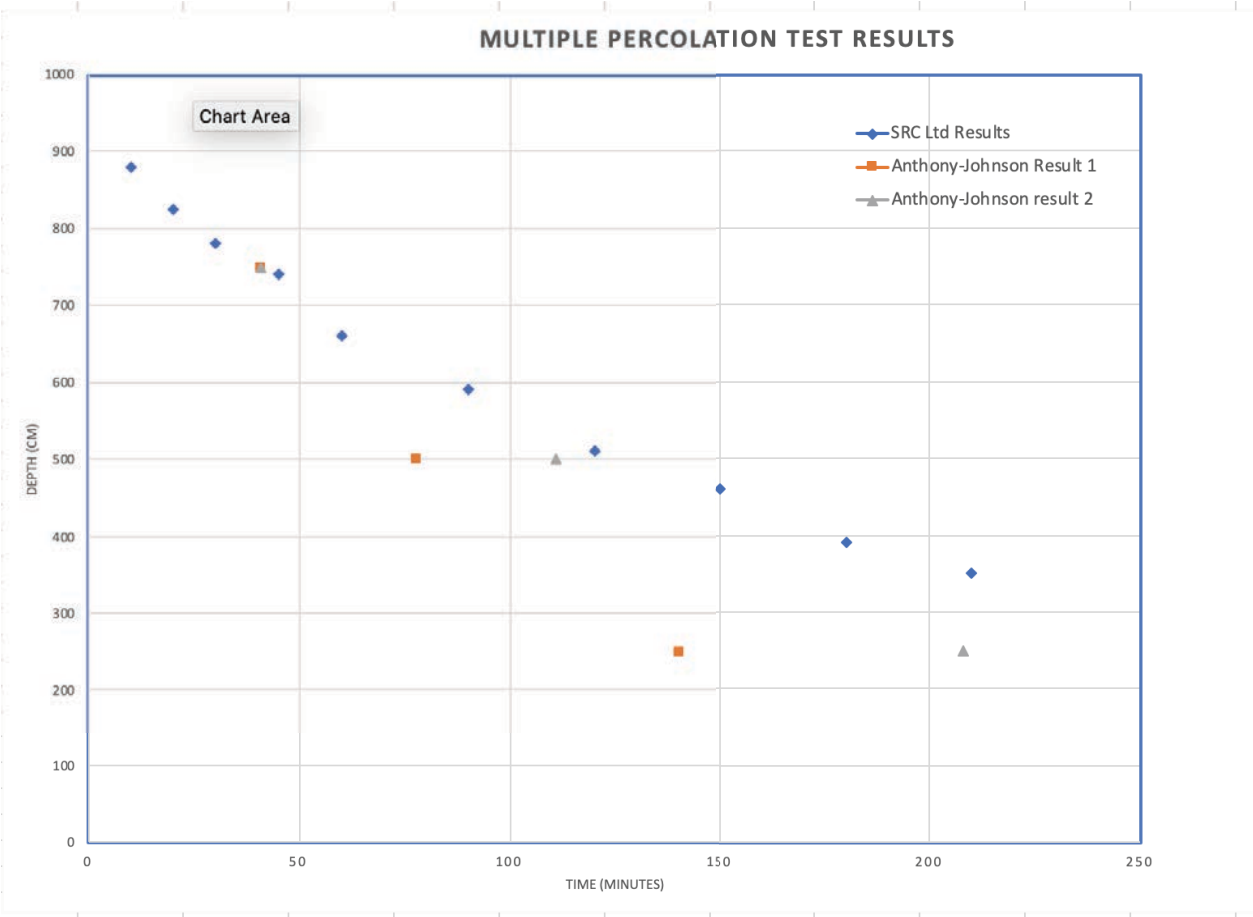


Image 10.0: Percolation test results

4.0 Conclusion & Recommendations:

4.1 Foundations:

In considering findings of the geotechnical survey, in conjunction with findings of that conducted by SRC Ltd, it is considered that strip foundations remain a suitable solution to all proposed properties.

Given the findings of trial pits and boreholes conducted for both surveys, the following recommendations are made:

1) The span of beam and block flooring should be limited to no more than 3 meters between supporting foundations, whether in the form of load bearing partitions, cavity walls or sleeper walls.
2) Where the client limits the span of beam and block flooring to 3 meters, strip footings may be suitably limited in width to 750mm for Cavity walls, 600mm for internal load bearing partitions and 450mm for sleeper walls.

It is noted that the geotechnical survey conducted by SRC Ltd exposed a black inclusion, likely organic, at a depth of 2.9 meters to borehole 1, located in proposed residential plot 2. Whilst not encountered during this survey, the risk of organic inclusions has been reviewed and given the extensive data collected by both surveys, is considered as being suitably mitigated. Organic matter is noted as being set at such a depth as to have no influence upon proposed foundations. Spread to the underside of foundations, coupled with significant overburden yields a limited change in bearing to the head of the organic matter.

4.1.1 Single Storey Structures:

Based upon the above recommendations, it is noted that, for a bungalow, formed with beam and block flooring, spanning 3 meters between intermediate supports a line load of 40 kN/m run may be considered, yielding a bearing pressure of 53kN/ SQ meter. Internal load bearing walls, supporting beam and block floor yield a line load of 31 kN/m and resultant bearing pressure of 52 kN/ SQ meter for 600mm wide strip footings. Sleeper walls, formed of 450 wide strips yield a bearing pressure of 64 kN/ SQ meter when supporting beam and block ground flooring only.

Given the ground conditions, lack of CLAY, limited moisture content and greenfield nature of the site, use should be made of a Gen 3 concrete mix, poured to a depth of 225mm minimum. Given the weaker underlying saturated SAND strata, set at 2800mm, it is recommended that trench fill concrete is avoided.

4.1.2 Two Storey Structures:

Where two storey structures are to be formed, it is recommended that the width of strip footings being increased throughout. To this end, footings to cavity walls should be increased to 900mm in width. To load bearing internal partitions and sleeper walls, 600mm wide strips should be employed. Concrete should be poured to a depth of 300mm throughout, at a founding depth of 750mm and beam and block flooring should be limited to a 3 meter span.

4.2: Soak-away

Soakaways, serving surface water runoff from roofs should be formed of crates, wrapped within a geotextile so as to prevent silting. They should be servevia a drainage system incorporating a suitable Silt trap.

4.2.1: Bungalows:

Soak-aways to the two bungalows at plot 4 and 5 have been designed for an individual surface are of 170 square meters roof covering. Allowing for attenuation and 20% rainfall increase due to climate change, a crate system is recommended, formed 2 meters below invert depth, 1 meter wise and 5.5 meters long.

The design makes allowance for the depth, which is noted as lying above ground water table. The width is limited by virtue of safe access during construction and it is advised that the risk of side wall collapse means that access during installation of the crates will not be possible. All works must be carried out from ground level.

4.2.2: Two storey structure

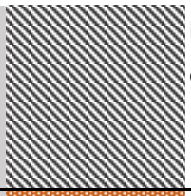
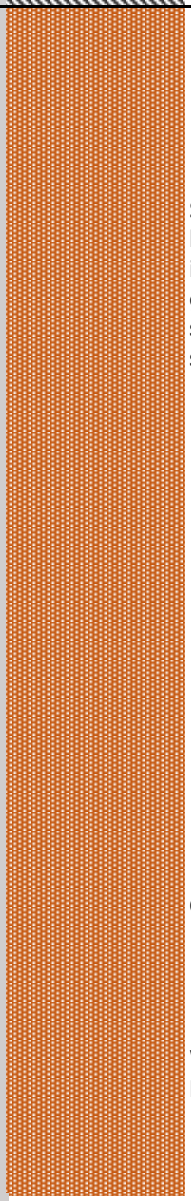
The soak away to plot 8 has been designed to serve a total roof area of 212 square meters. As with the design to the bungalows, allowance has been made for attenuation and 20% increase in rainfall intensity due to climate change.

A crate system is required, formed 2 meters below invert, 1 meter in width and 6 meters long. As previously, the design makes allowance for the depth, which is noted as lying above ground water table. The width is limited by virtue of safe access during construction and it is advised that the risk of side wall collapse means that access during installation of the crates will not be possible. All works must be carried out from ground level.

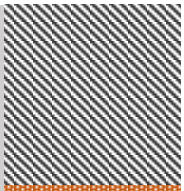
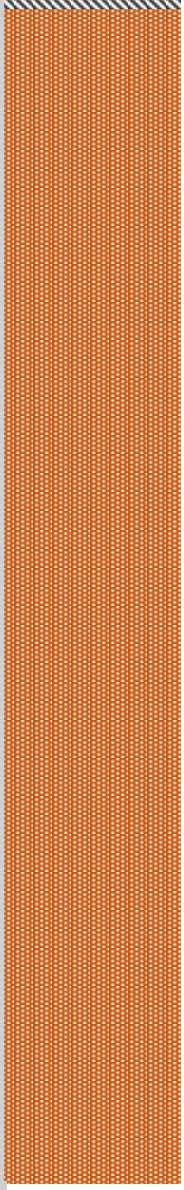
Appendix:

Depth (mm)	Log	Notes
100		Topsoil, Brown, friable, Silty, some clay,
200		limited moisture, roots.
300		
400		
500		SAND, fine grained with SILT present. Very limited cohesion, some mottling, orange SAND interspersed with red/ brown blotches- likely geologically historic organic matter/ organic staining. Moisture contained in samples but no saturation
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		Grey SILT, indicative of Barroway Drove beds.
2800		Coarse grained SILT, saturated.
2900		
3000		
3100		

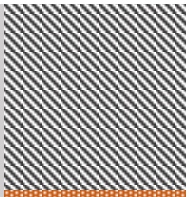
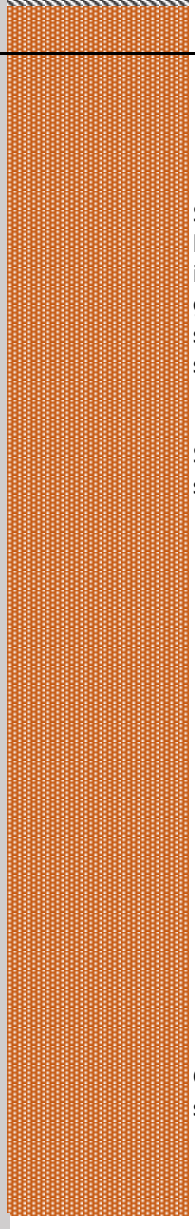
Trial Pit 1

Depth (mm)	Log	Notes
100		Dark loamy topsoil with some SILT can CLAY content. Limited moisture content.
200		
300		
400		
500		SAND, fine grained with SILT present. Very limited cohesion, some mottling, orange SAND interspersed with red/ brown blotches- likely geologically historic organic matter/ organic staining. Moisture contained in samples but no saturation
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		Ground water entering Trial pit
2500		
2600		
2700		Walls to trial pit collapsing/ undermining. Potential for running SANDs from this depth
2800		
2900		
3000		
3100		

Trial Pit 2

Depth (mm)	Log	Notes
100		Dark loamy topsoil with some SILT can CLAY content. Limited moisture content. No significant cohesion
200		
300		
400		
500		SAND, fine grained with SILT present. Very limited cohesion, some mottling, orange SAND interspersed with red/ brown blotches- likely geologically historic organic matter/ organic staining. Moisture contained in samples but no saturation
600		
700		
800		
900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		Walls to trial pit collapsing/ undermining. Potential for running SANDs from this depth
2800		
2900		
3000		Ground water entering trial pit from 2800mm
3100		

Trial Pit 3

Depth (mm)	Log	Notes
100		Dark loamy topsoil with some SILT can CLAY content. Limited moisture content. No significant cohesion
200		
300		
400		
500		
600		SAND, fine grained with SILT present. Very limited cohesion, some mottling, orange SAND interspersed with red/ brown blotches- likely geologically historic organic matter/ organic staining. Moisture contained in samples but no saturation
700		
800		
900		
1000		
1100		
1200		
1300		
1400		Some grey SAND/ Coarse SILT intermixed in striations
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
2500		
2600		
2700		Grey SILT with increased moisture content- saturated
2800		
2900		
3000		
3100		

Trial Pit 4

PLOT 8 Soakaway design: Surface water runoff from 212 square meters of roof)

SOAKAWAY DESIGN (BRE DIGEST 365/SUDS)

SOAKAWAY DESIGN

In accordance with BRE Digest 365 - Soakaway design

Tedds calculation version 2.0.04

Design rainfall intensity

Location of catchment area	Norwich
Impermeable area drained to the system	A = **212.0** m^2
Return period	Period = **100** yr
Ratio 60 min to 2 day rainfall of 5 yr return period	r = **0.410**
5-year return period rainfall of 60 minutes duration	M5_60min = **20.0** mm
Increase of rainfall intensity due to global warming	$p_{climate}$ = **20** %

Soakaway / infiltration trench details

Soakaway type	Rectangular
Minimum depth of pit (below incoming invert)	d = **2000** mm
Width of pit	w = **1000** mm
Length of pit	l = **5926** mm
Percentage free volume	V_{free} = **95** %

Soil infiltration rate (BRE digest 365)

Length of trial pit	l_{trial} = **1000** mm
Width of trial pit	b_{trial} = **900** mm
Depth of trial pit (below invert)	d_{trial} = **1500** mm
Free volume (if fill used)	V_{trial} = **100** %
75% depth of pit	$d_{75} = (d_{trial} \times 0.75)$ = **1125.00** mm
50% depth of pit	$d_{50} = (d_{trial} \times 0.50)$ = **750.00** mm
25% depth of pit	$d_{25} = (d_{trial} \times 0.25)$ = **375.00** mm
Test 1 - time to fall from 75% depth to 25% depth	T1 = **99** min
Test 2 - time to fall from 75% depth to 25% depth	T2 = **172** min
Test 3 - time to fall from 75% depth to 25% depth	T3 = **210** min
Longest time to fall from 75% depth to 25% depth	t_{lg} = max(T1, T2, T3) = **210** min
Storage volume from 75% to 25% depth	$V_{p75_25} = (l_{trial} \times b_{trial} \times (d_{75} - d_{25})) \times V_{trial}$ = **0.68** m^3
Internal surface area to 50% depth	$a_{p50} = ((l_{trial} \times b_{trial}) + (l_{trial} + b_{trial}) \times 2 \times d_{50})$ = **3.75** m^2
Surface area of soakaway to 50% storage depth	$A_{s50} = 2 \times (l_{trial} + b_{trial}) \times d_{trial} / 2$ = **2.850** m^2
Soil infiltration rate	$f = V_{p75_25} / (a_{p50} \times t_{lg})$ = **14.3×10^{-6}** m/s
Wetted area of pit 50% full	$a_{s50} = l \times d + w \times d$ = **13853000** mm^2

Table equations

Inflow (cl.3.3.1)	$I = M100 \times A$

3 Westgate Street
Southery
Downham Market
PE38 0PA

Outflow (cl.3.3.2) $O = a_{s50} \times f \times D$

Storage (cl.3.3.3) $S = I - O$

Duration, D (min)	Growth factor Z1	M5 rainfalls (mm)	Growth factor Z2	100 year rainfall, M100 (mm)	Inflow (m^3)	Outflow (m^3)	Storage required (m^3)
5	0.38	9.0	1.89	17.1	3.62	0.06	3.56
10	0.53	12.6	1.95	24.7	5.23	0.12	5.11
15	0.64	15.3	1.99	30.4	6.45	0.18	6.28
30	0.81	19.4	2.02	39.2	8.31	0.36	7.95
60	1.00	24.0	2.01	48.3	10.25	0.71	9.53
120	1.20	28.9	1.98	57.2	12.12	1.42	10.69
240	1.43	34.4	1.93	66.6	14.11	2.85	11.26
360	1.59	38.1	1.91	72.6	15.38	4.27	11.11
600	1.77	42.4	1.87	79.3	16.82	7.12	9.69
1440	2.20	52.8	1.79	94.6	20.05	17.10	2.95

Required storage volume $S_{req} = \mathbf{11.26}\ m^3$

Soakaway storage volume $S_{act} = l \times d \times w \times V_{free} = \mathbf{11.26}\ m^3$

PASS - Soakaway storage volume

Time for emptying soakaway to half volume $t_{s50} = S_{req} \times 0.5 / (a_{s50} \times f)$ = 7hr 54min 9s

PASS - Soakaway discharge time less than or equal to 24 hours

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Plots 4 and 5 Soakaway design: Surface water runoff , each from 170 square meters of roof

SOAKAWAY DESIGN (BRE DIGEST 365/SUDS)

SOAKAWAY DESIGN

In accordance with BRE Digest 365 - Soakaway design

Tedds calculation version 2.0.04

Design rainfall intensity

Location of catchment area	Norwich
Impermeable area drained to the system	A = **170.0** m^2
Return period	Period = **100** yr
Ratio 60 min to 2 day rainfall of 5 yr return period	r = **0.410**
5-year return period rainfall of 60 minutes duration	M5_60min = **20.0** mm
Increase of rainfall intensity due to global warming	$p_{climate}$ = **20** %

Soakaway / infiltration trench details

Soakaway type	Rectangular
Minimum depth of pit (below incoming invert)	d = **2000** mm
Width of pit	w = **1000** mm
Length of pit	l = **5419** mm
Percentage free volume	V_{free} = **80** %
Soil infiltration rate	f = **14.3×10^{-6}** m/s
Wetted area of pit 50% full	a_{s50} = l × d + w × d = **12838705** mm^2

Table equations

Inflow (cl.3.3.1)	I = M100 × A
Outflow (cl.3.3.2)	O = a_{s50} × f × D
Storage (cl.3.3.3)	S = I - O

Duration, D (min)	Growth factor Z1	M5 rainfalls (mm)	Growth factor Z2	100 year rainfall, M100 (mm)	Inflow (m^3)	Outflow (m^3)	Storage required (m^3)
5	0.38	9.0	1.89	17.1	2.90	0.06	2.84
10	0.53	12.6	1.95	24.7	4.19	0.11	4.08
15	0.64	15.3	1.99	30.4	5.18	0.17	5.01
30	0.81	19.4	2.02	39.2	6.66	0.33	6.33
60	1.00	24.0	2.01	48.3	8.22	0.66	7.56
120	1.20	28.9	1.98	57.2	9.72	1.32	8.39
240	1.43	34.4	1.93	66.6	11.31	2.64	8.67
360	1.59	38.1	1.91	72.6	12.33	3.97	8.37
600	1.77	42.4	1.87	79.3	13.48	6.61	6.88
1440	2.20	52.8	1.79	94.6	16.08	15.86	0.21

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PE38 0PA

Required storage volume	S_{req} = **8.67** m^3
Soakaway storage volume	$S_{act} = l \times d \times w \times V_{free}$ = **8.67** m^3
	PASS - Soakaway storage volume
Time for emptying soakaway to half volume	$t_{s50} = S_{req} \times 0.5 / (a_{s50} \times f)$ = 6hr 33min 32s
	PASS - Soakaway discharge time less than or equal to 24 hours

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