PROPOSED AREA 1 AND AREA 2 OF THE DEVELOPMENT AT GREEN LANE, PINCHBECK

DRAINAGE STRATEGY

Revision A 09 July 2019
Report revised following consutlation
with LCC Highways and Anglian Water

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Introduction

An outline planning application (reference H14-0549-17) was approved by South Holland District Council for a residential development on the eastern side of an area south of Green Lane on the northern side of Pinchbeck, which is situated approximately 4.0 km north of Spalding.

A second planning application (reference H14-0137-19) has now been submitted to the Council for 64 houses on a larger area south of Green lane between Surfleet Road on the east and Bacon's Lane on the west.

The drainage strategy for area 1 used the dyke which runs north south between areas 1 and 2 as attenuation for the surface water from the development. As it is not now possible to utilise this central dyke to store the surface water an alternative method of disposing of the surface water will be designed.

An initial drainage strategy was submitted with the latest application, and a second strategy with swales adjacent to the access roads was drawn up following comments from Lincolnshire County Council. However the results from the recently produced ground investigation report have shown high levels of ground water. Therefore the option of draining the site access road using swales is not possible.

For all large developments (more than 10 dwellings) there is a requirement to apply sustainable drainage principles (SuDS) to the disposal of surface water from the site.

The CIRIA SuDS Manual 2015 explains the philosophy of SuDS in Chapter 1 of the manual as follows:

> The philosophy of sustainable drainage systems is about maximising the benefits and minimising the negative impacts of surface water runoff from developed areas.
>
> The SuDS approach involves slowing down and reducing the quantity of surface water runoff from a developed area to manage downstream flood risk, and reducing the risk of that runoff causing pollution. This is achieved by harvesting, infiltrating, slowing, storing, conveying and treating runoff on site and, where possible, on the surface rather than underground. Water then becomes a much more visible and tangible part of the built environment, which can be enjoyed by everyone.

The Technical Standards for Sustainable Drainage produced by the Local Authority SuDS Officer Organisation (LASOO) states that generally the aim for should be to discharge surface water runoff as high up the following hierarchy of drainage options as reasonably practicable:

1) Into the ground (infiltration).
2) To a surface water body.
3) To a surface water sewer or highway drain.
4) To a combined sewer.

Site Investigation

A 2.0 metre deep trial hole was excavated on the site in August and this found the subsoil to be silty sand overlying clay, which was found in the bottom 200mm of the hole. No ground water was found. A percolation test was carried out on the site and the rate of fall of the water in the trial pit was very small. The infiltration rate was calculated using methods in BRE Digest 365 and the results are shown on pages 11 and 12 of this report. The percolation rate was calculated to be 9.0 x 10^{-6} m/sec.

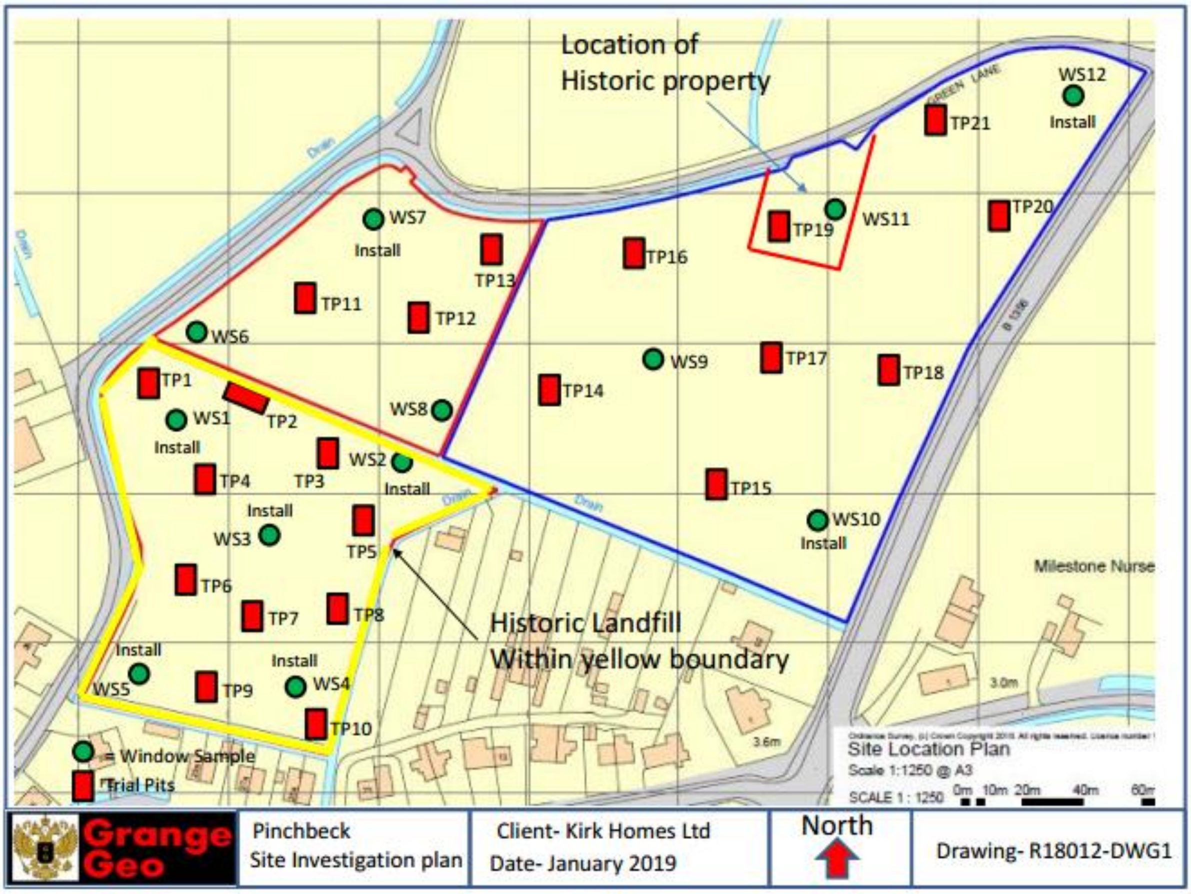
Recently a ground investigation report has been delivered which shows details of 21 trial pits excavated to a depth of 2.1 metres and 12 window sample boreholes to a maximum depth of 4.0 metres in most cases.

The window sample boreholes all indicate silty sand or sandy silt with only one reference to "slightly clayey silt" in all 12 boreholes.

The consultants have monitored the groundwater levels in 8 boreholes and the results are shown below.

Borehole	Monitoring visits	Depth to Groundwater range (m bgl)	Response Zone (m bgl)	Groundwater observations
WS7	25.01.2019 31.01.2019 05.02.2019 13.02.2019 21.02.2019 28.02.2019	0.76-0.82	1m to 5m bgl	No visual or olfactory evidence of contamination.
WS12		1.10-1.14	1m to 4m bgl	No visual or olfactory evidence of contamination.
WS10		1.05-1.10	1m to 4m bgl	No visual or olfactory evidence of contamination.
WS8		1.30-1.37	1m to 3m bgl	No visual or olfactory evidence of contamination.
WS2		1.10-1.14	0.5m to 2.5m bgl	No visual or olfactory evidence of contamination.
WS3		1.09-1.13	0.5m to 3m bgl	No visual or olfactory evidence of contamination.
WS4		1.05-1.07	0.5m to 2.5m bgl	No visual or olfactory evidence of contamination.
WS5		0.98-1.02	1m to 4m bgl	No visual or olfactory evidence of contamination.
WS1		0.95-0.99	0.5m to 2m bgl	No visual or olfactory evidence of contamination.

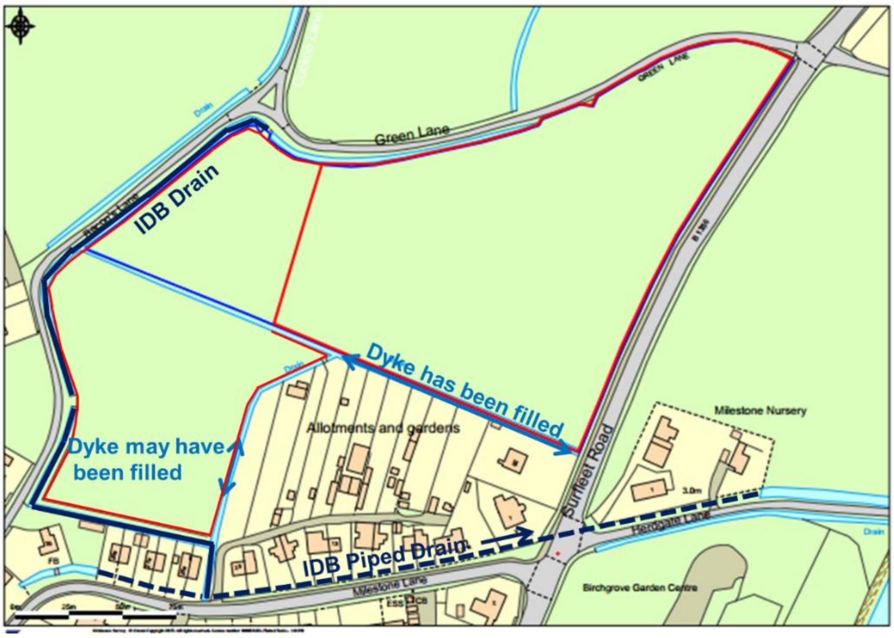
A plan of the location of all the boreholes is shown on the next page.



The results from three sample trial pits (Nos 7,11 and 17) are shown on pages 14 – 16 of this report.

Existing Drainage Systems

There are dykes around the site which provide drainage to the fields. These are not well maintained, but seem to be providing adequate drainage of the land at the present time. These are shown on the plan below.



It is unlikely that there are underdrains leading into the dykes as the land is free draining in this area. From local knowledge it seems that a short length of the north south dyke which flows southwards into the IDB drain has been filled and there is no confirmation that this has been piped. However drainage from the field seems to be able to flow southwards along the IDB open drain on the east side of Bacons Lane and then along the IDB open drain north of property nos 25,27,29 and 33 Milestone Lane flowing eastwards to discharge into the piped IDB drain on the north side of Milestone Lane.

Design of Surface Water Disposal

The design of the surface water drainage is complicated by the presence of areas of made ground around the site, particularly in the south west corner. The initial percolation test and the ground investigation report indicate that as long as the base of soakaways are above the standing ground water level adequate soakaways can be designed for the disposal of surface water from the roofs of the buildings in areas where there is no made ground around the site. As a large area of made ground has been identified in the south western corner the roof drainage from houses in this area will at this stage be designed to be discharged into a new surface water sewer.

The ground investigation report has recommended that a 600mm thick clean topsoil cover layer, underlain by a brightly coloured geo-textile marker layer should be installed in all soft landscaped areas on the site, and as the finished floor levels of the houses need to be raised to comply with the flood risk assessment it is likely that the whole of the site will be raised by 600mm.

With regard to the drainage of the roads on the development, it is proposed to construct the site access road with impermeable asphalt surfacing. In order to comply with SuDS recommendations Lincolnshire County Council (LCC) asked the developer to consider the option of using swales instead of gullies to collect the surface water from the roads. However the typical LCC design specification requires the base of the swale to be 1.0 metre above the ground water level, which is not achievable on this site. Therefore the use of swales is not possible on this site and the proposal is to discharge the surface water from the roads into gullies which will discharge into a surface water system located under the main access road.

Welland and Deepings IDB have stated that the drainage channels in this area are only able to receive discharges from development at greenfield rates. Therefore it will be necessary to provide storage for the surface water discharged from the roads and the houses in the south western area and discharge into the IDB system at a low flow rate. The options that have been considered for storage of the surface water are:

- An oversized surface water sewer under the access road.
- An underground or open storage facility in the south eastern corner of the site.
- An underground or open storage facility in the western side of the site.

The option of an underground attenuation chamber constructed with geocellular crates has been chosen as the area taken by an open pond would impact on the area of public space required for the development. Therefore an underground storage area combined with an oversized surface water sewer has been chosen.

It would be possible to provide two smaller attenuation chambers and two flow control valves and discharge into both the open drain on the western side of the site and the piped IDB drain near the junction of Milestone Lane and Surfleet Road. However this would be more expensive both to construct and to maintain in the future.

The option chosen at the present time is to construct an oversized sewer with a diameter of 900mm and this will provide storage as well as conveyance into an underground storage facility constructed with geocellular crates beneath the public open space on the south eastern corner of the site. The geocellular crates should be surrounded by a geomembrane which will form an impermeable liner to the chamber to form a watertight tank because of the high water table on the site. The geomembrane should be protected with a heavy duty geotextile to protect the geomembrane.

Sufficient storage capacity will be provided so that the volume of rainfall from a 1 in 100 year event with a 30% increase for climate change can be retained in the system and then discharged into the IDB watercourse at a rate of 5.7 litres/ second. This is the greenfield rate (1.4 litres/sec/ha) for the development which has a total site area of 4.07ha. This will then comply with the SuDS manuals and guidance that recommend that the surface water should be reduced as much as possible to manage downstream flood risk.

Anglian Water have been approached to take over the future maintenance of the sewers, the road drainage, the attenuation chamber, the flow control valve and the outfall pipework. They have advised that their current policy is not to adopt geocellular storage chambers under the SuDS S104 adoption process. However they would consider an application to adopt the pipework leading to the chamber.

A typical design will be shown in the calculations for a soakaway for a house with a roof area of 140 square metres. The soakaways will be designed to conform to all aspects of BRE365, particularly the clause requiring the water level in a soakaway to have reduced by 50% within 24 hours.

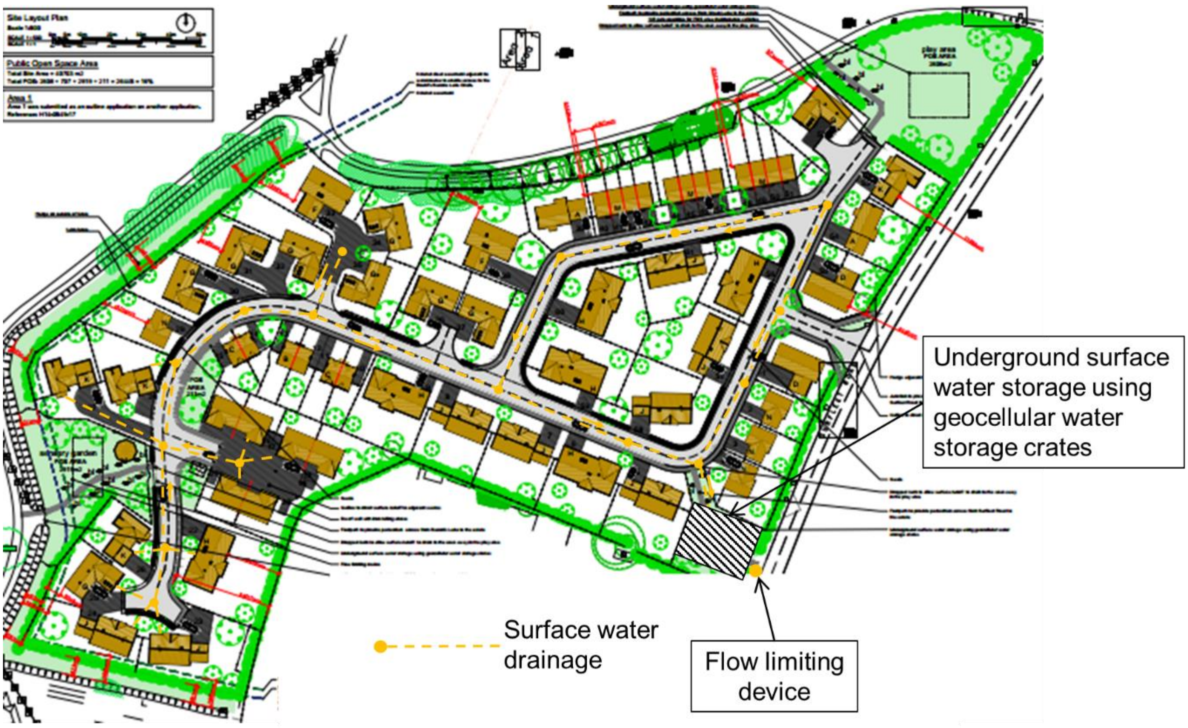
A schematic layout of this is shown below, and initial calculations are shown on pages 7 - 10.

Foul Water

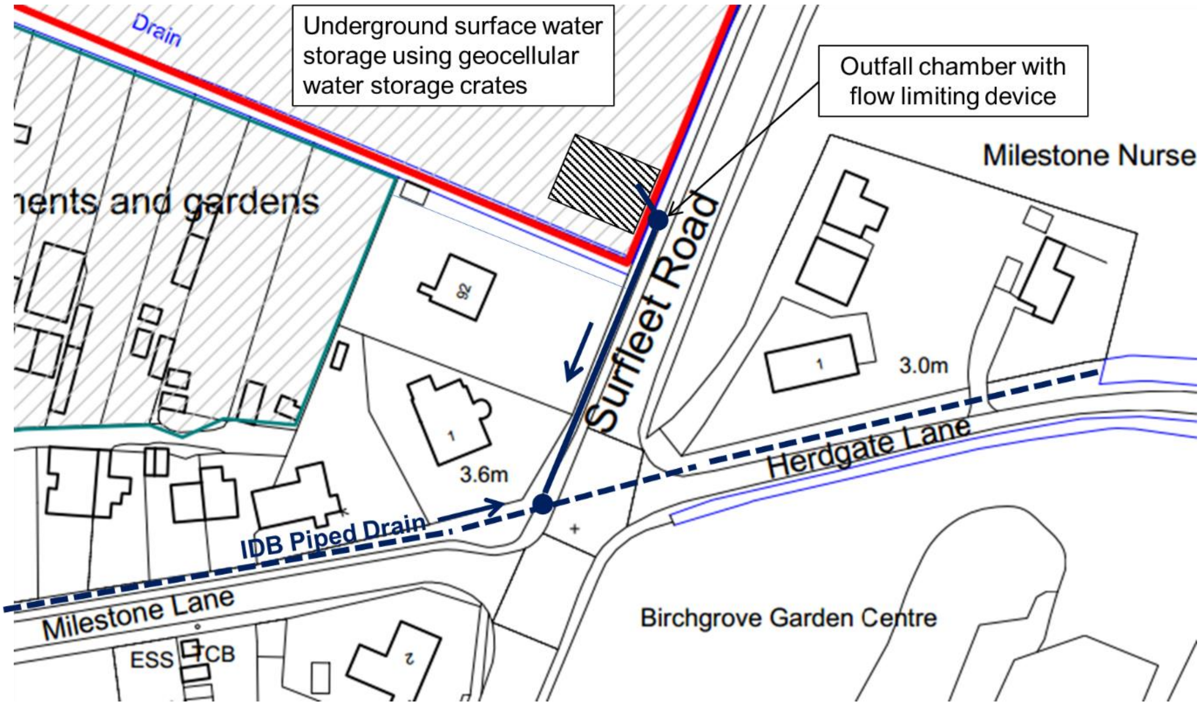
It is assumed the foul water sewer will be located under the new site road which will connect into the existing Anglian Water system in Pinchbeck.

DESIGN OF SURFACE WATER DRAINAGE SYSTEM

The layout of the proposed surface water drainage on the development is shown below, and a full page plan is shown on page 13.



The surface water will flow southwards from the flow limiting device and discharge into the piped IDB drain at the junction of Milestone Lane and Surfleet Road.



Total area of site = 4.07ha

The impermeable areas of roads……… 680 x 7.5 = 5,100 sq m

Houses on plots 16 – 28 ………………………………1,716 sq m

Total impermeable area ………………………………6,816 sq m

The volumes of rainfall for various storm durations in a 1 in 100 year event in 2115 can be calculated as follows:

Duration	M5_60min	Z1	M5-D	Z2	M100-D	Intensity mm/hour	Areal Factor	Areal Intensity mm/hour	Area (ha)	Volume cum/hr	Vol + 30% climate Change cum/hr	Total Volume cu m climate	Total Volume cu m	Volume litres/sec
15	24	0.64	15.36	1.98	30.41	121.65	0.94	114.35	0.682	779.882	1013.85	253.5	194.97	216.634
30	24	0.81	19.44	1.97	38.30	76.59	0.95	72.76	0.682	496.250	645.12	322.6	248.12	137.847
60	24	1	24	1.93	46.32	46.32	0.96	44.47	0.682	303.266	394.25	394.2	303.27	84.241
120	24	1.2	28.8	1.89	54.43	27.22	0.97	26.40	0.682	180.045	234.06	468.1	360.09	50.012
240	24	1.42	34.08	1.86	63.39	15.85	0.97	15.37	0.682	104.836	136.29	545.1	419.34	29.121
360	24	1.57	37.68	1.83	68.95	11.49	0.98	11.26	0.682	76.811	99.85	599.1	460.86	21.336
600	24	1.74	41.76	1.81	75.59	7.56	0.98	7.41	0.682	50.518	65.67	656.7	505.18	14.033
1440	24	2.16	51.84	1.81	93.83	3.91	0.98	3.83	0.682	26.130	33.97	815.3	627.12	7.258
2880	24	2.5	60	1.81	108.60	2.26	0.98	2.22	0.682	15.122	19.66	943.6	725.84	4.200

If an outflow from the system of 5.7 litres/sec is taken then the volume of attenuation required can be calculated as follows:

Duration mins	Total Rainfall in Duration mm	Total Rainfall Volume cu m into storage facility	Outflow into IDB Drain at 5.7 litres/sec	Total Storage Required	Total Time to empty storage hours
15	1013.8	253.46	5.13	248.33	12.35
30	645.1	322.56	10.26	312.30	15.72
60	394.2	394.25	20.52	373.73	19.21
120	234.1	468.12	41.04	427.08	22.81
240	136.3	545.14	82.08	463.06	26.57
360	99.9	599.12	123.12	476.00	29.20
600	65.7	656.74	205.20	451.54	32.00
1440	34.0	815.26	492.48	322.78	39.73
2880	19.7	943.59	984.96	-41.37	45.98

Therefore from the above table it can be seen that a total storage volume of 326 cu metres is required to store the rainfall from a 1 in 100 year event with 30% increase for climate change.

It is proposed to provide this storage with the oversized main surface water sewer, and the underground storage under the public open space on the eastern side of the development.

The 900mm diameter oversized sewer approximately 250 metres long has a volume of

250 x 0.64 = 160 cu metres.

The storage facility under the public open space will be created with 1728 geocellular crates which will be 24 metres x 18 metres x 800mm deep with a storage volume of 328.3 cu metres.

Therefore with this initial design a volume of 160 + 328.3 = 488.3 cu metres will be created. This ignores any volume of water that could soak away through the sides of the storage facility.

DESIGN TYPICAL SOAKAWAY FOR HOUSE

Assume a roof area of 140 square metres

Calculate Design Rainfall

The following table shows volumes of rainfall for storm durations from 15 minutes to 48 hours with a 30% allowance for climate change over 100 years.

Duration hours	Duration mins	M5_60min	Z1	M5-D	Z2	M100-D	Intensity mm/hour	Areal Factor	Areal Intensity mm/hour	Area (ha)	Volume cum/hr	Vol + 30% climate Change cum/hr	Total Volume climate cu m	Total Rainfall in Duration mm
0.25	15	24	0.64	15.36	1.98	30.41	121.65	0.94	114.35	0.014	16.009	20.81	5.2	28.6
0.5	30	24	0.81	19.44	1.97	38.30	76.59	0.95	72.76	0.014	10.187	13.24	6.6	36.4
1	60	24	1	24	1.93	46.32	46.32	0.96	44.47	0.014	6.225	8.09	8.1	44.5
2	120	24	1.2	28.8	1.89	54.43	27.22	0.97	26.40	0.014	3.696	4.80	9.6	52.8
4	240	24	1.42	34.08	1.86	63.39	15.85	0.97	15.37	0.014	2.152	2.80	11.2	61.5
6	360	24	1.57	37.68	1.83	68.95	11.49	0.98	11.26	0.014	1.577	2.05	12.3	67.6
10	600	24	1.74	41.76	1.81	75.59	7.56	0.98	7.41	0.014	1.037	1.35	13.5	74.1
24	1440	24	2.16	51.84	1.81	93.83	3.91	0.98	3.83	0.014	0.536	0.70	16.7	92.0
48	2880	24	2.5	60	1.81	108.60	2.26	0.98	2.22	0.014	0.310	0.40	19.4	106.4

Calculate Size of Soakaways using Polystorm units

Provide 56 No Polystorm units in an area of 14 metres x 1.0 metre wide x 800mm deep set at a depth of 1.2 metres.

Effective depth of the soakaways will be 1200mm.

The total storage volume of the Polystorm units is 0.19 x 56 = 10.64 cu metres.

The design method for sizing a soakaway is based upon the the equation of volumes:

I - O = S

I = The inflow from the impermeable area draining into the soakaway

The volume from the final column in the table above will be used for this

O = The outflow infiltrating into the soil during rainfall

The outflow O = a_{s50} x f x D

a_{s50} = the internal surface area of the soakaway to 50% effective depth. BRE states that the base area should be assumed to clog with fine particles and become ineffective in the long term.

f = the soil infiltration rate determined by percolation tests.

D = the storm duration

The equation used for working out the outflow in the storm duration in the table below is

O = 0.5 x (Area of sides of soakaway) x f x D.

Area of sides of soakaway = 0.8 x 2 x 15 = 24.0 sq.m.

S = The required storage in the soakaway to balance temporarily inflow and outflow.

Therefore tabulating these figures for the storm durations above firstly using soil infiltration rate of 9 x 10^{-6}.

Duration mins	Total Rainfall in Duration mm	Total Rainfall Volume cu m	Area of Sides of Soakaway	Soil Infiltration Rate	Outflow in storm duration	Total Storage Required	Total Time to empty Soakaway hours
15	28.6	5.2	24.0	0.00000900	0.10	5.1	6.69
30	36.4	6.6	24.0	0.00000900	0.19	6.4	8.52
60	44.5	8.1	24.0	0.00000900	0.39	7.7	10.41
120	52.8	9.6	24.0	0.00000900	0.78	8.8	12.36
240	61.5	11.2	24.0	0.00000900	1.56	9.6	14.39
360	67.6	12.3	24.0	0.00000900	2.33	10.0	15.82
600	74.1	13.5	24.0	0.00000900	3.89	9.6	17.34
1440	92.0	16.7	24.0	0.00000900	9.33	7.4	21.52
2880	106.4	19.4	24.0	0.00000900	18.66	0.7	24.91

Therefore it can be seen that the scheme is satisfactory as the volume of storage provided is 10.64 cu metres.

The times to empty the soakaways is within the guidance set by BRE digest 365, which states that soakaways should discharge from full volume to half volume within 24 hours.

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9 July 2019

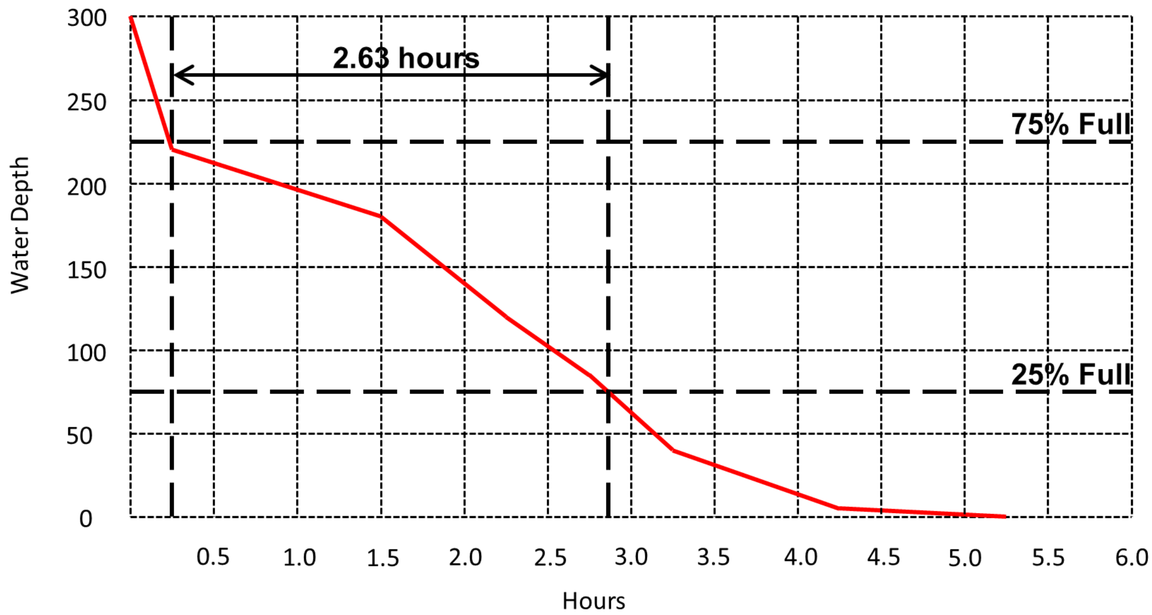
RESULTS OF PERCOLATION TEST

13th May 2017

Results

Hours	Time	Measurement mm	Water Depth
0.00	8.45am	700	300
0.25	9.00am	780	220
1.50	10.15am	820	180
2.25	11.00am	880	120
2.75	11.30am	915	85
3.25	12.00	960	40
4.25	13.00	995	5
5.25	14.00	1000	0

Graph of Water Level and Time



CALCULATION OF SOIL INFILTRATION RATE

On 13th May 2017 a trial hole was excavated to assess the depth of the ground water table on the site. This was excavated to a depth of 2.0 metres when a clay layer was found, but no ground water. On the same day one percolation tests to BRE 365 was carried out on the site. In this test a 750mm long x 500mm wide hole was excavated 1.0 metre deep. This hole was filled and water soaked away completely in 5.25 hours. Referring to the graph of the results the time taken to drain between 75% and 25% of the depth filled was 2.63 hours.

The soil infiltration rate will be calculated as follows:

$$\text{Soil Infiltration Rate} = \frac{V_{p75-25}}{A_{p50} \times t_{p75-25}}$$

Volume outflowing between 75% and 25% effective depth:

$$V_{p75-25} = (0.45 - 0.15) \times 0.75 \times 0.5 = \underline{0.1125 \text{ cu m}}$$

The mean surface area through which the outflow occurs, taken to be the pit sides to 50% effective depth and including the base of the pit:

$$A_{p50} = (0.75 \times 0.3 \times 2) + (0.5 \times 0.5 \times 2) + (0.75 \times 0.5) = \underline{1.325 \text{ s m}}$$

The time of outflow between 75% and 25% effective depth

$$t_{p75-25} = 2.63 \times 60 \times 60 = \underline{9{,}468}$$

$$\text{Soil Infiltration Rate} = \frac{0.1125}{1.325 \times 9468} = \underline{8.96 \times 10^{-6} \text{ m/sec}}$$


Underground surface water storage using geocellular water storage crates
Flow limiting device
Surface water drainage

SAMPLE TRIAL PIT DETAILS

Trial Pit Log	TP No: 7	[redacted]
Client: Kirk Homes Project: Pinchbeck, Spalding	Sheet: Method: 3T Rubber Tracked Excavator	

Sample Depth (m)	Sample Type	Testing result	Description	Depth mBGL	Legend
0.2	HSV	12kPa	Soft friable brown/dark brown very sandy silt. Sand is fine. Rare to frequent plastic artefacts within top 50mm. Frequent roots and rootlets. [Made Ground] Anthropogenic artefacts absent below 0.05		
0.5	ES		Dark brown/dark grey silty sand. Sand is fine. Frequent plastic artefacts including polythene and bulk bags, nylon string, frequent metal drinks cans and evidence of a fire including charcoal, burnt paper, and melted plastic. [Made Ground]	0.5	
			Orange very gravelly sand. Sand is fine, gravel is fine to coarse, subrounded of broken brick. [Made Ground]	0.95 1.0	
1.3	ES		Dark grey/black slightly silty, sandy gravel. Sand is fine to medium, gravel is fine to coarse, angular to rounded of ash and quartz. Frequent black/fire damaged timber and tree roots. [Made Ground/Fire Remnants]	1.2	
			Firm, friable brownvery sandy SILT. Sand is ine.	1.4	
1.6	ES B,D		Greyish brown mottled dark grey silty SAND. Sand is fine. Wet.	1.5	
				2.0	
				3.0	

General Comments:

1. Excavation terminated at 2.0m. Approximate excavator depth limit.
2. Groundwater ingress at 1.2m. Possible second strike at 1.5m.
3. Collapse between 1.0m and 1.4m.

Scale:	
Date:	21/01/2019
Logged by:	SW
Checked:	
Job No:	R18012

Grange Geo Consulting Ltd

Trial Pit Log

TP No: 11

[redacted]

Client: Kirk Homes
Project: Pinchbeck, Spalding

Sheet:
Method: 3T Rubber Tracked Excavator

Sample Depth (m)	Sample Type	Testing result	Description	Depth mBGL
			Soft, friable, brown very sandy silt/silty sand. Sand is fine. Occasional boulders of concrete. Frequent roots and rootlets. Occasional fineto medium shells and shell fragments.	
0.2	HSV	30kPa	Firm from 0.3m.	
0.4	HSV	74kPa		
0.5	ES B,D			0.5
			Firm, dark brown slightly gravelly SILT. Sand is fine. Gravel is fine, angular to subrounded of quartz, feldspar and flint. Frequent fine shells and shell fragments. [Possible Natural]	0.7
0.8	B		Abundent shells and shell fragments between 1.1m and 1.2m	1.0
			Soft, friable orangeish brown very sandy SILT. Sand is fine. Damp to wet.	1.2
1.5	B		Orangeish brown silty SAND. Sand is fine. Damp to wet.	1.5
			Soft, friable orangeish brown very sandy SILT. Sand is fine.	1.7
1.9	D		Grey/dark grey very silty SAND. Sand is fine.	1.8
				2.0
				2.1
				3.0

General Comments:

1. Excavation terminated at 2.1m. Approximate excavator depth limit.
2. Groundwater seepage at 1.0m. Possible second seepage at 1.8m.
3. below 1.2m

Scale:
Date: 22/01/2019
Logged by: SW
Checked:
Job No: R18012

Grange Geo Consulting Ltd

Trial Pit Log

TP No: 17

[redacted]

Client: Kirk Homes

Project: Pinchbeck, Spalding

Sheet:

Method: 3T Rubber Tracked Excavator

Sample Depth (m)	Sample Type	Testing result	Description	Depth mBGL
			Soft brown/dark brown very sandy silt. Sand is fine. Frequent roots and rootlets. [Made Ground/Topsoil]	
0.3	HSV	32kPa		
			Loose, friable orangeish light brown clayey, silty SAND. Sand is fine.	0.4
0.5	ES, B,D			0.5
1.0	HSV	34kPa		1.0
			Orangeish light brown silty SAND. Sand is fine.	1.1
1.5	D			1.5
			Firm, friable greyish brown very sandy SILT. Sand is fine. Wet.	
1.9	B,D			
				2.0
				3.0

General Comments:

1. Excavation terminated at 2.1m. Approximate excavator depth limit.
2. Groundwater seepage at 1.6m.
3. Collapse to base from 1.3m.

Scale:
Date: 22/01/2019
Logged by: SW
Checked:
Job No: R18012

Grange Geo Consulting Ltd