Barnsley MBC

Proposed Residential Development
Billingley View
Bolton upon Dearne
South Yorkshire

Flood Risk Assessment
Prepared by EWE Associates Ltd
Draft Rev0 November 2019

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CLIENT DETAILS

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CONTRACT

This report describes work commissioned by Barnsley MBC following written instruction by their representative on 20th June 2019. Barnsley MBC representative for the contract was Mr Ian Corner. Lea Favill of EWE Associates Ltd carried out the work.

Date: 23rd November 2019

Prepared by: ……  ……. Lea Favill
Director

REVISION HISTORY

Draft Report Rev0 issued 23rd November 2019
- 1No copy issued to Mr Ian Corner

EXECUTIVE SUMMARY

The proposed development site is currently a grassland area. There is an existing open ditch to the west which appears to be dry. The total site covers an area of 0.5 hectares and is considered to be 100% permeable as there are no roofed or paved areas within the site. The land within the site boundary lies between 39.284mOD and 43.83mOD. The site is located to the south of the centre of Bolton Upon Dearne. There is existing residential development to the east of the proposed development site. There is a school to the north and another to the south. Open fields are to the west. The proposal is to a residential development. The proposed impermeable area is estimated at approximately 0.19 hectares.

The flood risk from tidal, fluvial, and ordinary watercourses is considered to be very low. Ground floor levels should be elevated a minimum of 150mm above the external ground level to reduce risk of localised flooding.

It is considered that dry access and egress will be available at all times from the development.

Consideration has been given to the hierarchy for surface water disposal which recommends the SUDs approach which includes infiltration as the first tier. It is considered that shallow soakaways into the permeable limestone are a practical solution for the site at a depth of 1.9m below ground level.

It is considered that following the development there will be an increase in impermeable area and subsequently runoff from the site will also be increased to 1900m² (0.19 hectares).

Using WinDes sewer modelling software developed by Microdrainage the required attenuation has been calculated for the 1 in 100 year plus climate change (40%) event. The site will discharge into a series of crate soakaways located around the site.

It is concluded that there is a low risk of flooding from tidal and fluvial sources. The proposed drainage strategy discharges runoff to ground and uses sustainable drainage systems where appropriate.

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1. INTRODUCTION

Terms of Reference

This report was commissioned by Barnsley MBC to support a planning application for the construction of a residential development off Billingley View in Bolton Upon Dearne. The site is located to the west of Billingley View and to the south of the centre of Bolton Upon Dearne. The location of the site is shown on Table 2-1.

The development site lies within Zone 1 of the Environment Agency Flood Map (version 2.8.2), being the zone with risk of 1 in 1,000 year (0.1% Annual Exceedance Probability) or less for river and tidal/coastal flooding. The development site is within an existing developed area and is greater than 1 hectare.

It is usual for the Agency to raise an objection to development applications within the floodplain or Zone 2 or 3 of the flood map until the question of flood risk has been properly evaluated. The Agency will also object to developments where the total site area is in excess of 1 hectare until suitable consideration has been given to surface water runoff.

Approach to the Assessment

As there is a single source of flood risk – onsite surface water runoff – it is necessary to determine flood water levels at the site for the desired return periods emanating from this source. Consideration has also been given to the site flooding from either overland flow or ponding of localised rainfall within the site.

Barnsley MBC commissioned JBA Consulting Engineers to undertake a Strategic Flood Risk Assessment during September 2010. There are very few references to the development site and local area.

There are no tidal watercourses within close proximity of the site. It is therefore concluded that tidal flooding represents a very low flood risk to the site.

The closest main river fluvial watercourse is River Dearne which is at least 500m to the south of the site. The site is at least 30m above the extreme flood level within the watercourse. It is therefore concluded that the River Dearne represents a low flood risk to the site. The Carr Dike is approximately 400m to the north of the site. The site is at least 20m above the extreme flood level within the watercourse. It is therefore concluded that the Carr Dike represents a low flood risk to the site.

The closest ordinary fluvial watercourse is 250m to the north of the site. The site is at least 10m above the extreme flood level within the watercourse. It is therefore concluded that the ordinary watercourse represents a low flood risk to the site.

The proposed development will increase the paved and roofed area within the site. The site is currently un-occupied. The existing method of draining the site will be appraised. EWE Associates Ltd have undertaken a drainage feasibility study for the proposed development.

The storage volumes needed to attenuate surface water flow from the development to accommodate the required 1 in 100 year plus 40% climate change event, have therefore been calculated, using the proposed drainage strategy, as outlined above.

However, the volume balance requirements should be recalculated during the detailed design stage to reflect the actual development proposal, the extent of impermeable areas and runoff to be generated.

A walk over of the site was conducted by Mr Lea Favill, a senior river engineer during September 2019; during the visit a photograph survey of the site was undertaken. A spot level survey of the site was provided by the client. The survey was related to ordnance survey datum.

The requirements for flood risk assessments are generally as set out in National Planning Policy Framework (NPPF). The detail and complexity of the study required should be appropriate to the scale and potential impact of the development. For the purposes of this study, the following have been considered: -

- Available information on historical flooding in the area.
- Site level information.
- Details of structures, which may influence hydraulics of the watercourse and consideration of the effect of blockage of structures.
- Estimates of design levels, equivalent to a 200-year (coastal/tidal) and a 100-year (fluvial) return period flood event.
- Allowances for increased flows resulting from the effects of climate change.
- Allowances for sea level rise resulting from the effects of climate change.

Assess the existing runoff characteristics and the potential impact the proposed development will have on the runoff.

Further guidance is also provided in the CIRIA Research Project 624 “Development and Flood Risk: Guidance for the Construction Industry”.

Application of Sequential & Exceptions Test

The development site lies partly within Zone 1 of the Environment Agency Flood Map (version 2.8.2), being the zone with risk of 1 in 1,000 year (0.1% AEP) or less for river flooding. The proposed development is residential, as such considered to be more vulnerable.

Table 1-1: Flood Risk Vulnerability and Flood Zone 'Compatibility'

Flood Risk Vulnerability classification		Essential Infrastructure	Water compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	✓	Exception Test required	✓	✓
	Zone 3a	Exception Test required	✓	×	**Exception Test required**	✓
	Zone 3b	Exception Test required	✓	×	×	×

✓ Development is appropriate

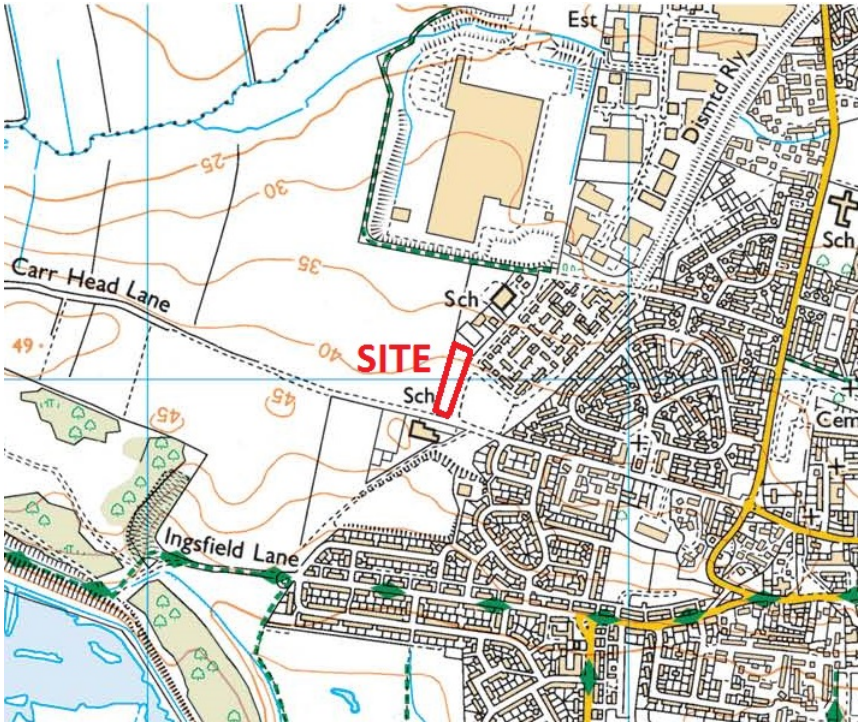
× Development should not be permitted

It is considered therefore, that a sequential test and exceptions test will not be required for this development project.

2. DETAILS OF THE SITE

Site Location

Table 2-1: Location Plan



Site Details

Table 2-2: Site Details	
Site Name	Billingley View Bolton Upon Dearne
Existing Land Use	Open grassland
Proposed Development	Residential
Grid Reference	SE 44630 03001
County	South Yorkshire
Local Planning Authority	Barnsley MBC
Internal Drainage Board	Not Applicable
Others	Not Applicable
Post Code	S63 8BP

Site Description

The proposed development site is currently a grassland area. An aerial photograph of the existing site is provided below. There is an existing open ditch to the west which appears to be dry.

The total site covers an area of 0.5 hectares and is considered to be 100% permeable as there are no roofed or paved areas within the site. The land within the site boundary lies between 39.284mOD and 43.83mOD. The existing site levels are shown at Appendix A of this report.

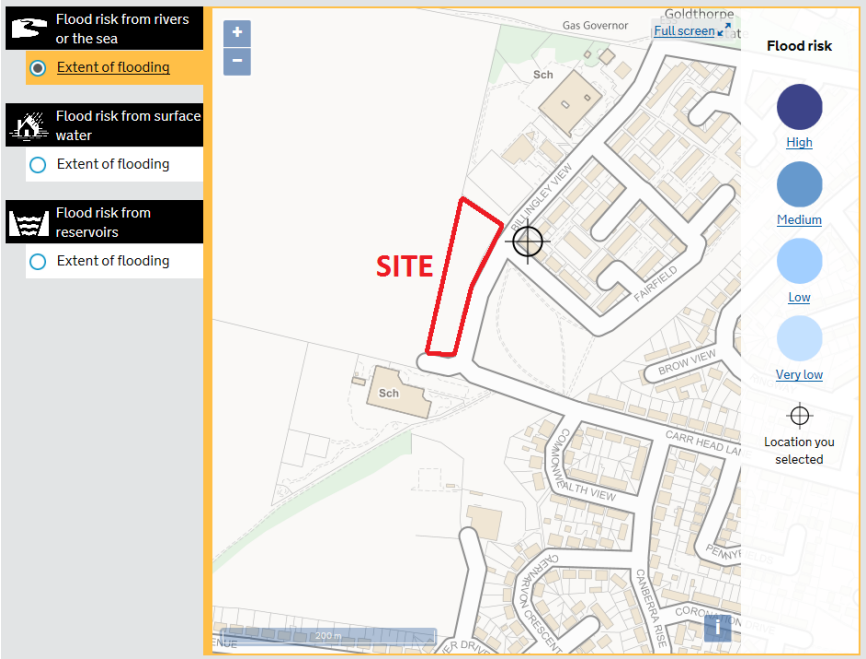
The site is located to the south of the centre of Bolton Upon Dearne. There is existing residential development to the east of the proposed development site. There is a school to the north and another to the south. Open fields are to the west.

The proposal is to a residential development. The proposed impermeable area is estimated at approximately 0.19 hectares.

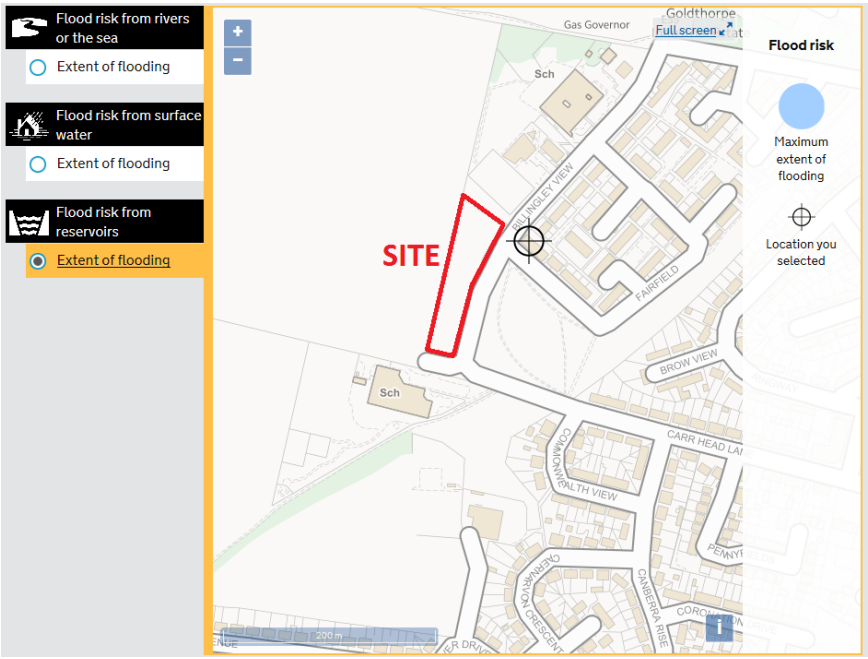
Site Photographs

3. INITIAL ASSESSMENT

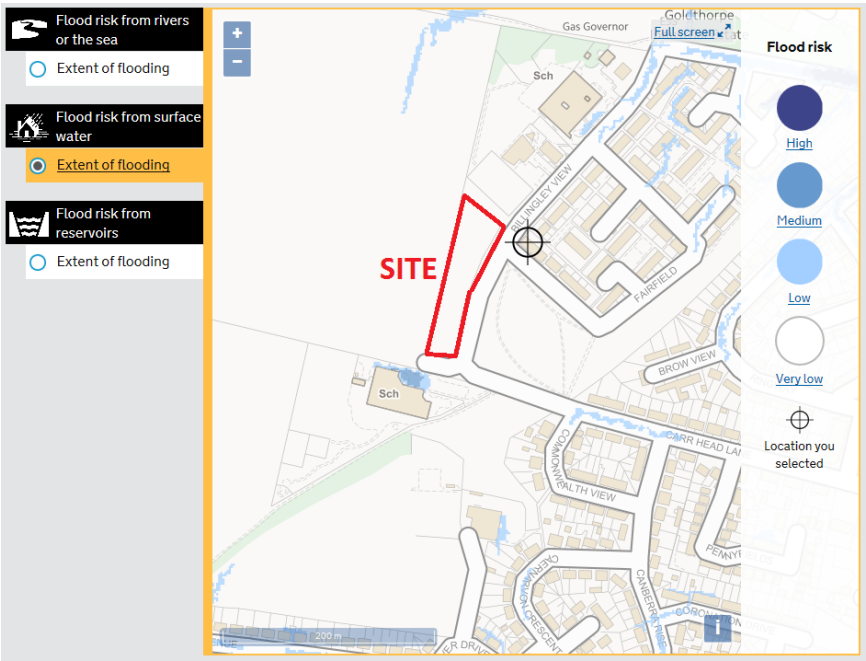
Environment Agency Flood Map



Environment Agency Reservoir Flood Map



Environment Agency Surface Water Flood Map



Past Flooding History

A search on the British Hydrological Society Chronology of British Hydrological Events website[1] found no records of past flooding within the Bolton Upon Dearne area close to the site.

Undertaking an internet-based search for flooding in the area provided no further information.

SFRA Flooding History

The SFRA contained no references to the site being flooded.

Environment Agency Flooding History

The Environment Agency provided no further information.

Environment Agency Reservoir Flood Risk

The Environment Agency reservoir risk map shows that the site is not located in an area which could be affected by a reservoir failure. As such, the probability of a flooding is extremely low.

1 http://www.dundee.ac.uk/geography/cbhe/

Environment Agency Surface Water Flood Risk

The Environment Agency surface water risk map shows the site is not located in an area which could be affected by surface water flooding. As such, the probability of a flooding is extremely low.

Overland Flow & Ponding

There is no significantly higher ground adjacent to the site which could promote overland flow of water across the site. Consequently, no further consideration will be given to this mechanism.

There are no depressed areas within the site which could encourage ponding, therefore, this flood mechanism has not been considered further.

Groundwater Flooding

Information on groundwater flooding is limited within the area. The SFRA makes no comment regards the potential for ground water flooding in the district.

Sewer Flooding

Yorkshire Water is the statutory water undertaker and is responsible for the public sewer systems within the Bolton Upon Dearne area. Yorkshire Water maintains a register of historical sewer flooding events (DG5 Register) within the area. There are no reported incidents close to the site. The SFRA provided no further information.

Possible Flooding Mechanisms

As there is a single source of flood risk – onsite runoff– it is necessary to determine flood water levels at the site for the desired return periods emanating from this source.

The proposed development will increase the impermeable area within the site. Consideration will need to be given to the existing drainage route and the drainage characteristics in order to evaluate the impact that surface water runoff from the site will have on the site and elsewhere.

4. FLOOD RISK ASSESSMENT

Requirements of the Environment Agency

The Environment Agency, as part of its development control procedures, generally require finished floor levels to be set above the 1% AEP plus climate change flood water level at the site. The development is residential in nature, as such, it is considered that access and egress from the development site will be essential during times of extreme floods.

Increase in Surface Water Runoff due to Development

Existing Drainage

The existing site is approximately 0.5 hectares in area and there are no roofed or paved areas within the site. There is a small open ditch within the west boundary of the site which appears to convey flows south. However, during the day of the site visit this ditch was dry. It is therefore considered that the site is 100% permeable.

The site consists of a sandy clay above sandstone. The sandstone is at least 1.9m deep.

Soil permeability test have been performed to the required local authority standard to assess surface water drainage requirements. The soakaway tests confirm that the underlying sandstone soils are adequate at a depth of approximately 1.9m. An infiltration rate of at least 0.45m/hr was established for the site.

The ground water level was not encountered in the trial pits. Borehole details and infiltration calculations are provided at Appendix A of this report.

Proposed Drainage Strategy

The drainage hierarchy has been used to determine the most appropriate means of surface water disposal for the site.

- Shallow infiltration devices. Generally, soakaway depths are between 1m and 2m below ground. This would locate the soakaway base within the sandstone layer which provides an infiltration rate of at least 0.45m/hr.
- Watercourses. There is a ditch watercourse close to the site which will allow a connection to be made.
- Surface water sewers. There is a surface water sewer to the east of the site which is the responsibility of Yorkshire Water.

At this stage there are three options available to the developer. Infiltration, watercourse and surface water sewer. Following the drainage hierarchy, it is considered that the soakaway option should be favoured at this stage in the development. Part of the development is to provide a 2m wide footway which will

form part of the adoptable highway. It is assumed that the footpath will slope towards the highway and any runoff will be directed to the highway drainage system.

Therefore, a crate soakaways will be located within the rear garden of each dwelling at least 5m from any proposed or existing building to provide the required attenuation up to and including the 1 in 100 year plus climate change 40% rainfall event.

Discharge to Soakaways

The drainage strategy drawing is provided at Appendix D of this report is based on an infiltration rate of 0.45m/hr at a maximum depth of 1.9m below ground within the sandstone layer.

It is estimated that a single crate soakaway 2m by 2m by 0.8m deep will drain a roofed and paved area of 120m². Therefore, a single crate soakaway has be located in the rear garden of each property to serve both roofed and paved areas. A sump manhole has been positioned directly upstream of the crate soakaway to collect any silts.

There is a single paved area of 175m² which will be used as a shared drive. A crate soakaway 3m by 3m by 0.8m deep is required for this area.

The outputs from calculations using the WinDes Source Control Software developed by Micro Drainage are provided at Appendix E and F of this report.

Table 4-1: Size of Infiltration Devices for 100yr+CC40% event

Area	Size of Infiltration Device (m)
Maximum drained area = 120m2 – 16 areas within site	Type S1 - 2m x 2m x 0.8m deep crate tank infiltrating at 0.45m/hr
Maximum drained area = 180m2 – 1 area within site	Type S2 - 3m x 3m x 0.8m deep crate tank infiltrating at 0.45m/hr

SUDs

The Environment Agency requires that adequate pollution control is incorporated into the proposed drainage system in order to prevent deterioration of the quality of the water environment. However, this is only applicable for surface water originating from access roads and communal parking areas, which needs to be passed through a petrol/oil interceptor or equivalent system prior to discharge into the existing surface water sewer or infiltration system. It is noted however, that this will not apply to surface water originating from roof drainage.

To reduce the impact of surface water runoff from the development in accordance with the requirements of the Environment Agency and Local Authority, the employment of SUDS techniques to limit runoff volumes and rates from the site are recommended. SUDS techniques can also be used to provide an appropriate level of treatment to the runoff.

It is normal practice to ensure that the 1 in 30 year event is maintained within the drainage system and the 1 in 100 year is permitted to flood the surface as long as there is no flooding to buildings and the flood volume is contained within the site boundary in specific areas proposed for this purpose.

The following section will provide some possible SUDS techniques which could be employed on the site to balance flows in excess of the 1 in 30 year event. SUDS techniques will also provide treatment to the runoff to remove a proportion of the pollution and protect the quality of the downstream watercourses. Following guidance from CIRIA Report C522 the following levels of treatment will be provided:

- Roofs – 1 level
- Driveways – 1 level
- Roads and communal parking areas – 2 levels.

The site investigation report for the site confirms that the site is underlain by a layer of sandstone which allows a good infiltration.

The following SUDS techniques shown below within Table 4-2. The precise combination of methods used will be dependent upon the site constraints identified at the final design stage

Table 4-2: SUDS Techniques and Suitability of Use

Method	Description	Potential for use at site
Filter drains	Drainage trench filled with gravel and provided with a pipe	Shallow ground conditions suitable.
Swales	Shallow grass ditch	Shallow ground conditions suitable.
Permeable surfaces	Pavement surfaces that allow water to pass through into underlying storage in sub base e.g. permeable concrete block paving or porous asphalt.	Shallow ground conditions suitable.
Ponds and basins	Open areas that are used to store and treat rainwater. Ponds are permanent bodies of water and basins are generally dry and occasionally store water.	Limited room within site for ponds.
Green roofs	Roof system that is vegetated with plants (note sedum plants rather than grass so no mowing is required)	Not incorporated into design
Infiltration devices	Methods that allow rainwater to soak into the ground, e.g. soakaways.	Shallow ground conditions suitable. Preferred option at this stage.
Storage tanks	Underground tanks that temporarily store water in the drainage system.	Potential solution if discharge is to the sewer.

Adoption, Maintenance & Inspection

Adoption

The crate tanks will be located within private gardens will be the responsibility of the individual land owners who will be made aware of the future liabilities.

Construction

The Proposed drainage system is simple in design however, its construction is essential to ensure that the system functions as it has been designed. As such it is recommended that construction inspection check list is adopted during the construction phase of the works to ensure that the drainage system is correctly installed. The inspection checklist is provided at Appendix G of this report and has been taken from the CIRIA Sustainable Drainage Systems Manual.

Post Construction

Following construction regular inspection is recommended. The main concern is to reduce the level of siltation entering the crate tanks and as such a catchpit manhole should be located directly upstream of the crate tanks to intercept any silt being washed down into the soakaway. It is recommended that this manhole is lifted and inspected on a monthly basis and any silt located in the bottom removed. Furthermore the location of the tank within the site should be clearly marked on a plan. This area should also be inspected for any deformation of the topsoil which could indicate settlement or failure. A log book should be completed which will show the inspection and maintenance history of the system. The log book, site plan and construction check list should form maintenance manual for the system. The maintenance plan has been tabulated below and will be the responsibility of the appointed management company.

Maintenance Schedule	**Required action**	**Frequency**
Monitoring	Inspect catchpit manhole for silt and debris	Monthly
	Inspect crate tank locations for ground deformation	3 monthly
	Inspect crate tank for silt buildup	6 monthly
Regular Maintenance	Litter and debris removal from road gullies	Monthly
	Remove silt and debris from catchpit manholes	Monthly
Occasional Maintenance	Remove silt from crate tank	6 monthly
Remedial actions	Repair deformation of topsoil once settlement stopped	As required
	Repair deformation of paved areas once settlement stopped	As required

Foul Drainage

There is an existing foul sewer located within Billingley View which is approximately 1.7m deep. It is considered that the whole site can drain by gravity to the sewer.

5. MITIGATION MEASURES

Raising Floor Levels/Land Raising

The flood risk from tidal, fluvial, and ordinary watercourses is considered to be very low. Ground floor levels should be elevated a minimum of 150mm above the external ground level to reduce risk of localised flooding.

Emergency Access & Egress

It is considered that dry access and egress will be available at all times from the development.

Control of Runoff

Consideration has been given to the hierarchy for surface water disposal which recommends the SUDs approach which includes infiltration as the first tier. It is considered that shallow soakaways into the permeable limestone are a practical solution for the site at a depth of 1.9m below ground level.

It is considered that following the development there will be an increase in impermeable area and subsequently runoff from the site will also be increased to 1900m² (0.19 hectares).

Using WinDes sewer modelling software developed by Microdrainage the required attenuation has been calculated for the 1 in 100 year plus climate change (40%) event. The site will discharge into a series of crate soakaways located around the site.

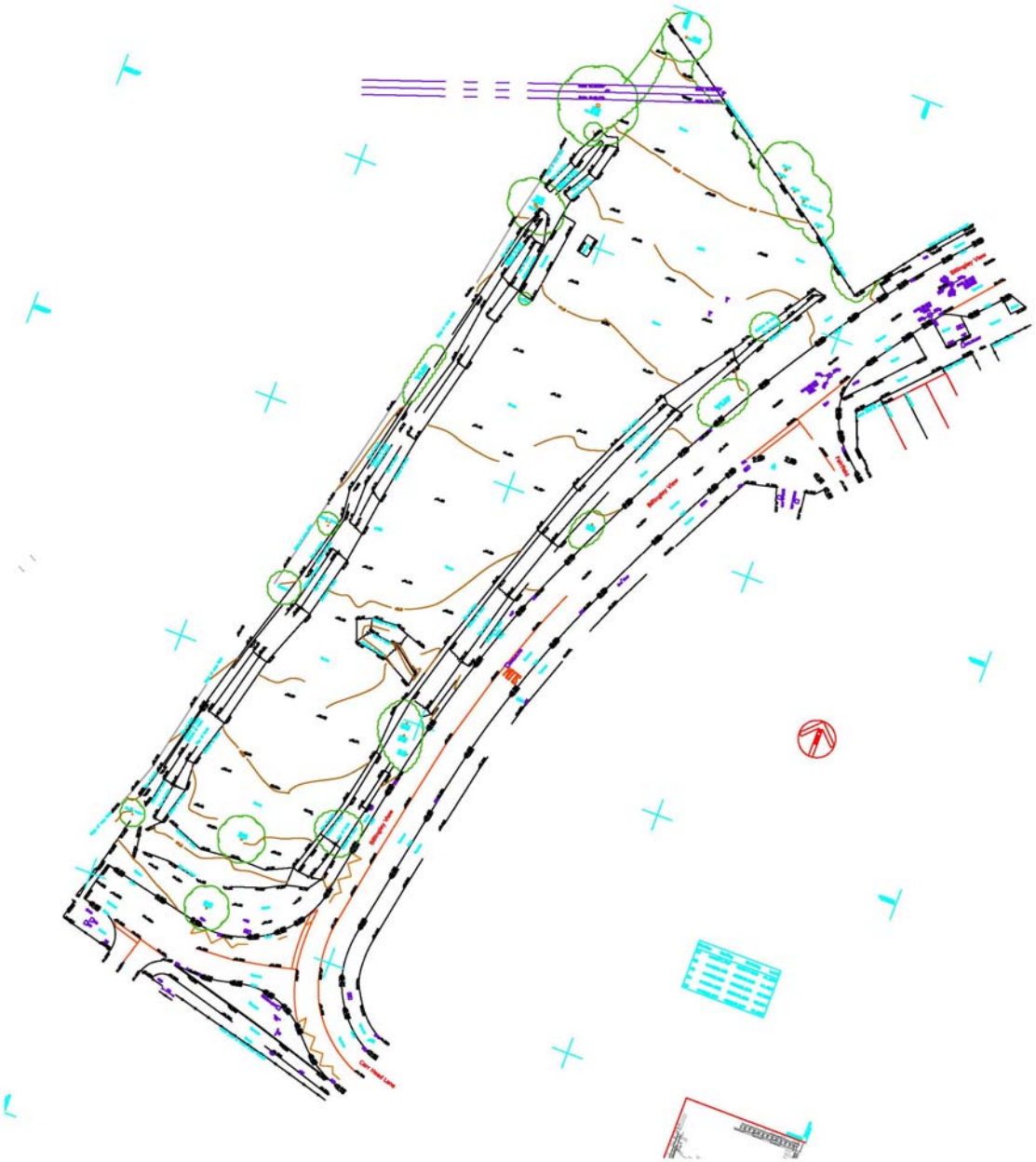
It is recommended that during the detailed phase of the development the following items are considered.

- The proposed surface water drainage system should be modelled using Micro Drainage WinDes or similar. The model should be used to analyse the possibility that the design for surface water may fail or becomes blocked and as such should design a backup plan. Overland floodwater should be routed away from vulnerable areas. Acceptable depths and rates of flow are contained in EA and Defra document FD2320/TR2 “Flood Risk Assessment Guidance for New Development Phase 2”.
- The maintenance and adoption regimes for all elements of the development should be considered for the lifetime of the development.

6. CONCLUSION

It is concluded that there is a low risk of flooding from tidal and fluvial sources. The proposed drainage strategy discharges runoff to ground and uses sustainable drainage systems where appropriate.

Appendix A: - Existing Site Levels



Appendix B: - Soakaway Test Results

Hamson Barron Smith

Table 1 Ground Conditions

Stratum	Depth to top (m bgl)	
	SA01	SA01
TOPSOIL: Dark brown slightly gravelly fine to coarse sand.	0.00	0.00
Brown sandy slightly gravelly CLAY.	0.35	-
Weathered SANDSTONE. Recovered as sandy subangular fine to coarse gravel of sandstone.	1.00	0.35
Base of pit.	1.90	1.90

3.1 Topsoil

Topsoil was encountered both of the trial pits to a depth of 0.35m bgl. The materials comprised dark brown slightly gravelly fine to coarse sand.

3.2 Clay

In SA01 the topsoil was underlain by a thin layer of sandy gravelly clay, which is interpreted as completely weathered bedrock. This material was present to 1.0m bgl and comprised brown sandy slightly gravelly.

3.3 Mexborough Rock

Bedrock comprising highly weathered sandstone was recorded at between 0.35m (SA02) and 1.00m (SA01) bgl. The material was recorded as a sandy gravel. The gravel consisted of subangular fine to coarse sandstone.

3.4 Groundwater

No groundwater was recorded in the pits.

4 BRE Assessment

4.1 Soakaway drainages

Infiltration testing was undertaken in accordance with BRE 365 (2016) in two locations (SA01 and SA02). The stratum tested was the Mexborough Rock. The tests entailed draining the pits three times. Infiltration rates were recorded as follows:

- SA01 Test 1 3.22 x 10^{-4} ms^{-1}
- SA01 Test 2 6.80 x 10^{-4} ms^{-1}
- SA01 Test 3 3.75 x 10^{-4} ms^{-1}

- SA02 Test 1 1.52 x 10^{-4} ms^{-1}
- SA02 Test 2 1.26 x 10^{-4} ms^{-1}
- SA02 Test 3 1.46 x 10^{-4} ms^{-1}

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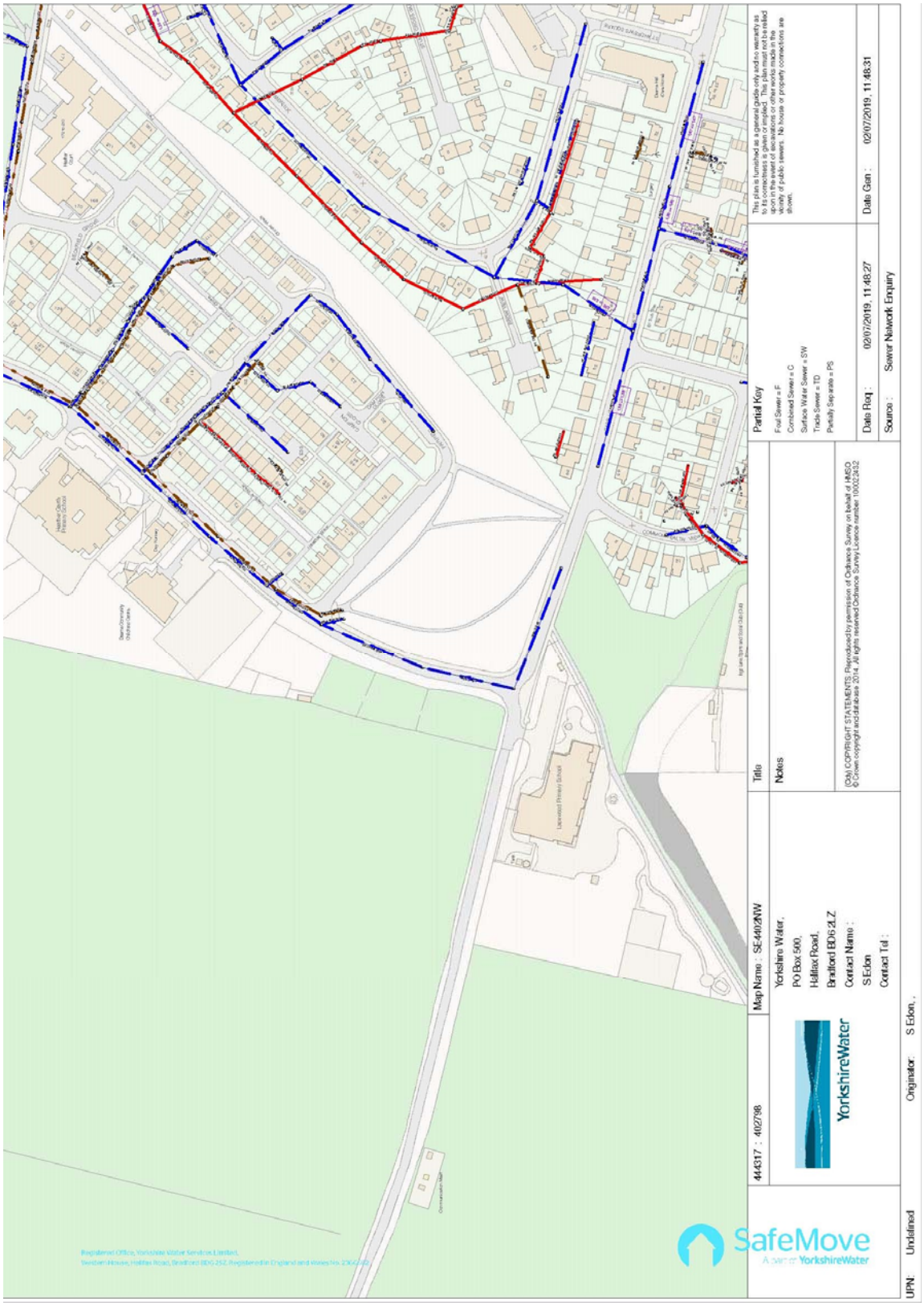
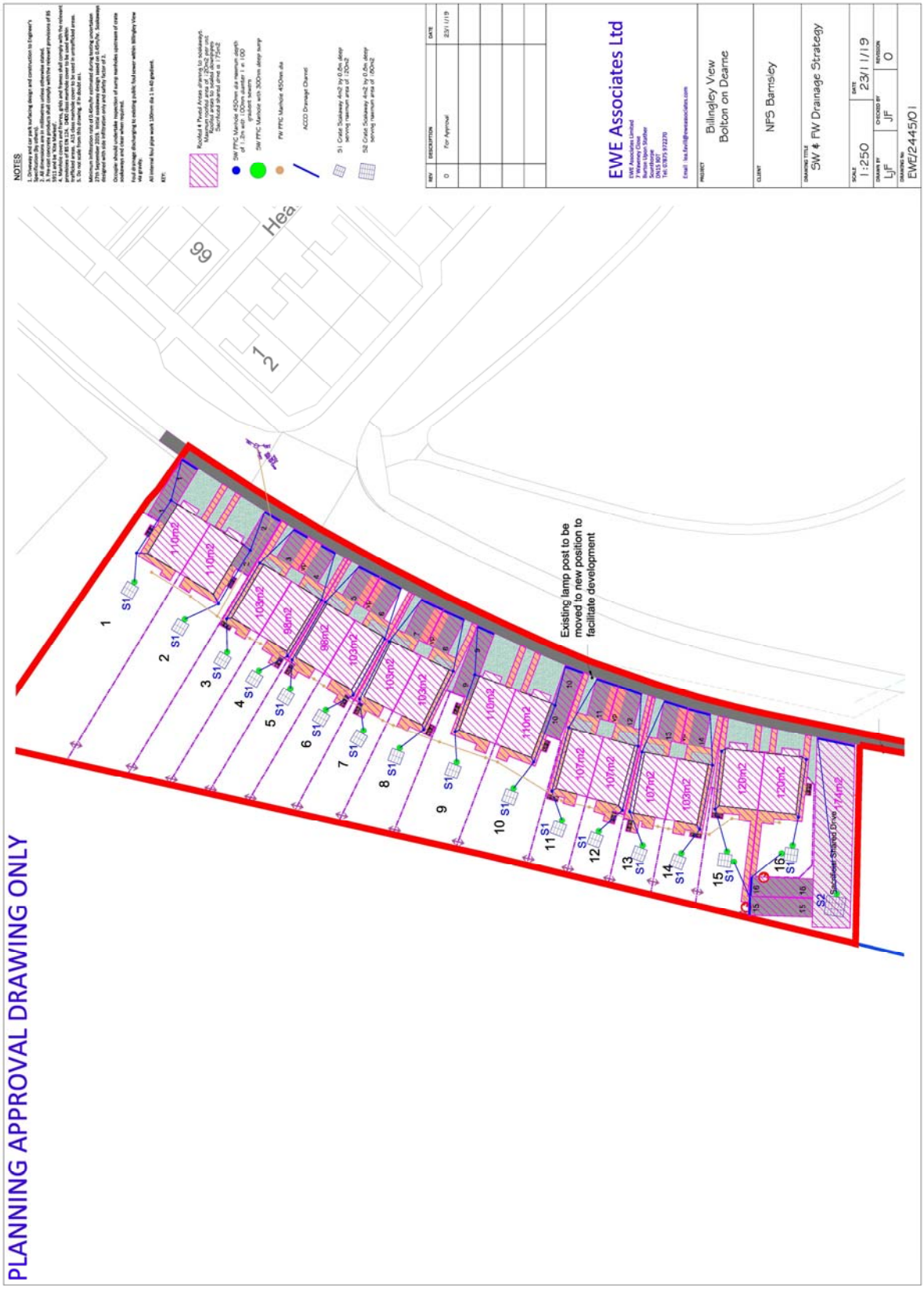
Appendix C: - Yorkshire Water Sewer Plan



Appendix D: - Drainage Strategy Drawing



Appendix E: - WINDES Calculations S1

EWE Associates Ltd		Page 1
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		Micro Drainage
Date 23/11/2019 15:49	Designed By Windows7	
File 100yr+CC40% S1 cr...	Checked By	
Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 72 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	39.455	0.955	0.6	3.6	O K
30 min Summer	39.547	1.047	0.7	4.0	O K
60 min Summer	39.585	1.085	0.7	4.1	O K
120 min Summer	39.596	1.096	0.7	4.2	O K
180 min Summer	39.578	1.078	0.7	4.1	O K
240 min Summer	39.549	1.049	0.7	4.0	O K
360 min Summer	39.486	0.986	0.6	3.7	O K
480 min Summer	39.425	0.925	0.6	3.5	O K
600 min Summer	39.370	0.870	0.5	3.3	O K
720 min Summer	39.323	0.823	0.5	3.1	O K
960 min Summer	39.263	0.763	0.4	2.9	O K
1440 min Summer	39.171	0.671	0.4	2.5	O K
2160 min Summer	39.075	0.575	0.3	2.2	O K
2880 min Summer	39.008	0.508	0.3	1.9	O K
4320 min Summer	38.891	0.391	0.2	1.5	O K
5760 min Summer	38.821	0.321	0.2	1.2	O K
7200 min Summer	38.774	0.274	0.1	1.0	O K
8640 min Summer	38.740	0.240	0.1	0.9	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Summer	176.295	18
30 min Summer	102.497	31
60 min Summer	59.592	50
120 min Summer	34.646	84
180 min Summer	25.228	118
240 min Summer	20.143	152
360 min Summer	14.668	218
480 min Summer	11.711	282
600 min Summer	9.835	346
720 min Summer	8.528	410
960 min Summer	6.998	532
1440 min Summer	5.295	780
2160 min Summer	4.007	1148
2880 min Summer	3.288	1504
4320 min Summer	2.303	2244
5760 min Summer	1.789	2944
7200 min Summer	1.470	3680
8640 min Summer	1.253	4408

EWE Associates Ltd		Page 2
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		Micro Drainage
Date 23/11/2019 15:49 File 100yr+CC40% S1 cr...	Designed By Windows7 Checked By	
Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
10080 min Summer	38.714	0.214	0.1	0.8	O K
15 min Winter	39.569	1.069	0.7	4.1	O K
30 min Winter	39.674	1.174	0.8	4.5	O K
60 min Winter	39.713	1.213	0.8	4.6	Flood Risk
120 min Winter	39.704	1.204	0.8	4.6	Flood Risk
180 min Winter	39.659	1.159	0.7	4.4	O K
240 min Winter	39.607	1.107	0.7	4.2	O K
360 min Winter	39.508	1.008	0.6	3.8	O K
480 min Winter	39.423	0.923	0.6	3.5	O K
600 min Winter	39.351	0.851	0.5	3.2	O K
720 min Winter	39.291	0.791	0.5	3.0	O K
960 min Winter	39.212	0.712	0.4	2.7	O K
1440 min Winter	39.099	0.599	0.3	2.3	O K
2160 min Winter	38.992	0.492	0.3	1.9	O K
2880 min Winter	38.922	0.422	0.2	1.6	O K
4320 min Winter	38.814	0.314	0.2	1.2	O K
5760 min Winter	38.752	0.252	0.1	1.0	O K
7200 min Winter	38.712	0.212	0.1	0.8	O K
8640 min Winter	38.683	0.183	0.1	0.7	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
10080 min Summer	1.094	5144
15 min Winter	176.295	18
30 min Winter	102.497	31
60 min Winter	59.592	52
120 min Winter	34.646	88
180 min Winter	25.228	126
240 min Winter	20.143	162
360 min Winter	14.668	230
480 min Winter	11.711	296
600 min Winter	9.835	362
720 min Winter	8.528	426
960 min Winter	6.998	552
1440 min Winter	5.295	798
2160 min Winter	4.007	1168
2880 min Winter	3.288	1532
4320 min Winter	2.303	2252
5760 min Winter	1.789	2992
7200 min Winter	1.470	3720
8640 min Winter	1.253	4408

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Windy Ridge Barn Thealby Lane Winterton DN15 9TG		Micro Drainage
Date 23/11/2019 15:49 File 100yr+CC40% S1 cr...	Designed By Windows7 Checked By	
Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
10080 min Winter	38.662	0.162	0.1	0.6	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
10080 min Winter	1.094	5144

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Micro Drainage	Source Control W.12.4	

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
Site Location	444250 403600 SE 44250 03600
C (1km)	-0.024
D1 (1km)	0.328
D2 (1km)	0.423
D3 (1km)	0.232
E (1km)	0.300
F (1km)	2.371
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time / Area Diagram

Total Area (ha) 0.012

Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.010	4-8	0.002

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Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
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File 100yr+CC40% S1 cr...	Checked By	
Micro Drainage	Source Control W.12.4	

Model Details

Storage is Online Cover Level (m) 40.000

Cellular Storage Structure

Invert Level (m) 38.500 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.45000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	4.0	4.0	2.600	0.0	14.4
0.200	4.0	5.6	2.800	0.0	14.4
0.400	4.0	7.2	3.000	0.0	14.4
0.600	4.0	8.8	3.200	0.0	14.4
0.800	4.0	10.4	3.400	0.0	14.4
1.000	4.0	12.0	3.600	0.0	14.4
1.200	4.0	13.6	3.800	0.0	14.4
1.400	0.0	14.4	4.000	0.0	14.4
1.600	0.0	14.4	4.200	0.0	14.4
1.800	0.0	14.4	4.400	0.0	14.4
2.000	0.0	14.4	4.600	0.0	14.4
2.200	0.0	14.4	4.800	0.0	14.4
2.400	0.0	14.4	5.000	0.0	14.4

Appendix F: - WINDES Calculations S2

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Windy Ridge Barn Thealby Lane Winterton DN15 9TG		Micro Drainage
Date 23/11/2019 15:50	Designed By Windows7	
File 100yr+CC40% S2 cr...	Checked By	
Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+40%)

Half Drain Time : 81 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	39.157	0.657	0.5	5.6	O K
30 min Summer	39.236	0.736	0.6	6.3	O K
60 min Summer	39.295	0.795	0.6	6.8	O K
120 min Summer	39.317	0.817	0.7	7.0	O K
180 min Summer	39.322	0.822	0.7	7.0	O K
240 min Summer	39.317	0.817	0.7	7.0	O K
360 min Summer	39.294	0.794	0.6	6.8	O K
480 min Summer	39.266	0.766	0.6	6.5	O K
600 min Summer	39.236	0.736	0.6	6.3	O K
720 min Summer	39.208	0.708	0.6	6.1	O K
960 min Summer	39.173	0.673	0.5	5.8	O K
1440 min Summer	39.111	0.611	0.5	5.2	O K
2160 min Summer	39.038	0.538	0.4	4.6	O K
2880 min Summer	38.984	0.484	0.4	4.1	O K
4320 min Summer	38.879	0.379	0.3	3.2	O K
5760 min Summer	38.815	0.315	0.2	2.7	O K
7200 min Summer	38.770	0.270	0.2	2.3	O K
8640 min Summer	38.737	0.237	0.2	2.0	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Summer	176.295	21
30 min Summer	102.497	34
60 min Summer	59.592	62
120 min Summer	34.646	96
180 min Summer	25.228	128
240 min Summer	20.143	162
360 min Summer	14.668	230
480 min Summer	11.711	298
600 min Summer	9.835	364
720 min Summer	8.528	430
960 min Summer	6.998	558
1440 min Summer	5.295	810
2160 min Summer	4.007	1176
2880 min Summer	3.288	1552
4320 min Summer	2.303	2288
5760 min Summer	1.789	3000
7200 min Summer	1.470	3744
8640 min Summer	1.253	4416

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Windy Ridge Barn Thealby Lane Winterton DN15 9TG		Micro Drainage
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Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
10080 min Summer	38.712	0.212	0.2	1.8	O K
15 min Winter	39.236	0.736	0.6	6.3	O K
30 min Winter	39.328	0.828	0.7	7.1	O K
60 min Winter	39.439	0.939	0.8	7.6	O K
120 min Winter	39.981	1.481	1.3	7.7	Flood Risk
180 min Winter	39.647	1.147	1.0	7.7	O K
240 min Winter	39.431	0.931	0.8	7.6	O K
360 min Winter	39.354	0.854	0.7	7.2	O K
480 min Winter	39.300	0.800	0.7	6.8	O K
600 min Winter	39.256	0.756	0.6	6.5	O K
720 min Winter	39.216	0.716	0.6	6.1	O K
960 min Winter	39.163	0.663	0.5	5.7	O K
1440 min Winter	39.076	0.576	0.4	4.9	O K
2160 min Winter	38.985	0.485	0.4	4.1	O K
2880 min Winter	38.922	0.422	0.3	3.6	O K
4320 min Winter	38.816	0.316	0.2	2.7	O K
5760 min Winter	38.755	0.255	0.2	2.2	O K
7200 min Winter	38.714	0.214	0.2	1.8	O K
8640 min Winter	38.685	0.185	0.1	1.6	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
10080 min Summer	1.094	5152
15 min Winter	176.295	21
30 min Winter	102.497	34
60 min Winter	59.592	60
120 min Winter	34.646	92
180 min Winter	25.228	132
240 min Winter	20.143	172
360 min Winter	14.668	246
480 min Winter	11.711	316
600 min Winter	9.835	384
720 min Winter	8.528	452
960 min Winter	6.998	582
1440 min Winter	5.295	840
2160 min Winter	4.007	1212
2880 min Winter	3.288	1588
4320 min Winter	2.303	2332
5760 min Winter	1.789	3056
7200 min Winter	1.470	3752
8640 min Winter	1.253	4496

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Windy Ridge Barn Thealby Lane Winterton DN15 9TG		Micro Drainage
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Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
10080 min Winter	38.664	0.164	0.1	1.4	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
10080 min Winter	1.094	5240

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Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
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Micro Drainage	Source Control W.12.4	

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
Site Location	444250 403600 SE 44250 03600
C (1km)	-0.024
D1 (1km)	0.328
D2 (1km)	0.423
D3 (1km)	0.232
E (1km)	0.300
F (1km)	2.371
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time / Area Diagram

Total Area (ha) 0.018

Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.010	4-8	0.008

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Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 23/11/2019 15:50 File 100yr+CC40% S2 cr...	Designed By Windows7 Checked By	
Micro Drainage	Source Control W.12.4	

Model Details

Storage is Online Cover Level (m) 40.000

Cellular Storage Structure

Invert Level (m) 38.500 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.45000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	9.0	9.0	2.600	0.0	19.8
0.200	9.0	11.4	2.800	0.0	19.8
0.400	9.0	13.8	3.000	0.0	19.8
0.600	9.0	16.2	3.200	0.0	19.8
0.800	9.0	18.6	3.400	0.0	19.8
1.000	0.0	19.8	3.600	0.0	19.8
1.200	0.0	19.8	3.800	0.0	19.8
1.400	0.0	19.8	4.000	0.0	19.8
1.600	0.0	19.8	4.200	0.0	19.8
1.800	0.0	19.8	4.400	0.0	19.8
2.000	0.0	19.8	4.600	0.0	19.8
2.200	0.0	19.8	4.800	0.0	19.8
2.400	0.0	19.8	5.000	0.0	19.8

Appendix G: - Construction Checklist

A7 Construction inspection checklist

Phase and inspection item	Inspection date	Condition*	Date phase completed	Remarks/remedial works
Pre-excavation				
Runoff from areas of bare soil diverted to site control				
Runoff from contaminated areas diverted to site control				
Excavation				
Soil is not smeared or compacted so that permeability is reduced				
Excavation is to required size and gradient and is located in correct position				
Side slopes are correct				
All debris (eg loose roots) removed from base feature				
There is no groundwater seepage in the base of the feature				
Depth of excavation is correct				
Construction				
Earthworks materials to specification with test results				
Filter materials in accordance with specification with test results				
Compaction acceptable				
Inlets and outlets constructed in accordance with drawings and specification and drawings				
Construction to required line and levels				
Planting				
Planting in accordance with specification				
Planting established				
Handover inspection				
No silting from construction				
No erosion or bare areas of planting				
All litter removed and inlets and outlets operating correctly				

* Acceptable or unacceptable

CIRIA C609 303