

SUSTAINABLE DRAINAGE CONCEPT DESIGN FOR RESIDENTIAL DEVELOPMENT AT CROSS ROAD, SUTTON ST EDMUND

FINAL REPORT

ECL0072-2/ SWANN EDWARDS ARCHITECTURAL DESIGN

DATE OCTOBER 2019

ELLINGHAM CONSULTING LTD

Email: tim@ellinghamconsulting.co.uk

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1.0 INTRODUCTION

This Sustainable Drainage Concept Design has been prepared in accordance with National Planning Policy Framework (NPPF) and the Non-statutory technical standards for sustainable drainage systems.

This Sustainable Drainage Design and Evaluation Guide produced by Lincolnshire County Council sets out the requirements for a Sustainable Drainage. This document has been prepared following the guidance within the document for the Concept Design Stage. This Sustainable Drainage Concept Design forms the Preliminary Design Statement for consideration by planners, regulatory bodies, water companies and stakeholders.

This Sustainable Drainage Concept Design has been produced on behalf of SH & MB Properties Ltd in respect of a development that consists of ten new dwellings at Cross Road, Sutton St Edmund. A Flood Risk Assessment has been produced for the development by Ellingham Consulting in October 2019. An outline planning application for the proposed development is to be submitted by Swann Edwards Architectural Design.

2.0 SITE LOCATION AND DESCRIPTION

2.1 Site Location

The site is located at Cross Road, Sutton St Edmund, Spalding, PE12 0LS. The National Grid Reference of the site is 53712/31322.

The location of the site is shown in Figure 1.



Figure 1 – Location Plan (© OpenStreetMap contributors)

2.2 Existing Site

The site is an arable field on the southern side of Cross Road. A Site and Location Plan is provided in Attachment 1. The site is bound by residential development to the west and Cross Road to the north. The Little Eau Drain forms the eastern boundary of the site and there is agricultural land to the south. The area of development is approximately 1.6 hectares.

A topographic survey of the site has been undertaken and is provided in Attachment 2. The site has a shallow slope from west to east. Typical levels in the north west and south west of the site are +1.6m OD and +1.8m OD respectively. On the eastern boundary typical levels are +1.2m OD. The carriageway level of Cross Road to the north of the site varies between +1.8m OD and +2.1m OD.

The site is in the North Level Internal Drainage Board (IDB) District. The site and the surrounding land are within the Tydd catchment and drain under gravity to the North Level Main Drain. The Little Eau Drain on the eastern boundary of the site is an IDB maintained watercourse. The topographic survey shows that the invert level of Little Eau Drain is on average -1.3m OD.

The online British Geological Survey maps indicate that the site is likely to be underlain by West Walton Formation and Amptill Clay Formation mudstone. The bedrock is shown to be overlain with superficial deposits of clay and silt.

2.3 Available Flood Risk Information

The site is located partly within Flood Zone 3, an area with a high probability of flooding, and partly within Flood Zone 2, an area with a medium probability of flooding, of the Environment Agency Flood Maps for Planning as shown in Figure 2.

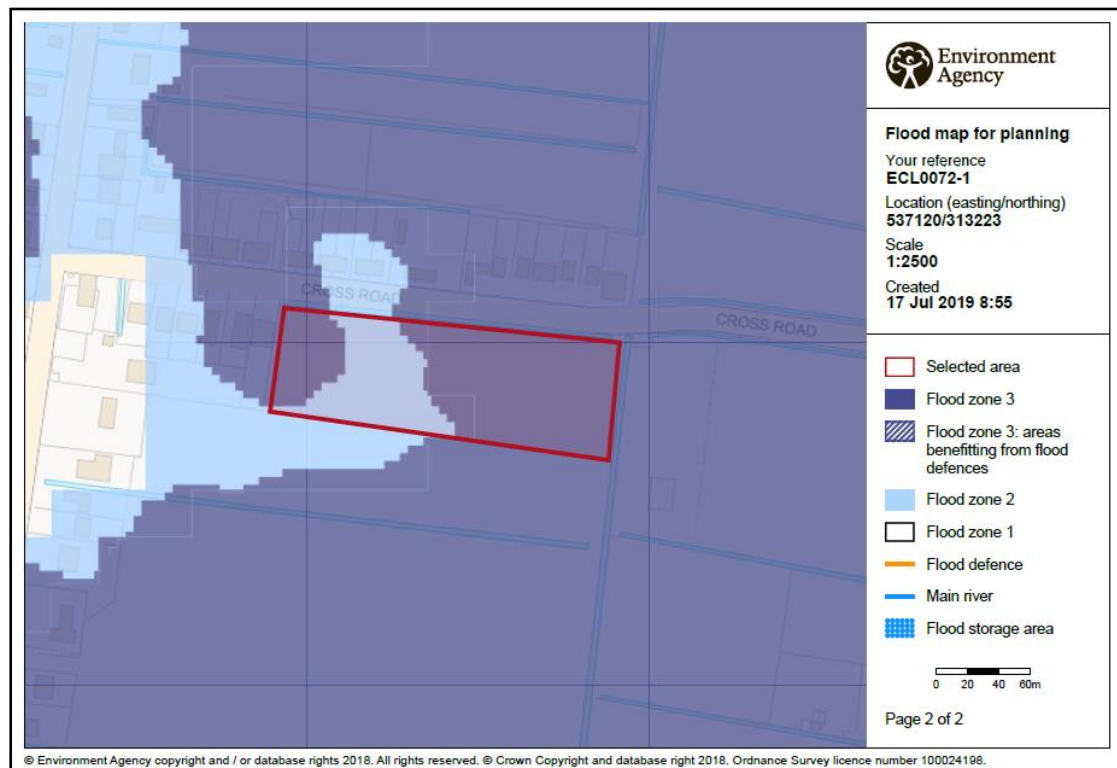


Figure 2 – Environment Agency Flood Map for Planning

The Environment Agency Long Term Flood Risk maps show that:

- part of the site has a medium risk of flooding from rivers or the sea (annual probability between 1% and 3.3%) and the remainder of the site has a low risk (annual probability between 0.1% and 1%);
- an area on the western side of the site extending up to 10m from the boundary has a low risk (annual probability between 0.1% and 1%) of surface water flooding; and
- the site is not within an area at risk of reservoir flooding.

Within the South East Lincolnshire SFRA:

- the Residual Flood Hazard Map for the present day 1% fluvial and 0.5% tidal event shows that the site is outside of the 'Low Hazard' area;
- the Residual Flood Hazard Map for the 2116 1% fluvial and 0.5% tidal event shows that the site is outside of the 'Low Hazard' area;

- the Residual Peak Depth Map for the present day 1% fluvial and 0.5% tidal event shows that the site is not at risk of flooding; and
- the Residual Peak Depth Map for the 2116 1% fluvial and 0.5% tidal event shows that the site is not at risk of flooding.

3.0 THE PROPOSED DEVELOPMENT AND APPROACH TO SuDS

3.1 Proposed Development

The proposed development consists of ten new dwellings. The dwellings will be two storey and will have their own access to Cross Road.

3.2 Existing Flow Routes

Based upon the contours and the existing drainage features at the site rainwater would infiltrate into the ground. Ground water levels would be influenced by the Little Eau Drain located on the eastern boundary of the site. This watercourse would also collect any surface conveyance across the site.

3.3 Applying the Hierarchy for Discharge

The Sustainable Drainage Design and Evaluation Guide produced by Lincolnshire County Council states that the way rainfall leaves a development should follow the preferred hierarchy:

- re-use on site;
- infiltration into the ground;
- a natural watercourse;
- surface water sewer; and
- combined sewer.

The rainfall landing within the garden of each property will infiltrate with no change following the development. There are 3 primary areas within the site where there would be a change to the natural flow routes following the development. These areas and the approach to the management of surface water are show in Table 1.

Drainage Area	Indicative Proposal
Residential Roofs	Infiltration to a designed soakaway
Driveways and Parking Areas	Infiltration through a permeable surface
Patios and Pathways at each dwelling	Infiltration within adjacent areas

Table 1 – Approach to surface water management

Due to the scale of the development it is not proposed that the site is divided into sub-catchments for the purpose of developing SuDS.

3.4 Modified Flow Routes

Following the implementation of the drainage strategy the flow route at the site:

- rainwater from roof areas will infiltrate into the ground via a soakaway within the property boundary;

- flow routes for driveways and parking areas will be unchanged with infiltration through a permeable surface;
- flow routes for areas of garden, patios and pathways will be unchanged; and
- any surface conveyance will continue to discharge to the Little Eau Drain on the eastern boundary of the site.

4.0 PRELIMINARY DESIGN STAGE

4.1 Run-off Collection

Based upon the proposed layout shown in Attachment 1 the drainage areas are as follows:

- dwelling / garage roof areas – 1440m³;
- driveway and parking area - 1370m³; and
- patios and pathways - 358m³.

4.2 Source Control

Runoff will be managed as close as possible to where rain falls. The runoff from the three drainage areas identified above will be managed as follows:

- rainwater from dwelling / garage roof areas will be collected using traditional gutter and pipe and will infiltrate through a designed soakaway within the boundary of each property;
- the driveways and parking areas will be gravel and therefore have a permeable surface. Rainfall will be able to infiltrate into the ground at the point where it lands as it does on the greenfield site; and
- alongside patios and pathways, a filter strip will be provided so that sheet flow runoff from these areas can infiltrate as closely as possible.

4.3 Management and Maintenance

It is recommended a SuDS Maintenance Plan is developed during the detailed design stage. It is anticipated that SuDS located within property boundaries will be the responsibility of the property owner.

4.4 Water Quality Considerations

One of the advantages of SuDS is the benefit it provides in managing pollution. The treatment required to mitigate pollution depends upon the level of pollution hazard.

Residential roofs are considered to have a very low pollution hazard level and therefore do not require any specific SuDS components to mitigate pollution. The use of gravel and infiltration for the residential driveways is appropriate because they have a low pollution hazard level.

5.0 MANAGEMENT OF SURFACE WATER RUNOFF

5.1 Infiltration Approach

The site is currently completely permeable. It is proposed that the rainwater falling on the driveways and surfaced areas around the dwellings is managed by infiltration.

The roofs of the dwellings and garages increase both the rate and volume of runoff because runoff flows more quickly from the site and natural volume losses do not happen as they did before development. It is proposed that the runoff from roof areas is managed by soakaways.

5.2 Suitability of the Site for Soakaway

To confirm the suitability of the site for runoff to be managed by soakaway, infiltration testing was undertaken at the site. On 25 September 2019 two percolation tests were undertaken. The ground conditions at the site varied and as such a total of 4 trial pits were undertaken along the length of the site. The Infiltration Test Report is provided in Attachment 3.

The trial pits identified that:

- the western and central part of the site is underlain by medium dense silty sand;
- the trial pit in the centre of the site encountered groundwater 2.6m below ground level;
- the eastern side of the site is underlain by slightly sandy very silty clay; and
- the anticipated position of the change between the two materials is such that 75% of the site is silty sand and 25% of the site is silty clay.

The infiltration rates calculated for the two test pits were 1.47×10^{-05} m/s (test pit 01) and 1.68×10^{-05} m/s (test pit 02) indicating the site is suited to private domestic soakaways.

5.3 Estimating the size of soakaways

Using HR Wallingford's tool for the design and evaluation of SuDS the infiltration volume for the soakaways was estimated. The calculation is provided in Attachment 4 and the depths and volumes are shown in Table 2.

Property Type	Dwelling Location	Depth (m)	Volume (m ³)
A (156m ²)	Western (Plots 1-5)	0.81	4.7
B/C (136m ²)	Western (Plots 1-5)	0.69	4.0
A (156m ²)	Eastern (Plots 6-10)	0.84	4.8
B/C (136m ²)	Eastern (Plots 6-10)	0.72	4.1

Table 2 – Infiltration Volume Estimates

The table gives the depth and volume requirements for the different property types and for different locations within the site. The property types and plot numbers are shown on the Site Plan in Attachment 1. The depth is based upon a plan area measuring 2.4m x 2.4m.

Within the calculation:

- the infiltration rate from test pit 02 has been used for plots 1 to 5;
- the infiltration rate from test pit 01 has been used for plots 6 to 10;
- rainfall events with a return period of 10 years have been considered;
- a factor of safety of 1.5 has been applied; and
- a climate change allowance has been incorporated.

5.4 Soakaway Location and Depth

The soakaway calculations have been prepared on the basis that run-off from each property is managed within the boundary of the property. The soakaway for each property will be within its garden. BRE Digest 365 Soakaway Design states that soakaways should not normally be constructed closer than 5m to a building foundation.

During the infiltration testing ground water was identified at 2.6m and 2.8m below ground level. The maximum ground water level at the site would be limited by the Little Eau Drain. However, considering the potential for higher water levels during the extended period of wet weather it is recommended that the soakaway units have 0.5m of cover and are not more than 1m deep (i.e. up to 1.5m below the surface).

6.0 CONCLUSIONS AND RECOMMENDATIONS

As a result of this concept design, the following conclusions have been reached.

- The proposal is the construction of 10 new dwellings at Cross Road, Sutton St Edmund.
- A range of SuDS systems have been considered for incorporation at the proposed development with the preferred approach described in Section 3.3.
- Run-off from driveways and parking areas will infiltrate and runoff from impermeable areas surrounding the properties will drain to filter strips.
- Infiltration testing was undertaken and confirmed that the site was suitable for private domestic soakaways.
- Surface water discharge from roof areas will be to private soakaways within the boundary of each property. The volume required at each property varies between 4.0m³ and 4.8m³ depending on the location of the property and the impermeable area. The volume has been estimated for all events up to the 1 in 10 year with climate change.
- It is proposed that the property owners are responsible for the SuDS.
- The runoff is from sources with a low pollution hazard and therefore no specific water quality recommendations have been made.
- This strategy has been prepared in line with Local and national Policy requirements.

ATTACHMENT 1

SITE AND LOCATION PLANS (Dwg SE-1186 PP1000)

General Notes
1. This drawing shall not be scaled, figured dimensions only to be used.
2. All dimensions are shown in 'mm' unless otherwise stated.
3. The contractor, sub-contractors and suppliers must verify all dimensions on site prior to the commencement of any work.
4. This drawing is to be read in conjunction with all relevant engineers and specialist sub-contractors drawings and specifications.
5. Any discrepancies are to be brought to the designers attention.

SITE PLAN KEY

- Indicates surrounding buildings (OS Location Plan)
- Indicates proposed new dwellings House Type A
- Indicates proposed new dwellings House Type B
- Indicates proposed new dwellings House Type C
- Indicates neighboring properties (from ordinance survey location plan)
- Indicates new specimen trees
- Hatch indicates position of new washed gravel private driveway
- Indicates lawned garden
- Indicates patios and footpaths
- Indicates position of proposed site accesses
- Indicates minimum 9.0m easement for drain
- Indicates site entrance to be in accordance with the Lincolnshire County Council Residential Access Construction Specification. Install drainage channel at the edge of the highway boundary so surface water does not drain from the new driveway onto the highway

Status
FOR APPROVAL

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Job Title
Proposed Residential Development
Land South of Cross Lane
Sutton St Edmund, Lincs
for: SH & MB Properties Ltd

Date
May 2019

Scale
Various
Sheet Size
A1

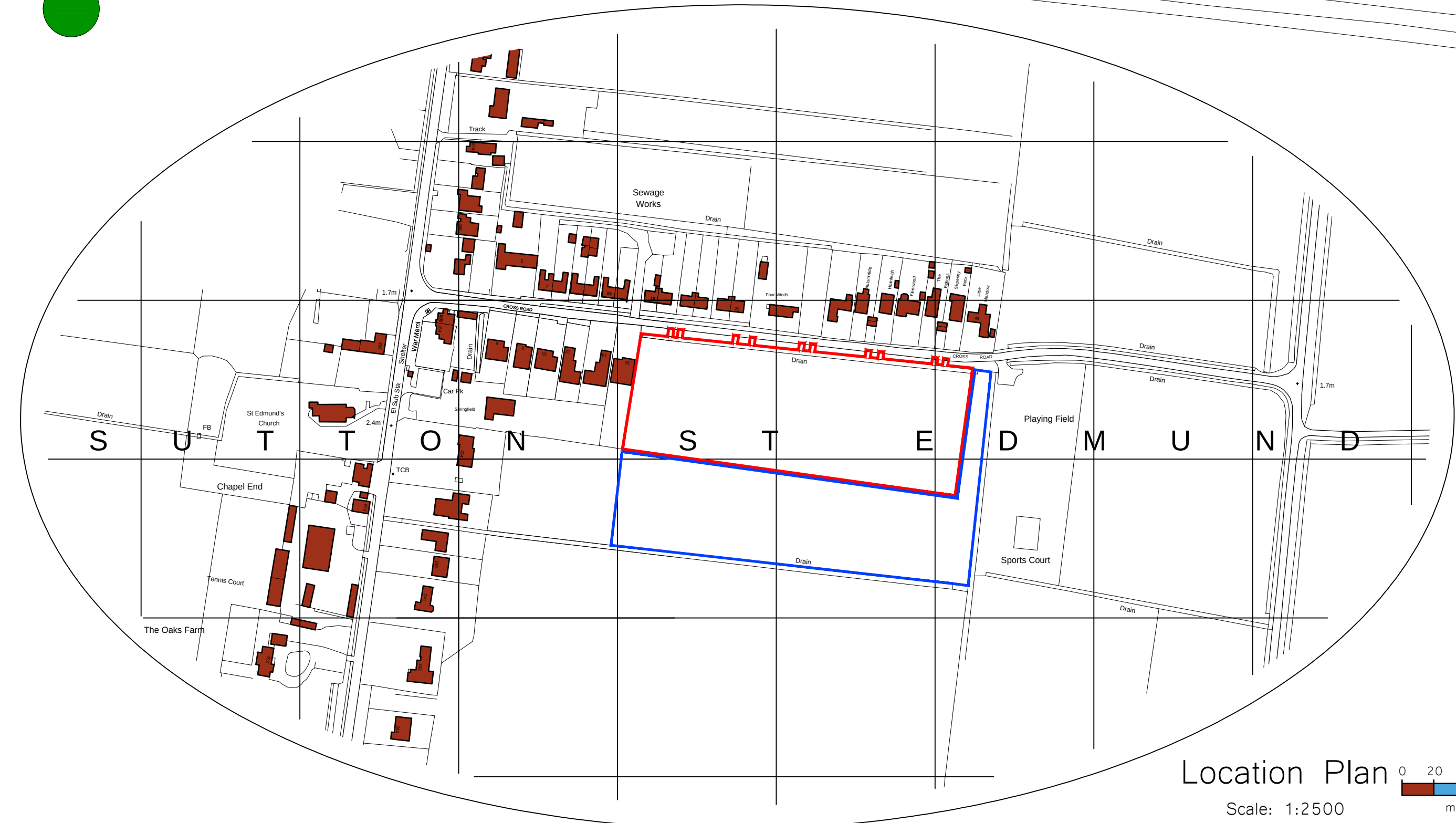
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Site and Location Plans

Job No.
SE-1186

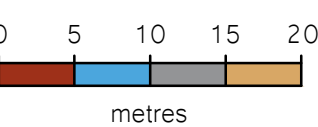
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PP1000

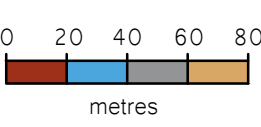
Revision



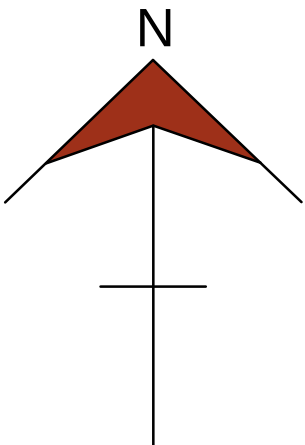
Site Plan
Scale: 1:500



Location Plan
Scale: 1:2500



Schedule of Sizes						
Plot	Unit Type	Location	Bedrooms	People	Floor Area	Notes
Plot 1	Type A		4 Bed	7 Person	192.0m2 exc garage	Integral Garage
Plot 2	Type B		4 Bed	7 Person	166.0m2 exc garage	Integral Garage
Plot 3	Type B		4 Bed	7 Person	166.0m2 exc garage	Integral Garage
Plot 4	Type C		4 Bed	7 Person	166.0m2 exc garage	Detached Garage
Plot 5	Type A		4 Bed	7 Person	192.0m2 exc garage	Integral Garage
Plot 6	Type B		4 Bed	7 Person	166.0m2 exc garage	Integral Garage
Plot 7	Type A		4 Bed	7 Person	192.0m2 exc garage	Integral Garage
Plot 8	Type C		4 Bed	7 Person	166.0m2 exc garage	Detached Garage
Plot 9	Type A		4 Bed	7 Person	192.0m2 exc garage	Integral Garage
Plot 10	Type B		4 Bed	7 Person	166.0m2 exc garage	Integral Garage



ATTACHMENT 2

TOPOGRAPHIC SURVEY CROSS ROAD (Dwg 6998-1)

ATTACHMENT 3

INFILTRATION TEST RESULTS

INFILTRATION TEST RESULTS

PROPOSED 10 PLOT DEVELOPMENT

LAND OFF CROSS LANE,

SUTTON ST EDMUND, LINCOLNSHIRE

PROJECT No: 37019

DOCUMENT REF: 37019-REP-01

For SH & MB PROPERTIES LTD
C/O Tim Ellingham
Ellingham Consulting Ltd

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1. INTRODUCTION

Acting upon instruction from Tim Ellingham of Ellingham Consulting Ltd, on behalf of our client SH & MB Properties Ltd, SRC attended site on 25th September 2019 to undertake suitable percolation testing to establish the suitability of the site for the use of infiltration drainage techniques.

The object of this report is to describe the tests undertaken, their results and conclusions that can be drawn from these results.

It should be noted that ground water levels are likely to vary with seasonal and weather differences.

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2. LOCATION & SITE DESCRIPTION

2.1 Site location

Situated on the South side of Cross Lane, Sutton St Edmund, PE12 0LS suitable national grid reference TF 371132. The proposed site layout is shown on our drawing 37019/SK01, contained within Appendix A.

2.2 Site description

The Site currently stands as active agricultural land and is bound on the East and South by large IDB drains, a domestic plot to the West and a highway with associated drain to the North.

3. PERCOLATION TESTS

Two No percolation tests were undertaken in accordance to test methodology within BRE digest 365. The proposed development is within an area with a low probability of flooding, is smaller than one hectare and is not affected by any known flooding.

The ground conditions on the site varied greatly and as such trial pit logs were recorded and additional trial pits were undertaken along the length of the site to establish where the change in conditions occurred.

Test pit 01 was undertaken on the Eastern side of the site and was underlain by a slightly sandy very silty firm clay. At 1.3m below ground a thin layer of organic clay/peat was encountered, followed by more very silty clay.

Test pit 02 was undertaken on the Western side of the site and was underlain by medium dense silty sand. This continued down to the extent of the pit.

Test pits 03 contained similar material to test pit 02, was moist from 1.5m below ground level but extended to 2.6m below ground level where the ground water was encountered, and pit sides began collapsing.

Test pit 04 is believed to be situated close to the change in material, the to 1m below ground level the silty clay was encountered then a larger layer of organic peaty material, this was then underlain by the silty sand. The test pit extended to 2.8m and water was encountered at the bottom of the exploration.

Trial pit logs are contained within Appendix B.

4. INFILTRATION TEST RESULTS

Both test pit 01 and 02 saw the test water soakaway, however neither test pit emptied within the 4 hour test window.

Test pit 01's infiltration rate was calculated at 1.47×10^{-05} m/s.

Test pit 02's infiltration rate was calculated at 1.68×10^{-05} m/s.

The above results are more than sufficient for the use of private domestic soakaways for the roof surface water and should also prove sufficient for the use of a drainage field or similar for private foul treatment plants should no public sewer connection be available.

5. CONCLUSIONS

The tests undertaken and their results have proved that the site is suitable for the use of soakaway/infiltration drainage techniques.

It should be noted that the infiltration results for the Eastern side of the site are slightly less favourable and as such infiltration features or soakaways located on plots 6 through 10 should utilise the infiltration calculated from test pit 01.

For and on behalf of **SIDEBOTTOM RICHARDSON CHENG LTD**



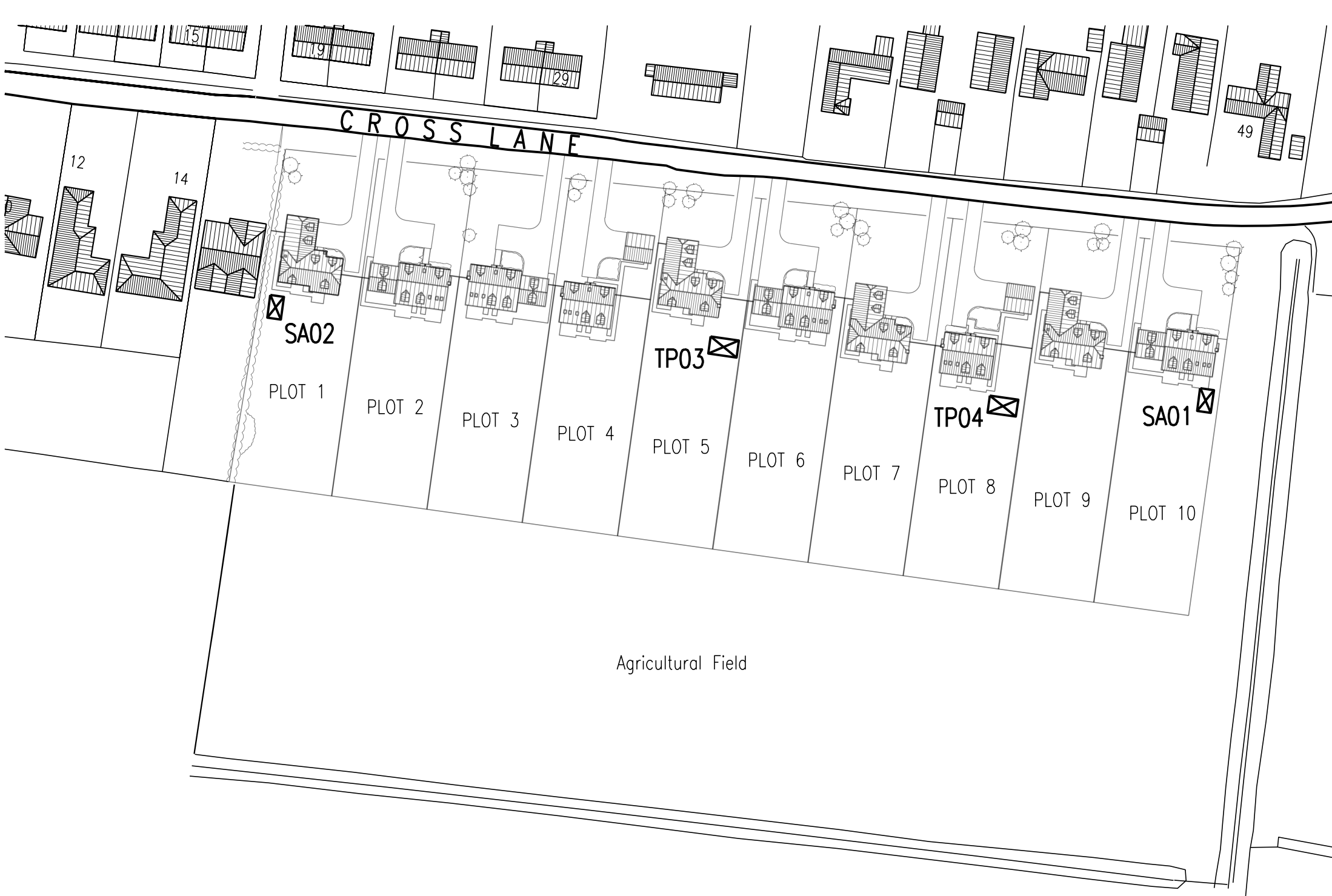
A. Wilson CEng MStructE

14th October 2019

APPENDIX A

Trial pit location plan

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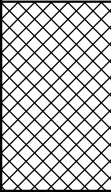
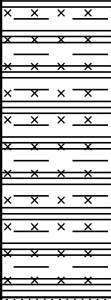
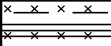


Rev	Date	Remarks
Status		
FOR INFORMATION		
 SIDEBOTTOM RICHARDSON CHENG LTD CONSULTING STRUCTURAL AND CIVIL ENGINEERS 15 High Street, Spalding, Lincs. PE11 1TW Tel: 01775 712660 Fax: 01775 712635 Email: src@src ltd.com		
Project		
Proposed Residential Development, Cross Lane, Sutton St Edmund, For SH & MB Properties Ltd.		
Title		
Site Plan Showing Trial Pit & Soakaway Test Locations		
Date	Sep, '19	Scale
Drawn	SA	Checked
Design	SRC	File Name
DRG No. 37019/SK01		Rev
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APPENDIX B

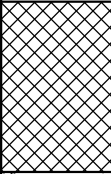
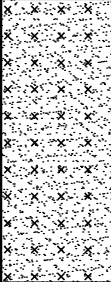
Trial pit logs

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						Logged By APW			
Equipment & Methods Digger			Site Coordinates:			Triol Pit No. 1			
			Ground Level:						
Description	Reduced Level	Legend	Depth (Thick)	Samples				Test Required	M.P.T. Blow Count (Depth)
				Depth	Sample Reference	Sample Type No.			
Topsoil.			500mm						
Browney Dark Grey Firm Silty Clay.			(800mm) 1300mm						
50mm Peat.									
Browney Dark Grey Firm Silty Clay.			(200mm) 1500mm						
Remarks									

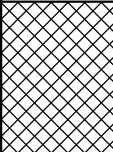
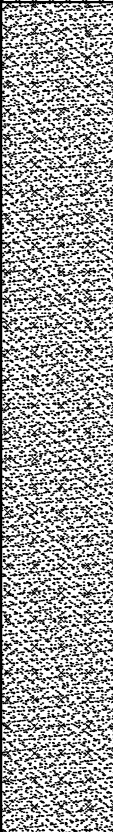
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Yellow Brown, Mid Dense, Sandy Silt				(750mm) 1200mm									
Remarks													

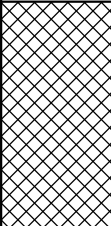
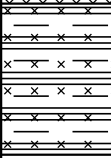
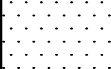
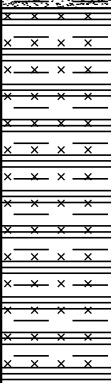
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Location Land South of Cross Lane, Sutton St Edmund				Carried Out For SH & MB Properties Ltd.				Date Undertaken					
								Logged By APW					
Equipment & Methods Digger				Site Coordinates:				Triol Pit No. 3					
				Ground Level:									
Description		Reduced Level	Legend	Depth (Thick)	Samples			Test Required	M.P.T. Blow Count (Depth)				
					Depth	Sample Reference	Sample Type No.						
Topsoil.				400mm									
Orangey Brown Silty Sand.				(2200mm) 2600mm									
Wet at 1500mm ▼													
Soft Grey Sandy Silt.													
Remarks Water at 2.6m													

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Status FOR INFORMATION													
Date		Sep, '19		Drawn		SA		Checked		APW			
Scale		1:20		Design		SRC		File Name		37019-TP04			
Location Land South of Cross Lane, Sutton St Edmund				Carried Out For SH & MB Properties Ltd.				Date Undertaken					
								Logged By APW					
Equipment & Methods Digger				Site Coordinates:				Trial Pit No. 4					
				Ground Level:									
Description		Reduced Level	Legend	Depth (Thick)	Samples			Test Required	M.P.T. Blow Count (Depth)				
					Depth	Sample Reference	Sample Type No.						
Topsoil.				600mm									
Grey, Brown, Firm Silty Clay.				(400mm) 1000mm									
Peat.				(200mm) 1200mm									
Yellowy, Brown Silty Sand.				(600mm) 1800mm									
Loose wet Grey Sandy Silt.				(1000mm) 2800mm									
Trial Pit Terminated.													
Remarks Water Seeping at 2.8m													

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APPENDIX C

Percolation test results and Infiltration rate calculation

Soak-Away Test SA 01
Job Reference Infiltration tests, Sutton St Edmunds
SH & MB Properties Ltd.

SA01	
TIME (Mins)	DEPTH mm (d)
0	895
20	845
50	795
115	690
145	660
175	620
205	590
235	560

Job No. 37019

Date
Trial Dimensions

A = 1.55 m
 B = 0.6 m
 C = 1.5 m

C.S.Area of
 SA01 = 0.93 m²

Total Volume = 0.312 m³
 75% Volume = 0.234 m³
 25%Volume = 0.078 m³

Time Taken From 75% Volume to 25% Volume

107 Mins

Effective Depth From 75% Volume to 25% Volume

0.1675 m

50% Effective Internal Surface Area Including Base area

1.65025 m²

Soil Infiltration rate, f

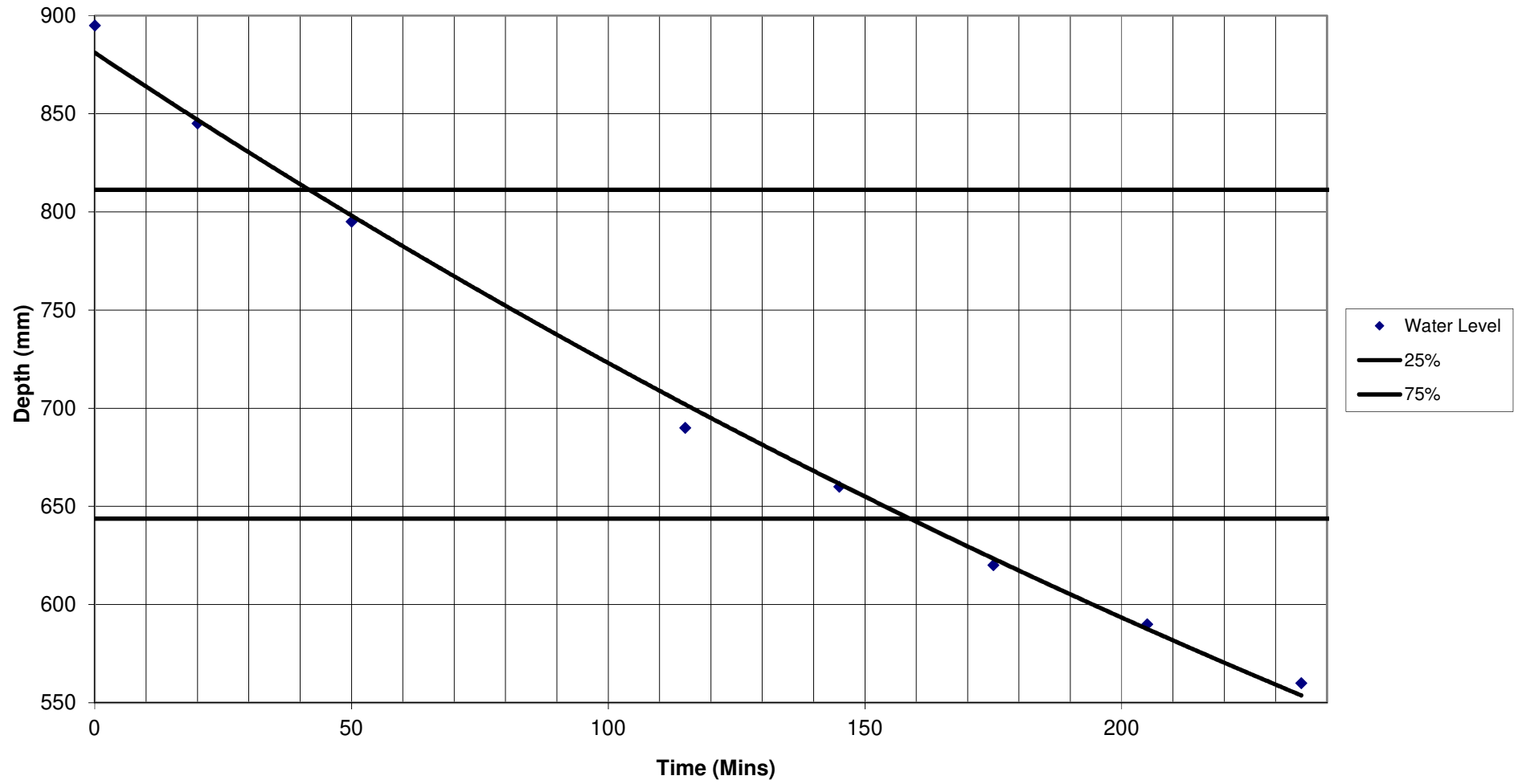
1.47032E-05 m/s

1.47 X 10⁻³ mm/s

Infiltration Test, Sutton St Edmunds, SH & MB Properties Ltd.

Job No. 37019

Plot showing water level against time for SA01



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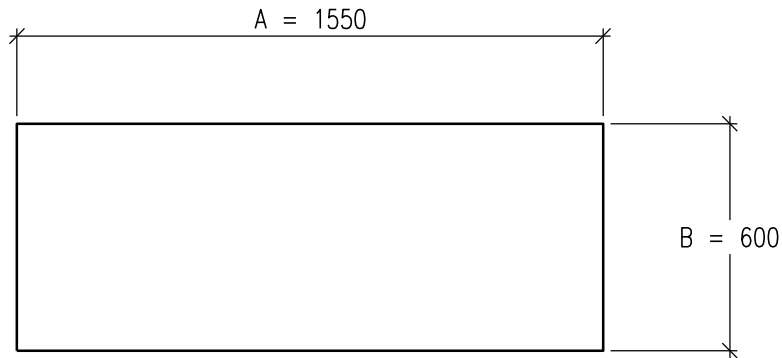
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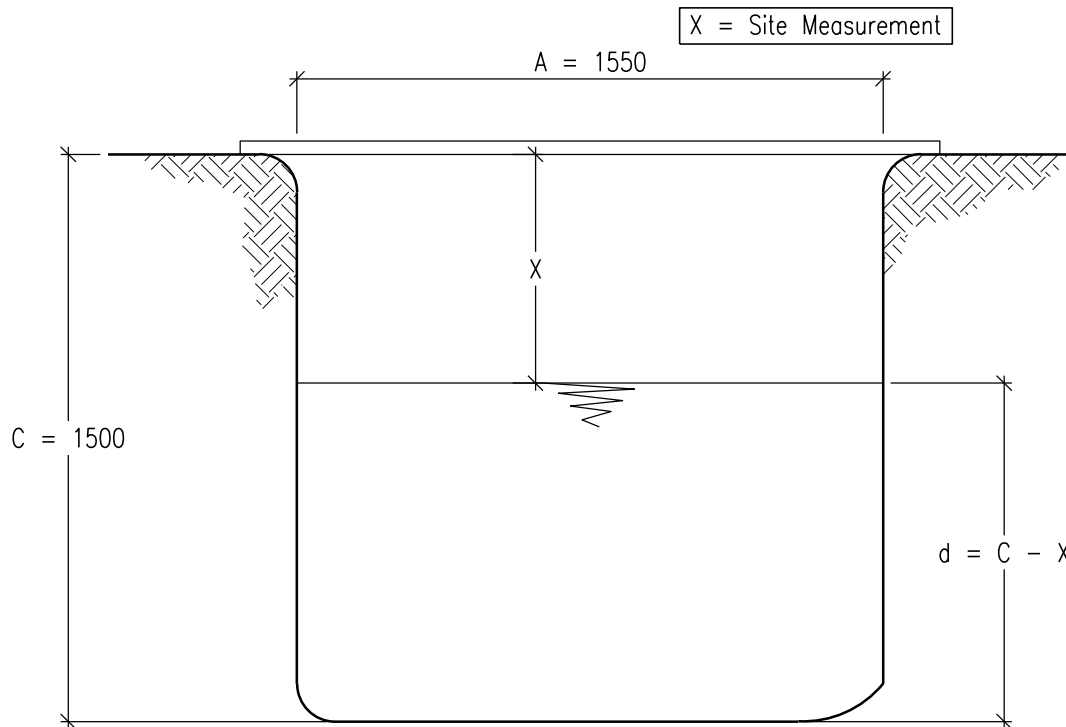
37019-SA01

Project Infiltration Tests, Sutton St Edmund,
For SH & MB Properties Ltd.

Title Infiltration Soak Away Sketch



Plan On SA01



Section Through SA01

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Soak-Away Test SA 02
Job Reference Infiltration tests, Sutton St Edmunds
SH & MB Properties Ltd.

SA01	
TIME (Mins)	DEPTH mm (d)
0	810
15	765
30	720
80	630
95	610
115	580
135	560
155	520
185	500
215	480

Job No. 37019

Date
Trial Dimensions

A = 1.55 m
 B = 0.6 m
 C = 1.2 m

C.S.Area of
 SA01 = 0.93 m²

Total Volume = 0.307 m³
 75% Volume = 0.230 m³
 25%Volume = 0.077 m³

Time Taken From 75% Volume to 25% Volume

93 Mins

Effective Depth From 75% Volume to 25% Volume

0.165 m

50% Effective Internal Surface Area Including Base area

1.6395 m²

Soil Infiltration rate, f

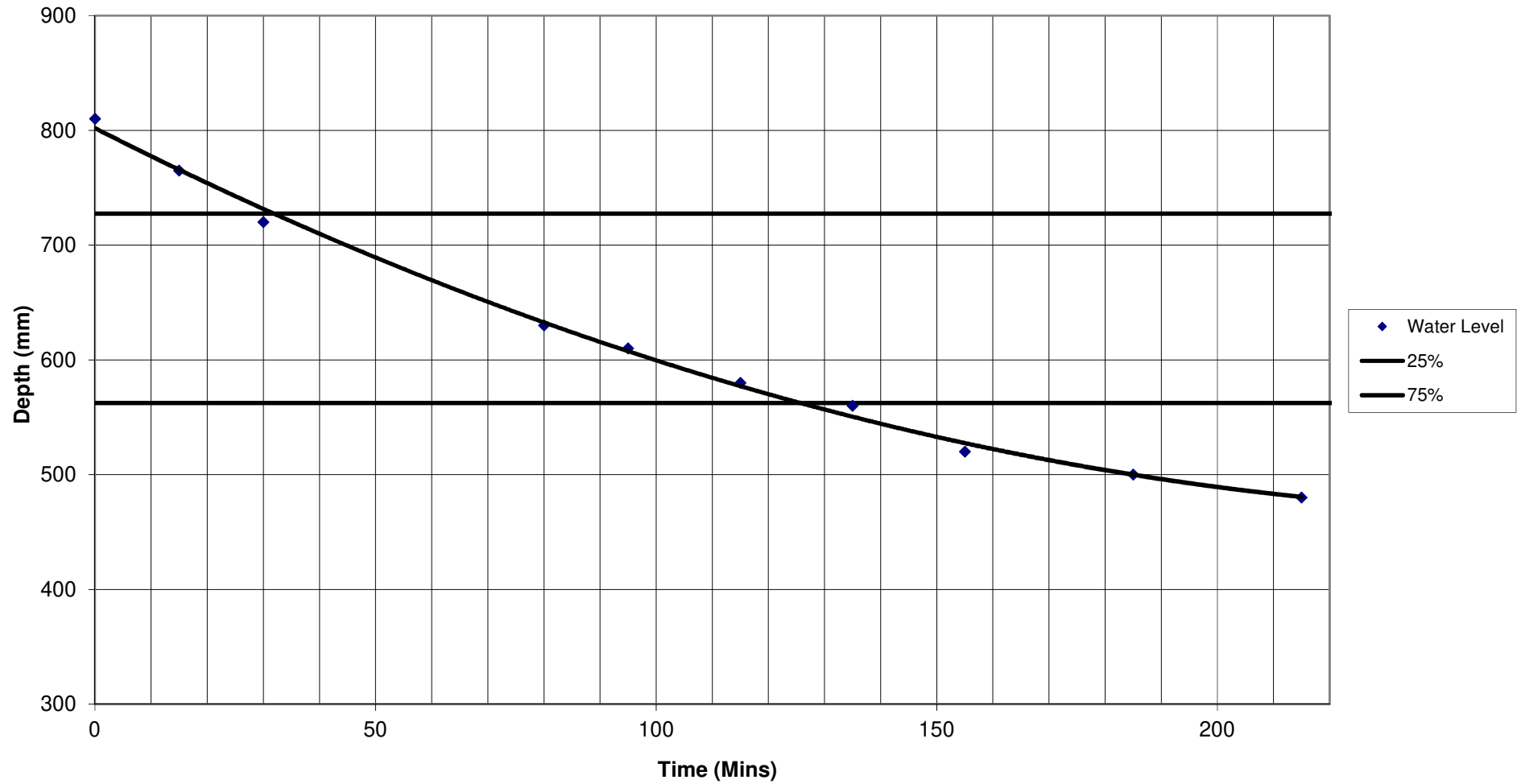
1.67734E-05 m/s

1.68 X 10⁻³ mm/s

Infiltration Test, Sutton St Edmunds, SH & MB Properties Ltd.

Job No. 37019

Plot showing water level against time for SA02



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File Name

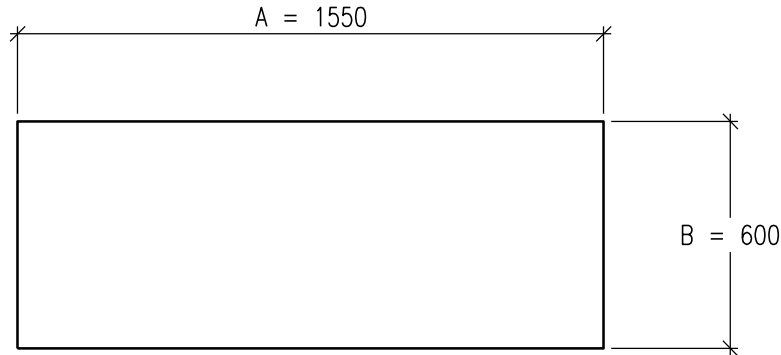
370019-SA02

Project

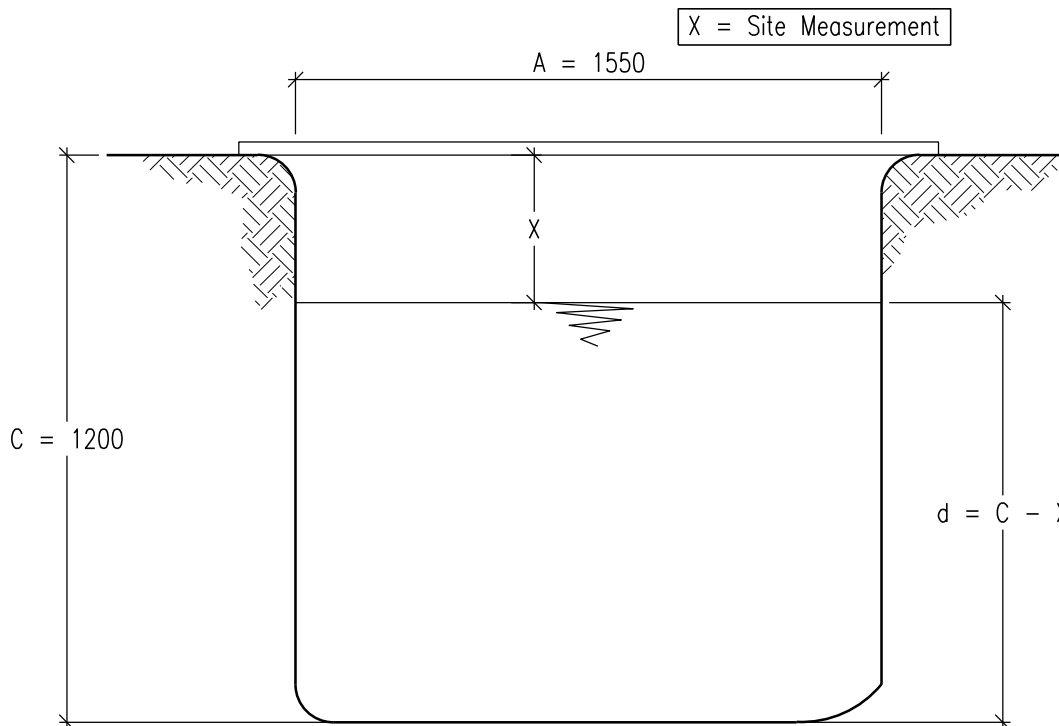
Infiltration Tests, Sutton St Edmund,
SH & MB Properties Ltd.

Title

Infiltration Soak Away Sketch



Plan On SA02



Section Through SA02

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ATTACHMENT 4

INFILTRATION VOLUME ESTIMATES

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INFILTRATION SYSTEMS DESIGN Comparison

GEOMETRY

Rectangular soakaway 1		Rectangular soakaway 2		Rectangular soakaway 3		Rectangular soakaway 4	
Width (m)	2.4	Width (m)	2.4	Width (m)	2.4	Width (m)	2.4
Length (m)	2.4	Length (m)	2.4	Length (m)	2.4	Length (m)	2.4
Diameter (m)							
Soakaway base area (m2)	5.76	Soakaway base area (m2)	5.76	Soakaway base area (m2)	5.76	Soakaway base area (m2)	5.76

PARAMETERS

Porosity	0.95	Porosity	0.95	Porosity	0.95	Porosity	0.95
Effective porosity							
Infiltration coefficient (m/h)	0.06048	Infiltration coefficient (m/h)	0.06048	Infiltration coefficient (m/h)	0.05292	Infiltration coefficient (m/h)	0.05292
Factor of safety	1.5	Factor of safety	1.5	Factor of safety	1.5	Factor of safety	1.5

AREA TO BE DRAINED

Contributing area		Contributing area		Contributing area		Contributing area	
Property Type A (Plots 1,5)	156	Property Type B/C (Plots 2,3,4)	136	Property Type A (Plots 7,9)	156	Property Type B/C (Plots 6,8,10)	136
Total area (m2)	156	Total area (m2)	136	Total area (m2)	156	Total area (m2)	136

DESIGN RAINFALL

M5-60 rainfall depth (mm)	20	M5-60 rainfall depth (mm)	20	M5-60 rainfall depth (mm)	20	M5-60 rainfall depth (mm)	20
Rainfall ratio r	0.4	Rainfall ratio r	0.4	Rainfall ratio r	0.4	Rainfall ratio r	0.4
Climate change factor	1.1	Climate change factor	1.1	Climate change factor	1.1	Climate change factor	1.1
FEH factor	1	FEH factor	1	FEH factor	1	FEH factor	1
Return period (years)	10	Return period (years)	10	Return period (years)	10	Return period (years)	10

Rainfall Duration (h)	Intensity (mm/h)	Rainfall Duration (h)	Intensity (mm/h)	Rainfall Duration (h)	Intensity (mm/h)	Rainfall Duration (h)	Intensity (mm/h)
0.083333333	120.78	0.083333333	120.78	0.083333333	120.78	0.083333333	120.78
0.166666667	84.546	0.166666667	84.546	0.166666667	84.546	0.166666667	84.546
0.25	69.182	0.25	69.182	0.25	69.182	0.25	69.182
0.5	43.866	0.5	43.866	0.5	43.866	0.5	43.866
1	27.28	1	27.28	1	27.28	1	27.28
2	16.436	2	16.436	2	16.436	2	16.436
4	9.649	4	9.649	4	9.649	4	9.649
6	7.135	6	7.135	6	7.135	6	7.135
10	4.702	10	4.702	10	4.702	10	4.702
24	2.441	24	2.441	24	2.441	24	2.441

RESULTS

Maximum water depth (m)	0.81	Maximum water depth (m)	0.69	Maximum water depth (m)	0.84	Maximum water depth (m)	0.72
Time for half-emptying (h)	4.79	Time for half-emptying (h)	4.4	Time for half-emptying (h)	5.57	Time for half-emptying (h)	5.15