Project Name	: Shepherd Neame, Faversham
Job No	: 18-120
Note Title	: Flood Risk Assessment and Drainage Strategy - Addendum 2
Author	: MSS
Checked	: JW
Approved	: GG
Date	: November 2022

1.0 INTRODUCTION

1.1 Background

1.1.1 Odyssey has been commissioned by Milliken and Company Chartered Surveyors and Town Planners to provide a Flood Risk Assessment (FRA) and Drainage Strategy with respect to the construction of a proposed residential development comprising seven barn style residential units at Queen Court Farmyard Site, Water Lane, Ospringe, Faversham.

1.1.2 The site currently comprises approximately 0.7 hectares (ha) with five existing buildings. The development proposal is to demolish the five buildings and construct seven dwellings, with associated car parking areas and a new access road onto Water Lane.

1.1.3 The Flood Risk Assessment (FRA) and Drainage Strategy was submitted to Kent County Council (KCC) as part of the full planning application (reference 22/504036/FULL) for the proposed development.

1.1.4 Following the submission of the application, comments were received from KCC in their capacity as the Lead Local Flood Authority (LLFA), in September 2022 (KCC reference: SBC/2022/091730). A copy of the LLFA consultation comments is provided in **Appendix A**.

1.1.5 This FRA Addendum, which should be read in conjunction with the submitted FRA and Drainage Strategy (reference 18-120-04A), provides additional information as requested by the LLFA.

2.0 RESPONSE TO KENT COUNTY COUNCIL COMMENTS

2.1.1 KCC provided the following comments (***in bold italics***) in September 2022. Odyssey's response directly follows each comment.

"More information is requested regarding the swale network along the centre of the site to capture flows from the critical culvert along Vicarage Lane as other than a general description in the flood risk assessment no further information is provided."

2.1.2 The Proposed Nailbourne Channel Section drawing **18-120-003E** showing the plan, long section and cross sections of the proposed swale is presented in **Appendix B**.

2.1.3 Additional information regarding the proposed swale can be found in the fluvial modelling input data. The modelling report which has a link to the model files is included in **Appendix C.**

"There are also issues regarding the pollution mitigation index. Whilst two components or more in a series can be utilized to increase the overall mitigation index these should utilise the SuDS management train and simply doubling the depth of soil will not satisfactorily reduce pollutants infiltrating to groundwater."

2.1.4 The surface water on the site is deemed to have 'low' pollution hazard potential in line with CIRIA 753 The SuDS Manual, pollution is generated from the roofs and roads, where there will only be small numbers of vehicle movements. This is conveyed in **Table 7.1** of the Flood Risk Assessment and Drainage Strategy (report reference: 18-120-04A) submitted as part of the planning application.

2.1.5 The low level of pollution hazard for the residential car parking area and road is mitigated in the drainage strategy. However, it should be noted that a significant proportion of the site is only roofs, which naturally have a lower pollution hazard index ('very low' pollution hazard level).

2.1.6 Permeable paving, a swale or a basin would be the preferred options. However, due to the steepness and the size of the site, the modelled flooded extents, the swale managing the overland flow path, and the site layout, these would not provide sufficient attenuation storage for the 1 in 100 year design storm including an allowance for climate change. The layer of soil with good contaminant attenuation potential is considered the most appropriate method for treating the surface water generated on the site.

2.1.7 Another option could be a proprietary treatment device. However, this would have to be installed prior to the attenuation tank, which would cause flooding as the flows for a larger storm would be restricted and/or cause an unsatisfactory treatment of the surface water when water would have to overflow through the device. If the device is installed after lined attenuation, an infiltration solution would be required to infiltrate the water after treatment, which is considered to be an inefficient design. For these reasons a proprietary treatment solution is not deemed to be a viable option.

2.1.8 A filter drain could be designed in at detailed design stage to collect water from the proposed impermeable surfaces. This could provide additional water quality treatment to contribute alongside the layer of soil with a good contaminant attenuation potential. However, filter drains significantly impact the maintenance requirements.

2.1.9 The filter drain SuDS Mitigation indices are shown in **Table 2.1**. And the total combined SuDS mitigation indices acting with a 300mm layer of soil with good contaminant attenuation potential are presented in **Table 2.2**.

Table 2.1: SuDS Mitigation Indices for Proposed SuDS Features

Type of SuDS Component	Total Suspended Solids (TSS)	Metals	Hydrocarbons
Filter Drain	0.4	0.4	0.4

Table 2.2: SuDS Mitigation Indices for Surface Water Infiltrating ultimately into the Ground

Total Suspended Solids (TSS)	Metals	Hydrocarbons
(0.4 +0.2) = 0.6 > 0.5 therefore ok	(0.4+0.15) =0.55> 0.4 therefore ok	(0.4+0.15) =0.55 >0.4 therefore ok

2.1.10 However, it is proposed that the 600mm layer of soil with good contaminant attenuation potential, is the most appropriate solution and as shown in line with CIRIA 753 The SuDS Manual guidance, it is sufficient to treat the surface water generated on site to the required level. It is proposed that reconsideration of the water quality treatment mechanisms could be included in a suitably worded condition.

"It is also noted that FEH 1999 was used within the microdrainage calculations. KCC require the use of the more detailed and up-to date FEH13 dataset within drainage design submissions. Where FeH data is not available, 26.25mm should be manually input for the M5-60 value, as per the requirements of our latest drainage and planning policy statement (November 2019); the FSR dataset should not be used: http://www.kent.gov.uk/__data/assets/pdf_file/0003/49665/Drainage-and-Planning-policy-statement.pdf ."

2.1.11 As advised by KCC, an up-to-date FEH13 dataset has been used to update the drainage strategy. All the other parameters of the drainage strategy aside from the FEH input data have remained the same.

2.1.12 The updated drainage strategy drawing **18-120-100B** is presented in **Appendix D.** Supporting MicroDrainage calculations are also presented in **Appendix D**.

APPENDIX A

LLFA Comments

Alice Reeves
Swale Borough Council
Swale House
East Street
Sittingbourne
Kent
ME10 3HT

Flood and Water Management
Invicta House
Maidstone
Kent
ME14 1XX
Website: www.kent.gov.uk/flooding
Email: suds@kent.gov.uk
Tel: 03000 41 41 41
Our Ref: SBC/2022/091730
Date: 21 September 2022

Application No: 22/504036/FULL

Location: Queen Court Barns Water Lane Ospringe Kent ME13 8UA

Proposal: Erection of new barn development for 7no. dwellings, parking barns, cycle/bin storage, waste water pumping station, new vehicular and pedestrian access, reuse of victorian outbuilding for storage, new permissive footpath link, hard and soft landscaping works, communal and community open space.

Thank you for your consultation on the above referenced planning application.

Kent County Council as Lead Local Flood Authority have reviewed the Flood Risk Assessment prepared by Odyssey on the 10th August 2022 and are in general agreement with the methods proposed for dealing with surface water, namely infiltration. However there are some concerns raised to which we have the following comments:

1. More information is requested regarding the swale network along the centre of the site to capture flows from the critical culvert along Vicarage Lane as other than a general description in the flood risk assessment no further information is provided.

2. There are also issues regarding the pollution mitigation index. Whilst two components or more in a series can be utilized to increase the overall mitigation index these should utilise the SuDS management train and simply doubling the depth of soil will not satisfactorily reduce pollutants infiltrating to groundwater.

3. It is also noted that FEH 1999 was used within the microdrainage calculations. KCC require the use of the more detailed and up-to date FEH13 dataset within drainage design submissions. Where FeH data is not available, 26.25mm should be manually input for the M5-60 value, as per the requirements of our latest drainage and planning policy statement (November 2019); the FSR dataset should not be used:

http://www.kent.gov.uk/__data/assets/pdf_file/0003/49665/Drainage-and-Planning-policy-statement.pdf

We would therefore request that a holding objection is put in place until the information above is received to our satisfaction.

This response has been provided using the best knowledge and information submitted as part of the planning application at the time of responding and is reliant on the accuracy of that information.

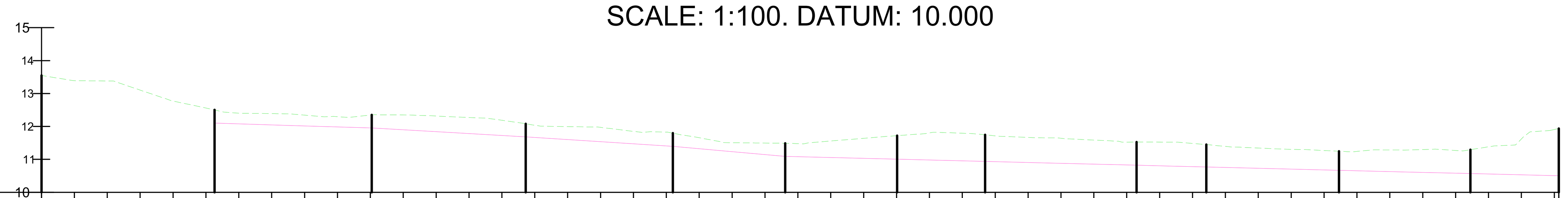
Yours faithfully,

Gideon Miller
Graduate Flood Risk Officer
Flood and Water Management

APPENDIX B

Proposed Nailbourne Channel Sections

LONG SECTION PROFILE
SCALE: 1:100. DATUM: 10.000



Chainage	Existing Levels	Proposed Levels	Level Difference
00.000	13.550	13.150	-0.400
05.000	13.390	12.951	-0.439
10.000	13.380	12.752	-0.629
15.000	13.104	12.552	-0.552
20.000	12.773	12.353	-0.420
25.000	12.558	12.155	-0.403
30.000	12.403	12.079	-0.323
35.000	12.389	12.048	-0.342
40.000	12.343	12.016	-0.327
45.000	12.295	11.985	-0.310
50.000	12.348	11.954	-0.394
55.000	12.349	11.897	-0.451
60.000	12.316	11.840	-0.475
65.000	12.272	11.782	-0.490
70.000	12.188	11.724	-0.464
75.000	12.036	11.665	-0.371
80.000	11.995	11.601	-0.394
85.000	11.973	11.537	-0.436
90.000	11.850	11.473	-0.377
95.000	11.827	11.408	-0.419
100.000	11.655	11.323	-0.332
105.000	11.505	11.233	-0.273
110.000	11.495	11.143	-0.352
115.000	11.477	11.079	-0.398
120.000	11.557	11.054	-0.503
125.000	11.639	11.029	-0.610
130.000	11.721	11.004	-0.717
135.000	11.804	10.978	-0.826
140.000	11.794	10.954	-0.840
145.000	11.713	10.929	-0.784
150.000	11.667	10.904	-0.763
155.000	11.642	10.879	-0.763
160.000	11.586	10.854	-0.732
165.000	11.522	10.829	-0.694
170.000	11.523	10.804	-0.720
175.000	11.483	10.779	-0.705
180.000	11.394	10.754	-0.640
185.000	11.343	10.729	-0.614
190.000	11.303	10.704	-0.599
195.000	11.269	10.679	-0.590
200.000	11.241	10.654	-0.587
205.000	11.285	10.629	-0.656
210.000	11.298	10.604	-0.695
215.000	11.270	10.579	-0.691
220.000	11.381	10.554	-0.827
225.000	11.619	10.529	-1.090
230.000	11.935	10.500	-1.435
230.697	11.905	10.504	-1.401

SECTION 1 PROFILE
SCALE: H 1:500,V 1:500. DATUM: 10.000

Chainage	[illegible]
Existing Levels	13.292 [illegible]
Proposed Levels	13.173 13.297
Level Difference	-0.255 -0.263

SECTION 2 PROFILE
SCALE: H 1:500,V 1:500. DATUM: 10.000

Chainage	[illegible]
Existing Levels	12.674 [illegible]
Proposed Levels	12.370 12.153 12.482
Level Difference	-0.082 -0.359 -0.064

SECTION 3 PROFILE
SCALE: H 1:500,V 1:500. DATUM: 10.000

Chainage	[illegible]
Existing Levels	11.889 [illegible]
Proposed Levels	11.972 12.260
Level Difference	-0.358 -0.154

SECTION 4 PROFILE
SCALE: H 1:500,V 1:500. DATUM: 10.000

Chainage	[illegible]
Existing Levels	12.467 [illegible]
Proposed Levels	11.772 11.917
Level Difference	-0.280 -0.189

SECTION 7 PROFILE
SCALE: H 1:500,V 1:500. DATUM: 10.000

Chainage	[illegible]
Existing Levels	11.497 [illegible]
Proposed Levels	[illegible]
Level Difference	[illegible]

SECTION 9 PROFILE
SCALE: H 1:500,V 1:500. DATUM: 10.000

Chainage	[illegible]
Existing Levels	11.815 [illegible]
Proposed Levels	[illegible]
Level Difference	[illegible]

SECTION 5 PROFILE
SCALE: H 1:500,V 1:500. DATUM: 10.000

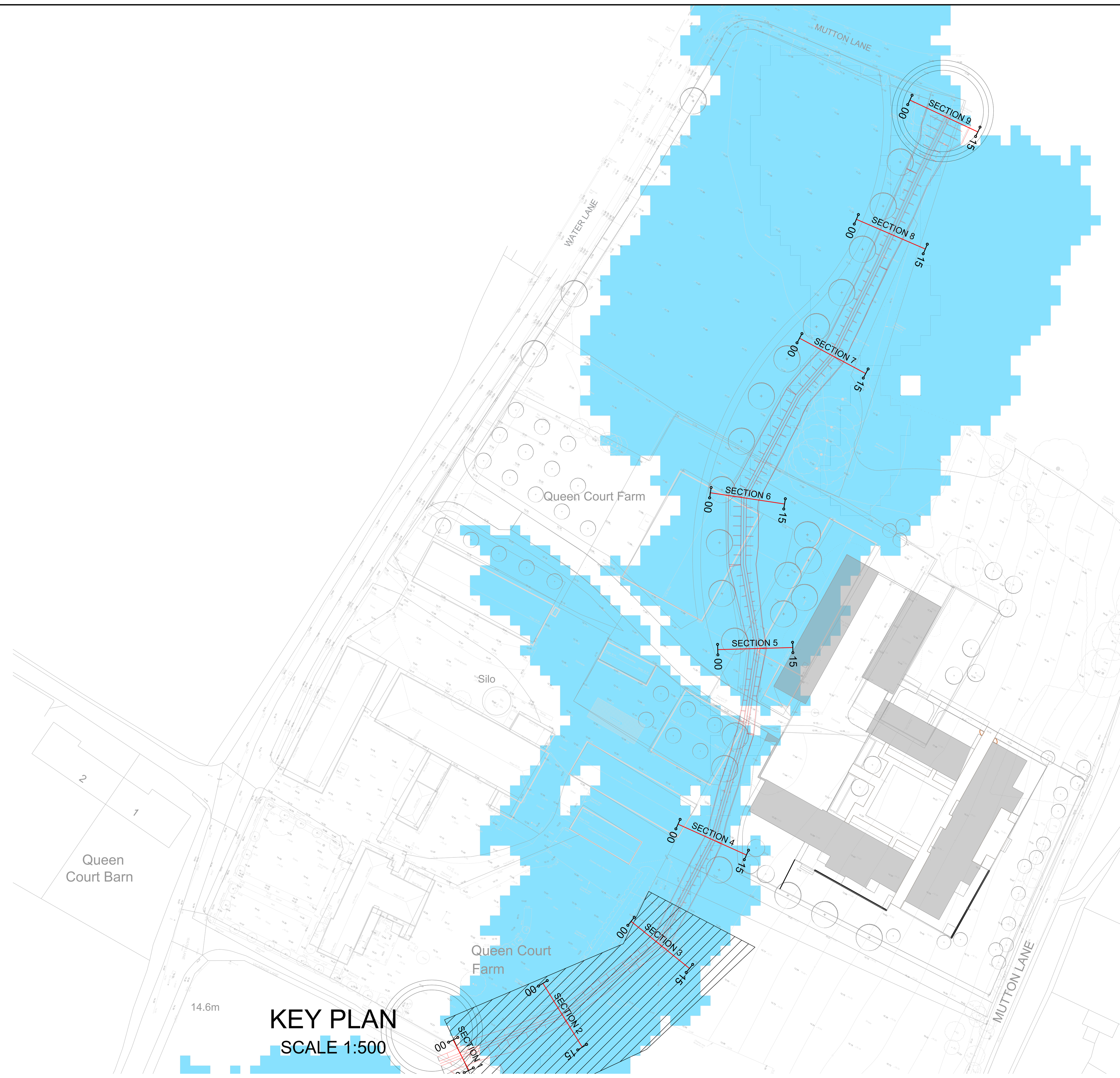
Chainage	[illegible]
Existing Levels	11.529 [illegible]
Proposed Levels	11.216 11.283
Level Difference	-0.261 -0.217

SECTION 6 PROFILE
SCALE: H 1:500,V 1:500. DATUM: 10.000

Chainage	[illegible]
Existing Levels	11.810 [illegible]
Proposed Levels	[illegible]
Level Difference	[illegible]

SECTION 8 PROFILE
SCALE: H 1:500,V 1:500. DATUM: 10.000

Chainage	[illegible]
Existing Levels	11.214 [illegible]
Proposed Levels	[illegible]
Level Difference	[illegible]



KEY PLAN
SCALE 1:500

NOTES

1. DO NOT SCALE FROM THIS DRAWING. WORK FROM FIGURED DIMENSIONS ONLY.
2. ALL DIMENSIONS SHOWN ON THIS DRAWING ARE IN METRES.
3. ALL DIMENSIONS, LEVELS AND SURVEY GRID CO-ORDINATES ARE TO BE CHECKED ON SITE AND THE ENGINEER NOTIFIED IMMEDIATELY OF ANY DISCREPANCIES PRIOR TO THE COMMENCEMENT OF THE WORKS.

LEGEND

- EXISTING GROUND PROFILE
- PROPOSED GROUND PROFILE
- MODELLED 1 IN 100 YEAR + 22% CLIMATE CHANGE FLUVIAL FLOODPLAIN
- PROPOSED SWALE

FOR PLANNING PURPOSES ONLY

Rev	Amendments	Drn	Chk	App	Date
E	UPDATED SITE LAYOUT AND FLOOD EXTENTS	JW	GG	GG	03.11.22
D	CHANNEL UPDATED TO NEW LAYOUT	HM	JH	GG	11.03.21
C	CHANNEL UPDATED TO SUIT CLIENT'S REQUIREMENTS	HM	JH	GG	11.01.21
B	PROPOSED CHANNEL AMENDED	JH	GG	GG	29.09.20
A	MODELLED FLOODPLAIN ADDED	JH	GG	GG	16.09.20

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Job Title
SHEPHERD NEAME
FAVERSHAM

Drawing Title
PROPOSED NAILBOURNE CHANNEL SECTIONS

Client
MILIKEN & COMPANY CHARTERED SURVEYORS & TOWN PLANNERS

Scale	Date	Designed
AS SHOWN @A0	JUL 20	SOM
Drawn	**Checked**	**Approved**
SOM	NM	GG
Job No	**Drawing No**	**Rev**
18-120	18-120/003	E

P:\18-120 - Shepherd Neame, Faversham\Tech\Acad\Drawings\18-120-003 Proposed Nailbourne Channel Sections.dwg

APPENDIX C

Fluvial Flooding Modelling Report

ODYSSEY

DEVELOPING JOURNEYS

PROPOSED RESIDENTIAL DEVELOPMENT AT SHEPHERD NEAME, QUEEN COURT FARMYARD SITE, OSPRINGE, FAVERSHAM

FLUVIAL FLOOD MODELLING STUDY

PROPOSED RESIDENTIAL DEVELOPMENT AT SHEPHERD NEAME, QUEEN COURT FARMYARD SITE, OSPRINGE, FAVERSHAM

FLUVIAL FLOOD MODELLINGSTUDY
ON BEHALF OF SHEPHERD NEAME LTD

Prepared by
Odyssey
Tuscany House
White Hart Lane
Basingstoke
Hampshire
RG21 4AF

Tel: 01256 331144

August 2022

DOCUMENT CONTROL SHEET

Project Name Shepherd Neame, Queen Court Farmyard Site, Ospringe, Faversham

Project No. 18-120

Rev	Issue Purpose	Author	Checked	Reviewed	Approved	Date
-	Draft for comment	ES	JH	GG	RS	March 2020
A	Revised flood mitigation strategy	JH	GG	JH	GG	February 2021
B	Minor amendments	JH	GG	JH	GG	February 2021
C	Updated proposed model to include access road and updated layout	SZ	LCS	RA	GG	August 2022

CONTENTS

APPENDICES

1.0 INTRODUCTION

1.1 Appointment and Brief

1.1.1 Odyssey has been commissioned by Shepherd Neame Ltd to carry out site-specific hydraulic modelling of the Nailbourne for the development of nine barn style residential units at Queen Court Farmyard Site, Water Lane, Ospringe, Faversham. Refer to **Figure 1.1** for the site location plan.

1.1.2 According to the current Environment Agency (EA) Flood Map for Planning, a large part of the site is shown to fall within the Flood Zone 3. It was also confirmed that the EA do not hold suitable flood level data for the site area to inform a site-specific Flood Risk Assessment for the site.

1.1.3 The east part of the site, which is subject to the development proposals, currently sits on gently rising land outside of Flood Zones 2 & 3. However, due to the close proximity of the proposed development to the floodplain area and other proposed access and landscaping works that are within the floodplain area, it was necessary to carry out site-specific river (fluvial) modelling for the site to accurately determine flood extents and levels at the site.

1.1.4 Please see **Table 1.1** below for the project summary.

Table 1.1: Project Summary

Project name:	Queen Court Farmyard site, Ospringe, Faversham
Project type:	Hydraulic modelling of the mainly fluvial flow and watercourses at the site and its immediate surroundings.
What is being modelled?	The Nailbourne (Westbrook Stream)
What existing modelling exists?	No hydraulic modelling currently exists.
What modelling has been undertaken and why was that approach chosen?	ESTRY-TUFLOW as detailed 1d (1-dimensional)-2D (2-dimensional) modelling package.
What hydrological analysis exists?	No hydrological analysis is available for the watercourses at the site.
What hydrological analysis has been undertaken?	Peak flow estimates and hydrographs for the 20%,5%,1% 1% plus climate change and 0.1% Annual Exceedance Probability (AEP) scenarios.
What outputs have been produced?	Flood maps and levels for the 5%, 1%, 1% plus climate change Annual Exceedance Probability (AEP) and 0.1% scenarios.

1.2 Scope of Works

1.2.1 The primary aim of the modelling study is to identify and quantify the fluvial flood risk associated with the fluvial flows generated by the local catchment.

1.2.2 The flood levels and floodplain extents were therefore established for the following design events:

- 20% AEP (1 in 5 year);
- 5% AEP (1 in 20 year);
- 1% AEP (1 in 100 year);
- 1% AEP plus 22% climate change allowance (1 in 100 year + 22%CC);
- 0.1% AEP (1 in 1000 year).

1.3 Project Limitations

1.3.1 Odyssey's hydraulic modelling is based on best practice and current guidance at the time of undertaking the project.

1.3.2 The baseline modelling assesses flood risk for an existing site/area in its current state.

1.3.3 The modelling undertaken is based on the interpretation and assessment of data provided by third parties. Odyssey cannot be held responsible for the accuracy of the third-party data and the conclusions and findings of this report may change if the data is amended or updated after the date of consultation.

1.3.4 The conclusions of the modelling report are based on the data gathered for the purpose of the project and therefore are limited in their accuracy in proportion to the validity of the dataset. The data gathered in turn has been based on an agreed scope of works. Odyssey cannot guarantee that the data used is the best available at the time of the modelling, but it is the best available data that could be gathered within the scope of the agreed instruction.

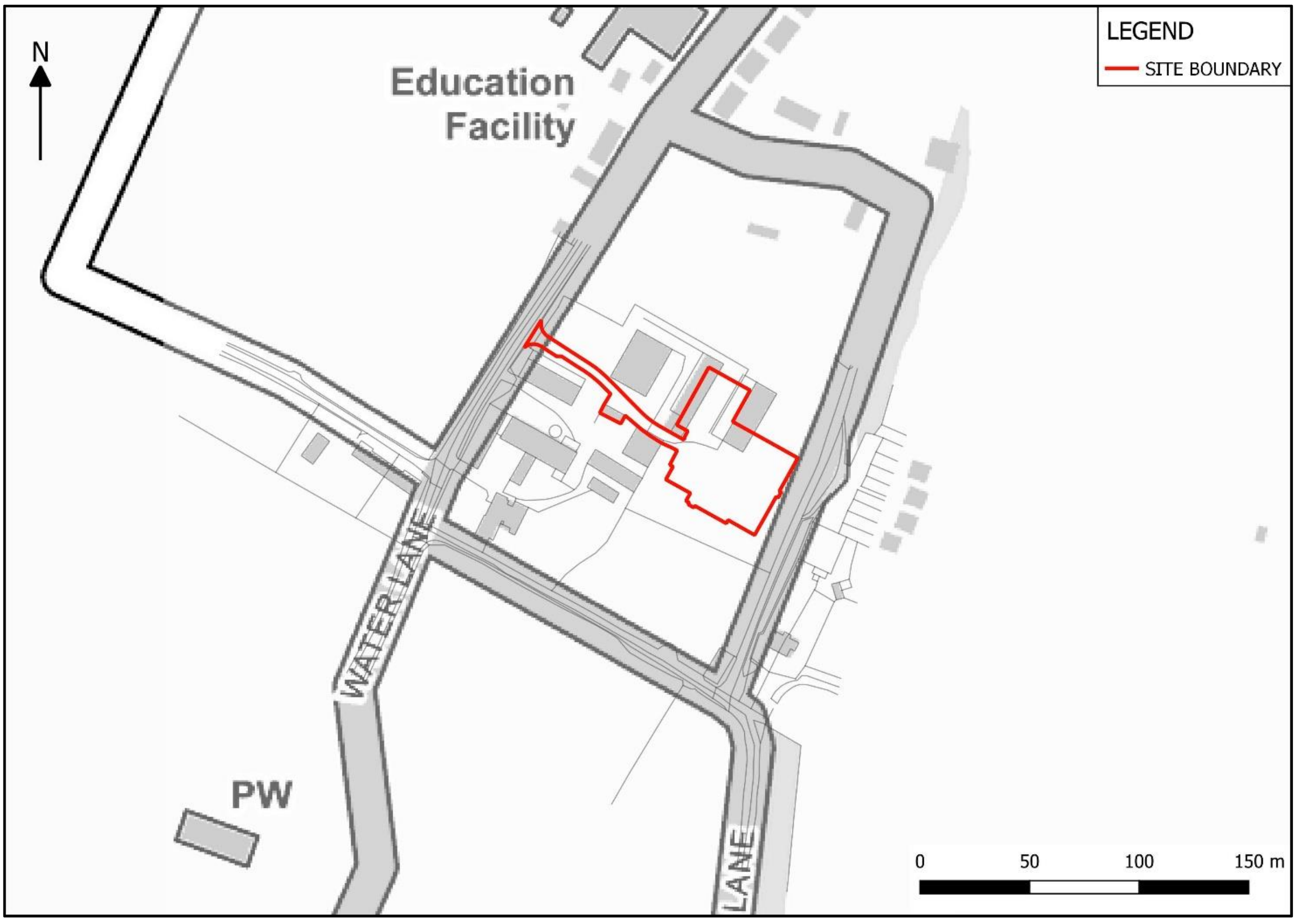
1.4 Site Description

1.4.1 The site is located in Ospringe, Faversham, Kent. Refer to **Figure 1.1** below for the site location map and **Table 1.2** below for a summary.

Table 1.2: Site Description Summary

Site National Grid Reference:	The Ordnance Survey (OS) grid reference at the centre of the site is (600161E, 160488N).
Site area:	The total site area is approximately 1.5 hectares (ha), and the proposals are to erect barn style dwellings within the former farmyard area with associated parking areas infrastructure.
Current use:	The site currently comprises of existing residential buildings. There are large sections of concrete hardstanding and open green space at the site.
Wider setting:	The site is bounded by Water Lane to the west, Vicarage Lane to the south and Mutton Lane to the north and east.
Existing water bodies:	The Westbrook Stream (a winterbourne) has not flowed for many years. The stream though currently dry rises from the Kent Downs to the south and used to flow past Ospringe Church and then through Queen Court Farm before turning west and discharging into Water Lane which acted as both road and river. This section on Water Lane was culverted in the early 1960s and the stream has since dried up.
Existing flood defences:	There are no known formal flood defences currently protecting the site.
Any other important comments:	No.

Figure 1.1: Site Location



2.0 INPUT DATA

2.1 Key Input Data

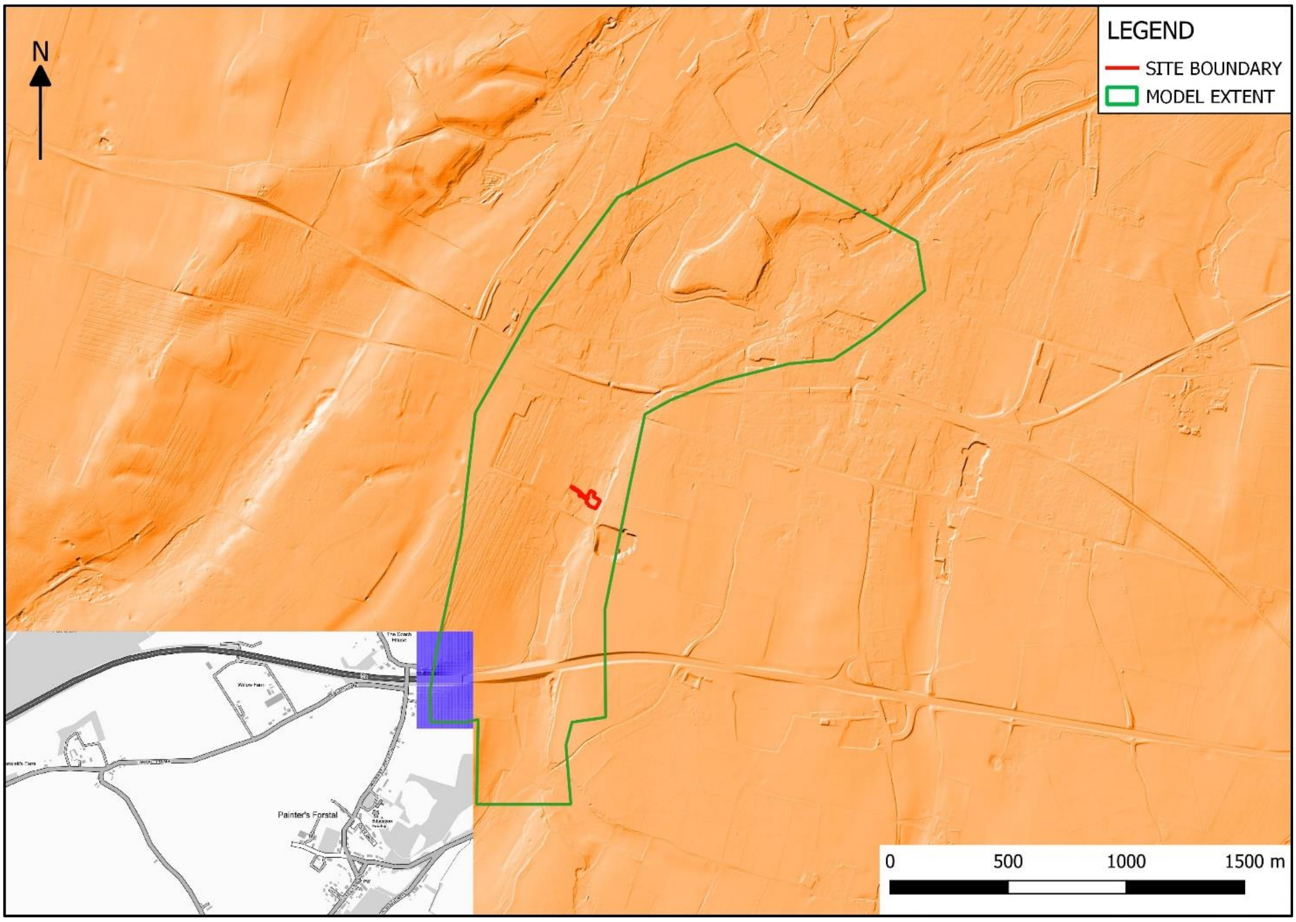
2.1.1 Various sources of information have been utilised for this project with some of the relevant data sets listed in **Table 2.1** below.

Table 2.1: Datasets Utilised

Dataset	Source	Date	Use	Quality[1]
Topographical channel survey	Trigon Surveys Ltd	Surveyed in January 2016	Provides cross section and structure details for the modelled ditches and fluvial key flood routes. Also forms basis of ground level data for the site. Refer to Appendix B.	1
LiDAR (Light Detection and Ranging)	Environment Agency LiDAR	Flown in 2019, 2011 and 2004. Latest data downloaded in February 2021	Forms the basis of ground level data for the 2D component of the hydraulic model.	1-2
NextMap DTM	NextMap	2012	A small area at the upstream do not have LiDAR coverage. NextMap DTM data has been utilised in the model build. Refer to Figure 2.1 below for coverage.	2

[1] Data quality scoring taken from Multi-Coloured Manual (Flood Hazard Research Centre, 2005) – 1 = best possible, 2 = data with known deficiencies, 3 = gross assumptions, 4 = heroic assumptions

Figure 2.1: EA LiDAR DTM (orange area) and NEXTMap DTM (blue area) Data Coverage



3.0 MODELLING METHODOLOGY

3.1 Hydrological Analysis

3.1.1 A full hydrological analysis was undertaken in order to derive the peak flow and hydrographs for the hydraulic model as described in **Table 3.1** below. Refer to **Appendix A** for the full hydrological analysis.

Table 3.1: Hydrological Analysis

Summary of hydrological analysis required:	Design flow hydrographs for input into the hydraulic models.
Number and location of flood estimation points:	Two flow estimation points at: • NGR 599950,159650 (Upstream of the site at the M2) • NGR 600300,160800 (Downstream of the site at the A2 Canterbury Road)
Peak flows, hydrographs or hyetographs?	Hydrographs
Return periods:	1 in 5, 20, 100 and 1 in 1000 year (20%, 5%, 1%, 0.1% AEP respectively).
Climate change estimation?	1% AEP (1 in 100 year) increased by 22%.
Choice of approach?	Revitalised Flood Hydrographs (ReFH) scaled to Statistical Method peak flows.
Reason for approach:	The statistical method for estimating flood flows is favoured as it is based on a much larger dataset of flood events and has been more directly calibrated to reproduce flood frequency on UK catchments giving it a greater confidence in deriving the index flood (QMED).
Comparison against other approaches undertaken?	Yes – ReFH peak flows.
How flows were incorporated into the hydraulic model?	ReFH hydrographs scaled to fit statistical method peak flows and incorporated into ESTRY- TUFLOW.

3.1.2 The key catchment descriptors for all the catchments assessed in the hydrological analysis are in **Table 3.2**.

Table 3.2: Key Catchment Characteristics

Catchment:	M2	A2
EASTING (m)	599950	600300
NORTHING (m)	159650	160800
AREA (ha)	50.44	52.63
FARL:	1	1
PROPWET:	0.34	0.34
BFIHOST:	0.714	0.713
LDP (km):	7.42	8.46
DPLBAR (km):	52.7	52.2
DPSBAR (m/km):	760	755
SAAR (mm):	28.76	28.84
SPRHOST:	0.0035	0.0048
URBEXT1990	0.0032	0.0042
URBEXT2000	0.023	0.0241
FPEXT:	No	No
Pumped watercourse?		
Any unusual catchment features? In particular is BFIHOST>0.65, SPRHOST<0.20, URBEXT>0.125, FARL<0.90 or high FPEXT?		

3.1.3 The Final peak flow estimates for the above catchments were calculated using the FEH Statistical Analysis method and summarised in **Table 3.3**. The FEH catchment plans are shown in **Figure 3.1** and **Figure 3.2** below. Refer to **Appendix A** for the full hydrological analysis.

Table 3.3: Summary of Peak Flows

Catchment:	Reach A (m^3/s)	Reach B (m^3/s)
20% AEP (1 in 5 year)	6.02	6.17
5% AEP (1 in 20 year)	8.04	8.24
1% AEP (1 in 100 year)	10.71	10.97
0.1% AEP (1 in 1000 year)	19.95	20.28

Figure 3.1 FEH Catchment near the M2

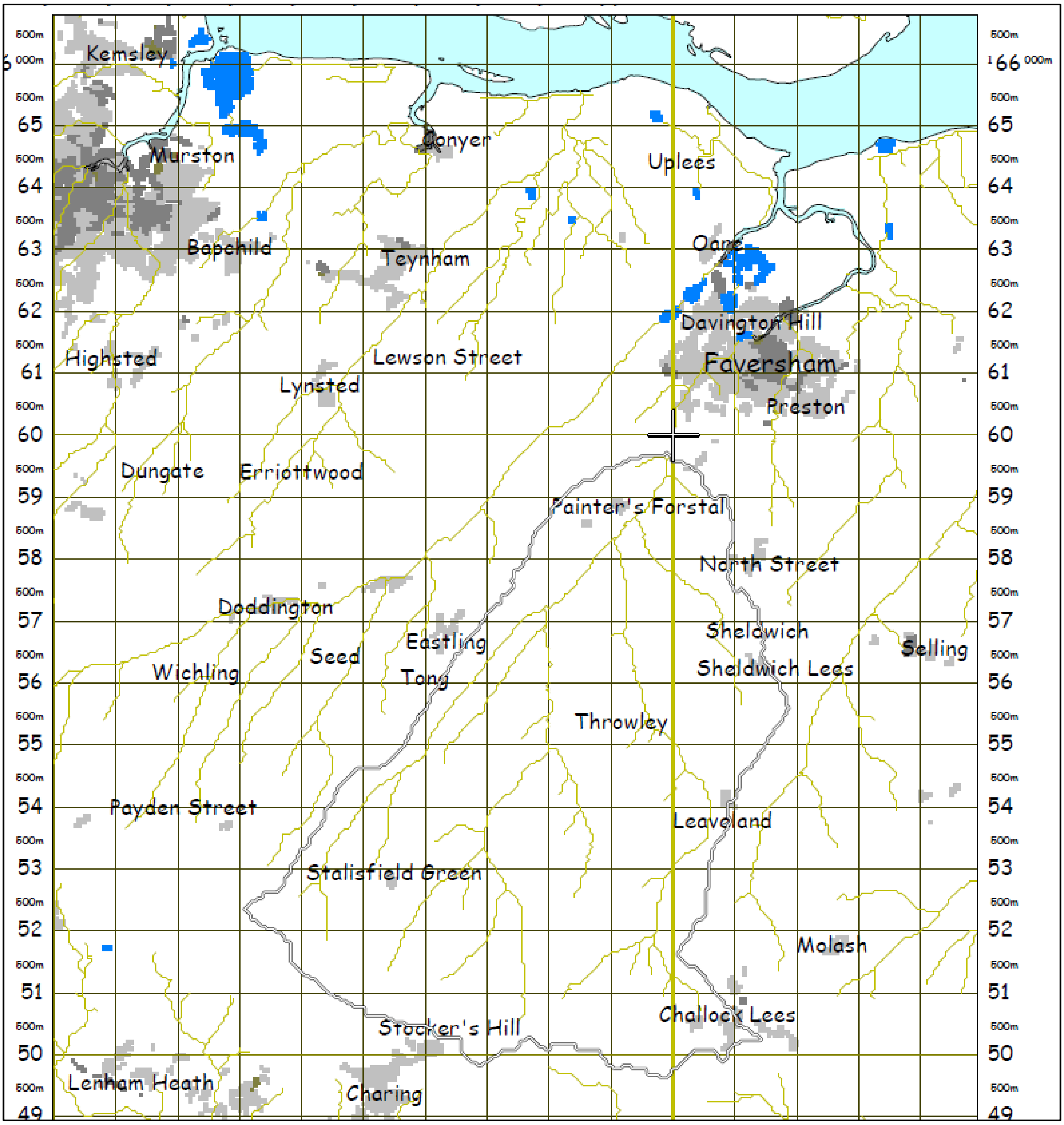
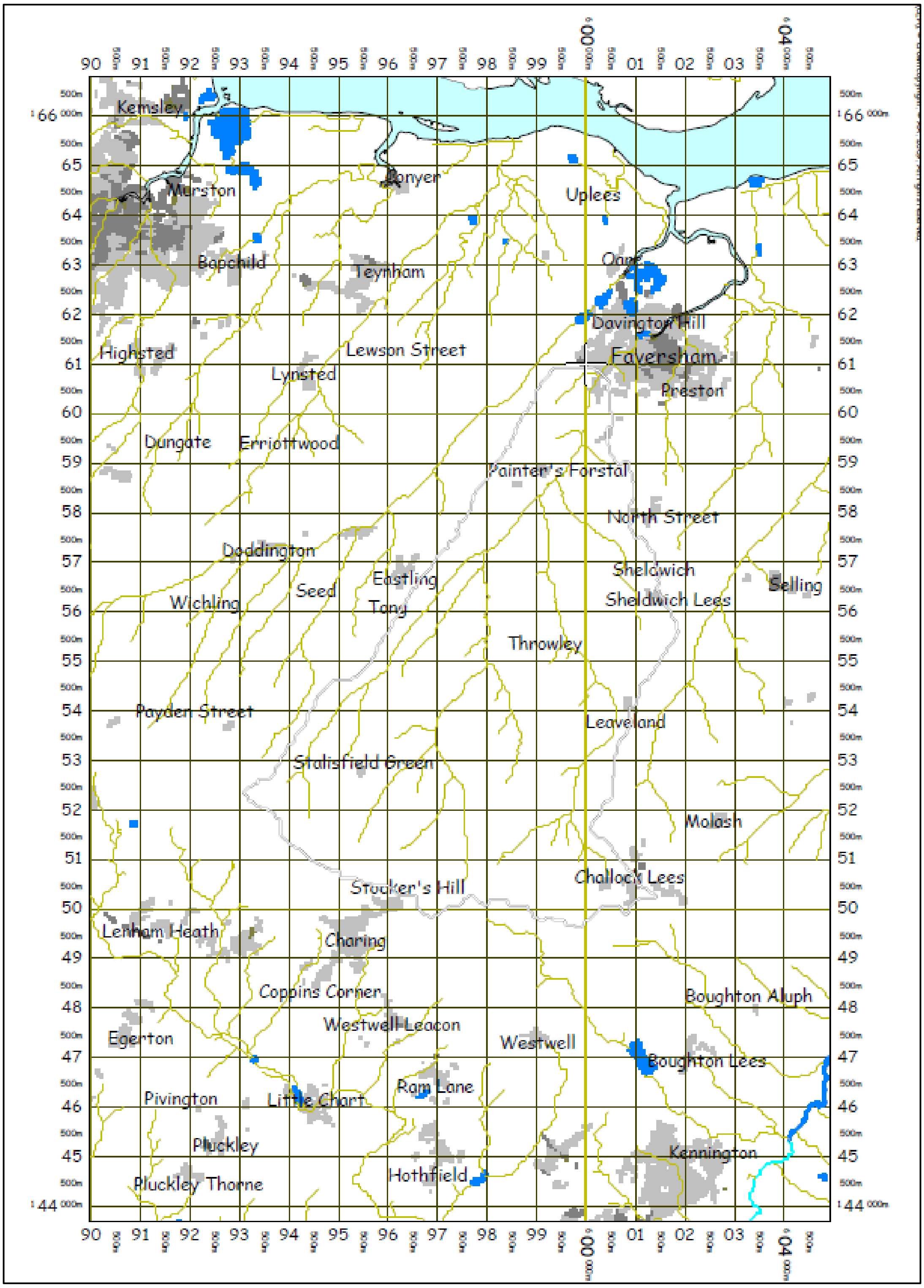


Figure 3.2 FEH Catchment near the A2



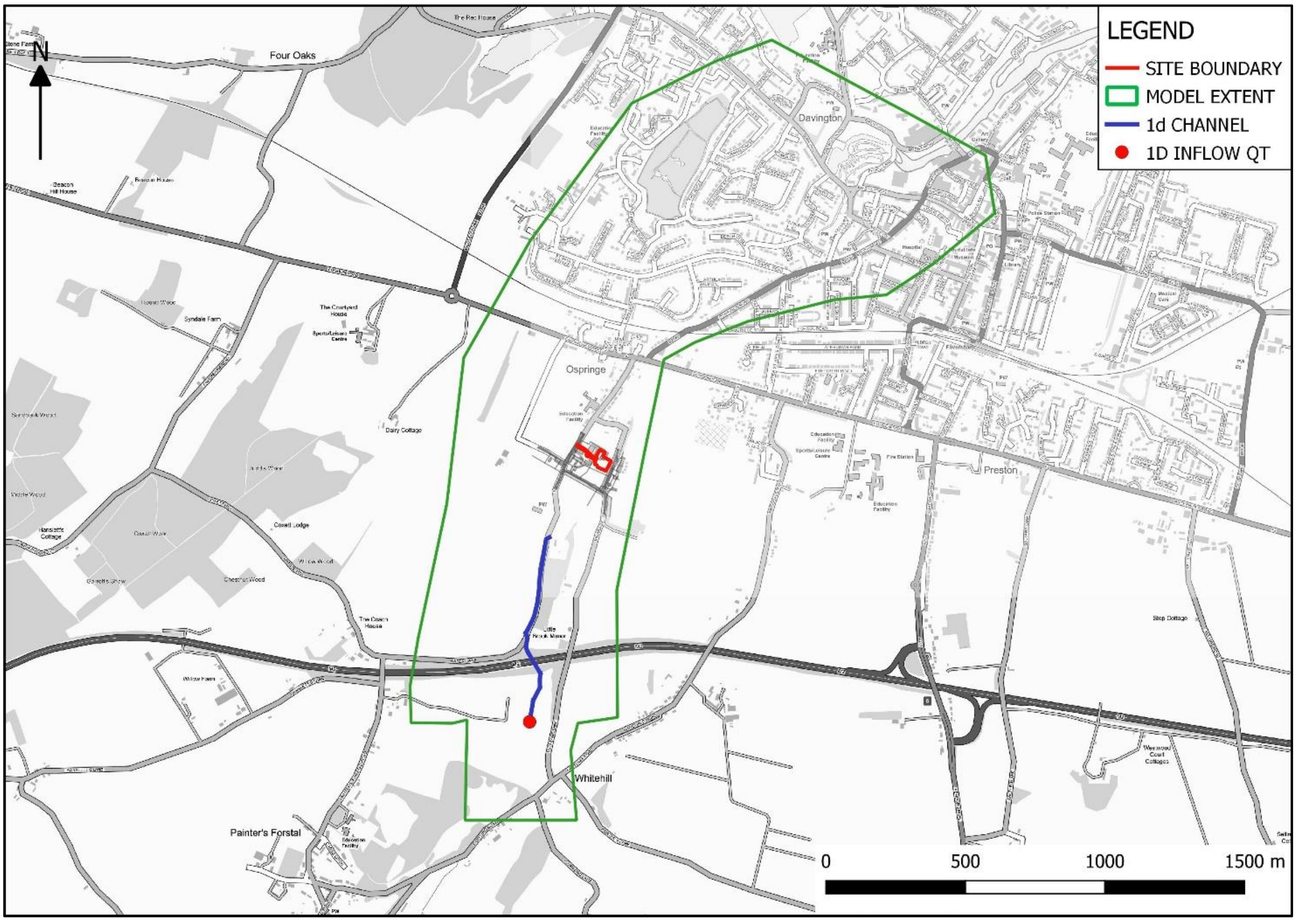
3.1.4 The process in the baseline hydraulic modelling is detailed in **Table 3.4** below.

Table 3.4: Hydrological Analysis *(continued overleaf)*

Summary of hydrological analysis required:	Design flow hydrographs.
What modelling exists?	There are no existing hydraulic models for the area.
What modelling has been undertaken and why was that approach chosen?	**ESTRY-TUFLOW** combines an accurate, very stable 1D channel solver able to model channels and culverted networks with a 2D floodplain model based on a finite grid approach. The two solvers are dynamically linked, such that water can flow from the channel to the floodplain, and vice-versa.
What software version(s) have been used?	TUFLOW – 2020-10-AA-iDP-w64 Double Precision modelling is necessary as the model is direct rainfall and is modelled on a relatively small 2d grid/time step combination.
How have watercourse channels been represented?	The watercourse geometry was constructed using ESTRY and based on the surveyed cross sections. Where appropriate, sections were trimmed to ensure no double counting of the floodplain. 2No. cross sections at the upstream end of the hydraulic model were extracted from NextMap DTM data. Refer to **Figure 3.4** below for the hydraulic model schematic.
How have watercourse channel structures been represented?	The culverts within the model domain have all been modelled as per the recommendations in TUFLOW.
How have sewer networks been represented?	No sewer networks were modelled as part of the above proposals.
How has the floodplain/ground surface been represented?	The 2D domain was constructed using TUFLOW and based upon filtered LiDAR data and NextMap 5m DTM data. A grid size of 4m was chosen to allow for detailed modelling of the fluvial flow paths. Refer to **Figure 3.4** below for the hydraulic model schematic.
How have different models been linked?	The boundary between the 1D and 2D models was chosen, as appropriate, for each individual cross section. An HX boundary (Head-eXchange or Head from eXternal source) was used for the link in TUFLOW, which takes the water level from Flood Modeller Pro and applies it along the boundary to allow flow into the 2D domain. The area between the 1D-2D boundary (HX lines) was set to 'inactive' in the 2D model to ensure that flow was not double-counted. Care was also taken to ensure that the width of the 1D element was reflected in the width of the inactive cells.
Have any adjustments to the raw DTM been made?	The site topographical survey was incorporated into the hydraulic model. To ensure a better and more accurate link between the two models, a thick Z line (a 3D polyline) was snapped along the boundary based on surveyed levels (and where needed LiDAR) to ensure that the 2D domain levels match the Flood Modeller Pro model.
How have flood defences been represented?	There are no known formal flood defences along the modelled watercourses.

What boundary conditions have been used?	A HQ (head verses flow) boundary based on floodplain slope in TUFLOW was created to allow flow to exit the model at the downstream end of the 2D domain.	
What roughness values have been used?	Channel and floodplain roughness were represented within the model by using Manning's n values for roughness. Parameters were chosen with reference to standard values, using site visit photographs and engineering judgement.	
	TUFLOW	**Manning's n**
	Grass	0.04
	Woodland	0.06
	Roads	0.02
	Buildings	1.00
	Water	0.03
	Roadside	0.02
	Manmade Surface	0.03
	Stability	1.00
	Railway Track	0.03
Are there any changes to default model or run parameters? Why?	No changes to default parameters.	
What timestep has been used?	A 1.5 second 2D TUFLOW time step was used for different model runs. This is in accordance with the recommendations that the 2D time step should be no smaller than a quarter of the 2D grid size.	

Figure 3.4: Hydraulic Model Schematic



4.0 MODEL PROVING

4.1.1 **Table 4.1** below summarises the calibration and verification of the hydraulic models.

Table 4.1: Calibration and Sensitivity

Was data available for calibration and verification?	No.
Is there an existing model that can be compared against?	There is currently no existing model for the area.
Has sensitivity testing been undertaken in lieu of calibration?	Yes.
Has sensitivity testing been undertaken to support the calibration?	Not applicable.

4.2 Sensitivity Analysis

Table 4.2: Calibration and Sensitivity

What sensitivity tests have been undertaken?	+/-20% roughness, +/-20% culvert coefficients and 50% blockage at the Vicarage Lane culvert immediately upstream of the site.
Are there any significant differences between the baseline and sensitivity tests?	**Roughness** +20% Roughness – fairly minor differences. Approximately 0.07m maximum increase in peak water level at the site for +20% roughness for a localised area but generally less than 0.001m. -20% Roughness - fairly minor differences. Approximately 0.07m maximum decrease in peak water level at the site for -20% roughness for a localised area but generally less than 0.001m. **Culvert Coefficient** Culvert coefficients – minor differences. 20mm increase in peak water level at the site.
Is the model sensitive to key parameters tested?	**Roughness –** On average generally not sensitive to changes in roughness. **Culvert Coefficient –** On average generally not sensitive to changes in roughness.

4.3 Blockage Analysis

Table 4.3: Calibration and Sensitivity

Was blockage analysis undertaken?	Yes
What scenarios were tested?	A 50% blockage of the culvert on Vicarage Lane immediately upstream of the site.
What were the key outcomes?	The hydraulic modelling results show that there is a maximum increase of 0.03m in flood levels at the site as a result of the blockage. Care will have to be taken to ensure that the culvert is kept clear of debris.

4.4 Run Performance

4.4.1 A summary of the run performance is summarised in **Table 4.2** below.

Table 4.4: Run Performance

Is the model stable?	Yes, very little fluctuation in model results.
Is the mass balance error sensible?	Yes, the final cumulative mass balance is less than 1% for all model runs. It is less than 3% in accordance with the recommended value as stated in the TUFLOW manual.
Are there any negative water depths?	No
What warnings and checks does the model give? Are any systematic of problems?	All warnings and checks associated with non-critical checks by TUFLOW.
Any other comments?	No
Is the model 'healthy'?	Yes

5.0 MODEL RESULTS

5.1 Baseline Design Runs

5.1.1 The primary purpose of the hydraulic modelling study is to identify the pre-development fluvial flood flow routes in order to determine the land available for development purposes and mitigation strategy. The model was used to predict fluvial flood levels for the following events.

- 20% AEP (1 in 5 year);
- 5% AEP (1 in 20 year);
- 1% AEP (1 in 100 year);
- 1% AEP plus 22% climate change (1 in 100 year plus 22% climate change);
- 0.1% AEP (1 in 1000 year)

5.1.2 The modelling results show that the M2 Motorway 500m upstream of the site and the Vicarage Lane immediately to the south constitute critical hydraulic structures. The embankments act as a hydrological boundary and the culverts throttles the flows before being discharged through the site.

5.1.3 The predicted peak water levels for the watercourse and ditches indicate that fluvial flood flows are generally out of bank at the modelled ditch, adjacent to Water Lane. The floodplain is significantly wider at the upstream end of the M2 Motorway.

5.1.4 The baseline modelling results are shown in **Figures 5.1** to **5.5**. The results show a flow path through the centre of the site.

Figure 5.1: Baseline 1 in 5 Year Peak Flood Depths

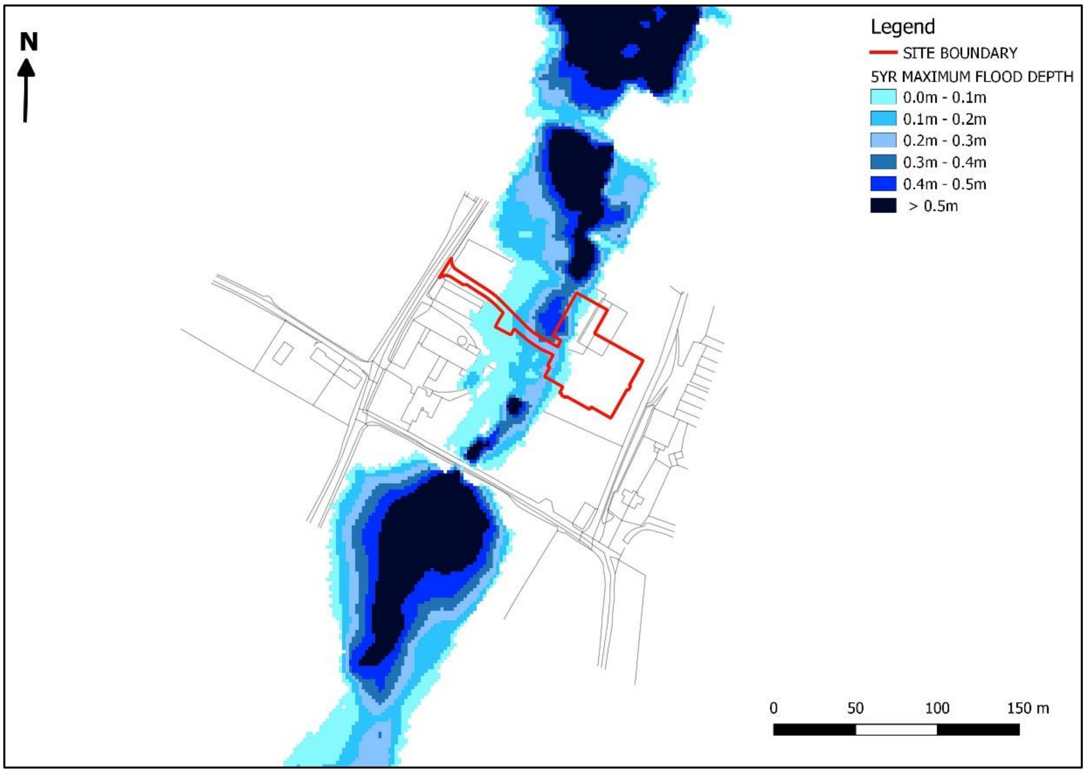


Figure 5.2: Baseline 1 in 20 Year Peak Flood Depths

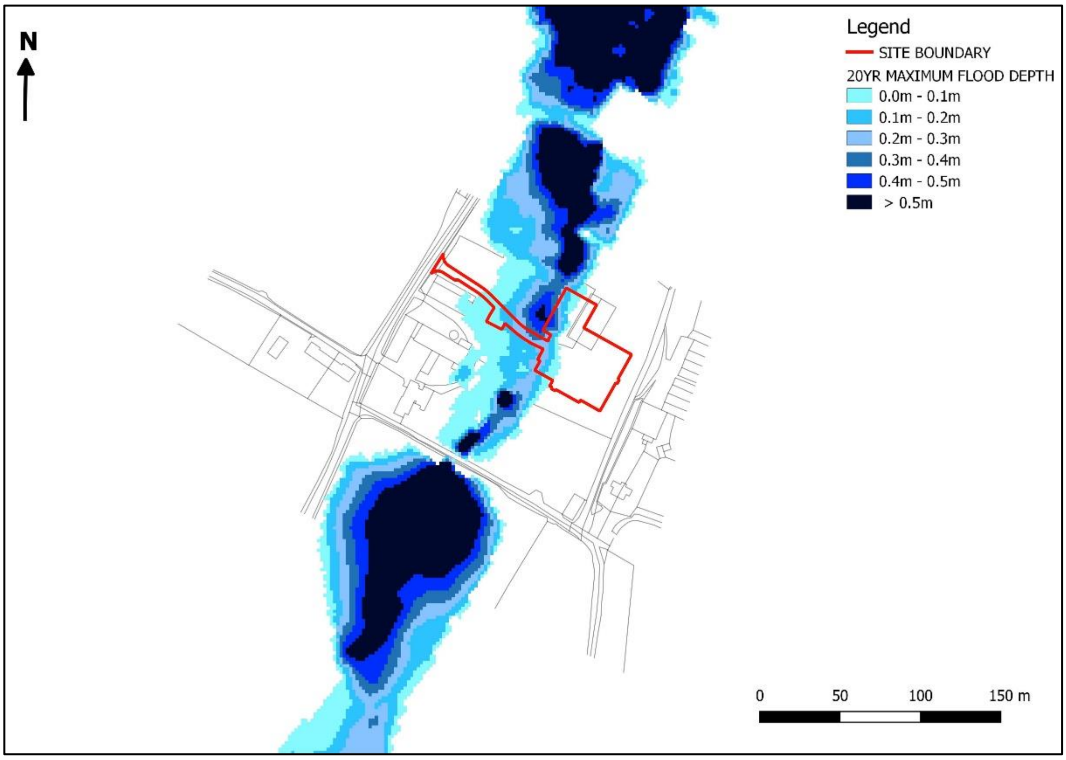


Figure 5.3: Baseline 1 in 100 Year Peak Flood Depths

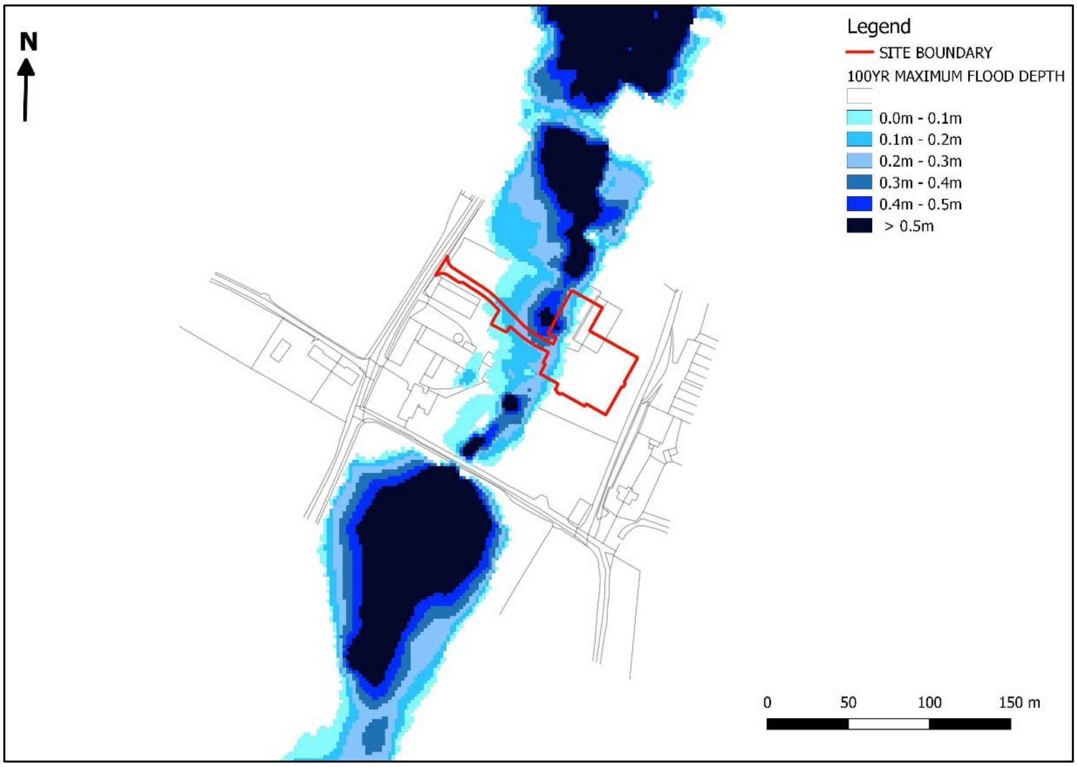


Figure 5.4: Baseline 1 in 100 Year Plus Climate Change (22%) Peak Flood Depths

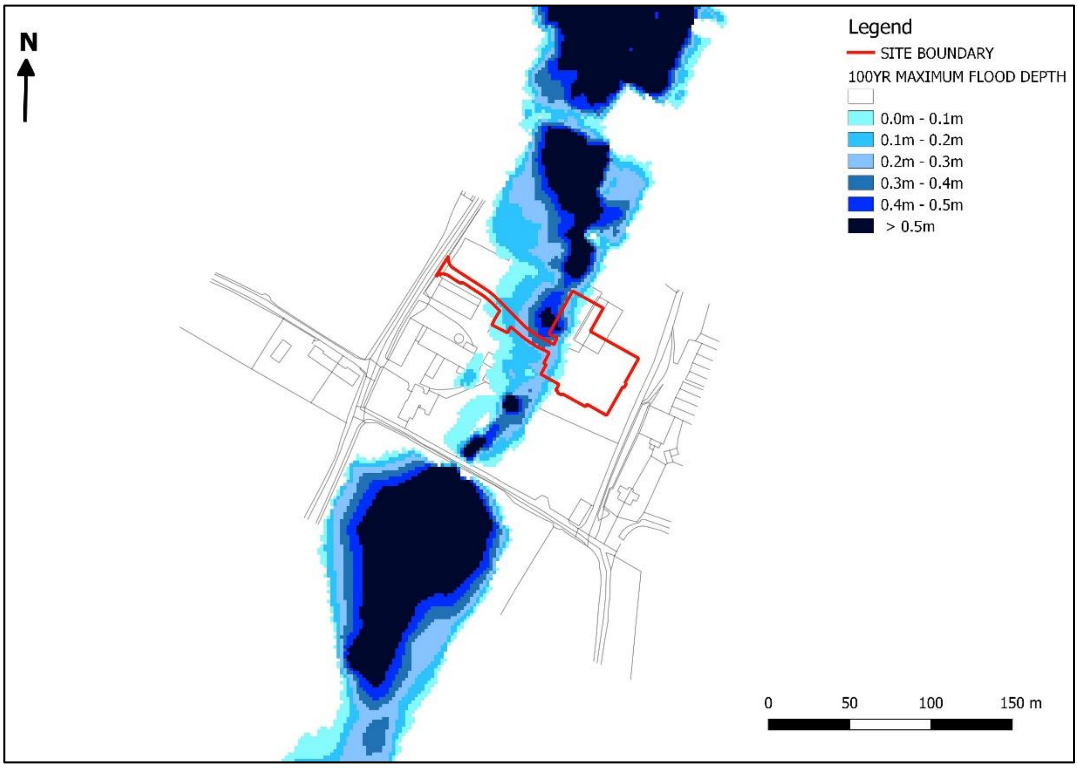
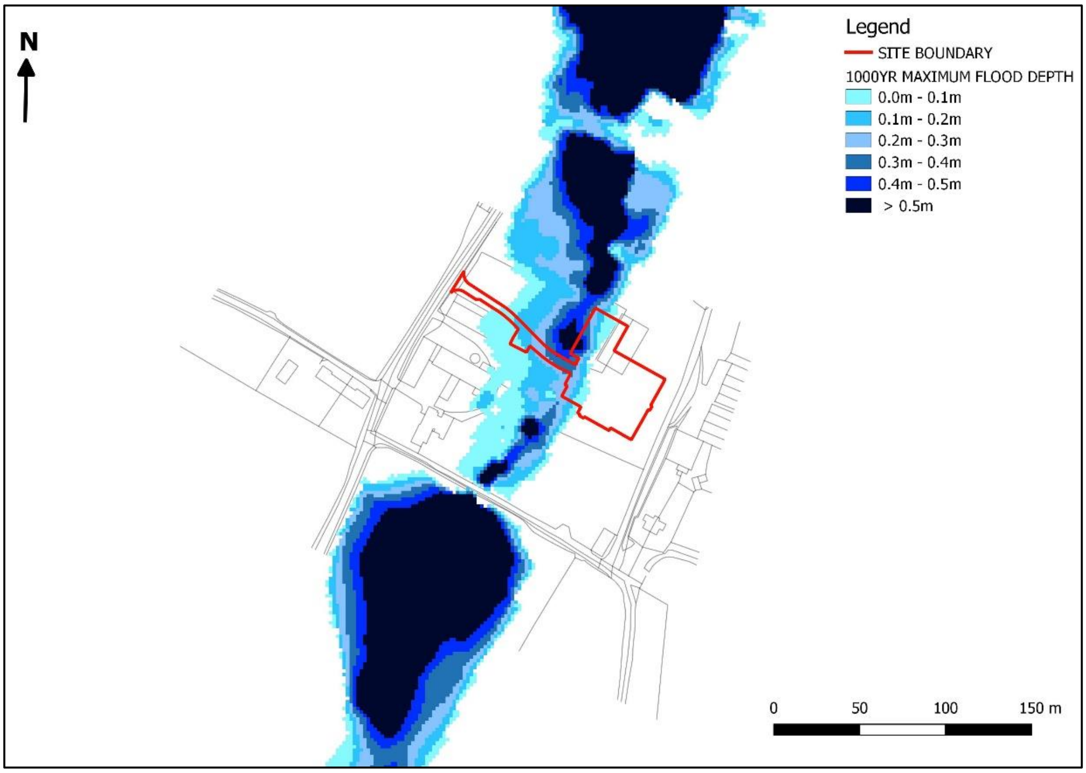


Figure 5.5: Baseline 1 in 1000 Year Plus Climate Change



5.2 Proposed Design Runs

5.2.1 A proposed swale network will be built along the centre of the site which will capture the flows from the critical culvert along Vicarage Lane. A safe access and egress route is required as part of the proposed development. Culverts have been proposed to allow for continuation of flow through the access road. This includes two 0.9mm diameter circular culverts at the location of the access road over the swale and three 0.45m diameter flood relief culverts two to the west of the main culvert and one to the east. A schematic of the proposed swale, access road, culverts and recommended finish floor levels is shown in **Figure 5.6**.

5.2.2 The post development modelled flood depths and levels for the 1% AEP plus 22% climate change scenario are shown in **Figure 5.7** and **5.8**.

5.2.3 The development proposal will not pose an impact to the downstream flood flow and water level. The inclusion of the access road poses a minimal increase in water levels off site. However, an increase of up to 0.15m above the original proposed flood levels is predicted to a section of the garages of the Phase 1 development in the south-west. This is shown in **Figure 5.9** below.

Figure 5.6: Proposed Development Schematic

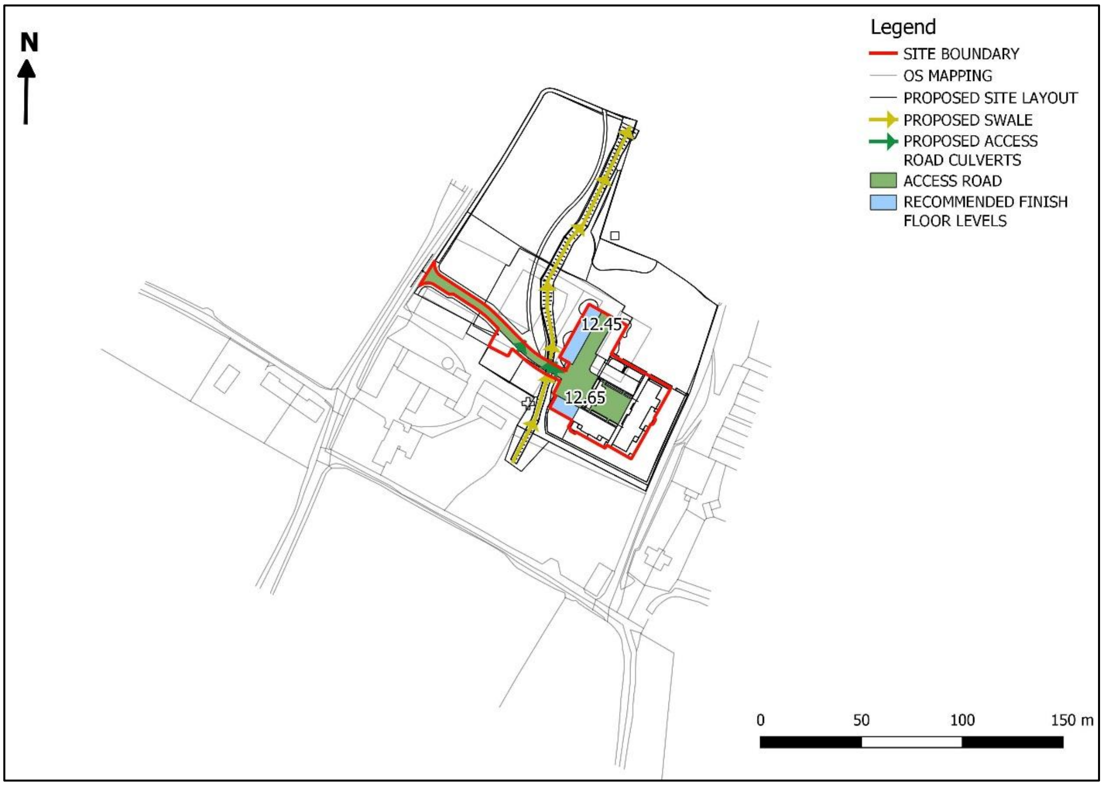


Figure 5.7: Post 1 in 100 Year Plus Climate Change (22%) Peak Flood Depths

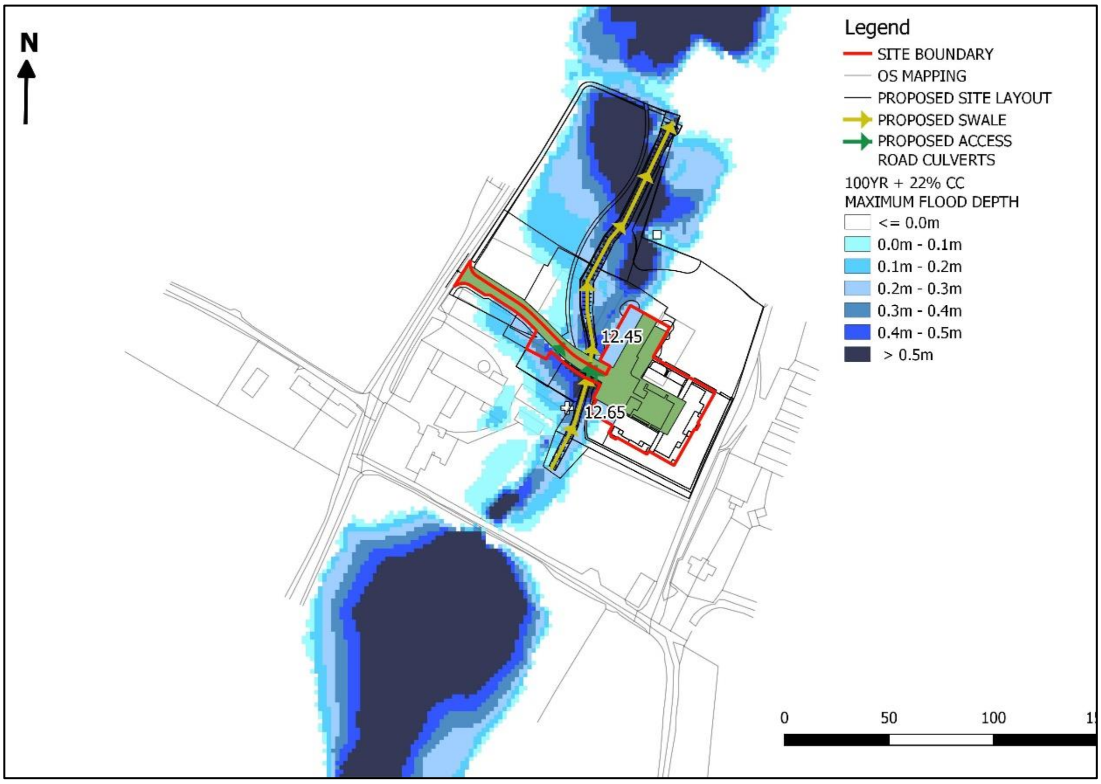


Figure 5.8: Post 1 in 100 Year Plus 22%CC Peak Flood Levels with Access Road

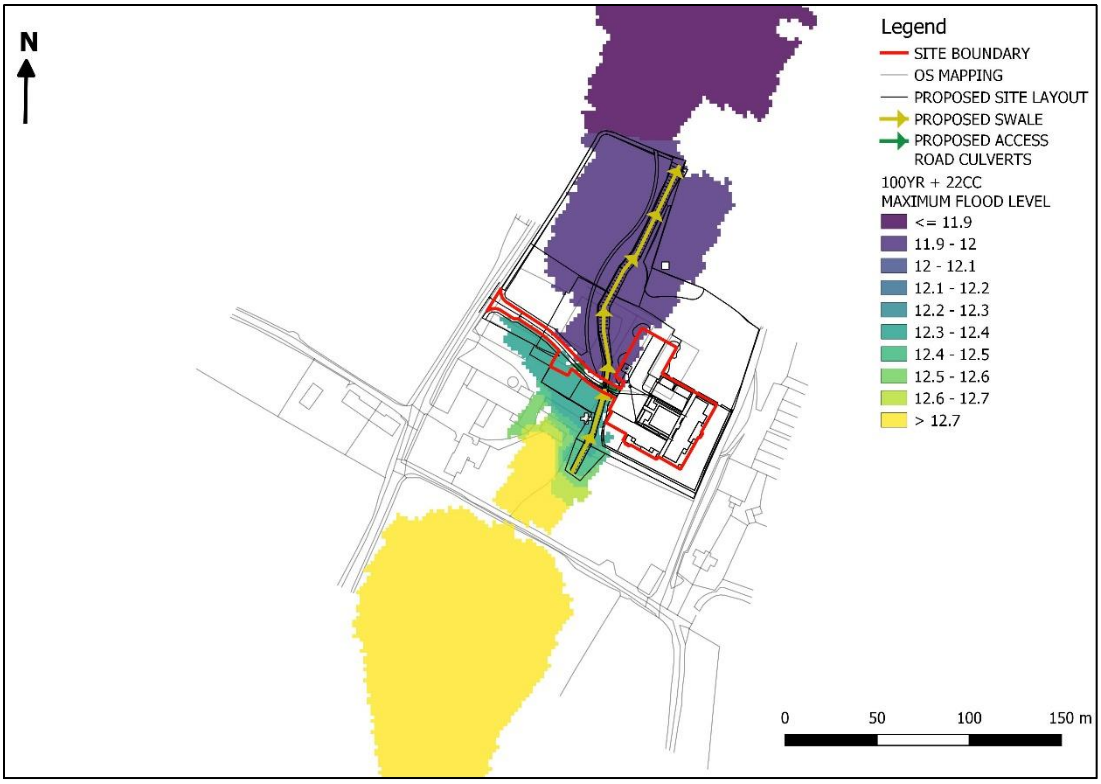
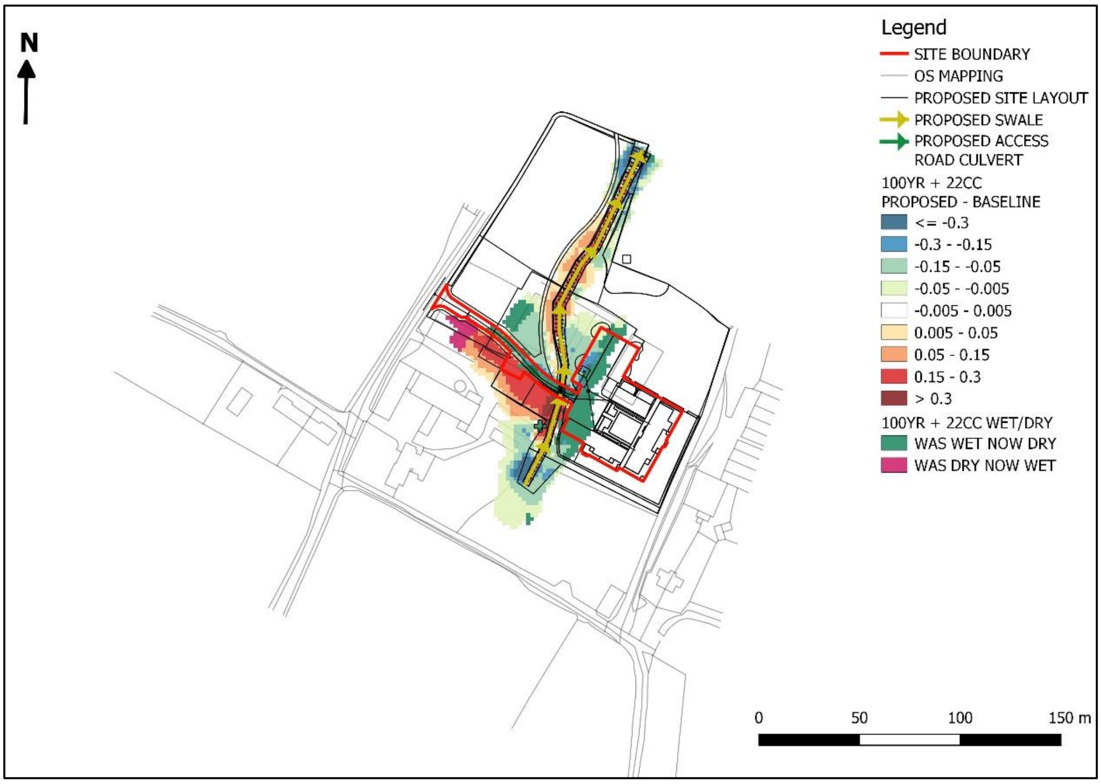


Figure 5.9: Peak Flood Depth Comparison Map



5.2.4 The minimum recommended finished floor levels are shown in **Figure 5.6** which are based on an increase of 300mm above the flood levels of 12.3mAOD to 12.4mAOD upstream of the access road and 11.9mAOD to 12.2mAOD downstream of the access road associated with the 1% AEP plus 22% climate change design event. The recommended minimum level for the access road is 12.6mAOD which is based on an increase of 300mm above the design flood level of 12.3mAOD. However, the proposed access road is required to be higher (13.3mAOD) in some locations to allow for suitable cover of 1.2m above the proposed swale culvert.

6.0 CONCLUSIONS & RECOMMENDATIONS

6.1.1 Odyssey has been commissioned by Shepherd Neame Ltd to carry out a site-specific fluvial modelling of the Nailbourne for the development of nine barn style residential units at Queen Court Farmyard Site, Water Lane, Ospringe, Faversham.

6.1.2 According to the current Environment Agency (EA) Flood Map for Planning, a large part of the site falls within Flood Zone 3, excluding the east part of the Queen Court Farmyard area which comprises gently rising land subject to the development proposals for barn style residential units.

6.1.3 The predicted peak water levels for the watercourse and ditches indicate that water levels are generally, out of bank at the modelled ditch adjacent to Water Lane. It was also observed that the floodplain is significantly wider at the upstream end of the M2 Motorway.

6.1.4 The fluvial flood extents show a flow path through the centre of the site.

6.1.5 It is proposed to build a swale network along the centre of the site to capture the flows from the critical culvert underneath Vicarage Lane. A safe access and egress route is required as part of the proposed development.

6.1.6 The proposed development sits outside of the floodplain and remains dry during the 1% AEP plus 22% climate change scenario assuming the recommended finish floor levels are accommodated.

6.1.7 The sensitivity analysis has shown that the flood levels are not sensitive to variation in roughness and downstream boundary but are sensitive to culvert blockages.

6.1.8 It is recommended that the hydraulic assessment is accepted as best available source of information and the modelling results should be used to inform the following for a Flood Risk Assessment:

- Confirmation of the above flood mitigation option to ensure that the proposals do not exacerbate flooding in all areas upstream and downstream of the site.
- Finished floor levels of buildings adjacent to the flood flow path and level of the access road to ensure it forms a safe access and egress route.

APPENDIX A

Hydrology

1.1 FEH Index Flood (QMED)

1.1.1 QMED from Catchment Descriptors

1.1.1 The study reach is The Nailbourne (Westbrook Stream), a tributary of Faversham Creek that runs through the Faversham town centre in Kent.

1.1.2 The FEH catchment descriptors are initially used to derive an estimate of QMED (Table 1). Since the catchment of the study reach is classified as essentially rural ($URBEXT_{2000}$ < 0.030), urban adjustment would be unnecessary.

Table 1 QMED from Catchment Descriptors at Subject Site

Site	QMED from catchment descriptors (m^3/s)
Reach Nr A2	4.234
Reach Nr M2	4.132

1.1.2 QMED at Donor Sites

1.1.3 The flow estimation process requires the adjustment of the empirically derived QMED flows using recorded flow data at one or more nearby Environment Agency flow measurement stations. The Environment Agency does not operate any gauging stations in the Faversham Creek catchment or its tributaries. The nearest gauging stations, as available on the NRFA website (version 3.3.4, released August 2014), with catchments that drain areas within 10km of the site are summarised in Table 2.

Table 2 EA Gauging Stations near the Cold Ash Catchment

CEH Ref No.	Watercourse	Location	Grid Ref	Flow record start	Flow record end	Number of years
40011	Great Stour	Horton	TR115553	01/07/1964	30/09/2012	48
40008	Great Stour	Wye	TR048470	18/07/1960	30/09/2012	52
40022	Great Stour	Chart Leacon	TQ992422	20/03/1967	30/09/2012	45
40005	Beult	Stilebridge	TQ758477	01/10/1958	30/09/2001	43

1.1.4 NRFA provides the following comments on these four gauges:

- **40011 - Great Stour at Horton.** A broad crested weir with crest width 10.55 m, insensitive, in trapezoidal section with velocity-area section for flows >20 m^3/s. The weir is a British Standard horizontal and broad crested, both upstream and downstream faces having a rounded nose, however it has a non-standard 0.02 m height variation along the crest width (1.8m). Flow is contained by sloping side bunds, with no wing walls. Bed is open textured gravel of considerable depth, which is a feature of the River Stour from Wye to Canterbury. There is a confluence 0.2 km upstream of the gauge, upstream of which the Stour flows through multiple channels. Telemetry present. All flows contained and the station has never gone out of range at the weir throughout the record, however a 2002 station review revealed that secondary flow paths present along the public footpath between the channel and sewage ponds. Structure-full flow 46.0 m^3/s; bank full flow 46.23 m^3/s. Problems with downstream channel erosion at the end of the concrete structure, resulting in a local channel widening of approximately 2 m. Electromagnetic gauge installed 1992 but rarely used as weir rating is so reliable. Flow records are suitable for medium range floods (QMED) determination and pooling group analysis.

- **40008 - Great Stour at Wye**. A triangular profile Crump weir with 7.63m width, drowns at approximately 3 m^3/s / 0.63m. Velocity-area station present downstream for high flows gauging. Previously a broad crested weir (1960-62) which was subject to premature drowning frequently due to weed growth and the low design of the weir sill. Low confidence in this site. In 1962, sill was raised and the downstream section was dredged by approximately 23cm. It was proposed to clear the weed annually to prevent further drowning, however conservation concerns have halted this in recent years. The River Stour is wide and shallow at the gauging station, the floodplain is limited by the railway line. Wye Bridge contains 5 arches with secondary arches between the river & railway line to accommodate very high flows. Inspection of the gauge in 2002 for a rating review suggests a secondary flow path upstream of Wye Bridge possibly results in flow through the secondary culverts, bypassing the gauge. Bank is overtopped at 1.65m stage, flow contained in floodplain to 1.85m stage; possible secondary flow path present along footpath between railway station and channel. The visit also revealed some siltation and in channel vegetation. The weir conforms to British Standards up to 0.3m stage. Flow records are suitable for QMED and pooling.
- **40022 - Great Stour at Chart Leacon**. A flat V shape weir with 7.96m wide crest superseded a Velocity Area station (1967-1979). The VA station was installed to provide design data for future structure and was subject to vegetation problems. Flat V weir has very shallow approach depth, flow becomes non-modular at stages >0.217m. The gauge suffers from vegetation and channel siltation problems, the latter possibly caused by concrete energy dissipation blocks downstream of the gauge. The 2002 review suggests that these may reduce the effectiveness of the gauge at moderate flows due to the already limited drop off of the weir. The weir does not conform to British Standard as the downstream slope is inadequate and the approach channel is not straight and uniform. Outflow from Singleton Lake will impact flow over the weir. Gauge is located 3.5km upstream of the confluence with the East Stour. The low modular limit, Singleton Lake outflows & backwater effects from the B2229 road bridge hinder the gauges effectiveness at high flows. Gaugings taken by wading with rods, which can result in an underestimation of flow through the gauge. Telemetry present. Flow records are suitable for QMED determination however may not be suitable for pooling due to few high flow gaugings and rating cannot be validated beyond QMED.
- **40005 - Beult at Stilebridge**. Weir was demolished in July 2001, leaving a cableway 33m upstream. The new Flat-V weir has now been completed in 2003. It is slightly upstream of the old site, by the cableway. A crest tapping sensor is due to be installed as well as a downstream level recorder. An ultrasonic gauge with the new structure came online in October 2002, however it has yet to be calibrated. Flood banks confine flows, the floodplain beyond this is approximately 300-400m wide. Structure limit at 1m / 6.1 m^3/s. Telemetry present. The previous weir consisted of a compound broad-crested structure, with the central flume separated by short divide piers (which could trap debris) from the broad-crested flanking sections. The ends of the dividing walls caused disturbance of flow, although modelling showed a negligible overall impact. Old station was regarded as full range (aside from largest exceptional events). The station is located on a long and reasonably straight reach of the River Beult at approximately 110m downstream of the Stilebridge and 12 km upstream of the Medway confluence. The Medway may control the levels in severe floods. Some upstream accretion & colonisation by reeds, unlikely to jeopardise rating. Data presented only for the original weir site, hence no data from July 2001. Flow records are suitable for QMED and pooling.

1.1.5 From the comments provided by NRFA, the flow data is considered suitable for QMED at all four stations and therefore a detailed analysis of the high flow ratings at these four gauges is not considered necessary as part of this study. Therefore, the available AMAX series at these sites is used in the flood estimation process described below.

1.1.3 Donor Adjusted QMED

1.1.6 FEH requires that the catchment descriptor derived QMED at an ungauged site is adjusted using the ratio between QMED from the catchment descriptors and QMED from flow data at a local donor gauging station. As detailed above there are four suitable potential donor gauging stations with flow records considered suitable for estimating QMED. However in selecting a suitable gauging station FEH provides hydrological similarity criteria as follows;

- AREA - a factor of no more than 4 or 5

- FARL - a difference of no more than 0.05.
- BFIHOST - a difference of no more than 0.18
- SAAR - a factor of no more than 1.25
- SPRHOST - difference of no more than 15

1.1.7 A comparison of the catchment descriptors at the four potential donor gauging stations with the study reach (Table 3) suggests that the adjacent Great Stour gauges share similar characteristics of the study reach. However it is noted that the receiving catchments of all Great Stour gauges are classified as slightly urbanised ($0.030 \le URBEXT_{2000} < 0.060$) whereas the catchment of the study reach is classified as essentially rural ($URBEXT_{2000} < 0.030$), these gauges may therefore not be suitable as a donor.

Table 3 Catchment Descriptors at Subject Sites and Donor Gauging Stations

Site	AREA	FARL	BFIHOST	SAAR	SPRHOST	URBEXT2000
Reach Nr A2	52.63	1.000	0.713	755	28.84	0.0042
Reach Nr M2	50.44	1.000	0.714	760	28.76	0.0032
40011	341.97	0.965	0.706	747	25.40	0.0321
40008	226.42	0.983	0.659	741	28.00	0.0452
40022	66.96	0.967	0.744	726	23.30	0.0348
40005	278.05	0.992	0.353	691	44.56	0.0148

1.1.8 Although the gauges may not be suitable as a donor due to the difference in urbanisation, as a check QMED is calculated from flow data and catchment descriptors at the gauge 40022 to confirm whether the QMED ratio is low or high in this area.

1.1.9 For stations with more than 13 years of flow data FEH recommends that QMED is calculated from annual maximum (AMAX) data.

Table 4 QMED Ratio at Donor Gauging Stations

Station	QMED-Catchment Descriptors (m^3/s)	QMED-Catchment Descriptors adjusted for urban influence (m^3/s)	QMED-AMAX (m^3/s)	Ratio
40022	3.648	3.961	5.123	1.293

1.1.10 This ratio between QMED from AMAX data and catchment descriptors suggests the QMED from catchment descriptors underestimates that from flow data with a ratio of 1.293. However the Revised Statistical method requires a further adjustment based on geographical proximity as detailed below.

1.1.4 Revised Donor Adjusted QMED

1.1.11 In addition to adjusting QMED based on the ratio of QMED estimates from catchment descriptors and flow data, the Revised Statistical method requires that the QMED ratio at a donor gauging station is also adjusted according to the distance between the catchment centroids using an exponent 'a'. Exponent 'a' is derived as the straight line distance between the centroid of the subject catchment and the donor gauging station, which in this case is 40022. This exponent in the ratio of QMED at this station gives a revised adjustment ratio at the site of interest of 1.101 (Table 5).

Table 5 Adjusted QMED Ratio at Donor Gauging Stations

Site	Centroid Easting	Centroid Northing	Centroid Distance (km)	Exponent 'a'	Unadjusted Ratio	Adjusted Ratio
Reach Near A2	598182	154399				
40022	604436	145695	10.718	0.374	1.293	1.101

1.1.5 Flood Frequency Curve

1.1.12 The calculation of a flood frequency curve and the peak flows at the flood estimation points requires the construction of a pooling group and the fitting of an extreme value distribution to the pooled group data.

1.1.13 Table 6 below gives details of the pooling group including any stations added or removed and reasons for this.

Table 6 Pooling Group Details

Station removed (with reasons)
203049 (Clady @ Clady Bridge) – Station in Ireland
41020 (Bevern Stream @ Clappers Bridge) – Low BFIHOST value (0.355)
25006 (Greta @ Rutherford Bridge) – Low BFIHOST value (0.241)
27010 (Hodge Beck @ Bransdale Weir) – Low BFIHOST value (0.341)
Final Pooling Group
53023 (Sherston Avon @ Fosseway)
43014 (East Avon @ Upavon)
84009 (Nethan @ Kirkmuirhill)
54025 (Dulas @ Rhos-y-pentref)
48803 (Carnon @ Bissoe)
47009 (Tiddy @ Tideford)
45008 (Otter @ Fenny Bridges)
43017 (West Avon @ Upavon)
55013 (Arrow @ Titley Mill)
72014 (Conder @ Galgate)
67005 (Ceiriog @ Brynkinalt Weir)
28061 (Churnet @ Basford Bridge)
12006 (Gairn @ Invergairn)
96003 (Strathy @ Strathy Bridge)
73008 (Bela @ Beetham)
53023 (Sherston Avon @ Fosseway)

1.1.14 The revised pooling group contains 15 stations with 509 station years of record. Guidance from the WINFAP Software indicates the pooling group is 'acceptably homogeneous and a review of the pooling group is not required' (H2 = -1.2640). There was no valid reason for the removal of any other of the component stations and the pooling group was considered acceptable. A 500 year record length is reasonable to calculate the 1 in 100 year peak flow and the 1 in 1000 year peak flow was extrapolated using ReFH. The pooling ground for the 1 in 1000 year event is likely to be inhomogeneous.

1.1.15 Two extreme value distributions are often used on the pooled group data (i) the Generalised Logistic (GL) and (ii) the General Extreme Value (GEV) distribution both fitted to the annual maximum data by the method of L-Moments. FEH indicates that the GL distribution can often provide the best fit to extreme value flood series and in this case WINFAP indicates that the GL provides an acceptable distribution for this site.

1.1.16 The results of the frequency analysis based on the QMED donor adjustment factor of 1.101 and on the basis that the GL distribution is recommended by WINFAP. Refer to Table 7 for the full range of results.

Table 7 Pooled Group Growth Curve and Flood Frequency Curves (m^3/s) for individual catchments

	Return periods	2	5	10	20	30	50	100	1000
	Growth Curve	1.000	1.323	1.542	1.767	1.905	2.088	2.354	3.435
Flood Frequency Curves (m^3/s)	Reach Near A2	4.662	6.167	7.188	8.237	8.880	9.733	10.973	16.013
	Reach Near M2	4.550	6.020	7.016	8.040	8.668	9.500	10.711	15.629

1.1.6 Extension to the 1 in 1000 Year Event

1.1.17 The FEH Statistical method was originally recommended for return periods only up to the 1 in 200 year event and noted as not suitable for extrapolating to very extreme events such as the 1 in 1000 year event. Flood estimates for longer return periods were historically derived using the FSR/FEH rainfall-runoff method as the rainfall growth curves for long return periods could be defined with much more confidence than flood growth curves. However the original FEH rainfall-runoff method was known to overestimate flows and more recently the extension of the Statistical method has been preferred.

1.1.18 The Environment Agency's Flood Estimation Guidelines provide two suggestions for calculating extreme floods up to the 1000 year event. Firstly using the Statistical method but the 1 in 1000 year pooling group is likely to be inhomogeneous with many component stations hence a simple extension of the 1 in 200 year and more recently the 1 in 100 year event has been proposed. A second approach is to derive the ReFH growth factor for the 1 in 100 year to 1 in 1000 year event which is then applied to the Statistical method 1 in 100 year peak flow.

1.1.19 The Statistical method flood frequency curve is extended to the 1 in 1000 year event using the ReFH growth factor as described above. (Table 8).

Table 8 Statistical Method Pooling Group Extended to 1 in 1000 year using ReFH

	Return periods	2	5	10	20	30	50	100	1000
Flood Frequency Curves (m^3/s)	Reach Near A2	4.662	6.167	7.188	8.237	8.880	9.733	10.973	20.282
	Reach Near M2	4.550	6.020	7.016	8.040	8.668	9.500	10.711	19.948

1.1.7 Hydrograph Shape

1.1.20 If a design hydrograph is required it is recommended that the hydrograph shape from the ReFH method is used and forced to fit the peak flows from the Statistical method, referred to as the hybrid method. This can be achieved in the WHS's ReFH 2 software suite.

1.1.21 The FEH Guidelines suggest two hybrid methods for ungauged sites:

1.1.22 Generating the hydrograph using ReFH method and scaling the ordinates so the peak flow matches the statistical estimate.

1.1.23 Adjusting the parameters of the ReFH model until the simulated peak flows match the preferred values. This might appear more elegant than option (a) but should be used with caution. It may prove difficult to match the statistical results over a range of return periods, because the ReFH method may give a different growth curve.

1.1.24 Option a) is the quickest method and often the best. The flood hydrographs from this method are provided in Figure 1-3 to Figure 1-4.

Figure 1-3 Hybrid Flood Hydrograph – Reach Near A2

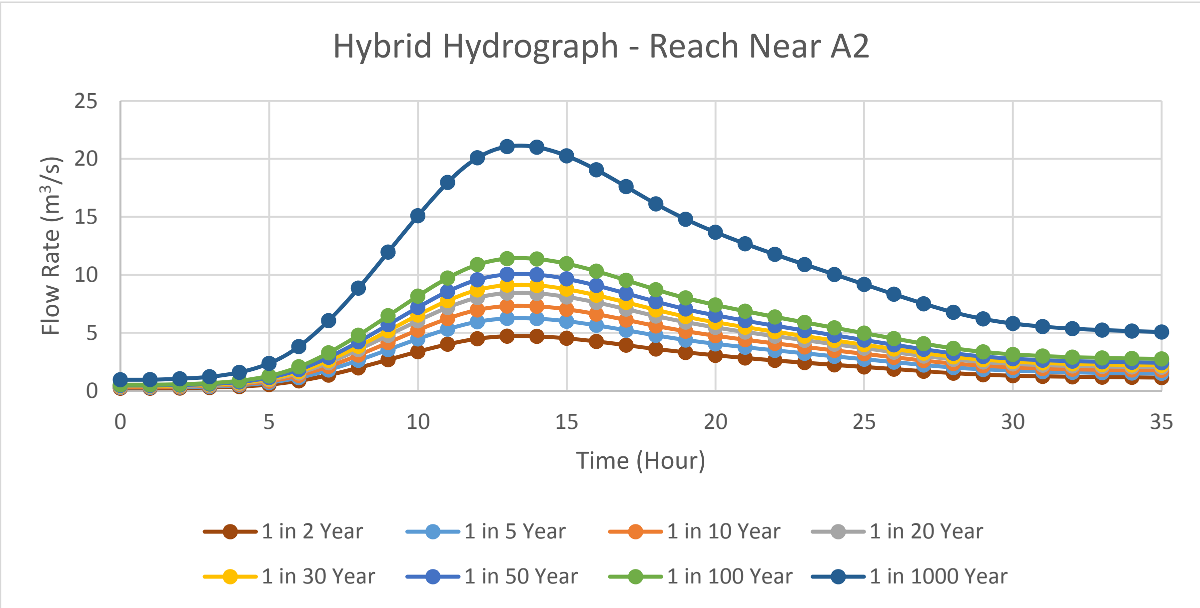
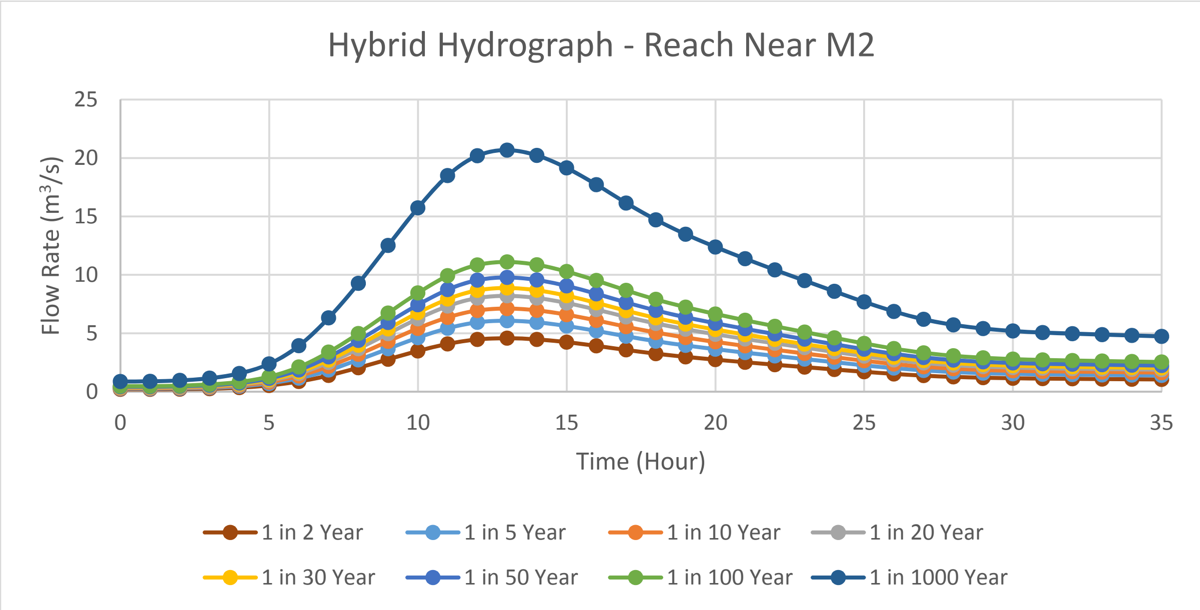


Figure 1-4 Hybrid Flood Hydrograph – Reach Near M2



UK Design Flood Estimation

Generated on 06 January 2016 09:35:13 by jho
Printed from the ReFH Flood Modelling software package, version 2.1.5798.30211

Summary of estimate using the Flood Estimation Handbook revitalised flood hydrograph method (ReFH)

Site details Checksum: 8C20-D687

Site name: Reach Nr A2

Easting: 600300

Northing: 160800

Country: England, Wales or Northern Ireland

Catchment Area (km^2): 52.63

Using plotscale calculations: No

Site description: None

Model run: 5 year

Summary of results

Rainfall - FEH 1999 (mm):	42.75	Total runoff (ML):	232.28
Total Rainfall (mm):	29.04	Total flow (ML):	659.82
Peak Rainfall (mm):	6.60	Peak flow (m^3/s):	7.01

Parameters

** Where the user has overriden a system-generated value, this original value is shown in square brackets after the value used.*

Rainfall parameters (Rainfall - FEH 1999 model)

Name	Value	User-defined?
Duration (hr)	11	No
Timestep (hr)	1	No
SCF(Seasonal correction factor)	0.72	No
ARF(Areal reduction factor)	0.94	No
Seasonality	Winter	n/a

Loss model parameters

Name	Value	User-defined?
Cini (mm)	92.68	No
Cmax (mm)	710.31	No
Use alpha correction factor	Yes	No
Alpha correction factor	1	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	6.33	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	1.26	No
BL (hr)	65.9	No
BR	1.86	No

Urbanisation parameters

Name	Value	User-defined?
Urban area (km^2)	0.35	No
Urbext 2000	0	No
Urban runoff factor	0.7	No
Imperviousness factor	0.3	No
Tp scaling factor	0.5	No
Sewered area (km^2)	0.00	Yes
Sewer capacity (m^3/s)	0.00	Yes

Time series data

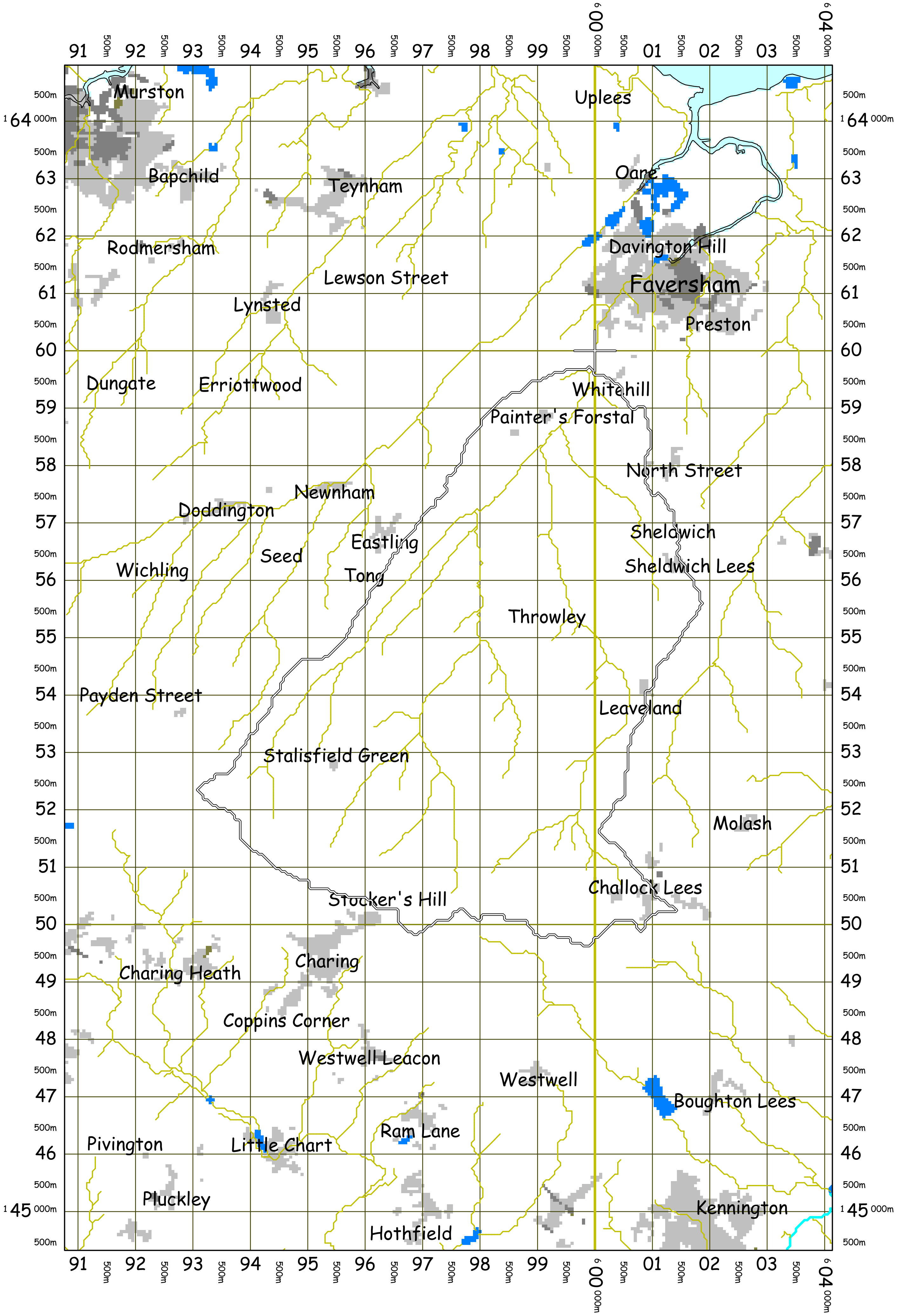
Time (hh:mm)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
00:00	0.638	0.000	0.084	0.000	1.258	1.258
01:00	1.068	0.000	0.142	0.010	1.239	1.249
02:00	1.780	0.000	0.241	0.049	1.221	1.270
03:00	2.943	0.000	0.408	0.135	1.205	1.340
04:00	4.790	0.000	0.690	0.300	1.192	1.493
05:00	6.598	0.000	1.003	0.599	1.186	1.785
06:00	4.790	0.000	0.766	1.102	1.191	2.293
07:00	2.943	0.000	0.487	1.810	1.212	3.023
08:00	1.780	0.000	0.300	2.628	1.254	3.882
09:00	1.068	0.000	0.182	3.467	1.317	4.784
10:00	0.638	0.000	0.110	4.248	1.402	5.650
11:00	0.000	0.000	0.000	4.882	1.506	6.388
12:00	0.000	0.000	0.000	5.250	1.622	6.872
13:00	0.000	0.000	0.000	5.272	1.743	7.014
14:00	0.000	0.000	0.000	5.033	1.859	6.892
15:00	0.000	0.000	0.000	4.635	1.965	6.600
16:00	0.000	0.000	0.000	4.152	2.057	6.210
17:00	0.000	0.000	0.000	3.637	2.135	5.772
18:00	0.000	0.000	0.000	3.142	2.197	5.339
19:00	0.000	0.000	0.000	2.717	2.246	4.963
20:00	0.000	0.000	0.000	2.354	2.283	4.637
21:00	0.000	0.000	0.000	2.033	2.310	4.343
22:00	0.000	0.000	0.000	1.738	2.328	4.066
23:00	0.000	0.000	0.000	1.459	2.337	3.797
24:00	0.000	0.000	0.000	1.193	2.339	3.532
25:00	0.000	0.000	0.000	0.937	2.334	3.271
26:00	0.000	0.000	0.000	0.693	2.322	3.015
27:00	0.000	0.000	0.000	0.472	2.303	2.775
28:00	0.000	0.000	0.000	0.288	2.279	2.566
29:00	0.000	0.000	0.000	0.158	2.251	2.409
30:00	0.000	0.000	0.000	0.079	2.220	2.299
31:00	0.000	0.000	0.000	0.035	2.188	2.223
32:00	0.000	0.000	0.000	0.012	2.156	2.168
33:00	0.000	0.000	0.000	0.002	2.124	2.126
34:00	0.000	0.000	0.000	0.000	2.092	2.092

Time (hh:mm)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
35:00	0.000	0.000	0.000	0.000	2.060	2.060
36:00	0.000	0.000	0.000	0.000	2.029	2.029
37:00	0.000	0.000	0.000	0.000	1.999	1.999
38:00	0.000	0.000	0.000	0.000	1.969	1.969
39:00	0.000	0.000	0.000	0.000	1.939	1.939
40:00	0.000	0.000	0.000	0.000	1.910	1.910
41:00	0.000	0.000	0.000	0.000	1.881	1.881
42:00	0.000	0.000	0.000	0.000	1.853	1.853
43:00	0.000	0.000	0.000	0.000	1.825	1.825
44:00	0.000	0.000	0.000	0.000	1.797	1.797
45:00	0.000	0.000	0.000	0.000	1.770	1.770
46:00	0.000	0.000	0.000	0.000	1.744	1.744
47:00	0.000	0.000	0.000	0.000	1.717	1.717
48:00	0.000	0.000	0.000	0.000	1.691	1.691
49:00	0.000	0.000	0.000	0.000	1.666	1.666
50:00	0.000	0.000	0.000	0.000	1.641	1.641
51:00	0.000	0.000	0.000	0.000	1.616	1.616
52:00	0.000	0.000	0.000	0.000	1.592	1.592
53:00	0.000	0.000	0.000	0.000	1.568	1.568
54:00	0.000	0.000	0.000	0.000	1.544	1.544
55:00	0.000	0.000	0.000	0.000	1.521	1.521
56:00	0.000	0.000	0.000	0.000	1.498	1.498
57:00	0.000	0.000	0.000	0.000	1.475	1.475
58:00	0.000	0.000	0.000	0.000	1.453	1.453
59:00	0.000	0.000	0.000	0.000	1.431	1.431
60:00	0.000	0.000	0.000	0.000	1.410	1.410
61:00	0.000	0.000	0.000	0.000	1.389	1.389
62:00	0.000	0.000	0.000	0.000	1.368	1.368
63:00	0.000	0.000	0.000	0.000	1.347	1.347
64:00	0.000	0.000	0.000	0.000	1.327	1.327
65:00	0.000	0.000	0.000	0.000	1.307	1.307
66:00	0.000	0.000	0.000	0.000	1.287	1.287
67:00	0.000	0.000	0.000	0.000	1.268	1.268

Appendix

Catchment descriptors

Name	Value	User-defined value used?
Area (km^2)	52.63	No
ALTBAR	112	No
ASPBAR	27	No
ASPVAR	0.46	No
BFIHOST	0.71	No
DPLBAR (km)	8.46	No
DPSBAR (mkm^{-1})	52.2	No
FARL	1	No
LDP	14.11	No
PROPWET (mm)	0.34	No
RMED1H	12.3	No
RMED1D	35.3	No
RMED2D	43.1	No
SAAR (mm)	755	No
SAAR4170 (mm)	775	No
SPRHOST	28.84	No
Urbext2000	0	No
Urbext1990	0	No
URBCONC	0	No
URBLOC	0	No
Urban Area (km^2)	0.35	No
DDF parameter C	-0.02	No
DDF parameter D1	0.35	No
DDF parameter D2	0.35	No
DDF parameter D3	0.3	No
DDF parameter E	0.31	No
DDF parameter F	2.53	No
DDF parameter C (1km grid value)	-0.02	No
DDF parameter D1 (1km grid value)	0.32	No
DDF parameter D2 (1km grid value)	0.36	No
DDF parameter D3 (1km grid value)	0.31	No
DDF parameter E (1km grid value)	0.32	No
DDF parameter F (1km grid value)	2.52	No



599950 159650 [TQ 99950 59650]

0 0.5 1
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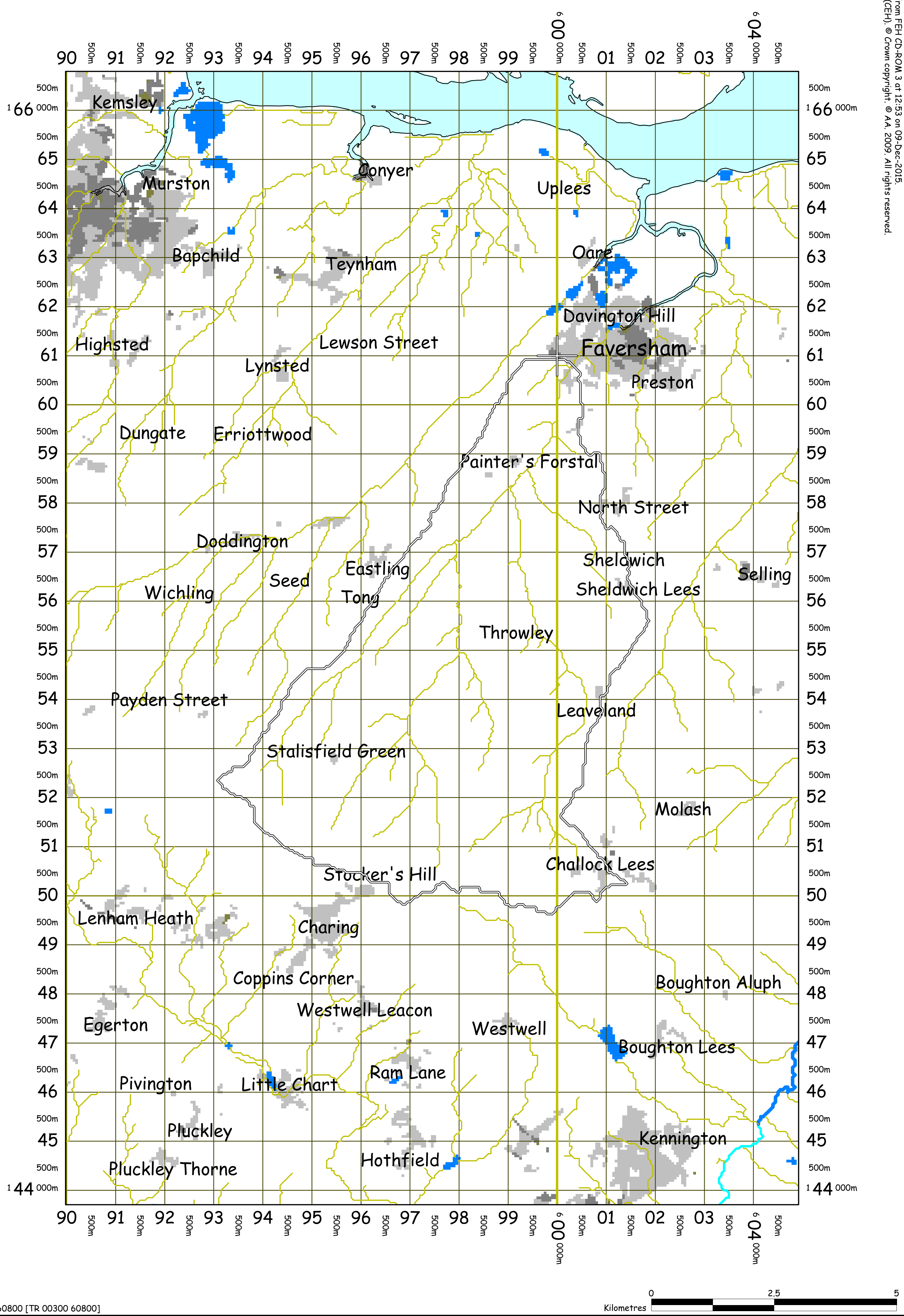


600300 160800 [TR 00300 60800]

UK Design Flood Estimation

Generated on 06 January 2016 09:39:44 by jho
Printed from the ReFH Flood Modelling software package, version 2.1.5798.30211

Summary of estimate using the Flood Estimation Handbook revitalised flood hydrograph method (ReFH)

Site details Checksum: 8C20-D687

Site name: Reach Nr A2

Easting: 600300

Northing: 160800

Country: England, Wales or Northern Ireland

Catchment Area (km^2): 52.63

Using plotscale calculations: No

Site description: None

Model run: 1000 year

Summary of results

Rainfall - FEH 1999 (mm):	172.12	Total runoff (ML):	1045.81
Total Rainfall (mm):	116.91	Total flow (ML):	2965.22
Peak Rainfall (mm):	26.57	Peak flow (m^3/s):	28.00

Parameters

** Where the user has overriden a system-generated value, this original value is shown in square brackets after the value used.*

Rainfall parameters (Rainfall - FEH 1999 model)

Name	Value	User-defined?
Duration (hr)	11	No
Timestep (hr)	1	No
SCF(Seasonal correction factor)	0.72	No
ARF(Areal reduction factor)	0.94	No
Seasonality	Winter	n/a

Loss model parameters

Name	Value	User-defined?
Cini (mm)	92.68	No
Cmax (mm)	710.31	No
Use alpha correction factor	Yes	No
Alpha correction factor	0.66	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	6.33	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	1.26	No
BL (hr)	65.9	No
BR	1.86	No

Urbanisation parameters

Name	Value	User-defined?
Urban area (km^2)	0.35	No
Urbext 2000	0	No
Urban runoff factor	0.7	No
Imperviousness factor	0.3	No
Tp scaling factor	0.5	No
Sewered area (km^2)	0.00	Yes
Sewer capacity (m^3/s)	0.00	Yes

Time series data

Time (hh:mm)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m³/s)	Baseflow (m³/s)	Total Flow (m³/s)
00:00	2.567	0.000	0.230	0.000	1.258	1.258
01:00	4.300	0.000	0.406	0.029	1.239	1.268
02:00	7.167	0.000	0.735	0.138	1.222	1.360
03:00	11.851	0.000	1.373	0.389	1.211	1.600
04:00	19.286	0.000	2.657	0.900	1.209	2.109
05:00	26.567	0.000	4.516	1.902	1.228	3.130
06:00	19.286	0.000	3.899	3.773	1.285	5.058
07:00	11.851	0.000	2.655	6.634	1.404	8.038
08:00	7.167	0.000	1.702	10.162	1.608	11.769
09:00	4.300	0.000	1.056	13.984	1.909	15.893
10:00	2.567	0.000	0.642	17.753	2.311	20.064
11:00	0.000	0.000	0.000	21.078	2.807	23.884
12:00	0.000	0.000	0.000	23.347	3.375	26.722
13:00	0.000	0.000	0.000	24.026	3.978	28.004
14:00	0.000	0.000	0.000	23.363	4.573	27.936
15:00	0.000	0.000	0.000	21.801	5.131	26.932
16:00	0.000	0.000	0.000	19.704	5.630	25.335
17:00	0.000	0.000	0.000	17.348	6.062	23.409
18:00	0.000	0.000	0.000	14.999	6.421	21.421
19:00	0.000	0.000	0.000	12.958	6.715	19.673
20:00	0.000	0.000	0.000	11.225	6.951	18.177
21:00	0.000	0.000	0.000	9.716	7.139	16.856
22:00	0.000	0.000	0.000	8.353	7.285	15.637
23:00	0.000	0.000	0.000	7.081	7.391	14.472
24:00	0.000	0.000	0.000	5.873	7.460	13.333
25:00	0.000	0.000	0.000	4.697	7.496	12.193
26:00	0.000	0.000	0.000	3.561	7.498	11.060
27:00	0.000	0.000	0.000	2.498	7.470	9.968
28:00	0.000	0.000	0.000	1.576	7.415	8.990
29:00	0.000	0.000	0.000	0.893	7.337	8.230
30:00	0.000	0.000	0.000	0.456	7.246	7.702
31:00	0.000	0.000	0.000	0.203	7.146	7.348
32:00	0.000	0.000	0.000	0.069	7.042	7.111
33:00	0.000	0.000	0.000	0.012	6.937	6.949
34:00	0.000	0.000	0.000	0.000	6.833	6.833

Time (hh:mm)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
35:00	0.000	0.000	0.000	0.000	6.730	6.730
36:00	0.000	0.000	0.000	0.000	6.629	6.629
37:00	0.000	0.000	0.000	0.000	6.529	6.529
38:00	0.000	0.000	0.000	0.000	6.430	6.430
39:00	0.000	0.000	0.000	0.000	6.334	6.334
40:00	0.000	0.000	0.000	0.000	6.238	6.238
41:00	0.000	0.000	0.000	0.000	6.144	6.144
42:00	0.000	0.000	0.000	0.000	6.052	6.052
43:00	0.000	0.000	0.000	0.000	5.961	5.961
44:00	0.000	0.000	0.000	0.000	5.871	5.871
45:00	0.000	0.000	0.000	0.000	5.782	5.782
46:00	0.000	0.000	0.000	0.000	5.695	5.695
47:00	0.000	0.000	0.000	0.000	5.610	5.610
48:00	0.000	0.000	0.000	0.000	5.525	5.525
49:00	0.000	0.000	0.000	0.000	5.442	5.442
50:00	0.000	0.000	0.000	0.000	5.360	5.360
51:00	0.000	0.000	0.000	0.000	5.279	5.279
52:00	0.000	0.000	0.000	0.000	5.200	5.200
53:00	0.000	0.000	0.000	0.000	5.121	5.121
54:00	0.000	0.000	0.000	0.000	5.044	5.044
55:00	0.000	0.000	0.000	0.000	4.968	4.968
56:00	0.000	0.000	0.000	0.000	4.893	4.893
57:00	0.000	0.000	0.000	0.000	4.820	4.820
58:00	0.000	0.000	0.000	0.000	4.747	4.747
59:00	0.000	0.000	0.000	0.000	4.676	4.676
60:00	0.000	0.000	0.000	0.000	4.605	4.605
61:00	0.000	0.000	0.000	0.000	4.536	4.536
62:00	0.000	0.000	0.000	0.000	4.468	4.468
63:00	0.000	0.000	0.000	0.000	4.400	4.400
64:00	0.000	0.000	0.000	0.000	4.334	4.334
65:00	0.000	0.000	0.000	0.000	4.269	4.269
66:00	0.000	0.000	0.000	0.000	4.204	4.204
67:00	0.000	0.000	0.000	0.000	4.141	4.141
68:00	0.000	0.000	0.000	0.000	4.079	4.079
69:00	0.000	0.000	0.000	0.000	4.017	4.017
70:00	0.000	0.000	0.000	0.000	3.957	3.957

Time (hh:mm)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
71:00	0.000	0.000	0.000	0.000	3.897	3.897
72:00	0.000	0.000	0.000	0.000	3.839	3.839
73:00	0.000	0.000	0.000	0.000	3.781	3.781
74:00	0.000	0.000	0.000	0.000	3.724	3.724
75:00	0.000	0.000	0.000	0.000	3.668	3.668
76:00	0.000	0.000	0.000	0.000	3.613	3.613
77:00	0.000	0.000	0.000	0.000	3.558	3.558
78:00	0.000	0.000	0.000	0.000	3.505	3.505
79:00	0.000	0.000	0.000	0.000	3.452	3.452
80:00	0.000	0.000	0.000	0.000	3.400	3.400
81:00	0.000	0.000	0.000	0.000	3.349	3.349
82:00	0.000	0.000	0.000	0.000	3.298	3.298
83:00	0.000	0.000	0.000	0.000	3.248	3.248
84:00	0.000	0.000	0.000	0.000	3.200	3.200
85:00	0.000	0.000	0.000	0.000	3.151	3.151
86:00	0.000	0.000	0.000	0.000	3.104	3.104
87:00	0.000	0.000	0.000	0.000	3.057	3.057
88:00	0.000	0.000	0.000	0.000	3.011	3.011
89:00	0.000	0.000	0.000	0.000	2.966	2.966
90:00	0.000	0.000	0.000	0.000	2.921	2.921
91:00	0.000	0.000	0.000	0.000	2.877	2.877
92:00	0.000	0.000	0.000	0.000	2.834	2.834
93:00	0.000	0.000	0.000	0.000	2.791	2.791
94:00	0.000	0.000	0.000	0.000	2.749	2.749
95:00	0.000	0.000	0.000	0.000	2.708	2.708
96:00	0.000	0.000	0.000	0.000	2.667	2.667
97:00	0.000	0.000	0.000	0.000	2.627	2.627
98:00	0.000	0.000	0.000	0.000	2.587	2.587
99:00	0.000	0.000	0.000	0.000	2.548	2.548
100:00	0.000	0.000	0.000	0.000	2.510	2.510
101:00	0.000	0.000	0.000	0.000	2.472	2.472
102:00	0.000	0.000	0.000	0.000	2.435	2.435
103:00	0.000	0.000	0.000	0.000	2.398	2.398
104:00	0.000	0.000	0.000	0.000	2.362	2.362
105:00	0.000	0.000	0.000	0.000	2.326	2.326
106:00	0.000	0.000	0.000	0.000	2.291	2.291

Time (hh:mm)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
107:00	0.000	0.000	0.000	0.000	2.257	2.257
108:00	0.000	0.000	0.000	0.000	2.223	2.223
109:00	0.000	0.000	0.000	0.000	2.189	2.189
110:00	0.000	0.000	0.000	0.000	2.156	2.156
111:00	0.000	0.000	0.000	0.000	2.124	2.124
112:00	0.000	0.000	0.000	0.000	2.092	2.092
113:00	0.000	0.000	0.000	0.000	2.061	2.061
114:00	0.000	0.000	0.000	0.000	2.029	2.029
115:00	0.000	0.000	0.000	0.000	1.999	1.999
116:00	0.000	0.000	0.000	0.000	1.969	1.969
117:00	0.000	0.000	0.000	0.000	1.939	1.939
118:00	0.000	0.000	0.000	0.000	1.910	1.910
119:00	0.000	0.000	0.000	0.000	1.881	1.881
120:00	0.000	0.000	0.000	0.000	1.853	1.853
121:00	0.000	0.000	0.000	0.000	1.825	1.825
122:00	0.000	0.000	0.000	0.000	1.797	1.797
123:00	0.000	0.000	0.000	0.000	1.770	1.770
124:00	0.000	0.000	0.000	0.000	1.744	1.744
125:00	0.000	0.000	0.000	0.000	1.717	1.717
126:00	0.000	0.000	0.000	0.000	1.692	1.692
127:00	0.000	0.000	0.000	0.000	1.666	1.666
128:00	0.000	0.000	0.000	0.000	1.641	1.641
129:00	0.000	0.000	0.000	0.000	1.616	1.616
130:00	0.000	0.000	0.000	0.000	1.592	1.592
131:00	0.000	0.000	0.000	0.000	1.568	1.568
132:00	0.000	0.000	0.000	0.000	1.544	1.544
133:00	0.000	0.000	0.000	0.000	1.521	1.521
134:00	0.000	0.000	0.000	0.000	1.498	1.498
135:00	0.000	0.000	0.000	0.000	1.476	1.476
136:00	0.000	0.000	0.000	0.000	1.453	1.453
137:00	0.000	0.000	0.000	0.000	1.432	1.432
138:00	0.000	0.000	0.000	0.000	1.410	1.410
139:00	0.000	0.000	0.000	0.000	1.389	1.389
140:00	0.000	0.000	0.000	0.000	1.368	1.368
141:00	0.000	0.000	0.000	0.000	1.347	1.347
142:00	0.000	0.000	0.000	0.000	1.327	1.327

Time (hh:mm)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
143:00	0.000	0.000	0.000	0.000	1.307	1.307
144:00	0.000	0.000	0.000	0.000	1.287	1.287
145:00	0.000	0.000	0.000	0.000	1.268	1.268

Appendix

Catchment descriptors

Name	Value	User-defined value used?
Area (km^2)	52.63	No
ALTBAR	112	No
ASPBAR	27	No
ASPVAR	0.46	No
BFIHOST	0.71	No
DPLBAR (km)	8.46	No
DPSBAR (mkm^{-1})	52.2	No
FARL	1	No
LDP	14.11	No
PROPWET (mm)	0.34	No
RMED1H	12.3	No
RMED1D	35.3	No
RMED2D	43.1	No
SAAR (mm)	755	No
SAAR4170 (mm)	775	No
SPRHOST	28.84	No
Urbext2000	0	No
Urbext1990	0	No
URBCONC	0	No
URBLOC	0	No
Urban Area (km^2)	0.35	No
DDF parameter C	-0.02	No
DDF parameter D1	0.35	No
DDF parameter D2	0.35	No
DDF parameter D3	0.3	No
DDF parameter E	0.31	No
DDF parameter F	2.53	No
DDF parameter C (1km grid value)	-0.02	No
DDF parameter D1 (1km grid value)	0.32	No
DDF parameter D2 (1km grid value)	0.36	No
DDF parameter D3 (1km grid value)	0.31	No
DDF parameter E (1km grid value)	0.32	No
DDF parameter F (1km grid value)	2.52	No

UK Design Flood Estimation

Generated on 06 January 2016 09:39:20 by jho
Printed from the ReFH Flood Modelling software package, version 2.1.5798.30211

Summary of estimate using the Flood Estimation Handbook revitalised flood hydrograph method (ReFH)

Site details Checksum: 8C20-D687

Site name: Reach Nr A2

Easting: 600300

Northing: 160800

Country: England, Wales or Northern Ireland

Catchment Area (km²): 52.63

Using plotscale calculations: No

Site description: None

Model run: 100 year

Summary of results

Rainfall - FEH 1999 (mm):	95.01	Total runoff (ML):	547.89
Total Rainfall (mm):	64.53	Total flow (ML):	1551.96
Peak Rainfall (mm):	14.66	Peak flow (m³/s):	15.15

Parameters

** Where the user has overriden a system-generated value, this original value is shown in square brackets after the value used.*

Rainfall parameters (Rainfall - FEH 1999 model)

Name	Value	User-defined?
Duration (hr)	11	No
Timestep (hr)	1	No
SCF(Seasonal correction factor)	0.72	No
ARF(Areal reduction factor)	0.94	No
Seasonality	Winter	n/a

Loss model parameters

Name	Value	User-defined?
Cini (mm)	92.68	No
Cmax (mm)	710.31	No
Use alpha correction factor	Yes	No
Alpha correction factor	0.88	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	6.33	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	1.26	No
BL (hr)	65.9	No
BR	1.86	No

Urbanisation parameters

Name	Value	User-defined?
Urban area (km^2)	0.35	No
Urbext 2000	0	No
Urban runoff factor	0.7	No
Imperviousness factor	0.3	No
Tp scaling factor	0.5	No
Sewered area (km^2)	0.00	Yes
Sewer capacity (m^3/s)	0.00	Yes

Time series data

Time (hh:mm)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
00:00	1.417	0.000	0.166	0.000	1.258	1.258
01:00	2.374	0.000	0.284	0.021	1.239	1.259
02:00	3.956	0.000	0.491	0.097	1.222	1.319
03:00	6.541	0.000	0.860	0.270	1.208	1.478
04:00	10.645	0.000	1.528	0.608	1.202	1.810
05:00	14.664	0.000	2.366	1.237	1.208	2.445
06:00	10.645	0.000	1.907	2.337	1.237	3.574
07:00	6.541	0.000	1.251	3.935	1.302	5.237
08:00	3.956	0.000	0.785	5.830	1.414	7.243
09:00	2.374	0.000	0.482	7.819	1.577	9.395
10:00	1.417	0.000	0.291	9.716	1.791	11.507
11:00	0.000	0.000	0.000	11.316	2.052	13.368
12:00	0.000	0.000	0.000	12.319	2.345	14.665
13:00	0.000	0.000	0.000	12.499	2.652	15.151
14:00	0.000	0.000	0.000	12.027	2.952	14.979
15:00	0.000	0.000	0.000	11.140	3.228	14.368
16:00	0.000	0.000	0.000	10.017	3.474	13.491
17:00	0.000	0.000	0.000	8.795	3.683	12.478
18:00	0.000	0.000	0.000	7.600	3.857	11.457
19:00	0.000	0.000	0.000	6.569	3.996	10.565
20:00	0.000	0.000	0.000	5.691	4.107	9.798
21:00	0.000	0.000	0.000	4.920	4.194	9.114
22:00	0.000	0.000	0.000	4.216	4.258	8.475
23:00	0.000	0.000	0.000	3.555	4.303	7.858
24:00	0.000	0.000	0.000	2.925	4.329	7.254
25:00	0.000	0.000	0.000	2.315	4.337	6.652
26:00	0.000	0.000	0.000	1.732	4.328	6.060
27:00	0.000	0.000	0.000	1.196	4.304	5.499
28:00	0.000	0.000	0.000	0.740	4.266	5.006
29:00	0.000	0.000	0.000	0.413	4.218	4.631
30:00	0.000	0.000	0.000	0.209	4.163	4.372
31:00	0.000	0.000	0.000	0.092	4.105	4.197
32:00	0.000	0.000	0.000	0.032	4.044	4.076
33:00	0.000	0.000	0.000	0.005	3.984	3.989
34:00	0.000	0.000	0.000	0.000	3.924	3.924

Time (hh:mm)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
35:00	0.000	0.000	0.000	0.000	3.865	3.865
36:00	0.000	0.000	0.000	0.000	3.807	3.807
37:00	0.000	0.000	0.000	0.000	3.749	3.749
38:00	0.000	0.000	0.000	0.000	3.693	3.693
39:00	0.000	0.000	0.000	0.000	3.637	3.637
40:00	0.000	0.000	0.000	0.000	3.583	3.583
41:00	0.000	0.000	0.000	0.000	3.529	3.529
42:00	0.000	0.000	0.000	0.000	3.476	3.476
43:00	0.000	0.000	0.000	0.000	3.423	3.423
44:00	0.000	0.000	0.000	0.000	3.372	3.372
45:00	0.000	0.000	0.000	0.000	3.321	3.321
46:00	0.000	0.000	0.000	0.000	3.271	3.271
47:00	0.000	0.000	0.000	0.000	3.222	3.222
48:00	0.000	0.000	0.000	0.000	3.173	3.173
49:00	0.000	0.000	0.000	0.000	3.125	3.125
50:00	0.000	0.000	0.000	0.000	3.078	3.078
51:00	0.000	0.000	0.000	0.000	3.032	3.032
52:00	0.000	0.000	0.000	0.000	2.986	2.986
53:00	0.000	0.000	0.000	0.000	2.941	2.941
54:00	0.000	0.000	0.000	0.000	2.897	2.897
55:00	0.000	0.000	0.000	0.000	2.853	2.853
56:00	0.000	0.000	0.000	0.000	2.810	2.810
57:00	0.000	0.000	0.000	0.000	2.768	2.768
58:00	0.000	0.000	0.000	0.000	2.726	2.726
59:00	0.000	0.000	0.000	0.000	2.685	2.685
60:00	0.000	0.000	0.000	0.000	2.645	2.645
61:00	0.000	0.000	0.000	0.000	2.605	2.605
62:00	0.000	0.000	0.000	0.000	2.566	2.566
63:00	0.000	0.000	0.000	0.000	2.527	2.527
64:00	0.000	0.000	0.000	0.000	2.489	2.489
65:00	0.000	0.000	0.000	0.000	2.452	2.452
66:00	0.000	0.000	0.000	0.000	2.415	2.415
67:00	0.000	0.000	0.000	0.000	2.378	2.378
68:00	0.000	0.000	0.000	0.000	2.342	2.342
69:00	0.000	0.000	0.000	0.000	2.307	2.307
70:00	0.000	0.000	0.000	0.000	2.272	2.272

Time (hh:mm)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
71:00	0.000	0.000	0.000	0.000	2.238	2.238
72:00	0.000	0.000	0.000	0.000	2.205	2.205
73:00	0.000	0.000	0.000	0.000	2.171	2.171
74:00	0.000	0.000	0.000	0.000	2.139	2.139
75:00	0.000	0.000	0.000	0.000	2.106	2.106
76:00	0.000	0.000	0.000	0.000	2.075	2.075
77:00	0.000	0.000	0.000	0.000	2.043	2.043
78:00	0.000	0.000	0.000	0.000	2.013	2.013
79:00	0.000	0.000	0.000	0.000	1.982	1.982
80:00	0.000	0.000	0.000	0.000	1.953	1.953
81:00	0.000	0.000	0.000	0.000	1.923	1.923
82:00	0.000	0.000	0.000	0.000	1.894	1.894
83:00	0.000	0.000	0.000	0.000	1.866	1.866
84:00	0.000	0.000	0.000	0.000	1.838	1.838
85:00	0.000	0.000	0.000	0.000	1.810	1.810
86:00	0.000	0.000	0.000	0.000	1.783	1.783
87:00	0.000	0.000	0.000	0.000	1.756	1.756
88:00	0.000	0.000	0.000	0.000	1.729	1.729
89:00	0.000	0.000	0.000	0.000	1.703	1.703
90:00	0.000	0.000	0.000	0.000	1.678	1.678
91:00	0.000	0.000	0.000	0.000	1.652	1.652
92:00	0.000	0.000	0.000	0.000	1.627	1.627
93:00	0.000	0.000	0.000	0.000	1.603	1.603
94:00	0.000	0.000	0.000	0.000	1.579	1.579
95:00	0.000	0.000	0.000	0.000	1.555	1.555
96:00	0.000	0.000	0.000	0.000	1.532	1.532
97:00	0.000	0.000	0.000	0.000	1.509	1.509
98:00	0.000	0.000	0.000	0.000	1.486	1.486
99:00	0.000	0.000	0.000	0.000	1.463	1.463
100:00	0.000	0.000	0.000	0.000	1.441	1.441
101:00	0.000	0.000	0.000	0.000	1.420	1.420
102:00	0.000	0.000	0.000	0.000	1.398	1.398
103:00	0.000	0.000	0.000	0.000	1.377	1.377
104:00	0.000	0.000	0.000	0.000	1.357	1.357
105:00	0.000	0.000	0.000	0.000	1.336	1.336
106:00	0.000	0.000	0.000	0.000	1.316	1.316

Time (hh:mm)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
107:00	0.000	0.000	0.000	0.000	1.296	1.296
108:00	0.000	0.000	0.000	0.000	1.277	1.277

Appendix

Catchment descriptors

Name	Value	User-defined value used?
Area (km^2)	52.63	No
ALTBAR	112	No
ASPBAR	27	No
ASPVAR	0.46	No
BFIHOST	0.71	No
DPLBAR (km)	8.46	No
DPSBAR (mkm^{-1})	52.2	No
FARL	1	No
LDP	14.11	No
PROPWET (mm)	0.34	No
RMED1H	12.3	No
RMED1D	35.3	No
RMED2D	43.1	No
SAAR (mm)	755	No
SAAR4170 (mm)	775	No
SPRHOST	28.84	No
Urbext2000	0	No
Urbext1990	0	No
URBCONC	0	No
URBLOC	0	No
Urban Area (km^2)	0.35	No
DDF parameter C	-0.02	No
DDF parameter D1	0.35	No
DDF parameter D2	0.35	No
DDF parameter D3	0.3	No
DDF parameter E	0.31	No
DDF parameter F	2.53	No
DDF parameter C (1km grid value)	-0.02	No
DDF parameter D1 (1km grid value)	0.32	No
DDF parameter D2 (1km grid value)	0.36	No
DDF parameter D3 (1km grid value)	0.31	No
DDF parameter E (1km grid value)	0.32	No
DDF parameter F (1km grid value)	2.52	No

UK Design Flood Estimation

Generated on 06 January 2016 09:36:51 by jho
Printed from the ReFH Flood Modelling software package, version 2.1.5798.30211

Summary of estimate using the Flood Estimation Handbook revitalised flood hydrograph method (ReFH)

Site details Checksum: 8C20-D687

Site name: Reach Nr A2

Easting: 600300

Northing: 160800

Country: England, Wales or Northern Ireland

Catchment Area (km²): 52.63

Using plotscale calculations: No

Site description: None

Model run: 20 year

Summary of results

Rainfall - FEH 1999 (mm):	62.43	Total runoff (ML):	349.99
Total Rainfall (mm):	42.40	Total flow (ML):	990.58
Peak Rainfall (mm):	9.64	Peak flow (m³/s):	10.05

Parameters

** Where the user has overriden a system-generated value, this original value is shown in square brackets after the value used.*

Rainfall parameters (Rainfall - FEH 1999 model)

Name	Value	User-defined?
Duration (hr)	11	No
Timestep (hr)	1	No
SCF(Seasonal correction factor)	0.72	No
ARF(Areal reduction factor)	0.94	No
Seasonality	Winter	n/a

Loss model parameters

Name	Value	User-defined?
Cini (mm)	92.68	No
Cmax (mm)	710.31	No
Use alpha correction factor	Yes	No
Alpha correction factor	0.96	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	6.33	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	1.26	No
BL (hr)	65.9	No
BR	1.86	No

Urbanisation parameters

Name	Value	User-defined?
Urban area (km^2)	0.35	No
Urbext 2000	0	No
Urban runoff factor	0.7	No
Imperviousness factor	0.3	No
Tp scaling factor	0.5	No
Sewered area (km^2)	0.00	Yes
Sewer capacity (m^3/s)	0.00	Yes

Time series data

Time (hh:mm)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
00:00	0.931	0.000	0.119	0.000	1.258	1.258
01:00	1.560	0.000	0.202	0.015	1.239	1.253
02:00	2.600	0.000	0.344	0.069	1.221	1.290
03:00	4.298	0.000	0.590	0.191	1.206	1.397
04:00	6.995	0.000	1.015	0.428	1.196	1.624
05:00	9.636	0.000	1.511	0.859	1.195	2.055
06:00	6.995	0.000	1.179	1.597	1.210	2.807
07:00	4.298	0.000	0.758	2.646	1.249	3.894
08:00	2.600	0.000	0.471	3.870	1.317	5.187
09:00	1.560	0.000	0.287	5.137	1.419	6.556
10:00	0.931	0.000	0.173	6.326	1.553	7.880
11:00	0.000	0.000	0.000	7.308	1.716	9.024
12:00	0.000	0.000	0.000	7.895	1.899	9.794
13:00	0.000	0.000	0.000	7.959	2.089	10.048
14:00	0.000	0.000	0.000	7.622	2.273	9.895
15:00	0.000	0.000	0.000	7.035	2.442	9.477
16:00	0.000	0.000	0.000	6.311	2.591	8.902
17:00	0.000	0.000	0.000	5.533	2.717	8.250
18:00	0.000	0.000	0.000	4.780	2.820	7.600
19:00	0.000	0.000	0.000	4.133	2.902	7.034
20:00	0.000	0.000	0.000	3.581	2.966	6.546
21:00	0.000	0.000	0.000	3.094	3.014	6.108
22:00	0.000	0.000	0.000	2.647	3.049	5.697
23:00	0.000	0.000	0.000	2.226	3.071	5.298
24:00	0.000	0.000	0.000	1.825	3.082	4.907
25:00	0.000	0.000	0.000	1.437	3.081	4.518
26:00	0.000	0.000	0.000	1.068	3.070	4.138
27:00	0.000	0.000	0.000	0.731	3.049	3.780
28:00	0.000	0.000	0.000	0.449	3.019	3.468
29:00	0.000	0.000	0.000	0.248	2.983	3.231
30:00	0.000	0.000	0.000	0.125	2.944	3.068
31:00	0.000	0.000	0.000	0.055	2.902	2.957
32:00	0.000	0.000	0.000	0.019	2.859	2.878
33:00	0.000	0.000	0.000	0.003	2.816	2.820
34:00	0.000	0.000	0.000	0.000	2.774	2.774

Time (hh:mm)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
35:00	0.000	0.000	0.000	0.000	2.732	2.732
36:00	0.000	0.000	0.000	0.000	2.691	2.691
37:00	0.000	0.000	0.000	0.000	2.651	2.651
38:00	0.000	0.000	0.000	0.000	2.611	2.611
39:00	0.000	0.000	0.000	0.000	2.571	2.571
40:00	0.000	0.000	0.000	0.000	2.533	2.533
41:00	0.000	0.000	0.000	0.000	2.494	2.494
42:00	0.000	0.000	0.000	0.000	2.457	2.457
43:00	0.000	0.000	0.000	0.000	2.420	2.420
44:00	0.000	0.000	0.000	0.000	2.383	2.383
45:00	0.000	0.000	0.000	0.000	2.348	2.348
46:00	0.000	0.000	0.000	0.000	2.312	2.312
47:00	0.000	0.000	0.000	0.000	2.277	2.277
48:00	0.000	0.000	0.000	0.000	2.243	2.243
49:00	0.000	0.000	0.000	0.000	2.209	2.209
50:00	0.000	0.000	0.000	0.000	2.176	2.176
51:00	0.000	0.000	0.000	0.000	2.143	2.143
52:00	0.000	0.000	0.000	0.000	2.111	2.111
53:00	0.000	0.000	0.000	0.000	2.079	2.079
54:00	0.000	0.000	0.000	0.000	2.048	2.048
55:00	0.000	0.000	0.000	0.000	2.017	2.017
56:00	0.000	0.000	0.000	0.000	1.987	1.987
57:00	0.000	0.000	0.000	0.000	1.957	1.957
58:00	0.000	0.000	0.000	0.000	1.927	1.927
59:00	0.000	0.000	0.000	0.000	1.898	1.898
60:00	0.000	0.000	0.000	0.000	1.870	1.870
61:00	0.000	0.000	0.000	0.000	1.842	1.842
62:00	0.000	0.000	0.000	0.000	1.814	1.814
63:00	0.000	0.000	0.000	0.000	1.786	1.786
64:00	0.000	0.000	0.000	0.000	1.760	1.760
65:00	0.000	0.000	0.000	0.000	1.733	1.733
66:00	0.000	0.000	0.000	0.000	1.707	1.707
67:00	0.000	0.000	0.000	0.000	1.681	1.681
68:00	0.000	0.000	0.000	0.000	1.656	1.656
69:00	0.000	0.000	0.000	0.000	1.631	1.631
70:00	0.000	0.000	0.000	0.000	1.606	1.606

Time (hh:mm)	Rain (mm)	Sewer Loss (mm)	Net Rain (mm)	Runoff (m^3/s)	Baseflow (m^3/s)	Total Flow (m^3/s)
71:00	0.000	0.000	0.000	0.000	1.582	1.582
72:00	0.000	0.000	0.000	0.000	1.558	1.558
73:00	0.000	0.000	0.000	0.000	1.535	1.535
74:00	0.000	0.000	0.000	0.000	1.512	1.512
75:00	0.000	0.000	0.000	0.000	1.489	1.489
76:00	0.000	0.000	0.000	0.000	1.467	1.467
77:00	0.000	0.000	0.000	0.000	1.445	1.445
78:00	0.000	0.000	0.000	0.000	1.423	1.423
79:00	0.000	0.000	0.000	0.000	1.401	1.401
80:00	0.000	0.000	0.000	0.000	1.380	1.380
81:00	0.000	0.000	0.000	0.000	1.359	1.359
82:00	0.000	0.000	0.000	0.000	1.339	1.339
83:00	0.000	0.000	0.000	0.000	1.319	1.319
84:00	0.000	0.000	0.000	0.000	1.299	1.299
85:00	0.000	0.000	0.000	0.000	1.279	1.279

Appendix

Catchment descriptors

Name	Value	User-defined value used?
Area (km^2)	52.63	No
ALTBAR	112	No
ASPBAR	27	No
ASPVAR	0.46	No
BFIHOST	0.71	No
DPLBAR (km)	8.46	No
DPSBAR (mkm^{-1})	52.2	No
FARL	1	No
LDP	14.11	No
PROPWET (mm)	0.34	No
RMED1H	12.3	No
RMED1D	35.3	No
RMED2D	43.1	No
SAAR (mm)	755	No
SAAR4170 (mm)	775	No
SPRHOST	28.84	No
Urbext2000	0	No
Urbext1990	0	No
URBCONC	0	No
URBLOC	0	No
Urban Area (km^2)	0.35	No
DDF parameter C	-0.02	No
DDF parameter D1	0.35	No
DDF parameter D2	0.35	No
DDF parameter D3	0.3	No
DDF parameter E	0.31	No
DDF parameter F	2.53	No
DDF parameter C (1km grid value)	-0.02	No
DDF parameter D1 (1km grid value)	0.32	No
DDF parameter D2 (1km grid value)	0.36	No
DDF parameter D3 (1km grid value)	0.31	No
DDF parameter E (1km grid value)	0.32	No
DDF parameter F (1km grid value)	2.52	No

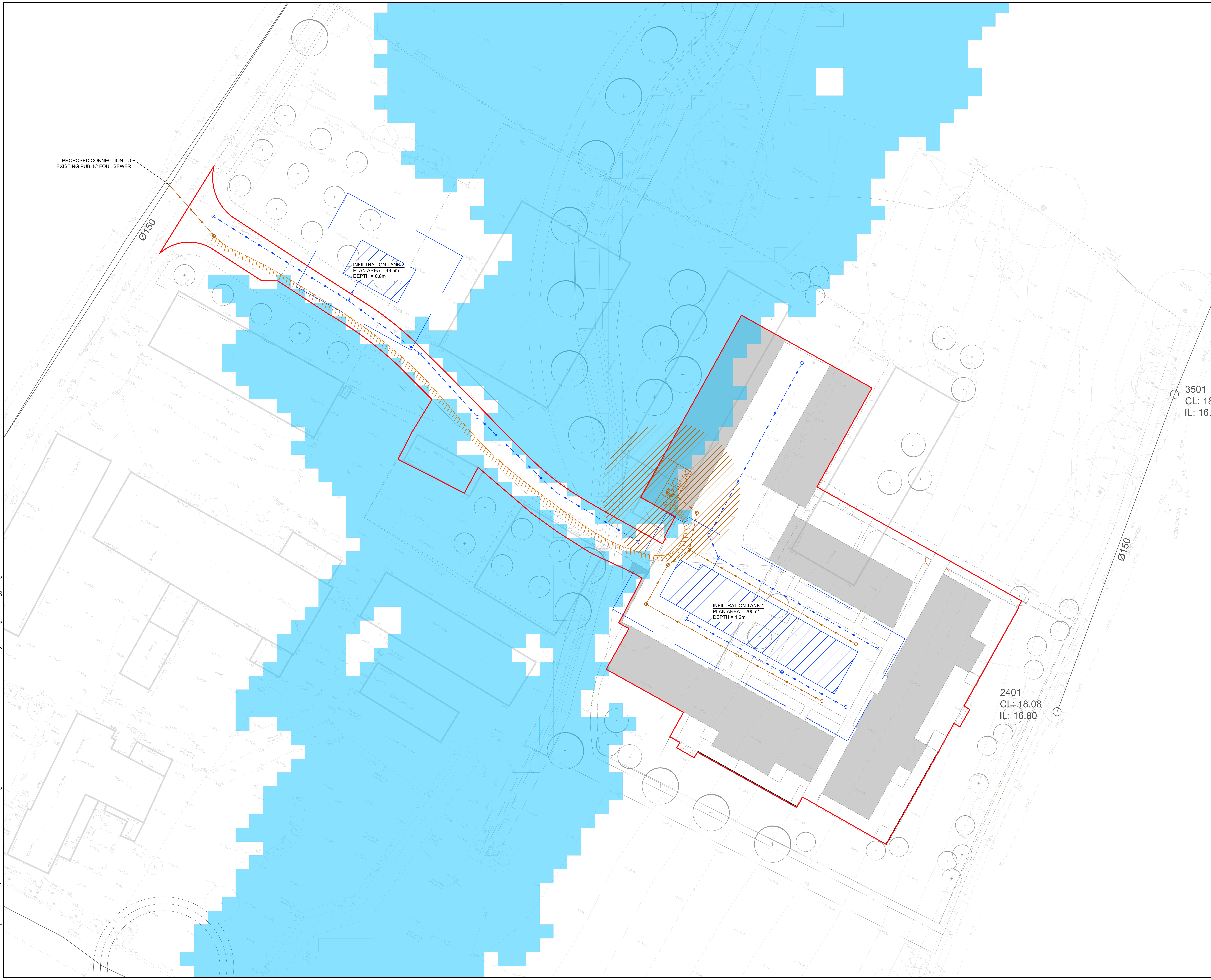
APPENDIX B

Link to Hydraulic Model Files

https://odysseymarkides.sharepoint.com/:f:/g/EuoJdDQxFWRJtpLAcWAbv1QBom3Oqy0I Mr7LQWZ-dly4Yw?e=QGNfBi

APPENDIX D

Updated Drainage Strategy and MicroDrainage Calculations



NOTES

1. DO NOT SCALE FROM THIS DRAWING. WORK FROM MEASURED DIMENSIONS ONLY.
2. THIS DRAWING IS FOR PLANNING PURPOSES ONLY AND IS TO BE READ IN CONJUNCTION WITH ALL OTHER DRAWINGS ISSUED BY THE ARCHITECT.
3. SURROUNDING TOPOGRAPHICAL DATA WAS PRODUCED BY HOOK SURVEYS IN OCTOBER 2011. ODYSSEY DOES NOT TAKE RESPONSIBILITY FOR THE ACCURACY OF THE SURVEY INFORMATION.
4. SITE LAYOUT HAS BEEN PROVIDED BY ON ARCHITECTURE (DWG REFERENCE 21.153-ONA-XX-00-DR-A-0101 P4 DATED 29.07.22).
5. PROPOSALS ARE INDICATIVE ONLY TO DEMONSTRATE THE PRELIMINARY DRAINAGE STRATEGY AND ARE SUBJECT TO EVOLVE IN LINE WITH DETAILED DESIGN REQUIREMENTS.
6. INFILTRATING SuDS FEATURES HAVE BEEN DESIGNED WITH AN INFILTRATION COEFFICIENT OF 1.0×10^{-5}m/s.
7. CONNECTION TO EXISTING SOUTHERN WATER SEWER IS SUBJECT TO DISCUSSIONS WITH SOUTHERN WATER TO CONFIRM CAPACITY.
8. THE FOUL PUMPING STATION IS TO BE PRIVATE AND UNDERGROUND, RAISED GROUND LEVELS AT THE PUMPING STATION WOULD BE IMPLEMENTED SO THAT THE PUMPING STATION IS NOT IMPACTED BY THE FLOOD EXTENTS.

LEGEND:

- SITE BOUNDARY
- PROPOSED SURFACE WATER SEWER NETWORK
- PROPOSED FOUL WATER SEWER NETWORK
- EXISTING FOUL WATER SEWER PIPEWORK AND MANHOLE (SOUTHERN WATER)
- INFILTRATING CELLULAR STORAGE TANK WITH 5m BUFFER
- INDICATIVE TYPE 2 FOUL PUMPING STATION WITH 10m BUFFER FROM THE WET WELL
- 1 IN 100 YEAR PLUS 22% CLIMATE CHANGE DESIGN FLOOD EXTENTS
- PROPOSED FOUL RISING MAIN

Rev	Amendments	Drn	Chk	App	Date
B	AMENDED FOR UPDATED RAINFALL DATA	MSS	JW	GG	03.11.22
A	AMENDED FOR NEW SITE LAYOUT	MSS	JW	GG	03.08.22

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Job Title
SHEPHERD NEAME
FAVERSHAM

Drawing Title
PRELIMINARY DRAINAGE
STRATEGY - PHASE 2

Client
MILIKEN & COMPANY CHARTERED
SURVEYORS & TOWN PLANNERS

Scale	Date	Designed
1:250 @ A1	AUG 21	JW
Drawn	**Checked**	**Approved**
HM	JW	GG

Job No	Drawing No	Rev
18-120	18-120/100	B

P:\18-120 - Shepherd Neame, Faversham\Tech\Acad\Drawings\100 Series - Phase 2\18-120-100 Preliminary Drainage Strategy.dwg

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

Half Drain Time : 1222 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	10.288	0.208	0.2	9.8	O K
30 min Summer	10.352	0.272	0.2	12.8	O K
60 min Summer	10.416	0.336	0.2	15.8	O K
120 min Summer	10.489	0.409	0.2	19.2	O K
180 min Summer	10.540	0.460	0.2	21.6	O K
240 min Summer	10.581	0.501	0.2	23.5	O K
360 min Summer	10.642	0.562	0.2	26.4	O K
480 min Summer	10.684	0.604	0.2	28.4	O K
600 min Summer	10.711	0.631	0.2	29.7	O K
720 min Summer	10.727	0.647	0.2	30.4	O K
960 min Summer	10.735	0.655	0.2	30.8	O K
1440 min Summer	10.719	0.639	0.2	30.0	O K
2160 min Summer	10.673	0.593	0.2	27.9	O K
2880 min Summer	10.627	0.547	0.2	25.7	O K
4320 min Summer	10.538	0.458	0.2	21.5	O K
5760 min Summer	10.462	0.382	0.2	18.0	O K
7200 min Summer	10.398	0.318	0.2	15.0	O K
8640 min Summer	10.345	0.265	0.2	12.5	O K
10080 min Summer	10.301	0.221	0.2	10.4	O K
15 min Winter	10.313	0.233	0.2	11.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	136.235	0.0	19
30 min Summer	89.957	0.0	34
60 min Summer	56.544	0.0	64
120 min Summer	35.448	0.0	122
180 min Summer	27.286	0.0	182
240 min Summer	22.773	0.0	242
360 min Summer	17.749	0.0	362
480 min Summer	14.837	0.0	482
600 min Summer	12.846	0.0	602
720 min Summer	11.374	0.0	720
960 min Summer	9.288	0.0	952
1440 min Summer	6.851	0.0	1168
2160 min Summer	4.947	0.0	1540
2880 min Summer	3.899	0.0	1936
4320 min Summer	2.764	0.0	2728
5760 min Summer	2.170	0.0	3520
7200 min Summer	1.809	0.0	4320
8640 min Summer	1.567	0.0	5016
10080 min Summer	1.394	0.0	5752
15 min Winter	136.235	0.0	19

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
30 min Winter	10.385	0.305	0.2	14.4	O K
60 min Winter	10.458	0.378	0.2	17.8	O K
120 min Winter	10.542	0.462	0.2	21.7	O K
180 min Winter	10.601	0.521	0.2	24.5	O K
240 min Winter	10.649	0.569	0.2	26.8	O K
360 min Winter	10.723	0.643	0.2	30.2	O K
480 min Winter	10.774	0.694	0.2	32.6	O K
600 min Winter	10.808	0.728	0.2	34.2	O K
720 min Winter	10.831	0.751	0.2	35.3	O K
960 min Winter	10.849	0.769	0.2	36.2	O K
1440 min Winter	10.833	0.753	0.2	35.4	O K
2160 min Winter	10.772	0.692	0.2	32.5	O K
2880 min Winter	10.707	0.627	0.2	29.5	O K
4320 min Winter	10.578	0.498	0.2	23.4	O K
5760 min Winter	10.463	0.383	0.2	18.0	O K
7200 min Winter	10.368	0.288	0.2	13.6	O K
8640 min Winter	10.290	0.210	0.2	9.9	O K
10080 min Winter	10.228	0.148	0.2	6.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	89.957	0.0	33
60 min Winter	56.544	0.0	62
120 min Winter	35.448	0.0	122
180 min Winter	27.286	0.0	180
240 min Winter	22.773	0.0	238
360 min Winter	17.749	0.0	356
480 min Winter	14.837	0.0	472
600 min Winter	12.846	0.0	586
720 min Winter	11.374	0.0	700
960 min Winter	9.288	0.0	924
1440 min Winter	6.851	0.0	1342
2160 min Winter	4.947	0.0	1664
2880 min Winter	3.899	0.0	2128
4320 min Winter	2.764	0.0	2984
5760 min Winter	2.170	0.0	3808
7200 min Winter	1.809	0.0	4544
8640 min Winter	1.567	0.0	5272
10080 min Winter	1.394	0.0	5944

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 600233 160515 TR 00233 60515
Data Type	Point
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) 0.039

Time From:	**(mins) To:**	**Area (ha)**
0	4	0.039

Model Details

Storage is Online Cover Level (m) 12.080

Cellular Storage Structure

Invert Level (m) 10.080 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.03600 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	**Area (m²)**	**Inf. Area (m²)**	**Depth (m)**	**Area (m²)**	**Inf. Area (m²)**
0.000	49.5	49.5	0.801	0.0	72.0
0.800	49.5	72.0			

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

Half Drain Time : 1690 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Volume (m³)	Status
15 min Summer	9.807	0.267	1.0	50.8	O K
30 min Summer	9.890	0.350	1.0	66.5	O K
60 min Summer	9.974	0.434	1.0	82.5	O K
120 min Summer	10.072	0.532	1.0	101.0	O K
180 min Summer	10.142	0.602	1.0	114.3	O K
240 min Summer	10.198	0.658	1.0	125.0	O K
360 min Summer	10.286	0.746	1.0	141.7	O K
480 min Summer	10.348	0.808	1.0	153.5	O K
600 min Summer	10.391	0.851	1.0	161.7	O K
720 min Summer	10.420	0.880	1.0	167.1	O K
960 min Summer	10.447	0.907	1.0	172.3	O K
1440 min Summer	10.437	0.897	1.0	170.5	O K
2160 min Summer	10.383	0.843	1.0	160.2	O K
2880 min Summer	10.329	0.789	1.0	150.0	O K
4320 min Summer	10.229	0.689	1.0	131.0	O K
5760 min Summer	10.144	0.604	1.0	114.8	O K
7200 min Summer	10.072	0.532	1.0	101.1	O K
8640 min Summer	10.010	0.470	1.0	89.3	O K
10080 min Summer	9.957	0.417	1.0	79.2	O K
15 min Winter	9.840	0.300	1.0	56.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
15 min Summer	136.235	0.0	19
30 min Summer	89.957	0.0	34
60 min Summer	56.544	0.0	64
120 min Summer	35.448	0.0	124
180 min Summer	27.286	0.0	182
240 min Summer	22.773	0.0	242
360 min Summer	17.749	0.0	362
480 min Summer	14.837	0.0	482
600 min Summer	12.846	0.0	602
720 min Summer	11.374	0.0	722
960 min Summer	9.288	0.0	960
1440 min Summer	6.851	0.0	1370
2160 min Summer	4.947	0.0	1692
2880 min Summer	3.899	0.0	2072
4320 min Summer	2.764	0.0	2856
5760 min Summer	2.170	0.0	3680
7200 min Summer	1.809	0.0	4464
8640 min Summer	1.567	0.0	5264
10080 min Summer	1.394	0.0	5960
15 min Winter	136.235	0.0	19

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
30 min Winter	9.933	0.393	1.0	74.7	O K
60 min Winter	10.028	0.488	1.0	92.7	O K
120 min Winter	10.140	0.600	1.0	113.9	O K
180 min Winter	10.221	0.681	1.0	129.3	O K
240 min Winter	10.286	0.746	1.0	141.7	O K
360 min Winter	10.389	0.849	1.0	161.3	O K
480 min Winter	10.463	0.923	1.0	175.4	O K
600 min Winter	10.516	0.976	1.0	185.5	O K
720 min Winter	10.553	1.013	1.0	192.5	O K
960 min Winter	10.593	1.053	1.0	200.1	O K
1440 min Winter	10.601	1.061	1.0	201.5	O K
2160 min Winter	10.533	0.993	1.0	188.8	O K
2880 min Winter	10.463	0.923	1.0	175.5	O K
4320 min Winter	10.324	0.784	1.0	149.0	O K
5760 min Winter	10.198	0.658	1.0	125.0	O K
7200 min Winter	10.089	0.549	1.0	104.3	O K
8640 min Winter	9.994	0.454	1.0	86.2	O K
10080 min Winter	9.912	0.372	1.0	70.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Time-Peak (mins)
30 min Winter	89.957	0.0	33
60 min Winter	56.544	0.0	62
120 min Winter	35.448	0.0	122
180 min Winter	27.286	0.0	180
240 min Winter	22.773	0.0	240
360 min Winter	17.749	0.0	356
480 min Winter	14.837	0.0	474
600 min Winter	12.846	0.0	590
720 min Winter	11.374	0.0	706
960 min Winter	9.288	0.0	934
1440 min Winter	6.851	0.0	1384
2160 min Winter	4.947	0.0	1984
2880 min Winter	3.899	0.0	2220
4320 min Winter	2.764	0.0	3116
5760 min Winter	2.170	0.0	3984
7200 min Winter	1.809	0.0	4824
8640 min Winter	1.567	0.0	5616
10080 min Winter	1.394	0.0	6352

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	2013
Site Location	GB 600233 160515 TR 00233 60515
Data Type	Point
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) 0.202

Time (mins) From:	**To:**	**Area (ha)**
0	4	0.202

Model Details

Storage is Online Cover Level (m) 11.940

Cellular Storage Structure

Invert Level (m) 9.540 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.03600 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	**Area (m²)**	**Inf. Area (m²)**	**Depth (m)**	**Area (m²)**	**Inf. Area (m²)**
0.000	200.0	200.0	1.201	0.0	267.9
1.200	200.0	267.9			