Clowes Development (UK) Ltd

P/2015/00875

Received 12/05/15

Proposed Mixed Development
Dove Way
Uttoxeter
Staffordshire

Flood Risk Assessment

Prepared by EWE Associates Ltd
Draft RevA September 2011

EWE Associates Ltd
Windy Ridge Barn
Thealby Lane
Winterton
Scunthorpe
North Lincolnshire
DN15 9TG
t: 0845 8377783
M: 07875 972270
e: lea.favill@eweassociates.com

CLIENT DETAILS

Clowes Developments (UK) Ltd

Third Floor,
The Royal Buildings,
Victoria Street,
Derby,
DE1 1ES

FAO Mr Paul Shanley

CONTRACT

This report describes work commissioned by Clowes Developments (UK) Ltd following written instruction by their representative on 24th February 2011. Clowes Developments (UK) Ltd is referred to as the Client and their representative for the contract was Mr Paul Shanley. Lea Favill of EWE Associates Ltd carried out the work.

Date: 16th September 2011

Prepared by: …… ……Lea Favill
Director

REVISION HISTORY

Draft Report Rev0 issued 12th July 2011 - Mr Paul Shanley - 1No. copy
Draft Report RevA issued 16th September 2011 - Mr Paul Shanley - 1No. copy - Mr Matthew Montague – 1No. copy

EXECUTIVE SUMMARY

The proposed development site is located to the north east of Uttoxeter, Staffordshire. The site is located adjacent to the Dove Way. The site is split into two distinct parcels of land. The first is to the east of the Dove Way and is adjacent to the Severn Trent Water Sewerage works. This parcel of land is referred to as site A. The second parcel of land is located adjacent to the residential/commercial area off Pennycroft Lane. This section of the site has the Uttoxeter Brook meandering through in a west to east direction eventually discharging under the Dove Way via a large box culvert. This parcel of land is referred to as site B.

Site A covers a total area of approximately 4.71 hectares. Ground levels within the developable site boundary vary from 77.30mOD located in the southern corner adjacent to the Uttoxeter Brook and the Dove Way, up to 81.59mOD located in the northern corner of the site adjacent to the Dove Way and the A50 by-pass. The site generally slopes from the north to the south towards the Uttoxeter Brook. As such any runoff within the site is likely to drain in this direction towards the Uttoxeter Brook. The existing site is predominantly farmland and as such is considered to be 100% permeable. There was evidence of ground water and ponded water within the lower areas of the site close to the brook.

Site B covers a total area of approximately 2.42 hectares. Ground levels within the developable site boundary vary from 76.96mOD located in the south east corner adjacent to the Dove Way, up to 83.84mOD located adjacent to the western boundary of the site adjacent to Pennycroft Lane. The site generally slopes from the north to the south towards the Uttoxeter Brook. As such any runoff within the site is likely to drain in this direction towards the Uttoxeter Brook. The existing site is predominantly farmland and as such is considered to be 100% permeable. There was evidence of ground water and ponded water within the lower areas of the site close to the brook.

A preliminary proposal for the development is to construct a mixed development. The proposal is to construct a commercial development within Site A and a residential development within Site B. Both sites will incorporate numerous buildings, access roads and car parking areas. The impermeable area of the proposed development will be increased above that of the existing site and hence, the overall surface water runoff from the site will be increased.

The majority of the proposed development site lies within Zone 1 of the Environment Agency Flood Map (version 2.8.2), being the zone with risk of 1 in 1000 year (0.1% AEP) or less for river flooding, however is, greater than 1 hectare.

The River Dove is located to the east of the site. The 1 in 100 year plus climate change flood level has been estimated at between 75.90mOD and 76.40mOD. The 1 in 1,000 year flood level has been estimated at between 76.45mOD and 76.64mOD.

The lowest ground level within the sites is 76.96mOD. As such during the 1 in 100 year plus climate change and the 1 in 1,000 year events the water level would be at least 0.32m below the lowest ground level within the site.

The Uttoxeter Brook flows through Site B and passes the south east corner of Site A. Tabulated overleaf are the modelled flood levels during the 1 in 100 year, 1 in 100 year plus climate change and 1 in 1,000 year extreme flood events for the modified Uttoxeter Brook through Site B.

It is considered that the lower areas within site B will need to be raised to a level of at least 79mOD to enable the site to be drained to the adjacent Uttoxeter Brook via gravity whilst using double 1m diameter pipes for attenuation. As such it is recommended that the internal floor levels within site B of any dwellings are raised to a level of at least 79.3mOD. This will generally ensure that the internal ground floor levels within this site are at least 300mm above the estimated 1 in 100 year plus climate change level in the area.

It is proposed that site A is developed for commercial uses. The peak 1 in 100 year plus climate change flood level in line with the south east corner of site A has been estimated at 77.41mOD. As such it is recommended that any buildings within this area are elevated at least 300mm above the estimated 1 in 100 year plus climate change flood level, hence a level of 77.71mOD.

Water Levels at Key Locations during unobstructed flow for modified channel

Cross Section Reference	100yr Water Level (mOD)	100yr+CC Water Level (mOD)	1000yr Water Level (mOD)	Comments
2806	81.08	81.12	81.23	In channel
2733	80.10	80.69	81.08	In channel
2711	78.83	78.87	78.96	In channel
2667	78.47	78.51	78.59	In channel
2636	78.27	78.31	78.40	In channel
2631	78.20	78.25	78.35	In channel
2614U	77.95	78.00	78.11	In channel
2608D	77.76	77.80	77.90	In channel
2562	77.55	77.59	77.71	In channel
2518	77.44	77.47	77.52	In channel

Dry emergency access and egress is essential for the proposed residential development during extreme flood events. Site B will be raised to ensure that the dwellings and road ways are elevated above the 1 in 1,000 year flood level thus raising site B into flood zone 1, low risk. As such dry access from the site will be available for pedestrians to the south west into the existing residential area off Pennycroft Lane which is presently within flood zone 1, low risk. Dry access will also be available onto Dove Way to the north east of the site. Site A is located within flood zone 1, low risk and as such dry access will be available onto Dove Way at all times. However, during extreme events Dove Way to the north and south of the site could be flooded and may not be safe to cross. As such the pedestrian access through Site B will be available to flood zone 1, low risk.

Consideration has been given to the hierarchy for surface water disposal which recommends the SUDs approach which includes infiltration as the first tier. It is considered that infiltration drainage will be impractical solution for the majority of the site due to shallow ground water levels, made ground and contaminated ground. However, house soakways have been adopted for part of the site where ground levels are higher.

However, other SUDs techniques can be used within the site and they have been considered. The second tier is to discharge to a watercourse and therefore the Uttoxeter Brook to the south east of the site is a viable option for the site.

It is considered that following the development there will be an increase in impermeable area and subsequently runoff from the site as the existing site is 100% permeable. The impermeable area will be increased to approximately 60% following the development.

Using WInDes Source Control software developed by Microdrainage the required attenuation has been calculated for the 1 in 100 year plus climate change (30%) event. The site was spilt into seven separate areas with all areas discharging into the Uttoxeter Brook at a Greenfield runoff rate of 5 l/s/ha. It is proposed that the roof drainage within area 1 is drained to traditional house soakaways as the ground levels are elevated The attenuation sizes have been tabulated overleaf.

In conclusion there is a risk of fluvial flooding from the Uttoxeter Brook. The re-profiling of the Uttoxeter Brook should reduce the flood risk to an acceptable level within Site B. Incorporation of sustainable urban drainage systems should be considered where practically possible to mitigate against flooding caused by surface water runoff. Consultation must also be undertaken with the relevant water authority to establish agreements regarding the allowable peak discharges into the Uttoxeter Brook.

Modified Rational Method balance volumes during 1 in 100 year +CC event

Drainage Area	Drainage Method	Approx Volume (m^3)
Area 1	Double pipe	130m^3
Area 1 roof	House Soakaways	
Area 2	Pond	354m^3
Area 3	Pond	1628m^3
Area 4	Pipes	155m^3
Area 5	Crates	68m^3
Area 6	Crates	137m^3
Total		2472m^3

CONTENTS

APPENDICES:

APPENDIX A: - EXISTING GROUND LEVELS

APPENDIX B: - PROPOSED LAYOUT

APPENDIX C: - RIVER DOVE ENVIRONMENT AGENCY FLOOD DATA

APPENDIX D: - RIVER DOVE FLOOD ENVELOPE

APPENDIX E: - UTTOXETER BROOK ENVIRONMENT AGENCY FLOOD DATA

APPENDIX F: - UTTOXETER BROOK HYDROGRAPHS

APPENDIX G: - HEC RAS LONGITUDINAL SECTION AND TABLES FOR EXISTING UTTOXETER BROOK.

APPENDIX H: - HEC RAS LONGITUDINAL SECTION AND TABLES FOR PROPOSED UTTOXETER BROOK

APPENDIX I: - DRAINAGE STRATEGY DRAWING

APPENDIX J: - WINDES CALCULATION SHEETS SITE A AREA 3

APPENDIX K: - WINDES CALCULATION SHEETS SITE A AREA 4

APPENDIX L: - WINDES CALCULATION SHEETS SITE A AREA 5

APPENDIX M: - WINDES CALCULATION SHEETS SITE A AREA 6

APPENDIX N: - WINDES CALCULATION SHEETS SITE B AREA 1

APPENDIX O: - WINDES CALCULATION SHEETS SITE B AREA 2

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

Terms of Reference

This report was commissioned to supplement a planning application for a proposed mixed development off the Dove Way within Uttoxeter, Staffordshire. The site is large and as such is presently accessed from numerous points but can generally be accessed directly off the Dove Way. The location of the site is shown on Table 2-1.

The development site lies partially within Zone 3 of the Environment Agency Flood Map (version 2.8.2), being the zone with risk of 1 in 100 year (1% AEP) or greater for river flooding and 1 in 200 year (0.5% AEP) or greater for tidal/coastal flooding. The development site also lies partially within Zone 2 of the Environment Agency Flood Map (version 2.8.2), being the zone with risk of 1 in 1000 year (0.1% AEP) or greater for river flooding. The majority of the proposed development site lies within Zone 1 of the Environment Agency Flood Map (version 2.8.2), being the zone with risk of 1 in 1000 year (0.1% AEP) or less for river flooding, however is, greater than 1 hectare.

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

Approach to the Assessment

As there are three potential sources of flood risk – the River Dove, Uttoxeter Brook and surface water runoff – it is necessary to determine flood water levels at the site for the desired return periods emanating from these sources.

The River Tean/River Dove is located to the north and east of the site. In line with the site the river is open channel. Directly upstream of the site the river passes under the A50 bypass before flowing south across the lowland area between Uttoxeter and Doveridge. The river is considered to be Main River and as such the responsibility for flood defence and land drainage lies with the Environment Agency.

The Environment Agency has been approached for modelled flood data for the river. The Environment Agency has modelled flood data which may assist in predicting the design flood level for the river adjacent to the proposed development site.

The Uttoxeter Brook meanders through the site from the north west corner eventually discharging into the River Dove to the east of the site. The brook is considered to be Main River and as such the responsibility for flood defence and land drainage lies with the Environment Agency.

The Environment Agency has been approached for modelled flood data for the river. The Environment Agency has modelled flood data which may assist in predicting the design flood level for the river adjacent to the proposed development site. The modelling data shows that part of the residential site could be flooded due to shallow overtopping. A copy of the modelled has been obtained from the Environment Agency. EWE Associates Ltd has constructed a simple 1d HEC RAS model of the critical section in order to develop a widening strategy for the brook to ensure that flows remain in channel and do not flood the site during critical events.

East Staffordshire Borough Council has completed a level 1 and level 2 Strategic Flood Risk Assessment (SFRA) for the district. The SFRA was completed by Haskoning UK Ltd with the level 1 being completed during February 2008 and the level 2 during August 2008. The SFRA has been referred to in this report, however, there a very few site specific references within the report.

The proposed development is a permeable site. It is considered that the impermeable area within the site will be considerably increased following the proposed development. As such this assessment will consider the existing discharge routes from the site. An initial drainage strategy will be developed based on the existing data available. There is a site specific site investigation report available completed by BWB Consulting on behalf of East Staffordshire Borough Council during 2010.

A walk over of the site was conducted by Mr Lea Favill, Principal Engineer on 30th March 2011; during the visit a photograph survey of the site was undertaken. Following this a meeting was held with the Environment Agency Development Control Engineer and the proposed development was discussed. Following receipt of the Uttoxeter Brook flood level data a further site visit was undertaken during 6th June 2011. A topographical survey completed

by Greenhatch Group, drawing 12236_OGL dated April 2008 was provided by the client. The survey has been calibrated to GPS.

The requirements for flood risk assessments are generally as set out in Annex E of PPS25. The detail and complexity of the study required should be appropriate to the scale and potential impact of the development. For the purposes of this study, the following have been considered:-

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

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

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

Application of Sequential & Exceptions Test

Commercial Site

The proposed commercial development site lies within Zone 1 of the Environment Agency Flood Map (version 2.8.2), being the zone with risk of 1 in 1000 year (0.1% AEP) or less for river flooding. The site is located within an area adjacent to the sewerage works. The proposed development is commercial and as such is considered to be "less vulnerable" respectively according to PPS25 as shown below in Table 1-1.

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

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

✓ Development is appropriate

× Development should not be permitted

As the proposed development site lies within Zone 1 of the Environment Agency Flood Map there are no sites which could be considered to represent a lower flood risk in immediate area. Therefore, it is considered that further investigation into alternative sites is unnecessary and the proposed development site is appropriate for commercial use.

Residential Site

The proposed residential development site lies partially within Zone 3 of the Environment Agency Flood Map (version 2.8.2), being the zone with risk of 1 in 100 year (1% AEP) or less for river flooding. The site is located within an area adjacent to existing residential development. The proposed development is residential and as such is considered to be "more vulnerable" respectively according to PPS25 as shown below in Table 1-1.

Table 1-2: Flood Risk Vulnerability and Flood Zone 'Compatibility'

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

✓ Development is appropriate

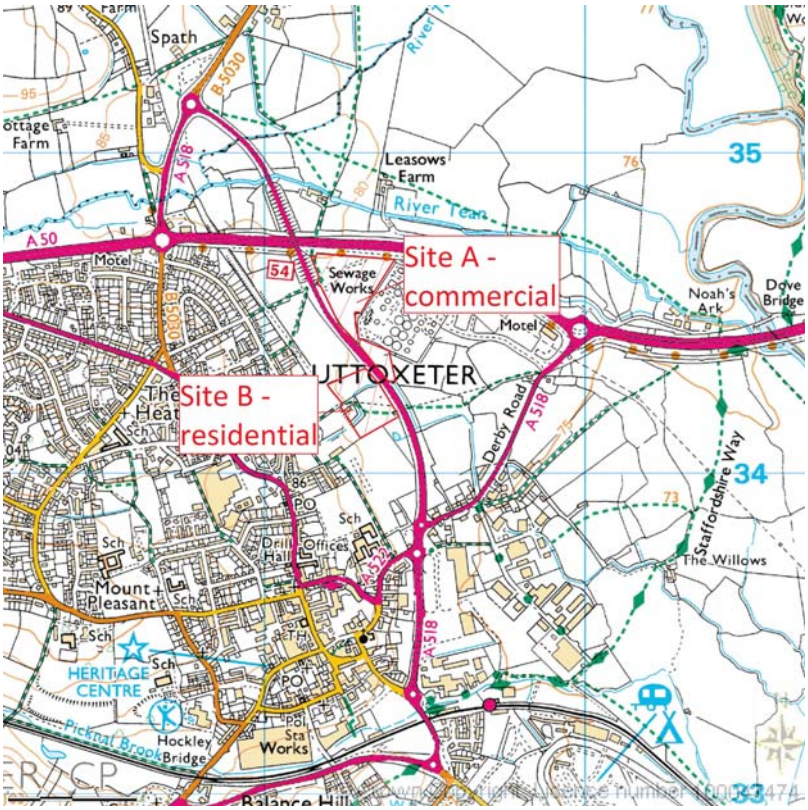
× Development should not be permitted

It is considered that part of the proposed residential development will be to improve the Uttoxeter Brook within the residential site area to provide a maintenance strip and to also introduce a two stage channel which will increase the channel capacity. The works will also involve the removal of a small access culvert. It is considered that following the works that the design flood events will remain in channel and as such the habitable areas of the site will be located within flood zone 1 low risk. As such it is considered that a sequential and exceptions test will not be required for this part of the development.

2. DETAILS OF THE SITE

Site Location

Table 2-1: Location Plan



Ordnance Survey Licence no.: WL1005160

Site Details

Table 2-2: Site Details

Site Name	Mixed Development, Dove Way, Uttoxeter
Existing Land Use	Open vegetated areas and farmland
Proposed Development	Mixed Development
Grid Reference	SK 09371 34285 centre of sites
County	Staffordshire
Local Planning Authority	East Staffordshire Borough Council
Internal Drainage Board	Not Applicable
Others	Not Applicable

Site Description

The proposed development site is located to the north east of Uttoxeter, Staffordshire. The site is located adjacent to the Dove Way. The site is split into two distinct parcels of land. The first is to the east of the Dove Way and is adjacent to the Severn Trent Water Sewerage works. This parcel of land is referred to as site A. The second parcel of land is located adjacent to the residential/commercial area off Pennycroft Lane. This section of the site has the Uttoxeter Brook meandering through in a west to east direction eventually discharging under the Dove Way via a large box culvert. This parcel of land is referred to as site B.

Existing site levels are shown in the topographical survey in Appendix A of this report. Aerial photographs of the existing sites are shown below in Figure 2.1 and Figure 2.2 which shows the agricultural nature of the sites relative to the residential areas and the sewerage works.

Site A covers a total area of approximately 4.71 hectares. Ground levels within the developable site boundary vary from 77.30mOD located in the southern corner adjacent to the Uttoxeter Brook and the Dove Way, up to 81.59mOD located in the northern corner of the site adjacent to the Dove Way and the A50 by-pass. The site generally slopes from the north to the south towards the Uttoxeter Brook. As such any runoff within the site is likely to drain in this direction towards the Uttoxeter Brook. The existing site is predominantly farmland and as such is considered to be 100% permeable. There was evidence of ground water and ponded water within the lower areas of the site close to the brook.

Site B covers a total area of approximately 2.42 hectares. Ground levels within the developable site boundary vary from 76.96mOD located in the south east corner adjacent to the Dove Way, up to 83.84mOD located adjacent to the western boundary of the site adjacent to Pennycroft Lane. The site generally slopes from the north to the south towards the Uttoxeter Brook. As such any runoff within the site is likely to drain in this direction towards the Uttoxeter Brook. The existing site is predominantly farmland and as such is considered to be 100% permeable. There was evidence of ground water and ponded water within the lower areas of the site close to the brook.

A preliminary proposal for the development is to construct a mixed development. The proposal is to construct a commercial development within Site A and a residential development within Site B. Both sites will incorporate numerous buildings, access roads and car parking areas. The proposed layout is provided at Appendix B of this report.

The impermeable area of the proposed development will be increased above that of the existing site and hence, the overall surface water runoff from the site will be increased.

Site Photographs

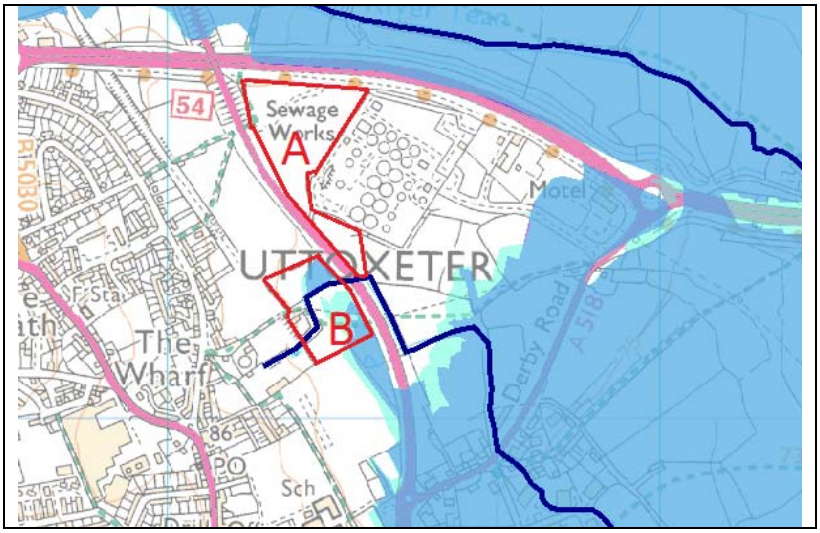
Figure 2.1: Aerial Photograph of the Existing Site A.

Figure 2.2: Aerial Photograph of the Existing Site B.

3. INITIAL ASSESSMENT

Environment Agency Flood Map

Figure 3.1: Environment Agency Flood Zones



Past Flooding History

A search on the British Hydrological Society Chronology of British Hydrological Events website[1] found no specific instances of flooding in the immediate vicinity of the proposed development or within the larger Uttoxeter area.

Undertaking an internet based search for flooding in the area found references to the River Dove and the River Tean flooding arable farmland within the Uttoxceter area. However, no specific instances of flooding within the immediate vicinity of the proposed development were found.

Environment Agency Flooding History

The Environment Agency provided no historical flood information close to the site.

SFRA Flooding History

The SFRA provided no historical flood information close to the site. There are thirteen references to flooding within the Uttoxeter area. The majority of these were incidents within the Picknall Brook and the River Dove.

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

Possible Flooding Mechanisms

As there are three potential sources of flood risk – the River Dove/River Tean, Uttoxeter Brook and surface water runoff – it is necessary to determine flood water levels at the site for the desired return periods emanating from these sources.

The River Tean is approximately 220m to the north of the site. The river is open channel with no flood defences adjacent and therefore overtopping will need to be considered. However, the A50 bypass is located between the site and the river which generally directs flood flows east towards the River Dove where the river flows beneath the A50 bypass. From here the site could potentially be flooded. As such consideration will be given to the River Dove flooding the site.

The River Dove is approximately 1200m to the east of the site. The river is open channel with no flood defences adjacent and therefore overtopping will need to be considered.

The Uttoxeter Brook meanders through Site B. The brook is open channel with no flood defences adjacent and therefore overtopping will need to be considered.

The proposed development is greater than 1 hectare and as such, consideration will need to be given to potential flooding as a result of surface water runoff resulting from the proposed development. The proposed development will increase the drained impermeable area and hence the overall surface water runoff from the site will also be increased. Consideration will need to be given to the existing drainage route and characteristics in order to evaluate the potential impact that surface water runoff from the site will have on the site and neighbouring land uses to inform the detailed drainage system design for the proposed development.

Due to the local topography, site B falls towards the south east where the Uttoxeter Brook is located. There is existing ground elevated to the south and west of site B could result in overland flows being directed through site B especially during extreme rainfall events where the drainage system design is exceeded.

There are no significantly depressed areas which could encourage ponding and as such, this mechanisms will not be considered further for the purposes of this report.

Information on groundwater flooding is limited within the district. The site investigation report suggests that there is shallow ground water in the lower lying areas of the site. The following comment was extracted from the SFRA,

The Environment Agency's groundwater team was consulted and confirmed that there have been very few recorded incidences of groundwater flooding within East Staffordshire. The only events that have occurred are as a result of the cessation of the quarrying of gravel and sand in the area and thus the abstraction of water from the pits. Once the abstraction machines were removed, the groundwater levels rose and filled some of the pits, hence the existence of the Branston Water Park. As a result of this, there has been one report regarding the occurrence of minor cellar flooding.

As such the risk of flooding from ground water is considered to be low; however, the ground water level may influence the proposed drainage strategy within the site.

Severn Trent Water is the statutory water undertaker and is responsible for the public sewer systems within Uttoxeter area. Severn Trent Water maintains a register of historical sewer flooding events (DG5 Register) within the area. There are no report instances close to the development site.

4. FLOOD RISK ASSESSMENT

Requirements of the Environment Agency

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

The Environment Agency will request that the runoff from the proposed development is restricted to the existing peak runoff rate. The existing site is not considered to be 'brownfield development' hence a further 30% reduction will not need to be applied to the estimated peak run off rate in order to accommodate climate change over the lifetime of the development. They will further insist that the proposed 1 in 2 year runoff can be maintained and also insist that the 1 in 30 year event is not allowed to flood the surface; hence the water must remain within the pipes, manholes, and storage systems. The 1 in 100 year plus climate change event will be allowed to flood the surface but flood water will not be permitted to enter any of the buildings within the site. The 1 in 100 year plus climate change flood must also be limited to the development boundary and must not be allowed to migrate to adjacent properties.

River Dove

The River Dove rises on the slopes of Axe Edge, close to the Leek to Buxton Road and runs southward for 45 miles to join the River Trent to the north of Burton Upon Trent. It is predominantly a rural river, flowing through Derbyshire and Staffordshire. The confluence with the River Tean is directly upstream of the A50 road bridge.

The River Dove is located approximately 1200m to the east of the site. In line with the site there are no flood defences which protect the site or Uttoxeter.

1 in 100 year flood event within the River Dove

The Environment Agency has provided modelled flood levels for the River Dove directly in line with the site. The data provided is shown at Appendix C of this report. It is considered that node references RD77D to RD75 which are in line with the site are the most representative. The 1 in 100 year flood level has been estimated at between 75.71mOD and 76.30mOD between these nodes.

The lowest ground level within the sites is 76.96mOD. As such during the 1 in 100 year event the water level would be at least 0.6m below the lowest ground level within the site.

As such during the 1 in 100 year flood event the site and its access route will not be flooded.

Increase in estimated flood level due to Climate Change

PPS25 states that *'…Flood risk assessment should be carried out to the appropriate degree at all levels of the planning process, to assess the risks of all forms of flooding to and from development taking climate change into account. The future users of the development must not be placed in danger from flood hazards and should remain safe throughout the lifetime of the plan or proposed development and land use*.'

As part the proposed development is for a residential land use, consideration has therefore been given to take into account the potential effects of climate change over the next 100 years in accordance with PPS25. The Environment Agency provided an estimated 1 in 100 year plus climate change flood level in line with the site.

The data provided is shown at Appendix C of this report. It is considered that node references RD77D to RD75 which are in line with the site are the most representative. The 1 in 100 year plus climate change flood level has been estimated at between 75.90mOD and 76.40mOD between these nodes.

The lowest ground level within the sites is 76.96mOD. As such during the 1 in 100 year event the water level would be at least 0.56m below the lowest ground level within the site. The 1 in 100 year plus climate change flood envelope has been annotated onto the topographical survey of the area to the south east of the site. The flood map is provided at Appendix D of this report.

As such during the 1 in 100 year plus climate change flood event the site and its access route will not be flooded.

Extreme 1 in 1,000 year flood event within the River Dove

The Environment Agency has provided modelled flood levels for the River Dove directly in line with the site. The data provided is shown at Appendix C of this report. It is considered that node references RD77D to RD75 which are in line with the site are the most representative. The 1 in 1,000 year flood level has been estimated at between 76.45mOD and 76.64mOD between these nodes.

The lowest ground level within the sites is 76.96mOD. As such during the 1 in 1,000 year event the water level would be at least 0.32m below the lowest ground level within the site.

As such during the 1 in 1,000 year flood event the site and its access route will not be flooded.

Uttoxeter Brook

Uttoxeter Brook rises within the centre of Uttoxeter and conveys flows north east towards the Dove Way where it turns south east towards the River Dove. The brook is generally shallow (1.5m maximum) with a narrow bed width (1.5m maximum) with steep sides. There are no flood defences or flood walls and as such relies upon the natural bank top for its defence. The upper reaches of the brook flows through Site B and adjacent to the lower part of Site A.

1 in 100 year flood event within the Uttoxeter Brook

The Environment Agency has provided modelled flood levels for the Uttoxeter Brook from its upstream limit adjacent to Pennycroft Lane to downstream of Derby Road. The data provided is shown at Appendix E of this report.

Node references 2466 and 2473D are located adjacent to Site A. The 1 in 100 year flood level is estimated at between 77.28mOD and 77.30mOD and the lowest bank top level in this area has been surveyed at 77.60mOD. As such during the 1 in 100 year event Site A will not be flooded from the Uttoxeter Brook.

Node references 2473U to 2806 are located adjacent to Site B. Generally the 1 in 100 year flood is maintained within the natural river channel and as such the site is not flooded. However, there is a small 600mm diameter culvert within the centre of the site which backs up during the 1 in 100 year flood resulting in overtopping of the right bank of the Uttoxeter Brook. The right bank top level has been surveyed by the Environment Agencies modelling consultants at 78.53mOD (node 2631U) and the 1 in 100 year flood level at this node has been estimated at 78.59mOD. As such during this event the right bank will be overtopped by 0.06m resulting in the lower area within the south east part of Site B being flooded. Eventually the flows will continue through the site and re-enter the Uttoxeter Brook via the small watercourse to the south of the site. The flood envelope produced by the Environment Agency is also provided at Appendix E which clearly shows the overtopping upstream of the culvert.

Increase in estimated flood level due to Climate Change

PPS25 states that '*…Flood risk assessment should be carried out to the appropriate degree at all levels of the planning process, to assess the risks of all forms of flooding to and from development taking climate change into account. The future users of the development must not be placed in danger from flood hazards and should remain safe throughout the lifetime of the plan or proposed development and land use*.'

As part the proposed development is for a residential land use, consideration has therefore been given to take into account the potential effects of climate change over the next 100 years in accordance with PPS25. The Environment Agency provided an estimated 1 in 100 year plus climate change flood level in line with the site.

Node references 2466 and 2473D are located adjacent to Site A. The 1 in 100 year plus climate change flood level is estimated at between 77.29mOD and 77.31mOD and the lowest bank top level in this area has been surveyed at 77.60mOD. As such during the 1 in 100 year plus climate change event Site A will not be flooded from the Uttoxeter Brook.

Node references 2473U to 2806 are located adjacent to Site B. Generally the 1 in 100 year plus climate change flood is maintained within the natural river channel and as such the site is not flooded. However, there is a small 600mm diameter culvert within the centre of the site which backs up during the 1 in 100 year plus climate change flood resulting in overtopping of the right bank of the Uttoxeter Brook. The right bank top level has been surveyed by the Environment Agencies modelling consultants at 78.53mOD and the 1 in 100 year plus climate change flood level at this node has been estimated at 78.65mOD (node 2631U). As such during this event the right bank will be overtopped by 0.120m resulting in the lower area within the south east part of Site B being flooded. Eventually the flows will continue through the site and re-enter the Uttoxeter Brook via the small watercourse to the south of the site. The flood envelope produced by the Environment Agency is also provided at Appendix E which clearly shows the overtopping upstream of the culvert.

Extreme 1 in 1,000 year flood event within the Uttoxeter Brook

The Environment Agency has provided modelled flood levels for the Uttoxeter Brook from its upstream limit adjacent to Pennycroft Lane to downstream of Derby Road. The data provided is shown at Appendix E of this report.

Node references 2466 and 2473D are located adjacent to Site A. The 1 in 1,000 year flood level is estimated at between 77.30mOD and 77.33mOD and the lowest bank top level in this area has been surveyed at 77.60mOD. As such during the 1 in 100 year event Site A will not be flooded from the Uttoxeter Brook.

Node references 2473U to 2806 are located adjacent to Site B. Generally the 1 in 100 year flood is maintained within the natural river channel and as such the site is not flooded. However, there is a small 600mm diameter culvert within the centre of the site which backs up during the 1 in 1,000 year flood resulting in overtopping of the right bank of the Uttoxeter Brook. The right bank top level has been surveyed by the Environment Agencies modelling consultants at 78.53mOD (node 2631U) and the 1 in 1,000 year flood level at this node has been estimated at 78.72mOD. As such during this event the right bank will be overtopped by 0.190m resulting in the lower area within the south east part of Site B being flooded. Eventually the flows will continue through the site and re-enter the Uttoxeter Brook via the small watercourse to the south of the site. The flood envelope produced by the Environment Agency is also provided at Appendix E which clearly shows the overtopping upstream of the culvert.

Uttoxeter Brook Re-profile Modelling

It was found that during the 1 in 100 year flood event the right bank of the Uttoxeter Brook within Site B was overtopped by 0.06m and during the 1 in 100 year plus climate change flood event the right bank was overtopped by 0.120m. During the extreme 1 in 1,000 year flood event the right bank was overtopped by 0.190m. The overtopping is generally a result of the access culvert located within the centre of Site B causing flows to back up and overtop the right bank. As such it is proposed to remove the culvert and modify the channel to provide a two stage channel which will also be used to access the brook by the Environment Agency for maintenance purposes. This section considers the proposed modifications to the channel within Site B. The existing geometry and flow data used within the Uttoxeter Brook model by the Environment Agencies consultants have been used to construct a 1d HEC RAS model in order to allow the proposed modifications to be modelled.

Hydrological Assessment

The estimation of peak flows for a range of annual probabilities or 'design' events has been required to enable the flood mapping of the watercourses adjacent to the site to be undertaken. The Environment Agency provided the hydrographs for the Uttoxeter Brook used in the recently completed modelling exercise. The hydrographs for the 1 in 100 year, 100 year plus climate change and the 1 in 1,000 year extreme flood event at node reference 2806 (upstream limit of the study) are provided at Appendix F of this report. Hydrographs for each node reference within the site were provided by the Environment Agency. However, it was found that the hydrographs at node 2806 were representative of the section of the brook within Site B. The following peak flows shown below in Table 4-1 have been extracted from the hydrographs and used within the HEC RAS model.

Table 4-1: Peak flows within Site B

Return Period	Peak Flow (m^3/s)
1 in 100 year	1.87
1 in 100 year plus climate change	2.23
1 in 1,000 year extreme	3.25

Hydraulic Modelling

Introduction

The purpose of the hydraulic modelling has been to produce peak water levels from the derived design flow estimates for the Uttoxeter Brook catchment, in order to establish the capacity of the brook adjacent to the development site.

A steady-state (backwater) model has been used for hydraulic modelling in this study. The HEC-RAS v4.0 software package developed by the US Army Corps of Engineers has been used. The advantages of backwater models are that they are inherently conservative, as they do not allow any attenuation of the design discharge.

Topographic Survey – In-bank Cross Sections

The geometry of natural channel is irregular and cannot be characterised by simple mathematical relationships. Therefore representation in mathematical models requires that the stream geometry, in the form of discrete cross sections, be taken transversely at key locations in the watercourse. The cross sections used by the Environment Agencies modelling consultants were used to construct the geometry data within the model. The cross sections are referred to as cross section 2518, 252, 2608, 2631D, 2631U, 2667, 2733 and 2806.

The locations of the cross sections, as surveyed, are shown at Appendix E.

Topographic Survey – Over-bank Cross Sections

The in-bank survey described previously is sufficient to estimate water levels provided the flows remain within the confines of the main channel. In order to account for conveyance when flow overtops the main channel banks, the in-bank cross sections should be extended across the full width of the floodplain. Therefore section lines have been extended across the development site.

Levees have been used in suitable locations in the model to prevent water being conveyed along sections of the floodplain where it would be unable to reach.

The topographical survey provided by the client has been used to extend the in-channel cross sections further into the flood plain.

Model Schematisation

The HEC-RAS model comprises of a single reach Uttoxeter Brook reach 001. The extents of the model are given below in Table 4-2 and shown at Appendix E.

Table 4-2: Model Extents

Watercourse	Upstream Extent	Downstream Extent
Uttoxeter Brook	Cross Section 2806 prior to culvert from urbanised area	Cross section 2473U directly upstream of A50 by-pass box culvert

In total 10 cross sections, of which there are two access culverts within the study reach which has been used to develop the model as shown in Table 4.4.

Channel roughness parameters, specified as Manning's n, were derived for each model cross section from the application of Cowan's procedure and the comparison of photographs with published values (e.g. Chow, 1957). For the purposes of specifying Manning's n values, the Uttoxeter Brook was considered as a single reach characterised by similar floodplain and channel bank roughness conditions. A description of the reach is provided in Table 4.3 overleaf. The values were verified by EWE Associates Ltd during a site inspection. During the site inspection an Engineer walked along the bed of the watercourse for the entire study reach. The manning's values were adjusted slightly to suit the modelled flood levels predicted by the Environment Agencies modelling consultants. The tabulated manning's values were found to produce slightly increased water levels above the original model results. As such the model was conservatively adopted.

Table 4-3: Estimated Manning's n Values for local watercourse

Cross Section References	Main Channel Manning's n Value	Floodplain Manning's n Value		Location	Description
		Left	Right		
2667	0.055	0.040	0.040	Directly downstream of the site	Main Channel: vegetation, sections of straight channel with sharp bends , full with no rifts or deep pools. The channel contains weeds and stones. Floodplain: Agricultural/grassland paddocks

Boundary Conditions

The Uttoxeter Brook flows downstream through Site B for 288m. The downstream water level was set at the corresponding estimated flood level for node reference 2518 as estimated by the Environment Agencies modelling consultants. The downstream flood levels were used within the model as shown below in Table 4-4. The HEC-RAS model was run for all the design flows given in Table 4.1.

Table 4-4: Downstream boundary levels

Return Period	Level (m)
1 in 100 year	77.44
1 in 100 year plus climate change	77.47
1 in 1,000 year extreme	77.52

Model Coefficients

Flow contraction and expansion coefficients were determined using the HEC-RAS Users Manual. Contraction and expansion coefficients are used by the hydraulic model computations to determine the transition losses due to the expansion and constriction of flow, between two adjacent cross sections. The manual suggests that values of 0.1 (contraction) and 0.3 (expansion) are typical for a gradual transition along an open channel. Typical bridge contraction and expansion coefficients are estimated to vary from 0.1 to 0.6 for contraction and between 0.3 and 0.8 for expansion.

In this instance, coefficients of 0.3 and 0.5 have been applied to the contraction and expansion sections upstream and downstream of the bridges. Values of 0.1 and 0.3 have been adopted for the open channel sections.

Structure Data

Two structures, considered hydraulically significant, has been identified within Uttoxeter Brook and modelled using the HEC-RAS bridge routine (See Table 4.5).

Table 4-5: Bridge and Culvert Details

HEC-RAS Reference	Structure	Description	Structure Length (m)	Piers
CUL2611	Single 600mm diameter Culvert	Pedestrian Access	5m	None
CUL2722	Twin 600mm diameter culvert	Vehicular Access	21m	None

Assumptions & Limitations of the Model

The representation of any complex system by a model requires a number of assumptions to be made. In the case of a one dimensional hydraulic model of a river system it must be assumed that:

- The cross sections accurately represent the river.
- The hydrological analysis based on the gauged data (where available) can be extrapolated to other parts of the system.
- The design flows are an accurate representation of flows of a given return period.

Limitations of the Model

Owing to the lack of gauged data for local watercourse during flood events in this part of the catchment, the model has not been calibrated against observed flood levels. Instead, careful consideration has been given to the selection of roughness, structure discharge coefficients and ineffective flow boundaries. The theory of these is well understood and the model may be considered appropriate for flows up to bank full capacity and simple flow on the floodplain.

The model is less appropriate for complex out-of-bank flow routes that may not be represented in the schematisation. Also the model will not represent flooding from the drainage system where backing up in the sewers may lead to flooding away from the watercourse.

Model Simulations

Introduction

The primary aim of this study was to initially construct a model which would generate similar flood levels to the model which was constructed by the Environment Agencies modelling consultant. However, it should be noted that the Environment Agency model was a 2d ISIS model which also used unsteady hydrographs and therefore there are likely to be differences between the models.

The HEC-RAS steady state model has been used in conjunction with the design peak flows to determine water levels in the Uttoxeter Brook during the 100-year return period flood event. The 1 in 100 year plus 20% to account for climate change and the 1 in 1,000 extreme flood level has also been considered.

Un-obstructed Flow Simulation

Tabulated below in Table 4-6 are the modelled flood levels during the 1 in 100 year, 1 in 100 year plus climate change and 1 in 1,000 year extreme flood events for the existing Uttoxeter Brook through Site B. The model has been constructed in order to provide an initial baseline for the proposed modification works which will be undertaken as part of the proposed development. The HEC RAS table and the longitudinal section through the brook are provided at Appendix G of this report.

Table 4-6: Water Levels at Key Locations during unobstructed flow

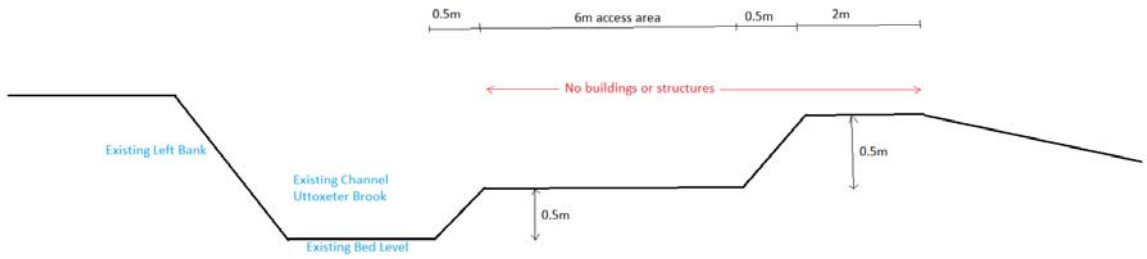
Cross Section Reference	100yr Water Level (mOD)	100yr+CC Water Level (mOD)	1000yr Water Level (mOD)	Comments
2806	81.08	81.12	81.23	In channel
2733	80.33	80.95	81.10	In channel
2711	79.05	79.16	79.32	In channel
2667	78.44	78.46	78.60	In channel
2636U	78.53	78.53	78.65	Overtops right bank
2631D	78.20	78.25	78.37	In channel
2614	77.95	78.01	78.15	In channel
2608	77.82	77.89	78.06	In channel
2562	77.56	77.62	77.77	In channel
2518	77.44	77.47	77.52	In channel

Un-obstructed Flow Simulation – Proposed Modification to Channel

During the extreme 1 in 1,000 year flood event the right bank upstream of the 600mm diameter access culvert is overtopped by 0.190m resulting in the lower part of the site to the south east being flooded. As such it is proposed that the 600mm diameter culvert is removed and replaced with a single span access bridge approximately 20m downstream. The soffit of the bridge will be constructed above the estimated 1 in 1,000 year flood level to ensure that the structure does not impede flows. Removing the access culvert reduces the water level within the brook during the 1 in 100 year and the 1 in 100 year plus climate change events sufficiently that flows remain in channel. However, during the 1 in 1,000 year there is still some minor overtopping.

As such the main channel of the Uttoxeter Brook between cross sections 2518 and 2711 will be re-profiled to provide a two stage channel. The higher level will be 6m wide to allow permanent access for the Environment Agency and will be 0.5m higher than the existing bed level. It is considered that the main channel will not require any regarding. A typical proposed section through the brook is shown below in Figure 4.1.

Figure 4.1: Typical section through the Uttoxeter Brook within Site B.



Tabulated below in Table 4-7 are the modelled flood levels during the 1 in 100 year, 1 in 100 year plus climate change and 1 in 1,000 year extreme flood events for the modified Uttoxeter Brook through Site B. The HEC RAS table and the longitudinal section through the brook are provided at Appendix H of this report.

Table 4-7: Water Levels at Key Locations during unobstructed flow for modified channel

Cross Section Reference	100yr Water Level (mOD)	100yr+CC Water Level (mOD)	1000yr Water Level (mOD)	Comments
2806	81.08	81.12	81.23	In channel
2733	80.10	80.69	81.08	In channel
2711	78.83	78.87	78.96	In channel
2667	78.47	78.51	78.59	In channel
2636	78.27	78.31	78.40	In channel
2631	78.20	78.25	78.35	In channel
2614U	77.95	78.00	78.11	In channel
2608D	77.76	77.80	77.90	In channel
2562	77.55	77.59	77.71	In channel
2518	77.44	77.47	77.52	In channel

Flood Mapping

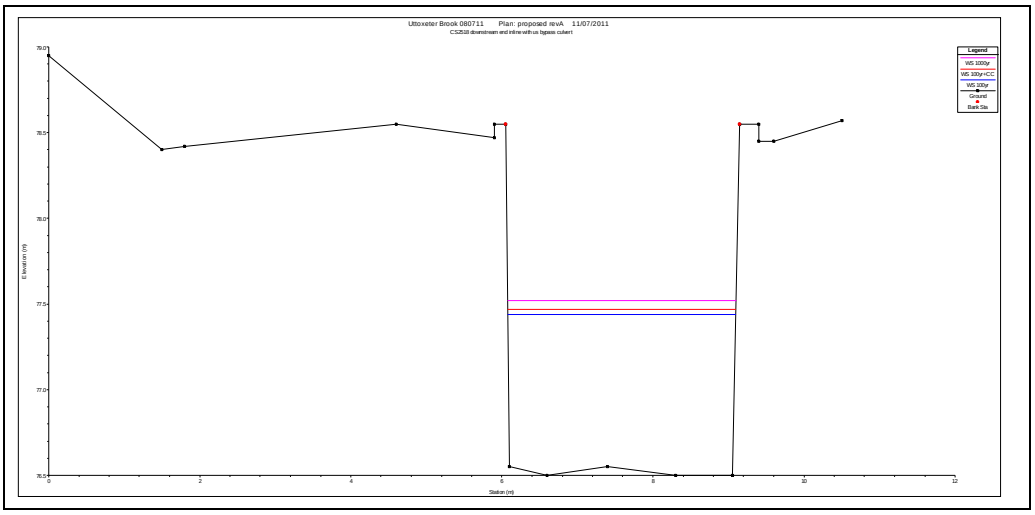
Overview

It is required that a cross section through the main channel of the Uttoxeter Brook within Site B be produced for the 1 in 100 year, 1 in 100 year return period event plus 20% for climate change and the 1 in 1,000 year extreme flood events. The longitudinal section and the tabulated results for the Uttoxeter Brook are provided at Appendix F.

Results

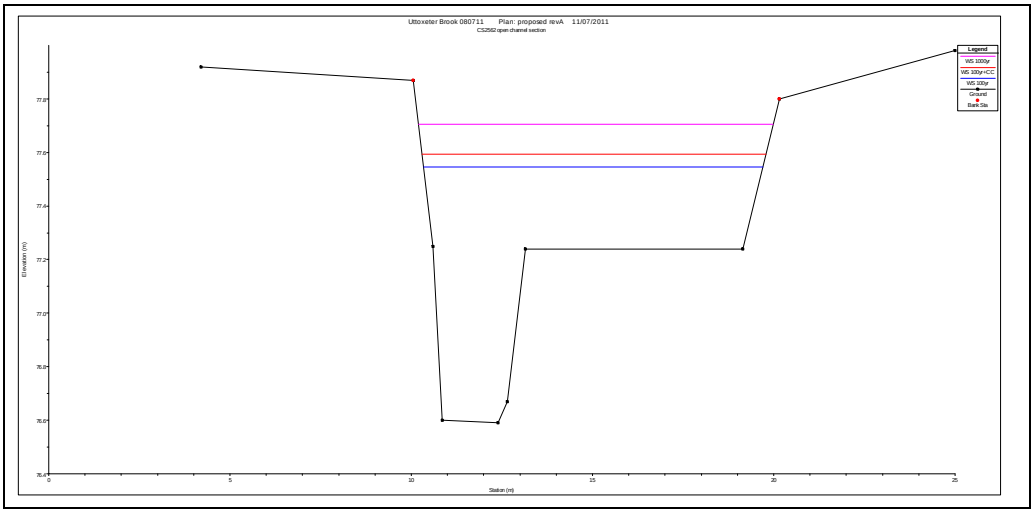
Cross Section 2518 is located at the downstream end of the site and the HEC RAS output section is shown below at Figure 4.2. A maximum 1 in 1,000 year flood level of 77.52mOD was estimated. The water is maintained within the channel and the site is not flooded.

Figure 4.2: Cross Section 2518 HEC RAS Output



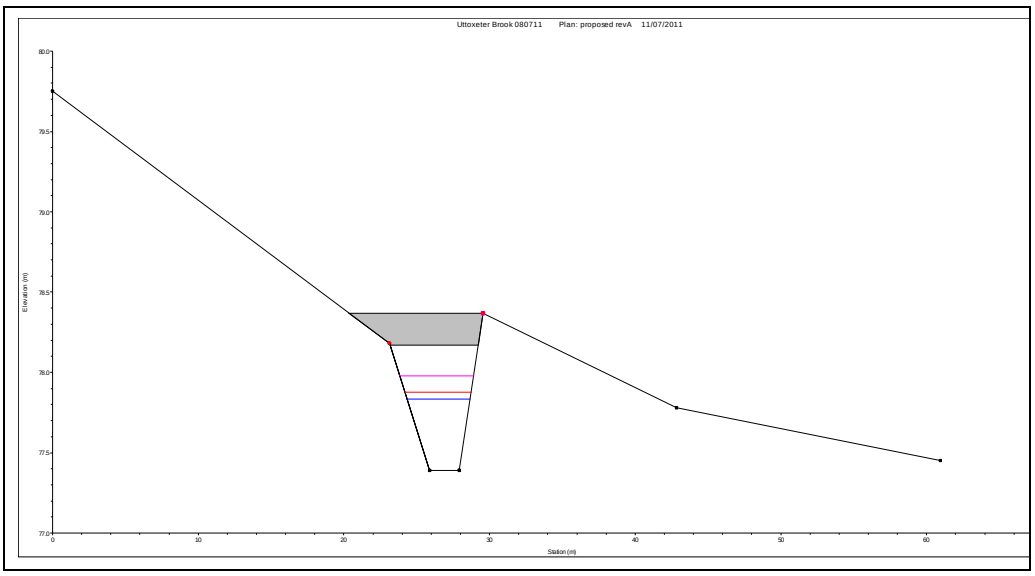
Cross Section 2562 is located at the downstream end of the site and the HEC RAS output section is shown below at Figure 4.3. A maximum 1 in 1,000 year flood level of 77.71mOD was estimated. The water is maintained within the channel and the site is not flooded. The right bank has been modified to include a two stage channel.

Figure 4.3: Cross Section 2562 HEC RAS Output



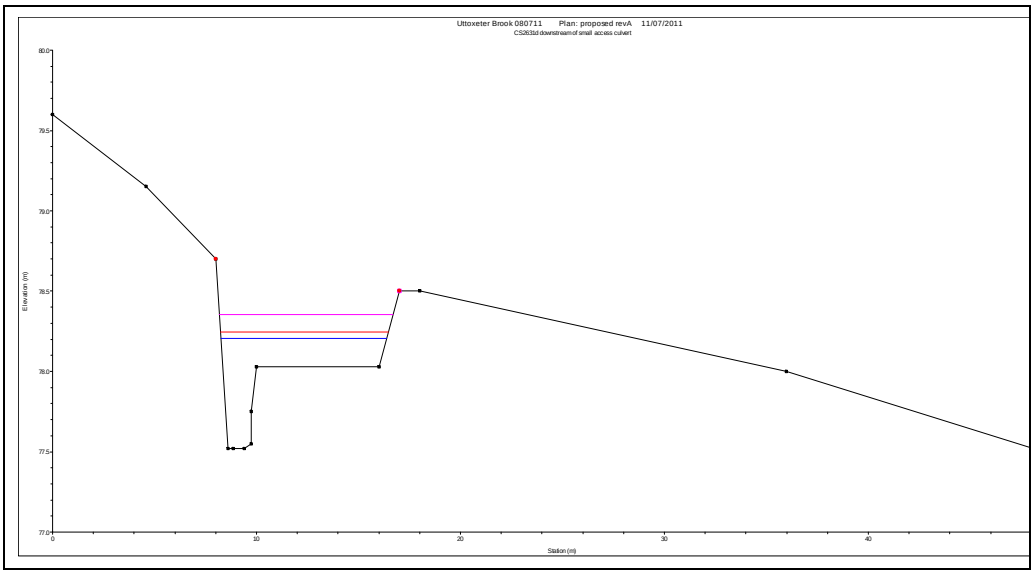
Cross Section 2611 is located at the downstream end of the new access bridge and the HEC RAS output section is shown below at Figure 4.4. A maximum 1 in 1,000 year flood level of 77.90mOD was estimated directly upstream of the bridge. The water is maintained within the channel and the site is not flooded. The right bank has not been modified to include a two stage channel due to the proposed bridge abutments.

Figure 4.4: Cross Section 2611 HEC RAS Output



Cross Section 2631 is located at the downstream end of the access culvert which was removed and the HEC RAS output section is shown below at Figure 4.5. A maximum 1 in 1,000 year flood level of 78.35mOD was estimated directly upstream of the bridge. The water is maintained within the channel and the site is not flooded. The right bank has been modified to include a two stage channel.

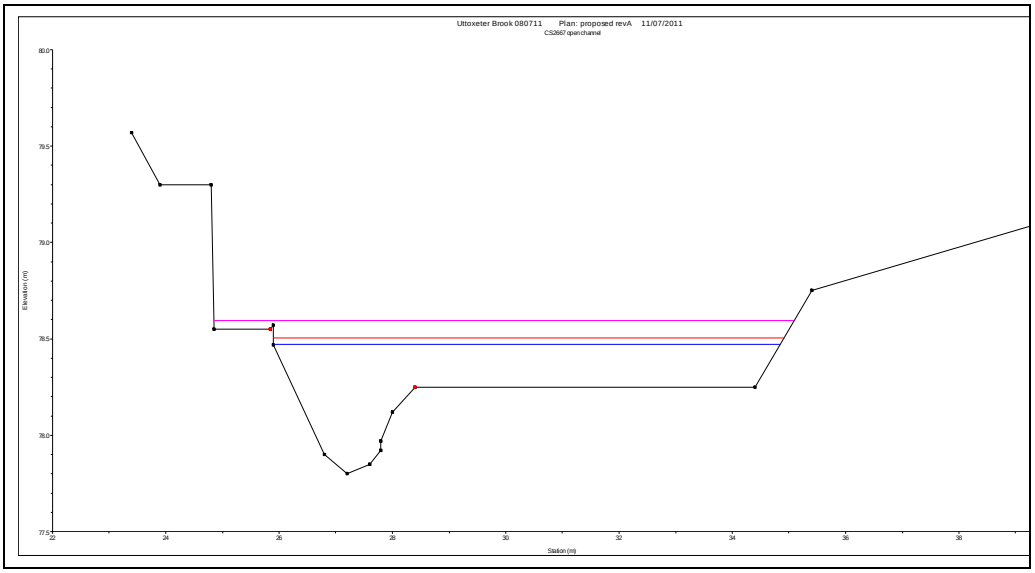
Figure 4.5: Cross Section 2631 HEC RAS Output



Cross Section 2667 is located at the upstream end of the site and the HEC RAS output section is shown overleaf at

Figure 4.6. A maximum 1 in 1,000 year flood level of 78.59mOD was estimated. The water is maintained within the channel and the site is not flooded. The right bank has been modified to include a two stage channel.

Figure 4.6: Cross Section 2667 HEC RAS Output



Conclusion

It is concluded that the proposed modification to the Uttoxeter Brook which include the removal of the 600mm diameter access culvert and the modification of the channel to provide a two stage channel result in the water levels remaining in channel up to and including the 1 in 1,000 year extreme event.

Surface Water Runoff

Existing Development Site

The proposed development site has been split into two distinct areas. Site A is located to the north of the Dove Way and Site B is to the south.

Site A

Site A consists of a single large field which is presently used for grazing and a smaller field which again is used for grazing. The combined area has been estimated at 4.71 hectares. There are no buildings or structures within the site and no paved areas to increase runoff. As such the existing site is considered to be 100% permeable. It is assumed that there is no formalised field drainage system eventually discharging to a positive outfall. As such the site is considered to discharge in a south easterly direction at the existing Greenfield runoff rate towards the Uttoxeter Brook as illustrated in Appendix A of this report by the green arrows.

During the day of the site inspection there was signs of ground water and ponded water close to the Uttoxeter Brook in the lower areas of Site A.

Site investigation data is available for the development site which shows that the ground water level was encountered as high as 76mOD within Site A. The report also shows the higher areas within Site A are generally made ground over Alluvial Clay and Mudstone which suggest that the area would not be suitable for infiltration drainage.

The Severn Trent Water sewer plan shows that SiteA1 is crossed by a gravity foul sewer and a pumped foul sewer which eventually discharge into the adjacent sewerage treatment works to the north east of Site A. There are no surface water or combined sewers within Site A.

Based on the above it is considered that the whole of the site will be able to practically discharge surface water to the Uttoxeter Brook. It is unlikely due to high ground water levels, the presence of made ground and alluvial clay that infiltration drainage will be a practical solution for Site 1. It is considered that any overland flow resulting from extreme rainfall events is likely to flow in a south east direction eventually discharging into the Uttoxeter Brook at the south east corner of the site.

For the purpose of this assessment the peak discharge rate from the site of 5 l/s/ha has been conservatively adopted. During a meeting with the Environment Agency Development Control Officer it was confirmed that this would be an appropriate discharge rate for the area. Any discharge from the site into the Uttoxeter Brook will require the consent of Environment Agency and as such they will also need to be approached to agree the discharge restriction from the site.

It is recommended that a soil permeability test is performed to the required local authority standard to assess potential for soakaway use. If the soakaway tests confirm that the underlying soils are not adequate for soakaways the Uttoxeter Brook which is located to the south east of the site adjacent to the Dove Way should be adopted as a point of discharge for the roof and highway drainage within Site A.

Site B

Site B consists of a two small fields which are presently used for grazing. The combined area has been estimated at 2.42 hectares. There are no buildings or structures within the site and no paved areas to increase runoff. As such the existing site is considered to be 100% permeable. It is assumed that there is no formalised field drainage system eventually discharging to a positive outfall. As such the site is considered to discharge in a south easterly

direction at the existing Greenfield runoff rate towards the Uttoxeter Brook as illustrated in Appendix A of this report by the green arrows.

During the day of the site inspection there was signs of ground water and ponded water close to the Uttoxeter Brook in the lower areas of Site B and within the south east parcel of the site.

Site investigation data is available for the development site which shows that the ground water level was encountered as high as 79.5mOD within Site B. The report also shows the higher areas within Site B are generally topsoil over sands and gravels which suggest that the higher parts of the site may be suitable for infiltration drainage.

The Severn Trent Water sewer plan shows that Site B is crossed by a gravity foul sewer which eventually discharge into the sewerage treatment works to the north of Site B. There are no surface water or combined sewers within Site B.

Based on the above it is considered that the upper part of the site will be able to practically discharge surface water to the Uttoxeter Brook. It is likely that some of the upper parts of the site will be able to discharge some runoff via infiltration. However, due to the presence of a ground water source and the adjacent contaminated site is is assumed that only roof water will be acceptable in this area. It is assumed that the lower part of the site will not be able to practically discharge surface water drainage via infiltration due to the high ground water levels, the presence of made ground and alluvial clay. It is therefore assumed that some land raising will be required in this area to enable the site to be discharged to the Uttoxeter Brook via gravity. It is considered that any overland flow resulting from extreme rainfall events is likely to flow in a south east direction eventually discharging into the Uttoxeter Brook.

For the purpose of this assessment the peak discharge rate from the site of 5 l/s/ha has been conservatively adopted. During a meeting with the Environment Agency Development Control Officer it was confirmed that this would be an appropriate discharge rate for the area. Any discharge from the site into the Uttoxeter Brook will require the consent of Environment Agency and as such they will also need to be approached to agree the discharge restriction from the site.

It is recommended that a soil permeability test is performed to the required local authority standard to assess potential for soakaway use. If the soakaway tests confirm that the underlying soils are not adequate for soakaways the Uttoxeter Brook which is located to the south east of the site adjacent to the Dove Way should be adopted as a point of discharge for the roof and highway drainage within Site B.

Proposed Development Drainage Strategy

Site A

Due to the presence of elevated ground water within the lower parts of the site and made ground overlying Alluvial Clay in the upper areas it is considered that infiltration drainage is not a practical solution for this site. However, due to the existing ground levels within the site it is considered that the site will be able to drain via gravity to the Uttoxeter Brook, which is located within the south east corner of site A, at a Greenfield runoff rate of 5 l/s/ha. This has been made easier by the developer splitting the site into sub areas and providing attenuation within each sub area separately. As such room within the development site has been made for ponds and sub base drainage systems. Site A has been split into areas 3, 4, 5 and 6 and are shown on the Drainage Strategy plan provided at Appendix I of this report.

Site B

Due to the presence of elevated ground water within the lower parts of the site and made ground overlying Alluvial Clay it is considered that infiltration drainage is only a practical solution for the higher parts of the site. If soil permeabilities at the site are very low (less than 1×10^{-6} m/s) it will be impractical to rely on infiltration drainage to dispose of the stormwater runoff. As such, it will be necessary to adopt the discharge to the Uttoxeter Brook. At this stage no infiltration tests have been carried out on the site and therefore it is difficult to establish the likely infiltration rate for the site.

Due to the potential contamination of the ground water source only infiltration drainage has been adopted for the roofed areas within the upper part of the site. The road drainage will be directed to a balancing pond before discharging to the Uttoxeter Brook, which is located within the centre of the site, at a Greenfield runoff rate of 5 l/s/ha.

It is considered that the lower areras of the site will need to be raised in order to allow a gravity discharge to the Uttoxeter Brook. It is envisaged that oversized pipes will be required to provide attenuation in this area before discharging to the Uttoxeter Brook at a Greenfield runoff rate of 5 l/s/ha. Site B has been split into areas 1 and 2 and is shown on the Drainage Strategy plan provided at Appendix I of this report.

Site A Area 3 – Discharge to Uttoxeter Brook via Pond

Area 3 which is 2.71 hectares in area is 100% permeable, however, infiltration drainage is assumed to be impractical in this area and therefore a piped connection to the Uttoxeter Brook will be provided within the highway to discharge at the current Greenfield runoff rate. The increase in runoff will be attenuated by the introduction of a pond 1750m² in area.

The existing Greenfield runoff rate has been estimated at 5 l/s/ha and therefore based on a total area of 2.71 hectares the 1 in 2 year Greenfield runoff from the site is estimated at 13.6 l/s. It is considered that a hydro-brake or office plate will be required prior to discharging into the sewer connection to the brook to regulate the flow. A flapped outfall will need to be constructed adjacent to the Uttoxeter Brook.

An assessment of the required balance volume has been made assuming the post development impermeable area is 2.71 hectares. Using WinDes Source Control software developed by Microdrainage the required attenuation has been calculated for the 1 in 100 year plus climate change (30%) event. The peak discharge was set at 13.6 l/s has been used for the storage calculations within the model.

Reference should be made to Appendix J where the calculation sheets are provided. The attenuation sizes have been tabulated below in Table 4-8.

Table 4-8: Modified Rational Method balance volume for Area 3

Return Period	Approx Volume (m³)
1 in 100 year + CC	Pond 1750m² by 0.93m deep = 1628m³

The proposed drainage strategy has been annotated onto the site layout drawing provided at Appendix I which clearly shows the points of discharge from area 3 and the area proposed for attenuation.

Site A Area 4 – Discharge to Uttoxeter Brook via oversized pipes

Area 4 which is 0.3117 hectares in area is 100% permeable, however, infiltration drainage is assumed to be impractical in this area and therefore a piped connection to the Uttoxeter Brook will be provided within the highway to discharge at the current Greenfield runoff rate. The increase in runoff will be attenuated by the introduction of an oversized pipe within the main highway. This area consists of the main highway within the lower part of the site which connects areas 3, 5, 6 and 7.

The existing Greenfield runoff rate has been estimated at 5 l/s/ha and therefore based on a total area of 0.31 hectares the 1 in 2 year Greenfield runoff from the site is estimated at 1.6 l/s. However, it is considered impractical to reduce flows to below 2 l/s as the device will be prone to blockages and therefore it is proposed that the discharge from Area 4 into the Uttoxeter Brook is limited to 2 l/s. It is considered that a hydro-brake or office plate will be required prior to discharging into the sewer connection to the brook to regulate the flow. A flapped outfall will need to be constructed adjacent to the Uttoxeter Brook.

An assessment of the required balance volume has been made assuming the post development impermeable area is 0.31 hectares. Using WinDes Source Control software developed by Microdrainage the required attenuation has been calculated for the 1 in 100 year event. The peak discharge was set at 2 l/s has been used for the storage calculations within the model.

Reference should be made to Appendix K where the calculation sheets are provided. The attenuation sizes have been tabulated below in Table 4-9.

Table 4-9: Modified Rational Method balance volume for Area 4

Return Period	Approx Volume (m³)
1 in 100 year	Oversized pipe 350m of 0.75m diameter pipe

The proposed drainage strategy has been annotated onto the site layout drawing provided at Appendix I which clearly shows the points of discharge from area 4 and the area proposed for the oversized pipes. It is proposed that during the 1 in 100 year plus climate change (30%) event that the additional volume above the 1 in 100 year volume which will be stored below ground will be maintained within the carriageway.

Site A Area 5 – Discharge to Uttoxeter Brook via crate system

Area 5 which is 0.127 hectares in area is 100% permeable, however, infiltration drainage is assumed to be impractical in this area and therefore a piped connection to the Uttoxeter Brook will be provided within the highway to discharge at the current Greenfield runoff rate. The increase in runoff will be attenuated by the introduction of 68m³ of crates.

The existing Greenfield runoff rate has been estimated at 5 l/s/ha and therefore based on a total area of 0.028 hectares the 1 in 2 year Greenfield runoff from the site is estimated at 0.7 l/s. However, it is considered impractical to reduce flows to below 2 l/s as the device will be prone to blockages and therefore it is proposed that the discharge from Area 6 into the Uttoxeter Brook is limited to 2 l/s. It is considered that a hydro-brake or office plate will be required prior to discharging into the sewer connection to the brook to regulate the flow. A flapped outfall will need to be constructed adjacent to the Uttoxeter Brook.

An assessment of the required balance volume has been made assuming the post development impermeable area is 0.127 hectares. Using WinDes Source Control software developed by Microdrainage the required attenuation has been calculated for the 1 in 100 year plus climate change (30%) event. The peak discharge was set at 2 l/s has been used for the storage calculations within the model.

Reference should be made to Appendix M where the calculation sheets are provided. The attenuation sizes have been tabulated below in Table 4-10.

Table 4-10: Modified Rational Method balance volume for Area 6

Return Period	Approx Volume (m³)
1 in 100 year + CC	Crates 14m x 12m x 0.4m to provide required 68m³

The proposed drainage strategy has been annotated onto the site layout drawing provided at Appendix L which clearly shows the points of discharge from area 6 and the area proposed for attenuation.

Site A Area 6 – Discharge to Uttoxeter Brook via crate system

Area 6 which is 0.23 hectares in area is 100% permeable, however, infiltration drainage is assumed to be impractical in this area and therefore a piped connection to the Uttoxeter Brook will be provided within the highway to discharge at the current Greenfield runoff rate. The increase in runoff will be attenuated by the introduction of 137m³ of crates.

The existing Greenfield runoff rate has been estimated at 5 l/s/ha and therefore based on a total area of 0.23 hectares the 1 in 2 year Greenfield runoff from the site is estimated at 1.2 l/s. However, it is considered impractical to reduce flows to below 2 l/s as the device will be prone to blockages and therefore it is proposed that the discharge from Area 7 into the Uttoxeter Brook is limited to 2 l/s. It is considered that a hydro-brake or office plate will be required prior to discharging into the sewer connection to the brook to regulate the flow. A flapped outfall will need to be constructed adjacent to the Uttoxeter Brook.

An assessment of the required balance volume has been made assuming the post development impermeable area is 0.23 hectares. Using WinDes Source Control software developed by Microdrainage the required attenuation has been calculated for the 1 in 100 year plus climate change (30%) event. The peak discharge was set at 2 l/s has been used for the storage calculations within the model.

Reference should be made to Appendix M where the calculation sheets are provided. The attenuation sizes have been tabulated below in Table 4-11.

Table 4-11: Modified Rational Method balance volume for Area 7

Return Period	Approx Volume (m³)
1 in 100 year + CC	Crates 19m x 18m x 0.4m to provide required 137m³

The proposed drainage strategy has been annotated onto the site layout drawing provided at Appendix N which clearly shows the points of discharge from area 7 and the area proposed for attenuation.

Site B Area 1 – Discharge to Uttoxeter Brook via Pond

Area 1 which is 0.31 hectares in area is 100% permeable, however, infiltration drainage is assumed to be impractical in this area and therefore a piped connection to the Uttoxeter Brook will be provided within the highway to discharge at the current Greenfield runoff rate. The increase in runoff will be attenuated by the introduction of an oversized pipe within the main highway. It is considered that the roof drainage in this area will be directed to traditional house soakways.

The existing Greenfield runoff rate has been estimated at 5 l/s/ha and therefore based on a total area of 0.31 hectares the 1 in 2 year Greenfield runoff from the site is estimated at 1.55 l/s. However, it is considered impractical to reduce flows to below 2 l/s as the device will be prone to blockages and therefore it is proposed that the discharge from Area 1 into the Uttoxeter Brook is limited to 2 l/s. It is considered that a hydro-brake or office plate will be required prior to discharging into the sewer connection to the brook to regulate the flow. A flapped outfall will need to be constructed adjacent to the Uttoxeter Brook.

An assessment of the required balance volume has been made assuming the post development impermeable area is 0.31 hectares. Using WinDes Source Control software developed by Microdrainage the required attenuation has been calculated for the 1 in 100 year plus climate change (30%) event. The peak discharge was set at 2 l/s has been used for the storage calculations within the model.

Reference should be made to Appendix N where the calculation sheets are provided. The attenuation sizes have been tabulated below in Table 4-12.

Table 4-12: Modified Rational Method balance volume for Area 1

Return Period	Approx Volume (m^3)
1 in 100 year + CC	Oversized double pipe 250m of 0.75m diameter pipe

The proposed drainage strategy has been annotated onto the site layout drawing provided at Appendix I which clearly shows the points of discharge from area 1 and the area proposed for the oversized pipes.

Site B Area 2 – Discharge to Uttoxeter Brook via oversized pipes

Area 2 which is 0.6 hectares in area is 100% permeable, however, infiltration drainage is assumed to be impractical in this area and therefore a piped connection to the Uttoxeter Brook will be provided within the highway to discharge at the current Greenfield runoff rate. The increase in runoff will be attenuated by the introduction of a pond 580m^2 in area.

The existing Greenfield runoff rate has been estimated at 5 l/s/ha and therefore based on a total area of 0.6 hectares the 1 in 2 year Greenfield runoff from the site is estimated at 3 l/s. It is considered that a hydro-brake or office plate will be required prior to discharging into the sewer connection to the brook to regulate the flow. A flapped outfall will need to be constructed adjacent to the Uttoxeter Brook.

An assessment of the required balance volume has been made assuming the post development impermeable area is 0.6 hectares. Using WinDes Source Control software developed by Microdrainage the required attenuation has been calculated for the 1 in 100 year plus climate change (30%) event. The peak discharge was set at 3 l/s has been used for the storage calculations within the model.

Reference should be made to Appendix O where the calculation sheets are provided. The attenuation sizes have been tabulated below in Table 4-13.

Table 4-13: Modified Rational Method balance volume for Area 2

Return Period	Approx Volume (m^3)
1 in 100 year+CC	Pond 580m^2 by 0.63m deep = 354m^3

The proposed drainage strategy has been annotated onto the site layout drawing provided at Appendix I which clearly shows the points of discharge from area 2 and the area proposed for the oversized pipes.

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

SUDS

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

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

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

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

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

The level of treatment indicates the number of SUDS techniques that will be used to treat pollution. For example if two levels are required the runoff may enter a filter drain that leads to a basin or pond before outfall. It is recommended that source control techniques are used. In practice there will be little outflow from these techniques for a 1 in 2 year storm as most of the rainfall will be held within the system and will disperse via evapotranspiration. Further detail of the potential to use SUDS within this site it provided below within Table 4-14. The precise combination of methods used will be dependent upon the site constraints identified at the final design stage.

Initial data suggests that it may be impractical use infiltration drainage within the majority of the site due to the presence of shallow ground adjacent to the Uttoxeter Brook and within the lower parts of the site. As such it is considered that the only area where infiltration could be adopted is within site B area 1 where the ground levels are considerably higher than the estimated ground water levels. However, due to the presence of a ground water source and the potential for contamination within the adjacent site it is recommended that only roof water is drained via infiltration at this stage.

The impermeable area within the site will be increased to approximately 60% following development. There will therefore be a significant increase in surface water runoff from the site when it is developed. It is considered that the site currently infiltrates the underlying soils with overland flows being directed to the Uttoxeter Brook to the south east of the site.

The development site is considered to be of a reasonable size with space set aside, in which to incorporate appropriate SUDs techniques. As such the following SUDS techniques shown below in Table 4-14 have been considered for use at this site.

Table 4-14: SUDS Techniques

SUDs Group	Suitability for Proposed Development
Retention	✓
Wetland	✖
Infiltration	✖
Filtration	✖
Detention	✓
Open Channel	✓
Source Control	✓

Foul Water Drainage

Site A is currently Greenfield and as such there is no existing foul water discharge from this parcel. There are several gravity foul sewers crossing the site.

Site B is currently Greenfield and as such there is no existing foul water discharge from this parcel. There are several gravity foul sewers crossing the site.

A developer enquiry will be submitted to STW to agree points of discharge and allowable discharge rates for foul flows generated by the proposed development of Site A & B.

5. MITIGATION MEASURES

Raising Floor Levels/Land Raising

The River Dove is located to the east of the site. The 1 in 100 year plus climate change flood level has been estimated at between 75.90mOD and 76.40mOD. The 1 in 1,000 year flood level has been estimated at between 76.45mOD and 76.64mOD.

The lowest ground level within the sites is 76.96mOD. As such during the 1 in 100 year plus climate change and the 1 in 1,000 year events the water level would be at least 0.32m below the lowest ground level within the site.

The Uttoxeter Brook flows through Site B and passes the south east corner of Site A. Tabulated below in Table 5-1 are the modelled flood levels during the 1 in 100 year, 1 in 100 year plus climate change and 1 in 1,000 year extreme flood events for the modified Uttoxeter Brook through Site B.

Table 5-1: Water Levels at Key Locations during unobstructed flow for modified channel

Cross Section Reference	100yr Water Level (mOD)	100yr+CC Water Level (mOD)	1000yr Water Level (mOD)	Comments
2806	81.08	81.12	81.23	In channel
2733	80.10	80.69	81.08	In channel
2711	78.83	78.87	78.96	In channel
2667	78.47	78.51	78.59	In channel
2636	78.27	78.31	78.40	In channel
2631	78.20	78.25	78.35	In channel
2614U	77.95	78.00	78.11	In channel
2608D	77.76	77.80	77.90	In channel
2562	77.55	77.59	77.71	In channel
2518	77.44	77.47	77.52	In channel

It is considered that the lower areas within site B will need to be raised to a level of at least 79mOD to enable the site to be drained to the adjacent Uttoxeter Brook via gravity whilst using double 1m diameter pipes for attenuation. As such it is recommended that the internal floor levels within site B of any dwellings are raised to a level of at least 79.3mOD. This will generally ensure that the internal ground floor levels within this site are at least 300mm above the estimated 1 in 100 year plus climate change level in the area.

It is proposed that site A is developed for commercial uses. The peak 1 in 100 year plus climate change flood level in line with the south east corner of site A has been estimated at 77.41mOD. As such it is recommended that any buildings within this area are elevated at least 300mm above the estimated 1 in 100 year plus climate change flood level, hence a level of 77.71mOD.

Emergency Access & Egress

Dry emergency access and egress is essential for the proposed residential development during extreme flood events. Site B will be raised to ensure that the dwellings and road ways are elevated above the 1 in 1,000 year flood level thus raising site B into flood zone 1, low risk. As such dry access from the site will be available for pedestrians to the south west into the existing residential area off Pennycroft Lane which is presently within flood zone 1, low risk. Dry access will also be available onto Dove Way to the north east of the site. Site A is located within flood zone 1, low risk and as such dry access will be available onto Dove Way at all times. However, during

extreme events Dove Way to the north and south of the site could be flooded and may not be safe to cross. As such the pedestrian access through Site B will be available to flood zone 1, low risk.

Surface Water Runoff Attenuation

Consideration has been given to the hierarchy for surface water disposal which recommends the SUDs approach which includes infiltration as the first tier. It is considered that infiltration drainage will be impractical solution for the majority of the site due to shallow ground water levels, made ground and contaminated ground. However, house soakways have been adopted for part of the site where ground levels are higher.

However, other SUDs techniques can be used within the site and they have been considered. The second tier is to discharge to a watercourse and therefore the Uttoxeter Brook to the south east of the site is a viable option for the site.

It is considered that following the development there will be an increase in impermeable area and subsequently runoff from the site as the existing site is 100% permeable. The impermeable area will be increased to approximately 60% following the development.

Using WInDes Source Control software developed by Microdrainage the required attenuation has been calculated for the 1 in 100 year plus climate change (30%) event. The site was spilt into seven separate areas with all areas discharging into the Uttoxeter Brook at a Greenfield runoff rate of 5 l/s/ha. It is proposed that the roof drainage within area 1 is drained to traditional house soakaways as the ground levels are elevated The attenuation sizes have been tabulated below in Table 5-2.

Table 5-2: Modified Rational Method balance volumes during 1 in 100 year +CC event

Drainage Area	Drainage Method	Approx Volume (m^3)
Area 1	Double pipe	130m^3
Area 1 roof	House Soakaways	
Area 2	Pond	354m^3
Area 3	Pond	1628m^3
Area 4	Pipes	155m^3
Area 6	Crates	68m^3
Area 7	Crates	137m^3
Total		2472m^3

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

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

- The maintenance and adoption regimes for all elements of the development should be considered for the lifetime of the development.

- Consenting will be required from the Environment Agency for any connections/outfalls into the Uttoxeter Brook.

Overland Flow

During the detailed surface water drainage design stage provision should be made for any offsite overland flow routes which cross the site, especially within site B where there is higher ground to the south west.

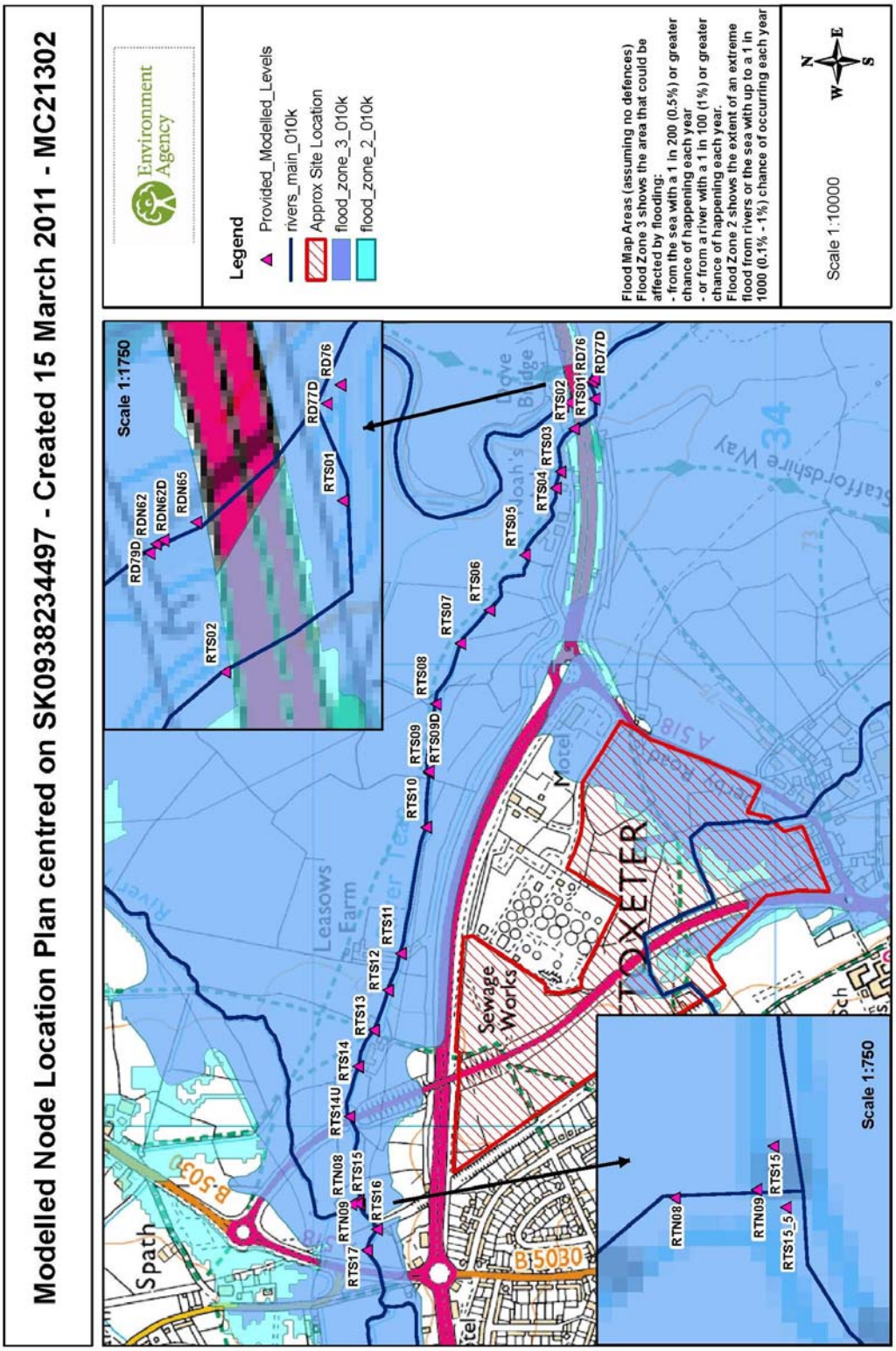
6. CONCLUSION

In conclusion there is a risk of fluvial flooding from the Uttoxeter Brook. The re-profiling of the Uttoxeter Brook should reduce the flood risk to an acceptable level within Site B. Incorporation of sustainable urban drainage systems should be considered where practically possible to mitigate against flooding caused by surface water runoff. Consultation must also be undertaken with the relevant water authority to establish agreements regarding the allowable peak discharges into the Uttoxeter Brook.

Appendix A: - Existing Ground Levels

Appendix B: - Proposed Layout

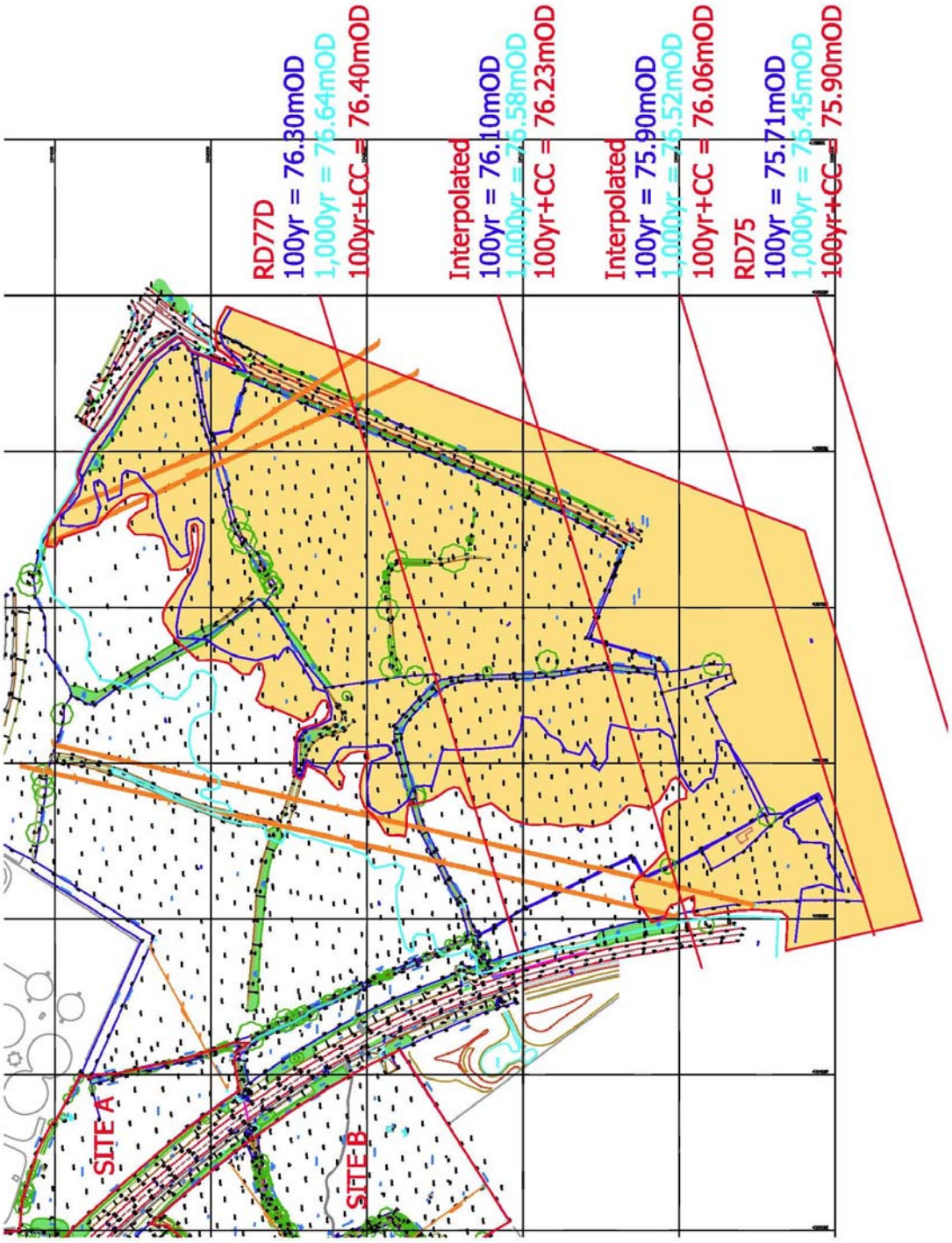
Appendix C: - River Dove Environment Agency Flood Data


Modelled Node Location Plan centred on SK093823497 - Created 15 March 2011 - MC21302
Environment Agency
Legend
Provided_Modelled_Levels
rivers_main_010k
Approx Site Location
flood_zone_3_010k
flood_zone_2_010k
Flood Map Areas (assuming no defences)
Flood Zone 3 shows the area that could be affected by flooding:
- from the sea with a 1 in 200 (0.5%) or greater chance of happening each year
- or from a river with a 1 in 100 (1%) or greater chance of happening each year.
Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 1 in 1000 (0.1% - 1%) chance of occurring each year
Scale 1:10000
N
E
S
W
Scale 1:1750
RD79D
RDN62
RDN62D
RDN65
RTS02
RD77D
RD76
RTS01
RTS08
RTS07
RTS06
RTS05
RTS04
RTS03
RTS02
RTS01
RD76
RD77D
RTS09
RTS09D
RTS10
RTS11
RTS12
RTS13
RTS14
RTS14U
RTS15
RTS16
RTS17
RTN08
RTN09
Sewage Works
B5030
Spath
Leasows Farm
Staffordshire Way
A518
UTTOXETER
Scale 1:750
RTN08
RTN09
RTS15
RTS15_5
© Environment Agency copyright and / or database rights 2010. All rights reserved. © Crown Copyright and database right. All rights reserved. Environment Agency, 100026380, 2010.
Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 08708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

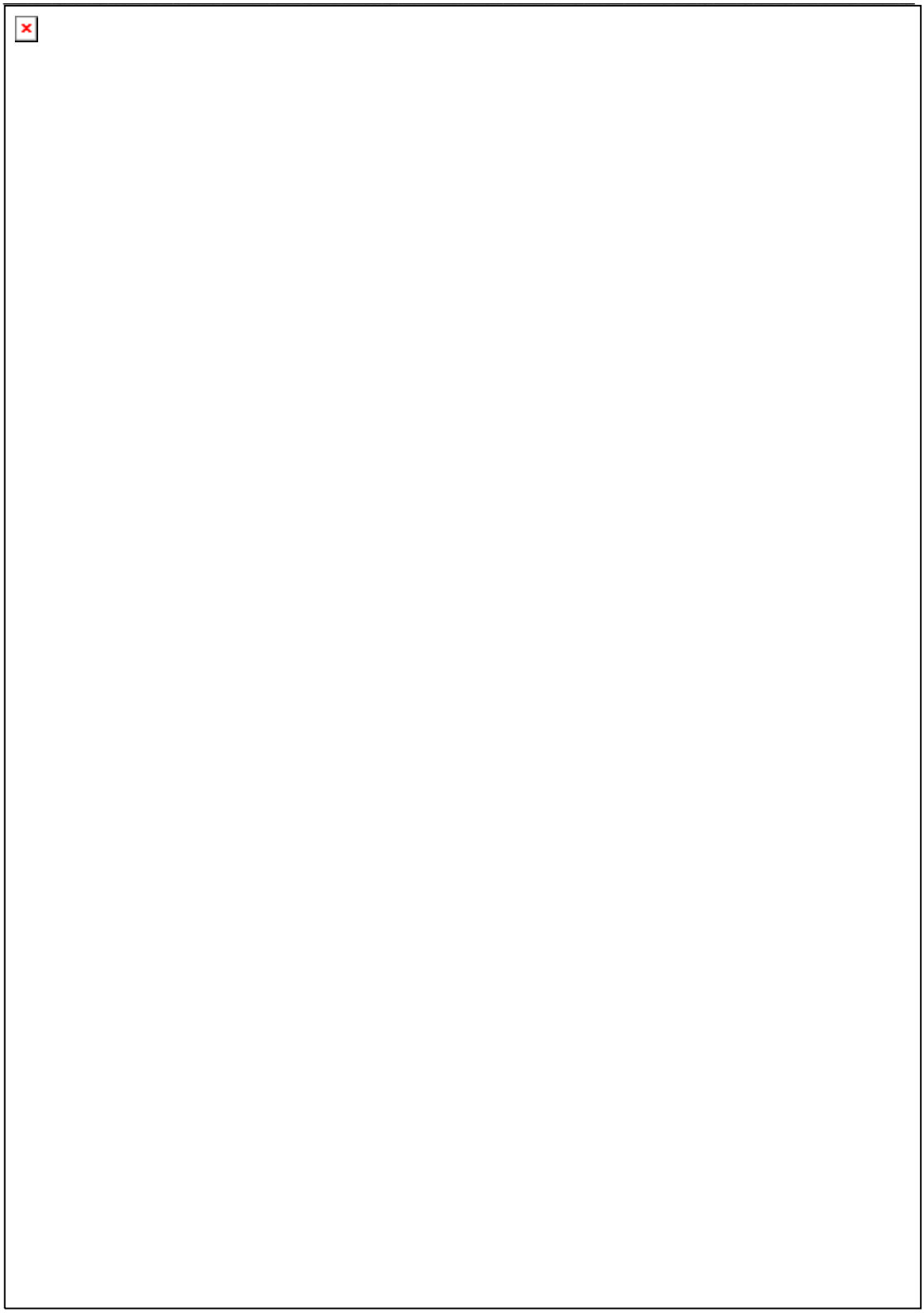
Modelled Levels - MC21302

		Return Periods (yrs) Levels (mAOD)									
		Undefended	Defended								
NodePoint	Reference	1:100_UD	1:20_D	1:50_D	1:75_D	1:100_D	1:100_cc_D	1:200_D	1:1000_D	X	Y
RD79A	River Dove Flood Risk Mapping Study 2009	77.40	76.90	77.18	77.30	77.40	77.78	77.76	78.48	410550	334471
RD79D		76.98	76.60	76.82	76.91	76.98	77.27	77.26	77.87	410556	334464
RDN62		76.93	76.57	76.78	76.86	76.93	77.21	77.20	77.75	410559	334462
RDN62D		76.67	76.33	76.53	76.61	76.67	76.94	76.93	77.47	410561	334459
RDN65		76.56	76.24	76.42	76.50	76.56	76.78	76.77	77.23	410567	334447
RD77D		76.30	76.07	76.21	76.26	76.30	76.40	76.39	76.64	410612	334397
RD76		76.19	75.96	76.09	76.15	76.19	76.27	76.27	76.42	410619	334392
RD75		75.71	75.50	75.62	75.67	75.71	75.90	75.89	76.45	410764	334212
RTS17		83.76	83.42	83.62	83.70	83.76	83.90	83.89	83.96	408732	334884
RTS16		83.10	82.94	83.06	83.08	83.10	83.16	83.15	83.20	408779	334863
RTS15_5		82.68	82.51	82.60	82.65	82.67	82.70	82.70	82.75	408831	334899
RTS15		82.54	82.42	82.47	82.51	82.54	82.59	82.58	82.64	408841	334901
RTS14		80.95	80.83	80.90	80.93	80.95	81.02	81.00	81.12	409130	334904
RTS13		80.39	80.32	80.36	80.38	80.39	80.43	80.42	80.50	409209	334869
RTS12		79.86	79.80	79.84	79.85	79.86	79.90	79.90	79.97	409296	334838
RTS11		79.46	79.41	79.44	79.45	79.46	79.51	79.50	79.57	409375	334810
RTS10		78.20	78.17	78.19	78.19	78.20	78.26	78.25	78.76	409649	334756
RTS09		77.84	77.78	77.80	77.82	77.84	78.10	78.09	78.74	409766	334750
RTS09D		77.83	77.77	77.80	77.81	77.83	78.09	78.08	78.73	409770	334751
RTS08		77.71	77.30	77.52	77.62	77.71	78.07	78.05	78.72	409915	334735
RTS07		77.70	77.25	77.50	77.61	77.70	78.06	78.04	78.71	410046	334682
RTS06		77.68	77.21	77.48	77.59	77.68	78.04	78.03	78.70	410119	334619
RTS05		77.67	77.19	77.47	77.58	77.67	78.04	78.02	78.70	410238	334542
RTS04		77.63	77.14	77.42	77.53	77.63	78.00	77.99	78.72	410382	334475
RTS03		77.62	77.12	77.41	77.52	77.62	78.00	77.98	78.64	410418	334465
RTS02		75.80	75.75	75.77	75.78	75.80	75.81	75.81	76.21	410511	334436
RTS01		76.30	76.07	76.21	76.26	76.30	76.40	76.39	76.64	410576	334391
RTN09		82.62	82.43	82.54	82.59	82.62	82.66	82.65	82.72	408834	334904
RTN08		82.55	82.35	82.47	82.52	82.55	82.58	82.58	82.65	408833	334917
RTS14U		81.45	81.37	81.42	81.44	81.45	81.49	81.48	81.56	409022	334922
RD72		73.37	73.33	73.35	73.36	73.36	73.39	73.39	73.46	411511	333301
RD71		72.95	72.82	72.89	72.92	72.95	73.03	73.03	73.28	411253	333049
RD70		72.65	72.49	72.59	72.62	72.65	72.74	72.74	72.99	411187	332657
RD74		74.90	74.79	74.86	74.88	74.90	74.96	74.96	75.10	411119	333975
RD73		74.11	74.03	74.08	74.10	74.11	74.17	74.17	74.30	411342	333731
RD74D		74.83	74.73	74.79	74.81	74.83	74.89	74.89	75.02	411116	333965

Appendix D: - River Dove Flood Envelope

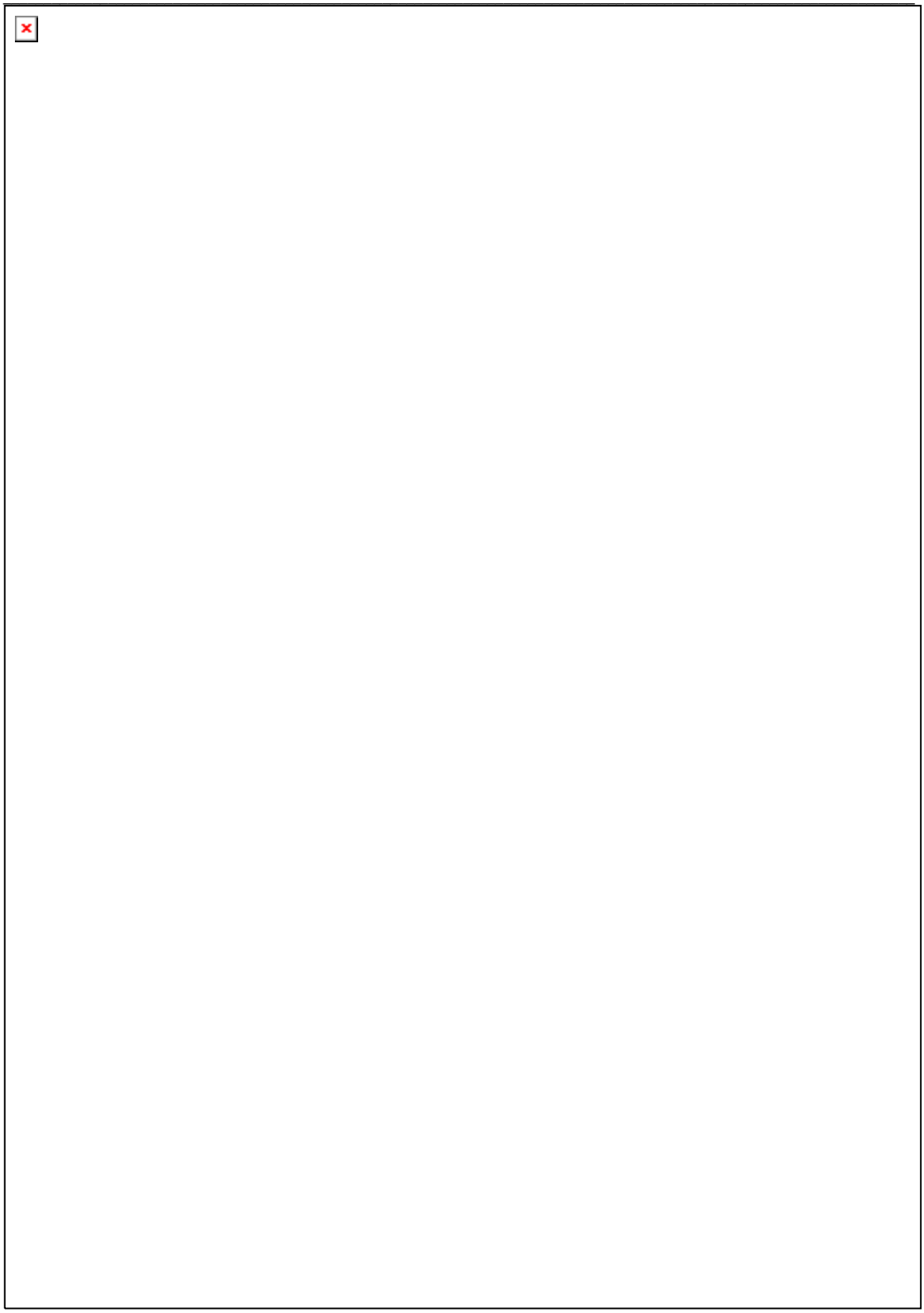


Appendix E: - Uttoxeter Brook Environment Agency Flood Data

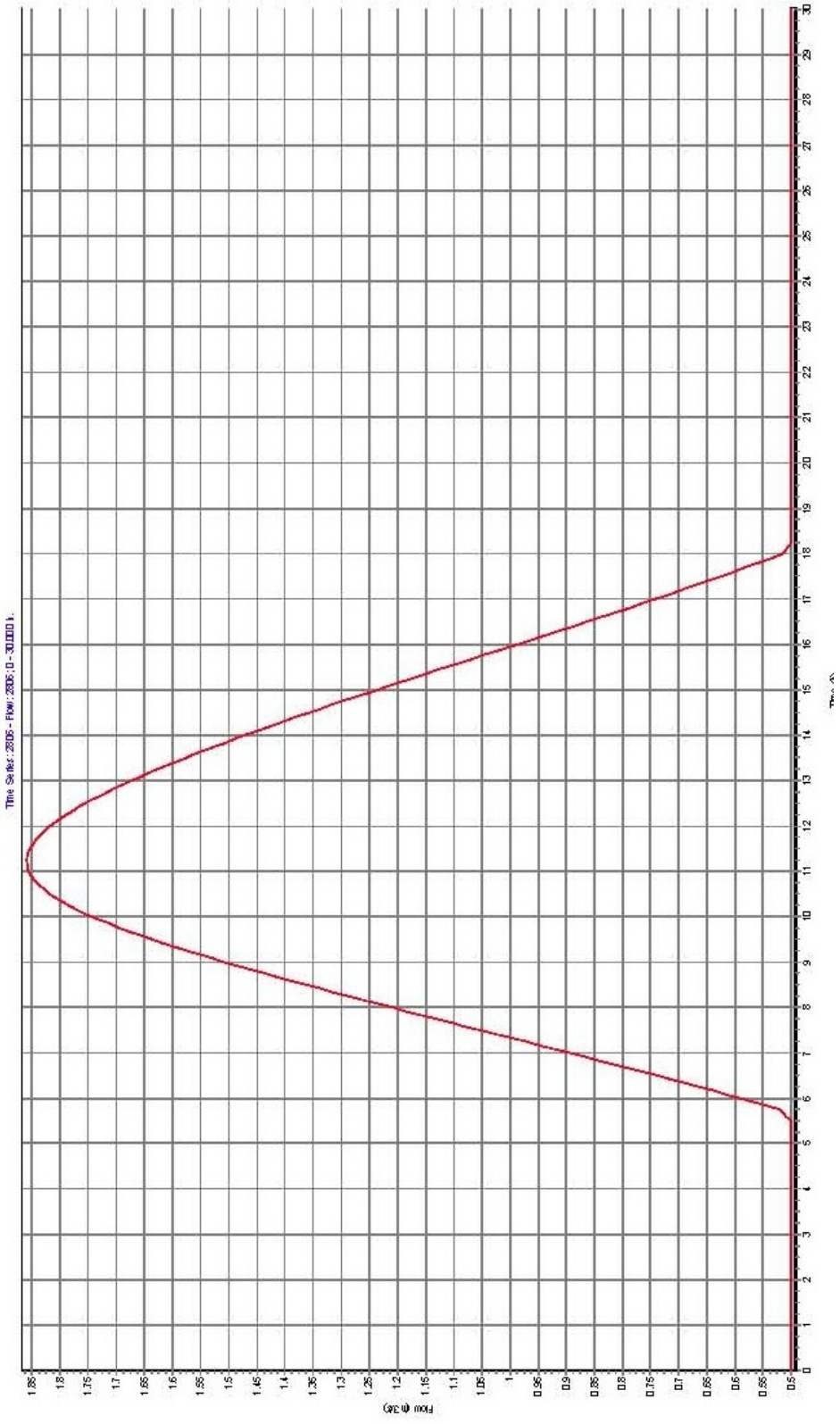


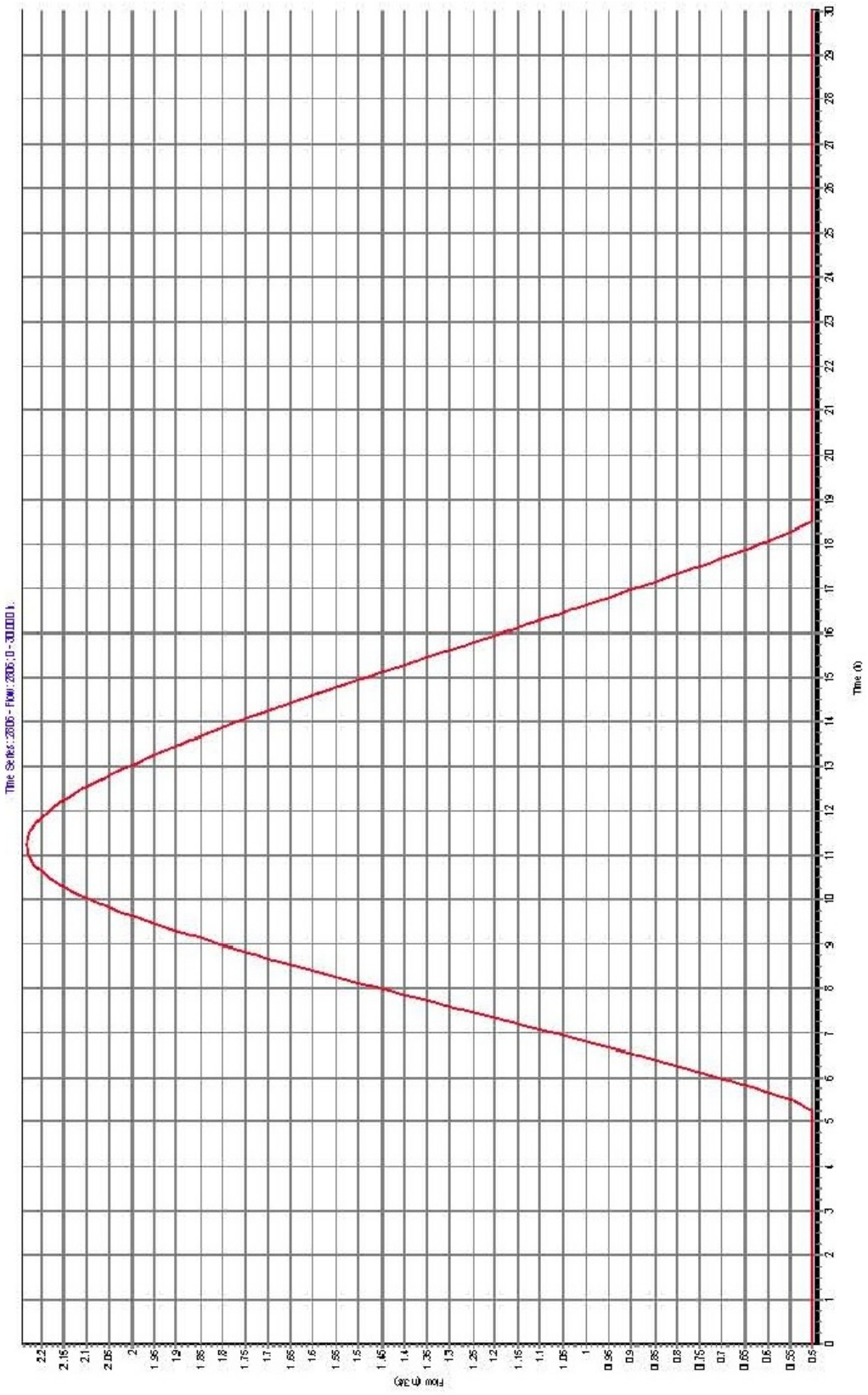
Modelled Levels - 15/DE

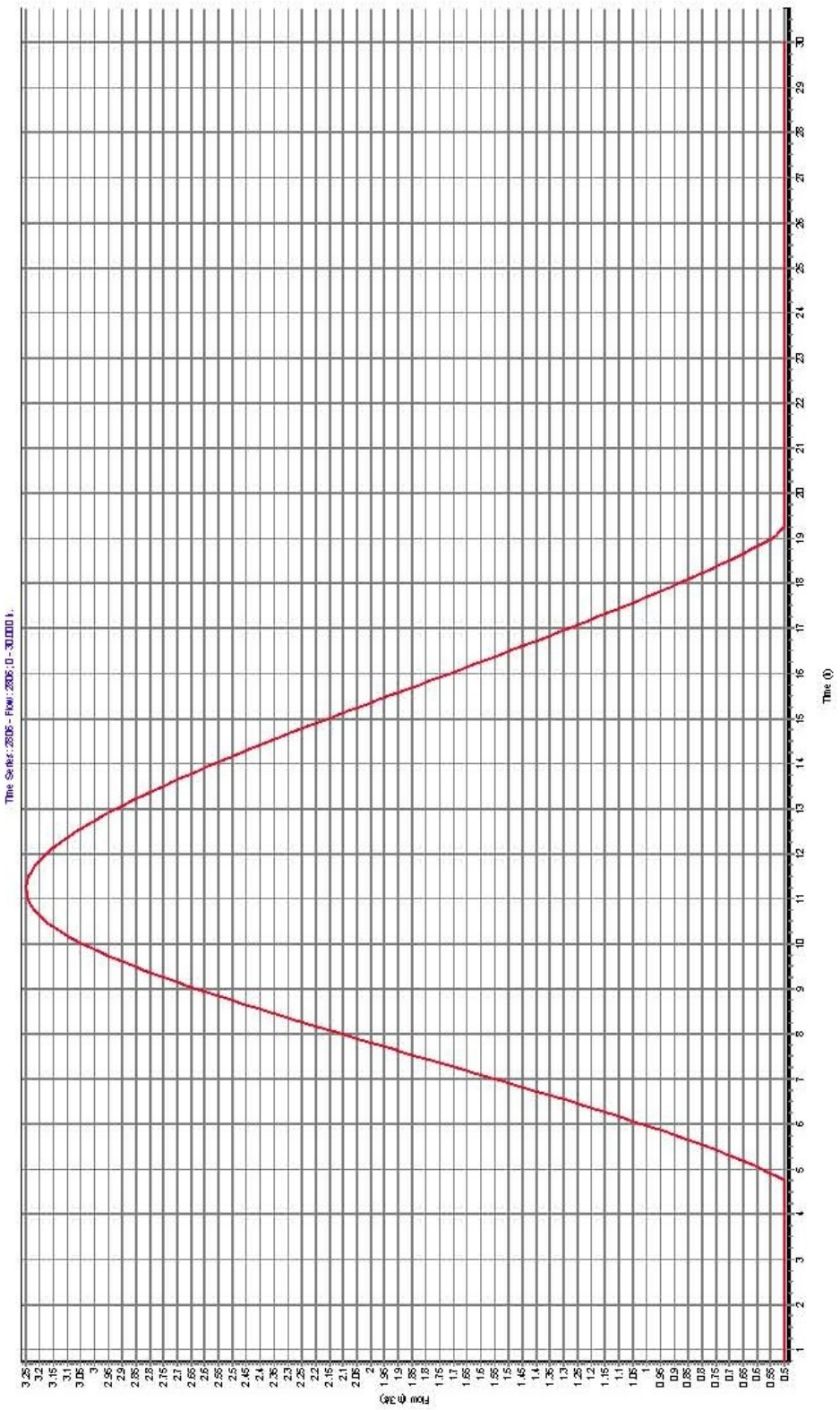
	Return Periods (yrs) Modelled Levels (mAOD)							
	Defended							Undefended
Node Point	1:20yr	1:50yr	1:75yr	1:100yr	1:100yr+cc	1:200yr	1:1000yr	1:100yr
2806	81.03	81.07	81.08	81.09	81.19	81.18	81.33	81.09
2806_01	80.28	80.38	80.43	80.52	80.93	80.90	81.13	80.52
2806_02	79.70	80.06	80.25	80.42	80.91	80.88	81.10	80.42
2806_03	79.67	80.05	80.25	80.42	80.91	80.88	81.10	80.42
2733	79.66	80.05	80.24	80.42	80.91	80.88	81.10	80.42
2711	78.76	78.85	78.88	78.90	78.96	78.95	79.09	78.90
2667	78.55	78.67	78.71	78.73	78.77	78.76	78.81	78.73
2631U	78.34	78.52	78.57	78.59	78.65	78.64	78.72	78.59
2631D	78.20	78.29	78.31	78.32	78.35	78.34	78.39	78.32
2608	77.81	77.89	77.91	77.92	77.95	77.95	77.99	77.92
2562	77.41	77.49	77.52	77.53	77.56	77.56	77.61	77.53
2518	77.33	77.41	77.43	77.44	77.47	77.47	77.52	77.44
2497	77.31	77.36	77.39	77.39	77.41	77.41	77.44	77.39
2473U	77.24	77.28	77.30	77.30	77.31	77.31	77.33	77.30
2473D	77.24	77.28	77.30	77.30	77.31	77.31	77.33	77.30
2466	77.23	77.26	77.28	77.28	77.29	77.29	77.30	77.28
2416	77.21	77.24	77.26	77.26	77.26	77.26	77.26	77.26
2380U	77.00	77.10	77.14	77.15	77.16	77.15	77.17	77.14
2380D	76.98	77.06	77.09	77.09	77.11	77.10	77.12	77.09
2330	76.68	76.71	76.73	76.73	76.73	76.73	76.74	76.73
2297	76.60	76.63	76.65	76.65	76.66	76.66	76.66	76.65
2278U	76.56	76.59	76.60	76.61	76.61	76.61	76.62	76.61
2278D	76.47	76.49	76.50	76.51	76.51	76.51	76.52	76.51
2248	76.40	76.42	76.43	76.43	76.44	76.44	76.45	76.43
2217	76.35	76.37	76.38	76.38	76.39	76.39	76.40	76.38
2182	76.30	76.32	76.33	76.34	76.34	76.34	76.35	76.34
2143	76.21	76.23	76.24	76.24	76.24	76.24	76.25	76.24
2093	76.12	76.14	76.14	76.14	76.15	76.15	76.15	76.15
2049	76.08	76.10	76.11	76.11	76.11	76.11	76.11	76.11
2014	76.05	76.08	76.09	76.09	76.09	76.09	76.09	76.09
1975U	75.92	75.94	75.96	75.97	75.97	75.97	75.99	75.97
1975D	75.80	75.83	75.85	75.86	75.86	75.86	75.87	75.86
1917	75.35	75.41	75.42	75.43	75.44	75.44	75.46	75.43
1738	75.17	75.22	75.23	75.24	75.24	75.24	75.26	75.24
1684	74.98	75.05	75.06	75.07	75.07	75.07	75.09	75.07



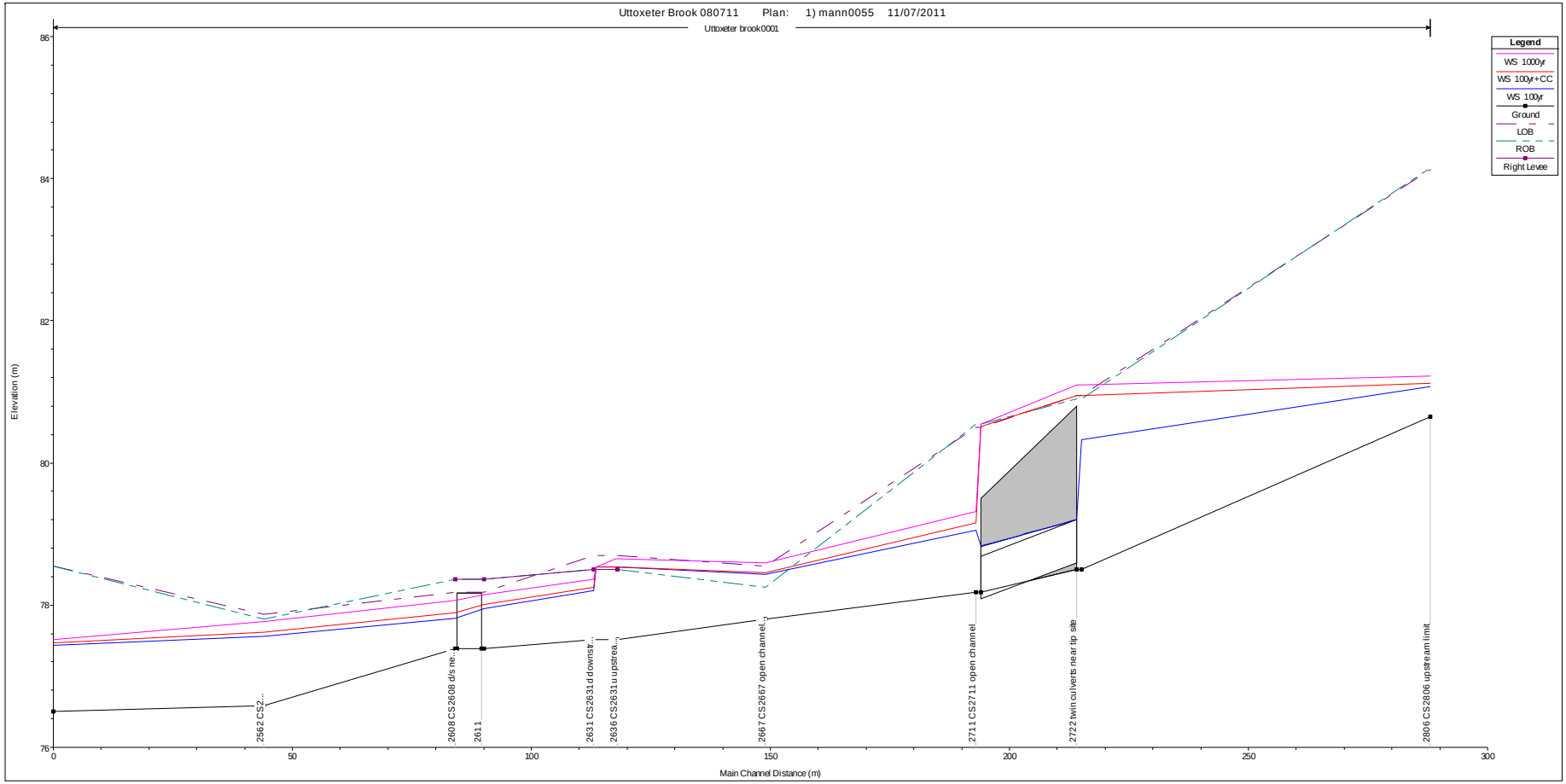
Appendix F: - Uttoxeter Brook Hydrographs




Time (h)
Flow (cms)


Time Series: 2936 - Flow: 2936 (0 - 30.0000 h)
Time (h)
Flow (cms)

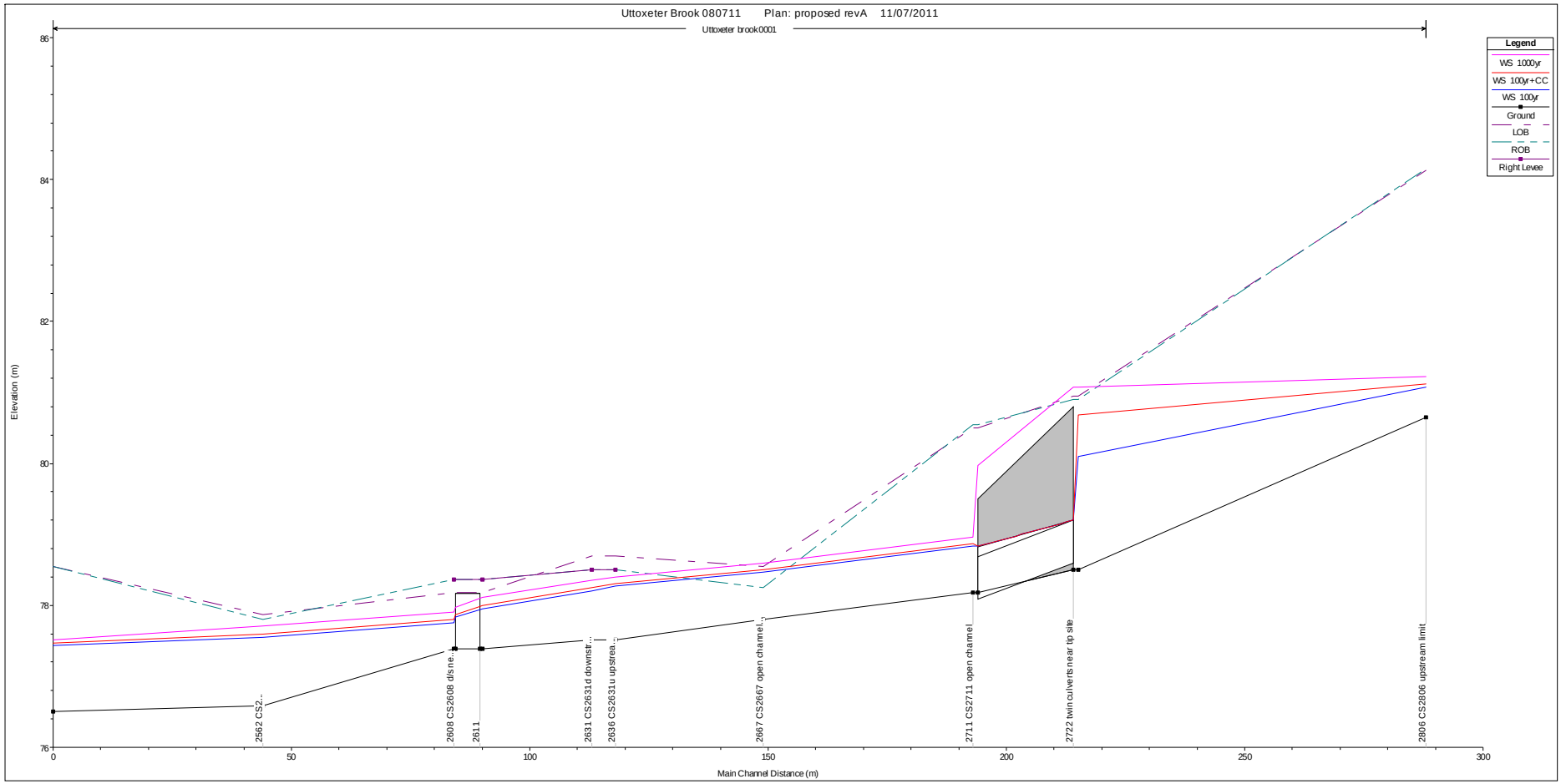
Appendix G: - HEC RAS Longitudinal Section and Tables for Existing Uttoxeter Brook.



HEC-RAS Plan: mann0055 River: Uttoxeter brook Reach: 0001

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
0001	2806	100yr	1.87	80.65	81.08	81.08	81.25	0.044154	1.84	1.02	3.01	1.01
0001	2806	100yr+CC	2.23	80.65	81.12	81.12	81.31	0.043479	1.94	1.15	3.01	1.01
0001	2806	1000yr	3.25	80.65	81.23	81.23	81.48	0.043375	2.21	1.47	3.02	1.01
0001	2733	100yr	1.87	78.50	80.33	79.02	80.34	0.000779	0.45	4.14	2.44	0.11
0001	2733	100yr+CC	2.23	78.50	80.95	79.06	80.96	0.000507	0.39	5.66	2.88	0.09
0001	2733	1000yr	3.25	78.50	81.10	79.19	81.11	0.000748	0.50	7.03	7.44	0.10
0001	2722		Culvert									
0001	2711	100yr	1.87	78.18	79.06	78.63	79.11	0.005818	0.96	1.95	2.37	0.34
0001	2711	100yr+CC	2.23	78.18	79.16	78.68	79.21	0.006076	1.02	2.19	2.38	0.34
0001	2711	1000yr	3.25	78.18	79.32	78.81	79.40	0.008234	1.26	2.58	2.39	0.39
0001	2667	100yr	1.87	77.80	78.44	78.41	78.58	0.033912	1.70	1.10	3.17	0.92
0001	2667	100yr+CC	2.23	77.80	78.46	78.46	78.64	0.039745	1.89	1.18	3.25	1.00
0001	2667	1000yr	3.25	77.80	78.60	78.60	78.78	0.028528	1.91	1.79	5.34	0.88
0001	2636	100yr	1.87	77.52	78.53	78.14	78.53	0.000043	0.08	19.73	41.75	0.03
0001	2636	100yr+CC	2.23	77.52	78.53	78.21	78.53	0.000062	0.09	19.73	41.75	0.04
0001	2636	1000yr	3.25	77.52	78.65	78.37	78.65	0.000063	0.10	24.57	41.81	0.04
0001	2634		Culvert									
0001	2631	100yr	1.87	77.52	78.20	78.14	78.38	0.034702	1.85	1.01	2.10	0.85
0001	2631	100yr+CC	2.23	77.52	78.25	78.21	78.46	0.038603	2.01	1.11	2.21	0.91
0001	2631	1000yr	3.25	77.52	78.37	78.37	78.65	0.046039	2.34	1.39	2.51	1.01
0001	2614	100yr	1.87	77.39	77.95	77.76	78.00	0.008190	0.95	1.97	4.95	0.48
0001	2614	100yr+CC	2.23	77.39	78.01	77.80	78.06	0.008179	1.00	2.24	5.23	0.49
0001	2614	1000yr	3.25	77.39	78.15	77.90	78.21	0.007646	1.08	3.02	5.95	0.48
0001	2608	100yr	1.87	77.39	77.82	77.76	77.92	0.023206	1.30	1.35	4.26	0.70
0001	2608	100yr+CC	2.23	77.39	77.89	77.80	77.98	0.018071	1.33	1.68	4.64	0.70
0001	2608	1000yr	3.25	77.39	78.06	77.90	78.15	0.012341	1.28	2.54	5.51	0.60
0001	2562	100yr	1.87	76.59	77.56		77.60	0.003668	0.81	2.32	3.32	0.31
0001	2562	100yr+CC	2.23	76.59	77.62		77.66	0.004179	0.88	2.52	3.46	0.33
0001	2562	1000yr	3.25	76.59	77.77		77.83	0.005372	1.07	3.05	3.81	0.38
0001	2518	100yr	1.87	76.50	77.44	76.86	77.46	0.002422	0.68	2.75	3.02	0.23
0001	2518	100yr+CC	2.23	76.50	77.47	76.90	77.50	0.003141	0.79	2.84	3.02	0.26
0001	2518	1000yr	3.25	76.50	77.52	77.01	77.58	0.005769	1.09	2.99	3.02	0.35

Appendix H: - HEC RAS Longitudinal Section and Tables for Proposed Uttoxeter Brook



HEC-RAS Plan: proposed revA River: Uttoxeter brook Reach: 0001

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
0001	2806	100yr	1.87	80.65	81.08	81.08	81.25	0.044154	1.84	1.02	3.01	1.01
0001	2806	100yr+CC	2.23	80.65	81.12	81.12	81.31	0.043479	1.94	1.15	3.01	1.01
0001	2806	1000yr	3.25	80.65	81.23	81.23	81.46	0.043375	2.21	1.47	3.02	1.01
0001	2733	100yr	1.87	78.50	80.10	79.01	80.12	0.001131	0.52	3.58	2.43	0.14
0001	2733	100yr+CC	2.23	78.50	80.69	79.06	80.70	0.000687	0.44	5.01	2.45	0.10
0001	2733	1000yr	3.25	78.50	81.08	79.19	81.09	0.000789	0.51	6.86	7.26	0.10
0001	2722		Culvert									
0001	2711	100yr	1.87	78.18	78.83		78.92	0.014401	1.32	1.42	2.35	0.54
0001	2711	100yr+CC	2.23	78.18	78.87		78.98	0.016970	1.47	1.51	2.35	0.59
0001	2711	1000yr	3.25	78.18	78.96		79.14	0.025007	1.89	1.72	2.36	0.71
0001	2667	100yr	1.87	77.80	78.47		78.50	0.006273	0.84	2.45	8.94	0.41
0001	2667	100yr+CC	2.23	77.80	78.51		78.54	0.006132	0.86	2.77	9.01	0.40
0001	2667	1000yr	3.25	77.80	78.59		78.64	0.005801	0.92	3.62	10.24	0.40
0001	2636	100yr	1.87	77.52	78.27	78.12	78.30	0.006905	0.72	2.60	8.29	0.41
0001	2636	100yr+CC	2.23	77.52	78.31	78.15	78.34	0.006914	0.77	2.90	8.39	0.42
0001	2636	1000yr	3.25	77.52	78.40	78.20	78.44	0.006652	0.87	3.74	8.65	0.42
0001	2631	100yr	1.87	77.52	78.20	78.12	78.25	0.014525	0.91	2.06	8.12	0.58
0001	2631	100yr+CC	2.23	77.52	78.25	78.15	78.29	0.012813	0.93	2.39	8.23	0.55
0001	2631	1000yr	3.25	77.52	78.35	78.20	78.40	0.009965	0.99	3.28	8.51	0.51
0001	2614	100yr	1.87	77.39	77.95	77.76	78.00	0.008436	0.96	1.95	4.93	0.49
0001	2614	100yr+CC	2.23	77.39	78.00	77.80	78.05	0.008716	1.02	2.19	5.18	0.50
0001	2614	1000yr	3.25	77.39	78.11	77.90	78.18	0.009236	1.15	2.82	5.77	0.53
0001	2611		Bridge									
0001	2608	100yr	1.87	77.39	77.76	77.76	77.90	0.039871	1.67	1.12	3.96	1.01
0001	2608	100yr+CC	2.23	77.39	77.80	77.80	77.96	0.039504	1.74	1.28	4.17	1.00
0001	2608	1000yr	3.25	77.39	77.90	77.90	78.08	0.036326	1.90	1.71	4.68	1.00
0001	2562	100yr	1.87	76.59	77.55		77.56	0.001767	0.46	4.10	9.36	0.22
0001	2562	100yr+CC	2.23	76.59	77.59		77.61	0.001809	0.49	4.56	9.49	0.23
0001	2562	1000yr	3.25	76.59	77.71		77.72	0.001977	0.58	5.64	9.79	0.24
0001	2518	100yr	1.87	76.50	77.44	76.86	77.46	0.002422	0.69	2.75	3.02	0.23
0001	2518	100yr+CC	2.23	76.50	77.47	76.90	77.50	0.003141	0.79	2.84	3.02	0.26
0001	2518	1000yr	3.25	76.50	77.52	77.01	77.58	0.005769	1.09	2.99	3.02	0.35

Appendix I: - Drainage Strategy Drawing

Appendix J: - WinDes Calculation Sheets Site A Area 3

EWE Associates Ltd		Page 1
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		Micro Drainage
Date 16/07/2011 11:27	Designed By Lea	
File Area3 - 100yr+CC ...	Checked By	
Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	9.366	0.366	12.6	640.7	O K
30 min Summer	9.480	0.480	12.6	839.2	O K
60 min Summer	9.595	0.595	12.6	1041.1	O K
120 min Summer	9.706	0.706	12.6	1235.1	Flood Risk
180 min Summer	9.764	0.764	12.6	1336.6	Flood Risk
240 min Summer	9.799	0.799	12.6	1397.8	Flood Risk
360 min Summer	9.840	0.840	12.6	1470.8	Flood Risk
480 min Summer	9.863	0.863	12.6	1510.0	Flood Risk
600 min Summer	9.874	0.874	12.7	1528.7	Flood Risk
720 min Summer	9.877	0.877	12.7	1534.2	Flood Risk
960 min Summer	9.870	0.870	12.7	1523.3	Flood Risk
1440 min Summer	9.851	0.851	12.6	1489.8	Flood Risk
2160 min Summer	9.815	0.815	12.6	1425.9	Flood Risk
2880 min Summer	9.774	0.774	12.6	1354.2	Flood Risk
4320 min Summer	9.691	0.691	12.6	1208.9	O K
5760 min Summer	9.611	0.611	12.6	1070.1	O K
7200 min Summer	9.535	0.535	12.6	935.8	O K
8640 min Summer	9.458	0.458	12.6	801.1	O K
10080 min Summer	9.380	0.380	12.6	665.9	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Summer	128.285	26
30 min Summer	84.226	41
60 min Summer	52.662	70
120 min Summer	31.800	130
180 min Summer	23.353	188
240 min Summer	18.644	246
360 min Summer	13.543	366
480 min Summer	10.792	484
600 min Summer	9.043	602
720 min Summer	7.823	722
960 min Summer	6.219	884
1440 min Summer	4.493	1118
2160 min Summer	3.241	1516
2880 min Summer	2.568	1932
4320 min Summer	1.847	2764
5760 min Summer	1.461	3576
7200 min Summer	1.217	4336
8640 min Summer	1.048	5104
10080 min Summer	0.923	5752

EWE Associates Ltd		Page 2
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 16/07/2011 11:27	Designed By Lea	
File Area3 - 100yr+CC ...	Checked By	
Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Winter	9.411	0.411	12.6	719.0	O K
30 min Winter	9.538	0.538	12.6	941.7	O K
60 min Winter	9.667	0.667	12.6	1168.1	O K
120 min Winter	9.793	0.793	12.6	1387.1	Flood Risk
180 min Winter	9.859	0.859	12.6	1502.7	Flood Risk
240 min Winter	9.899	0.899	12.9	1573.4	Flood Risk
360 min Winter	9.948	0.948	13.2	1659.7	Flood Risk
480 min Winter	9.976	0.976	13.4	1708.5	Flood Risk
600 min Winter	9.991	0.991	13.5	1734.6	Flood Risk
720 min Winter	9.998	0.998	13.6	1746.2	Flood Risk
960 min Winter	9.996	0.996	13.6	1743.2	Flood Risk
1440 min Winter	9.966	0.966	13.3	1691.2	Flood Risk
2160 min Winter	9.918	0.918	13.0	1606.6	Flood Risk
2880 min Winter	9.860	0.860	12.6	1505.5	Flood Risk
4320 min Winter	9.740	0.740	12.6	1295.0	Flood Risk
5760 min Winter	9.622	0.622	12.6	1088.7	O K
7200 min Winter	9.500	0.500	12.6	875.7	O K
8640 min Winter	9.364	0.364	12.6	637.2	O K
10080 min Winter	9.277	0.277	12.6	485.2	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Winter	128.285	26
30 min Winter	84.226	41
60 min Winter	52.662	70
120 min Winter	31.800	126
180 min Winter	23.353	184
240 min Winter	18.644	242
360 min Winter	13.543	358
480 min Winter	10.792	474
600 min Winter	9.043	588
720 min Winter	7.823	700
960 min Winter	6.219	916
1440 min Winter	4.493	1168
2160 min Winter	3.241	1624
2880 min Winter	2.568	2080
4320 min Winter	1.847	2984
5760 min Winter	1.461	3864
7200 min Winter	1.217	4680
8640 min Winter	1.048	5272
10080 min Winter	0.923	5664

EWE Associates Ltd		Page 3
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 16/07/2011 11:27 File Area3 - 100yr+CC ...	Designed By Lea Checked By	
Micro Drainage	Source Control W.12.4	

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time / Area Diagram

Total Area (ha) 2.710

Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	1.000	4-8	1.000	8-12	0.710

EWE Associates Ltd		Page 4
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 16/07/2011 11:27 File Area3 - 100yr+CC ...	Designed By Lea Checked By	
Micro Drainage	Source Control W.12.4	

Model Details

Storage is Online Cover Level (m) 10.000

Tank or Pond Structure

Invert Level (m) 9.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1750.0	1.400	0.0	2.800	0.0	4.200	0.0
0.200	1750.0	1.600	0.0	3.000	0.0	4.400	0.0
0.400	1750.0	1.800	0.0	3.200	0.0	4.600	0.0
0.600	1750.0	2.000	0.0	3.400	0.0	4.800	0.0
0.800	1750.0	2.200	0.0	3.600	0.0	5.000	0.0
1.000	1750.0	2.400	0.0	3.800	0.0		
1.200	0.0	2.600	0.0	4.000	0.0		

Hydro-Brake® Outflow Control

Design Head (m) 1.000 Hydro-Brake® Type Md4 Invert Level (m) 9.000
Design Flow (l/s) 13.6 Diameter (mm) 132

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	3.6	1.200	14.9	3.000	23.5	7.000	35.9
0.200	10.7	1.400	16.1	3.500	25.4	7.500	37.2
0.300	12.5	1.600	17.2	4.000	27.2	8.000	38.4
0.400	11.0	1.800	18.2	4.500	28.8	8.500	39.6
0.500	10.4	2.000	19.2	5.000	30.4	9.000	40.7
0.600	10.8	2.200	20.1	5.500	31.8	9.500	41.9
0.800	12.2	2.400	21.0	6.000	33.3		
1.000	13.6	2.600	21.9	6.500	34.6		

Appendix K: - WinDes Calculation Sheets Site A Area 4

EWE Associates Ltd		Page 1
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 16/07/2011 11:42 File Area4 - 100yr 21s...	Designed By Lea Checked By	
Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m^3)	Status
15 min Summer	9.519	0.519	1.2	56.3	O K
30 min Summer	9.589	0.589	1.3	73.3	O K
60 min Summer	9.658	0.658	1.3	90.1	O K
120 min Summer	9.724	0.724	1.4	105.6	O K
180 min Summer	9.757	0.757	1.4	113.0	O K
240 min Summer	9.776	0.776	1.5	116.9	O K
360 min Summer	9.793	0.793	1.5	120.4	O K
480 min Summer	9.797	0.797	1.5	121.2	O K
600 min Summer	9.792	0.792	1.5	120.2	O K
720 min Summer	9.784	0.784	1.5	118.7	O K
960 min Summer	9.768	0.768	1.4	115.3	O K
1440 min Summer	9.733	0.733	1.4	107.7	O K
2160 min Summer	9.694	0.694	1.4	98.6	O K
2880 min Summer	9.661	0.661	1.3	90.8	O K
4320 min Summer	9.604	0.604	1.3	76.9	O K
5760 min Summer	9.555	0.555	1.2	65.0	O K
7200 min Summer	9.512	0.512	1.2	54.7	O K
8640 min Summer	9.474	0.474	1.1	45.9	O K
10080 min Summer	9.438	0.438	1.1	38.4	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Summer	98.681	19
30 min Summer	64.789	34
60 min Summer	40.510	64
120 min Summer	24.461	122
180 min Summer	17.964	182
240 min Summer	14.342	242
360 min Summer	10.418	362
480 min Summer	8.302	480
600 min Summer	6.956	596
720 min Summer	6.017	642
960 min Summer	4.784	760
1440 min Summer	3.456	1024
2160 min Summer	2.493	1432
2880 min Summer	1.975	1844
4320 min Summer	1.421	2640
5760 min Summer	1.124	3456
7200 min Summer	0.936	4184
8640 min Summer	0.806	4928
10080 min Summer	0.710	5648

EWE Associates Ltd		Page 2
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 16/07/2011 11:42 File Area4 - 100yr 21s...	Designed By Lea Checked By	
Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m^3)	Status
15 min Winter	9.548	0.548	1.2	63.1	O K
30 min Winter	9.626	0.626	1.3	82.3	O K
60 min Winter	9.706	0.706	1.4	101.4	O K
120 min Winter	9.787	0.787	1.5	119.2	O K
180 min Winter	9.835	0.835	1.5	127.9	O K
240 min Winter	9.864	0.864	1.5	132.7	O K
360 min Winter	9.897	0.897	1.6	137.5	O K
480 min Winter	9.911	0.911	1.6	139.3	O K
600 min Winter	9.910	0.910	1.6	139.2	O K
720 min Winter	9.901	0.901	1.6	138.0	O K
960 min Winter	9.872	0.872	1.5	133.9	O K
1440 min Winter	9.824	0.824	1.5	126.1	O K
2160 min Winter	9.755	0.755	1.4	112.6	O K
2880 min Winter	9.705	0.705	1.4	101.3	O K
4320 min Winter	9.621	0.621	1.3	81.0	O K
5760 min Winter	9.551	0.551	1.2	63.9	O K
7200 min Winter	9.491	0.491	1.2	49.8	O K
8640 min Winter	9.438	0.438	1.1	38.3	O K
10080 min Winter	9.389	0.389	1.0	29.1	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Winter	98.681	19
30 min Winter	64.789	33
60 min Winter	40.510	62
120 min Winter	24.461	122
180 min Winter	17.964	180
240 min Winter	14.342	238
360 min Winter	10.418	352
480 min Winter	8.302	466
600 min Winter	6.956	576
720 min Winter	6.017	684
960 min Winter	4.784	856
1440 min Winter	3.456	1094
2160 min Winter	2.493	1556
2880 min Winter	1.975	1992
4320 min Winter	1.421	2852
5760 min Winter	1.124	3640
7200 min Winter	0.936	4400
8640 min Winter	0.806	5184
10080 min Winter	0.710	5856

EWE Associates Ltd		Page 3
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 16/07/2011 11:42 File Area4 - 100yr 2ls...	Designed By Lea Checked By	
Micro Drainage	Source Control W.12.4	

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+0

Time / Area Diagram

Total Area (ha) 0.310

Time (mins)	Area (ha)
0-4	0.310

EWE Associates Ltd		Page 4
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 16/07/2011 11:42 File Area4 - 100yr 2ls...	Designed By Lea Checked By	
Micro Drainage	Source Control W.12.4	

Model Details

Storage is Online Cover Level (m) 10.500

Pipe Structure

Diameter (m) 0.750 Length (m) 350.000
Slope (1:X) 750.000 Invert Level (m) 9.000

Hydro-Brake® Outflow Control

Design Head (m) 1.500 Hydro-Brake® Type Md4 Invert Level (m) 9.000
Design Flow (l/s) 2.0 Diameter (mm) 46

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	0.9	1.200	1.8	3.000	2.9	7.000	4.4
0.200	0.8	1.400	2.0	3.500	3.1	7.500	4.5
0.300	0.9	1.600	2.1	4.000	3.3	8.000	4.7
0.400	1.0	1.800	2.2	4.500	3.5	8.500	4.8
0.500	1.2	2.000	2.3	5.000	3.7	9.000	4.9
0.600	1.3	2.200	2.4	5.500	3.9	9.500	5.1
0.800	1.5	2.400	2.6	6.000	4.0		
1.000	1.6	2.600	2.7	6.500	4.2		

Appendix L: - WinDes Calculation Sheets Site A Area 5

EWE Associates Ltd		Page 1
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		Micro Drainage
Date 16/07/2011 12:05	Designed By Lea	
File Area6 - 100yr+CC ...	Checked By	
Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 511 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	9.192	0.192	0.0	1.2	1.2	30.6	O K
30 min Summer	9.249	0.249	0.0	1.2	1.2	39.7	O K
60 min Summer	9.304	0.304	0.0	1.2	1.2	48.6	O K
120 min Summer	9.352	0.352	0.0	1.2	1.2	56.2	O K
180 min Summer	9.372	0.372	0.0	1.2	1.2	59.3	O K
240 min Summer	9.379	0.379	0.0	1.2	1.2	60.5	O K
360 min Summer	9.380	0.380	0.0	1.3	1.3	60.7	O K
480 min Summer	9.377	0.377	0.0	1.2	1.2	60.1	O K
600 min Summer	9.372	0.372	0.0	1.2	1.2	59.4	O K
720 min Summer	9.366	0.366	0.0	1.2	1.2	58.5	O K
960 min Summer	9.354	0.354	0.0	1.2	1.2	56.4	O K
1440 min Summer	9.326	0.326	0.0	1.2	1.2	52.0	O K
2160 min Summer	9.285	0.285	0.0	1.2	1.2	45.6	O K
2880 min Summer	9.248	0.248	0.0	1.2	1.2	39.6	O K
4320 min Summer	9.176	0.176	0.0	1.2	1.2	28.2	O K
5760 min Summer	9.115	0.115	0.0	1.2	1.2	18.4	O K
7200 min Summer	9.092	0.092	0.0	1.1	1.1	14.6	O K
8640 min Summer	9.080	0.080	0.0	1.0	1.0	12.8	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Summer	128.285	19
30 min Summer	84.226	33
60 min Summer	52.662	64
120 min Summer	31.800	122
180 min Summer	23.353	182
240 min Summer	18.644	240
360 min Summer	13.543	346
480 min Summer	10.792	400
600 min Summer	9.043	464
720 min Summer	7.823	524
960 min Summer	6.219	662
1440 min Summer	4.493	938
2160 min Summer	3.241	1344
2880 min Summer	2.568	1756
4320 min Summer	1.847	2508
5760 min Summer	1.461	3112
7200 min Summer	1.217	3752
8640 min Summer	1.048	4416

EWE Associates Ltd		Page 2
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 16/07/2011 12:05	Designed By Lea	
File Area6 - 100yr+CC ...	Checked By	
Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
10080 min Summer	9.073	0.073	0.0	0.9	0.9	11.6	O K
15 min Winter	9.215	0.215	0.0	1.2	1.2	34.3	O K
30 min Winter	9.279	0.279	0.0	1.2	1.2	44.6	O K
60 min Winter	9.342	0.342	0.0	1.2	1.2	54.6	O K
120 min Winter	9.397	0.397	0.0	1.3	1.3	63.3	O K
180 min Winter	9.423	0.423	0.0	1.3	1.3	67.1	O K
240 min Winter	9.437	0.437	0.0	1.3	1.3	68.7	O K
360 min Winter	9.445	0.445	0.0	1.4	1.4	69.4	O K
480 min Winter	9.437	0.437	0.0	1.3	1.3	68.6	O K
600 min Winter	9.427	0.427	0.0	1.3	1.3	67.5	O K
720 min Winter	9.418	0.418	0.0	1.3	1.3	66.4	O K
960 min Winter	9.399	0.399	0.0	1.3	1.3	63.6	O K
1440 min Winter	9.359	0.359	0.0	1.2	1.2	57.2	O K
2160 min Winter	9.300	0.300	0.0	1.2	1.2	47.8	O K
2880 min Winter	9.244	0.244	0.0	1.2	1.2	38.9	O K
4320 min Winter	9.121	0.121	0.0	1.2	1.2	19.4	O K
5760 min Winter	9.084	0.084	0.0	1.1	1.1	13.4	O K
7200 min Winter	9.072	0.072	0.0	0.9	0.9	11.4	O K
8640 min Winter	9.064	0.064	0.0	0.8	0.8	10.2	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
10080 min Summer	0.923	5144
15 min Winter	128.285	19
30 min Winter	84.226	33
60 min Winter	52.662	62
120 min Winter	31.800	120
180 min Winter	23.353	178
240 min Winter	18.644	234
360 min Winter	13.543	346
480 min Winter	10.792	448
600 min Winter	9.043	482
720 min Winter	7.823	556
960 min Winter	6.219	712
1440 min Winter	4.493	1012
2160 min Winter	3.241	1452
2880 min Winter	2.568	1876
4320 min Winter	1.847	2504
5760 min Winter	1.461	3056
7200 min Winter	1.217	3744
8640 min Winter	1.048	4416

EWE Associates Ltd		Page 3
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 16/07/2011 12:05	Designed By Lea	
File Area6 - 100yr+CC ...	Checked By	
Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m^3)	Status
10080 min Winter	9.059	0.059	0.0	0.7	0.7	9.4	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
10080 min Winter	0.923	5240

EWE Associates Ltd		Page 4
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 16/07/2011 12:05	Designed By Lea	
File Area6 - 100yr+CC ...	Checked By	
Micro Drainage	Source Control W.12.4	

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time / Area Diagram

Total Area (ha) 0.130

Time (mins)	Area (ha)
0-4	0.130

EWE Associates Ltd		Page 5
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 16/07/2011 12:05	Designed By Lea	
File Area6 - 100yr+CC ...	Checked By	
Micro Drainage	Source Control W.12.4	

Model Details

Storage is Online Cover Level (m) 10.000

Cellular Storage Structure

Invert Level (m) 9.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 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	168.0	168.0	0.500	0.0	191.3
0.400	168.0	188.7			

Hydro-Brake® Outflow Control

Design Head (m) 1.000 Hydro-Brake® Type Md4 Invert Level (m) 9.000
Design Flow (l/s) 2.0 Diameter (mm) 51

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.2	1.200	2.2	3.000	3.5	7.000	5.4
0.200	1.0	1.400	2.4	3.500	3.8	7.500	5.6
0.300	1.1	1.600	2.6	4.000	4.1	8.000	5.8
0.400	1.3	1.800	2.7	4.500	4.3	8.500	5.9
0.500	1.4	2.000	2.9	5.000	4.6	9.000	6.1
0.600	1.6	2.200	3.0	5.500	4.8	9.500	6.3
0.800	1.8	2.400	3.2	6.000	5.0		
1.000	2.0	2.600	3.3	6.500	5.2		

Appendix M: - WinDes Calculation Sheets Site A Area 6

EWE Associates Ltd		Page 1
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 16/07/2011 12:13	Designed By Lea	
File Area7 - 100yr+CC ...	Checked By	
Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+30%)

Half Drain Time : 1028 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m^3)	Status
15 min Summer	9.168	0.168	0.0	1.2	1.2	54.6	O K
30 min Summer	9.220	0.220	0.0	1.2	1.2	71.4	O K
60 min Summer	9.272	0.272	0.0	1.2	1.2	88.2	O K
120 min Summer	9.321	0.321	0.0	1.2	1.2	104.2	O K
180 min Summer	9.346	0.346	0.0	1.2	1.2	112.3	O K
240 min Summer	9.360	0.360	0.0	1.2	1.2	116.9	O K
360 min Summer	9.376	0.376	0.0	1.2	1.2	122.1	O K
480 min Summer	9.383	0.383	0.0	1.3	1.3	124.4	O K
600 min Summer	9.385	0.385	0.0	1.3	1.3	125.1	O K
720 min Summer	9.384	0.384	0.0	1.3	1.3	124.6	O K
960 min Summer	9.379	0.379	0.0	1.2	1.2	123.2	O K
1440 min Summer	9.368	0.368	0.0	1.2	1.2	119.5	O K
2160 min Summer	9.348	0.348	0.0	1.2	1.2	112.9	O K
2880 min Summer	9.326	0.326	0.0	1.2	1.2	106.0	O K
4320 min Summer	9.285	0.285	0.0	1.2	1.2	92.6	O K
5760 min Summer	9.248	0.248	0.0	1.2	1.2	80.4	O K
7200 min Summer	9.212	0.212	0.0	1.2	1.2	68.8	O K
8640 min Summer	9.176	0.176	0.0	1.2	1.2	57.0	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Summer	128.285	19
30 min Summer	84.226	34
60 min Summer	52.662	64
120 min Summer	31.800	124
180 min Summer	23.353	182
240 min Summer	18.644	242
360 min Summer	13.543	362
480 min Summer	10.792	480
600 min Summer	9.043	600
720 min Summer	7.823	700
960 min Summer	6.219	806
1440 min Summer	4.493	1052
2160 min Summer	3.241	1468
2880 min Summer	2.568	1876
4320 min Summer	1.847	2720
5760 min Summer	1.461	3512
7200 min Summer	1.217	4320
8640 min Summer	1.048	5016

EWE Associates Ltd		Page 2
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 16/07/2011 12:13	Designed By Lea	
File Area7 - 100yr+CC ...	Checked By	
Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
10080 min Summer	9.139	0.139	0.0	1.2	1.2	45.3	O K
15 min Winter	9.189	0.189	0.0	1.2	1.2	61.2	O K
30 min Winter	9.246	0.246	0.0	1.2	1.2	80.0	O K
60 min Winter	9.305	0.305	0.0	1.2	1.2	98.9	O K
120 min Winter	9.360	0.360	0.0	1.2	1.2	117.0	O K
180 min Winter	9.389	0.389	0.0	1.3	1.3	126.3	O K
240 min Winter	9.406	0.406	0.0	1.3	1.3	131.8	O K
360 min Winter	9.429	0.429	0.0	1.3	1.3	138.1	O K
480 min Winter	9.444	0.444	0.0	1.4	1.4	141.2	O K
600 min Winter	9.452	0.452	0.0	1.4	1.4	142.4	O K
720 min Winter	9.452	0.452	0.0	1.4	1.4	142.5	O K
960 min Winter	9.442	0.442	0.0	1.3	1.3	140.7	O K
1440 min Winter	9.420	0.420	0.0	1.3	1.3	135.7	O K
2160 min Winter	9.390	0.390	0.0	1.3	1.3	126.7	O K
2880 min Winter	9.359	0.359	0.0	1.2	1.2	116.7	O K
4320 min Winter	9.300	0.300	0.0	1.2	1.2	97.4	O K
5760 min Winter	9.244	0.244	0.0	1.2	1.2	79.2	O K
7200 min Winter	9.184	0.184	0.0	1.2	1.2	59.9	O K
8640 min Winter	9.122	0.122	0.0	1.2	1.2	39.6	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
10080 min Summer	0.923	5648
15 min Winter	128.285	19
30 min Winter	84.226	33
60 min Winter	52.662	62
120 min Winter	31.800	122
180 min Winter	23.353	180
240 min Winter	18.644	238
360 min Winter	13.543	354
480 min Winter	10.792	468
600 min Winter	9.043	580
720 min Winter	7.823	688
960 min Winter	6.219	894
1440 min Winter	4.493	1112
2160 min Winter	3.241	1580
2880 min Winter	2.568	2020
4320 min Winter	1.847	2900
5760 min Winter	1.461	3752
7200 min Winter	1.217	4608
8640 min Winter	1.048	5016

EWE Associates Ltd		Page 3
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 16/07/2011 12:13	Designed By Lea	
File Area7 - 100yr+CC ...	Checked By	
Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
10080 min Winter	9.096	0.096	0.0	1.2	1.2	31.2	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
10080 min Winter	0.923	5456

EWE Associates Ltd		Page 4
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 16/07/2011 12:13 File Area7 - 100yr+CC ...	Designed By Lea Checked By	
Micro Drainage	Source Control W.12.4	

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time / Area Diagram

Total Area (ha) 0.230

Time (mins)	Area (ha)
0-4	0.230

EWE Associates Ltd		Page 5
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 16/07/2011 12:13	Designed By Lea	
File Area7 - 100yr+CC ...	Checked By	
Micro Drainage	Source Control W.12.4	

Model Details

Storage is Online Cover Level (m) 10.000

Cellular Storage Structure

Invert Level (m) 9.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 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	342.0	342.0	0.500	0.0	371.6
0.400	342.0	371.6			

Hydro-Brake® Outflow Control

Design Head (m) 1.000 Hydro-Brake® Type Md4 Invert Level (m) 9.000
Design Flow (l/s) 2.0 Diameter (mm) 51

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.2	1.200	2.2	3.000	3.5	7.000	5.4
0.200	1.0	1.400	2.4	3.500	3.8	7.500	5.6
0.300	1.1	1.600	2.6	4.000	4.1	8.000	5.7
0.400	1.3	1.800	2.7	4.500	4.3	8.500	5.9
0.500	1.4	2.000	2.9	5.000	4.5	9.000	6.1
0.600	1.6	2.200	3.0	5.500	4.8	9.500	6.2
0.800	1.8	2.400	3.1	6.000	5.0		
1.000	2.0	2.600	3.3	6.500	5.2		

Appendix N: - WinDes Calculation Sheets Site B Area 1

EWE Associates Ltd		Page 1
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 17/09/2011 15:13 File Area1 - 100yr+CC ...	Designed By Lea Checked By	
Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m^3)	Status
15 min Summer	9.480	0.480	1.4	75.5	O K
30 min Summer	9.546	0.546	1.5	98.5	O K
60 min Summer	9.611	0.611	1.6	121.5	O K
120 min Summer	9.672	0.672	1.7	142.8	O K
180 min Summer	9.703	0.703	1.7	153.3	O K
240 min Summer	9.721	0.721	1.7	159.1	O K
360 min Summer	9.739	0.739	1.7	165.0	O K
480 min Summer	9.746	0.746	1.8	167.1	O K
600 min Summer	9.745	0.745	1.7	166.9	O K
720 min Summer	9.740	0.740	1.7	165.2	O K
960 min Summer	9.726	0.726	1.7	160.9	O K
1440 min Summer	9.697	0.697	1.7	151.3	O K
2160 min Summer	9.663	0.663	1.7	139.6	O K
2880 min Summer	9.635	0.635	1.6	129.8	O K
4320 min Summer	9.585	0.585	1.6	112.3	O K
5760 min Summer	9.542	0.542	1.5	96.9	O K
7200 min Summer	9.503	0.503	1.4	83.3	O K
8640 min Summer	9.468	0.468	1.4	71.3	O K
10080 min Summer	9.435	0.435	1.3	60.7	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Summer	128.285	20
30 min Summer	84.226	34
60 min Summer	52.662	64
120 min Summer	31.800	124
180 min Summer	23.353	182
240 min Summer	18.644	242
360 min Summer	13.543	362
480 min Summer	10.792	482
600 min Summer	9.043	600
720 min Summer	7.823	700
960 min Summer	6.219	808
1440 min Summer	4.493	1054
2160 min Summer	3.241	1468
2880 min Summer	2.568	1876
4320 min Summer	1.847	2684
5760 min Summer	1.461	3464
7200 min Summer	1.217	4256
8640 min Summer	1.048	5016
10080 min Summer	0.923	5752

EWE Associates Ltd		Page 2
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 17/09/2011 15:13	Designed By Lea	
File Area1 - 100yr+CC ...	Checked By	
Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m^3)	Status
15 min Winter	9.507	0.507	1.4	84.7	O K
30 min Winter	9.580	0.580	1.5	110.6	O K
60 min Winter	9.654	0.654	1.6	136.6	O K
120 min Winter	9.727	0.727	1.7	161.1	O K
180 min Winter	9.767	0.767	1.8	173.4	O K
240 min Winter	9.792	0.792	1.8	180.5	O K
360 min Winter	9.823	0.823	1.8	188.2	O K
480 min Winter	9.838	0.838	1.9	191.7	O K
600 min Winter	9.842	0.842	1.9	192.6	O K
720 min Winter	9.839	0.839	1.9	192.0	O K
960 min Winter	9.822	0.822	1.8	188.0	O K
1440 min Winter	9.782	0.782	1.8	177.7	O K
2160 min Winter	9.726	0.726	1.7	161.0	O K
2880 min Winter	9.684	0.684	1.7	147.0	O K
4320 min Winter	9.611	0.611	1.6	121.4	O K
5760 min Winter	9.548	0.548	1.5	98.9	O K
7200 min Winter	9.493	0.493	1.4	79.7	O K
8640 min Winter	9.444	0.444	1.4	63.5	O K
10080 min Winter	9.400	0.400	1.3	49.9	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Winter	128.285	20
30 min Winter	84.226	34
60 min Winter	52.662	64
120 min Winter	31.800	122
180 min Winter	23.353	180
240 min Winter	18.644	238
360 min Winter	13.543	354
480 min Winter	10.792	468
600 min Winter	9.043	580
720 min Winter	7.823	692
960 min Winter	6.219	896
1440 min Winter	4.493	1122
2160 min Winter	3.241	1580
2880 min Winter	2.568	2044
4320 min Winter	1.847	2896
5760 min Winter	1.461	3744
7200 min Winter	1.217	4536
8640 min Winter	1.048	5272
10080 min Winter	0.923	6048

EWE Associates Ltd		Page 3
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 17/09/2011 15:13 File Area1 - 100yr+CC ...	Designed By Lea Checked By	
Micro Drainage	Source Control W.12.4	

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time / Area Diagram

Total Area (ha) 0.320

Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.300	4-8	0.020

EWE Associates Ltd		Page 4
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 17/09/2011 15:13 File Area1 - 100yr+CC ...	Designed By Lea Checked By	
Micro Drainage	Source Control W.12.4	

Model Details

Storage is Online Cover Level (m) 11.000

Double Pipe Structure

Diameter (m) 0.750 Length (m) 250.000
Slope (1:X) 600.000 Invert Level (m) 9.000

Hydro-Brake® Outflow Control

Design Head (m) 1.000 Hydro-Brake® Type Md4 Invert Level (m) 9.000
Design Flow (l/s) 2.0 Diameter (mm) 51

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.2	1.200	2.2	3.000	3.5	7.000	5.4
0.200	1.0	1.400	2.4	3.500	3.8	7.500	5.6
0.300	1.1	1.600	2.6	4.000	4.1	8.000	5.8
0.400	1.3	1.800	2.7	4.500	4.3	8.500	5.9
0.500	1.4	2.000	2.9	5.000	4.6	9.000	6.1
0.600	1.6	2.200	3.0	5.500	4.8	9.500	6.3
0.800	1.8	2.400	3.2	6.000	5.0		
1.000	2.0	2.600	3.3	6.500	5.2		

Appendix O: - WinDes Calculation Sheets Site B Area 2

EWE Associates Ltd		Page 1
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 17/09/2011 15:06	Designed By Lea	
File Area2 - 100yr+CC ...	Checked By	
Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m^3)	Status
15 min Summer	9.218	0.218	2.0	126.7	O K
30 min Summer	9.286	0.286	2.0	166.0	O K
60 min Summer	9.355	0.355	2.0	206.0	O K
120 min Summer	9.422	0.422	2.0	244.7	O K
180 min Summer	9.457	0.457	2.1	265.2	O K
240 min Summer	9.479	0.479	2.1	277.9	O K
360 min Summer	9.506	0.506	2.2	293.4	O K
480 min Summer	9.521	0.521	2.2	302.3	O K
600 min Summer	9.529	0.529	2.3	307.1	O K
720 min Summer	9.533	0.533	2.3	309.3	O K
960 min Summer	9.532	0.532	2.3	308.8	O K
1440 min Summer	9.522	0.522	2.2	303.0	O K
2160 min Summer	9.504	0.504	2.2	292.1	O K
2880 min Summer	9.483	0.483	2.1	280.0	O K
4320 min Summer	9.440	0.440	2.1	255.2	O K
5760 min Summer	9.400	0.400	2.0	231.9	O K
7200 min Summer	9.363	0.363	2.0	210.4	O K
8640 min Summer	9.328	0.328	2.0	190.4	O K
10080 min Summer	9.296	0.296	2.0	171.4	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Summer	128.285	25
30 min Summer	84.226	39
60 min Summer	52.662	68
120 min Summer	31.800	128
180 min Summer	23.353	186
240 min Summer	18.644	246
360 min Summer	13.543	364
480 min Summer	10.792	484
600 min Summer	9.043	602
720 min Summer	7.823	722
960 min Summer	6.219	954
1440 min Summer	4.493	1168
2160 min Summer	3.241	1552
2880 min Summer	2.568	1964
4320 min Summer	1.847	2776
5760 min Summer	1.461	3632
7200 min Summer	1.217	4400
8640 min Summer	1.048	5192
10080 min Summer	0.923	6048

EWE Associates Ltd		Page 2
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 17/09/2011 15:06	Designed By Lea	
File Area2 - 100yr+CC ...	Checked By	
Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+30%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m^3)	Status
15 min Winter	9.245	0.245	2.0	142.1	O K
30 min Winter	9.321	0.321	2.0	186.1	O K
60 min Winter	9.398	0.398	2.0	231.0	O K
120 min Winter	9.474	0.474	2.1	274.8	O K
180 min Winter	9.514	0.514	2.2	298.2	O K
240 min Winter	9.539	0.539	2.3	312.7	O K
360 min Winter	9.571	0.571	2.3	331.0	O K
480 min Winter	9.590	0.590	2.4	341.9	O K
600 min Winter	9.601	0.601	2.4	348.3	O K
720 min Winter	9.607	0.607	2.4	351.9	O K
960 min Winter	9.610	0.610	2.4	353.6	O K
1440 min Winter	9.597	0.597	2.4	346.1	O K
2160 min Winter	9.572	0.572	2.3	332.0	O K
2880 min Winter	9.544	0.544	2.3	315.5	O K
4320 min Winter	9.483	0.483	2.2	280.2	O K
5760 min Winter	9.425	0.425	2.0	246.6	O K
7200 min Winter	9.371	0.371	2.0	215.4	O K
8640 min Winter	9.321	0.321	2.0	185.9	O K
10080 min Winter	9.269	0.269	2.0	156.1	O K

Storm Event	Rain (mm/hr)	Time-Peak (mins)
15 min Winter	128.285	25
30 min Winter	84.226	39
60 min Winter	52.662	68
120 min Winter	31.800	126
180 min Winter	23.353	184
240 min Winter	18.644	242
360 min Winter	13.543	358
480 min Winter	10.792	474
600 min Winter	9.043	588
720 min Winter	7.823	702
960 min Winter	6.219	924
1440 min Winter	4.493	1326
2160 min Winter	3.241	1648
2880 min Winter	2.568	2108
4320 min Winter	1.847	3028
5760 min Winter	1.461	3912
7200 min Winter	1.217	4760
8640 min Winter	1.048	5616
10080 min Winter	0.923	6456

EWE Associates Ltd		Page 3
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 17/09/2011 15:06 File Area2 - 100yr+CC ...	Designed By Lea Checked By	
Micro Drainage	Source Control W.12.4	

Rainfall Details

Rainfall Model	FSR	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
Region	England and Wales	Cv (Winter)	0.840
M5-60 (mm)	20.000	Shortest Storm (mins)	15
Ratio R	0.400	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+30

Time / Area Diagram

Total Area (ha) 0.534

Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.250	4-8	0.250	8-12	0.034

EWE Associates Ltd		Page 4
Windy Ridge Barn Thealby Lane Winterton DN15 9TG		
Date 17/09/2011 15:06 File Area2 - 100yr+CC ...	Designed By Lea Checked By	
Micro Drainage	Source Control W.12.4	

Model Details

Storage is Online Cover Level (m) 10.000

Tank or Pond Structure

Invert Level (m) 9.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	580.0	1.400	0.0	2.800	0.0	4.200	0.0
0.200	580.0	1.600	0.0	3.000	0.0	4.400	0.0
0.400	580.0	1.800	0.0	3.200	0.0	4.600	0.0
0.600	580.0	2.000	0.0	3.400	0.0	4.800	0.0
0.800	580.0	2.200	0.0	3.600	0.0	5.000	0.0
1.000	580.0	2.400	0.0	3.800	0.0		
1.200	0.0	2.600	0.0	4.000	0.0		

Hydro-Brake® Outflow Control

Design Head (m) 1.000 Hydro-Brake® Type Md4 Invert Level (m) 9.000
Design Flow (l/s) 3.0 Diameter (mm) 63

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.7	1.200	3.3	3.000	5.3	7.000	8.1
0.200	1.7	1.400	3.6	3.500	5.7	7.500	8.3
0.300	1.7	1.600	3.9	4.000	6.1	8.000	8.6
0.400	1.9	1.800	4.1	4.500	6.5	8.500	8.9
0.500	2.2	2.000	4.3	5.000	6.8	9.000	9.1
0.600	2.4	2.200	4.5	5.500	7.1	9.500	9.4
0.800	2.7	2.400	4.7	6.000	7.5		
1.000	3.0	2.600	4.9	6.500	7.8		