Mr Roger Auckland

Proposed Change of Use
Scout Bridge Farm
Huddersfield Road
Penistone

Flood Risk Assessment

Prepared by EWE Associates Ltd
Final Rev0 July 2013

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CLIENT DETAILS

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CONTRACT

This report describes work commissioned by Mr Roger Auckland following written instruction on 25th June 2013. Mr Roger Auckland representative for the contract was Mr Michael Coates. Lea Favill of EWE Associates Ltd carried out the work.

Date: 16th July 2013

Prepared by: …… …… Lea Favill
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REVISION HISTORY

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EXECUTIVE SUMMARY

The proposed development is currently an outbuilding used for storage and garages. The total site area has been estimated at approximately 160m² (20m x 8m) which is considered to be totally roofed. As such, it is considered that the existing site is 100% impermeable.

The external ground levels directly adjacent to the building to be redeveloped vary between 206.952mOD up to 207.434mOD. The existing internal ground floor level of the building is 207.382mOD. There is an existing residential dwelling adjacent to the site.

The proposed development is to redevelop the existing building to provide residential accommodation. It is considered that the roofed area will remain as at present, approximately 160m² following the redevelopment.

The development site appears from initial inspection to lie 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.

The site is located adjacent to the Scout Dike. The 1 in 100 year flood level has been estimated at 205.27mOD and the 1 in 100 year plus climate change flood level for the site has been estimated at 205.34mOD. The existing ground floor level building is 207.382mOD. Therefore, during the 1 in 100 year flood event, 1 in 100 year plus climate change flood event and the extreme 1 in 1,000 year flood event the building remains dry.

It is therefore recommended that a minimum internal ground floor level of 600mm above the estimated 1 in 100 year plus climate change flood level is adopted for the development, hence 205.34mOD plus 0.6m equals 205.94mOD.

As the development is residential, it is considered that dry access and egress from the development site will be essential during extreme flood events. The Scout Dike 1 in 100 year plus climate change flood level has been estimated at 205.34mOD which is less than the lowest existing ground floor level within the building. As such, the building will remain dry and a safe area above the potential floods.

The access road which links the building with Huddersfield Road to the south of the site which is located within flood zone 1, low risk, is above the estimated flood level. As such, it is considered that during the 100 year and the 100 year plus climate change flood events that the site and access route to the south will remain dry.

It is concluded that there is a low risk of fluvial flooding to the proposed redevelopment from the Scout Dike and that the building is located within flood zone 1, low risk based on the simple model used within this assessment. Raising the internal ground floor levels 600mm above the estimated 1 in 100 year plus climate change flood level will reduce the risk of flooding to an acceptable level. It is unlikely that the proposed development will have any adverse impact on the surface water drainage in the area.

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1. INTRODUCTION

Terms of Reference

This report was commissioned by Roger Auckland to support a planning application for the change of use of one of the outbuildings to provide a single residential dwelling within the domestic garden of Scout Bridge Farm, Penistone near Sheffield. The site can presently be accessed from the south off Huddersfield Road. The location of the site is shown on Table 2-1.

The development site appears from initial inspection to lie 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. The overall size of the development is less 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 potentially two sources of flood risk – Scout Dike and surface water runoff – it is necessary to determine flood water levels at the site for the desired return periods emanating from these sources. Consideration has also been given to the site flooding from either overland flow or ponding of localised rainfall within the site.

Barnsley Metropolitan Council commissioned a level 1 SFRA which was completed by JBA Consulting during November 2010. References have been taken from the assessment; however, there is very little site specific information within the report relevant to the area close to the site.

The Scout Dike flows adjacent to the north east of the building in a south easterly direction eventually discharging into the River Don to the south of Penistone. In line with the site the dike is open channel. Directly downstream of the site the dike passes over a small weir and then passes beneath Huddersfield Road Bridge. The dike is considered to be Non Main River, as such, the responsibility for flood defence and land drainage lies with the local authority and riparian owners.

There are no modelled flood levels which may assist in predicting the design flood level for the river adjacent to the proposed development site. As such, a simplified HEC RAS model has been constructed to estimate the in-channel capacity of the river in line with the site. It should be noted that the model is considered fit for purpose and is not intended as a rigorous study of the Scout Dike.

The proposed development is simply a change of use of an existing building which is positively drained to the adjacent Scout Dike. The proposal will not increase the impermeable areas within the site or alter the surface water drainage system in any way. It is therefore considered that the proposed development will have an

insignificant impact on the surface water runoff and this mechanism has not been considered further.

A walk over of the site was conducted by Mr Lea Favill, Principal Engineer on 27th June 2013; during the visit a photograph survey of the site was undertaken. A spot level survey of the development site and cross sections through the dike local to the site were undertaken by EWE Associates Ltd during the site visit.

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

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

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

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

Application of Sequential & Exceptions Test

The development site appears from initial inspection to lie 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. The proposed development is residential, as such, is considered to be more vulnerable.

Table 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	✓	×	×	×

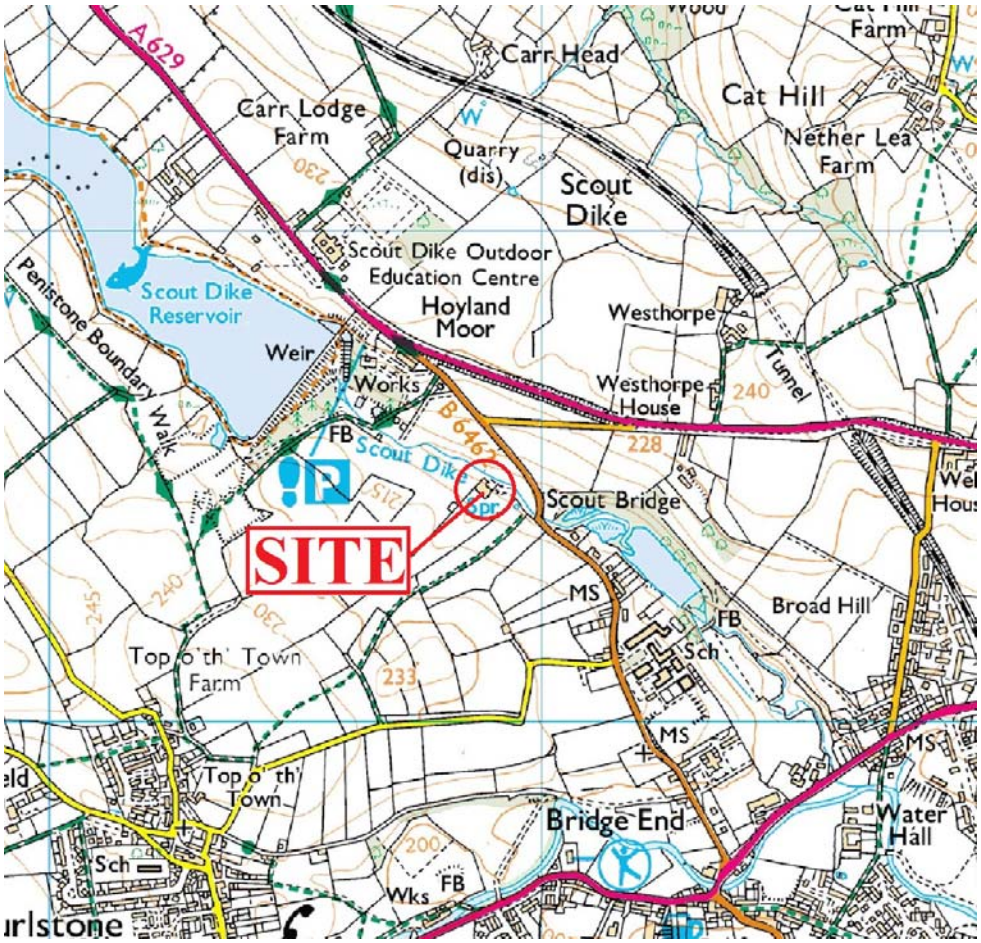
✓ Development is appropriate

× Development should not be permitted

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	Scout Bridge Farm, Penistone
Existing Land Use	Out buildings
Proposed Development	Residential
Grid Reference	SE 23973 04430
County	West Yorkshire
Local Planning Authority	Barnsley Metropolitan Council
Internal Drainage Board	Not Applicable
Others	Not Applicable
Post Code	S36 7EZ

Site Description

The proposed development is currently an outbuilding used for storage and garages. An aerial photograph of the site is shown below in Figure 2.1. The total site area has been estimated at approximately 160m² (20m x 8m) which is considered to be totally roofed. As such, it is considered that the existing site is 100% impermeable.

The external ground levels directly adjacent to the building to be redeveloped vary between 206.952mOD up to 207.434mOD. The existing internal ground floor level of the building is 207.382mOD. The ground levels within the site are illustrated at Appendix A of this report. There is an existing residential dwelling adjacent to the site.

The proposed development is to redevelop the existing building to provide residential accommodation. The proposed floor plans are provided at Appendix B of this report.

It is considered that the roofed area will remain as at present, approximately 160m² following the redevelopment.

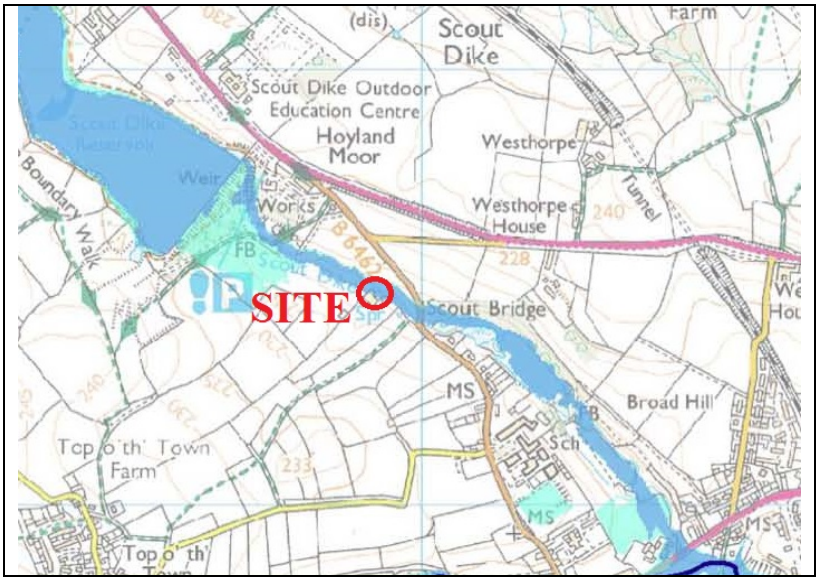
Site Photographs

Figure 2.1: Aerial Photograph of the Existing Site.

3. INITIAL ASSESSMENT

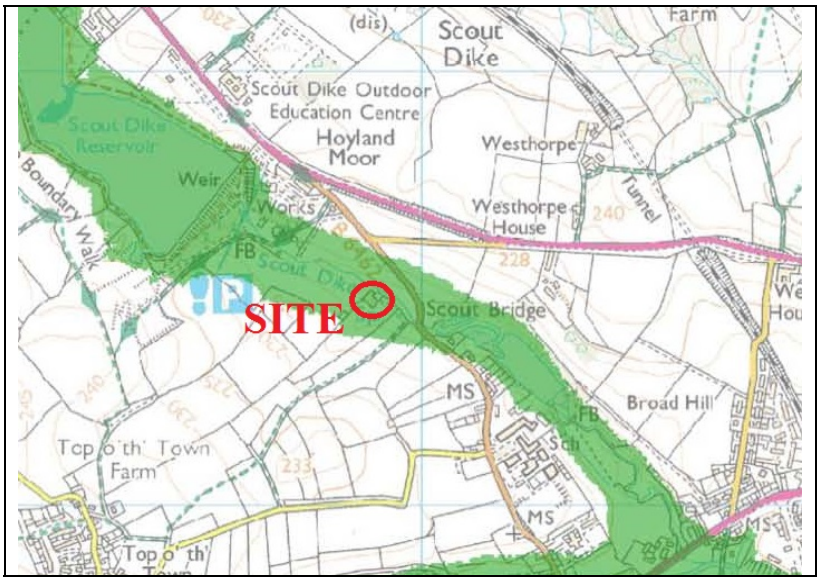
Environment Agency Flood Map

Figure 3.1: Environment Agency Flood Zones



Environment Agency Reservoir Flood Map

Figure 3.2: Environment Agency Reservoir Flood Map



Past Flooding History

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

Undertaking an internet based search for flooding found no further reference to flooding close to the site.

SFRA Flooding History

The SFRA contained no references to the site being flooded.

Environment Agency Flooding History

The Environment Agency could not provide any records of historical flooding close to the site.

Reservoir Flood Risk

The reservoir flood map shows that the Scout Dike could be at risk if a reservoir breached. The source of risk appears to be from the group of reservoirs north of the site which includes Scout Dike Reservoir, Royd Moor Reservoir, Ingbirchworth Reservoir and Broadstone Reservoir. The Scout Dike would act as a conduit for the reservoirs if they were to breach. The site is shown to be within the potential flood area.

The reservoir flood map shows the consequences of a full breach of the dam structure with the reservoir at full capacity, as such a worse case scenario. However, the flood maps do not consider the probability of such a failure. Following discussions with Yorkshire Water who are responsible for Reservoirs it was commented that the probability of failure is low as the reservoir is inspected and maintained in accordance with the Reservoirs Act. As such, the dam is regularly inspected for defects and any necessary works undertaken prior to a failure. Therefore, the probability of a failure is extremely low.

Possible Flooding Mechanisms

As there is a single remaining source of flood risk which requires detailed consideration – Scout Dike – it is necessary to determine flood water levels at the site for the desired return periods emanating from this source.

The Scout Dike which is to the east of the site is not defended by earth embankments which extend above the natural ground level. Therefore, consideration will need to be given to overtopping only.

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

Information on groundwater flooding is limited within the Barnsley Metropolitan Council. The SFRA provided no further information. In addition, reference to the Groundwater Vulnerability Map and Source Protection Zones produced by the Environment Agency indicate that district is not underlain by an aquifer and are therefore unlikely to be source of significant flood risk.

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

4. FLOOD RISK ASSESSMENT

Requirements of the Environment Agency

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

Scout Dike

The Scout Dike is a tributary of the River Don and the head of the watercourse is to the north of the site close to Holmfirth. The watercourse has a reasonably sized catchment upstream of the site which is predominantly rural. Upstream of the site the watercourse is generally open channel. Directly downstream of the site the dike flows over a weir and then passes beneath B6462 Huddersfield Road Bridge which represents the most significant restriction to flows close to the site. The view over the weir towards the bridge is shown below in Figure 4.1.

Figure 4.1: View downstream towards Huddersfield Road Bridge.

The Environment Agency has confirmed that flood level data for the river is not available. Therefore a hydrological assessment of the catchment and a simple river modelling has been carried out to establish the flow in the river for a series of flood events.

Table 4.1 below summarises the water levels (based on the HEC-RAS simulation) within the site. These return periods may be used to determine the relative risk for out-of-bank flows at various locations within the site. Cross section CS103 is located directly downstream of the building to be redeveloped. The model was initially run un-obstructed. Following this sensitivity analysis was conducted by increasing Manning's values within the main channel.

Table 4.1: Water Levels at CS220 during various scenarios

Location	Cross Section Reference	Model scenario	1 in 100 year plus climate change
Downstream of building	103	Normal unobstructed	205.34
		Manning's n increased by +0.01	205.37

During the 1 in 100 year plus climate change flood the estimated water level adjacent to the development site is at a level of 205.34mOD. The flood water overtops the left bank in line with the site, however, the building is not flooded.

Sensitivity analysis has been carried out on the model. Consideration has been given to the impact of increasing the Manning's 'n' values within the study reach by adding 0.01 to the main channel. The 1 in 100 year plus climate change flood level is increased to 205.37mOD at CS103.

5. HYDROLOGICAL ASSESSMENT

Introduction

The estimation of peak flows for a range of annual probabilities or 'design' events has been required to enable the flood mapping of the dike adjacent to the site to be undertaken. This chapter describes the processes carried out to provide these estimates.

The Environment Agency Flood Estimation guidelines suggest the use of the Flood Estimation Handbook (FEH) for derivation of peak flow estimates. The hydrological analysis has concentrated on the production of peak flow estimates for use with a steady state hydraulic model rather than hydrographs.

The objective of the hydrological study is to determine peak flows for annual exceedence probability (AEP) flood events 100 year and 100 year plus climate change. Due to the size of the development it is considered that the ReFH Rainfall Runoff Method is appropriate for this assessment.

Methods of Flood Estimation

The catchment is un-gauged, relatively small sized and generally rural in nature. From the FEH CD Rom the catchment descriptors have been derived. The FARL value for the catchment has been estimated at 0.722 which suggests there is attenuation upstream of the study reach provided by the reservoirs. As such, the ReFH Rainfall Runoff Method is suitable for deriving flows for the catchment. The flows have been derived directly downstream of the site at the weir upstream of Huddersfield Road Bridge. The catchment area of 11.52km² has been estimated at this point.

Flow Estimation Point

Flow estimates have been made at a single point along the study reach. The location of the flow estimation point used in the hydrological study is described in **Table 5-1** below. The flow estimation point has been annotated onto the plan provided at Appendix C of this report.

Table 5-1: Flow Estimate Point

Site code	Location	Grid Reference	Catchment area from FEH CD-ROM (km^2)
Q1	downstream limit at the weir	SE 23973 04430	11.52

The Scout Dike Adjacent to the Site

The catchment of the dike is of a small size, and relatively steep, and there are no gauging stations within the watercourse.

ReFH Rainfall Runoff Method

The rainfall-runoff method involves constructing a simple model of the catchment, with three parameters. These can be best estimated when there is rainfall and river level or flow data for a number of flood events, however this information was not available for the study catchments and so the parameters were estimated using catchment descriptors, as described in Volume 4 of the FEH. Design flows were estimated from design rainfall events, which are prescribed by the FEH. The ReFH Spreadsheet software was used to estimate peak flows for a range of annual probabilities.

The estimated 1 in 100 year, 1 in 100 year plus climate change (+20%) and the extreme 1 in 1,000 year flows for the flow locations is provided below in Table 5-2. The full calculations are provided at Appendix D of this report.

Table 5-2: Flow Estimates for ReFH Method

Site code	Location	Estimated 1 in 100 year flow	Estimated 1 in 100 year plus climate change flow	Estimated 1 in 1,000 year flow
Q1	Downstream weir	7.00	8.40	13.70

The 1 in 100 year has been estimated at 7.00m³/s (Q1). Consideration has been given to take into account the potential effects of climate change and water level rise over the next 100 years in accordance with NPPF. A 1 in 100 year plus climate change return period incorporating the precautionary sensitivity range of a 20% increase in rainfall intensity and peak river flows recommended by NPPF, provided a design flow of 8.40m³/s (Q1).

6. HYDRAULIC MODELLING

Introduction

The purpose of the hydraulic modelling has been to produce peak water levels from the derived design flow estimates for the Scout Dike catchment, in order to establish the capacity of the dike adjacent to the development site. The model has been used specifically to estimate a flood level for the river inline with the 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. A spot level survey of the site was undertaken by EWE Associates Ltd and a cross section survey was undertaken by EWE Associates Ltd and included a total of 5 cross sections within the river.

The locations of the cross sections, as surveyed, are shown at Appendix C. The positions of the cross sections were based primarily on the location of structures and significant changes in channel and structure geometry. Other factors influencing the final cross-section locations were conditions on site (visibility, access and obstructions).

Model Schematisation

The HEC-RAS model comprises of a single reach the river study reach 1. The extents of the model are given below in Table 6-1 and shown at Appendix C.

Table 6-1: Model Extents

Watercourse	Upstream Extent	Downstream Extent
Scout Dike	Directly upstream of the building to be redeveloped	Directly Upstream of Huddersfield Road Bridge

In total 5 cross sections, of which there is a single weir and a single wooden pedestrian access bridge within the study reach which has been used to develop the model as shown in Table 6.3.

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 river was considered as a single reach characterised by similar floodplain and channel bank roughness conditions. A description of the reach is provided in Table 6.2 overleaf. The values were verified by EWE Associates Ltd during a site inspection. During the site inspection an Engineer walked along the dike for the entire study reach.

Table 6-2: Estimated Manning's n Values for the Scout Dike

Cross Section References	Main Channel Manning's n Value	Floodplain Manning's n Value		Location	Description
		Left	Right		
40	0.045	0.035	0.035	Centre of site	Main Channel: sections of straight channel with sweeping bends , full with no rifts or deep pools. The channel contains stones. Floodplain: Access roads and gardens

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

A single structure, considered hydraulically significant, has been identified within the river and modelled using the HEC-RAS bridge routine (See Table 6.3).

Table 6-3: Bridge Details

HEC-RAS Reference	Structure	Description	Structure Length (m)	Piers
BR41.5	2m wide timber pedestrian access bridge	Access Bridge	2m	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 river 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.

Levels of Confidence in Modelled Water Levels

The confidence or accuracy of the levels provided by computational hydraulic models is dependent on several related factors, namely, the accuracy of the flow rate adopted, the friction of the channel and the model schematisation. The mathematical representation of the hydraulics is also important but in general, errors due to this source are minor compared to the others. To maintain meaningful accuracy figures for water level, these should be quoted for a given flow rate and assumed roughness (in other words ignoring return period which is a major source of uncertainty).

Calibration of the model has not been possible due to the absence of known flow and level data during past events. However it is considered that the model is appropriate for the purpose of this flood risk assessment.

7. MODEL SIMULATION

Introduction

The primary aim of this study was to assess the capacity of the existing channel within the development site, and to assess the impact of the river on the proposed development site itself.

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

Un-obstructed Flow Simulation

During the 1 in 100 year flood event the water remains in channel in line within the site and directly upstream of the Huddersfield Bridge.

Table 7-1 summarises the water levels (based on the HEC-RAS simulation) at locations in line and downstream of the development site. During the 1 in 100 year plus climate change flood event the water floods downstream of the site generally within the left bank area away from the building to be redeveloped. During the extreme 1 in 1,000 year event the left bank of the channel is overtopped by up to 0.6m directly downstream of the site. It is unlikely that the site will be flooded during this event.

Table 7-1: Water Levels at Key Locations during normal flow

Cross Section Reference	100yr Water Level (mOD)	100yr+CC Water Level (mOD)	1,000yr Water Level (mOD)
136	205.22	205.27	205.47
103	205.27	205.34	205.56
43	205.24	205.31	205.51

Model Sensitivity – Sensitivity to Roughness

The sensitivity of the modelled water levels to channel and floodplain roughness was checked by varying the standard values of Manning's n by +0.010 for the 1 in 100 year, 1 in 100 year plus climate change and the extreme 1 in 1,000 year return period design events. The results indicated that a 0.010 increase in Manning's n (channel only) would cause a maximum water level increase of 0.04m within the site.

The study watercourse is not considered to be highly sensitive to roughness. Careful consideration has been given to specifying Manning's n, so there is reasonable confidence in the model results.

Table 7-2: Water Level increase due to increase in Manning's

Cross Section Reference	100yr Water Level (mOD)	100yr+CC Water Level (mOD)	1,000yr Water Level (mOD)
136	205.22	205.27	205.47
103	205.29	205.37	205.60
43	205.26	205.33	205.54

Sensitivity to Design Flow

There are uncertainties associated with the estimated design flows for the river, as these estimates are based entirely on un-gauged procedures.

A method of assessing the effect of uncertainties in the design flood estimates is to increase the 100-year return period flow by 20%, which incorporates the effects of climate change. This 20% increase in flow causes a corresponding increase in water levels with a maximum difference of 0.07m downstream of the site when compared to the 1 in 100 year estimated flood level.

Hence, applying a freeboard of 600mm above the estimated 1 in 100 year plus climate change flood level will allow for a significant increase in flood flow.

8. FLOOD MAPPING

Overview

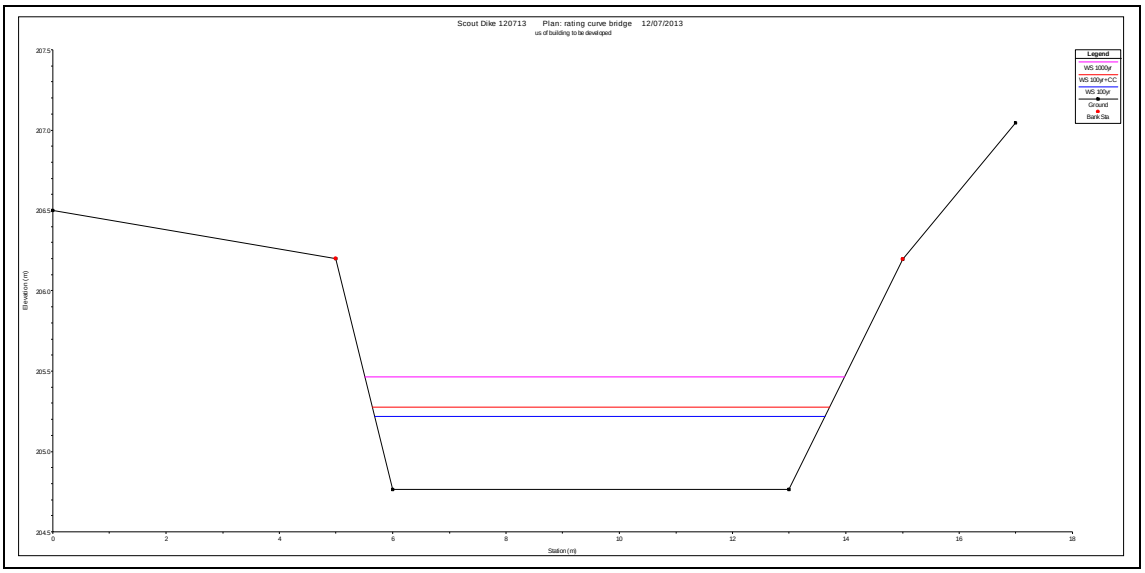
It is required that a cross section through the channel in line with the site be produced for the 100-year return period event plus 20% for climate change. This involves the interpretation of flood levels derived from the HEC-RAS model into floodplain extents through comparison with the site survey. The longitudinal section for the river is provided at Appendix E. Longitudinal section of the river is provided which shows the estimated water levels during the 100 year (blue), 100 year plus climate change (red) and the 1 in 1,000 year (magenta) during normal conditions. The tabulated data is provided at Appendix F.

Basic Methodology

The channel cross sections surveyed were conservatively adopted for the proposed development site; the cross sections were used within the HEC-RAS model.

Cross Section 136 is located in line with the upstream boundary of the building to be redeveloped and the HEC RAS output section is shown below at Figure 8.1. A maximum 1 in 100 year plus 20% allowance for climate change flood level of 205.27mOD was estimated. The water is maintained within the channel and the site is not flooded.

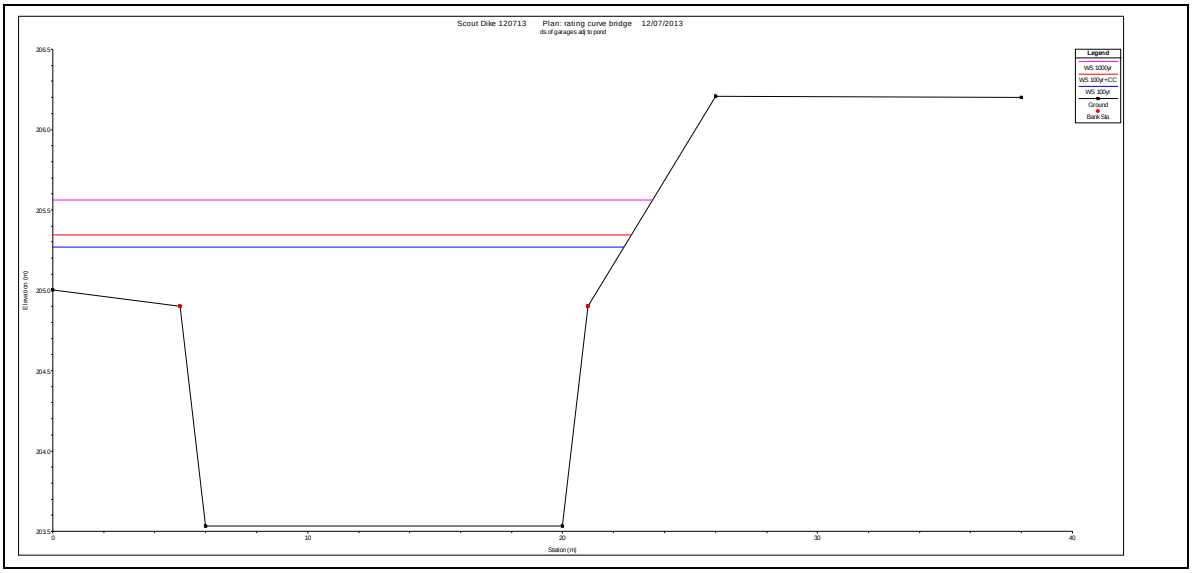
Figure 8.1: Cross Section 136 HEC RAS Output



Cross Section 103 is located in line with the downstream boundary of the building to be redeveloped and the HEC RAS output section is shown overleaf at Figure 8.2. A maximum 1 in 100 year plus 20% allowance for climate change flood level of 205.34mOD was estimated. The water floods the left bank however, the building

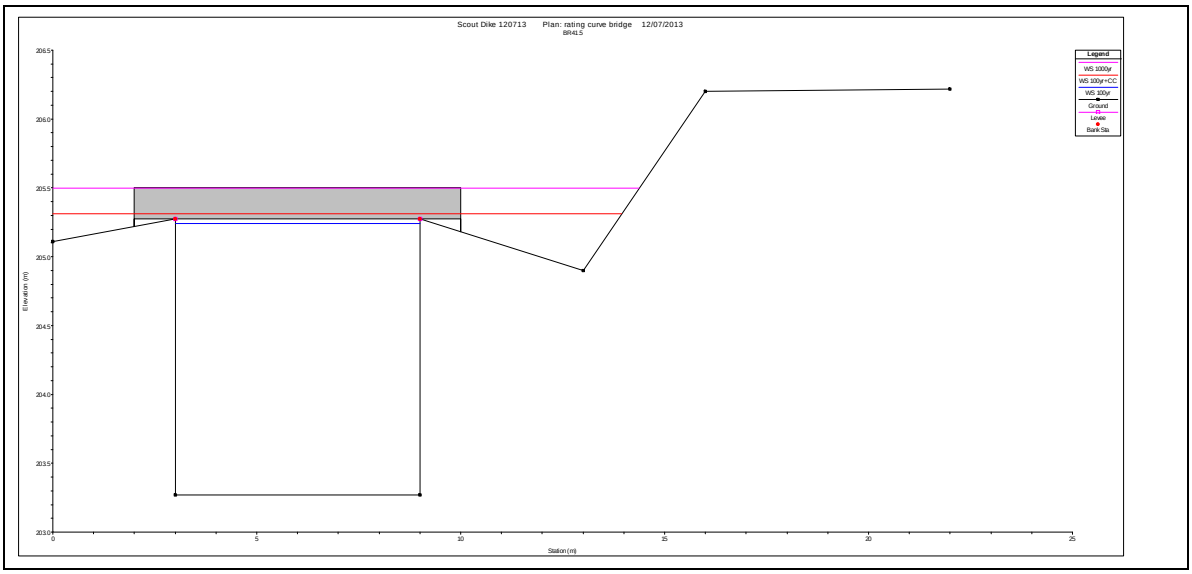
located on the right bank is not affected and the building and its access road is not flooded.

Figure 8.2: Cross Section 145 HEC RAS Output



Cross Section 43 is located is located directly upstream of the pedestrian access bridge which is downstream of the building to be redeveloped and upstream of the weir and the HEC RAS output section is shown overleaf at Figure 8.3. A maximum 1 in 100 year plus 20% allowance for climate change flood level of 205.31mOD was estimated. The water floods the left and right banks however, the access road is not flooded.

Figure 8.3: Cross Section 145 HEC RAS Output



Results

During the 1 in 100 year flood event the water is generally maintained within the channel with minor flooding of the left bank. During the 1 in 100 year plus climate change event the water level floods the left bank with the building remaining dry. During the extreme 1 in 1,000 year event there is flooding of both the left and right banks downstream of the site with the building remaining dry.

9. MITIGATION MEASURES

Raising Floor Levels/Land Raising

The site is located adjacent to the Scout Dike. The 1 in 100 year flood level has been estimated at 205.27mOD and the 1 in 100 year plus climate change flood level for the site has been estimated at 205.34mOD. The existing ground floor level building is 207.382mOD. Therefore, during the 1 in 100 year flood event, 1 in 100 year plus climate change flood event and the extreme 1 in 1,000 year flood event the building remains dry.

It is therefore recommended that a minimum internal ground floor level of 600mm above the estimated 1 in 100 year plus climate change flood level is adopted for the development, hence 205.34mOD plus 0.6m equals 205.94mOD.

Emergency Access & Egress

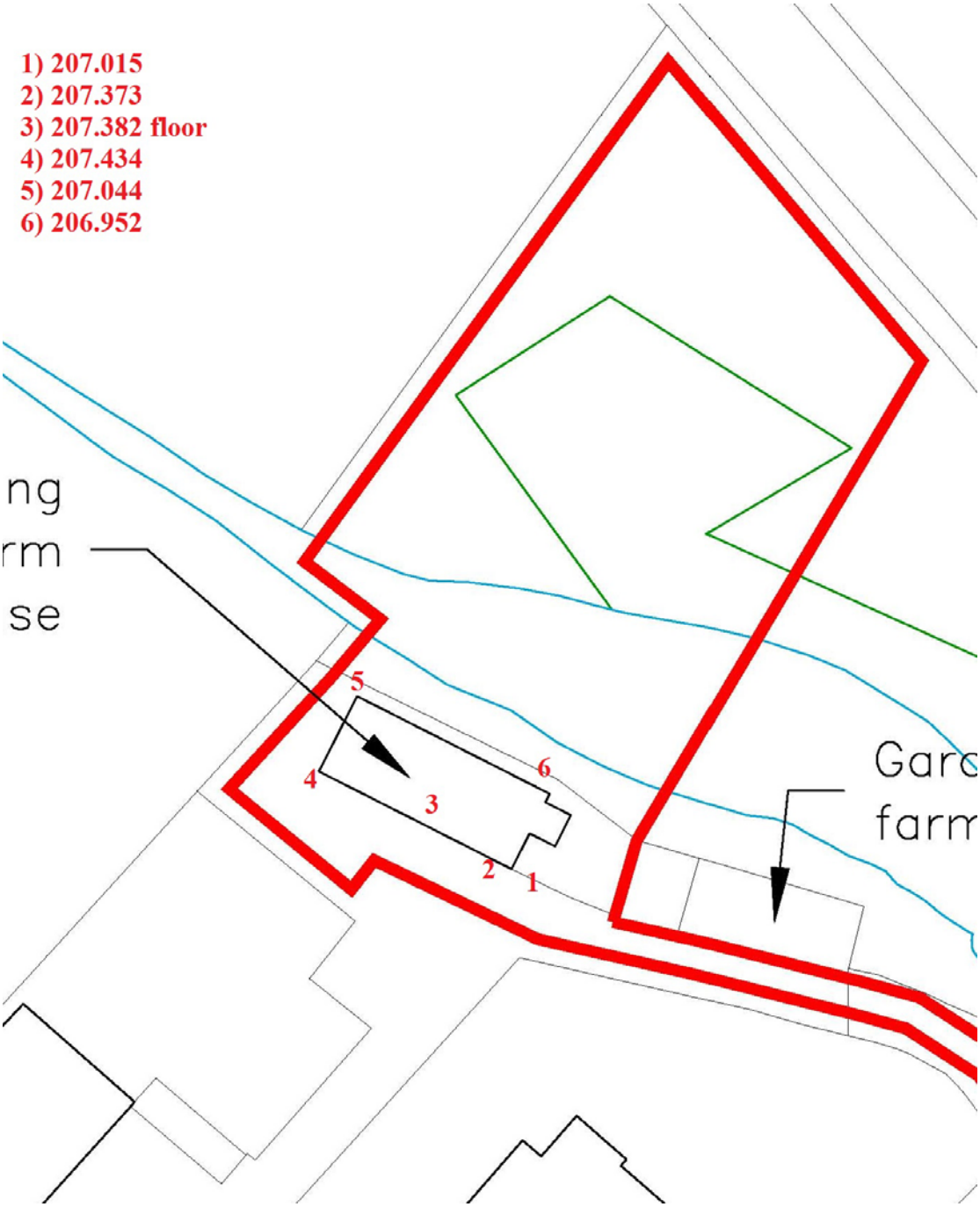
As the development is residential, it is considered that dry access and egress from the development site will be essential during extreme flood events. The Scout Dike 1 in 100 year plus climate change flood level has been estimated at 205.34mOD which is less than the lowest existing ground floor level within the building. As such, the building will remain dry and a safe area above the potential floods.

The access road which links the building with Huddersfield Road to the south of the site which is located within flood zone 1, low risk, is above the estimated flood level. As such, it is considered that during the 100 year and the 100 year plus climate change flood events that the site and access route to the south will remain dry.

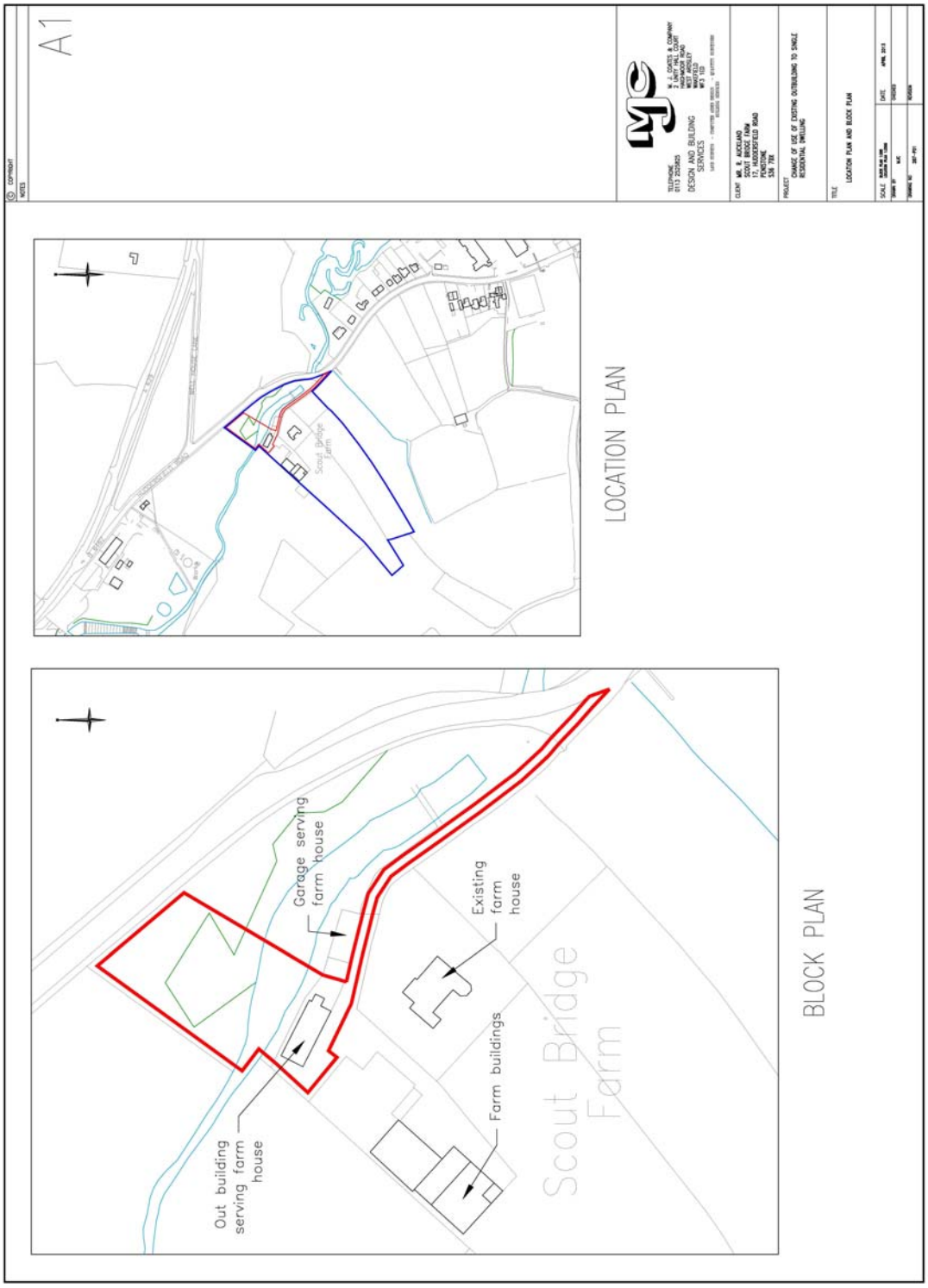
10. CONCLUSION

It is concluded that there is a low risk of fluvial flooding to the proposed redevelopment from the Scout Dike and that the building is located within flood zone 1, low risk based on the simple model used within this assessment. Raising the internal ground floor levels 600mm above the estimated 1 in 100 year plus climate change flood level will reduce the risk of flooding to an acceptable level. It is unlikely that the proposed development will have any adverse impact on the surface water drainage in the area.

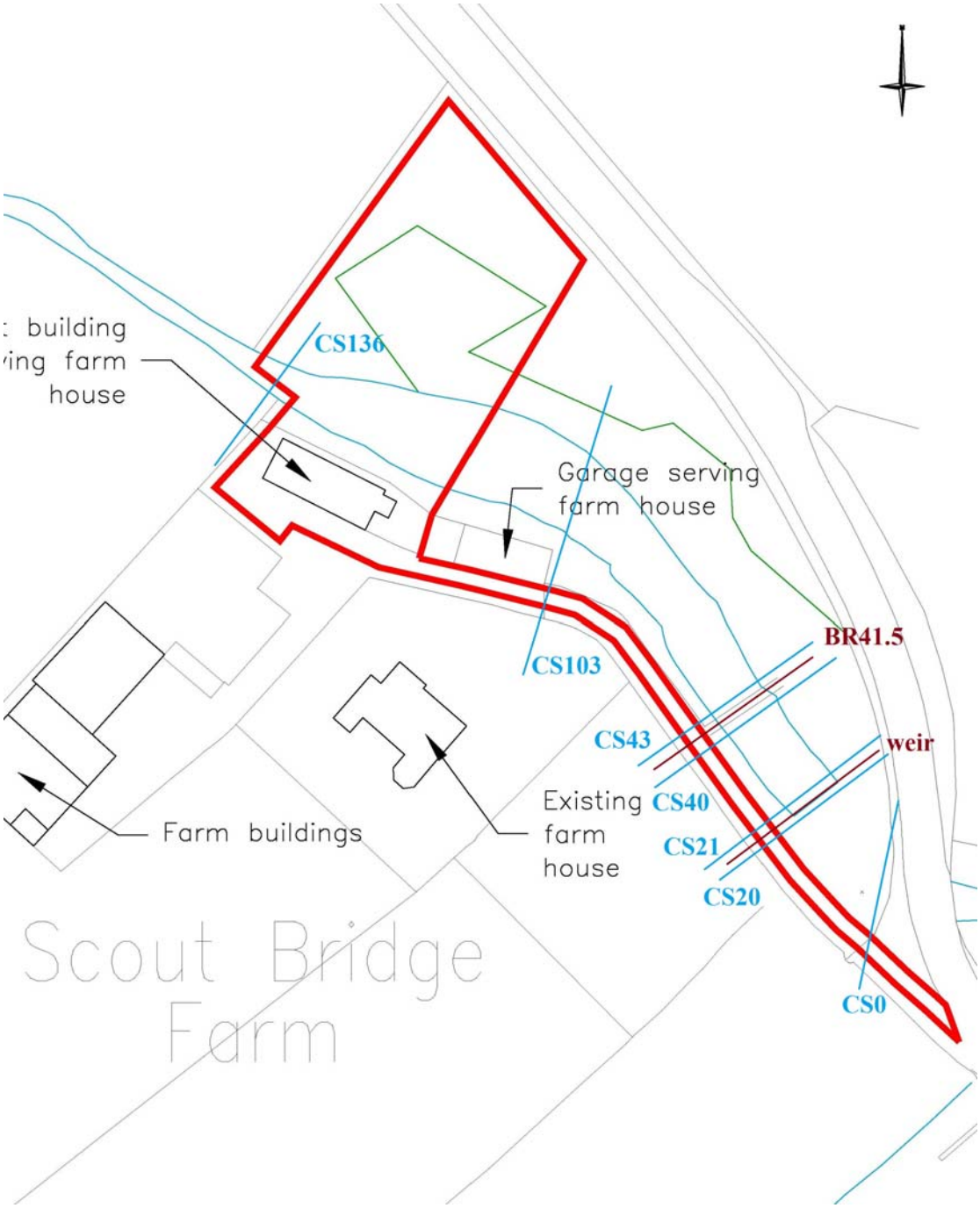
Appendix A: - Existing Ground Levels



Appendix B: - Proposed Layout Plan



Appendix C: - Cross Section Locations



Appendix D: - ReFH Flow Calculations

Revitalised FSR/FEH rainfall runoff method

Spreadsheet application report

User name	Lea Favill	**Catchment name**		**Date/time modelled**	11-Jul-2013 17:21
Company name	EWE Associates Ltd	**Catchment easting**	424000	**Version**	1.4
Project name	Scout Dike at weir - 1,000y	**Catchment northing**	404450		
		Catchment area	11.52		

Summary of model setup

Design rainfall parameters		Loss model parameters		Routing model parameters		Baseflow model parameters	
Return period (yr)	1000	**C_{max} (mm)**	513	**T_p (hr)**	3.63	**BL (hr)**	48.2
Duration (hr)	7.4	**C_{ini} (mm)**	96	**U_p**	0.65	**BR**	1.59
Timestep (hr)	0.2	**α factor**	0.7	**U_k**	0.8	**BF_0 (m^3/s)**	0.5
Season	Winter						

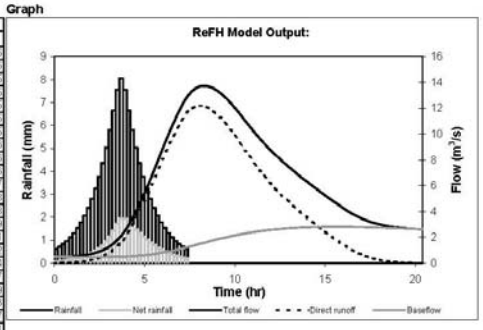
Summary of results

FEH DDF rainfall (mm)	149	**Peak rainfall (mm)**	8.1
Design rainfall (mm)	113.2	**Peak flow (m^3/s)**	13.7

Results

Series	Design Rainfall	Net rainfall	Direct runoff	Baseflow	Total flow
Unit	mm	mm	m^3/s	m^3/s	m^3/s
0.0	0.6	0.1	0.0	0.5	0.5
0.2	0.7	0.1	0.0	0.5	0.5
0.4	0.8	0.1	0.0	0.5	0.5
0.6	1.0	0.1	0.0	0.5	0.5
0.8	1.1	0.2	0.0	0.5	0.5
1.0	1.3	0.2	0.0	0.5	0.5
1.2	1.5	0.2	0.1	0.5	0.5
1.4	1.8	0.3	0.1	0.5	0.6
1.6	2.1	0.3	0.1	0.5	0.6
1.8	2.4	0.4	0.2	0.5	0.6
2.0	2.8	0.5	0.2	0.5	0.7
2.2	3.2	0.5	0.3	0.5	0.8
2.4	3.8	0.7	0.4	0.5	0.8
2.6	4.4	0.8	0.5	0.5	0.9
2.8	5.0	1.0	0.6	0.5	1.1
3.0	5.8	1.2	0.8	0.5	1.2
3.2	6.7	1.4	0.9	0.5	1.4
3.4	7.6	1.7	1.2	0.5	1.7
3.6	8.1	2.0	1.4	0.5	1.9
3.8	7.6	1.9	1.8	0.5	2.3
4.0	6.7	1.8	2.2	0.5	2.7
4.2	5.8	1.6	2.6	0.5	3.1
4.4	5.0	1.5	3.1	0.5	3.7
4.6	4.4	1.3	3.6	0.6	4.2
4.8	3.8	1.2	4.2	0.6	4.8
5.0	3.2	1.0	4.8	0.6	5.4
5.2	2.8	0.9	5.4	0.6	6.1
5.4	2.4	0.8	6.1	0.7	6.8
5.6	2.1	0.7	6.7	0.7	7.5
5.8	1.8	0.6	7.4	0.8	8.1
6.0	1.5	0.5	8.0	0.8	8.8
6.2	1.3	0.5	8.7	0.9	9.5
6.4	1.1	0.4	9.3	0.9	10.2
6.6	1.0	0.3	9.9	1.0	10.9
6.8	0.8	0.3	10.4	1.0	11.5
7.0	0.7	0.2	10.9	1.1	12.0
7.2	0.6	0.2	11.4	1.2	12.6
7.4	0.0	0.0	11.7	1.2	13.0
7.6	0.0	0.0	12.0	1.3	13.3
7.8	0.0	0.0	12.1	1.4	13.5
8.0	0.0	0.0	12.2	1.5	13.7
8.2	0.0	0.0	12.2	1.5	13.7
8.4	0.0	0.0	12.1	1.6	13.7
8.6	0.0	0.0	12.0	1.7	13.7
8.8	0.0	0.0	11.8	1.8	13.6
9.0	0.0	0.0	11.6	1.8	13.4
9.2	0.0	0.0	11.3	1.9	13.2
9.4	0.0	0.0	11.0	2.0	12.9
9.6	0.0	0.0	10.6	2.0	12.7
9.8	0.0	0.0	10.3	2.1	12.4
10.0	0.0	0.0	9.9	2.1	12.0
10.2	0.0	0.0	9.5	2.2	11.7
10.4	0.0	0.0	9.1	2.3	11.3
10.6	0.0	0.0	8.7	2.3	11.0
10.8	0.0	0.0	8.3	2.3	10.6
11.0	0.0	0.0	7.9	2.4	10.3
11.2	0.0	0.0	7.5	2.4	9.9
11.4	0.0	0.0	7.1	2.5	9.6
11.6	0.0	0.0	6.8	2.5	9.3
11.8	0.0	0.0	6.5	2.5	9.0
12.0	0.0	0.0	6.2	2.6	8.7
12.2	0.0	0.0	5.9	2.6	8.5
12.4	0.0	0.0	5.6	2.6	8.2
12.6	0.0	0.0	5.3	2.7	7.9
12.8	0.0	0.0	5.0	2.7	7.7
13.0	0.0	0.0	4.8	2.7	7.4
13.2	0.0	0.0	4.5	2.7	7.2
13.4	0.0	0.0	4.2	2.7	7.0
13.6	0.0	0.0	4.0	2.7	6.8
13.8	0.0	0.0	3.8	2.8	6.5
14.0	0.0	0.0	3.5	2.8	6.3
14.2	0.0	0.0	3.3	2.8	6.1
14.4	0.0	0.0	3.1	2.8	5.9
14.6	0.0	0.0	2.9	2.8	5.7
14.8	0.0	0.0	2.7	2.8	5.5
15.0	0.0	0.0	2.4	2.8	5.3
15.2	0.0	0.0	2.2	2.8	5.1

Graph



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Revitalised FSR/FEH rainfall runoff method

Spreadsheet application report

15.4	0.0	0.0	2.0	2.8	4.8
15.6	0.0	0.0	1.8	2.8	4.7
15.8	0.0	0.0	1.6	2.8	4.5
16.0	0.0	0.0	1.4	2.8	4.3
16.2	0.0	0.0	1.3	2.8	4.1
16.4	0.0	0.0	1.1	2.8	3.9
16.6	0.0	0.0	0.9	2.8	3.7
16.8	0.0	0.0	0.8	2.8	3.6
17.0	0.0	0.0	0.7	2.8	3.5
17.2	0.0	0.0	0.6	2.8	3.3
17.4	0.0	0.0	0.5	2.8	3.2
17.6	0.0	0.0	0.4	2.8	3.2
17.8	0.0	0.0	0.3	2.8	3.1
18.0	0.0	0.0	0.2	2.8	3.0
18.2	0.0	0.0	0.2	2.7	2.9
18.4	0.0	0.0	0.2	2.7	2.9
18.6	0.0	0.0	0.1	2.7	2.8
18.8	0.0	0.0	0.1	2.7	2.8
19.0	0.0	0.0	0.1	2.7	2.8
19.2	0.0	0.0	0.0	2.7	2.7
19.4	0.0	0.0	0.0	2.7	2.7
19.6	0.0	0.0	0.0	2.7	2.7
19.8	0.0	0.0	0.0	2.7	2.7
20.0	0.0	0.0	0.0	2.6	2.7
20.2	0.0	0.0	0.0	2.6	2.6
20.4	0.0	0.0	0.0	2.6	2.6
Total (mm)	**113.2**	**27.4**	**27.4**	**11.6**	**39.1**

Audit comments

Model run with ReFH dll version 1.4.0005

Catchment
Catchment descriptors imported from file
Catchment descriptor file = 'Scout Dike csv.csv'
Catchment decriptor file exported from CD ROM version 1
BFIHOST value of 0.649 used
PROPWET value of 0.34 used
SAAR value of 1042 used
DPLBAR value of 4.17 used
DPSBAR value of 62.2 used
URBEXT value of 0.01 used
C value of -0.026 used
D1 value of 0.415 used
D2 value of 0.458 used
D3 value of 0.268 used
E value of 0.307 used
F value of 2.412 used

Rainfall
Recommended season is Winter, as URBEXT < 0.125
ReFH design standard Seasonal Correction Factor of 0.79 applied
ReFH design standard Areal Reduction Factor of 0.96 applied

Loss Model
C_{max} derived from catchment descriptors
ReFH design standard C_{ini} used
ReFH design standard α factor used

Routing Model
T_p derived from catchment descriptors
ReFH design standard used for U_k
ReFH design standard used for U_k

Baseflow Model
BL derived from catchment descriptors
BR derived from catchment descriptors
ReFH design standard BF_0 used

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Revitalised FSR/FEH rainfall runoff method

Spreadsheet application report

User name	Lea Favill	**Catchment name**		**Date/time modelled**	11-Jul-2013 17:19
Company name	EWE Associates Ltd	**Catchment easting**	424000	**Version**	1.4
Project name	Scout Dike at weir - 100yr	**Catchment northing**	404450		
		Catchment area	11.52		

Summary of model setup

Design rainfall parameters		Loss model parameters		Routing model parameters		Baseflow model parameters	
Return period (yr)	100	**C_{max} (mm)**	513	**T_p (hr)**	3.63	**BL (hr)**	48.2
Duration (hr)	7.4	**C_{ini} (mm)**	96	**U_p**	0.65	**BR**	1.59
Timestep (hr)	0.2	**α factor**	0.83	**U_k**	0.8	**BF_{II} (m^3/s)**	0.5
Season	Winter						

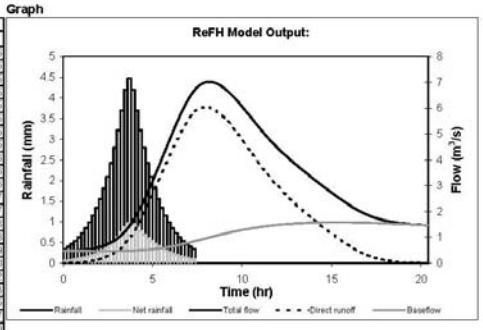
Summary of results

FEH DDF rainfall (mm)	82.7	**Peak rainfall (mm)**	4.5
Design rainfall (mm)	62.9	**Peak flow (m^3/s)**	7

Results

Series	Design Rainfall	Net rainfall	Direct runoff	Baseflow	Total flow
Unit	mm	mm	m^3/s	m^3/s	m^3/s
0.0	0.3	0.1	0.0	0.5	0.5
0.2	0.4	0.1	0.0	0.5	0.5
0.4	0.5	0.1	0.0	0.5	0.5
0.6	0.5	0.1	0.0	0.5	0.5
0.8	0.6	0.1	0.0	0.5	0.5
1.0	0.7	0.1	0.0	0.5	0.5
1.2	0.9	0.1	0.0	0.5	0.5
1.4	1.0	0.2	0.1	0.5	0.5
1.6	1.2	0.2	0.1	0.5	0.6
1.8	1.3	0.2	0.1	0.5	0.6
2.0	1.6	0.3	0.1	0.5	0.6
2.2	1.8	0.3	0.2	0.5	0.7
2.4	2.1	0.4	0.2	0.5	0.7
2.6	2.4	0.4	0.3	0.5	0.8
2.8	2.8	0.5	0.4	0.5	0.8
3.0	3.2	0.6	0.5	0.5	0.9
3.2	3.7	0.7	0.6	0.5	1.0
3.4	4.2	0.9	0.7	0.5	1.2
3.6	4.5	1.0	0.9	0.5	1.3
3.8	4.3	0.9	1.0	0.5	1.5
4.0	3.7	0.9	1.3	0.5	1.7
4.2	3.2	0.8	1.5	0.5	2.0
4.4	2.8	0.7	1.8	0.5	2.3
4.6	2.4	0.6	2.0	0.5	2.5
4.8	2.1	0.5	2.3	0.5	2.8
5.0	1.8	0.5	2.6	0.5	3.2
5.2	1.6	0.4	2.9	0.6	3.5
5.4	1.3	0.4	3.3	0.6	3.8
5.6	1.2	0.3	3.6	0.6	4.2
5.8	1.0	0.3	3.9	0.6	4.5
6.0	0.9	0.2	4.2	0.6	4.9
6.2	0.7	0.2	4.5	0.7	5.2
6.4	0.6	0.2	4.8	0.7	5.5
6.6	0.5	0.1	5.1	0.7	5.8
6.8	0.5	0.1	5.3	0.8	6.1
7.0	0.4	0.1	5.6	0.8	6.3
7.2	0.3	0.1	5.7	0.8	6.6
7.4	0.0	0.0	5.9	0.9	6.7
7.6	0.0	0.0	6.0	0.9	6.9
7.8	0.0	0.0	6.0	0.9	7.0
8.0	0.0	0.0	6.0	1.0	7.0
8.2	0.0	0.0	6.0	1.0	7.0
8.4	0.0	0.0	6.0	1.0	7.0
8.6	0.0	0.0	5.9	1.1	7.0
8.8	0.0	0.0	5.8	1.1	6.9
9.0	0.0	0.0	5.6	1.1	6.8
9.2	0.0	0.0	5.5	1.2	6.7
9.4	0.0	0.0	5.3	1.2	6.5
9.6	0.0	0.0	5.2	1.2	6.4
9.8	0.0	0.0	5.0	1.3	6.2
10.0	0.0	0.0	4.8	1.3	6.1
10.2	0.0	0.0	4.6	1.3	5.9
10.4	0.0	0.0	4.4	1.3	5.7
10.6	0.0	0.0	4.2	1.4	5.6
10.8	0.0	0.0	4.0	1.4	5.4
11.0	0.0	0.0	3.8	1.4	5.2
11.2	0.0	0.0	3.6	1.4	5.0
11.4	0.0	0.0	3.4	1.4	4.9
11.6	0.0	0.0	3.3	1.5	4.7
11.8	0.0	0.0	3.1	1.5	4.6
12.0	0.0	0.0	3.0	1.5	4.4
12.2	0.0	0.0	2.8	1.5	4.3
12.4	0.0	0.0	2.7	1.5	4.2
12.6	0.0	0.0	2.5	1.5	4.1
12.8	0.0	0.0	2.4	1.5	3.9
13.0	0.0	0.0	2.3	1.5	3.8
13.2	0.0	0.0	2.2	1.5	3.7
13.4	0.0	0.0	2.0	1.6	3.6
13.6	0.0	0.0	1.9	1.6	3.5
13.8	0.0	0.0	1.8	1.6	3.4
14.0	0.0	0.0	1.7	1.6	3.3
14.2	0.0	0.0	1.6	1.6	3.1
14.4	0.0	0.0	1.5	1.6	3.0
14.6	0.0	0.0	1.4	1.6	2.9
14.8	0.0	0.0	1.2	1.6	2.8
15.0	0.0	0.0	1.1	1.6	2.7
15.2	0.0	0.0	1.0	1.6	2.6

Graph



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Revitalised FSR/FEH rainfall runoff method

Spreadsheet application report

15.4	0.0	0.0	0.9	1.6	2.5
15.6	0.0	0.0	0.8	1.6	2.4
15.8	0.0	0.0	0.8	1.6	2.3
16.0	0.0	0.0	0.7	1.6	2.2
16.2	0.0	0.0	0.6	1.6	2.2
16.4	0.0	0.0	0.5	1.6	2.1
16.6	0.0	0.0	0.4	1.6	2.0
16.8	0.0	0.0	0.4	1.6	1.9
17.0	0.0	0.0	0.3	1.6	1.9
17.2	0.0	0.0	0.3	1.6	1.8
17.4	0.0	0.0	0.2	1.6	1.8
17.6	0.0	0.0	0.2	1.5	1.7
17.8	0.0	0.0	0.1	1.5	1.7
18.0	0.0	0.0	0.1	1.5	1.6
18.2	0.0	0.0	0.1	1.5	1.6
18.4	0.0	0.0	0.1	1.5	1.6
18.6	0.0	0.0	0.1	1.5	1.6
18.8	0.0	0.0	0.0	1.5	1.6
19.0	0.0	0.0	0.0	1.5	1.5
19.2	0.0	0.0	0.0	1.5	1.5
19.4	0.0	0.0	0.0	1.5	1.5
19.6	0.0	0.0	0.0	1.5	1.5
19.8	0.0	0.0	0.0	1.5	1.5
20.0	0.0	0.0	0.0	1.5	1.5
20.2	0.0	0.0	0.0	1.5	1.5
20.4	0.0	0.0	0.0	1.5	1.5
Total (mm)	**62.9**	**13.7**	**13.7**	**7.1**	**20.8**

Audit comments

Model run with ReFH dll version 1.4.0005

Catchment
Catchment descriptors imported from file
Catchment descriptor file = 'Scout Dike csv.csv'
Catchment decriptor file exported from CD ROM version 1
BFIHOST value of 0.649 used
PROPWET value of 0.34 used
SAAR value of 1042 used
DPLBAR value of 4.17 used
DPSBAR value of 62.2 used
URBEXT value of 0.01 used
C value of -0.026 used
D1 value of 0.415 used
D2 value of 0.458 used
D3 value of 0.268 used
E value of 0.307 used
F value of 2.412 used

Rainfall
Recommended season is Winter, as URBEXT < 0.125
ReFH design standard Seasonal Correction Factor of 0.79 applied
ReFH design standard Areal Reduction Factor of 0.96 applied

Loss Model
C_{max} derived from catchment descriptors
ReFH design standard C_{ini} used
ReFH design standard α factor used

Routing Model
T_p derived from catchment descriptors
ReFH design standard used for U_b
ReFH design standard used for U_k

Baseflow Model
BL derived from catchment descriptors
BR derived from catchment descriptors
ReFH design standard BF_0 used

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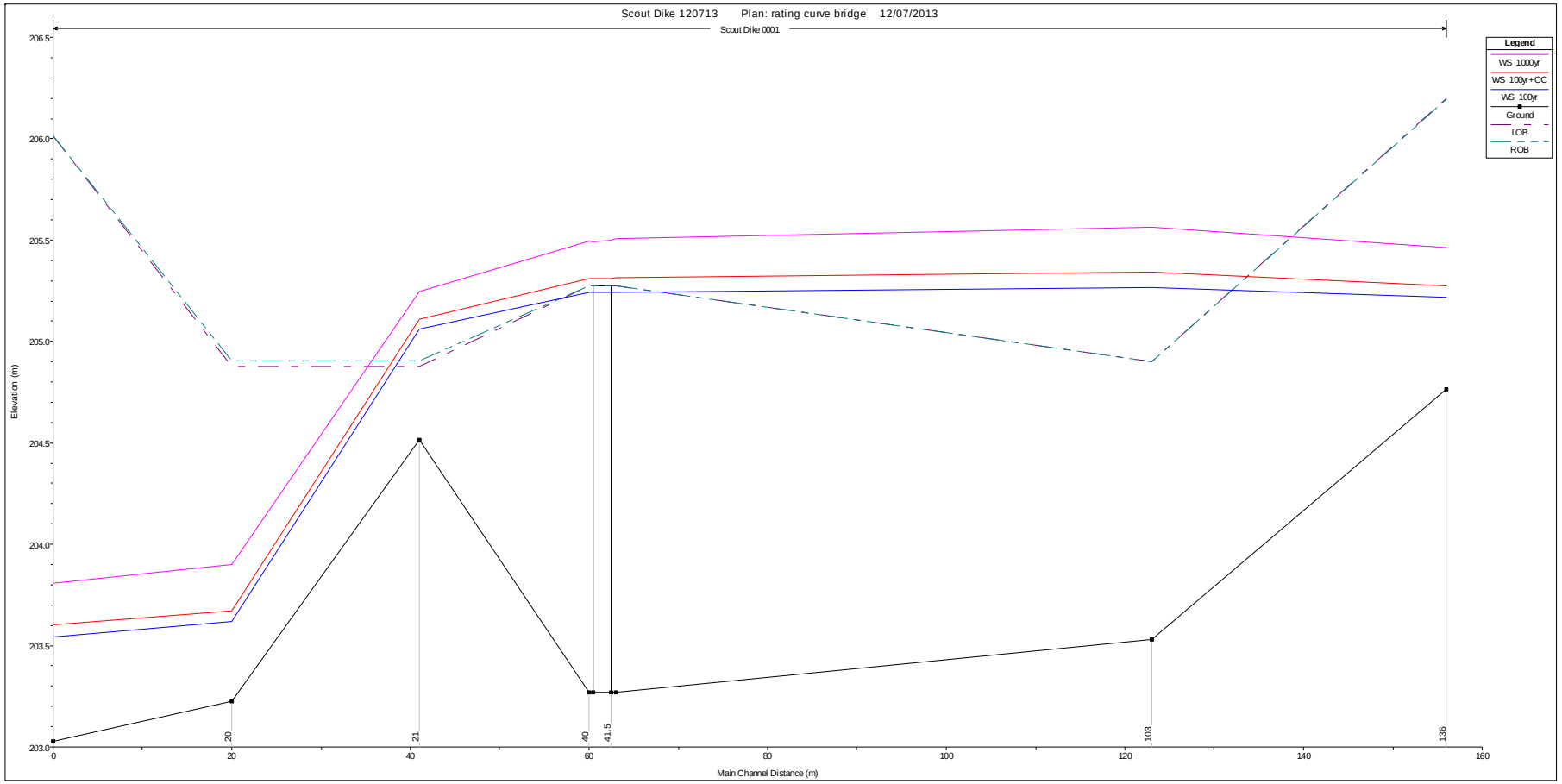
Appendix E: - Longitudinal Section



Appendix F: - HEC RAS Table

HEC-RAS River: Scout Dike Reach: 0001

Reach	River Sta	Profile	Plan	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
0001	136	100yr	rating bridge	7.00	204.76	205.22	205.22	205.43	0.028436	2.06	3.40	7.95	1.01
0001	136	100yr	Mannings	7.00	204.76	205.22	205.22	205.43	0.042473	2.06	3.40	7.95	1.01
0001	136	100yr+CC	rating bridge	8.40	204.76	205.27	205.27	205.52	0.027575	2.18	3.86	8.07	1.01
0001	136	100yr+CC	Mannings	8.40	204.76	205.27	205.27	205.52	0.041192	2.18	3.86	8.07	1.01
0001	136	1000yr	rating bridge	13.70	204.76	205.47	205.47	205.79	0.025529	2.52	5.43	8.47	1.01
0001	136	1000yr	Mannings	13.70	204.76	205.47	205.47	205.79	0.038109	2.52	5.43	8.47	1.01
0001	103	100yr	rating bridge	7.00	203.53	205.27	203.82	205.27	0.000077	0.26	28.28	22.41	0.06
0001	103	100yr	Mannings	7.00	203.53	205.29	203.82	205.29	0.000109	0.25	28.68	22.48	0.06
0001	103	100yr+CC	rating bridge	8.40	203.53	205.34	203.86	205.35	0.000093	0.29	29.99	22.70	0.07
0001	103	100yr+CC	Mannings	8.40	203.53	205.37	203.86	205.37	0.000130	0.29	30.50	22.79	0.07
0001	103	1000yr	rating bridge	13.70	203.53	205.56	203.99	205.57	0.000158	0.41	35.04	23.53	0.09
0001	103	1000yr	Mannings	13.70	203.53	205.60	203.99	205.60	0.000214	0.40	35.84	23.66	0.09
0001	43	100yr	rating bridge	7.00	203.27	205.24	203.79	205.26	0.000563	0.59	11.83	6.00	0.13
0001	43	100yr	Mannings	7.00	203.27	205.26	203.79	205.27	0.000825	0.59	11.91	6.00	0.13
0001	43	100yr+CC	rating bridge	8.40	203.27	205.31	203.86	205.33	0.000855	0.66	13.71	13.95	0.15
0001	43	100yr+CC	Mannings	8.40	203.27	205.33	203.86	205.35	0.001200	0.64	13.97	13.99	0.14
0001	43	1000yr	rating bridge	13.70	203.27	205.51	204.08	205.55	0.001465	0.92	16.46	14.40	0.20
0001	43	1000yr	Mannings	13.70	203.27	205.54	204.08	205.57	0.001947	0.87	16.89	14.47	0.18
0001	41.5		Bridge										
0001	40	100yr	rating bridge	7.00	203.27	205.24	203.79	205.26	0.000564	0.59	11.82	6.00	0.13
0001	40	100yr	Mannings	7.00	203.27	205.25	203.79	205.27	0.000827	0.59	11.89	6.00	0.13
0001	40	100yr+CC	rating bridge	8.40	203.27	205.31	203.86	205.33	0.000863	0.66	13.65	13.94	0.15
0001	40	100yr+CC	Mannings	8.40	203.27	205.33	203.86	205.35	0.001216	0.65	13.89	13.98	0.14
0001	40	1000yr	rating bridge	13.70	203.27	205.50	204.08	205.54	0.001503	0.92	16.30	14.37	0.20
0001	40	1000yr	Mannings	13.70	203.27	205.52	204.08	205.56	0.002034	0.89	16.63	14.42	0.19
0001	21	100yr	rating bridge	7.00	204.51	205.06	205.06	205.21	0.027055	1.75	4.14	14.14	0.94
0001	21	100yr	Mannings	7.00	204.51	205.06	205.06	205.21	0.039684	1.73	4.14	14.14	0.93
0001	21	100yr+CC	rating bridge	8.40	204.51	205.11	205.11	205.27	0.024643	1.82	4.83	15.00	0.91
0001	21	100yr+CC	Mannings	8.40	204.51	205.11	205.11	205.27	0.036653	1.81	4.79	14.96	0.91
0001	21	1000yr	rating bridge	13.70	204.51	205.25	205.25	205.45	0.021499	2.06	7.07	17.53	0.90
0001	21	1000yr	Mannings	13.70	204.51	205.24	205.24	205.44	0.031172	2.03	7.01	17.47	0.88
0001	20	100yr	rating bridge	7.00	203.23	203.62	203.79	204.20	0.096582	3.37	2.08	5.30	1.72
0001	20	100yr	Mannings	7.00	203.23	203.89	203.79	204.09	0.027327	1.98	3.54	5.30	0.77
0001	20	100yr+CC	rating bridge	8.40	203.23	203.67	203.86	204.32	0.093099	3.56	2.36	5.30	1.71
0001	20	100yr+CC	Mannings	8.40	203.23	203.96	203.86	204.20	0.029807	2.17	3.88	5.30	0.81
0001	20	1000yr	rating bridge	13.70	203.23	203.90	204.11	204.65	0.068767	3.85	3.56	5.30	1.50
0001	20	1000yr	Mannings	13.70	203.23	204.05	204.11	204.55	0.056921	3.15	4.35	5.30	1.11
0001	0	100yr	rating bridge	7.00	203.03	203.54	203.42	203.66	0.012806	1.51	4.62	9.14	0.68
0001	0	100yr	Mannings	7.00	203.03	203.61	203.42	203.70	0.012804	1.34	5.24	9.19	0.56
0001	0	100yr+CC	rating bridge	8.40	203.03	203.60	203.48	203.74	0.012803	1.62	5.18	9.19	0.69
0001	0	100yr+CC	Mannings	8.40	203.03	203.68	203.48	203.78	0.012802	1.43	5.88	9.24	0.57
0001	0	1000yr	rating bridge	13.70	203.03	203.81	203.65	204.00	0.012820	1.94	7.07	9.32	0.71
0001	0	1000yr	Mannings	13.70	203.03	203.91	203.65	204.06	0.012802	1.70	8.04	9.39	0.59