Flood Risk Assessment

Land off Sheffield Road, Penistone

Report Reference: SM/2031/080710/FRA

August 2008

Report to:

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Jaguar Estates

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ECUS Ltd

Report to: **Jaguar Estates**
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Report Title: **Flood Risk Assessment: Land off Sheffield Road, Penistone**

Revision: **FINAL**

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Originated By: ..... Date: 18th August 2008

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1 Introduction

1.1.1 Provided below is a Flood Risk Assessment for the proposed development for land *off Sheffield Road, Penistone. This is considered proportionate and appropriate for* the development proposed in its current context and follows the General Principles outlined by the Government[1] and aims to demonstrate that the development is sustainable in terms of flood risk.

1.2 Sources of Information and Consultation

1.2.1 Table 1 presents sources of information that have been consulted in producing this Phase 1 site investigation.

Table 1: Sources of Information and Search Results

Source	Results
Site Developer	Has provided information about the current site use and the development proposals.
The Environment Agency	Information regarding the flood history, flood data, assets, and other related information for the site has been obtained in order to complete this report.
Dr. Will Shepherd - Pennine Water Group	Has provided Surface Run-off calculations.
Piper Networking	*The website was accessed in order to gain further* information regarding the FRA Guidance (www.pipernetworking.com)
British Geological Survey (BGS)	Geological Map Sheet 86, Glossop, Solid and Drift edition, 1:50,000 scale, was consulted.

[1] TSO 2006 Planning Policy Statement 25: Development and Flood Risk. Annex E: The Assessment of Flood Risk.

2 Site Details

2.1 Site Location

2.1.1 The proposal is for the development of residential properties and live/work units with associated gardens and car parking at an area of land located off Sheffield Road, Penistone, hereafter referred to as the 'site'. It is understood that this assessment is to facilitate the change of land use classification for the site in the Barnsley Metropolitan Borough Council (MBC) Local Development Framework.

2.1.2 Figure 1 shows the site location which centres on grid reference 425490, 403270.

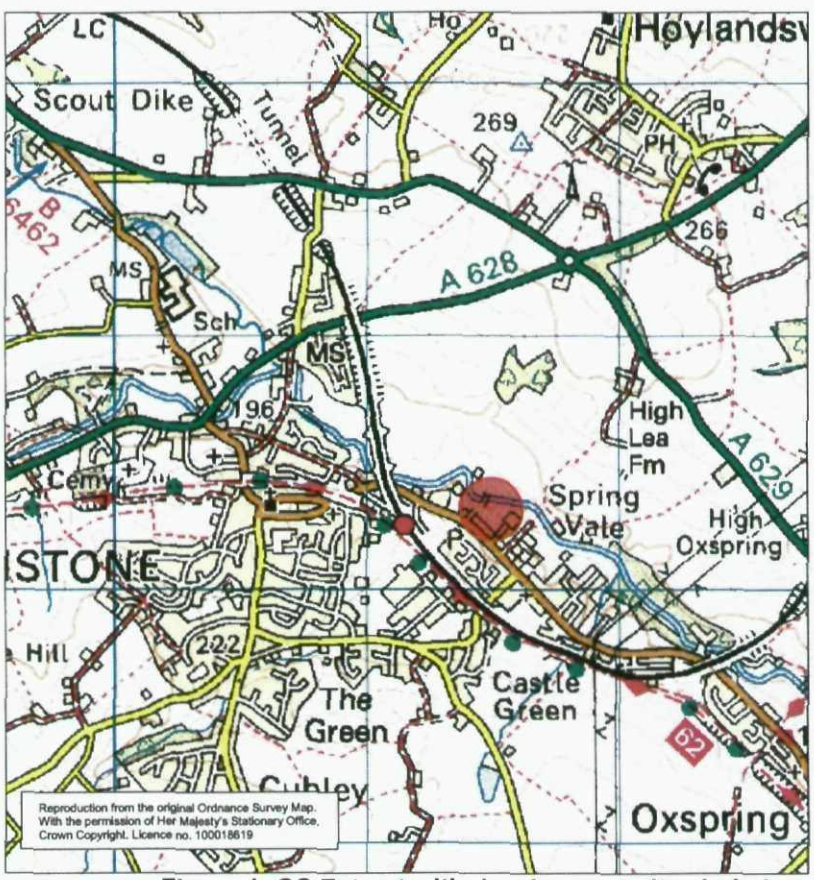


Figure 1: OS Extract with development site circled

2.1.3 The site is irregularly shaped and approximately 1.3 ha in size. The current site layout can be clearly seen in Figure 2.

2.1.4 The River Don forms the northern boundary of the site and flows in an easterly direction. A drain runs along the eastern boundary of the site and flows in a northeasterly direction into the River Don.

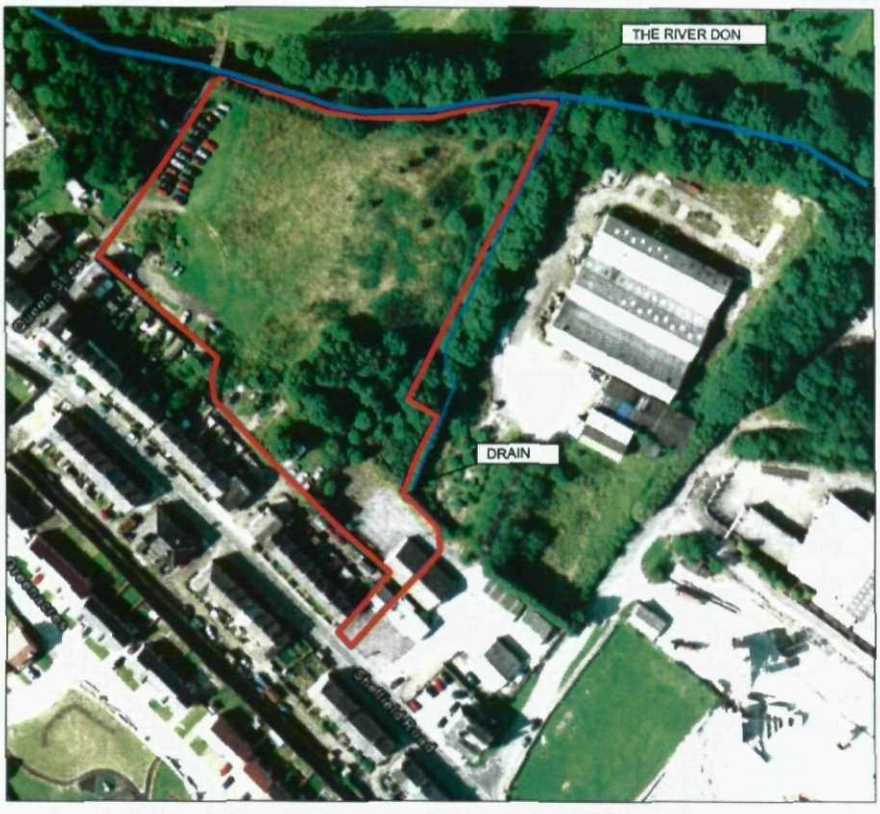


Figure 2: Aerial view of the site

2.1 Development Category

2.1.5 The site has been historically associated with the works located immediately to the east of the site but due to the nature of the land the site is considered to be Greenfield. The site currently comprises open grassy land with a wooded area located on the eastern boundary. Figure 2 shows that the site is also used for car parking.

2.1.6 The site is largely surrounded by industrial and residential land use although a cricket pitch and open fields lie to the north of the site, beyond the River Don. Large industrial units are located to the east and southeast, residential properties are located to the south and southwest, beyond Sheffield Road, and a large depot is located to the west of the site, beyond Queen Street. Queen Street leads onto a track which runs along the western boundary of the site and includes a bridge crossing over the River Don.

2.1.7 The proposed development will consist of residential properties including garden and landscaped areas, live/work units, a main access road with linked drives, and parking for residents of Sheffield Road. The proposed development layout can be seen in Appendix 1.

2.1.8 Within the Barnsley MBC Unitary Development Plan (UDP)[2] the site is currently designated as an area for Employment Uses. The UDP states that the site is a privately owned area of unused land which was allocated for industry in the former District Plan and is located adjacent to a former steel stockholder's premises and

[2] Barnsley Metropolitan Borough Council (2000) – The Barnsley Unitary Development Plan, Penistone Community Area, Volume 12.

other industrial uses. Due to residential properties being located immediately on the southern boundary of the site any industrial uses proposed must not adversely affect the residential amenities of these dwellings. The UDP states that Class B1 uses would be preferred.

2.1.9 The site is believed to be an operational development greater than 1 ha and it is considered that the proposed development may increase the flood risk vulnerability classification of the site as described in PPS25, 2006.

3 Flood Zone Status

3.1.1 The Environment Agency's Flood Zone map (Figure 3) indicates that the majority of the site is located within Flood Zone 1, which has a less than 1 in 1000 annual probability of river flooding in any year. The map indicates that only the part of the site immediately adjacent to the River Don is shown to be at risk of flooding and lies on the edge of Flood Zone 2. A more detailed map is presented in Appendix 2. Flood Zone 2 is an area which has a moderate probability of flooding and falls within the extent of flood from rivers without defences, at the time of the Agency's assessment of the likelihood of flooding. Generally this means that the chance of flooding from a river each year is 0.1-1.0% (1 in 100 - 1 in 1000) or greater.

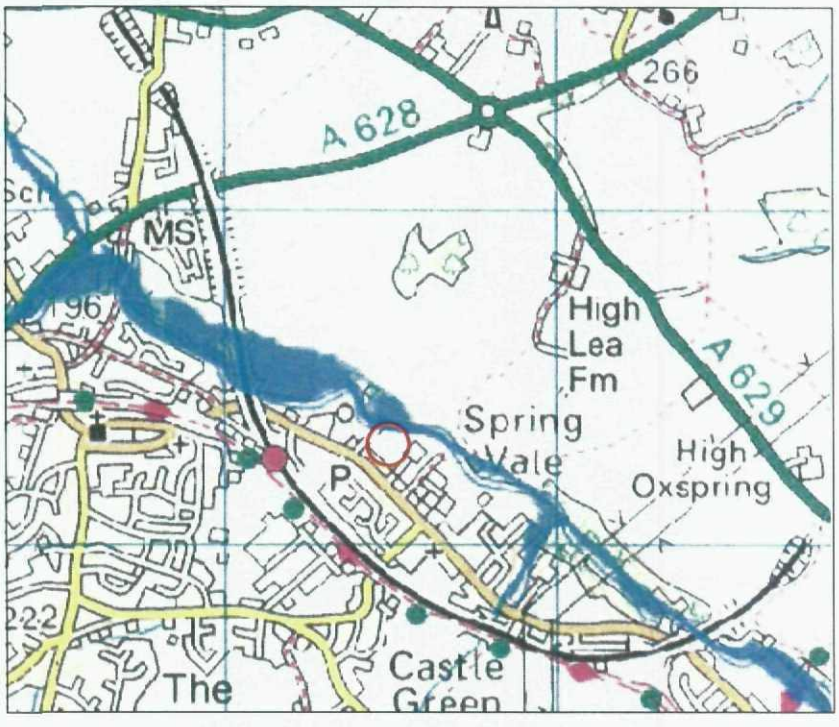


Figure 3: Extract from Environment Agency Flood Map

KEY	
○	Site
■	Flooding from rivers or sea without defences
■	Extent of extreme flood
■	Flood defences
■	Areas benefiting from flood defences

3.1.2 The flood map does not indicate any flood defences located on the area of the site.

3.1.3 The flood defence asset register plan provided in Appendix 3 shows flood defences in the area surrounding the site.

3.1.4 The Environment Agency has provided information on the flooding history of the site, presented in Appendix 4. It indicates that there has been no known flood history on

the site. Even in the June 2007 extreme flood events flood waters from the River Don in the area were dispersed onto open flood plain land to the northwest of the site with the southern bank largely unaffected.

4 Flood Risk Assessment

4.1.1 The site is on developable Greenfield land. It is understood that neither a sequential or exception test has been requested or is required for this development.

4.1.2 This flood risk assessment will demonstrate that the residual risks of flooding to people and property are acceptable and can be satisfactorily managed.

Flooding by Rivers

4.1.3 The majority of the site is located within Flood Zone 1 with the northern boundary of the site indicated to be within Flood Zone 2. There are two surface water courses in the vicinity. The River Don forms the northern boundary of the site and an unnamed drain, recorded as an "ordinary watercourse" by the Environment Agency, forms the eastern boundary of the site.

4.1.4 Site level information has been obtained from the client in the form of a topographical survey conducted by Acanthus WSM Architects (Drawing No. 2326.01.002G, dated March 2005). This is presented in Appendix 5. The drawing indicates that the land increases in height across the site in a southerly direction from the River Don towards Sheffield Road, reaching a maximum height of 197.5 m above Ordnance Datum (aOD) at the southern boundary of the site. The top of bank level forming the northern boundary is c.188 m aOD and the site level at the most northerly point of the developments is between 189.0 m to 190.0 m aOD.

4.1.5 The flood levels on the River Don in the area of the site have been modelled by Jeremy Benn Associates (JBA) in 2004. Outputs from the model are included in Appendix 6.

4.1.6 Modelling has been completed for the bridge located at the northeastern corner of the site (NGR SE 25446 0335). The 1 in 100 year flood levels (1.00% AEP) at the Bridge are modelled at 188.231 m aOD. The bank level (right bank) adjacent to the site is surveyed as being 188.801 m aOD. This shows that the bank located on the northeastern boundary of the site is higher than the anticipated 1 in 100 year flood event. It can be seen that the level of the bank is also higher than the anticipated 1 in 1000 year flood event.

4.1.7 It is understood that the development includes a "no build zone" located along the northern and eastern boundary of the site. The Environment Agency have stipulated that due to the River Don being designated as a "main river", under the terms of the Water Resources Act 1991 and of The Yorkshire Land Drainage Byelaws 1980, prior written consent of the Agency is required for any works within 8 m of the top of the bank of the river. The Agency would require a strip of land 6 m from the bank of the River Don and 3 m from the top of the drain (one the eastern boundary) to be left clear of buildings, structures, fences and trees to facilitate access, essential maintenance and possible future improvements. Ground levels should not be raised in this area. As a result of this requirement it is understood that the proposed "no build zone" will ensure that the development will begin at levels at least above 189.0 m aOD. This indicates that the proposed development will not be at risk from flooding from the River Don or the unnamed drain.

4.1.8 Climate change may increase the potential for flooding through not only rises in sea-level, but also rainfall intensity and river flows. Current guidance[3] proposes a precautionary approach to these impacts, recommending a 20% incremental allowance in peak river flows for the period up to 2115. Utilising the modelling data provided by JBA, which shows a positive correlation between discharge (m^3/s) and water level, a 20% increase in river flow as a result of climate change would

[3] TSO 2006 Planning Policy Statement 25: Development and Flood Risk. Annex B Climate Change

correspond to a rise in 1% AEP flood levels to approximately 188.37 m aOD; still below the height of proposed floor level. It is therefore considered that there is a minimal risk of fluvial flooding to future site occupiers.

4.1.9 No mitigation is considered necessary provided the no build zone is maintained.

Flooding by Groundwater

4.1.10 Flooding from groundwater can occur when water levels in the ground rise above surface elevations. This is more likely to occur in low-lying areas underlain by permeable rocks (aquifers) as stated in PPS 25.

4.1.11 The local geology comprises Penistone Flags sandstone of the Carboniferous Coal Measures and superficial alluvium deposits following the course of the River Don. The underlying strata are classified as a Minor Aquifer[4] - considered important for local supplies and in supplying base flow to rivers.

4.1.12 The minor aquifer strata beneath the site are considered unlikely to allow significant quantities of groundwater to rise rapidly in a heavy rainfall event. The proximity of the River Don, and likely hydraulic continuity between the river and groundwater beneath the site, indicates that flooding from groundwater would be unlikely to occur without flooding from the river.

4.1.13 The site is not located within a Source Protection Zone (SPZ) set by the Environment Agency for the protection of a groundwater supply in the vicinity.

4.1.14 No mitigation is considered necessary.

Flooding by Overland Flow

4.1.15 Flooding from overland flows can occur if a significant volume of intercepted rainfall or surface runoff does not reach any drainage channel or permeable ground and is able to form significant surface accumulations.

4.1.16 The area surrounding the site mainly comprises of residential properties located to the south of the site and industrial properties located to the west and east. Therefore, the majority of the surrounding area consists of hardstanding. The main source of surface run-off with potential to flood the site is from the surrounding streets. It is considered that the run-off would flow into the numerous drainage channels in the area. If the volume of water in the drainage channels exceeds the capacity of the drains the excess drainage water should run directly to the River Don. Providing that the surface overflow pathways through the site to the river are maintained there and that adequate drainage to account for overland flow from surrounding areas is provided should be no surface accumulation on site. It is therefore considered unlikely that flooding from overland flow will occur.

4.1.17 The Agency's Flood Zone map (Appendix 1) indicates that the surrounding areas to the south, west and east are areas outside flood zones 2 & 3 and will allow ample routes for safe egress from the site should there be any flooding by overland flow.

Contribution to Flood Risk

4.1.18 The site is unlikely to be affected by flooding from rivers or groundwater. It is however required to demonstrate that the redevelopment of the site will not have a detrimental impact on the risk of flooding and the surface water drainage in the area. This can occur if the new development generates significant additional volumes of surface water run-off.

4.1.19 The site currently comprises of open grassland and wooded areas which are permeable and allow the infiltration of surface water through the site. The proposed

[4] National Rivers Authority. Policy & Practice for the Protection of Groundwater: Regional Appendix; Yorkshire Region.

development will comprise of approximately 50% hardstanding in the form of residential buildings, access roads and car parking introducing a significant amount of impermeable surfacing.

4.1.20 From aerial photographs, the site appears to be in a greenfield condition and it is preferable for solutions to provide runoff behaviour which are similar to greenfield behaviour[5].

4.1.21 The run-off from the site has been calculated for the current scenario to provide a baseline against which to compare the calculated run-off from the site post-development. The detailed calculations are included as Appendix 7 with the findings summarised here.

4.1.22 Included within the calculations are the following assumptions:

1) The development area is 1.3 ha.

2) The development area will have 50% of the surface as hardstanding.

3) The calculations have considered return periods of 1, 30 and 100 years with duration of 15 and 30 minutes for runoff rates. The time of concentration will be short due to the small size of the site. Runoff volumes use a 100 year return period 6 hour event as recommended in CIRIA SUDS manual.

4.1.23 The calculations provided in Appendix 7 indicate the following:

Greenfield peak runoff rate:

Qpeak 1yr: 4.8 l/s

Qpeak 30yr: 10.0 l/s

Qpeak 100yr: 12.0 l/s

Developed peak runoff rate:

	15 min duration	30 min duration
Qpeak 1yr	47.6 l/s	31.6 l/s
Qpeak 30yr	150.8 l/s	94.4 l/s
Qpeak 100yr	228.3 l/s	139.8 l/s

Greenfield runoff volume: 433 m^3

Developed runoff volume: 400 m^3

4.1.24 The calculations show that the development results in runoff rates exceeding the Greenfield assumption but with a negligible effect on the runoff volume. (The calculated developed volume is slightly smaller for a combination of reasons, including the empirical nature of the equations and inbuilt assumptions.)

4.1.25 *Overall this indicates that although impermeable surfacing will be present onsite* there will be little change in runoff volume from current site conditions.

[5] EA/DEFRA Preliminary rainfall runoff management for developments, EA/DEFRA W5-074/A, 2004.

5 Flood Risk Management

Management Techniques

5.1.1 All new developments should take into consideration sustainable surface water drainage to mitigate any adverse off–site impacts. Therefore, site drainage will be designed to take into account surface water volumes reported above. The following information provided by the Environment Agency should also be considered:

5.1.2 The Environment Agency have stated that if it is proposed to discharge surface water drainage from the site to the River Don the Agency would require:

- The flow to be attenuated to 5 litres/second/hectare;
- Any balancing facility to be sized to accommodate a 1 in 30 year flow;
- A 1 in 100 year flow to be retained within the site without causing flooding to property.

Residual risk

5.1.3 It is considered that the risk of flooding on the site by external causes is minimal and that it is unlikely that the site would have the potential to impact on the flood risk to its environs as a result of the increase in impermeable cover.

5.1.4 Through careful design and management of sustainable drainage systems additional reduction in surface water volumes will be achieved.

6 Conclusion

6.1.1 The majority of the development site is indicated to be within Flood Zone 1 with the northern boundary of the site lying in Flood Zone 2. Hydraulic modelling data provided by the Environment Agency and the agreement of the "No Build Zone" will ensure that the proposed development will be above the 1 in 100 year flood level. The proposed design and layout of the site will not increase run-off or impact on drainage infra-structure of the area.

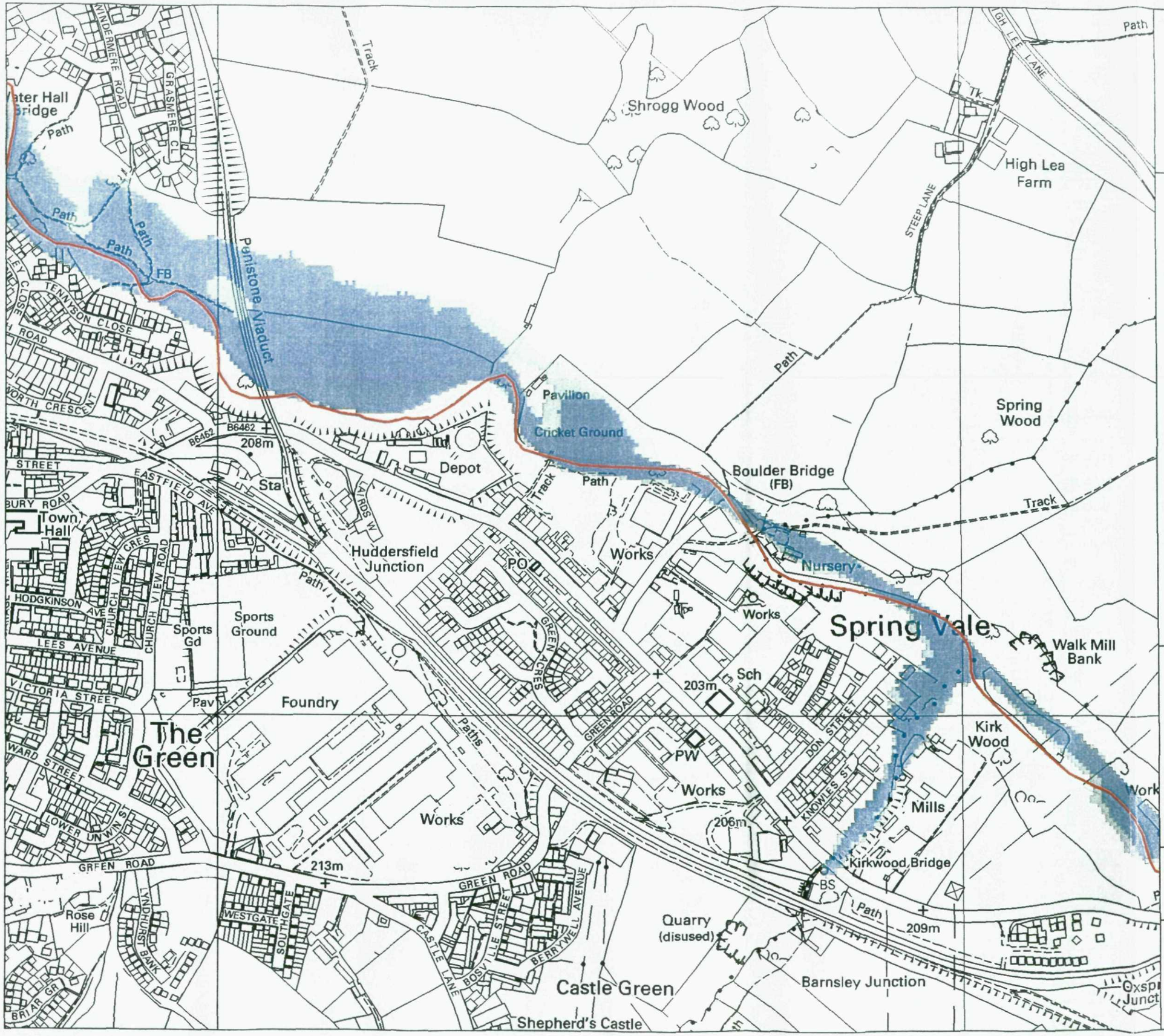
6.1.2 It is considered that the residual risks of flooding to people and property are acceptable and that the development will not increase the likelihood of flooding elsewhere.

Appendix 1: Proposed Development Plan

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Appendix 2: Flood Zone Data

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Environment Agency

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FLOOD ZONE DATA FOR ENGLAND

Information - User Note

The Flood Zones have been produced in accordance with the requirements of government planning Policy on Development and Flood Risk (Planning Policy Guidance PPG25 in England dated July 2001 and the Draft Technical Advice Note TAN15 in Wales dated July 03). The Flood Zones are for planning consultations.

The Flood Zones are based on information available at that time and will benefit from updates as better information becomes available. For example changes in hydrological river response, observations following flood events or improved modelling techniques.No consideration has been given to climate change at this time.

It should be noted that locations adjacent to rivers, not included at this stage of the survey, maybe at risk of flooding. When in doubt the Environment Agency should be consulted.

These maps may also be used by Local Authority Emergency Planners when producing Major Incident Flood Response Plans. The extents of any Flood Warning Service provided by the Environment Agency is contained within the Local Flood Warning Plan

Zone 3 (England) and Zone C (Wales) is the Agency's best estimate of the areas of land with a 100 to 1 (1%) chance or greater of flooding each year from rivers in catchments greater than 3 sq.km or with 200 to 1 (0.5%) chance or greater of flooding each year from the sea, without the presence of any defences.

Zone 2 (England) and Zone B (Wales) is the Agency's best estimate of the areas of land that could flood under extreme conditions with a 1000 to 1 or (0.1%) chance of flooding each year from rivers and the sea without the presence of defences.

Flood Zone Data For England

- main river
- flood zone 2
- flood zone 3
- areas benefiting from flood defences
- flood map flood defences

17/07/2008

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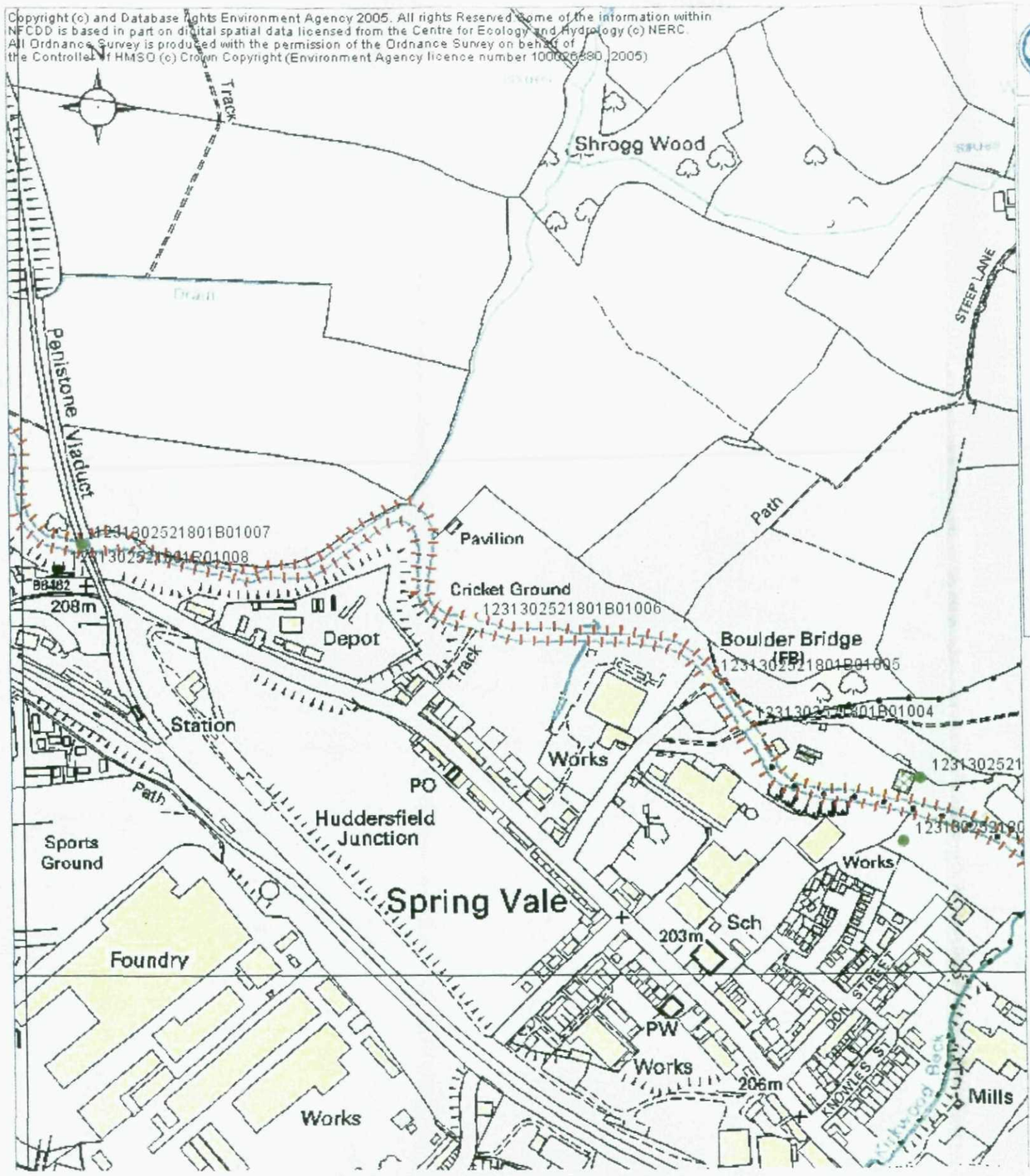
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Appendix 3: The Flood Defence Asset Register Plan

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ENVIRONMENT AGENCY

- Structure
- Overall Condition: .. 0
- Overall Condition: .. 1
- Overall Condition: .. 2
- Overall Condition: .. 3
- Overall Condition: .. 4
- Overall Condition: .. 5
- Overall Condition: .. 9
- Defence
- Overall Condition: .. 0
- Overall Condition: .. 1
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- Overall Condition: .. 3
- Overall Condition: .. 4
- Overall Condition: .. 5
- Overall Condition: .. 9

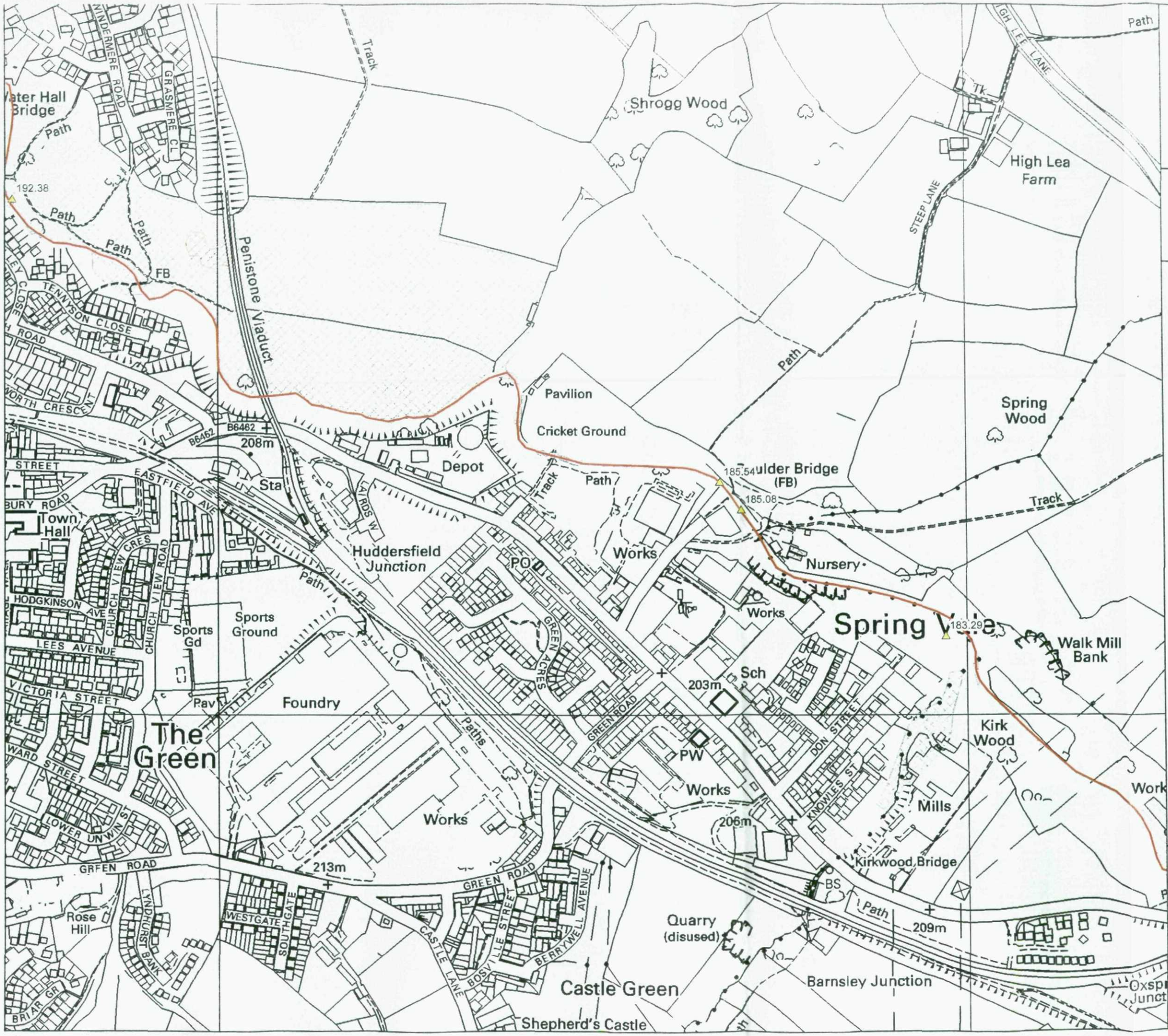
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Appendix 4: Flooding History

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Flood Extent and Flood Levels - Information

The extent of flooding is only shown for those watercourses surveyed after the flood event. Other flooding may have occured which is not shown. This is the best information currently available.

Flooding History: Flood Levels & Flood Extents

Legend

- Main River
- Autumn 2000 Flood Event Flood Level (m)
- June 2007 Flood Event Extent
- Autumn 2000 Flood Event Flood Extent

21/07/2008

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Appendix 5: Topographical Survey

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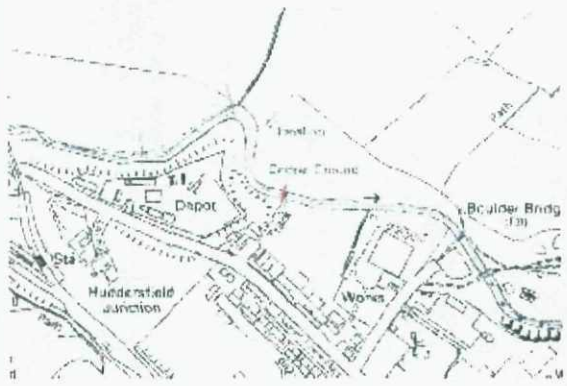
Appendix 6: Hydraulic Modelling of the River Don

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Environment Agency - North East Region
Upper Don Flood Warning Improvements
ISIS Hydraulic Model Summary Sheet

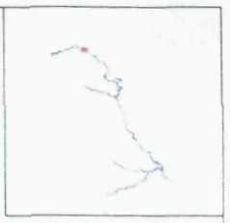
jba

Location Plan



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Cross Section References



River: RIVER DON

Reach: REACH 18

Chainage: 26483

Section Type: BRIDGE, SECTION, SPILL

OS NGR: SE 25446 03358

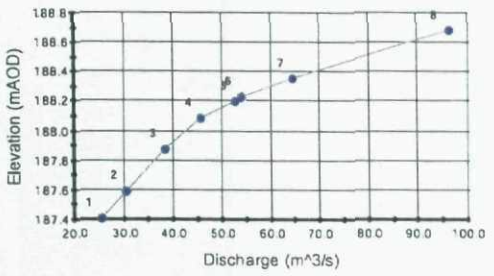
Survey Dwg Ref: N/A

Photograph Ref: DON18_26483.JPG

Next
Section d/s: 26483d
Section u/s: 26643



Rating Curve



Number represents model profile number

Summary of Results

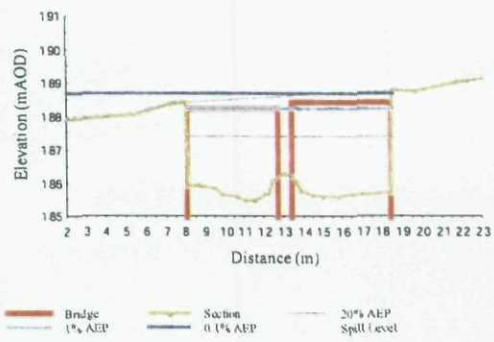
Profile No	AEP (%)	Flow (m^3/s)	Water Level (mAOD)	Velocity (m/s)
1	20.0	25.5	187.414	1.49
2	10.0	30.5	187.596	1.60
3	4.0	38.4	187.880	1.72
4	2.0	45.6	188.090	1.72
5	1.3	52.8	188.202	1.72
6	1.0	54.0	188.231	1.72
7	0.5	64.6	188.357	1.72
8	0.1	96.0	188.686	1.72

Level of Left Bank 188.418 mAOD

Level of Right Bank 188.801 mAOD

AEP: Annual Exceedance Probability = 1/T, where T = Return Period (Years)

Cross Section Profile



RIVER DON: REACH 18: CROSS SECTION NUMBER 26483u

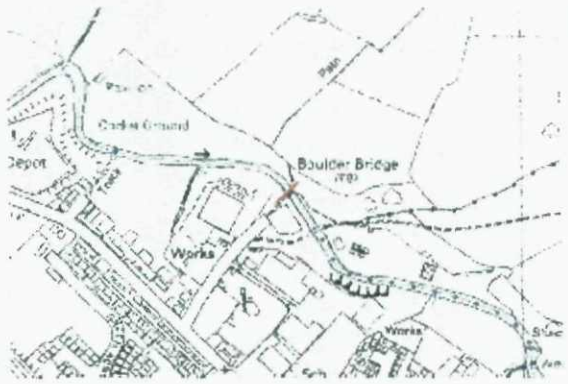
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Upper Don Flood Warning Improvements
ISIS Hydraulic Model Summary Sheet

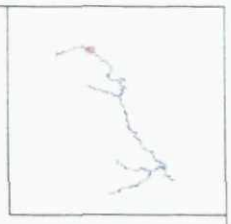
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Location Plan



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Cross Section References



River: RIVER DON

Reach: REACH 18

Chainage: 26231

Section Type: BRIDGE, SECTION, SPILL

OS NGR: SE 25679 03298

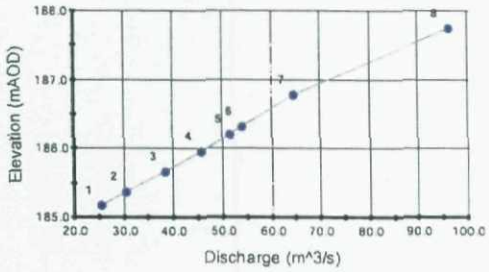
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Next
Section d/s: 26231d
Section u/s: 26483d



Rating Curve



Number represents model profile number

Summary of Results

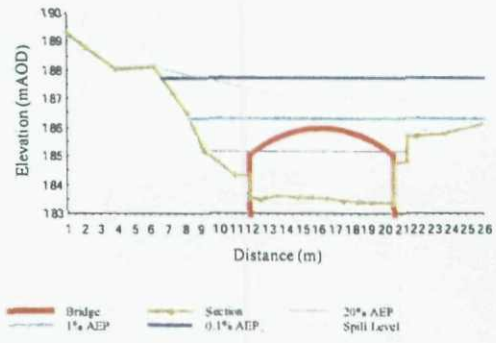
Profile No	AEP (%)	Flow (m^3/s)	Water Level (mAOD)	Velocity (m/s)
1	20.0	25.5	185.188	1.57
2	10.0	30.5	185.384	1.63
3	4.0	38.4	185.678	1.72
4	2.0	45.6	185.969	1.73
5	1.3	51.5	186.217	1.73
6	1.0	54.0	186.328	1.73
7	0.5	64.5	186.784	1.73
8	0.1	96.0	187.748	1.73

Level of Left Bank 188.142 mAOD

Level of Right Bank 185.724 mAOD

AEP: Annual Exceedance Probability = 1/T, where T = Return Period (Years)

Cross Section Profile



RIVER DON: REACH 18: CROSS SECTION NUMBER 26231u

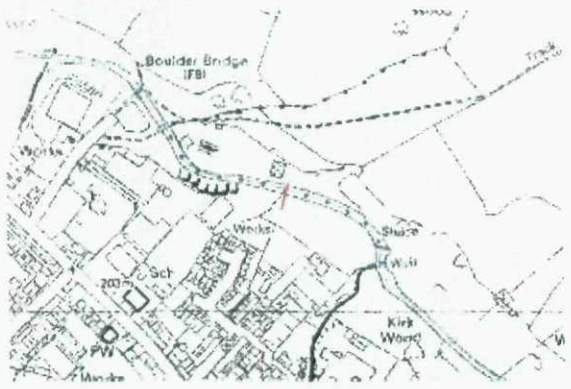
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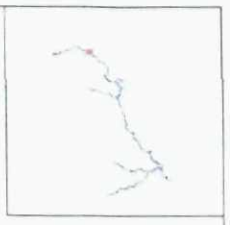
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Location Plan



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Cross Section References



River: RIVER DON

Reach: REACH 18

Chainage: 25967

Section Type: SECTION

OS NGR: SE 25880 03156

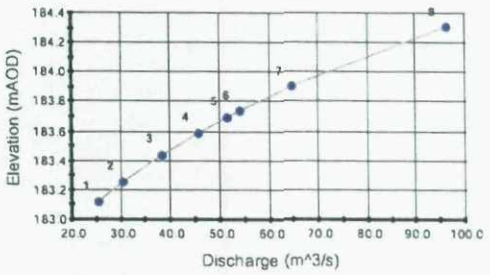
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Section d/s: 25782
Section u/s: 26170d



Rating Curve



Number represents model profile number

Summary of Results

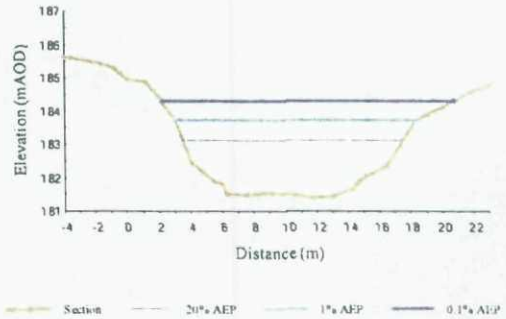
Profile No	AEP (%)	Flow (m^3/s)	Water Level (mAOD)	Velocity (m/s)
1	20.0	25.5	183.126	1.43
2	10.0	30.5	183.261	1.54
3	4.0	38.4	183.445	1.71
4	2.0	45.6	183.594	1.85
5	1.3	51.5	183.700	1.96
6	1.0	54.0	183.745	2.01
7	0.5	64.5	183.911	2.19
8	0.1	95.9	184.310	2.63

Level of Left Bank 184.891 mAOD

Level of Right Bank 183.695 mAOD

AEP: Annual Exceedance Probability = 1/T, where T = Return Period (Years)

Cross Section Profile



RIVER DON: REACH 18: CROSS SECTION NUMBER 25967

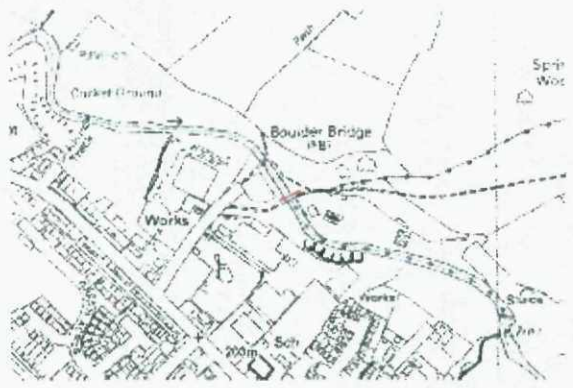
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Location Plan



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Cross Section References



River: RIVER DON

Reach: REACH 18

Chainage: 26170

Section Type: BRIDGE, SECTION

OS NGR: SE 25718 03251

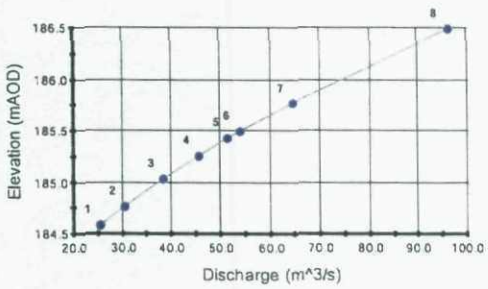
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Photograph Ref: DON18_26170us.JPG

Next
Section d/s: 26170d
Section u/s: 26231d



Rating Curve



Number represents model profile number

Summary of Results

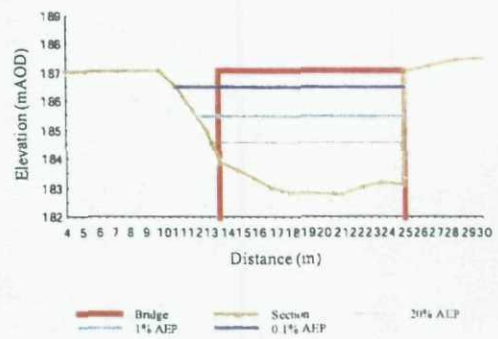
Profile No	AEP (%)	Flow (m^3/s)	Water Level (mAOD)	Velocity (m/s)
1	20.0	25.5	184.594	1.52
2	10.0	30.5	184.775	1.61
3	4.0	38.4	185.037	1.73
4	2.0	45.6	185.259	1.83
5	1.3	51.5	185.434	1.90
6	1.0	54.0	185.500	1.93
7	0.5	64.5	185.775	2.05
8	0.1	96.0	186.495	2.32

Level of Left Bank 187.084 mAOD

Level of Right Bank 187.054 mAOD

AEP: Annual Exceedance Probability = 1/T, where T = Return Period (Years)

Cross Section Profile



RIVER DON: REACH 18: CROSS SECTION NUMBER 26170u

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Appendix 7: Surface Runoff Calculations

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Penistone Development

Grid Ref	425490	403270		
SAAR		876	mm	from www.uksuds.com
FSR Soil Type		3		from www.uksuds.com
Hydrological region		3		from www.uksuds.com
Catchment area		1.3	Ha	Whole development area, stated on topological svy plan 0.555556

Rainfall **15 min durn** **30 min durn**

As site small, time of concentration will be small, durations of 15 and 30 minutes will be used

1 yr RP (M1)	6.08	8.09	mm	from FEH CD ROM, POT scale used as return period <1.0004 years
30 yr RP (M30)	19.28	24.13	mm	from FEH CD ROM
100 yr RP (M100)	29.19	35.74	mm	from FEH CD ROM
M100-6hour	73.92	73.92	*mm*	from FEH CD ROM M100-6Hour used for runoff volume calcs as specified in CIRIA SUDS manual
1 yr RP (M1)	24.3	16.2	mm/hr	Mean intensity ,i
30 yr RP (M30)	77.1	48.3	mm/hr	Mean intensity ,i
100 yr RP (M100)	116.8	71.5	mm/hr	Mean intensity ,i
M100-6hour	12.3	12.3	mm/hr	Mean intensity ,i

Greenfield runoff rate

$QBAR_{rural} = 0.00108AREA^{0.89}.SAAR^{1.17}.SOIL^{2.17}$ Catchment mean annual peak flow from CIRIA SUDS manual

AREA (A)	1.3	1.3	Ha	As area is less than 50 Ha, value of 50 Ha to be used in runoff rate formula, actual value to be interpolated.
SOIL index	*0.4*	*0.4*		*Based on soil type, value from the Wallingford Procedure Volume 1*
Qbar	0.221	0.221	m3/s	based on 50 Ha ($0.5km^2$)
Qbar	4.423	4.423	l/s/Ha	But EA/DEFRA report 'Preliminary rainfall runoff management for developments' states minimum value to be used is 1l/s/Ha
Qbar	4.423	4.423	l/s/Ha	Value of Qbar to be used
1 yr	0.837	0.837		Growth factor from CIRIA SUDS manual
30 yr	1.74	1.74		Growth factor from CIRIA SUDS manual
100 yr	2.08	2.08		Growth factor from CIRIA SUDS manual
Qpeak 1yr	3.702	3.702	l/s/Ha	
Qpeak 30yr	7.696	7.696	l/s/Ha	
Qpeak 100yr	9.200	9.200	l/s/Ha	
Qpeak 1yr	4.81	4.81	l/s	
Qpeak 30yr	10.01	10.01	l/s	
Qpeak 100yr	11.96	11.96	l/s	

Greenfield runoff volumes

Runoff Volume = Percentage Runoff (PR) x Catchment Area x Rainfall Depth

$PR_{RURAL} = SPR + DPR_{CWI} + DPR_{RAIN}$ Greenfield percentage runoff from CIRIA SUDS manual

SPR	40	40	%
CWI	124	124	from CIRIA SUDS manual
DPR_{CWI}	-0.25	-0.25	DPRCWI = 0.25 (CWI – 125)
DPR_{RAIN} M100-6Hour	5.30	5.30	DPRRAIN = $0.45(P - 40)^{0.7}$ for P > 40 mm (where P is rainfall depth)
PR_{RURAL}	45.05	45.05	%
Runoff volume	433	433	m^3

Development runoff rate

$Q = 3.61 \times C_V \times i \times A$ Design peak runoff rate (l/s) from CIRIA SUDS manual

$C_V = \frac{PR}{100}$ for whole catchment

PR = 0.829PIMP + 25SOIL + 0.078UCWI – 20.7

PIMP = percentage impermeability (0 to 100) obtained by dividing the total directly connected impervious area (both roofs and roads) by the total contributing area

PIMP	60	60 %	From Plans
UCWI	140	140 Winter	from CIRIA SUDS manual - winter value higher than summer.
PR	50.0	50.0 %	
C_V	0.50	0.50	
Qpeak 1yr	57.0	37.9 l/s	
Qpeak 30yr	180.8	113.2 l/s	
Qpeak 100yr	273.8	167.6 l/s	

Development runoff volume

Runoff Volume = Percentage Runoff (PR) x Catchment Area x Rainfall Depth

Runoff volume	480	480 m^3