APPENDIX 2
WYRE FOREST DISTRICT NFCDD

Appendix 2 - Kidderminster Defences (FRM System FR/06/S120, EA)

NFCDD Reference	Actual Condition	Asset Type	Maintainer	Description	Location
0310312650401L02	2	raised defence (man-made)	Environment Agency	Wall	KIDDERMINSTER
0310312650401L03	2	maintained channel	local authority	Concrete Arch Bridge	Worcester Road, KIDDERMINSTER
0310312650401L05	2	maintained channel	private	Steel Sheet Piles with Concrete Capping	KIDDERMINSTER
0310312650401L07	3	raised defence (man-made)	private	Wall	KIDDERMINSTER
0310312650401L08	3	maintained channel	private	Wall	KIDDERMINSTER
0310312650401L09	3	raised defence (man-made)	private	Wall	KIDDERMINSTER
0310312650401L12	2	raised defence (man-made)	private	Wall	KIDDERMINSTER
0310312650401L14	2	raised defence (natural)	private	Steep Natural Rock Face	KIDDERMINSTER
0310312650401L15	2	raised defence (natural)	private	High Ground	KIDDERMINSTER
0310312650401L17	2	raised defence (man-made)	private	WALL	KIDDERMINSTER
0310312650401L18	2	raised defence (man-made)	private	Brick Wall	KIDDERMINSTER
0310312650401L19	2	maintained channel	local authority	Brick Abutment to Arched Bridge	Green Street, KIDDERMINSTER
0310312650401L20	2	raised defence (man-made)	private	Brick Wall	KIDDERMINSTER
0310312650401L21	2	maintained channel	private	Supermarket Wall	KIDDERMINSTER
0310312650401L24	2	maintained channel	local authority	Brick Abutment to Arch Bridge	New Road, KIDDERMINSTER
0310312650401L25	2	maintained channel	private	Steel Sheet Pile Channel Side	off New Road, KIDDERMINSTER
0310312650401L27	2	maintained channel	private	Steel Sheet Piles with Concrete Capping	KIDDERMINSTER
0310312650401L29	2	maintained channel	private	Steel Sheet Piles with Concrete Capping	KIDDERMINSTER
0310312650401L30	2	maintained channel	private	Brick Wall of Building	KIDDERMINSTER
0310312650401R03	2	maintained channel	private	Concrete Bridge Abutment	Worcester Rd, KIDDERMINSTER
0310312650401R05	2	maintained channel	private	Steel Sheet Piles with Concrete Capping Beam	KIDDERMINSTER
0310312650401R08	2	maintained channel	private	Wall	KIDDERMINSTER
0310312650401R09	3	maintained channel	private	Wall	KIDDERMINSTER
0310312650401R11	2	maintained channel	private	Concrete Channel Side and Brick Retaining Wall	KIDDERMINSTER
0310312650401R12	2	maintained channel	private	Concrete Wall and Brick Wall forming Bridge Abutment	KIDDERMINSTER
0310312650401R13	2	maintained channel	private	Wall	KIDDERMINSTER
0310312650401R14	2	maintained channel	private	Retaining Brick Wall	KIDDERMINSTER
0310312650401R16	2	maintained channel	private	Brick Masonry Wall	KIDDERMINSTER

0310312650401R19	2	maintained channel	local authority	Brick Masonry Abutment to Arch Bridge	Green St, KIDDERMINSTER
0310312650401R20	3	maintained channel	private	Wall	KIDDERMINSTER
0310312650401R21	3	maintained channel	private	Wall	KIDDERMINSTER
0310312650401R22	2	maintained channel	private	Brick Abutment to Bailey Bridge forms Channel Side	Bailey Bridge, KIDDERMINSTER
0310312650401R23	3	maintained channel	private	Wall	KIDDERMINSTER
0310312650401R24	2	maintained channel	private	Brick Abutment to Arch Bridge	New Road, KIDDERMINSTER
0310312650401R25	2	maintained channel	private	Steel Sheet Piles with Concrete Capping	KIDDERMINSTER
0310312650401R27	2	maintained channel	private	Steel Sheet Piles with Concrete Capping	KIDDERMINSTER
0310312650401R29	2	maintained channel	private	Steel Sheet Piles with Concrete Capping	KIDDERMINSTER
0310312650501L01	2	maintained channel	private	Channel Side	KIDDERMINSTER
0310312650501L02	2	raised defence (man-made)	private	Wall	KIDDERMINSTER
0310312650501L03	2	maintained channel	private	Factory Wall	KIDDERMINSTER
0310312650501L04	2	maintained channel	private	Channel Side and Factory Supports	KIDDERMINSTER
0310312650501L05	2	maintained channel	private	Channel Side and Factory Wall	KIDDERMINSTER
0310312650501L06	2	maintained channel	private	Factory Wall	KIDDERMINSTER
0310312650501L07	2	maintained channel	private	Factory Wall	KIDDERMINSTER
0310312650501L08	2	maintained channel	local authority	Brick Masonry Abutment to Arched Bridge	Green St, KIDDERMINSTER
0310312650501L10	2	maintained channel	private	Brick Masonry Wall	KIDDERMINSTER
0310312650501L11	3	maintained channel	private	Arched Bridge Abutment	KIDDERMINSTER
0310312650501L12	3	raised defence (man-made)	private	Wall	KIDDERMINSTER
0310312650501R01	3	raised defence (man-made)	private	Wall	KIDDERMINSTER
0310312650501R02	2	maintained channel	private	Cement Bag Channel SIde	KIDDERMINSTER
0310312650501R03	2	maintained channel	private	Concrete Wall	KIDDERMINSTER
0310312650501R04	2	maintained channel	private	Wall	KIDDERMINSTER
0310312650501R08	2	maintained channel	private	Brick Masonry Abutment to Arch Bridge	Green St, KIDDERMINSTER
0310312650501R10	4	maintained channel	private	Masonry Wall	off New Road, KIDDERMINSTER
0310312650501R11	3	maintained channel	private	Arched Bridge Abutment	KIDDERMINSTER
0310312650601L01	2	maintained channel	local authority	Concrete Bridge Abutment	Round Hill, KIDDERMINSTER
0310312650601L02	3	maintained channel	private	channel side	KIDDERMINSTER
0310312650601L03	3	maintained channel	private	Cement bag wall	KIDDERMINSTER

0310312650601L05	3	maintained channel	private	wall	KIDDERMINSTER
0310312650601L07	2	maintained channel	private	Brick Masonry Wall	KIDDERMINSTER
0310312650601L08	2	maintained channel	local authority	Concrete Bridge Abutment	Tram St, KIDDERMINSTER
0310312650601L09	2	maintained channel	private	Brick Masonry Factory Wall forming Channel Side	KIDDERMINSTER
0310312650601L10	2	maintained channel	private	Brick Masonry Factory Wall	KIDDERMINSTER
0310312650601L11	2	maintained channel	private	Brick Masonry Factory Wall	KIDDERMINSTER
0310312650601L12	2	maintained channel	private	Factory Wall	KIDDERMINSTER
0310312650601L13	3	maintained channel	private	Channel Side with car park on crest	Fire Station, KIDDERMINSTER
0310312650601L14	2	maintained channel	local authority	Brick Masonry Highway Bridge Abutment	Castle Road, KIDDERMINSTER
0310312650601L24	1	raised defence (man-made)	private	flood defence wall	ROUNDHILL BR-E/W BIFURCTN - kidderminster
0310312650601R01	2	maintained channel	local authority	Concrete Highway Bridge Abutment	Stourport Rd, KIDDERMINSTER
0310312650601R04	2	raised defence (man-made)	private	Wall	KIDDERMINSTER
0310312650601R05	2	maintained channel	private	Concrete and Brick Factory Wall	Round Hill, KIDDERMINSTER
0310312650601R08	2	maintained channel	private	Brick Masonry Bridge Abutment	Tram St, KIDDERMINSTER
0310312650601R10	2	maintained channel	private	Brick Masonry Wall	Fire Station, KIDDERMINSTER
0310312650601R11	2	raised defence (man-made)	private	Fire Station	KIDDERMINSTER
0310312650601R14	2	maintained channel	local authority	Brick Masonry Highway Bridge Abutment	KIDDERMINSTER
0310312650601R20	1	raised defence (man-made)	private	flood defence wall	ROUNDHILL BR-E/W BIFURCTN - kidderminster
0310312650601R24	1	raised defence (man-made)	private	flood defence wall	ROUNDHILL BR-E/W BIFURCTN - kidderminster
0310312650701L01	3	maintained channel	private	REGRADED CHANNEL SIDE	KIDDERMINSTER
0310312650701L02	3	raised defence (man-made)	local authority	BRICK WALL	KIDDERMINSTER
0310312650701L03	3	maintained channel	local authority	Concrete Bridge Abutment	KIDDERMINSTER
0310312650701L04	3	maintained channel	private	Concrete Capped Steel Sheet Piled Wall	KIDDERMINSTER
0310312650701L06	3	maintained channel	private	Wall	KIDDERMINSTER
0310312650701L07	3	maintained channel	private	Wall	KIDDERMINSTER
0310312650701L08	3	maintained channel	private	Brick Masonry Wall of Building	KIDDERMINSTER
0310312650701L09	2	maintained channel	private	Wall	KIDDERMINSTER
0310312650701L10	3	maintained channel	private	Wall	KIDDERMINSTER
0310312650701L13	3	maintained channel	private	Brick Masonry Wall	KIDDERMINSTER
0310312650701L14	3	maintained channel	local authority	Brick Masonry Bridge Abutment	KIDDERMINSTER

0310312650701L15	3	maintained channel	private	Arched Bridge	KIDDERMINSTER
0310312650701L16	3	maintained channel	private	Stone Protection to Channel Side	KIDDERMINSTER
0310312650701L18	3	maintained channel	local authority	Concrete Bridge Abutment	KIDDERMINSTER
0310312650701L19	3	maintained channel	Environment Agency	Rebuilt Sheet Piled Wall (Concrete Capping)	REAR OF SAINSBURY'S PETROL STATIONRetail Park, KIDDERMINSTER
0310312650701L20	3	maintained channel	private	Stone Protection to Channel Side	REAR OF SAINSBURY'S PETROL STATION, CROSSLEY RETAIL PARK, KIDDERMINSTER
0310312650701L22	2	maintained channel	Environment Agency	Rebuilt Sheet Piled Wall (Concrete Capping)	Retail Park, KIDDERMINSTER
0310312650701L23	3	maintained channel	private	Stone Protection to Channel Side	Blakebrook, KIDDERMINSTER
0310312650701L24	2	raised defence (man-made)	private	Wall	KIDDERMINSTER
0310312650701L25	2	raised defence (man-made)	private	Wall	KIDDERMINSTER
0310312650701R01	2	raised defence (man-made)	private	REGRADED CHANNEL SIDE	KIDDERMINSTER
0310312650701R02	3	maintained channel	private	Wall	KIDDERMINSTER
0310312650701R03	3	maintained channel	private	Concrete Bridge Abutment	KIDDERMINSTER
0310312650701R04	2	raised defence (man-made)	private	Wall	KIDDERMINSTER
0310312650701R06	3	maintained channel	private	Masonry Wall forming side of pub	Bull Ring, KIDDERMINSTER
0310312650701R07	3	raised defence (man-made)	private	Wall	KIDDERMINSTER REAR OF DOCTORS SURGERY
0310312650701R13	2	raised defence (man-made)	private	Wall	KIDDERMINSTER
0310312650701R14	3	maintained channel	private	Stone Masonry Bridge Abutment	KIDDERMINSTER
0310312650701R16	3	raised defence (man-made)	private	Wall	KIDDERMINSTER
0310312650701R17	3	maintained channel	private	Channel Side	KIDDERMINSTER
0310312650701R18	3	maintained channel	private	Concrete Bridge Abutment	KIDDERMINSTER
0310312650701R19	3	maintained channel	private	Channel Side	KIDDERMINSTER, D/S RDBRIDGE CROSSLEY RETAIL PARK
0310312650701R22	1	raised defence (man-made)	Environment Agency	Masonry Wall with 1.4m Fencing	Mill St Car Park, Kidderminster Town Centre FAS
0310312650701R23	1	raised defence (man-made)	Environment Agency	Masonry Wall	Town Mills, Kidderminster Town Centre FAS
0310312650701R24	2	raised defence (man-made)	Environment Agency	Masonry Wall with 2.0m Fencing	Ideal Buildings, Kidderminster Town Centre FAS
0310312650701R25	2	maintained channel	private	Wall	Blakebrook, KIDDERMINSTER
0310312650701R26	2	maintained channel	private	Concrete Wall	Blakebrook, KIDDERMINSTER
0310312650801L01	3	raised defence (man-made)	Environment Agency	Flood Bank	Cofton Embankment, KIDDERMINSTER FAS.From Blakedown Brook Confluence (side channel) to Canal Culvert.

0310312650801L02	1	raised defence (man-made)	Environment Agency	Flood Bank	Blakedown Brook, KIDDERMINSTER FAS
0310312650801L03	2	raised defence (man-made)	Environment Agency	Flood Bank	Canal Embankment, KIDDERMINSTER FAS
0310312650801R01	1	raised defence (man-made)	Environment Agency	Control Embankment	By Puxton Lane, KIDDERMINSTER FAS
0310312650802L01	2	raised defence (man-made)	private	Wall to Spillway	KIDDERMINSTER
0310312650802L02	2	raised defence (man-made)	local authority	Canal Embankment	KIDDERMINSTER
0310312650803R01	3	raised defence (man-made)	Environment Agency	Flood Bank	Beechcote, KIDDERMINSTER FAS
0310312650803R02	2	raised defence (man-made)	Environment Agency	Flood Bank	Beechcote, KIDDERMINSTER FAS

2.303278689

APPENDIX 3
HOO BROOK HYDROLOGY AND HYDRAULICS

APPENDIX 3 – HOO BROOK HYDROLOGY AND HYDRAULICS

1.1 Hydrology

The hydrological analysis has been undertaken by using the Flood Estimation Handbook (FEH). This is the standard method for flow estimation by practitioners and the Environment Agency (EA). The FEH methods that have been used in this study are discussed below.

1.1.1 Median Flood Flow (QMED)

The median flood flow (QMED), or index flood expected at a given site, is an important parameter to define as it is this that feeds into the estimation of flood flows. In order to adopt a precautionary approach a QMED was derived using a range of methods, these are considered below and summarised in **Table A3**.

- *Estimating QMED from Flood Data*

The watercourse is not gauged and therefore it is not possible to undertake direct analysis of observed data. Even though there are gauges within the vicinity of the site, these have been discounted, as they are not suitable for QMED and pooling, or are situated on very different catchments than that of the study site.

- *Estimating QMED from Catchment Descriptors (FEH)*

Catchment descriptors are measures that seek to capture key features of the drainage basin. In Chapter 3 of the FEH (Volume 3) these can be used in a series of calculations (3.1 to 3.3) to estimate the QMED for any given set of catchment descriptors. Using the catchment descriptors FEH is able to calculate a QMED for the study site. The calculated QMED from the catchment descriptors for the two tributary inflows; HooN1 is **0.168 m^3s^{-1}** and HooS1 is **1.945 m^3s^{-1}**.

- *Estimating QMED from CEH*

The Centre for Ecology and Hydrology (CEH) were commissioned to produce a data set of flows along all watercourses with an area of 0.5km^2 based on catchment characteristics. Given that this contains estimates of QMED for specific localities along the watercourse it is appropriate that this estimate is consulted. The QMED value for the HooN1 is **0.360 m^3s^{-1}** and for HooS1 is **2.960 m^3s^{-1}**.

- *Estimating QMED by Data transfer (FEH)*

In Chapter 4 of the FEH (Volume 3) there are a series of methods that can be used to obtain a QMED through a transfer of data from a catchment that is hydrologically similar. This uses the QMED ratio between catchment descriptor derived QMED and observed QMED for donor sites that are hydrologically similar. This ratio can then be applied to the QMED that is calculated from catchment descriptors for the study site. Using the top three gauged sites from a suitably homogenous pooling group created in WINFAP-FEH, we can decide on a conservative ratio that can be used in the calculation. **Tables A1 and A2** shows the sites used and the QMED values.

Table A1 – Estimations of QMED for HooN1

River	QMEDcds	QMEDobs	Ratio
Brompton Beck	0.384	0.732	1.907
Costa Beck	0.449	1.309	2.915
		Average	2.411
HooN1	0.168	0.405	(using average ratio)
HooN1	0.168	**0.490**	(using Costa Beck)

Table A2 – Estimations of QMED for HooS1

River	QMEDcds	QMEDobs	Ratio
Winterbourne Stream	3.031	0.388	0.128
Lud	2.192	3.046	1.390
Hamble	4.670	7.907	1.693
		Average	
HooS1	1.945	2.082	(using average ratio)
HooS1	1.945	0.249	(using Winterbourne Stream)
HooS1	1.945	**3.293**	(using Hamble)

The value used for HooN1 inflow was **0.490 m^3s^{-1}** derived from the Costa Beck ratio and the value for HooS1 inflow was **3.293 m^3s^{-1}** derived from the Hamble ratio. These were selected as they were more conservative values.

- *Estimating QMED from FEH Rainfall Runoff method*

Using the rainfall runoff method in ISIS a flow was calculated for the 2 year flood return period event (QMED). The critical storm durations used for the HooN1 and HooS1 inflows were 3.3 and 15.5 hours respectively. This gave QMED values of **0.862 m^3s^{-1}** for HooN1 and **3.355 m^3s^{-1}** for HooS1.

- QMED Summary

Table A3 – QMED Summary Table

Method	HooN1	HooS1
Estimating QMED from catchment descriptors (FEH)	0.168	1.945
Estimating QMED from CEH	0.360	2.960
Estimating QMED by Data transfer (FEH)	0.490	3.293
Estimating QMED from Rainfall Runoff method (FEH)	**0.862**	**3.355**

Given that this FRA is adopting the precautionary approach, the QMED values derived from the rainfall runoff method were selected.

1.1.2 Flood Estimation

Flood records are often too short to allow reliable estimation of the long return-period floods required by an FRA in accordance with PPS25. The recommendation in FEH is therefore to pool data from groups of catchments that are hydrologically similar in order to achieve a reliable estimate of a long return-period flood required. This process produces a growth curve that can be used with the estimate of QMED to produce a design flood.

A pooling group was generated and the resulting growth curve was derived. For comparison, the growth curve generated by the FEH rainfall runoff method was also calculated. The rainfall runoff method yielded the higher flows, and therefore in accordance with the precautionary principle, these flows were taken forward for use in the hydraulic modelling.

The design flood flows of 5% (1 in 20 year return period), 1% (1 in 100 year return period) and 0.1% (1 in 1000 year return period), the design flood flow encompassing climate change and the growth factors used are presented below (**Tables A4 & A5**).

Table A4 – Growth Curve

RP	HooN1		HooS1	
	Growth Factor	Q (m^3s^{-1})	Growth Factor	Q (m^3s^{-1})
2	1.000	0.87	1.00	3.36
5	1.457	1.26	1.41	4.72
10	1.793	1.55	1.78	5.98
20	2.180	**1.89**	**2.20**	**7.37**
25	2.407	2.08	2.35	7.88
50	3.037	2.63	2.82	9.46
100	3.712	**3.21**	**3.33**	**11.17**
200	4.539	3.93	3.94	13.23
500	5.908	5.11	4.93	16.55
1000	7.454	**6.45**	**6.02**	**20.20**

Table A5 – Design Flood Flows

Annual Return Period	HooN1	HooS1
20	1.89	7.37
100 Year	3.21	11.17
100 Year +20% Climate Change	3.85	13.40
1000 Year	6.45	20.20
1000 Year +20% Climate Change	7.74	24.24

1.2 Hydraulic Modelling

1.2.1 Introduction

In order to correct the flood zone misalignment of Hoo Brook, a hydraulic model was constructed in ISIS (Version 3.1).

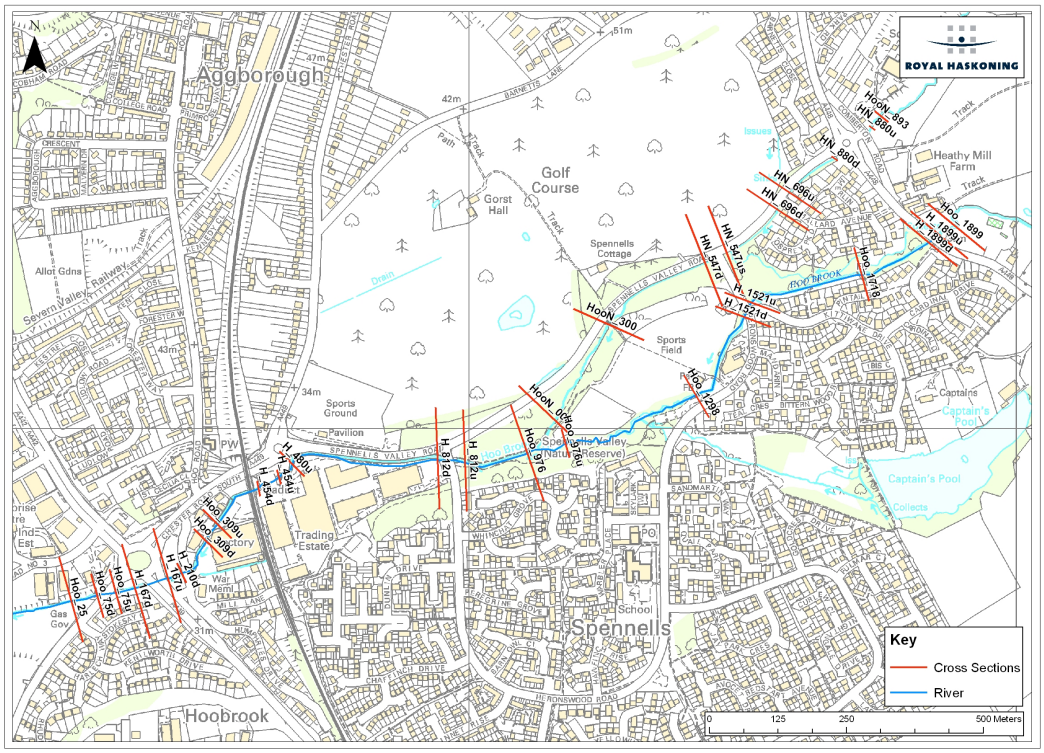
1.2.2 Survey and Data Used

The model was built using channel section data obtained from a topographic survey undertaken by Total Surveys in October 2008. As the survey is so recent it resembles the watercourse at its present state and can therefore be regarded as the most appropriate for this study.

Channel Cross Sections:

The topographic survey of the channel cross sections were not extended a long distance into the floodplain. The cross sections were therefore extended using LiDAR data. A plan of the modelled cross sections can be seen below in **Figure A3**.

Figure A3 – Modelled Cross Sections, Hoo Brook



River Structures:

The model includes the structures deemed from the site survey to be hydraulically significant. The structures included in the model are as shown in **Table A6**.

Table A6 – Structure Summary Table

Structure Name	Description	How Modelled
HN_880ou	80m culvert beneath Comberton Road and A448	Modelled as an open orifice with spill joining sections HN880u and HN_880d
HN_696ou	22m culvert beneath Millard Avenue	Modelled as an open orifice with spill joining sections HN_696u and HN_696d
HN_547ou	25m culvert beneath Heronswood Road	Modelled as an open orifice with spill adjoining sections HN_547us and HN_547d
HN_1899bu	24m culvert beneath A448	Modelled as a arch bridge joining sections H_1899u and H_1899d
H_1521bu	28m culvert beneath Heronswood Road	Modelled as an arch bridge joining sections H_1521u and H_1521d
H_812bu	22m culvert beneath Heronswood Road	Modelled as an arch bridge joining sections H_812u and H_812d
H_480ou	14m culvert beneath Trading Estate entrance to Homebase	Modelled as an open orifice joining sections H_480u and H_480d

H_454bu	32m culvert beneath Trading Estate Car Park	Modelled as an arch bridge joining sections H_454u and H_454d
H_309bu	10m bridge to factory car park	Modelled as an arch bridge joining sections Hoo_309u and Hoo_309d
H_210bu	20m Humphreys Drive bridge	Modelled as an arch bridge joining sections H_210u and H_210d
H_167bu	46m A449 bridge	Modelled as an arch bridge joining sections H_167u and H_167d
Hoo_75bu	40m Wilden Lane bridge	Modelled as an arch bridge joining sections Hoo_75u and Hoo_75d

1.2.3 Manning's *n* Co-efficient of Roughness

Channel and floodplain roughness has been represented in the model by use of an appropriate Manning's *n* value. The values were assessed with recommendations given in "Open Channel Hydraulics", (VT Chow 1959) equation 5-12.

Manning's 'n' values were calculated for the channel and floodplain, and are summarised in **Table A7** below.

Table A7 – Manning's 'n' coefficient of roughness used in the model (V.T. Chow, Open Channel Hydraulics, 1959)

Short Grass

Channel / Floodplain Conditions		**Values**	
Material involved	Earth	n_0	0.020
Degree of irregularity	Minor	n_1	0.000
Variation of cross sections	Gradual	n_2	0.000
Relative effects of obstruction	Minor	n_3	0.010
Vegetation	Medium	n_4	0.010
Degree of Meandering	Minor	n_5	1.000
		TOTAL	0.045

Fine bed material

Channel / Floodplain Conditions		**Values**	
Material involved	Earth	n_0	0.020
Degree of irregularity	Gradual	n_1	0.000
Variation of channel cross sections	Gradual	n_2	0.000
Relative effects of obstruction	Minor	n_3	0.010
Vegetation	Low	n_4	0.010
Degree of Meandering	Minor	n_5	1.000
		TOTAL	0.04

1.3 Downstream Boundary Conditions

The downstream boundary is located 85m downstream of the A449 roundabout. Sensitivity tests were undertaken on the downstream boundary levels used from 28.5 to

31mAOD in 0.5mAOD intervals. For the purpose of this modelling, the downstream boundary was selected as a fixed level of 29mAOD.

2 FLOOD ZONE DEFINITION

The results from the modelling were plotted onto the LiDAR data to establish the amended flood zone surrounding the Hoo Brook.

2.1.1 Analysis and Synthesis of Results

Examining the results presented in **Table A8**, and Figures B3 to G3, it can be observed that in general, the amended Flood Zones 2 and 3 have reduced in size from the original misaligned Flood Zones. There is a small corridor either side of the existing Flood Zones downstream of the Viaduct that has enlarged as a result of the new modelling. The area is currently a mix of industrial and residential.

Table A8 - River Modelling Results

	Max Flow					Stage				
	T20	**T100**	**T100cc**	**T1000**	**T1000cc**	**T20**	**T100**	**T100cc**	**T1000**	**T1000cc**
South Branch										
H_1899u	7.411	11.167	13.399	20.197	24.235	38.006	38.106	38.155	38.262	38.316
H_1899d	7.411	11.167	13.4	20.197	24.235	37.83	37.889	37.917	38.019	38.086
Hoo_1718	7.401	11.157	13.388	20.179	24.209	36.988	37.18	37.274	37.544	37.702
H_1521u	7.401	11.157	13.388	20.177	24.207	36.009	36.306	36.458	36.846	37.032
H_1521d	7.401	11.157	13.388	20.177	24.207	35.788	36.014	36.134	36.477	36.621
Hoo_1298	7.4	11.156	13.387	20.176	24.178	33.914	34.231	34.348	34.584	34.65
Hoo_976u	3.621	3.196	4.899	16.116	18.56	32.927	33.2	33.264	33.421	33.5
Hoo_976	7.488	11.215	13.444	20.22	24.248	32.927	33.2	33.264	33.421	33.5
North Branch										
HooN_893	1.621	2.847	3.416	6.448	7.737	38.052	38.357	38.453	38.828	38.93
HN_880d	1.606	2.823	3.39	6.416	7.7	37.792	38.098	38.204	38.653	38.745
HN_696d	1.607	2.818	3.38	6.375	7.663	36.445	36.667	36.749	37.062	37.168
HN_547us	1.599	2.815	3.379	6.398	7.686	35.418	35.785	35.868	36.129	36.168
HN_547d	1.599	2.815	3.379	6.398	7.686	35.057	35.29	35.356	35.602	35.671
HooN_300	1.597	2.808	3.377	6.375	7.636	33.8	34.159	34.282	34.526	34.593
HooN_000	16.486	36.478	44.592	67.539	78.544	32.927	33.2	33.264	33.421	33.5
Downstream of Confluence										
H_812u	7.586	11.211	13.433	20.215	24.242	32.893	33.17	33.231	33.383	33.459
H_812d	7.586	11.211	13.433	20.215	24.242	32.503	32.749	32.858	33.132	33.239
H_480u	7.361	11.208	13.429	20.206	24.233	32.162	32.398	32.501	32.748	32.861
H_480d	7.361	11.208	13.429	20.206	24.233	31.161	31.34	31.414	31.568	31.752
H_454u	7.271	9.864	10.78	13.306	13.668	31.136	31.375	31.5	31.769	31.876
H_454d	7.271	9.864	10.78	13.306	13.667	30.885	30.988	30.997	31.161	31.237
Hoo_309u	7.422	11.207	13.43	20.195	24.21	30.029	30.405	30.479	30.66	30.791
Hoo_309d	6.943	11.203	13.424	20.171	24.18	29.786	30.143	30.238	30.563	30.725
H_210u	6.947	11.203	13.424	20.169	24.175	29.26	29.556	29.751	30.359	30.57
H_210d	6.947	11.203	13.424	20.169	24.175	29.2	29.411	29.542	30.017	30.375
H_167u	6.906	11.203	13.424	20.169	24.175	29.12	29.281	29.402	29.861	30.241

H_167d	6.906	11.203	13.424	20.169	24.175	29.104	29.222	29.304	29.573	29.749
Hoo_75u	6.908	11.203	13.424	20.168	24.175	29.063	29.141	29.209	29.468	29.66
Hoo_75d	6.908	11.203	13.424	20.168	24.175	29.007	29.017	29.025	29.057	29.082
Hoo_25	6.913	11.203	13.424	20.168	24.175	29	29	29	29	29

APPENDIX 4
GUIDANCE

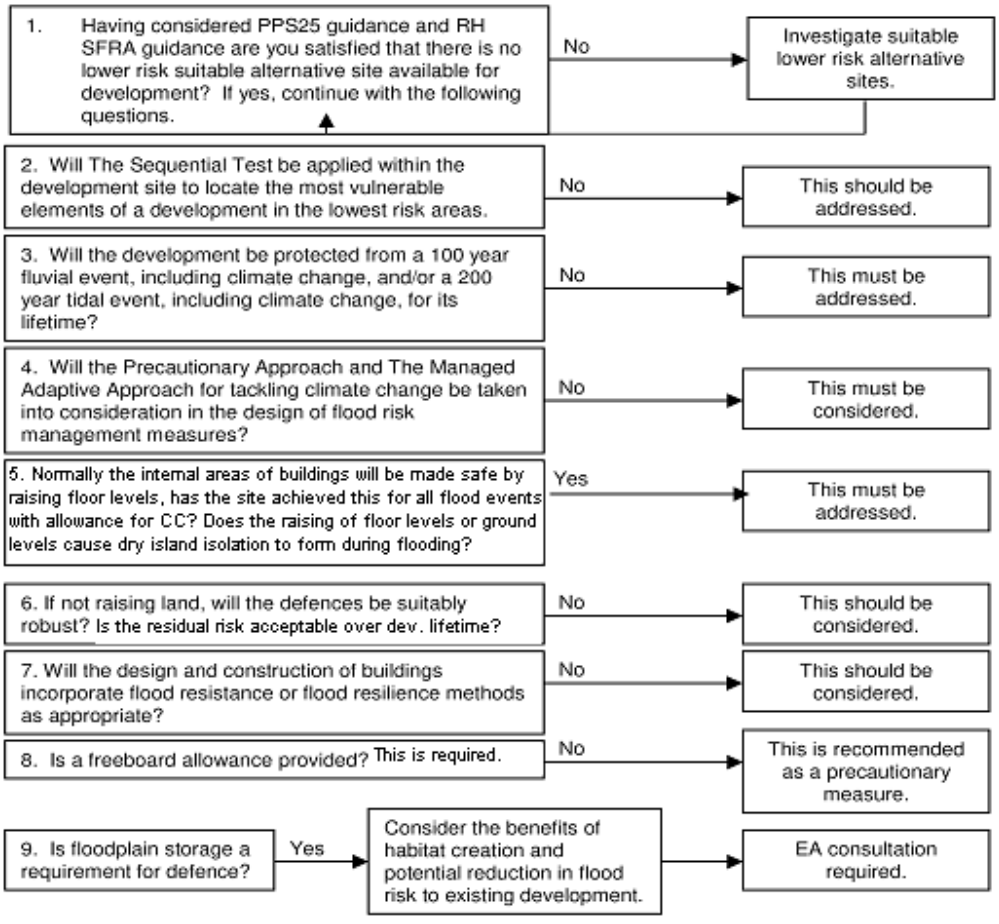
GUIDANCE NOTE:
REVIEW OF FRAs

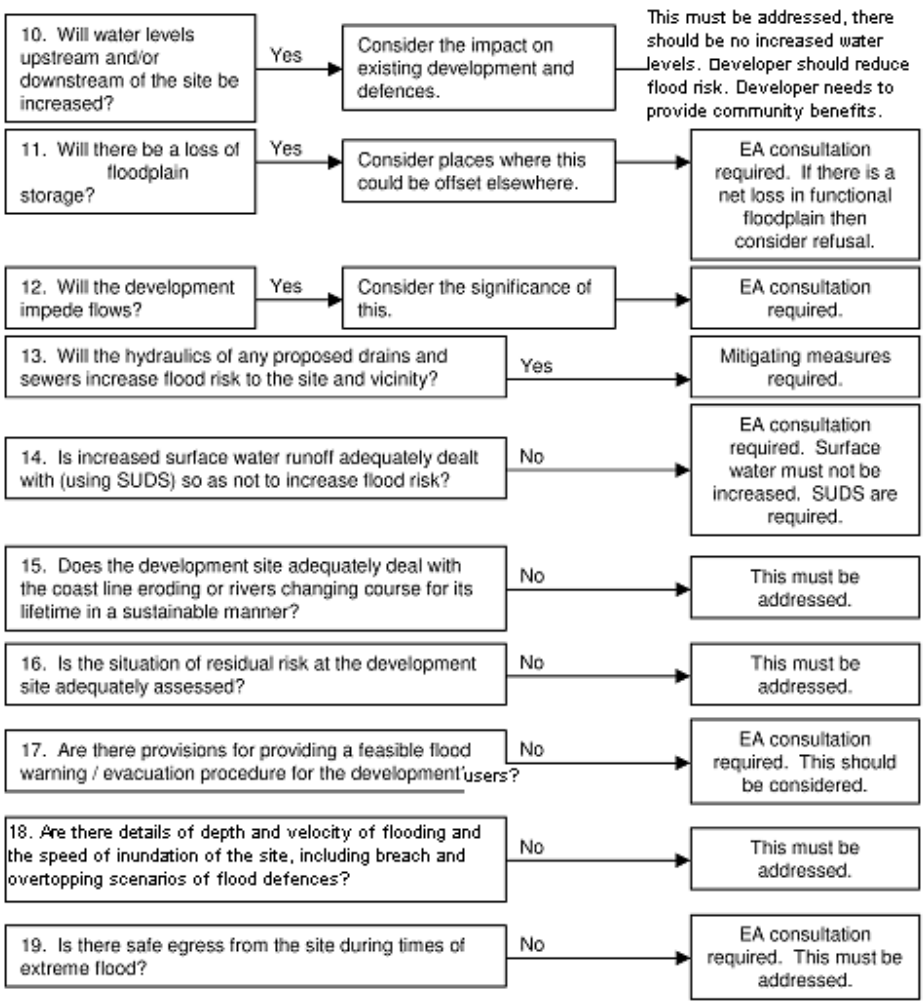
Review of Flood Risk Assessment –
Residential/ Commercial/ Industrial Development

The Planning Authority must be satisfied that the FRA has considered all sources of flooding, including determining the extent of flood zones, along with any historical flooding that may have occurred.

Method

Below is a checklist for planners reviewing FRAs for residential, commercial and industrial development sites within or treated as within EA Flood Zones 2, 3a and 3b. It contains a list of questions which address areas highlighted as important in an FRA by PPS25. All questions should be answered before the final decision is made. In reviewing each question, you must be satisfied that the FRA has adequately dealt with the issue. If you are not satisfied, the required action is shown. If you are satisfied, then move onto the next question. Once you have reviewed all the questions, an overall decision about the suitability of the site for development can be made. In order to comply with the Sequential Test, the answer to Question 1 should be yes before you can proceed with the following questions.





If the site is in a potential flood risk area, including within 10 meters of an unmodelled watercourse or culverted watercourse then the site is treated as Flood Zone 3. Guidance outlined within PPS25 should then be followed to deal with developments within Flood Zone 3.

ROYAL HASKONING

GUIDANCE NOTE: THE EXCEPTION TEST

1. Acceptance of the Risk

The Level 1 and Level 2 has identified the potential flood risk to each of the proposed development sites put forward by the Council. The Sequential Test would direct all development away from areas of flood risk. When allocating or approving land for development in flood risk areas, Councils are expected to demonstrate there are no suitable alternative development sites located in lower flood risk areas.

If it is necessary to apply the Exception Test, there is an underlying acceptance of an existing degree of flood risk. However, it is essential that this risk is not ignored, but rather mitigated against in the planning process and design of new developments.

2. Planning and Design

Maintenance

Many existing properties and proposed development sites within the Wyre Forest District are protected by flood defences from flooding from the River Stour, Severn and other Ordinary watercourses. Tables 10 and 19 outline the defence and asset conditions within the District. The SFRA has demonstrated that the majority of these defences are adequate forms of defence if maintained regularly. The potential risk to people and property behind the flood defences has been assessed through the analysis of breach scenarios. The future maintenance and upgrade of the defences is therefore essential in ensuring the safety of people and property behind the defences.

Of the defences in the District, only one has a 'poor' asset condition assigned to it. As referred to in the main report, defence 19 is situated downstream of Kidderminster, protecting Castle Road from flooding. The 'poor' asset condition assigned to the defence defines it as structurally unsound now or in the near future. The Local Planning Authority must closely monitor this defence, as it will require major remedial works and replacement within 1 – 5 years. In the short term, extensive repair is required in order to prevent total failure occurring. The effects of this defence breaching can be seen in the model outputs.

The standard of all the defences in Bewdley are currently at 1% AEP standard, which will not withstand the effects of climate change. There are also residual risks associated with the speed at which the demountable defences are erected. This must be taken into account when considering the development of areas currently benefiting from the protection of these defences, namely sites D6 and D32. All of the defences in Bewdley have scheduled inspection dates as listed in the EA FRM System.

Access and Egress

For a given development which may require the application of the Exception Test, a site specific FRA must investigate whether safe access and egress constitutes dry access routes or depth and velocity combinations that are below the thresholds for all events. PPS25 Companion Guide December 2009 paragraph 4.60 states that access routes should allow occupants to safely access and exit their dwellings in design flood conditions. Access conditions should include the voluntary and free

movement of people during a design flood. The Local Authority in conjunction with their Emergency Planners should consider evacuation and rescue issues for extreme flood events. When dealing with issues of safe access and egress the Local Planning Authority will need to take into account the proposed use of the development, the vulnerability of the occupants and the availability of emergency services and flood forecasting along with the flood hazard and speed of inundation. With use of the hydraulic models, including any updates in the future, basic issues of flood depth and velocity will identify appropriate safe uses of land within the sites, and thus indicate if the development is likely to be 'safe' (Part C of the Exception Test). Tables 15 and 23 should assist Wyre Forest District Council in identifying the principal sites that will have limited access and egress routes in the event of a specific flood event.

Flood Resilience

A fundamental level of flood resistance and/or resilience should be achieved in all flood risk areas, following good building practice and complying with the requirements of the Building Regulations 2000 should reach these standards.

Flood resistance can be described as 'dry proofing' where floodwater is prevented from entering the building. This may be achieved by raising floor levels or placing flood barriers across doorways.

Flood resilience may be described as ' wet proofing' where it is acknowledged that floodwater can easily enter and exit the property and all internal features are designed appropriately to take this into account, such as raising electrical sockets and fitting tiled floors.

Further guidance for homeowners and developers, can be downloaded from
www.ciria.org/flooding/reducing_the_impact.htm

Safe Development

All new development should have finished floor levels set 600mm above the 1% annual probability flood event with allowances for climate change, although in some circumstances it may be difficult for water compatible development to achieve this, and providing it is non-residential then flood resilience and protection measures may be more appropriate. All development should consider the effects of extreme floods events and aim to be safe, it is expected that more vulnerable and highly vulnerable development should be flood free for events up to the 0.1% annual probability flood event.

Applicants should also show that the area around a development is safe, in particular for car parking, the PPS25 companion guide advises on this.

In areas of high velocity, or where a building is in close proximity to the river banks, buildings will need to be structurally designed to withstand the effects of flooding, erosion, and debris.

Impacts of Development on Flood Risk Elsewhere

New development should be aiming to reduce flood risk elsewhere, and there should be no increase elsewhere. FRAs should show that there are no losses in flood storage areas, were there are losses then flood storage compensation should be provided elsewhere. Similarly new development should not obstruct flood flow routes. Opportunities for reducing flood risk should be considered within the FRA, this could include increasing flood storage areas, improving flow conveyance, or removing culverted watercourses. Improving flood defence structures, such as trash screens, defences, or

where it is not viable to remove culverted watercourses, then repairing them or improving their capacity are ways of reducing flood risk. Advise should be sought from the Environment Agency and Local Planning Authority at pre-application stage.

GUIDANCE NOTE: EMERGENCY PLANNING

1. Essential Infrastructure

The success of emergency response is dependent upon a pre-planned course of action. In relation to flooding it is vital that essential emergency infrastructure, such as hospitals and fire stations, are able to operate and not rendered useless by being flooded themselves. In planning new infrastructure it is essential that flood risk is taken into account. Section G11 of PPS25 states that:

"Essential Infrastructure which has to be located in flood risk areas should be designed to remain operational when floods occur."

The Flood Risk Vulnerability and Flood Zone Compatibility Table (D3.22, PPS25) states that essential infrastructure should be sited in Flood Zones 1 or 2.

2. Access Routes

In the event of a severe flood, either by overtopping or defence breach, consideration must be given to the safe evacuation of people of different levels of mobility. For the high risk design flood event (1% with climate change) people should be able to have safe access without the intervention of the emergency services, taking into account their mobility. The flood extent maps within the SFRA highlight the flood risk to access routes during different flooding scenarios.

Further guidance is given in the Sections 4.53 to 4.69 in the PPS25 Practice Guide, 2009.

3. Emergency Planning

Paragraphs 7.25 to 7.38 in PPS25 Practice Guide, 2009 refers to Flood Warning and Evacuation Plans.

The purpose of flood warning is to provide advice which permits those people vulnerable to impending flooding to take actions which lessen the consequences of inundation, should it be experienced. The Environment Agency operates a flood warning system across much of England and Wales and since 1996 has undertaken to disseminate warnings to people who are at risk, so that they can take action to protect themselves and their property.

Whilst the EA predominantly focuses on flood warnings to protect life and property, there is also an increasing need for LPAs and emergency services to utilise timely flood-warnings to protect critical infrastructure.

Wyre Forest District Council Emergency Planning Unit is responsible for coordination and planning for flood events. They liaise with the emergency services as well as the EA. The role of the Emergency Planning Unit at other times is to prepare contingency plans, promote education and awareness and to respond to calls to queries or concerns from the public.

The *National Flood Response Centre* provides support and guidance to the Government, EA, emergency services and local authority partners. It is designed to coordinate and disseminate timely information as well as collate and process data post events.

The Emergency Planning Unit, in partnership with the emergency services, should look to increase awareness through media campaigns as well as working with the EA to promote the importance of timely actions with respect to flooding.

It is strongly recommended that the rapid inundation studies carried out within this Strategic Flood Risk Assessment are referenced when future planning for emergency flood events. There is also need for climate change to be considered in planning for dry access routes, flood resilient building design and the production of Emergency Plans.

ROYAL HASKONING

GUIDANCE NOTE: DEALING WITH SURFACE WATER

1. Requirements of PPS25 regarding surface water management

Urban developments can have a big effect on the quantity and speed of surface water runoff. By replacing vegetated ground with buildings and paved areas the amount of water being absorbed into the ground is severely reduced, therefore increasing the amount of surface water present. This additional surface water increases the demand on drainage systems in built up areas. Traditional drainage systems are designed to get rid of the water as quickly as possible to prevent flooding in the built up area. This can cause problems, particularly downstream, by altering the natural flow patterns of the catchment. In addition, water quality can be affected due to pollutants from the built up areas being washed into the watercourse due to the lack of treatment of the water. One technique which can reduce this problem is the use of Sustainable Drainage Systems (SUDS).

2. What are SUDS?

Sustainable Drainage Systems (SUDS) are techniques designed to control surface water runoff before it enters the watercourse. They are designed to mimic natural drainage processes, along with treating the water to reduce the amount of pollutants getting into the watercourse. They can be located as close as possible to where the rainwater falls and provide varying degrees of treatment for the surface water, using the natural processes of sedimentation, filtration, adsorption and biological degradation.

3. Adoption of SUDS

To help overcome the specific problems of SUDS adoption, and as an interim measure, the National SUDS Working Group (NSWG) has developed an Interim Code Of Practice for SUDS (NSWG, 2004). This code of practice is complemented by CIRIA publication Model Agreements for SUDS, which provides a set of planning model agreements for use between those public organisations with statutory or regulatory responsibilities relating to SUDS.

The single most authoritative source for SUDS design and implementation which should be cited in LDF policies is **The SUDS Manual – 2007, CIRIA C697** which provides comprehensive guidance on every aspect of SUDS. The Environment Agency has also provided an outline guide for developers which recommend that SUDS should be cost-effectively designed to work with retained natural features such as ditches or ponds, and to form an integral part of hard and soft landscaped areas [7]. In this way, they can contribute towards an attractive scheme that enhances the nature conservation and amenity value of the development, while also recycling the valuable water resource.

It is recommended within this report that sustainable drainage systems are designed on a site by site basis.

4. The Purpose of SUDS

SUDS are more sustainable than traditional methods because they can:

- Manage the speed of the runoff

- Protect or enhance the water quality
- Reduce the environmental impact of developments
- Provide a habitat for wildlife
- Encourage natural groundwater recharge.

In addition, they can be used to create more imaginative and attractive developments and are designed so that less damage is done, than conventional systems, if their capacity is exceeded.

5. Places where are SUDS appropriate

Surface water management using SUDS can be implemented at all scales and in most urban settings, ranging from hard-surfaced areas to soft landscaped features, even if there is limited space. The geology within Kidderminster and Stourport is unsurveyed and mainly urban with little spare space. For this reason, storage ponds are not the most suitable form of surface water management, though underground storage tanks could be used. The remainder of the District has well drained sandy and coarse loamy soils over soft sandstone. This is ideal for the use of infiltration techniques in the form of green roofs, permeable surfaces, swales and ponds.

Care must be adopted when dealing with brownfield sites and potential contamination to ensure that appropriate SUDS are used for the site conditions to ensure no mobilisation of contaminants by infiltration.

Underground storage tanks should be considered only when surface SUDS are proven and accepted by the LPA as not viable for the site circumstances.

6. The different types of measures

SUDS are made up of one or more structures built to manage surface water runoff, and used in conjunction with good site management. There are five general methods:

i. **Prevention** – this can involve minimizing paved areas, replacing tarmac with gravel, rainwater recycling, cleaning and sweeping, careful disposal of pollutants, and general maintenance.

ii. **Filter strips and swales** – these are vegetated surface features that drain water evenly off impermeable areas. Swales (figure 1) are long shallow channels whilst filter strips (figure 2) are gently sloping areas of ground. Both of these mimic natural drainage by allowing rainwater to run in sheets through vegetation, slowing and filtering the flow.

Figure 1 - Cross-section of a Swale

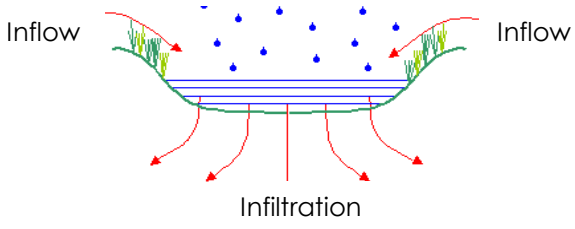
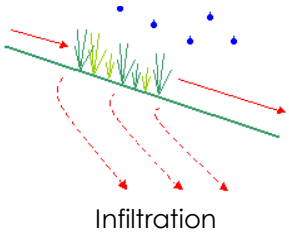


Figure 2 - Cross-section of a Filter Strip



iii. **Permeable surfaces and filter drains** – these are devices that have a volume of permeable material below ground to store surface water. Runoff flows to this storage area via a permeable surface.

iv. **Infiltration devices** – these enhance the natural capacity of the ground to store and drain water. They include soakaways, infiltration trenches and infiltration basins. See figure 3.

v. **Basins and ponds** – these are areas for storage of surface runoff e.g. floodplains, wetlands, and flood storage reservoirs. They can be designed to control flows by storing water then releasing it slowly once the risk of flooding has passed. See figure 4.

Figure 3 Cross-section through an Infiltration Basin

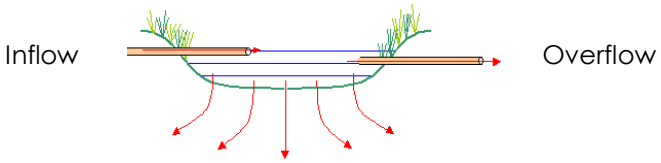
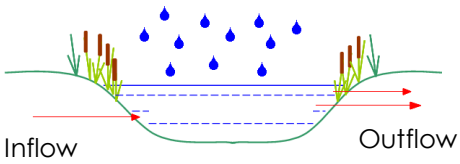


Figure 4 - Cross-section of a Pond



Water level varies in the pond

7. References

Information taken from:

- *Planning Policy Statement 25 – Development and Flood Risk*, December 2006
- www.ciria.org/suds

APPENDIX 5
FLOOD RISK VULNERABILITY CLASSIFICATION

Appendix 5 – Flood Risk Vulnerability Classification (PPS25, 2006: pp25)

Essential Infrastructure	• Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk, and strategic utility infrastructure, including electricity generating power stations and grid and primary substations.
Highly Vulnerable	• Police stations, Ambulance stations and Fire stations and Command Centres and telecommunications installations required to be operational during flooding. • Emergency dispersal points. • Basement dwellings. • Caravans, mobile homes and park homes intended for permanent residential use. • Installations requiring hazardous substances consent.[19]
More Vulnerable	• Hospitals. • Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. • Buildings used for: dwelling houses; student halls of residence; drinking establishments; nightclubs; and hotels. • Non–residential uses for health services, nurseries and educational establishments. • Landfill and sites used for waste management facilities for hazardous waste.[20] • Sites used for holiday or short-let caravans and camping, **subject to a specific warning and evacuation plan**.
Less Vulnerable	• Buildings used for: shops; financial, professional and other services; restaurants and cafes; hot food takeaways; offices; general industry; storage and distribution; non–residential institutions not included in 'more vulnerable'; and assembly and leisure. • Land and buildings used for agriculture and forestry. • Waste treatment (except landfill and hazardous waste facilities). • Minerals working and processing (except for sand and gravel working). • Water treatment plants. • Sewage treatment plants (if adequate pollution control measures are in place).

Water-compatible Development	• Flood control infrastructure. • Water transmission infrastructure and pumping stations. • Sewage transmission infrastructure and pumping stations. • Sand and gravel workings. • Docks, marinas and wharves. • Navigation facilities. • MOD defence installations. • Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. • Water-based recreation (excluding sleeping accommodation). • Lifeguard and coastguard stations. • Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms. • Essential ancillary sleeping or residential accommodation for staff required by uses in this category, **subject to a specific warning and evacuation plan**.

Notes:

1) This classification is based partly on Defra/Environment Agency research on Flood Risks to People (FD2321/TR2)[21] and also on the need of some uses to keep functioning during flooding.

2) Buildings that combine a mixture of uses should be placed into the higher of the relevant classes of flood risk sensitivity. Developments that allow uses to be distributed over the site may fall within several classes of flood risk sensitivity.

3) The impact of a flood on the particular uses identified within this flood risk vulnerability classification will vary within each vulnerability class. Therefore, the flood risk management infrastructure and other risk mitigation measures needed to ensure the development is safe may differ between uses within a particular vulnerability classification.

[19] DETR Circular 04/00 – para. 18: *Planning controls for hazardous substances*. www.communities.gov.uk/index.asp?id=1144377

[20] See *Planning for Sustainable Waste Management: Companion Guide to Planning Policy Statement 10* for definition. www.communities.gov.uk/index.asp?id=1500757

APPENDIX 6
TECHNICAL NOTE

A COMPANY OF

ROYAL HASKONING

Technical Note

HASKONING UK LTD.
COASTAL & RIVERS

To	:	Paul Flynn (Environment Agency)
From	:	Rachel Ranger (RH)
Date	:	10th June 2009
Copy	:	Jon Elmer (Wyre Forest D.C.); Mike Stringer (Royal Haskoning)
Our reference	:	9T6121/N00002/301854/1
Subject	:	**River Stour Hazard Mapping - Breach Locations**

Dear Paul

As part of the Kidderminster Level 2 SFRA, Royal Haskoning are undertaking Hazard Mapping of the River Stour through Kidderminster. An alternative approach, as outlined in our last Technical Note, has already been agreed with Sue Munns regarding the construction of the 2d model. This Technical Note has been prepared in order to propose breach locations in the Kidderminster flood defences and it is intended that the Environment Agency agree and endorse these locations.

THE METHOD

As outlined in our last Technical Note, the breaches are required to:

- Assess residual flood risk to Kidderminster town and potential development sites; and
- Simulate the consequence of a catastrophic failure of the storage dam.

Residual flood risk will be assessed by simulating breaches with a 20m width in hard defences. The breach will be taken down to ground level and the start of the breach will be taken at the point of overtopping or the peak of the event, whichever is the sooner. This approach has been taken from Agency guidance for the production of Hazard Mapping, (Anglian Region).

As highlighted in our last Technical Note we have allowed for a maximum of six breach locations. We have also focussed on locating the breaches in defences which are identified as protecting potential development sites and/or where the LiDAR indicates a drop in ground level behind the defence towards other potential development sites. Initially we have selected defences where the NFCDD identifies the condition of the defence to be greater than 3, but, where they are shown to protect potential development sites, we have also selected defences which the NFCDD identifies as having a standard of protection of less than 100 years. These have been selected in preference to defences of a condition greater than 3 which are not identified as directly protecting potential development sites.

The event of catastrophic dam failure will be undertaken by simulating a failure of the 'front' wall of the dam.

BREACH LOCATIONS

Based on the methodology outlined above, we propose the following breach locations, which are illustrated on the attached map. A figure overlaying the potential development sites with the

LiDAR has also been attached to assist in highlighting the variation in ground level between the defences and the potential development sites. The reasoning behind the locations of these breaches is summarised below:

Breach 1

- The defence is identified in the NFCDD as having a condition of 3
- Ground level drops away from the defence towards potential development sites and the canal

Breach 2

- The defence is identified in the NFCDD as having a condition of 3
- Ground level drops away from the defence towards potential development sites and the canal

Breach 3

- The defence is identified in the NFCDD as having a condition of 3
- A development site is located directly behind this defence, beyond which the ground level drops away towards more potential development sites

Breach 4

- The defence is identified in the NFCDD as having a condition of 3
- A development site is located directly behind this defence, beyond which the ground level drops away towards more potential development sites

Breach 5

- The defence is identified in the NFCDD as having a standard of less than 100 years
- The ground level is low with multiple development sites located behind the defence

Breach 6

- The defence is identified in the NFCDD as having a standard of less than 100 years
- A development site is located directly behind this defence, beyond which the ground level drops away towards the canal

Dam

We have also proposed to assess the consequences of a major defence failure of the flood alleviation scheme dam. Whilst this is probably the least likely breach to occur (due to the strict requirements placed on the inspection of reservoirs), it would result in the greatest consequences to the town of Kidderminster. We propose to simulate the inflow from the dam failure using the methodology adopted by the Agency in its ongoing Reservoir Inundation project.

I hope that these locations meet with your approval. I will of course be more than happy to discuss this with you in greater detail if required.

Kind regards

Rachel Ranger
For and on behalf of Royal Haskoning

APPENDIX 7
EA SIGN OFF LETTER

Mr Jonathan Elmer
Wyre Forest District Council
Planning Policy
Duke House
Clensmore Street
Kidderminster
DY10 2JX

Our ref: SV/2010/103971/SF-01/PO1-L02
Your ref:

Date: 15 March 2010

Dear Sir

Strategic Flood Risk Assessment Level 2 - Revised Version March 2010

We are of the view that the Level 2 Strategic Flood Risk Assessment (SFRA), as revised and amended in March 2010, provides a useful part of the Evidence Base for the Local Development Framework (LDF) to inform the location, type and phasing of future development within the District.

The SFRA Level 2, in conjunction with the Level 1 SFRA, will be of assistance to the local authority and developers in targeting development to areas at least risk of flooding. In accordance with government guidance, the document emphasizes the importance of the need to take account of climate change in assessing flood risk, to reduce the risk of flooding to new development and as a consequence of new development, both now and for the lifetime of the development.

The conclusions and recommendations provide a helpful basis for you to progress the LDF and to inform policies within your forthcoming Local Development Documents (LDD's). We would expect explicit linkages and references between the SFRA's and the LDD's to aid the transparency of the documents.

You will of course be aware that the SFRA presents the data and consequent recommendations at the current time, and revisions/updates will be required in the future as new information, legislation, policy etc is made available.

Yours faithfully

Mrs Hilary Berry
Senior Planning Officer

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