hafrenwater
environmental water management

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Dear Ed

Flood Risk to Hill Farm solar array, Duns Tew.

This letter report presents the results of preliminary flood modelling of Deddington Brook in support of a planning application for the extension of an existing solar array at Hill Farm near Duns Tew, Oxfordshire. It is in response to a request from the Environment Agency for further information to support the proposed location of infrastructure relative to published flood zone boundaries.

1. Introduction

The design of a solar array at Duns Tew needs to take into consideration the risk of fluvial flooding to the site from Deddington Brook. The Environment Agency have advised that all infrastructure should be located outside of Flood Zone 3 and water sensitive equipment should be located at an elevation above the 1 in 100-year annual recurrence interval flood event with 25% climate change adjustment (climate change adjusted design event).

It is understood the Environment Agency have concerns regarding the accuracy of published fluvial flood risk mapping for the reach of Deddington Brook adjacent to the proposed solar array at Duns Tew.

Implementation of a detailed hydraulic flood routing model is problematic due to difficulties in obtaining a topographic survey of the site. Therefore, an attempt has been made to obtain a 'sanity check' of published flood boundaries together with an estimate of the climate change adjusted design event level for the site using readily available data.

It is stressed that this is not intended to define flood zone boundaries and is not a fully documented flood modelling study.

Industry standard methods have been used to establish design flood peak estimates (Section 3) and to implement hydraulic flood routing of Deddington Brook (Section 4).

2. Data

Topographic data has been sourced from a LiDAR DTM (DEFRA data services website) which has a spatial resolution of 5m and is likely to have a vertical accuracy of up to +/-0.2m compared to ground surveys.

The catchment boundary for Deddington Brook upstream of the proposed solar array and its catchment descriptors have been sourced from the FEH website (Figure 1). There

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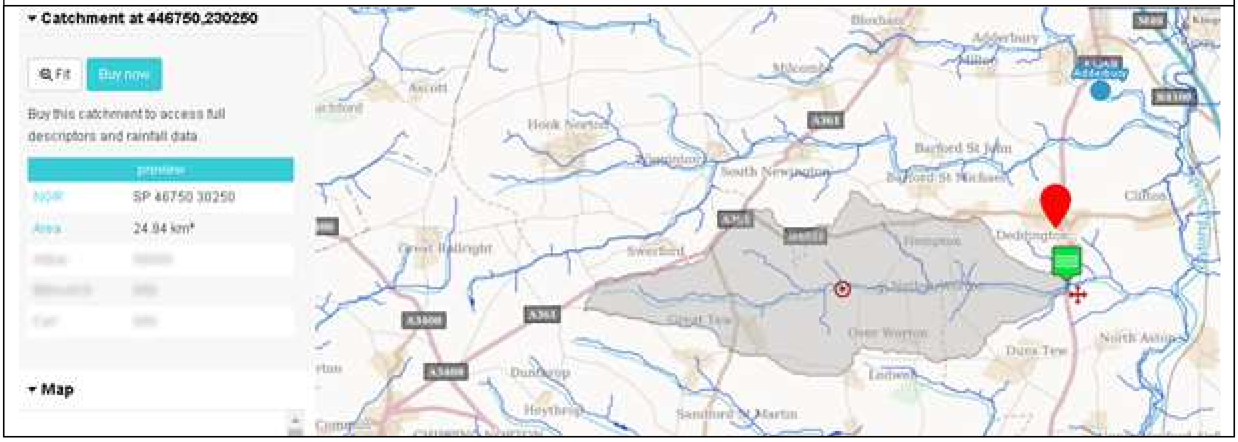
appears to be no reason to alter the catchment boundary or to adjust catchment descriptors.

Figure 1 Deddington Brook FEH catchment boundary



3. Design Flood Peak Estimation

There are no river flow/level gauging stations within the Deddington Brook catchment. The nearest gauges are in neighbouring catchments to the north and all have catchment areas far greater than the site.

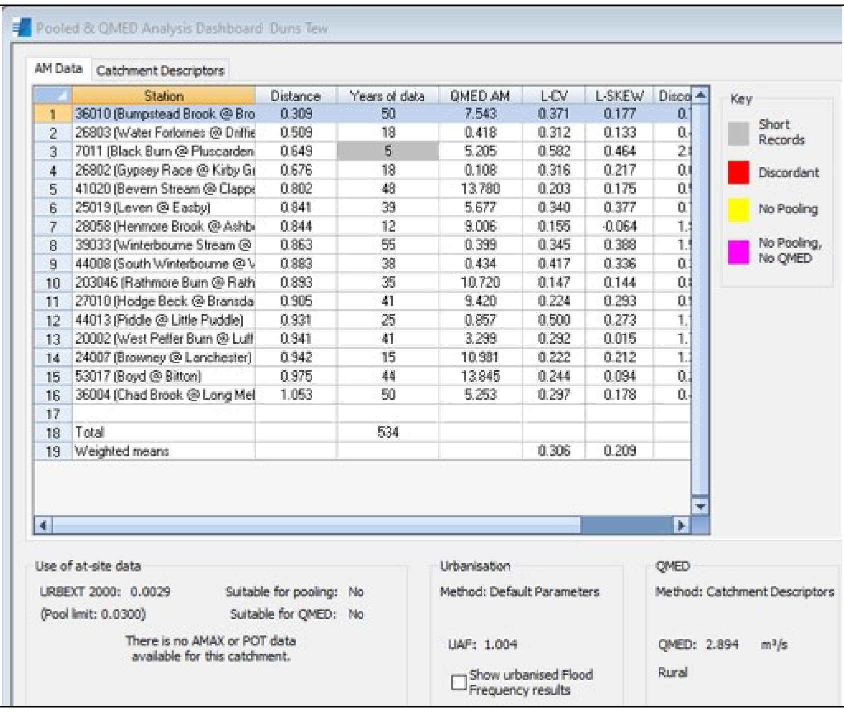
Design Flood Peak estimates have been obtained by two methods. The FEH statistical method using the 'revised QMED estimation method' by CEH to obtain the median flood peak and a growth curve to obtain design flows for other return periods. A second method involving a new rainfall – runoff model is the 'Revitalised Flood Hydrograph Model version 2 (ReFH2). This method uses the FEH-13 DDF model and the default Critical Storm duration should be used for design peaks.

WINFAP 4 has been used to implement the FEH statistical method and version ReFH2.2 has been used.

QMED can be adjusted by factors that represent the relationship between QMED estimates derived from catchment descriptors and QMED estimates derived from gauged flow records at representative (donor) catchments. QMED can also be adjusted for the presence of urban areas which cause greater runoff compared to rural land use. QMED was adjusted for a small proportion of urban area (URBEXT2000 = 0.0029).

Growth curves have been obtained by a pooled analysis of gauge records on a selection of hydrologically similar catchments (Figure 2). The default pooling group provided by WINFAP4 software was reviewed and accepted without amendment.

Figure 2 Pooling group and QMED estimate



	Station	Distance	Years of data	QMED AM	L-CV	L-SKEW	Disco
1	36010 (Bumpstead Brook @ Bro	0.309	50	7.543	0.371	0.177	0.
2	26803 (Water Forlornes @ Driffie	0.509	18	0.418	0.312	0.133	0.
3	7011 (Black Burn @ Pluscarden	0.649	5	5.205	0.582	0.464	2.
4	26802 (Gypsey Race @ Kirby Gr	0.676	18	0.108	0.316	0.217	0.
5	41020 (Bevern Stream @ Clappe	0.802	48	13.780	0.203	0.175	0.
6	25019 (Leven @ Easby)	0.841	39	5.677	0.340	0.377	0.
7	28058 (Henmore Brook @ Ashb	0.844	12	9.006	0.155	-0.064	1.
8	39033 (Winterbourne Stream @	0.863	55	0.399	0.345	0.388	1.
9	44008 (South Winterbourne @ V	0.883	38	0.434	0.417	0.336	0.
10	203046 (Rathmore Burn @ Rath	0.893	35	10.720	0.147	0.144	0.
11	27010 (Hodge Beck @ Bransda	0.905	41	9.420	0.224	0.293	0.
12	44013 (Piddle @ Little Puddle)	0.931	25	0.857	0.500	0.273	1.
13	20002 (West Peffer Burn @ Luff	0.941	41	3.299	0.292	0.015	1.
14	24007 (Browney @ Lanchester)	0.942	15	10.981	0.222	0.212	1.
15	53017 (Boyd @ Bitton)	0.975	44	13.845	0.244	0.094	0.
16	36004 (Chad Brook @ Long Mel	1.053	50	5.253	0.297	0.178	0.
17							
18	Total		534				
19	Weighted means				0.306	0.209	

The abovementioned index flood/growth curve method includes no provision for the estimation of design flood peaks with a return period of 1 in 1,000-years. It is accepted practise that a 1,000-year return period design flood peak estimate is obtained as follows:

Q1000 = Q1000ReFH2 x Q100Stat / Q100ReFH2

Where

Q1000 = 1000-year design flood peak (17.10)
Q1000ReFH2 = 100-year design flood peak from ReFH2 rainfall – runoff model (15.25)
Q100Stat = 100-year design flood peak from growth curve x QMED (9.98)
Q100ReFH2 = 100-year design flood peak from ReFH2 rainfall – runoff model. (8.9)

The ReFH2 method has used design storm rainfall depths with a default 'Recommended Storm Duration' of 9 hours. Rainfall depths have been obtained from the FEH 2013 depth duration frequency model assuming a winter storm profile. Default values for all other ReFH2 model parameters have been used (Figure 3).

Figure 3 ReFH2 model parameters

Parameters

Where the user has overriden a system-generated value, this original value is shown in square brackets after the value used.
** Indicates that the user locked the duration/timestep*

Rainfall parameters (Rainfall - FEH 2013 model)

Name	Value	User-defined?
Duration (hh:mm:ss)	09:00:00	No
Timestep (hh:mm:ss)	01:00:00	No
SCF (Seasonal correction factor)	0.7	No
ARF (Areal reduction factor)	0.95	No
Seasonality	Winter	No

Loss model parameters

Name	Value	User-defined?
Cini (mm)	98.71	No
Cmax (mm)	502.71	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No
Use seasonal CIni for equations	Yes	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	5.32	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	0.58	No
BL (hr)	55.36	No
BR	1.41	No

Urbanisation parameters

Name	Value	User-defined?
Urban area (km^2)	0.11	No
Urbext 2000	0	No
Impervious runoff factor	0.7	No
Imperviousness factor	0.3	No
Tp scaling factor	0.5	No
Exporting drained area (km^2)	0.00	Yes
Sewer capacity (m^3/s)	0.00	Yes

Table 1 Design flood peak estimates

Method	1 in 30yr (m3/s)	1 in 100yr (m3/s)	1 in 100yr +25% cc (m3/s)	1 in 1,000yr (m3/s)
FEH QMED/Growth Curve	7.38	9.98	-	-
ReFH2	6.83	8.92	-	15.25
Selected values	7.4	10.0	12.5	17.1

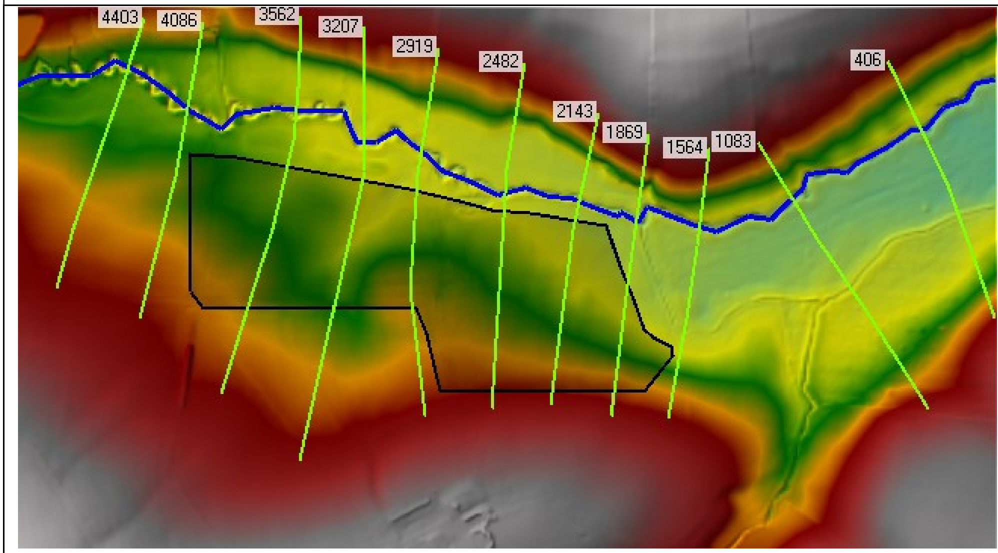
4. Hydraulic Flood Routing

A 1-dimensional (1-D) steady flow routing model of Deddington Brook has been implemented in the US Army Corps of Engineers Hec-Ras software vers 5.06. The model extent encompasses the reach of Deddington Brook adjacent to the proposed length of solar array and is extended by at least 100m upstream and downstream (Figure 4). The model extent ensures that boundary conditions will not influence the estimation of water levels adjacent to the site.

A road bridge is located approximately 750m downstream of the site. No details of the bridge opening and deck are available and thus the hydraulic effects of this structure cannot be modelled. Given the combination of flood depth (~2m) and channel gradient (~1 in 600) the likelihood of backwater effects at the site is marginal.

Deddington Brook channel geometry has been defined by LiDAR at 11 model cross sections which are typically spaced at 100m intervals along the modelled reach (Figure 4). What appear to be informal banks along the channel have been conservatively assumed to be discontinuous so that modelled flow is allowed to extend across the floodplain.

Figure 4 Flood routing model extent

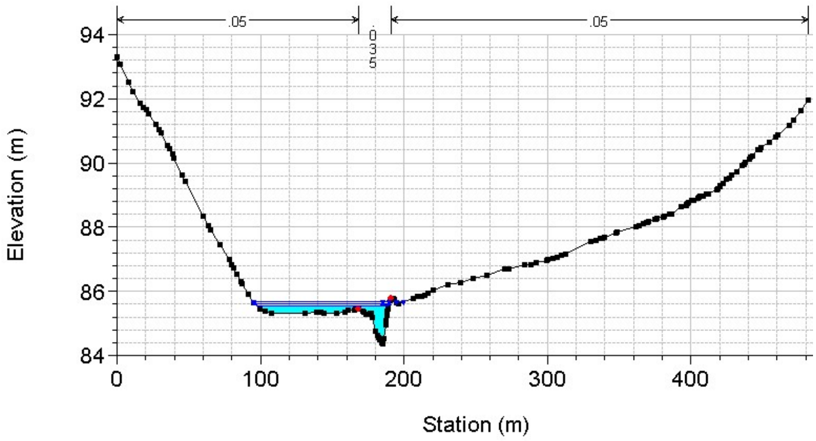


Model boundaries comprise:

- Upstream flow boundary containing the design flood peak estimates in Table 1.
- Downstream normal flow condition commensurate with a channel slope of 0.002.

Hydraulic flow resistance has been defined by Manning's n values. It is understood that vegetation along the valley is overgrown. Therefore, conservative values of Manning's n of 0.035 has been used for the channel and 0.05 for areas beyond the defined channel (Figure 5).

Figure 5 Manning's n values



5. Results

Water level profiles along Deddington Brook have been modelled for 1 in 100-year and 1 in 1000-year design flood events for comparison with published flood zone outlines (Figures 6 and 7).

Flood Zone definitions are set out in the National Planning Policy Guidance:

- Flood Zone 1 - land assessed as having a less than 1 in 1,000 annual probability of river flooding in any year
- Flood Zone 2 - land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding in any year
- Flood Zone 3 - land assessed as having a 1 in 100 or greater annual probability of river flooding in any year

Estimates of the 1 in 100-year plus climate change adjustment design flood levels within Deddington Brook adjacent to the proposed solar array site are given in Table 2.

Table 2 Indicative Modelled Flood Levels

Design Flood Event	ID 4086 – western site boundary	ID 2919 – centre of site	1869 – eastern site boundary
1 in 100-year plus 25% climate change	86.84	85.89	85.19
1 in 100-year plus 35% climate change	86.85	85.91	85.21
1 in 1000-year	86.90	85.98	85.27

Note: see Figure 4 for locations

The model exhibits no warnings other than divided flow at some cross sections where there appears to be a bank. The site has not been visited and it was conservatively assumed that the bank is not continuous and water is not prevented from flowing along the floodplain.

No sensitivity checks involving changes to Manning's n or boundary conditions have been made.

Figure 6 Indicative modelled flood levels along Deddington Brook

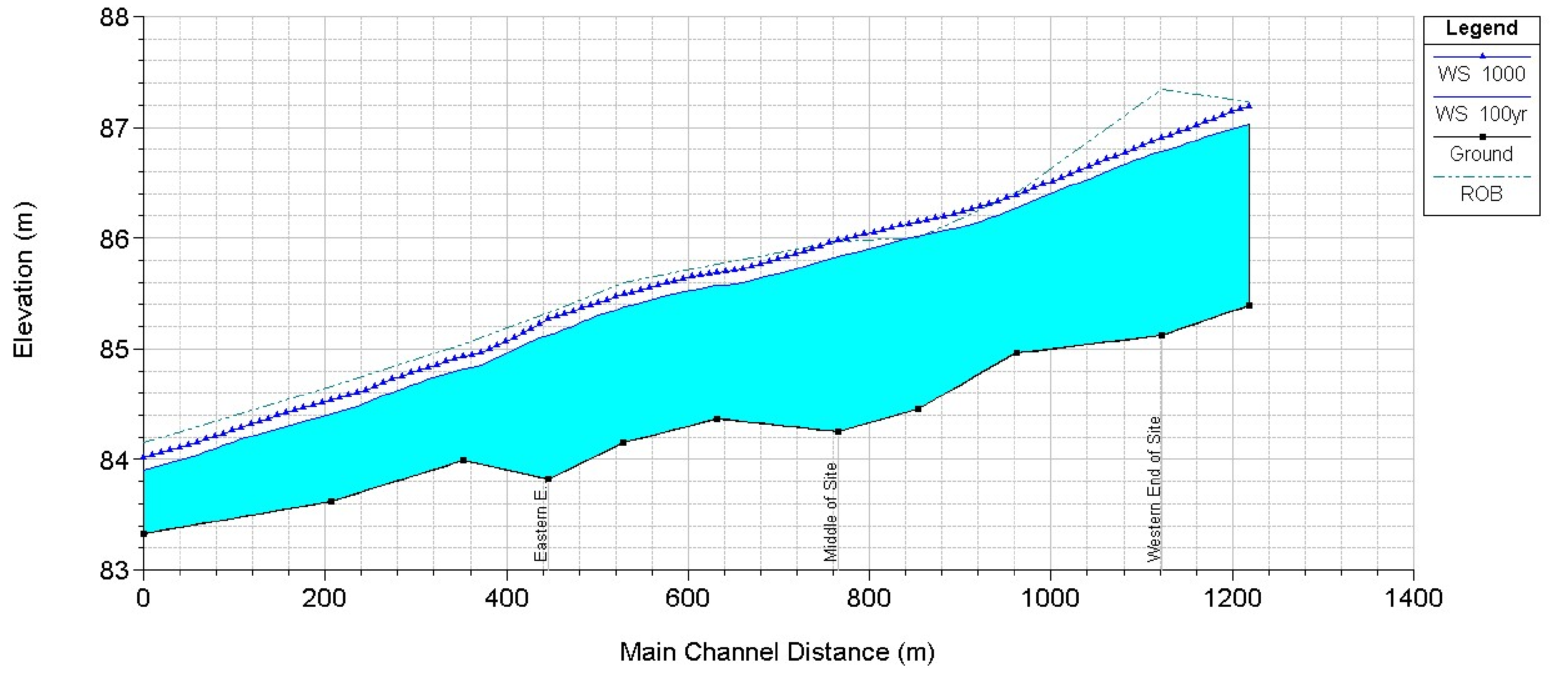


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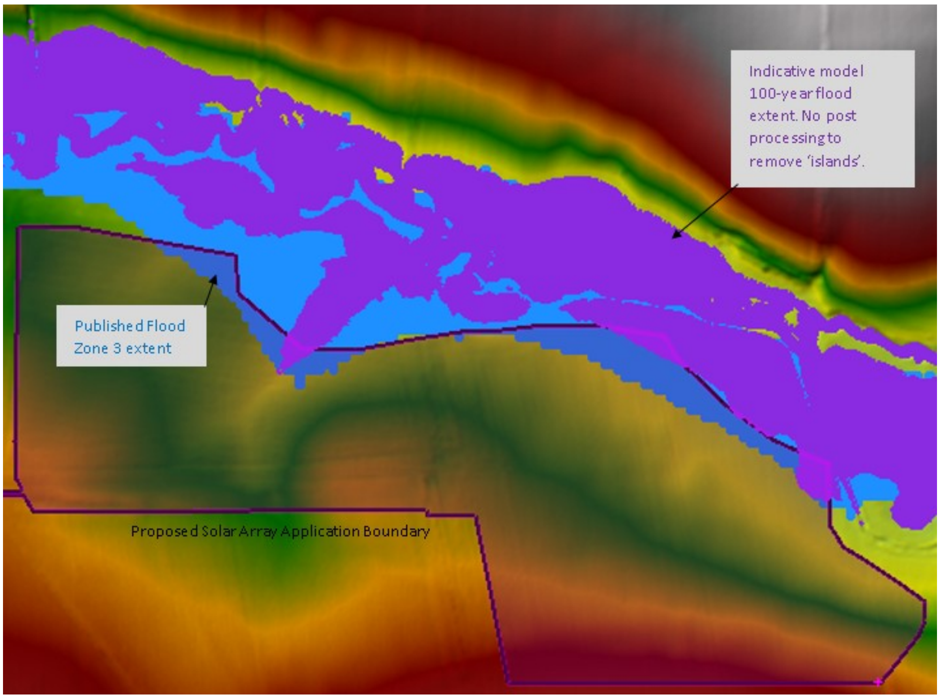
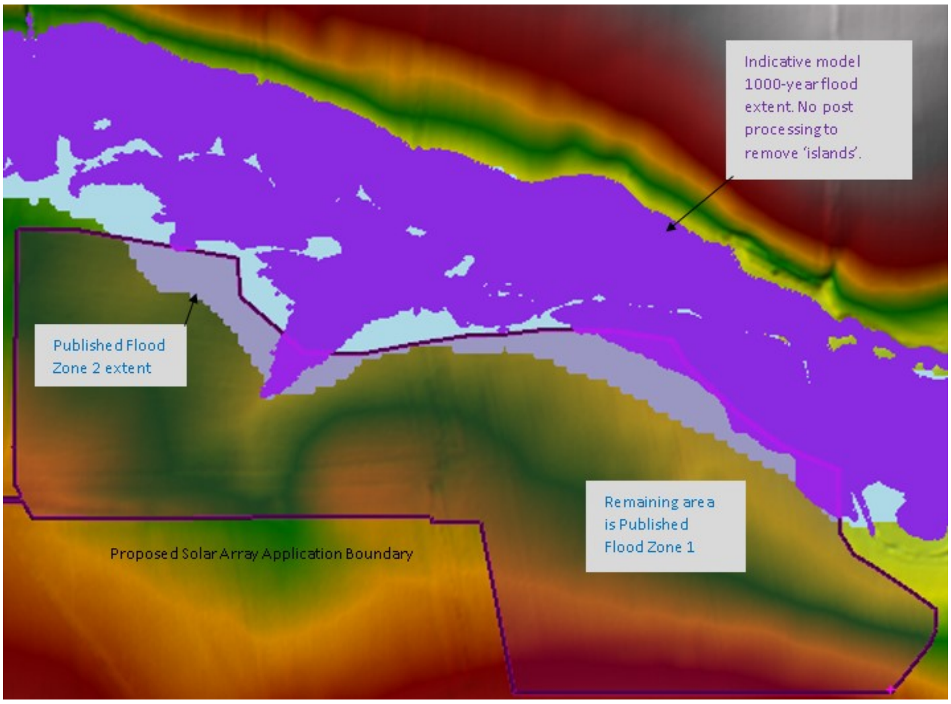
Figure 7 Indicative Modelled and Published Flood Boundaries

Flood Zone 3



Flood Zones 1 and 2



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6. Conclusions

Indicative flood modelling has been carried out to provide a 'sanity check' on the location of published Environment Agency flood outlines and to provide an estimate of a climate change adjusted flood level at the proposed solar panel site. Whilst modelling is based on industry standard techniques its results are only indicative of flood conditions in Deddington Brook rather than a detailed assessment. The results are not intended to replace published flood mapping.

Due to the difficulties in obtaining a site survey modelling has relied on LiDAR data to define both the channel and floodplain areas. Whilst this may affect the accuracy of the modelled conveyance capacity of the channel its relatively small size compared to the floodplain will reduce its impact on the overall accuracy of modelled flood boundaries. Also, the model has not included the potential backwater effects from a bridge located over 600m downstream of the modelled reach. It is thought that the large distance will ameliorate any backwater effects in the vicinity of the proposed solar array.

The results of flood modelling suggest published flood boundaries based on broad scale modelling techniques are potentially an overestimate of the extent of flooding during 1 in 100-year (Flood Zone 3 boundary) and 1 in 1,000-year (Flood Zone 1 boundary) design storm events along the southern bank of Deddington Brook adjacent to the proposed solar array.

The flood modelling also suggests that flood levels for a 1 in 100-year year plus 25% (35%) climate change design event are generally 0.09m (0.07m) lower than the 1 in 1,000-year event (Flood Zone 1 boundary). This result supports guidance in Section 2.3 Cherwell DC SFRA Level 2 (May 2017) that in the absence of modelled climate change flood outlines the 1 in 1,000-year boundary can be used as a proxy to guide development.

Flood model results also suggests that elevating solar panels by 0.8m above ground level in addition to locating panels in Flood Zone 1 may be an overly cautious requirement as the 1 in 1,000-year (Flood Zone 1) boundary more or less coincides with the level of the climate change adjusted 1 in 100-year design event.

Yours sincerely

Peter Dunn
Senior Hydrologist