



Oxfordshire Highways

Cogges Link Road Proposed Revisions to Flood Mapping: River Windrush at Witney - July 2008

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**Oxfordshire Highways
Cogges Link Road**

Proposed Revisions to Flood Mapping: River Windrush at Witney – July 2008

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1. Introduction

1.1 Background

- 1.1.1 The proposed Cogges Link Road (CLR) crosses the historic floodplain of the River Windrush to the south of Witney and just to the north of the A40. Part of the scheme falls within the 100 year floodplain as defined by the Environment Agency (EA) and the river must be crossed by bridges which will require the EA's approval. The scheme has been under development for nearly 20 years and has received planning permission in a previous form. The present scheme layout is shown in Figure 1.
- 1.1.2 The EA has indicated that all development proposals must now be assessed following the approach set out in PPS25. This requires, amongst other conditions, that climate change be taken into account when assessing the impact of any proposal on flood risk. For the purposes of works on statutory Main River, PPS25 indicates that a 20% increase in river flows above the present estimate of the 100 year return period flood is appropriate.
- 1.1.3 The EA has previously supplied water levels from their flood mapping studies for the 100 year flood but are unable to supply the same data for the climate change case. Oxfordshire Highways were given the choice of accommodating water levels 300mm above those for the 100 year case, as previously provided by the EA, or undertaking further hydraulic modelling studies to arrive at a more realistic estimate.
- 1.1.4 The impact of a 300mm rise in flood level on the proposed scheme was studied and it was clear that this would have a substantial impact on the extent of the flood plain and thus on the scale of mitigation measures required. Oxfordshire Highways therefore chose to pursue the hydraulic modelling option.
- 1.1.5 This report sets out the modelling process and presents proposals for revisions to the flood mapping along part of the River Windrush at Witney in Oxfordshire.
- 1.1.6 The EA provided copies of the Section 105 study outputs and associated survey data for use as a basis for the study. The July 2007 floods in Witney took place during the modelling process and event rainfall, flow, water level and flood extent data was also supplied by the EA.

2 Hydrological analysis

2.1 Review of Section 105 Model Flood Data

2.1.1 The EA has provided copies of the hydrological and hydraulic analyses supporting the Lower Windrush Section 105 study which was finalised in 2002. These reports set out the development of design flood hydrographs appropriate to the particular conditions of the River Windrush. The process and outputs are said to have been agreed with Dave Rylands of EA Thames Region.

2.1.2 The design hydrographs derived for the Section 105 study are unusual in being two months in overall duration and, apparently, based on the CATCHMOD hydrological model as directed by the Environment Agency, which is more commonly associated with water resource projects. The Section 105 modelling report states that a dimensionless hydrograph was derived from the synthesised flows for use in flood mapping. The S105 design hydrograph at Worsham derived in this way is shown in Figure 2 (see Figure 8 for location).

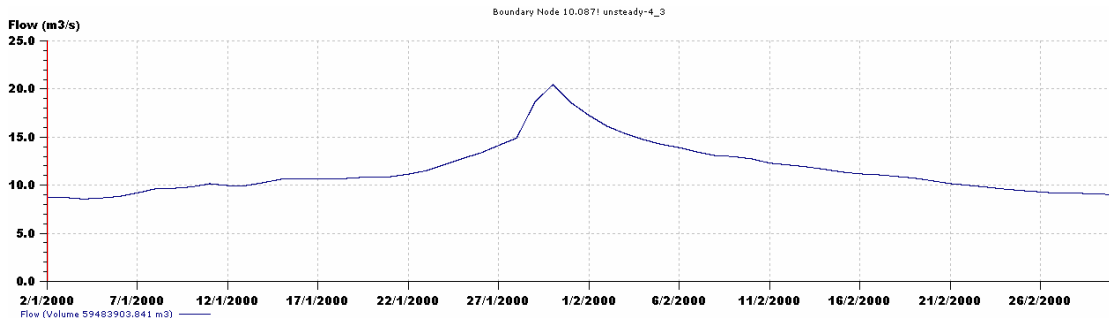


Figure 2 Design 100 year flood at Worsham Gauging Station (model node 10.087)

2.1.3 A sample of the long term flow record as published by the National River Flow Archive is shown in Figure 3. This shows a consistent pattern of fairly rapid responses to rainfall followed by long recessions. The S105 design hydrograph is not consistent with these characteristics and is not considered appropriate for further use in this analysis.

Sample Hydrograph of Gauged Daily Flows

Max. and min. daily mean flows from 1942 to 2006 excluding those for the featured year (2006; mean flow; 2.88 m³s⁻¹)

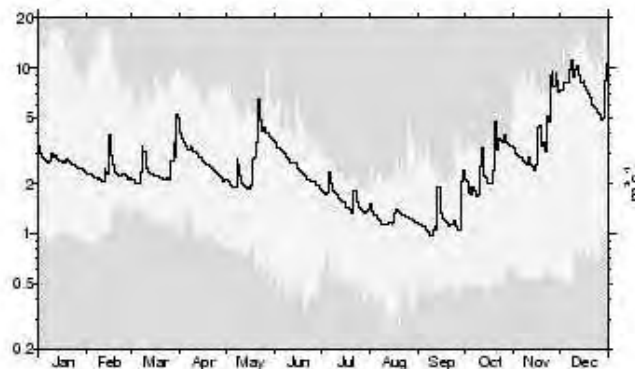


Figure 3 Sample hydrograph at Worsham Gauging Station (038076)

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- 2.1.4 The design flood magnitudes used in the S105 analysis are based on statistical analysis of Newbridge and Worsham flow gauge data and pooling group analysis, apparently using the initial version of WINFAP-FEH though this is not clearly documented. It is not clear whether the final analysis is based entirely on actual recorded flows. The statistical approach to estimating the peak flow is considered appropriate in principle. However the WINFAP-FEH software and the historic flood dataset have been extensively revised since the S105 analysis and revision of the analysis is considered essential.
- 2.1.5 The S105 report does not consider possible alternatives to the CATCHMOD approach to flow modelling. Trials have now been carried out using the FEH rainfall-runoff methodology and alternative approaches using various reservoir-based hydrological models. These are considered further below in the context of the July 2007 flood but the key conclusions from these trials are that the S105 study was correct in not considering the FEH rainfall-runoff approach, and similarly the “revitalised” version of the FEH which has the same key characteristics. The reservoir-based modelling approach shows promise, in principle, but it seems likely to under predict the peak flows, as was found in the original CATCHMOD analysis.
- 2.1.6 It is concluded that the underlying flood analysis in the S105 study is not to current standards. It is considered, however, that the overall approach of using the FEH statistical approach to estimating flood peak flows combined with a method of deriving hydrograph shapes from observed flows is the most appropriate methodology for the Windrush.
- 2.1.7 This assessment does not extend to full consideration of the flows at Newbridge and downstream in the River Thames as these are not material to the flood conditions in the Witney area. Ground levels north of the A40 at Witney are around 78mOD. Flood plain levels near Newbridge are around 63m OD. It seems reasonable to assume that large variations in the flood level in the Thames at Newbridge could therefore occur without having any impact on flood levels upstream from the A40.

2.2 Worsham statistical flood analysis

- 2.2.1 Worsham gauging station is at the upstream limit of the Lower Windrush hydraulic model as developed for the S105 study (see Figure 8). It has a catchment area of 296km² as compared to 362km² at the Newbridge gauge close to the Windrush/Thames confluence. The catchment area to the Bridge Street bridge in Witney, where flooding reached the national news, is 330km² and the area between Witney and Newbridge is characterised by multiple river channels and extensive gravel workings so the flow at Worsham may be expected to be a good indicator of the flow to be expected in the Windrush at Witney.
- 2.2.2 Flow gauging at the Worsham site is known to go back to 1942 but the earlier records are considered unreliable. The EA has supplied annual maximum (AMAX) flows from 1988 for use in the current study. The station was reconstructed as an ultrasonic gauge in 1995 and the EA considers it to be of a high standard. It is particularly notable that flows remain within the gauging section up to above the July 2007 flood which is the highest recorded to date.
- 2.2.3 Following consideration of the S105 analysis as set out above, a new statistical analysis, attached as Appendix 4, was carried out for Worsham gauge using version 2 of the WINFAP-FEH software. The results, using alternative QMED estimates and the AMAX data for the Worsham the gauge, are given below, with the Section 105 values for comparison. The Pooling Group analysis presented also takes account of version 2.2 of the HiFlows data set:

Windrush at Worsham	Generalised Logistic Distribution – Donor QMED	Generalised Logistic Distribution – Gauged AMAX QMED	Censored single station GL analysis – Gauged AMAX QMED	Section 105 – Hydrological Report	S105- Hydraulic Modelling Report
Return Period (years)	Design flow (m ³ /s)	Design flow (m ³ /s)	Design flow (m³/s)	Design flow (m ³ /s)	Design flow (m³/s)
2	10.6	9.55	9.55	8.6	
5	14.2	12.76	13.30	10.5	12.24
10	16.5	14.83	15.86	11.9	
20	18.7	16.87	18.49		16.61
25	19.5	17.54	19.37	13.8	
50	21.8	19.67	22.24	15.2	
100	24.3	21.91	25.35	16.5	20.46
200	26.9	24.27	28.76	-	
500	30.6	27.61	33.78	-	25.46
1000	33.7	30.32	38.01	-	28.58

- 2.2.4 The “S105 Hydrological Report” figures are based on the CATCHMOD-simulated long term series, with an initial adjustment for under-prediction. The difference between the two sets of S105 flows is consistent with the application of a further adjustment factor estimated by comparing the CATCHMOD-based Newbridge flows with a pooling-group based estimate of the Newbridge flows but this process is not set out explicitly in the S105 reports.

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- 2.2.5 The analysis set out in Appendix 4 concludes that the best estimate of the design flood flows at Worsham is given by the “Censored single station GL analysis – Gauged AMAX QMED” column in the above table. This analysis gives flows in excess of those finally used in the S105 analysis, which is justified, in part, by considering the AMAX data from the Worsham gauge which contains five out of twenty values equal to or greater than the S105 estimate of the 20 year flood.
- 2.2.6 The SPRHOST parameter for the catchment to Worsham is 15.33%, which is within the band (less than 20%) for which the permeable catchment adjustment might be applied. The Worsham gauge shows, however, a clear, response to rainfall events and it is considered reasonable to expect the AMAX series to be dominated by direct responses to rainfall, though many events will have substantial contributions from the recessions of preceding events.

2.3 The July 2007 Flood

2.3.1 As noted previously, the July 2007 floods hit Witney during the current study. Figure 4 shows how the gauging stations on the River Windrush responded to that event. The plot also shows cumulative point rainfall at Worsham recording raingauge and a suggested correction to the Worsham flows during the 21st and 22nd of July where the flows drop instantaneously, remain low for a while, then suddenly recover to follow a normal-looking recession curve. From discussions with EA hydrometric staff with experience of the Worsham gauge, it seems reasonable to assume that this was due to temporary impairment of the ultrasonic gauge by debris. The questionable data has been replaced by a recession curve from the peak flow tangential to the recession curve following the recovery, the time of which corresponds to the time when work to unblock gauges was known to be under way.

2.3.2 The plot shows that the peak flow recorded at Worsham corresponds to a rainfall of about 104mm. It is notable that the Newbridge flow responds simultaneously with the Worsham gauge but takes a further two days to peak. This is attributable to the considerable flood plain and channel storage available between the two gauges. The further tributaries between the two gauges, and indications that further rain fell after the peak flow at Worsham, are consistent with the small increase in total recorded flow at the downstream gauging station. This comparison suggests that the flow records are both reasonable though they extend beyond previous peak flows at both locations.

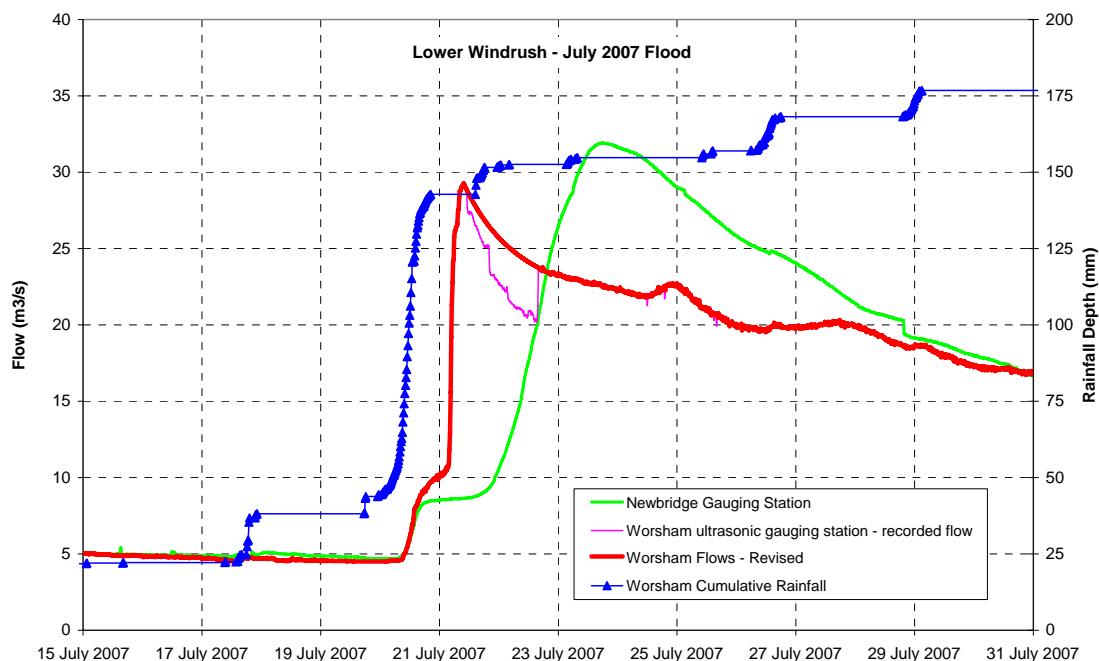


Figure 4 Lower Windrush Flows – July 2007 Flood

2.3.3 The event return period at Witney in July 2007 is of particular interest as it provides a recent reference standard against which any proposals affecting the Windrush at Worsham can be compared. This can probably be estimated most

sensibly by considering the magnitude of the event at Worsham gauging station which, as noted above, covers almost 90% of the relevant catchment. The statistical analysis presented in the Section 105 study was a little unclear but suggested a return period in excess of 1000 years. The updated analysis presented here suggests a most likely flow return period of about 220 years, although possible alternative approaches still suggest return periods ranging from less than 50 years to approaching 1000 years.

- 2.3.4 Using data from the Worsham rain gauge and considering the FEH-CDROM predicted t-year point rainfall for the Worsham catchment, the 104mm rainfall recorded mainly on the 20th July would have a return period of about 250 years. This could be indicative that the corresponding flood return period would have a return period of 250 years or less, which seems consistent with the above statistical analysis.

2.4 Model Boundary Conditions

- 2.4.1 The S105, 100 year flood, model hydrological boundary conditions comprise a number of time-varying hydrographs derived from CATCHMOD, as discussed above, some small constant flows introduced to ensure numerical stability at low flows, some large simplified flows representing conditions in the River Thames and a stage-time boundary at the downstream end of the model near Farmoor Reservoir.
- 2.4.2 The hydrographs used in the S105 analysis are however considered inappropriate, following the above discussion. A number of approaches were considered, including the FSR Rainfall-Runoff methodology and linear reservoir-based catchment models.
- 2.4.3 The FEH rainfall-runoff approach, as shown in Figure 5, shows clearly that, with a considerable flattening of the unit hydrograph (i.e. 4.5 times UH time to peak), the FEH synthetic flood hydrograph can reflect the recorded peak flow, but the hydrograph is an entirely different shape to the observed hydrograph. Without the calibration factor, the peak flow would be 4.5 times higher and the recession would be almost vertical if plotted on the same chart.

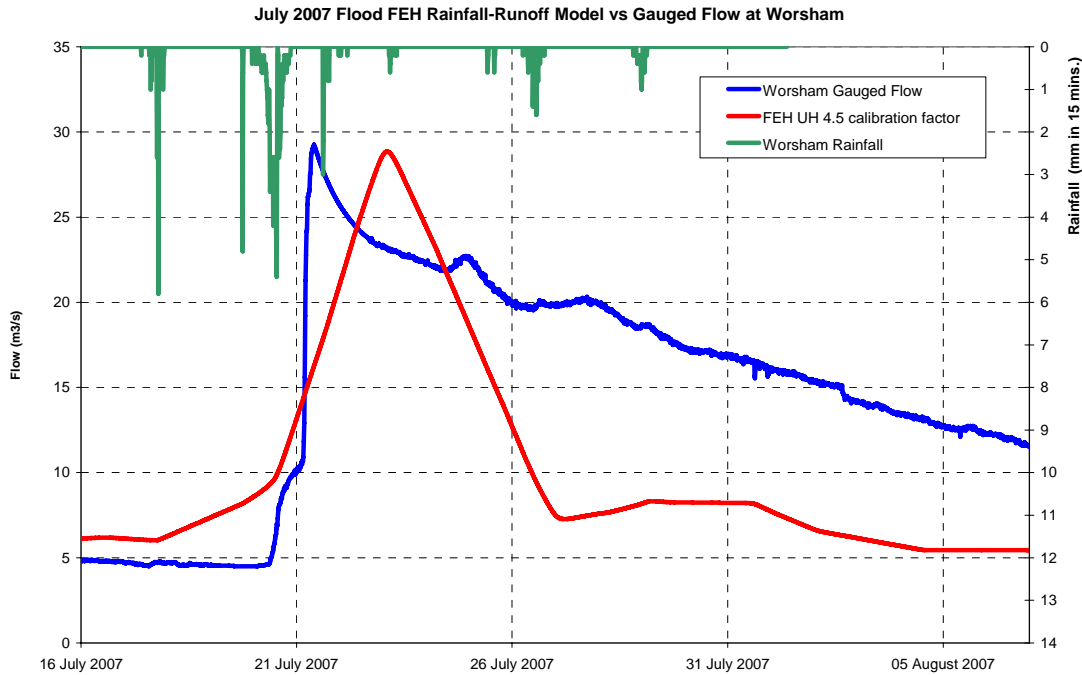


Figure 5 FEH Rainfall-runoff model

2.4.4 The “Simple” reservoir-based flow simulation, as shown in Figure 6, shows clearly that such an approach can reproduce the general shape of the hydrograph but may have difficulty with the peak flow, as was found when CATCHMOD was used. Although this approach may have potential for further development, it would have to be applied in a similar way to the S105 analysis used CATCHMOD since the appropriate design rainfall events are not pre-defined.

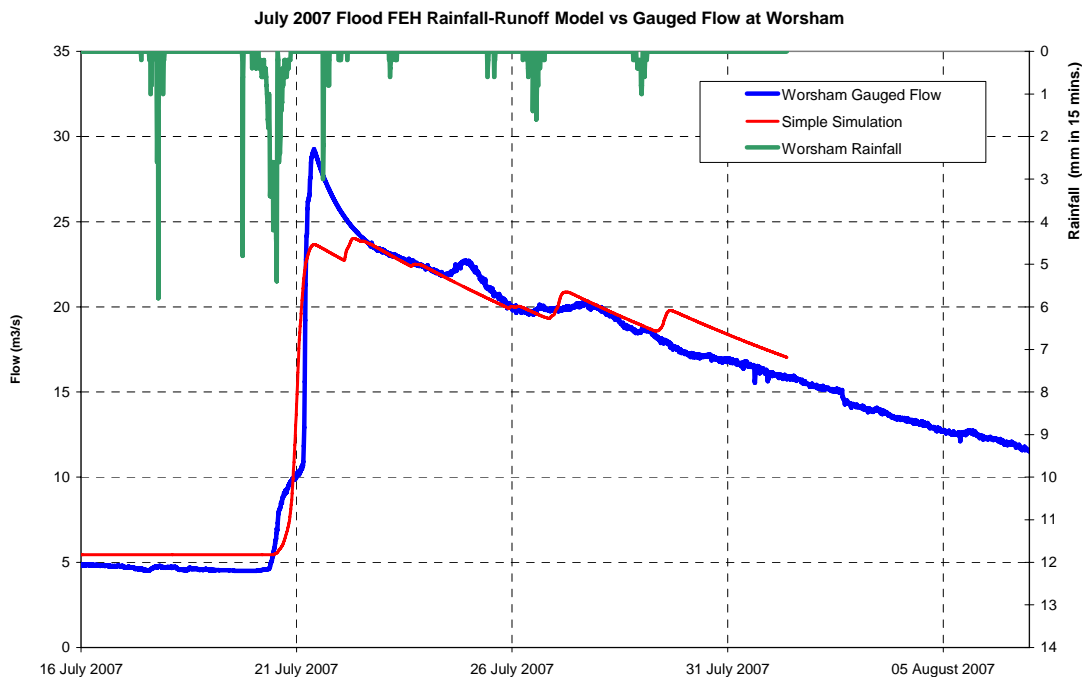


Figure 6 Simple reservoir-based flow simulation

- 2.4.5 It was concluded that the most appropriate approach for the current study would be to adopt the July 2007 flood hydrograph, after adjustment of the recession to remove the observed interference with the recorded flows, as a standard hydrograph to be factored in proportion to the peak flow required by a design flood event. The long recessions observed suggest that most flows in the catchment are essentially responses to rainfall events rather than general baseflow so baseflow has not been dealt with separately. In practice, however, it has been found to be necessary to increase the initial low flows for floods of less than a 100 year return period in order to avoid modelling problems.
- 2.4.6 The S105 study concluded that a very long timebase event would be necessary to represent the catchment response. It was also considered necessary to consider time-varying flows. The approach adopted above is considered reasonable in the particular circumstances of the Windrush but sensitivity tests have been undertaken to demonstrate the difference between using the July 2007 hydrograph and assuming steady flows. For this purpose, the same inflow hydrographs are used up to the peak inflow at which time the flow is set constant to the end of the simulation.
- 2.4.7 The S105 analysis identifies four small tributary catchments contributing flows to the hydraulic model, all of which are much smaller than the Worsham catchment at the upstream end of the model. The S105 model inflows are clearly factored from the Worsham flows in most cases and it is considered reasonable to use the same proportions for the inflows to the updated model. Figure 7 shows how these flows are derived for the July 2007 flood event. Of these, Emma's Dyke and Rushy Common Ditch enter downstream of the Cogges Link Road area of interest.

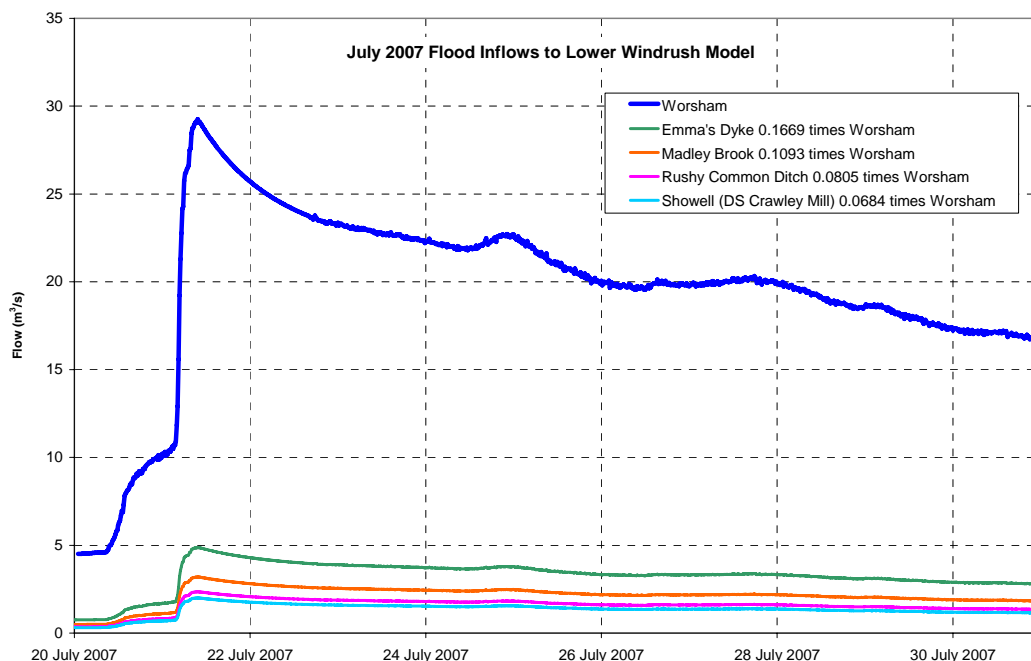


Figure 7 July 2007 Flood Inflows for Lower Windrush Model

2.4.8 The complete Lower Windrush model includes flows and water levels relating to conditions in the River Thames. As noted above, the conditions in the Thames have no effect on water levels and flows at the Cogges Link Road scheme. For the purposes of the current study, the observed downstream stage from Farmoor was adopted as a downstream boundary and flows in the Thames upstream from the Windrush confluence were based on the flows assumed in the S105 100year design case. This approach will require further consideration if reliable results are required within the Thames floodplain.

2.5 Design Flood with Allowance for Climate Change (100 year plus 20%)

2.5.1 Taking the recommended 100 year flood of 25.34 from Section 2.2.1, above, and adding a 20% allowance for climate change gives a required peak flow of 30.40m³/s at Worsham, which would have a return period of about 273 years under current conditions and would be a little more severe than the July 2007 flood. The hydrograph at Worsham is derived by scaling the July 2007 flood in proportion to the peak flows required and the Windrush tributary flows are defined as fractions of the Worsham flow.

2.5.2 This flow is substantially higher than would have been obtained by applying a factor of 1.20 to the S105 100 year flood, which would have been 24.55m³/s. It is considered that 30.40m³/s at Worsham is a reasonably conservative design flow which takes proper account of recent experience of flooding in the catchment.

3 Modelling Process

3.1 Existing Model and Proposed Modelling Approach

- 3.1.1 The EA provided a copy of the hydraulic model previously developed by Peter Brett Associates for flood mapping along the lower Windrush under the Section 105 process and finalised in 2002. The model extends from Worsham Gauging Station to the north of Witney to Farmoor on the River Thames, as shown in Figure 8.
- 3.1.2 Following an initial review of the supplied model, a proposal was submitted to the EA (see Appendix 1) setting out a possible approach to the modelling process for their approval. The EA's response, included as Appendix 2, was generally supportive of the proposed approach but added some useful comments and additional requirements. The final approach taken varies from the original proposal, as explained below, in response to the EA's comments and following further experience of using the model.
- 3.1.3 The complexity of the channel system is such that, whilst the CLR affects directly only a small part of the River Windrush, it would be difficult to find appropriate places to truncate the model. It was therefore decided to use the full extent of the model as supplied as a basis for assessing the flood levels and extent in the Witney area although initial proposals suggested that the model would be so truncated.
- 3.1.4 Following review of the model it was concluded that it would be necessary, at a minimum, to:
- improve the level of detail at which the floodplains were modelled, largely replacing extended cross sections with spill units and flood plain reservoirs;
 - add secondary channels in the immediate vicinity of the CLR (Farm Mill bypass channel and Hardwick Brook from Windrush east channel to A40);
 - add the new bridge over the Windrush at the Aquarius development.
- 3.1.5 It was evident that much of this could be carried out using the survey data provided together with the S105 model. No data was available however for the Farm Mill bypass channel or the Aquarius Bridge so the survey of these areas was carried out in parallel with the check survey reported in section 3.3, below.

3.2 Model Enhancement Process – Stage 1

- 3.2.1 The original model, which was constructed using ISIS, has been imported into Wallingford Software's InfoWorksRS program, which merges the ISIS computational engine with a GIS shell providing flood mapping tools as well as a graphical user interface.
- 3.2.2 The model was first extended and upgraded to make good the omissions noted above and the potential flood extents were reassessed with the inflows used for the original S105 100 year flood mapping increased by 20%. At this stage, no fundamental adjustments were been made to the model parameters: new cross sections were allocated the same friction factors as adjacent sections and spill units were given coefficients in the same range as those in the original model.

- 3.2.3 This stage of the modelling provided modelled flood extents for the “100 year plus 20%” climate-change-enhanced flows of the same order as, or less than, the 100 year flood extents produced by the original study. Within the flood plain area, this is largely due to flows being retained within channels with banks above the general flood plain level, whereas the original model allowed disconnected flows to take place remote from the main river channel. It should be noted here that the areas affected have not been removed from the model but have been incorporated as flood plain storage. The land between the two channels of the Windrush downstream from Farm Mill is particularly notable because any spill from the river entering this area will drain freely towards the A40 and not be retained at the level in the adjacent river channel. There may be potential for betterment in such areas as part of the proposed road works. Comparative plots are provided in Section 5, Flood Mapping.
- 3.2.4 It was noted at this stage that flood mapping from the model in the Town Bridge area was a reasonable match to the Section 105 flood extents. However there was no indication in the model results that flows could run overland to bypass the bridge, as was known to have occurred in July 2007. In advance of details of that flood being available, it was assumed that the conditions in July 2007 must have been considerably in excess of the 100 year flood and that modelling using the observed flows from that flood would demonstrate the linkage between increased flood flows and increased flood extent.

3.3 Check Survey

- 3.3.1 In response to the EA’s guidance, check survey, principally on bridges, was carried out to verify that the various surveys on which the model was based were to consistent datums and also to relate the traditional Ordnance Datum to the GPS datum now used by the EA. Additional channel sections were also surveyed on the un-modelled secondary channels and the main river in the vicinity of the CLR bridges.
- 3.3.2 The key results of the survey are set out in Appendix 3 and the complete report, which has also been submitted separately to the EA, is included as Appendix 4. The survey showed that the EA’s new GPS datum is about 0.063m lower than the historic Ordnance Survey datum in the area. The bridge soffit levels taken during the survey were found to be generally consistent with this difference, having regard to the difficulty of finding the exact point at which a previous level was taken.
- 3.3.3 The possible exceptions to this conclusion are structures G and B, two long disused railway bridges, where the level difference was about 75mm, on average. It is considered, however, that these differences are more likely to be explained by the continuing deterioration of the structures than by errors in the level data.
- 3.3.4 Overall, it is concluded that:
- the difference between the old OS and new GPS datums, the latter being lower by about 0.063m, is not material to the survey of general ground levels;
 - the previous surveys in the immediate area of the CLR are consistent with the old OS datum;

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- absolute model water levels are likely to be slightly higher than would be the case if the model had been built exclusively with survey data based on the new GPS standard and can be regarded as slightly conservative.
- 3.3.5 Therefore no adjustment is required to the levels in the existing model and it is considered reasonable to add additional survey data based on the new datum without adjustment, subject to recording of the process.
- 3.3.6 It was not considered necessary to investigate the photogrammetry supplied with the S105 model other than to establish that it has been carried out to EA standards. The S105 documentation shows this to have been reported on as “Lower Windrush: River Thames Confluence to Minster Lovell”, Date: 06/09/1996, Surveyor: Atkins AMC, Con Ref: V1667, Survey Date: July/August 1996; Survey Type: Photogrammetry; Job No: 3592. This indicates that the survey will have been to the pre-GPS OS datum. The accuracy of any such photogrammetric survey, particularly with regard to soft ground levels, is less than the difference between the datums as identified above.

3.4 Town Bridge Area Model Enhancement Using July 2007 Floods

- 3.4.1 The July 2007 floods took place during the modelling process. There was severe flooding in the Town Bridge area and upstream, which reached the national news, but apparently relatively little in the area of the CLR scheme. The EA has published a report “Witney Flood Review July 2007” which indicates that they consider the flood at Witney to have had a return period as high as 300 years; they have also provided mapping of verified areas of flooding which they have supplied in a GIS format for inclusion in this report.
- 3.4.2 The verified flood mapping for the July 2007 event, part of which is reproduced in Figure 18 and Figure 19, appears to be consistent with observations of the flooding which showed no inundation in the area of the CLR, although the EA does not warrant that areas shown as not flooding in July 2007 did not actually flood. However the mapping from the revised model and the Section 105 flood outline as provided with the base hydraulic model, both show flooding in that area arising from an event of lesser magnitude.
- 3.4.3 Initial trials with the recorded July 2007 flows suggested that that flood could have been of the same order as the 100 year flood plus 20%, in terms of flows likely to be experienced at the Town Bridge. It became evident that the model could not reproduce the observed flooding at this location. Inspection of the modelled water levels showed that the original flood mapping was consistent with water levels in the river having been used as flood plain depths even though no hydraulic linkage existed between the relevant point in the river model and the flooded area. At the same time, the possible use of more realistic “n” values, as discussed below, seemed to suggest a further reduction in flood extent rather than an increase.
- 3.4.4 As a possible solution, the approach applied elsewhere in the model, of representing more complex flood plain areas with spill units and reservoirs, was used to represent the flow path through the buildings to the north east of the Town Bridge, which were known to have flooded in July 2007. In doing this, it became evident that the water level driving flooding in this area is that some 300m upstream from the bridge. Initial trials with this revised model showed flood extents much closer to those reported in July 2007.

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- 3.4.5 As well as flow through the buildings to the east of the Town Bridge, flood water entered High Street, to the west. It appears that much of this must have come through the pedestrian access to Riverside House immediately upstream of the bridge on the right bank of the river. Further adjustments to the model showed that this behaviour could be reproduced in principle.
- 3.4.6 The flood mapping in this area has not been fully developed at this time because it is difficult to estimate the actual flow rates where the flood flow runs, largely, through buildings and down streets as this is beyond the scope of the current project. Current indications are, however, that the peak flow rates needed to reproduce the observed flooding need not have been a large proportion of the total flood flow. Potential for flooding well beyond that suggested in the S105 study and close to that observed in July 2007 is confirmed.

3.5 Model Enhancement Stage 2 – Using July 2007 Floods

- 3.5.1 Review of the hydraulic parameters in the model shows that Manning's "n" is generally set at 0.050 for both channel and floodplain. The main Windrush channels in the area between the Town Bridge and the A40, at a minimum, are generally regular and free of significant obstruction, at least within the width of the main channel – many sections have an informal berm which is dry during periods of low flow. An "n" of 0.050 is at the upper bound of likely values for such conditions – a more reasonable value would be in the region of 0.025 to 0.040, lower values being particularly appropriate where the "n" value for areas inundated only at higher flows are allocated higher "n" values.
- 3.5.2 The 0.050 "n" value allocated to flood plain areas, whilst appropriate for very regular, unobstructed, flood plain with a significant depth of flow, is rather low for an irregular flood plain with a generally low depth of flow. An "n" of 0.100 would be a more appropriate initial value.
- 3.5.3 A series of trials of possible alternative "n" values in the area of more detailed study was instituted, using flood extent and flows through known areas of flooding in July 2007 as key calibration parameters.
- 3.5.4 Channel "n" was varied in this way to approximately 2km south of the A40 to provide a consistent downstream boundary for the principal area of interest between Farm Mill and the A40.

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4 Details of Model Enhancement

4.1 Introduction

- 4.1.1 The model as supplied was not georeferenced but the main cross-section locations were provided separately in a GIS format, in survey drawings in various formats and drawings forming part of the Section 105 Flood Mapping deliverables. GIS data was also provided for polygons showing the locations of the flood plain reservoirs in the model and lines indicating the positions of the modelled spill units. Before any enhancements were applied, the complete model was laid out in InfoWorksRS using this information such that the cross sections and spill units were all centred on their correct locations and correctly oriented with respect to the direction of flow implied by the model connectivity.
- 4.1.2 IWRS tools allow cross-sections to be automatically rotated normal to links (real river channel link or connectivity link to next hydraulic component). This is generally sufficient to allow models to be understood but not adequate for flood mapping which requires the cross-sections to be correctly positioned. It was decided to limit the detailed flood mapping to the area from the A40 to just north of Witney. Within this area, the model cross sections and spill units were then laid out manually to match as far as possible the locations shown in the available information.
- 4.1.3 Up to this point, no change has been made to the underlying model – georeferencing is initially a visualisation process, though it is possible within IWRS to set the length of channel links equal to their geographic length. Cross-sections and spill units are displayed at the length specified in the model data. This is a powerful tool for verifying the schematisation of a model - issues such as unfeasibly long spill units and impossible cross-connections are easily investigated. In the case of the Windrush model, no problems of this type were identified.
- 4.1.4 As discussed above, various locations were identified at which model enhancements were found to be necessary.

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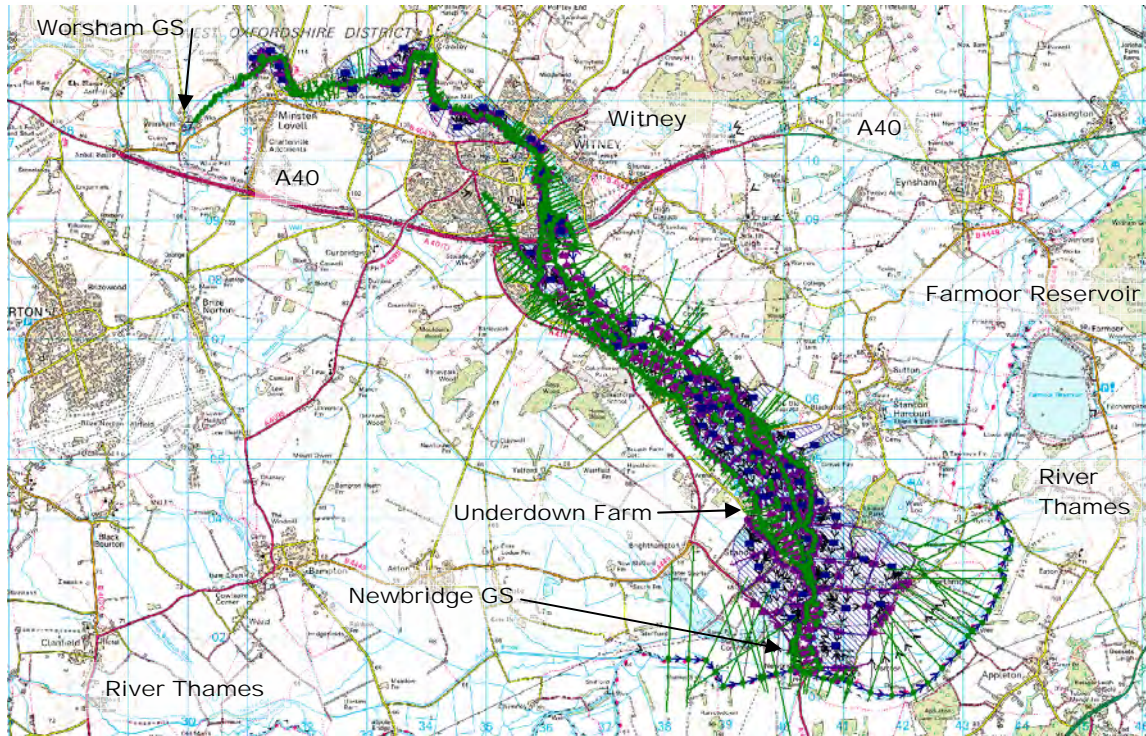


Figure 8 Hydraulic model extent

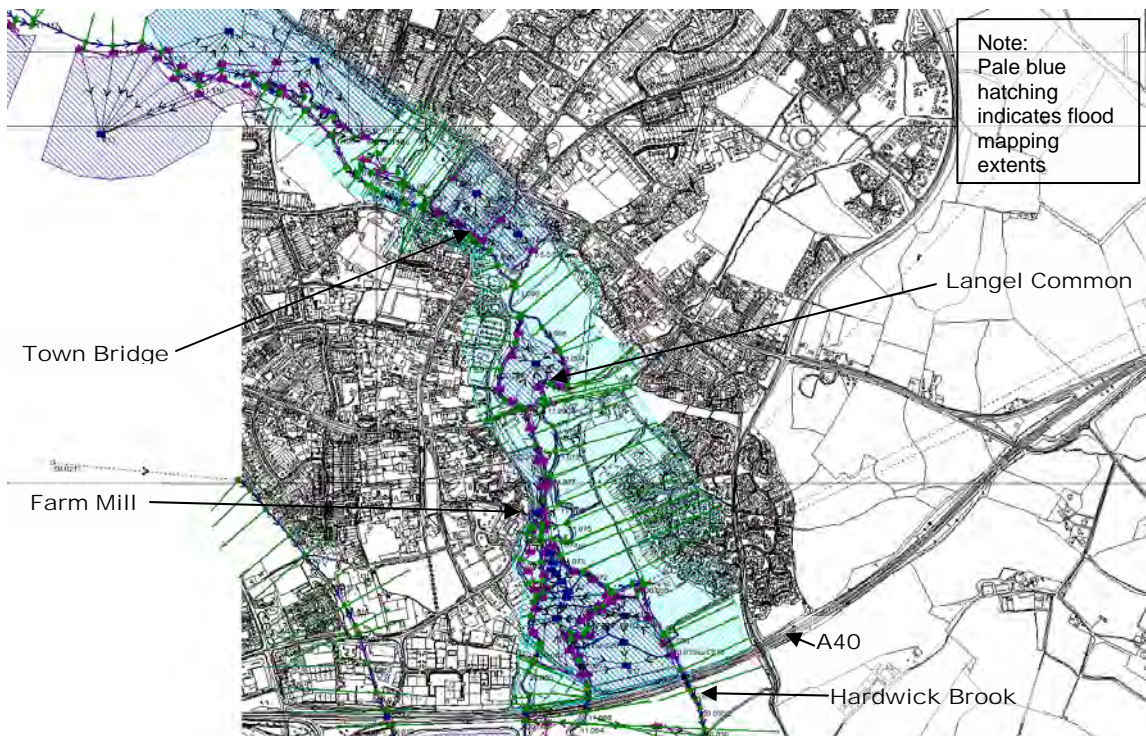


Figure 9 Extent of enhanced flood mapping

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4.2 Town Bridge Area

- 4.2.1 Figure 10 and Figure 11 show the model layout as received and as modified, respectively.
- 4.2.2 Additional conveyance has been added to the east of the Town Bridge to reproduce the observed flooding in July 2007. Flow magnitude and flood depth through a heavily built-up area is difficult to represent reliably in a 1-D model, particularly when there is a significant fall in the direction of flow. Data provided by the EA suggests that the water levels in the July 2007 flood upstream of the bridge area were significantly higher than they were adjacent to Bridge Street. This is consistent with the flow path being heavily constrained where it passes through the buildings at the edge of the undeveloped flood plain. The spill unit controlling flow from the flood plain into the housing has been configured to represent only the significant gaps between the properties. This allows sufficient flow to pass to reproduce much of the observed flooding upstream of Bridge Street whilst having relatively little effect on the flow in the river.
- 4.2.3 Flooding downstream of Bridge Street is not presently so well represented because it is highly dependant on the routes taken by the flood water through the housing and reshaping of the ground associated with the Aquarius, and other, developments.
- 4.2.4 Photographic evidence of flood water levels at Riverside House, just upstream from the Town Bridge, confirms that the river level rose above the footpath level outside Riverside House. The modelling of the bridge using a Bernoulli loss unit was not considered to provide a clear enough understanding of what is happening at this bridge so it has been remodelled as a USBPR bridge which allows aspects of the bridge geometry to be represented more clearly. This arrangement did not initially give a high enough afflux to reproduce the observed flood levels. The bridge is however complex in shape with a transition from flat soffits to arched soffits at some point under the bridge, together with an asymmetric taper and the west opening being off the flow line in the river. This suggested that head losses under surcharged conditions could realistically be 50% more than normal for a bridge of that type. The introduction of a calibration factor of 1.5 readily reproduced the observed water levels.
- 4.2.5 It is understood that desilting of the bridge area is under way. Data is being sought on the extent of this work but the modelling is currently based on the survey supplied by the EA for the project.
- 4.2.6 The observed flooding, as shown by the EA's flood mapping affected properties along the High Street for around 500m from the bridge. The ground model based on the photogrammetry supplied by the EA does not clearly show a flow path in this direction from which it is concluded that the extent of flooding is largely determined by the building lines along the road. About 130m from the bridge there is a turning towards the access to the Aquarius development and the shopping centre. Photographic evidence and the ground model, which identifies the road levels fairly clearly, suggests that much of the flooding experienced from that turning down towards the shopping area is likely to have originated largely from the spill from the river at Riverside House. However ground levels at the lowest points in the area are such that they could also have been flooded from the river more directly or by surface water unable to discharge freely due to high river levels. More detailed survey would be

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required to clarify the situation and the flood mapping in this area is provided only to confirm that flooding in the general area is predicted.

4.2.7 Just downstream from the Town Bridge, the river is crossed by the Aquarius development access bridge which was constructed after delivery of the model provided to us by the EA. This bridge was surveyed for the current modelling exercise and added to the model. Provision has not been made for bypassing or overtopping of this bridge at present. All modelled scenarios presently show it to pass the 100 year plus 20% flood and the July 2007 flood without surcharging. However photographic evidence suggests that water escaped from the river via the channel which runs into the development just upstream.

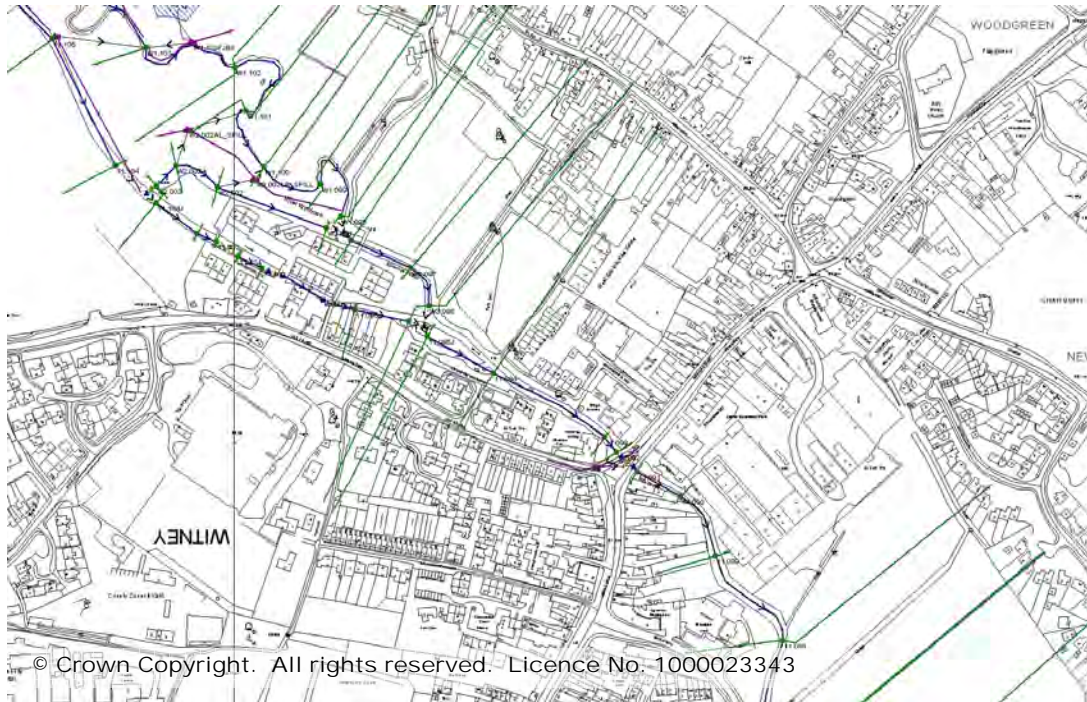


Figure 10 Town Bridge area – model as provided

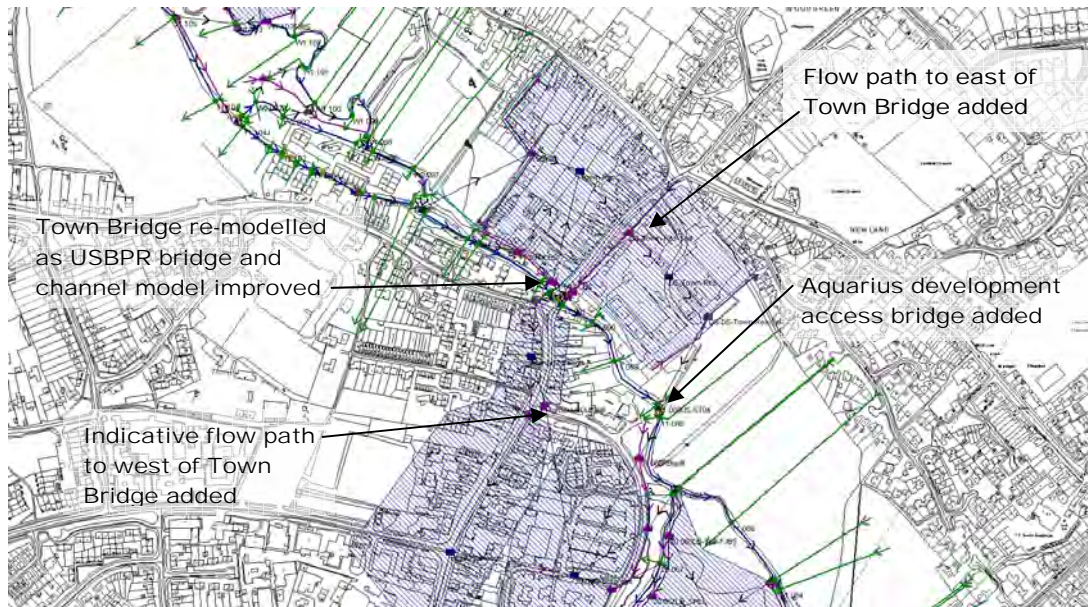


Figure 11 Town Bridge area – enhanced model

4.3 Langel Common Area

- 4.3.1 This is shown in Figure 12 and Figure 13. The July 2007 flood was notable for the observed flow across the footpath running across the full width of the floodplain at the southern side of Langel Common. The model as provided to us did not represent this flow route adequately so the arrangement of spills and reservoir in this area was reviewed and updated. The calibrated model reproduces flow over the footpath as observed.
- 4.3.2 It may be noted here that only limited flooding is shown on the EA's flood mapping to the east of the river and to the south of the Church. A small area is walled round the Church and the Priory but the rest of the area is open and there is photographic evidence of flood water in the car park south west of the Blake Primary School. This is considered further below.

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Figure 12 Langel Common area – model as provided (prior to section realignment)

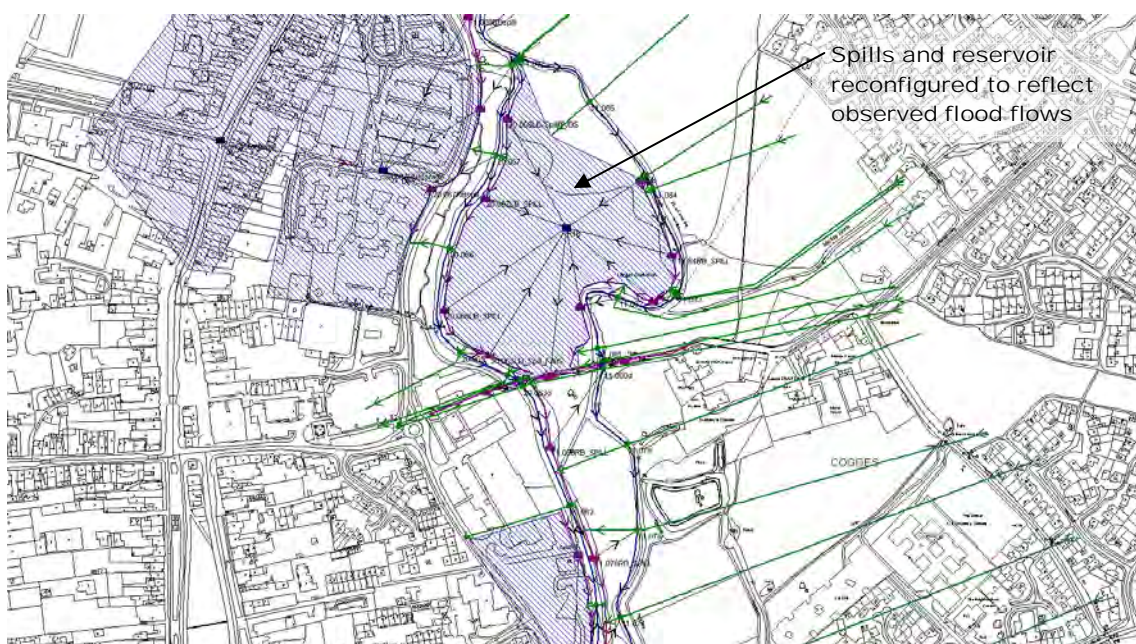


Figure 13 Langel Common area – enhanced model

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4.4 Farm Mill/A40 Area

- 4.4.1 This is shown in Figure 14 and Figure 15. This area has received the most detailed attention in the current because it is most affected by the proposed route of the CLR.
- 4.4.2 To the west of the main Windrush channels, the by-pass channel at the disused Farm Mill was not originally modelled. Since provision must be made for this flow route in the CLR project, it is necessary to extend the model to include it. The weir, bridges and channel have been surveyed and incorporated into the model. It was also found that the extended cross sections on the right bank of the western channel incorporated a parallel channel which would only carry water in times of flood and drains towards the bypass channel. This area of the model was revised accordingly.
- 4.4.3 Between the west and east channels of the Windrush, the flood plain was initially represented by spill units and extended cross sections. Inspection of the sections showed that the initial flood extents were derived for a situation in which flow occurred in parts of the sections disconnected from the main river channel. Spill units between the two channels were placed in some cases down the middle of the floodplain at a lower level than either of the adjacent river banks. Inspection of the survey data and the ground model showed that this area of flood plain is clearly “dished” and should only flood when the adjacent river channels overtop their banks. It was also found that there was a significant gradient along the floodplain which would result in any overbank flows running rapidly towards the south and clear of the proposed CLR route.
- 4.4.4 To the east of the main Windrush channels runs the Hardwick Brook, which has its own culvert under the A40 and crosses the CLR alignment. Site inspection confirms that this channel is generally dry in the Cogges area, except when water levels in the Windrush are high enough to spill down the brook. The channel was originally modelled up to an intermediate location fed by a rather distant spill from the Windrush. The full length of the channel up to the Windrush confluence was therefore incorporated in the model.
- 4.4.5 The modelling of Hardwick Brook was complicated by the presence of a storm outfall and attenuation pond discharging to the Brook. The pond is believed to have been constructed as mitigation works for the adjacent housing development. It appears that the first part of the Hardwick Brook may have been regraded to take flow from this outfall towards the Windrush whereas, under flood conditions, flow would be expected to go in the opposite direction from the Windrush into Hardwick Brook. The pond is represented in the ground model and can be seen in the mapped flood extents.
- 4.4.6 Inspection of the survey data showed that some flow would approach the Hardwick Brook along the back edge of the flood plain in major floods. This has not been taken into account explicitly but it is most likely that the effect would be insignificant in a major flood.

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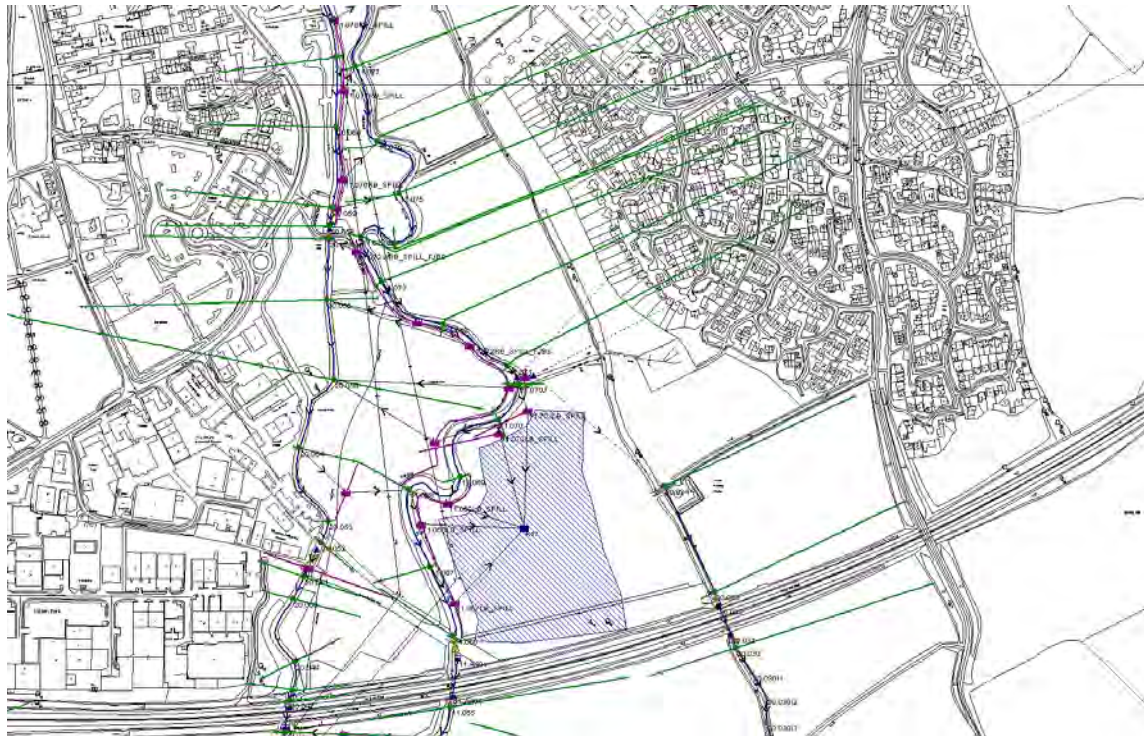


Figure 14 Farm Mill/A40 – model as provided

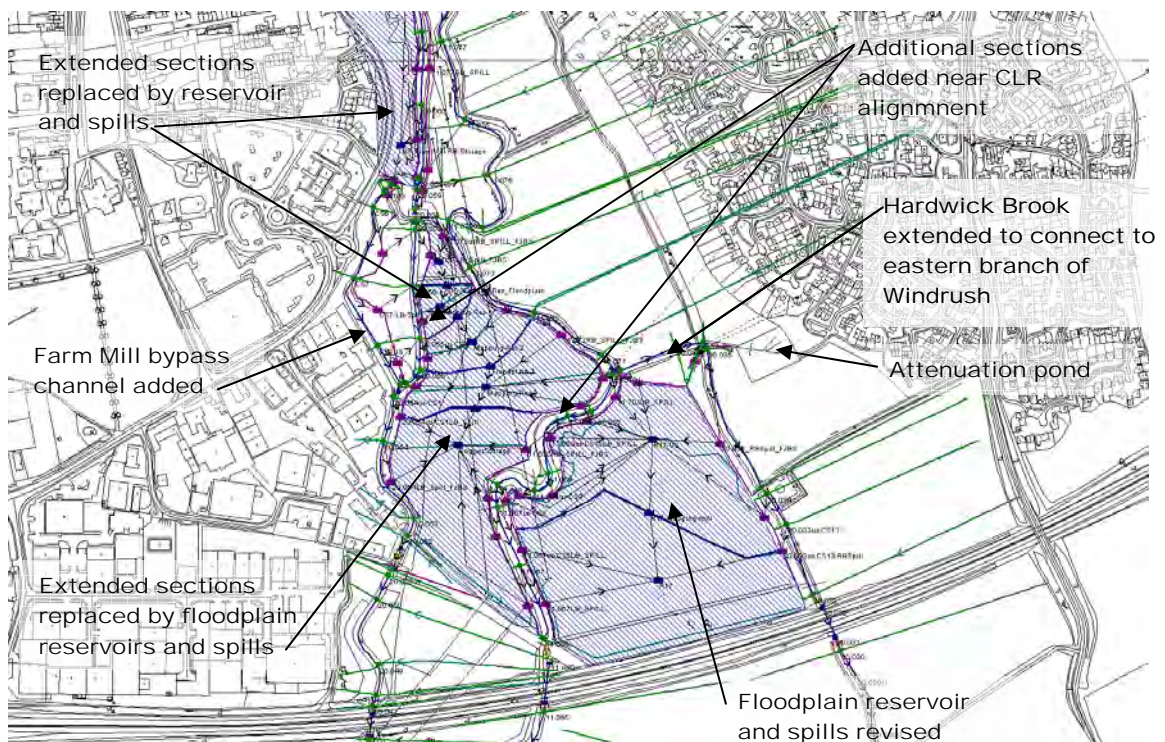


Figure 15 Farm Mill/A40 – enhanced model

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4.5 Underdown Farm Area

4.5.1 This is shown in Figure 16. This area received attention because it gave problems with the running of the model in the early part of the project. The improved schematisation shown, which made use of the original survey data, resulted in a significant improvement in model stability but has no direct bearing on the water levels in the area of the CLR.

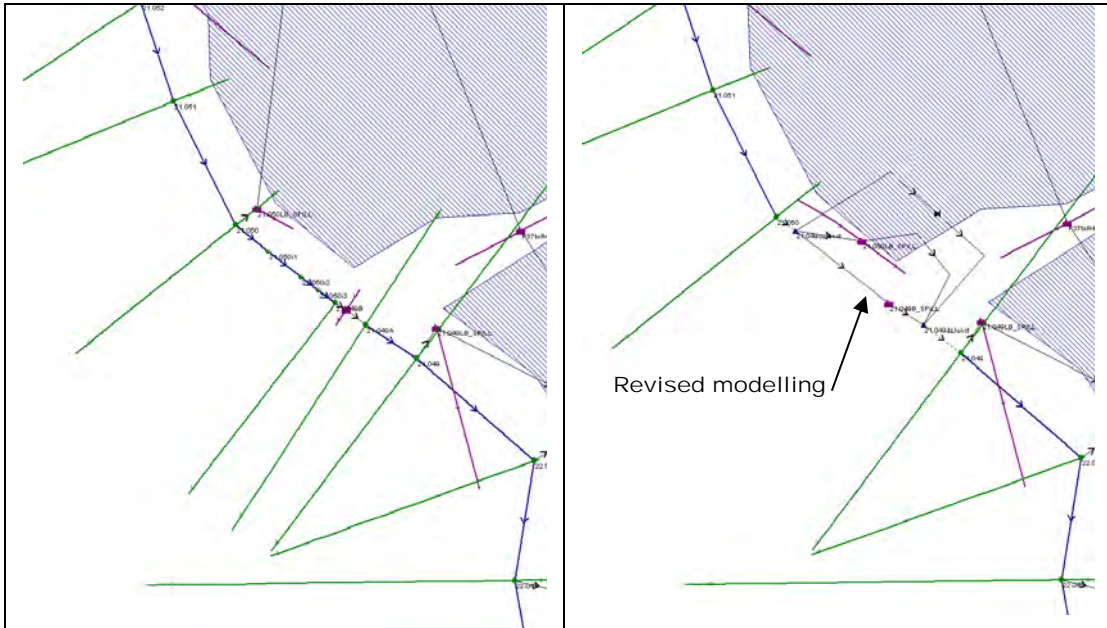


Figure 16 Enhanced modelling at Underdown Farm (disused mill)

5 Flood Mapping and Model Verification

5.1 Introduction

- 5.1.1 IWRS includes flood mapping functions. Once the necessary components have been defined, a model run can generate flood extent and depth for the overall peak water levels and for any time step during the simulation period. This can be displayed immediately over maps or aerial photographs.
- 5.1.2 The EA provided photogrammetric survey for the Windrush model area as 3D drawings. This was processed into a standard grid format compatible with ArcView for use with IWRS both for flood mapping and for model verification and revision.
- 5.1.3 The mapped flood extents for each set of modelling assumptions are therefore readily available for use in model validation/calibration.
- 5.1.4 Following the July 2007 flood at Witney, the EA has provided flood level data with associated photographs and the observed flood outlines in GIS format. The Flood level data has been put in a datasheet format and is attached as Appendix 6.
- 5.1.5 Supporting photographic evidence is currently published on the Internet in the Witney Floods Gallery at <http://www.witney.net/floods/>. Oxfordshire Highways is not responsible for the contents or safe operation of third party websites.
- 5.1.6 Jacobs staff visited Witney on the 25th July, 2007 when flows had fallen but were still high and it was possible to see where flooding had taken place. Notes from this visit are attached as Appendix 7. These notes also refer to reports from others of observed flooding during the event.

5.2 Calibration against EA Flood Level Data

- 5.2.1 The level data supplied by the EA and set out in Appendix 6 is referred to by the reference numbers used by the EA. The locations are shown in Figure 17. Much of the supplied data is either at locations remote from the river channel, and likely to be influenced by features such as the flows down Hailey Road, point 25, in particular, or is based on wet marks on walls which could have been subject to splashing and/or capillary rise. Nevertheless, these points are indicative of the extent of flooding and there are a number of points which relate directly to levels in the River Windrush. These are listed below with the observed and modelled water levels:

Point	Description	Model node	Observed Level (mOD)	Modelled level (mOD)
15	"Sign in Riverside Gardens"	11.094	82.06	81.55
4	Window d/s Bridge Street	11.091	81.19	81.03
3	Unclear - take location as coordinates.	11.089	80.86	80.56
2	Wing wall of bridge to Windrush Quay	11.088US-ST04	79.89	80.29
1	"Base of 5% deposit sign"	11.088US-ST04	80.57	80.29
7	Parking behind Waterside Court	11.088US-ST04	80.08	80.29
7A	Path by Waterside Court	11.088US-ST04	80.76	80.29
6	D/s face of Aquarius access bridge	11.088	80.09	80.20
5	D/s of Aquarius access bridge	11.088	80.50	80.20

- 5.2.2 It can be seen that the recorded flood levels are often difficult to reconcile with one another. However the levels immediately downstream of the Aquarius access bridge and the Witney Bridge Street bridge are within 0.20m of the modelled water levels and the higher levels can be explained to some degree by alternative flood routes bypassing the Bridge Street bridge.
- 5.2.3 The Witney Floods Gallery contains photographs of the Bridge Street bridge and Riverside House, just upstream, during the flood. These clearly show the flood level rising just above the pavement level outside Riverside House and flood water discharging to the Bridge Street/High Street/Mill Street junction via the entrance to the grounds of Riverside House. The ground level at the entrance is about 81.17mOD. The nearest model node is 11.092 where the maximum modelled water level is 81.36mOD. This is consistent with observed flooding.
- 5.2.4 The Witney Floods Gallery also contains a photograph of the upstream side of the Aquarius access bridge showing the flood level clear below the bridge soffit, and no indication of recent wetting to the soffit. The recent survey gave a soffit level for this bridge of 80.72mOD. The modelled upstream water level is 80.29mOD giving a freeboard of 0.43m, which is consistent with the photograph.
- 5.2.5 Further confirmation of the general level of flooding is given by photographs in The Witney Floods Gallery of flood water spilling across the footpath across the river at Langel Common. These show bridge decks above flood level but around 0.10m to 0.20m depth of water flowing across the footpath. The model gives a maximum water level in storage area R16 of 79.89mOD. The lowest point on the spill unit "11.08_xtra_Spill_FJBS" is about 29.73mOD, giving a potential overtopping by 0.16m, consistent with observed conditions. The nodes downstream of the footpath, 20.063d and 11.080d, have maximum modelled water levels of 79.77 and 79.68, which are at about the footpath level. The photograph also shows little sign of a significant drop in water level across the footpath, which is consistent with this observation.

5.3 Calibration against Jacobs Flood Observations

- 5.3.1 The Jacobs flood observation and information received from others indicated that
- a small amount of flow must have taken place over the area between the two channels of the Windrush,
 - flooding had affected the Cogges Museum car park and approached the adjoining school and
 - by the 25th July the river was generally in-bank, though the water levels in the bridges under the A40 were above the footway levels.
- 5.3.2 Trials with a range of "n" values for channel roughness in the area discussed in Section 3.5 showed that values of 0.035 to 0.040 were consistent with some flooding in the Cogges Car Park area. However the model was showing excessive flows, on the basis of modelled flood extent, in the western Windrush channel downstream from Farm Mill, and with an "n" of 0.040, too much flooding remained by the 25th July to be consistent with the site observations. It was concluded that the flow in the western Windrush channel needed to be reduced and that this could reasonably be simulated by reducing the hydraulic capacity of the structures round Farm Mill. The waterway areas of these were consequently all reduced by 50% as a trial. This was sufficient to increase the

flow in the eastern channel enough to show flooding in the Cogges Car Park with a general channel “n” of 0.035 whilst only reducing the Farm Mill flows by about 15% in total.

- 5.3.3 This configuration then was found to show a small flow into the floodplain area from the Farm Mill area. Water levels in the eastern channel remained below the modelled bank levels but in the vicinity of photo 003 in Jacobs observations, at node 11.073, the model shows a freeboard of only about 0.10m, consistent with some local overtopping, possibly assisted by being on the outside of a bend. The area round photo 006 is predicted to flood from the adjacent river, which is consistent with levels in that area being low enough to provide a return path to the river for small flows across the floodplain.

5.4 Comparison with EA Flood Extent Data

- 5.4.1 The flood outline obtained from the model for the July 2007 flood flows is compared in Figure 18 and Figure 19 with the GIS version of the July 2007 flood extents as supplied by the EA. Areas with apparent differences between the two flood extents are identified by letters A to H on Figure 18.
- 5.4.2 Area A to the north is affected by the major overland flows down Hailey Road and surface water drainage issues in general so the EA outline in this area is likely to cover a larger area than would be flooded directly from the Windrush. Similar issues may affect area B on the opposite bank of the Windrush. Area C is subject to complex overland flows passing through the buildings to the south of Bridge Street. The flood mapping in this area has not been fully developed and probably requires detailed ground modelling and 2D flow modelling to reproduce the flow patterns experienced. Area D has been subject to development since the survey used for the ground model was carried out. It would be advisable to include this area in any enhanced modelling carried out for area C.
- 5.4.3 Area E covers High Street and Witan Way. The ground model does not support the existence of distinct flow paths in this area so it can be assumed that the observed flooding was largely due to flow being routed between buildings along streets. The model provides an indicative representation of the flow pattern assuming flow from upstream of Bridge Street into High Street is split between Witan Way and High Street but the mapping represents only the water levels in modelled reservoirs at key locations. The areas of flooding simulated at the Welch Way/High Street junction and in the shopping area are constrained by the extent of the ground level data but it appears that the Welch Way/High Street area is sufficiently low lying for it to experience flooding from a combination of high river levels in the Windrush by Witan Way and local surface water runoff. Detailed ground modelling and 2D flow modelling would again be required to reproduce the effects of fluvial flooding in the area. It is however likely that an integrated urban drainage/fluvial flooding approach would be required to obtain a proper understanding of the issues.
- 5.4.4 Area F is flooded from the Madeley Brook which is not covered by the model except as a tributary flow.
- 5.4.5 Area G is not shown as flooding in the EA's data. The EA does not guarantee that an area they do not show as having flooding did not flood in reality. The model clearly shows water levels well above the left bank of the eastern Windrush channel in this area and, although the immediate area round the

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Church and the Priory is walled, there is no constraint on flows spreading out towards Cogges in the “moat” area and downstream.

5.4.6 Area H is shown by the EA as being wholly flooded. The simulation shows it as having small patches of flooding and being surrounded by channels flowing full. It is considered that the modelled flooding is reasonably consistent with the EA’s observed flood extents.

5.5 Sensitivity Analysis and Detailed Model Results

5.5.1 A range of alternative hydraulic parameters were tested and the model was run for events from five years to 1000 years return period. The effect of a steady flow was also tested as was the effect of assuming that all flows passed through the Bridge Street bridge since it is difficult to quantify flows through heavily built-up areas. The results of these further studies are presented in Appendix 8, Hydraulic Model Development.

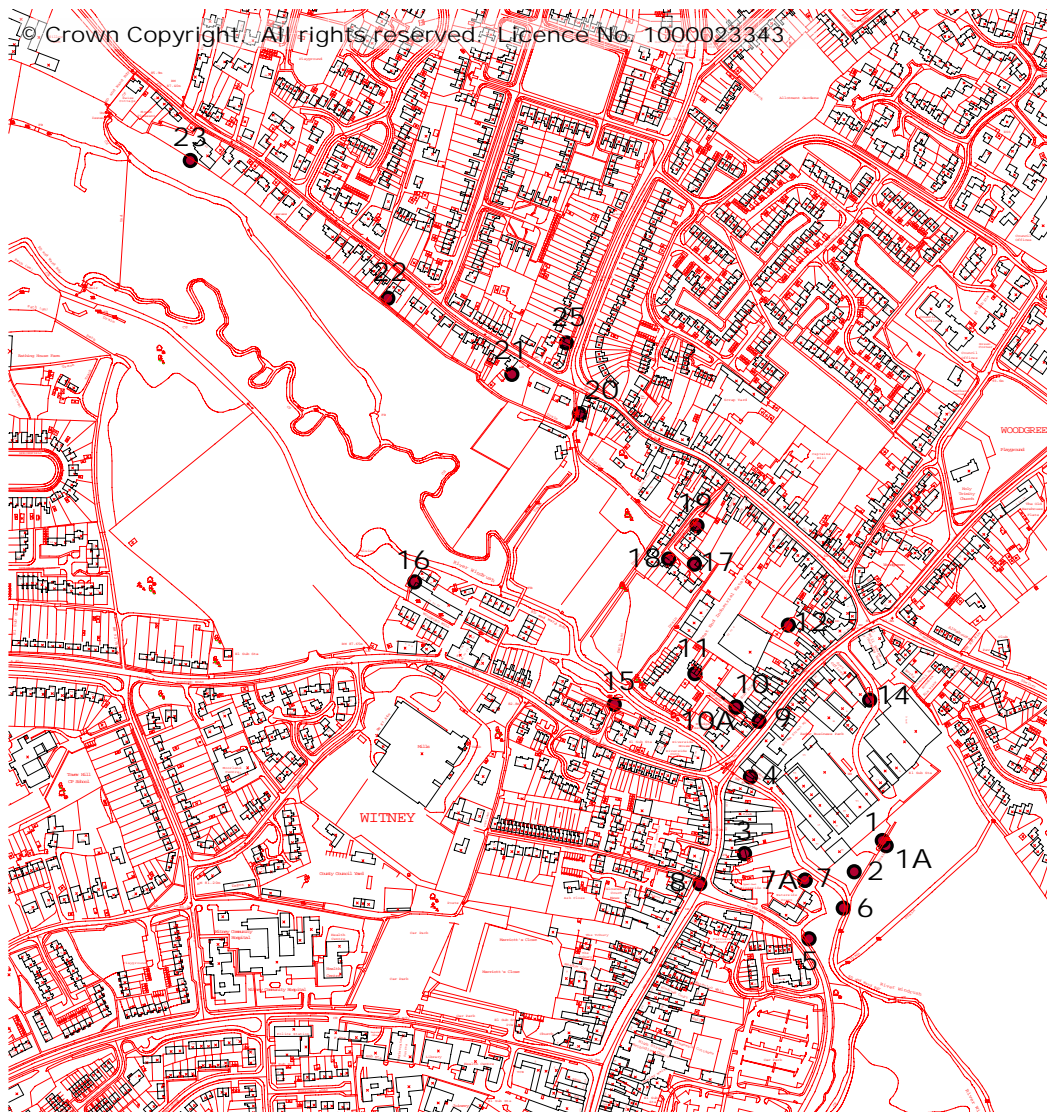


Figure 17 EA Flood Survey Locations

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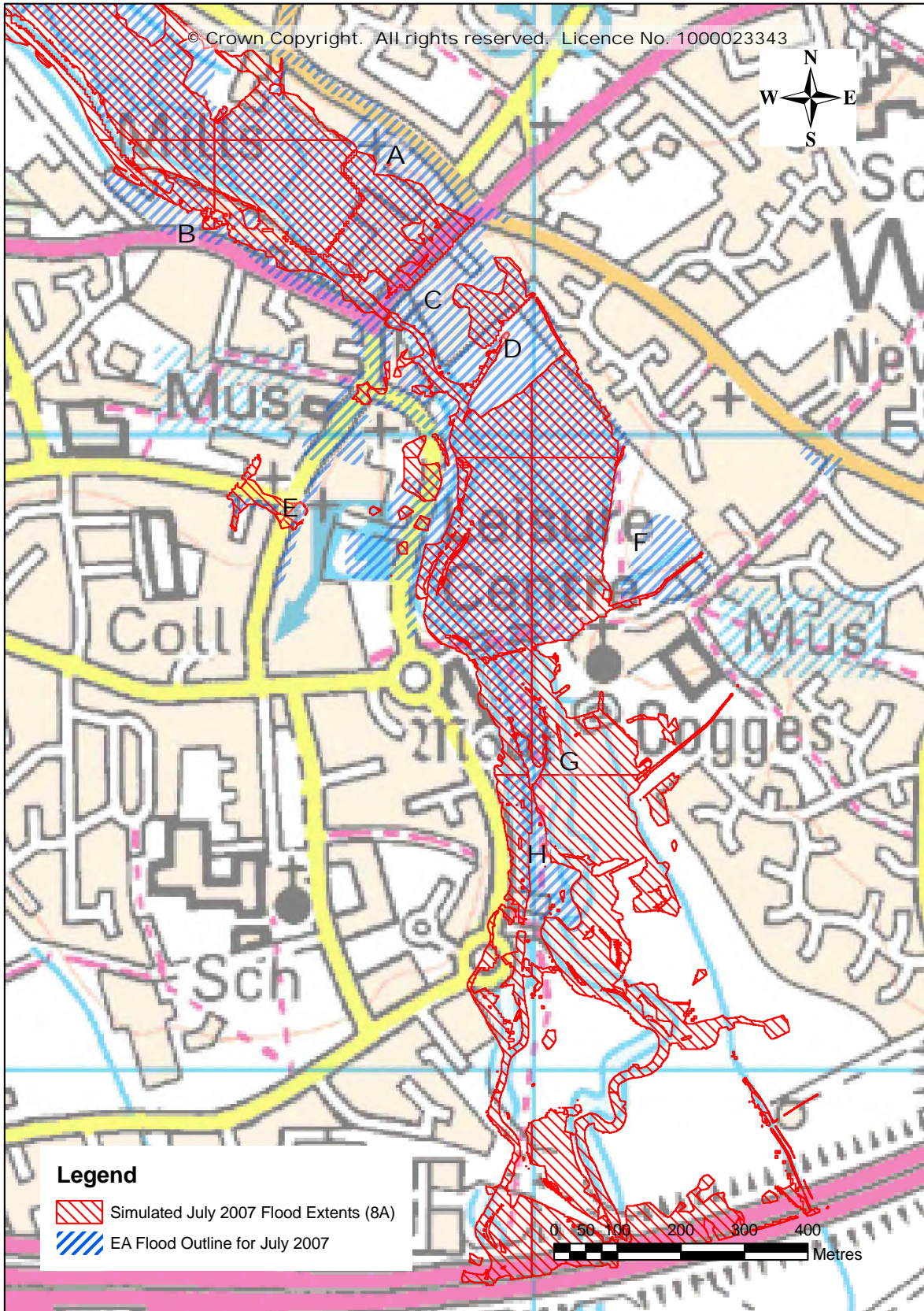


Figure 18 Observed and simulated July 2007 flood extents – 50k mapping

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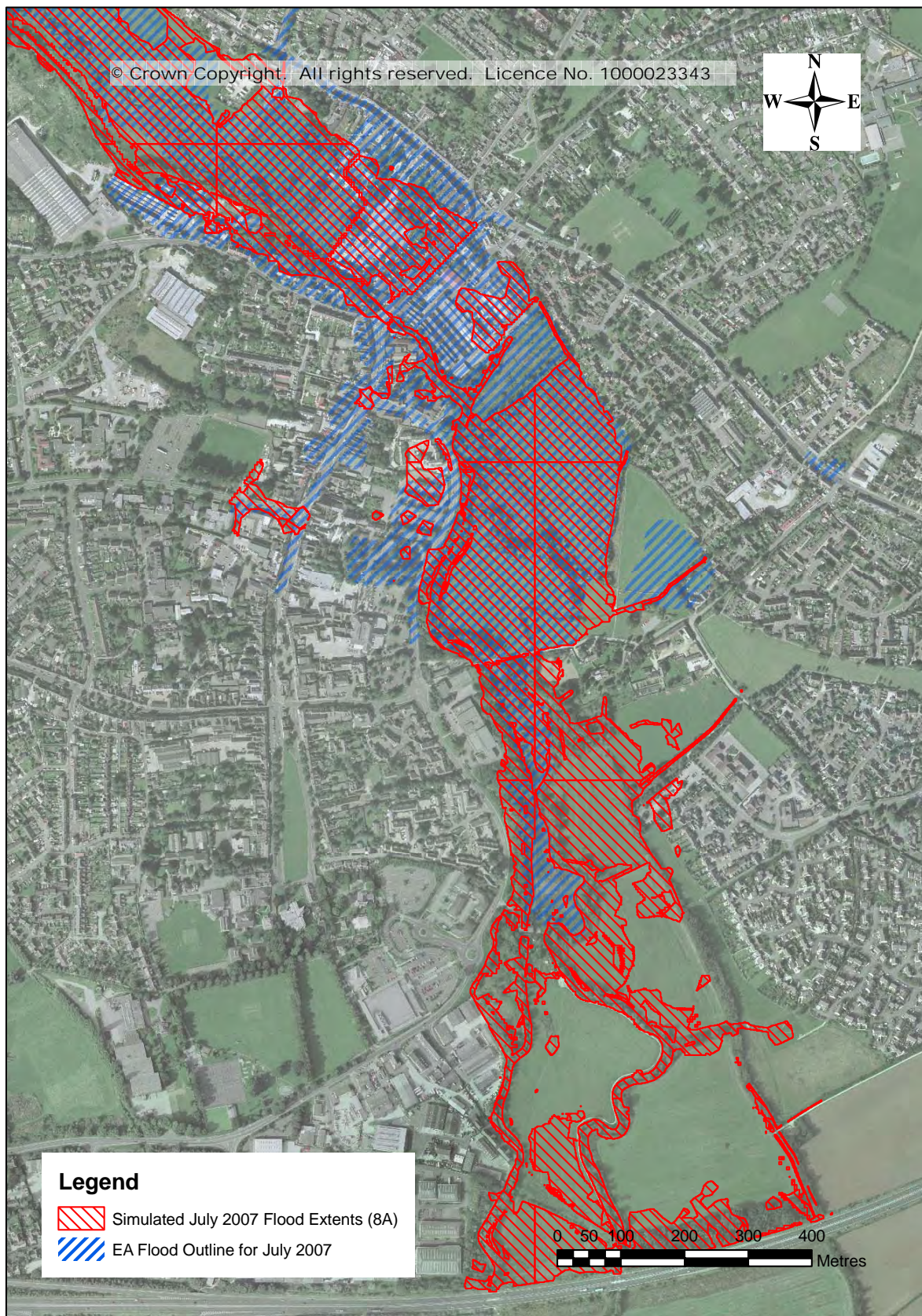


Figure 19 Observed and simulated July 2007 flood extents – aerial photography

5.6 Proposed 100 year flood extent vs. Section 105 flood extent

- 5.6.1 Figure 20 shows how the proposed 100 year flood mapping produced using the model calibrated using the July 2007 event data (calibration 8A) compares with the Section 105 outline. This comparison is between direct model output and flood outlines produced in accordance with S105 guidance so there may be some areas in which the S105 outlines differ due to manual intervention. In general, the updated outline is similar to the S105 version, except in the Bridge Street bridge and Cogges areas. The areas to the bottom left of the figure and south of the A40 have not been revised at this time.
- 5.6.2 The Bridge Street results suggest that properties on the upstream, north western, side will be at risk in the 100 year event. The risk of flooding to properties on the downstream, south eastern, side is much smaller but cannot be ruled out. An area is shown as not being at risk which corresponds approximately to the Aquarius development. It is likely that both flood outlines are unreliable in this area due to changes in ground levels since the photogrammetric survey used was carried out.
- 5.6.3 The significant reduction in the flood extents between Cogges and the A40 is consistent with the observations made on the S105 hydraulic modelling. Some additional areas of flooding are identified in the revised extents and some water should be shown along the line of the Hardwick Brook to the east of the main channels.

5.7 100 Year plus 20% Design Flood Extent

- 5.7.1 Figure 21 shows the climate change-adjusted 100 year flood extent, with the Section 105 flood mapping, again, for comparison. There are a number of areas where the “100 year plus 20% flood extent” requires refinement. In particular, the area to the south east of Bridge street should be shown as subject to more general flooding, and flooding along the streets on the opposite side of the river should be clarified.
- 5.7.2 Much of the S105 flood outline is not dissimilar to the “100 year plus 20%” flood extent but there are substantial additional areas of flood risk in the general vicinity of the CLR. The modelling also shows small flows taking place over the banks of the various channels into the historic floodplain areas and across the proposed CLR alignment. The area is shown in more detail in Figure 22 where this minor flooding is evidenced by the small patches of ponded storage within the footprint of the road. The modelling suggests a flow of about $0.02\text{m}^3/\text{s}$ could flow into the area between the Windrush channels and $0.25\text{m}^3/\text{s}$ could flow into the area to the east of the Windrush. The lack of ponding shows that there is sufficient gradient for these flows to run freely in the most part across the floodplain, and the CLR alignment.
- 5.7.3 It is concluded that the proposed CLR will have a small effect on the “100 year plus 20%” flood but that it is not practicable to fully quantify this.

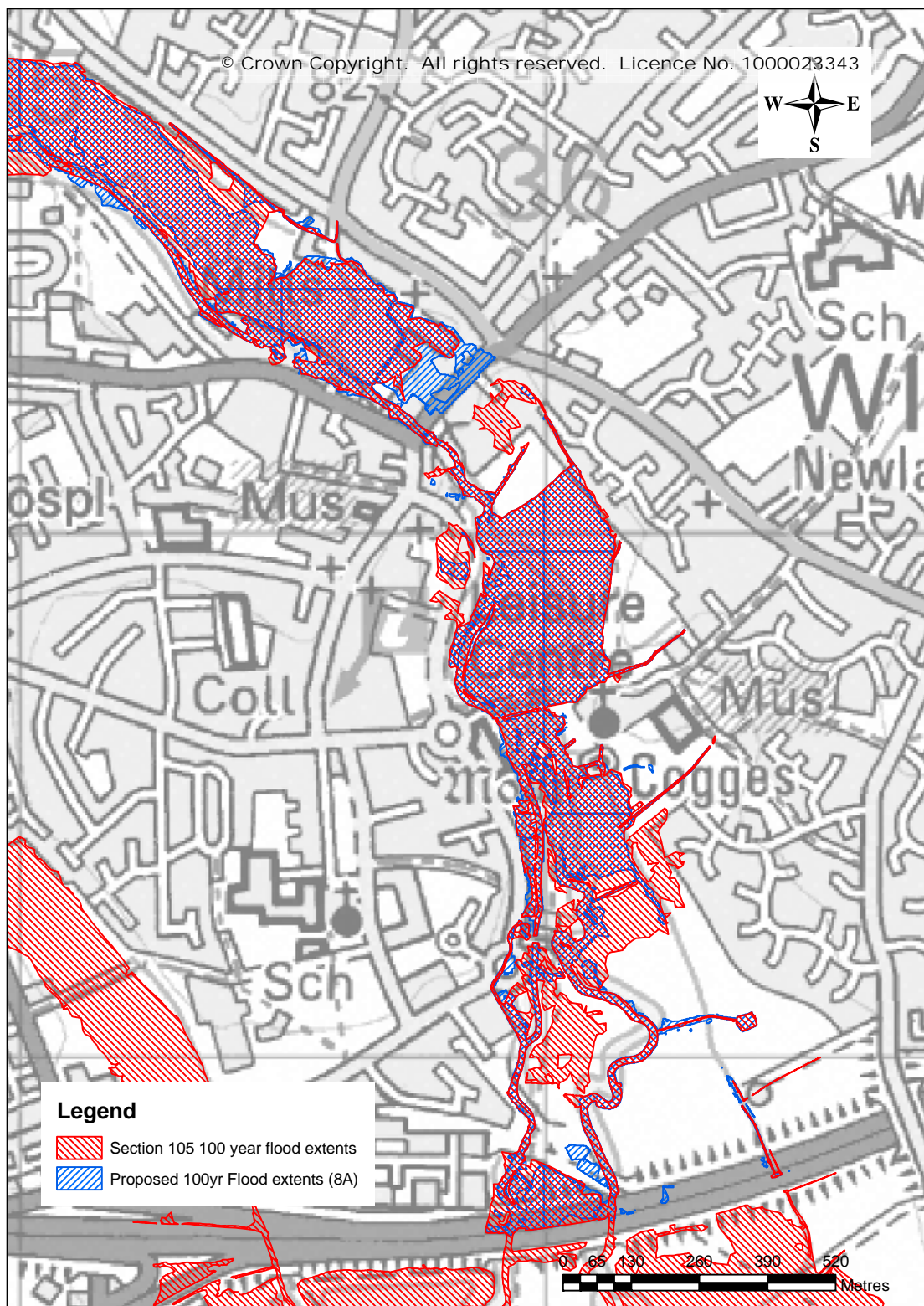


Figure 20 Proposed 100 year simulated flood extent and S105 flood outline

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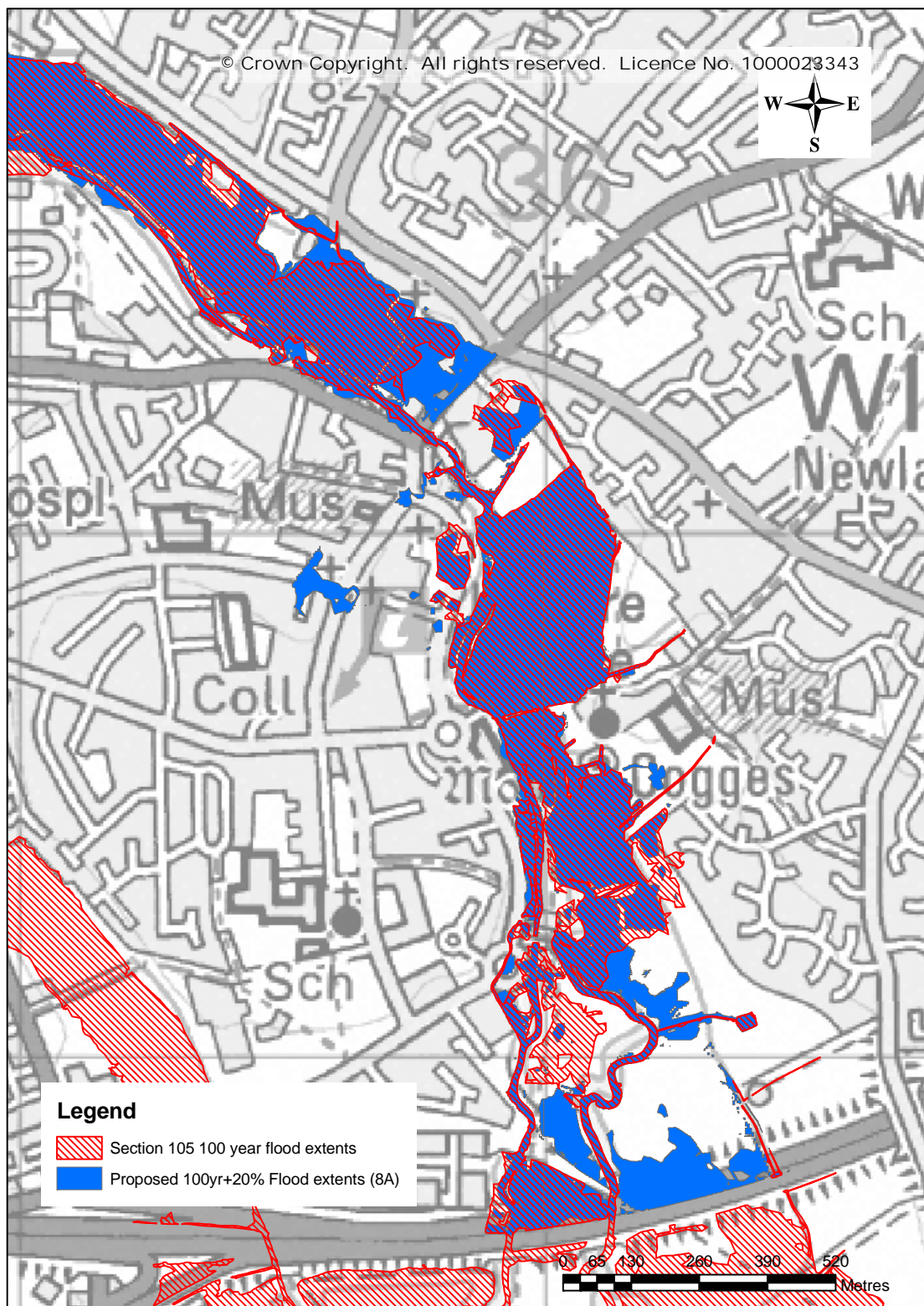


Figure 21 100 Year plus 20% Design Flood Extent

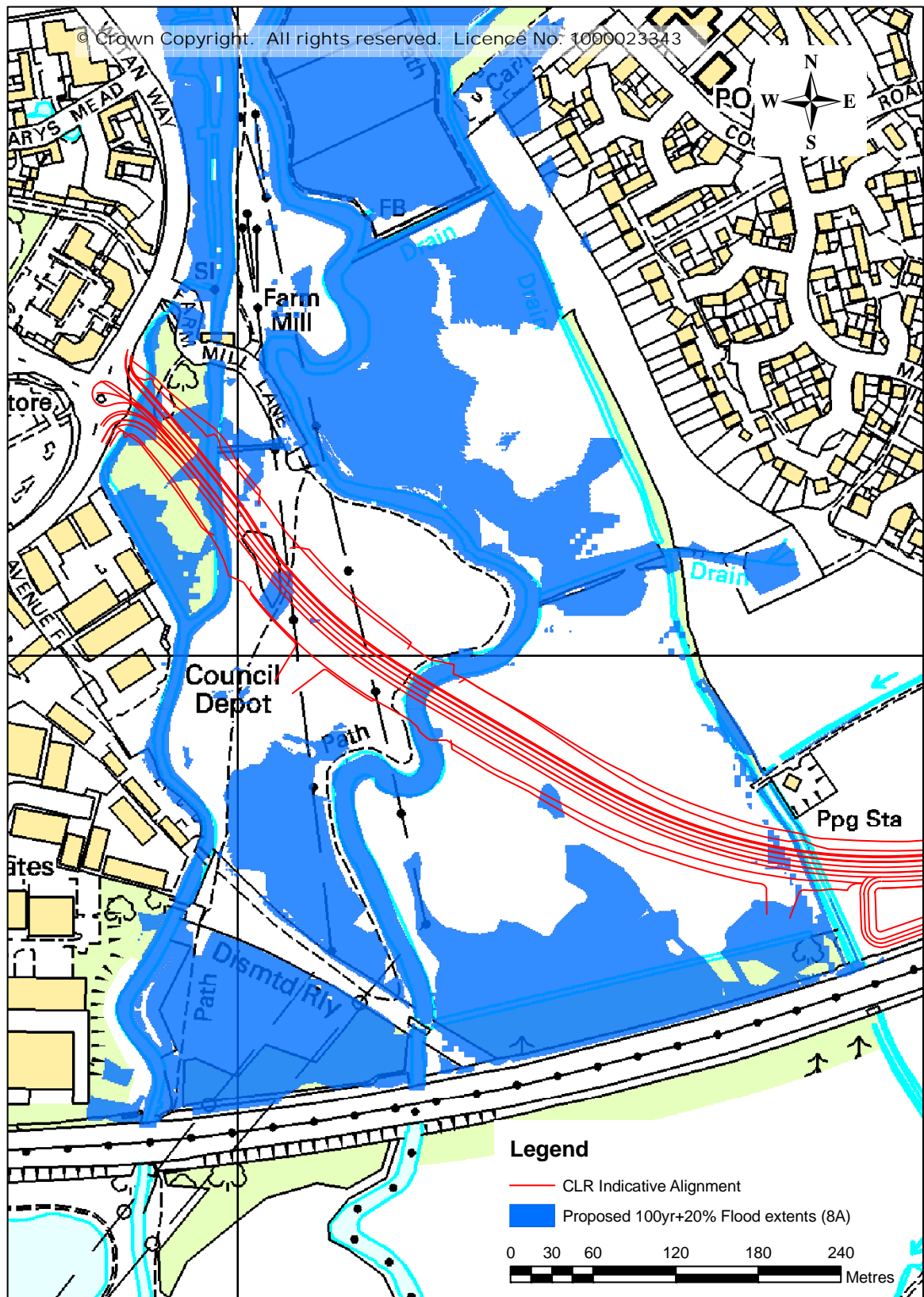


Figure 22 100 Year plus 20% Design Flood Extent and proposed CLR alignment

6 Conclusions and Recommendations

6.1 Conclusions

- 6.1.1 Previous assessments of the area of the flood plain at Witney in Oxfordshire at risk from flooding showed that the proposed Cogges Link Road (CLR) fell, in part within the 100 year flood extents and would therefore require compensation storage in accordance with EA practice. The addition of the climate change allowance in PPS25 appeared likely to increase the storage requirements further.
- 6.1.2 It is now shown that the works required for CLR lie mainly outside the area at risk from a 100 year flood, other than where the river is bridged, but would have a small effect on the flood plain when 20% is added to the 100 year flood flows to allow for climate change, as indicated in PPS25.
- 6.1.3 This conclusion is supported by upgrading of the existing Section 105 flood mapping model both in level of detail in the model schematisation and in the roughness parameters used and reassessment of the hydrological inputs.
- 6.1.4 The upgraded model is further validated by reference to the July 2007 flood event, which has been assessed to have a return period in the region of 220 years and flooded the centre of Witney, yet was observed to have remained largely in-bank within the area of the proposed road works.
- 6.1.5 It is concluded that little flood storage volume will be lost, up to the flood magnitude specified in PPS25, and a nominal volume of compensation storage will be required in respect of the CLR scheme. This will have an element of betterment and the details will be agreed with the EA as the project progresses.
- 6.1.6 The scheme naturally remains subject to the EA's detailed requirements with regard to the minimisation of impacts on both Main River and ordinary watercourses. Discussions are proceeding with the EA regarding their detailed requirements for the control of outflow into watercourses adjacent to the scheme. Initial guidance on these matters has been provided by the EA and is reflected in the outline drainage design covered in the report CLR 09 "Preliminary Drainage Design – Outfall and Storage Proposals". It is expected that the present flood modelling report will assist in the development of an agreed detailed drainage design.

6.2 Recommendations

- 6.2.1 The reported enhancements to the hydraulic model have been focussed on the area relevant to the proposed CLR, principally between the A40 and the Town Bridge. The changes to the roughness parameters applied in the upgrading process could be of more general applicability and it would be appropriate for the whole model to be revised and the corresponding flood mapping to be updated.
- 6.2.2 In particular, the flooding mechanism in the area of the Bridge Street bridge in Witney, on both the east and west sides of the river, has been demonstrated to be different to that implied in the original model. The modelling of this area would benefit from a more detailed survey and the application of 2D modelling

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techniques to represent the complex flow patterns round buildings more realistically.

- 6.2.3 Complex flow patterns are inevitable in extensive flooded areas such as were observed in Witney in July 2007. Consideration should be given to the wider use of 2D flood modelling in any future improvements to the model.

Appendix 1

Draft proposal to EA for hydraulic modelling in connection with the proposed CLR

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Smith, Julian

From: Smith, Julian
Sent: 01 June 2007 13:39
To: 'Customer Contact Thames West'
Cc: Mullins, Jon; Shelton, Richard; Elder, Alastair; Francis, Marcus; julian.hartless@oxfordshire.gov.uk
Subject: Your Ref: WIR 24169 - Cogges Link - Draft Methodology Proposal

FTAO Caroline Callard/Eleanor Foster

Hi,

Following our earlier discussions and receipt of the Lower Windrush hydraulic model, our draft proposal for the work which we will be undertaking on behalf of Oxfordshire CC in support of the Cogges Link project is as follows:

1. The existing hydraulic model and associated hydrology are for the Windrush from upstream of Witney to the Thames. As the project area is well upstream within the overall model, we propose to cut the model at points where reasonable downstream hydraulic boundaries can be established. The validity of these cut-off points for the Cogges Link location will be supported by sensitivity studies on the boundary conditions.
2. We will compare the model sections with the project survey data in the Cogges Link area. We will consider whether any observable differences may be due to datum changes and agree adjustments where necessary. In principle, we would seek to keep the model with its original survey datum and adjust water levels if necessary, before application. We will carry out surveys of relevant hydraulic structures where any uncertainty remains.
3. We will re-schematise the model in the Cogges Link area to allow the proposed structures to be inserted with minimum disturbance and prepare models of the channel system with and without the proposed crossing. The revised model will be verified by reference to the existing model results.
4. We will review the hydrology based on the available river gauge data for the Windrush to confirm appropriate design flood flows.
5. Having carried out a preliminary inspection of the Windrush hydrology, we believe that flood level would be best estimated from a steady-state hydraulic model. We propose, therefore, to establish before and after flood extents for steady flows corresponding to 20 year, 100 year and 100 year plus 20% flood flows.
6. The steady state runs would be supported by unsteady flow simulations based on recent recorded flow sequences with peak flows of an appropriate magnitude, scaled if necessary to match specific flow peaks.
7. In parallel with the above activities, we will explore possible scenarios for compensation storage, which will be tested by inclusion in the model.
8. We will seek the EA's views at critical stages in this process and submit our conclusions in draft form for discussion before finalisation.

If you feel that this draft proposal forms a sufficient basis for a meeting with representatives from your Hydraulic Modelling and Development Control Teams to agree the details before we proceed with the study, we will be pleased to receive your suggestions for a meeting date. If you require further information before proceeding to that stage, please let me know as soon as possible.

Many thanks for your assistance in this matter.

Regards,

Julian Smith
JACOBS
Thorncroft Manor, Dorking Road, Leatherhead, Surrey, KT22 8JB T. Direct 01372 863612, Mobile 07904 079145, Reception 01372 863601 Please consider the environment before printing this e-mail

Appendix 2

Flood Risk Mapping and Data Management Review Comment from EA

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Flood Risk Mapping and Data Management Review Comment

Project: Cogges Link Road

Items reviewed: Email from Julian Smith dated the 7th June 2007 detailing the draft methodology / proposal

Date received: 7th June 2007

Reviewed by: Eleanor Foster (modelling) and David McKnight (Development Control)

Date of Review: 2nd- 3rd of July 2007

Approval Status: In general the methodology was approved but the following comments should be actioned.

Comments:

1.
 - ✓ The proposal to cut the model, choose reasonable hydraulic boundaries and carry out sensitivity analyses on these boundaries is thought to be appropriate.
 - ✓ The model must be extensive enough to assess the baseline flood risk in the development area in order to satisfy the objectives of the FRA.
 - ✓ The downstream boundary should be far enough downstream not to impact on flood levels in the area of interest.

2.
 - ✓ Any new channel, spill and site specific spot height survey data needs to be carried out using dual frequency GPS in accordance with Environment Agency specifications
 - ✓ Check surveys should be undertaken at key locations to ensure that the survey data provided in the Lower Windrush is compatible with current conditions. If it is not then new survey needs to be carried out to GPS in accordance with Environment Agency specifications.
 - ✓ If the survey data in the model is based on the OSBM networks and is comparable with current conditions stability checks should be carried out. If the OSBM network is considered stable the difference between OSBM and GPS derived levels should be applied as additional freeboard in the design. If the OSBM network is unstable new survey should be carried out using dual frequency GPS in accordance with our Environment Agency Survey specifications (<http://www.environment-agency.gov.uk/subjects/flood/1217883/1218166/1218189/533791/533832/?>).



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3.
 - ✓ The model should be schematised in order to model the river and flood mechanisms appropriately not to facilitate the insertion of new structures.
 - ✓ Every effort should be made to obtain local flood data in order to ground truth / calibrate and validate the model. It is not considered best practice to validate a model using a previous model.
 - ✓ We advise that a post scheme model is not developed for use in the FRA for the Cogges Link Road to define the requirement for flood compensation. It is essential to agree the flood plain extents for all events up to and including the design flood event, (1% annual probability of occurrence plus climate change level). Once we have agreed the flood plain extents and levels, you will be required to provide flood plain compensation on a level for level, volume for volume basis. This is to ensure that adequate flood plain compensation is provided for any displaced flood plain as a result of the scheme.
 - ✓ Modelling the resultant impacts of works to demonstrate no or negligible impacts of any development is not acceptable due to the inherent tolerances and overall sensitivity associated with hydraulic modelling. Whilst small increases of flood levels downstream due to the removal of flood storage may not be significant enough to be identified from modelling, the cumulative impact of these losses may become significant over time resulting in an increased risk of flooding to people and property.
 - ✓ When the appropriate flood storage compensation has been provided, we have no objection to you testing the whole scheme including the bridge impacts upstream or downstream via the use of the hydraulic model. However, lost flood plain storage must be compensated on a like for like basis.
4.
 - ✓ A review of the hydrology is a fundamental part of this work. It is important to use up to date local data where available to improve design flood flow estimates. The choice of hydrological methodology used should be justified in terms of its appropriateness for the catchment. If the Flood Estimation Handbook methodologies are to be used these should be carried out in accordance with the Environment Agency Guidelines (attached). It is expected that the Hiflows data set is used. The revitalised rainfall runoff method should be used in place of the rainfall runoff method but it should be carried out in parallel to the statistical method.
5.
 - ✓ Sensitivity testing should be carried out on Mannings N values, hydrological inflows and structure / spill coefficients. This is in accordance with our best practice guidance entitled "Using Computer River Modelling As Part Of A Flood Risk Assessment" which is attached.



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- ✓ Blockage scenarios are also required
- ✓ Comments on model stability would be useful.
- ✓ Default parameters should be used and if they are not this needs to be justified.
- ✓ Please provide GIS output of the outlines, node point locations and associated flood levels, cross section locations and the extents of the watercourses modelled. Attached are the attributes that we enter into our database, you may wish to follow this as a template (NFCDD 1 Model Data Attributes.xls).
- ✓ If a Flood Map change is sort for both Flood Zones the 1000-year undefended event will also need to be modelled.
- ✓ Please justify the decision to run the model steady state. A steady state model is only thought to be appropriate where attenuation is not important and there are no structures, which operate with time.

Points and methods of contact

All data requests should be made through our External Relations team. We welcome close working with ourselves but any data submissions or queries relating to the planning application should be directed to Planning Liaison in the first instance. Please note that we aim to review any modelling data within 15 working days.

Appendix 3

Comparison of EA GPS datum, OS benchmarks and levels from survey data used in model

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**Cogges Link Road, Witney Topographic Survey
Jacobs Geomatics**

Structure Soffit Level Comparison

Structure	2007 Level (m)	1990 Level (m)	Diff (m)	Difference less variation between OSGM02 and OSBM system
A	79.580	79.629	0.049	-0.013
B	78.680	78.662	-0.018	-0.081
C	79.970	80.010	0.040	-0.022
D (US1)	80.825	80.863	0.038	-0.025
D (US2)	80.823	80.863	0.040	-0.022
D (DS1)	80.766	80.836	0.070	0.007
D (DS2)	80.828	80.908	0.080	0.017
E	79.110	79.170	0.060	-0.002
F	78.470	78.520	0.050	-0.013
G	78.680	78.680	0.000	-0.063
H (US1)	79.241	79.270	0.029	-0.034
H (DS1)	78.663	78.680	0.017	-0.045
H (DS2)	78.652	78.710	0.058	-0.005
I	80.040	80.060	0.020	-0.043
J	78.800	78.840	0.040	-0.022

Note: Levels for 1990 are based on heights obtained by measuring from local Ordnance Survey Benchmarks and are taken from supplied drawings A01S 1431/6, 1431/8, 1431/9, 1465/5, 1465/6 and SURV 4051/4. Level for Structure J was observed in 1997

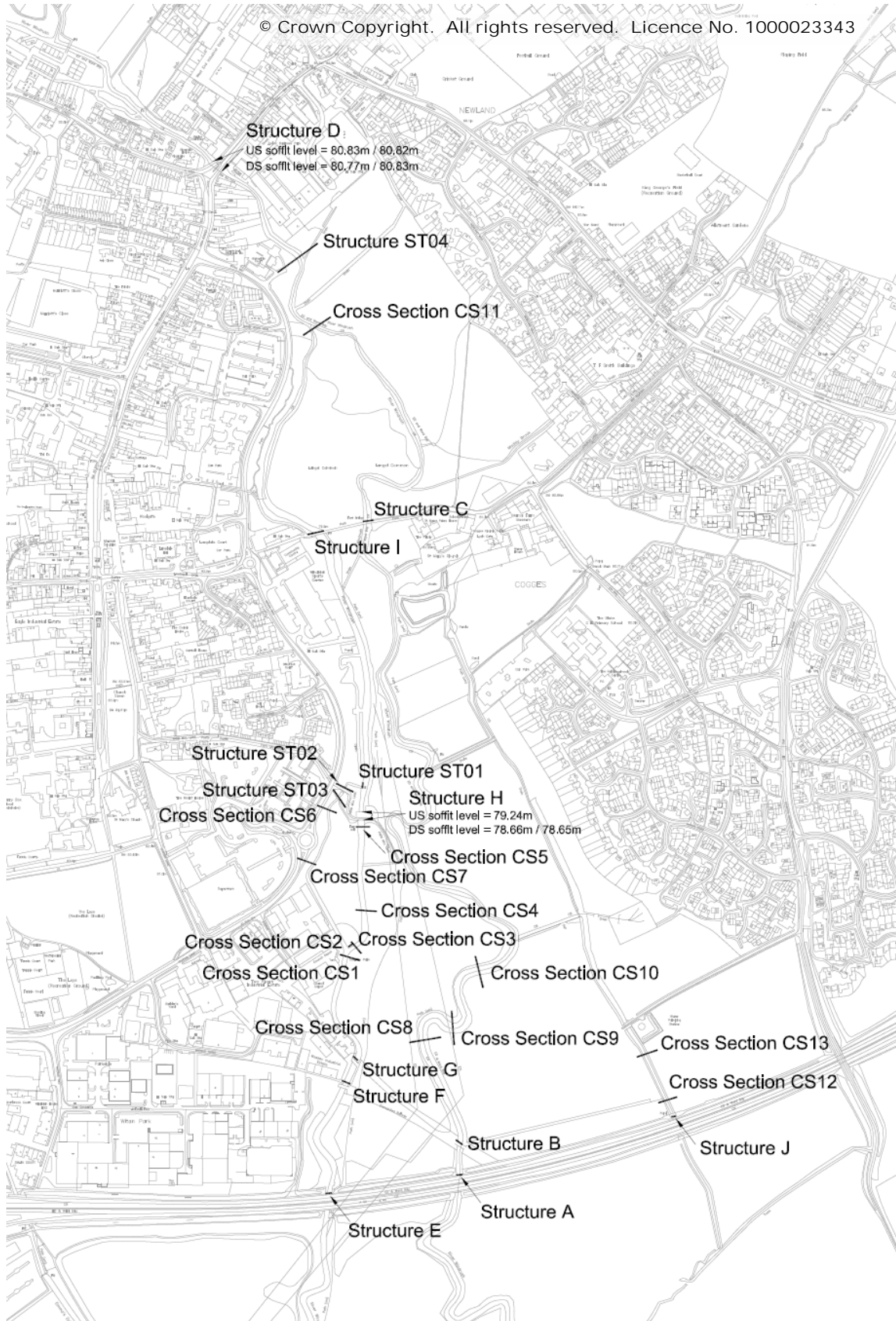
Levels for 2007 are based on OSGB36 using the OSGM02 transformation

Difference between OSGM02 and OSBM system calculated as mean difference observed between two local Ordnance Survey Benchmarks as below:

OSBM SP3577 1018	
Published height (m AD)	82.724
Observed OSGM02 height (m AD)	82.672
Difference (m)	0.052
OSBM SP3623 0970	
Published height (m AD)	80.880
Observed OSGM02 height (m AD)	80.807
Difference (m)	0.073
Mean difference (m) =	0.063

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Appendix 4

Cogges Link Survey Report

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Appendix 5

Worsham Flood Study Report

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Appendix 6

Flood Data from the Environment Agency

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Appendix 7

Jacobs Flood Observations

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Appendix 8

Hydraulic Model Development

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