Addendum to Strategic Flood Risk Assessment for Dacorum Borough Council, St Albans City & District Council, Three Rivers District Council and Watford Borough Council

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Three Rivers District Council

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Halcrow

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Document history

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1 Introduction

1.1 Background to study

A Level 1 Strategic Flood Risk Assessment (SFRA) was produced for Dacorum Borough Council, St Albans City & District Council, Three Rivers District Council and Watford Borough Council in August 2007 by Halcrow Group Ltd (see Reference 1).

Based on the Level 1 SFRA, Three Rivers District Council (the Council) identified that 17 of its potential development sites lie within flood risk areas. A Level 2 SFRA was therefore carried out during 2011-2012 by Halcrow Group Ltd for the Council to provide further detailed flood risk evidence to support its LDF plan-making process in respect to 17 sites (see Reference 2). As part of this work it was identified that insufficient flood modelling data existed for four of the sites, in Kings Langley along the River Gade.

Therefore in March 2012, Halcrow Group Ltd was commissioned to carry out a flood modelling study of the relevant length of the River Gade in order to provide the detailed modelling information. The Level 2 SFRA has been updated accordingly.

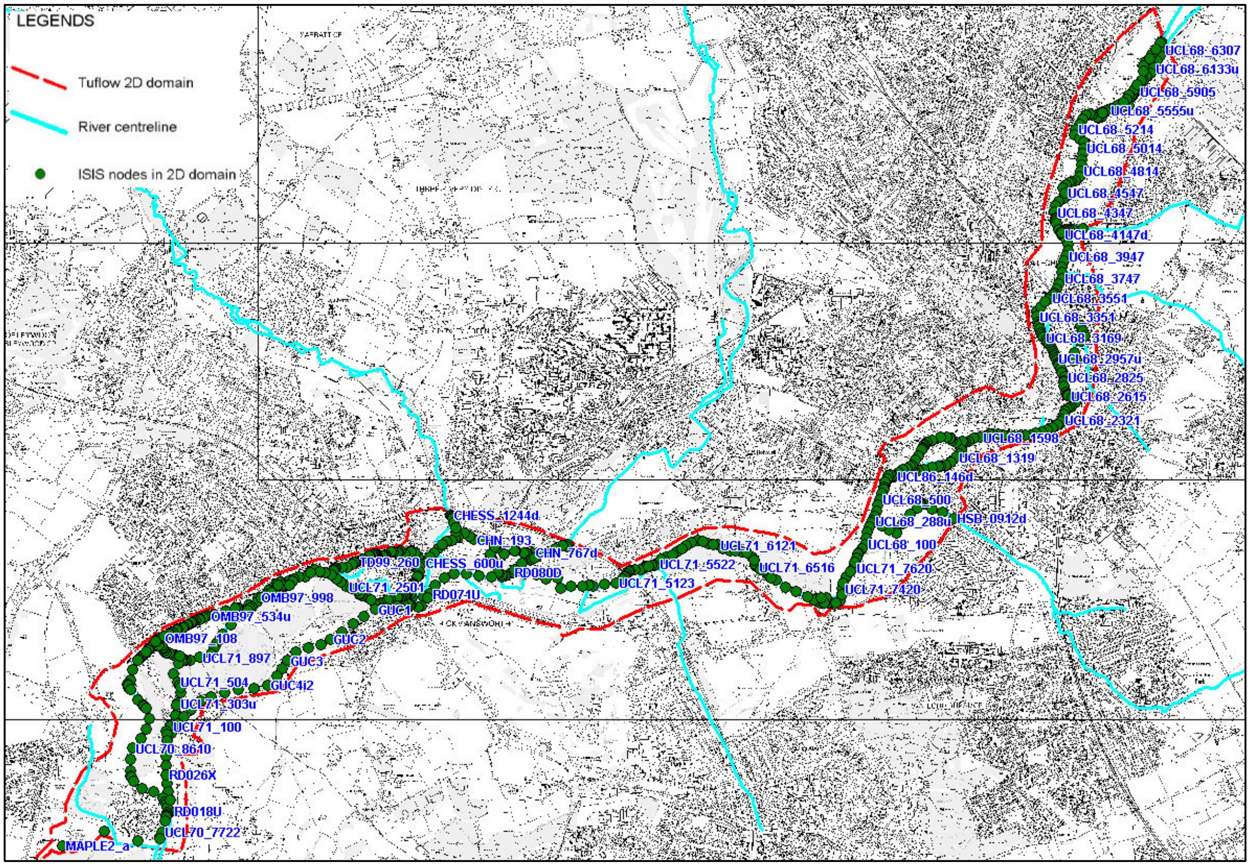
The purpose of this addendum is to feed the information back into the Level 1 SFRA in order to maintain it as an up-to-date evidence base. The new modelling has been used to update the SFRA flood zone maps, being provided to the Council in electronic format.

1.2 The flood zone maps beyond the Kings Langley area

In addition to the River Gade modelling commissioned for this project, another important change since the 2007 SFRA is that a modelling project was carried out along the Upper Colne (see Reference 3) in 2008-2011. The modelling extent covers the area shown in Figure 1-1. The flood extents from the Upper Colne modelling had already been incorporated into the Environment Agency's national flood map prior to work beginning on the Level 2 SFRA. Therefore the Council's updated SFRA flood zone maps incorporate both the River Gade modelling and the Upper Colne modelling.

The new flood zone maps will be used in place of the 2007 SFRA flood zones for future development planning.

Figure 1-1: River Colne Tuflow modelling domain

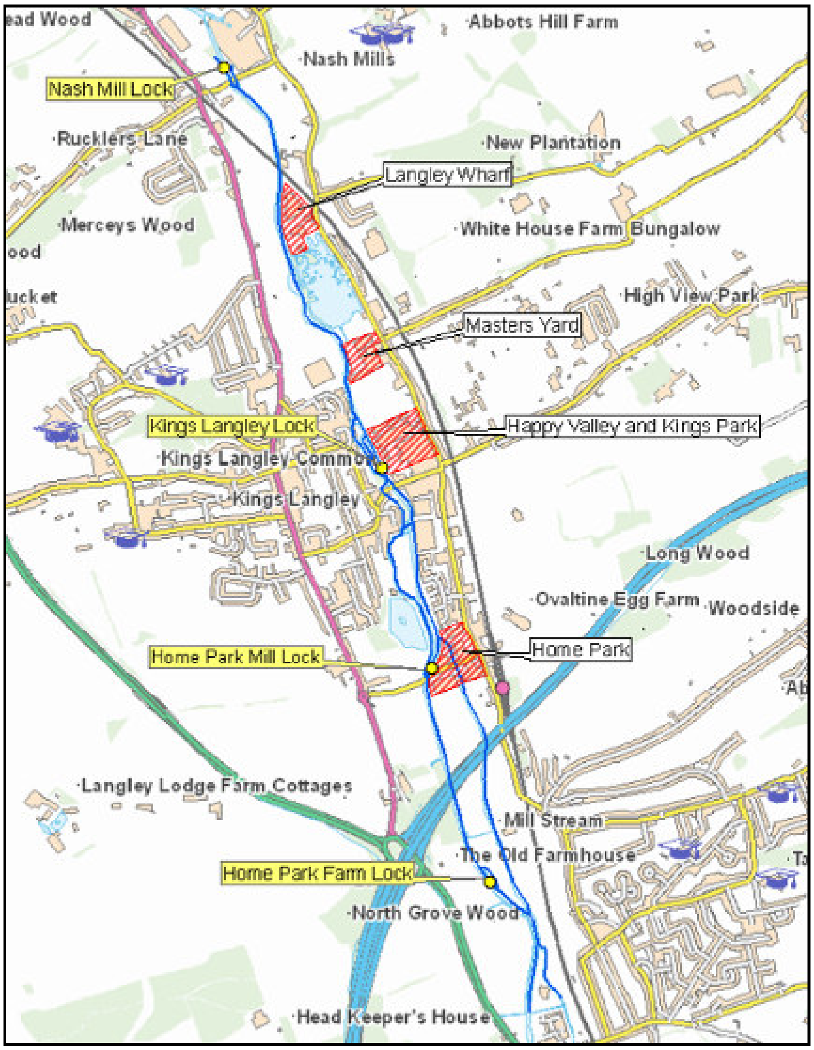


2 Study area

2.1 Study area

The study area encompasses the watercourse system that passes the four potential development sites in Kings Langley. The watercourses include the River Gade, the Grand Union Canal and a number of side channel reaches. Figure 2-1 shows a map of the modelled length of watercourses, with the four proposed development areas marked on.

Figure 2-1: Location plan



3 River Gade Model

3.1 Channel survey

A channel and structure cross section survey was carried out by Capital Surveys Ltd. The survey commenced in April 2012 and was completed in June 2012. The survey was used to gather details of river and structure profiles, including cross-sections of the river bed, the river banks and any structures in the river channel such as bridges, culverts and weirs. The survey extended from north of Kings Langley at Nash Mills (506990,204340) to approximately 3.5km downstream at Hunton Bridge (508170, 200990).

3.2 Hydrological Analysis

The hydrology used in the River Gade model is based on a previous modelling project, the Upper Colne SFRM Flood Modelling and Mapping Study, which was completed by Halcrow Group Ltd in 2011 (see Reference 3). The Upper Colne project included modelling of part of the River Gade, downstream of the four developments sites. Whilst the modelled channel was downstream of the sites, the analysis to determine inflows to the model included hydrological analysis of the whole Gade catchment.

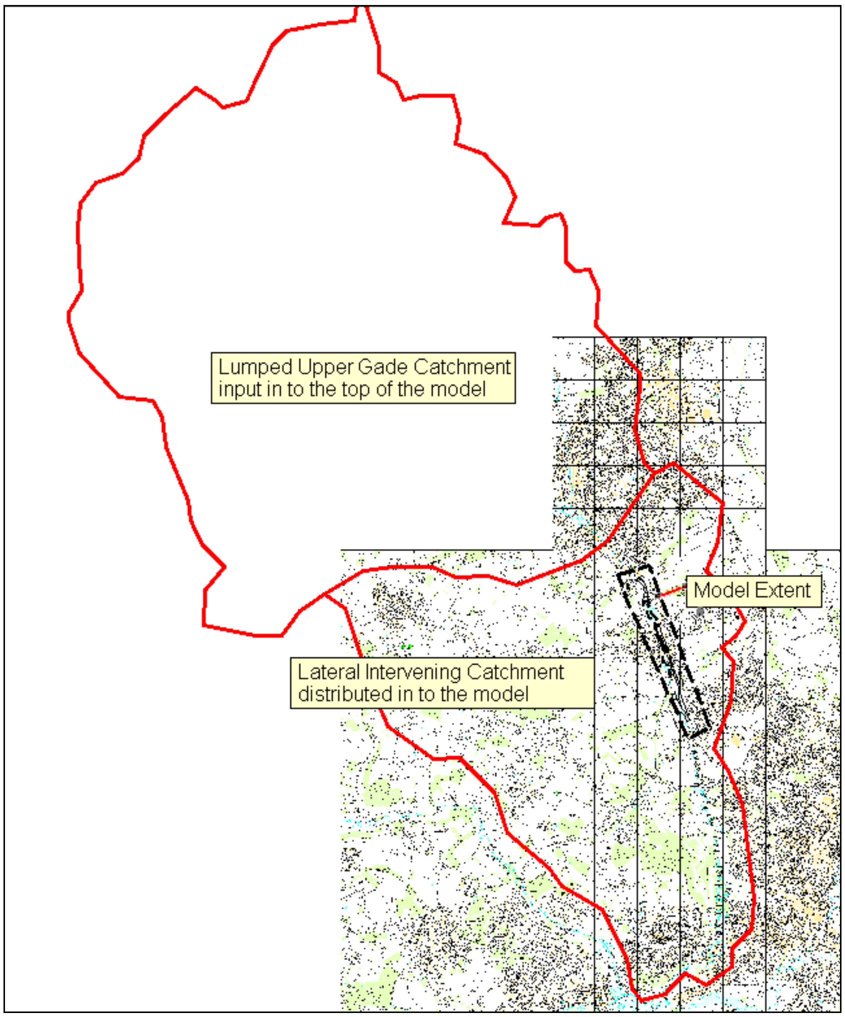
The Upper Colne hydrology was reviewed, which led to the following methodology being adopted for the River Gade model in this study:

- Statistical hydrological analysis was carried out on the River Gade at locations NGR 508105, 195013 (the Whole Gade catchment) and NGR 506154, 205186 (the Upper Gade catchment). The Upper Gade catchment location is sufficiently close to represent a suitable inflow into the top of the River Gade model. The remaining inflow which enters along the River Gade model intervening length was calculated based on the Whole Gade minus the Upper Gade area, defined as the Intervening Catchment.
- The Upper Colne hydrological analysis derived Qmed (the 1 in 2 year peak flow) for the Whole Gade catchment based on observed data from Croxley Green gauging station (Site id: 7188). The Upper Gade catchment is ungauged and therefore Qmed was derived using donor transfer from the downstream Croxley Green gauging station. These Qmed estimates were retained for this River Gade modelling study.
- However, given the low flood flows and likely onset of flooding, the Upper Colne flood frequency curve used to extrapolate Qmed to higher return period events was adjusted to a more conservative curve for the River Gade model (the Generalised Logistic rather than the Pearson III, with the 1 in 1000 year further scaled by the ratio of the ReFH 1 in 100 year and 1 in 1000 year).
- The Upper Colne modelling derived hydrograph shapes using the ReFH methodology. The parameters were calibrated to obtain a more accurate hydrograph shape, magnitude, volume and timing. The same donor correction factors derived from the calibration of ReFH model parameters were applied to the Upper Gade and Intervening catchment ReFH ISIS units in this River Gade modelling study.

- A critical storm duration of 10.25 hours was identified as appropriate for the River Gade model developed.

The catchment boundaries for the Upper Gade and Intervening catchment are shown in Figure 3-2, compared to the hydraulic model extent. The Upper Gade catchment is added to the model as a lumped inflow boundary, however, the Intervening catchment is added gradually down the model length using lateral inflow boundaries, with the distribution weighted based on assumed drainage areas and topographic assessment.

Figure 3-2: Catchment boundaries and model extent



3.3 Modelled scenarios

The model was run for the 1 in 2, 10, 20, 50, 75, 100, 200 and 1000 year return period events together with a 1 in 100 year climate change scenario.

3.4 Hydraulic model

The main objectives of the hydraulic model was to produce a stable hydraulic model capable of simulating design flows up to and including an event with a 1000 year return period for a food risk assessment of the four developments areas.

The initial approach to modelling was to develop a 1D in-bank model for the whole study area, using iSIS 1D modelling software. Approximately 3.7km of the Grand Union Canal has been modelled along with approximately 3 km of side channels. The water level at the canal is kept constant by means of structures such as weirs and locks.

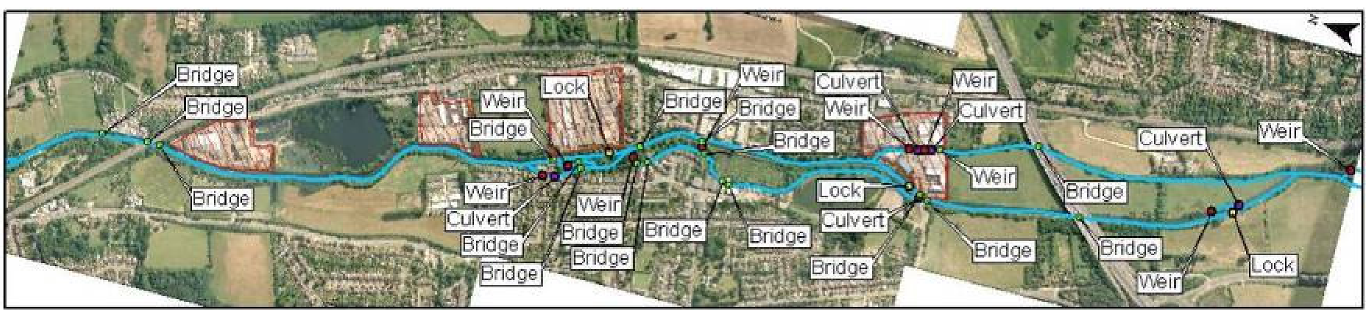
3.4.1 Construction of iSIS model

The iSIS cross sections to define the river channel were obtained from the survey data. In addition 'interpolate' and 'replicate' cross sections have been added to the hydraulic model to increase model stability and the accuracy with which the water profile is calculated. The location of the resulting cross sections are shown in Figure 2.3.

Figure 3-3: Channel cross sections

Structures such as bridges, weirs and locks were incorporated into the model using appropriate iSIS units. The iSIS unit parameters were obtained from the survey data. The structures are shown in Figure 2.4.

Figure 3-4: Location of structures in the study area



In selected locations the iSIS channel was augmented to include floodplain, modelled as either extended cross sections or Reservoir Units. The choice of floodplain unit was based on the hydraulic characteristics of the floodplains, e.g. flow direction, terrain characteristics and location of development areas.

- Extended cross sections have been used to model the floodplain at two locations: at the Allot Gardens between the River Gade and the Grand Union Canal, and between Home Park Mill Stream and the Grand Union Canal where the cross sections from the stream were extended from the right bank to the canal.

- Four ISIS Reservoir Units were used to represent the floodplains along the right bank of the Grand Union Canal, from the Home Park Mill lock to the downstream boundary. Floodplain Units were used to link flow between the Reservoir Units with the elevation-area curve for the Reservoir Units obtained from LiDAR data.

3.4.2 Boundary conditions

The inflows to the hydraulic model were added as a point inflow for the Upper Gade catchment at the upstream end of the model, and distributed lateral inflows for the Intervening catchment along the model reaches. Given the lack of a gauging station near the outfall of the hydraulic model developed, further reconciliation of the hydrological flows after hydraulic routing was not possible.

Downstream conditions at the GUC are controlled by the presence of the Old Mill House lock, a weir located at the divergence of the Hunton Bridge Mill Stream and the Grand Union Canal, and a second weir located on a bypass channel on the Old Mill House lock. The second weir is 690 m downstream of the last surveyed cross section in the model and thus no survey data was available for this structure. In order to obtain an approximate boundary, the weir was measured using Google Earth satellite images, and the elevation was approximated to produce a water level of 65.12 m which is the water level provided by the survey (for a 1m^3/s baseflow). The resulting weir elevation was of 65.00 m.

The approximated downstream boundary may lead to an overestimation of the water levels at the Grand Union Canal in the vicinity of the downstream boundary since it does not take in to account the volume of water that could overflow between the estimated location of the weir and the actual location of the weir. This is considered to be a conservative approach and is as such acceptable.

Further consultation with the Environment Agency agreed that due to the uncertainty with the assumed downstream boundary, any site specific flood risk assessments from this downstream boundary up to the M25 (~700m upstream) should gain additional channel and structure information to increase confidence in peak flood estimates. With respect to the updated Flood Zones produced, the right bank of the Grand Union Canal in this region retains the conservative JFLOW derived flood extent.

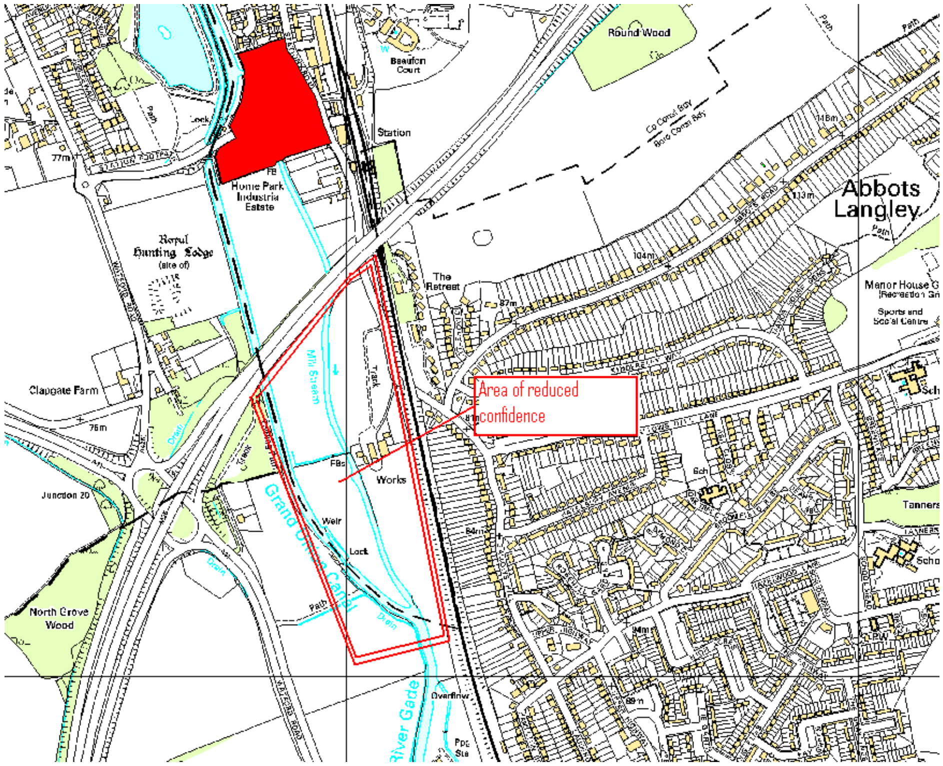


Figure 3-1: Area of reduced confidence

3.4.3 Calibration

No data was available to calibrate the model (lack of a gauging station near the outfall of the hydraulic model developed, or observed flood extents). However, modelled water levels in the Grand Union Canal (GUC) (for 1 m^3/s base flow) have been compared to the water levels gathered during the channel and structure survey. The variation of water levels between the surveyed levels and the model initial conditions (base flow) are shown in Table 3-1 below:

Table 3-1: Base flow validation

	Water level for 1m³/s base flow (mAOD)	Survey water level (mAOD)	Difference (m)
GUC - Upstream of Kings Langley Lock (reach 4)	71.67	71.69	-0.02
GUC - Upstream of Home Park Mill Lock (reach 3)	69.00	69.00	0.00
GUC - Upstream of Home Park Farm Lock (reach 2)	67.34	67.32	0.02
GUC - downstream of Home Park Farm Lock (reach 1)	65.14	65.13	0.01

Although this comparison may not allow comment on the accuracy of the hydraulic model to represent high flood flows, it does demonstrate the model represents the in-bank hydraulic features correctly. Given the relatively low flood flows for the chalky Gade catchment, this also provides some confidence in the routed flood flows.

3.4.4 Model stability

The stability of the model was checked using non-convergence analysis. This indicated that for the majority of the events, there are no model convergence issues indicating that the model is numerically stable. Where non-convergence does occur, it is for less than 1% of the model run time and occurs outside of the peak of the flood event. Therefore, the instabilities encountered are minor and within normal bounds for hydraulic models and do not affect the accuracy of the model results.

3.4.5 Sensitivity analysis

Sensitivity analysis investigates the sensitivity of model results to the uncertainty in values of model parameters that have been estimated or assumed. This provides an indication of how important individual model parameters are in determining model behaviour and the extent of flood inundation. The sensitivity analysis was undertaken for the 1 in 100 year event to test the sensitivity of the model to channel and floodplain roughness and spills and weir coefficients. Based on the sites investigated the model was not found to be sensitive to these parameters.

3.4.6 Freeboard

The freeboard in some cross sections of the Grand Union Canal is lower than 0.2 m for the 1 in 100 year event. The recommended freeboard for flood defences is 0.5 meters (though this would not be expected to be achieved for the 1 in 1000 year event). There is no specification for canal freeboards. It is recommended that a full top of bank survey along the Grand Union Canal is undertaken to check that there are no low points in the bank level that are not reflected in the survey cross sections and hence improve confidence in the model results. However, it is recognised that gaining this information is beyond the scope of a strategic mapping study, but may should be considered for further assessment during any future site specific assessments.

Further details on the River Gade modelling are available in the modelling report (see Reference 4).

4 Flood Mapping

4.1 Flood extents

GIS flood extents were produced from the model results. These are shown in Figure 4-1 (available as separate A3 map) for the 1 in 20, 100 and 1000 year return periods, which correspond to Flood Zones 3b, 3a and 2, respectively. As noted previously, there are no identified raised defences in the River Gade model and thus no distinction of defended and undefended scenarios.

4.2 Comparison with previous SFRA flood zones

The new flood zones from the River Gade modelling were compared to the previous Level 1 SFRA flood zones, to assess the main areas of difference. Only Flood Zone 3a and 2 were compared as no Flood Zone 3b existed for the previous SFRA.

In the upstream reaches, the new flood zones were considerably less extensive as both Flood Zone 3a and 2 remained in bank, whereas for the previous SFRA flooding occurred along most of the watercourse length.

For the downstream reaches the River Gade modelling showed some flooding, mainly on the west bank of the river, but this was generally much less extensive than the previous SFRA flood zones. However, there were a few areas where the River Gade modelling showed more extensive flooding than the previous SFRA flood zones:

- For Flood Zone 3a the River Gade modelling showed more flooding across the M25 motorway.
- For Flood Zone 2 the River Gade modelling showed more flooding across the M25 motorway and in the fields to either side of the motorway. The River Gade modelling also showed a small amount of flooding on the west bank of the river at Mill Lane which did not occur in the previous SFRA modelling, although this did flood elsewhere in the vicinity.

NOTE/ The flooding of the M25 shown in the new floodmaps, represents flooding of the floodplain underneath M25 which is raised above the platform on numerous columns. The M25 which is at a significant height is not expected to flood and this should be noted when assessing the floodmaps for emergency planning purposes. Previous modelling does not show flooding of this floodplain area due to false blockages within the DTM being incorrectly retained within the model potentially resulting in an overestimate of flooding upstream of the M25.

The increase in flooding at Mill Lane is relatively small and does not inundate any properties. This out of bank flooding may not actually occur and could be confirmed by comparing the bank elevation at this point with the modelled peak water levels.

These out of bank modelled flood incidents are illustrated in Figures 4-2, 4-3 and 4-4.

The River Gade modelling did not cause flooding of any of the four proposed development sites by any of the flood zones and as such would recommend that all the identified development areas be re-classified as being within Flood Zone 1.

Figure 4-2: Flood Zone 3 at motorway

Figure 4-3: Flood Zone 2 at motorway

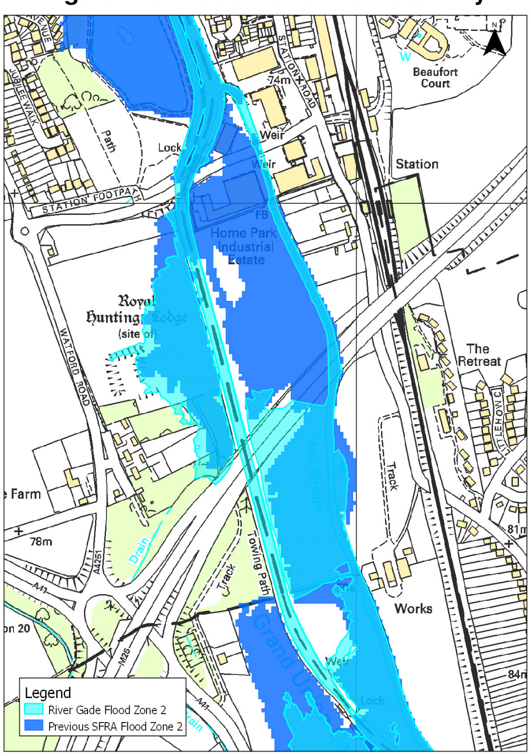
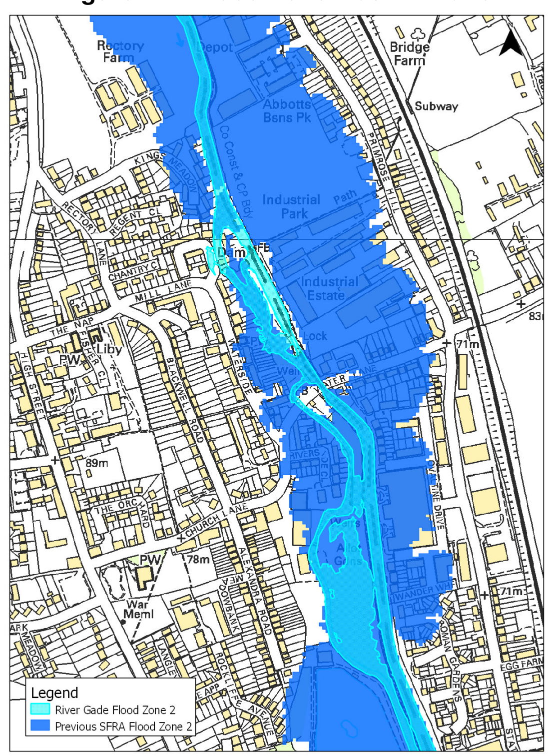


Figure 4-4: Flood Zone 2 at Mill Lane



4.3 Depth, Velocity and Hazard mapping

It was intended that the next stage of hydraulic modelling would involve coupling the iSIS model with Tuflow software to model the floodplains. Tuflow is a form of 2D modelling software which enables representation of complex floodplain flow paths and provides outputs from which maps of depth, velocity and hazard can be created. However, based on the results from the 1D model for the 1000 year return period event, it was not necessary to develop a 2D Tuflow model of the floodplain as none of the development areas were shown to be at risk of fluvial flooding.

4.4 Updated Flood Zones

As discussed in Section 1, the SFRA flood zones have been updated to incorporate the latest modelling. To summarise, the flood zones are as follows:

- **Flood Zone 2:** uses the Environment Agency's flood zone 2 map downloaded from the Datashare website in July 2011. This incorporates the Upper Colne detailed modelling; elsewhere the flood extents are from JFlow. The Environment Agency's flood zone has been modified to update it with the River Gade 1 in 1000 year flood extent. Note/Towards the downstream boundary of the new Gade modelling, the conservative JFLOW extents have been retained for the right bank floodplain of the Grand Union Canal.

- **Flood Zone 3a:** uses the Environment Agency's flood zone 3 map downloaded from the Datashare website in July 2011. This incorporates the Upper Colne detailed modelling; elsewhere the flood extents are from JFlow. The Environment Agency's flood zone has been modified to update it with the River Gade 1 in 100 year flood extent. Note/Towards the downstream boundary of the new Gade modelling, the conservative JFLOW extents have been retained for the right bank floodplain of the Grand Union Canal.

- **Flood Zone 3b:** No flood zone 3b is available from the Environment Agency. A 1 in 20 year flood extent is available from the River Colne modelling results and the River Gade modelling results for their respective areas. For the remaining areas, it is recommended that flood zone 3b is assumed to be as large as flood zone 3a as a precautionary approach.

4.5 Future Flood Risk Assessments on the River Gade

As mentioned in Section 3.4.2 and shown in Figure 3-1, any future site specific flood risk assessments from this downstream boundary up to the M25 (~700m upstream) should gain additional channel and structure information to increase confidence in peak flood estimates.

5 References

1. Dacorum Borough Council, St Albans City and District Council, Three Rivers District Council, Watford Borough Council Strategic Flood Risk Assessment, Halcrow Group Ltd, August 2007

2. Three Rivers District Council Strategic Flood Risk Assessment for Flood Risk Sites, Halcrow Group Ltd, in progress

3. Upper Colne SFRM Flood Modelling and Mapping Study (TH769,TH013), Halcrow Group Ltd (2008-2011)

4. Level 2 SFRA – River Gade Modelling, Three Rivers District Council, Halcrow Group Ltd, July 2012

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