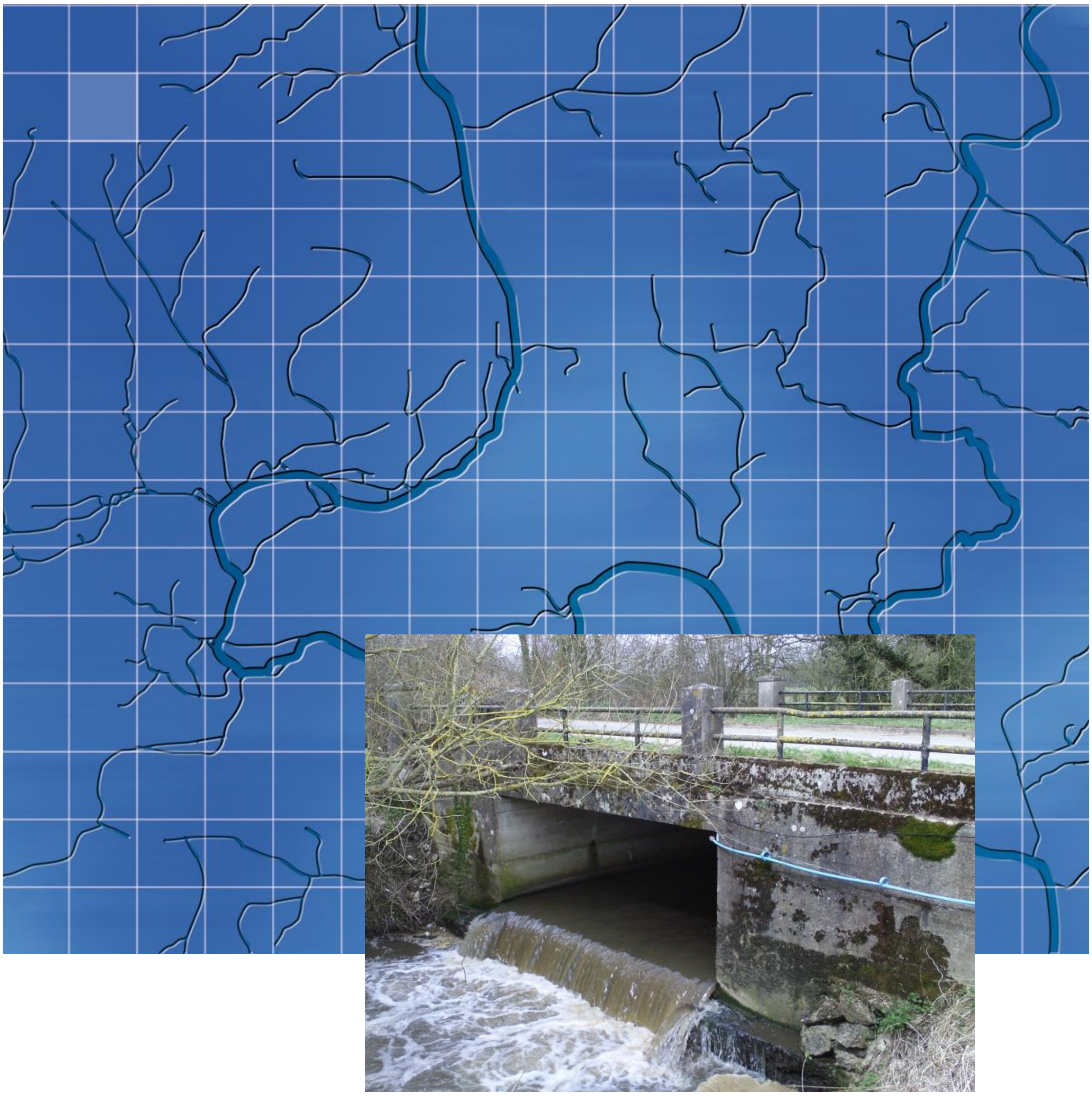
**Network Rail**

January 2014

# Langford Lane – Hydraulic Model Report



Wallingford HydroSolutions Limited

# Network Rail

# Langford Lane – Hydraulic Model Report

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For and on behalf of Wallingford HydroSolutions Ltd.

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Approved by P. Blackman
Position *Technical Director*

Date **24th January 2014**

# Contents

# 1 Introduction and Background

## 1.1 Purpose of the Report

Wallingford HydroSolutions (WHS) has been contracted to provide hydrology and flood modelling on behalf of Chiltern Railways and Network Rail, to inform a Flood Risk Assessment for proposed essential infrastructure works along the Bicester to Oxford Railway line.

This report will assess flood risk to, and as a result of, development taking place and will accompany the Flood Risk Assessment submitted as a requirement of the conditions of the Transport and Works Act Order. The proposed works include the construction of a new road and bridge over the existing railway line, the planned route of which crosses a number of watercourses.

Flood risk to the site needs to be considered in order to assess whether the proposed development will have any impact on third-parties. If significant impact is found, mitigation measures will be considered and tested for appropriateness to reduce this risk.

## 1.2 Background

### 1.2.1 Site Description

The proposed works centre around Langford Lane, located to the south west of Bicester town centre (457796, 220338). The surrounding area downstream of the railway embankment is predominantly farmland, a mix of pasture and agriculture. Figure 1 provides an overview of the land use in the surrounding area.

A number of watercourses are found within the study area. The Langford Brook is the dominant watercourse, which passes through the site joining the River Ray approximately 5km downstream. The Langford Brook has a number of tributaries, the Gagle Brook, Wendlebury Brook and Merton Ditch. A sketch of the watercourses in the area of interest is provided in Figure 1.

There are several flow routes through the catchment that are complex in nature with a number of drainage ditches linking watercourses which would otherwise not be connected. One example is the un-named watercourse, which links the Gagle brook to the lower reaches of Langford Brook. These additional flow networks are considered in more detail later in the report.

Based on ground observations and ground profiles across the area, it would appear that the Langford Brook does not follow its natural route, but has been diverted in the past. As a result, the banks of the Langford Brook are marginally raised above the surrounding area in a number of locations. It is thought that the original route of the Langford Brook would have been more in line with that taken by the un-named watercourse.

Current Environment Agency Flood Maps suggest that the area is at risk of flooding during the 1 in 100 year plus climate change and 1 in 1000 year events. It has been confirmed by the Environment Agency that this flood mapping is based on JFLOW modelling, with flood mapping upstream of the railway embankment to the north west of Langford Lane being based on more detailed modelling techniques. Figure 2 shows an extract from the Environment Agency Flood Maps available online.

There are no formal defences within the study area, although as stated earlier the watercourses do have raised banks.

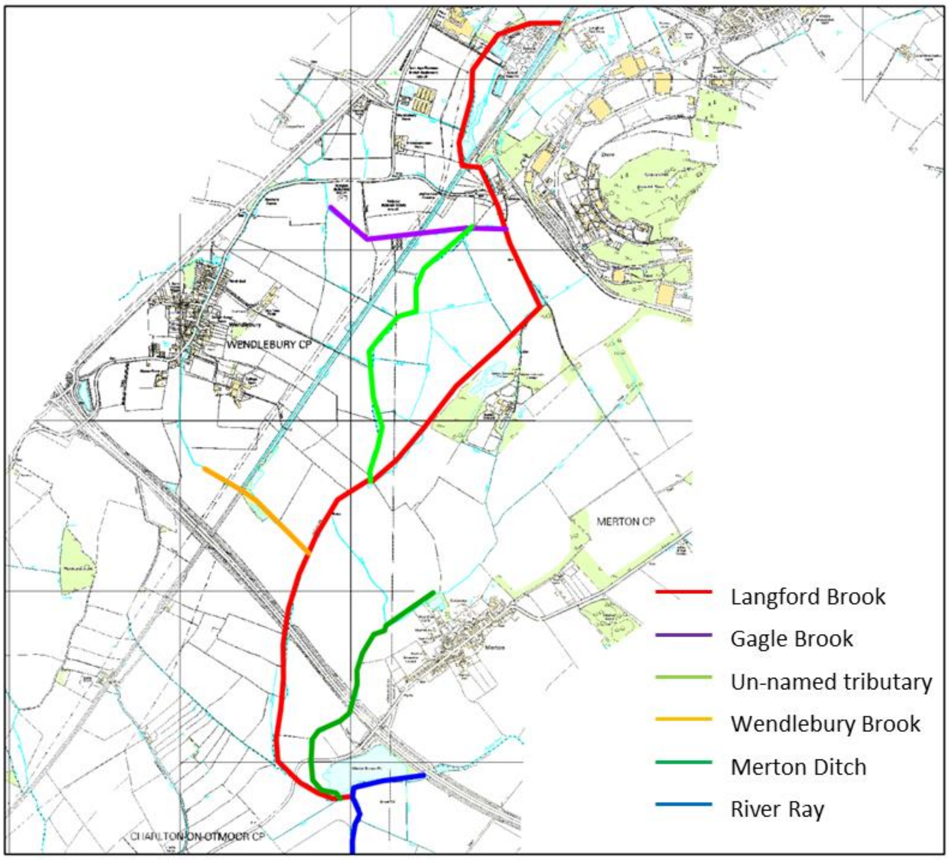



**Figure 1 – Overview of land use and watercourses in the study area**

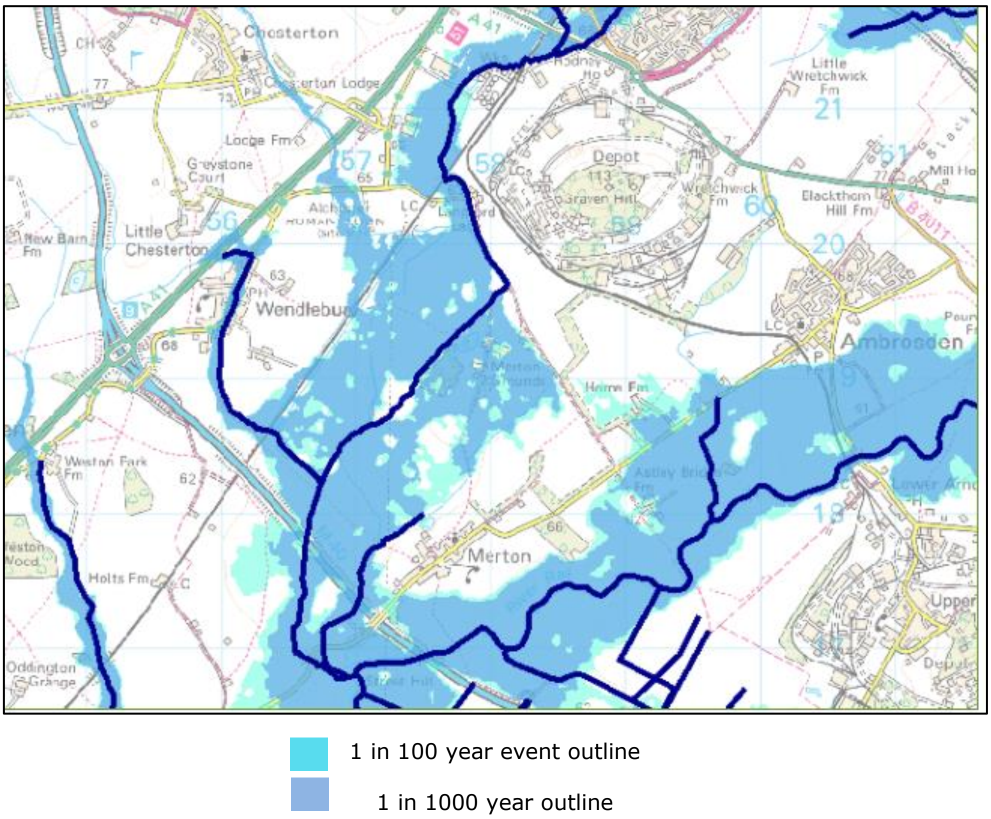



**Figure 2 – Extract from the Environment Agency flood map (available online) showing extensive flood extent in the area.**

### 1.2.2 Development Proposal

As part of the proposed railway upgrade works between Bicester and Oxford, there is a requirement to close the level crossing at Langford Lane. As a result, a new access road is required in order to allow access to a number of houses and stable units that are currently served by the existing crossing. The proposed works involve the construction of a new carriageway across existing farmland, a bridge over the railway to the south of the existing level crossing, as well as three bridges across watercourses.

Due to the archaeological sensitivity of the area, the carriageway will be raised above the floodplain. This is required in order to preserve potential archaeological in-situ deposits. Figure 3, outlines the proposed road alignment.

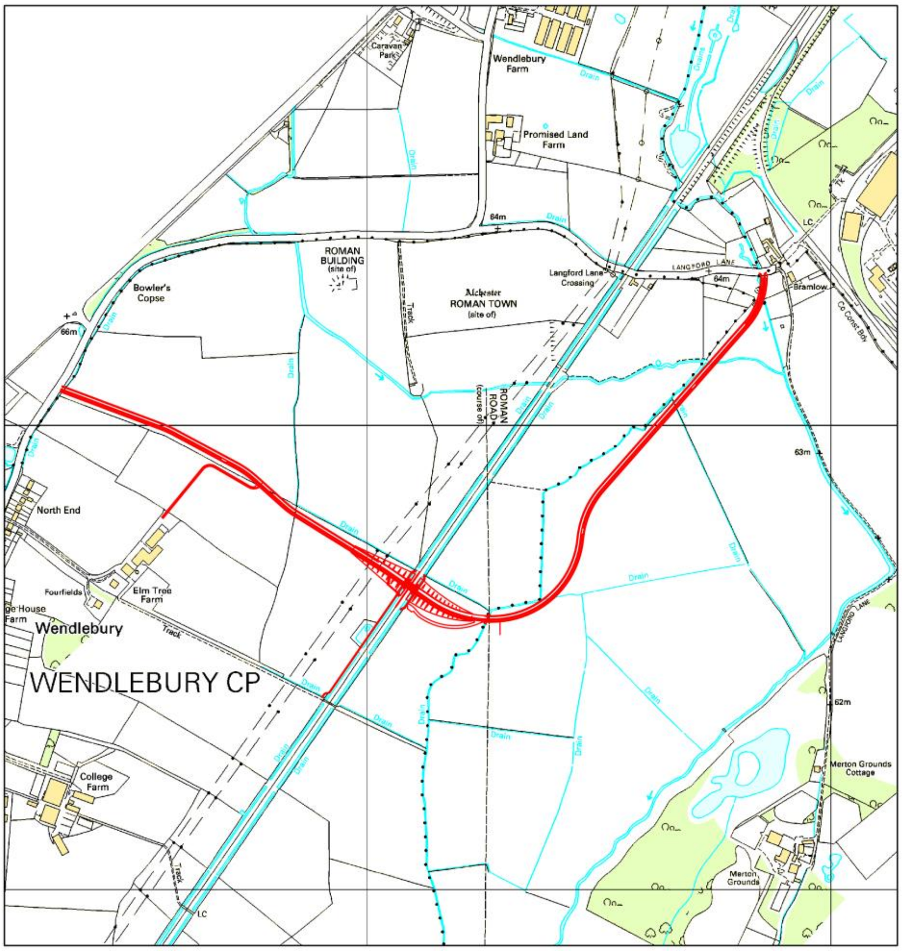



**Figure 3 – Proposed alignment of Langford Lane, following closure of existing level crossing, (proposed works shown in red).**

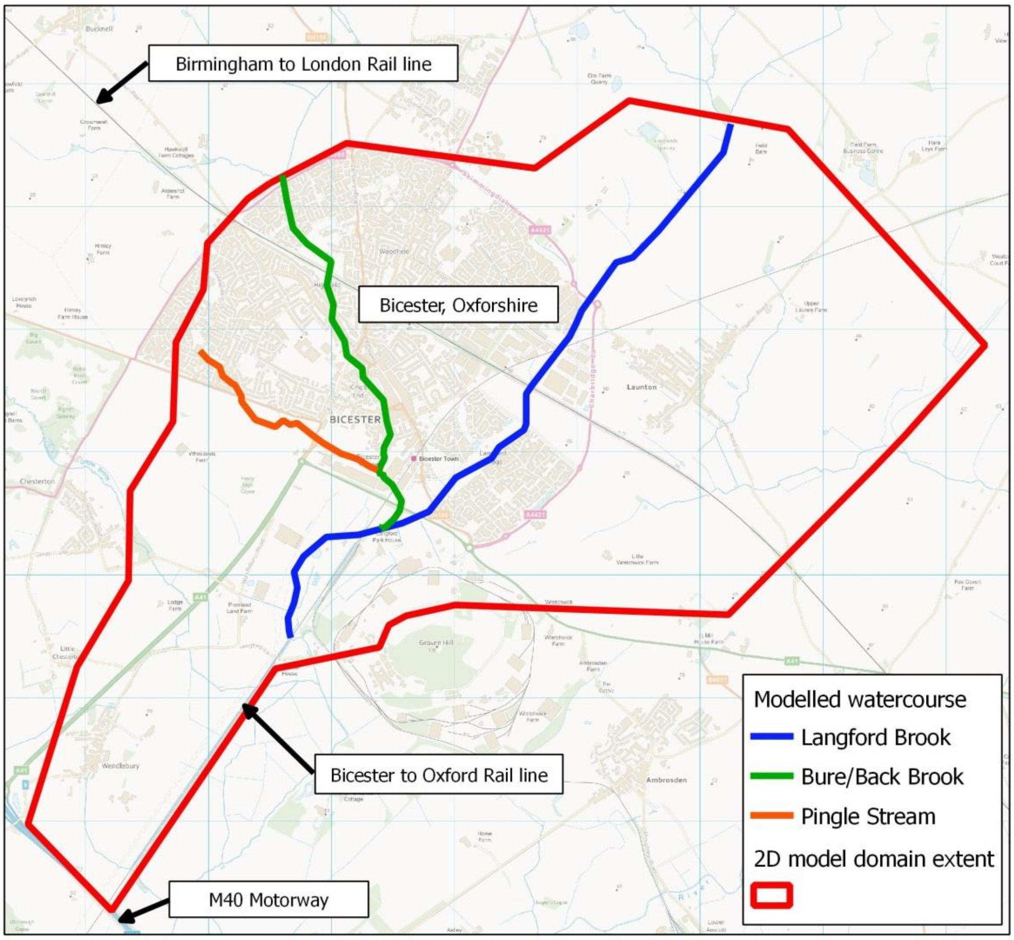
## 1.3 Previous model study

In 2009 Peter Brett Associates LLP (PBA)[1] were commissioned by the Environment Agency to undertake hydraulic modelling for watercourses found to pass through the town of Bicester, Oxfordshire. This modelling was undertaken under the Strategic Flood Risk Mapping framework to create flood risk maps of the town and to gain a better understanding of the risk in this area.

The hydraulic model was a fully integrated 1D/2D model using ISIS-TUFLOW modelling software (ISIS version 3.1, TUFLOW version 2008-08-AH-isp). The project modelled a number of watercourses in the

[1] Peter Brett Associates. 2009. Bicester Flood Risk Mapping Study.

Cherwell Catchment; these were the Langford Brook, Pingle Stream, Bure/Back Brook. These watercourses run through the main town, as highlighted in Figure 4.




**Contains Ordnance Survey data © Crown copyright and database right 2013.**

**Figure 4 – Peter Brett Associates (2009) - Bicester Flood risk mapping study, model extent.**

The model was reviewed by the Environment Agency at the time of completion, and was found to be appropriate for use in flood risk mapping. The mapping produced by this model is currently being used by the Environment Agency as flood risk mapping for the area. The model grid size used within this model was 10m. The current model extent does not include the area of interest for this study. The downstream extent of the PBA model is the railway line upstream of Langford Lane as shown in Figure 4. As a result additional hydraulic modelling is required to allow this study to analyse flood risk to and as a result of the development.

A full copy of the original model and model report is available from the Environment Agency on request.

## 1.4 Other data used within this study

### 1.4.1 River Section Survey

In order to construct the 1D element of the extended hydraulic model a river channel survey was undertaken. The survey was carried out by Interlock Surveys Ltd in spring 2013. The catchment is very flat and through a site walkover undertaken in summer 2013 it was noted that the channel dimensions are relatively consistent. Locations of survey sections and the sections themselves are provided within Appendix 1.

### 1.4.2 LiDAR Data

LiDAR data were used to build up a ground profile representation within the 2D model extent. The LiDAR data were provided by the Environment Agency, through the Geomatics Team. LiDAR data at 2m horizontal resolution was adopted for this hydraulic model. The vertical accuracy of the LiDAR provided is ±0.15m.

# 2 Hydrological model

The hydrological modelling has been undertaken by WHS for use within this hydraulic model. This report is included alongside this report as a separate document[2]. As such, no further detailing of the hydrological assessment will be made within this hydraulic model report. The location of the inflow and downstream boundaries are however discussed within section 3.3.1.

However, the hydrological study has highlighted that the hydrology used in the existing PBA model is likely to be very conservative.

The PBA study provided QMED values (the median flood, which is used to scale the peak flow estimates) at each site which are higher than the 68% confidence limits associated with estimating the QMED using the standard methodology for ungauged rural catchments within the Flood Estimation Handbook (FEH). This indicated that the QMED estimates (and subsequent peak flows for given return periods) derived from the PBA data are likely to be conservative.

This difference has also been highlighted in the Environment Agency's review of the modelling work undertaken to assess the impacts of the Bicester Chord carried out by JBA[3].

Since the modelling work undertaken to inform this study is based on scaling the original PBA hydrology to obtain peak flows, it is likely that the predicted flood outlines are conservative.

# 3 Hydraulic model

## 3.1 Introduction and methodology

The scope of modelling work was set out in a number of discussions and email communications with the Environment Agency, these are included within Appendix 4. As outlined previously, the current Environment Agency hydraulic model does not extend to the development site; rather, its downstream boundary is set at the railway embankment upstream at NGR: 457673,220495.

As the proposed works are downstream of this site an extension to the existing model was required. The existing Environment Agency model is an ISIS-Tuflow 1D-2D model with a 10m cell resolution. We decided to develop a model with a 2m horizontal resolution in the 2D domain in order to allow for modelling of proposed development features and potential mitigation measures. As a result, it was considered appropriate to trim the existing model in order allow conversion to a 2m cell resolution and to reduce the model size.

The 2m grid resolution, will allow the development features (i.e. roads etc.) to be mapped and modelled more accurately, and therefore allow for a more accurate assessment of their true impacts on flood risk and levels across the wider area.

As the current Environment Agency model consists of a 1D-2D hydraulic model, it was considered appropriate to use the same modelling software in order to undertake this assessment. ISIS – TUFLOW, allows a detailed assessment of both 1D (in channel) flow patterns, levels, velocities but also allows greater analysis of 2D (floodplain) flow routes, flow patterns and flood depths. The combination of 1D-2D allows a better overall understanding to be gained of how the river catchment operates holistically,

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[2] WHS. 2013. Langford Lane Hydrology Report
[3] JBA. 2013. Bicester FRA Review. Ref:2012s6055.

allowing the modeling of different parts of the catchment which could not be undertaken using only one type of modeling method. The combination of open-channel assessment, alongside, overland flow enables a more integrated approach to modeling.

## 3.2 Model extent and critical watercourses

The model is a combination of existing Environment Agency model, and a new area extending the model downstream. As previously stated the Environment Agency model has been trimmed. Figure 5 outlines the extent of the model, and highlights the "new" and "existing" model areas.

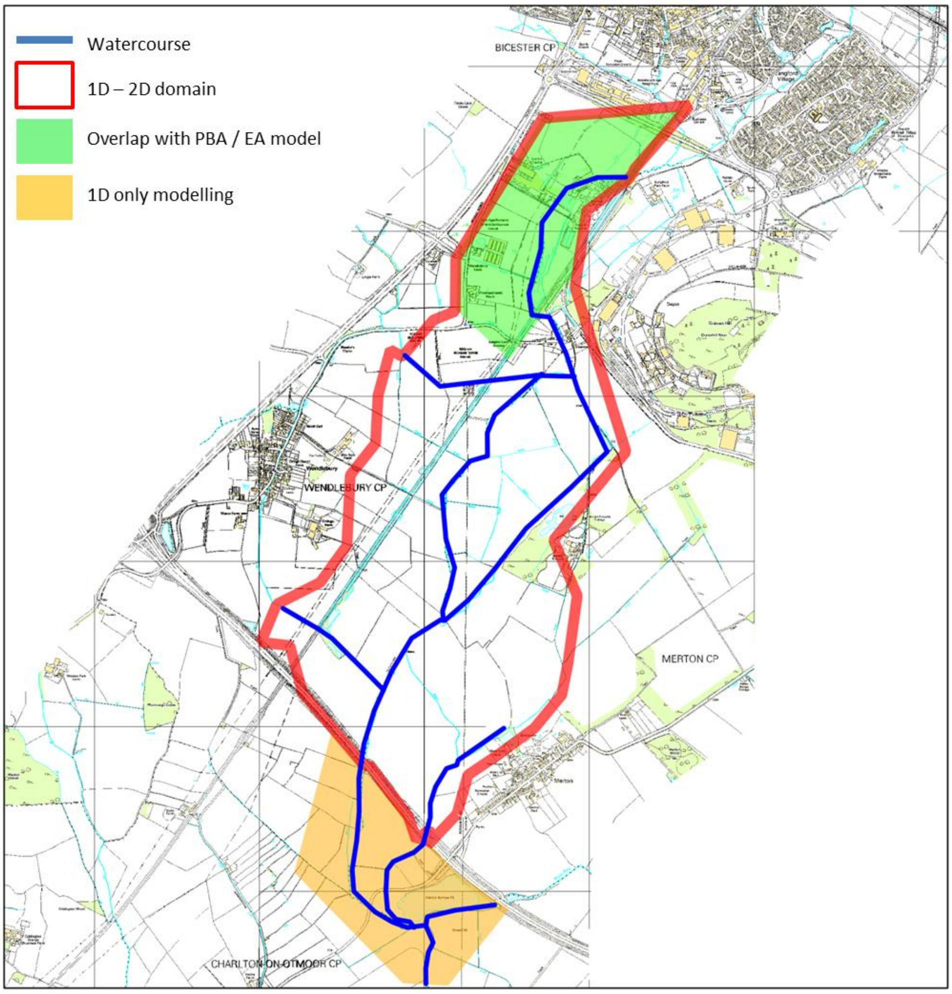


**Figure 5 – WHS Model, model domain schematic**

In total, 6 watercourses were modeled by this study. Table 1 outlines the watercourses, along with the upstream and downstream grid reference to mark the model extent. Figure 1 shows the relationship between each of the watercourses, and allows for an overview of what the study is modeling.

**Table 1 – Watercourse extents modelled by this study.**

| Watercourse | Upstream | Downstream |
|---|---|---|
| Langford Brook (existing) | 458251,221335 | 457674,220497 |
| Langford Brook (extension) | 457674,220497 | 457005,216799 |
| Gagle Brook | 456863,220264 | 457896,220114 |
| Wendlebury Brook | 456122,218739 | 456750,218226 |
| Merton Ditch | 457748,218150 | 456937,216785 |
| River Ray | 457458,216915 | 457001,216192 |
| Un-named Watercourse | 457718,220124 | 457107,218669 |

To summarize, a 1D-2D hydraulic model will be undertaken to allow consideration of the impacts of proposed development works at Langford Lane. ISIS version 3.6.0.156 will be used as the 1D modeling package. TUFLOW version 2012-05-AE-iDP-w64 will be used as the 2D component. The 1D element of TUFLOW (Estry) was used to model culverts within the flood plain at a number of locations; this is discussed in more detail within the structures section of the report.

As all potential overland flow will return to the channel at the motorway embankment, modelling downstream of the motorway embankment was undertaken in 1D only.

The downstream boundary was set at the River Ray to allow the model to test different scenarios and the sensitivity of flood levels in the floodplain upstream of the motorway to flood levels in the River Ray. Sensitivity analysis showed that the Ray is not the dominant flood mechanism at the Langford Lane. Details of this analysis are provided within section 3.7.

## 3.3 1D Modeling

As stated the assessment of in stream flood conditions was undertaken using ISIS (Halcrow, version 3.6.0.156) one dimensional unsteady state hydraulic model. The model comprised of survey sections provided by Interlock Surveys ltd. A 1D schematic of the model layout is presented in section 3.3.5. A model log outlining decisions and method for each cross section within the model is presented within Appendix 2.

As previously stated the existing Environment Agency model was trimmed, with the new model upstream boundary located at ISIS node LA.1350D (NGR458251, 221335). This was considered to be appropriate, located approximately 1.5km upstream of the development area. Figure 5 outlines the location of the boundaries used within the model.

### 3.3.1 Boundary conditions

Hydrological analysis was undertaken as outlined within the hydrology report. The associated hydrographs for each watercourse were applied at the upstream boundary of each watercourse.

The downstream boundary was located on the River Ray, on the downstream side of Fencott Bridge (NGR: 457001, 216192).The boundary was simulated as a normal depth boundary. Based on the slope of the River Ray, the boundary was set to a slope value of 0.001, or 1:1000.

### 3.3.2 River Channel cross sections

River channel cross sections were input into ISIS based on survey data provided by Interlock Surveys Ltd. To aid in model stability linkages between the 1D and 2D model domains a number of interpolated sections were added. River section dimensions are provided in Appendix 1. For more detail on the cross section at each 1D node, please refer to the model log provided alongside this report in Appendix 2. This outlines any assumptions and the method behind representation in more detail for each 1D ISIS node. The channel sections were surveyed after a long period of rainfall and as such the water levels recorded are not considered to be representative of base flow conditions.

### 3.3.3 Mannings 'n'

The resistance to flow in the channel and over the floodplain is replicated in the hydraulic model by the use of a roughness co-efficient. In this study Manning's 'n' was used as the roughness coefficient. The Manning roughness coefficients applied to the modelled channels and floodplains have been estimated from a site visit undertaken in September 2013 using tables of recommended values[4].

A Manning's 'n' of 0.035 was considered appropriate for the majority of the channel bed. Guidance from Chow[4] describes this value as representative of a clean, relatively straight channel, with no rifts or deep pools, with some stones and weeds. This is considered representative of the channel network in this location. The bed material of the channel is very fine and therefore this value is considered suitable. At a number of locations the in stream Manning's value was increased to 0.04 to reflect local changes in bed morphology.

In channel bank conditions were modelled with a manning's value that varied along the reach. Values of between 0.035 and 0.05 were used to reflect the local vegetation based on review of the site survey data, the September 2013 site visit and aerial photography. The in channel bank manning's values were based on both Chow[4] and the conveyance estimation system[5].

The original ISIS model sections adopted from the Environment Agency model used values of 0.05 to 0.06 for the channel sections. These values are considered to be relatively high for the channel type and its nature, in particular as the survey photos and site walkover confirmed that the bed and lower banks of the watercourses were relatively smooth with little or no cobbles.

A photo of a typical cross section is provided within Figure 6. This photograph is taken downstream of ISIS node LB4.

**Figure 6 – Typical channel cross section along the Langford Brook. This section is taken at LB4.**

[4] Ven Te Chow. 1959. Open-Channel Hydraulics. McGraw Hill. ISBN 0070107769
[5] Environment Agency. 2001. Conveyance Estimation System

### 3.3.4 Structures

Within the 1D model a total of 14 bridges, three culverts and one weir have been modelled. Table 2 outlines the split of these structures between watercourses.

**Table 2 – Total number and type of structure represented within the model by watercourse.**

| Watercourse | Bridge | Culvert | Weir |
|---|---|---|---|
| Un-named Tributary | 2 | 1 | - |
| Gagle Brook | 2 | - | 1 |
| Wendlebury Brook | 2 | - | - |
| Merton Ditch | 4 | 1 | - |
| Langford Brook | 3 | 1 | - |
| River Ray | 1 | - | - |

Each of the structures modelled is outlined in more detail within the model log in Appendix 2. This outlines how each structure was modelled and any assumptions that were made. Survey data for the sections are also provided within Appendix 1.

### 3.3.5 1D model schematic

Figure 7 shows the ISIS 1D model schematic, illustrating the overall construction of the 1D component of the model. Interpolated cross sections have been removed from the schematic for clarity. Junctions between structures and spills have also been removed; however the spills have been placed adjacent to their corresponding structure.

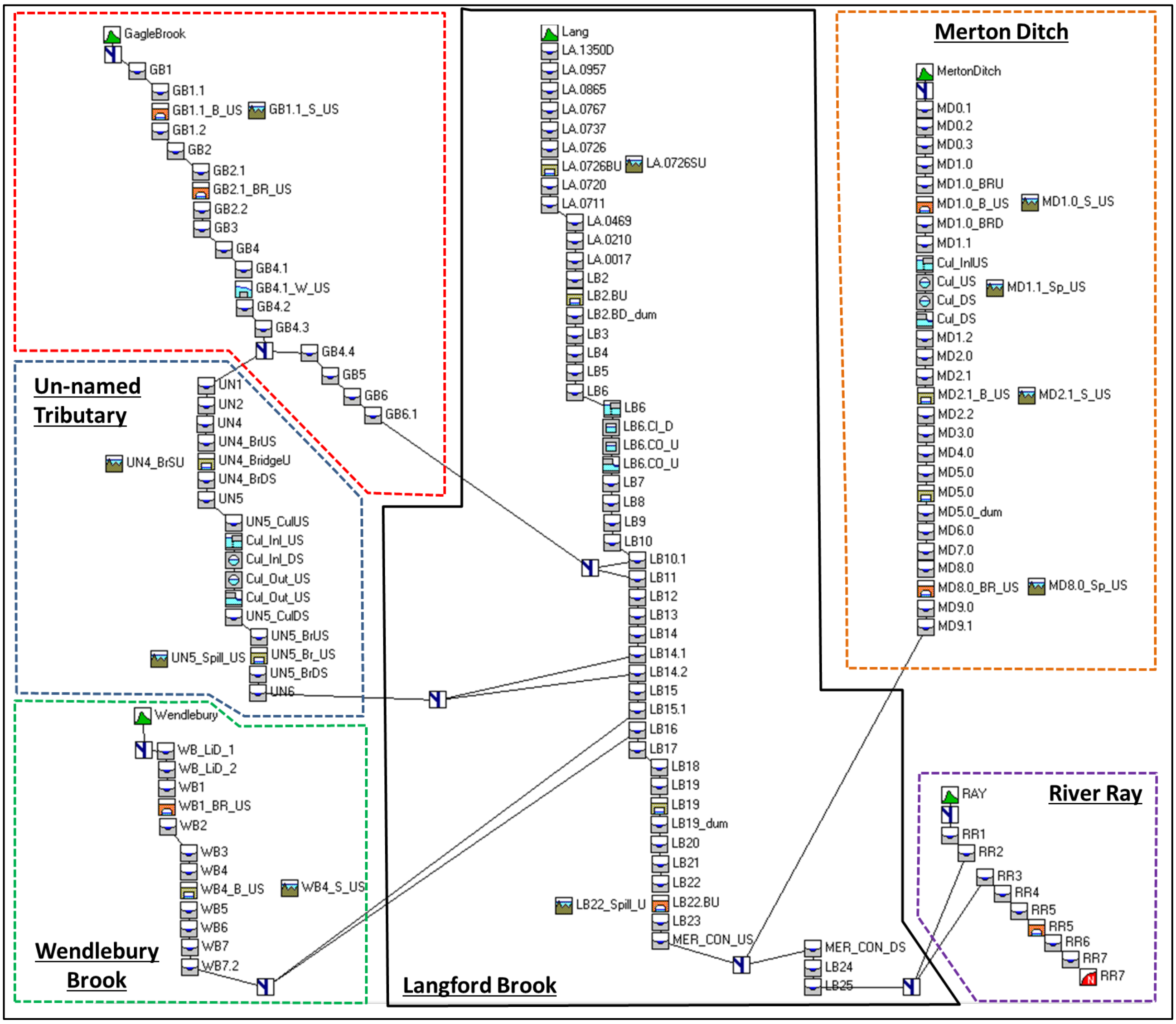


**Figure 7 – Schematic of 1D ISIS model, nodes are referenced to correspond with the cross sectional reference assigned by surveyors. The model log and survey output has been provided within the appendices for further information.**

### 3.3.6 Development – 1D alterations

No alterations to the 1D model were required to allow for the modelling of the proposed development. The proposed development has been designed to use clear span bridges and will therefore have no impact on in stream conditions, with soffit levels being set above the 1 in 100 year plus climate change level.

## 3.4 2D Modeling

2D modelling allows the flow of flood waters across the floodplain to be considered. Using 2D modelling, features such as buildings or a change in topography can be incorporated into a DTM (digital terrain model) of the floodplain. This allows for consideration of impacts caused as a result of development works (which alter the ground levels across an area). This study used 2D modelling in order to assess the change in flood depths, velocities, water levels upstream and downstream of the proposed Langford Lane works.

A number of files were used in order to build up a digital representation of the floodplain and the potential flood routes that exist. Additional topographical layers were added to alter the digital terrain model, with proposed post-development levels. The construction of the 2D domain is considered in the following sections.

TUFLOW was used as the 2D model package. The 2D model component was run using a 2m grid cell size, which is small enough to allow for 2D flood plain features such as the proposed road works to be represented accurately.

### 3.4.1 Floodplain topography

Lidar data was used as the underlying topographic data, for representation of the floodplain. A 2m resolution data set was used, and converted to a 2m model grid. Flood plain extent was considered to be relatively large in this area, as the topography is very flat. As a result, a large 2D code polygon (defining the active area for modeling to occur) was used. This reduces the risk of glass walling occurring. Figure 8 highlights the area of 2D model extent.

A number of topographic features were added to the 2D model that had been removed from the LiDAR during the filtering process. Bridge decks were represented within the 2D domain at a number of locations. The locations of these structures are identified within Figure 8.

Modeling the spills within the 2D domain was undertaken to allow for consideration of the deck being an active part of the system, enabling the potential transfer of water from one bank to another. Standard model convention is that where the bridge deck is greater than 2 model grid cells in width, 2D representation is appropriate. The bridge decks were represented as Z shapes, with a level assigned equal to the deck level from survey, or in the case of the motorway decks, LiDAR levels. More information on the deck levels assigned can be found within the model log, within Appendix 2.

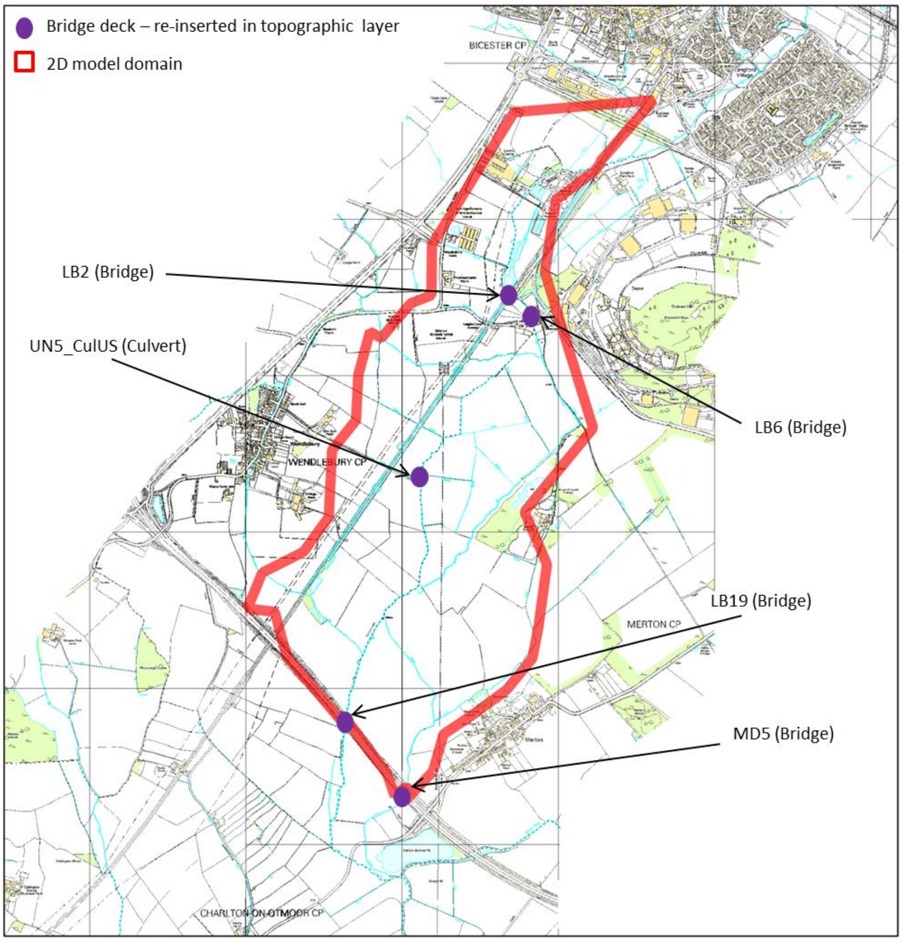


**Figure 8 – 2D model extent with identification of structures re-inserted into the topography (having been removed during filtering process of LiDAR).**

A drainage channel exists connecting the Gagle brook and the un-named watercourse. As shown in Figure 9, the bed level of this channel is above that of the Gagle Brook, but may act as a diversion channel during higher stages as it forms a low point in the right bank. As a result it was represented within the 2D domain. A number of bed levels for the channel were known from the river section survey. Figure 9 shows the location of the drainage channel, with the four known bed levels. The drainage channel passes under the railway embankment via a culvert and this was represented as a 1D Estry unit within the 2D domain, along with other culverts that pass under the railway line. These culverts are outlined in more detail within section 3.4.3 of this report. The DTM levels along the channel were lowered using a z-line, with the known bed levels read in as z-points. The drainage channel was modelled as approximately 2-4m wide.

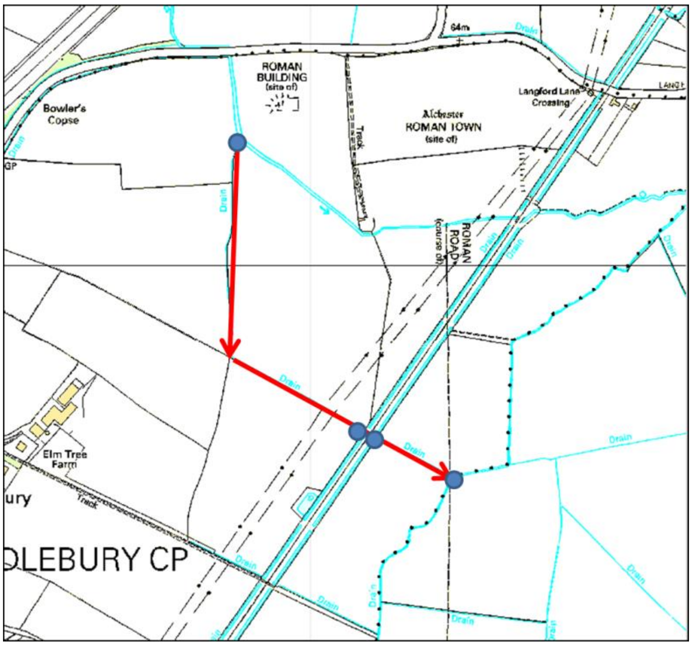


**Figure 9 – Large drainage channel between the Gagle Brook and the un-named watercourse, known bed levels shown as blue markers.**

### 3.4.2 Roughness Co-efficient

A baseline Mannings 'n' roughness coefficient was applied across the 2D domain. The floodplain is essentially rural pastureland / agricultural land. The 2d_mat_LLB_Mann_R_002.shp and 2d_mat_Bicester_001.mif provided within the model files allows analysis of the manning's values used. Table 3 summarises the Manning's 'n' values applied to those areas highlighted within the model files. The Manning's values assigned to the different land uses are based on those within the original PBA Langford Brook model (Environment Agency approved), outlined within the .tmf file, however the default ground Manning's n was lowered as outlined.

**Table 3 – Mannings 'n' values used within the 2D floodplain.**

| Code in .tmf file | Description | Manning's n Value |
|---|---|---|
| 1 | Inland Water | 0.03 |
| 2 | Dense Vegetation | 0.09 |
| 3 | Roads | 0.03 |
| 4 | Dense Urban Areas / Individual large buildings | 0.15 |
| 5 | Rail | 0.035 |
| 6 | Default PBA (now redundant) | 0.05 |
| 7 | General Land Surface (short grass) | 0.035 |
| 8 | Scrub woodland | 0.05 |
| 9 | Height varying grass (set as default) | 0.045 |

### 3.4.3 Structures

A number of hydraulic structures are modeled within the 2D domain. These take the form of ESTRY 1D culvert units. These culverts have been modeled within ESTRY as they are considered dry at the start of a simulation. ISIS does not allow dry channels or structures, although dummy flows can be used. It was however considered appropriate for this study to represent these flow routes using ESTRY. Figure 10 outlines the locations of a number of culverts, with Table 4 outlining the dimensions of the culvert based on available culvert condition reports and survey data[6].

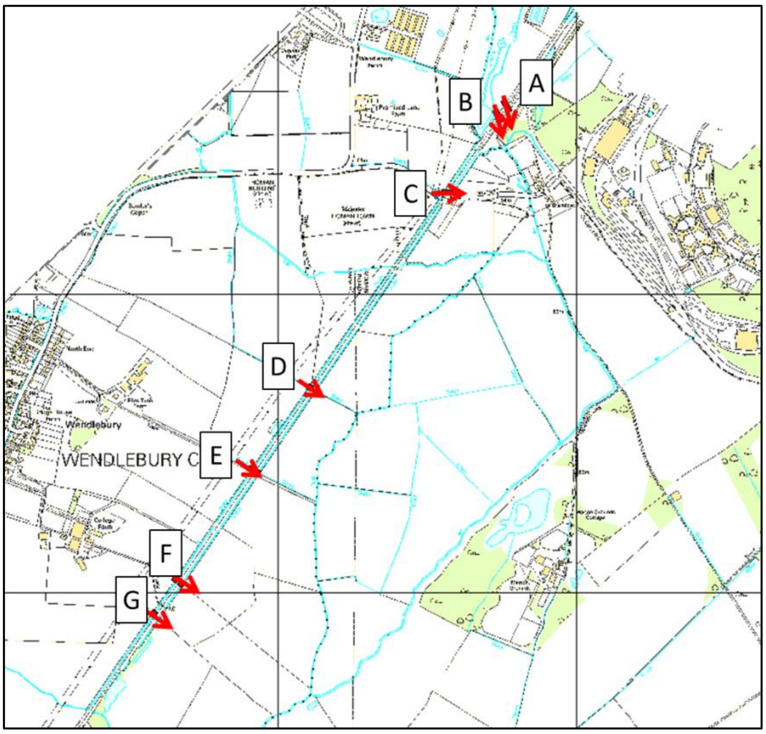


**Figure 10 – Location of culvert units represented in ESTRY (1D component of TuFLOW).**

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[6] Atkins. 2013. Culvert Strategy Report – Culvert condition Review

**Table 4 – Culvert dimensions used within ESTRY 1D units**

| Reference | Type | Dimensions |
|---|---|---|
| A | Box | 0.91 x 0.91 |
| B | Box | 1.22 x 1.22 |
| C | Box | 1.22 x 1.22 |
| D | Box | 0.77 x 0.77 |
| E | Box | 0.77 x 0.77 |
| F | Box | 0.61 x 0.61 |
| G | Box | 0.61 x 0.61 |

### 3.4.4 Interpolate bank levels

At a number of locations, the interpolated bank level within the 2D domain was considered inappropriate when compared to LiDAR levels. Although there are errors associated with LiDAR data, the vertical accuracy is considered to be +/- 0.15m. Figure 11 highlights one of these locations within the original model extent. Here the interpolated bank levels based on the levels from the ISIS nodes were causing a raised 'wall' within the 2D domain, preventing the movement of water between the channel and the 2D domain and vice versa. As such bank levels along the 2D HX line were reviewed, with a number of new zpts added to better represent the bank levels.

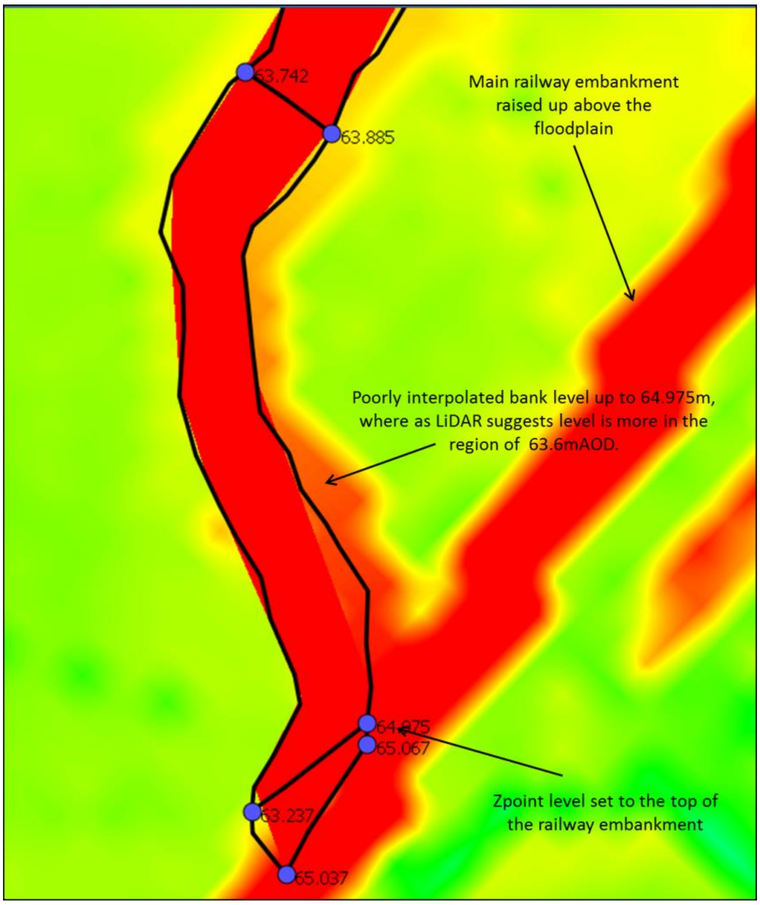



**Figure 11 – Example of where poorly interpolated bank levels have raised the level causing a potential barrier against flows. The red bank levels indicate levels up to 65.00m AOD, interpolated poorly due to the point to south set to main railway embankment levels.**

### 3.4.5 Drainage ditches connected to main channel

A number of drainage ditches connect to the main watercourse within this reach of the Langford Brook. LiDAR data was used to confirm the connectivity between drainage ditches in the floodplain and the main channel and the 2D bank levels set on the HX boundary line were lowered to the bed level obtained from LiDAR (this will be a conservative level due to the inability of LiDAR to penetrate water). Bank levels were lowered locally and then raised back to the main watercourse bank level based on LiDAR. Figure 12 highlights a number of these locations.

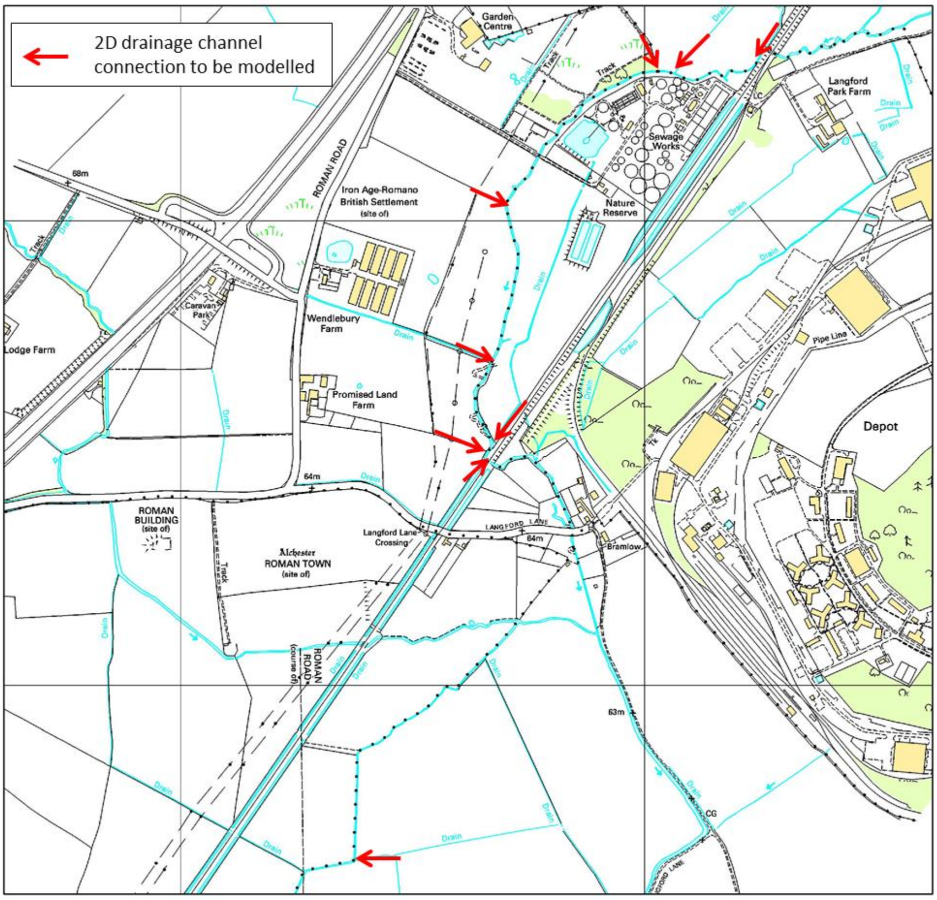



**Figure 12 – 2D drainage channel connections to main channel represented as lowered bank levels.**

### 3.4.6 Downstream boundary

No 2D downstream boundary exists within this model. All flows return to the 1D model through either of the two motorway crossings (Langford Brook, or Merton Ditch). As a result no 2D boundary was required.

### 3.4.7 Development – 2D alterations.

A number of alterations were made to the 2D domain in order to simulate the predicted impacts as a result of the proposed works. The proposed vertical alignment of the Langford Lane access road was provided by Atkins and input into the model as a zshape set to raise the associated zpoints to the required design level. The location of the zhape and zpt level are highlighted in Figure 13. The crossing points of watercourses were represented within the 1D domain.

Two culverts were also inserted as Estry 1D culverts, these were located where the carriageway crosses a drainage ditch and therefore allows conveyance of potential flood flows within these channels through the raised embankment. Table 5 highlights the assumed dimensions for the two culverts, with Figure 13 showing their location.

**Table 5 – New Langford Lane assumed culvert dimensions.**

| Reference | Type | Dimensions (m) |
|---|---|---|
| A | Box culvert | 0.5 x 0.5 |
| B | Box culvert | 1.0 x 1.0 |

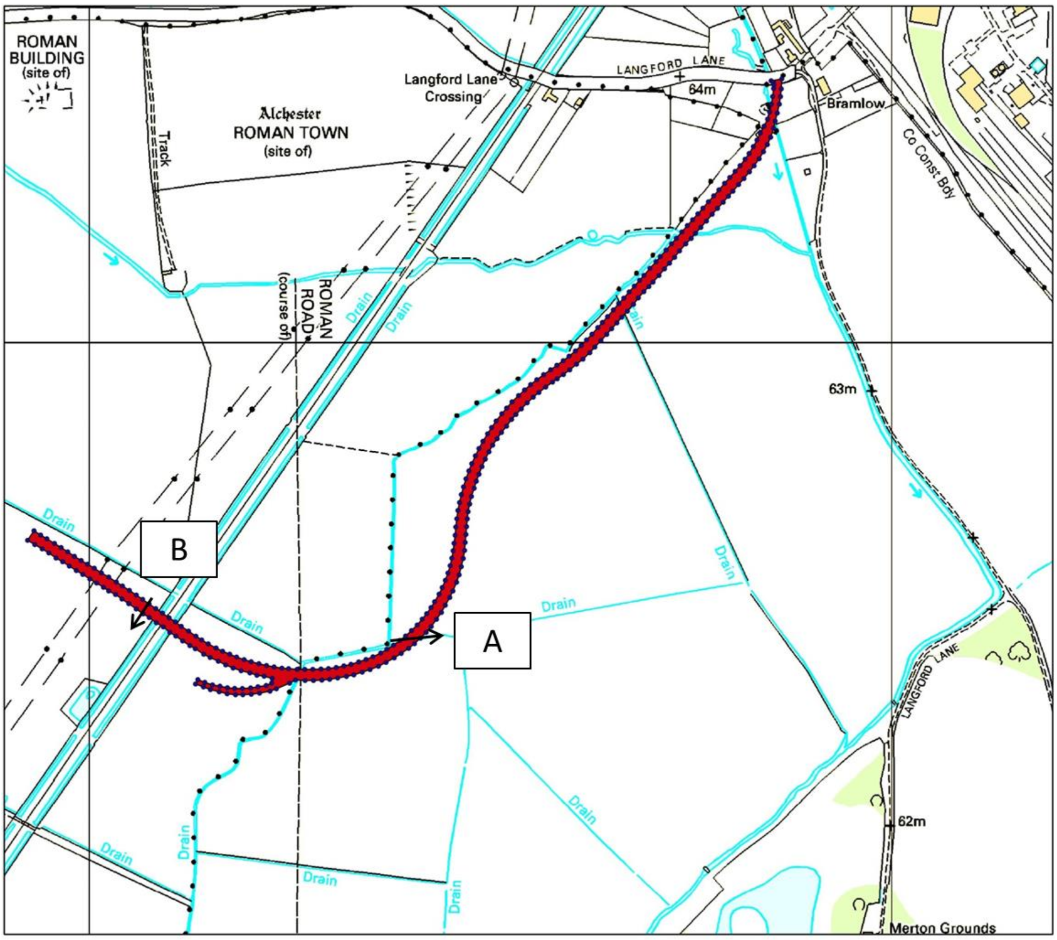



**Figure 13 – Location of additional culvert units represented in ESTRY (1D component of TUFLOW) for the proposed new Langford Lane works, and the final carriageway alignment. (Langford Lane Zshape shown in red, culvert locations shown by black arrow).**

## 3.5 Model Runs

A number of simulations were undertaken in order to assess the impacts of the proposed works. The following flow events were simulated:

*Baseline Simulations*

- 1 in 100 year plus climate change in Langford Brook and its tributaries combined with QMED on River Ray,

*Sensitivity (on baseline simulations)*

- 1 in 5 year in Langford Brook and its tributaries combined with 1 in 100 year plus climate change flows on River Ray

- 1 in 100 year plus CC in the Langford Brook and its tributaries, with 1 in 100 year plus CC on River Ray.

*Post Development*

- 1 in 100 year plus climate change on the Langford Brook and its tributaries and QMED on River Ray.

## 3.6 Results

### 3.6.1 Baseline conditions

Figure 17 highlights the predicted flood extent during the 1 in 100 year plus climate change event on the watercourses in the vicinity of Langford Lane for the baseline scenario. The predicted extent shows that the vast majority of the proposed alignment is outside of the predicted flood extent.

As shown by Figure 17 the predicted flood extent is considerably reduced over that predicted by the Environment Agency flood risk mapping. There are a number of reasons for this clear difference in extent. The main factors for this are considered to be the limitations of JFLOW modelling (basis of the current Environment Agency flood-map). The original JFlow model does not model the capacity of river channels accurately as it is based on a ground DTM. As such, it is likely that floodplain flows are more likely to occur, as the capacity of channels is reduced, if modelled at all. The model is likely to have used a grid cell size of greater than $10m^2$, as such the capacity of the channel where modelled may be over conservative in nature and is unlikely to have picked up the raised banks of the watercourses.

The Environment Agency Flood Map also suggests that the culvert underneath the existing Langford Brook may not have been modelled within the JFlow model, as the bridge an watercourse at this location are outside of Flood Zone 3. As such, in the JFlow model it appears that flood waters back up upstream of the existing road crossing before spilling over Langford Lane (at points that are lower than the bridge deck). This changes the flood mechanisms considerably, forcing more flood water out onto the floodplain. The flood waters then flow directly south and, given the reduced accuracy grid cell size, are unlikely to return "in channel" as the Gagle Brook channel is unlikely to be well defined within the JFlow model. This therefore over predicts the flood extent south of Langford Lane including the location around the un-named watercourse.

The updated model has also allowed for the presence of raised banks along the watercourse to be considered in more detail and better represented. As a result, more flow is retained within channel. Manning's values, both in stream and on the floodplain, have also been refined resulting in reductions in predicted flood extent. As highlighted within Figure 14 below, flood flows are retained in bank, for the northerly reach of the un-named tributary, resulting in the significant reduction in flood extent in the 2D domain. As shown within Figure 15, the raised embankments noted within this channel result in the retention of flows within stream.

The flood extent is also notably reduced along the Gagle Brook. 1 in 100 year plus climate change flows are relatively low for this watercourse, reaching a maximum of 1.17 cumecs. As such, given the channel's capacity see Figure 16, flood waters are also retained in channel. Within the original EA flood maps, again modelled by JFlow, the relatively narrow channel is unlikely to have been modelled within the original 2D domain, meaning the floodwaters flow across the floodplain with no account of in channel capacity. As such the JFlow model provides this very extensive flood extent with predicted low flood depths.

Although the flood extent predicted is reduced, a small proportion of the road alignment was shown to be within the flood extent, therefore consideration of flood consequence, and flood compensatory storage was undertaken.

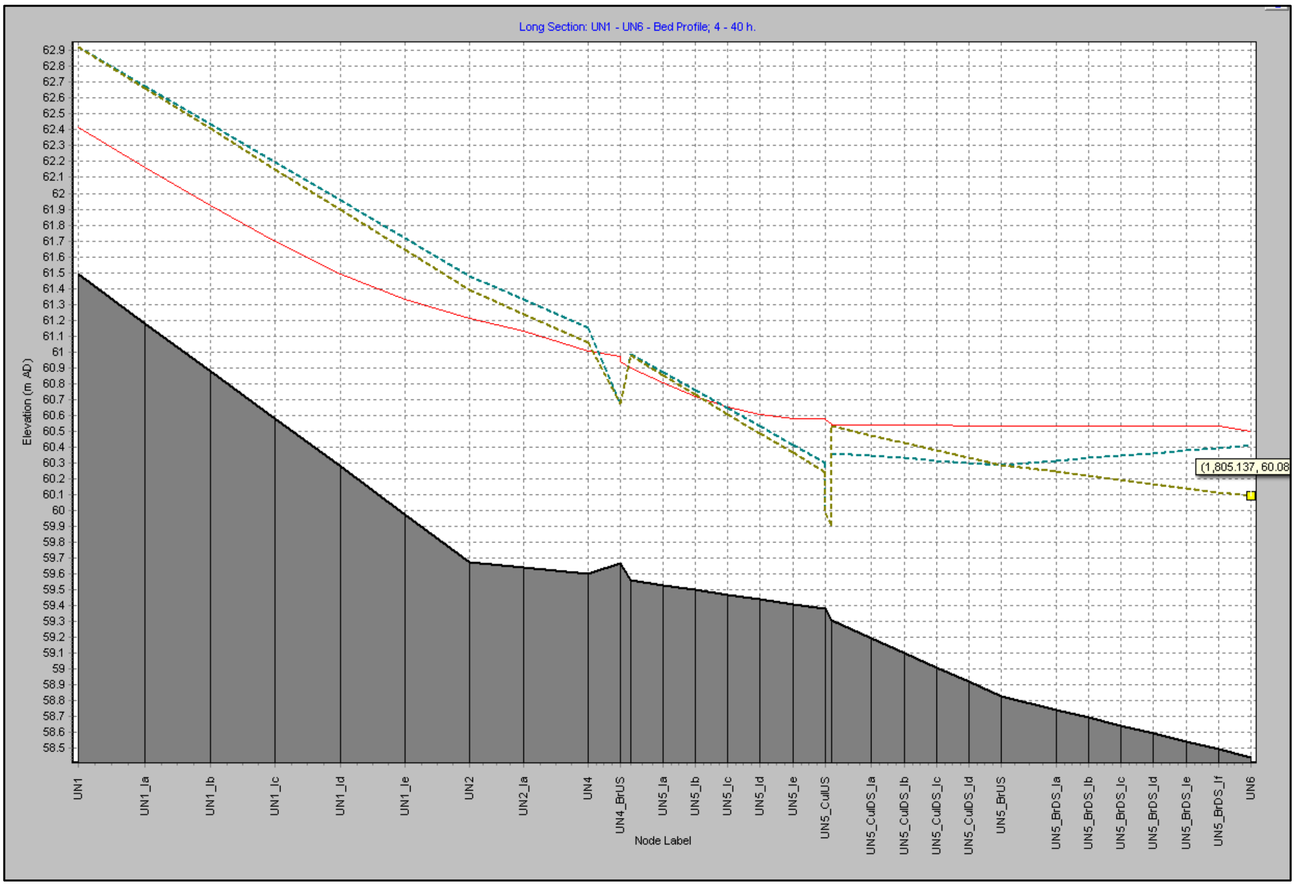



**Figure 14 – Maximum flood level predicted during the 1 in 100 year plus climate change event on the un-named watercourse. Flood flows are retained in bank for the northern reach.**

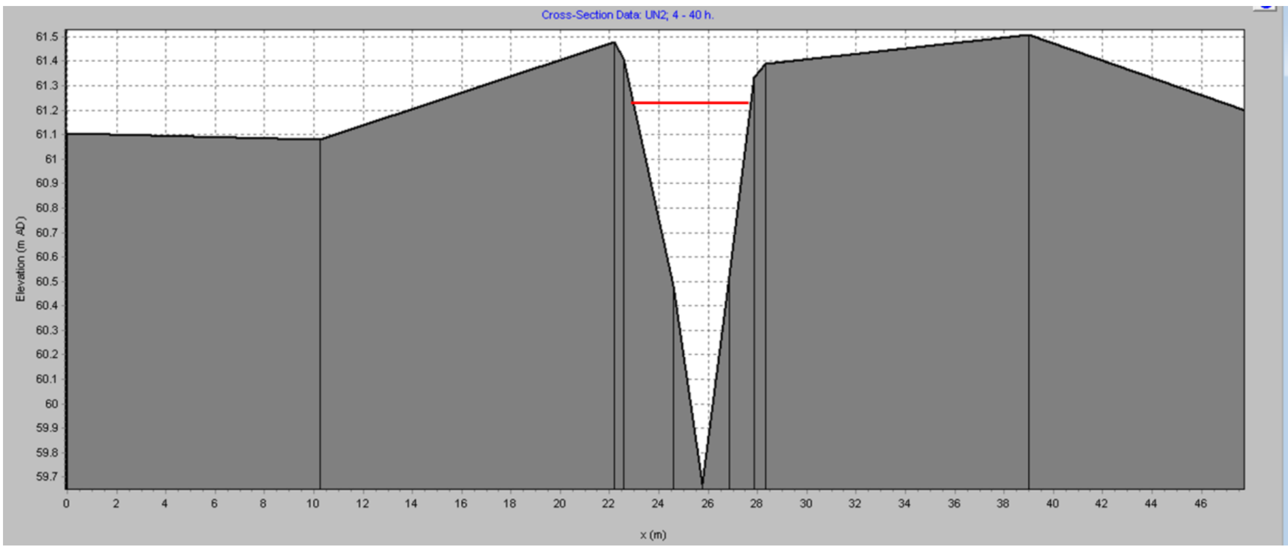



**Figure 15 – Maximum flood level predicted during the 1 in 100 year plus climate change event on the un-named watercourse at section UN2. This cross section was clipped so that the floodplain was modelled in 2D, this image highlights the role the raised river banks play in preventing the surrounding land from flooding during the 1 in 100 year plus climate change event.**

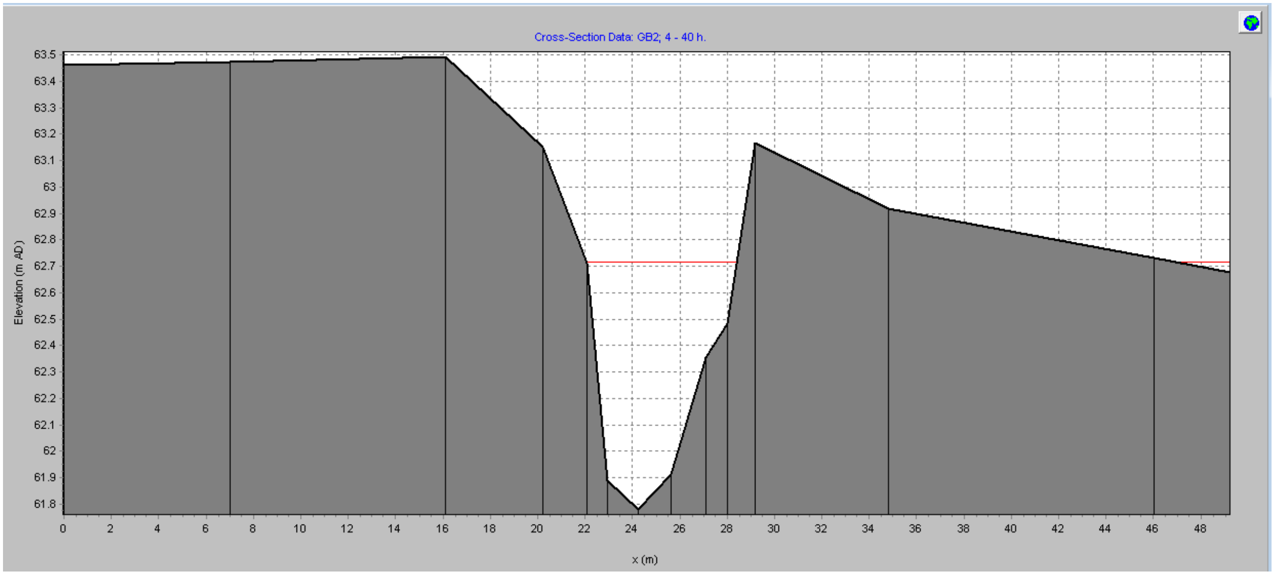



**Figure 16 – Maximum flood level predicted during the 1 in 100 year plus climate change event on the Gagle Brook section GB2. This cross section was clipped so that the floodplain was modelled in 2D, this image has been created so as to highlight the channel capacity in relation to the maximum predicted flood level.**

### 3.6.2 Post Development

The model was run for the post development scenario. This was undertaken to consider the flood impacts in the surrounding area as a result of the small encroachment into the flood extent and the 3 clear span crossings of the watercourses.

Appendix 3 provides a summary table of the predicted maximum flood levels within the 1D network as a result of the proposed development. As outlined within the table, flood levels do not change as a result of the clear span bridges or the small encroachment into the flood extent. This is as expected due to the proposed bridge crossings having no in stream influence and due to the majority of the flow remaining in channel adjacent to the proposed alignment.

Figure 17 shows the predicted post development flood extent in relation to the baseline extent. This shows there is no significant change in the predicted extent. A small reduction in extent is predicted and this is due to the assumed raising of a low point within the drainage channel bank, which previously allowed out of bank flows to occur.

Figure 18 below shows a summary of the change in flood depth as a result of the proposed development. As shown, no significant increase in flood depths is predicted. Minor increases are found in two locations; however these occur in isolated cells along the unnamed tributary (immediately downstream of the crossing), and on the Gagle Brook (downstream of the crossing).

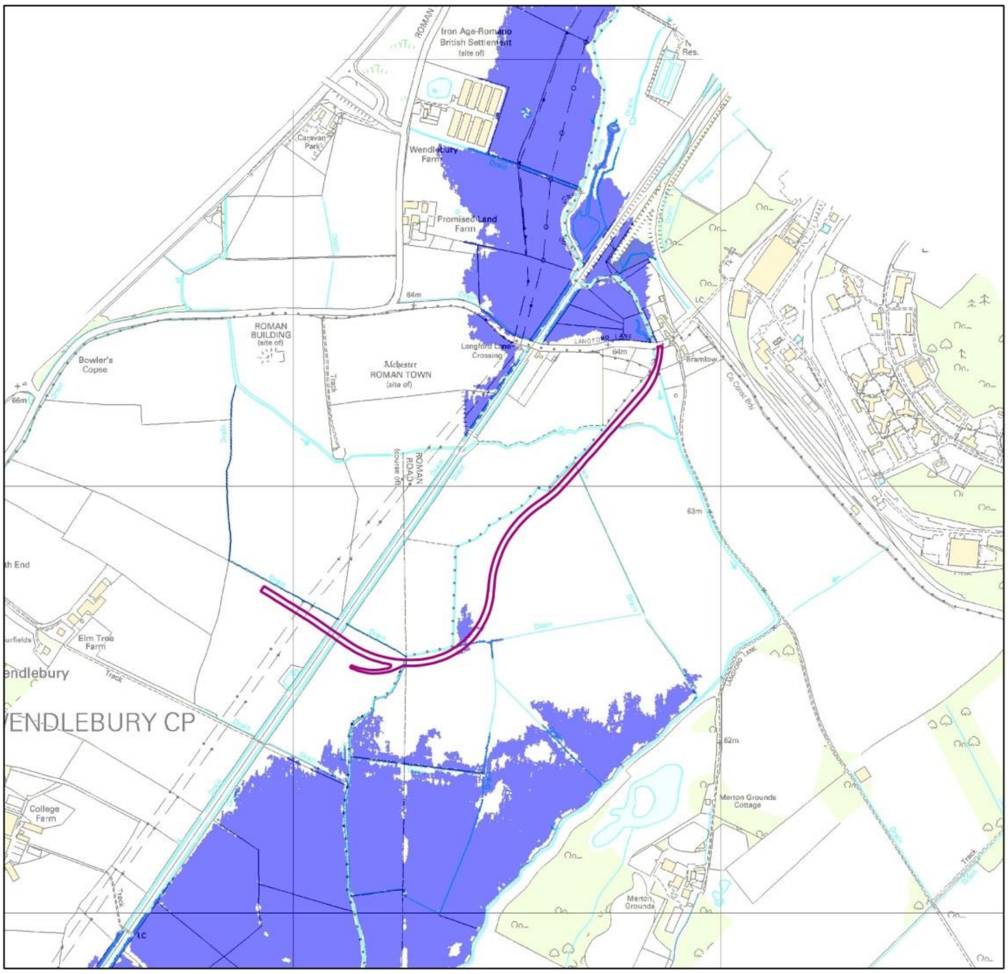



**Figure 17 – Predicted 1 in 100 year plus climate change flood extent in relation to the proposed road alignment for the baseline scenario.**

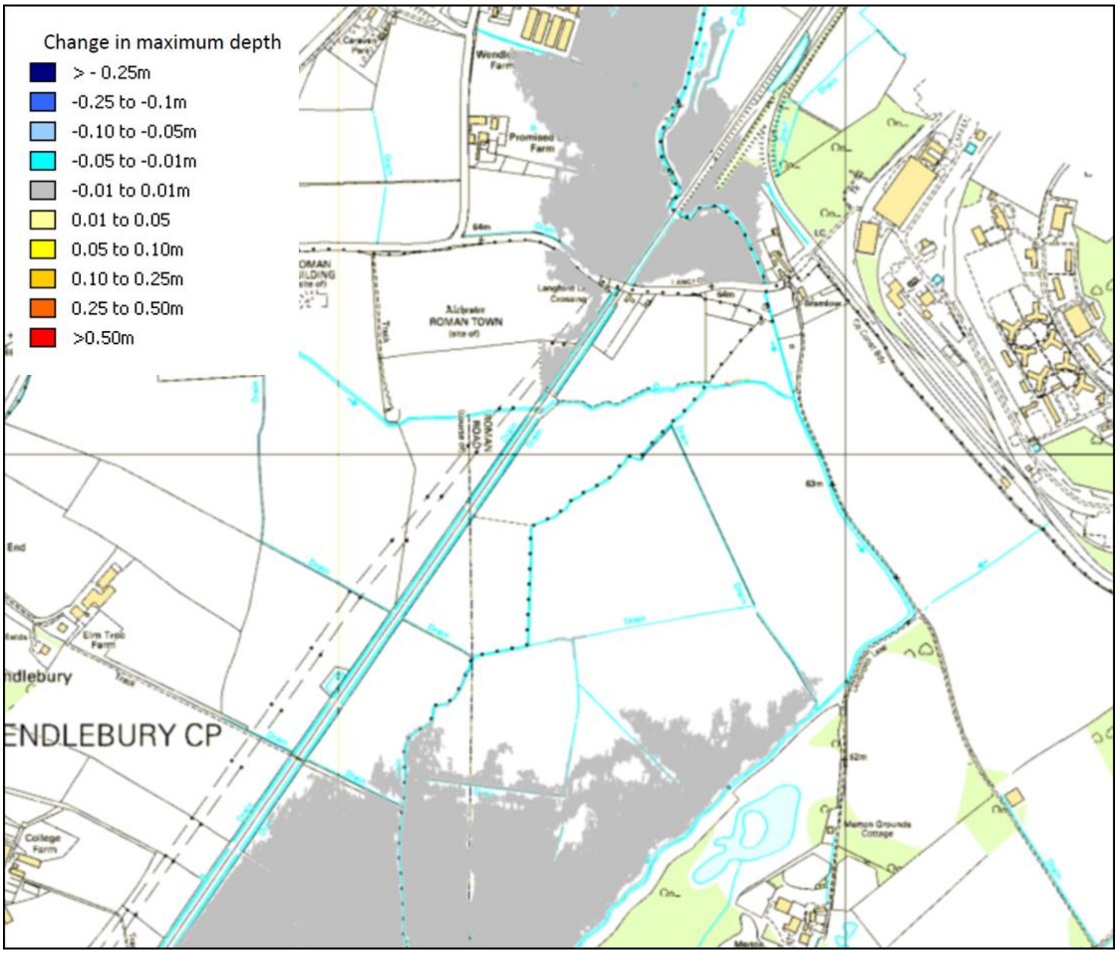



**Figure 18– Predicted change in flood depth as a result of the proposed development for the 1 in 100 year plus climate change event**

Flood extents for the 1 in 100 year plus climate change event are considerable both upstream of the existing Langford Lane, and closer to Wendlebury downstream. Significant volumes of water are held upstream of the existing Langford Lane, which is raised above the floodplain and is a considerable restriction to conveyance. Bed levels are also significantly lower downstream of the existing Langford Lane crossing, as such the associated maximum flood levels are lower as shown within the 1D model results.

## 3.7 Sensitivity Analysis

Sensitivity analysis was conducted on the boundary conditions and combinations of flood events to ensure that the appropriate peak water level was considered at the development location. In particular the influence of the River Ray at Langford Lane was tested. The outcomes of the sensitivity testing are presented within Table 6 below. The 1 in 100 year plus climate change flow modelled on both the Langford Brook and the River Ray confirmed that the 1 in 100 year plus climate change flow on the Langford Brook and its tributaries resulted in the greatest flood levels. The River Ray was confirmed as having no influence at this point in the catchment during this design event.

**Table 6 – Predicted maximum flood levels at bridge crossing locations for the Langford Lane development during a range of scenarios.**

| Watercourse | ISIS Node (ref) | 1 in 5 year Langford Brook, 1 in 100yr CC River Ray | 1 in 100yr CC Langford Brook, 1 in 5 year River Ray | 1 in 100yr CC in all watercourses |
|---|---|---|---|---|
| Langford Brook | LB7 | 62.28 | 62.92 | 62.92 |
| Gagle Brook | GB5 | 61.83 | 62.42 | 62.42 |
| Un-named watercourse | Un4BrUS | 60.42 | 60.97 | 60.97 |

Due to the conservative estimation of peak flows based on the original PBA model as referred to in section 2 and the application of a 20% climate change allowance, it was not considered necessary to conduct a sensitivity test on peak flows or on Manning's values. The conservative estimation of peak flows, which are approximately 1.7 times those calculated through standard techniques, is considered to already result in a conservative estimation of flood levels. The Manning's value has been critically reviewed based on the site survey, walkover visit and aerial photography and is considered to be representative of the site conditions.

## 3.8 Conclusions

The majority of the proposed development alignment is located outside of the predicted 1 in 100 year plus climate change extent. Clear span bridges will be used as crossing points at the three locations that cross watercourses. As such, no impact on instream flood conditions will occur. Post development scenarios were run to assess the impact of the development on the 2D flood depths in the floodplain.

The post development scenario predicts no impact on in stream flood levels and no significant impact on flood plain flood depths. As such the development is not considered to cause significant change in flood depths or risk.

There will be a potential requirement for flood mitigation as a result of the development and very small amounts of flood storage lost. This is assessed within the main flood risk assessment report for the Langford Lane access road.

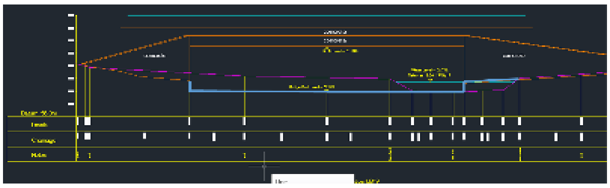
# Appendix 1 River Channel and Structure Cross sections

# Appendix 2 Hydraulic Modelling Log

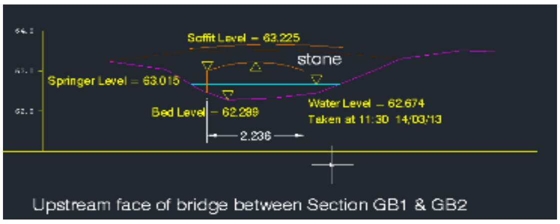
# 1D nodes

| Node | Type | Method | Comments |
|---|---|---|---|
| **Langford Brook** | | | |
| LA.1350D | Channel | Original Model | Upstream extent of model (Railway embankment downstream of Bicester town as shown on mapping) Mannings changed from 0.05 down to 0.04 as this was considered high in previous model. |
| LA.1350D.1 | Interpolate | Original Model | |
| LA.0957 > LA.0017 | Mixture | Original Model | As with LA.1350D mannings altered |
| LB2 | Channel | Original Model | Original model reference was LA.0000 |
| LB2.BU | Bridge | Survey | Channel Cross section based on that provided by survey for LB2. Bridge dimensions based on survey. Spill to be represented in 2D domain. Mannings changes in structure to 0.035 to highlight the use of the concrete (With some bed material). Standard |
| LB3 | Channel | Survey | Distance downstream to next surveyed cross section = 171.11m, therefore split up into 5 sections (4 interpolates) of 34.22m. Mannings set to 0.04 |
| LB3_Ia - LB3_Id | Interpolate | NA | See section LB3 |
| LB4 | Channel | Survey | Taken from survey. Distance downstream calculated as 71.21. As a reslt split into two sections (1 interpolate) of distance 35.610 (channel section) and 35.6 (interpolate). |
| LB4_Ia | Interpolate | NA | See section LB4 |
| LB5 | Channel | Survey | Taken from survey. Distance downstream calculated as 34.49m. Usually this would be ok however stability of steady run suggested more interpolates should be added. In total section made up of 1 channel section and 4 interpolates. Due to ongoing stabilitiy issues the distances between the interpolates needed to vary. See model for distances |
| LB6 | Channel | Survey | Based on survey. Upstream section of Langford Road crossing. |
| LB6 Culvert | Culvert | Survey | Based on the photograph of this bridge, it was concluded that this structure would be best represented as a box culvert. As shown in the picture below. |
| | | |  Langford Lane Bridge (Section LB6+7) |
| | | | Culvert dimensions based on survey. Please note the drop in bed elevation on the downstream side of this structure. This has been represented within the model a a step rather than a weir due its presence immediately downstream side of the structure. Mannings has been reduced within the culvert to 0.02 to replicate concrete |
| | | | Culvert inlet modelled as a rectangular, concrete inlet structure with 90 degree headwalls. Please see photos for more details. Standard parameters were used. |
| LB7 | Channel | Survey | Downstream river section of langford Lane bridge. Based on survey section. Distance downstream was found to be approximately 52.58m, initially this had not required an interpolate however due to later runs, an interpolate was added to stabilise the model. Distance downstream for section and interpolate was 26.29m |
| LB7_Ia | Interpolate | NA | See section LB7 |
| LB8 | Channel | Survey | Taken from survey. Distance downstream calculated as 87.945m. Originally only 1 interpolate was added to split the distance into two equal parts, however it was recommended through steady state run that a nother section was added between the channel section and interpolate. Therefore in total two interpolates were added. LB8 (21.990m) LB8_Ia (21.98m) LB8_Ib (43.975m) |
| LB8_Ia and LB8_Ib | Interpolate | NA | See section LB8 |
| LB9 | Channel | Survey | Taken from survey. Distance downstream calculated as 43.588m. Due to recommendations from steady state run, the section was split into two with distances of 21.794m for both distance downstreams. Interpolate was used. |
| LB9_Ia | Interpolate | NA | See section LB9 |
| LB10 | Channel | NA | Taken from survey. Based on survey distance from LB10 to LB11 is 40.02m. Therefore no interpolate was used. Within the model LB10.1 (See next section) was added to allow a junction to allow Gaggle brook to join the main watercourse. |
| LB10.1 | Channel | See comment | Gagle brook joins the langford brook immediately upstream of Section LB11. As a result a copy of LB11 will be used as the upstream section. The right bank level will be adjusted to 62.6 as shown in the survey (see CAD drawing). Bed levels were not changed. Section trimmed to LB and RB as the rest is unknown. |
| LB10.1 (Junction) | Junction | NA | Junction between LB10.1, LB11 and Gaggle Brook Downstream section (GB6.1). |
| LB11 | Channel | Survey | Taken from survey. Distance downstream calculated as 487.275m. As a result, 9 interpolates were added. Distance downstream for LB11 = 37.275. Distance downstream for the 9 interpolates = 50m |
| LB11_Ia to LB11_Ii | Interpolate | NA | See Section LB11 |
| LB12 | Channel | Survey | Taken from survey. Distance downstream calculated as 427.449m. Total of 8 interpolates added. LB12 downstream distance = 27.46m, interpolates = 50m |
| LB12_Ia to LB12_Ih | Interpolate | NA | See section LB12 |

Lower Langford Brook Hydraulic Model 1D ISIS Sections

| Node | Type | Method | Comments |
|---|---|---|---|
| LB13 | Channel | Survey | Taken from survey. Distance downstream calculated as 544.373m. As a result a total of 10 interpolates were added. LB13 distance downstream = 44.373, 10 interpolates at 50m. |
| LB13_Ia to LB13_Ij | Interpolate | NA | See section LB13 |
| LB14 | Channel | Survey | Taken from survey. Distance downstream calculated as 562.018. Originally 10 added interpolates at 50m, plus the LB14 distance downstream set as 62.018. However based on model development the distance downstream of the final interpolate (LB14_Ij) was reduced to 33.6m. This is because additional sections were required in order to allow for the Unnamed Tributary to enter as a tributary through a junction. |
| LB14_Ia to LB14_Ij | Interpolate | NA | See section LB14 |
| LB14.1 | Channel Section | See Comment | In order to allow for the Unnamed trib to enter via a junction at this location a new channel cross section was required. This has been made up based on interpolation from various cross sections. The channel shape was based on LB15 (closest actual survey section approx 16.40m downstream). Left bank and right bank ridge levels were interpolated between LB14_Ij and LB15. This was also carried out for the bed level (58.434). Bed level was calculated to be 0.008m higher than at section LB15. As a result, all inchannel levels were also increased by this value, to allow for a better reflection of presumed instream conditions. |
| LB14.1 (Junction) | Junction | NA | Junction between LB14.1, LB14.2 and Un-named trib downstream section (UN6). |
| LB14.2 | Channel Section | See Comment | Copy of section LB14.1 (See above). This is thought approriate as it is attempting to model conditions immediately downstream of LB14.2 and therefore levels etc are not considered to change. |
| LB15 | Channel Section | Survey | Taken from survey. Distance downstream calculated as 577.14m. Therefore reach split into 1 channel section and 11 interpolates. Channel DS = 38.570, interpolates = 10 @ 50 1@ 38.570 |
| LB15_Ia to LB15_Ik | Interpolates | NA | See section LB15 |
| LB15.1 | Channel Section | See Comment | Section required at junction (Upstream) with Wendlebury Brook. |
| | | | Comparison of section 15 and 16 was made to see if the channel was found to alter as a result of the tributary entering the river. The width remained approximately the same (13m) and depth (2.5) also. As a result it was considered approptiate to use a copy of section LB16 as the upstream section of this confluence as the channel was not found to alter as a result of the trib. |
| LB16 | Channel Section | Survey | Taken from survey. Distance downstream calculated as 276.811m. As a result 5 interpolates were also used. LB16 Ds = 46.140, interpolates = 46.410 also. |
| LB16_Ia to LB16_Ie | Interpolates | NA | See Section LB!6 |
| LB17 | Channel Section | Survey | Taken from survey. Distance downstream calculated as 60.083m. As a result one interpolate was added. DS for both = 30.40m |
| LB17_Ia | Interpolate | NA | See Section LB17 |
| LB18 | Channel Section | Survey | Taken from survey. Distance downstream calculated as 74.426m. As a result one interpolate was added. DS for both = 37.213 |
| LB18_Ia | Interpolate | NA | See section LB18 |
| LB19 | Channel Section | Survey | Based on survey at this section. Upstream of motorway crossing. Channel is shown to change at face of motorway bridge, this is reflected within the bridge unit cross section (See section LB19 Bridge). Width of section is much wider than earlier sections, however this will also be reflected in the 2D domain. |
| LB19 Bridge | Bridge | Survey | Based on survey section as shown in sketch below. Channel section at bridge based on blue line shown below in CAD sketch. All other properties taken from survey. |
| | | |  |
| LB20 | Channel Section | Survey | Based on survey. As now in 1D only domain. No interpolates required. |
| LB21 | Channel Section | Survey | Based on survey. As now in 1D only domain. No interpolates required. |
| LB22 | Channel Section | Survey | Based on survey. Upstream face of bridge unit. |
| LB22.BU | Arch Bridge | Survey | Based on survey. Channel cross section taken from LB22. No changes to standard parameters. Mannings through structure set at 0.04 to match channel. |
| LB22.Spill | Spill Unit | Survey | Spill unit to represent spill over structure. Width of section set to that of LB22. Level set to bridge deck level shown in survey as 60.540 |
| LB23 | Channel Section | Survey | Based on survey. |
| MER_CON_US | Channel Section | See comment | Although this may slightly reduce accuracy of the model. Section LB24 was copied for the two extra sections required at the junction of Merton Ditch. Based on the topography, it is thought that this is most likely to be a good reflection of the channel levels at this point. |
| MER_CON_DS | Channel Section | See Comment | See comment for MER_CONUS. See model schematic for better representation of connections. |
| MER_CON Junction | Junction | NA | Junction between Merton ditch downstream section and Langford Brook (MER_CON_US and MER_CON_DS). |
| LB24 | Channel Section | Survey | Based on survey. As now in 1D only domain. No interpolates required. |
| LB25 | Channel Section | Survey | Based on survey. As now in 1D only domain. No interpolates required. |
| **Gaggle Brook** | | | |
| GB1 | Channel Section | Survey | Based on survey. Right bank trimmed to discount the un-named drainage ditch from the section. Mannings set to 0.04 as thought appropriate. Ditance downstream to footbridge between section 1 and 2 was found to be 310.408, this was divided between 6 sections (5 interpolates and GB1) to give downstream distances of 51.73m each. |
| GB1_Ia to GB1_Ie | Interpolate | NA | See section GB1 |

Lower Langford Brook Hydraulic Model 1D ISIS Sections

| Node | Type | Method | Comments |
|---|---|---|---|
| GB1.1 | Channel Section | See Comment | Section based on basic survey upstream of footrbidge structure. Shown on long section of river survey. Due to the size and nature of the structure it was decided to model this in 1D. The spill was alos modelled within 1D due to the width of the structure being under 2 2D cell widths wide. |
| GB1.1_B_US | Arch Bridge | Survey | Based on survey provided on long section. Arch bridge thought suitbale (see image below). Standard bridge paramters used. |
| | | |  |
| Spill unit | Spill Unit | Survey | Spill over the bridge modelled within an inline spill unit, set to the width of the cross section and the level of the carriageway across the river, as shown in the survey data. |
| GB1.2 | Channel Section | See Comment | Section based on basic survey upstream of footrbidge structure. Shown on long section of river survey.Please note that the survey has been drawn right to left bank on the downstream side and therefore the section has been flipped to conform to the left right standard method of drawing sections. Distance between downstream section and GB2 was found to be 266.095, as a result the section was split into 6 distances to aid in stability of 44.35m |
| GB2 | Channel Section | Survey | Based on survey at this location. Survey section taken approximately 11m upstream of railway culvert. As such a new section was added at the upstream face (See next cross section for more details). |
| GB2.1 | Channel cross section | Survey | As the river was shown to alter its cross section dramatically at the face of the strucutre. A section was added based on the detail provided in the survey for the strucutre. This area is seen as being relatively channelised. Distance downstream to bridge = 0 |
| GB2.1 Bridge | Arch Bridge | Survey | Arch bridge with multiple openings, based on survey data at this location. Channel section matched that of section 2.1 upstream. Standard co-efficients were applied. Spill of bridge (railway embankment) to be modelled within the 2D domain. |
| GB2.2 | Channel Cross section | Survey | Section based on basic survey upstream of footrbidge structure. Shown on long section of river survey.Please note that the survey has been drawn right to left bank on the downstream side and therefore the section has been flipped to conform to the left right standard method of drawing sections. Distance between downstream section and GB3 was found to be 57.532, as such no interpolates were used. |
| GB3 | Channel Cross section | Survey | Based on survey at this location. Downstream sitance to GB4 was calculated as 131.716m. As such two interpolates added. The sections had distance downstream as 50m, with the second interpolate having a reduced distance as 31.716m |
| GB3_Ia and GB3_Ib | Interpolates | NA | See section GB3 |
| GB4 | Channel Cross section | Survey | Based on survey provided at this location. It was noted on site that a weir was placed between the sections GB4 and GB5. It was decided to model the weir to improved the accuracy of the model. The distance from GB4 to the weir was calculated as being approximately 141.745. As such two interpolates were added. The channel section and first interpolae were given downstream distance of 50m, with the second interpolate 41.745m. |
| GB4_Ia and GB4_Ib | Interpolates | NA | See section GB4 |
| GB4.1 | Channel cross section | Survey | Section based on basic survey upstream of weir as shown in long section survey. |
| GB4.1_W_US | Weir | Survey | The semi-permanent weir has been modelled at this location. Only a basic sketch ha sbeen provided and so levels will have to be manually taken from the cross sections provided by the surveyor. Weir level based on average level of sandbags = 62.347. Width set to 4.856 as this is the mid width between the two levels. |
| GB4.2 | Channel section | Survey | Section based on basic survey upstream of footrbidge structure. Shown on long section of river survey.Please note that the survey has been drawn right to left bank on the downstream side and therefore the section has been flipped to conform to the left right standard method of drawing sections. Distance between downstream section and GB4.3 (see note below) was found to be 20.1m as a result no interpolates were used between these two sections. |
| GB4.3 | Channel section | See comment | At this point in the model, flow can move out of the Gaggle brook and down through the un-named tributatry (See later in log). Therefore a section upstream and downstream of a junction unit was required. Based on a comparison between section GB4.2 and GB5, it was found that the channel was a very similar shape. As such a simple V shaped channel was used. Bed and bank levels were interpolated between GB5 and GB4.2. As such RB = 62.923, LB = 62.79 and bed level =61.053 |
| GB4.4 | Channel Section | See comment | Section downstream of confluence with un-named trib. Due to section GB5 and GB4.2 being similar width and depth, it was not considered required to increase the channel size downstream of the confluence. As such and due to the very flat topography section GB4.4 was a copy of GB4.3 (which had been interpolated). Distance downstream to GB5 was approximately 11m, therefore no interpolates were used. |
| GB5 | Channel section | Survey | Based on survey at this location. Downstream distance to GB6 was found to be 91.48m, as such 1 interpolate was used. Distance downstream from GB5 to interpolate was set to 50m, distance from interpolate to GB6 was set to 41.483m. |
| GB5_Ia | Interpolates | NA | See section GB5 |
| GB6 | Channel section | Survey | Based on survey at this location. Downstream distance to Langford Brook confluence was 79.8m. As such 1 interpolate was used between section GB6 and GB6.1(See section below). Both were given downstream distances of 39.90m. |

Lower Langford Brook Hydraulic Model 1D ISIS Sections

| Node | Type | Method | Comments |
|---|---|---|---|
| GB6_Ia | Interpolates | NA | See section GB6 |
| GB6.1 | Channel section | See comment | As section GB6 was not surveyed at the confluence, a new section was added to reflect the conditions at the confluence. Simple U section used. Bed levels based on that shown in long profile, bank levels altered to that also shown on survey (cross section location drawing). Distance downstream = 0. |
| **Wendlebury Brook** | | | |
| WB_LiD_1 | Channel section | See comment | Model upstream boundary was extended upstream. To allow for assessment of impacts to be assessed at this location. As a result LiDAR was used to base two sections on. Raw LiDAR was suggesting that the channel was 0.5m deep, however based on photography, this was thought to be over conservative. As a result, LiDAR was analysed at a known survey section which had ground survey taken on it. WB3 surveyed bed level = 59.084mAOD, LiDAR suggests 60.165m. Therefore the suggested error in channel is 1.08m. LiDAR was therefore used to calculate bank levels, with the bed levels lowered by 1.08m. Later inspection of model long section, suggested that LID_1 was representaive of the long profile slope, howver LID_" was not. as a result, the bed level of LID_2 was raised based on interpolation beween |
| WB_LiD_2 | Channel Section | See comment | |
| WB1 | Channel Section | Survey | Based on survey at upstream face of culvert underneath the railway embankment. |
| WB1 Bridge structure | Arch Bridge | Survey | Based n structure survey at this location. Channel section adopted from WB1 (Upstream face). Mannings reduced to 0.025 to replicate concrete. Springing and soffit based on the survey data. |
| WB2 | Channel Section | Survey | Based on survey at this location. Distance downstream of WB2 to WB3 was calculated as approximatley 201.195m. As such, the distance downstream of WB2 was set to 51.195, 3 interpolaes were also added with lengths of 50m. |
| WB2_Ia to WB2_Ic | Interpolates | NA | See section WB2 |
| WB3 | Channel Section | Survey | Based on survey at this location. Distance downstream of WB3 to WB4 was calculated as approximatley 82.376m. As such one interpolate was added, the distance downstream for both sections was set as, 41.19m. |
| WB3_Ia | Interpolates | NA | See section WB3 |
| WB4 | Channel Section | Survey | Cross section based on survey. This section is immediately upstream of a small bridge structure. This bridge has been modelled within the 1D model and the spill is also represented in 1D due to its width (not considered appropriate to model within 2D). |
| WB4 Bridge structure | USBPR Bridge unit | Survey | Based on structure survey at WB4. Channel section is based on WB4. Opening based on survey. Standard paramaters used. |
| WB4 Bridge Spill | Spill | Survey | Flat spill, based on width of channel and set to a flat level of 61.271mAOD as represented within the CAD survey. |
| WB5 | Channel section | Survey | Channel section at downstream face of bridge structure. Section data based on that provided within survey. Distance to section downstream WB6 is approxmiamtely 157.44. Three interpolates added. All section within this reach given a downstream distance of 39.360m. |
| WB5_Ia to WB5_Ic | Interpolates | NA | See section WB5. |
| WB6 | Channel Secion | Survey | Section data based on that provided within survey. Distance to section downstream WB7 is approxmiamtely 126.9m. Originally two interpolates were used, all sections having a downstream distance of 42.3m. However following steady state, another interpolate was used between interpolate WB5_Ib and section wB6. As such the final two interpolates WB5_IB and WB5_Ic now have a downstream distance to next section of 21.150m. |
| WB6_Ia to WB6_Ic | Interpolates | NA | See section WB6 |
| WB7 | Channel Section | Survey | Based on channel cross section survey at this location. This section was not taken at the confluence (8m downstream). As such a final section was added WB7.2 (see below). |
| WB7.2 | Channel Section | Survey | This section is a simple U shape (similar to that of WB7 only 8m upstream). The bed lowered to that of bed at the langford brook as picked up by survey calculated to be 58.167 Banks based on the section location survey at this location. |
| **Merton Ditch** | | | |
| MD0.1 | Channel Section | LiDAR | Requirement to extend the modle upstream to assess changes, impacts and flow routes upstream of current model survey section area. As such LiDAR was used to create model sections at these locations. Bed levels were however set based on section MD1.0. Interpolation of bed slope through MErton ditch suggests that the slope is virtually 0. As such the bed levels were set equal that of MD1.0 (surveyed). Sections were deactivated at bank level. |
| MD0.2 | Channel Section | LiDAR | |
| MD0.3 | Channel Section | LiDAR | |
| MD1.0 | Channel Section | Survey | Based on survey section at this location. Distance downstream to footbridge = 10m therefore no interpolate was required. |
| MD1.0_BRU | Channel Section | See comment | Section based on basic survey taken at the upstream face of the structure as shown on long profile survey drawings. |
| MD1.0_ Bridge unit | Arch BRidge | See comment | Section based on basic survey taken at the upstream face of the structure as shown on long profile survey drawings. Mannings reduced to 0.035 to account for non-natural materials used howveer bed material appears present. |
| MD1.0 Bridge spill | Spill | See comment | Bridge spill modelled in 1D. Set to width of structure (5m approximately), set to a flat level of 60.050m as highlighted in survey. |
| MD1.0_BRD | Channel Section | See comment | Due to no real change in levels upstream and downstream of bridge based on the basic survey. The upstream cross section was replicated downstream. Therefore the US and DS cross sections are the same. Based on the basic survey, and distance from area of interest this is thought sufficient. |
| MD1.1 | Channel Section | See comment | Section based on basic survey taken at the upstream face of the culvert as shown on long profile survey drawings. |
| MD1.1 Culvert | Culvert | See Comment | Culvert based on survey provided from long section of survey. Culvert modelled as a circular conduit as shown in photography. Inlet modelled as a standard Concrete, square edged culvert unit. Outlet uses standard parameters and co-effficents. Mannings reduced above the axis to 0.02 to reflect concrete, however below, bed material is assumed and therefore roughness = 0.04. |

| Node | Type | Method | Comments |
|---|---|---|---|
| MD1.2 | Channel Section | See comment | Section based on basic survey taken at the upstream face of the culvert as shown on long profile survey drawings. .Please note that the survey has been drawn right to left bank on the downstream side and therefore the section has been flipped to conform to the left right standard method of drawing sections. Distance downstream to section MD2.0 is approx. 70m although this is greater than the usual 50m maximum allowed, due to the location of the section in relation to the area of study and the minimal predicted 1 in 1000 year flows down this watercourse, no interpolate has been used. |
| MD2.0 | Channel Section | Survey | Based on survey provided at this location. Distance downstream to bridge structure downstream is approximately 156.152m. As such two interpolates were used. Distance downstream to first interpolate is 52.152m, both interpolates have a value of 52.00m. |
| MD2.0_Ia to MD2.0_Ib | Interpolates | NA | See section MD2.0 |
| MD2.1 | Channel Section | See Comment | Section based on basic survey taken at the upstream face of the culvert as shown on long profile survey drawings. This has been used as the upstream section data for this structure. |
| MD2.1 Bridge | USBPR Bridge unit | Survey | Section based on basic survey taken at this location, based on the long profile sketches. Note: For sensitivity run of 1 in 100 year CC event on the Ray and Langford Brook, this was modelled as an orifice unit to aid in stability. This is not considered to have any impact at Langford Lane. |
| MD2.1 Spill | Spill Unit | See Comment | Spill modelled within 1D domain. Width set to that of the structure/channel. Flat level set to 59.650 as found from survey. |
| MD2.2 | Channel Section | Survey | Channel section at downstream face of bridge strucutre. This is a copy of section MD2.1, This is thought to be sufficient representation of downstream conditions based on photographs and on site observations. Distance between MD2.2 and MD3.0 is 134.73. Two interpolates added, the distance downstream for all sections within the reach is set to 44.91m. |
| MD2.2_Ia and MD2.2_Ib | Interpolates | NA | See section MD2.2 |
| MD3.0 | Channel Section | Survey | Based on survey data. No other changes. Distance downstream results in no new interpolates being required |
| MD4.0 | Channel Section | Survey | Based on survey data. No other changes. Distance downstream results in no new interpolates being required |
| MD5.0 | Channel Section | Survey | Upstream cross section of motorway bridge. Based on survey at this section. |
| MD5.0 Bridge | USBPR Bridge unit | Survey | Bridge section, based on survey at this location. No non-standard parameters or co-efficients applied. |
| MD6.0 | Channel Section | Survey | Based on survey data. No other changes. Distance downstream to section MD7.0 = 108.671. Due to initial instabilities at this location downstream of the bridge a number of interpolates have been added. In total 7 interpolates with a downstream distance of 13.5, distance between channel survey section and first interpolate =14.171 |
| MD6.0_IA to MD6.0_Ig | Interpolates | NA | See Section MD6.0 |
| MD7.0 | Channel Section | Survey | Based on survey data. No other changes. Distance downstream to section MD8.0 = 316.468. Total of 7 interpolates added. MD7.0 distance downstream = 39.968, all interpolates =39.5m |
| MD7.0_Ia to MD7.0_Ig | Interpolates | NA | See section MD7.0 |
| MD8.0 | Channel Section | Survey | Section based on survey at this location. This section makes the upstream section of main road bridge downstream of the motorway crossing. This area is modelled in 1D only. |
| MD8.0 Bridge | Arch Bridge | Survey | Arch bridge based on survey data |
| MD8.0 Bridge Spill | Spill | Survey | Spill modelled within the 1D domain as this is in 1D only section of the model. Set to width of the bridge (6.241 and the elevation of the carriageway, approximately 60.00mAOD. |
| MD9.0 | Channel Section | Survey | Section based on survey at this location. This section makes the dowsntream section of main road bridge downstream of the motorway crossing. Distance downstream to confluence with Langford Brook = 307.86m. As a result 3 interpolates added. Distance downstream from MD9.0 to first interpolate = 77.610m. Interpolates = 76.75m |
| MD9.0_Ia to MD9.0_Ic | Interpolates | NA | See section MD9.0 |
| MD9.1 | Channel Section | See comment | As section MD9.0 was not located at the confluence with the Langford Brook a new cross section was created. Shape of channel based on MD9.0. From survey (Plan) bank levels were shown to be on average (between the two 0.82m lower than those at section MD9.0. As a result originally all inchannel levels were reduced by 0.82 to account for this. However, based on Survey of Langford Brook, bed level at the ocnfluence was shown to be 57.78m, therefore any levels that were lower than this within the section were changed to this level. This produced a relatively flat bottomed channel section. |
| **Un-named Tributary** | | | |
| UN1 | Channel Section | Survey | Section based on survey at section 1. Distance downstream between UW1 and UW2 was originally 587.550. However, section UN1 (UW1) was moved upstream by 15.45m to the confluence with Gaggle Brook. Due to the very flat nature of the area no levels were changed. New downstream distance was 603m. As a result 5 interpolates were added. Channel section distance downstream = 103m, interpolates = 100m. Left bank and right bank level altered to reflect that of Gaggle BRook in this location. Bank levels at surveyed location were read in on the 2D HXI boundary line (See notes of 2D model section). |
| UN1_Ia to UN1_Ie | Interpolates | NA | See Section UN1 |
| UN2 | Channel Section | Survey | Section based on survey at UW2. Distance downstream to UW4 was calculated as 182.081. As a result, one interpolate was added. Distance downstream to interpolate = 82.081, interpolate distance downstream to next section = 100.00m |
| UN2_Ia | Interpolates | NA | See Section UN2 |
| UN4 | Channel Section | Survey | Section based on survey at UW4. Distance downstream to footbridge structure was calculated as 48.822m, therefore no interpolate required. |
| UN4_BrUS | Channel Section | See comment | Channel section is upstream of footbridge crossing. Section data was taken from basic survey carried out at this section (See long section). |
| UN4_BRUS Bridge unit | USBPR Bridge unit | See comment | Structure based on section UN4_BrUS (channel), structure detailing taken from survey at this point (See long section). |
| UN4_BRUS Spill | Spill | See comment | Spill modelled in 1D domain, set to width of structure approximately 5.976, and level of crossing 60.910 (based on survey). |

| Node | Type | Method | Comments |
|---|---|---|---|
| UN4_BrDS | Channel Section | See Comment | Copy of upstream section UN4_BrUS. Due to flat nature of catchment and watercourse levels are not found to change much upstream and downstream therefore this is considered to be a fair reflection. Distance downstream to section 5 is 15.838m, therefore interpolate not required. |
| UN5 | Channel Section | Survey | Section based on survey at this location. Distance to downsream culvert structure is approximately 300m. Therefore two interpolates added. All sections within reach have distance downstream set to 100m. |
| UN5_Ia and UN5_Ib | Interpolates | NA | See Section UN5 |
| UN5_CulUS | Channel Section | See comment | Culvert section found downstream of section UN5. Therefore channel section required at upstream of strucutre. This is based on basic survey taken at this section (shown on long section of survey plans). |
| UN5_CulUS Culvert Unit | Culvert | See comment | Modeled as a circular conduit unit. Channel section taken from UN5_CulUS. Inlet type modelled as a standard concrete, headwalled, square edge structure. Structure dimensions based on survey. Mannings value above axis set to 0.02, below to 0.03 to reflect the presence of some bed material. Outlet modelled using standard parameters/co-efficients. |
| UN5_CulDS | Channel Section | See Comment | Downstream section of culvert. This is based on basic survey taken at this section (shown on long section of survey plans). Please note section originally drawn backwards in CAD, therefore flipped to convert to standard left-right orientation. Distance to next structure downstream = 260.917. As a result two interpolates added. Section to first interpolate = 60.917m, both interpolates have lengths of 100m/ |
| UN5_CulDS_Ia and UN5_CulDS_Ib | Interpolates | NA | See Section UN5_CulDS |
| UN5_BrUS | Channel Section | See comment | Bridge section found between UN5 and UN6. Therefore channel section required at upstream of strucutre. This is based on basic survey taken at this section (shown on long section of survey plans). |
| UN5_BrUS Bridge unit | USBPR Bridge unit | See Comment | USBPR bridge based on survey data found on long section of CAD plans. Upstream channel section also based on section above long section (See CAD files). |
| UN5_BrUS Spill Unit | Spill Unit | See Comment | Spill unit modelled within 1D model. Width set to that of structure 5.643m, level set to 60.470 based on CAD survey. |
| UN5_BrDS | Channel Section | See Comment | Downstream channel section of bridge. This is a copy of the upstream section. Based on the flat nature of the catchment and the fact that site observations suggest no difference in real levels either side, this method is considered sufficient. Distance to next section downstream = 384.101m. As a result three interpolates added. Section to first interpolate = 84.101m, interpolates have lengths of 100m. |
| UN5_BrDS_Ia to UN5_BrDS_Ic | Interpolates | NA | See section UN5_BrDS. |
| UN6 | Channel Section | Survey | Based on survey at this location. Section moved downstream by approximately 8m to confluence with Langford Brook. Bank levels altered to reflect the Langford Brook levels in this area. Bank levels at surveyed location were read in on the 2D HXI boundary line (See notes of 2D model section). |

## Model Files

**Colour coding for file names**

| | |
|---|---|
| BLACK | File used in both baseline and post development simulations |
| GREEN RED | Files interchangeable between post development (red) and baseline (Green) |
| PURPLE | Files used only within the post development simulation |

| File name | Type | Format | Comments |
|---|---|---|---|
| LLB_BSC_0100F_2113_042.tcf | Tuflow Control File | .TCF | Tuflow Control File for baseline simulation |
| LLB_BSC_0100F_2113_042.tgc | Tuflow Geometry Control File | .TGC | Tuflow Geometry Control File for baseline simulation |
| LLB_BSC_0100F_2113_042.tbc | Tuflow Boundary Control File | .TBC | Tuflow Boundary Control File for baseline simulation |
| LLB_BSC_0100F_2113_042.ecf | Estry Control File | .ECF | Estry Control File for baseline simulation |
| LLB_BSC_0100F_2113_CSp.tcf | Tuflow Control File | .TCF | Tuflow Control File for post development simulation |
| LLB_BSC_0100F_2113_CSp.tgc | Tuflow Geometry Control File | .TGC | Tuflow Geometry Control File for post development simulation |
| LLB_BSC_0100F_2113_CSp.tbc | Tuflow Boundary Control File | .TBC | Tuflow Boundary Control File for post development simulation |
| LLB_BSC_0100F_2113_CSp.ecf | Estry Control File | .ECF | Estry Control File for post development simulation |
| | | | |
| **TCF files** | | | |
| 1D_ISIS_Nodes_LLB_P_004 | 1D ISIS Nodes | .shp (P) | 1D ISIS node points to connect 1D and 2D domains. |
| 1D_ISIS_NWK_LLB_L_004 | 1D ISIS Network | .shp (L) | 1D ISIS network to be connected to 2D domain via spill connections |
| 2d_iwl_LLB_Lake_R_032 | 2D Initial Water Level | .shp ( R) | Initial water levels set in 2D lakes as shown using the hyperlink. Water level set in all water bodies as 59.927mAOD. This is based on cross section WB3 which picks up the water level in lake adjacent. This may over estimate levels in some areas, but is considered conservative as this will reduce available storage. **This does cause relatively high mass balance error (greater than +-1%) within the first hour. Following this mass balance settles.** |
| WHS1160_mat_001 | Mannings reference file | .tmf | Materials reference file. This used the mannings previously agreed within the existing model. Two new categories were added which were absent in the original model. Woodland, and General surface (to represent the generic land use), set at values of 0.045 and 0.035 respectively. |
| **.TGC Files** | | | |
| 2d_loc_LLB_L_001 | Location Line | .shp (L) | Line to define the SW corner of the model. Grid size is 5000 x 4500m. SW corner located at 452310, 216112. |
| 2d_code_LLB_2DAct_R_001 | 2D code polygon | .shp ( R) | 2D code polygon. Sets area over domain to be "active". |
| 2d_code_LLB_1D_R_006 | 2D code polygon | .shp ( R) | Code polygon to deactivate the 1D domain from the 2D polygon. Snapped to HXI line which highlights the banks. |
| 2d_code_LLB_1D_R_CSP | 2D code polygon | .shp ( R) | Code polygon to deactivate the 1D domain from the 2D polygon. Snapped to HXI line which highlights the banks. Slight change due to allignment of Langford Lane (on un-named watercourse) however extremely minor. |
| mergeddtmv3 | DTM | .ASC | Merged DTM tiles provided by Environment Agency. |
| 2d_bc_LLB_HXI_L_042 | HX Boundary Lines | .shp (L) | HX boundary lines and CN lines to connect the 1D domain to 2D domain. Set to bank widths of main channels modelled within 1D as shown in the Model summary sheet. See below comment with regard to adoption of existing EA model. |
| 2d_bc_LLB_HXI_P_042 | HX boundary Points | .shp (P) | Points to be used to give elevation along HX lines. These were set to be the LB and RB levels as found in ISIS model at each section. A number of additional ZPTs were used along the line. A number o zpoints have been added along the HX line where the bank levels were being interpolated incorrectly, these have had to be based on LiDAR levels. Upstream of the railway embankment (upstrem of Langford Lane) this layer has adopted the existing EA model. |
| 2d_bc_LLB_HXI_L_CSp | HX Boundary Lines | .shp (L) | HX boundary lines and CN lines to connect the 1D domain to 2D domain. Set to bank widths of main channels modelled within 1D as shown in the Model summary sheet. |
| 2d_bc_LLB_HXI_P_CSp | HX boundary Points | .shp (P) | Points to be used to give elevation along HX lines. These were set to be the LB and RB levels as found in ISIS model at each section. A number of additional ZPTs were used along the line. A number o zpoints have been added along the HX line where the bank levels were being interpolated incorrectly, these have had to be based on LiDAR levels. |
| 2d_zsh_LLB_Bridges_R_030 | Z Shape Topography | .shp ( R) | Zshape to raise 2D topography where spills over birdges are to be modelled within the 2D domain. |
| 2d_zsh_LLB_Bridges_P_030 | Z Shape Topography | .shp (P) | Zpoints to raise zhape (above) to bridge deck levels. |
| 2d_zsh_LLB_Stab_R_030 | Zshape Topography | .shp ( R) | Zshape to smooth out some areas of model instability, smooting of DTM in a number of locations upstream of new model boundary. This is as a result of changing the grid cell size from that of the original model. |
| 2d_zsh_LLB_Culinlet_R_030.shp | Zshape Topography | .shp ( R) | Z shape, two cells in width to flatten out 2D inlet to Estry culverts. |
| 2d_zsh_LLB_Culinlet_P_030.shp | Z Shape Topography | .shp (P) | Z shape zpoints to set the zshape (above) to appropriate level |
| 2d_zsh_LLB_Culinlet_R_CSp.shp | Zshape Topography | .shp ( R) | Z shape, two cells in width to flatten out 2D inlet to Estry culverts. A copy of that used within the baselin emodel, with additional zshape to accommodate new culvert through the Langford Lane proposed route. |
| 2d_zsh_LLB_Culinlet_P_CSp.shp | Z Shape Topography | .shp (P) | See above |
| 2d_zsh_LLB_UnTrib_L_004 | Z Shape topography | .shp (L) | Z line read in as one cell thick to model the drainage channel from Gaggle Brook to the Un-named trib, via a culvert under the railway embankment. This has been given level data based on the Point layer (see file below). |
| 2d_zsh_LLB_UnTrib_P_030 | Z Shape Topography | .shp (P) | Z points to set topography of the drainage channel (described above). |
| 2d_zsh_LLB_LangLaneEm_R_001 | Z Shape Topography | .shp ( R) | Z shape file to represent the proposed embankment on either side of the main carriageway. |

Lower Langford Brook Hydraulic Model 2D TUFLOW Log

| File name | Type | Format | Comments |
|---|---|---|---|
| 2d_zsh_LLB_LangLaneEm_P_001 | Z Shape Topography | .shp (P) | Z points to set topography of the embankment shape to those proposed in the vertical allignment drawings proposed by Atkins. |
| 2d_zsh_LLB_LangLane_R_001 | Z Shape Topography | .shp ( R) | Z shape file to represent the proposed main carriageway. |
| 2d_zsh_LLB_LangLane_P_001 | Z Shape Topography | .shp (P) | Z points to set topography of the carriagway to that proposed in the vertical allignment drawings proposed by Atkins. |
| 2d_mat_Bicester_001 | Materials Layer | .mif | Polygons used within the original model. No changes to polygons was made, only to the default mannings being applied. |
| 2d_mat_LLB_Mann_R_002 | Materials Layer | .shp ( R) | Polygons for new model area to represent different mannings values. This has been carried out using a combination of mastermap data and aerial photography. |
| 2d_mat_LLB_Mann_R_CSp | Materials Layer | .shp ( R) | Added material polygon to allow for the proposed road to be accurately modelled in the post development scenario. |
| **.TBC Files** | | | |
| 2d_bc_LLB_HXI_L_042 | HX Boundary | .shp (L) | See .TGC reference |
| 2d_bc_LLB_HXI_L_CSp | HX Boundary | .shp (L) | See .TGC reference |
| 2d_bc_LLB_Cul_L_032 | HX Boundary | .shp (L) | HX boundary to link 1D Estry Culvert units into the 2D Domain |
| 2d_bc_LLB_Cul_L_Csp | HX Boundary | .shp (L) | As above for post development scenario |
| **.ECF Files** | | | |
| 1d_EST_NWK_LLB_L_032 | 1D Network Line | .shp (L) | 1D network Line representing the location and dimensions of culverts to be used underneath the railway embankment. |
| 1d_EST_NWK_LLB_L_CSp | 1D Network Line | .shp (L) | As above, but with added culverts through the proposed Langford Lane development. |

# Appendix 3 Hydraulic Model 1D Results

| Maximum Water Level (mAOD) - Clear Span | | | | | | |
|---|---|---|---|---|---|---|
| | 1 in 100CC | | | 1 in 1000 | | |
| Node | Pre | Post | Diff | Pre | Post | Diff |
| LA.1350D | 65.37 | 65.37 | **0.00** | 65.46 | 65.46 | **0.00** |
| LA.1350D.1 | 64.94 | 64.94 | **0.00** | 64.99 | 64.99 | **0.00** |
| LA.0957 | 64.62 | 64.62 | **0.00** | 64.69 | 64.69 | **0.00** |
| LA.0865 | 64.53 | 64.53 | **0.00** | 64.63 | 64.63 | **0.00** |
| LA.0767 | 64.38 | 64.38 | **0.00** | 64.55 | 64.55 | **0.00** |
| LA.0737 | 64.24 | 64.24 | **0.00** | 64.45 | 64.45 | **0.00** |
| LA.0726 | 64.25 | 64.25 | **0.00** | 64.43 | 64.43 | **0.00** |
| LA.0726BU | 64.25 | 64.25 | **0.00** | 64.43 | 64.43 | **0.00** |
| LA.0720BD | 64.25 | 64.25 | **0.00** | 64.27 | 64.27 | **0.00** |
| LA.0726SU | 64.25 | 64.25 | **0.00** | 64.43 | 64.43 | **0.00** |
| LA.0726SD | 64.25 | 64.25 | **0.00** | 64.27 | 64.27 | **0.00** |
| LA.0720 | 64.25 | 64.25 | **0.00** | 64.27 | 64.27 | **0.00** |
| LA.0711 | 64.24 | 64.24 | **0.00** | 64.27 | 64.27 | **0.00** |
| LA.0469 | 63.92 | 63.92 | **0.00** | 64.03 | 64.03 | **0.00** |
| LA.0210 | 63.84 | 63.84 | **0.00** | 63.98 | 63.98 | **0.00** |
| LA.0017 | 63.75 | 63.75 | **0.00** | 63.90 | 63.90 | **0.00** |
| LB2 | 63.66 | 63.66 | **0.00** | 63.78 | 63.78 | **0.00** |
| LB2.BU | 63.66 | 63.66 | **0.00** | 63.78 | 63.78 | **0.00** |
| LB2.BD | 63.64 | 63.64 | **0.00** | 63.76 | 63.76 | **0.00** |
| LB3 | 63.63 | 63.63 | **0.00** | 63.75 | 63.75 | **0.00** |
| LB2.BD_dum | 63.64 | 63.64 | **0.00** | 63.76 | 63.76 | **0.00** |
| LB4 | 63.55 | 63.55 | **0.00** | 63.72 | 63.72 | **0.00** |
| LB5 | 63.52 | 63.52 | **0.00** | 63.70 | 63.70 | **0.00** |
| LB6 | 63.31 | 63.31 | **0.00** | 63.49 | 63.49 | **0.00** |
| LB6.CI_D | 63.16 | 63.16 | **0.00** | 63.34 | 63.34 | **0.00** |
| LB6.CO_U | 63.13 | 63.13 | **0.00** | 63.31 | 63.31 | **0.00** |
| LB7 | 62.92 | 62.92 | **0.00** | 63.08 | 63.08 | **0.00** |
| LB8 | 62.81 | 62.81 | **0.00** | 62.97 | 62.97 | **0.00** |
| LB9 | 62.65 | 62.65 | **0.00** | 62.82 | 62.83 | **0.01** |
| LB10 | 62.45 | 62.45 | **0.00** | 62.64 | 62.66 | **0.01** |
| LB10.1 | 62.43 | 62.43 | **0.00** | 62.63 | 62.65 | **0.01** |
| LB11 | 62.43 | 62.43 | **0.00** | 62.63 | 62.65 | **0.01** |
| LB12 | 61.85 | 61.85 | **0.00** | 62.00 | 62.01 | **0.01** |
| LB13 | 61.26 | 61.26 | **0.00** | 61.30 | 61.30 | **0.00** |
| LB14 | 60.67 | 60.67 | **0.00** | 60.69 | 60.69 | **0.00** |
| LB14.1 | 60.50 | 60.50 | **0.00** | 60.55 | 60.55 | **0.00** |
| LB14.2 | 60.50 | 60.50 | **0.00** | 60.55 | 60.55 | **0.00** |
| LB15 | 60.49 | 60.49 | **0.00** | 60.54 | 60.54 | **0.00** |
| LB15.1 | 60.31 | 60.32 | **0.00** | 60.38 | 60.38 | **0.00** |
| LB16 | 60.31 | 60.32 | **0.00** | 60.38 | 60.38 | **0.00** |
| LB17 | 60.22 | 60.22 | **0.00** | 60.26 | 60.26 | **0.00** |
| LB18 | 60.21 | 60.21 | **0.00** | 60.25 | 60.25 | **0.00** |
| LB19 | 60.21 | 60.21 | **0.00** | 60.26 | 60.26 | **0.00** |
| LB20 | 60.21 | 60.21 | **0.00** | 60.25 | 60.25 | **0.00** |
| LB19_dum | 60.21 | 60.21 | **0.00** | 60.25 | 60.25 | **0.00** |
| LB21 | 60.16 | 60.16 | **0.00** | 60.20 | 60.20 | **0.00** |

| | | | | | | |
|---|---|---|---|---|---|---|
| LB22 | 59.97 | 59.97 | **0.00** | 60.03 | 60.03 | **0.00** |
| LB22.BU | 59.97 | 59.97 | **0.00** | 60.03 | 60.03 | **0.00** |
| LB22_Spill_U | 59.97 | 59.97 | **0.00** | 60.03 | 60.03 | **0.00** |
| LB22_Spill_D | 59.67 | 59.67 | **0.00** | 59.72 | 59.72 | **0.00** |
| LB22.BD | 59.67 | 59.67 | **0.00** | 59.72 | 59.72 | **0.00** |
| LB23 | 59.67 | 59.67 | **0.00** | 59.72 | 59.72 | **0.00** |
| MER_CON_US | 59.49 | 59.49 | **0.00** | 59.53 | 59.54 | **0.00** |
| MER_CON_DS | 59.49 | 59.49 | **0.00** | 59.53 | 59.54 | **0.00** |
| LB24 | 59.47 | 59.47 | **0.00** | 59.50 | 59.50 | **0.00** |
| LB25 | 59.45 | 59.45 | **0.00** | 59.48 | 59.48 | **0.00** |
| GB1 | 63.31 | 63.31 | **0.00** | 63.35 | 63.35 | **0.00** |
| GB1.1 | 62.89 | 62.89 | **0.00** | 63.07 | 63.07 | **0.00** |
| GB1.1_B_US | 62.89 | 62.89 | **0.00** | 63.07 | 63.07 | **0.00** |
| GB1.1_B_DS | 62.88 | 62.88 | **0.00** | 63.06 | 63.06 | **0.00** |
| GB1.1_S_US | 62.89 | 62.89 | **0.00** | 63.07 | 63.07 | **0.00** |
| GB1.1_S_DS | 62.88 | 62.88 | **0.00** | 63.06 | 63.06 | **0.00** |
| GB1.2 | 62.88 | 62.88 | **0.00** | 63.06 | 63.06 | **0.00** |
| GB2 | 62.72 | 62.72 | **0.00** | 62.98 | 62.98 | **0.00** |
| GB2.1 | 62.72 | 62.72 | **0.00** | 62.98 | 62.98 | **0.00** |
| GB2.1_BR_US | 62.72 | 62.72 | **0.00** | 62.98 | 62.98 | **0.00** |
| GB2.1_BR_DS | 62.71 | 62.71 | **0.00** | 62.95 | 62.95 | **0.00** |
| GB2.2 | 62.71 | 62.71 | **0.00** | 62.95 | 62.95 | **0.00** |
| GB3 | 62.69 | 62.69 | **0.00** | 62.92 | 62.92 | **0.00** |
| GB4 | 62.65 | 62.65 | **0.00** | 62.85 | 62.85 | **0.00** |
| GB4.1 | 62.61 | 62.61 | **0.00** | 62.75 | 62.75 | **0.00** |
| GB4.1_W_US | 62.61 | 62.61 | **0.00** | 62.75 | 62.75 | **0.00** |
| GB4.1_W_DS | 62.42 | 62.42 | **0.00** | 62.63 | 62.67 | **0.05** |
| GB4.2 | 62.42 | 62.42 | **0.00** | 62.63 | 62.67 | **0.05** |
| GB4.3 | 62.42 | 62.42 | **0.00** | 62.62 | 62.65 | **0.03** |
| GB4.4 | 62.42 | 62.42 | **0.00** | 62.62 | 62.65 | **0.03** |
| GB5 | 62.42 | 62.42 | **0.00** | 62.62 | 62.64 | **0.02** |
| GB6 | 62.43 | 62.43 | **0.00** | 62.63 | 62.65 | **0.01** |
| GB6.1 | 62.43 | 62.43 | **0.00** | 62.63 | 62.65 | **0.01** |
| UN1 | 62.42 | 62.42 | **0.00** | 62.62 | 62.65 | **0.03** |
| UN2 | 61.21 | 61.20 | **-0.01** | 61.37 | 61.40 | **0.03** |
| UN4 | 61.01 | 61.01 | **0.00** | 61.12 | 61.17 | **0.05** |
| UN4_BrUS | 60.97 | 60.98 | **0.00** | 61.08 | 61.14 | **0.05** |
| UN4_BridgeU | 60.97 | 60.98 | **0.00** | 61.08 | 61.14 | **0.05** |
| UN4_BrSU | 60.97 | 60.98 | **0.00** | 61.08 | 61.14 | **0.05** |
| UN4_BrSD | 60.94 | 60.94 | **0.00** | 61.04 | 61.08 | **0.05** |
| UN4_BridgeD | 60.94 | 60.94 | **0.00** | 61.04 | 61.08 | **0.05** |
| UN4_BrDS | 60.94 | 60.94 | **0.00** | 61.04 | 61.08 | **0.05** |
| UN5 | 60.90 | 60.90 | **0.00** | 60.99 | 61.03 | **0.04** |
| UN5_CulUS | 60.58 | 60.58 | **0.00** | 60.68 | 60.68 | **0.00** |
| Cul_Inl_US | 60.58 | 60.58 | **0.00** | 60.68 | 60.68 | **0.00** |
| Cul_Inl_DS | 60.57 | 60.57 | **0.00** | 60.68 | 60.68 | **0.00** |
| Cul_Out_US | 60.55 | 60.55 | **0.00** | 60.62 | 60.62 | **0.00** |
| Cul_Out_DS | 60.54 | 60.54 | **0.00** | 60.61 | 60.61 | **0.00** |
| UN5_CulDS | 60.54 | 60.54 | **0.00** | 60.61 | 60.61 | **0.00** |
| UN5_CulDS_la | 60.54 | 60.54 | **0.00** | 60.61 | 60.61 | **0.00** |

| | | | | | | |
|---|---|---|---|---|---|---|
| UN5_CulDS_Ib | 60.54 | 60.54 | **0.00** | 60.61 | 60.61 | **0.00** |
| UN5_CulDS_Ic | 60.53 | 60.53 | **0.00** | 60.61 | 60.61 | **0.00** |
| UN5_CulDS_Id | 60.53 | 60.53 | **0.00** | 60.61 | 60.61 | **0.00** |
| UN5_BrUS | 60.53 | 60.53 | **0.00** | 60.61 | 60.61 | **0.00** |
| UN5_Br_US | 60.53 | 60.53 | **0.00** | 60.61 | 60.61 | **0.00** |
| UN5_Spill_US | 60.53 | 60.53 | **0.00** | 60.61 | 60.61 | **0.00** |
| UN5_Spill_DS | 60.53 | 60.53 | **0.00** | 60.61 | 60.61 | **0.00** |
| UN5_Br_DS | 60.53 | 60.53 | **0.00** | 60.61 | 60.61 | **0.00** |
| UN5_BrDS | 60.53 | 60.53 | **0.00** | 60.61 | 60.61 | **0.00** |
| UN6 | 60.50 | 60.50 | **0.00** | 60.55 | 60.55 | **0.00** |
| WB_LiD_1 | 61.29 | 61.29 | **0.00** | 61.52 | 61.52 | **0.00** |
| WB_LiD_2 | 60.74 | 60.74 | **0.00** | 60.90 | 60.90 | **0.00** |
| WB1 | 60.63 | 60.63 | **0.00** | 60.78 | 60.78 | **0.00** |
| WB1_BR_US | 60.63 | 60.63 | **0.00** | 60.78 | 60.78 | **0.00** |
| WB1_BR_DS | 60.55 | 60.55 | **0.00** | 60.62 | 60.62 | **0.00** |
| WB2 | 60.55 | 60.55 | **0.00** | 60.62 | 60.62 | **0.00** |
| WB3 | 60.41 | 60.41 | **0.00** | 60.59 | 60.59 | **0.00** |
| WB4 | 60.40 | 60.40 | **0.00** | 60.59 | 60.59 | **0.00** |
| WB4_B_US | 60.40 | 60.40 | **0.00** | 60.59 | 60.59 | **0.00** |
| WB4_B_DS | 60.40 | 60.40 | **0.00** | 60.59 | 60.59 | **0.00** |
| WB4_S_US | 60.40 | 60.40 | **0.00** | 60.59 | 60.59 | **0.00** |
| WB4_S_DS | 60.40 | 60.40 | **0.00** | 60.59 | 60.59 | **0.00** |
| WB5 | 60.40 | 60.40 | **0.00** | 60.59 | 60.59 | **0.00** |
| WB6 | 60.38 | 60.38 | **0.00** | 60.58 | 60.57 | **0.00** |
| WB7 | 60.31 | 60.31 | **0.00** | 60.37 | 60.37 | **0.00** |
| WB7.2 | 60.31 | 60.32 | **0.00** | 60.38 | 60.38 | **0.00** |
| MD0.1 | 59.76 | 59.76 | **0.00** | 59.98 | 59.98 | **0.00** |
| MD0.2 | 59.75 | 59.75 | **0.00** | 59.97 | 59.97 | **0.00** |
| MD0.3 | 59.74 | 59.74 | **0.00** | 59.96 | 59.96 | **0.00** |
| MD1.0 | 59.74 | 59.74 | **0.00** | 59.95 | 59.95 | **0.00** |
| MD1.0_BRU | 59.73 | 59.73 | **0.00** | 59.94 | 59.94 | **0.00** |
| MD1.0_B_US | 59.73 | 59.73 | **0.00** | 59.94 | 59.94 | **0.00** |
| MD1.0_B_DS | 59.64 | 59.64 | **0.00** | 59.83 | 59.83 | **0.00** |
| MD1.0_S_US | 59.73 | 59.73 | **0.00** | 59.94 | 59.94 | **0.00** |
| MD1.0_S_DS | 59.64 | 59.64 | **0.00** | 59.83 | 59.83 | **0.00** |
| MD1.0_BRD | 59.64 | 59.64 | **0.00** | 59.83 | 59.83 | **0.00** |
| MD1.1 | 59.63 | 59.63 | **0.00** | 59.83 | 59.83 | **0.00** |
| Cul_InlUS | 59.63 | 59.63 | **0.00** | 59.83 | 59.83 | **0.00** |
| MD1.1_Sp_US | 59.63 | 59.63 | **0.00** | 59.83 | 59.83 | **0.00** |
| Cul_US | 59.60 | 59.60 | **0.00** | 59.83 | 59.82 | **0.00** |
| Cul_DS | 59.55 | 59.55 | **0.00** | 59.82 | 59.82 | **0.00** |
| Cul_OutDS | 59.50 | 59.50 | **0.00** | 59.81 | 59.81 | **0.00** |
| MD1.2 | 59.50 | 59.50 | **0.00** | 59.81 | 59.81 | **0.00** |
| MD1.1_Sp_DS | 59.50 | 59.50 | **0.00** | 59.81 | 59.81 | **0.00** |
| MD2.0 | 59.50 | 59.50 | **0.00** | 59.81 | 59.80 | **0.00** |
| MD2.1 | 59.50 | 59.50 | **0.00** | 59.80 | 59.80 | **0.00** |
| MD2.1_B_US | 59.50 | 59.50 | **0.00** | NA | NA | **-** |
| MD2.1_B_DS | 59.50 | 59.50 | **0.00** | NA | NA | **-** |
| MD2.1_S_US | 59.50 | 59.50 | **0.00** | NA | NA | **-** |
| MD2.1_S_DS | 59.50 | 59.50 | **0.00** | NA | NA | **-** |

| | | | | | | |
|---|---|---|---|---|---|---|
| MD2.2 | 59.50 | 59.50 | **0.00** | 59.789 | 59.788 | **0.00** |
| MD2.2_Ia | 59.50 | 59.50 | **0.00** | 59.788 | 59.787 | **0.00** |
| MD2.2_Ib | 59.50 | 59.50 | **0.00** | 59.786 | 59.785 | **0.00** |
| MD3.0 | 59.50 | 59.50 | **0.00** | 59.772 | 59.771 | **0.00** |
| MD4.0 | 59.50 | 59.50 | **0.00** | 59.745 | 59.745 | **0.00** |
| MD5.0 | 59.50 | 59.50 | **0.00** | 59.753 | 59.753 | **0.00** |
| MD6.0 | 59.50 | 59.50 | **0.00** | 59.751 | 59.75 | **0.00** |
| MD5.0_dum | 59.50 | 59.50 | **0.00** | 59.75 | 59.749 | **0.00** |
| MD7.0 | 59.50 | 59.50 | **0.00** | 59.743 | 59.742 | **0.00** |
| MD8.0 | 59.49 | 59.49 | **0.00** | 59.694 | 59.694 | **0.00** |
| MD8.0_BR_US | 59.49 | 59.49 | **0.00** | 59.694 | 59.694 | **0.00** |
| MD8.0_Sp_US | 59.49 | 59.49 | **0.00** | 59.694 | 59.694 | **0.00** |
| MD8.0_Sp_DS | 59.49 | 59.49 | **0.00** | 59.659 | 59.659 | **0.00** |
| MD8.0_BR_DS | 59.49 | 59.49 | **0.00** | 59.659 | 59.659 | **0.00** |
| MD9.0 | 59.49 | 59.49 | **0.00** | 59.659 | 59.659 | **0.00** |
| MD9.1 | 59.49 | 59.49 | **0.00** | 59.534 | 59.536 | **0.00** |
| RR1 | 59.74 | 59.74 | **0.00** | 59.744 | 59.744 | **0.00** |
| RR2 | 59.45 | 59.45 | **0.00** | 59.484 | 59.484 | **0.00** |
| RR3 | 59.45 | 59.45 | **0.00** | 59.484 | 59.484 | **0.00** |
| RR4 | 58.94 | 58.94 | **0.00** | 58.968 | 58.968 | **0.00** |
| RR5 | 58.53 | 58.53 | **0.00** | 58.561 | 58.561 | **0.00** |
| RR6 | 58.50 | 58.50 | **0.00** | 58.522 | 58.522 | **0.00** |
| RR7 | 58.48 | 58.48 | **0.00** | 58.5 | 58.5 | **0.00** |

# Appendix 4 Correspondence

From: Paul Blackman
Sent: 13 March 2013 09:04
To: Matt Holmes; Tracey Haxton; euan.hampton@hydrosolutions.co.uk
Subject:FW: Chiltern Railways - Modelling for Langford Lane and College Farm Access Roads

FYI – issued with slight adjustments.

From: Paul Blackman [mailto:paul.blackman@hydrosolutions.co.uk]
Sent: 13 March 2013 09:03
To: 'Purbrick, Lewis'
Cc: 'James, Veronica L'; 'Ian Gilder'; Andrew Deacon; Harrison, Catherine
Subject: RE: Chiltern Railways - Modelling for Langford Lane and College Farm Access Roads

Dear Lewis

We have now received and reviewed the existing Bicester model and associated reporting, so I thought
it was worth summing up our proposed approach to any modelling required for the FRA's associated with the proposed road crossings at Langford Lane and the College Farm access road, for your approval
in principle.

1. EA has already confirmed that the existing Bicester model is appropriate for use in the FRA. It is assumed that the EA also consider that the Peter Brett Associates hydrological analysis of the Langford Brook catchment (used in the model) is appropriate for use in the FRA modelling as an upstream boundary condition. Re-assessment of the Langford Brook hydrology through Bicester is outside of the scope of the modelling for the Chiltern Railways FRA's.
2. EA has confirmed that there are no hydrological data available for other tributaries of the Langford Brook downstream of the current model extent (Wendlebury Brook, Gagle Brook, Merton Ditch) that could be used to refine the hydrological analysis. In the absence of other hydrological data, WHS will use current best practice FEH hydrological techniques following standard EA guidance for these ungauged tributary catchments.
3. WHS will undertake approximate hydraulic modelling of a short section of the River Ray to help define downstream boundary conditions at the confluence of the Langford Brook. EA has confirmed that no hydrological data or studies are available for the River Ray and so WHS will undertake an analysis based on standard EA guidance.
4. The existing 1D component of the Bicester model will be extended downstream along the Langford Brook to the M40, using surveyed section data at locations previously supplied to and agreed with the EA. The 1D component will be further extended beyond the M40 to the Langford Brook's confluence with the River Ray to ensure a reliable downstream boundary condition.
5. The existing Bicester 1D 2D model utilises a 2D domain with a 10m grid resolution. To facilitate the assessment of impacts of the proposed road crossings, WHS proposes to refine the grid resolution to 2 or 3m using commercially available Lidar data. Rather than refining the 2D domain of the whole of the existing Bicester model, WHS propose to construct an independent model with its upstream boundary set at a suitable point upstream of the existing railway bridge over the Langford Brook (NGR 457627,220540).

Our hydrological analysis is currently underway and the hydraulic model construction will be
developed

during late March and April when the additional river cross section data are received. I would be grateful
for your approval in principle to the approach outlined above and should you have any comments, these
would be gratefully received within the next two weeks if possible.

Best Regards

Paul
Paul Blackman CEng MICE
Technical Director

Wallingford HydroSolutions Ltd
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Fax: +44 1491 692424
Email: paul.blackman@hydrosolutions.co.uk
Web: www.hydrosolutions.co.uk


From: Purbrick, Lewis [mailto:lewis.purbrick@environment-agency.gov.uk]
Sent: 22 January 2013 17:14
To: Paul Blackman
Cc: James, Veronica L; Steve Barker; Ian Gilder
Subject: RE: Chiltern Railways - Holts Farm Access Road

Dear Paul,
Following on from our discussion yesterday please find attached our modelling guidance document. It may answer some of the questions below but I have asked our Regional Flood modelling
team to look at your questions and provide more bespoke comments where required.

As discussed yesterday I would suggest extending the model limits back up stream on the Langford Brook and Merton Ditch to ensure floodplain interactions between are represented.

Regards,

Lewis Purbrick MCIWEM, C.WEM
Technical Advisor | Flood and Coastal Risk Management | Partnerships and Strategic Overview (Oxfordshire and Buckinghamshire) | South East | West Thames
Environment Agency | Red Kite House, Howbery Park, Crowmarsh Gifford, Oxfordshire, OX10 8BD
Tel: 01491 828464 | Email: lewis.purbrick@environment-agency.gov.uk

Flood alert: Flooding is possible. Be prepared
Be prepared to act on your flood plan. Prepare a flood kit of essential items. Monitor local water levels and the flood forecast on our website

Flood warning: Flooding is expected. Immediate action required.
Move family, pets and valuables to a safe place. Turn off gas, electricity and water supplies if safe to do so. Put flood protection equipment in place.

Severe flood warning: Severe flooding. Danger to life.
Stay in a safe place with a means of escape. Be ready should you need to evacuate from your home. Co-operate with the emergency services. Call 999 if you are in immediate danger.

If you are in a flood risk areas please sign up to our free flood warning system. This is the most immediate
and localised source of information on flooding: visit www.environment-agency.gov.uk/flood or call 0845
988 1188.

You can follow us on Twitter at @EnvAgencySE

From: Paul Blackman [mailto:paul.blackman@hydrosolutions.co.uk]
Sent: 09 January 2013 15:42
To: Purbrick, Lewis
Cc: James, Veronica L; Steve Barker; Ian Gilder
Subject: RE: Chiltern Railways - Holts Farm Access Road

Hi Lewis

Thanks for this.

You will have noticed that we submitted a request before Christmas to your external relations team to
confirm the availability of data and prices and I understand that this is currently with you for action.

Whilst we await confirmation of these data, I would like to confirm with the EA the extent and nature of
any modelling required to demonstrate that the proposed access road is acceptable or that suitable mitigation can be incorporated. You have previously highlighted that the Wendlebury Brook is of particular concern to you. With this in mind I attach a sketch indicating a proposed approximate extent
of the model, and provide an outline methodology below:

1. Model to be developed initially as a 1D model using Isis.
2. The 1D model will be based on any available EA topographic data supplemented by new river section survey data as required.

3. River section locations will be relatively closely spaced to current guidelines in the vicinity of the proposed road crossings, and more coarsely spaced at other reaches of the river. All structures in the rivers will be picked up within the extents highlighted on the attached plan.
4. If initial runs of the 1D model indicate that floodplain interactions are significant then a 2D component (Tuflow) could be added as appropriate based on Lidar data for the immediate floodplain.
5. Hydrological input boundaries will be split between the Wendlebury Brook, Langford Brook and Merton Ditch. Any available EA hydrology or gauge data would be useful here as the catchments are relatively permeable and standard FEH methods may require further refinement.
6. The downstream limit of the proposed model is at the confluence with the Ray. The influence of the Ray on flood levels at the point of interest is unknown at this stage and currently we are assuming that the Ray is not required to be modelled hydrologically or hydraulically (ie that the Q100 flows associated with the brooks and ditches provide the worst case flood levels north of the M40). In this case, as a boundary condition we would assume a flood level in the Ray at top of 'natural' bank, generally considered to be equivalent to a Qmed flow. This is a key assumption in terms of the extent of any required survey work and so any knowledge your team may have on the influence of the Ray on flood levels to the north of the M40 would be useful.

I would be grateful if you would confirm whether this methodology is acceptable and any further modelling specifications that might be applicable.

We plan to visit the site in mid-January to confirm the above assumptions and to identify the extent and
locations of any required survey data. This would provide a good opportunity to meet with you and/or
your colleagues to confirm the nature of the flooding problems at Wendlebury and to confirm the extent and methodology for this modelling work. Please could you confirm some dates in January that
you would be available to meet in this regard.

Many thanks

Paul

Paul Blackman CEng MICE
Technical Director

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Email: paul.blackman@hydrosolutions.co.uk
Web: www.hydrosolutions.co.uk

From: Purbrick, Lewis [mailto:lewis.purbrick@environment-agency.gov.uk]
Sent: 18 December 2012 17:34
To: Paul Blackman
Cc: James, Veronica L; Steve Barker; WT Enquiries
Subject: RE: Chiltern Railways - Holts Farm Access Road

Paul,

Following on from our discussion last week I have checked whether we have any additional survey
or hydrology data in this area. The only things I can find records for that might be relevant are the following, rather old, survey. The only hydrology we have for the area is on the Langford Brook through
Bicester as discussed.

Reference
Survey_Type
Watercourse/Location
Title
Year
01373
C
LANGFORD
BROOK
NEW RAY CONFLUENCE TO MRL STRATTON AUDLEY
1990
04008
C
WENDLEBURY BROOK
MANOR FARM TO NORTH END WENDLEBURY CHANNEL SURVEY
1997
LD11214
C
RAY
(OXON)
CONFLUENCE WITH CHERWELL TO 900M U/S OF BLACKTHORN BRIDGE
1978

If you think any of these would be of any use they can requested via our External Relations team (WTenquiries@environment-agency.gov.uk), there may be a charge for them.

Regards,

Lewis Purbrick MCIWEM, C.WEM
Technical Advisor | Flood and Coastal Risk Management | Partnerships and Strategic Overview (Oxfordshire and Buckinghamshire) | South East | West Thames
Environment Agency | Red Kite House, Howbery Park, Crowmarsh Gifford, Oxfordshire, OX10 8BD
Tel: 01491 828464 | Email: lewis.purbrick@environment-agency.gov.uk



From: Paul Blackman [mailto:paul.blackman@hydrosolutions.co.uk]
Sent: 05 December 2012 14:13
To: Purbrick, Lewis
Cc: James, Veronica L; Steve Barker
Subject: Chiltern Railways - Holts Farm Access Road



Dear Lewis

Thanks for your time this afternoon. As discussed, please find attached the latest sketch alignment of
the proposed access road. As you will see and as confirmed with Veronica, the proposed road is located
immediately upstream of the M40.

I look forward to discussing with you further on Friday when you have had a chance to review the available flood level data and confirm with your colleagues the appropriate design criteria for the river
crossings.

Best Regards

Paul
Paul Blackman CEng MICE
Technical Director

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