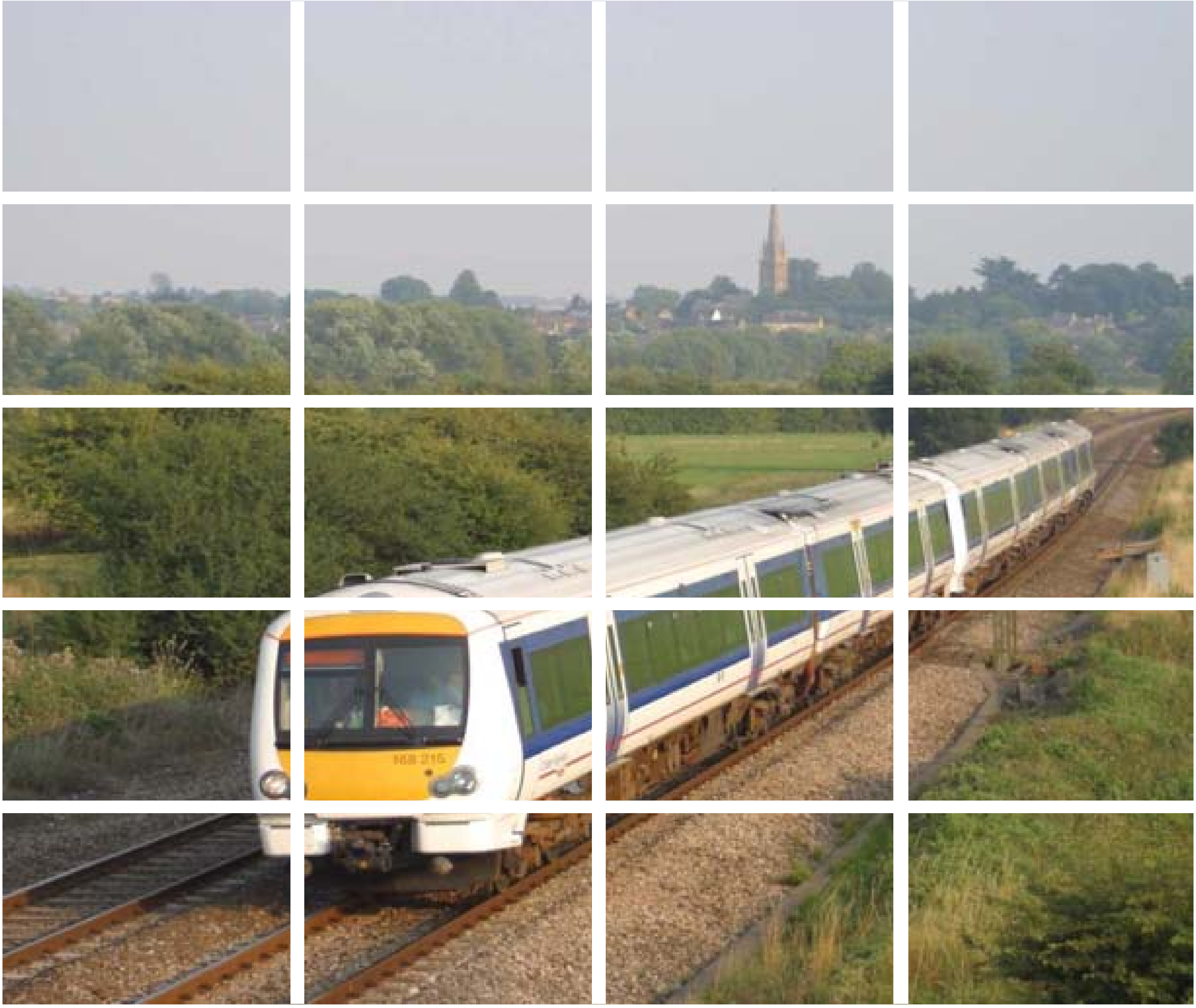

Network Rail/Chiltern Railways

Condition 14 – Safe Access and Egress under Flood Conditions for the Residents of Mill Lane and Mill Street, Islip

Discharge of Planning Condition 14 of TWA ref: TWA/10/APP/01: (Chiltern Railways (Bicester to Oxford Improvements) Order, 2012

Version I

May 2014

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REPORT

Network Rail/Chiltern Railway

Condition 14 – Safe Access and Egress under Flood Conditions for the Residents of Mill Lane and Mill Street, Islip - Discharge of Planning Condition 14 of TWA ref: TWA/10/APP/01: (*Chiltern Railways (Bicester to Oxford Improvements) Order, 2012*

For and on behalf of
Environmental Resources Management

Approved by: Ian Gilder

Signed:

Position: Technical Director

Date: 23 May 2014

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CONTENTS

1 INTRODUCTION

Environmental Resources Management (ERM) has been engaged by Chiltern Railways and Network Rail to undertake an assessment of safe access and egress of residents of properties on Mill Lane and Mill Street as a result of the Bicester to Oxford Improvements Scheme (referred to as East West Rail (EWR) Phase 1 and the Scheme), in particular the closure of the existing Mill Lane level crossing.

This report provides a detailed assessment of the flood risk within Islip with regard to the safe access and egress of the area in and around Mill Lane and Mill Street. It draws on the flood extents, depths, velocities and hazard discussed in the technical Wallingford HydroSolutions (WHS) report on their linked 1D – 2D hydrodynamic model of the River Ray and its floodplain around Islip (*Islip Safe Access & Egress: Hydraulic Modelling Report – WHS V1.03* (**Annex A**).

1.1 BACKGROUND

1.1.1 The Scheme

Chiltern Railways and Network Rail are proposing to construct a new railway (including the reconstruction of an existing railway) between Bicester and Oxford, together with the construction or reconstruction of stations at Bicester Town, Islip, Water Eaton and Oxford. These improvements will facilitate the operation of direct railway services between London Marylebone, High Wycombe, Bicester Town and Oxford.

The Bicester to Oxford line encompasses 38 at grade road, pedestrian and bridleway crossings along its route. In order to improve safety and meet current Network Rail and Office of Rail Regulation (ORR) guidelines, all at grade crossings will be re-directed, re-provided in a different form, or removed.

The overall Scheme includes the removal of all level crossings along the route other than that at London Road, Bicester where the Inspector accepted that the closure of the crossing in this location would give rise to grossly disproportionate costs. This overall approach to crossing closures was accepted by the Inspector in his decision and forms part of the Scheme under the TWA Order (TWA/10/APP/01).

1.1.2 *Current Access and Egress Arrangements*

The level crossings along the route are to be closed as they are considered to be the greatest source of safety risk on the rail network. Of the crossings, 17 are currently public highway, footpath and bridleway crossings, whilst the remaining 21 provide private access to properties and businesses in the vicinity of the Scheme.

Within Islip, access and egress to/from the properties on Mill Street and Mill Lane, which lie adjacent to the River Ray, can currently be taken to the west along Mill Lane across the existing Mill Lane level crossing to Kidlington Road, as well as to the east along Mill Street and Church Lane to the north. *Figure 1* sets out these locations.

The existing Mill Lane level crossing is a 'miniature warning light equipped' crossing with user-operated gates. As part of the Scheme this crossing is to be closed and a bridleway bridge (part of Work No. 16 as set out in the Order) is to be provided in place of the existing road crossing.

As no replacement vehicular crossing is proposed in this location the only vehicular access and egress route for properties on Mill Lane and Mill Street will be via Mill Street and then either along Church Lane or Lower Street to the east. The eastern end of Mill Street, at its junction with Church Lane, is however located within the flood plain as assessed by the Environment Agency (EA). Access may, therefore, be restricted in the event of a flood.

1.1.3 *The Requirement for an Assessment of Access and Egress for Residents of Mill Lane and Mill Street*

Planning Condition 14 - 'Safe Access and Egress under Flood Conditions' set out in Annex 1 to the letter from Martin Woods (Head of TWA Orders Unit) dated 17th October 2012 (ref: TWA/10/APP/01) has been included in recognition of public concern regarding safe access and egress from parts of Islip in times of flood due to the closure of the Mill Lane level crossing.

Condition 14 states:

> *'The level crossings at Mill Lane, Islip and Langford Lane and the Northfield Farm accommodation bridge shall not be closed permanently until a detailed assessment of any increase in flood hazard, in particular, the safe access and egress of residents of properties in Mill Lane and Mill Street, Islip; Alchester House and Bramlow, Langford Lane and Northfield Farm or any other residential properties in the vicinity of each of these crossings, and details of such mitigation measures as are practicable, have been submitted to and approved in writing by the local planning authority in consultation with the Environment Agency.*
>
> *Development shall be in accordance with the approved assessment and details.*

Reason: To ensure that appropriate measures are taken to maintain safe access to residential properties under severe flood conditions'.

Historically, the level crossing at Mill Lane, which is to be closed as part of the Scheme, is reported to be used by residents of Mill Lane and Mill Street for access and egress under flooding events.

The *Islip Safe Access & Egress: Hydraulic Modelling Report – WHS V1.03* (**Annex A**), confirms this as it shows that Mill Lane is located outside of the floodplain. It therefore does not flood and so currently provides safe access and egress for the residents of Mill Lane and Mill Street.

1.1.4 Scope and Purpose of the Report

The main purpose of this report is to investigate flooding issues at Islip, to identify the impacts on access and egress for residents of the properties on Mill Lane and Mill Street and to set out any practicable mitigation options available to Chiltern Railways and Network Rail. The report sets out the results of the appraisal of these options.

The assessment took into account all currently available information from the EA relating to flooding in the area, in addition to the *Islip Safe Access & Egress: Hydraulic Modelling Report – WHS V1.03*. In addition ERM and WHS staff undertook a site walkover during flood conditions on 17th January 2014. Photographs from this visit are contained in **Annex B**.

2 ASSESSMENT

2.1 SOURCE OF FLOODING

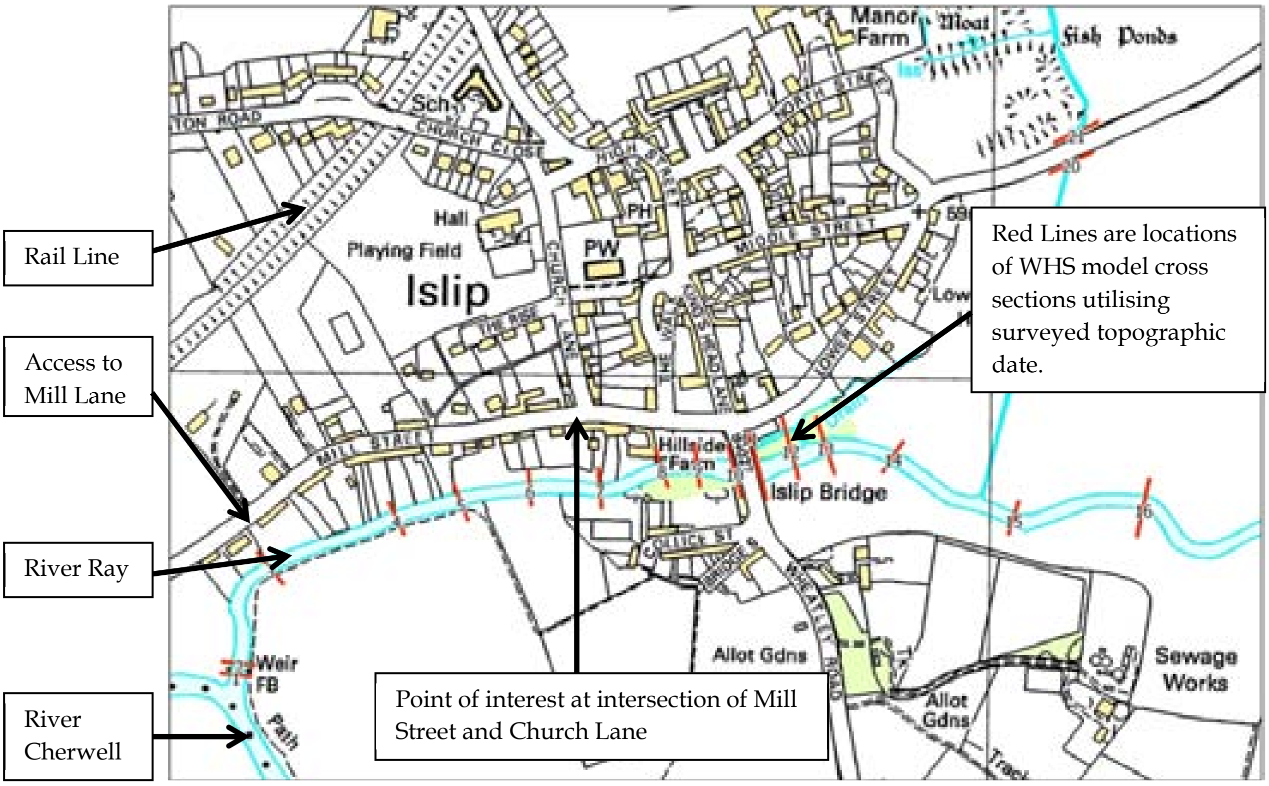
2.1.1 *Fluvial*

The primary risk of flooding in the Mill Street area is from the fluvial flood waters related to the River Ray and it's confluence with the River Cherwell.

2.1.2 *Surface Water*

The local preferential flow paths for surface water are down the hill, on which Church Lane sits, onto the relatively flat sections of Mill Street and Lower Street. **Figure 1** shows these locations.

Figure 1: Annotated Location Plan Showing Location of Main Flood Features



Source: Islip Safe Access & Egress: Hydraulic Modelling Report – WHS V1.03

There are highway gullies to pick up and direct surface water flows. Given the local topography, built environment, limited catchment and drainage infrastructure, it is considered unlikely that significant pluvial sourced surface flows would limit access and egress along Mill Street.

In addition, during the flood event of January 2014 (**Annex B**) there were no surcharging or elevated water levels in gullies on Mill Street despite the locally elevated water levels in the River Ray.

2.2 *MODEL SUMMARY*

WHS, in consultation with ERM, has produced a linked 1 and 2 dimensional model (1D-2D). This is based on data provided by the EA site evaluation, topographic survey data and on current best estimates of the local hydrological environment around Islip. The model has been produced to address the concerns regarding flood extent and behaviour along Mill Lane and Mill Street, especially at its intersection with Church Lane and to inform ERM's access and egress assessment requirements for the proposed development scheme. The *Islip Safe Access & Egress: Hydraulic Modelling Report – WHS V1.03*, is provided in **Annex A** of this report.

WHS has based much of the model geometry on an earlier Peter Brett Associates (PBA) model which was confirmed as being acceptable to the EA, and which modelled flood events on the River Cherwell. Following the review of the PBA model by WHS, the hydrology inputs have subsequently been found to be unreliable, particularly concerning the assumption that a previous event was a 1:100 storm. WHS has, therefore, updated the hydrographs (river level over time) utilised to model flooding at Islip.

The model of the River Ray was produced following a detailed topographic survey of the river and its surrounds. As with the River Cherwell model, WHS has produced up to date 'best' estimates of the hydrographs for the River Ray.

Both the River Cherwell and River Ray models have used large flood events of at least 1 in 100 years (a 1% chance of occurring in any year) plus an allowance for climate change in line with published best practice. The use of two large events here rather than the alternative use of 'combined probability' events ensure a robust and precautionary approach in line with current Government Policy on flood risk planning.

2.3 *MODEL OUTPUT*

The River Cherwell and River Ray models have been run for the 1 in 100 year plus 20% for climate change and 1 in 1000 year events. The analysis conducted has included the geographical extents of flooding, depths and velocities of the water and also the hazard to people associated with these characteristics.

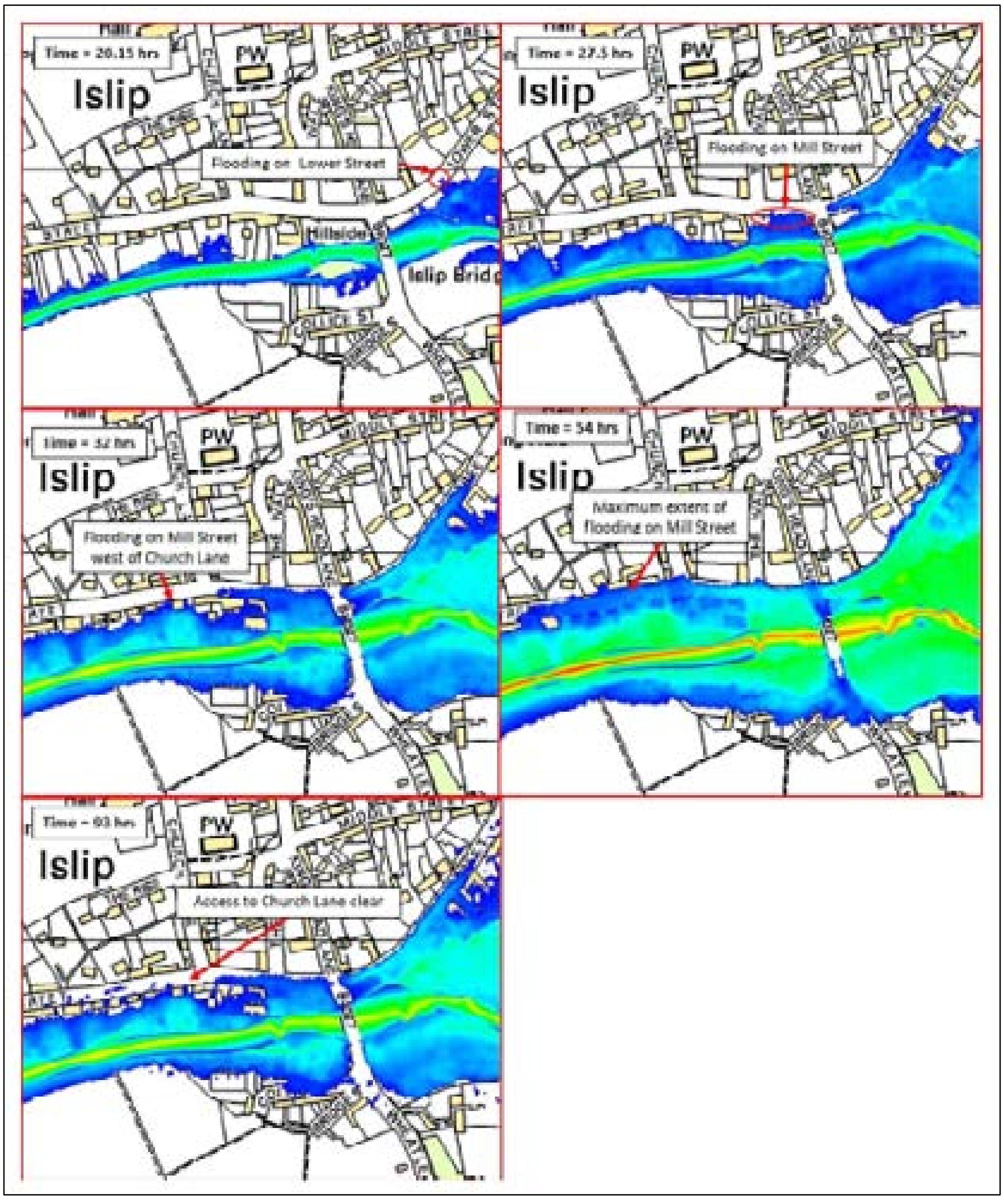
Figure 2 illustrates the growing and receding flood extents over the course of a four-day worst case 1 in 1000 year flood event (the worst case scenario - 0.1% chance in any year).

The findings of the model indicate that there would potentially be considerable warning time prior to any 'cut off' of the route for access and/or egress through the Mill Street/Church Lane junction. Section 4.6 of the *Islip Safe Access & Egress: Hydraulic Modelling Report – WHS V1.03* (**Annex A**) states that:

> *'Looking at the 1 in 1000 year event which provides the worst case scenario, flooding starts to become apparent on Lower Street to the east of the B 4027 Bridge at about 20.15 hours into the simulation. This is the first real indication that residents might have that flooding of the River Ray is likely to start affecting the local road network. From this initial onset of flooding along Lower Street there is a further 7 hours before flooding of Mill Street to the West of the B 4027 bridge commences at around 27.4 hours into the simulation.'*

Figure 2 shows the spread of this flood event and the accompanying timelines. It demonstrates that residents of the properties along Mill Street and Mill Lane could potentially have 27.4 hours warning from the beginning of a flood event along the River Ray and being informed by the EA Flood Warning system before it began to affect their access and egress at the Mill Street/Church Lane junction.

Figure 2: The Extent of Flood Water During 1 in 1000 Year Flood Event as Flood Waters Expand and Contract Over Time During Event



Source: Islip Safe Access & Egress: Hydraulic Modelling Report – WHS V1.03

The hazard associated with the 1 in 1000 flood event extents shown in **Figure 2** is illustrated further in **Figure 3.**

The perceived hazard of flooding is a function of depth and water velocity and is used to classify the flood risk to people as a result of flooding. Each element within the model is assigned one of four hazard categories 'Extreme Hazard', Significant Hazard', Moderate Hazard, or 'Very Low Hazard'.

The derivation of these categories is based on the guidance set out in Flood Risks to People FD23216[1] and is set out in **Table 1**.

Table 1: Hazard to People Flood Ratings

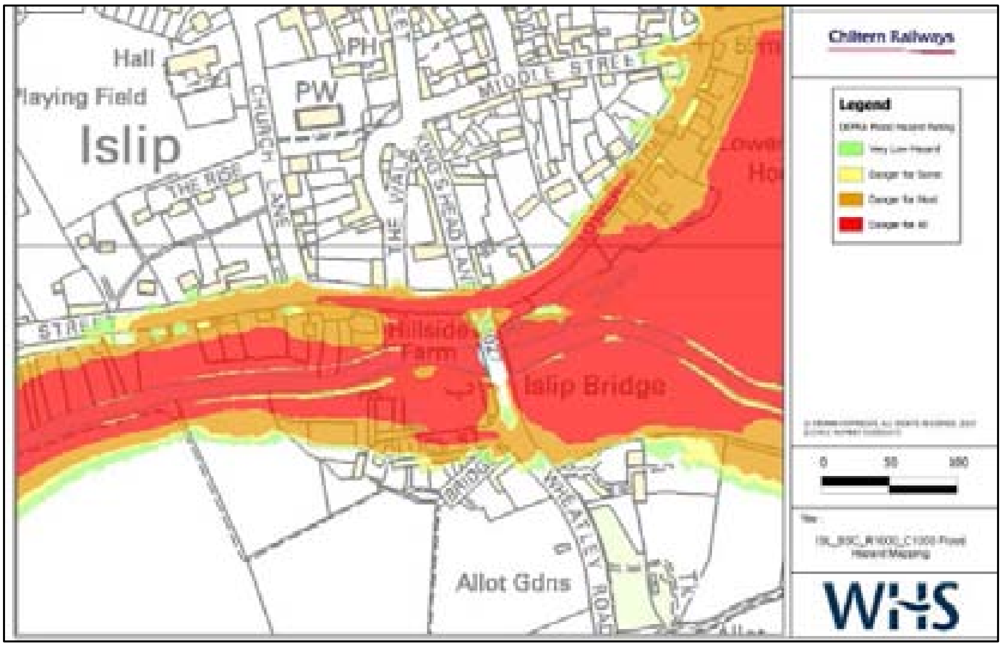
Thresholds for Flood Hazard Rating (FD2320)	Degree of Flood Hazard	Description
< 0.75	Low	**Very Low Hazard (Caution)** – "Flood zone with shallow flowing water or deep standing water"
0.75 – 1.25	Moderate	**Dangerous for some (including , the elderly and infirm)** – "Danger flood zone deep or fast flowing water
1.25 – 2.00	Significant	**Dangerous for most people (including the general public)** – "Danger flood zone with deep fast flowing water
> 2.00	Extreme	**Dangerous for all (including the emergency services)** – "Extreme danger: flood zone with deep fast flowing water"
Source: Table 3.2 in Defra and Agency (2006) *The Flood Risks to People Methodology*, Flood Risks to People Phase 2, FD2321 Technical Report 1		

There is a moderate to significant flood hazard rating associated with the 1 in 1000 flood event for the area around the intersection of Church Lane and Mill Street.

Figure 3 illustrates the extreme worst case scenario for flooding along Mill Street. The flood hazard along Mill Street is noted as being Moderate to Significant as set out in **Table 1**. Lesser events (although still extreme events) have also been modelled, including the 1 in 100 year event as shown in **Figure 4** and the 1 in 20 year event in **Figure 5**. These can be used to illustrate the extents of lower return period events and is a representation of land falling within the 'functional floodplain'. Section 2.4 sets out the impacts that these three events will have in terms of access and egress.

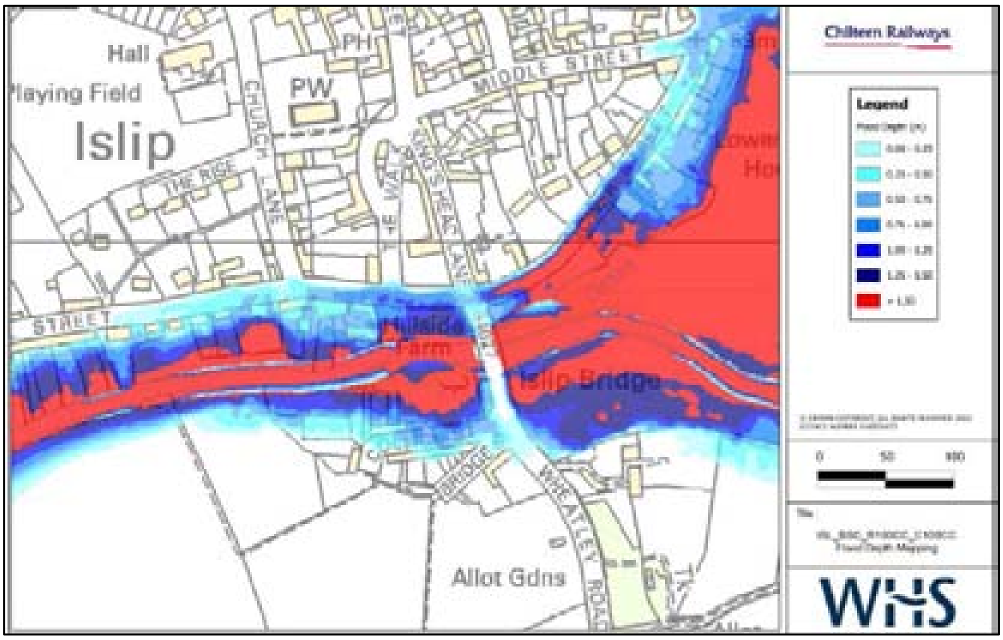
[1] Defra and Agency (2006) *The Flood Risks to People Methodology*, Flood Risks to People Phase 2, FD2321 Technical Report 1, HR Wallingford et al. did the report for Defra/EA Flood and Coastal Defence R&D Programme, March 2006

Figure 3: Flood Hazard Mapping for 1 in 1000 Year Event



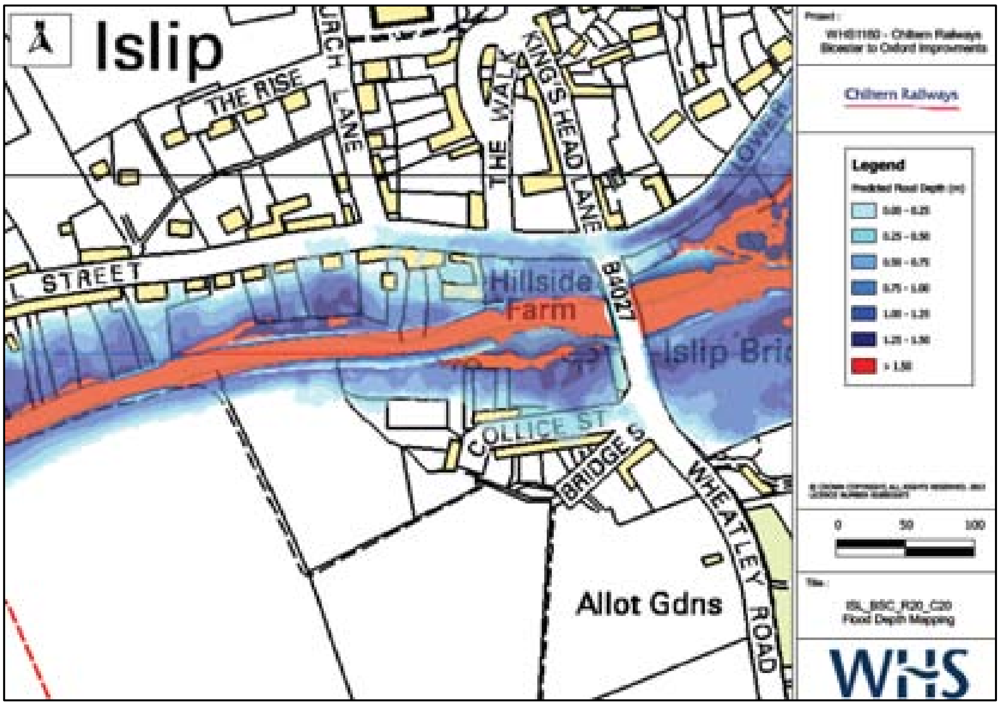
Source: Islip Safe Access & Egress: Hydraulic Modelling Report – WHS V1.03

Figure 4: Flood Depths for 1 in 100 Year Plus Climate Change Flood Event



Source: Islip Safe Access & Egress: Hydraulic Modelling Report – WHS V1.03

Figure 5: 1 in 20 Year Return Period Event Flood Extents



2.4 *MODEL RESULTS*

The results of the modelling for the 1 in 1000 year event (the worst case scenario) show that after a reasonable time period, approximately 20 hours of rising river levels, Mill Street east of Church Lane and Kings Head Lane will begin to flood. This is the first real indication that residents along Mill Lane and Mill Street might have that flooding of the River Ray is likely to start affecting the local road network.

The key concern in terms of safe access and egress from the properties along Mill Street and Mill Lane is when the access from the western section of Mill Street will start to prevent access out through Church Lane. 7 hours after flooding becomes apparent east of Church Lane and Kings Head Lane, flooding begins to the west of the bridge (B4027) on Mill Street. After a further period of approximately 5 hours, flooding will then begin to encroach on Mill Street prior to its junction with Church Lane (from west to east). This is the point where access and egress to the properties on Mill Street and Mill Lane will begin to be affected.

The modelling predicts that flooding along Mill Street to the west of the Church Lane junction occurs at about 32 hours into the simulation of rising river levels which would prevent access/egress along Church Lane. The modelling shows that there is a 12 hour window between flooding becoming physically apparent on Lower Street to when the access would be cut off from Mill Street to Church Lane.

The modelling predicts access to Church Lane would remain impassable for some 61 hours until the floodwaters recede, allowing access from Mill Street to Church Lane to become flood free at about 93 hours into the simulation.

For a 1 in 20 year event, even at the peak of flooding, a dry access for pedestrians and shallow flooding suitable for vehicular fording is retained for the Mill Street/Church Lane junction.

During all these events Mill Lane and the existing level crossing remains free of flood water, currently providing a safe means of access and egress for the residents of Mill Lane and Mill Street.

2.5 *IMPACTS OF FLOODING ON ACCESS AND EGRESS FOR RESIDENTS OF MILL LANE AND MILL STREET*

During a large flood event, caused by either intense rainfall within the catchment or a prolonged period of less intense rainfall within the catchment, the River Ray will bust it banks.

The initial flooding will occur on Lower Street in the area to the west of the car-park area at the junction with Mill Street.

Prior to flooding from Lower Street overtopping Mill Street at the point of the junction with the Kings Head Lane, waters from the River Ray will rise through gardens behind properties fronting onto Mill Street and start to flood the road directly at the section between Church Lane and Kings Head Lane.

As waters continue to rise, there will be flooding along Mill Street towards the junction with Church Lane; waters from residential gardens of properties adjoining the road will allow flood waters west of Church Lane to flood onto Mill Street.

During extreme events the multiple flows paths will combine to result in the inundation of the junction of Church Lane and Mill Street and will result in access and egress from the properties on Mill Street and Mill Lane being prevented.

Access and egress for the properties on Mill Lane and Mill Street during such an event is currently provided by the existing Mill Lane level crossing linking to Kidlington Road.

The closure of this crossing, as part of the approved Scheme will, therefore, affect safe access and egress from properties on Mill Street and Mill Lane.

The Scheme proposes the diversion of vehicular traffic from the north of the railway line via Mill lane onto Kidlington Road and from the south of the railway line via Mill Street. It also proposes the construction of a DDA compliant bridge for pedestrian, cyclist and equestrian use.

3 OPTIONS APPRAISAL

3.1 INTRODUCTION

The modelling results support local evidence that within the limit of flood events defined by the National Planning Policy Framework as requiring consideration, the Mill Street and Church Lane junction will flood to such an extent that residents of Mill Lane and at the western end of Mill Street will not have a safe, dry route of access and egress once the Mill Lane level crossing is closed. In addition, at the peak of an event, depths are likely to impede access by emergency vehicles.

To try and achieve practicable mitigation, as required under Condition 14, a number of options have been identified and assessed in terms of the potential to offer safe access and egress for residents of properties in Mill Lane and Mill Street. These options are described and assessed in terms of their practicability.

3.2 OPTION ONE: RETAINING THE EXISTING CROSSING

Option one considers the practicality of retaining the existing crossing in its current form.

3.2.2 *Rationale for the Closure of the Crossing as part of the Scheme*

The option to retain the Mill Lane level crossing, along with all the other crossings along the route, was considered in detail as part of the original TWA application and examined during the TWA Inquiry.

The overall approach to crossing closures was accepted by the Inspector and forms part of the Scheme under the TWA Order. Level crossings along the route are to be closed as they are considered to be the greatest source of safety risk on the rail network as a whole. A large body of evidence was presented at the TWA Inquiry in support of this position. The arguments and policy position are summarised here.

The Office of Rail Regulation (ORR) is the safety regulator for all railway safety matters in Great Britain. The ORR published its *'Policy on Level Crossings'* in 2007 (Inquiry Document CD/3.18) which states that:

- level crossings on the national rail network present the biggest risk of train accidents that could kill passengers;
- level crossings pose particular problems for rail companies because they cannot control the actions of drivers and pedestrians at level crossings;

- except in exceptional circumstances, there should be no new level crossings on any railway;

- relevant authorities must recognise the wider benefits that safety improvements at level crossings (for example, replacing them with bridges) can bring about, particularly for road users;

- rail companies should take all reasonable opportunities to remove or replace existing level crossings or make them safer, but they should also take account of the effect safety measures have on those who use level crossings and those who live or work in properties alongside them; and

- The Rail Safety and Standards Board is the rail industry's independent safety body. In 2006 it published a brief for a research report 'Attitudes to, processes and funding for crossing closures' (Inquiry Document CRCL/P/7/B Appendix 3) which set out the ORR's position that level crossings are hazardous to train-borne passengers and that the first and best solution to the problem posed by level crossings is to close them.

Network Rail's own policy as set out in *'Our Approach to Managing Level Crossing Safety'* (Inquiry Document CRCL/P/7/B Appendix 5) is that only in exceptional circumstances will Network Rail permit new crossings to be introduced onto the network, and where reasonably practicable, will seek to close or divert crossings or enhance their safety in other ways.

Network Rail uses tools such as the All Level Crossing Risk Model (ALCRM) when making decisions on level crossing closures. ALCRM is a computer programme that provides a method of assessing safety risk at level crossings. It uses site specific data producing an estimate of the risk individual at a particular crossing, ranked from A (Highest) down to M (Lowest), and an estimate of the collective risk at the crossing, ranked from 1 down to 13. Network Rail specifically reviews options when a score of A, B or C and/or 1, 2 or 3 results from an ALCRM assessment.

ALCRM was used to evaluate the risk at Mill Lane level crossing receiving a B2 ranking. In line with this ranking and policy position of Network Rail, ORR and the Rail Safety and Standards Board, the decision was made to close the existing crossing.

The existing Mill Lane level crossing is a 'Miniature Warning Light' (MWL) equipped level crossing. It is shown in **Figure 6**. A motorist wishing to take a vehicle across the line must cross the railway five times in order to use the crossing as intended. Before each traverse of the line the motorist must ascertain if it is safe to cross by referring to the MWL which shows a green light when it is safe to cross and a red light when it is not. The motorist first needs to open the near side gate and cross the railway on foot to open the far side gate, returning on foot before driving across the railway. After driving across the railway the motorists has to re-cross on foot to close what has become the far side gate after which the railway is again crossed on foot to close what has become the near side gate.

Wicket gates are provided for pedestrians who determine whether it is safe to cross by reference to the MWLs.

Figure 6: The Existing Mill Lane Crossing

The ORR states that MWL equipped level crossings on a public highway do not accord with current guidance. Maintaining a crossing of this type on a public road over a railway operating at the speed proposed in the Scheme also does not accord with current industry practices.

MWL equipped level crossings are no longer installed at public highway level crossings and are generally only found at level crossings where there are private vehicular rights. This type of level crossing also exhibits a disproportionate share of the risk to users as when the gates or barriers are left open.

The Inspector accepted the evidence on risk and the national policy position on the desirability of closing level crossings along the railway on safety grounds.

The only exception to closures along the route of this Scheme is the level crossing at London Road, Bicester. The decision to retain the London Road crossing was informed by a number of site specific factors which makes it a very different situation from that at Mill Lane. The factors influencing the decision to keep the London Road crossing included:

- the Inspector accepted that the closure of the crossing in this location would give rise to grossly disproportionate costs in his report dated the 15th July 2011.

- an All Level Crossing Risk Model (ALCRM) rating of G3 which shows that the crossing is considered reasonably safe when viewed against crossing such as that at Mill Lane which scored a much higher B2 (ALCRM), showing it to be unsafe;

- the high levels of vehicular traffic when compared to crossings such as Mill Lane level crossing – London Road is a heavily trafficked B Road within an urban centre; and

- London Road Crossing is located within a confined urban context forming part of the existing highway network. Closure of this crossing would have necessitated the construction of a substantial vehicular bridge. The confined urban surroundings would have severely restricted the design of this and would have resulted in disproportionate costs to the Scheme.

At the Public Inquiry Aidan Nelson of Community Safety Partnerships presented evidence on behalf of Chiltern Railways on safety policy and risk reduction. His evidence (Inquiry Document CRCL/P//7/A), accepted by the Inspector, is that:

> *It is my opinion that, at other than Bicester's London Road level crossing, there are no exceptional grounds on which retention of any of the existing level crossings on the Oxford to Bicester railway can be justified. Given the range of alternative grade separated routes across the railway that either exist or will be provided within the Order Scheme, the proposals contained within the Order are inherently reasonable having regard to Network Rail's ALCRM risk ranking and the levels of use that have been identified during the development of the Order Scheme*.

The decision to close the existing Mill Lane crossing took into account Network Rails and ORR's safety standards. It is the stated policy of Network Rail to close levels crossings in all but exceptional circumstances for reasons of safety. The option of keeping the level crossing open has been ruled out as being impractical from a safety perspective with a suitable replacement bridge being provided, a view which the Inspector fully supported in his final report dated the 15^{th} July 2011.

It is noteworthy that *Paragraph 6.23.1* of the Inspector's report states that '*Islip Parish Council supports the proposed closure of the Mill Lane level crossing that forms part of the Scheme*'.

The retention of the existing level crossing in its current form is therefore not considered a practicable solution on safety grounds.

3.3 *OPTION TWO: RETAINING THE CROSSING WITH AN EMERGENCY ACCESS ONLY PROVISION*

Option two considers the practicality of retaining the existing crossing and allowing for emergency access during times of flood when access can't be gained via Mill Street.

In order to achieve this, the level crossing would need to be upgraded from a MWL equipped level crossing to an automatic full barrier crossing. This would require the crossing to be fully integrated into the signalling system so it could be controlled from the nearest signal box.

To prevent misuse of the level crossing by vehicles other than those in an emergency situation such as a flooding event would require a system where the Network Rail signalling system was made aware of such an event. A communication system would have to be installed so that users during an emergency could request access across the level crossing. The signalman would then need to take into account other rail traffic and the type and speed of the trains currently on the network before starting the procedure to open the gates. It is noteworthy that no such system exists anywhere else on the UK rail network at the present moment.

The upgrading of the crossing and the installation of the communication system would pose substantial operational and cost issues associated with its safe integration into the signalling system.

While an upgraded crossing would be likely to be inherently safer than the existing crossing, there would still be safety risks arising from the retained crossing.

The retention and upgrading of Mill Lane level crossing is not a practicable solution on grounds of safety, cost and construction programme delays.

3.4 *OPTION THREE: UPGRADED EQUESTRIAN BRIDGE FOR USE BY EMERGENCY VEHICLES*

Option three considers the practicality of upgrading the proposed non-vehicular bridge for use by emergency vehicles.

3.4.2 *The Replacement Bridge*

The Scheme will lead to closure of the level crossing at Mill Lane and replacement with a bridge suitable for pedestrian, cyclist and equestrian traffic only (Works No. 16).

The proposed replacement structure, referred to as Works No. 16 in the TWA Order, consists of a 49m long, three span continuous steel/reinforced concrete composite structure with a carriageway width of 3.5m, reinforced earth approach ramps and 1.8m high parapets throughout to comply with regulations for equestrian usage.

Safe access and egress on foot from properties on Mill Lane and Mill Street will be maintained by the proposed bridge as set out under Works No. 16.

3.4.3 *The Rationale for the Provision and Design of the Replacement Bridge*

The closure of the existing level crossing and replacement non-vehicular bridge as proposed as part of the Scheme should be seen in the context of the low traffic volumes on Mill Lane.

A traffic survey undertaken for Chiltern Railways in 2010 showed a maximum of 10 vehicles using the level crossing in a day. The 2010 survey confirmed the low traffic volumes found in a previous survey undertaken by Network Rail in 2007 when 14 cars were found to use the level crossing in a day.

The low volume of traffic using Mill Lane was a key consideration, alongside the safety issues, in the decision to close the level crossing and replace it with a non-vehicular bridge. Early public consultation carried out by Chiltern Railways with residents of Islip indicated that there was strong opposition to a road bridge on the basis that this could result in increased use of Mill Lane and Mill Street as a through route.

The proposed bridge design was constrained by the need to limit deviation from the existing highway alignment (and therefore reduce third party land take), to minimise its visual and aesthetic impact on surrounding residential properties and the local area, and consideration of construction, maintenance and drainage requirements.

The bridge design as set out in Work No 16 was pursued as it had a far lower visual impact than any other of the options considered during the development of the scheme, by virtue of its utilising the cutting to the north of the railway line to reduce the height of construction above the surrounding land and the use of natural earth ramps.

The Inspector, at the TWA Inquiry accepted that the replacement bridge presented a suitable option at this location.

An option of providing emergency vehicle access via an upgrade of the replacement bridge (Works No. 16) during a flood event was discussed, in principle, with Oxfordshire County Council and the Environment Agency following the TWA Order being made in 2012. For this to be a viable option the proposed replacement bridge and its approaches set out under Works No 16, would have to be upgraded to vehicular standards from the current provision for equestrian and pedestrians.

This would require a significant redesign of the bridge as set out in the Order under Work No. 16, to a vehicular bridge, which would have to adhere to all requisite vehicular standards. The redesign would need to include changes to the proposed approach roads to allow safe visibility at the junctions.

The new design and resultant increased land take would have the potential to increase the bridge's visual impact when viewed by the surrounding residents. A redesign of the bridge parapets would be required in order to make them resistant to potential vehicle impacts. The change in specification would add significant additional loadings onto the existing structure as currently proposed, requiring a new bridge sub-structure and an increased overall structural footprint.

The visual impact of the replacement bridge options was an issue raised by a number of local objectors and one of the reasons why subway options were explored as discussed in Section 3.5. A redesign of the bridge to vehicular standards would result in a higher visual impact than the bridge to be delivered by the Scheme (Work No. 16) which utilises the cutting to the north of the railway line to reduce the height of construction above the surrounding land.

The works required to upgrade the bridge would also have increased cost and maintenance implications for the Scheme. Chiltern Railways estimated costs for the construction of Works No. 16 is already £1.35 million. The cost of the redesign itself and the additional cost of a larger structure in terms of construction and maintenance are not allowed for within the existing Scheme budget.

The existing TWA Order also does not currently allow for the development of a vehicular bridge at this location under Works No. 16. The current design of the bridge is informed by the Revised Design and Access Statement (RDAS), January 2011 (Inquiry Document CD/1.19/1). Condition 5 of the 'Deemed Permission' states that 'The design, layout and appearance and external materials of the stations and the bridges shall conform generally to those set out in the Revised Design and Access Statement, January 2011 (Inquiry Document CD/1.19/1)'.

A complete redesign of the bridge to vehicular standards taking into account previous local objections in terms of the visual impact of an increased structure and land take would not 'generally conform' to the design that is shown in the RDAS – Annex H (Drawing 5083741-RLS-BOX-CBR-08592 Rev P02) . A redesign to vehicular standards would delay the scheduled closing of the level crossing and ultimately delay the opening of the line. The resulting programme implications associated with undertaking a redesign and the lack of certainty in securing agreement to such an option from the local residents and the Local Planning Authority (LPA) may result in the Scheme not being open to passenger traffic by May 2015. This would have a substantial impact on existing and future users of the railway line as well as on the overall financial viability of the Scheme.

For reasons of cost, programming and certainty of delivery around the requirement for additional consents the upgrade of the replacement bridge to allow for emergency vehicle access is not considered to be a practicable solution.

3.5 OPTION FOUR: SUBWAY OPTION TO ALLOW FOR EMERGENCY ACCESS

Option four considers the practicality of providing a subway in the vicinity of the current Mill Lane level crossing for emergency vehicle access.

Consideration was given to a number of subway alternatives at Mill Lane during Scheme development. All of the subways options were rejected as they were not supported by local residents on grounds of impacts (perceived and real) on personal security.

A subway also presented a practical difficulty in providing a reliable means of drainage. Given that any subway would have been below the water table and would form a low point in the local landscape, it is likely that water would have continually entered the subway, requiring a pump system to run continuously. Perimeter drains could have been used to minimise the inflow of surface water but these would have become less effective with time and would have required regular heavy maintenance.

A subway would require two pumps (a main and a standby) and a small building in which to house them. The pumps would draw water from the subway to a swale or underground attenuation tank, for which further land would be required. Any discharge of the tank into the River Cherwell would require Environment Agency approval over which there is no certainty because of the potential effects on downstream flood intensity.

For the stated reasons, a subway option was not pursued as part of the Scheme. As such a subway would require additional land, outside of the

Order limits, not only for the subway itself but also for housing the pumping system as well as planning permission.

There would also be substantial additional costs and programme delay in acquiring the additional land, developing an engineering solution and gaining consent for a subway.

A system would also have to be developed to block access to all but emergency vehicles requiring prior agreement between the residents of Mill Street and Mill Lane with the emergency services.

For reasons of cost, programming and certainty of delivery the provision of a subway for emergency access is not considered to be a practicable solution.

3.6 OPTION FIVE: RAISED WALKWAY OR ROAD

Option five considers the practicality of providing a raised walkway or road to allow for safe access and egress during a flood event.

The Scheme engineers have examined the potential for a raised walkway or road in the vicinity of Mill Street and Church Lane.

There is insufficient space to provide an elevated walkway or road in this location as Mill Street abuts all the houses on the south side and some on the north side (see Photographs A1 and A3 in **Annex B**).

The steep gradient from Mill Street up to Church Lane also precludes a suitable engineering solution to allow either some or all of the area around the junction to be elevated.

There is no practicable engineering solution that would deliver a raised walkway or road in the vicinity of Mill Street and Church Lane.

3.7 OPTION SIX: CONTINGENCY PLANNING

Option six considers the practicality of developing contingency planning measures for residents of properties in Mill Street and Mill Lane.

The modelling work presented in **Section 2.4** shows that there is sufficient time available from when flooding begins in the vicinity of the River Ray to allow contingency planning to provide safe access and egress for the residents of Mill Street and Mill Lane.

3.7.2 Effectiveness of Contingency Planning

The modelling shows that there is both sufficient time and visible precursors which would allow suitably informed residents to safely evacuate the area by vehicle. **Section 2.4** of this report shows that there is currently a 12 hour period from when flooding becomes apparent on Lower Street to when the junction of Mill Street and Church Lane becomes impassable to vehicular and pedestrian traffic. In addition, those directly affected by the flooding would have waters rising through their gardens and properties prior to any loss of access/egress via the Mill Street/Church Lane junction. There would then be a further period of seven hours before the rising flood waters would effectively close the junction.

This period can provide a window for safe access and egress for the properties on Mill Street and Mill Lane. This period could be extended through the use of the EA's Floodline Warnings Direct service which would inform the local residents before a flooding event began.

3.7.3 Existing Arrangements for Islip Residents

Residents in properties on Mill Street and Mill Lane can currently sign up the EA's Floodline Warnings Direct service. There is currently no flood management plan in place for the residents of Mill Lane and Mill Street area.

3.7.4 Additional Contingency Planning Measures

In addition to the measures that local residents can already access directly from the EA, it is proposed that a Flood Management Plan (FMP) is drawn up that can be implemented in times of flood. The FMP would likely require identification of suitable local Flood Wardens to implement any practical aspects of the plan. **Annex C** provides detailed advice on FMPs and the role of Flood Wardens on the receipt of a flood warning from the EA.

Network Rail could provide assistance, such as funding a Flood Management Consultant, to support the development of a specific FMP for the residents of Mill Lane and Mill Street. The FMP would be developed in conjunction with the EA, the Thames Valley Local Resilience Forum and the local residents through Islip Parish Council.

The role of residents and Parish Councils is, generally, recognised to be exceptionally valuable in ensuring the successful implementation of any local flood management strategy.

Key elements of the FMP could include:

- ensuring all residents within the area of Mill Street and Mill Lane who would be affected by flooding are enrolled in the EA's Flood Warning and Flood Alert systems. This should ensure that maximum warning times are available to these residents, enabling access and egress during a flood event;

- appointment of a 'Community Flood Warden' from the local community who can provide help and liaise with all interested parties prior to the direct intervention of Emergency Services. Help could be provided in a variety of ways, including:

    - ensuring members of the community have received direct flood warnings, understand what they mean and where they obtain further information;
    - work as a community to prepare for a flood event and identify vulnerable people from within the community who may need extra help;
    - report blocked drains, ditches, etc. to the relevant authority; and
    - develop and maintain the FMP.

The implementation of a FMP can prolong the period of safe access and egress for residents of Mill Lane and Mill Street. With measures proposed under Option Six, it is considered that during large flood events, greater than a 1 in 20 year return period, there would be sufficient time for residents of properties in Mill Lane and Mill Street to safely egress the site.

Contingency planning in the form of an FMP provides the only practicable means of mitigating such large flood events.

4 CONCLUSIONS AND RECOMMENDATIONS

Condition 14 required that a detailed assessment of any increase in flood hazard, in particular, the safe access and egress of residents of properties in Mill Lane and Mill Street, Islip in light of the closure of the Mill Lane Level Crossing be carried out. This report along with the *Islip Safe Access & Egress: Hydraulic Modelling Report – WHS V1.03* (attached here as **Annex A**) provides this detailed assessment.

In summary the assessment concludes that during extreme flood events the junction of Church Lane and Mill Street will flood resulting in access and egress from the properties on Mill Street and Mill Lane being prevented. Access and egress for the properties on Mill Lane and Mill Street during such an event is currently provided by the existing Mill Lane level crossing. The closure of this crossing as part of the Scheme will therefore affect safe access and egress from these properties.

Following on from this, the Condition requires that such 'mitigation measures as are practicable' be assessed and submitted to the LPA. A number of options were assessed in **Section 3** (Options Appraisal). The inherently unsafe nature of retaining the level crossing and the significant technical challenges posed in engineering terms either from an elevated vehicular bridge or subway at the existing crossing location or further pedestrian access at the junction of Mill Street and Church Lane, means that options one to five all present problems which mean that they do not offer practicable solutions for safe access and egress.

The options appraisal demonstrates that mitigation of flood event access risks for the properties on Mill Lane and Mill Street are best dealt with through the contingency planning as set out in Option 6. This is based on a significant time period elapsing between when it becomes apparent that river levels are rising (20 hours), to when flooding becomes apparent west of the bridge (B4027) on Mill Street (27 hours) and to when the access would be cut off from Mill Street to Church Lane (32 hours). This time period does offer the opportunity for a potential flood warning / contingency planning solution as a means of providing safe access and egress for the residents for Mill Lane and Mill Street.

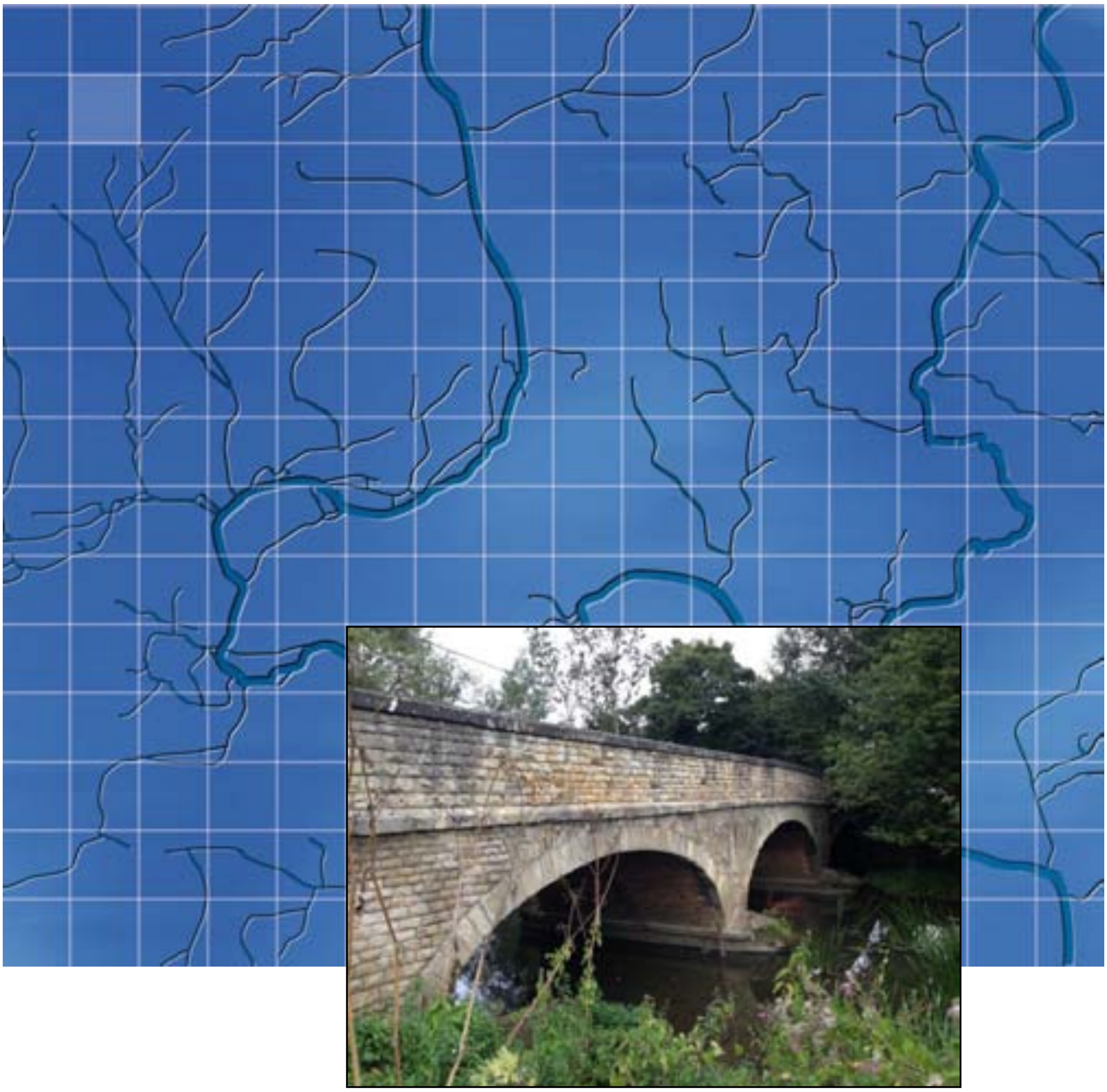
It is therefore concluded that contingency planning provides the only practicable mitigation noting the accepted need to close the level crossing. Network Rail will provide practical assistance to support the development of a specific FMP for the residents of Mill Lane and Mill Street in conjunction with the EA and the Thames Valley Local Resilience Forum.

Annex A - Islip Safe Access & Egress: Hydraulic Modelling Report

Chiltern Railways and Network Rail

May 2014

Islip Safe Access & Egress: Hydraulic Modelling Report



Wallingford HydroSolutions Limited

Chiltern Railways and Network Rail

Islip Safe Access & Egress: Hydraulic Modelling Report

Document issue details

WHS1160

Version number	Issue date	Issue status	Issuing Office
V1.01	07/11/2013	DRAFT	Cardiff
V1.02	10/12/2013	DRAFT	Cardiff
V1.03	18/12/2013	DRAFT	Cardiff
V1.03	19/12/2013	FINAL	Cardiff
V1.04	12/05/2014	FINAL (updated to address the EA review comments)	Cardiff

For and on behalf of Wallingford HydroSolutions Ltd.

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Appendix 3 Topographic Survey Data

1 Introduction

Wallingford HydroSolutions (WHS) has been commissioned by Environmental Resources Management (ERM) on behalf of Chiltern Railways and Network Rail to construct a linked 1D – 2D hydraulic model to assess access and egress arrangements under flood conditions for residents of properties in Mill Lane and Mill Street as a result of the Bicester to Oxford Improvements Scheme (referred to as East West Rail (EWR) Phase 1), in particular the closure of the existing Mill Lane level crossing.

This modelling work provides a detailed assessment of the flood risk within Islip and reports on the flood extents, depths, velocities and hazard along the critical access route (Mill Street) within Islip in order to inform ERM's safe access and egress assessment as required by Condition 14 attached to the deemed planning permission

WHS has constructed a linked 1D – 2D hydrodynamic model of the River Ray and its floodplain around Islip to more accurately model flood behaviour and provide ERM with the required outputs of flood depth, velocity and hazard along with durations of flooding along Mill Street and Mill Lane. It should be noted that a conservative approach has been adopted in this modelling by assuming a combination of extreme events on both the River Ray and River Cherwell. Further details and justification of this approach is presented in section 4.7 of this report.

This technical report presents the background to the linked 1D – 2D modelling undertaken using ISIS and TuFLOW modelling software, the model build methodology and subsequent output results.

2 Background

2.1 Location/ Site Description

The area of interest is along Mill Street and Mill Lane which are situated in the south of Islip and runs adjacent to the River Ray from the B 4027 downstream to the confluence with the River Cherwell (Figure 1). The surrounding area is a mixture of built up urban area within the town of Islip, with the wider floodplain around Islip being made up of predominantly farmland, which is a mix of pasture and crops.

Two main watercourses are within the study area, the River Cherwell flowing from the north west and the River Ray flowing from the east, which joins with the River Cherwell approximately 400m downstream of the B 4027 road bridge.

The current Environment Agency (EA) flood mapping shows that the eastern section of Mill Street is at risk of fluvial flooding during the 1 in 100 and the 1 in 1000 year flood events.

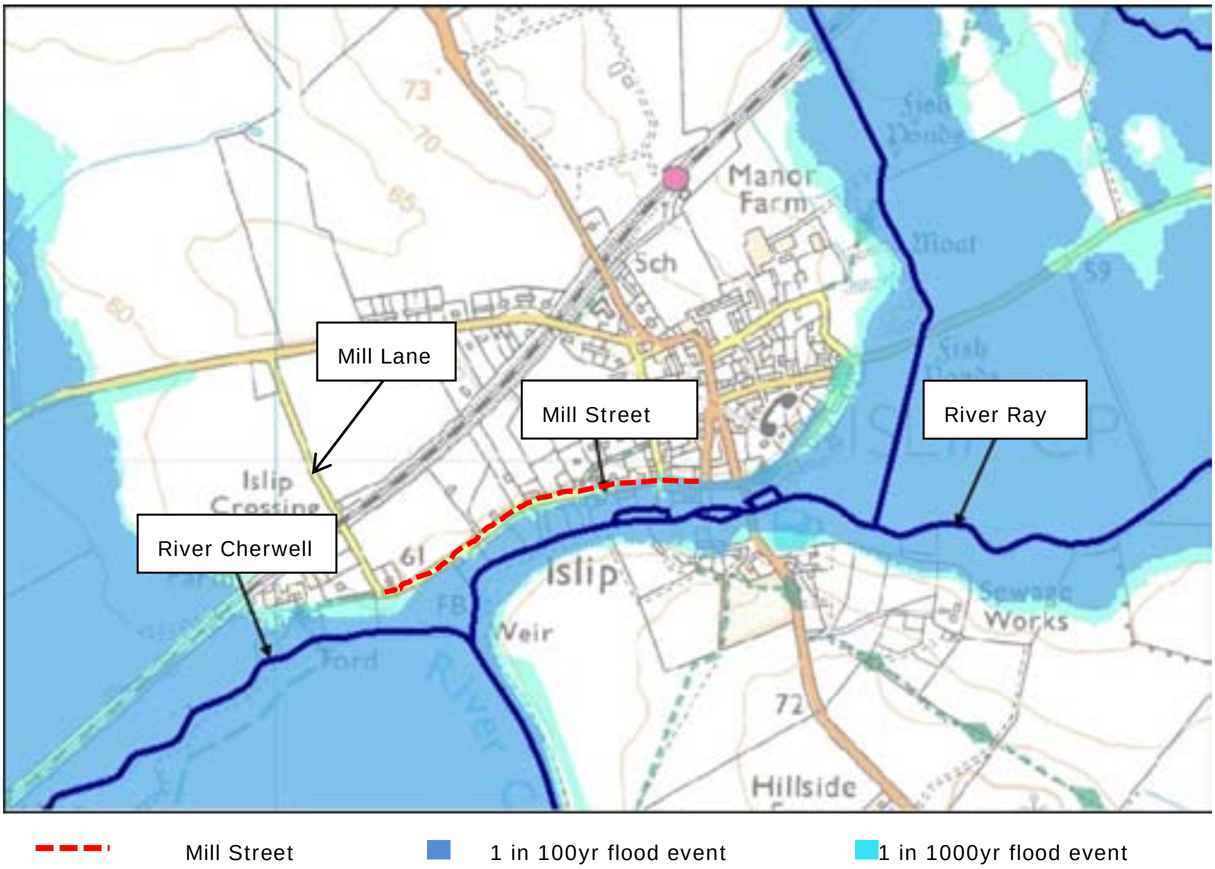

Figure 1 – Extract from the Environment Agency Flood Map (available online) showing extensive flood extent surrounding the study area.

3 Model Construction

3.1 Main Sources of Data Used

The main sources of data used in this modelling study include;

- **Topographic Survey Data** - In order to construct the 1D element of the hydraulic model, a river channel survey was undertaken by Usk Land Surveys[1]. This cross sectional survey data along with a detailed topographic survey of Mill Street and Mill Lane are provided electronically alongside this report.

- **LiDAR data** - LiDAR data[2] has been provided by the EA, through the Geomatics Team. LiDAR data at $2m^2$ resolution was adopted for this hydraulic model. This resolution was considered suitably detailed to model the flow routes along Mill Street. The vertical accuracy of the LiDAR provided is between ±0.15m.

- **Lower Cherwell Hydraulic Model –** An existing 1D hydraulic Model was built by PBA in 2005[3] and provided on licence by the EA. This model has been used to generate downstream boundary conditions for the new Islip linked 1D – 2D model.

- **Updated hydrology** – An updated hydrological assessment was prepared by WHS specifically for use in this modelling study. Please refer to Appendix 1 for full hydrology report.

- **Calibration Data** – The EA has previously provided ERM and WHS with historic flood outlines for events in April 1998, January 2003, July 2007 and January 2008 for Islip. However, there are no levels associated with this and no estimated return periods for the events, which means that the data are of limited benefit for calibration purposes. However, the EA has confirmed that all of these events at Islip are likely to be less severe than the 1 in 100 year event. Based on this knowledge, we have reviewed the historic flood outlines (known to be below the 1 in 100 year event) against the updated WHS model outputs to ensure that the flood predictions along Mill Street are in line with or are greater than the observed data. EA correspondence relating to this matter is provided in Appendix 2.

- **10K OS Mapping -** for use in model reporting and land use classification.

3.2 PBA Modelling of the Lower River Cherwell

Peter Brett Associates LLP was commissioned in 2005 by the EA to undertake hydraulic modelling of the Lower River Cherwell that extends from Thrupp Railway Bridge to the River Thames confluence at Oxford, which also incorporates the town of Kidlington. This modelling was undertaken under the Strategic Flood Risk Mapping framework to create flood risk maps of the area and to gain a better understanding of the risk.

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[1] Topographic Survey of River Channel and Mill Street conducted by Usk Land Surveys in August 2013. (See Appendix 2 for details)

[2] LiDAR data purchased from the EA Gemomatics Group website. (2m horizontal resolution with a vertical accuracy of between 0.05 – 0.15m)

[3] Peter Brett Associates. August 2005. Lower Cherwell Flood Risk Mapping. Project Ref 10509/45

The hydraulic modelling assessment was undertaken using ISIS modelling software (Version 2.3) and includes survey data collected by the EA for river channel sections and modified Digital Terrain Model (DTM)[4] data to represent the topography of the floodplain. The entire study reach is modelled as a 1D ISIS model which incorporates the river channel, floodplain and any structures within a 1D hydraulic modelling domain.

This model only includes the River Cherwell and no hydraulic representation of the River Ray is provided. The model was reviewed by the EA 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 EA as flood risk mapping for the area.

This model has been provided by the EA for use in this modelling study and the model has been considered fit for purpose.

A full copy of the existing PBA model[3] and modelling report is available from the EA on request.

3.3 Modelling Approach

ERM requires a detailed assessment of the flood behaviour along Mill Street to inform their assessment of safe access and egress for the residents of properties on Mill Lane and Mill Street, to the west of the junction with Church Lane. To estimate flooding extents, depths and velocities, WHS has developed a modelling approach that uses ISIS 1D modelling software to simulate the river channel hydraulics, which is then dynamically linked to a TuFLOW 2D domain to simulate overland flow in the floodplain.

The hydraulic model utilises topographic survey data[1] to represent the river channel and hydraulic structures. An updated hydrological analysis conducted by WHS has been used to generate model inflows and boundary conditions to inform the 1D ISIS model build. The 1D model of the main river is dynamically linked to a 2D domain, which has been modelled using TuFLOW modelling software. LiDAR data[2] has been used to represent floodplain topography in the 2D domain and will allow overland flows to be accurately modelled. This approach will generate model outputs of flood depth, velocity and flood hazard along Mill Street and ensure that dynamic flood behaviour can be simulated and quantified.

The Islip hydraulic modelling has been carried out in a number of stages that include:

- Review of existing PBA modelling data[3] which included the manipulation and extraction of the most appropriate data to inform this updated modelling study. Data extracted from the existing PBA model[3] include;
    - The PBA 1D model[3] was trimmed to a location approximately 2km upstream and 3km downstream of the site. The extent of the trimmed model is shown in Figure 4.
    - The Updated WHS Hydrology has been used as inflows into the trimmed PBA model for both the River Cherwell and River Ray and additionally as inflows into the updated WHS Islip model. Details of updated hydrological assessment are provided in Appendix 1 of this report.
- Re-run the trimmed PBA model[3] with the updated WHS hydrology to generate downstream boundary conditions for the WHS Islip model. Section 3.4.3 contains details of downstream boundary conditions.

[4] DTM based on (SAR) data and has a 5m horizontal resolution with a vertical accuracy of +/- 0.5m.

- Review of the topographic survey data[1] and construction of the Islip 1D ISIS model which includes all river sections and hydraulic structures.
- Dynamic linking of the 1D ISIS model of the River Ray main channel to a 2D floodplain modelled in TuFLOW based on LiDAR data[2] to represent the floodplain topography. The 2D domain has then been updated with various structures and roughness coefficients to represent actual ground conditions. Section 3.5 contains details of the 2D model build.
- Run the two design event scenarios to inform the safe access and egress assessment. These include;
  - 1 in 100 year event (plus a 20% increase in peak flow as an allowance for climate change)
  - 1 in 1000 year event.
- Results extraction, analysis and reporting. Details provided in section 4.
- Sensitivity testing of the hydraulic model. Details provided in section 4.7.

3.4 1D Model Build

3.4.1 Updated WHS Hydrology

An updated hydrological assessment has been conducted by WHS to inform the Islip modelling study. The existing PBA modelling hydrology was conducted in 2005, which is now seen to be outdated by more up to date methods and does not make an assessment of the 1 in 1000 year flood event. Therefore, WHS has conducted an updated hydrological assessment using the current industry standard techniques and benefiting from a longer gauged record to estimate peak flood flows including the 1 in 1000 year event. Appendix 1 contains the full hydrology report.

3.4.2 Model Inflows (River Ray)

The final design hydrographs for the River Ray calculated by WHS have been used as inflows at the upstream boundary of the ISIS 1D model. Figure 2 shows the final inflow hydrographs used in the Islip hydraulic modelling.

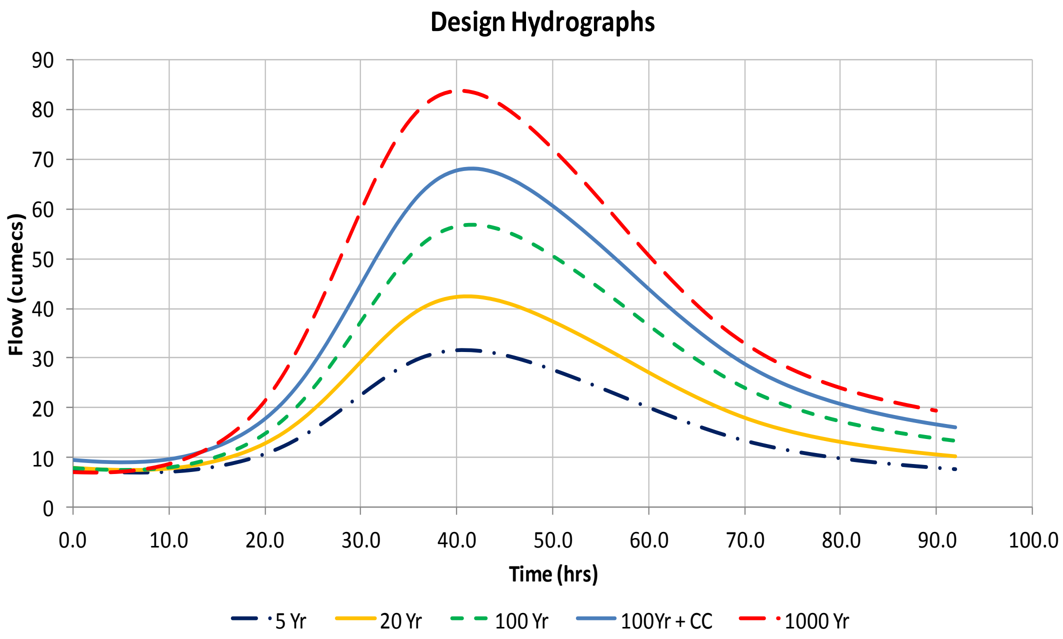

Figure 2 – Final Design Hydrographs for the River Ray

3.4.3 Downstream Boundary Conditions

The River Ray discharges into the River Cherwell immediately downstream of Islip. Therefore, the downstream boundary conditions in the updated Islip model will be heavily influenced by water levels in the River Cherwell. To represent this downstream boundary condition a head-time boundary unit has been applied at the downstream extent of the 1D ISIS model to represent flood levels in the River Cherwell.

Flood levels in the River Cherwell have been obtained by using a trimmed section of the existing PBA Model[3] that has been simulated for a range of design events using the updated WHS hydrology. The various stage - time hydrographs have then been extracted from model node CH.024 (model node adjacent to the confluence of the River Ray and River Cherwell) and these were inputted as the downstream boundary condition of the Islip model. Figure 3 below shows the extracted stage – time hydrographs used in the updated Islip modelling.

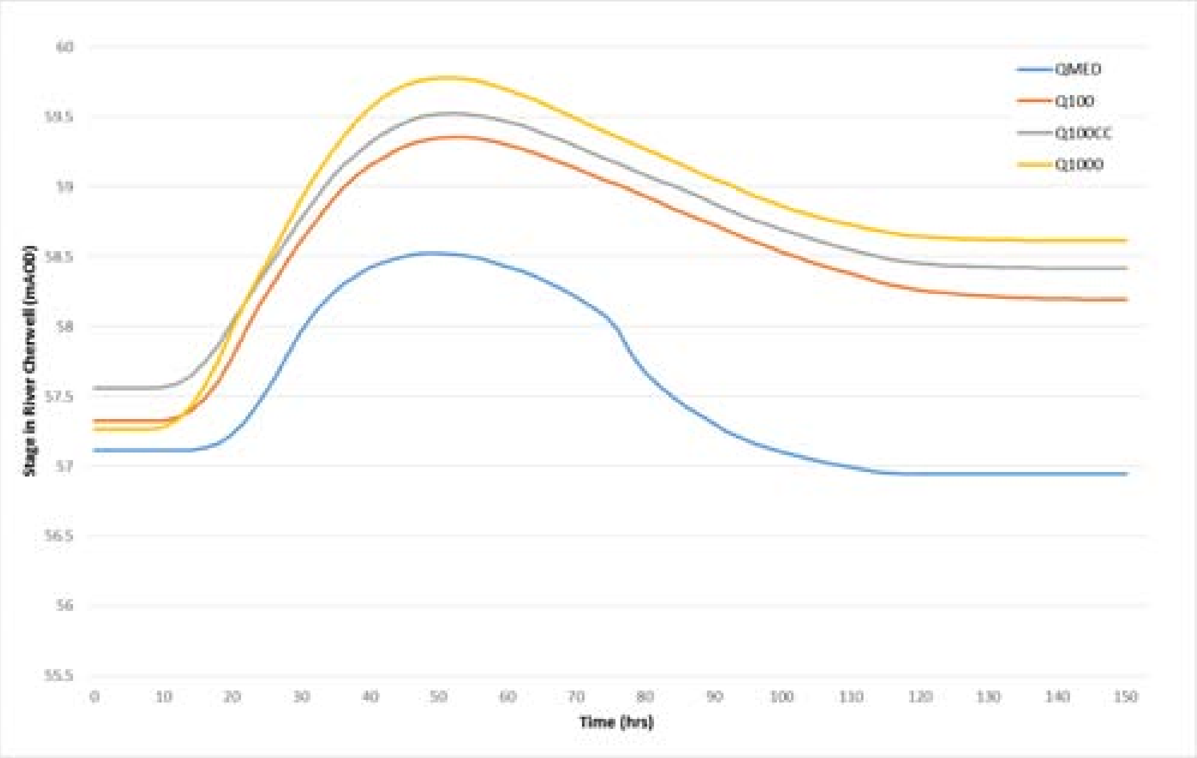

Figure 3 – Stage Hydrographs (extracted from the trimmed PBA model at node (CHU.024))

Figure 4 shows the locations of where the existing PBA model[3] has been trimmed and where the stage – time hydrographs have been extracted. The existing PBA model[3] has been trimmed at model node CHU.050 situated some 2km Upstream of the River Ray and River Cherwell confluence and at model node CH.095 some 3km downstream. A copy of the full and the trimmed PBA model[3] is available on request.

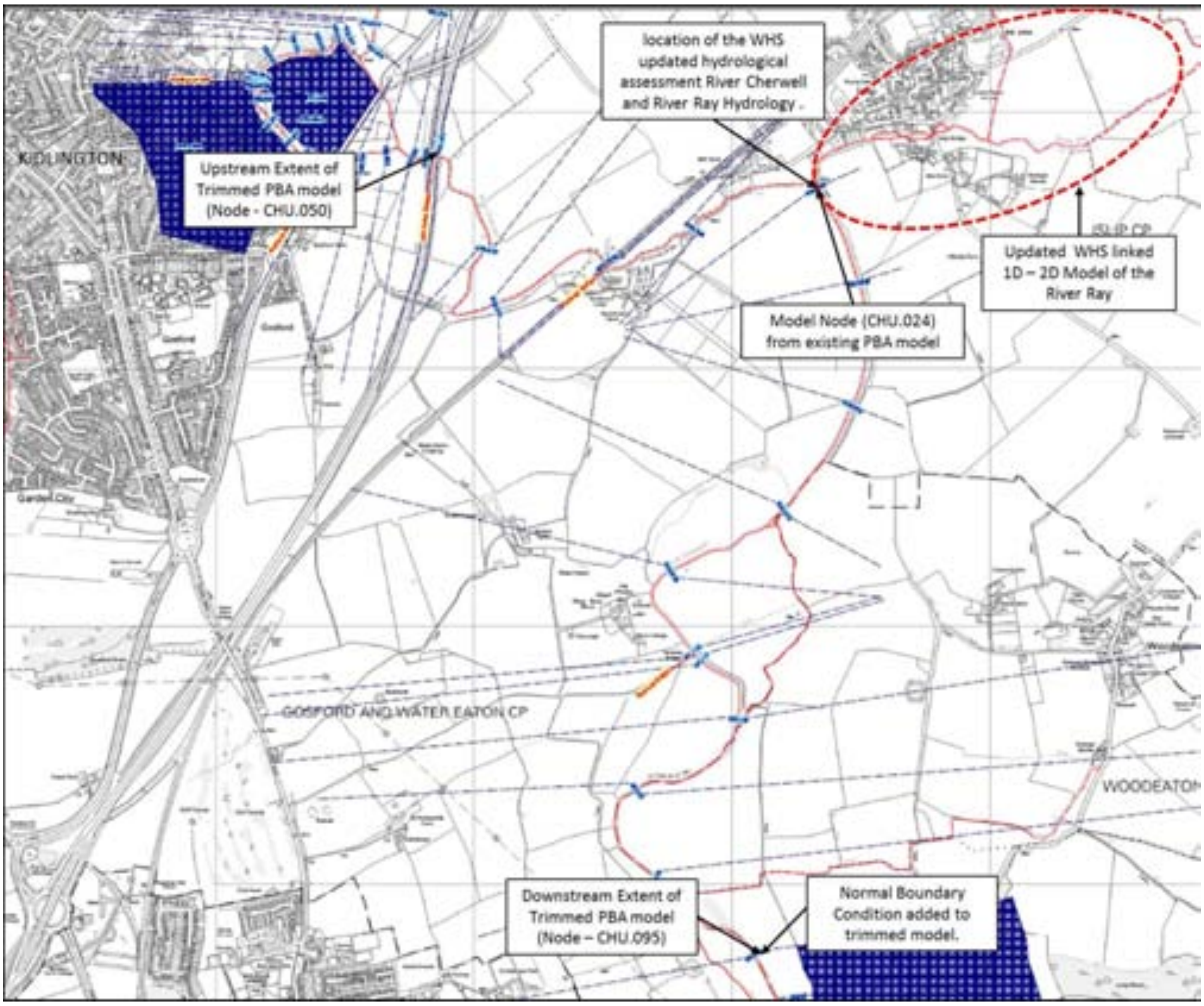

Figure 4 – Model Schematic of the Existing PBA Model[3] showing how the Trimmed WHS Model has extracted the Downstream Boundary Conditions.

3.4.4 River Channel Cross Sections

The 1D element of the model has been modelled using ISIS 1D modelling software. To inform the 1D element the river channel cross sections have been surveyed by Usk Land Surveys and imported into ISIS to develop the 1D portion of the model. Locations of the river channel cross section survey data used in this modelling are shown in Figure 5 and Figure 6 and surveyed sections are provided in Appendix 3.

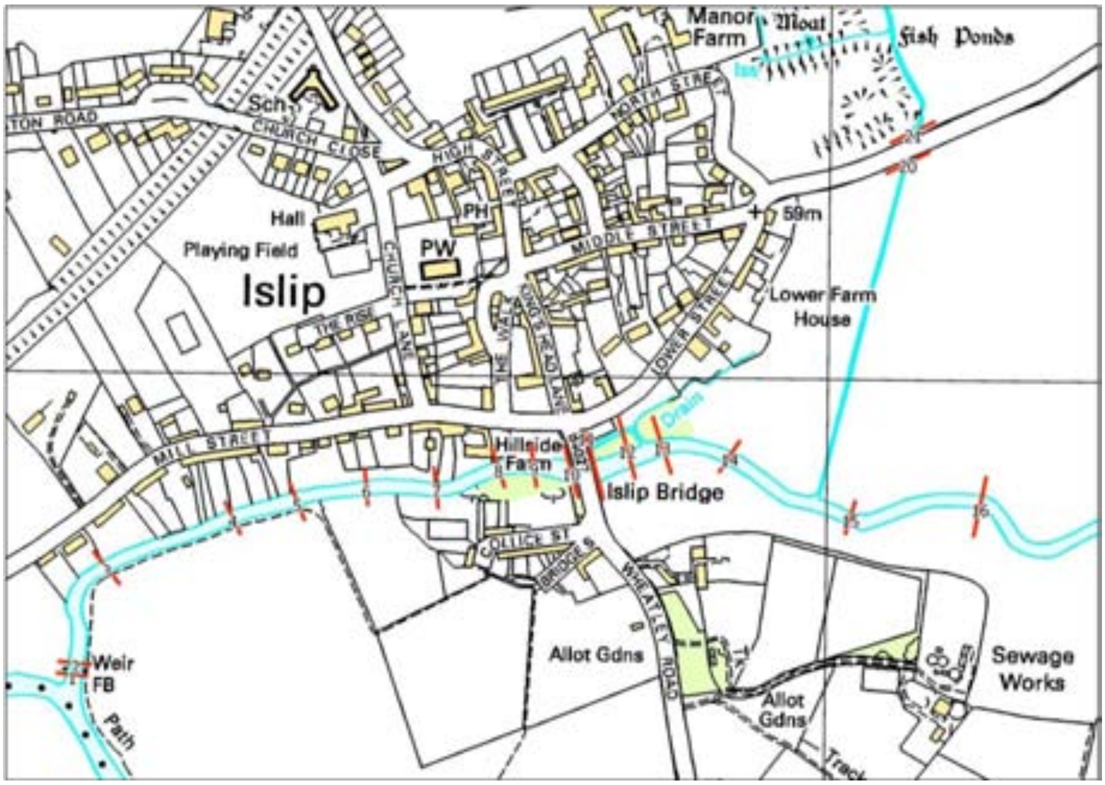

Figure 5 - Cross Section Locations in the Downstream Reach

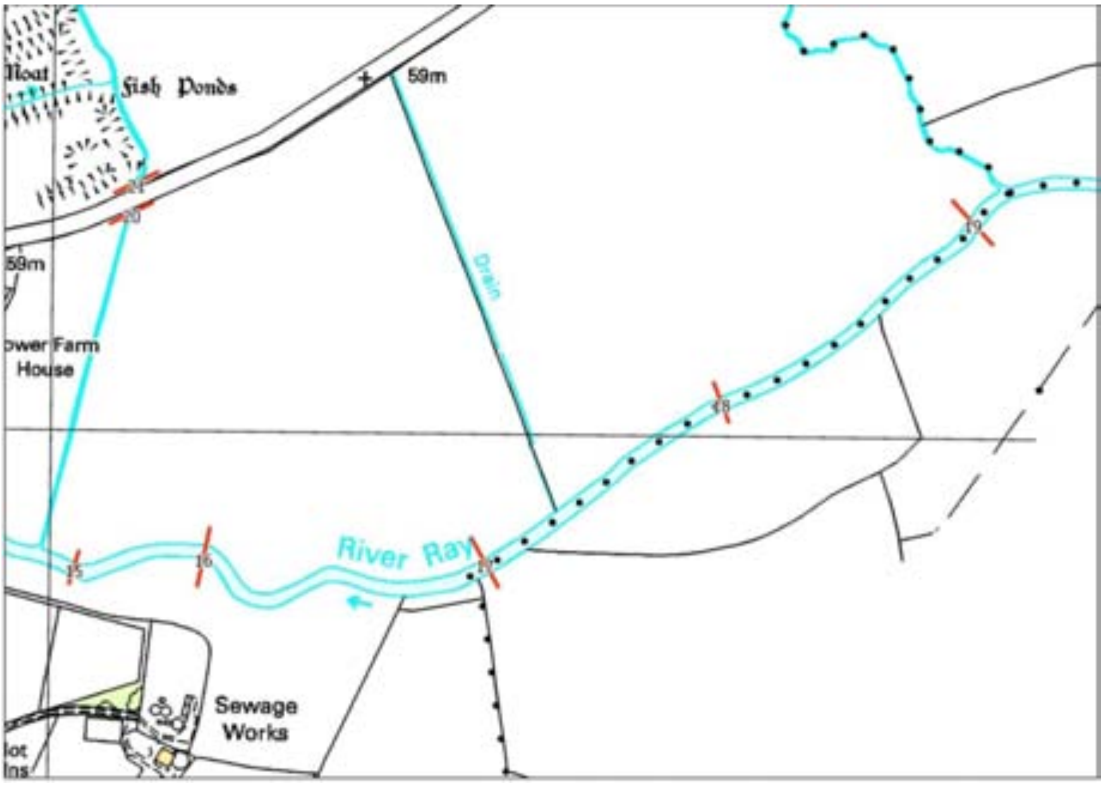

Figure 6 - Cross Section Locations in the Upstream Reach

3.4.5 In-bank Manning's n

Generally the in-bank manning's n values used for the river channel sections has been set at 0.06 based on Chow. 1959[5]. The PBA modelling study[3] uses this value based on observations from site visits. This value represents a relatively clear channel that is affected by vegetation along the banks which from the WHS site visit seems to be a reasonable assumption.

3.4.6 Structures

A number of structures were surveyed and included in the hydraulic model. In total, one bridge (B4027 road bridge) and an automated weir exist. Each structure is considered in turn, to outline how they were modelled and any assumptions that were made.

B 4027 Road Bridge (1.010)

Immediately downstream of cross section (1.010) in the centre of Islip the watercourse passes under a large arched road bridge, see Figure 7. The bridge has been modelled as a standard arch bridge unit using the survey data[1] provided. An inline spill unit was included and modelled in the 1D domain to simulate overtopping flows over and around the bridge.

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[5] Chow, V T (1959). *Open-channel hydraulics*. McGraw-Hill.

Figure 7 – B 4027 Road Bridge (Arch Bridge)

Automated Weir (1.001)

Situated at the confluence of the River Ray and River Cherwell is an automated weir that controls water levels in the River Ray and is also a gauging weir, see Figure 8. In ISIS this structure has been modelled as a sharp crested weir with dimensions taken from the topographic survey data[1]. The calibration coefficient has been set to unity as recommended in the ISIS user guide. The user guide suggests that for a well maintained weir constructed to the standard specification the calibration coefficient should be set to unity. Therefore, based on site observations and best available guidance the calibration coefficient has not been manually altered.

The EA has confirmed that this weir is operated based on local conditions and there is no formal operation protocol that can be provided. (Details of correspondence with the EA on this matter is provided in Appendix 2). As this structure will be drowned out at the very high flows that the model simulates it will have little influence on predicted flooding at Islip. Therefore, this weir is modelled as per the survey data[1] from August 2013. A USPBR bridge unit has also been modelled directly upstream of this weir to introduce an additional head loss that will be experienced due to the bridge structure associated with the weir. Again dimensions of this structure have been taken from the topographic survey data[1].

Figure 8 – Automated Weir at Islip

3.4.7 1D Model Schematic

Figure 9 shows the ISIS 1D model schematic, illustrating the overall construction of the 1D component of the model.

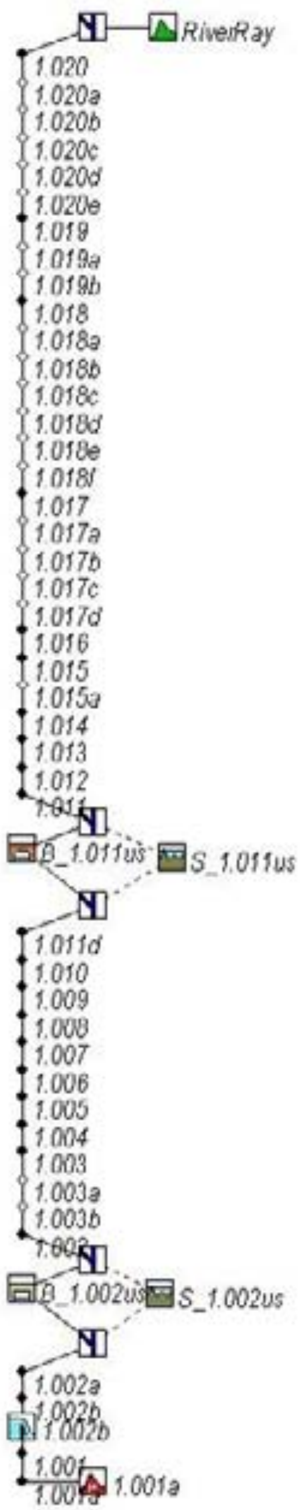

Figure 9 – ISIS Model Schematic

3.5 2D Model Build

2D modelling allows the dynamic behaviour associated with flow of flood water across the floodplain to be considered. Using 2D modelling features such as buildings or changes in topography can be incorporated into a DTM (digital terrain model) of the floodplain. This allows for consideration of flow depths, velocities and hazards to be more accurately modelled and assessed. This study used 2D modelling in order to report on the flood depths, velocities and hazards in and around Islip to inform the safe access and egress assessment being conducted by ERM.

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 the dynamic flood behaviour along Mill Street to be simulated.

3.5.1 Model Setup

The TuFLOW model has been developed using version: 2012-05-AC-Isp-W32. The model has been simulated using a 1 second TuFLOW timestep (1 second timestep in 1D ISIS model) and a grid cell size of 2m to accurately represent flood behaviour along Mill Street in the 2D domain. Ground levels across the site have been obtained from LiDAR data[2] and modified with topographic survey levels where provided.

Figure 10 shows the extent of the active TuFLOW area, which covers 1.41km^2. The extent of this 2D domain has been selected to minimise the risk of glass walling affecting the results at Islip due to the relatively flat floodplain topography.

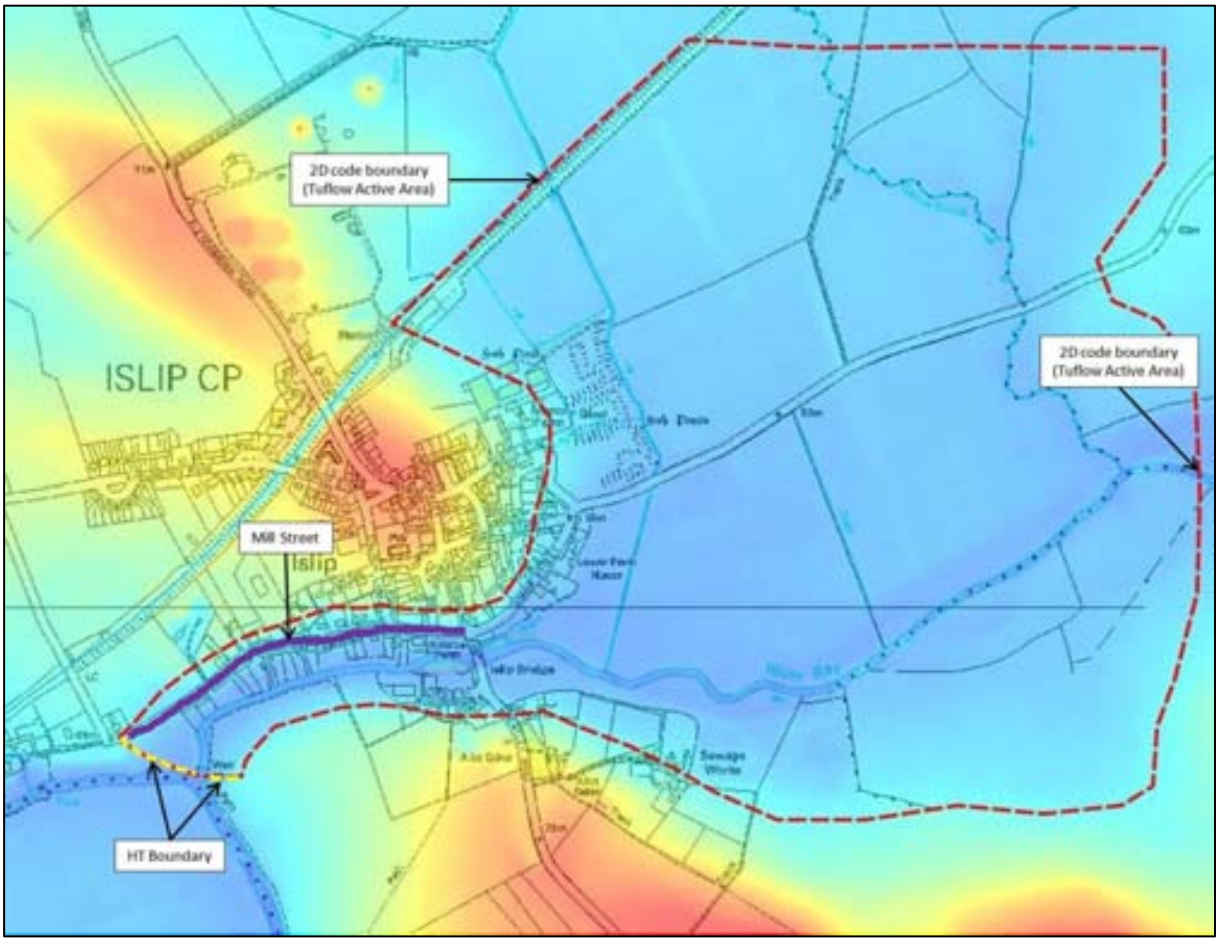

Figure 10 – TuFLOW Active Model Area

3.5.2 Floodplain Topography

A bare earth DTM defined by LiDAR data[2] of the floodplain was used to reflect the base elevations of the area, while disregarding the influence of insignificant barriers to flow such as vegetation, fences and walls that are not designed to protect against flooding. A 2m horizontal 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 profile is very flat. As a result, a large 2D code polygon (defining the active area for modeling to occur) was used. Figure 10 highlights the area of 2D model extent.

Buildings within the flood plain were modelled as 'stubby buildings' through the increase of the manning's n (ground roughness) value to 0.1 and raising of building footprints by 0.3m. This approach assumes that buildings impede flood waters, but to a limited extent.

To represent natural flow routes within the floodplain a number of topographic features have been manually filtered out of the LiDAR data that had not been automatically removed during the initial filtering process. Bridge decks have been manually removed to the river bed level to allow flow routes north on the Islip floodplain and these locations are identified within Figure 11.

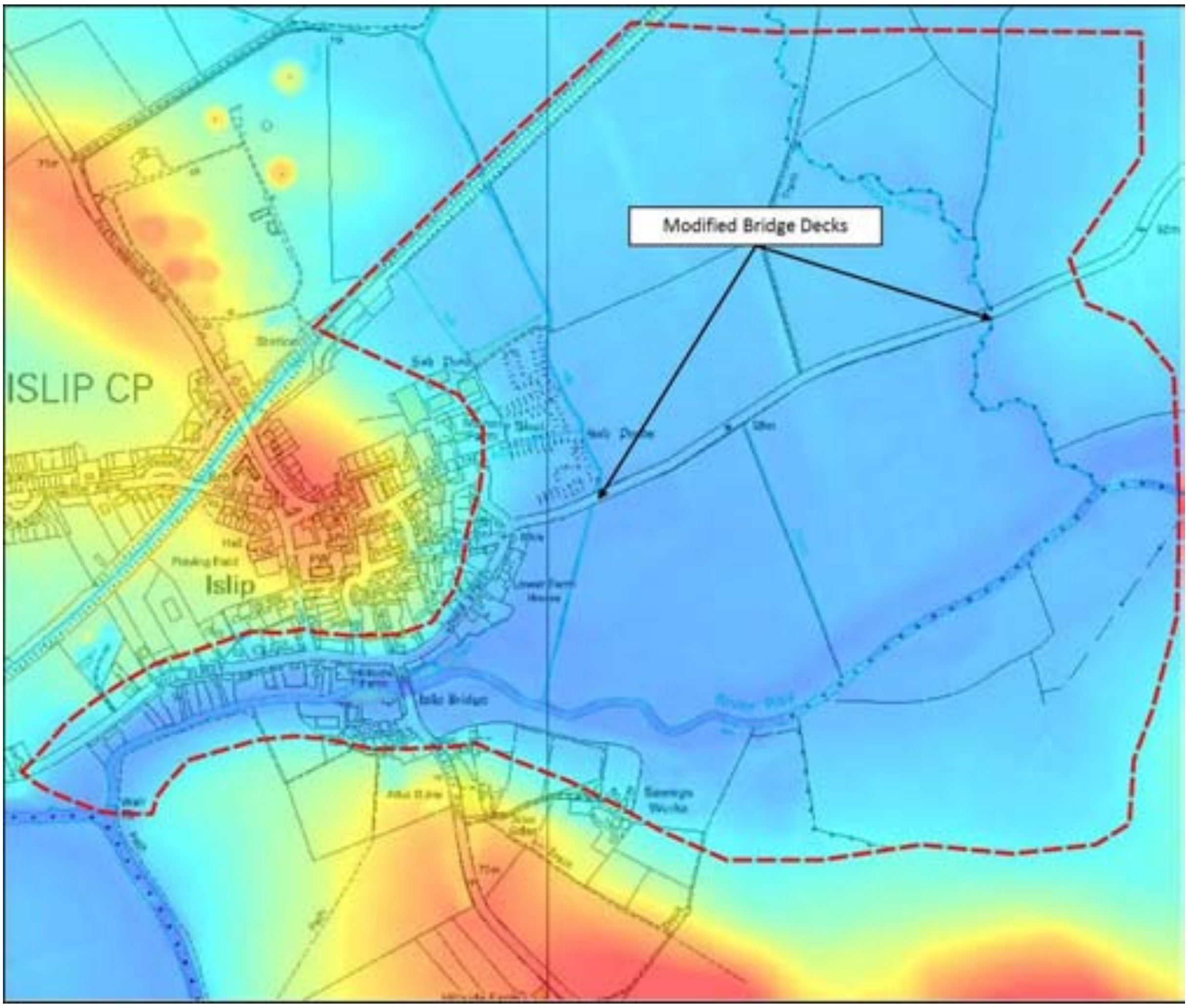

Figure 11 – Locations of the Modified Bridge Decks Modelled in the 2D Domain. (These structures have been manually removed from the original LiDAR data)

3.5.3 Floodplain Roughness Co-efficient

The hydraulic roughness affects the conveyance capacity of the land or riverbed. Within the TuFLOW model, hydraulic roughness is defined by the dimensionless Manning's n coefficient.

A number of material roughness classifications have been identified based on engineering judgement and available literature (e.g Chow. 1959)[5]. The distribution of these features has been defined using aerial photography and OS mapping in order to vary the conveyance rates throughout the floodplain. Table 1 presents the key land use types identified along with their corresponding roughness values.

Table 1 – Manning's n Values Used in TuFLOW Model

Manning's n value	Description
0.045	Default – Open ground, Fields etc.
0.020	Roads
0.100	Woodland Areas
0.100	'Stubby' Buildings

3.5.4 2D Downstream Boundary

To define water levels on the River Cherwell a time dependant head boundary (HT) Boundary has been included at the downstream extent of the model (see Figure 10). This boundary is located along the western edge of the 2D model code boundary along the confluence of the River Ray and River Cherwell. This boundary is included to replicate the water level within the Cherwell during an extreme flood event and allow for flooding from the Cherwell to be introduced at the downstream extent of the 2D domain. The stage – time hydrographs presented in Figure 3 were also inputted into this boundary in the 2D domain as well as in the 1D ISIS model and the development of these has been explained in section 3.4.3.

4 Modelling Results

4.1 Final Model Simulations

The following simulations have been modelled to assess flood risk for the baseline site conditions at Islip.

- **ISL_BSC_R100CC_C100CC** - This simulation represents a 1 in 100 year (plus a 20% increase in peak flow as an allowance for climate change) flood on the River Ray simulated with a 1 in 100 year (plus a 20% increase in peak flow as an allowance for climate change) flood simulated on the River Cherwell.

- **ISL_BSC_R1000_C1000** – This simulation represents a 1 in 1000 year flood on the River Ray simulated with a 1 in 1000 year flood simulated on the River Cherwell.

The results of both simulations are fully presented and reported in the following sections. It should be noted that the event combinations modelled as part of this study that assume that the extreme flood events are modelled on both watercourses represents a conservative approach. More details and justification for this approach is investigated and explained in the sensitivity testing presented in section 4.7.

4.2 Results Summary

To aid in the assessment of flooding impacts along Mill Street, a number of assessment points were considered within the 2D domain and these are highlighted in Figure 12. Maximum flood depths, velocities and hazard ratings at each of the assessment points are highlighted in Table 2 and Table 3 with the critical points to the west of the junction with Church Lane highlighted in red. Flood maps showing the maximum flood depths, flow velocities and flood hazard[6] are presented in sections 4.3, 4.4 and 4.5. The .asc flood depth, velocity and hazard grids are to be provided in electronic form accompanying this report for ERM to use for their own reporting and mapping.

[6] Defra and Agency (2006) *The Flood Risks to People Methodology*, Flood Risks to People Phase 2, FD2321 Technical Report 1, HR Wallingford et al. did the report for Defra/EA Flood and Coastal Defence R&D Programme, March 2006.

Table 2 –Model Results Summary for 1 in 100 year plus climate change event

Assessment Point	Maximum Flood Depth (mAOD)	Maximum Flow Velocity (m/s)	Dominant Flood Hazard Rating	Duration of Flooding (hrs)
Lower Street 1	0.41	0.10	Danger for Most	36.5
Lower Street 2	1.20	0.15	Danger for Most	73
Lower Street 3	1.56	0.19	Danger for All	78.5
Lower Street 4	1.80	0.41	Danger for All	80.5
B 4027	0.54	1.48	Danger for Most	48
Mill Street 1	0.92	1.07	Danger for All	73.75
Mill Street 2	0.91	0.44	Danger for Most	69.75
Mill Street 3	**0.32**	**0.39**	**Danger for Most**	**33.75**
Mill Street 4	**0.40**	**0.22**	**Danger for Most**	**38.5**
Mill Street 5	**0.14**	**0.48**	**Very Low Hazard**	**23.5**

Table 3 - Model Results Summary for 1 in 1000 year event

Assessment Point	Maximum Flood Depth (mAOD)	Maximum Flow Velocity (m/s)	Dominant Flood Hazard Rating	Duration of Flooding (hrs)
Lower Street 1	0.66	0.11	Danger for Most	83.5
Lower Street 2	1.45	0.19	Danger for All	> 100
Lower Street 3	1.81	0.23	Danger for All	> 100
Lower Street 4	2.06	0.46	Danger for All	> 100
B 4027	0.77	1.49	Danger for All	91.5
Mill Street 1	1.16	1.09	Danger for All	> 100
Mill Street 2	1.15	0.48	Danger for All	> 100
Mill Street 3	**0.56**	**0.55**	**Danger for Most**	**81.75**
Mill Street 4	**0.65**	**0.42**	**Danger for Most**	**85**
Mill Street 5	**0.40**	**0.42**	**Danger for Most**	**74.75**

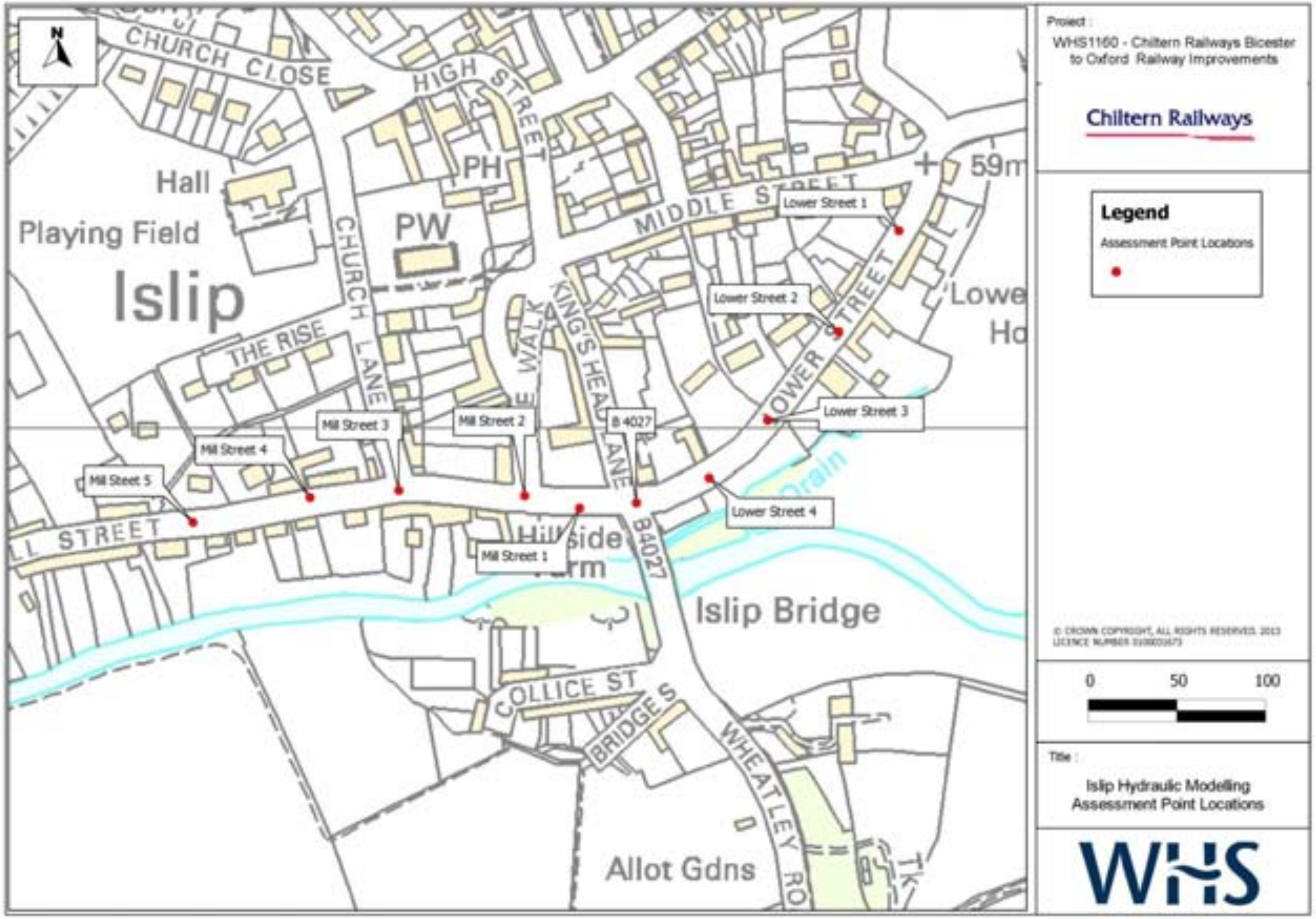

Figure 12 – PO Point Locations within the 2D Domain

4.3 2D Flood Depths

Figure 13 and Figure 14 present the flood depth grids generated from the TuFLOW modelling output files for both the 1 in 100 year (plus an allowance for climate change) and the 1 in 1000 year flood events . The modelling has predicted that flooding will occur along Mill Street from the B 4027 west along Mill Street to about 100 to 150m past the junction with Church Lane, depending on the scenario modelled. Flood depths west of the Church Lane junction are generally below 500mm for the 1 in 100 year (plus an allowance for climate change) event and below 600mm for the 1 in 1000 year flood event.

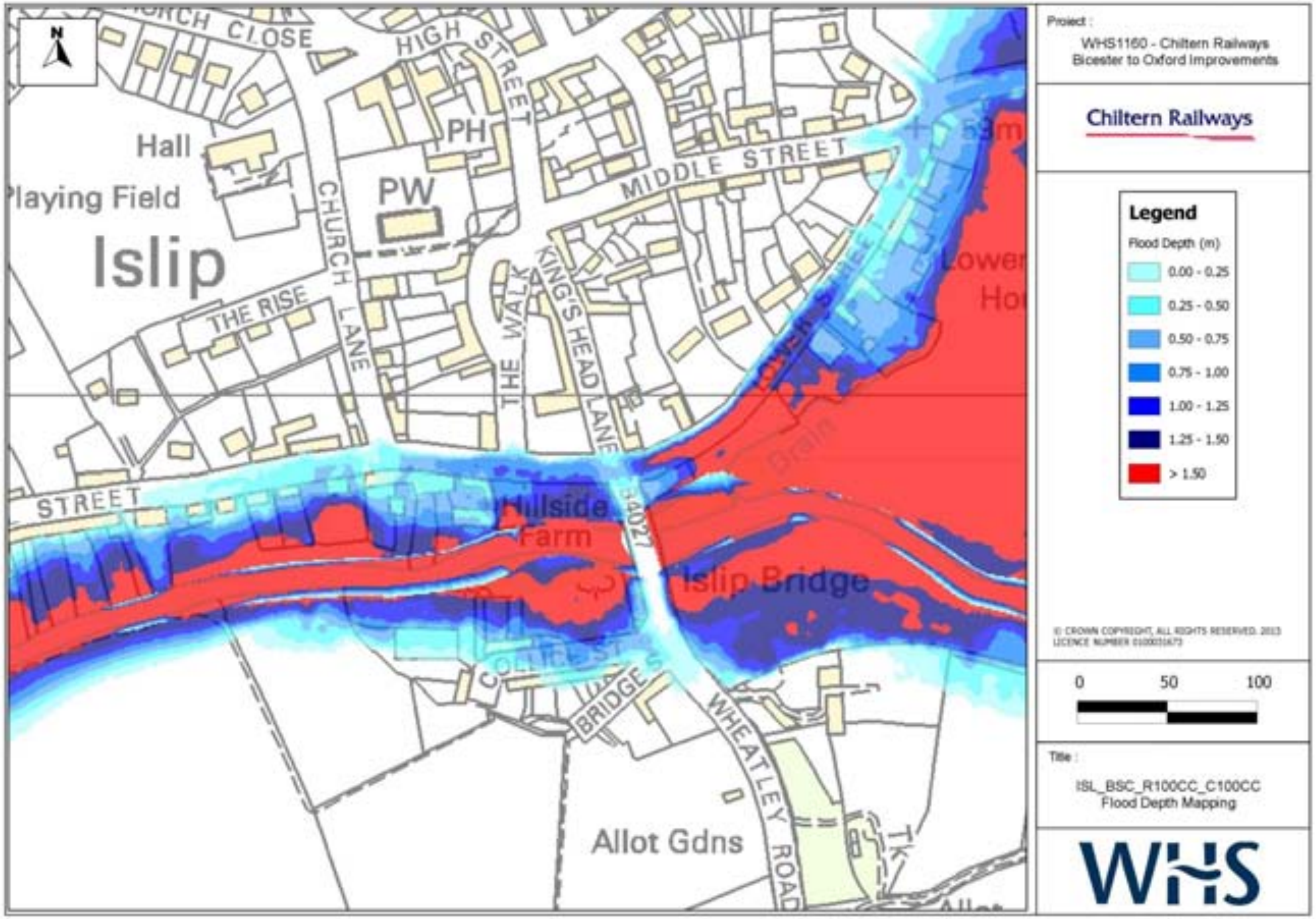

Figure 13 – Flood Depth Mapping for the 1 in 100 Year (plus an allowance for climate change) Flood Event

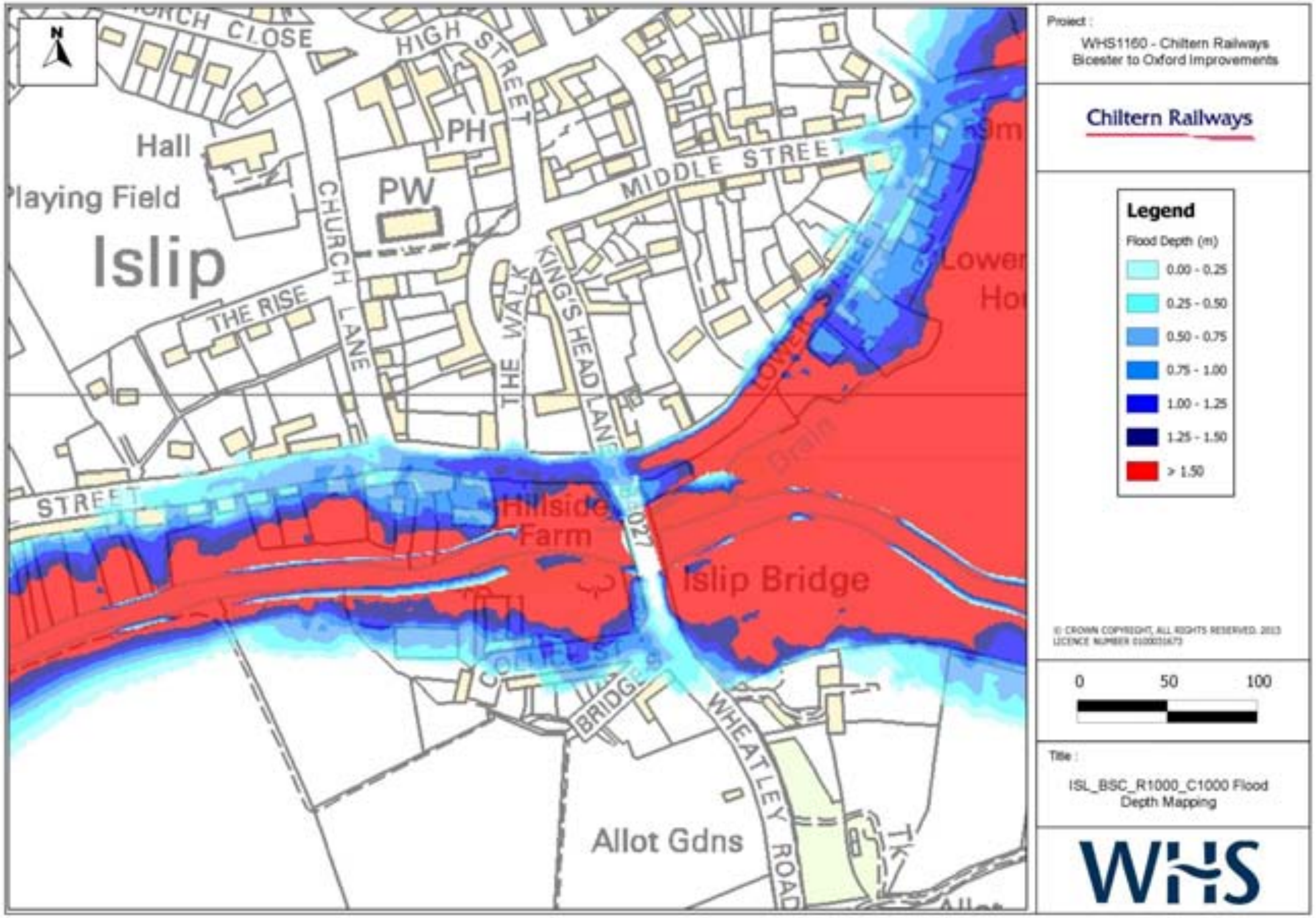

Figure 14 – Flood Depth Mapping for the 1 in 1000 year Flood Event

4.4 2D Flow Velocities

Figure 15 and Figure 16 present the flood velocity grids generated from the TuFLOW modelling output files. Flood velocities are generally low along Mill Street with flow velocities of generally less than 0.6 m\s predicted to the west of Church Lane but there are isolated patches of higher velocities predicted adjacent to the Church Lane junction where velocities increase to 0.9 m\s for both the 1 in 100 year event (plus an allowance for climate change) and the 1 in 1000 year flood event.

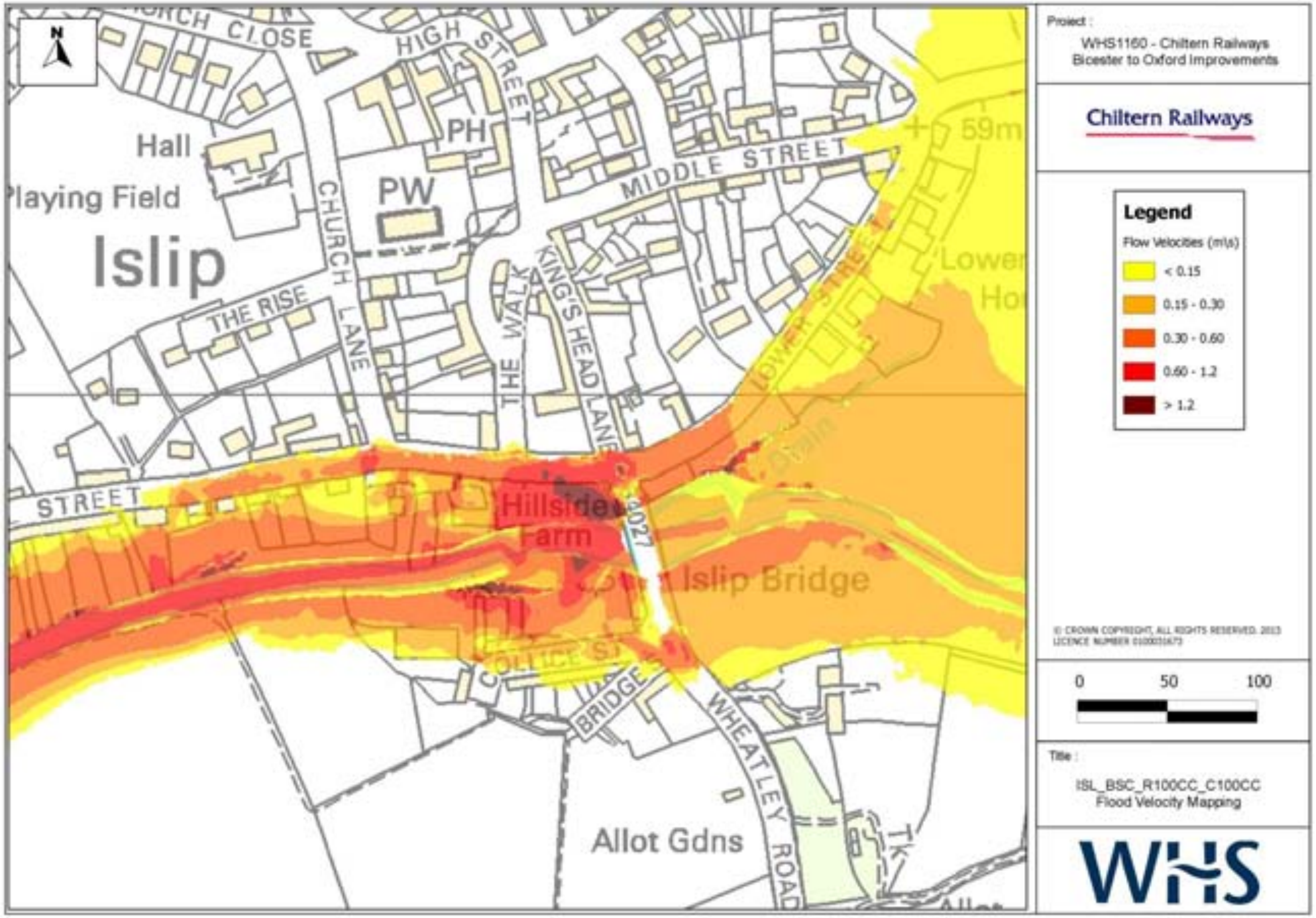

Figure 15 – Flow Velocity Mapping for the 1 in 100 Year (plus an allowance for climate change) Flood Event

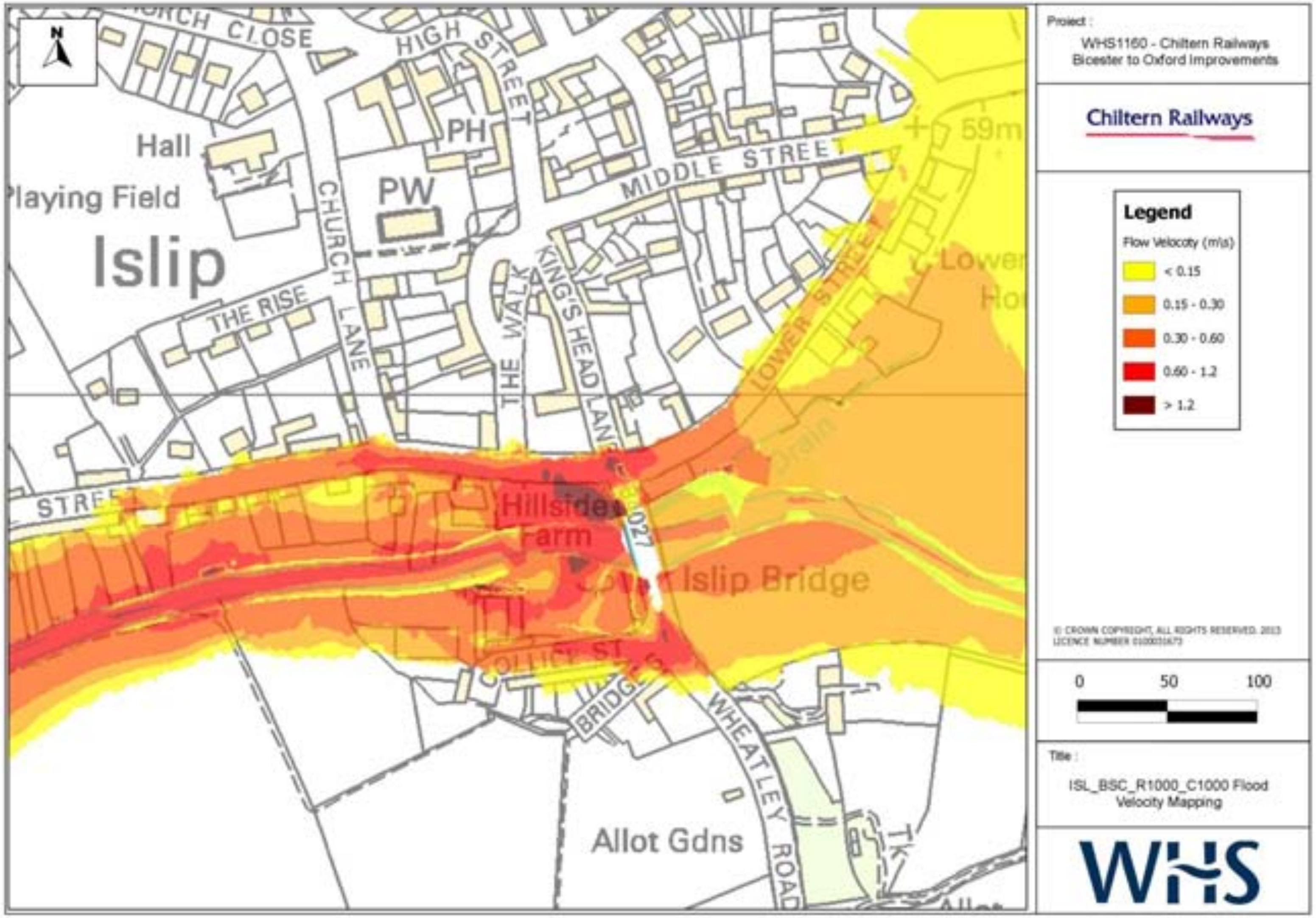

Figure 16 – Flow Velocity Mapping for the 1 in 1000 Year Flood Event

4.5 Flood Hazard

The hazard of flooding is a function of depth and velocity, combined with a debris factor[7] and is used to classify the flood risk to people as a result of flooding.

In order to assess the maximum flood hazard during a flood event, the hazard level at each cell of the TuFLOW grid is assessed at every time step of the model simulation. Each element within the model is assigned one of four hazard categories 'Extreme Hazard', Significant Hazard', Moderate Hazard, or 'Very Low Hazard'.

The derivation of these categories is based on the guidance set out in Flood Risks to People FD2321[6] and a summary of these is provided in Table 4.

Figure 17 and Figure 18 present the flood hazard ratings generated in the town of Islip.

Table 4 – Hazard to People Flood Ratings. (Source Table 3.2 in FD2321[6])

Thresholds for Flood Hazard Rating (FD2320)	Degree of Flood Hazard	Description
< 0.75	Low	**Very Low Hazard (Caution)** – "Flood zone with shallow flowing water or deep standing water"
0.75 – 1.25	Moderate	**Dangerous for some (including , the elderly and infirm)** – "Danger flood zone deep or fast flowing water
1.25 – 2.00	Significant	**Dangerous for most people (including the general public)** – "Danger flood zone with deep fast flowing water
> 2.00	Extreme	**Dangerous for all (including the emergency services)** – "Extreme danger: flood zone with deep fast flowing water"

[7] A conservative debris factor has been used in the modelling that represents (0.5) for shallow depths between 0 – 0.25m and (1) for depths greater than 0.25m.

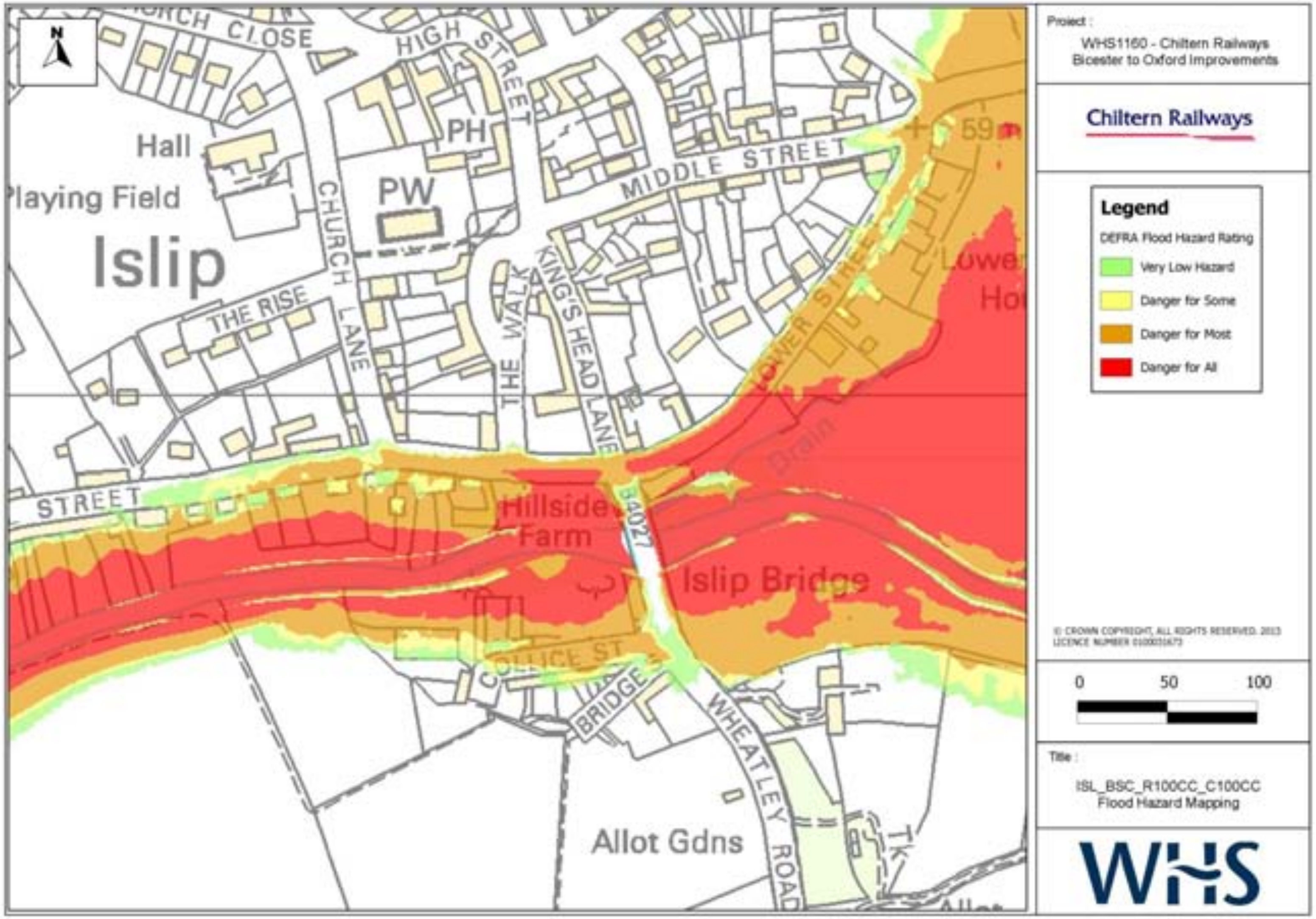

Figure 17 – Flood Hazard Mapping for 1 in 100 Year (plus an allowance for climate change)

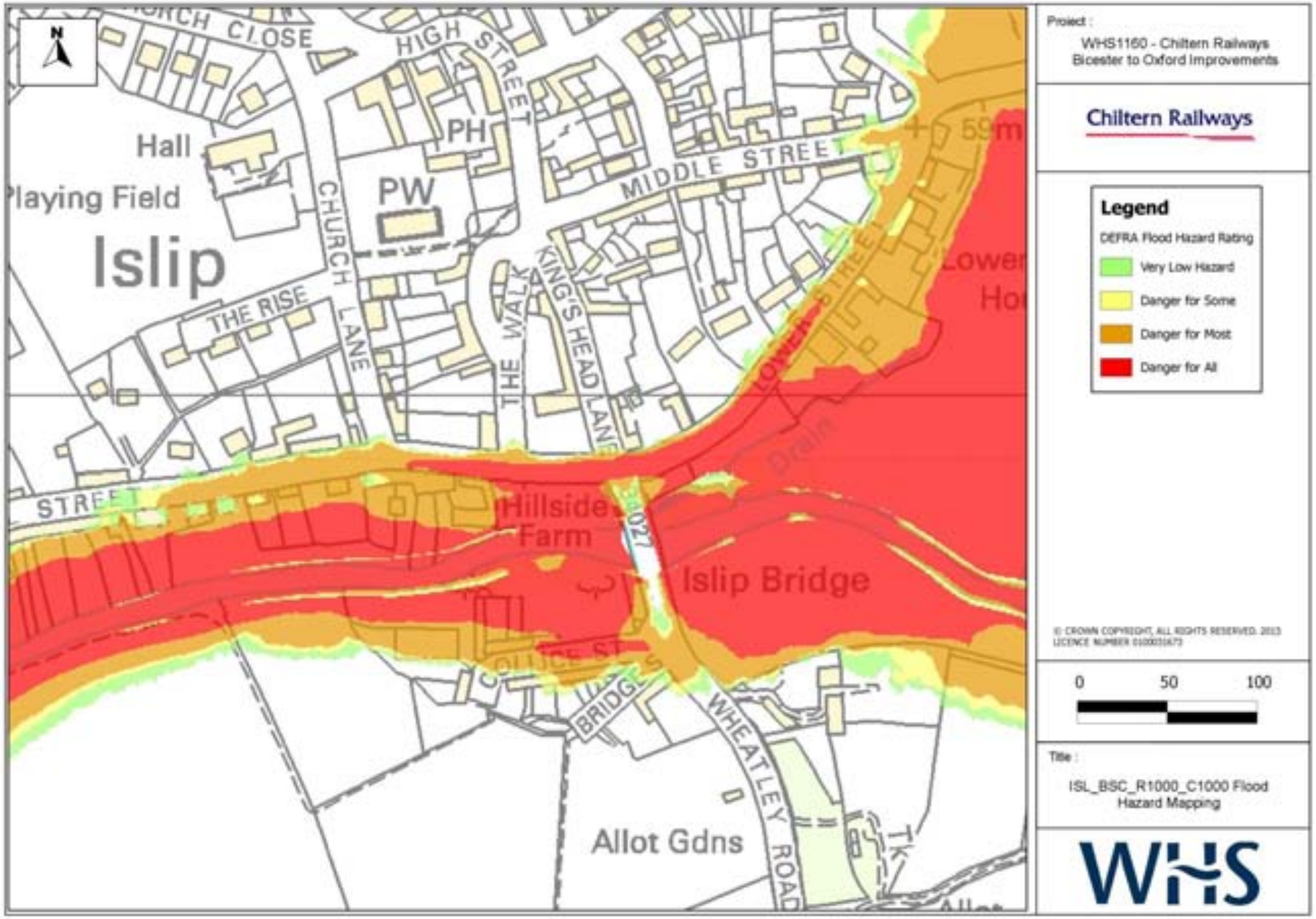

Figure 18 – Flood Hazard Mapping for 1 in 1000 Year Event

4.6 Flood Warning Time

An assessment of likely warning times that residents within Islip might have from the onset of flooding at key areas within Islip has been conducted. This will provide ERM with additional information on the likely warning times and durations of flooding along Mill Street. Looking at the 1 in 1000 year event which provides the worst case scenario, flooding starts to become apparent on Lower Street to the east of the B 4027 Bridge at about 20.15 hours into the simulation. This is the first real indication that residents might have that flooding of the River Ray is likely to start affecting the local road network. From this initial onset of flooding along Lower Street there is a further 7 hours before flooding of Mill Street to the West of the B 4027 bridge commences at around 27.5 hours into the simulation.

However, the key concern is when the access from the western section of Mill Street will start to prevent access out through Church Lane. The modelling has predicted that flooding along Mill Street to the west of the Church Lane junction occurs at about 32 hours into the simulation which would lead to the potential access route along Church Lane becoming impassable after about 35 hours. This indicates that there is a 14.45hr window between flooding becoming apparent on Lower Street to when the access would be cut off from Mill Street to Church Lane. The modelling predicts access to Church Lane would remain impassable for some 61 hours until floodwaters will recede allowing access from Mill Street to Church Lane to become flood free at about 93hrs into the simulation. Figure 19 provides a time series plot of the flood propagation within Islip.

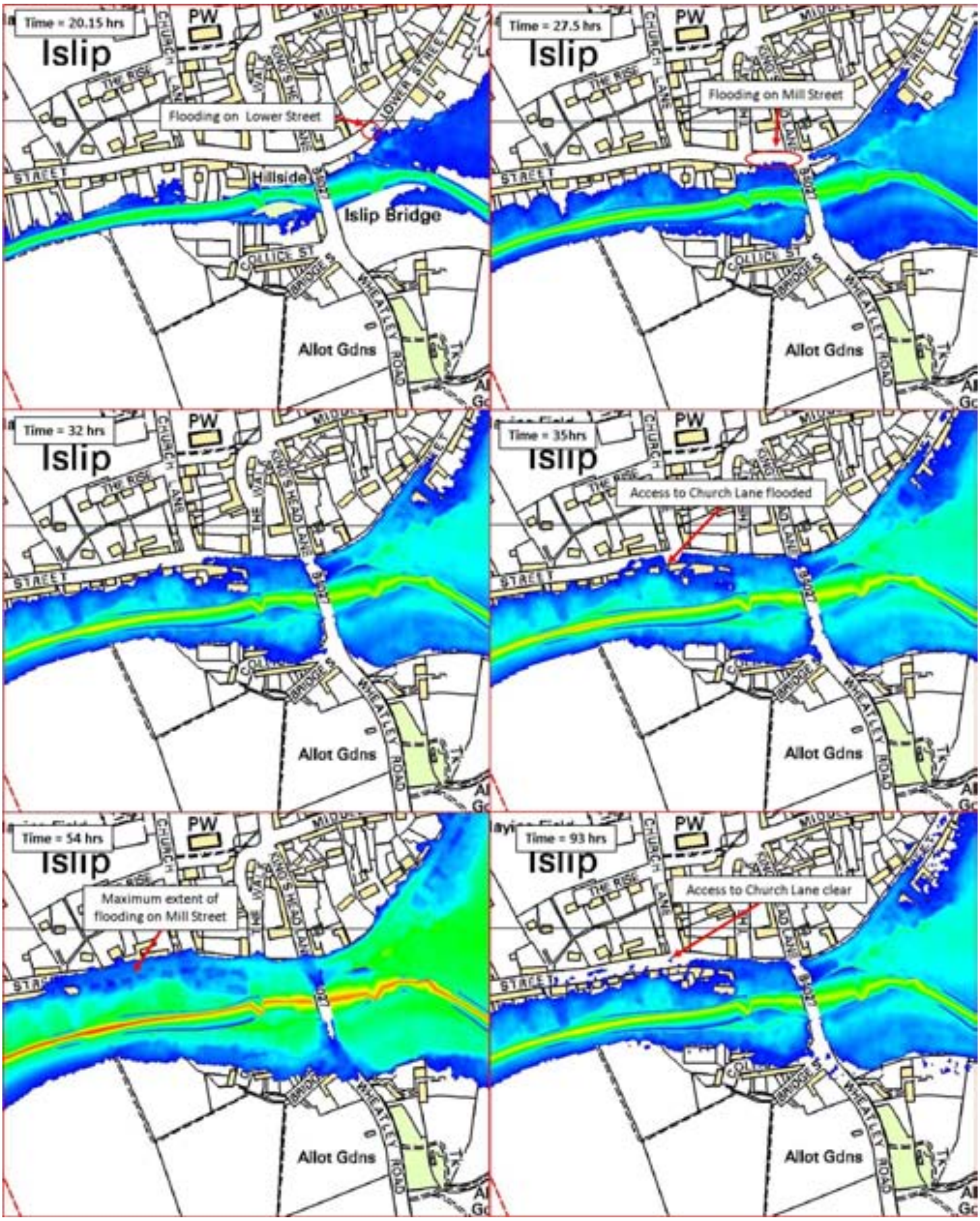

Figure 19 – Time Series Plot Showing the Onset of 1 in 1000 Year Event Flooding in Islip

4.7 Sensitivity Analysis

Sensitivity tests have been undertaken to determine the impact of parameter uncertainties on the predicted flood level. Our sensitivity testing has focussed on the combination of design events on both the River Ray and River Cherwell watercourses. The dominant river that affects flooding at the site of interest in Islip is the extreme flood event on the River Cherwell.

WHS has conducted a sensitivity test on the likely combination of events on both the River Ray and the River Cherwell. Our design runs have assumed that there is an extreme event (i.e Q100CC or Q1000 year event) influencing both watercourses simultaneously. However, this is likely to be a conservative estimate of flooding within Islip and we have tested this assumption with a QMED flow (equivalent to 1 in 2 year) on the River Ray combined with the extreme events on the Cherwell to see what change in flood levels would result.

The results of the sensitivity test are shown in Tables 5 and 6 and show that there is a maximum of 120mm difference in flood depth at our site of interest on Mill Street.

However, this combination of an extreme event on both the River Cherwell and a QMED event on the River Ray represents a less conservative scenario and is likely to under predict flood levels. Given the lack of flood level data from historic events with which to calibrate the model and the inherent uncertainties involved, it is considered that the assumptions made in our baseline models are appropriate, and precautionary.

Table 5 – (1 in 100 Year (plus an allowance for climate change) Event) Change in 2D Flood Depth at Selected Assessment Points for Sensitivity Testing Showing Impact of Assumed Ray Inflow Event

Assessment Point	1 in 100 year plus cc on both rivers Maximum Flood Depth (mAOD)	1 in 2 year on Ray, 100 year plus cc on Cherwell Maximum Flood Depth (mAOD)	Difference (m)
Lower Street 1	0.41	0.22	0.19
Lower Street 2	1.20	1.01	0.19
Lower Street 3	1.56	1.37	0.18
Lower Street 4	1.80	1.63	0.18
B 4027	0.54	0.41	0.13
Mill Street 1	0.92	0.78	0.14
Mill Street 2	0.91	0.77	0.14
Mill Street 3	**0.32**	**0.19**	**0.12**
Mill Street 4	**0.40**	**0.29**	**0.11**
Mill Street 5	**0.14**	**0.06**	**0.09**

Table 6 – (1 in 1000 Year Event) Change in 2D Flood Depth at Selected Assessment Points for Sensitivity Testing Showing Impact of Assumed Ray Inflow Event

Assessment Point	1 in 1000 year on both rivers Maximum Flood Depth (mAOD)	1 in 2 year on Ray, 1000 year plus cc on Cherwell Maximum Flood Depth (mAOD)	Difference (m)
Lower Street 1	0.66	0.46	0.20
Lower Street 2	1.45	1.26	0.20
Lower Street 3	1.81	1.62	0.19
Lower Street 4	2.06	1.87	0.19
B 4027	0.77	0.65	0.12
Mill Street 1	1.16	1.03	0.13
Mill Street 2	1.15	1.01	0.14
Mill Street 3	**0.56**	**0.44**	**0.12**
Mill Street 4	**0.65**	**0.54**	**0.11**
Mill Street 5	**0.40**	**0.31**	**0.09**

4.7.1 Sensitivity on 1D Manning's roughness

Following review of the model by the EA's consultants, comments were raised that the 1D manning's n value is considered to be high and additional sensitivity testing should be undertaken to assess the impact of this parameter on the model results. Therefore WHS have undertaken additional modelling to assess the impact of lowering the 1D Manning's value on flooding along Mill Street. The original 1D roughness value used was 0.05 and this has been lowered by 20% down to a value of 0.04 for the sensitivity model run. The results show that there is very little change in predicted flood depths along the study area with a maximum difference in depth of up to 30mm predicted. This is consistent with the predicted flooding mechanism, whereby flood levels are heavily influenced by downstream flood levels in the Cherwell, rather than conveyance capacity in the Ray. Therefore it can be concluded that based on the findings of this sensitivity analysis the higher 1D manning's values of 0.05 are adequate and present an appropriate conservative scenario.

The results of this sensitivity test are shown in Table 7 and show that there is a maximum of 30mm difference in flood depth at our site of interest on Mill Street.

Table 7 – (1 in 100 Year (plus an allowance for climate change) Event) Change in 2D Flood Depth at Selected Assessment Points for Sensitivity Testing Showing Impact of reduced Manning's Roughness Values in the 1D River Channel

Assessment Point	1 in 100 year plus cc on both rivers Maximum Flood Depth (mAOD)	1 in 100 year plus cc on both rivers (1D Manning's values reduced by 20%) Maximum Flood Depth (mAOD)	Difference (m)
Lower Street 1	0.41	0.38	0.03
Lower Street 2	1.20	1.17	0.03
Lower Street 3	1.56	1.53	0.03
Lower Street 4	1.80	1.77	0.03
B 4027	0.54	0.52	0.02
Mill Street 1	0.92	0.89	0.03
Mill Street 2	0.91	0.88	0.03
Mill Street 3	**0.32**	**0.29**	**0.03**
Mill Street 4	**0.40**	**0.38**	**0.02**
Mill Street 5	**0.14**	**0.13**	**0.01**

Appendix 1 Hydrology Report

1 Introduction

Flood hydrographs are required for two sites on the River Ray at Islip and the River Cherwell. The locations are required as input to a hydraulic model designed to assess the potential impacts of flooding at Islip. Data, where appropriate, is being used from an existing hydraulic model by Peter Brett Associates[1] (PBA). Flood design hydrographs are required for the 1 in 5, 1 in 20, 1 in 100, 1 in 100 year + climate change and 1 in 1000 year design events. A 20% increase in peak flow is used to allow for climate change as per the National Planning Policy Framework (NPPF)[2].

2 Summary of Hydrology Sites

A summary of the upper and lower extents of the hydraulic model is presented within Figure 1.

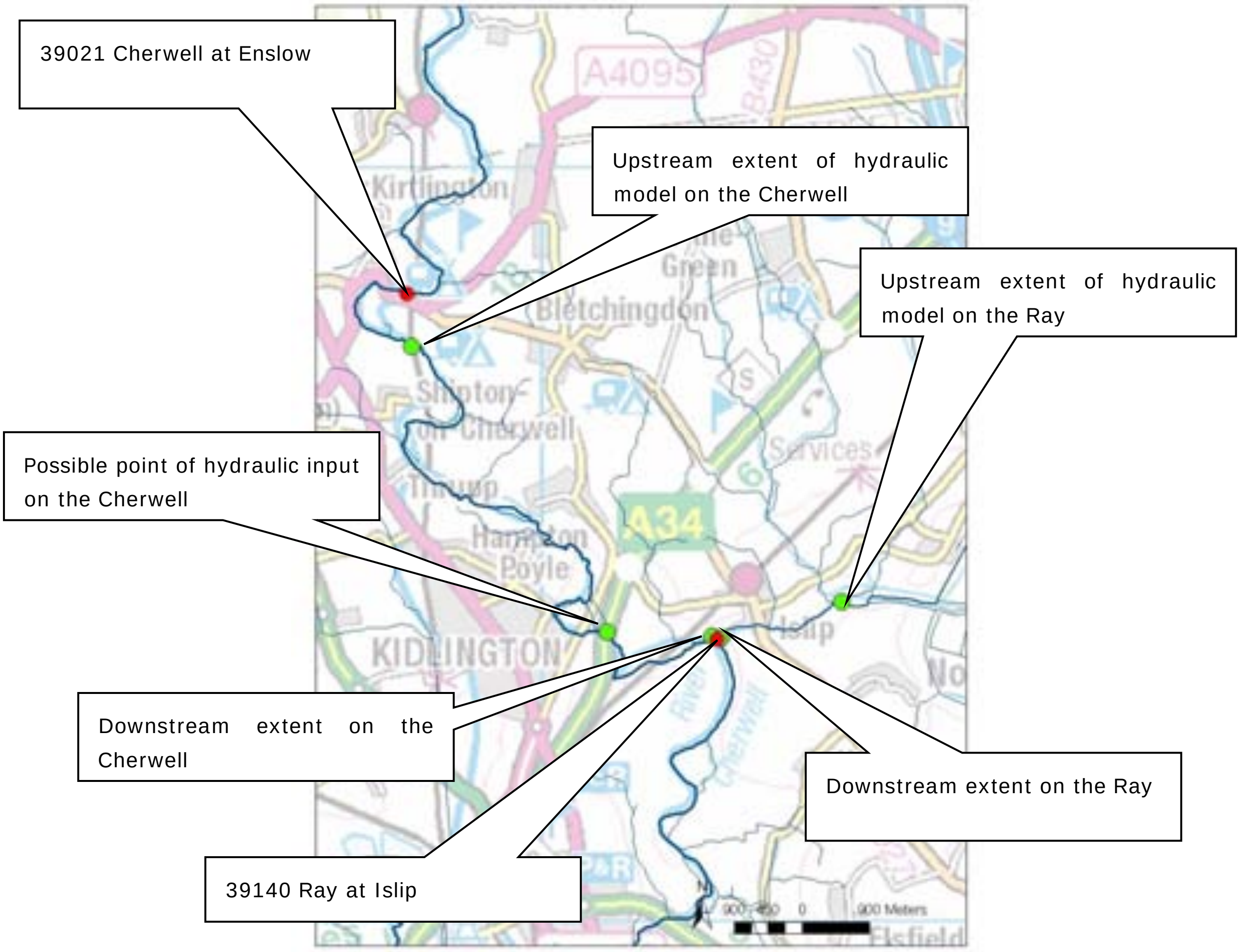

Figure 1 - Location of the Hydrology Sites with Reference to the Extents of the Hydraulic Model

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[1] Peter Brett Associates. August 2005. Lower Cherwell Flood Risk Mapping. Project Ref 10509/45
[2] Department for Communities and Local government (DCLG), 2012, National Planning Policy Framework.

The location of the hydraulic model input is just downstream of the Cherwell at Enslow gauging station and upstream of Islip on the River Ray. In order to maintain the water balance within the flood estimation procedure the hydrology will be estimated on each river close to the confluence of the Cherwell and Ray and put into the model at the upper extents. The extent of the flood plains between the hydrology location and the upper extents of the model was not considered to be significant. The flood plain extent will affect the growth curves (the rate at which the peak flow increases for given return period) as the extent is used as a parameter in selecting the appropriate pooling group. In this case the differences are small hence it is appropriate to estimate the hydrology at the downstream location and use these within the model at the upstream extents of the hydraulic model.

3 Flood Estimation Approach

The main methodologies utilised will be the statistical methodology, as implemented within WINFAPv3 and the Revitalised Rainfall runoff methodology (ReFH).

Data is available from two gauging stations, 39021 Cherwell at Enslow and 39140 Ray at Islip. The former is upstream of the northernmost extent of the hydraulic model, the latter is located close to the confluence between the Ray and Cherwell. Both stations were reviewed for use as a source of local data.

3.1 Review of local data

3.1.1 Cherwell at Enslow 39021

The Cherwell at Enslow gauging station is located at 448250, 218350, some 15 km upstream of the confluence with the River Ray. The catchment, as cited within the FEH HiFlows dataset, is approximately 555.4km^2.

The station is currently within the HiFlows dataset and is appropriate for both estimation of the QMED and for use within the pooling group (although there is a comment that there may be issues with bypassing). The data is therefore appropriate for use to improve the flood estimates on the Cherwell.

The data used within the previous PBA hydraulic model states that the hydrograph produced at the Enslow gauging station during the Easter 1998 event is considered by the EA to be a 1 in 100 event at that point in the Cherwell catchment. The hydrograph from this event was used in the PBA study and rescaled for each required return period for the River Cherwell hydrology. The PBA report was published in 2005 hence it was thought to be of benefit to obtain the intervening years data. As discussed in Section 4.1 of this hydrology report there have been two large events, in 2007 and 2012, which provide valuable information on floods in the Cherwell. The sensitivity of calculating the growth curves using additional data (and the methodologies by which this is completed) is also discussed. Based on this data the 1998 event is no longer assumed to be the 100 year event.

Flow data is available for the Cherwell at Enslow from January 1965 to September 2013. Flow data at 15 minute resolution was provided by the Environment Agency (EA) for the period January 2005 to September 2013. The annual maxima were calculated from this dataset. The HiFlows dataset contains annual maxima up to 2008 and comparison between the two overlapping periods indicated that the datasets were compatible. An extended annual maxima dataset for the Cherwell at Enslow was therefore used to the estimates of QMED and the growth curve within the Cherwell.

3.1.2 Ray at Islip 39140.

The Ray at Islip is located at 452350, 213700. The catchment area is approximately 290.1km2.

Flow data is available at 15 minute resolution from February 1995 to August 2013. This data was provided by the EA.

The station is not currently within the HiFlows dataset. The reason for the exclusion from the HiFlows-UK dataset was unknown. The Centre for Ecology and Hydrology (CEH), who are in the current process of managing and updating the HiFlows dataset, could not confirm why the station was not included and conjectured that this omission may be due to the fact that the station was relatively new and did not have enough years of data to be considered at the time this dataset was produced. The NRFA does not report any hydrometric issues related to measurement at high flows[3].

The station was not used within the PBA study[4] as consultation with the hydrometric team from Thames Region indicated there was uncertainty in the reliability of the Islip gauge. However, the hydrograph from the Easter 1998 event was used within the assessment as representative of the 1 in 100 year event and subsequently rescaled for additional return periods. The EA has since confirmed that the flood event on the Ray was below the 1 in 100 year event (Please see Appendix 2) hence this hydrograph is not utilised within the current study.

As the PBA study was completed in 2005 the data was reassessed using all the data currently available. Analysis of the fifteen minute annual maxima produced the following conclusions:

1. Many of the peak flows within the record are of the same order. There is a plateau of the peaks at approximately $20m^3/s$. This is unusual for a distribution of annual maxima and may be an indication that the rating at the gauging station is not well calibrated at high flows, e.g. due to extensive out of bank flow.
2. Quality control comments against peak flow events often note manual manipulation by the hydrometric team to remove spurious data.
3. Comparison between 15 minute data and daily data yielded the following findings. Whilst none of these are conclusive in finding the data to be inappropriate for use, in combination they are convincing.
    a. The peak annual maxima flow from the daily dataset is sometimes higher than that within the 15 minute dataset.
    b. The peak annual maxima event from the 15 minute and daily dataset is not always the same.
    c. The peak event within each dataset does not have the same ranking. This is most obvious with the April 1998 event. The annual maxima associated with the 15 minute data is $11.3m^3/s$, the 11^{th} largest annual maxima out of the 16 year record. The daily data provides a peak flow of $18.4m^3/s$, the 3^{rd} largest annual maxima in the 16 year record. Given that this event within the Cherwell is cited as being the 1 in 100 year event the 15 minute data is not thought to be reliable.

In conclusion the data from the Ray at Islip is not appropriate for use as local data to improve the estimation of flood flows within the catchment.

[3] http://www.ceh.ac.uk/data/nrfa/data/station.html?39021
[4] Peter Brett Associates. August 2005. Lower Cherwell Flood Risk Mapping. Project Ref 10509/45

4 Flood Estimates

The flood estimates for the Cherwell Hydrology Site and the Ray Hydrology Site are presented within this section.

4.1 Cherwell Hydrology

The Cherwell hydrology catchment is approximately 575km^2. The average annual rainfall is 663mm[5] and the annual runoff 208mm[6].

The catchment is dominated by the Hydrology of Soil Type (HOST) classes 2 and 25. Characteristics of these are described in Table 1 . The base flow index value (BFIHOST) of 0.59 suggests a flow regime of relatively high permeability, relatively unresponsive to rainfall.

Catchment characteristics were derived from the FEH CDROM These were checked and compared with OS mapping and were found to be suitable for use. The location used is 452250, 213700.

Table 1 - Dominant HOST Soil Classifications Occurring in the Catchment

HOST class	Fractional extent (%)	Description of substrate	Description of soils	Permeability
2	38.9	Limestone	Mineral soils, no gleyed layer	High
20	14.1	Impermeable – soft massive clays	High storage mineral soil, gleyed layer at depth	Medium
25	30.36	Impermeable – soft massive clays	Mineral soil, shallow depth to gleyed layer	Low

Statistical Method

Estimate of the index flood (QMED)

The gauging station at Enslow is just upstream of the site, 96% of the Cherwell hydrology catchment drains through gauged catchment. Data from the gauge is therefore used to enhance the estimation of both the QMED and growth curve.

The FEH methodology recommends that the QMED can be estimated from gauged records if there is more than 14 years of annual maxima data. For the Cherwell at Enslow there are 48 years of annual maxima thus this can provide a reliable estimate of QMED. Using the annual maxima the QMED at the gauging station was 29.95m^3/s.

The donor transfer methodology is used to transfer the data from the gauging station to the catchment site. This uses the method outlined within Equation 1 and Equation 2.

[5] NERC (CEH). 2009. Flood Estimation Handbook CD-ROM 3.
[6] WHS LowFlows Enterprise.

$$\mathbf{QMED_{s,adj}} = \mathbf{QMED_{s,cds}} \left(\frac{\mathbf{QMED_{g,obs}}}{\mathbf{QMED_{g,cds}}}\right)^{a_{sg}}$$

Equation 1

Where $QMED_{s,adj}$ is the adjusted QMED for the site, $QMED_{s,cds}$ is the catchment descriptor QMED for the site, $QMED_{g,obs}$ is the QMED observed at the gauging station, $QMED_{g,cds}$ is the catchment descriptor QMED and a_{sg} is the exponent.

The exponent, a_{sg}, is related to the model error variance and the sampling error associated with the donor gauging station. In general, where long records are available, the sampling error is much smaller than the model error. The correlation between the model errors for the regression equation are expressed as a function of geographical distance and are expressed as Equation 2.

$$a_{sg} = 0.4598\exp\left(-0.0200d_{sg}\right) + (1 - 0.4598)\exp\left(-0.4785d_{sg}\right)$$

Equation 2

Where d_{sg} is the geographic distance between the centroids of the target and donor gauge.

Neither site has a high urban extent value thus both are classed as essentially rural; Urbext2000 is 0.024 within the gauged catchment and 0.025 within Cherwell hydrology catchment. In order to be consistent within the methodology the QMED from catchment descriptors without the urban adjustment is used within the donor transfer methodology. The methodology ensures that the impact of the urban landuse is implicitly included within the estimation of the QMED.

The catchment descriptor QMED at the Cherwell hydrology site is $34.23m^3/s$. Using the donor transfer methodology the Q MED at the Cherwell hydrology site is $31.09m^3/s$.

Pooling Group and Growth Curve

Due to the close proximity of the Cherwell hydrology site and the gauging station the data from the gauged site was also utilised to produce the growth curve.

The FEH methodology recommended that Single Site Analysis (i.e. using the annual maxima data) is insufficient unless the site record is more than twice the target return period. Hence an enhanced single site analysis was completed using WINFAP FEHv3. Please note that the following formation of the pooling group and growth curves relate to the gauged site. The growth curves are then combined with the QMED at the Cherwell Hydrology site to create the final flood peak dataset.

An initial pooling group was created for the catchment using WINFAP FEHv3. As per current guidance a minimum of 500 station years was used to derive this. The initial pooling group of 17 stations was reviewed and 9 stations were removed. This initial pooling group was developed using all HiFlows datasets (not just those identified as being suitable for pooling) in order to ensure that no potential stations suitable might be excluded. Five extra stations were then added, based on catchment similarity and appropriateness for inclusion in a pooling group, see Table 2. The final pooling group of 13 stations includes a total of 539 station years. The group is classified as being not heterogeneous (H_2 = 0.711).

The pooled data was calculated to fit the GL distribution best (Z=-4.74). The acceptable value of Z is that the absolute value should be less than 1.64, hence the distribution fit is unacceptable according to FEH guidance. In order to understand this, it is worthwhile understanding the generation of the heterogeneity and goodness of fit (Z) tests.

The heterogeneity is based on whether the sites within the pooling group have the same growth curve. The heterogeneity measure used to establish whether the group is heterogeneous or not is based on the L-CV and L-skewness. The pooling group is not heterogeneous as the H2 statistic is 0.711.

The goodness of fit test is used to determine whether a selected distribution is acceptable and to find the best-fitting distribution. As the L-CV (variance) and the L-Skew (skewness) are used to derive the growth curve parameters the L-kurtosis (peakedness) is used to establish whether the growth curve distribution fits well. In this case the distribution is not acceptable. Sensitivity analysis on the methodology indicated that the Z value did not change markedly due to the methodology of the enhanced single site analysis nor the inclusion or exclusion of the Cherwell at Enslow within the pooling group hence it is not due to the methodology nor the attributes of the site. In general, a high absolute goodness of fit value is due to one station having a very high kurtosis due to the presence of a singular large event within the distribution. In this example there is no one station heavily impacting on the Z value. Visual analysis of the pooled dataset indicates a number of stations with individual large events which have a marked impact on the growth curve, thus it is not just one station affecting the Z value. The data from these large events provides valuable information to the pooled dataset hence it is important that this is not removed for this reason.

As the distribution is assessed (using the Z value) as not acceptable, yet the best practice methodology has been used to produce this, a comparison of different sources of data was used to assess the reliability of the growth curve.

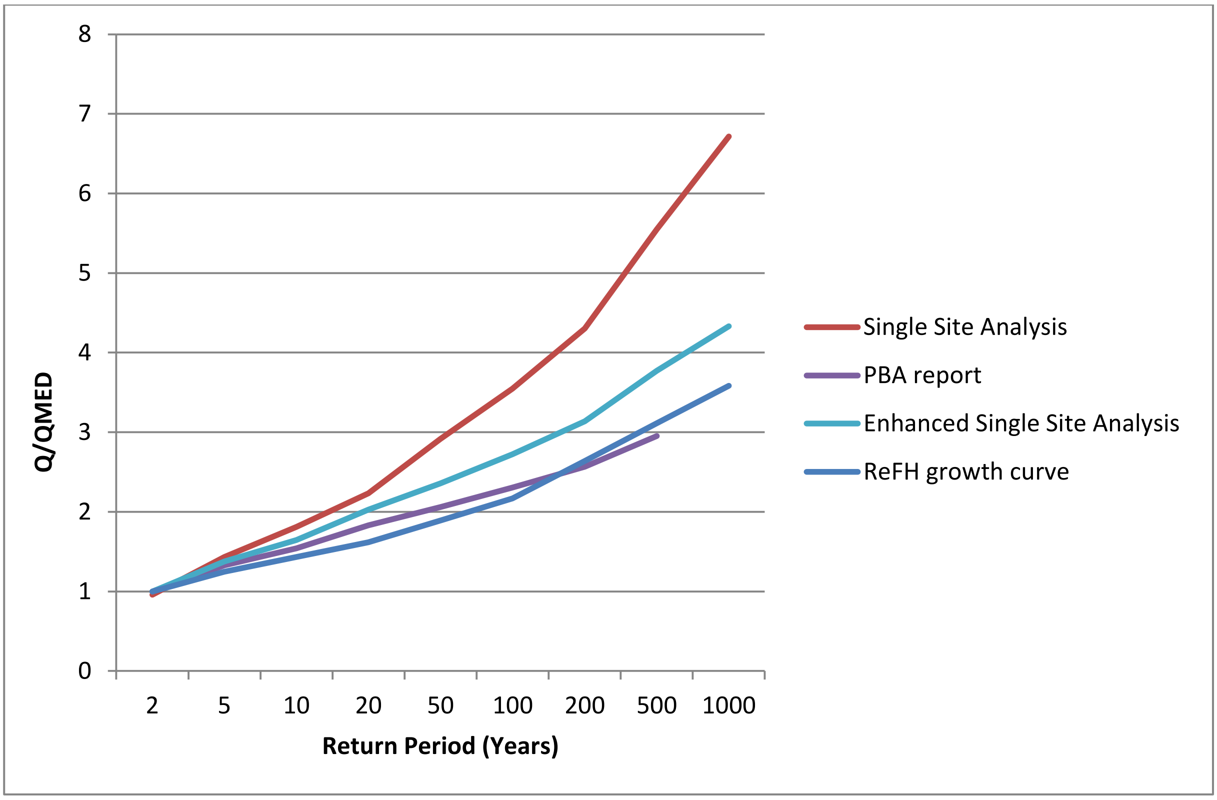

Figure 2 - Growth Curves for the Cherwell

Error! Reference source not found. Figure 2 illustrates the growth curves obtained using a number of different methodologies. The growth curves reported by PBA were generated (as far as can be determined) using single site analysis on the available annual maxima. Guidance indicates that the length of record should be twice as long as the return period required, hence this methodology is not recommended beyond a return period of 20 years. The sensitivity of using this methodology can be seen through comparison with the single site analysis using data up to 2012. This dataset included two additional large events, in 2007 and 2012, and yields a far higher growth curve. The enhanced single site analysis provides a growth curve which is based on the pooling group, thus provides more years data for analysis and can be considered a more reliable indication of the growth curve. The growth curve from the ReFH methodology (for the site on the Cherwell downstream) is also presented for comparison, the derivation of this is based on the values within Table 4. The enhanced site analysis growth curve represents a conservative estimate of the growth curve, when compared with the previous single site analysis and ReFH growth curves. This growth curve was produced using the best practice methodologies and provides a conservative estimate of the growth curve hence will be used to produce the final peak flows utilised within the hydrographs.

Table 2 - Pooling Group Selection and Reasons for Retaining or Removing from Final Pooling Group

Station	Distance SDM	Years of Rec.	AREA	SAAR	FARL	URBEXT 2000	Suitable for pooling	Suitable for QMED	Decision	Notes (Note where 'Not suitable for pooling' is noted these relate to comments within the HiFlows dataset)
39021 (Cherwell @ Enslow Mill)	0	43	555.43	664	0.094	0.976	Y	Y		
31005 (Welland @ Tixover)	0.404	47	419.59	636	0.098	0.971	Y	Y	Retain	
28024 (Wreake @ Syston Mill)	0.44	39	417.01	634	0.088	0.953	Y	Y	Retain	
39034 (Evenlode @ Cassington Mill)	0.479	37	427.14	691	0.068	0.965	Y	Y	Retain	
31004 (Welland @ Tallington)	0.485	42	708	632	0.087	0.925	Y	Y	Retain	
27014 (Rye @ Little Habton)	0.517	15	680.84	824	0.092	0.996	Y	Y	Retain	
21031 (Till @ Etal)	0.559	28	634.78	827	0.067	0.992	Y	Y	Retain	
43009 (Stour @ Hammoon)	0.584	41	518.88	849	0.123	0.992	Y	Y	Retain	
41014 (Arun @ Pallingham Quay)	0.656	35	382.69	805	0.085	0.958	Y	Y	Retain	
10003 (Ythan @ Ellon)	0.684	23	532.29	826	0.047	0.993	Y	Y	Add	
39006 (Windrush @ Newbridge)	0.691	59	361.6	744	0.075	0.951	Y	Y	Add	Permeable Adjustment methodology used
43008 (Wylye @ South Newton)	0.705	38	447.94	830	0.052	0.976	Y	Y	Add	Permeable Adjustment methodology used
10001 (Ythan @ Ardlethen)	0.769	46	456.97	830	0.043	0.992	Y	Y	Add	
22001 (Coquet @ Morwick)	0.775	46	578.21	850	0.04	0.993	Y	Y	Add	
36006 (Stour @ Langham)	0.283	46	571.36	580	0.086	0.985	N	Y	Reject	Not suitable for pooling.

Station	Distance SDM	Years of Rec.	AREA	SAAR	FARL	URBEXT 2000	Suitable for pooling	Suitable for QMED	Decision	Notes (Note where 'Not suitable for pooling' is noted these relate to comments within the HiFlows dataset)
36015 (Stour @ Lamarsh)	0.375	36	481.29	583	0.078	0.987	N	Y	Reject	Not suitable for pooling.
34004 (Wensum @ Costessey Mill)	0.495	34	559.72	672	0.13	0.93	N	N	Reject	Not suitable for pooling or QMED.
33005 (Bedford Ouse @ Thornborough Mill)	0.538	28	387.74	655	0.111	0.983	Y	Y	Reject	Bounded distribution
33037 (Bedford Ouse @ Newport Pagnell)	0.567	40	801.65	648	0.104	0.943	Y	Y	Reject	Bounded
21806 (Till @ Heaton Mill)	0.568	7	655.53	822	0.067	0.992	Y	Y	Reject	Remove as short record and discordancy noted. Growth curve significantly steeper than all other sites within the pooling group. Downstream of Till at Etal, but record covers different period.
21022 (Whiteadder Water @ Hutton Castle)	0.671	36	502.24	814	0.047	0.981	N	Y	Reject	Not suitable for pooling.
68001 (Weaver @ Ashbrook)	0.76	72	621.52	732	0.158	0.955	N	Y	Reject	Not suitable for pooling.
55003 (Lugg @ Lugwardine)	0.775	39	885.11	813	0.106	0.99	N	Y	Reject	Not suitable for pooling.

Flood Frequency Curve

A flood frequency curve for the catchment was derived using the adopted QMED estimate of 31.09m^3/sand the pooling group growth curve from the enhanced gauging station analysis at the Cherwell at Enslow. The resulting design flood peak flow estimates are shown in Table 3. Whilst the growth curve is steeper than the PBA results, the assumption by PBA that the April 1998 event represented the 1 in 100 year event and the subsequent scaling to this has resulted in the peak flows being lower than those used within the PBA hydraulic model.

Table 3 - Statistical Method Estimated Flood Flows for a Range of Design Return Period Events

Return Period	Peak Flow (m^3/s)
5	42.8
20	63.1
100	84.7
100 + 20%	101.6
1000	134.6

Flood Estimation Using the ReFH Rainfall Runoff Method

The ReFH Model was used to estimate a range of return period flood event hydrographs. The resulting peak flow estimates from the design hydrographs for the catchment are shown in Table 4. The critical duration for the catchment was 46 hours. To be conservative the critical duration was taken to be the duration that provided the highest peak within ReFH. This was different to the default duration recommended within the ReFH methodology.

This was used for derivation of the flood hydrographs for the Cherwell catchment and the Ray catchment.

Table 4 - ReFH Estimated Flood Flows for a Range of Design Return Period Events

Return Period	Peak Flow (m^3/s)
5	58.2
20	75.5
100	101.3
100 + 20%	121.6
1000	167.4

Summary of Results

The final flood hydrographs were estimated by rescaling the ReFH hydrographs by the statistical peak flow estimates, see Figure 3.

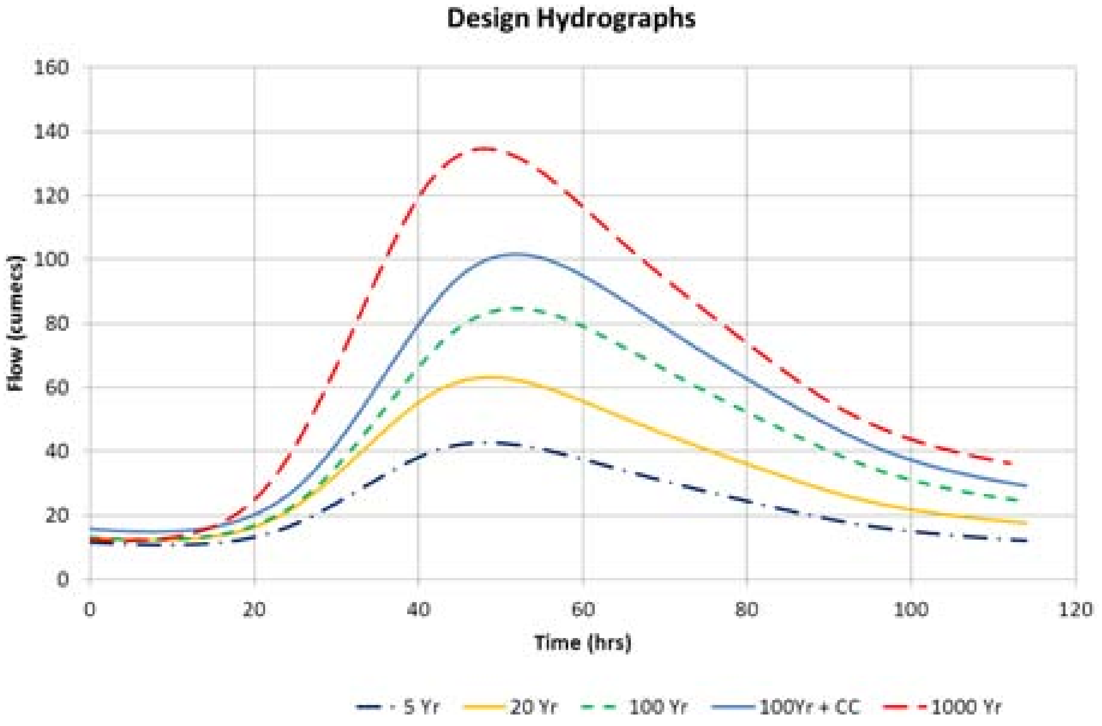

Figure 3 - Final Design Hydrographs

4.2 Ray Hydrology

The Ray Downstream catchment is approximately 290.01km^2 and includes several towns, the largest of which is Bicester. The average annual rainfall is 630mm[7] and the annual runoff 174mm[8].

The catchment is dominated by the Hydrology of Soil Type (HOST) classes 25 and 2. Characteristics of these are described in Table 5. The base flow index value (BFIHOST) of 0.49 suggests a flow regime of intermediate permeability and relatively responsive to rainfall.

Catchment characteristics were derived from the FEH CDROM These were checked and compared with OS mapping and were found to be suitable for use. The location used is 452350, 213750.

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[7] NERC (CEH). 2009. Flood Estimation Handbook CD-ROM 3.
[8] WHS LowFlows Enterprise.

Table 5 - Dominant HOST Soil Classifications Occurring in the Catchment

HOST class	Fractional extent (%)	Description of substrate	Description of soils	Permeability
25	40.1	Impermeable – soft massive clays	Mineral soil, shallow depth to gleyed layer	Low
2	23.5	Limestone	Mineral soils, no gleyed layer	High
23	11.1	Impermeable – soft massive clays	Low storage mineral soil, gleyed layer at depth	Low

Statistical Method

Estimate of the Index Flood (QMED)

Where possible QMED should be estimated using local data. Potential donor stations were assessed for this purpose.

Upstream of the Ray site is gauging station 39017, the Ray at Grendon Underwood. It is in the HiFlows dataset and is considered appropriate for the estimation of QMED. The centroid of this station is 10.1km from the Ray site. However, the station has a very different BFIHOST (0.25 difference). This is one of the descriptors included within the QMED catchment descriptor hence the gauge was not considered to be appropriate for use for data transfer.

On the main Cherwell river is the gauge 39021, the Cherwell at Enslow Mill. The centroid for this is approximately 24.8km from the centroid for the Ray site. The BFIHOST is 0.59, compared with a BFIHOST of 0.49 and the catchment area is almost twice the Ray site catchment. The alpha parameter is small therefore this catchment would have negligible influence when used for donor transfer. Furthermore despite the apparent similiarity in BFIHOST the geologies and soils within the two catchments are very different. Thus the value of the record as a donor is of limited value.

Estimates of the index flood were derived from catchment characteristics. The catchment is essentially rural. Previous guidance, based on the fact that the gauged data used to derive the catchment descriptor QMED equation had a threshold of URBEXT0.03 recommended that it was completed only where it exceeded 0.03. Recent guidance indicates that an adjustment for urban impacts should be included for all catchments to ensure that there are no discontinuities where catchments exceed this proportion. Applying the urban expansion factor to the catchment provides an adjusted URBEXT2000 values of 0.0218 thus the catchment is still essentially rural and the concern about a theoretical discontinuity (as the threshold of 3% is exceeded) is not an issue within this catchment (nor the Cherwell where this is not exceeded either). The urban adjustment was therefore not applied.

The estimates of QMED from catchment descriptors were calculated to be;

$QMED_{CDS\_raw} = 23.89 m^3/s$

Pooling Group and Growth Curve

An initial pooling group was created for the catchment using WINFAP FEHv3. As per current guidance a minimum of 500 station years was used to derive this. The initial pooling group of 14 stations was reviewed and 10 stations were removed. This initial pooling group was developed using all HiFlows datasets (not just those identified as being suitable for pooling) in order to ensure that no potential stations suitable might be excluded. Nine extra stations were then added, based on catchment similarity and appropriateness for inclusion in a pooling group, see Table 6. The final pooling group of 13 stations includes a total of 551 station years. The group is classified as being heterogeneous (H_2 = 2.97).

The pooled data was calculated to fit the Generalised Logistic distribution best (Z=0.56). Absolute Z values less that 1.64 are considered acceptable for growth curve fitting[9]. The flood growth curve estimated for the catchment is shown in Figure 4.

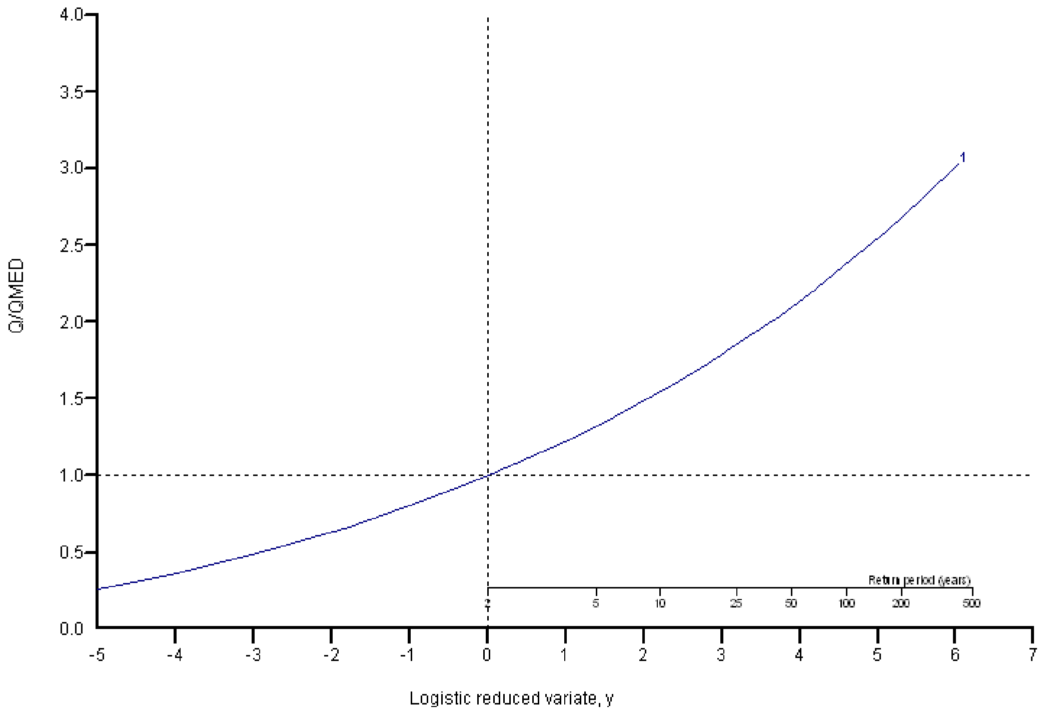


Figure 4 - Adopted Growth Curve for Target Catchment

[9] Robson, A.J. and Reed, D.W. (1999) Statistical procedures for flood frequency estimation.Volume 3 of the Flood Estimation Handbook. Centre for Ecology & Ecology.

Table 6 - Pooling Group Selection and Reasons for Retaining or Removing from Final Pooling Group

Station	Distance SDM	Years of Rec.	AREA	SAAR	FARL	URBEXT 2000	Suitable for pooling	Suitable for QMED	Decision	Notes (Note where 'Not suitable for pooling' is noted these relate to comments within the HiFlows dataset)
Target			***290.0***	***630***	***0.98***	***0.021***				
54016 (Roden @ Rodington)	0.731	48	261.94	693	0.981	0.014	Y	Y	Retain	
33019 (Thet @ Melford Bridge)	1.097	49	311.37	620	0.932	0.014	Y	Y	Retain	
40005 (Beult @ Stile Bridge)	1.126	42	278.05	691	0.992	0.015	Y	Y	Retain	
27087 (Derwent @ Low Marishes)	1.315	20	475.92	741	0.996	0.01	Y	Y	Retain	
68005 (Weaver @ Audlem)	1.513	40	201.44	719	0.95	0.007	Y	Y	Added	
204001 (Bush @ Seneirl Bridge)	1.725	37	298.98	1116	0.992	0.003	Y	Y	Added	
22006 (Blyth @ Hartford Bridge)	1.894	49	273.62	696	0.99	0.009	Y	Y	Added	
33011 (Little Ouse @ County Bridge Euston)	1.902	48	130.1	596	0.985	0.008	Y	Y	Added	
54041 (Tern @ Eaton on Tern)	1.938	37	193.51	719	0.954	0.015	Y	Y	Added	
15008 (Dean Water @ Cookston)	1.962	53	176.63	840	0.973	0.015	Y	Y	Added	
43009 (Stour @ Hammoon)	2.052	41	518.88	849	0.992	0.01	Y	Y	Added	
14001 (Eden @ Kemback)	2.058	39	308.72	800	0.992	0.011	Y	Y	Added	
25005 (Leven @ Leven Bridge)	2.07	48	194.15	726	0.994	0.014	Y	Y	Added	
28017 (Devon @ Cotham)	0.43	18	280.48	592	0.98	0.013	N	N	Rejected	Unsuitable for Pooling and QMED

Station	Distance SDM	Years of Rec.	AREA	SAAR	FARL	URBEXT 2000	Suitable for pooling	Suitable for QMED	Decision	Notes (Note where 'Not suitable for pooling' is noted these relate to comments within the HiFlows dataset)
39018 (Ock @ Abingdon Old Weir)	0.955	16	248.21	637	0.986	0.02	N	Y	Rejected	Unsuitable for Pooling
39081 (Ock @ Abingdon)	0.955	30	233.6	639	0.986	0.018	N	Y	Rejected	Unsuitable for Pooling
33044 (Thet @ Bridgham)	0.98	42	274.99	620	0.942	0.013	N	Y	Rejected	Unsuitable for Pooling
39040 (Thames @ West Mill Cricklade)	0.993	36	187.44	773	0.886	0.008	N	N	Rejected	Unsuitable for Pooling and QMED
33021 (Rhee @ Burnt Mill)	1.204	47	306.06	559	0.994	0.021	Y	Y	Rejected	Bounded
34006 (Waveney @ Needham Mill)	1.212	45	376.05	594	0.998	0.014	N	N	Rejected	Unsuitable for Pooling and QMED
54020 (Perry @ Yeaton)	1.258	46	188.05	739	0.954	0.014	Y	Y	Rejected	Bounded
33080 (Alconbury Brook @ Brampton)	1.314	37	212.63	564	0.999	0.017	N	N	Rejected	Unsuitable for Pooling and QMED
33046 (Thet @ Red Bridge)	1.353	42	143.43	624	0.944	0.016	N	Y	Rejected	Unsuitable for Pooling

Flood Frequency Curve

A flood frequency curve for the catchment was derived using the adopted QMED estimate of 23.89m^3/sand 2.86m^3/sand the pooling group growth curve. The resulting design flood peak flow estimates are shown in Table 7.

Table 7 - Statistical Method Estimated Flood Flows for a Range of Design Return Period Events

Return Period	Peak Flow (m^3/s)
5	31.60
20	42.36
100	56.78
100 + 20%	68.14
1000	83.86

Flood Estimation using the ReFH Rainfall Runoff Method

The ReFH Model was used to estimate a range of return period flood event hydrographs. The resulting peak flow estimates from the design hydrographs for the catchment are shown in Table 8. The critical duration for the Cherwell catchment was 46 hours. As this is the larger of the two catchments this has also been used for the duration of the event within the Ray catchment.

Table 8 - ReFH Estimated Flood Flows for a Range of Design Return Period Events

Return Period	Peak Flow (m^3/s)
5	46.10
20	59.51
100	78.95
100 + 20%	94.74
1000	126.54

Summary of Results

The final flood hydrographs were estimated by rescaling the ReFH hydrographs by the statistical peak flow estimates, see Figure 5.

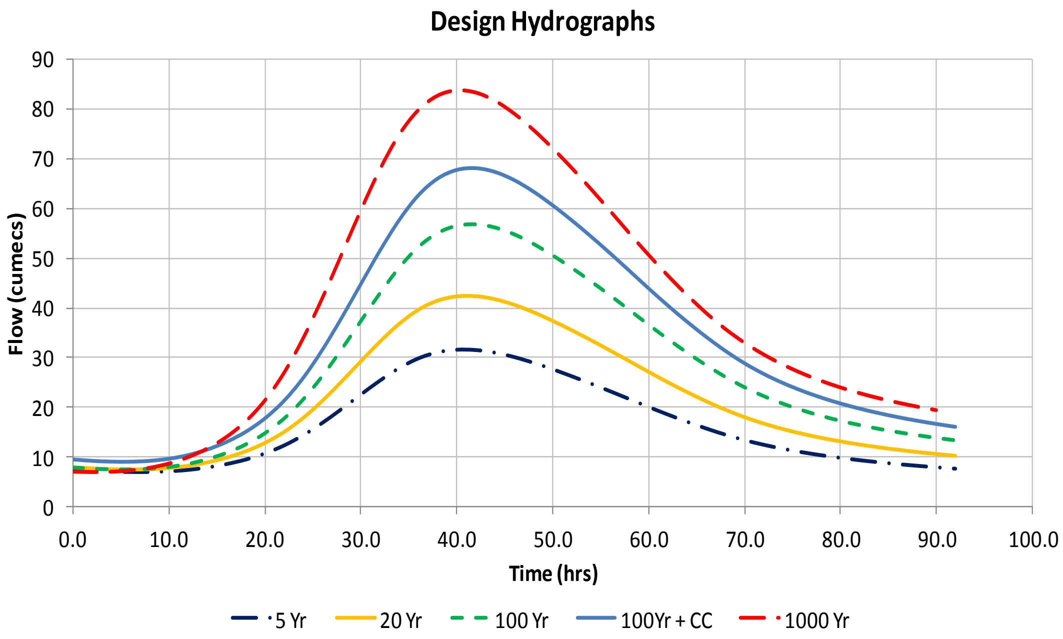


Figure 5 - Final Design Hydrographs

Appendix 2 EA Correspondence

Thomas Hughes

From:	Purbrick, Lewis
Sent:	08 October 2013 14:15
To:	tom.hughes@hydrosolutions.co.uk
Subject:	FW: WT11097: Flood Risk Data Request - Chiltern Railways

From: Purbrick, Lewis
Sent: 08 October 2013 14:13
To: 'tom.huges@hydrosolutions.co.uk'
Cc: 'Carrie.Hartley@erm.com'; James, Veronica L; WT Enquiries
Subject: Re: WT11097: Flood Risk Data Request - Chiltern Railways

Tom,

Following our conversation this afternoon I can confirm that we do not have estimated return periods for previous flood events in Islip (April 1998, Jan 2003, July 2007, Jan 2008). The only guidance I can provide in this respect is that we believe none of the past events have exceeded a 1 in 100 year event, and are probably well below this.

The weir at Islip is operated based on local conditions so there is no formal operation protocol we can provide. However the Operations Team have confirmed that during a major flood event it would be fully open, albeit flooded out. I hope this helps with the modelling of the structure. I have included a photo of Islip weir which I thought may also be of use. If you have any questions about the operation of the weir please feel free to contact the Operations Team Leader for the Islip area Richard Dale on 01491 828894.

Regards,

Lewis Purbrick MCIWEM, C.WEM
Flood Risk Management Advisor | Partnerships and Strategic Overview (Oxfordshire) | 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

Flooding. Are you or your family at risk?

Whether you live on the coast or inland you could be at risk from flooding.

It only takes a few minutes for you, your family or your friends to find out more and how to be prepared.

Share this information with your family and friends. Act now!

Find out if you're at risk from flooding

You can follow us on Twitter at @EnvAgencySE

From: Carrie Hartley [mailto:Carrie.Hartley@erm.com]
Sent: 13 August 2013 15:32
To: Enquiries, Unit
Cc: James, Veronica L
Subject: 130816/SRi07 - Flood Risk Data Request - Chiltern Railways

Re: Flood Risk Data Request – Chiltern Railways

I am contacting you in regards to data that is required for the Bicester to Oxford railway improvement scheme. There is a requirement for data to inform the Islip Safe access and egress modelling work as part of this scheme. This modelling work requires a linked 1D-2D model to be constructed of the lower River Ray at its confluence with the River Cherwell. We have already obtained the Lower Cherwell Hydraulic model built by PBA in 2005 which is to be used in the model build as well as additional topographic survey information.

In addition we require the following information:

- **Flow Data** – To include 15 minute flow data for the Enslow Mill 39021 (NGR: SP523137) and Ray at Islip 39140 (NGR: SP482183) gauging stations.

- **Model Calibration Data** - I understand the EA have previously provided historic flood extent data in GIS format for the Islip area. It would be useful if the EA would also supply;

    - Dates and times of these known events.
    - Estimate of the severity (Return period)
    - Any recorded levels (mAOD)
    - Flow data associated with these events where available.

- **Islip Gauging Weir**

From site investigations the weir at Islip seems to be automated. To inform the model build any information that can be provided on the operating program for this weir would be very helpful. (A map of the location of this structure is attached to this email)

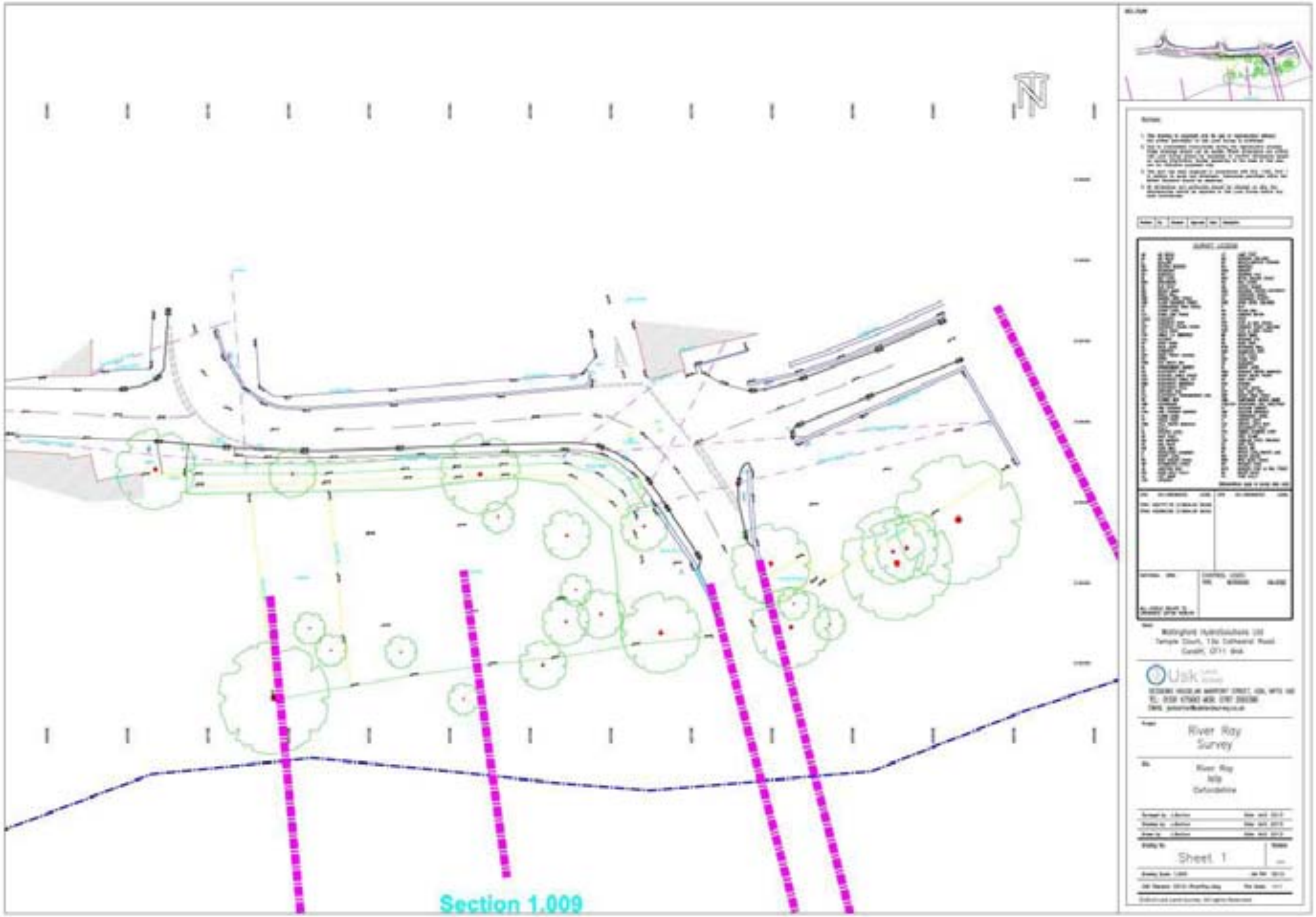
It would be very helpful if you could provide as much of the data outlined above to us to inform this study. I have attached a copy of the current service agreement between the EA and Chiltern Railways for the free transfer of data in association with this project.

I look forward to hearing from you in response to this request for data.

Regards
Carrie

2

Appendix 3 Topographic Survey Data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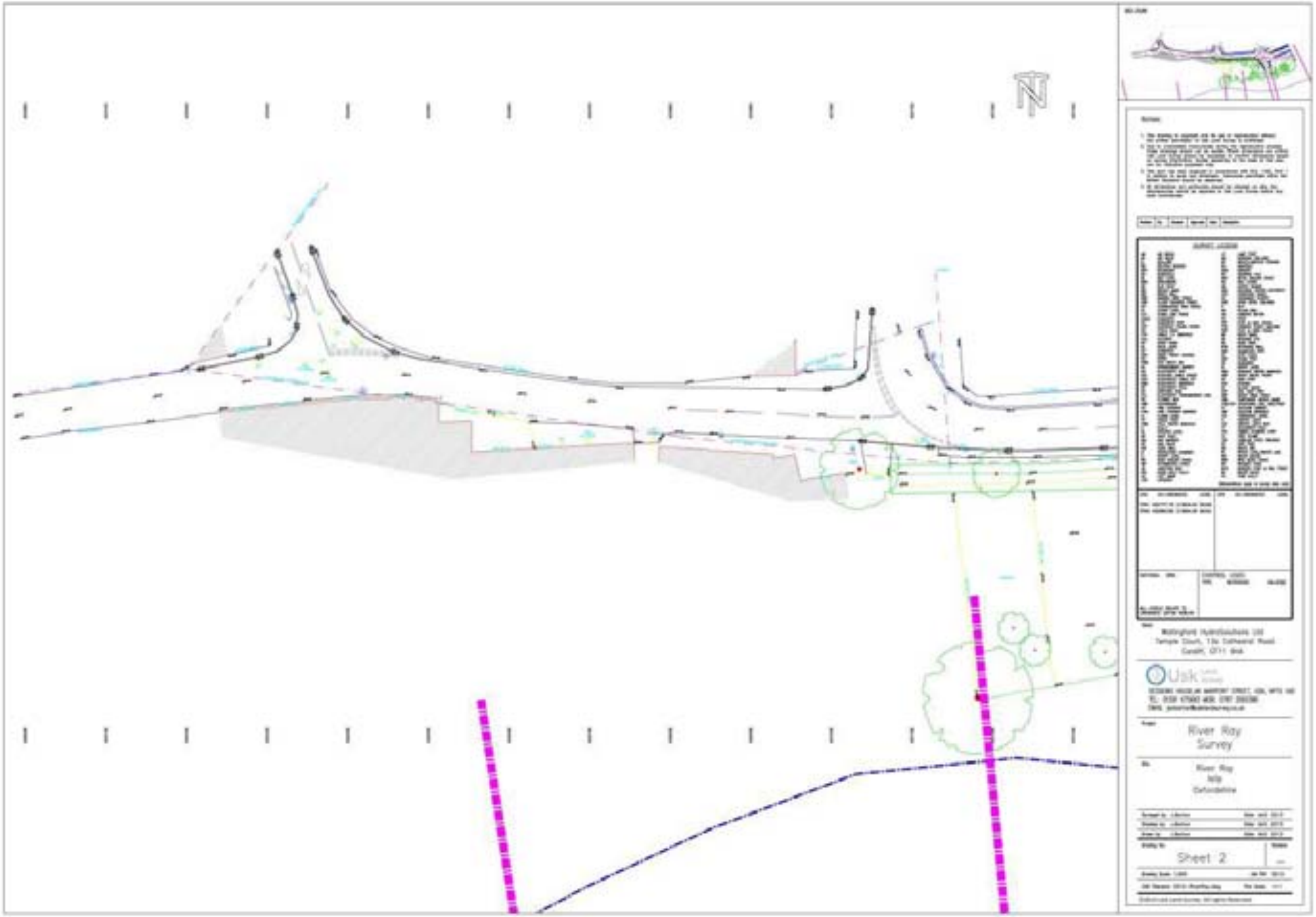
Sheet 1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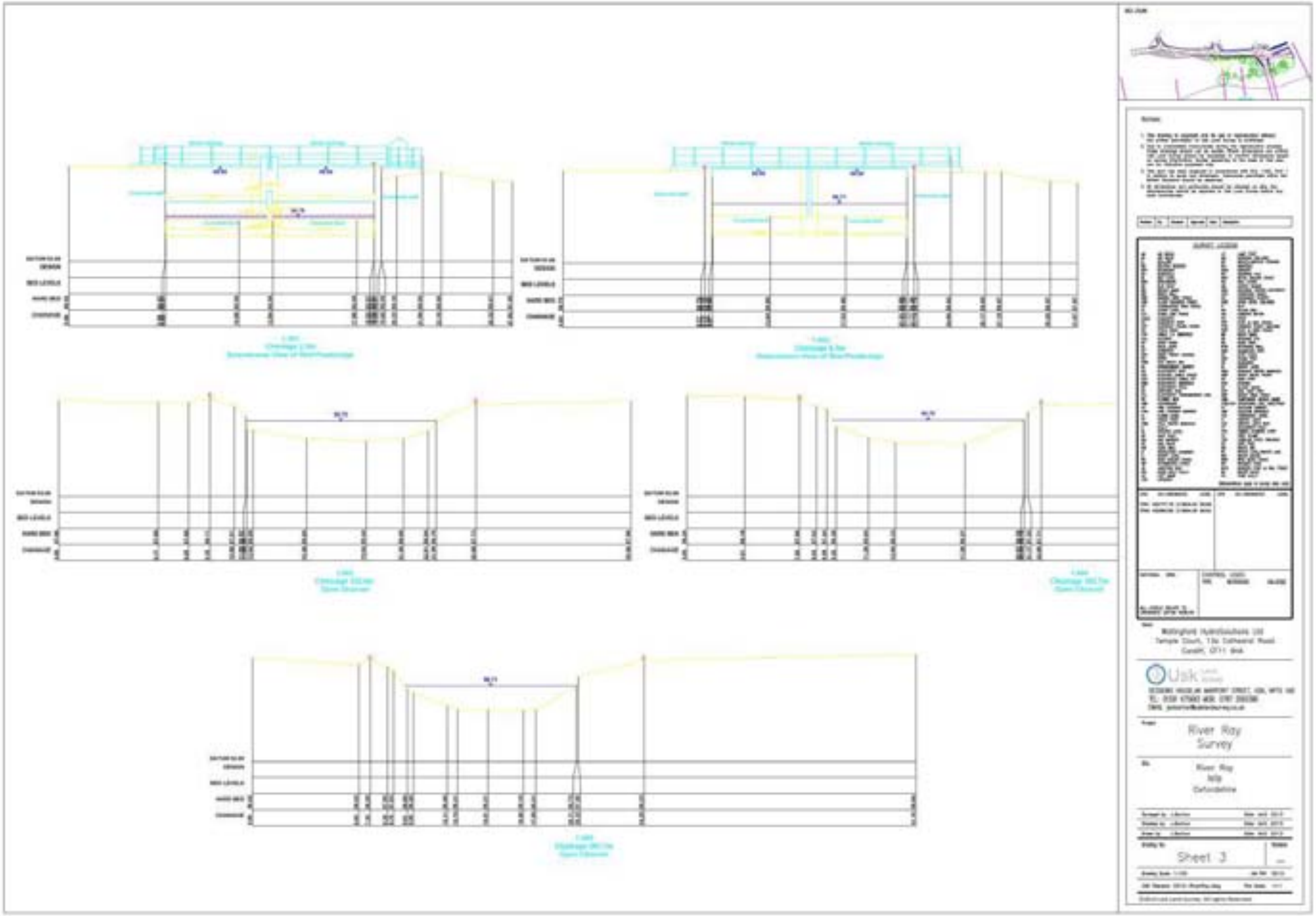
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Islip
Oxfordshire
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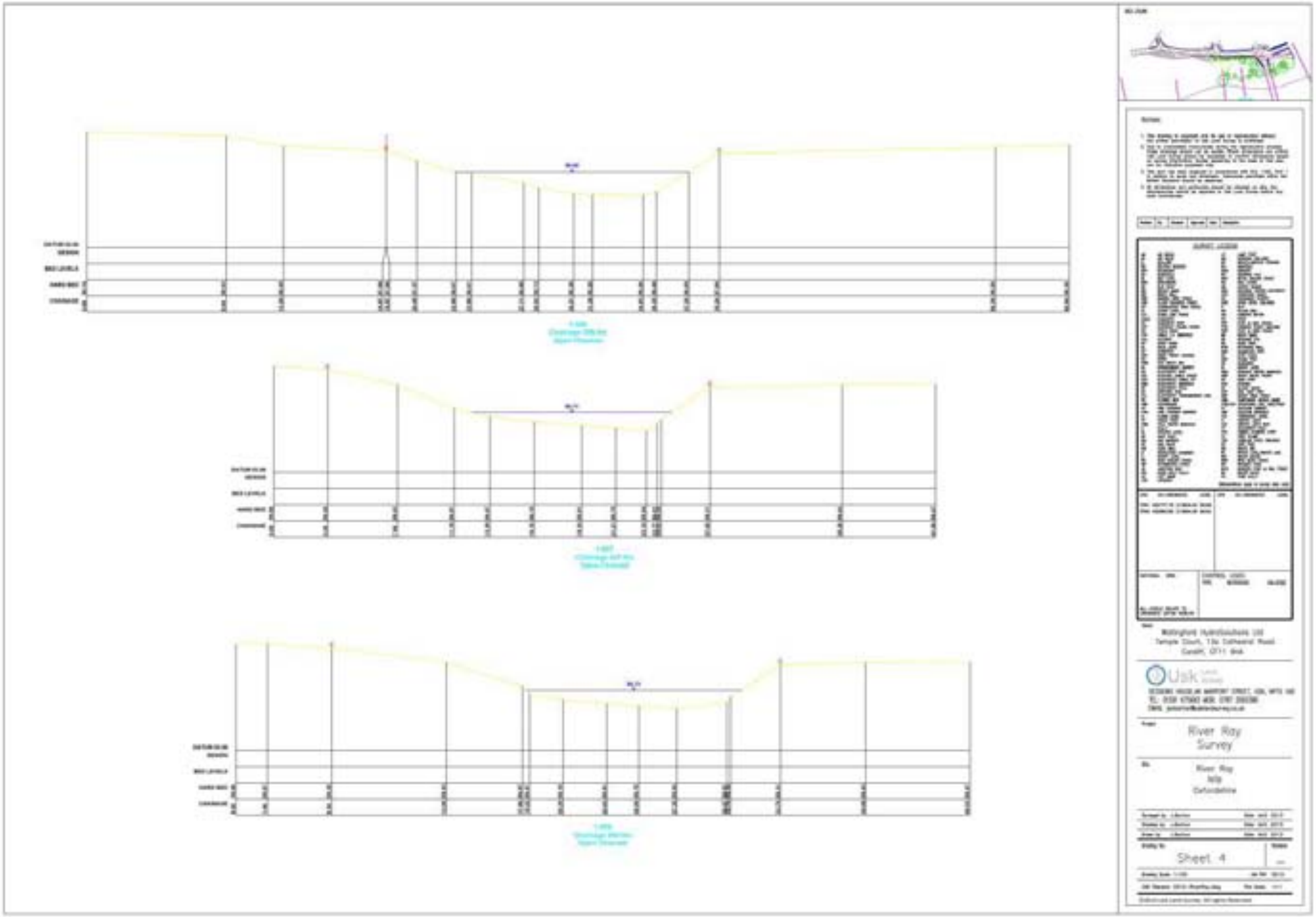
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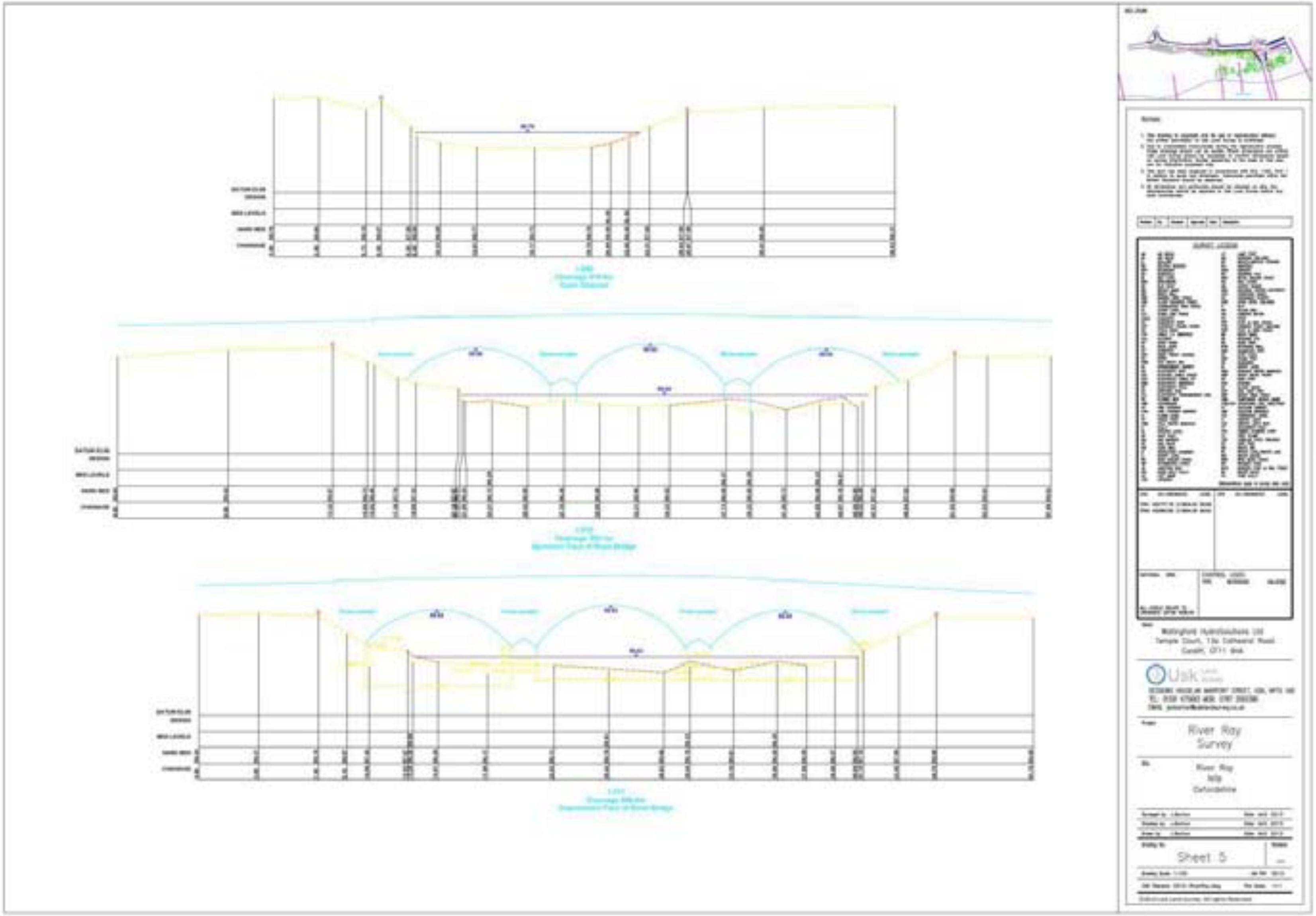
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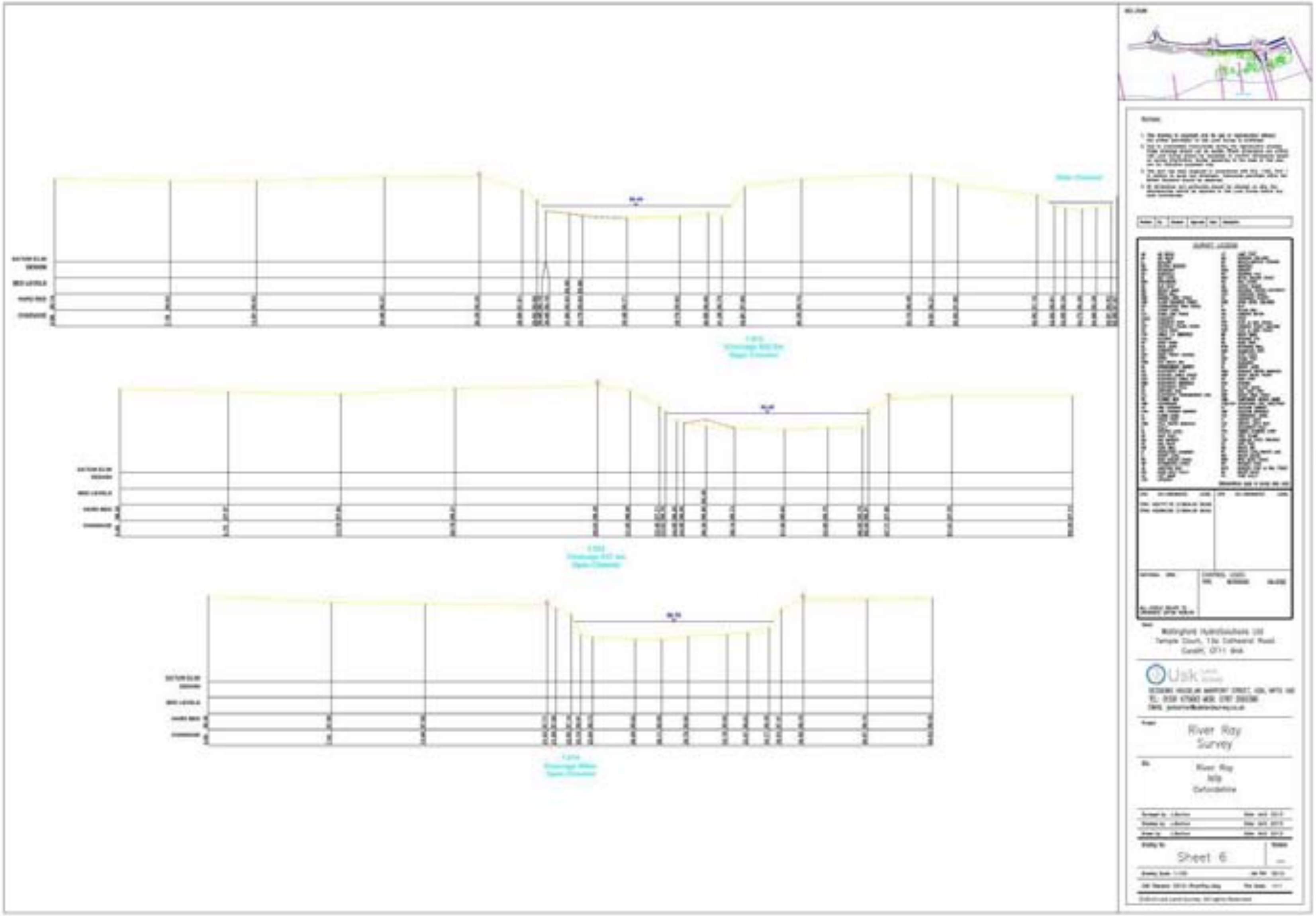
Oxfordshire
Sheet 5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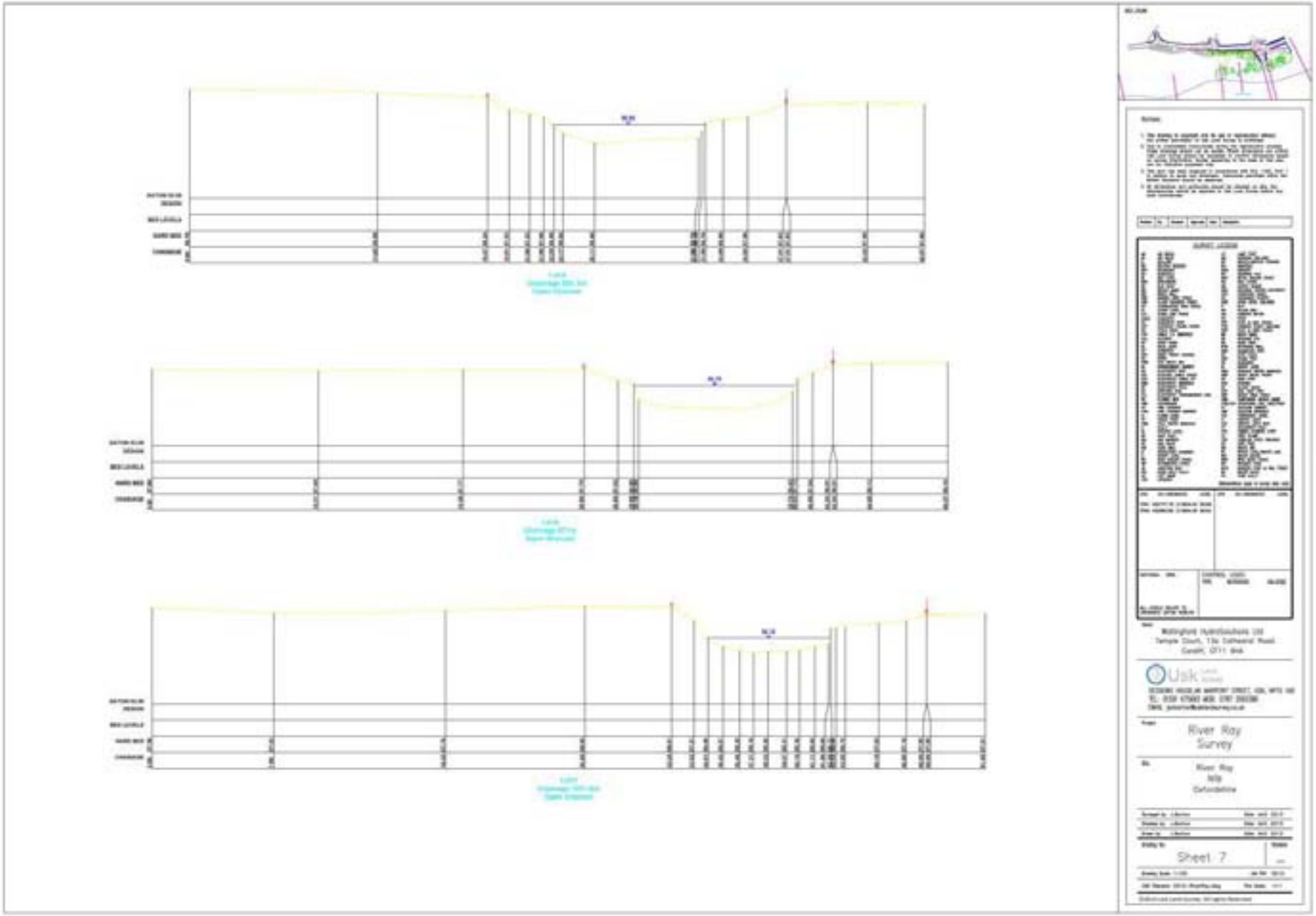
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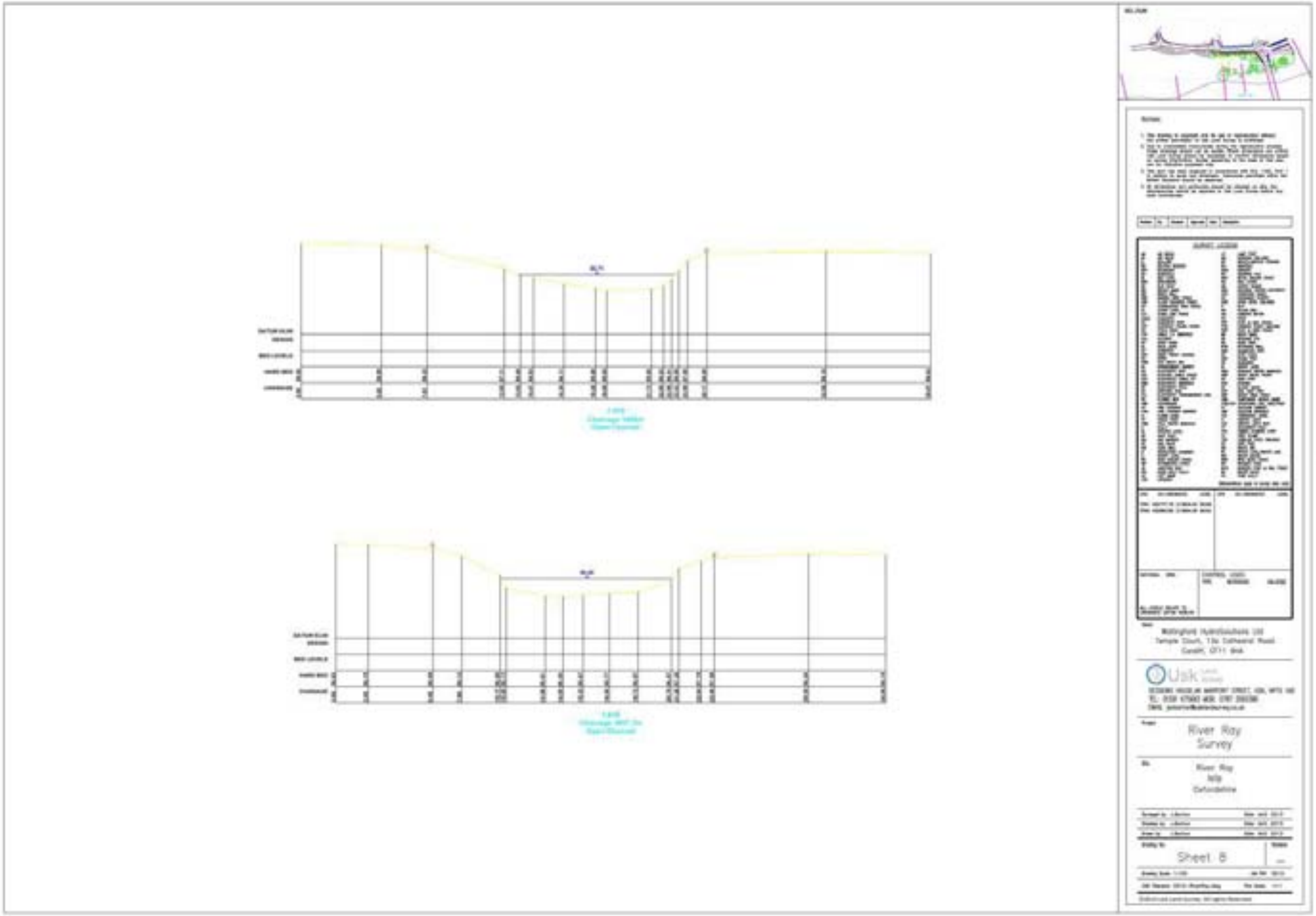
River Ray
Islip
Oxfordshire
Sheet 7


Usk
River Ray
Survey
River Ray
Islip
Oxfordshire
Sheet 8

Annex B – Photographs of ERM Site Visit

Photograph B1: Looking down Church Lane onto Mill Street

Photograph B2: Looking up Church Lane from Mill Street

Photograph B3: Looking west along Mill Street from junction with Church Lane

Photograph B4: Looking east along Mill Street from junction with Church Lane

Photograph B5: Look east to junction of Mill Street, Kings Head Lane and Lower Street

Photograph B6: Looking west along Lower Street to junction with Mill Street and Kings Head Lane

Annex C - Flood Management Planning

C1 FLOOD MANAGEMENT PLANNING

C1.1 INTRODUCTION

The following information is guidance on the nature and scope of flood management planning and a template for a detailed report. Any Flood Management Plan (FMP) should be prepared in discussion with local residents, the Parish Council, Thames Valley Local Resilience Forum, Environment Agency and local Emergency Services.

C1.2 LOCAL RESIDENTS

All residents within the area of Mill Street and Mill Lane who would be affected by flooding at the Mill Street / Church Lane junction should enrol in the Environment Agency Flood Warning and Flood Alert systems.

C1.3 IDENTIFICATION OF RESPONSIBLE PEOPLE

A Flood Warden/s for the area should be identified by the Parish Council as the person(s) responsible for aiding in the Flood Evacuation Plan. Details of the appointed flood warden(s) should be added to the Detailed Flood Plan (see section B4). If other roles within the local community deal with Health and Safety, close consultation between all persons with these health and safety responsibilities will be required. There should always be a minimum of one Flood Warden in the area.

The duties to be carried out are as follows:

• Be aware of the flood warning system for the area and how to enrol to the Environment Agency Flood Warning and Flood Alert systems;

• Be aware of, and be able to effectively disseminate, a Flood Muster Point for assembly of residents in the event that the local housing needs to be evacuated due to flooding;

• Be aware of, and be able to effectively disseminate, safe routes to reach the Flood Muster Point in the event that the area needs to be evacuated due to flooding;

• Identify critical equipment or services to be moved or turned off in the event of receiving a Flood Warning;

• Activate procedures in the event that a flood warning is received; and

• Co-ordinate safe evacuation of the area with Police and Fire Service in the event of a flood.

C1.4 FLOOD WARNINGS

The Environment Agency provides a flood warning service throughout England and Wales in areas at risk of flooding from rivers or the sea.

Currently the site is located or close to flood warning areas and flood alert areas for the 'River Ray and its tributaries from Shipton Lee to and including Islip' - including Ludgershall, Blackthorn and Murcott and 'River Cherwell from Lower Heyford to and including Oxford' - including Rousham, Enslow, Thrupp and Hampton Poyle .

The Environment Agency flood warning system is structured as shown below:

C1.4.1 Flood Alert

Flooding is possible. Be Prepared

Alerts are issued when water levels across the catchment have risen and flooding is possible but not imminent. This should usually provide between two hours and two days in advance of flooding and may not result in flooding. An alert is issued to provide time to prepare in case a flood warning is issued and are likely to be issued with more frequency than flood warnings.

C1.4.2 Flood Warning

Flooding is expected. Immediate action required.

Expected to provide two hours warning of flood waters rising at the site.

C1.4.3 Severe Flood Warning

Severe flooding. Danger to life.

Flood waters at or expected at the site soon and may pose risk to life.

C1.4.4 Warnings No Longer in Force

Flood warnings and flood alerts that have been removed within the last 24 hours.

Further details of the Environment Agency Flood Warning system can be found on the Environment Agency website (www.environmentagency. gov.uk).

C1.5 REGISTERING FOR THE FLOOD WARNING SERVICE

To register contact the local Environment Agency Flood Warning Team and ask to be added to the warning service.

• National EA floodline: 0845 988 1188.

Those in the area of Mill Street should request to be registered for the following Flood Alert and Flood Warning services:

• Flood Alert: River Ray and its tributaries from Shipton Lee to and including Islip and River Cherwell from Lower Heyford down to and including Oxford – this will provide a 'Watching Brief' alert, on average covering a time period of around two days, indicating that a Flood Warning may be issued within that period; and

• Flood Warning: River Ray and its tributaries from Shipton Lee to and including Islip and River Cherwell from Lower Heyford down to and including Oxford – this will provide at least a 2 hour advanced warning that a flood event could potentially affect the site.

In order to set up the service, the following details will need to be provided to the Environment Agency:

• Contact name of the person;

• Address of the site;

• 24 hour contact numbers; and,

• Email address.

C1.6 PREPARATION FOR A FLOOD EVENT

Key people within the area should be identified to take charge during a flood event. They will take responsibility for ensuring safe evacuation to a muster points and aid the Flood Warden in coordinating tasks to ensure the area is made safe during a flood event.

The Flood Warden should be responsible for the make up a flood kit(s) for use during a flood event and evacuation from the site. The kit(s) should include:

• Key documents, including a copy of the flood plan and evacuation routes;

- Torch;
- Mobile phone (with fully charged batteries) programmed with key contacts;
- First aid kits;
- Blankets; and
- Rubber gloves/waterproof clothing.

The flood kit(s) should be located at one central location and taken to the flood muster points by the appointed flood wardens.

The flood kit(s) should be subject to a quarterly inspection with the flood plan.

C1.7 IDENTIFICATION OF FLOOD MUSTER POINT

Hydraulic modelling has shown that the central areas of Islip are at the lowest risk of flooding. This area therefore represents the best muster point in the event of a flood warning being received. The location of the muster point should be disseminated to all local residents.

The muster location should be used as an information dissemination point for safe evacuation procedures. The Flood Warden should convey the precautionary approach being taken in order to promote a calm and measured response. Clear instruction should be given concerning the egress point, use of vehicles, likely period of evacuation and procedures for communicating the 'all clear' and re-entering the site.

Given the potential for waters to restrict site egress, it is recommended that the site is fully evacuated within two hours of receiving a Flood Warning.

The receipt of a Flood Alert should not trigger an evacuation, the alert is to provide additional advanced warning that a Flood Warning may be issued.

A suitable location should be provided that is outside of the potential influence of an extreme flood and away from the potential flow of flood waters in an event scenario. The chosen Muster Point should therefore be:

- Away from the potential overtopping points on Mill Street;
- Easily reachable by foot; and
- If possible, have access to food, water and comfort facilities.

A possible Muster Point for consideration is located at the local church which is elevated above the site and has sufficiently wide enough footpaths/vacant areas to accommodate those on site.

An additional figure should be appended to the 'Detailed Flood Plan' (see section C4) to show the locations of the Muster Point.

C1.8 CONSIDERATIONS/IDENTIFICATION OF OTHER HAZARDS

The Flood Warden in consultation with Parish Council/Residents should identify any critical / vulnerable equipment or services that may be moved or turned off in the event of receiving a flood warning.

The Flood Warden should always be aware that the size of a potential flood event will not be supplied as part of the Flood Warning, and that an extreme event could, therefore, occur. A precautionary approach should be taken when a Flood Warning is received, and vulnerable equipment moved above ground level.

The movement of equipment must, however, only be considered after all necessary steps have been taken to safeguard people and the Flood Warden's own safety.

C2 RESPONSE TO FLOOD WARNINGS

C2.1 PERSONAL SAFETY IN A FLOOD EVENT

Personal safety is considered first and foremost. If any of the actions detailed below cannot be carried out without undue risk then they should be ignored in favour of protecting people. The Flood Warden should be aware of any personnel requiring additional support during a flood evacuation, and appropriate arrangements should be in place. It may be prudent to include specific details within the Detailed Flood Plan.

All local residents should be notified of the following:

• Avoid walking or driving through flood water: six inches of fast-flowing water can knock over an adult and two feet of water can move a car;

• Be aware that flooding can cause manhole covers to be lifted and/or removed;

• Never try to swim through fast flowing water; and

• Avoid contact with flood water in case of contamination.

C2.2 FLOOD WARNING AND EVACUATION PROCEDURES

The following procedures should be followed in order to protect people and minimise the damage flooding can cause.

C2.2.1 Flood Alert Procedures: Dissemination of Flood Warning Information

The Flood Wardens should:

• Alert other members of the community, in particular those most vulnerable such as those with impaired hearing, sight or with restricted mobility;

• Monitor the weather forecast, Environment Agency website and river levels to enable a prompt response to flooding;

• Ensure that safe egress routes and Flood Muster Point are clearly known and are freely accessible;

• Prepare the flood kits, ensure mobile phone batteries and spares are fully charged and are programmed with all necessary emergency contact details;

• Identify all critical equipment and services and their isolation points; and

• Identify and inform local helpers to be ready to move critical equipment in event of Flood Warning being issued.

C2.2.2 *Flood Warning Procedures*

The Flood Wardens should:

• Confirm the time the warning was issued. The Flood Warden should allow no more than two hours from the time the warning is issued to completion of the site evacuation;

• The Flood Warden is to ensure that flood kits are retrieved and that mobile phones are fully charged and spare battery packs are held;

•Inform residents to turn off gas, water and electricity services at their isolation points;

• Inform residents to congregate at the Flood Muster Point via designated safe routes;

• Flood Wardens to complete a roll call of all at Flood Muster Point and identify if there vulnerable residents who may still be in flood areas;

• Flood Warden assist Emergency Services to disseminate precautionary approach, evacuation procedures, Evacuation Muster Point, likely time off-site and 'all clear' site re-entry procedures to site personnel; and

• Help to get locals to Evacuation Muster Point via the designated safe routes.

C2.2.3 *Severe Flood Warning: Immediate evacuation*

In the event that a Severe Flood Warning is issued:

• Go directly to the Flood Muster Point via the designated safe routes and liaise with Emergency Services

C2.3 *FLOOD MONITORING & SITE RE-OCCUPATION*

• The Flood Warden should wait until the 'all clear' Warning No Longer in Force has been issued by the Environment Agency's Flood Warning Service;

• Once they have received the Warning No Longer in Force message they should undertake discussions with any relevant Emergency Service personnel, to assess if it is safe for residents to return. The site should not be entered if there are indications that flood waters continue to inundate safe access and egress areas;

• If any inundation has occurred, or there is a suspicion inundation may have occurred, contact the emergency services and follow their instructions;

• If no inundation has occurred the Flood Warden will help residents to return to their homes.

C3 BRIEFING EXERCISES

Flood Wardens should be aware of:

- Their responsibilities;
- How to receive Flood Alert and Flood Warning;
- What each Flood Alert / Flood Warning means; and
- What to do in the event of receiving a flood warning.

No specific flood evacuation training needs to be implemented.

C4 DETAILED FLOOD PLAN TEMPLATE

The Detailed Flood Plan produced should include:

- Sign-off sheet to show regular review (quarterly) and any updates.
- Contact details for relevant Parish Council/Thames Valley Local Resilience Forum/ Environment Agency/ Emergency Service contacts.
- Details for any vulnerable residents who may require assistance
- Designated helpers and their contact details
- Safe access/egress route including map
- Checklist for Flood Alert versus Flood Warning
- Key locations e.g. junction boxes requiring sandbagging, isolation switch for critical systems, sensitive locations
- Location of First Aid and Flood Kits
- Location of flood protection materials
    - Pumps
    - Power Generators
    - Sand and Sandbags
    - Plywood
    - Plastic Sheeting

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