A38 Derby Junctions

TR010022

Volume 6

6.3 Environmental Statement Appendices

Appendix 13.2C: Little Eaton Flood Risk Assessment

Regulation 5(2)(a)

Planning Act 2008

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

April 2019

Infrastructure Planning

Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

A38 Derby Junctions Development Consent Order 202[ ]

6.3 Environmental Statement Appendices
Appendix 13.2C: Little Eaton Flood Risk Assessment

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A38 Derby Junctions

Little Eaton Junction Flood Risk Assessment

Report Number: HE514503-ACM-EWE-Z3_ZW_PR_ZZ-RP-HF-0001 P04 S4
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EXECUTIVE SUMMARY

Scheme Details

AECOM has been commissioned by Highways England to provide design services regarding the development of the A38 Derby Junctions Scheme (referred to herein as “the Scheme”). This Scheme concerns three junctions on the A38 in Derby as follows:

- A38/ A5111 Kingsway junction
- A38/ A52 Markeaton junction
- A38/ A61 Little Eaton junction

In flood risk terms, the Scheme at Little Eaton junction would increase impermeable surfacing and potential surface water runoff. The northern extent of the proposed Little Eaton junction falls within Flood Zone 1 (low flood risks), although most of the Scheme would be located within the extent of the extreme flood outline (Flood Zone 2) of the River Derwent, whilst the western elements fall within and adjacent to Flood Zone 3. The remaining parts of the Scheme are located within Flood Zone 1 with a very low risk of flooding. Special attention has therefore been made to the potential impact of the Scheme on the floodplain i.e. the loss of floodplain storage as a result of changes to the junction footprint.

In addition, there is significant attenuation of surface water runoff adjacent to the existing A38 associated with a stream emanating from Breadsall Manor, as well as surface water flooding downstream associated with Boosemore Brook and Dam Brook. As such, investigations have been undertaken to define appropriate surface water flooding solutions.

This Flood Risk Assessment (FRA) comprises one of a number of documents supporting the environmental assessment of the Scheme as reported in the Environmental Statement (ES). A separate Road Drainage Strategy (Report Number HE514503-ACM-HDG-A38_SW_PR_ZZ-RP-CD-0002, Highways England 2019) has been produced. The Road Drainage Strategy considers the management of surface water runoff from the proposals.

Flood Risk Assessment

An FRA has been undertaken in accordance with the National Policy Statement for National Networks (NPSNN) and the National Planning Policy Framework (NPPF) and taking into account guidance provided in the Design Manual for Roads and Bridges (DMRB). According to the NPSNN and NPPF, applications for development proposals of 1 hectare (ha) or greater located in Flood Zone 1 and all proposals for new development located in Flood Zones 2 and 3 should be accompanied by a FRA.

This FRA has therefore been undertaken to determine:

1) The risks of flooding to the Scheme.
2) The risks of flooding that could result from the Scheme.
3) Appropriate flood risk mitigation measures.

The main aim of this FRA is to demonstrate that flooding risks can be suitably managed associated with the Scheme. This FRA supports the environmental impact assessment (EIA) as reported within the Scheme ES. This FRA has been prepared following hydraulic modelling of the River Derwent and Dam Brook which has enabled suitable flood risk mitigation measures to be defined and incorporated into the Scheme design.

Outcome of the Flood Risk Assessment

This FRA has established that there would be a loss of River Derwent floodplain storage due to the increased footprint of the Scheme at Little Eaton junction and therefore mitigation measures are required. Hydraulic modelling has been used to test various flood storage and floodplain compensation areas for the 1 in 100 year flood event plus a climate change allowance, resulting in the definition of a suitable floodplain compensation area to the west of the River Derwent (south of the A38). Correspondence with the Environment Agency (EA) in June 2018 has confirmed their contentment with the proposed approach to fluvial flood risk mitigation and compensation proposals at Little Eaton junction, and that residual flood impacts are acceptable.

Surface water flood risk from the Scheme to adjacent areas would increase as a result of highway expansion associated with the Scheme. A road drainage strategy has been developed in parallel with this FRA which demonstrates that surface water risks can be managed appropriately. However, additional hydraulic modelling has been undertaken to assess local surface water flooding risks such that additional measures have been included within the Scheme design as follows:

- Diversion of Dam Brook into a new realigned watercourse that takes account of brook flooding, plus the provision of new ponds that would provide floodwater storage.
- Provision of a flood alleviation channel adjacent to the new A38 that would connect the unnamed surface watercourse downstream of Breadsall Manor with the realigned Dam Brook. A new 600mm diameter culvert would also be provided from the watercourse under the new A38 embankment that would connect into an existing 500mm diameter culvert in order to convey flows from the unnamed watercourse when the flow capacity of the flood alleviation channel is exceeded.

Incorporation of the mitigation measures as detailed herein indicate that flood risks associated with the Scheme at Little Eaton junction can be appropriately managed. Should the Scheme gain development consent, further consultation will be undertaken during the detailed design regarding Little Eaton junction with the EA, Derbyshire County Council (DCC), Severn Trent Water (STW) and other statutory agencies as applicable.

1 INTRODUCTION

1.1 Commission

1.1.1 AECOM has been commissioned by Highways England to provide design services regarding the development of the A38 Derby Junctions Scheme (referred to herein as "the Scheme"). This Scheme concerns three junctions on the A38 in Derby as follows:

- A38/ A5111 Kingsway junction
- A38/ A52 Markeaton junction
- A38/ A61 Little Eaton junction

1.1.2 AECOM has been requested by Highways England to carry out a Flood Risk Assessment (FRA) for the Scheme at Little Eaton junction. This FRA has been prepared in accordance with the National Policy Statement for National Networks (NPSNN[1]) and the National Planning Policy Framework (NPPF)[2], its associated Planning Practice Guidance (PPG)[3] and the Design Manual for Roads and Bridges (DMRB[4]).

1.1.3 The Road Drainage Strategy (Report Number HE514503-ACM-HDG-A38_SW_PR_ZZ-RP-CD-0002, Highways England 2019) is contained in Appendix 13.4 of the Environmental Statement (ES) (ES Volume 3). It has been developed alongside this report, with the flood risk and drainage assessments informing each other.

1.2 Scheme Background

1.2.1 The existing Little Eaton junction is currently an at-grade, five-armed roundabout located along the A38 at Derby and provides a connection between the A38, the A61 Alfreton Road (leading to A61 Frank Whittle Road) and the B6179 Alfreton Road (leading to Little Eaton). A small fifth arm provides access to land adjacent to the eastern part of Ford Lane.

1.2.2 This FRA is based on the best available flood risk information provided by the Environment Agency (EA) and further analysis using hydraulic modelling software. The EA Flood Map[5] shows that the majority of Scheme at Little Eaton junction lies within Flood Zone 2, with the western elements falling within or adjacent to Flood Zone 3.

1.2.3 Areas located within Flood Zone 3 are those that could be affected by flooding, either from rivers or the sea, assuming that there are no flood defences in place. These areas could be affected by a flood that has a 1% (1 in 100) or greater chance of happening each year. Flood Zone 2 shows the additional extent of an extreme flood. These areas are likely to be affected by a major flood, that has between a 1% (1 in 100) and a 0.1% (1 in 1,000) chance of occurring each year. The remaining areas of the Scheme at Little Eaton junction are located within Flood Zone 1 with less than 0.1% annual probability of flood risk (i.e. a very low risk of flooding).

[1] Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/387222/npsnn-print.pdf
[2] Available online: http://planningguidance.planningportal.gov.uk/blog/policy/
[3] Available online: http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/
[4] Available online: http://www.standardsforhighways.co.uk/ha/standards/dmrb/index.htm
[5] Available online: http://apps.environment-agency.gov.uk/wiyby/37837.aspx

1.2.4 Lead Local Flood Authorities (LLFAs)[6], in this case Derbyshire County Council (DCC), have responsibility for managing the risk of flooding from ordinary watercourses, surface water and groundwater. Whilst the Scheme falls within DCC administrative area, the boundary between Derby City Council (DCiC) and DCC falls along the centreline of the River Derwent, and thus DCiC is also a key partner as they are the neighbouring LLFA.

1.3 The Scheme

1.3.1 The Scheme entails the provision of grade-separation at Little Eaton junction to enlarge the roundabout at existing ground level with the new mainline A38 passing above the roundabout on two overbridges to the east and south of the existing roundabout (refer to Appendix A which provides details of the Scheme design and Scheme boundary). The existing northbound carriageway would form the northbound slip roads.

1.3.2 From the Scheme tie in at the north end of the River Derwent bridge, the proposed A38 swings slightly to the south of the existing A38 route and passes over a Flood Relief Arch/ Accommodation Bridge which would be extended. Continuing north, the existing railway bridge would be extended to carry the A38 southbound carriageway and southbound merge slip road. The existing northbound carriageway would be retained on the existing part of the railway bridge and to form the northbound diverge slip road.

1.3.3 The A38 would then pass over the two new junction bridges on embankment before continuing to the east of the existing A38 and re-joining the existing A38 alignment immediately south of the Water Treatment underbridge, which would not be affected.

1.3.4 Ford Lane, which joins the existing A38 between the Flood Relief Arch/ Accommodation Bridge and the bridge over the River Derwent, would be closed on safety grounds. The length of Ford Lane to the east of the railway line would tie into the new roundabout between the northbound slip road and the B6179.

1.3.5 During the Scheme construction phase, it is proposed to use an area to the south of the Little Eaton junction for temporary storage of excavated materials (following diversion of Dam Brook). In addition, a construction compound is proposed to the north of the junction accessed off the B6179 Alfreton Road.

1.4 Planning Process

1.4.1 The Scheme is a Nationally Significant Infrastructure Project (NSIP) and thus a Development Consent Order (DCO) application is to be made to the Planning Inspectorate (The Inspectorate). The DCO application will be accompanied by an Environmental Impact Assessment (EIA) as reported within an ES.

1.4.2 Given the above, the Scheme is subject to consideration by The Inspectorate rather than being subject to planning control by the Local Planning Authority (LPA). Highways England is the Applicant for the Scheme and upon its completion, Highways England would also be responsible for Scheme maintenance (with the exception of those parts of the Scheme that would be the responsibility of third parties such as the local authority and landowners).

[6] Available online: https://www.gov.uk/government/publications/ordinary-watercourse-regulation-advice-note

1.5 Aims and Objectives

1.5.1 This report comprises an FRA of the proposed Little Eaton junction. The assessment has involved evaluating flood risks to the Scheme site, advising on the potential constraints to the Scheme, assessing the potential impacts of the Scheme on flood risks in the wider area and defining applicable mitigation measures and a road drainage strategy. To complete this study the following objectives have been met:

- Review the development plans with respect to flood information in national and local policy documents, strategic flood risk documents and relevant previous and local studies that cover the area of the Scheme.
- Undertake hydraulic modelling to assess the potential Scheme impacts on the River Derwent floodplain i.e. loss of floodplain storage as a result of proposed changes to the junction footprint.
- Assess all other potential sources of flood risk including surface water, drainage infrastructure, groundwater and artificial sources.
- Undertake hydraulic modelling to define a new alignment for Dam Brook which would need to be diverted as part of the Scheme.
- Identify requirements for surface water runoff attenuation from the Scheme site and the implications for storm water attenuation/ storage.
- Propose suitable flood mitigation measures (where applicable) in line with the recommendations of current best practice.
- Produce a report that summarises flood risk at the site and surface water considerations appropriate for the Scheme, in accordance with the NPSNN, NPPF, PPG and DMRB.

2 SITE AND SURROUNDING AREA

2.1 Site Location

2.1.1 The existing Little Eaton junction is located approximately 3.4km to the north of Derby at Ordnance Survey National Grid Reference 436405, 339995. It forms the intersection of the A38 from the north-east and west with the A61 joining from the south. The B6179 Alfreton Road (access to Little Eaton village) and Ford Lane both join the roundabout to the north on separate arms. The Scheme location is illustrated in Figure 2-1.

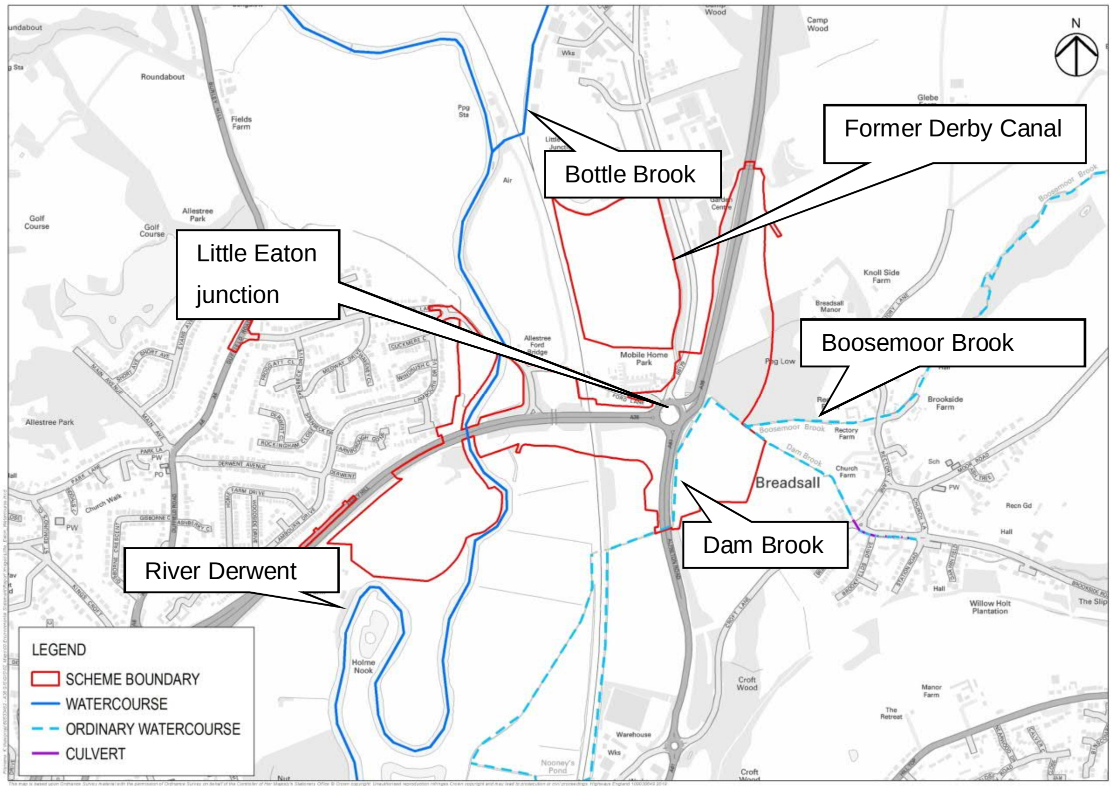

Figure 2-1: Site Location Map

2.2 Existing Junction

2.2.1 The existing Little Eaton junction is predominantly surrounded by open fields, the majority of which represent the floodplain of the River Derwent and its associated tributaries. The only exception is immediately to the north of the roundabout, where a number of residential and commercial properties are located (including the Ford Farm Mobile Home Park).

2.2.2 Within close proximity to the site are the villages of Breadsall (approximately 0.5km to the east), Allestree (approximately 0.5km to the west) and Little Eaton (approximately 1km to the north). The mainline Sheffield to Derby railway line passes beneath the A38 approximately 150m to the west of the junction.

2.3 Topographic Setting

2.3.1 The centre of the existing Little Eaton junction is currently at an elevation of approximately 52.5m above Ordnance Datum (mAOD). The A38 to the north gradually rises, as does the A38 to the west. The highway rises to approximately 58mAOD as it crosses the adjacent railway, but then slopes back to approximately 56mAOD as it crosses over the River Derwent approximately 300m to the west of the junction.

2.3.2 To the south, Alfreton Road (A61) falls away, whilst Alfreton Road (B6179) to the north remains at a similar level to the junction roundabout. Ford Lane, which runs west from the junction roundabout, parallel to the A38 also, falls away to a level of approximately 50.7mAOD where it reaches the edge of the railway line.

2.4 Local Water Features

2.4.1 Little Eaton junction is located within the River Derwent catchment. The River Derwent, which is a tributary of the River Trent, flows from north to south and flows beneath the A38 approximately 300m to the west of the junction roundabout (with the river being approximately 25m wide as it passes under the A38).

2.4.2 Other watercourses in the vicinity include Dam Brook, Boosemoor Brook and Bottle Brook (see Figure 3-1). Boosemoor Brook flows from the east and joins Dam Brook approximately 100m to the east of Little Eaton junction. Dam Brook then flows adjacent to the eastern side of the junction roundabout before flowing south adjacent to the A61. Approximately 250m to the south of the roundabout, Dam Brook flows beneath the A61 and the railway line within separate culverts and eventually discharges further downstream into the River Derwent.

2.4.3 Bottle Brook is a small tributary of the River Derwent which flows from north to south, through Little Eaton, before joining the River Derwent approximately 800m to the north of Little Eaton junction.

2.4.4 Sections of the former Derby Canal are located along Alfreton Road (B6179) – however, as this does not convey significant volume of flowing water, it is not considered within this FRA.

2.5 Geology/ Hydrogeology

2.5.1 Ground conditions comprise topsoil and Made Ground overlying Alluvium, underlain by rocks of the Millstone Grit Group (Mudstone, Siltstone and Sandstone).

2.5.2 The Made Ground primarily comprises embankment fill of the current road construction, whilst the Alluvium comprises firm silt and clay components to a thickness of up to 2.6m. This is underlain by a predominantly sand and gravel component.

2.5.3 The Millstone Grit Group materials encountered predominantly comprise fissured or laminated hard mudstone overlain further north by weak siltstone. To the north of the junction typically weak sandstone has also been recorded.

2.5.4 According to the EA groundwater mapping[7] and The A38 Derby Junctions Ground Investigation Report (Report Number HE514503-ACM-VGT-A38_SW_PR_ZZ-PR-GE-0003_P02_24, 2018), both the bedrock and superficial deposits areas are classified as a Secondary A aquifer; permeable layers capable of supporting water supplies at a local rather than a strategic scale, and in some cases forming an important source of base flow to rivers.

[7] Available at: http://apps.environment-agency.gov.uk/wiyby/37833.aspx

2.5.5 Groundwater used for drinking water is protected by the EA. The EA classifies zones around potable groundwater abstraction points as Source Protection Zones (SPZs). These are designed to limit potential pollution activities and have implications for how surface water is managed e.g. by infiltration. According to the EA, the majority of the Scheme site at Little Eaton junction lies within SPZ3 (Total Catchment) which has been cross checked with the EA's SPZ Online Map (Updated in October 2018). The SPZ further shows that the site is situated close to SPZ2 and SPZ1 to the east, associated with the River Derwent.

2.5.6 According to the EA, the groundwater SPZs are defined as follows:

- Inner Zone (Zone 1) – Defined as the 50 day travel time from any point below the water table to the source. This zone has a minimum radius of 50m.
- Outer Zone (Zone 2) – Defined by a 400 day travel time from a point below the water table. This zone has a minimum radius of 250m or 500m around the source, depending on the size of the abstraction.
- Total Catchment (Zone 3) – Defined as the area around a source within which all groundwater recharge is presumed to be discharged at the source.

2.5.7 Given the close proximity of the Scheme to the River Derwent, groundwater levels within the floodplain are high. Water strikes and monitoring indicate that groundwater levels of around 0.5m to 3.0m exist below ground levels, principally within the Alluvium.

3 REGULATORY POSITION

3.1 National Policy Statement for National Networks (NPSNN)

3.1.1 The primary basis for deciding whether or not to grant a Development Consent Order (DCO) is the National Policy Statement for National Networks (NPSNN) which, at Sections 4 and 5, sets out policies to guide how DCO applications will be decided and how the impacts of national networks infrastructure should be considered.

3.1.2 Flood risk paragraphs 5.90 – 5.115 state that the Secretary of State should be satisfied that flood risk will not be increased elsewhere and should only consider development appropriate in areas at risk of flooding where it can be demonstrated that: the most vulnerable development is located in areas of lowest flood risk unless there are overriding reasons to prefer a different location; development is appropriately flood resilient and resistant, including safe access and escape routes where required; that any residual risk can be safely managed, including by emergency planning; and that priority is given to the use of sustainable drainage systems (SuDs). Applications for projects should be accompanied by a flood risk assessment (FRA) to assess all risks of flooding and take climate change into account.

3.1.3 In preparing an FRA an applicant should:

- Consider the risk of all forms of flooding arising from the project (including in adjacent parts of the United Kingdom), in addition to the risk of flooding to the project, and demonstrate how these risks will be managed and, where relevant, mitigated, so that the development remains safe throughout its lifetime.
- Take the impacts of climate change into account, clearly stating the development lifetime over which the assessment has been made.
- Consider the vulnerability of those using the infrastructure including arrangements for safe access and exit.
- Include the assessment of the remaining (known as 'residual') risk after risk reduction measures have been taken in to account and demonstrate that this is acceptable for the particular project.
- Consider if there is a need to remain operational during a worst case flood event over the development's lifetime.
- Provide the evidence for the Secretary of State to apply the Sequential Test and Exception Test as appropriate.

3.2 National Planning Policy Framework (NPPF)

3.2.1 Section 14 of the NPPF (revised in February 2019) and the associated 2014 Planning Practice Guidance (PPG) provides the current guidance for planning with respect to flood risk and meeting the challenges associated with climate change. The NPPF advocates a sequential approach for the planning process in order to steer development to areas with the lowest possible risk of flooding. It is important to note the revision to the 2012 NPPF in 2018 and 2019. The FRA has been completed in accordance with the 2019 revision and the associated 2014 PPG.

3.2.2 As discussed in Section 1.2, the EA Flood Map indicates that the Scheme at Little Eaton junction is located within Flood Zone 2, with the western extent of the Scheme encroaching into Flood Zone 3. According to Table 2 within the PPG, the proposed junction at Little Eaton lies within the 'Essential Infrastructure' vulnerability classification. Table 3, which provides a matrix for the identification of vulnerability classifications, indicates that whilst 'Essential Infrastructure' developments are permitted within Flood Zone 2, the Exception Test must be passed for the development to be considered acceptable within Flood Zone 3.

3.3 Design Manual for Roads and Bridges (DMRB)

3.3.1 Highways England and other highway authorities have a responsibility to keep trunk roads and local roads respectively free from flooding (relevant legislation includes the Highways Act 1980 and the Land Drainage Acts 1991 and 1994).

3.3.2 The DMRB primarily refers to the former PPS25 (now superseded by the NPPF) for FRA and flood mitigation guidance, and emphasises the need for consultation with the EA early in the design process.

3.3.3 The DMRB offers guidance on hydraulic design of highway drainage systems, and assessment, and guidance on mitigation techniques for roads (and embankments) that encroach into floodplains.

3.3.4 More detailed discussion of highway surface water management and sustainable drainage is provided in Section 6.

3.4 Local Plans

3.4.1 Little Eaton junction falls just outside the DCiC boundary and lies within Erewash Borough Council (EBC) administrative area. The administrative boundary runs along the centre of the River Derwent. Due to the proximity of the Scheme to the administrative boundary, the Local Plans for both DCiC and EBC have been reviewed as part of this FRA (see below).

Derby City Council (DCiC)

3.4.2 The current adopted Local Plan for the study area is The City of Derby Local Plan – Part 1 Core Strategy (2017)[8] which sets out the long term strategy for promoting and managing development in the city up to 2028. The plan forms part of a statutory framework to be used in addition to the on-going policies from the City of Derby Local Plan Review (2006)[9].

3.4.3 In terms of flood protection, the Local Plan, 'GP3 Flood Protection' aims to protect important flood plain areas and provides guidance relating to development within these areas. The policy states:

'*Except where satisfactory compensatory measures are provided to off-set any potential adverse effects for development on the water environment and associated lands, planning permission will not be granted for development which:*

a. Lies within undefended areas at risk of flooding;

b. Would create or exacerbate flooding elsewhere;

[8] Available online: https://www.derby.gov.uk/media/derbycitycouncil/contentassets/documents/policiesandguidance/planning/Core%20Strategy_ADOPTED_DEC%202016_V3_WEB.pdf
[9] Available online: https://www.derby.gov.uk/media/derbycitycouncil/contentassets/documents/policiesandguidance/planning/CDLPR_2017.pdf

c. *Results in the loss of natural floodplain;*

d. *Would impede access to a watercourse for maintenance or flood defence purposes;*

e. *Does not provide for the adequate management of surface run-off using sustainable drainage principles, unless it can be demonstrated that their use is inappropriate.'*

3.4.4 The Scheme is a NSIP and therefore subject to a DCO. In order to obtain development consent, Highways England must demonstrate that flood risk has been adequately managed. Furthermore, planning consent will only be granted where compensating measures are proposed to mitigate potential flood problems.

3.4.5 The draft Core Strategy provides policy and guidance relating to flood risk and water management. It must be ensured that development is flood resilient and resistant and that flood risk is not increased to people or property within the surrounding area. Development must also be designed and laid out to incorporate sustainable drainage systems (SuDS) and ensure that runoff is directed to areas where it does not cause harm to others.

3.4.6 With part of the Scheme encroaching within the River Derwent floodplain, compensatory storage will be required to offset any adverse effects, in line with Local Plan policy discussed above.

Erewash Borough Council (EBC)

3.4.7 The policies within the Erewash Core Strategy[10] have been considered. This document sets out the strategy for development across the Borough between 2011 and 2028 guiding development to specific areas.

3.4.8 Under Policy 1: Climate Change, there is a section concerning Flood Risk and Sustainable Drainage where it is stated:

- *Development proposals that avoid areas of current and future flood risk and which do not increase the risk of flooding elsewhere and where possible reduce flood risk, adopting the precautionary principle, will be supported.*
- *Where no reasonable sites within Flood Zone 1 are available, allocations in Flood Zone 2 and Flood Zone 3 will be considered on a sequential basis.*
- *Where it is necessary to apply the Exception Test within the urban areas, it must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk.*
- *All new development should incorporate measures to reduce surface water run-off and the implementation of Sustainable Urban Drainage Systems into all new development will be sought unless it can be demonstrated that such measures are not viable or technically feasible.*

3.4.9 It is also stated within the Erewash Core Strategy that for development on green field sites, the aim should be to reduce or at least maintain run-off levels compared to those prior to development.

[10] Available online: http://www.erewash.gov.uk/media/files/Environment-and-Planning/Planning%20Policy/Core_Strategy_-_Submission_Version/CD01_-_Submission_Version_-_Erewash_Core_Strategy.pdf

3.5 Strategic Flood Risk Assessments (SFRA)

3.5.1 DCiC and EBC have both prepared Strategic Flood Risk Assessments for their administrative areas.

3.5.2 In October 2013 DCiC prepared a Level 1 Strategic Flood Risk Assessment (SFRA)[11] to assist the city in meeting the requirements of national policy. The SFRA provides general advice on flood risks and on the principles and application of sustainable drainage.

3.5.3 According to the SFRA, the River Derwent tends to produce high flood flows in proportion to the size of the catchment and the river can also rise rapidly. This is reflected in the June 2007 event (approximately 4 - 5% annual *exceedance probability* (AEP) event) where river levels rose from the 'normal' 700mm (approximately 30m^2) to 2,800mm (approximately 300m^2) over a 30 hour period.

3.5.4 Although flood defences have been installed around Derby City Centre to mitigate the effects of flooding through the overtopping of river banks, flooding still occurs in other areas along the River Derwent. The SFRA highlights that the River Derwent is channelled under the A38 to the west of the junction roundabout and then spreads over the wash lands either side of the river. On the left bank, flood defences are intermittent therefore water is able to flow outside the main river for approximately 2km. The wash lands in this area act as a conduit for floodwater, however, it is reported that for events up to a 25 year return period, flooding is considered more a nuisance rather than damaging.

3.5.5 The SFRA also states that there are potential flood risks associated with the Dam Brook and Boosemoor Brook due to the number of culverts along each watercourse. The SFRA indicates that the risk to areas other than Breadsall is considered to be low.

3.5.6 The Greater Nottingham SFRA Addendum was prepared by AECOM in September 2017[12] to improve the quality of information available and updates earlier work set out in the Greater Nottingham Strategic Flood Risk Assessment (2010) and the River Leen and Day Brook Strategic Flood Risk Assessment (2008). In relation to the study area, the report mainly focused on flood risk from the River Erewash, Ock Brook, River Derwent (Draycott) and River Trent in areas downstream of the Little Eaton junction. The area around the Little Eaton junction was not explicitly addressed in the SFRA.

3.6 Preliminary Flood Risk Assessment (PFRA)

3.6.1 In 2011 DCiC produced its Preliminary Flood Risk Assessment (PFRA)[13] which represented the first stage in recording and monitoring flooding in Derby. The high level assessment addresses flood risk from surface water, groundwater, ordinary watercourses and canals. Main rivers and reservoirs were excluded from the scope as they were covered under a separate assessment. A review of this document has

[11] Available online: https://www.derby.gov.uk/media/derbycitycouncil/contentassets/documents/policiesandguidance/planning/SFRA_1_Update_Explanation_V3.pdf
[12] Available online: http://www.nottinghamcity.gov.uk/planning-and-building-control/planning-policy/greater-nottingham-strategic-flood-risk-assessment-addendum/
[13] Available online: http://enjoyfreepdf.com/download/derby-city-council-preliminary-flood-risk-assessment/

shown that Little Eaton junction is located outside of the study area associated with this PFRA.

3.6.2 In the same year DCC produced a PFRA which included the Little Eaton junction. Due to the scale of the area covered by the PFRA, there is limited specific information relating to Little Eaton junction. However, figures within the report (based on 1km grids) shows that aside from the fluvial risk from the River Derwent, surface water is also considered a potential risk to the site.

3.7 Our City Our River

3.7.1 The Our City Our River Masterplan[14] has been developed jointly by DCiC and the EA since 2012, and sets out a shared vision to reduce flood risk in Derby and transform the City's relationship with the River Derwent by helping to encourage economic regeneration in areas currently at risk of flooding.

3.8 Consultation

3.8.1 AECOM has been consulting with DCiC, DCC, EA and STW regarding flooding and highway drainage design issues associated with the Scheme since 2015.

Derbyshire County Council (DCC) and Derby City Council (DCiC)

3.8.2 DCC is the LLFA responsible for managing the risk of flooding from surface water, groundwater and ordinary watercourses in the vicinity of the Scheme at Little Eaton junction, and has been consulted regarding local flood risks, available data and the drainage design. DCiC has also been consulted due to their proximity of their boundary to the Scheme at Little Eaton junction and the River Derwent.

3.8.3 DCC is also the Land Drainage Authority for Dam Brook and are responsible for issuing consents for any works requiring approval under the Land Drainage Act.

Environment Agency (EA)

3.8.4 With the River Derwent designated as a main river, the EA has been consulted throughout this study, mainly regarding the potential loss of floodplain storage as a result of the increased footprint of the Scheme at Little Eaton junction. The EA provided two hydraulic models (the Milford to Allestree model and the Lower Derwent model) to aid this assessment and has been made aware of the modelling approach. Further to this fluvial aspect, the EA has also emphasised that surface water runoff should be controlled to existing rates or less.

Severn Trent Water

3.8.5 Consultation has been undertaken with STW with regard to their assets in the vicinity of the Scheme at Little Eaton junction.

[14] Available at:
https://www.derby.gov.uk/media/derbycitycouncil/contentassets/documents/environmentandplanning/OurCityOurRiverMasterplan2013.pdf

4 SOURCES OF FLOODING AND FLOOD RISK

4.1 Introduction

4.1.1 The NPPF (and the NPSNN for NSIPs) requires that all potential sources of flooding that could affect a development are considered within a FRA. This includes flooding from rivers and the sea, directly from rainfall on the ground surface and rising groundwater, overwhelmed sewers and drainage systems. Flooding from reservoirs, canals, lakes and other artificial sources must also be considered. There should be demonstration of how these should be managed so that the development remains safe throughout its lifetime, taking into account climate change.

4.2 Historic Flooding

4.2.1 The Highways England Drainage Data Management System (HE DDMS) database was investigated for records of historic flooding at the Scheme site. There were four flood events reported in the vicinity of the Scheme (ID9929, ID10402, ID10315 and ID10029). The initial action was to unblock gullies with only one incident having a flood severity incident score above 0.0 (ID10315 score 6.3 where gully sucker was required). It was, however, reported that there are no HE DDMS recorded flood events that would have an influence on the Scheme.

4.3 Fluvial

4.3.1 Flooding from fluvial sources (rivers) can occur through inundation of floodplains from rivers and watercourses, or inundation of areas outside of the floodplain due to influence of bridges, embankments and other features that can restrict flow.

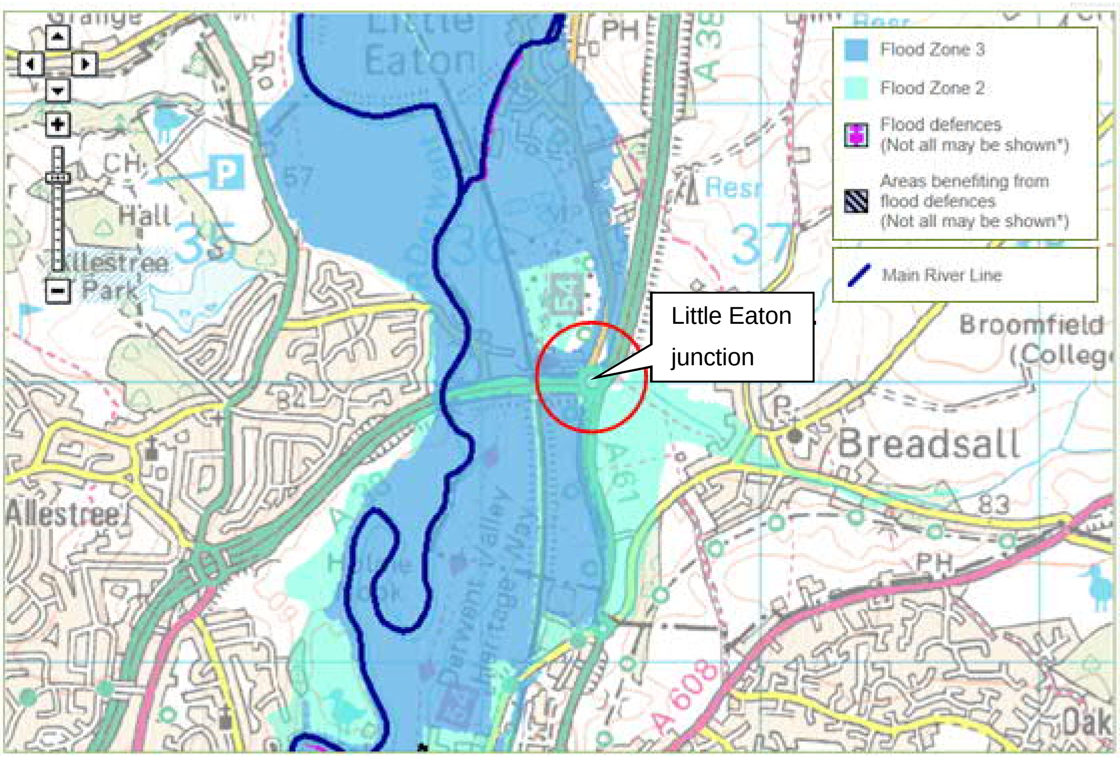

Figure 4-1: Environment Agency Flood Map

(areas not within Flood Zones 2 and 3 are within Flood Zone 1)

4.3.2 EA fluvial flood maps[15] (see Figure 4-1) show that Little Eaton junction is located within Flood Zone 2, with the western elements falling within or adjacent to Flood Zone 3.

4.3.3 With the changes to the existing junction footprint that would occur as a result of the Scheme, there would be a loss of floodplain storage associated with the River Derwent, and potential increases in flood levels with associated increases in flood risk. Modelling work has, therefore, been undertaken to understand the associated risks and develop suitable compensatory works and any other necessary mitigation measures - this is discussed further in Section 6 and within the Modelling Technical Note provided within Appendix B.

4.3.4 Although the EA Flood Map for Planning shows that the Scheme site for the construction compound at Little Eaton junction is in Flood Zone 2, results from the detailed hydraulic modelling displayed in Little Eaton Flood Modelling Update (April 2018)[16] found in Appendix B, confirms that the area is not susceptible to fluvial flooding at the 1% AEP plus 50% climate change event. The modelling report further notes that the land is raised up in the region, adding confidence to the assertion that the area is not susceptible to fluvial flooding.

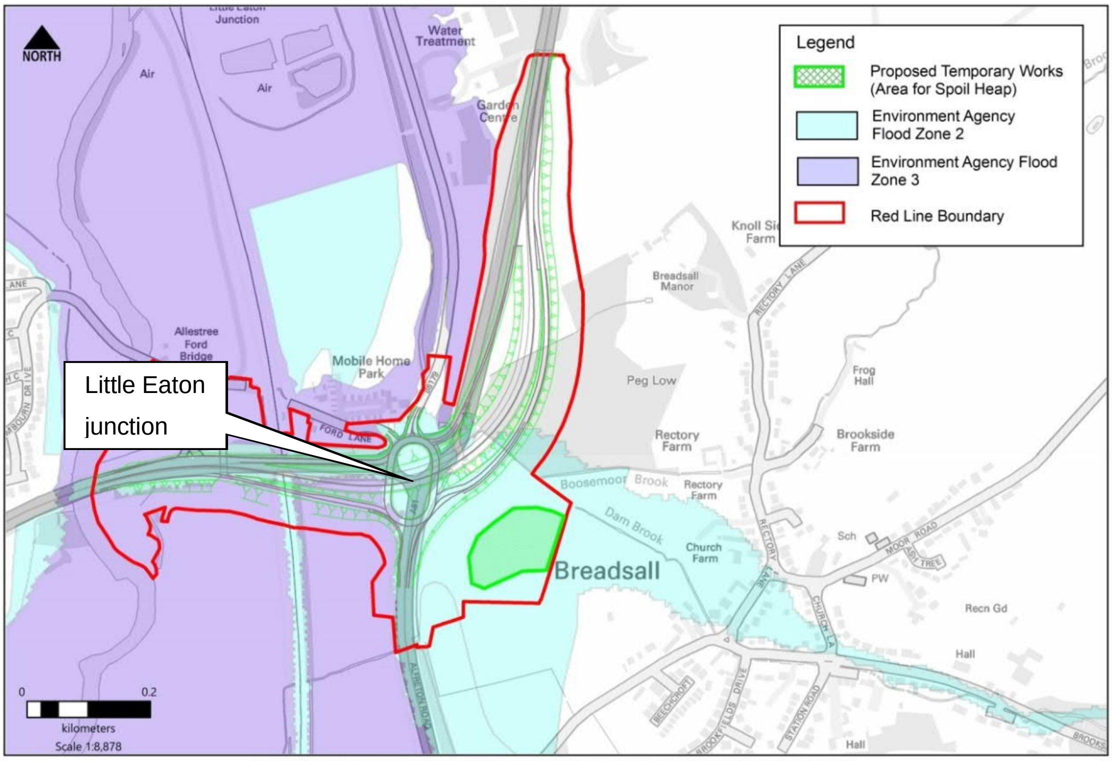

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Figure 4-2: Environment Agency Flood Zones

(areas not within Flood Zones 2 and 3 are within Flood Zone 1)

4.3.5 Figure 4-2 identifies that the area of the proposed material storage to the south of the junction is located within Flood Zone 2 and has between 0.1% and 1% chance of fluvial flooding in any given year.

[15] Available at: https://flood-map-for-planning.service.gov.uk/
[16] Technical Note 47071319-URS-05-TN-EN-030

4.3.6 Under Table 2 of the 2014 flood risk and coastal change PPG, the proposed material storage area would be categorised as Less Vulnerable, due to the intended land use being for 'minerals for working and processing'. The development is, therefore, considered to be 'appropriate' under Table 3 of the flood risk and coastal change PPG.

4.3.7 As highlighted in Figure 7 of Appendix B, the proposed material storage area lies outside of the modelled flooding extents of the River Derwent. The proposed material storage area was, therefore, not incorporated into the geometry of the detailed hydraulic model, as there is low fluvial flood risk to the site from the River Derwent. No additional mitigation measures are required in regards to fluvial flood risk for the proposed material storage area or the construction compound to the north of the junction.

4.4 Tidal

4.4.1 Little Eaton junction is effectively at no risk of flooding from tidal sources.

4.5 Groundwater

4.5.1 Groundwater flooding occurs as a result of water rising up from the underlying aquifer or from water flowing from springs. This tends to occur after long periods of sustained high rainfall, and the areas at most risk are often low-lying where the water table is more likely to be at shallow depth. Groundwater flooding is known to occur in areas underlain by major aquifers, although increasingly it is also being associated with more localised floodplain sands and gravels. It tends to occur sporadically in both location and time, and because of the more gradual movement and drainage of water, tends to last longer than fluvial, pluvial or sewer flooding.

4.5.2 As highlighted in the A38 Derby Junctions Ground Investigation Report (Report Number HE514503-ACM-VGT-A38_SW_PR_ZZ-PR-GE-0003_P02_24, 2018), due to the soils underlying Little Eaton junction being reasonably permeable. Groundwater monitoring was undertaken monthly between November 2016 and October 2017. The average groundwater level from exploratory hole locations screened within the Alluvium ranges between 0.42MgbI and 3.70Mbgl (48.83 and 50.80Maod).

4.5.3 It should be noted that there are no historical incidents of groundwater flooding at the Scheme site. However, as the site lies over permeable geology and with water strikes encountered below ground level within the vicinity, the risk from groundwater is considered to be medium.

4.6 Surface Water

4.6.1 Overland flow results from rainfall that fails to infiltrate the surface and travels over the ground surface; this is exacerbated where the permeability of the ground is low due to the type of soil and geology (e.g. clay soils) or urban development. Surface water flow is also promoted in areas of steep topography which can rapidly convey water that has failed to penetrate the surface.

4.6.2 EA surface water flood maps show that the majority of the area in the vicinity of Little Eaton junction is considered to have a 'Very Low' risk. This means that each year the area has a chance of flooding of less than 1 in 1,000 (0.1%). However, the eastern extent of the Scheme encroaches into an area considered to have a 'High' risk associated with the location of the Dam Brook. ‘High’ means that each year, the area has a chance of flooding of greater than 1 in 30 (3.3%).

4.6.3 In addition, there is significant attenuation of surface water runoff adjacent to the existing A38 associated with a stream emanating from Breadsall Manor.

4.6.4 The existing drainage of the carriageway east of the railway bridge drains to Dam Brook. Between the railway bridge and the River Derwent the road is on an embankment on the floodplain and the carriageway runoff is collected in a kerb and gully system which discharges to the drainage ditches and is then discharged into the River Derwent. Surface water drainage from other parts of the junction drain to other ditches/ ponds within the vicinity which ultimately discharge to either the Dam Brook or directly to the River Derwent.

4.6.5 As the Scheme at Little Eaton junction would increase the amount of impermeable surface, the amount of surface water runoff from the area would increase if not adequately mitigated. The existing roundabout currently drains to the River Derwent via small drainage channels to the west and Dam Brook to the east. As highlighted in the Road Drainage Strategy (Report Number HE514503-ACM-HDG-A38_SW_PR_ZZ-RP-CD-0002, Highways England 2019), west of Midland Mainline Railway Bridge, and the Scheme would drain to the River Derwent.

4.6.6 Analysis of the EA long term flood risk map shows that surface flood risk is considered low (between 0.1% and 1%) for the majority of the site proposed for use as temporary material storage area to the south of the junction. However, small pockets of high risk (<3.3%) occur on the eastern extent and in a small area in the centre of the site. Medium risk from surface water flooding (between 1% and 3.3%) occurs on the southern extent of site.

4.6.7 At the site of the construction compound to the north of the junction, there is a very low chance of surface water flooding with exception of a small pocket on the western boundary which has a low risk of surface flooding (0.1% to 1%).

4.6.8 Surface water flood risks to the Scheme are considered to be low, but mitigation measures would be required to control surface water flood risks from the proposed junction. These issues are discussed in Section 6.

4.7 Sewers

4.7.1 Flooding can occur as a result of infrastructure failure e.g. blocked sewers or failed pumping stations. Sewer flooding can occur when the system surcharges due to the volume or intensity of rainfall exceeding the capacity of the sewer, or if the system becomes blocked by debris or sediment.

4.7.2 No sewer flooding records have been identified in the vicinity of the Scheme at Little Eaton junction.

4.7.3 As described above, the Road Drainage Strategy states that the existing highway pavement and drainage collection systems would be replaced as part of the junction improvements.

4.7.4 Overall, the risk of sewer flooding at Little Eaton junction is considered to be low.

4.8 Artificial Sources

4.8.1 Artificial sources include raised channels such as canals or storage features such as ponds and reservoirs. There are several reservoirs in the vicinity of the Scheme at Little Eaton junction and in an unlikely event of a catastrophic dam failure the site could be at risk of inundation.

4.8.2 The EA's Reservoir Flood Map confirms that the Scheme at Little Eaton junction lies within the maximum flood extent with a catastrophic dam failure. However, the EA provides the following explanatory text in relation to the reservoir flood maps:

'Reservoir flooding is extremely unlikely to happen. There has been no loss of life in the UK from reservoir flooding since 1925. All large reservoirs must be inspected and supervised by reservoir panel engineers. As the enforcement authority for the Reservoirs Act 1975 in England, we ensure that reservoirs are inspected regularly and essential safety work is carried out'

4.8.3 Based on the information provided by the EA, site specific mitigation measures for this flood source are not considered appropriate. The risk from artificial sources is, therefore, considered to be low.

4.9 Climate Change

4.9.1 The United Kingdom Climate Impacts Programme is assessing implications of climate change in the UK. Climate change scenarios for the UK predict that winters will be wetter by up to 15% by the 2020s, summers will possibly be drier by up to 20% by the 2020s, snowfall amounts will decrease significantly, and extreme winter precipitation will become more frequent.

4.9.2 The EA confirmed that 50% allowance for climate change is appropriate for assessing watercourses at the Scheme site and this has been incorporated into the Derby Integrated Catchment Model (DICM) (and subsequent model updates, refer to Section 5). A 40% allowance for climate change has been made with regard to the drainage design.

4.10 Summary

4.10.1 The key findings of the flood risk review are as follows:

- The risk of fluvial flooding from the River Derwent to the proposed Little Eaton junction is considered to be high. Hydraulic modelling has been undertaken to assess the impact of the Scheme on the River Derwent i.e. loss of floodplain storage - this is described in Section 5.
- There is no realistic risk of tidal flooding in the vicinity of Little Eaton junction.
- The risk of groundwater flooding is considered to be medium.
- The risk of surface water flooding to Little Eaton junction is low. However, the risk of increased surface water runoff from the Scheme arrangement to surrounding areas is considered to be high. The road drainage strategy has been developed to describe how runoff would be controlled from the Scheme - this is summarised in Section 6. However, the eastern extent of the Scheme encroaches into an area considered to have a 'High' risk associated with the location of the Dam Brook, whilst there is significant attenuation of surface water runoff adjacent to the existing A38 associated with a stream emanating from

Breadsall Manor.

- The risk of sewer flooding is considered to be low.
- The risk of flooding from artificial sources is considered to be low.
- The EA and DCC have confirmed that 50% allowance for climate change is appropriate for assessing watercourses at the Scheme site.

5 HYDRAULIC MODELLING AND CONCEPTUAL ASSESSMENT OF FLUVIAL MITIGATION MEASURES

5.1 History & Overview

5.1.1 Hydraulic modelling has been used to assess the fluvial flood risk to the existing Little Eaton junction, the effects of the Scheme, and the associated compensatory works required to address the loss of floodplain volume.

5.1.2 The hydraulic modelling has essentially involved merging two separate models of the River Derwent, and then using this combined model to determine the 'baseline' flood risk. Subsequently, the model has been amended to reflect the Scheme design to determine its impact on flood risk.

5.1.3 Modelling undertaken in 2016 concluded that increased flood levels did occur as a result of the Scheme, but could be considered acceptable due to there being no direct impact on property. However, following a meeting with the EA on 17 August 2016, it was stated that the Scheme should aim to achieve zero flood level increase where possible (especially in developed areas of the Derwent floodplain, such as adjacent to Lambourn Drive, Allestree).

5.1.4 Additional flood risk modelling at Little Eaton junction was undertaken in order to further assess flood levels due to the Scheme within the River Derwent floodplain. Details of this modelling and the associated results were reported in a Technical Note 47071319-URS-05-TN-EN-030 (Highways England, November 2016). The modelling, and the associated mitigation optioneering, was targeted on the 1% AEP event plus 20% climate change allowance (in respect of fluvial peak flows). The Technical Note and flood model were submitted to the EA in December 2016, who provided external review comments regarding the model on 27 February 2017.

5.1.5 The results of the modelling and the external review model comments were discussed at a meeting with the EA on 21 March 2017. Subsequently AECOM responded to the EA comments on the model on 16 May 2017, with the EA generally agreeing with our responses on 26 May 2017. In addition, at the meeting with the EA, it was confirmed that the design condition should be the 1% AEP plus 50% climate change event (rather than the previously modelled 20% climate change allowance).

5.1.6 Details of the original modelling, as described above, are not presented in this version of the FRA. It is considered that this has now been sufficiently superseded to not require re-statement. Therefore, this version of the FRA presents the modelling undertaken following agreement of the required updates, along with the associated results and implications for the Scheme.

5.2 Little Eaton Flood Model: Updated Baseline

5.2.1 The combined model of the River Derwent, inclusive of the existing A38 Little Eaton junction, was updated to address the external review comments as mentioned in Section 5.1. In addition, new topographic survey and LiDAR DTM data was incorporated into the model. These changes formed an improved baseline model from which the impacts of the Scheme could be assessed.

5.2.2 Full details of the model updates are provided in the modelling Technical Note as supplied in Appendix B.

5.2.3 As the aim of this modelling exercise was to assess the impact of the Scheme on flood levels and floodplain storage, the model was only simulated for the 1% AEP plus 50% climate change event due to impacts of climate changes as assessed by The United Kingdom Climate Impacts Programme.

5.3 Little Eaton Flood Model: Proposed Junction

5.3.1 The updated Little Eaton Baseline Flood Model was used to assess the Scheme by replacing the existing junction layout with the proposed junction layout.

5.3.2 As discussed in Section 4.3, an increase in the junction footprint would result in the loss of floodplain storage associated with the River Derwent, and this has the potential to cause an increase in flood risk due to raised flood levels. This is discussed in more detail below.

5.4 Modelling Results

5.4.1 Flood risk modelling results are presented in Appendix C for both the existing Little Eaton junction and the Scheme.

5.4.2 As can be seen from the flood depth figures in Appendix C, the flood extents of the existing and proposed Scheme scenarios are practically identical, with the main changes occurring immediately to the south of the junction in the area where the Scheme (i.e. extension of the A38 road embankment) extends. Results show that by encroaching into the floodplain, the Scheme would have some minor impact on flood depths within the Scheme vicinity. This is shown in more detail within Figure 5-1 which shows a depth-difference plot between the existing and proposed Scheme scenario.

5.4.3 Figure 5-1 indicates that changes in flood levels are generally limited to a maximum increase of up to 20mm, although with some areas local to the proposed junction increasing by up to 50mm. There are also some areas where flood levels reduce; these occur immediately to the south of Little Eaton junction, and also to the east of the railway line. It should be noted that this figure does not show the entire flood extent. Where there is no impact, no colour is shown. Thus the Scheme would not affect flood depths in the majority of the surrounding settlements/ developed areas. The coloured areas only show the locations where there has been an impact on flood levels due to the Scheme.

5.4.4 As stated above, and indicated on Figure 5-1, the most significant changes in flood levels occur around the A38 junction. This is due to the changes in hydraulic behaviour of floodplain flow as a result of the proposed junction layout.

5.4.5 Table 5-1 provides further information regarding the changes in flood levels within the vicinity of the junction.

Table 5-1: Comparison of point-based flood levels between the Updated Baseline Model and Proposed Arrangement Model

Flood Assessment Point	1% AEP event plus 50% climate change allowance		
	Updated Baseline – Flood Level* (m AOD)	Proposed Arrangement – Flood Level* (m AOD)	Difference* (mm)
1	53.08	53.08	+10
2	53.15	53.16	0
3	53.07	53.07	0
4	52.56	52.57	+10
5	53.05	53.05	-10
6	51.81	51.84	+30
7	52.45	52.48	+30
8	50.46	50.43	-40
9	50.33	50.33	+10
10	50.31	50.29	-10

*Note that differences are calculated from exact model results, whilst calculated levels are rounded to 2 d.p.

5.4.6 The results in Table 5-1 show that for most locations, there are only marginal changes to flood depths. These marginal changes (i.e. ±30mm) are considered to be within the tolerance of the hydraulic model. As such, it is considered that the proposed arrangement would not result in significant changes in flood risk, although mitigation is still required in order to compensate for the loss of River Derwent floodplain.

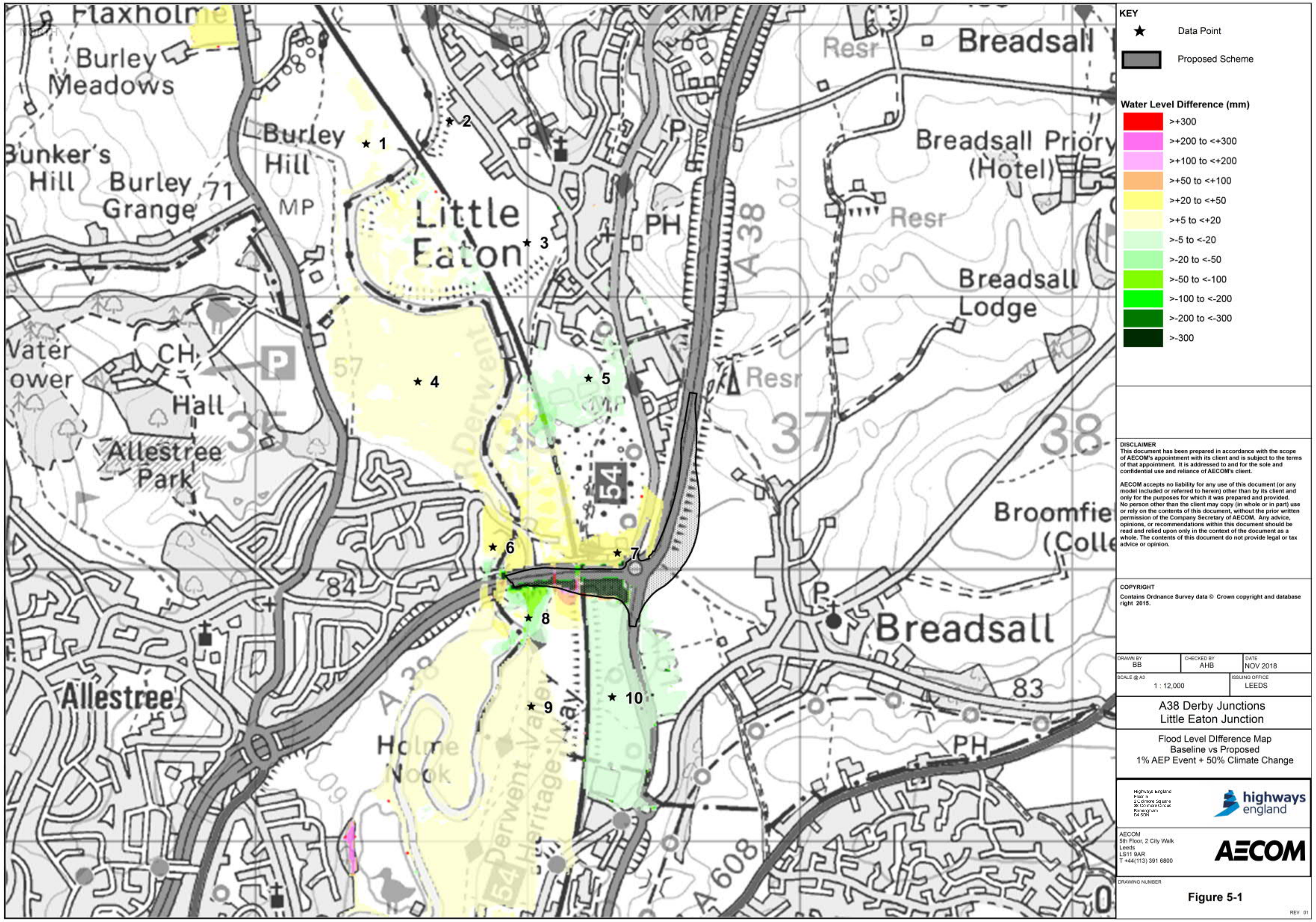

Figure 5-1: Flood Level/ Depth Difference Map of Updated E **oposed Arrangement Model**

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5.5 Little Eaton Flood Model: Proposed Junction with Compensatory Works

5.5.1 Several compensatory storage options have been modelled in order to meet the EA's requirement that there be no net loss of floodplain volume as a result of the Scheme.

5.5.2 Following the investigation of several options, a potentially appropriate location for the floodplain compensation works was identified downstream of the Scheme, on the right bank of the River Derwent. Appendix B provides more detail on the method used to determine the required volumes (i.e. volume lost as a result of the Scheme), and the subsequent ground modelling exercise that was undertaken to re-profile the floodplain in order to compensate for the volume lost.

5.5.3 Table 5-2 provides a summary of the compensatory works, in terms of required and provided compensatory volumes.

Table 5-2: Comparison of required and provide compensatory volumes

Lower Level (m AOD)	Upper Level (m AOD)	Cumulative Volume Required (m^3)	Cumulative Volume Provided (m^3)	Variation (m^3)
n/a	49.59	0	4,291	+4,291
49.59	49.73	18	5,619	+5,601
49.73	49.79	405	5,913	+5,508
49.79	49.82	609	6,484	+5,875
49.82	49.85	873	7,056	+6,183
49.85	49.88	1,320	7,627	+6,087
49.88	49.93	5,339	8,374	+3,035
49.93	50.19	12,439	10,853	-1,586
50.19	50.39	12,909	12,760	-149
50.39	50.42	12,995	13,304	+309

5.5.4 The compensatory works were included in a version of the Scheme model, and found that provision of the compensatory works would not result in unanticipated adverse effects on flood levels. This is confirmed by Figure 5-2 (and also Appendix C), which shows a depth-difference plot between the existing junction scenario and the proposed junction scenario inclusive of the compensatory storage area. The only difference is where the compensatory works have been included, which would flood to provide the level-for-level compensatory volume during some flood events (whereas previously this area was not flooded).

5.5.5 Correspondence with the EA in June 2018 has confirmed their contentment with the proposed approach to flood risk mitigation and floodplain compensation proposals at Little Eaton junction, and that residual flood impacts are acceptable.

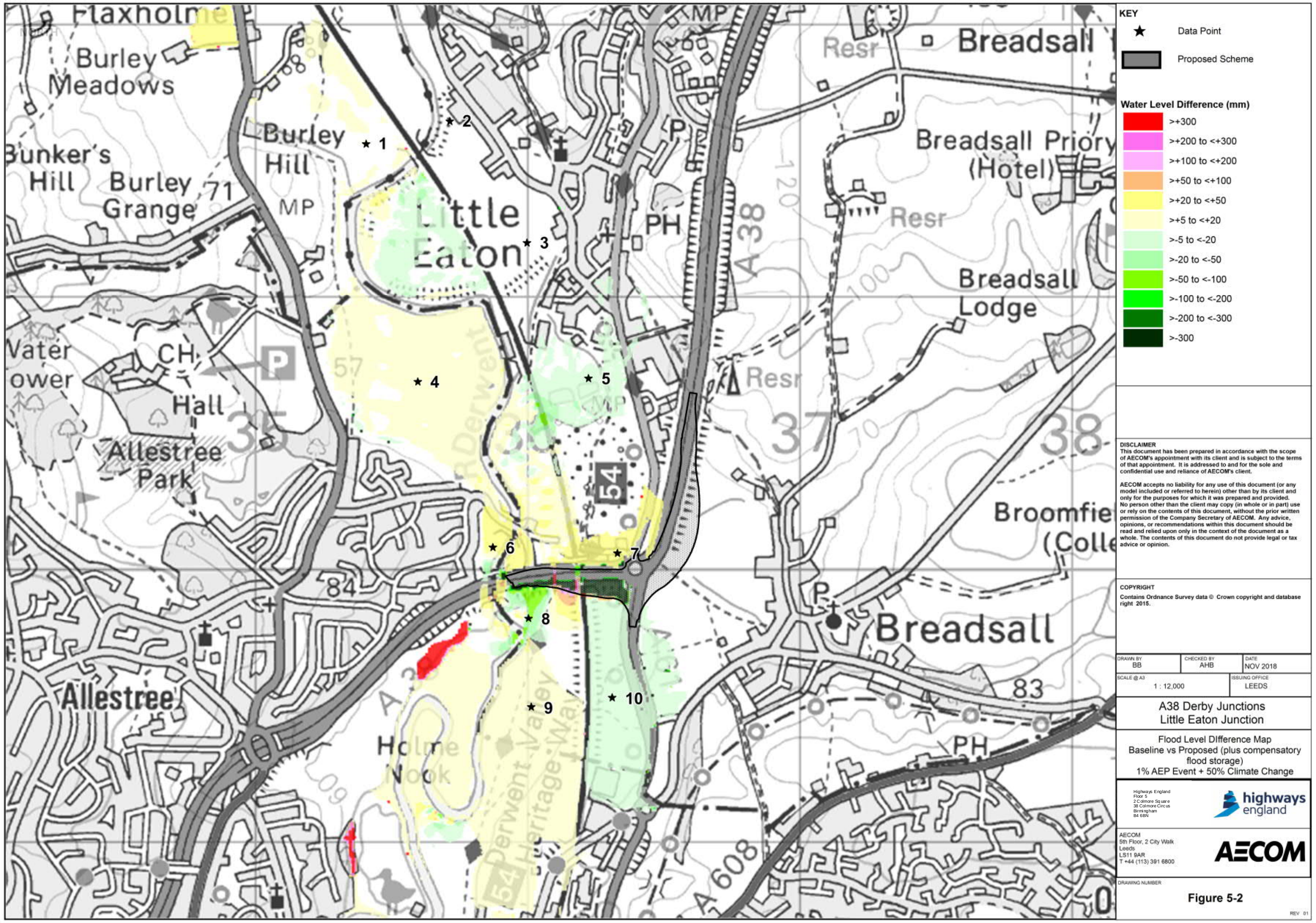


Figure 5-2: Flood Level/ Depth Difference Map of Updated Ba **posed Arrangement Model (with compensatory storage)**

6 SURFACE WATER FLOODING AND MITIGATION MEASURES

6.1 Overview

6.1.1 In terms of surface water mitigation, there are two elements that require consideration. Firstly, it was necessary to consider the surface water flood risks associated with Dam Brook (noting that the Scheme requires Dam Brook to be diverted) and flooding associated with a stream emanating from Breadsall Manor. Dam Brook is a tributary of the River Derwent which is located near to Breadsall, and which drains under the A61 close to the existing Little Eaton junction. Secondly, an assessment of highway surface water management strategies for the proposed junction and associated drainage was required.

6.1.2 Both of these surface water elements are discussed in the sections below.

6.2 Dam Brook and Stream from Breadsall Manor

6.2.1 The eastern extent of the Scheme encroaches into an area considered to have a 'High' risk of surface water flooding, according to the EA's surface water flood maps. This area is associated with the location of the Dam Brook. In addition, further to the north there is significant attenuation of surface water runoff adjacent to the existing A38 associated with a stream emanating from Breadsall Manor.

6.2.2 In order to assess the impact of the Scheme on surface water flood risk, for both the permanent and temporary works (which could entail material storage to the west of Dam Brook) and to identify potential mitigation measures, a surface water hydraulic model was developed. The model was developed using a 2D only direct rainfall approach. Full details of the modelling can be found in Appendix D (Surface Water Modelling Technical Note).

6.2.3 Modelling of the existing situation indicated that the current A38/ A61 alignment causes significant attenuation of surface water within an unnamed watercourse to the south-west of Breadsall Manor. This is related to the channel capacities and culvert networks in vicinity of the existing highway alignment.

6.2.4 For the Scheme scenario, the model was amended to reflect the realigned highway junction, the provision of highway runoff surface water attenuation basins (refer to Section 6.3), the diversion of Dam Brook and the creation of a series of ecological and flood storage ponds. It was also necessary to amend the alignment, length and inverts of the proposed culvert extension beneath the A38 to ensure a positive hydraulic gradient.

6.2.5 Implementation of the Scheme features did not result in an increased risk of surface water flooding to areas south of the proposed A38 alignment. However, attenuation of surface water on the upstream face of the proposed embankments, to the south-west of Breadsall Manor, resulted in an increased risk of flooding outside of the Scheme boundary. Additionally, the model indicated overtopping and inundation of the southernmost proposed attenuation basin during a 1% AEP + 50% climate change design event.

6.2.6 In order to address the surface water flooding issues that resulted from the Scheme, a series of mitigation measures was tested. The solution identified and incorporated into the Scheme comprised a multi-stage flood alleviation channel adjacent to the A38 embankment that would connect the unnamed surface watercourse downstream of Breadsall Manor with the realigned Dam Brook. In addition, a new 600mm diameter culvert would also be provided from the watercourse under the new A38 embankment that would connect into an existing 500mm diameter culvert in order to convey flows from the unnamed watercourse when the flow capacity of the flood alleviation channel is exceeded.

6.2.7 With these mitigation measures, the area to the west of the realigned Dam Brook would be appropriate for temporary material storage during the Scheme construction phase.

6.3 A38/ A61 Junction Realignment

6.3.1 The Road Drainage Strategy (Report Number HE514503-ACM-HDG-A38_SW_PR_ZZ-RP-CD-0002, Highways England 2019) is available as a separate report and should be read in parallel with this FRA. The Road Drainage Strategy report indicates that the highway drainage design at Little Eaton junction comprises the following:

- A highway runoff attenuation pond located to the east of the A61 that would be owned and operated by Highways England (pond would receive runoff from Highways England assets).
- A highway runoff attenuation pond located to the east of the A61 that would be owned and operated by DCC (pond would receive runoff from DCC assets).
- Attenuation using oversized pipes.
- Narrow filter drains.
- Combined kerb drainage units.
- Trapped gully pots and road-side linear drains.
- Petrol interceptors at outfalls and connections to existing public sewers.
- By-pass separators.

6.3.2 The surface water management strategy for the Scheme design is summarised as follows:

Runoff Collection and Conveyance

6.3.3 Little Eaton junction's preliminary drainage design has five catchments.

6.3.4 Runoff from the carriageway would be collected via a combination of road edge channels, gullies and combined kerb drainage units (where required). The proposed overbridges allow for bridge drainage/ combined kerb drainage units on the bridge deck.

6.3.5 The use of carrier pipes would ensure that spillages would be contained within the drainage system and would not infiltrate to ground close to source. Subsurface drainage would be provided via narrow filter drains where necessary.

Attenuation and Pollution Control

6.3.6 A GRR of 4.6l/s/ha has been agreed for use within the preliminary design calculations.

Catchment 12

6.3.7 The runoff from this catchment would outfall into the realigned Dam Brook. Attenuation storage up to and including the 100 year + 40%CC event would be provided by a lined attenuation pond and oversized pipes. The preliminary design allowable discharge rates have been calculated using a GRR of 4.6l/s/ha for the new impermeable areas and restricted to ensure betterment over the existing situation for the site.

6.3.8 Treatment of the runoff prior to discharge would be provided by the lined attenuation pond. The existing highway drainage design includes no vegetative treatment systems, so the Scheme would provide enhancements to runoff water quality. Penstocks would be provided upstream of the attenuation pond to allow cut off in the event of spillage on the highway. The spillage would be contained within the carrier/ system.

6.3.9 The attenuation pond is to be owned and maintained by Highways England, a shared access track with DCC is included within the preliminary design to service the pond.

Catchment 13

6.3.10 The runoff from this catchment would outfall into the realigned Dam Brook. Attenuation storage up to and including the 100 year + 40%CC event would be provided by a lined attenuation pond and oversized pipes. The preliminary design allowable discharge rates have been calculated using a GRR of 4.6l/s/ha for the new impermeable areas and restricted to ensure betterment over the existing situation for the site.

6.3.11 Treatment of the runoff prior to discharge would be provided by the lined attenuation pond. The existing highway drainage design includes no vegetative treatment systems, so the Scheme would provide enhancements to runoff water quality. Penstocks would be provided upstream of the attenuation pond to allow cut off in the event of spillage on the highway. The spillage would be contained within the carrier/ system.

6.3.12 The attenuation pond is to be owned and maintained by DCC, a shared access track with Highways England is included within the preliminary design to service the pond.

Catchment 14

6.3.13 The discharge from the catchment would be restricted to match existing discharge rates, ensuring no detriment in terms of downstream flood risk. Attenuation would be provided within the pipe network to ensure no flooding from the site in a 1 in 100 year + 40% CC rainfall event. The existing connections (subject to condition assessment) would be retained. No vegetative treatment has been provided within the design due to site constraints, matching existing conditions.

6.3.14 A petrol interceptor would be located upstream of the connection to the proposed discharge point.

Catchment 15

6.3.15 The discharge from the catchment would be restricted to match existing discharge rates, ensuring no detriment in terms of downstream flood risk. Attenuation would be provided within the pipe network to ensure no flooding from the site in a 1 in 100 year + 40% CC rainfall event. The existing connections (subject to condition assessment) would be retained. No vegetative treatment has been provided due to site constraints, matching existing conditions.

6.3.16 A petrol interceptor would be located upstream of the connection to the proposed discharge point.

Catchment 16

6.3.17 The proposed earthworks drainage would discharge via the existing outfall into Dam Brook. At catchment 16 there would be a reduction in the drained area and consequently a reduction in peak runoff flows.

Land Drainage

6.3.18 Dam Brook would be affected by the Scheme and would need to be realigned.

6.3.19 Proposed earthwork drainage would be located at the top of cuttings or at the toe of embankments to capture surface flows from natural catchments. These would outfall into the carrier pipe system.

6.3.20 Due to the areas of high and medium surface water flood risk at the proposed temporary materials storage area, appropriate mitigation measures to reduce risk associated with surface water flooding would be required (surface water attention and management). Mitigation measures are likely to be minimal in nature owing to the limited area of surface water flood risk and the nature of the proposed site use (temporary material storage).

7 CONCLUSIONS

7.1.1 This Flood Risk Assessment (FRA) has reviewed the Scheme proposals at Little Eaton junction. Flood risks to, and resulting from, the Scheme were assessed as follows:

- The risk of fluvial flooding from the River Derwent to the proposed junction is high. Hydraulic modelling has been undertaken to investigate the impact on flood risk and loss of floodplain storage as a result of the Scheme and mitigation measures for compensatory floodplain storage have been incorporated into the scheme design.
- There is no risk of tidal flooding.
- The risk of groundwater flooding is considered to be medium which is concluded in the A38 Derby Junctions Ground Investigation Report (Report Number HE514503-ACM-VGT-A38_SW_PR_ZZ-PR-GE-0003_P02_24, 2018).
- The risk of surface water flooding to the site is low, except in the vicinity of an unnamed watercourse to the south-west of Breadsall Manor (east of the proposed junction realignment), as well as an area of ‘High’ risk associated with Dam Brook.
- The risk of sewer flooding is considered to be low.
- The risk of flooding from artificial sources is considered to be low.

7.1.2 Hydraulic modelling has been undertaken to assess the amount of floodplain storage that would be lost as a result of the Scheme. The ISIS-TUFLOW model which has been created for this study was produced by combining the Lower Derwent model (south of the A38) and the Milford to Allestree model (north of the A38), both of which were provided by the EA. The combining of the two models involved updating the LiDAR and also the representation of the floodplain (i.e. changing the area within the vicinity of the junction from 1D to 2D).

7.1.3 Flood modelling demonstrated that the proposed junction encroaches into the River Derwent floodplain causing a loss of storage, and a change in hydraulic conditions around the river crossing. Whilst the impact on flood levels is considered to be minor, there would be a requirement to provide an area of floodplain compensation. Such an area has been identified to the west of the River Derwent and south of the A38, and proposed ground re-profiling would be able to provide the necessary compensation for the floodplain loss on a level-for-level and volume-for-volume basis. Correspondence with the EA in June 2018 has confirmed their contentment with the proposed approach to fluvial flood risk mitigation and floodplain compensation proposals at Little Eaton junction, and that residual flood impacts are acceptable.

7.1.4 Surface water flood risk associated with Dam Brook and an unnamed watercourse to the south-west of Breadsall Manor has been modelled for both the existing and proposed junction arrangement. The resulting increase in surface water flood risk as a result of the Scheme has been addressed by proposing a combination of mitigation measures as follows:

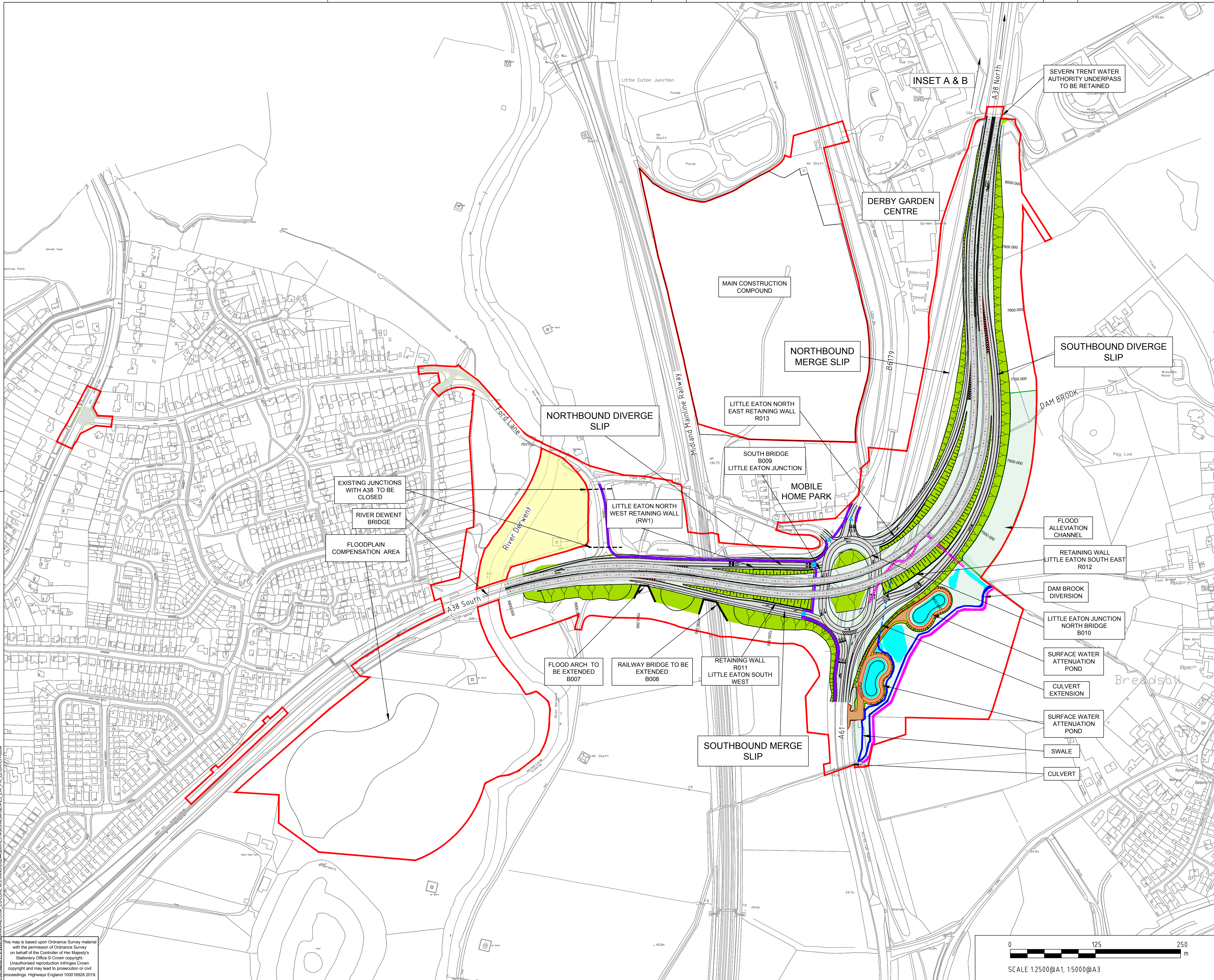
- Diversion of Dam Brook into a new realigned watercourse that takes account of brook flooding, plus the provision of new ponds.

- Provision of a flood alleviation channel adjacent to the new A38 that would connect a surface watercourse downstream of Breadsall Manor with the realigned Dam Brook. In addition, a new 600mm diameter culvert would also be provided from the watercourse under the new A38 embankment that would connect into an existing 500mm diameter culvert in order to convey flows from the unnamed watercourse when the flow capacity of the flood alleviation channel is exceeded.

7.1.5 Surface water flood risks from the Scheme junction itself would be managed through drainage designs as detailed in the Road Drainage Strategy (Report Number HE514503-ACM-HDG-A38_SW_PR_ZZ-RP-CD-0002, Highways England 2019). The main features of the design include two highway runoff attenuation ponds, attenuation using oversized pipes, narrow filter drains, combined kerb drainage units, trapped gully pots and road-side linear drains, petrol interceptors at outfalls and connections to existing public sewers, by-pass separators. The Road Drainage Strategy report is available as a separate report and should be read in parallel with this FRA.

7.1.6 Incorporation of the mitigation measures as detailed herein indicate that flood risks associated with the Scheme at Little Eaton junction can be appropriately managed.

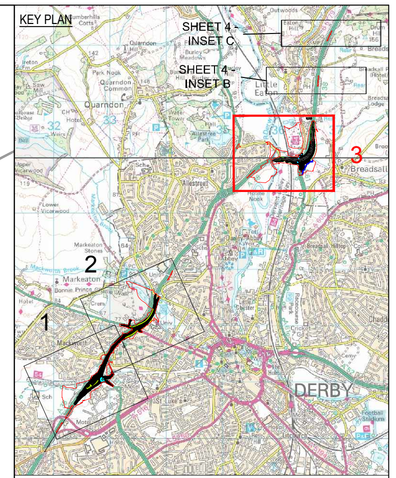
Appendix A Scheme Design and Boundary Drawings



0 125 250 m

SCALE 1:2500@A1, 1:5000@A3

KEY PLAN



NOTES

PLEASE REFER TO 1:1000 SERIES DRAWINGS FOR:
- MAIN PEDESTRIAN/CYCLE ROUTES AND CROSSING POINTS
- INDICATIVE ROAD MARKINGS
- MAINTENANCE ACCESS AREAS
- FENCING (INCLUDING ENVIRONMENTAL BARRIERS)

KEY:

- The Design
- Limits of Land to be acquired or used permanently or temporarily
- Proposed Footway/Cycleway
- Proposed Footway
- Public Right of Way Diversion
- Existing Right of Way to be stopped up
- Area Not Included within the DCO Boundary
- Proposed Controlled Crossing
- Proposed Un-Controlled Crossing
- Embankment
- Cuttings
- Access Track
- Combined Access track & Footway/C'way
- Environmental Mitigation
- Highway to be stopped up
- Proposed Culvert
- Streams

Revision Details	By / Check	Date	Suffix
First Issue	LE / GS	20/02/19	P01
First Issue	LE / GS	04/03/19	P02

Purpose of issue
FINAL

Client
Highways England
Floor 5
Two Colmore Square
38 Colmore Circus
Birmingham
B4 6BN

Development Consent Order Number
TR010022

Project Title
A38
DERBY JUNCTIONS

Drawing Title
GENERAL ARRANGEMENT
REGULATION 5(2)(O)
SHEET 3 OF 4

Designed	Drawn	Checked	Approved	Date
	LE	GS	GS	04/03/19

Internal Project No. 60533462
Suitability S3
Scale @ A1 1:2500
Zone Whole Scheme

Drawing Number
Highways England PIN | Originator | Volume
HE514503 -ACM -DCO-
A38_SW_PR_ZZ -DR-DC-0023
Location | Type | Role | Number

Rev P02

Appendix B Fluvial Modelling Technical Note

TECHNICAL NOTE

Project:	**A38 Derby Junctions**				
Title:	**Little Eaton Flood Modelling Update, April 2018**				
Doc ID:	**HE514503-ACM-EWE-Z3_ML_PR_ZZ-TN-HF-0001**				
Date:	**April 2018**	Version:	**P03**	Status:	**S4**

Revision	Date	Prepared by	Reviewed by	Approved by
P01	28.03.2018	Andrew Heath Brown	Simon Wild	Andy Wilson
P02	03.04.2018	Andrew Heath Brown	Simon Wild Gavin Sawyer	Andy Wilson
P03	10.04.2018	Andrew Heath Brown	Simon Wild	Andy Wilson

1 Background

1.1 A Level 2 Flood Risk Assessment (FRA) for the proposed A38 Little Eaton junction (referred to herein as the proposed scheme) was undertaken during PCF Stage 2 and reported in 47071319-URS-05-RP-EN-007-2F (Highways England, March 2016). As part of an agreed package of advanced PCF Stage 3 works, additional flood risk modelling at Little Eaton junction was undertaken in order to further lower flood levels due to the proposed scheme within certain areas of the River Derwent floodplain. Details of this modelling and the associated results were reported in a Technical Note 47071319-URS-05-TN-EN-030 (Highways England, November 2016). The modelling, and the associated mitigation optioneering, was targeted on the 1% Annual Exceedance Probability (AEP) event plus 20% climate change allowance (in respect of fluvial peak flows). The Technical Note and flood model were submitted to the Environment Agency in December 2016, who provided external review comments regarding the model on 27 February 2017. The results of the modelling and the external review model comments were discussed at a meeting with the Environment Agency on 21 March 2017. Subsequently AECOM responded to the Environment Agency comments on the model on 16 May 2017, with the Environment Agency generally agreeing with our responses on 26 May 2017.

1.2 Further modelling was undertaken and reported in a Technical Note that was submitted to the Environment Agency on 27 November 2017 (HE514503-ACM-EWE-Z3_JN_J3_ZZ-TN-LE-001), with the Environment Agency providing comments on the 25 January and 2 February 2018. Environment Agency comments included a number of actions needed with regard to the modelling, as well as concerns regarding the absence of floodplain compensation.

1.3 This technical note has been prepared to capture the current status of the Little Eaton junction flood risk modelling taking account of Environmental Agency comments.

2 Required Update for PCF Stage 3

2.1 As part of the ongoing PCF Stage 3 works, the associated flood risk modelling at Little Eaton junction has been undertaken to address a number of key factors, as set out below:

- Changes to capture Environment Agency external review comments on the hydraulic model of the Little Eaton A38 junction;
- Changes to capture amendments to the Little Eaton Junction proposed scheme design;
- Changes to capture data generated by an additional topographic survey of the area (including River Derwent cross sections), as well as an updated LiDAR ground model; and,
- Climate change allowances have changed in line with latest Environment Agency guidelines, requiring a 50% increase in peak flows at the 1% AEP event to be mitigated against (as per the Environment Agency request indicated at the meeting held 21 March 2017).

2.2 Full details of the flood risk model update process are presented below.

3 Overview

3.1 The process by which the A38 Little Eaton junction hydraulic model has been updated is summarised in **Figure 1**.

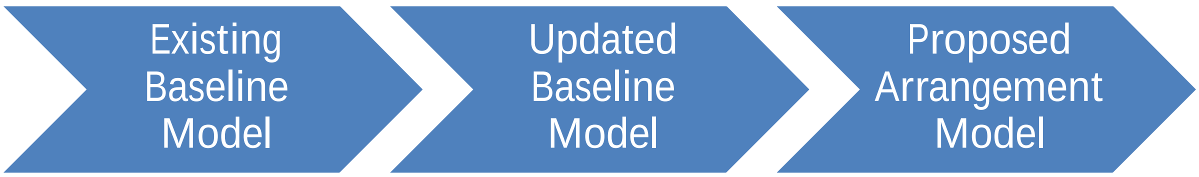


Figure 1: Process by which A38 Little Eaton junction hydraulic model has been updated

3.2 An overview of the Existing Baseline Model, followed by a summary of the development of the Updated Baseline Model and the Proposed Arrangement Model (representing the proposed scheme), is given below. The simulation and results of these two models is then discussed and analysed.

4 Existing Baseline Model

4.1 The Existing Baseline Model is that developed for the additional modelling investigations as previously described, and subsequently reported in Technical Note 47071319-URS-05-TN-EN-030 (Highways England, November 2016). This model was submitted to the Environment Agency and underwent a third-party review (CH2M Hill, February 2017). AECOM provided a response to this review (16 May 2017) which identified that the Existing Baseline Model had originated from two Environment Agency provided models of the River Derwent, and were therefore assumed to have been approved and suitable for assessing flood risk for the proposed scheme. Although the review was based on the Proposed Arrangement Model (at the time), any comment relating to the existing model set-up was not within AECOM's remit to address. Nevertheless, a series of AECOM actions were identified, some of which did address potential issues with the original models (particularly where it was considered that they may affect levels within the proposed scheme area). Following AECOM's response, the Environment Agency provided further comment on the proposed AECOM actions (26 May 2017). This confirmed that AECOM's proposed actions were acceptable.

5 Updated Baseline Model

5.1 The Updated Baseline Model incorporates a number of refinements over the Existing Baseline Model.

Additional Survey Data

5.2 Firstly, updated LiDAR data was provided via Highways England at a higher resolution than the previously utilised LiDAR data. The new data has a resolution of 0.25m as opposed to the previously used 2m resolution data. Initially, the new data was 'stamped' onto the original LiDAR; however, for file size/ management reasons, the resulting coverage was trimmed to the extent of the 2D domain. **Figure 2** demonstrates the coverage relative to the 2D domain.

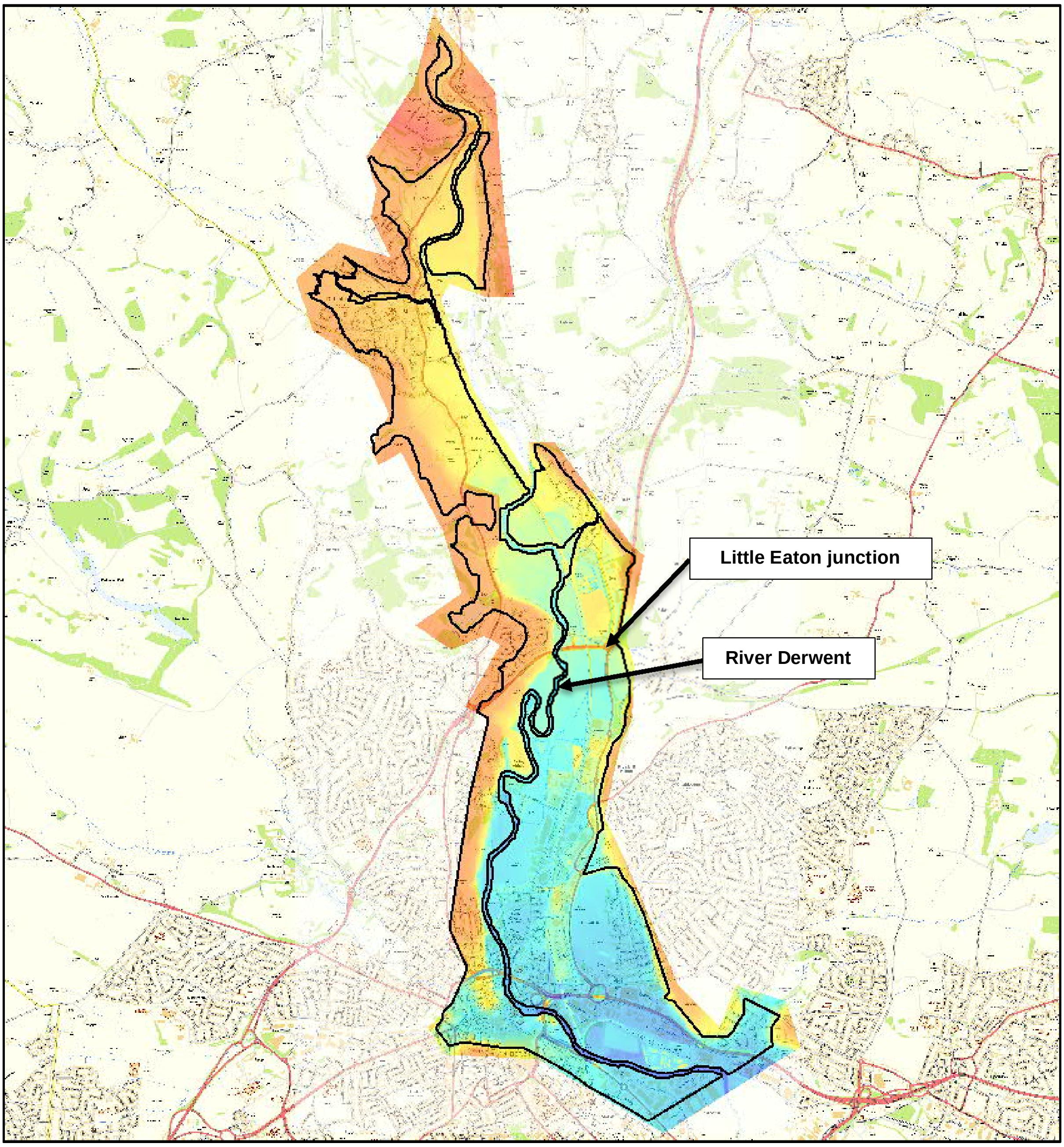


Figure 2: LiDAR coverage relative to the 2D domain

5.3 Topographic survey was also undertaken where the original models were joined (i.e. at the existing A38 bridge over the River Derwent). The survey extended downstream from the Ford Lane bridge (upstream face) to approximately 300m downstream of the existing A38 bridge, and included a total of 13 channel cross-sections within the River Derwent.

5.4 The model was updated to incorporate these sections, replacing the existing sections between DE069 and DE067 inclusive. As per the existing model, the A38 bridge was not modelled explicitly. The Ford Lane bridge representation within the model was retained, but with cross-section details amended to reflect those of the updated topographic survey.

5.5 As per the proposed AECOM actions (16 May 2017), the updates as detailed in the sections below have been made to the Existing Baseline Model.

In-bank Model

5.6 Following incorporation of the new survey cross-sections, the 1D in-bank model was reviewed:

- Panel markers and bank markers were added to the new cross-sections, and were also added to the existing cross-sections where missing or incorrectly placed;
- Additional panel markers were added where necessary;
- A review of panel marker placement was undertaken based on plotting the conveyance properties of each cross-section and ensuring the resultant stage-conveyance curve was reasonably smooth;
- A 1D model 'Health Check' was undertaken to confirm that panel markers and bank markers were not missing at any locations.

5.7 Manning's 'n' values were reviewed and are considered sensible for the modelled reach, particularly within the vicinity of the A38.

5.8 Although the external review identified the use of further interpolates, particularly due to some instances of large cross-section spacing, it was considered that the current 1D model (following the above amendments) was sufficiently stable to not require use of additional interpolates.

Out-of-bank Model

5.9 Environment Agency comments received 27 February 2017 regarding the out-of-bank model were more specific, and were addressed individually. For those where actions were required, these are discussed below.

5.10 The external review noted that the 2D domain was 'glass-walling' at North Parade Road during the 1% AEP event plus 20% climate change. Although AECOM stated that glass walling in this area is unlikely to have an effect on flood levels within the vicinity of the proposed scheme when considering the 1% AEP event plus 20% climate change event, it was conceded that this could be more problematic at higher flows (i.e. a 50% climate change event). As such, the 2D domain was extended at this point.

5.11 The external review noted that "*It is not recommended to use the Z flag without first checking that the reason for discrepancy in elevations between 1D and 2D domains is appropriate. 'f' is assigned a value of two and six for the HX lines. This should be further explained/ justified*". AECOM's response was that this set-up was as per the received models, and based on the assumption that these z flags/ 'f' values have been appropriately used, they did not need to be changed. However, the Environment Agency indicated that AECOM should be satisfied that the Z flag and f values are appropriate in the vicinity of the proposed scheme. As such, the following additional comments are provided:

- It was not clear why 'f' values of two and six had been applied to the HX lines; this was a legacy of the original Environment Agency model, and was not commented on in associated reports. A test of the baseline model was undertaken in which the f-values were set to zero, and it was determined that the impact was negligible;

- The survey data used to set the culvert inverts within the ESTRY part of the model was not available, so each culvert arrangement and their associated elevations/ inverts cannot be verified. The model grid resolution of 10m x 10m is large, and therefore it is necessary to use z-flags to reset ground levels locally for modelling purposes. AECOM consider that the culverts where z-flags have been applied are not critical in terms of the overall results and their impact on assessing the proposed scheme. The z-flag approach is appropriate, but further detailed analysis might indicate that a better resolution to this issue (such as revising the location of the 1D/2D connection) would be preferable.

5.12 The external review suggested that the source of data for defence levels was included in the accompanying report. AECOM's response was that since such data related to the original modelling, this information could only be extracted from the original modelling reports. For the Milford to Allestree model, the accompanying report entitled Lower Derwent PAR – Hydraulic Modelling Report (Black & Veatch, July 2010) stated that "*additional detail on the crest levels of minor flood banks along the river and flood defences at Little Eaton and Bottle Brook were obtained from topographic survey*". This topographic survey was referenced as being provided by CSL Survey (2003 and 2006), undertaken for the Environment Agency Derby Strategy. The banks (and associated defences) were modelled using z-lines (thick). No other information was provided in the Black & Veatch report. For the Lower Derwent model, the accompanying report entitled River Derwent Trent Confluence Flood Mapping – Final Hydraulic Modelling Report (JBA Consulting, November 2010) stated that "*The underlying topography was created from LIDAR data…" but that a "…'finer' representation of key structures (e.g. flood defences, river bank levels, localised ground raising, etc.) was required in various locations*". The report purported to give further detail within the appendices; however, this only stated which z-lines had been included to represent particular defences, but not how the data to define those z-lines had been sourced. No further information can therefore be provided.

5.13 As part of the 1D model update, the extents of the deactivated cross-sections were exported, and the boundary of the inactive area was adjusted accordingly. This addresses the external review recommendation to check the extent of the 2D inactive area against the extent of the 1D domain, and ensures no double-counting or exclusion of flow areas. A further concern raised by the Environment Agency was that there was some 'glass-walling' in sections around DE077 because there is no 1D-2D linking. In this area, the model set-up is as per the Environment Agency approved model received at the start of this project. The figure in **Appendix A** has been extracted from the Black & Veatch report, which accompanied the model passed to AECOM from the Environment Agency. It confirms that the area around DE077 is modelled in 1D only, with connections to 1D reservoir units. The Black & Veatch report confirms this was done to improve model stability. AECOM consider that the conveyance within this area of 1D only model will be appropriately calculated, since the railway embankment to the west and road to the east will contain the flows. AECOM also consider that the study area would not be significantly affected by this representation. It is not clear why section DE077 has not been connected to the 1D reservoir units, but again it is considered that this would not impact model results within the study area.

5.14 The external review concluded that Manning's 'n' roughness values used for floodplains were reasonable, but noted that a value of 1.0 was used to stabilise parts of the model. According to the River Derwent Trent Confluence Flood Mapping –

Final Hydraulic Modelling Report (JBA Consulting, November 2010), "*some high velocity areas were 'manually' allocated a roughness value of 1.0 in order to improve model stability locally*". AECOM has removed these roughness stability patches, and successfully run the model as a result.

Structures

5.15 There are no structures within the vicinity of the proposed scheme that have not been represented, with the exception of the A38 bridge itself. This has been excluded on the basis that it does not cause any significant restriction to River Derwent flow. The bridge is shown in **Figure 3**.

Figure 3: Existing A38 bridge opening (viewed from upstream)

5.16 The Environment Agency external review noted that the "*A601 bridge and footbridges are missing*". The A601 bridge is not in the vicinity of the proposed scheme, but it is assumed that it was originally excluded for the same reasons as the A38 bridge, particularly given that the Sowter Road/ St Mary's bridge immediately upstream is the main restriction at this location, and is included in the model.

5.17 The Ford Lane bridge did not have an in-line spill in the original model to represent flow over the parapet and onto the deck, nor was this included within the 2D domain. A spill has been added to represent this, based on a typical crest level of the parapet wall as obtained from the latest topographic survey (which only provided spot levels along the wall crest). The variation was not significant enough to warrant greater detail in the geometry. In reality, flow is unlikely to spill over the parapet wall as the adjacent floodplains are at a much lower elevation, and therefore all out-of-bank flow will go around the structure. No other structures were identified that would require an inline spill to represent flow over the deck.

Model Boundaries

5.18 Previously, the downstream boundary of the 2D domain caused water to back-up, since the boundary defaults to a vertical wall if no other boundary type is specified. The Environment Agency external review recommended that an HQ boundary should be applied at the downstream boundary of the 2D domain. This has been done, based on the typical slope of the adjacent floodplain.

6 Proposed Arrangement Model

6.1 The Proposed Arrangement Model has been developed from the Updated Baseline Model. The amendments were essentially to include representation of the proposed scheme junction design (March 2018), which was provided in a CAD drawing (LE FORD LANE STRINGS.dwg). This was converted into TUFLOW Z-Shape and Z-Line files, with associated elevations.

7 Model Simulation and Results

7.1 All model simulations have been undertaken for the 1% AEP event plus 50% climate change allowance (as per the model run done as a sensitivity check, and reported on within the previous Technical Note - 47071319-URS-05-TN-EN-030).

7.2 The Updated Baseline Model was originally run with the same simulation parameters applied as part of previous modelling work at Little Eaton junction (as reported in the Level 2 FRA - 47071319-URS-05-RP-EN-007-2F, and the follow-up Technical Note - 47071319-URS-05-TN-EN-030). However, it was necessary to change the Matrix Dummy Coefficient from a default of 0 to 0.0001 (does not impact on results). However, during early iterations of the Proposed Arrangement Model, some mass balance errors were identified. As such, a lower model time-step was used to reduce this error; this meant a reduction of the 2D time-step from 5 seconds to 2 seconds, and a reduction of the 1D time-step from 2.5 seconds to 1 second.

7.3 To ensure a like-for-like comparison against the results of the Proposed Arrangement Model, the Updated Baseline Model was run using these revised time-steps. The cumulative mass balance error was within the accepted 1% tolerance (see **Figure 4**).

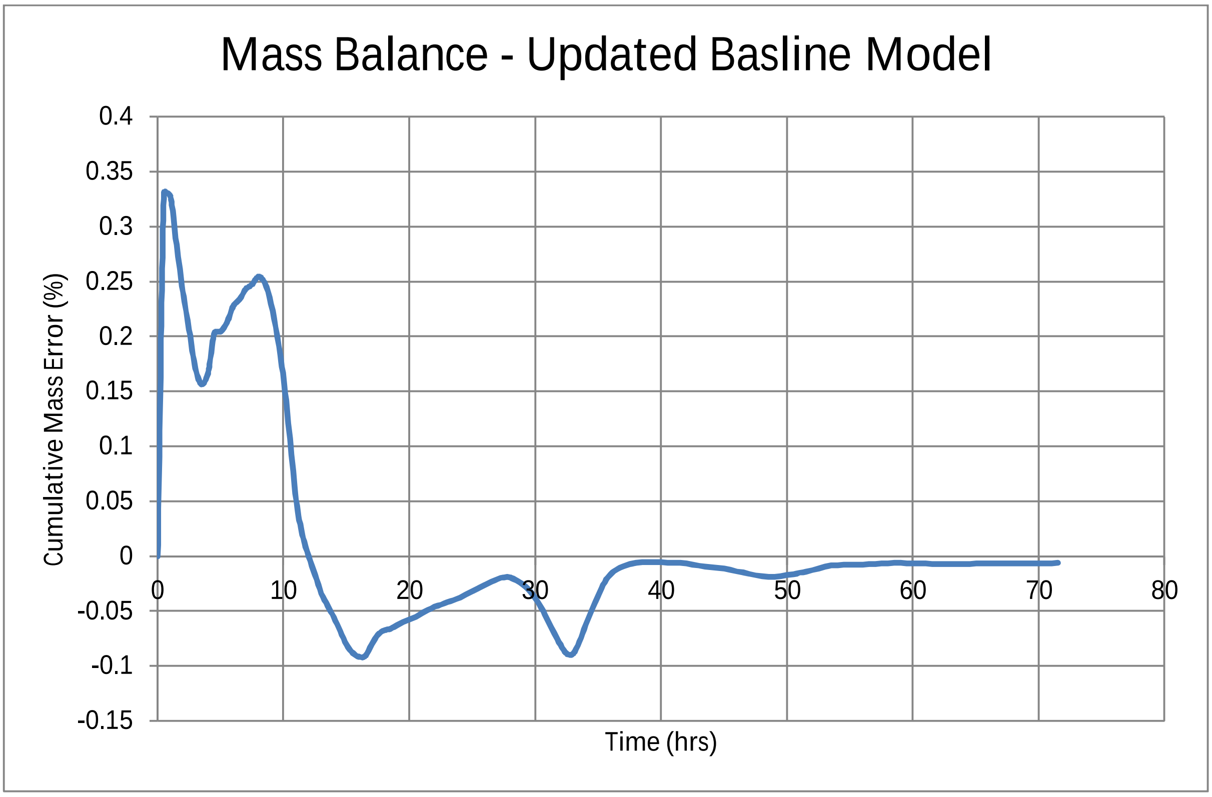


Figure 4: Cumulative mass error plot for Updated Baseline Model

7.4 The Proposed Arrangement Model was run with the same simulation parameters as the Updated Baseline Model (including the changes to time-steps). In addition, it was necessary to change the Matrix Dummy Coefficient from 0.0001 to 0.00001. The cumulative mass balance error was within the accepted 1% tolerance (see **Figure 5**).

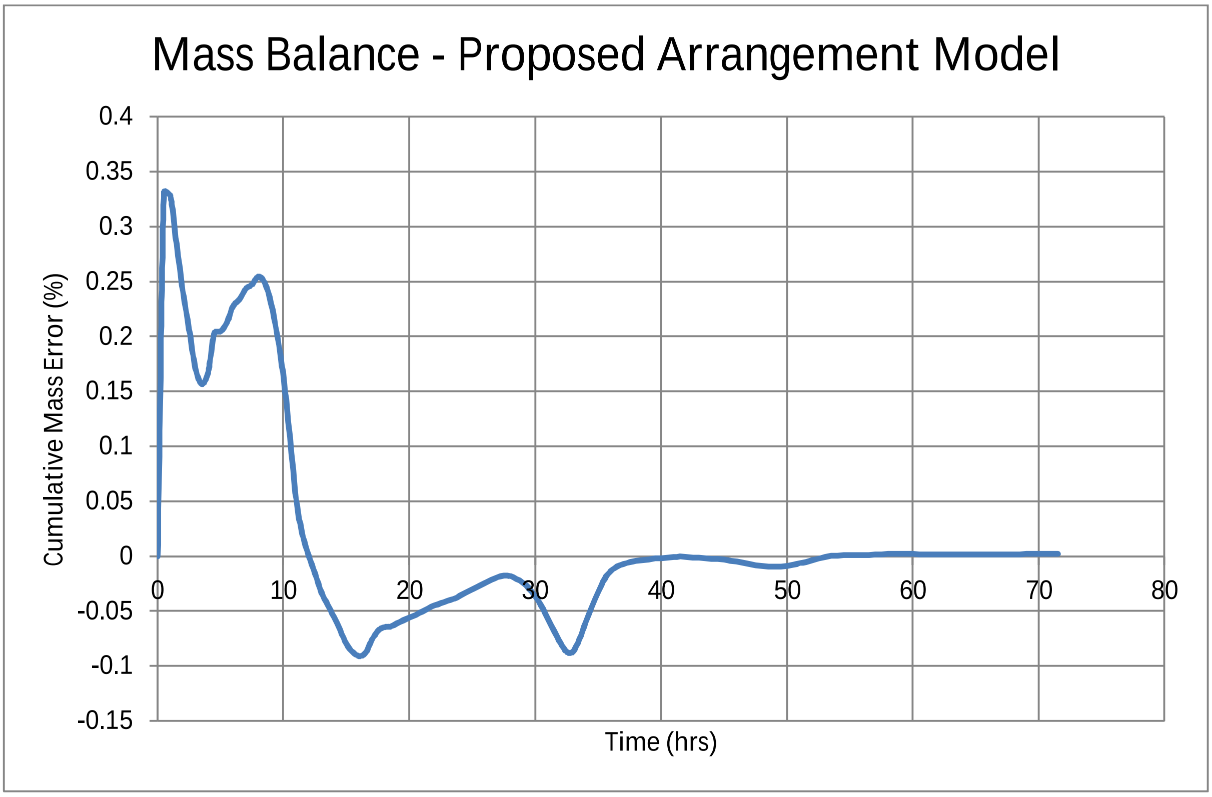


Figure 5: Cumulative mass error plot for Proposed Arrangement Model

7.5 Comparison of results between the Updated Baseline Model and the Proposed Arrangement Model has been undertaken as per previous reporting; a depth-difference map has been created (see **Figure 6)** as well as a point-inspection comparison, the results of which are presented in **Table 1**.

Table 1: Comparison of point-based flood levels between the Updated Baseline Model and Proposed Arrangement Model (also refer to Figure 6)

Flood Assessment Point	1% AEP event plus 50% climate change allowance		
	Updated Baseline – Flood Level* (m AOD)	Proposed Arrangement – Flood Level* (m AOD)	Difference* (mm)
1	53.08	53.08	+10
2	53.15	53.16	0
3	53.07	53.07	0
4	52.56	52.57	+10
5	53.05	53.05	-10
6	51.81	51.84	+30
7	52.45	52.48	+30
8	50.46	50.43	-40
9	50.33	50.33	+10
10	50.31	50.29	-10

*Note that differences are calculated from exact model results, whilst calculated levels are rounded to 2 decimal places

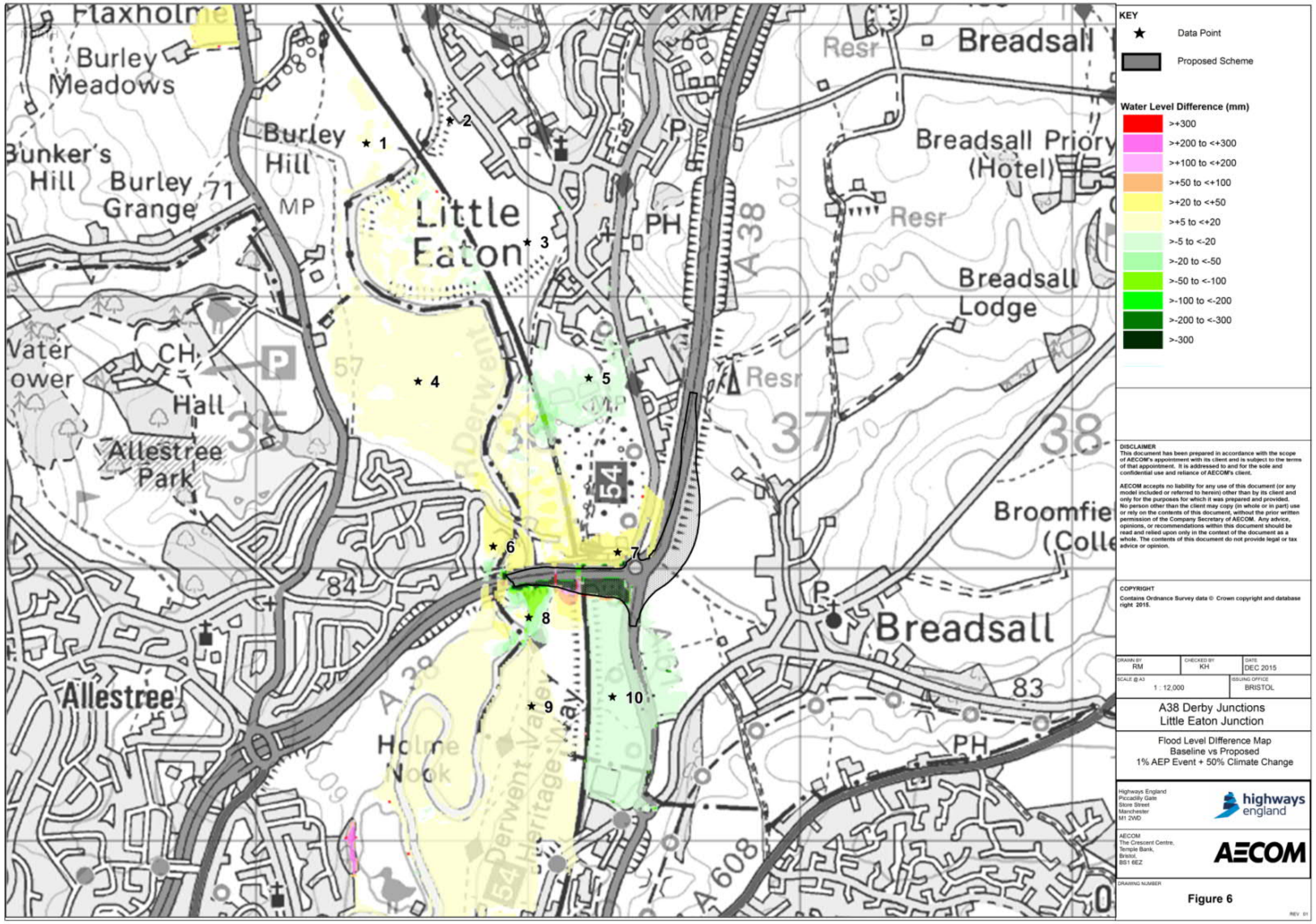


Figure 6: Flood Level/ Depth Difference Map of Updated Baseline Model against Proposed Arrangement Model

7.6 The results in **Table 1** show that for most locations, there would only be marginal changes to flood depths. These marginal changes (i.e. ±300mm) are considered to be within the tolerance of the model. As such, it is concluded that the proposed arrangement would not result in significant changes in flood risk that would require any mitigation strategies to be employed.

8 Floodplain Compensation

8.1 The Environment Agency reviewed the AECOM Technical Note results as submitted on 27 November 2017, with comments being provided on the 25 January and 2 February 2018. Environment Agency comments included a number of actions needed with regard to the modelling (as actioned herein), as well as concerns regarding the absence of floodplain compensation given that the proposed scheme would result in the removal of existing floodplain volume. Although modelling has shown that the proposed scheme would not have a significant impact on flood levels locally, the Environment Agency consider that floodplain compensation is required to mitigate against cumulative impacts of volumetric floodplain loss.

8.2 Given the above, an assessment of the volumetric loss in floodplain as a result of the proposed scheme was undertaken using the 2D grid representation of the resulting topography, as defined by the TUFLOW model. Volumetric losses were only calculated where there was an increase in existing ground levels, and there was flooding in the baseline (existing) scenario (for the 1% AEP event plus 50% climate change).

8.3 In practice, floodplain compensation is preferably provided on a level-for-level basis. Since floodplain compensation works cannot be provided immediately adjacent to the proposed scheme, an alternative location was identified downstream of the A38, within the right bank floodplain (refer to **Figure 7**). The following approach to calculating the volumetric loss was applied:

- Calculated volumetric losses below flood levels at 4-hour intervals throughout 1% AEP event plus 50% climate change;
- Calculated equivalent flood level for the same 4-hour intervals at the location of proposed compensatory works; and
- Determined the required volume to be provided between these flood level intervals.

8.4 Essentially, the approach used time as a proxy for level in determining the form of the compensation works. **Table 3** summarises the outcome of the assessment.

Table 3: Required compensatory volumes based on time, and the levels between which they need to be provided at the proposed compensatory works location

Time (hours)	Cumulative Volume Required (m^3)	Interval Volume Required (m^3)	Lower Level (m AOD)	Upper Level (m AOD)
8	0	0	n/a	49.59
12	18	18	49.59	49.73
16	405	386	49.73	49.79
20	609	205	49.79	49.82
24	873	264	49.82	49.85
28	1,320	447	49.85	49.88
32	5,339	4,019	49.88	49.93
40	12,439	7,099	49.93	50.19
44	12,909	471	50.19	50.39
Max	12,995	86	50.39	50.42

8.5 Based on this information, a ground modification exercise was undertaken utilising the same LiDAR data as used in the hydraulic model. The exercise sought to determine how the proposed area of compensatory works could be amended to provide the required interval volumes (as per **Table 3**). An additional consideration was that the land to be modified would need to retain a slope that would enable the landowner to retain the use of farm vehicles. The outcome of this was that there was significant over provision of required volume at the majority of intervals. There was some under provision at the higher flood levels, but the overall cumulative volume provided would be greater than that required - this is demonstrated in Table 4.

Table 4: Comparison of required and provided compensatory volumes

Time (hours)	Cumulative Volume Required (m^3)	Cumulative Volume Provided (m^3)	Variation (m^3)	Lower Level (m AOD)	Upper Level (m AOD)
8	0	4,291	+4,291	n/a	49.59
12	18	5,619	+5,601	49.59	49.73
16	405	5,913	+5,508	49.73	49.79
20	609	6,484	+5,875	49.79	49.82
24	873	7,056	+6,183	49.82	49.85
28	1,320	7,627	+6,087	49.85	49.88
32	5,339	8,374	+3,035	49.88	49.93
40	12,439	10,853	-1,586	49.93	50.19
44	12,909	12,760	-149	50.19	50.39
Max	12,995	13,304	+309	50.39	50.42

8.6 The proposed compensatory works were represented in a version of the proposed model using a z-shape, which applied a TIN in which contour lines representing the proposed ground profile were enforced as break lines. The resulting grid was checked to confirm that the z-shape had been applied correctly.

8.7 This model was run and it was found that there was negligible impact on flood levels as a result. The depth-difference map, shown in **Figure 7**, indicates that aside from the increased depths where the flood compensatory works would be located, there is generally an improvement in flood risk compared to the proposed arrangement model without compensatory work (i.e. no difference compared to baseline). Peak flood levels at the sample locations, in comparison to the baseline scenario, were as per the results presented in **Table 1**.

8.8 It is, therefore, concluded that the proposed compensatory works are appropriate from a flood risk viewpoint and would mitigate against cumulative impacts of floodplain loss.

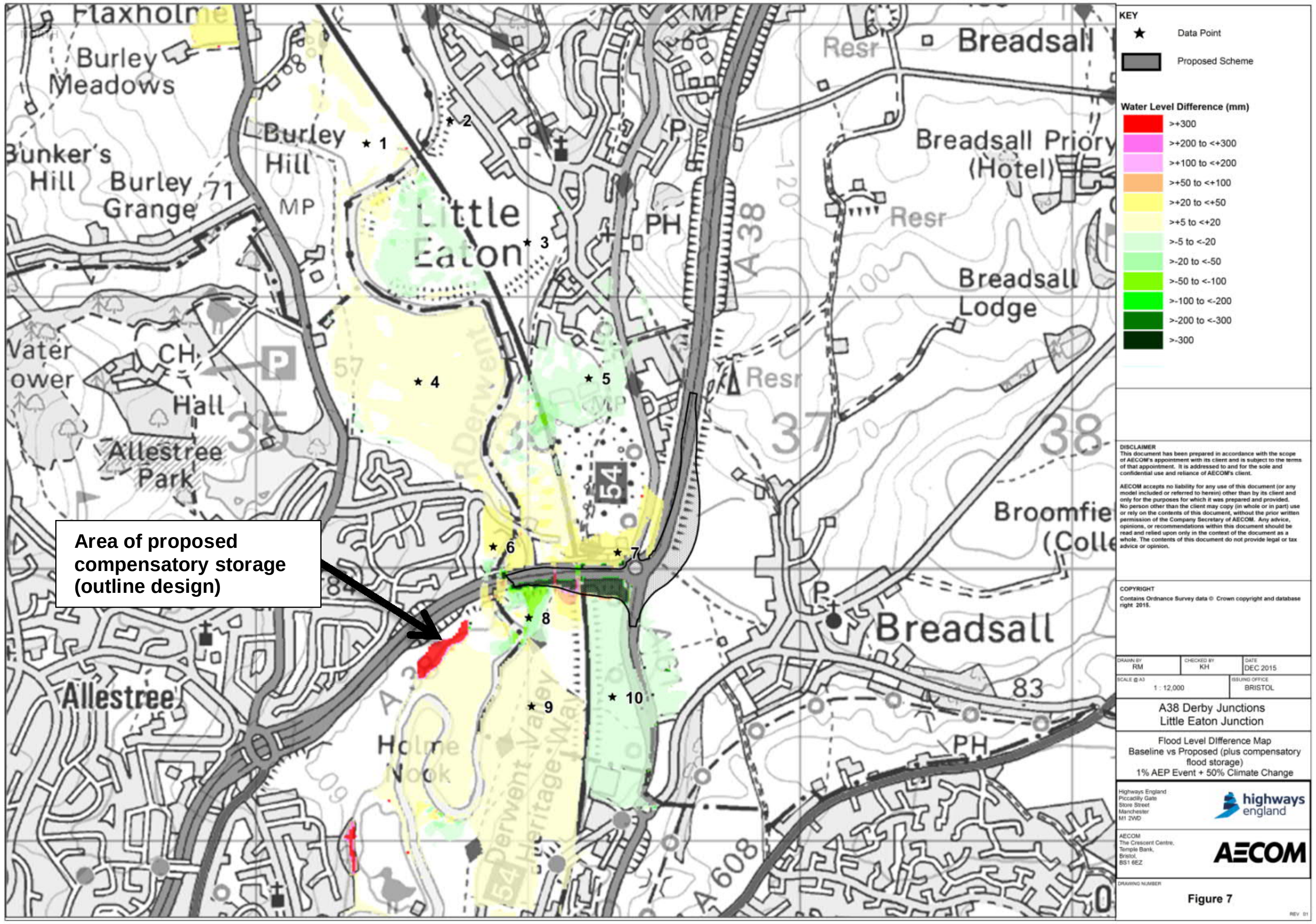


Figure 7: Flood Level/ Depth Difference Map of Updated Baseline Model against Proposed Arrangement Model (with outline compensatory storage)

9 Conclusions

Modelling

9.1 The existing baseline model has been updated with new channel survey, and refined in response to comments received from the Environment Agency and associated external reviewers. The updated baseline model is considered to be an improvement, and a suitable basis upon which the impacts resulting from the proposed scheme could be assessed.

9.2 The proposed arrangement model has been developed to include a suitable representation of the proposed scheme, and the resulting model outputs have been compared against the updated baseline results.

Flood Risk

9.3 The results of the modelling indicate that the proposed scheme would not result in any significant increase in flood risk, and that all localised increases in flood levels are within the model tolerances.

9.4 The Environment Agency stated that there should be no increase in flood levels to any of the properties located to the north of the proposed scheme on the western fringe of Little Eaton. The depth-difference maps confirm that this is the case.

Flood Compensation

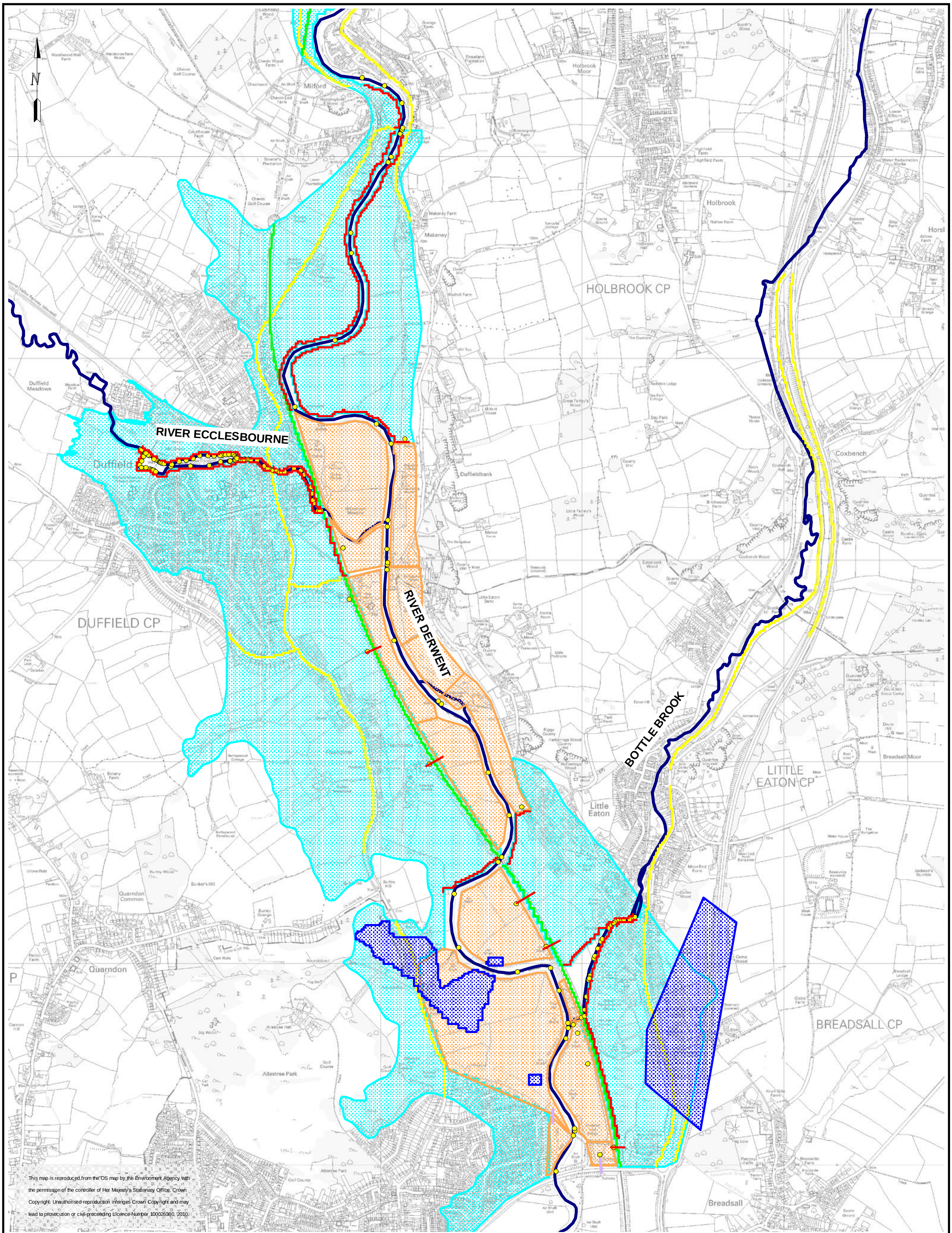
9.5 Whilst flood levels have been found to be acceptable for the proposed scheme, there would still be a volumetric loss in floodplain. The total area of land being raised is approximately 13,500m^2 with ground levels increasing from between 49.0m AOD - 49.5m AOD to 57.0m AOD. In terms of floodplain volumes, it has been estimated that approximately 13,000m^3 would be lost below existing flood levels.

9.6 The Environment Agency considers that floodplain compensation is required to mitigate against cumulative impacts of volumetric floodplain loss.

9.7 Provision of such compensatory storage volume could be achieved by re-profiling the floodplain downstream of the A38, on the right bank of the River Derwent. The outline proposals for ground re-profiling have been designed in such a way as to enable continued operation of farm vehicles and to avoid removing existing trees. The outline ground profiling proposals would over-provide the required volumes at lower flood levels, and although there would be some under-provision at higher flood levels, the overall volume provided would be in excess of that required during a 1% AEP event plus 50% climate change allowance. The modelling results obtained indicate that the outline compensatory works would be appropriate from a flood risk viewpoint and mitigate against cumulative impacts of floodplain loss. The outline ground re-profiling proposals may be subject to alteration during further design stages, noting that the model will need to be amended as such to confirm that the proposals continue to provide appropriate level-for-level compensatory volume, and do not increase flood risks elsewhere.

9.8 We request that the Environment Agency review the details as presented herein and pass comment as to whether the proposed outline flood mitigation strategy and the residual flood risks are acceptable.

Appendix A: Extract from the Lower Derwent PAR – Hydraulic Modelling Report (Black & Veatch, July 2010)



Key

- Tuflow Domain - HXE
- Railway - ZLN
- Road - ZLN
- ISIS Nodes
- LiDAR Correction Layer - ZSH
- ISIS Reservoir Units
- ISIS TUFLOW Join - HXI
- Grid Correction Layer - ZPLG
- ISIS Floodplain Culverts
- Main River

Lower Derwent PAR
Hydraulic Modelling Report

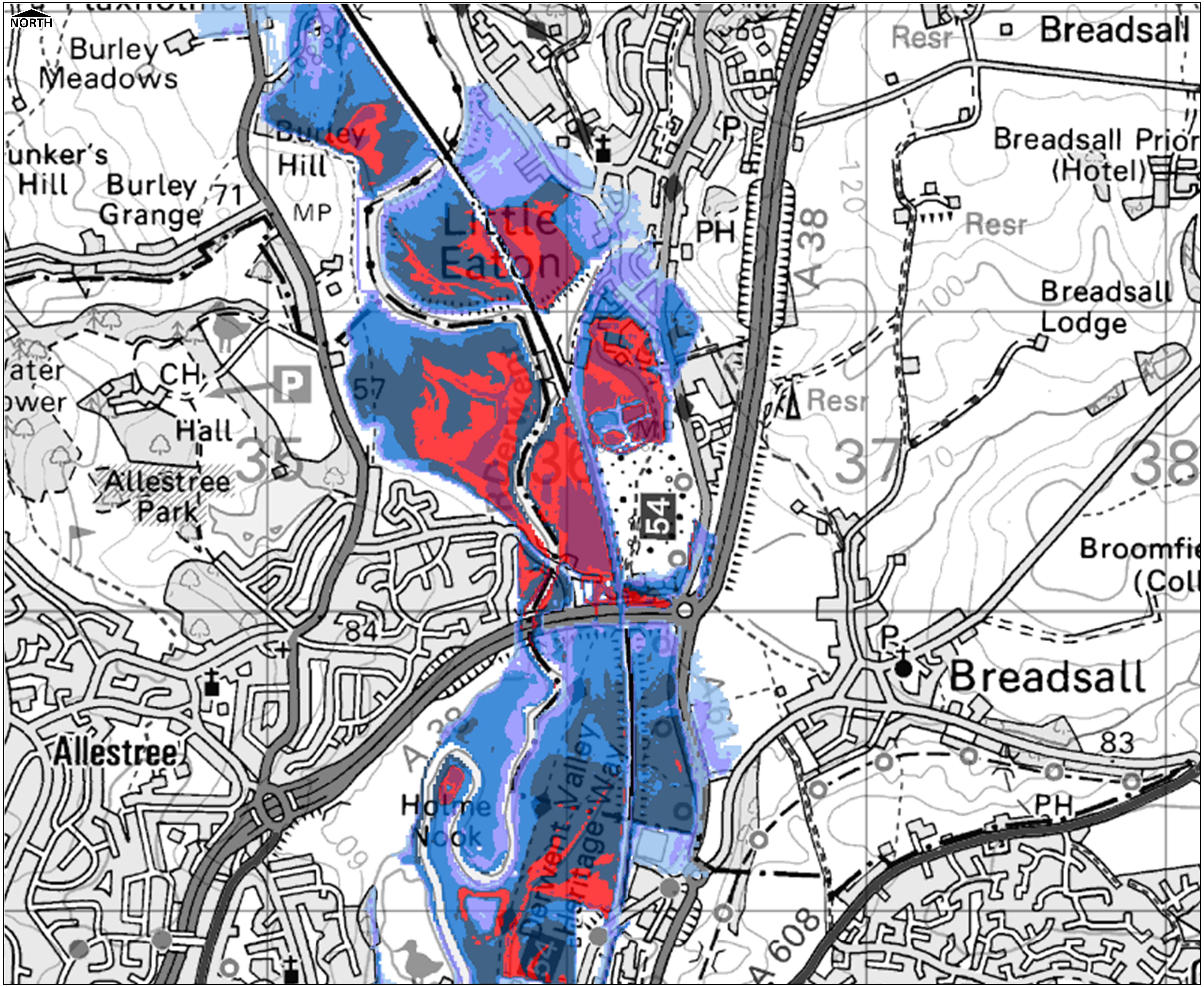
Model Layers

Environment Agency

Scale	Contract No	Designed	Date
1:17,500 (at A3)	108907	NG	July 2010
Date: July 2010	Drawing No.: Figure 3.1	Checked: MDR	Date: July 2010
		Drawn: NG	Date: July 2010
BLACK & VEATCH	ROYAL HASKONING	Checked: TPMP	Date: July 2010

23

Appendix C Fluvial Modelling Flood Depth Maps



KEY

Maximum Flood Depth (m)

- 0m - 0.50m
- 0.50m - 1.00m
- 1.00m - 1.50m
- 1.50m - 2.00m
- 2.00m - 2.50m
- >2.50m

TECHNICAL NOTE

DRAWN BY	CHECKED BY	DATE
RM	KH	DEC 2018

SCALE @ A3	ISSUING OFFICE
1 : 12,000	BRISTOL

A38 Derby Junctions
Little Eaton Junction

Flood Depth Map
Existing Scenario
1% AEP Event + 50% Climate Change

Highways England
Floor 5
2 Colmore Square
38 Colmore Circus
Birmingham
B4 6BN

highways england

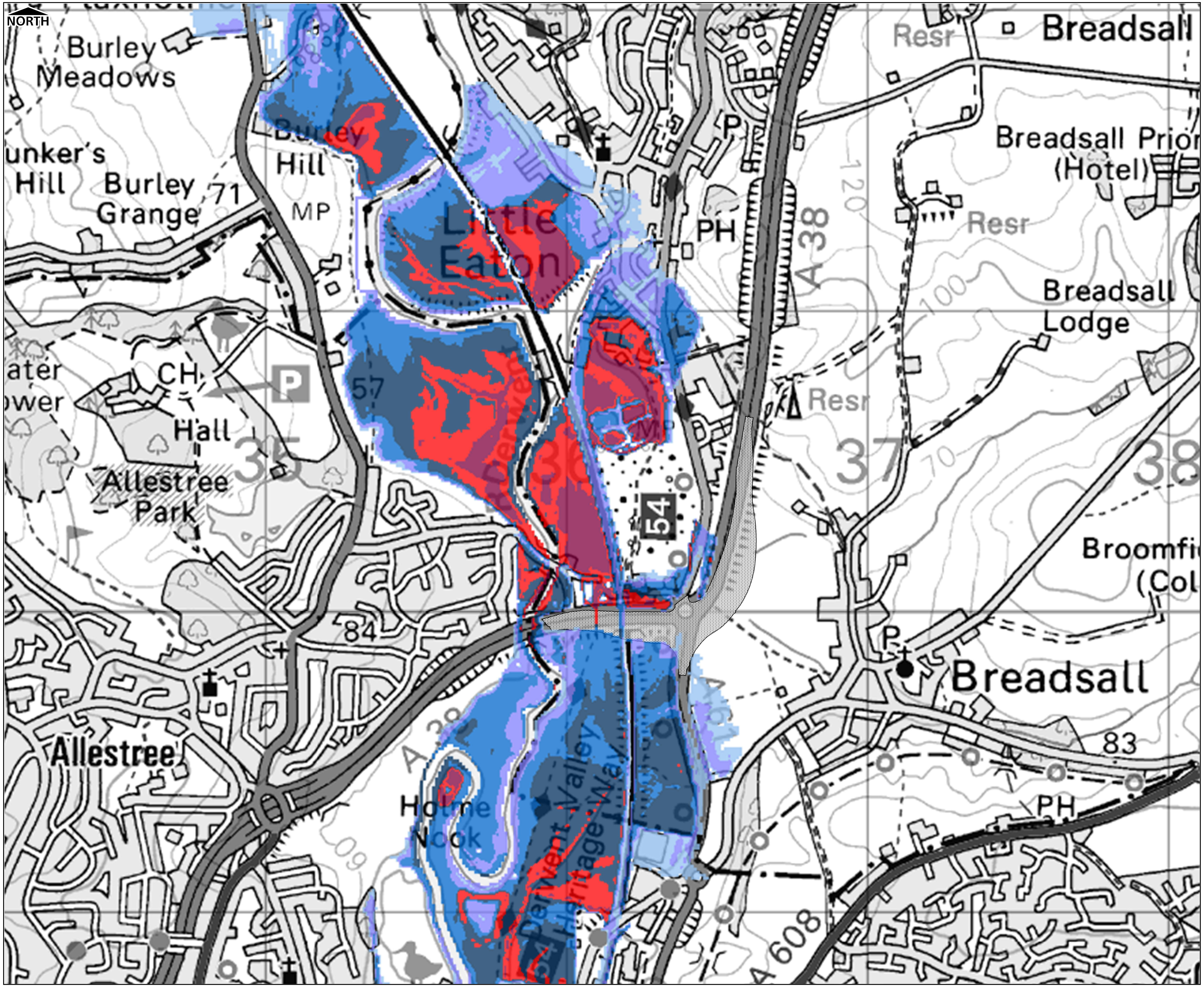
AECOM
The Crescent Centre,
Temple Bank,
Bristol,
BS1 6EZ

AECOM

DRAWING NUMBER

Appendix C1

REV 01



KEY

Proposed Scheme

Maximum Flood Depth (m)

- 0m - 0.50m
- 0.50m - 1.00m
- 1.00m - 1.50m
- 1.50m - 2.00m
- 2.00m - 2.50m
- >2.50m

TECHNICAL NOTE

DRAWN BY	CHECKED BY	DATE
RM	KH	DEC 2018

SCALE @ A3	ISSUING OFFICE
1 : 12,000	BRISTOL

A38 Derby Junctions
Little Eaton Junction

Flood Depth Map
Proposed Scenario
1% AEP Event + 50% Climate Change

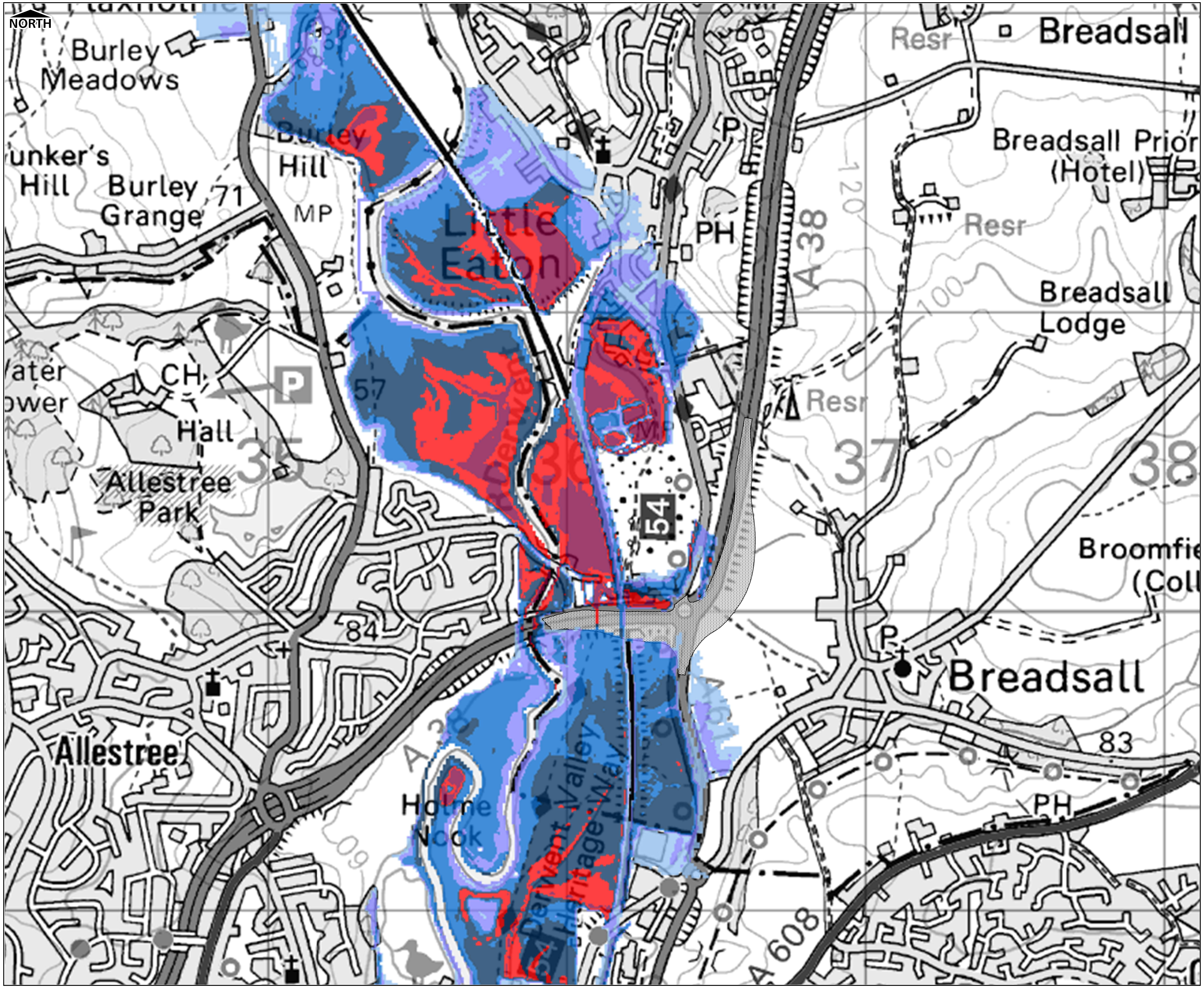
Highways England
Floor 5
2 Colmore Square
38 Colmore Circus
Birmingham
B4 6BN

AECOM
The Crescent Centre,
Temple Bank,
Bristol,
BS1 6EZ

DRAWING NUMBER

Appendix C2

REV 01



KEY

	Proposed Scheme

Maximum Flood Depth (m)

	0m - 0.50m
	0.50m - 1.00m
	1.00m - 1.50m
	1.50m - 2.00m
	2.00m - 2.50m
	>2.50m

TECHNICAL NOTE

DRAWN BY	CHECKED BY	DATE
RM	KH	DEC 2018

SCALE @ A3	ISSUING OFFICE
1 : 12,000	BRISTOL

A38 Derby Junctions
Little Eaton Junction

Flood Depth Map
Proposed Scenario + Compensatory Storage
1% AEP Event + 50% Climate Change

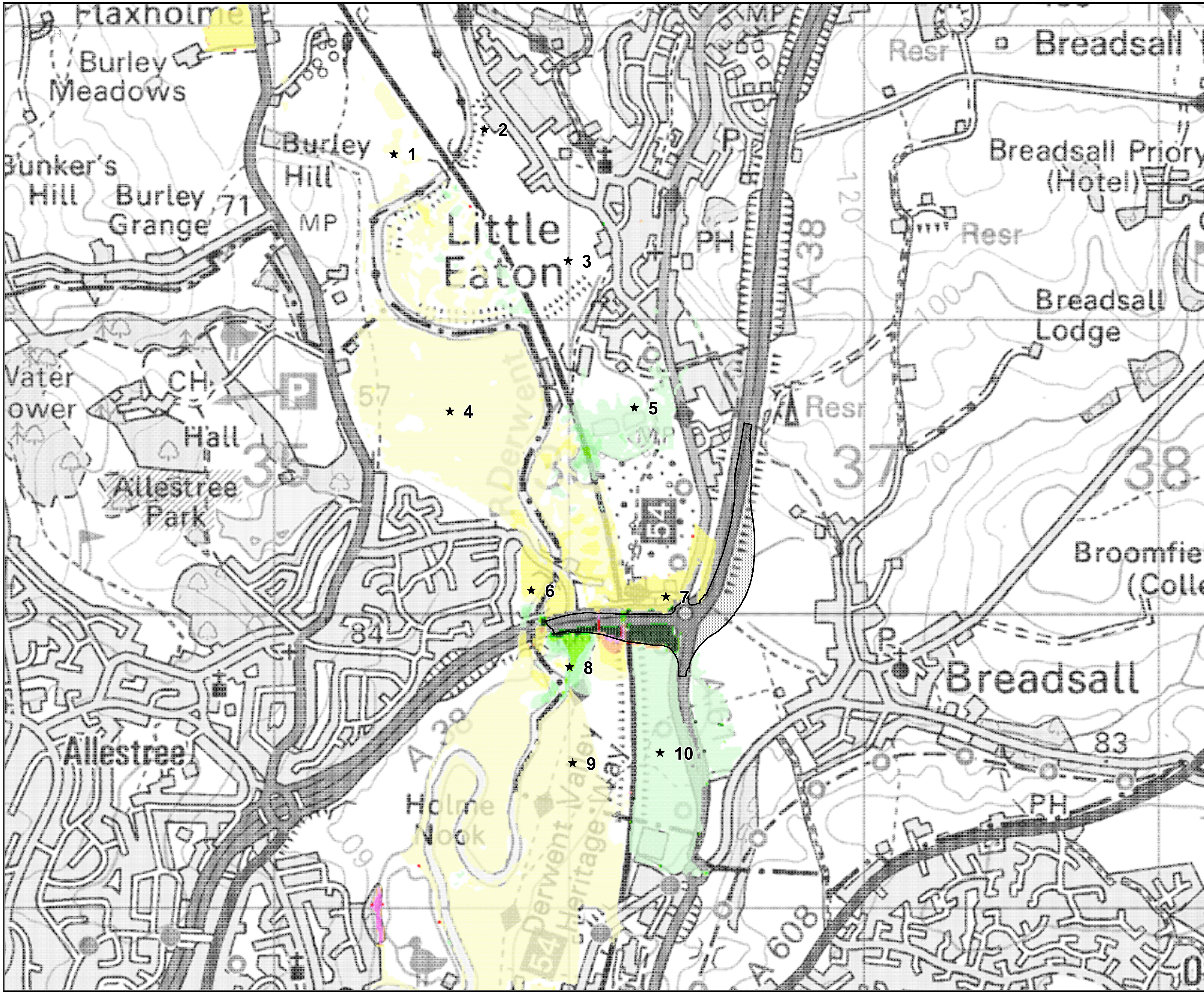
Highways England
Floor 5
2 Colmore Square
38 Colmore Circus
Birmingham
B4 6BN

AECOM
The Crescent Centre,
Temple Bank,
Bristol,
BS1 6EZ

DRAWING NUMBER

Appendix C3

REV 01



KEY

★ Data Point

Proposed Scheme

Water Level Difference (mm)

- >+300
- >+200 to <+300
- >+100 to <+200
- >+50 to <+100
- >+20 to <+50
- >+5 to <+20
- >-5 to <-20
- >-20 to <-50
- >-50 to <-100
- >-100 to <-200
- >-200 to <-300
- >-300

DRAWN BY	CHECKED BY	DATE
RM	KH	DEC 2018

SCALE @ A3	ISSUING OFFICE
1 : 12,000	BRISTOL

A38 Derby Junctions
Little Eaton Junction

Flood Level DIfference Map
Baseline vs Proposed
1% AEP Event + 50% Climate Change

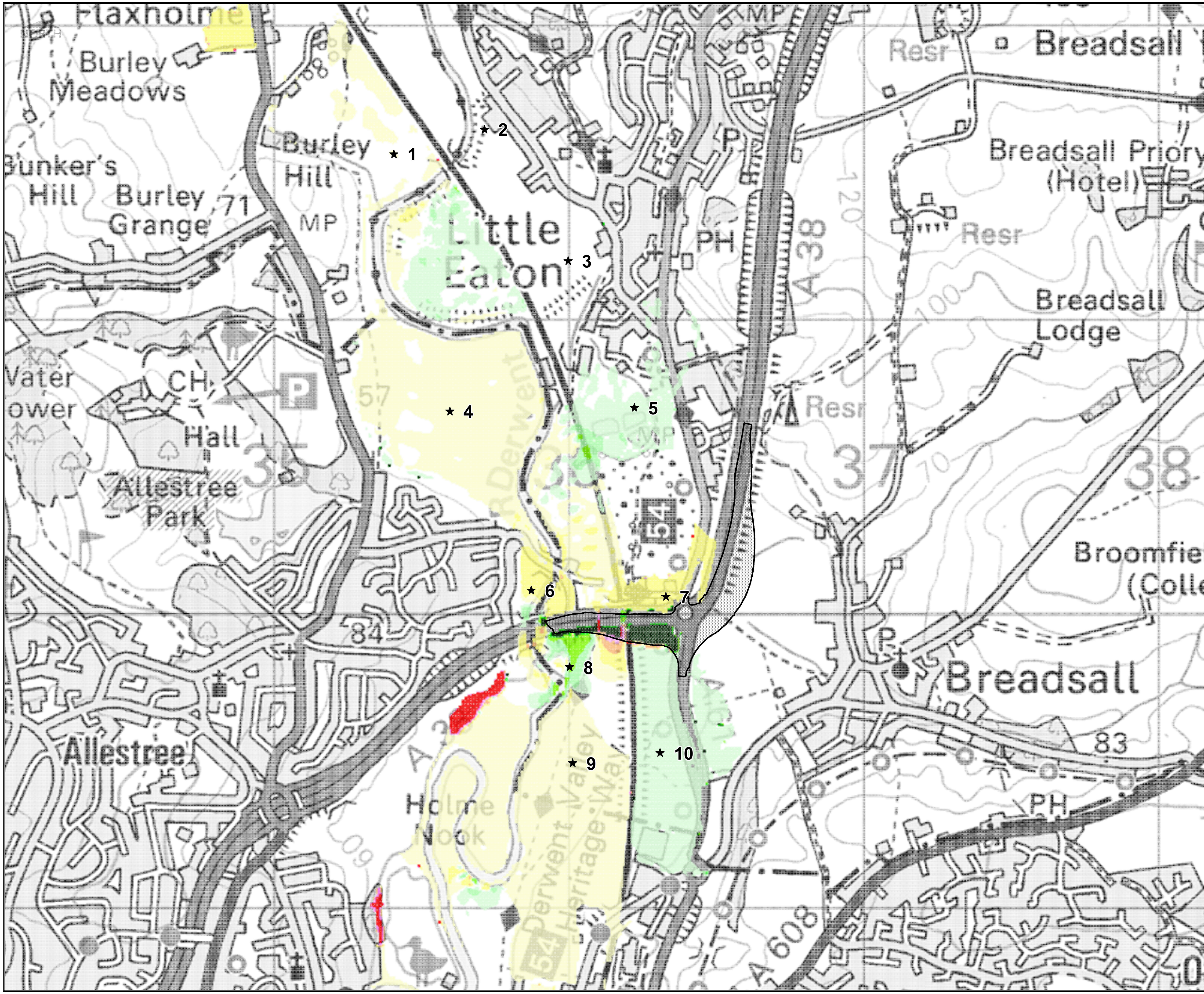
Highways England
Floor 5
2 Colmore Square
38 Colmore Circus
Birmingham
B4 6BN

AECOM
The Crescent Centre,
Temple Bank,
Bristol,
BS1 6EZ

DRAWING NUMBER

Appendix C4

REV 01



KEY

★ Data Point

Proposed Scheme

Water Level Difference (mm)

- >+300
- >+200 to <+300
- >+100 to <+200
- >+50 to <+100
- >+20 to <+50
- >+5 to <+20
- >-5 to <-20
- >-20 to <-50
- >-50 to <-100
- >-100 to <-200
- >-200 to <-300
- >-300

DRAWN BY	CHECKED BY	DATE
RM	KH	DEC 2018

SCALE @ A3	ISSUING OFFICE
1 : 12,000	BRISTOL

A38 Derby Junctions
Little Eaton Junction

Flood Level DIfference Map
Baseline vs Proposed (plus compensatory flood storage)
1% AEP Event + 50% Climate Change

Highways England
Floor 5
2 Colmore Square
38 Colmore Circus
Birmingham
B4 6BN

highways england

AECOM
The Crescent Centre,
Temple Bank,
Bristol,
BS1 6EZ

AECOM

DRAWING NUMBER

Appendix C5

REV 01

Appendix D Surface Water Modelling Technical Note

Project Name:	A38 Little Eaton Junction	
AECOM Project Number:	60533462	
Title:	Little Eaton Surface Water Modelling Technical Note	
Date:	05th February 2019	
Author:	William Madge/ Fiona Ryall	Consultant/ Graduate Consultant
Reviewer:	Katie Pearson	Associate
Approver:	Simon Wild	Regional Director

1. Introduction

This technical note outlines the methodology used to produce a surface water flood model for the Dam Brook ordinary watercourse, located east of the proposed A38 Little Eaton scheme near Breadsall, Derby (Figure 1-1).

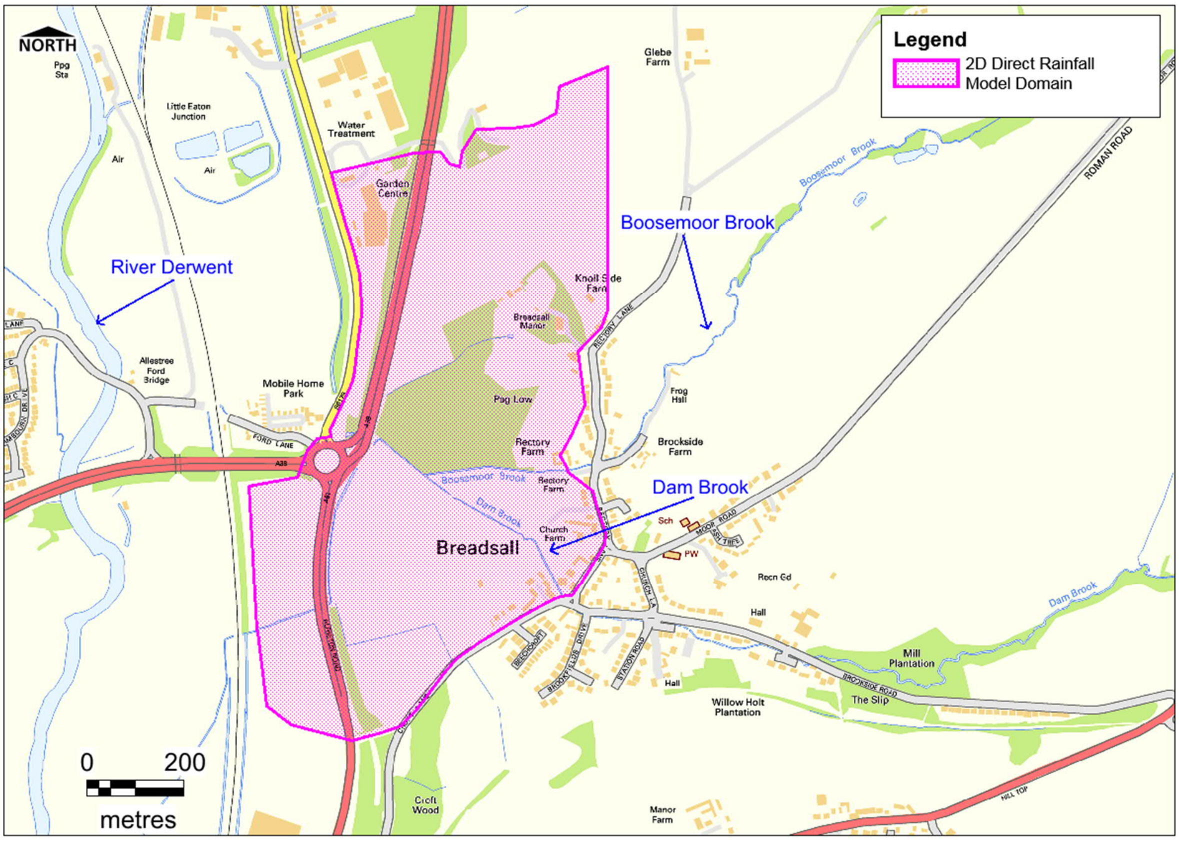


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Figure 1-1: Study Area

The aim of this work is to understand the risks of surface water flooding to and resulting from the Scheme, by undertaking direct rainfall modelling of the upstream catchment area. In particular, the following points have been addressed:

- Assessment of an area identified as posing a high risk of surface water flooding within the Scheme boundary;

- Assessment of an area proposed to be used for temporary spoil storage during Scheme construction; and
- Recommendation of mitigation measures.

2. Data Collection

2.1. Site Walkover

A site walkover was undertaken by AECOM in June 2018 to undertake site observations of critical assets and identify key hydrological features within the study area. This included identification of structures, such as the small 500mm diameter culvert conveying surface water runoff beneath the existing A38 alignment, downstream of Breadsall Manor (Figure 2-1).

Figure 2-1: Culvert beneath Existing A38 Alignment

2.2. Topography

A topographic survey was undertaken as part of the Scheme and has been used to determine the unnamed watercourse channel and culvert alignments in the model. It should be noted that no detailed watercourse cross sections or bank top survey were provided, though topographic spot points were used to inform channel bed elevations, culvert diameters and invert levels.

Floodplain levels were informed by open source LiDAR data, despite sparse coverage of 1m and 2m DTMs (Figure 2-2). In order to utilise the most accurate and available data, both 1m and 2m LiDAR DTMs were merged to define the 2D model domain (with the 1m resolution data taking precedent where applicable).

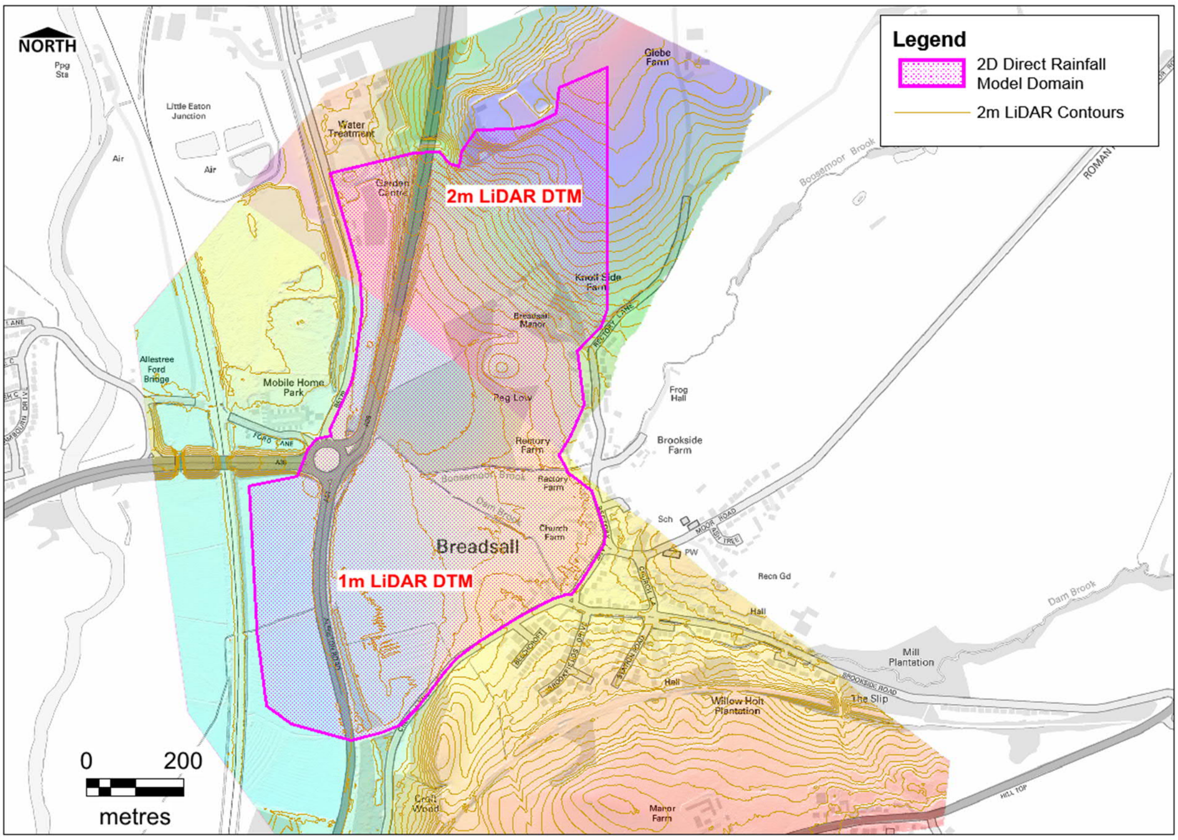

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Figure 2-2: LiDAR Coverage in Study Area

3. Hydrological Analysis

3.1. Introduction

Two Flood Estimation Points (FEPs) were selected based on the locations that would represent upstream boundary conditions for the Dam Brook and Boosemoor Brook watercourses. Catchment descriptors were downloaded from the Flood Estimation Handbook (FEH) Web Service to inform the hydrological analysis (Figure 3-1).

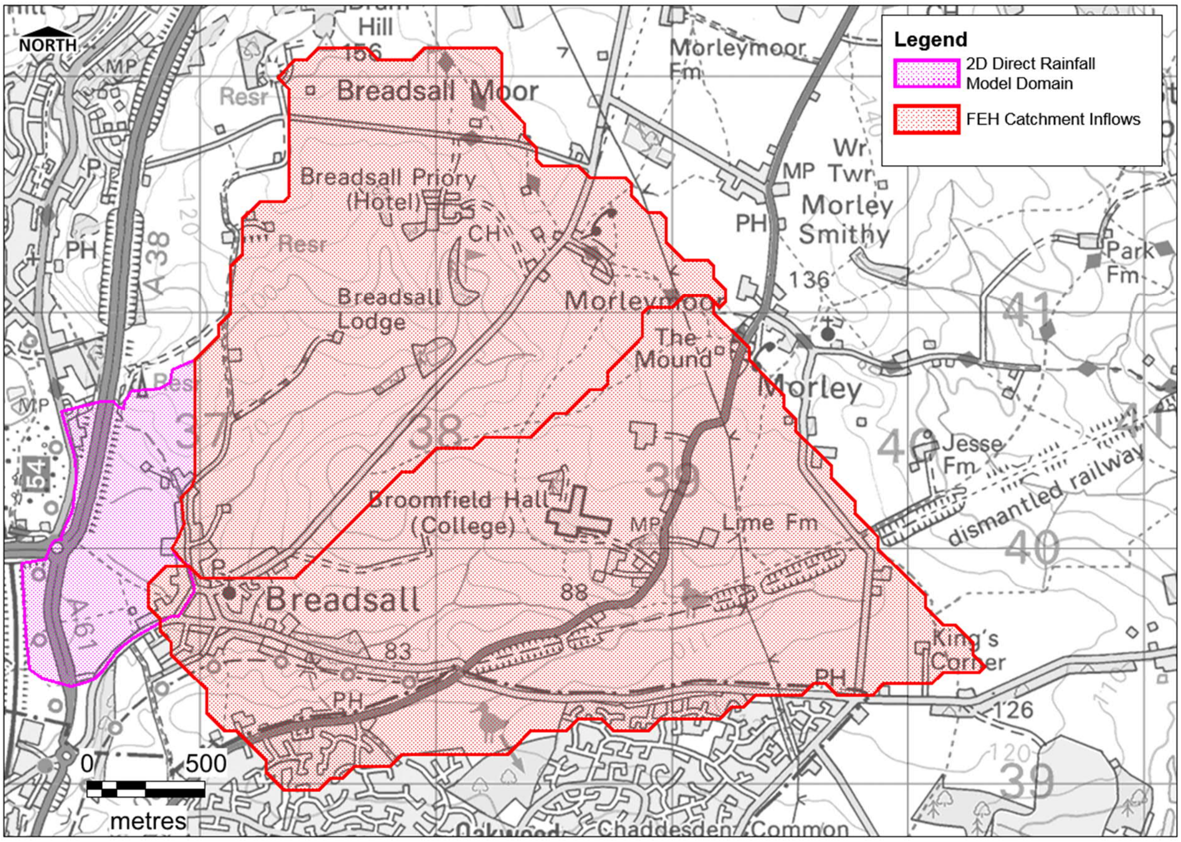

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Figure 3-1: Catchment Areas and Model Extent

3.2. Choice of Method for FEPs

The FEH Statistical and ReFH2 methodologies were undertaken to generate flow estimates at the two FEPs, which were defined by the following key catchment characteristics (Table 3-1).

Table 3-1: FEH Catchment Descriptors

Catchment Descriptor	Dam Brook FEP	Boosemoor Brook FEP
CATCHMENT X	436800	436650
CATCHMENT Y	339850	339950
AREA (km^2)	3.73	2.96
DPLBAR (km)	2.26	1.81
DPSBAR ($m\ km^{-1}$)	52.40	68.30
URBEXT (2000)	0.07	0.00

There were no suitable donor stations available to improve peak flows estimated by the FEH Statistical methodology, through QMED adjustment or enhanced single site analysis. Additionally Table 3-1 shows that the Dam Brook catchment is urbanised (URBEXT>0.03), so ReFH2 urban hydrographs could be expected to represent improved routing of surface water through the catchment to the FEP.

In summary, and to provide a consistent approach across all FEPs, ReFH2 urban hydrographs were used to represent upstream boundary conditions for the Dam Brook and Boosemoor Brook watercourses.

3.3. Design Rainfall Profiles

LiDAR analysis was undertaken to define watershed boundaries and thus determine the intermediate catchment areas that also drain towards the existing and proposed A38 alignments. Although open source LiDAR coverage is relatively sparse in the area, catchment delineation was not limited, and sufficient coverage of contributing catchment areas was achieved (Figure 2-2).

Once the 2D model domain had been defined the domain area and location was compared against the already captured FEP catchment descriptors. It was concluded that the Boosemoor Brook catchment descriptors were representative of the intervening catchment, and so the ReFH2 urban design rainfall profiles were extracted and applied as total direct rainfall across the 2D model domain using 2d_rf polygons.

OS MasterMap data was used to differentiate between 2d_rf polygons, both in terms of spatial extent and also by application of discrete interception ratios to each polygon (Table 3-2).

Table 3-2: Interception Ratios

OS MasterMap Description	Interception Ratio
Natural surface	0.50
Inland water	1.00
Structure	0.90
Scrub	0.50
Multiple surface (garden)	0.50
Road	0.90
Railway	0.35
Manmade surface or step	0.80
Nonconiferous trees	0.20
Coniferous trees	0.20
Path or track	0.75
Building	0.90
Unclassified (or broken)	0.50
Orchard	0.20
Marsh reeds or saltmarsh	0.20

4. Little Eaton Surface Water Flood Model

4.1. Model Software

A 2D only direct rainfall model was built using TUFLOW software (TUFLOW_2016_03_AE-w64.exe) to assess the impact of the existing and proposed A38 alignments on surface water runoff within the Dam Brook catchment.

4.2. Model Extent and Schematisation

The Little Eaton surface water flood model accounts for flows generated throughout the Dam Brook and Boosemoor Brook catchments, including intervening catchment areas, and extends to the downstream side of the existing A38 alignment (Figure 3-1).

The model comprises a single 2D domain with a grid resolution of 2m. This is a suitable resolution considering the average watercourse channel width, available LiDAR data and the need to work with practical model run times. The Little Eaton surface water model has a total simulation duration of 20hrs.

The existing watercourse channels and culverts are schematised in the 2D domain using levels picked up in the topographic survey (Figure 4-1).

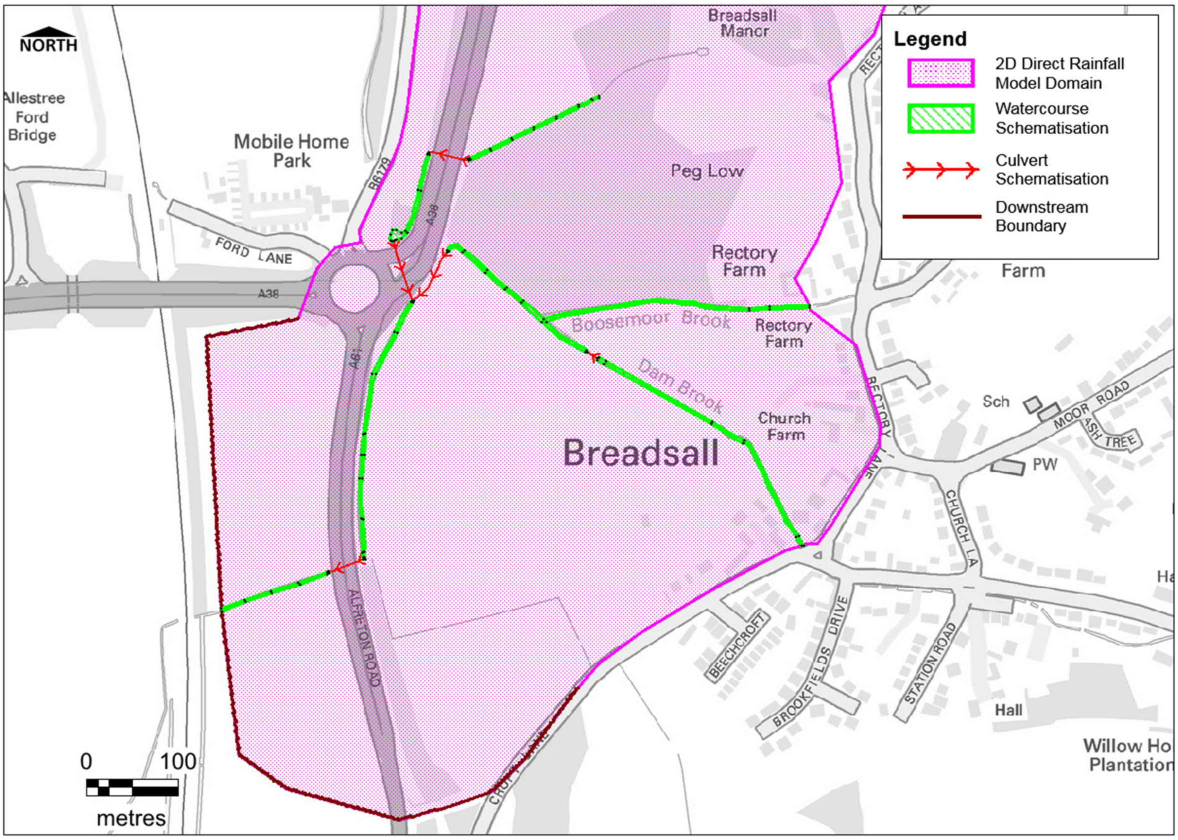

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Figure 4-1: Model Schematisation

Although the general watercourse alignment and gradient could be estimated from the available drawings, it was not possible to provide a detailed representation of in-channel capacity or conveyance in the absence of detailed watercourse survey. 2d_zshp files were used to define the channel bed elevations in the model; these were read from the available topographic spot levels and then interpolated between those values. Channel bank elevations were read in from the underlying LiDAR DTM.

4.3. Roughness Coefficients

Manning's n roughness values were assigned based on OS MasterMap feature codes. In addition to the interception ratios discussed in Section 3.3, this provided a detailed representation of rainfall runoff response within the study area.

4.4. Boundary Conditions

Upstream boundary conditions for Dam Brook and Boosemoor Brook were applied at the eastern edge of the 2D model domain using 2d_bc layers. Hydrograph inflows to each watercourse were generated by the hydrological analysis undertaken as part of this study (Section 3).

Initially it was considered whether rising levels on the River Derwent in flood would affect the ability of floodwater to drain out of the study area, and whether this should be represented in the downstream boundary of the model. However, considering the size of the study catchment compared to the River Derwent catchment, it is reasonable to assume that a peak flood flow on Dam Brook is unlikely to coincide with a peak flood flow on the River Derwent.

For a 4.5h duration rainfall event, the Little Eaton surface water flood model has a total simulation duration of 20 hrs and a peak flow at 5.25 hrs during the 1% AEP + 50% climate change event. The critical storm duration for the River Derwent is significantly longer and in the River Derwent the total simulation time is 72 hrs with a peak flow at 44.5 hrs in vicinity of the study area. Analysis of the River Derwent model results shows that floodwater begins backing up underneath the railway line at approximately 14 hrs, significantly later than the modelled peak flow on Dam Brook. Even at a simulation time of 20 hrs, flood levels on the River Derwent would not be high enough to result in locking of the downstream boundary and backing up of floodwater into the red line boundary (**Error! Reference source not found.**).

To consider potential interaction between the floodplain of the River Derwent and the smaller surface water catchments to the east, the 2D domain of the existing River Derwent model was expanded to include the Dam Brook catchment. The inclusion of the Dam Brook in the Derwent model shows an apparent increase in flood volumes in places where water could not flow, as it was outside the model extents. Depths upstream of the proposed A38 alignment were reduced, while a marginal increase in flood depths downstream of the proposed highway was also noted. These differences appear to be relatively minor and are the result of changes to the hydraulics of the system brought about through expansion of the model extents.

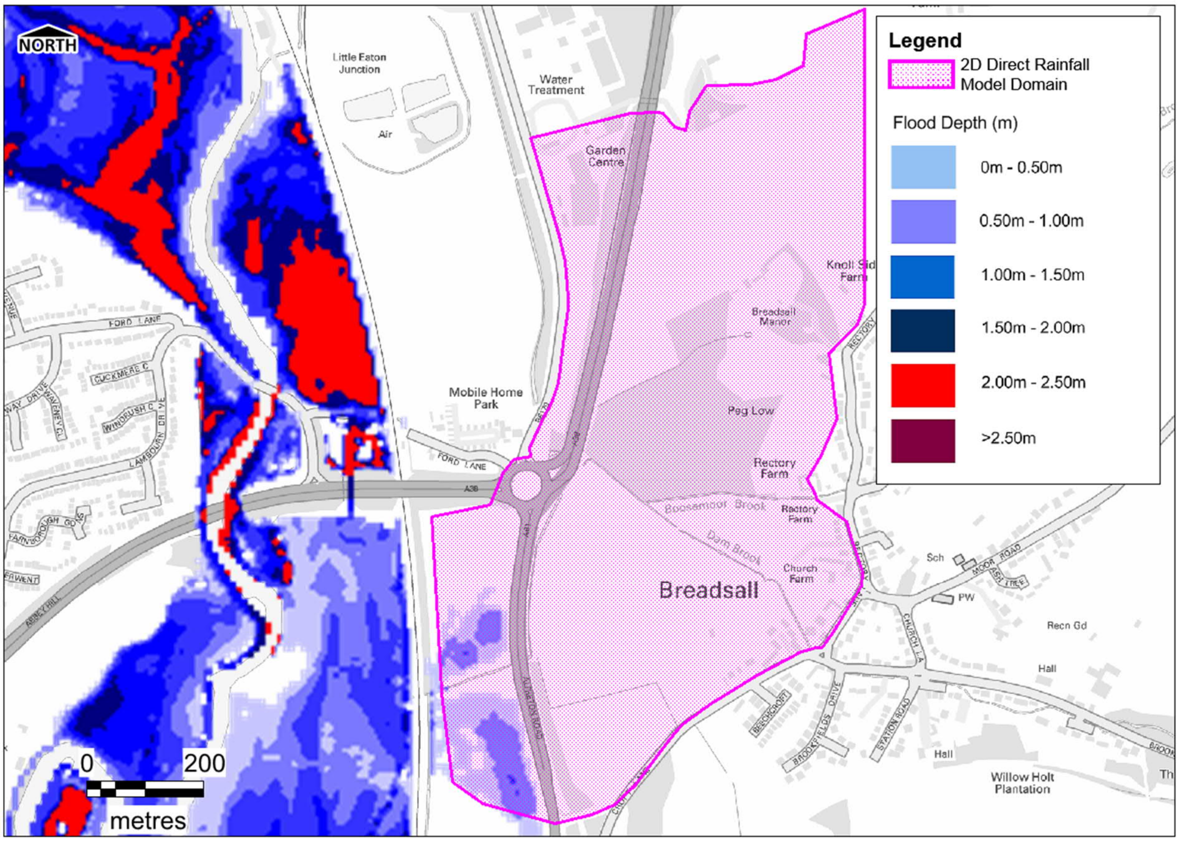

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Figure 4-2: River Derwent Flood Depths at t=20 hrs, Proposed Scenario, 1% AEP + 50% Climate Change

Therefore, a 2d_bc HQ boundary based on the channel bed gradient was used as the model downstream boundary.

4.5. Model Stability

The TUFLOW 2D Mass Balance output (Cumulative Mass Error %) mostly remains within +/-1% for all simulations, which is considered the normal criteria for a 'healthy' model. An exception would be for the first two hours of each simulation. However, this is not of concern because instability is often experienced at the start of direct rainfall model simulations, in response to the rapid wetting and drying of cells throughout the 2D domain.

5. Model Results

A number of model simulations were run for the baseline and proposed scenarios, but this technical note solely focusses on discussing the results associated with the 1% AEP + 50% climate change design flood event.

5.1. Existing Scenario

The baseline model highlights a significant attenuation of surface water runoff on the upstream face of the existing A38 alignment, downstream of Breadsall Manor (Figure 5-1). For reference, several point inspections are provided to illustrate the modelled depth of floodwater in vicinity of the Scheme boundary.

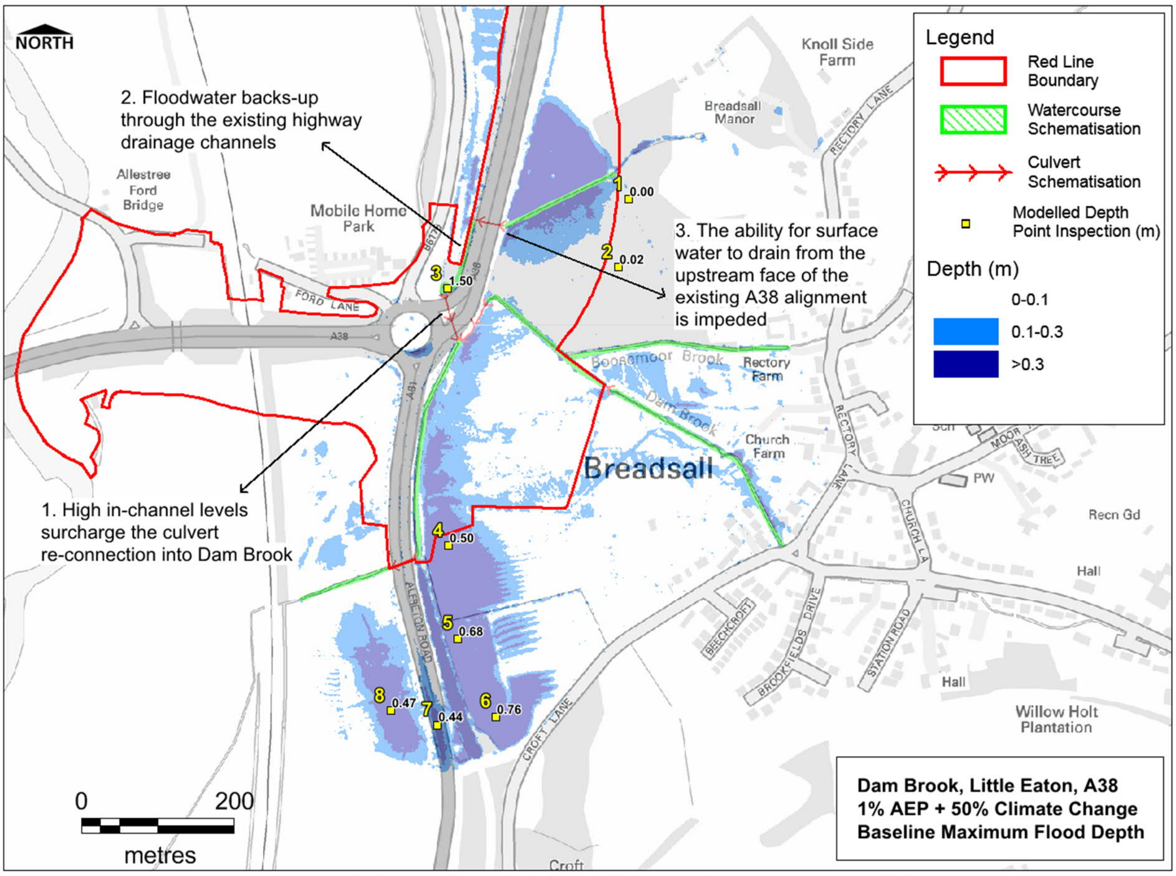

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Figure 5-1: Dam Brook 1% AEP + 50% Climate Change Baseline Maximum Flood Depths

Surface water attenuation appears to be predominantly caused by backing up of floodwater from the main Dam Brook channel. High in-channel flood levels are predicted to surcharge the culvert re-connection into Dam Brook, resulting in backing-up of floodwater through the existing highway drainage channels. The ability for surface water to drain from the upstream face of the existing A38 alignment is therefore impeded. The small diameter of the existing culvert in this location is also likely to cause a flow restriction (Figure 2-1).

The capacity of the main Dam Brook channel downstream of the Boosemoor Brook confluence is limited by the shallow bed gradient and the number of existing culvert structures. In times of flood, the model shows that the culvert structures surcharge, resulting in channel capacity exceedance and propagation of flow onto the floodplain. This mechanism contributes to a significant accumulation of surface water along the upstream face of Alfreton Road, to the south of the Scheme boundary. Once the available floodplain storage in this area is surpassed, floodwater overtops the existing embankment and flows across Alfreton Road, ponding in a depression immediately west of the highway.

5.2. Surface Water Management – Development of the Proposed Scenario

Between October 2018 and January 2019, the proposed design of surface water management measures has evolved, taking into account highway drainage, Water Framework Directive (WFD) requirements and ecological constraints which has been shown (see results below) to work in principle. A series of modelling tests has been undertaken to support the design evolution, but to aid clarity in the report, only the results of the final modelling scenario are reported in Section 5.3 of this report.

The existing culvert under the A38 would be retained for highway drainage of the proposed realigned roundabout and carriageway. Initially the proposals included an extension of this culvert in a straight line, between the two highway runoff attenuation basins to connect into the realigned Dam Brook channel. However, the invert level of the existing culvert outfall is 48.9m AOD and the proposed level of the realignment channel is 49.9m AOD. In order to provide a positive outfall in this location, the realignment channel levels would need to be reduced by at least 1m. Doing so would be detrimental to the morphological status of the channel and so this is not an option that has been tested in the model.

An alternative option to create a positive outfall was investigated with an extended culvert connecting into the base of the southernmost highway runoff attenuation basin. Whilst this option presented a viable gradient, the River Derwent hydraulic model simulations are shown to inundate the area north of the existing junction, before flowing through this culvert and into the study area (**Error! Reference source not found.**). It is therefore not possible to directly connect this culvert into an attenuation basin, due to the risk of fluvial inundation from the River Derwent. This flood mechanism would also require that highway drainage was adequately treated prior to entering the culvert.

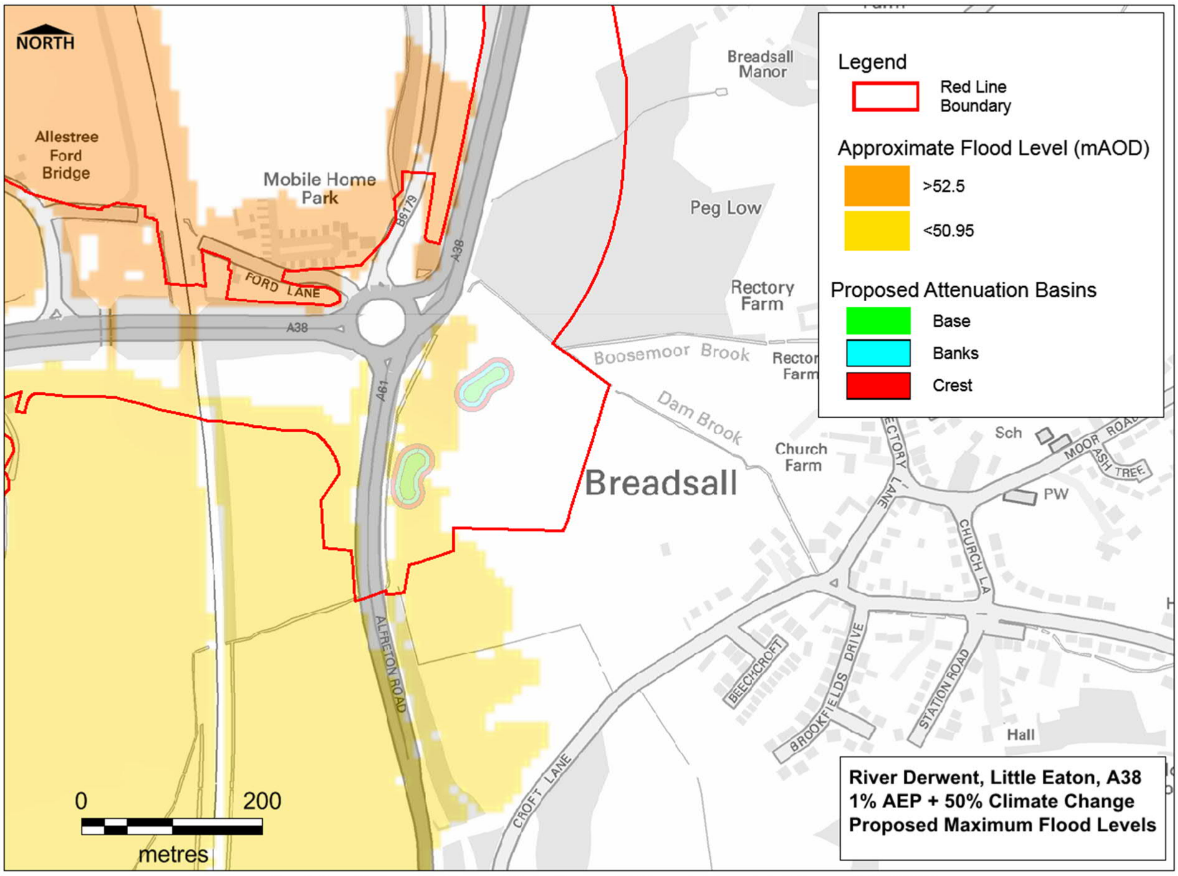

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Figure 5-2: River Derwent 1% AEP + 50% Climate Change Maximum Flood Levels

To reconcile the various topographic and hydraulic constraints, it was necessary to extend the existing culvert to connect into a new pond at the southernmost extent of the study area. This facilitates a positive outfall through the culvert to the pond, and from the pond back into the Dam Brook realignment channel. The culvert extension assumed an additional 209m of 900mm diameter pipe, with invert levels at the upstream and downstream faces of 48.90m AOD and 48.70m AOD, respectively.

5.3. Modelling of the Preferred Proposed Scenario

There are a number of elements to the Scheme design and surface water management measures for this junction which have the potential to influence or be influenced by surface water flood risk. For this reason, the hydraulic model has been modified to incorporate the Scheme design so that the potential impacts can be assessed and understood. To represent the Scheme design the 'proposed scenario' version of the hydraulic model includes representation of these design elements within the Scheme boundary (Figure 5-2):

- Realignment of the existing A38 Little Eaton junction into a new island and main line flyover;

Proposed levels were supplied to the modelling team in .xyz format. Ztin polygons were created for both the main line and junction arrangements, then stamped onto the baseline DTM.

- Construction of two runoff surface water attenuation basins to treat and attenuate highway drainage;

Proposed drawings were supplied to the modelling team. Zshape polygons were created to represent the base, banks and crest levels of the proposed attenuation basins.

- Extension of the existing culvert under the A38, which currently connects highway drainage channels (north of the island) to span the width of the proposed A38 alignment;

The existing culvert geometry was supplied as part of the baseline topographic survey. No design levels for the proposed culvert extension were supplied, so an alignment that could satisfy the various topographic and hydraulic constraints was assumed (see below).

- Watercourse realignment of Dam Brook to a new two-stage channel;

Proposed design levels were supplied to the modelling team in zshape format. These design levels were copied into the "proposed" model.

- Construction of new ecology ponds to replace habitat loss and provide floodwater storage.

Proposed design levels were supplied to the modelling team in zshape format. These design levels were copied into the "proposed" model.

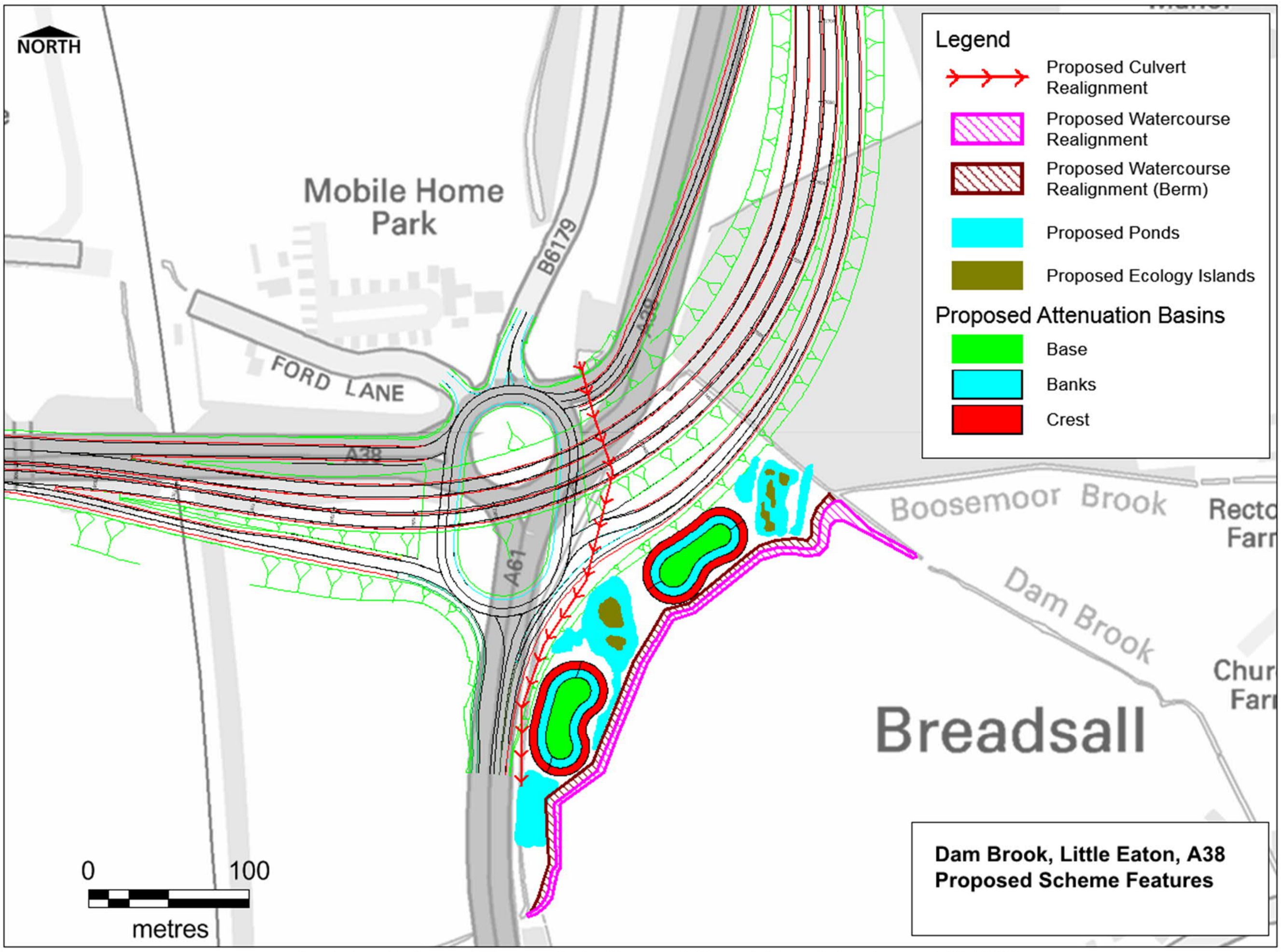

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Figure 5-2: Proposed Scheme Features

5.4. Model Results

The results of the hydraulic model with the Scheme design in place (as in Figure 5-2) are shown in Figure 5-3.

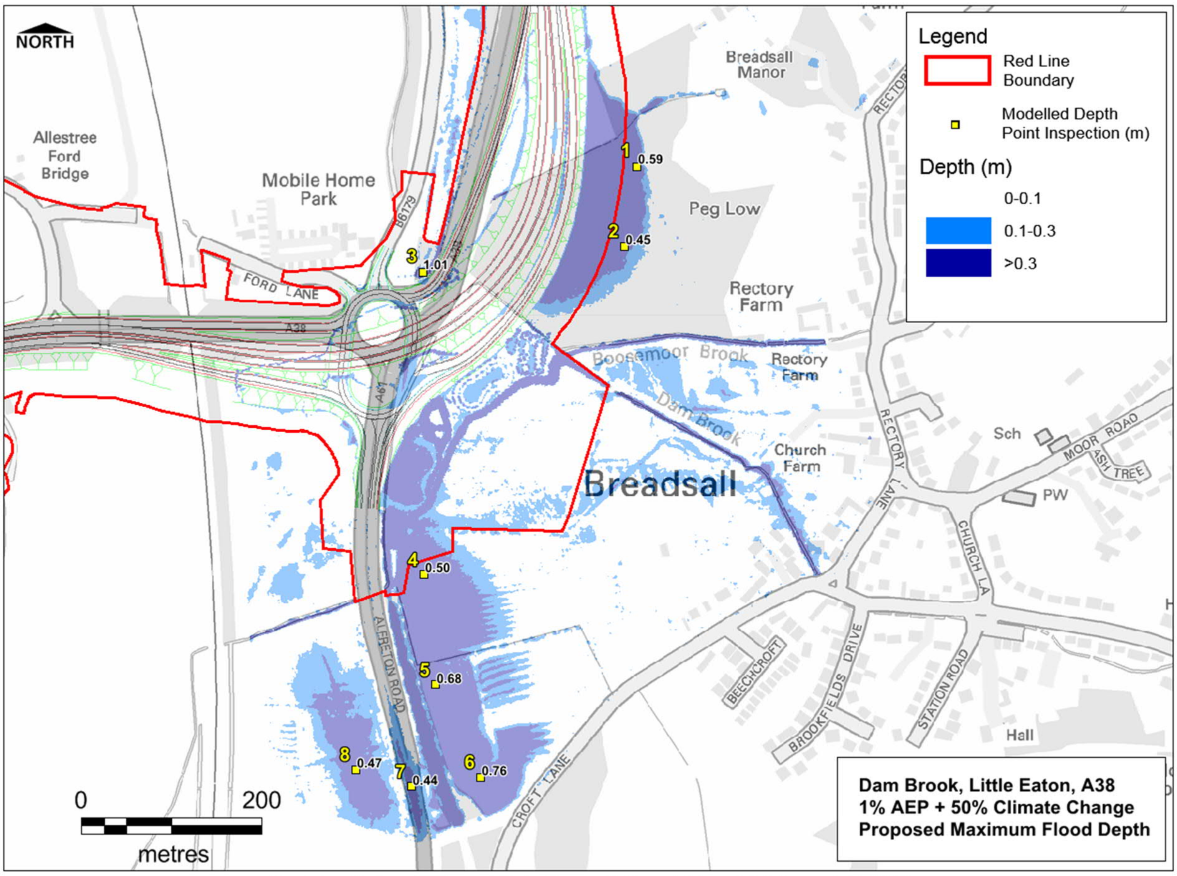

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Figure 5-3: Dam Brook 1% AEP + 50% Climate Change Proposed Maximum Flood Depths

Implementation of the proposed scheme features did not result in an increased risk of surface water flooding to areas south of the proposed A38 alignment. However, attenuation of surface water on the upstream face of the proposed embankments, beneath Breadsall Manor, resulted in an increased risk of flooding outside of the red line boundary. Mitigation options to resolve this issue were subsequently investigated (Section 5.5).

Additionally, the model indicated overtopping and inundation of the southernmost proposed attenuation basin during a 1% AEP + 50% climate change design event. The design team were consulted to determine whether this basin could be re-located, however this was not deemed viable at this stage of the project due to other constraints governing the highway drainage design. Mitigation options to resolve this issue were subsequently investigated (Section 5.5).

5.5. Mitigation Measures

Implementation of the Scheme features resulted in unacceptable impacts within and outside of the Scheme boundary. The two identified issues were resolved through iterative and model testing of potential mitigation measures as detailed below.

Surface Water Flooding Downstream of Breadsall Manor

Numerous model iterations were undertaken to resolve the surface water flooding impacts downstream of Breadsall Manor associated with an unnamed watercourse. This included modelling of a flood alleviation channel to connect the existing surface water flow paths directly into Dam Brook; the orientation, layout, levels and connections into Dam Brook were varied between model runs to maximise available storage. However, an alleviation channel alone did not provide sufficient storage within the Scheme boundary. Similarly, a new culvert under the proposed A38 alignment, combined with the existing A38 culvert and drainage channel arrangement, also did not provide enough capacity. Ultimately, a combined solution comprising both new culverts and a flood alleviation channel was tested and resulted in a positive outcome (refer to Figure 5-4).

In order to accommodate an alteration to the design of the proposed A38 alignment, it was necessary to culvert a previously open section of channel of the unnamed channel (see Figure 5-5). This section (approximately 14m in length) is located to the north of the proposed island, west of the main line alignment. The removal of the short open channel allows the connection of the new 600mm culvert (under the proposed main line alignment) with the existing culvert which carries flow beneath the A61.

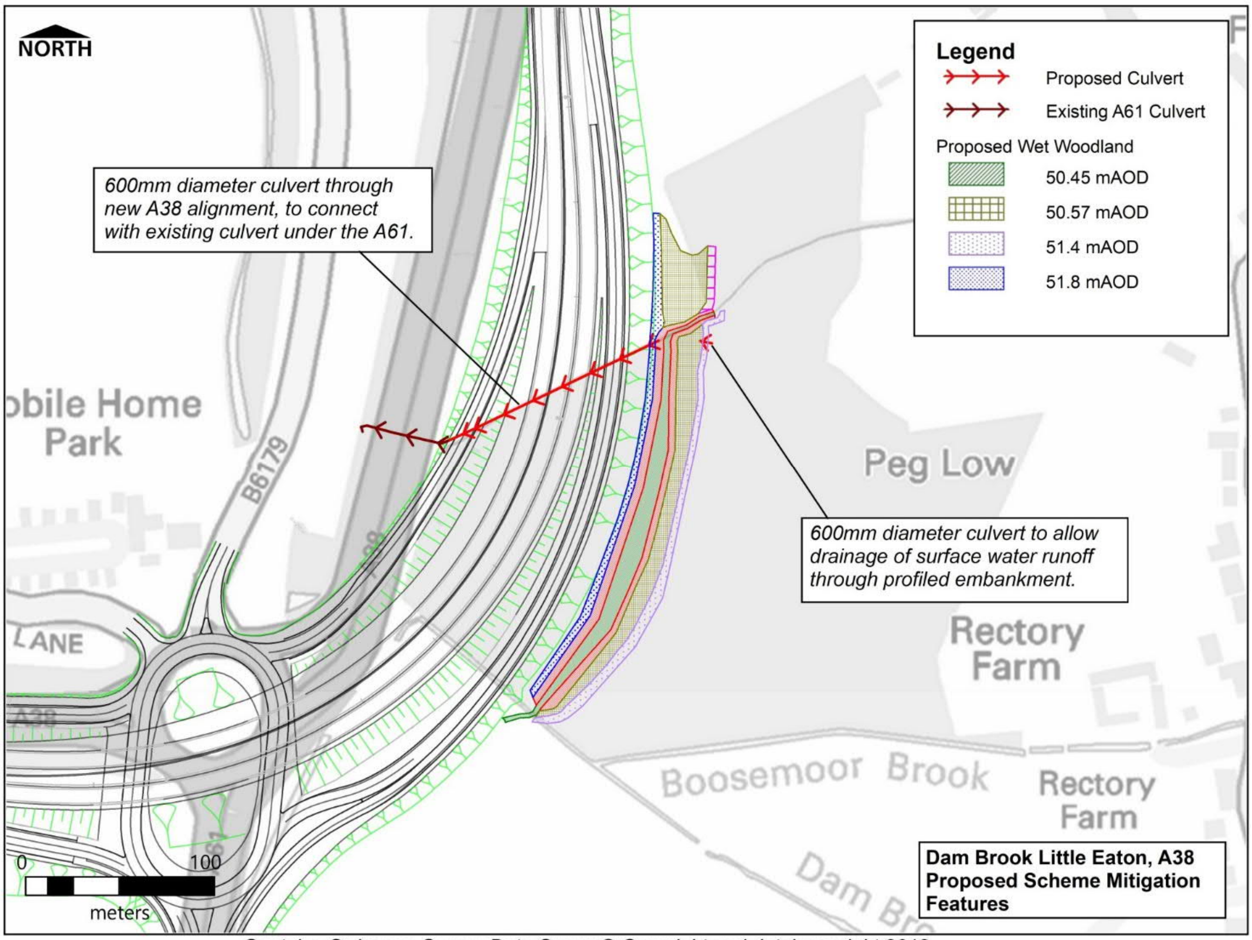

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Figure 5-4: Proposed Scheme Mitigation Features

The identified solution required:

- **A multi-staged flood alleviation channel:**
  - The AECOM ecology team were consulted on a suitable arrangement, because the potential for installation of a new wet woodland habitat was identified in this area.
- **Two new 600mm diameter culverts:**
  - The 600mm diameter culvert under the new A38 alignment was required to alleviate storage capacity issues during the 1% AEP + 50% climate change scenario.
  - The invert level was raised above the flood alleviation channel bed to 50.90 mAOD. This was chosen to allow regular filling of the channel during typical, frequent storm events, which would be required to best support a wet woodland habitat.
  - Both culverts were modelled with a flap valve, to prevent backing-up of floodwater through the system.
- **Raising of ground levels along the proposed A38 embankment toe to 51.80 mAOD**:
  - This would alleviate loading of floodwater against the embankment and could also help to achieve a more favourable cut-fill balance.
- **Change in layout of the ecology ponds to create a positive outfall for the realignment channel:**
  - The proposed ecology ponds were re-positioned to accommodate the open channel and swale alignment. The addition of open channel length means that overall bank length exceeds the 'existing + >50%' requirement outlined by the WFD. The ecology team were consulted, and the same proposed bank length for water vole habitat was maintained, together with pond bases that would be flush with the realigned Dam Brook channel bed. To sustain populations of fish such as the lamprey, the ponds are to have connectivity with the Dam Brook, acting as backwaters.

Southernmost Attenuation Basin Inundation

Similarly, multiple model simulations were undertaken to resolve the issues of surface water attenuation basins flooding from overtopping of the proposed crest levels. The two main constraints in this area were the maximum flood levels modelled on Dam Brook (50.95 mAOD) and the maximum flood levels modelled on the River Derwent (50.45 mAOD); these levels were established from the water height grids of each respective model. In order to prevent inundation of the southernmost highway runoff attenuation basin and provide a small degree of freeboard, it was necessary to raise the crest levels at the perimeter of each pond from 50.35 mAOD to 51.00 mAOD.

The proposed model was adapted to include all listed mitigation measures and then run as a "proposed mitigation" scenario. Additionally, an area of approximately 13,000m^2 was raised to simulate the temporary storage of spoil within the study area during the Scheme construction phase (Figure 5-5). For reference, a number of point inspections are provided to illustrate the modelled depth of floodwater in vicinity of the development proposals.

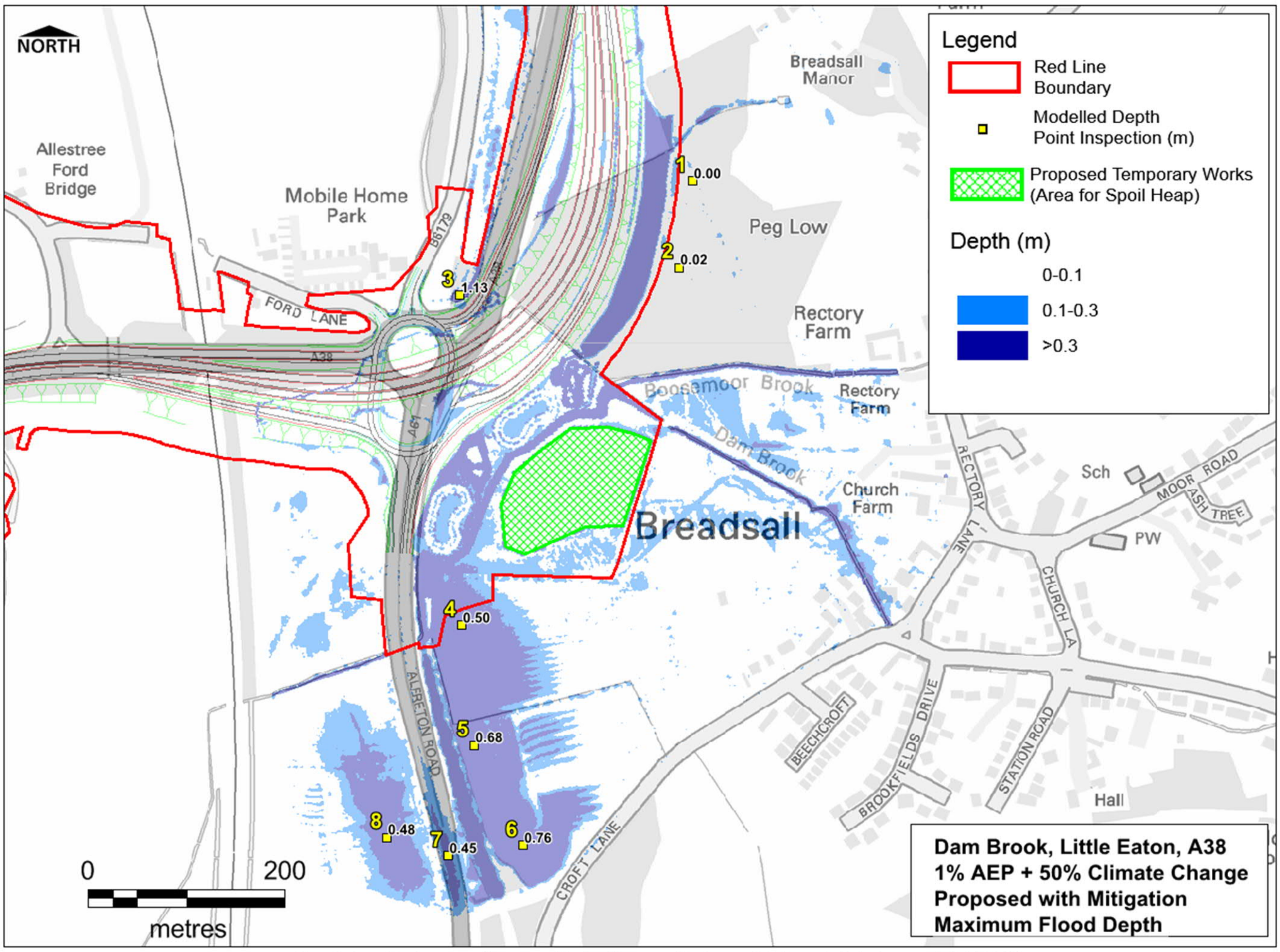

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Figure 5-5: Dam Brook 1% AEP + 50% Climate Change Proposed Mitigation Maximum Flood Depths

Comparison of the scenario results indicates that if the Scheme was implemented with the mitigation measures as modelled, then the risk of surface water flooding would not be increased within or outside of the Scheme boundary (refer to Table 5-1).

Table 5-1: Comparison of Baseline and Proposed Mitigation Peak Flood Levels

Flood Point	Baseline Scenario – Flood Level (m AOD)	Proposed Mitigation Scenario – Flood Level (m AOD)	Flood Level Difference (m)
1	n/a	n/a	n/a
2	n/a	n/a	n/a
3	51.15	50.78	- 0.37
4	50.61	50.62	+ 0.01
5	50.60	50.60	0.00
6	50.59	50.59	0.00
7	50.29	50.29	0.00
8	48.92	48.92	0.00

In summary, the layout of the “proposed mitigation” hydraulic model is illustrated in Figure 5-6.

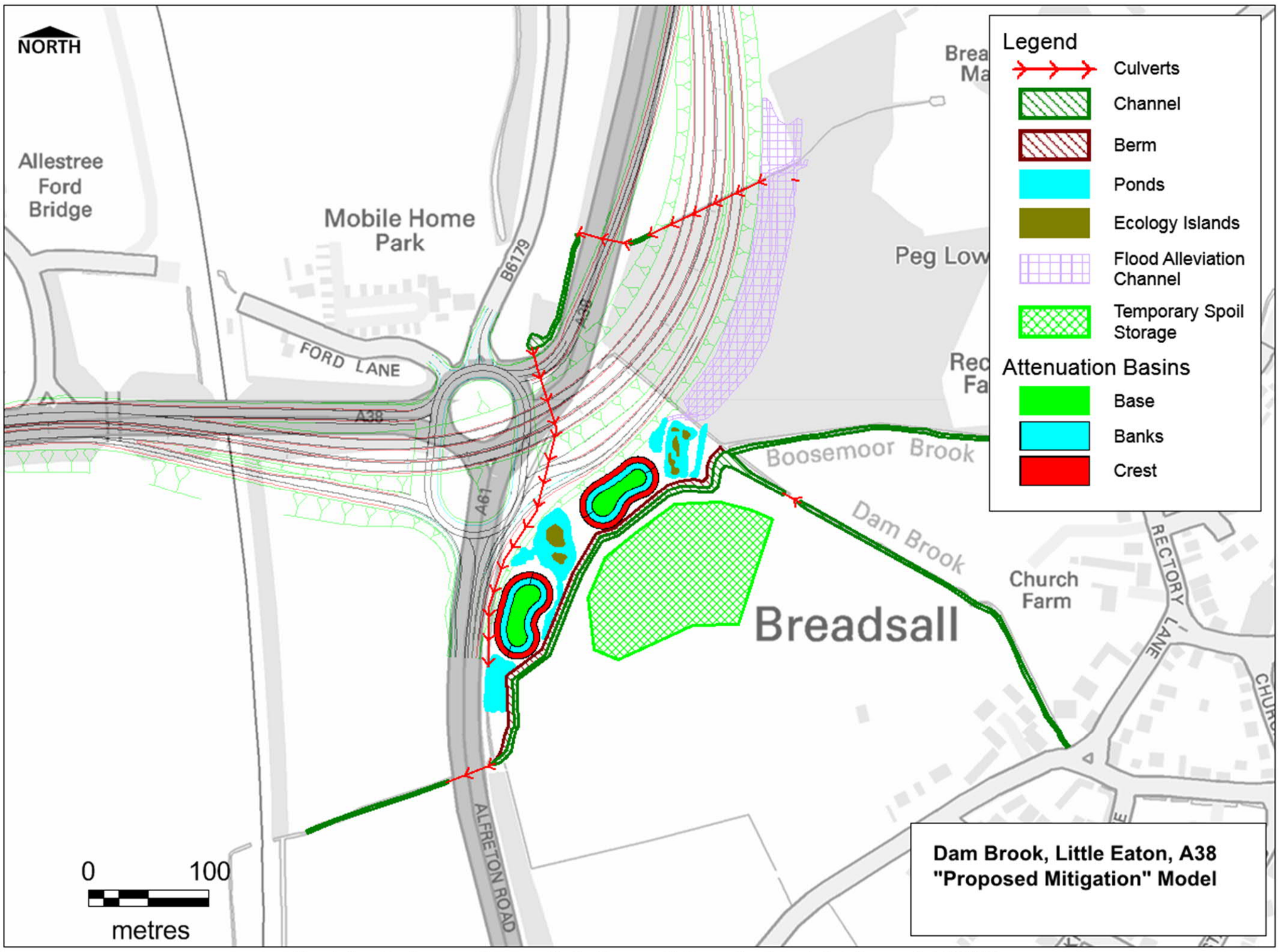

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Figure 5-6: "Proposed Mitigation" Hydraulic Model Layout

5.6. Refinements to the Proposed Scheme & Mitigation

A further constraint affecting the viability of a culverted solution is that the culvert passing to the north of the junction, as designed, would intersect the position of the highway drainage network to carry flows from the proposed mainline to the attenuation pond. The necessary invert levels would not allow the two systems to cross without issue. The alignment of the proposed culvert was therefore re-designed. Constraints of shallow gradient, minimum depth to cover levels required and site vehicle access requirements resulted in a revised proposal of an open channel swale to convey flows, rather than a culverted channel. This open channel swale had initially been proposed to outfall at the same location as the original extended culvert, namely the southernmost ecology pond. In an effort to improve conveyance, the swale channel was extended as far downstream as the Scheme boundary would allow, improving the overall gradient of the watercourse. In adding this open channel swale to the proposed design, it was necessary to amend the layout of the ecology ponds. The changes made to the ecology ponds in adding the open swale channel can be seen in Figure 5-8. Several solutions were tested as part of the modelling process. The newly proposed open channel swale, as shown in Figure 5-8, however, offered the most beneficial solution in terms of gradient, site access, water quality and an increase in open channel/ bank lengths which comply with the WFD minimum of 'Existing + >50%.'This is the final design which has been tested in the model and as reported in this Technical Note.

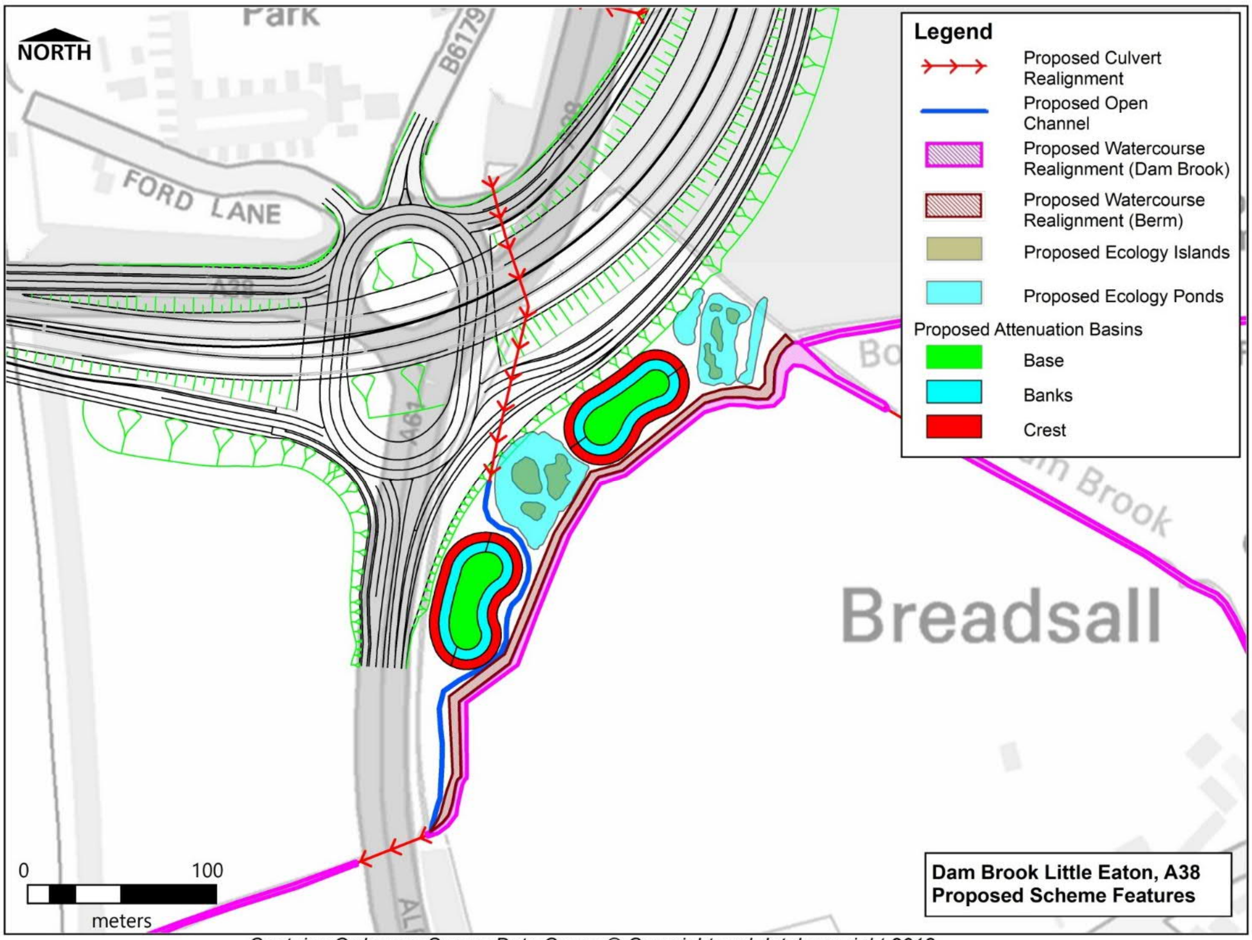

Figure 5-8: "Refined Proposed Mitigation" Hydraulic Model Layout

5.7. Final Proposed Scheme and Mitigation

The final proposed design comprises the following:

- **A multi-stage flood allevition channel/ wet woodland area** to the east of the proposed A38 alignment, which would convey flows from the unnamed watercourse from Breadsall Manor south, into an ecology pond and subsequently into Dam Brook.

- **Two new 600mm culverts** to carry flows to and from the flood alleviation channel to the west, under the A38, in the event of the storage capacity in the flood alleviation channel being exceeded. Flows from this culvert would then spill into the open channel north of the island.

- **A 900mm culvert** under the proposed A38 alignment, to take flows from the open channel to the north of the island. This new culvert then discharges into an approximate 216m swale where the road embankment ends. This swale then narrows and continues as a open channel between the southernmost attenuation pond and the re-aligned Dam Brook. The open channel would then join the Dam Brook immediately upstream of the existing culvert under the A61.

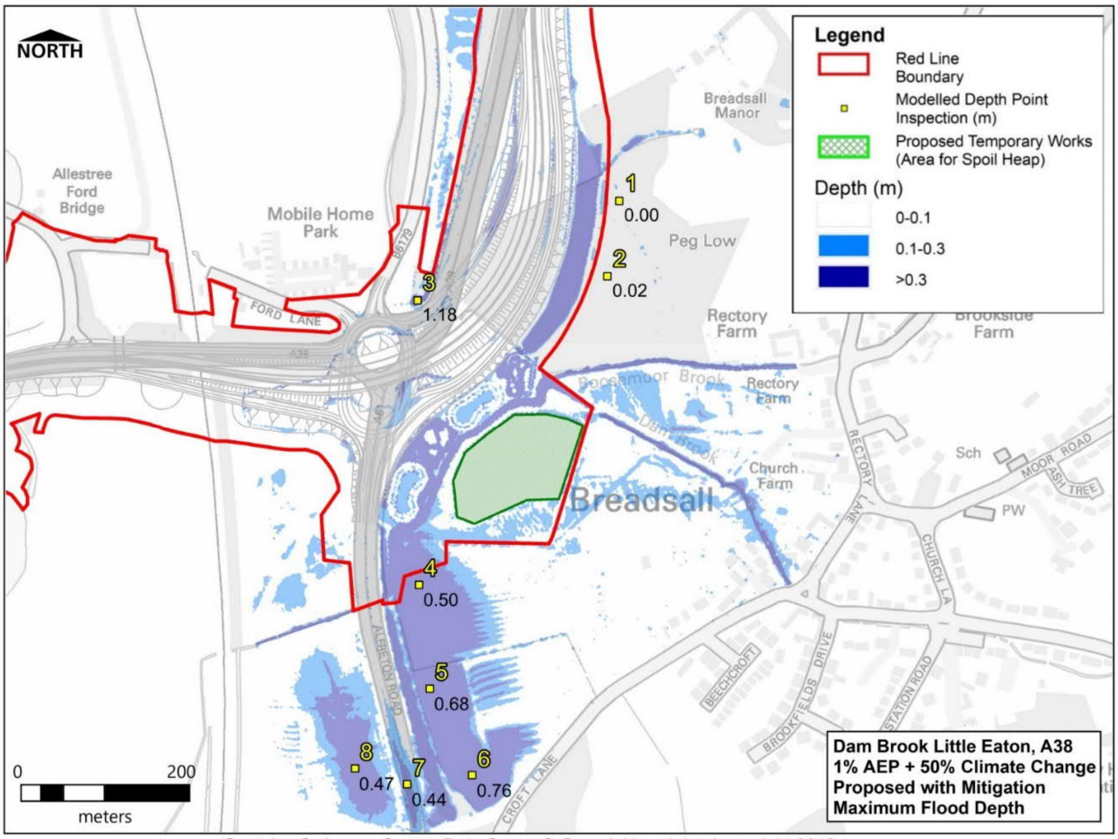

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Figure 5-8: Dam Brook 1% AEP + 50% Climate Change Final Proposed Mitigation Maximum Flood Depths

Comparison of the scenario results indicates that if the proposed design was implemented with the mitigation measures as modelled, then the risk of surface water flooding would not be increased significantly within or outside of the Scheme boundary (refer to Table 5-2).

Table 5-2: Comparison of Baseline and Proposed Mitigation Peak Flood Levels

Flood Point	Baseline Scenario – Flood Level (m AOD)	Proposed Mitigation Scenario – Flood Level (m AOD)	Flood Level Difference (m)
1	n/a	n/a	n/a
2	n/a	n/a	n/a
3	51.15	50.83	- 0.32
4	50.61	50.62	+ 0.01
5	50.60	50.60	0.00
6	50.59	50.60	+ 0.01
7	50.29	50.30	+ 0.01
8	48.92	48.93	+ 0.01

6. Model Limitations

The Little Eaton surface water modelling has been based on the best available data, although the main study limitations should be considered when interpreting the results:

- A lack of detailed watercourse survey including channel cross sections and bank top survey throughout the entire study area.
- Uncertainty regarding the geometry of the existing 500mm diameter culvert under the existing A38 alignment, downstream of Breadsall Manor.

7. Conclusions

This technical note presents a solution to appropriately manage the risks of surface water flooding as part of the Scheme development in line with the requirements of the National Planning Policy Framework (NPPF). The solution included within the Scheme design comprises:

- **A multi-stage flood allevition channel/ wet woodland area** to the east of the proposed A38 alignment, which would convey flows from the unnamed watercourse from Breadsall Manor south, into an ecology pond and subsequently into Dam Brook.

- **Two new 600mm culverts** to carry flows to and from the flood alleviation channel to the west, under the A38, in the event of the storage capacity in the flood alleviation channel being exceeded. Flows from this culvert would then spill into the open channel north of the island.

- **A 900mm culvert** under the proposed A38 alignment, to take flows from the open channel to the north of the island. This new culvert then discharges into an approximate 216m swale where the road embankment ends. This swale then narrows and continues as a open channel between the southernmost attenuation pond and the re-aligned Dam Brook. The open channel would then join the Dam Brook immediately upstream of the existing culvert under the A61.