E174

High Speed Two Phase 2a (West Midlands - Crewe)

Background Information and Data

CA5: South Cheshire

Hydraulic modelling report - Checkley Brook (BID-WR-004-010)

July 2017

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Department for Transport

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1 Introduction

1.1 Background

1.1.1 This document presents the results of the hydraulic modelling carried out in the South Cheshire area (CA5) relevant to High Speed Rail (West Midlands - Crewe). This report is also relevant to the Whitmore Heath and Madeley area (CA4).

1.1.2 The water resources and flood risk assessment is detailed in The High Speed Rail (West Midlands - Crewe) Environmental Statement (ES)[1]. Volumes 2, 3 and 4 discuss water resource and flood risk effects and Volume 5, Appendices sets out the following relevant to the South Cheshire area:

- a route-wide Water Framework Directive compliance assessment (Volume 5: Appendix WR-001-000);
- a water resources assessment (Volume 5: WR-002-005);
- a flood risk assessment (Volume 5: WR-003-005); and
- a route-wide draft water resources and flood risk operation and maintenance plan (Volume 5: Appendix WR-005-000).

1.2 Aims

1.2.1 The Proposed Scheme includes a number of locations where the route will cross watercourses and their floodplains. The Proposed Scheme crossing locations have the potential to increase flood risk where they restrict flood flows or change floodplain dynamics.

1.2.2 At the locations forming the focus for this report, the route will cross Checkley Brook and the River Lea on the proposed Checkley Brook viaduct and two unnamed watercourses on the Madeley Bridleway 2 accommodation underbridge.

1.2.3 A hydraulic model of Checkley Brook, the River Lea and the two unnamed watercourses was created to simulate the risk of flooding in this location for an approximate 2.3km stretch of Checkley Brook and an approximate 2.5km stretch of the River Lea. This report documents the methods used and discusses the results, assumptions and limitations imposed by them.

1.2.4 Hydraulic models of the existing conditions and also with the Proposed Scheme included have been evaluated to assess the impact of the Proposed Scheme on flood risk and to derive peak flood water levels relative to the proposed structures.

1.2.5 This report details the existing hydrological and hydraulic processes of the reaches modelled and how these will be affected by the Proposed Scheme.

[1] HS2 Ltd (2017), *High Speed Rail (West Midlands - Crewe) Environmental Statement (ES)*, www.gov.uk/hs2

1.3 Objectives

1.3.1 The objectives were to:

- conduct, where feasible, a site visit to inform understanding of existing conditions, including existing channel and floodplain characteristics, hydraulic structures and flow paths;
- estimate flow hydrographs at the Proposed Scheme crossing locations;
- develop a hydraulic model, commensurate with the level of detail required and available at this stage, to provide peak levels at key structures for the Proposed Scheme, based on the most suitable data available and flow hydrographs developed; and
- analyse the impact of the Proposed Scheme on flood risk levels obtained from the results of the following Annual Exceedance Probabilities (AEP): 50%, 20%, 5.0%, 1.33%, 1.0%, 1.0%+climate change (CC), 0.5% and 0.1%.

1.4 Justification of approach

1.4.1 The hydraulic model has been constructed to provide an awareness of existing flood risk to inform the Proposed Scheme design. The detail included identifies potential impacts of the Proposed Scheme on surrounding land, and to ensure that 0.6m freeboard to soffit is provided in a 1.0% +CC AEP event and 1.0m freeboard to track level is provided in a 0.1%AEP event.

1.4.2 A 2D hydraulic model was selected for this study as detailed 1D channel information was not available at the time of study and the Light Detection and Ranging (LiDAR) survey adequately portrayed the existing channels and features. Using a 2D approach allows for structures to be represented using the ESTRY solver within Two-dimensional Unsteady FLOW (TUFLOW).

1.4.3 Due to the Proposed Scheme crossing the floodplain on a viaduct, and thus causing a high level of risk for the design of the project and its impact on the environment, it was proposed that hydrological calculations be undertaken to a full level of detail. This considered Flood Estimation Handbook (FEH) Statistical, Revitalised Flood Hydrograph 2 (ReFH2) and the hybrid methods. This is particularly relevant in this location where both abutments are driven by flood risk.

1.5 Scope

1.5.1 The scope of the study is to undertake hydraulic modelling to enable an assessment to be made of the impact of the Proposed Scheme on the local environment. The models should be detailed enough to allow future assessment of different options associated with each crossing location, to allow the management of flood risk and correct sizing of crossing openings.

1.5.2 The report focuses upon:

- discussion of all relevant datasets, quality and gaps;
- hydrological analysis undertaken, approach used and calculation steps;
- integration of the hydrological analysis with the hydraulic modelling;
- hydraulic modelling methodology chosen, with clear identification of general methodologies and justification; and
- hydraulic modelling parameters, assumptions, limitations and uncertainty.

2 Site Characteristics

2.1 Description of the study area

Model reach

2.1.1 The section of the River Lea and Checkley Brook being modelled is located near Wrinehill. Figure 1 shows the modelled extent, with a number of upstream boundaries and the downstream boundary located approximately 300m east of Checkley New Farm. Approximately 2.4km of the River Lea and 1.9km of Checkley Brook has been modelled.

2.1.2 Within the study area, there are two isolated farms, Wrinehill Hall Farm and Wrinehill Mill Farm. Transport infrastructure in this area is significant, with Main Road and the West Coast Main Line (WCML). Main Road crosses the Checkley Brook floodplain upstream of the WCML, which crosses the floodplains of both watercourses upstream of the Proposed Scheme.

2.1.3 There are a number of culverted crossings along the study reaches, including beneath Main Road and WCML. There are a number of farm accesses that also cross the watercourses, particularly on the River Lea between the Stoke to Market Drayton Railway (also known as the Silverdale Line of the Stoke to Market Drayton Railway) and the Proposed Scheme.

2.1.4 There are a no large water bodies identified within the area of interest.

Hydrological description

2.1.5 Checkley Brook originates in the hills south-west of the village of Keele, Staffordshire and flows in a generally north-westerly direction before turning south-west towards the Proposed Scheme crossing.

2.1.6 The catchment area contributing to the downstream boundary of the proposed hydraulic model is $47.3km^2$ and is predominantly rural.

2.1.7 The River Lea originates in the hills to the south-east of Onneley, Staffordshire and flows east, before flowing north and then west towards the Proposed Scheme. The River Lea also crosses the Proposed Scheme beneath the River Lea viaduct closer to the source.

2.1.8 There are no gauging stations present at the locations for which flow estimates are required. No local gauging stations are therefore available for use as potential donor sites.

2.1.9 Standard Annual Average Rainfall at the proposed Checkley Brook viaduct is 770mm.

Railway alignment

2.1.10 The route of the Proposed Scheme crosses the study area from south-east to north-west, crossing the River Lea and Checkley Brook on the proposed

Checkley Brook viaduct and two unnamed watercourses on the Madeley Bridleway 2 accommodation underbridge. Further detail on the Proposed Scheme can be found in the design as shown in Maps CT-06-234 and CT-06-235 in the Volume 2 Map Book.

Flood mechanisms

2.1.11 Checkley Brook and the River Lea run parallel to each other beneath the Proposed Scheme, having both passed under the WCML through culverts upstream. The confluence of the two watercourses is approximately 400m downstream of the Proposed Scheme and flood waters pass between the two watercourses for this reach.

2.1.12 Two tributaries join the River Lea upstream of the Proposed Scheme near Wrinehill Hall Farm and have significant overland flow paths associated with them.

2.2 Existing understanding of flood risk

Sources of information

2.2.1 Sources of Environment Agency data were utilised as below:

- Flood Map for Planning (Rivers and Sea)[2]; and
- updated Flood Map for Surface Water (uFMfSW)[3].

2.2.2 The proposed Checkley Brook viaduct spans Flood Zones 2 (0.1%AEP) and 3 (1.0%AEP) of the Environment Agency Flood Map for Planning as shown in Figure 1

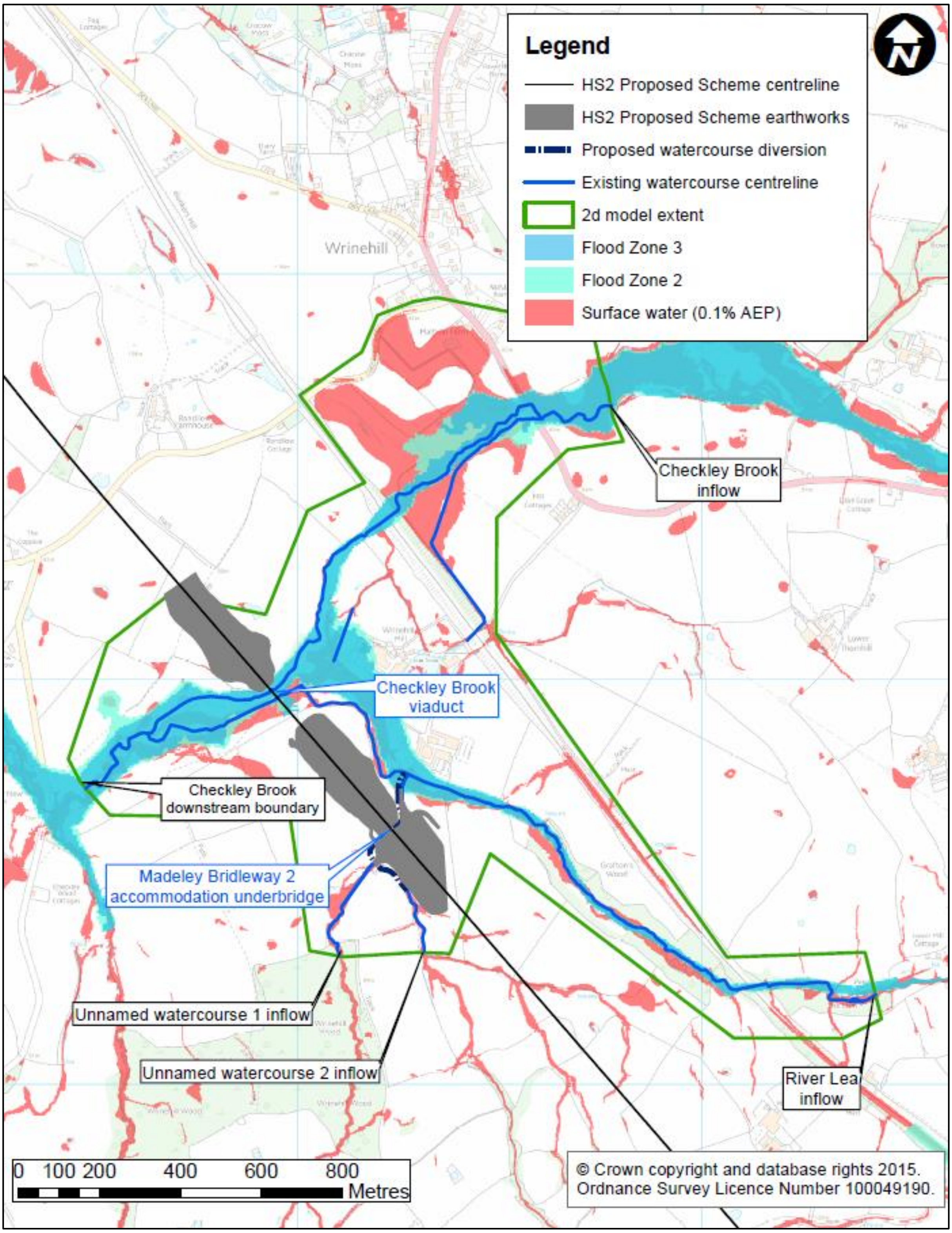
2.2.3 The uFMfSW shows that two flow paths originate from the south and intersect the location of the Proposed Scheme. These are the two tributaries notes in 2.1.12.

2.2.4 Available information does not indicate the presence of any flood defences within the model extent.

2.2.5 The Environment Agency flood maps are believed to be derived by National Generalised Modelling.

[2] Gov.uk, *Flood map for planning*, https://flood-map-for-planning.service.gov.uk
[3] Gov.uk, *Long term flood risk information*, https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?map=SurfaceWater

Figure 1: Environment Agency Flood Zones 2 and 3 and uFMfSW (0.1%AEP) at the River Lea at Checkley Brook



2.3 Availability of existing hydraulic models

2.3.1 An existing hydraulic model was supplied by the Environment Agency for this study.

2.3.2 The model provided was a 1D (ISIS) only model received in 2016. The model was developed in 2007.

2.3.3 The model was developed on behalf of the Environment Agency, however, the downstream extent of the model provided is located at the upstream extent of this model, and it has therefore not been used.

2.4 Site Visit

2.4.1 A site visit was undertaken in November 2016 to determine the dimensions of the channel and any existing infrastructure.

2.4.2 Several structures were visited along the River Lea and Checkley Brook however not all could be visited due to site access restrictions and general accessibility issues. For the structures that were visited, images were taken to ascertain dimensions and roughness.

2.4.3 The site visit also identified an additional channel present to the north east of the proposed Checkley Brook viaduct, discharging into a pond from which a drop inlet culvert returned some flow to the channel. However, the primary flow bypassed this control through an unidentifiable structure and therefore the drop inlet culvert and pond have not been included in the modelling.

3 Model approach and justification

3.1 Model conceptualisation

3.1.1 Model extents were carefully selected to ensure that the model boundaries did not have any impact on the flood extent in the area of interest.

3.1.2 Utilising a 2D modelling approach is appropriate for a floodplain of this nature because there are complex overland flow paths between the Checkley Brook and the River Lea, and across the floodplain itself beneath the proposed Checkley Brook viaduct. Using such an approach allows more confidence in the impact of the scheme on receptors, while also allowing more confidence in hydrology as floodplain flows can be properly accounted for. With all structures present being culverts, these can be easily represented with confidence using ESTRY.

3.2 Software

3.2.1 TUFLOW (2016-AA) has been used. This methodology is in line with standard practice to use the latest available build at the time modelling commenced, while TUFLOW is industry standard software.

3.3 Topographic survey

3.3.1 No additional topographic survey was commissioned for this study.

3.4 Input data

3.4.1 The elevation data for the domain was produced using 200mm LiDAR flown specifically for HS2 Ltd and covers 500m either side of the route centreline. In addition, 1m and 2m LiDAR, provided by the Environment Agency, was used for the remainder of the modelled extent.

4 Technical method and implementation

4.1 Hydrological assessment

4.1.1 The estimation of design peak flows and hydrographs was based on the application of the methodologies pre-approved by HS2 Ltd. These are standard in the UK Flood Risk Management Industry.

4.1.2 The FEH methodologies were followed, in particular the Statistical Method. No suitable gauging stations were available in the area so the FEH Pooling Group methodology was adopted. This uses recorded river flows in hydrologically similar catchments to estimate flows at the subject location. The calculations were based on the most up-to-date national database available at the time of undertaking the calculations. The data was obtained from the National River Flow Archive and/or HiFlowsUK.

4.1.3 In addition, the FEH Revitalised Rainfall Runoff Method, version 2 (part of ReFH2) was used to produce an alternative set of design peak flows and event probability. ReFH2 uses the recently updated FEH13 rainfall database and parameters. The calculations are based on relevant catchment descriptors of each catchment, which were obtained from the FEH Web Service database.

4.1.4 The two sets of design peak flows (from FEH Statistical Method and ReFH2) were analysed and compared. The methodology that produced the most conservative river flows was selected.

4.1.5 The ReFH2 outputs were adopted for the River Lea and Checkley Brook. For the small tributaries, FEH Statistical method calculations were not undertaken due to their very small catchment areas (<1km2) and thus, ReFH2 flow estimates are adopted.

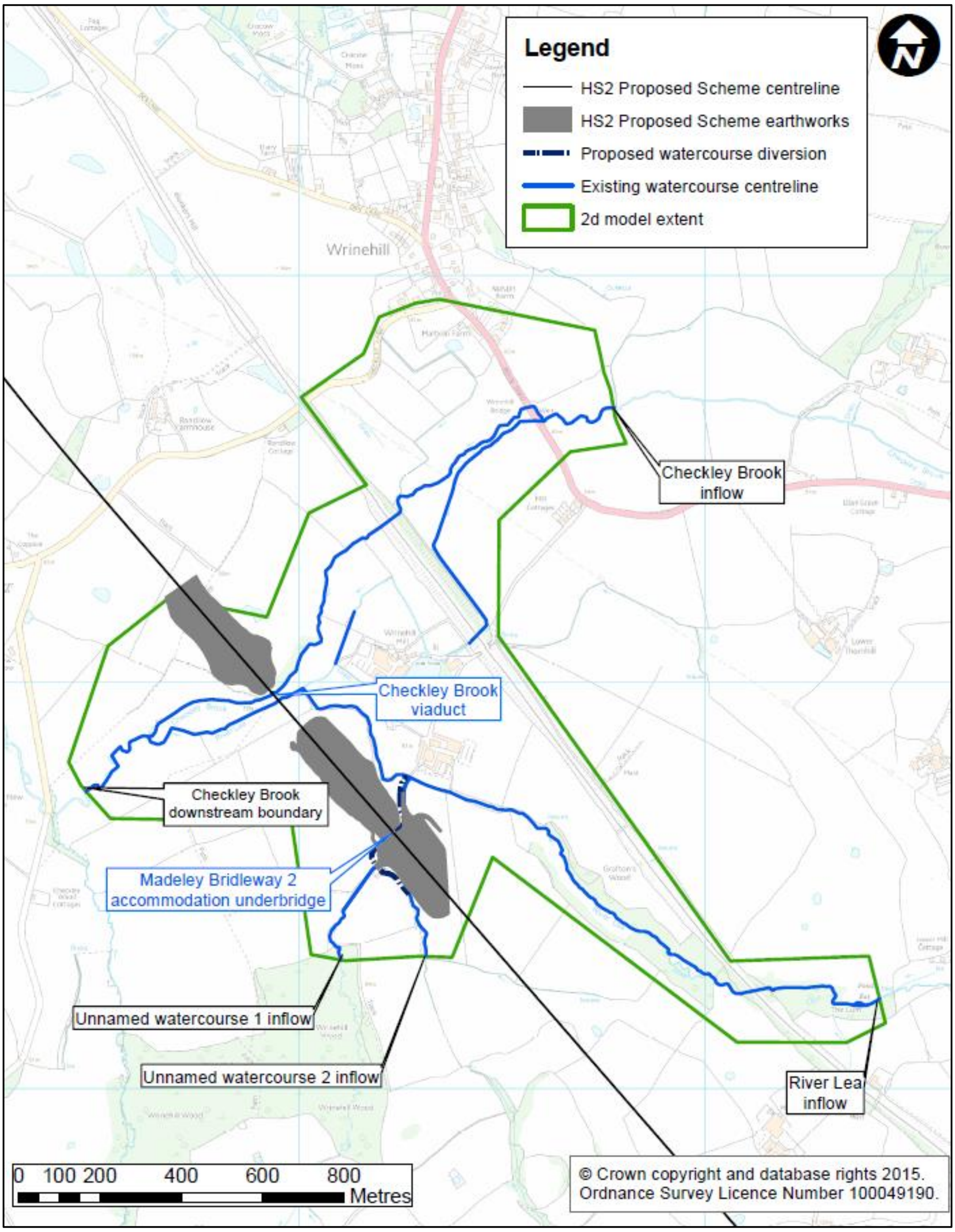
4.1.6 The design hydrographs used for the hydraulic modelling stage were generated using ReFH2 as the FEH Statistical method does not produce time series, just peak flows. The values were scaled so the peak flow for each return period matched that selected as the design value.

4.1.7 Table 1 shows the peak flows used for the computational hydraulic modelling work. Figure 2 highlights the inflow locations and the associated river networks assessed as part of this study.

Table 1: Peak flows used for hydraulic analysis

	AEP	Return period	Site code			
			Checkley Brook inflow	Unnamed watercourse 2 inflow	Unnamed watercourse 1 inflow	River Lea inflow
Flood peak (m^3/s)	50%	2yr	4.88	0.38	0.41	2.45
	20%	5yr	6.43	0.52	0.56	3.24
	5.0%	20yr	8.97	0.74	0.79	4.51
	1.33%	75yr	12.32	1.03	1.1	6.2
	1.0%	100yr	13.24	1.11	1.18	6.67
	1% + CC	100yr + CC	22.51	1.89	2.01	11.34
	0.5%	200yr	15.74	1.31	1.41	7.98
	0.1%	1000yr	22.78	1.9	2.06	11.86

Figure 2: Schematic of inflows and modelled river network



4.2 Hydraulic model build - baseline model

1D representation

4.2.1 Culverts were included in the ESTRY component of TUFLOW. The sizes of these culverts were based off site visit observations and the inverts were taken from available LiDAR.

2D Representation

4.2.2 The cell size of the model was set as 2m. Cell size and alignment for the 2D model grid was optimised to ensure appropriate representation of the flow pathways whilst maintaining reasonable run times. The alignment for the 2D model grid follows the rotation of the Proposed Scheme piers.

4.2.3 Checkley Brook has been defined manually as it was poorly represented within the LiDAR due to extensive tree cover.

Inflow boundaries

4.2.4 The study area has four inflows. Inflow boundaries were included for the River Lea, Checkley Brook and the two unnamed watercourses to the south. These are shown in Figure 2.

Downstream boundary

4.2.5 A normal depth boundary was used at the downstream extent of Checkley Brook, and also in the floodplain at the downstream extent. This generates a stage-discharge curve based on the bed slope which varies across the floodplain.

4.2.6 A normal depth slope of 0.0029m/m (1 in 345) was used within the Checkley Brook channel and slopes of 0.0053m/m (1 in 190) was used for the left bank floodplain and a slope of 0.0095m/m (1 in 105) was used for the right bank floodplain. These were derived from LiDAR.

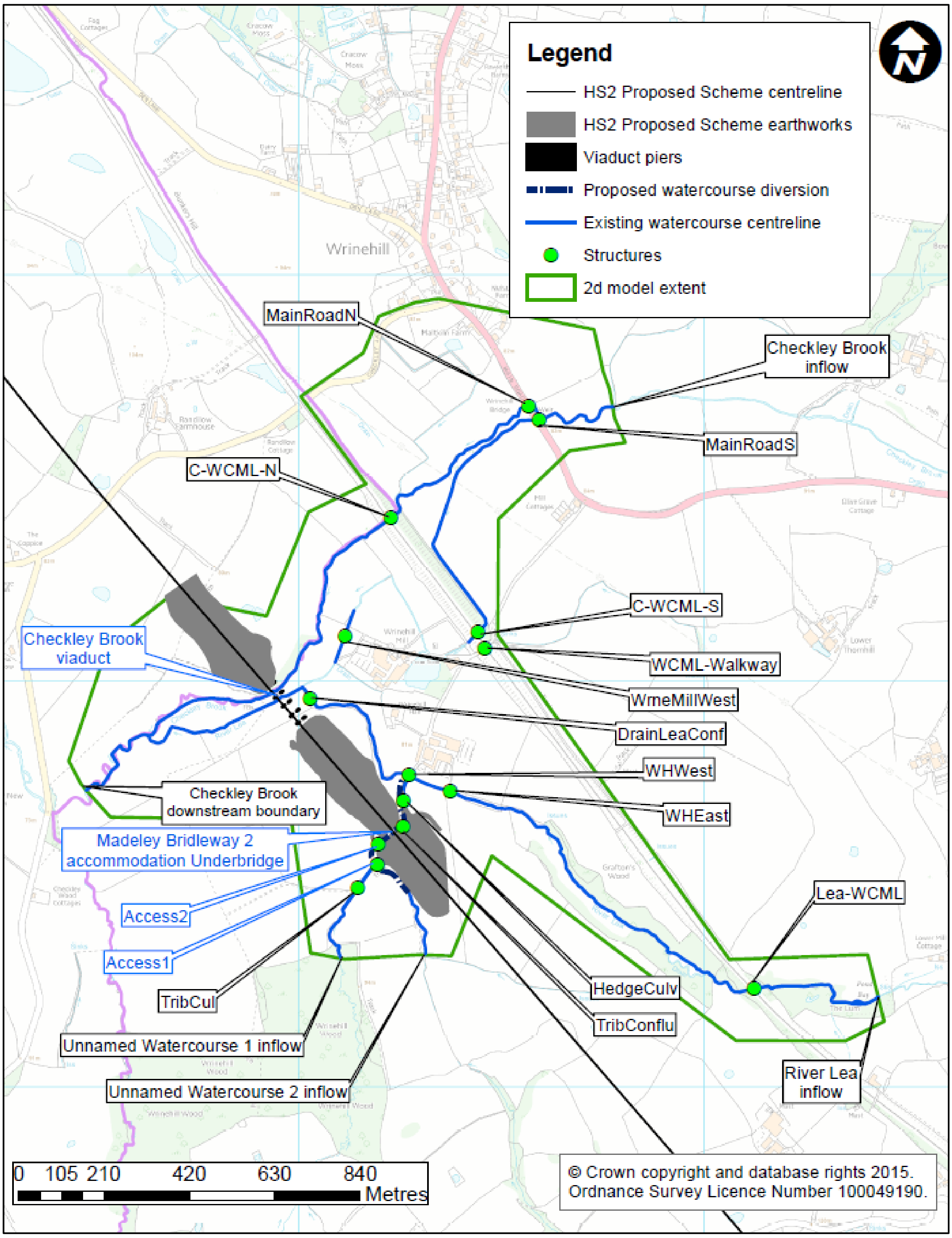
Key structures

4.2.7 There are a number of structures within the model extent that were modelled in a variety of ways. Additionally, there are a number of structures which are not modelled as no information is available. Those included in the model and deemed to be key hydraulic controls are detailed in Table 2. All structures, including key hydraulic controls, are shown in Figure 3.

Table 2: Key structures present within the modelled extent of the River Lea at Checkley

Structure reference	Structure description	Modelling representation and justification
C-WCML-N	Checkley Brook Culvert beneath WCML 53.0m (L) x 5.0m (W) x 2.5m (H)	Sprung arch culvert represented as a 2D ESTRY rectangular culvert with same surface area.

Figure 3: Existing and proposed structures within the model extent



4.2.8 A weir has been omitted on Checkley Brook immediately upstream of Main Road. This is due to its small height as it is likely to be drowned out at high flows.

4.2.9 Three small wooden footbridges located at the proposed Checkley Brook viaduct and immediately upstream have been omitted. Two of these are on the River Lea and one is on Checkley Brook. They are omitted due to the lack of impact, due to their construction and size, which they would have during a flood event.

Roughness

4.2.10 Roughness values utilised are in line with the recommended values stated within Chow, 1959[4].

4.2.11 The 2D domain roughness values have been informed by the land use classifications within the current Ordnance Survey (OS) Mastermap data together with information derived from aerial and site visit photography for specific features.

4.2.12 In some locations the OS Mastermap data has been modified to suit the cell size of the hydraulic model, to ensure that key features such as woodland, roads and the channel itself are represented.

4.3 Hydraulic model build – Proposed Scheme

4.3.1 The Proposed Scheme model has been edited from the baseline to include the following:

Viaduct piers

4.3.2 The proposed Checkley Brook viaduct spans approximately 180m and will be supported by 12 piers, spaced approximately 17.5-30m apart.

4.3.3 A deactivated code layer was used to represent the piers. The modelled dimensions of each pier constitute a deactivated area of the model of 16m^2 per pier, for a pier size of 8.05m x 2m (16.1m^2).

Topographic changes

4.3.4 The Proposed Scheme (Checkley North and South embankments) and the associated realignment of the access track have been included and the relevant heights for embankment crest and road alignment. The footprints of the embankments for the Proposed Scheme are based on the design as shown in Maps CT-06-234 and CT-06-235 in the Volume 2 Map Book.

4.3.5 The OS Mastermap layer was modified to correctly represent any changes to the roughness and planting associated with the Proposed Scheme.

Replacement floodplain storage areas

4.3.6 Although there are only localised changes between baseline and post-development, provision for replacement floodplain storage has been made based on the 1.0% + CC AEP levels, on a level for level, volume for volume basis. This has not been included within the hydraulic modelling.

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

Channel realignment or diversions

4.3.7 Small channel diversions have been made for the unnamed watercourses beneath the Madeley Bridleway 2 accommodation underbridge.

4.3.8 No realignments of the river channel have been proposed.

Production of flood extents

4.3.9 Flood extents have been derived using the direct output options now available in TUFLOW to produce ASCII output for the maximum depth and height. This has then been converted into a polygon, and cleaned to remove all bow ties (where two polygons overlap) as well as any dry islands less than 48m^2.

Modelling assumptions made

4.3.10 Existing LiDAR is assumed to be correct as no other information is available.

4.3.11 Culvert sizes have been assumed in a number of places within the model. Where a site visit to provide photos or measurements was not possible, they have been approximated based on LiDAR information. This provided road levels and ground levels, and the measured width of the top of structures from aerial photography.

4.3.12 Channel widths have been assumed based off LiDAR and site specific photos at crossing points. Channels have been defined on this basis in a number of locations.

4.4 Climate change

4.4.1 The climate change allowance for the Checkley Brook and River Lea is 70% based on the new climate change approach developed by the Environment Agency and published in February 2016.[5]

4.4.2 This climate change percentage considers the design life of the Proposed Scheme (120 years), the River Basin District (North West) and the receptors within the existing Flood Map for Planning. Due to the presence of more vulnerable receptors (National Planning Policy Framework Table 2[6]), the upper end value for the longest duration was chosen.

4.4.3 The new climate change guidance recommends consideration of the H++ scenario[7]. While these percentages have not been explicitly assessed, the sensitivity for the 20% increase in flow on the 1.0% + CC AEP event is assumed to be representative of an event greater than the H++ scenario.

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[5] Environment Agency, *Flood risk assessments: climate change allowances* https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances
[6] Gov.uk, *Flood Zone and flood risk tables* https://www.gov.uk/guidance/flood-risk-and-coastal-change#flood-zone-and-flood-risk-tables
[7] Environment Agency, *Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities*, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/571572/LIT_5707.pdf

5 Model results

5.1.1 The model has been run for the 50%, 20%, 5.0%, 1.33%, 1.0%, 1.0%+CC, 0.5% and 0.1% AEPs. The 1.0%+CC simulation is based on a 70% increase in flows.

5.1.2 The water level difference has been mapped for the 1.0%+CC and 5.0% AEPs. These flood maps are reported in Appendix A.

5.1.3 In all return periods modelled (except for the 50% AEP), impacts are observed around the realigned access track and watercourse of greater than 100mm immediately upstream of the Proposed Scheme. This impact is localised. There is a small localised impact around the confluence with the River Lea of 10-50mm (50-100mm in 5% AEP). There are no changes to the flood extent at the proposed Checkley Brook viaduct and very minimal changes to the flood extent at the Madeley Bridleway 2 accommodation underbridge.

5.1.4 More generally around the viaduct, average impacts of up to 10mm are observed in all return periods with localised patches of 10-50mm impact immediately upstream of the Proposed Scheme.

5.1.5 Model results conclude that the current proposed design ensures a freeboard of a minimum of 1m to the rail track in a 0.1%AEP event and a minimum of 0.6m to the viaduct soffit in a 1.0%AEP + CC (70%) event for all scenarios.

6 Model proving

6.1 Introduction

6.1.1 This section of the report presents the analysis of the model undertaken to ensure confidence in the stability of the model build, its response to input values and consistency with previous modelling.

6.2 Run performance

6.2.1 Model output has been assessed across all open channel and model structures to assess model stability and overall model performance.

6.2.2 Final cumulative mass balance error is within +/-1.0% for all return periods and blockage and sensitivity cases simulated.

6.3 Calibration and validation

6.3.1 There is no gauge situated within an appropriate distance of this location to provide calibration or validation data.

6.3.2 There is no additional anecdotal evidence available for any effective model validation exercise.

6.4 Verification

6.4.1 Model outputs have been compared with other readily available flood risk data such as Environment Agency Flood Maps for Planning.

6.4.2 Flood extents generated for this study are similar to the Environment Agency Flood Maps for Planning.

6.5 Sensitivity analysis

6.5.1 Sensitivity scenarios were undertaken as below:

- increase in flow by 20% (compared to 1.0%AEP+CC Proposed Scheme);
- increase in roughness (channel, structures and floodplain) (Manning's n) by 20% (compared to 1.0%AEP+CC Proposed Scheme);
- decrease in roughness (channel, structures and floodplain) (Manning's n) by 20% (compared to 1.0%AEP+CC Proposed Scheme);
- increase in downstream boundary gradient by 20% (compared to 1.0%AEP+CC Proposed Scheme); and
- decrease in downstream boundary gradient by 20% (compared to 1.0%AEP+CC Proposed Scheme).

Roughness

6.5.2 The model is sensitive to increases in roughness with a 20% increase resulting in increases in water level of between 50-100mm in some locations. Minimal increases in flood extent are observed.

6.5.3 Decreasing the roughness by 20% results in a general decrease in peak water level throughout the model with small decreases in the flood extent at the proposed Checkley Brook viaduct.

Inflows

6.5.4 An increase in inflow of 20% results in an increase of between 50-100mm at the proposed Checkley Brook viaduct.

6.5.5 The effect of increased flow has greater impact upstream of the Proposed Scheme, particularly upstream of the Checkley Brook Culvert beneath the WCML.

Downstream boundary

6.5.6 There was no impact to the Proposed Scheme crossing when the downstream boundary was reduced and increased by 20%, with negligible impact of ±10mm at the downstream boundary. No impact is seen greater than 20m from the Checkley Brook downstream extent.

Summary

6.5.7 The sensitivity analysis shows the model is moderately sensitive to changes in flows and roughness values at the proposed Checkley Brook viaduct. The changes in the downstream boundary gradient had no impact at the proposed Checkley Brook viaduct with minimal impact at the downstream boundary of the model.

6.5.8 Sensitivity tests conclude that the proposed design ensures a freeboard of a minimum of 0.6m to the viaduct soffit in a 1.0%AEP+CC (70%) event for all scenarios.

6.6 Blockage analysis

6.6.1 One blockage scenario was assessed, which modelled a 2% blockage at the proposed Checkley Brook viaduct.

6.6.2 This blockage scenario result was compared to the 0.1% AEP results for the Proposed Scheme model.

6.6.3 The viaduct blockage of 2% was represented for both tracks on the viaduct by expanding the size of the pier standing between the two channels by 2% of the length of the viaduct.

6.6.4 The results of blockage scenario 1 show negligible impact to flood levels and extents of up to 10mm generally around the proposed Checkley Brook viaduct and a very localised impact of up to 50mm immediately upstream of the viaduct. The flood extent shows negligible increases in the immediate vicinity of the proposed Checkley Brook viaduct.

6.6.5 Blockage tests conclude that the current proposed design ensures a freeboard of a minimum of 1m to the rail track in a 0.1%AEP event for all scenarios.

6.7 Run parameters

6.7.1 There is no deviation from default run parameters for all model runs.

6.7.2 The time step parameters used were 0.5 seconds for ESTRY and 1 second for the 2d model. This is the suggested approach for a grid size of 2m.

7 Limitations

7.1.1 Land access for new topographic survey was not possible and therefore all channels have been represented in 2D, meaning channel conveyance will not be fully represented in the model; however, this will lead to a conservative estimation of flood risk for the purposes of the Environmental Impact Assessment. Onsite observations have been used to reduce the number of assumptions. Culvert dimensions have been estimated based upon ground levels and watercourse size, which may impact flood extent and level predictions if these were to change.

7.1.2 No survey data was available for the watercourse and the model has been developed based on the LiDAR provided.

7.1.3 Calibration has not been able to be carried out due to a lack of available data.

8 Conclusions and recommendations

8.1.1 The aim of developing a hydraulic model of Checkley Brook and the River Lea to simulate the baseline and Proposed Scheme scenarios and to determine the peak water levels and flows throughout the catchment has been met.

8.1.2 Increases in water level observed due to the Proposed Scheme reach a maximum of up to 50mm close to the confluence of the diverted unnamed watercourses and the River Lea, although as discussed this is extremely localised. More generally, there is negligible impact in all return periods. These are detailed for a range of AEP and flood maps provided in Appendix A.

8.1.3 Blockage and sensitivity analyses have demonstrated that changes in key variables such as roughness, model inflows and downstream boundary location and gradient result in modelled water levels that remain below the critical freeboard requirements.

8.1.4 At detailed design stage, the hydraulic modelling of the watercourse should be revisited. Topographic survey data of the channel and associated structures should be collected and if preliminary results deem it necessary, this model should then be converted into a linked 1D-2D model. This will provide better representation of the channel conveyance processes and refine the model outputs, allowing the model to be used to confirm flood risk from the Phase 2a scheme.

9 References

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Appendix A: Flood level impact maps

1.1.1 The water level difference has been mapped for 5.0%AEP and 1.0%+CC AEP as described in Section 5, see Figures A-1 and A-2.

Figure A-1: Checkley Brook and River Lea at Checkley Impact Map for 5% AEP (1 in 20 year)

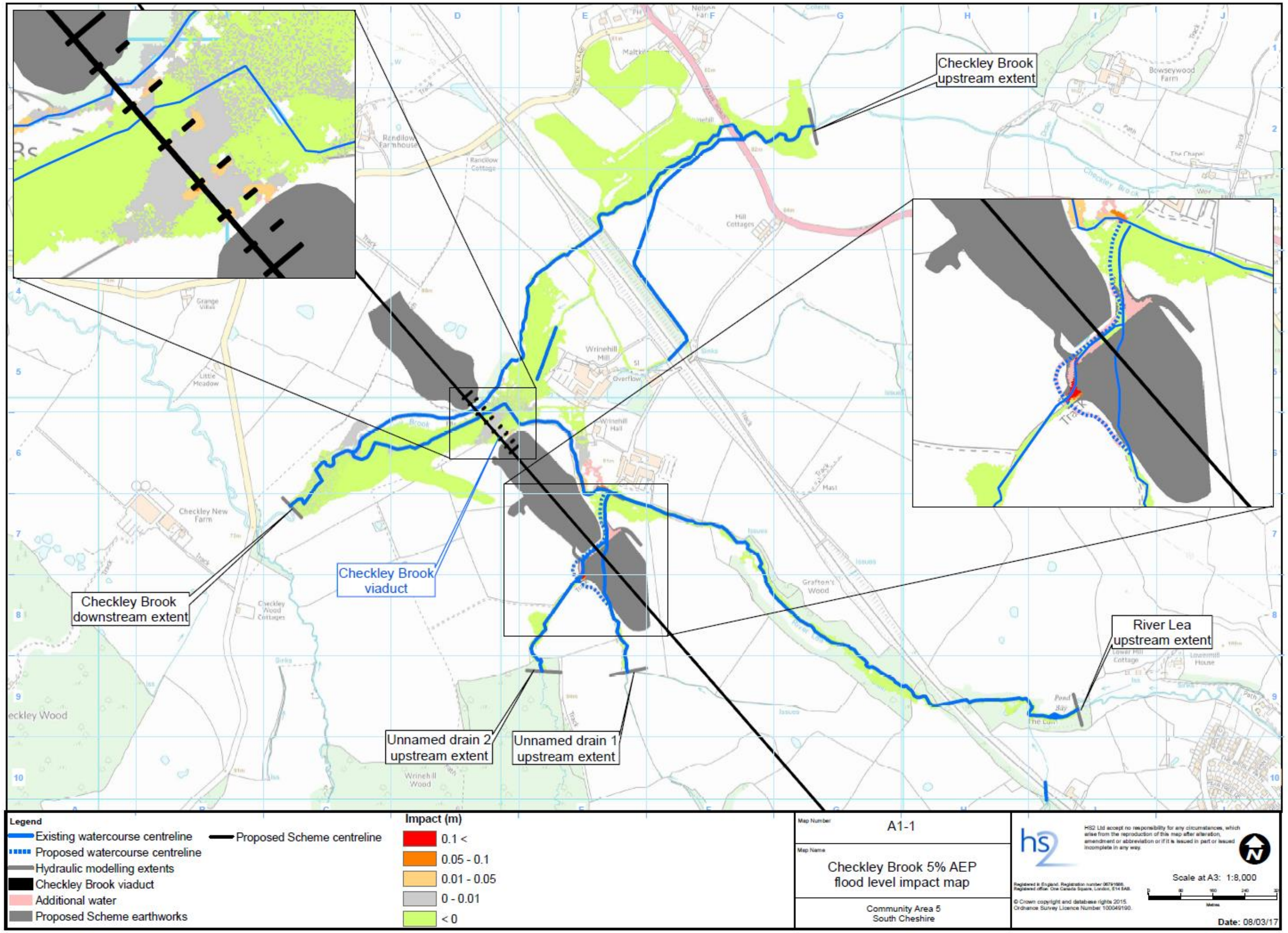
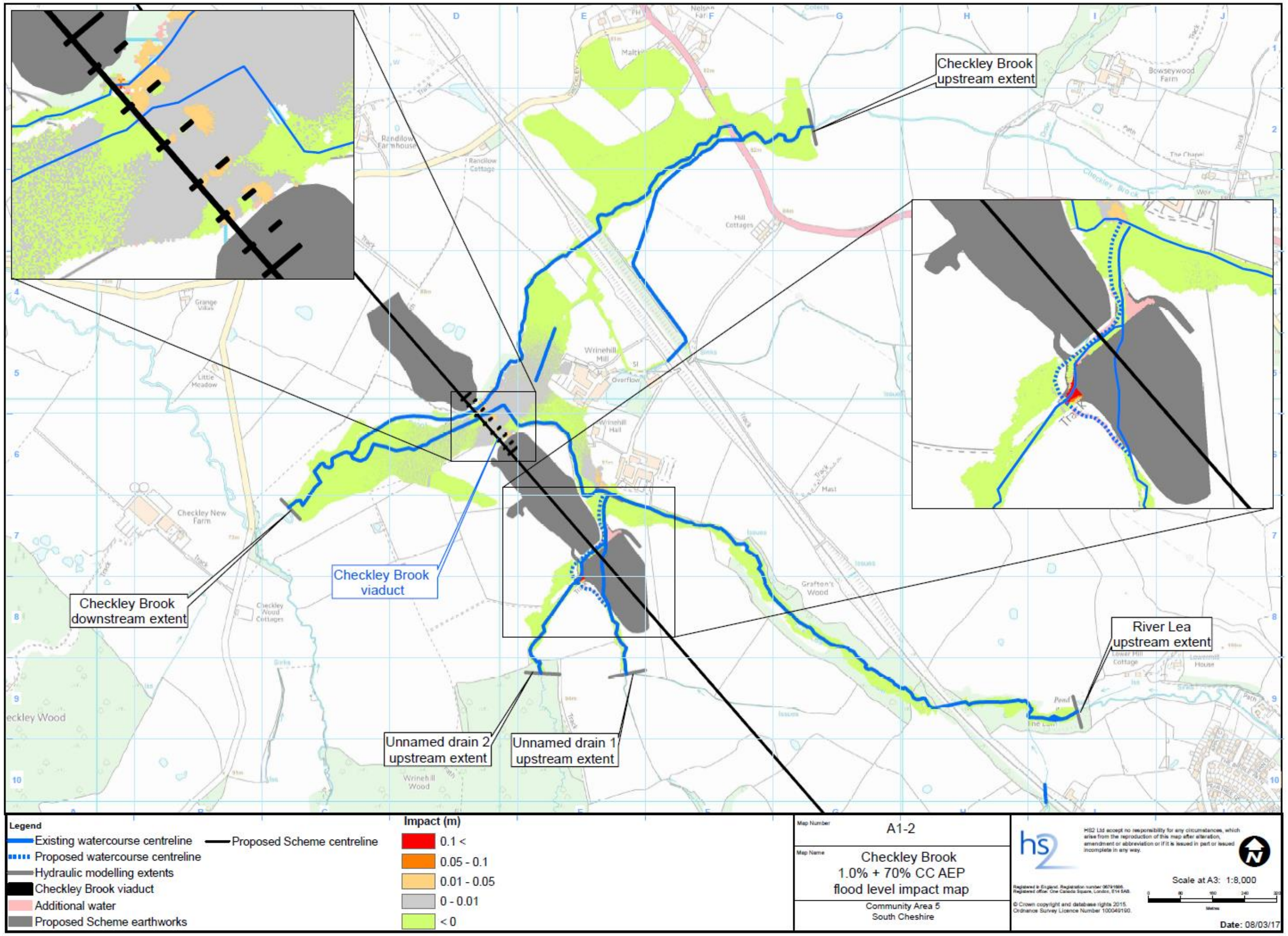


Figure A-2: Checkley Brook and River Lea at Checkley Impact Map for 1% AEP (1 in 100 year) plus 70% climate change allowance



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