Pell Frischmann

BEW Parcel SC1

Flood Risk Assessment

ARUN DISTRICT COUNCIL BN/11/22/OUT

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Contents

1 Introduction 4
1.1 Project Brief 4
1.2 Sources of Information 4
2 Background & Site Context 5
2.1 Planning Context 5
2.2 Site Location & Existing Use 5
2.3 Local Watercourses 6
2.4 Topography 9
2.5 Geology 9
2.6 Development Proposals 10
3 Policy Context 11
3.1 National Planning Policy Framework 11
3.2 Local Plan Policies 11
3.3 Neighbourhood Plans 12
3.4 Local SFRA 12
3.5 Local PFRA 12
3.6 Local Flood Risk Management Strategy 12
3.7 Lidsey Surface Water Management Plan 13
4 Assessment of Flood Risk 14
4.1 Desk-Based Information 14
4.2 Fluvial Flood Risk 14
4.3 Coastal & Tidal 21
4.4 Groundwater 23
4.5 Surface Water (Pluvial) 28
4.6 Sewers 30
4.7 Canals 30
4.8 Reservoirs 30
4.9 A29 Crossing Flood Model 30
4.10 Impact of the Proposed Development 36
5 Flood Risk Mitigation 38
5.1 Sequential Arrangement 38
5.2 Development Levels 38
5.3 Watercourse Standoff 38
5.4 School Stream Diversion 38
5.5 A29 Crossing Design Principles 40
5.6 Surface Water Management Strategy 40
5.7 Monitoring 40
5.8 A29 Crossing Floodplain Compensation 41
6 Conclusions & Recommendations 42

ARUN DISTRICT COUNCIL BN/11/22/OUT

Figures

Figure 2.1 Site Location Plan 6
Figure 2.2 Watercourse Map 7
Figure 2.3 Watercourse Photographs (Site Visit 05/03/2021) 8
Figure 2.4 Elevation Points Map 9
Figure 4.1 Flood Map for Planning 15
Figure 4.2 Modelled Fluvial Extents including Climate Change 17
Figure 4.3 School Stream Inflow Details 19
Figure 4.4 Photographs of School Stream Inflows 20
Figure 4.5 School Stream Culvert Inlet 21
Figure 4.6 Tidal Flood Extents – Undefended Scenario 22
Figure 4.7 Groundwater Monitoring Locations 24
Figure 4.8 Highest Groundwater Level Recorded (mAOD) 26
Figure 4.9 Shallowest Groundwater Depths Recorded During Monitoring 27
Figure 4.10 Risk of Flooding from Surface Water 29
Figure 4.11 Area of Floodplain where Impact is Analysed 31
Figure 4.12 Cross Section 1.008!!-4-1.007!!us Water Level Comparison 32
Figure 4.13 Cross Section 1.012!!-1-1.011!! Water Level Comparison 32
Figure 4.14 Cross Section 1.013!! Water Level Comparison 33
Figure 4.15 Water Depth Difference - Embankments - Baseline - 1%AEP + 35% Climate Change 34
Figure 4.16 Modelled Baseline Water Depth 35
Figure 4.17 Modelled Embankment Water Depth 36
Figure 5.1 Indicative Route of School Stream Diversion 39

Tables

Table 4.1 Desk-Based Assessment of Flood Risk 14
Table 4.2 Climate Change Allowances 16
Table 4.3 Summary of Highest Groundwater Levels Recorded 25
Table 4.4 Summary of Lowest Groundwater Levels Recorded 28
Table 5.1 Floodplain Compensation Provision 41

Appendices

Appendix 1 Topographical Survey
Appendix 2 Environment Agency Response to FoI Request
Appendix 3.1 A29 Crossing of Lidsey Rife: Flood Risk Technical Note
Appendix 3.2 EA Review and Modelling Log
Appendix 4 Groundwater Monitoring Factual Report
Appendix 5 Southern Water Sewer Records
Appendix 6 Floodplain Compensation Feasibility

ARUN DISTRICT COUNCIL BN/11/22/OUT

1 Introduction

1.1 Project Brief

1.1.1 Pell Frischmann has been appointed by the C.C Projects, Ashmarden Ltd and Hanbury (PM) Ltd to undertake a Flood Risk Assessment (FRA) to support an outline planning application covering a proportion of an allocated site. The site is referred to as BEW SC1 and forms the land south of Barnham Road and north of the railway line as well as the route of the A29 realignment in Arun District of West Sussex.

1.1.2 The purpose of this FRA is to review available information and assess the flood risk posed to the site and proposed development from a range of sources, now and in the future. The FRA has been carried out in accordance with the requirements of the National Planning Policy Framework (NPPF) and associated Planning Practise Guidance (PPG), in respect of flood risk and coastal change.

1.1.3 To complete the FRA, the following key stages of work were proposed:

- Collation of desk-based information and undertake a review of publicly available flood risk information including Environment Agency mapping and local data, policy, and guidance.
- Undertaking a desktop review of other data that has been made available such as topographical surveys, utility plans and proposed development layout options.
- Detailed hydraulic modelling information based on a baseline model provided by the Environment Agency
- Site visits carried out Pell Frischmann engineers and consultants to observe local hydrological features and characteristics.
- Consultation with relevant stakeholders to obtain further information on local risks and issues.
- Site-specific groundwater monitoring
- An assessment and indicative design of mitigation measures including watercourse diversions and crossings.
- Advice on appropriate flood risk mitigation measures for the proposed development.

1.2 Sources of Information

1.2.1 A review of relevant information and guidance from a range of sources has been undertaken and includes the following key documents:

- National Planning Policy Framework (NPPF), September 2023
- Planning Practice Guidance (PPG), August 2022
- Non-statutory technical standards for sustainable drainage systems, March 2015
- Environment Agency Flood Map for Planning and Risk of Flooding from Surface Water datasets from the DEFRA Spatial Data Catalogue
- Environment Agency hydraulic models of the ‘Aldingbourne’ Rife and ‘Arun to East Head’ coastal inundation
- DEFRA MagicMap, 2023
- British Geological Survey Geology of Britain Viewer, 2023
- British Geological Survey Mapping GeoIndex, 2023
- Arun District Local Plan 2011-2031, July 2018
- Barnham and Eastergate Neighbourhood Development Plan 2014-2029, December 2013
- West Sussex Strategic Flood Risk Assessment, January 2010
- West Sussex Preliminary Flood Risk Assessment, May 2011
- Lidsey Surface Water Management Plan, October 2014

ARUN DISTRICT COUNCIL BN/11/22/OUT

2 Background & Site Context

2.1 Planning Context

2.1.1 The Barnham Eastergate Westergate (BEW) site is a large site allocation within the Arun Local Plan 2011-2031 intended to provide "*…at least 2,300 dwellings over the Local Plan period and up to 3,000 in total*." The allocation also considers development of a community hub, local centre, and improvements to transport connections. It also allows for the development of a realigned route for the A29 through the scheme.

2.1.2 Subsequent to the site's allocation in the Local Plan, the BEW Framework Masterplan was produced to provide a comprehensive masterplan for the strategic site allocation, demonstrating how the site can contribute to the delivery of housing and employment needs of the Local Plan through the plan period (2011-2031).

2.1.3 Specifically, the Framework Masterplan set out flood risk constraints in relation to the network of ditches across the site and published Flood Zone extents along the Lidsey Rife corridor. It also outlined a comprehensive strategy for surface water management across the Framework Masterplan area in line with the requirements and recommendations of the Arun Strategic Surface Water Management Study.

2.1.4 The Framework Masterplan was endorsed by the Council's Development Control Committee in November 2020, subject to the submission of a Phasing and Infrastructure Delivery Plan.

2.1.5 This Flood Risk Assessment document has been prepared in line with the principles set out within this Framework Masterplan, providing bespoke assessment of risk across the application area, and updating the assessment based on the latest available data and standards.

2.2 Site Location & Existing Use

2.2.1 The site is located in the Arun district of West Sussex, to the west of Barnham, south of Eastergate and east of Westergate. It forms the first application submitted by the applicant for a major proportion of the BEW allocated site, and for clarity, will be referred to as 'BEW Parcel SC1'.

2.2.2 A site location plan is included for reference as **Figure 2.1**. In total, the application area covers approximately 92.5 hectares and includes the realignment of the A29.

ARUN DISTRICT COUNCIL BN/11/22/OUT

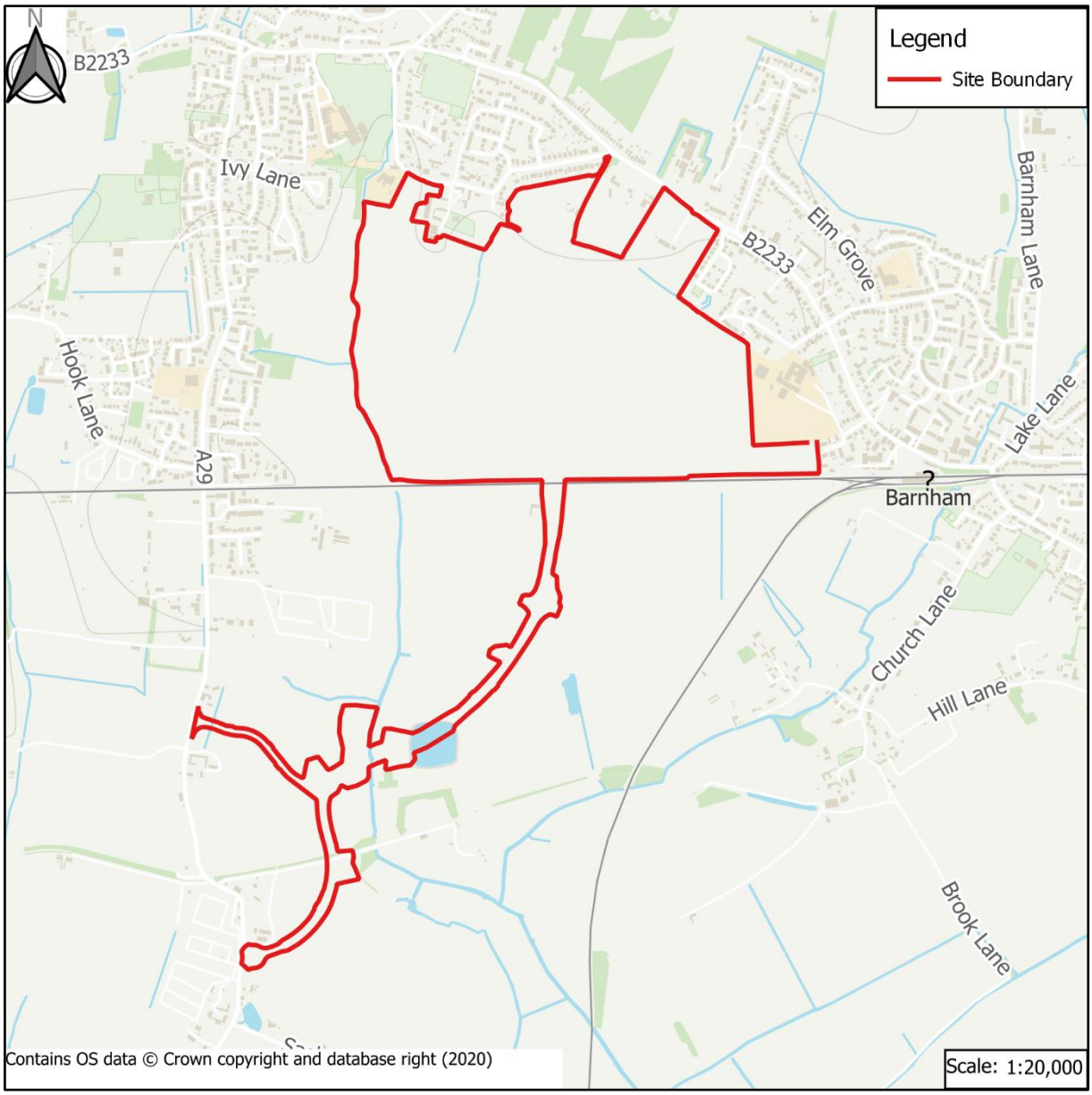


Figure 2.1 Site Location Plan

2.2.3 Adjoining the site to the east is St Philip Howard Catholic School with residential properties beyond, the north of the site is bound by Barnham Road and adjoining properties. To the immediate western boundary lies the Willows Caravan Park with the villages of Westergate and Woodgate further beyond, leading to Lidsey and the existing A29. To the south the land predominantly comprises open agricultural land, Lidsey oil fields and Lidsey Wastewater Treatment Works.

2.2.4 Currently, the site comprises open, arable land with occasional subdivisions formed by drainage ditches and hedgerows and a small number of nurseries. The topography generally increases in elevation from south to north along a central ridge line. The Lidsey Rife, which flows from north to south through the west of the site creates a significantly incised valley line.

2.3 Local Watercourses

2.3.1 The 'Lidsey Rife' flows in a southerly direction along the western boundary and is designated as a Main River, falling under the jurisdiction of the Environment Agency (EA). The Lidsey Rife is a tributary of the larger Aldingbourne Rife system, converging approximately 3.8km to the south of the southern boundary. The Aldingbourne Rife then outfalls to the sea via a sluice gate control at Bognor Regis Promenade.

2.3.2 There are several other ordinary watercourses and land drainage ditches / field drains present within the site and the surrounding area, predominantly appearing to serve a land drainage function. During several site visits carried out by representatives from Pell Frischmann, many ditches were observed to be dry, with no discernible flow direction or with isolated pools of standing water present.

2.3.3 An ordinary watercourse referred to as the 'School Stream' flows in culvert through the site. The actual route of the culvert is not known, but an assumed route has been indicated based on consultation with Arun District Council drainage engineers. A site visit did not identify any manholes, inspection chambers or other covers within the field that could indicate a route of the culvert, but the inlet and outfall were observed on a site visit carried out by Pell Frischmann's engineers.

2.3.4 **Figure 2.2** shows a plan of the local watercourses for context. Photographs of key watercourses are presented in **Figure 2.3**.

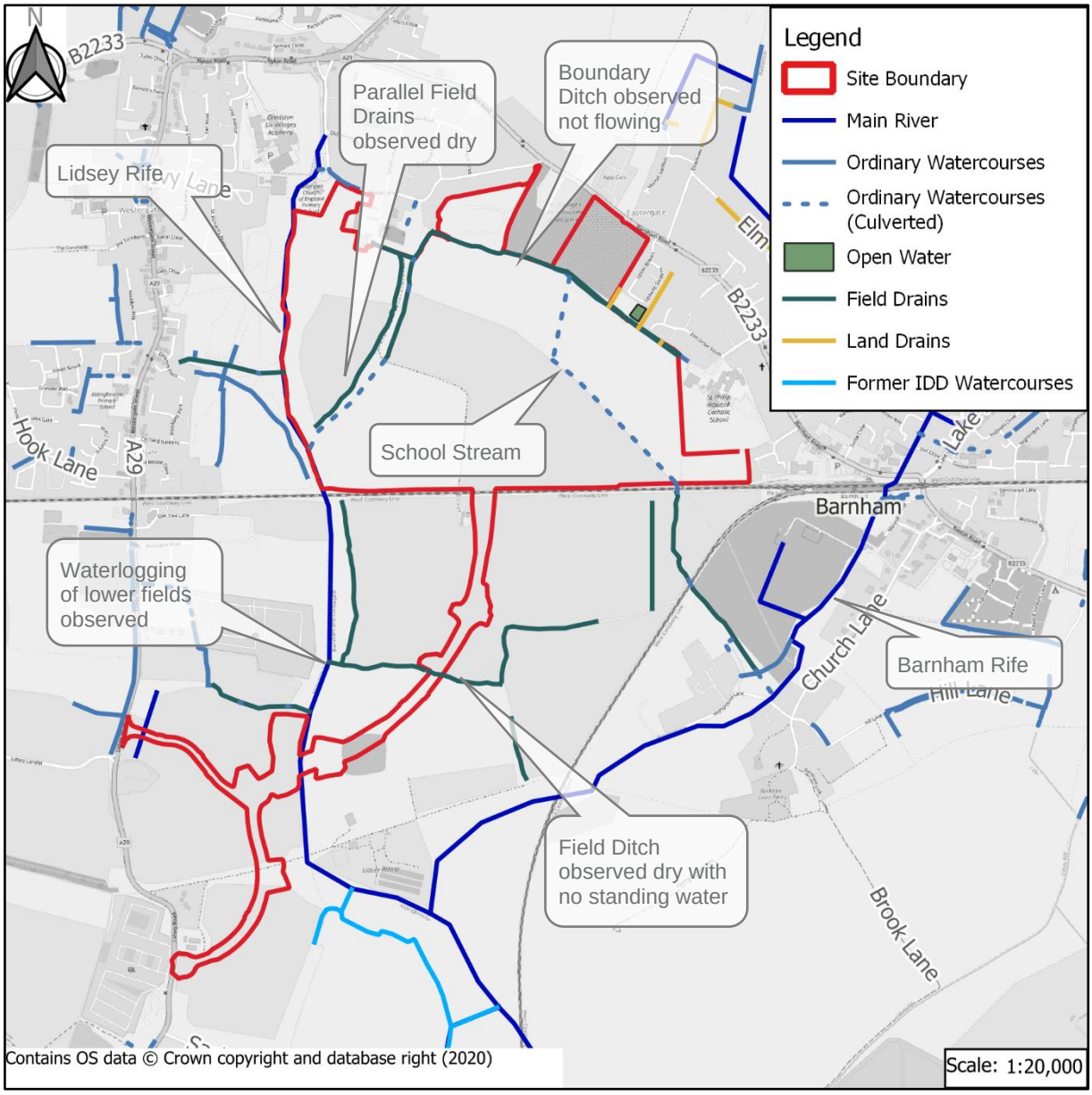


Figure 2.2 Watercourse Map

ARUN DISTRICT COUNCIL BN/11/22/OUT



Figure 2.3 Watercourse Photographs (Site Visit 05/03/2021)
Clockwise from top left: Photo A - Lidsey Rife looking upstream; Photo B - field ditch by A29 crossing looking east; Photo C – Over-deepened land drain looking north; Photo D – Field ditch by railway looking south

ARUN DISTRICT COUNCIL BN/11/22/OUT

2.4 Topography

2.4.1 The development site covers a large area and therefore has a varied, undulating topography. The low point of the site is found along the Lidsey Rife in the west where levels vary from 1.88m AOD in the south to 6.75m AOD in the north.

2.4.2 There is a high ridge point running north-south through the centre of the site. The most elevated point is found towards the north with levels around 10.96m AOD, adjacent to the railway levels are found around 9.73m AOD. This level along the railway falls eastwards to approximately 6.27m AOD before rising back up to meet Gospond Road at 8.78m AOD and also falls westwards towards the Lidsey Rife to levels around 1.88mAOD.

2.4.3 There levels are illustrated in **Figure 2.4** below. A topographical survey is included as **Appendix 1**.

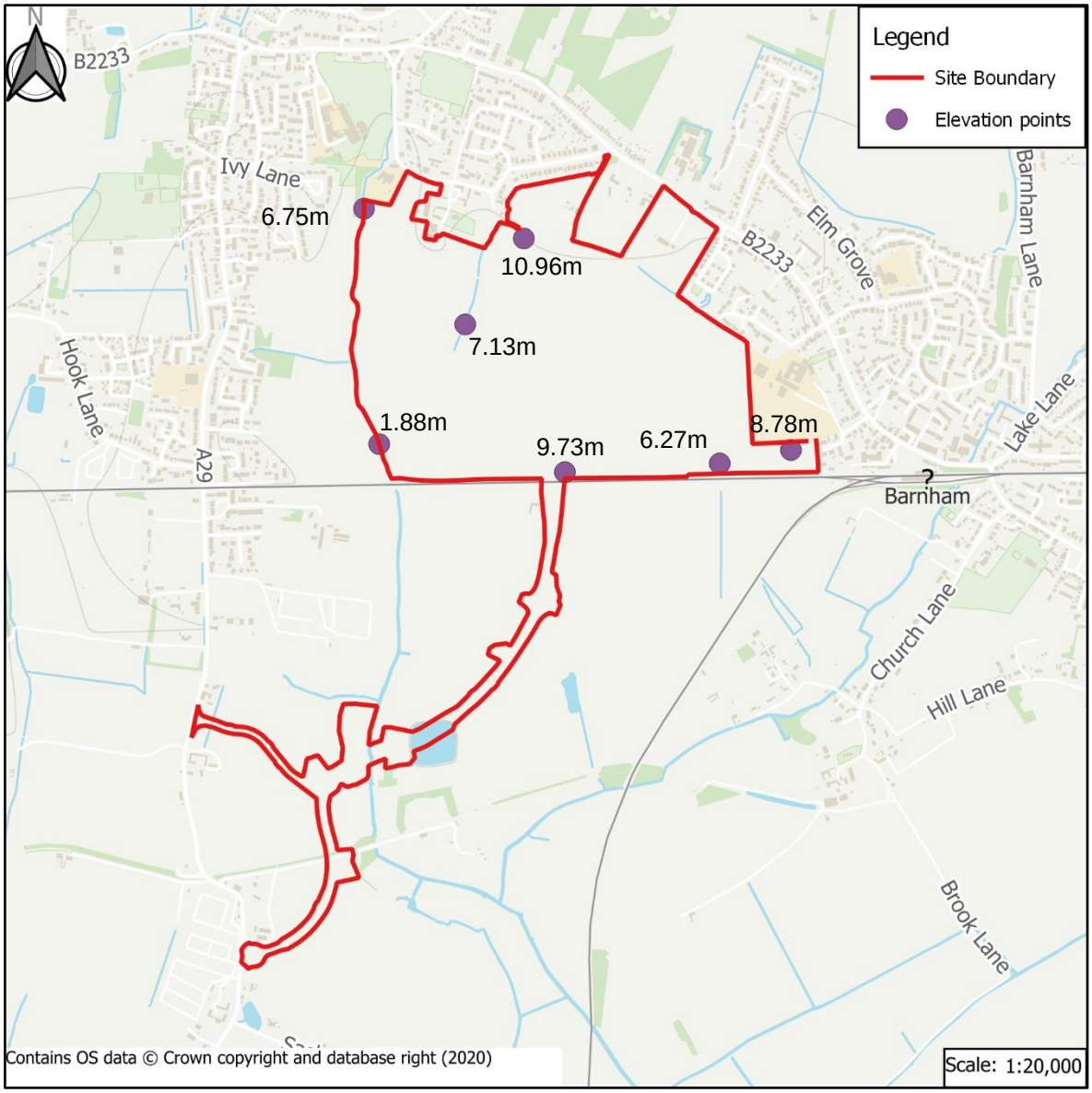


Figure 2.4 Elevation Points Map

2.5 Geology

2.5.1 British Geological Survey (BGS) mapping shows the site is underlain by superficial deposits comprising of Head (gravel, sand, silt, and clay), River Terrace Deposits and Raised Beach Deposits consisting of mainly silts, sands and gravels which are loosely consolidated allowing for infiltration into the strata. No

ARUN DISTRICT COUNCIL BN/11/22/OUT

significant areas of made ground are anticipated across the site, except around existing farm buildings and storage areas in the centre of the site.

2.5.2 The site is wholly underlain by bedrock geology of London Clay, a low permeability soil which limits movement of groundwater.

2.5.3 The superficial deposits are classified as a Secondary A aquifer defined as permeable layers capable of supporting water supplies at a local rather than strategic level. The bedrock geology is reported as an 'unproductive' aquifer.

2.6 Development Proposals

2.6.1 The site has been allocated as part of a wider Barnham, Eastergate Westergate development within the Arun Local Plan 2011-2031 where it is referenced as 'SD5 BEW'. Therefore, the principle of the development has been established. The Arun Local Plan 2011-2031 has carried out a sequential test confirming the appropriateness of the site for such a development. The endorsed Framework Masterplan also ensured the layout fully considered flood risk implications, particularly along the Lidsey Rife corridor.

2.6.2 Development proposals submitted as part of a planning application should be reviewed alongside this report.

3 Policy Context

3.1 National Planning Policy Framework

3.1.1 The National Planning Policy Framework[1] (NPPF) was first published in 2012, with a latest revision by the Ministry of Housing, Communities and Local Government made in September 2023.

3.1.2 The NPPF is the primary source of national planning guidance in England, setting out the Government's planning policies for England, and how they are expected to be applied by local councils.

3.1.3 'Chapter 14: Meeting the challenge of climate change, flooding and coastal change' outlines the guiding principles for managing flood risk as part of the planning process, notably paragraphs 159-169.

3.1.4 The Planning Practice Guidance[2] (PPG) sets out the vulnerability to flooding of different land uses. It encourages development to be in areas of lower flood risk where possible and stresses the importance of preventing increases in flood risk off site to the wider catchment.

3.1.5 The Planning Practice Guidance also states that alternative sources of flooding, other than fluvial (river flooding), should be considered when preparing a Flood Risk Assessment.

3.1.6 The Planning Practice Guidance includes a series of tables that define Flood Zones, the flood risk vulnerability classification of development land uses, and 'compatibility' of development within the defined Flood Zones.

3.1.7 Therefore, this Flood Risk Assessment has been completed in line with the guidance and requirements for the NPPF and Planning Practice Guidance.

3.2 Local Plan Policies

3.2.1 The Arun Local Plan 2011-2031[3] was adopted in July 2018. The Local Plan sets out how land within the district can be used and developed, providing policies the Council use to determine development and regeneration activities. The plan aims to oversee how Arun District Council encourages sustainable development, manages future growth, and continues to ensure changes across the District are appropriate to local need.

3.2.2 The site is allocated in the Local Plan and is subject to the strategic policies laid out within the plan.

3.2.3 The Local Plan lists polices that guide the design and principles of all development within the district land. Those relevant to this FRA are summarised as follows:

- Policy W SP1: Water
- Policy W DM1: Water Supply and Quality
- Policy W DM2: Flood Risk
- Policy W DM3: Sustainable Urban Drainage Systems
- Policy QE DM4: Contaminated Land
- Policy ECC SP1: Adapting to Climate Change

[1] Ministry of Housing, Communities and Local Government (September 2023); *The National Planning Policy Framework*
[2] Ministry of Housing, Communities and Local Government (August 2022); *Planning Practice Guidance on Flood risk and coastal change*
[3] Arun District Council (July 2018); *The Arun Local Plan 2011-2031*; Final Report; prepared by Arun District Council

ARUN DISTRICT COUNCIL BN/11/22/OUT

3.3 Neighbourhood Plans

3.3.1 Alongside the Arun Local Plan 2011-2031, the Site falls within the bounds of the Barnham & Eastergate Neighbourhood Plan[4] and the Aldingbourne Neighbourhood Plan[5]. These plans aim to provide local people with an ability to shape changes that should occur within the Parish and provide developers with clarity as to the requirements to be met for development within the Parish, whilst also setting out the vision for the future that reflects the thoughts and feelings of local people.

3.3.2 The Barnham & Eastergate Neighbourhood Plan covers the majority of the application site and lists policies that developers should follow. Those relevant to this FRA are listed as follows:

- Policy ES1: Flooding, Drainage and New Development
- Policy ES2: Watercourses

3.3.3 The Aldingbourne Neighbourhood Plan applies to land within the application west of the Lidsey Rife and also lists polices that developers should follow. Those relevant to this FRA are listed as follows:

- Policy EH4: Protection of Watercourses
- Policy EH5: Surface Water Management

3.4 Local SFRA

3.4.1 The West Sussex Strategic Flood Risk Assessment[6] (SFRA) was published in January 2010 by Capita Symonds on behalf of West Sussex County Council (WSCC). The SFRA was prepared to provide an appropriate evidence base for local policymaking, a summary of flood risk issues across the area and to support the application of the sequential test for suitability of allocated sites.

3.4.2 The SFRA also includes relevant background flooding data and a summary of flood risk within the district.

3.5 Local PFRA

3.5.1 The West Sussex Preliminary Flood Risk Assessment[7] was published in May 2011 by WSCC. The PFRA was prepared to assist WSCC meet their duties to manage local flood risk and deliver any legal requirements placed on them as the LLFA under the Flood Risk Regulations 2009.

3.5.2 The PFRA also identifies the past and future flood risk for the County and includes an assessment of where within the County flooding, including overland flow and direct rainfall, will occur along with the number of properties potentially at risk.

3.6 Local Flood Risk Management Strategy

3.6.1 The Local Flood Risk Management Strategy 2013-2018[8] (LFRMS) was produced by WSCC to comply with Section 9 of the Flood and Water Management Act 2010 and aims to provide a framework for meeting their requirements to develop, maintain, apply, and monitor a local strategy for flood risk management and how WSCC aim to achieve this.

[4] Barnham and Eastergate Parish Council (July 2014); *Barnham and Eastergate Neighbourhood Development Plan 2014-29*: Final Report; prepared by BEPC
[5] Arun District Council (June 2021); *Aldingbourne Neighbourhood Development Plan 2019-31*: Final Report; prepared by ADC
[6] West Sussex County Council (January 2010); *The West Sussex Strategic Flood Risk Assessment*: Final Report; prepared by Capita Symonds on behalf of WSCC
[7] West Sussex County Council (May 2011); *The West Sussex Preliminary Flood Risk Assessment*: Final Report; prepared by WSCC
[8] West Sussex County Council (2013); *The Local Flood Risk Management Strategy 2013-2018*: Final Report; prepared by WSCC

ARUN DISTRICT COUNCIL BN/11/22/OUT

3.6.2 The LFRMS provides further information regarding surface water runoff, groundwater and sewer flooding and flood risk around the County and the introduction of flood risk alleviation schemes at various scales, including SuDS.

3.7 Lidsey Surface Water Management Plan

3.7.1 The Lidsey Surface Water Management Plan[9] (SWMP) was developed through a partnership between WSCC, Southern Water, Arun District Council, and the Environment Agency and prepared by Atkins Consultants. The SWMP aims to provide context and information to support the delivery of the LFRMS with specific interest in the Lidsey area.

[9] West Sussex County Council, Southern Water, Arun District Council, Environment Agency (2013): *The Lidsey Surface Water Management Plan*: Final Report; prepared by Atkins on behalf of the above organisations

4 Assessment of Flood Risk

4.1 Desk-Based Information

4.1.1 The NPPF states all sources of flood risk must be identified and appraised as part of a development. Flooding can occur from a variety of sources individually, or in combination and can result from both natural and artificial processes

4.1.2 **Table 4.1** provides an initial desk-based review of flood risk from all sources, which are then assessed in further detail where the risk is considered significant and merits further investigation.

Table 4.1 Desk-Based Assessment of Flood Risk

Sources of Flood Risk	Degree of Risk			Comments
	Significant	Moderate	Low	
Fluvial		X		The Site is in Flood Zone 1, however, several small Watercourses and the Lidsey Rife have floodplain associated with them.
Coastal & Tidal			X	The site is within a few miles of the coast, but the extent of tidal inundation is limited to the Lidsey Rife corridor.
Groundwater	X			Susceptibility to groundwater flooding due to shallow groundwater levels.
Surface Water			X	Isolated areas of surface water risk present around the site boundaries.
Sewers		X		Limited extent of sewers on site but site visit investigations show evidence of foul water surcharge.
Canals			X	None in the vicinity.
Reservoirs & Waterbodies			X	One present in the south, heavily impounded, but risk remains low

4.2 Fluvial Flood Risk

4.2.1 The Environment Agency has produced a resource known as the Flood Map for Planning, which identifies areas at risk of flooding from Main Rivers and the sea. The site is shown to be located mostly within Flood Zone 1 (Low Probability) with areas of Flood Zone 2 (Medium Probability) and Flood Zone 3 (High Probability) limited to the Lidsey Rife and the tributaries along the western boundary. Flood Zone 1 is defined in the NPPF as land having less than a 1 in 1000 annual probability of flooding from rivers or the sea. An extract of this mapping is included for reference as **Figure 4.1**.

4.2.2 A request for information was also submitted to the Environment Agency as part of our review of available information. The EA's response, including specific details on flood extents, flood levels and other advisory information is included for reference as **Appendix 2**.

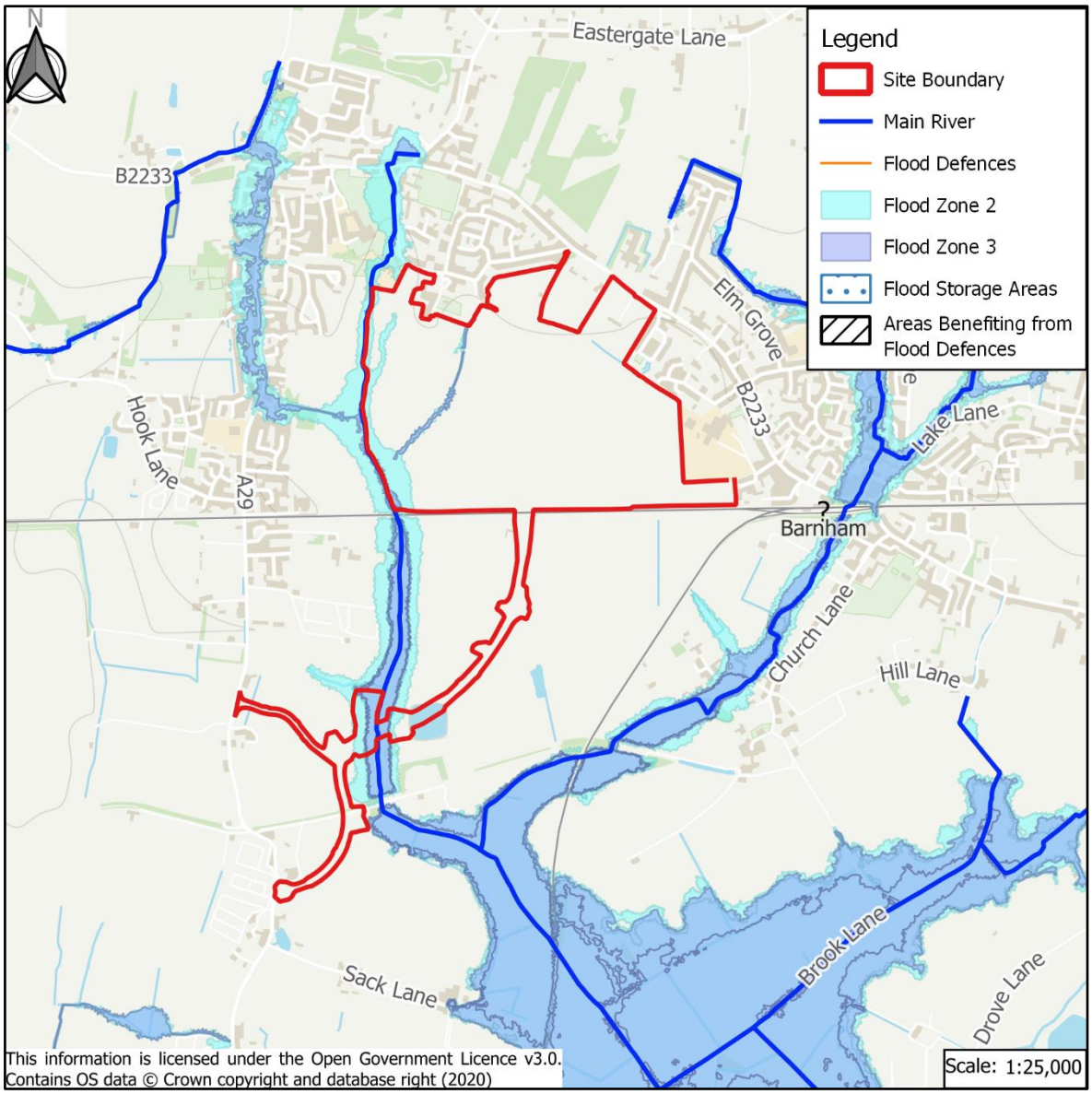


Figure 4.1 Flood Map for Planning

Lidsey Rife

4.2.3 The Flood Map for Planning, and further information supplied by the Environment Agency confirms the main body of the site is generally at low risk of flooding from the Lidsey Rife. Areas along the western boundary show limited floodplain extent due to the local topography and relatively well-defined floodplain parallel to the Rife.

4.2.4 Hydraulic modelling carried out by the EA as part of the Aldingbourne Flood Risk Mapping Study provides a series of applicable flood levels and updated extents along the Lidsey Rife, including an allowance for climate change.

4.2.5 It should be noted that the model used climate change allowances set out in a previous version of the guidance from February 2016. In July 2021 this guidance was updated[10] to provide revised climate change allowances across management catchments, rather than the river basin districts to provide more localised assessments. The site falls within the 'Arun and Western Streams' management catchment, the latest allowances summarised in **Table 4.2**.

[10] Environment Agency (2021); *Flood risk assessments: climate change allowances*; available via https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#peak-river-flow-allowances; updated 27 July 2021

Table 4.2 Climate Change Allowances

Design Epoch	Percentage Increase in Peak River Flow			
	Central	Higher Central	Upper	Previous (Upper) Allowances for 'South East' District
2020s	11%	16%	27%	35%
2050s	13%	19%	36%	45%
2080s	25%	36%	64%	105%

4.2.6 The guidance states the appropriate allowances to use, when considering the Flood Zone classification, development type and where strategic flood risk assessments identify critical issues. Based on this guidance, it would be prudent to consider the 'central allowance' for the 2080s epoch when considering the maximum flood level for any development in or near the Flood Zone of the Lidsey Rife.

4.2.7 When considering the proposed A29 crossing, it would be appropriate to consider the 'higher central' allowance for the 2080s epoch considering its potential to be considered as 'essential infrastructure' as a critical transport route even though alternative routes exist (such as along the current A29 route).

4.2.8 Therefore, as a conservative approach the 'higher central' allowance for the 2080s epoch will be used across this assessment for consistency. The 36% increase in peak river flows will therefore broadly equate to the 35% increase in river flows previously assessed and provided by the Environment Agency and so will be used as a proxy result.

4.2.9 Results from the Environment Agency's Aldingbourne Flood Risk Mapping Study consider both 'defended' and 'undefended' scenarios as part of the output. The accompanying report confirms that there are no formal raised defences within the Aldingbourne catchment, and so the difference in scenarios relates to the inclusion or removal of the Felpham Pumping Station at the downstream outfall of the Aldingbourne Rife. Therefore, as a 'design' event the defended scenario is considered within this FRA.

4.2.10 A plan showing the modelled flood extent for the 100 year +35% climate change allowance is provided for reference as **Figure 4.2**.

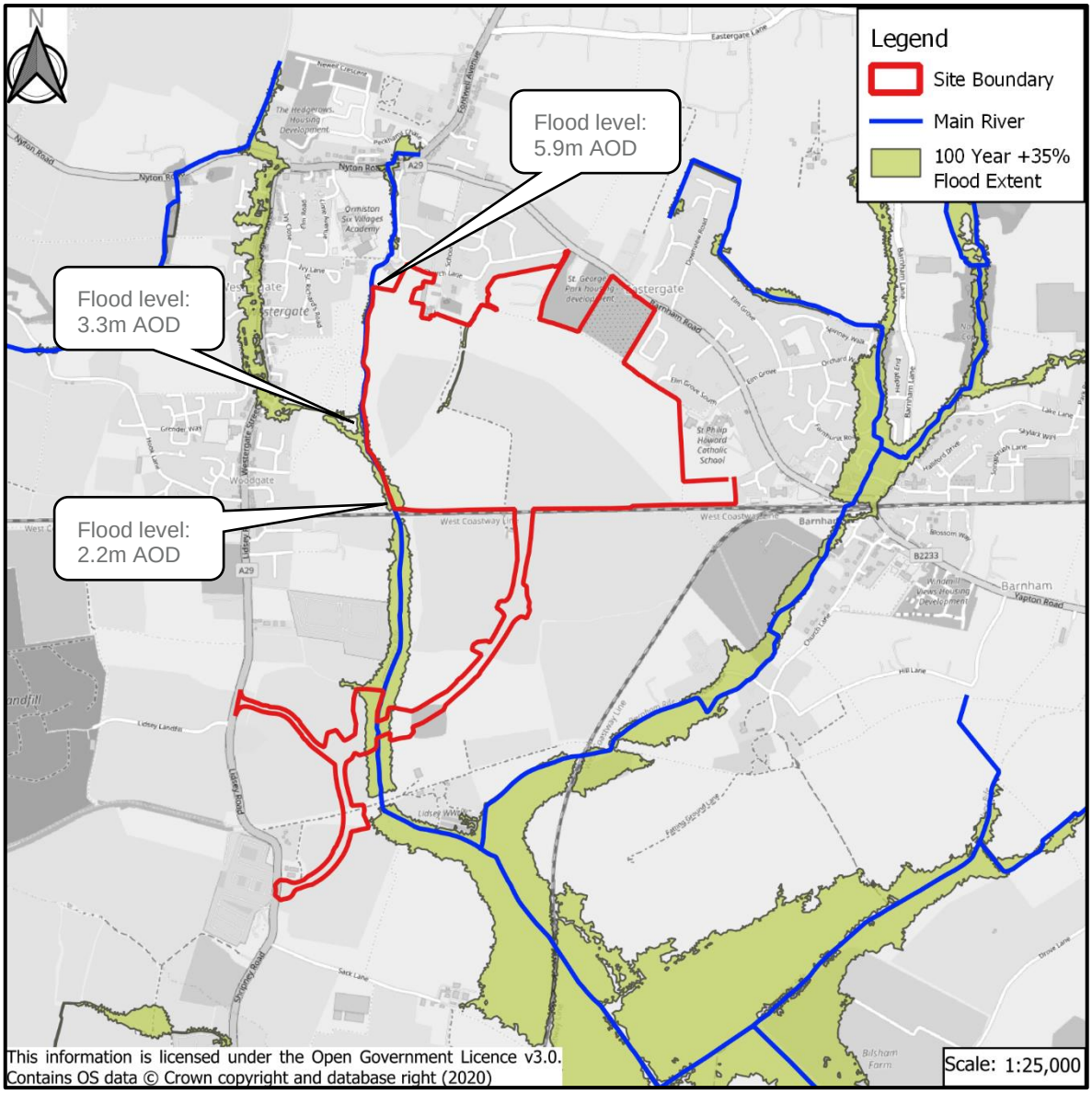


Figure 4.2 Modelled Fluvial Extents including Climate Change

4.2.11 Review of the flood extents confirm little to no floodplain extends within the site boundary, particularly north of the railway where floodplain is limited to a narrow corridor parallel to the Rife. Corresponding floodplain flood levels range from 2.2m AOD immediately north of the railway to 3.3m AOD at the confluence with the small ditch to the west to 5.9m AOD at the upstream-most part of the site boundary.

4.2.12 Mitigation has been incorporated by design as part of the Framework Masterplan process, whereby a linear park has been designated along the Lidsey Rife valley, setting development back considerably from the watercourse and, by extension, the associated floodplain.

4.2.13 Therefore, the risk of fluvial flooding from the Lidsey Rife to the main development area is considered to be low.

4.2.14 In respect of the proposed A29 alignment, part of the route must cross over the Lidsey Rife, close to the route of the disused canal north of Lidsey Sewage Treatment Works. Concept designs for the bridge crossing have been put forward, comprising a 30m clear span over the Lidsey Rife and its immediate floodplain. The soffit level of the crossing has been set to be at least 600mm above the 100-year +35% flood level of 2.2m AOD to ensure no surcharging of the structure takes place.

4.2.15 The impact of this crossing has been modelled using the Aldingbourne Flood Risk Mapping Study model provided by the Environment Agency. Further technical details are provided within the Technical Note prepared by Pell Frischmann included as **Appendix 3.1**.

4.2.16 The Technical Note confirms the crossing has no detrimental impact to flood risk offsite, with a nominal reduction in flood levels downstream of the site boundary. There are some localised increases in flood level around the bridge structure, but these are within the land ownership of the applicants and represent an acceptable change to the flooding in the vicinity as this increase can be accommodated within the landscaping corridor surrounding the Lidsey Rife, particularly as it does not increase flood risk downstream, contributing to an improvement in the current situation.

4.2.17 As part of ongoing consultation with the EA, the EA have reviewed the hydraulic model produced by Pell Frischmann and concluded the model is fit for purpose. A copy of the confirmation and associated model log is included as **Appendix 3.2**.

4.2.18 Therefore, the risk of flooding from the Lidsey Rife is not considered to be significant. Mitigation has been incorporated by design to avoid the floodplain for built development, and appropriate measures are recommended for the design of the A29 crossing to ensure it remains safe from flooding.

School Stream

4.2.19 As mentioned, there is a network of smaller watercourses and land drains across the site that are not specifically included within the Aldingbourne Flood Risk Mapping study.

4.2.20 In its current condition, the culverted School Stream may present a low risk of flooding to isolated areas. Based on a site visit carried out by representatives from Pell Frischmann, the catchment of the School Stream is relatively small, limited to the areas to the north that drain into the watercourse at several locations as indicated in **Figure 4.3**. Photographs of key inflows and sections of channel are included as **Figure 4.4**.

4.2.21 The FEH Web Service reports the School Stream catchment to extend some 0.866km^2 (86.6ha), covering a linear area of Barnham up to Fontwell Avenue. This is unlikely to be representative of the actual drainage catchment, due to the presence of other ditches in the area north of Barnham Road that would intercept this flow, and discrete topographical changes that would prevent water entering the School Stream.

ARUN DISTRICT COUNCIL BN/11/22/OUT

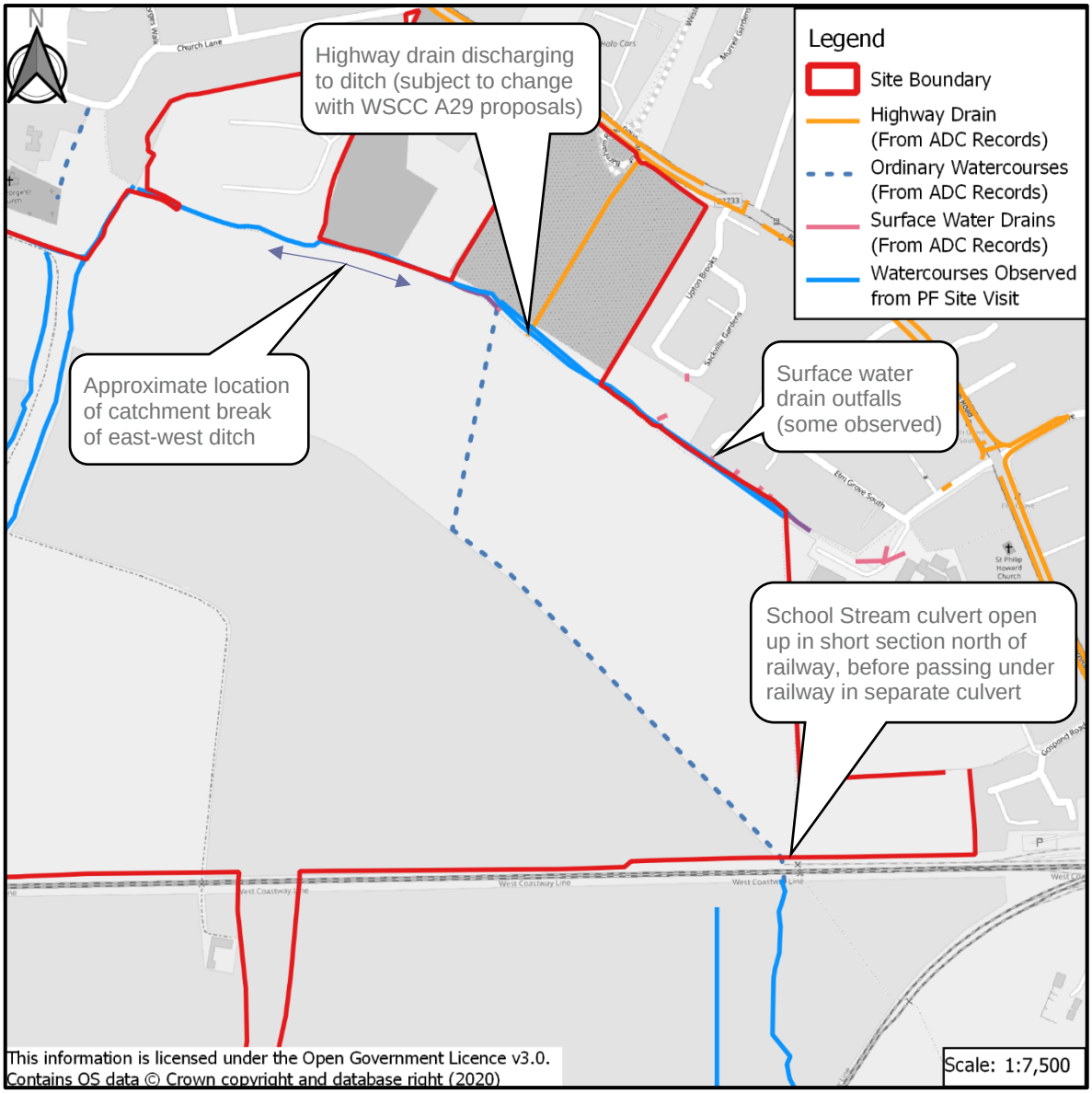


Figure 4.3 School Stream Inflow Details



Figure 4.4 Photographs of School Stream Inflows

Clockwise from top left: Outfall from Upton Brooks scheme, looking north; Surface water outfall from Upton Brooks Scheme looking north; Channel near Elm Grove South looking east towards site boundary; Surface water drain outfall off Elm Grove South at northeast site boundary, looking northwest (note dry channel)

4.2.22 The culvert inlet was observed to be of small diameter and partially blocked by vegetation and other debris trapped by the small trash screen (see **Figure 4.5**). A flow was noted into the culvert and observed at the outfall of the culvert by the railway, indicating that the culvert was free flowing along its length.

ARUN DISTRICT COUNCIL BN/11/22/OUT



Figure 4.5 School Stream Culvert Inlet

4.2.23 Proposals are put forward for deculverting the School Stream as part of redevelopment, rerouting the stream in an open channel through the site, and abandoning the culverted section. Further details of this diversion are included in Section 5.0 of this FRA.

Land Drains

4.2.24 Two parallel field drains located in the west of the site are shown to be partially affected by flooding because of surcharging along the Lidsey Rife, with small areas of Flood Zone 3 attributed to them. However, a site walkover confirmed no obvious sign of connectivity between these two ditches and the Lidsey Rife noting an absence of pipe inlets and their end and no signs of outfalls in the bank of the Rife.

4.2.25 During the site visit carried out in March 2021, there was no signs of water within the ditches either. Both channels stop a substantial distance from the Rife and again there were no signs of overland flows disturbing the ground cover crop or soils.

4.2.26 These ditches are thought to be ephemeral streams, conveying water during periods of high rainfall and supporting with draining the surrounding fields, rather than being permanent bodies of flowing water. As such, the risk of flooding from these is negligible and will be managed through redevelopment of the site.

4.2.27 Therefore, the site overall is not considered to be at significant risk of fluvial flooding.

4.3 Coastal & Tidal

4.3.1 The site is approximately 5km north of the Bognor Regis coastline and strategic documents including the SFRA, PFRA and CFMP, mention there is still a risk from costal and tidal flooding to the Arun District, but this is likely to occur through upstream surges through smaller watercourses.

ARUN DISTRICT COUNCIL BN/11/22/OUT

4.3.2 Under normal conditions, the flood defence infrastructure in place along the Arun to East Head shoreline adequately protects the site from flooding from tidal events. A review of the hydraulic modelling results provided by the Environment Agency (included as **Appendix 2**) confirm the site to be far removed from the defended tidal floodplain, in all events including the extreme 0.1% annual probability event and the 0.5% annual probability design events including sea level rise allowances attributed to climate change.

4.3.3 Moreover, the River Arun to Pagham Flood & Coastal Erosion Risk Management Strategy has a policy of maintaining the current flood defence standard along almost all of the frontage of this policy area, particularly around Bognor Regis and Felpham, which is the main area that would have a bearing on coastal flood risk affecting the development site.

4.3.4 The defences will therefore be subject to regular inspection, maintenance, and upgrade where necessary to maintain the current standard of protection into the future. Therefore, under normal conditions the site is not at significant risk of tidal flooding.

4.3.5 In the unlikely event of an undefended scenario, the information supplied by the Environment Agency from the Emsworth to Littlehampton West Bank Coastal Modelling Study includes modelled outputs from the Arun to East Head coastal flooding model. An extract of this mapping is included as **Figure 4.6** which confirms a limited floodplain extent in the southeast corner of the site.

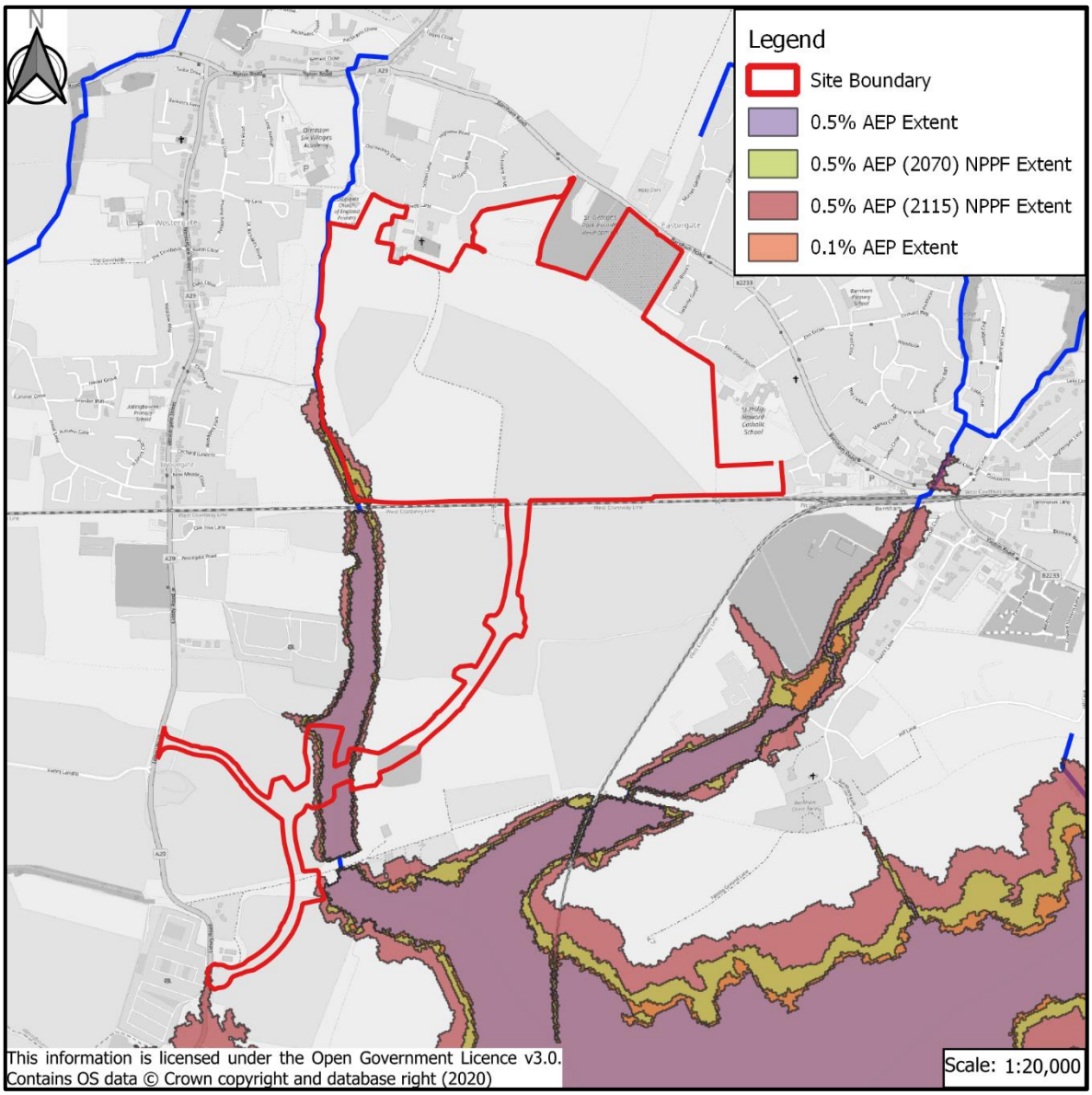


Figure 4.6 Tidal Flood Extents – Undefended Scenario

4.3.6 The extent is similar in scale to the extent of Flood Zone 3 discussed previously and falls well within the linear park area identified. The main events affecting the site are the 0.5% annual probability event when considering the impacts of sea level rise up to 2070 and 2115. Given how the flooding is tidally dominated, the flood level along the western boundary remains consistent, reported at 2.60m AOD in the 0.5% AEP (2070) event and 3.44m AOD for the 0.5% AEP (2115) event.

4.3.7 This is marginally higher than the fluvial flood level quoted previously (2.2m AOD) but given how the undefended scenario is considered a residual event it should be used to assess the effectiveness of mitigation designs, rather than setting design parameters. In any case, the minimum soffit level of 2.8m AOD would be elevated above the 0.5% AEP (2070) flood level providing a degree of robustness to the design. The road deck level is currently proposed at approximately 4.36m AOD over the Rife to allow for construction thickness of the bridge deck and road surfacing, therefore demonstrating the road would not be inundated in such an event, although some surcharging to the structure underneath may occur.

4.3.8 As such, the site is not considered to be at significant risk of flooding from tidal and coastal flooding. A low level of residual risk may be present to the A29 bridge structure in the unlikely event of an 'undefended' tidal flood event, which considered the removal of all raised flood defence infrastructure along the coastline.

4.4 Groundwater

4.4.1 The site is underlain by a bedrock of London Clay with River Terrace and Raised Beach superficial deposits, which can result in a shallow groundwater table in the superficial deposits, prevented from infiltrating further due to the generally impermeable clay bedrock. Issues related to high groundwater are well documented in Arun District, and across wider parts of West Sussex County. The problem is further confounded due to the proximity to the coast and potential interaction of raised sea levels on groundwater movement.

4.4.2 In line with Arun District and West Sussex County Council policy, groundwater monitoring has been installed across the site since October 2019 up to January 2021, with monitoring visits carried out approximately every 2 weeks over the Winter period (October-March) and monthly visits carried out over the summer (April-September).

4.4.3 In total, 22 boreholes were sunk across the site area to a target depth of 4m bgl, the locations of which are noted in **Figure 4.7**. It should be noted that the groundwater monitoring was scoped initially to cover the strategic Framework Masterplan area, and so a number of boreholes fall outside the current application boundary so are only included for wider context.

ARUN DISTRICT COUNCIL BN/11/22/OUT

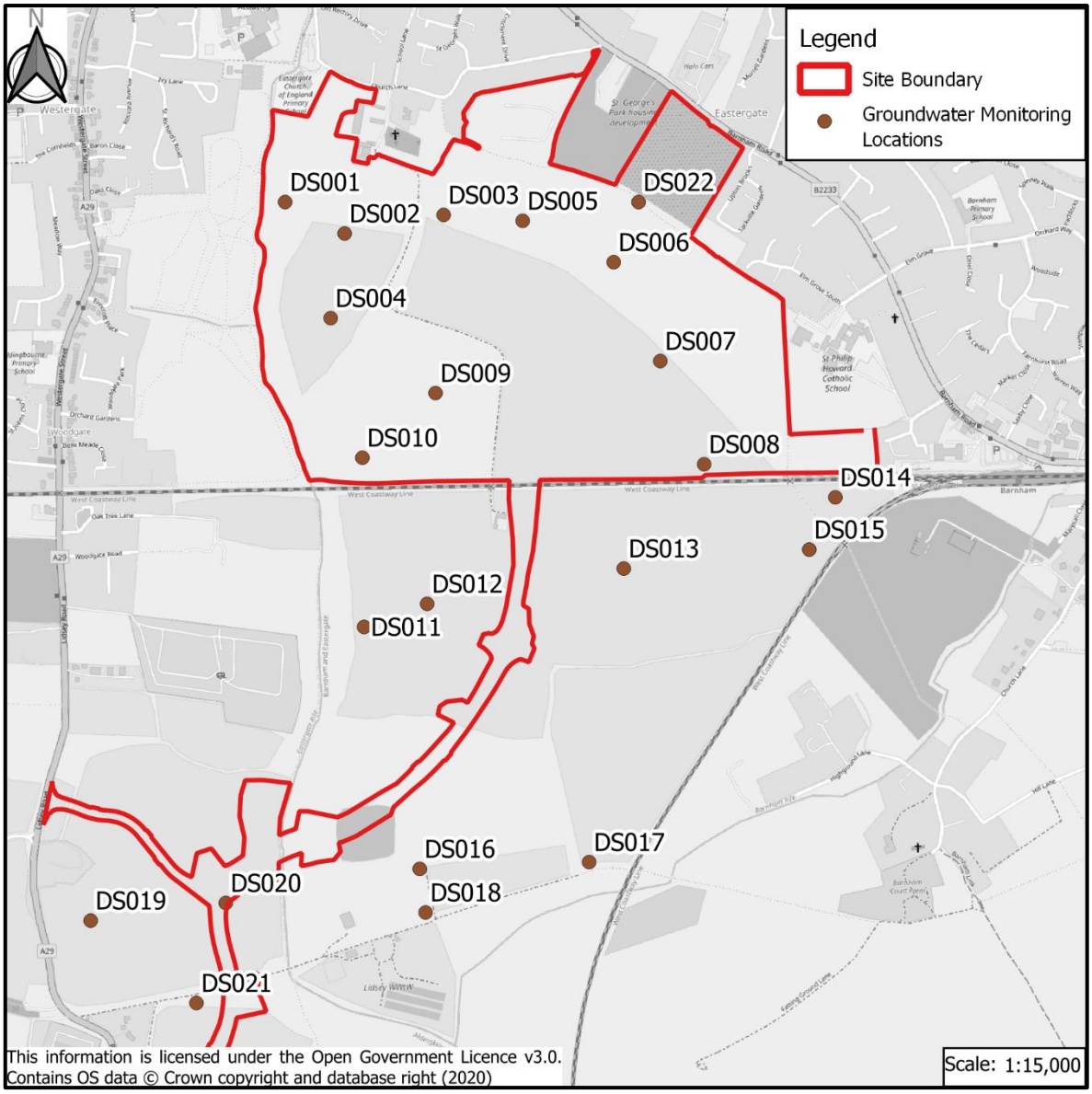


Figure 4.7 Groundwater Monitoring Locations

4.4.4 Of the 22 boreholes installed across the site, 5 (no.) boreholes had loggers installed to continuously record groundwater levels. These boreholes were:

- DS003 – In the northwest of the application site
- DS008 – In the southeast of the application site
- DS011 – Beyond the application site but close to the Lidsey Rife
- DS015 – Beyond the application site near the open section of School Stream
- DS020 – Along the route of the A29 near the Lidsey Rife crossing

4.4.5 Full details of the groundwater monitoring, including the Factual Report prepared by LandScience, have been included as **Appendix 4**. The shallowest recorded groundwater levels have been summarised in **Table 4.3**, including the date the shallowest records were made.

Table 4.3 Summary of Highest Groundwater Levels Recorded

Borehole Ref	Well Datum (mAOD)	Minimum Depth Below Ground Level (bgl)	Corresponding Water Level (mAOD)	Date of Minimum Depth Recording
DS001	6.12	0.11	6.01	23/12/2019
DS002	10.13	0.45	9.68	23/12/2019
DS003	9.8	0.3	9.5	17/02/2020
DS004	8.61	0.2	8.41	11/12/2020
DS005	10.29	0.15	10.14	23/12/2019
DS006	9.15	0.65	8.5	11/12/2020
DS007	8.22	0.45	7.77	23/12/2019
DS008	8.07	0.84	7.23	23/12/2019
DS009	9.69	0.3	9.39	11/12/2020
DS010	7.31	0.4	6.91	11/12/2020
*DS011**	*6.65*	*0.3*	6.35	*17/02/2020*
*DS012**	*8.63*	*0.3*	8.33	*23/12/2019*
*DS013**	*9.13*	*0.3*	8.83	*11/12/2020*
*DS014**	*8.06*	*0.5*	7.56	*11/12/2020*
*DS015**	*6.54*	*0.1*	6.44	*11/12/2020*
*DS016**	*7.96*	*0.1*	7.86	*10/01/2020*
*DS017**	*4.05*	*0.67*	3.38	*23/12/2019*
*DS018**	*6.37*	*0.05*	6.32	*23/12/2019*
*DS019**	*8.35*	*0.4*	7.95	*17/02/2020*
DS020	6.32	0.58	5.74	23/12/2019
*DS021**	*6.36*	*0.75*	5.61	*31/10/2019*
DS022	8.93	0.37	8.56	06/03/2020

***Denotes Boreholes Located Outside Application Boundary**

4.4.6 From review of the information, 6 out of the 12 boreholes on site recorded their shallowest groundwater results around December 2019. This coincides with several notable extreme rainfall events in the area that led to widespread flooding around West Sussex[11]. It has been reported by the Met Office[12] that the Winter statistics for 2019/2020 suggest the measures rainfall across England of 469.7mm was a 143% anomaly compared to their long-term baseline from 1981-2010. This included a number of named Winter Storms that passed the south coast in February and March 2020, although these did not result in the highest groundwater levels being recorded across the site.

4.4.7 Therefore, it can be considered the monitoring period is reflective of above-average rainfall conditions compared to the average for England and will provide a robust evidence base for this assessment.

4.4.8 Specialist analysis tools in QGIS have been used to provide spatial context and analysis of the results of the groundwater monitoring. Using the recorded data, triangulation of the results has been carried out to interpolate the results from known recording locations. Whilst not entirely accurate for discrete locations between the boreholes, the density of monitoring wells across the site provides a relatively high resolution when compared to other borehole monitoring data on a district- or county-wide scale and can be used to infer the overall hydraulic gradient of groundwater beneath the site.

4.4.9 When considering the results in context, the following conclusions can be inferred:

[11] BBC News (2019); *Flooding Brings travel disruption across south east of England;* accessed via https://www.bbc.co.uk/news/uk-england-50863956
[12] Met Office Press Release (02 Mar 2020); *Record breaking rainfall*; accessed via https://www.metoffice.gov.uk/about-us/press-office/news/weather-and-climate/2020/2020-winter-february-stats

ARUN DISTRICT COUNCIL BN/11/22/OUT

1. The recorded groundwater levels in mAOD are higher in the north and centre of the site, with positive hydraulic gradients to the west (towards the Lidsey Rife) and the east (towards the culverted School Stream) as shown in **Figure 4.8**.
2. The shallowest groundwater levels are typically found to the northwest of the application boundary, along the Lidsey Rife corridor and its tributaries as shown in **Figure 4.9**. Overall, during Winter periods groundwater can be relatively shallow across much of the application site.
3. At its deepest, groundwater was recorded between 1.4m and 2.79m below ground level within the application boundary, suggesting a relatively high degree of seasonal fluctuation in groundwater (+/-3m).

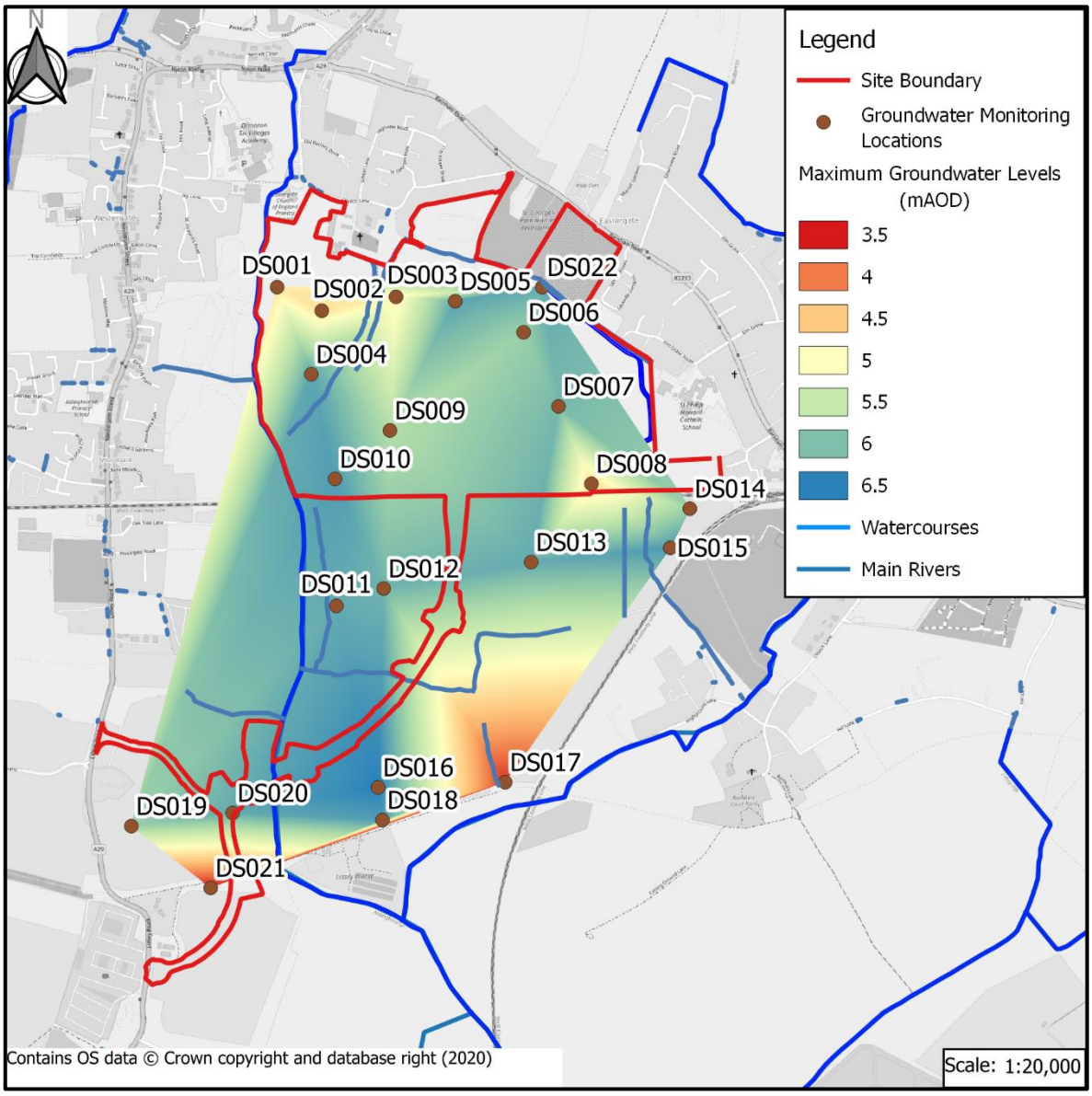


Figure 4.8 Highest Groundwater Level Recorded (mAOD)

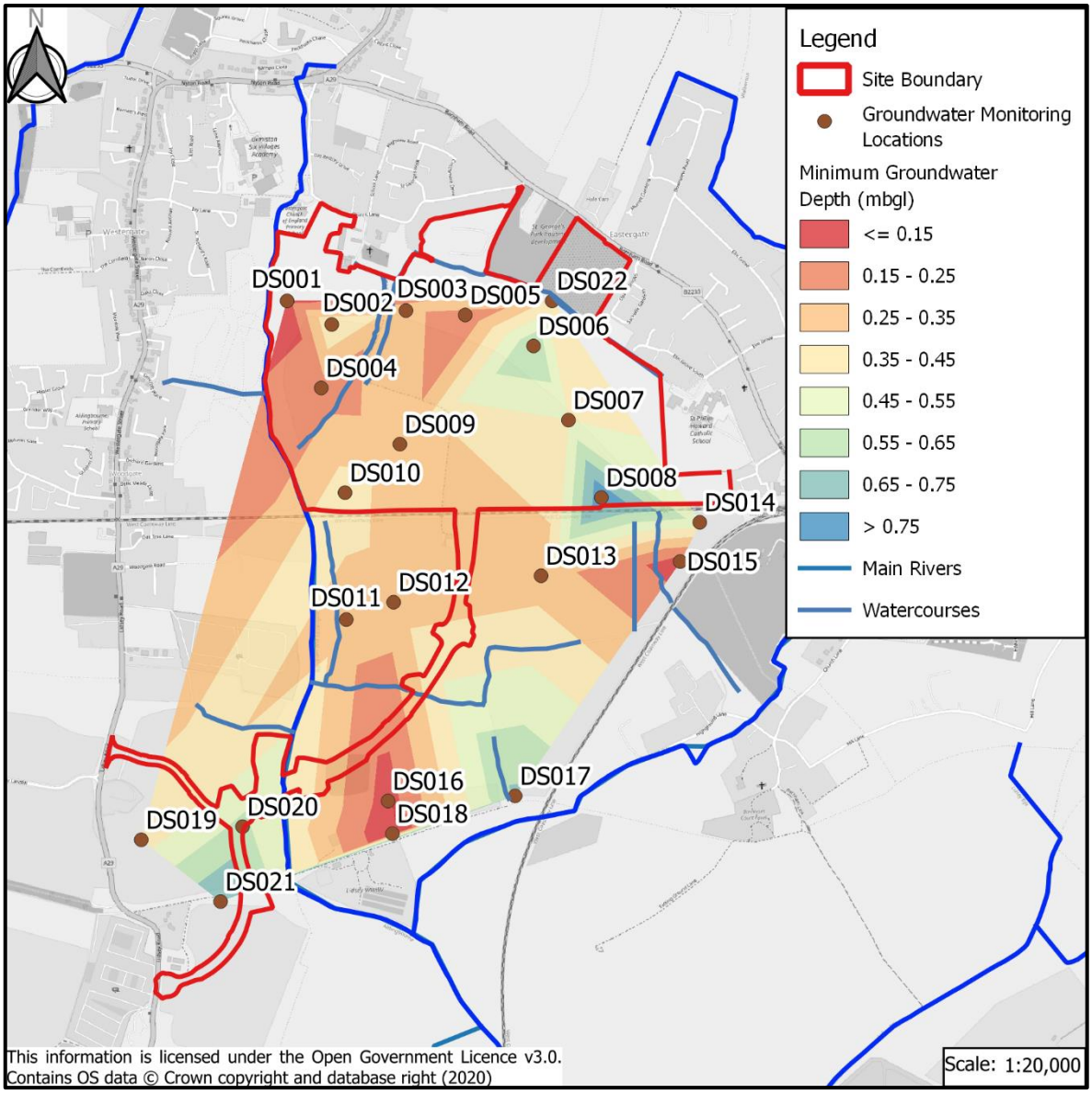


Figure 4.9 Shallowest Groundwater Depths Recorded During Monitoring

4.4.10 For contrast, **Table 4.4** provides a summary of the lowest (deepest) observed groundwater levels in the boreholes, again with dates these were recorded for reference. This shows a relatively high degree of fluctuation in levels based on prevailing conditions, although generally speaking groundwater remains relatively shallow beneath the site.

Table 4.4 Summary of Lowest Groundwater Levels Recorded

Borehole Ref	Well Datum (mAOD)	Maximum Depth Below Ground Level (bgl)	Corresponding Water Level (mAOD)	Date of Maximum Depth Recording
DS001	6.12	2.7	3.42	19/05/2020
DS002	10.13	2.75	7.38	31/10/2019
DS003	9.8	2.6	7.2	10/07/2020
DS004	8.61	1.46	7.15	31/10/2019
DS005	10.29	1.45	8.84	10/01/2020
DS006	9.15	1.8	7.35	19/05/2020
DS007	8.22	1.6	6.62	04/12/2019
DS008	8.07	2.79	5.28	10/07/2020
DS009	9.69	1.95	7.74	31/10/2019
DS010	7.31	1.4	5.91	19/05/2020
*DS011**	*6.65*	*1.5*	*5.15*	*10/07/2020*
*DS012**	*8.63*	*1.57*	*7.06*	*31/10/2019*
*DS013**	*9.13*	*1.5*	*7.63*	*10/01/2020*
*DS014**	*8.06*	*1.8*	*6.26*	*04/12/2019*
*DS015**	*6.54*	*1.39*	*5.15*	*10/07/2020*
*DS016**	*7.96*	*1.2*	*6.76*	*19/05/2020*
*DS017**	*4.05*	*3.7*	*0.35*	*04/12/2019*
*DS018**	*6.37*	*1.4*	*4.97*	*10/01/2020*
*DS019**	*8.35*	*1.8*	*6.55*	*19/05/2020*
DS020	6.32	1.5	4.82	10/07/2020
*DS021**	*6.36*	*3.82*	*2.54*	*23/12/2019*
DS022	8.93	1.51	7.42	10/01/2020

***Denotes Boreholes Located Outside Application Boundary**

4.4.11 Groundwater flooding by its nature can often be prolonged, extending over a longer period than typical flooding from rivers and the sea, so it's impacts can be more severe. There are no reported instances of groundwater flooding at the site, the SFRA refers to other flooding incidents around Arun District particularly around the centre of Barnham. However, this is not to say the site has not experienced groundwater flooding in the past.

4.4.12 Overall, there remains a risk of flooding at the site from groundwater sources that will be addressed and require further mitigation as part of the proposed development, although the risk is not considered to be significant.

4.5 Surface Water (Pluvial)

4.5.1 The risk of flooding from surface water has been mapped by the EA on a strategic scale to understand areas that may be susceptible to ponding and routing during periods of extreme rainfall. An extract of the latest mapping is included as **Figure 4.10**.

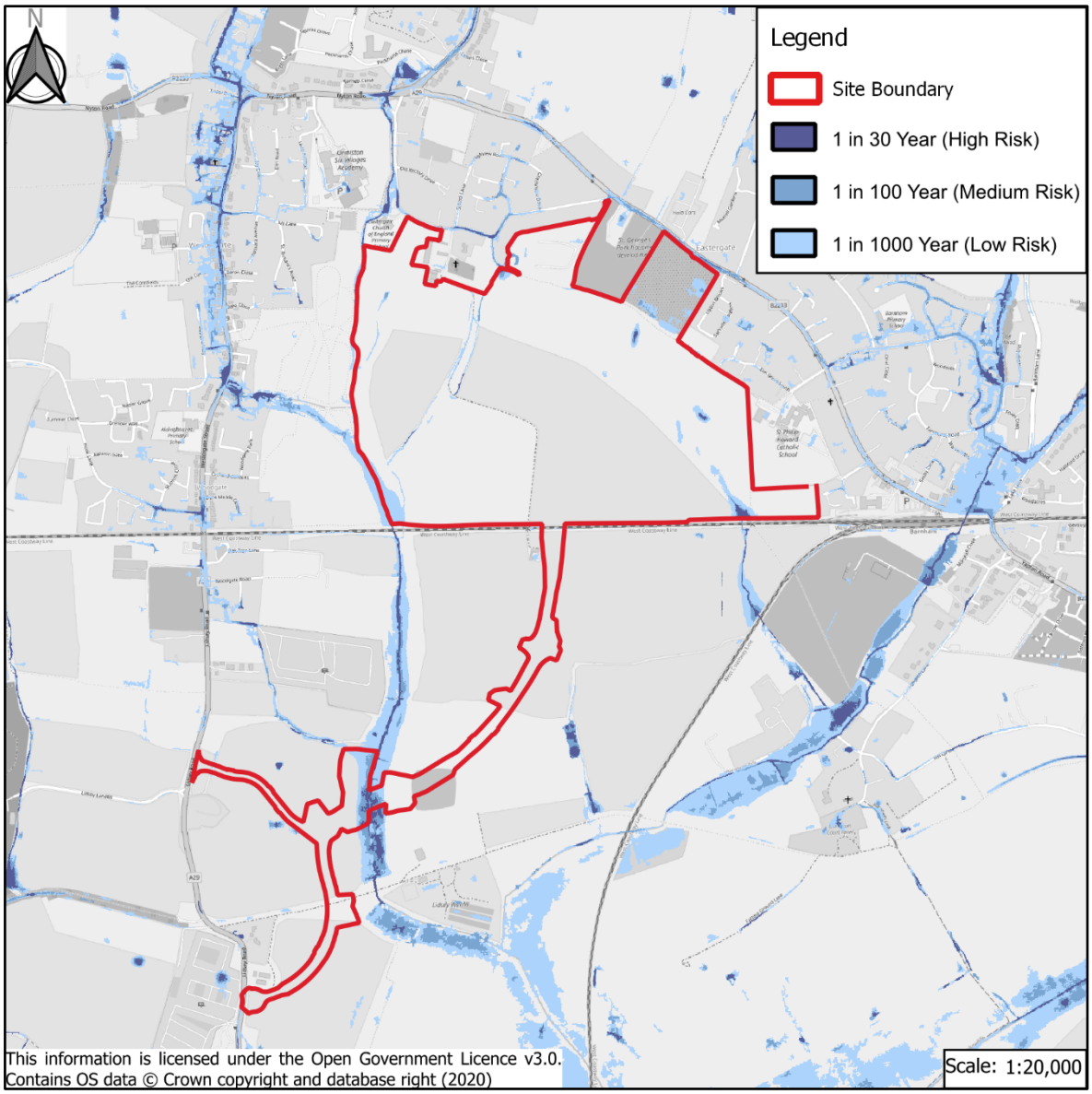


Figure 4.10 Risk of Flooding from Surface Water

4.5.2 Mapping suggests small areas of the site may be susceptible to ponding and surface water flooding. The ponding appears to be associated with localised topographical depressions which will be removed through the general earthworks strategy as the site is developed.

4.5.3 The small extent of high risk in the east of the site correlates with the location of a railway underpass and the interaction between the School Stream culvert outfall and its route under the railway. A positive connection does exist under the railway, but on several site visits this area was observed to be waterlogged and suffer from pooling of surface water.

4.5.4 The area of high risk of surface water flooding found in the south along the A29 realignment route will not affect the highway or infrastructure as the A29 will be bridged over the Lidsey Rife in this location.

4.5.5 Other areas susceptible to ponding and flooding surround the Lidsey Rife. The topography of this area limits the potential spread of surface water flooding due to a defined shallow valley shape encouraging runoff into the Lidsey Rife and away from the site.

4.5.6 Furthermore, as part of the proposed development, a surface water drainage strategy has been developed (refer to Pell Frischmann Sustainable Drainage Report document ref: 100148-PEF-ZZ-XX-RP-CD-000020) that outlines a sustainable strategy to manage surface water generated by the

development. Through managing the extra runoff generated, the risk of surface water flooding identified will be suitably managed.

4.5.7 Therefore, the risk of flooding from surface water is not considered to be significant. Mitigation has been incorporated by design to manage this risk.

4.6 Sewers

4.6.1 As the site is currently undeveloped, there is no existing surface water or foul network serving the site. However, there are foul sewers, owned by Southern Water, running parallel to the Lidsey Rife within, and in close proximity to the western boundary (see **Appendix 5**). Other sewers are present in the surrounding areas beneath Barnham Road and serving properties to the east and west.

4.6.2 The topography of the site is such that any flows from the boundaries would not flow into the site, as it falls from a high point in the centre. The sewer route along the Lidsey Rife is also at a much lower elevation that general ground levels and as such the risk of sewer flooding to the site is considered negligible.

4.7 Canals

4.7.1 The closest canal to the site is the Chichester Canal approximately 8.5km to the west. The canal flows from Chichester Basin for approximately 4 miles where it meets Chichester Harbour. This canal also connects to the Portsmouth and Arundel Canal.

4.7.2 Due to the distance and the intervening topography the risk posed to the site from flooding from canals is low.

4.8 Reservoirs

4.8.1 The EA produced strategic-scale mapping showing the potential risk of flooding from failure of large waterbodies and reservoirs, if the relevant impounding structure were to fail.

4.8.2 Mapping confirms the site is far removed from the extent of any potential flooding, from such structures.

4.8.3 There is however, a large, impounded reservoir to the south of the site that intersects with the proposed realignment of the A29. It is understood this reservoir is used for irrigation purposes of the surrounding fields, with infrastructure identified during site visits connecting the reservoir to the Lidsey Rife. The reservoir will be redundant as a result of redevelopment of the site and so will be removed as part of the enabling works for the A29 and such will no longer present any form of risk to the site.

4.9 A29 Crossing Flood Model

4.9.1 Due to the proposed A29 crossing, additional flood modelling has been completed by Pell Frischmann using a 1D-2D ICM model.

4.9.2 The model has identified an area of the Lidsey Rife of which the impact on the floodplain of the proposed A29 crossing has been assessed. **Figure 4.11** shows the area of floodplain where the impact has been analysed and cross sections where water level comparisons have been carried out.

ARUN DISTRICT COUNCIL BN/11/22/OUT



Figure 4.11 Area of Floodplain where Impact is Analysed

4.9.3 The model considered the water level comparisons between the baseline and a crossing with embankments and piers. The results of this are shown in **Figure 4.12**, **Figure 4.13**, and **Figure 4.14**.

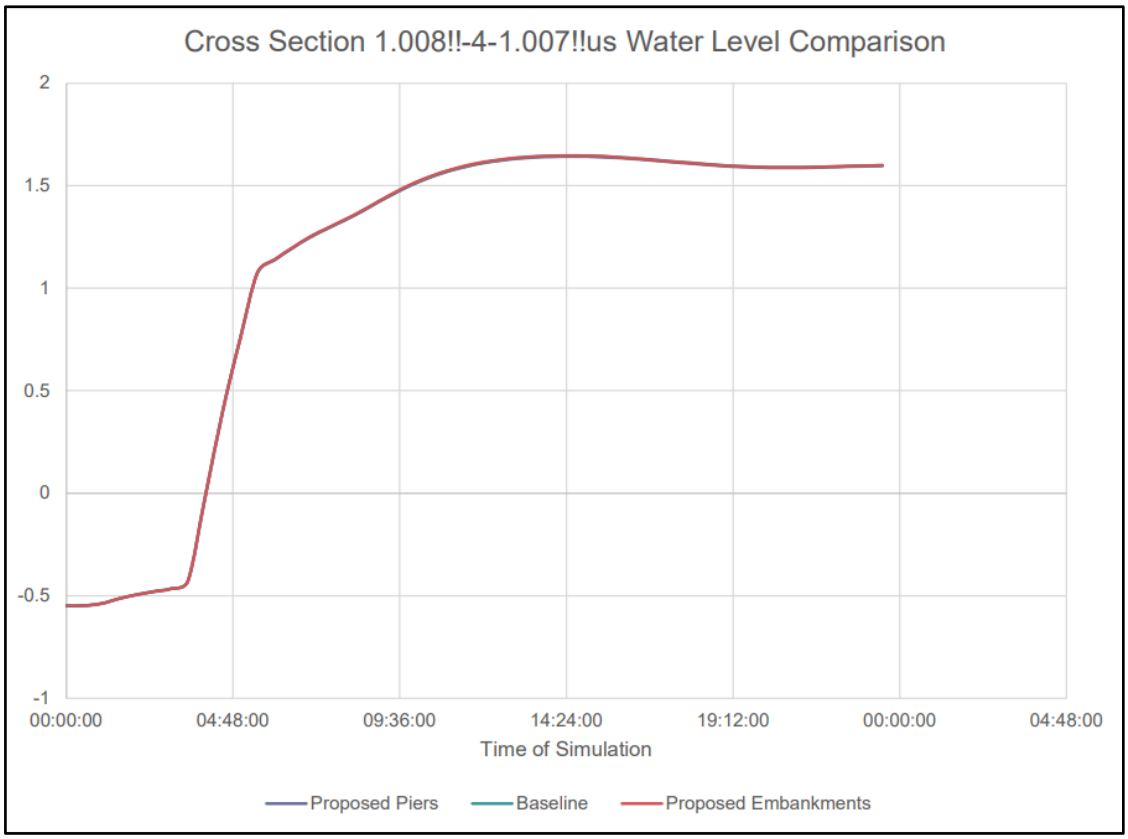


Figure 4.12 Cross Section 1.008!!-4-1.007!!us Water Level Comparison

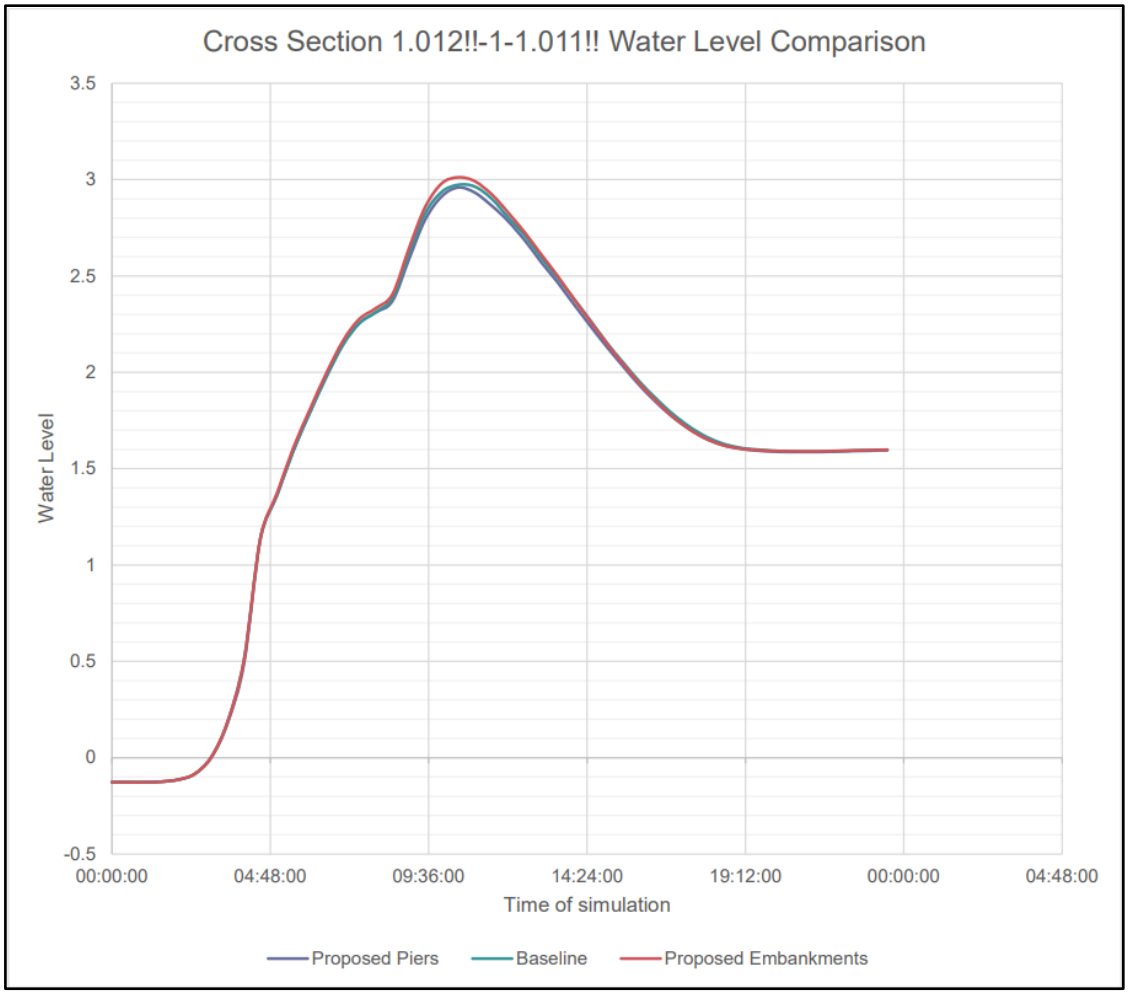


Figure 4.13 Cross Section 1.012!!-1-1.011!! Water Level Comparison

ARUN DISTRICT COUNCIL BN/11/22/OUT

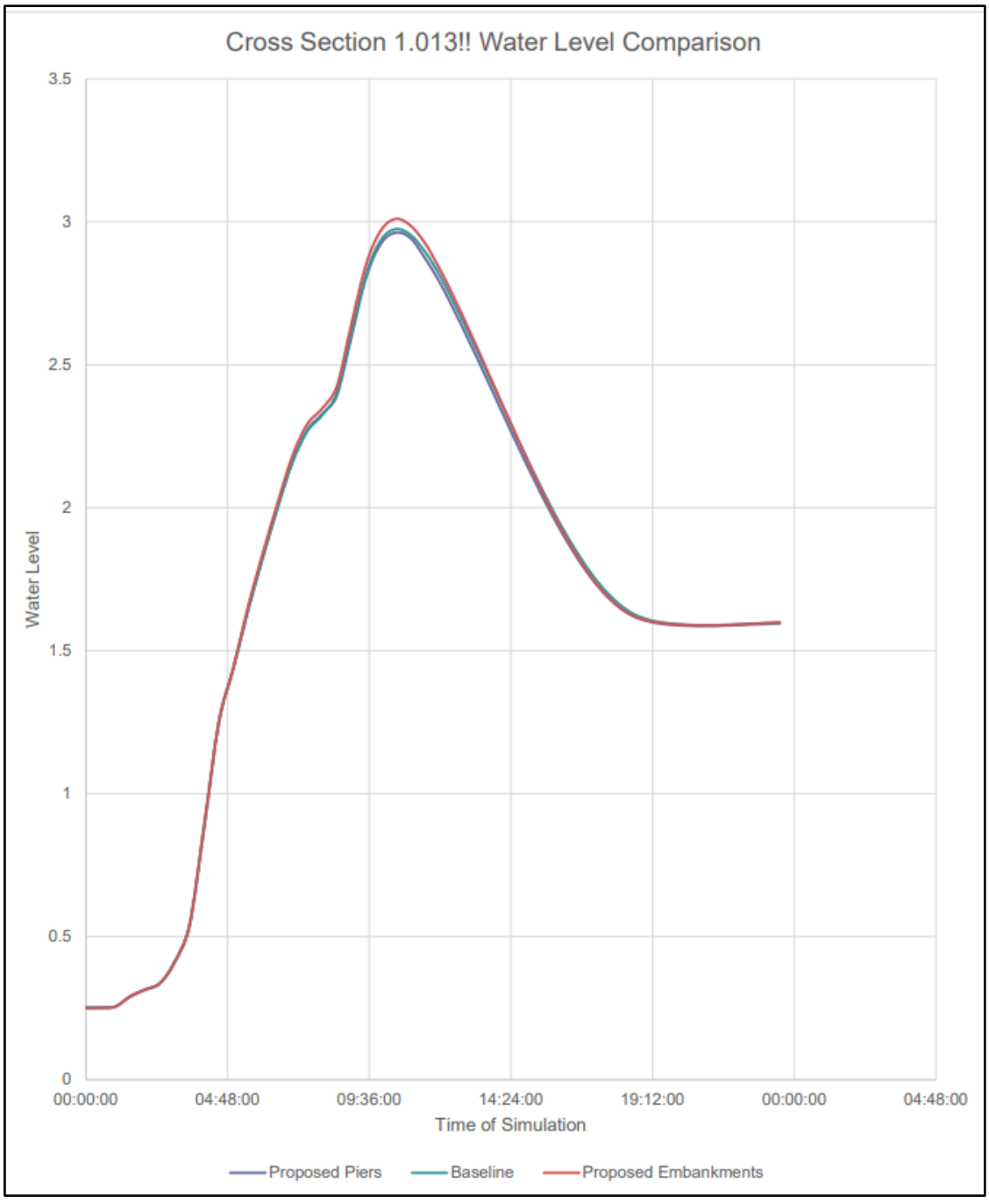


Figure 4.14 Cross Section 1.013!! Water Level Comparison

4.9.4 These graphs showcased that water levels remain consistent with both embankment and pier-based crossing designs when compared to the baseline. This suggests that water levels are unlikely to increase much beyond the baseline for the Lidsey Rife.

4.9.5 The flood level increase from the proposed A29 crossing has been modelled to be approximately 2-4cm on average above baseline, based on using raised embankments for the crossing. This 2-4cm on average is contained within the banks of the Lidsey Rife, and within the extents of the existing floodplain.

4.9.6 **Figure 4.15** shows the approximate 2-4cm on average above baseline increase to water depth within the Lidsey Rife, showing a consistent level change across the model area. The change in flood level is contained within the applicant's landholdings, and it limited in extent due to the restrictive culverts both upstream and downstream of the proposed bridge crossing.

ARUN DISTRICT COUNCIL BN/11/22/OUT



Figure 4.15 Water Depth Difference - Embankments - Baseline - 1%AEP + 35% Climate Change

4.9.7 However, it should be noted, the 2-4cm on average increase in water depths when compared to the baseline, does not impact flood extents, or extents of the floodplain. The baseline extent and depth is shown in **Figure 4.16**, with the modelled impact of the A29 crossing embankments shown in **Figure 4.17**.

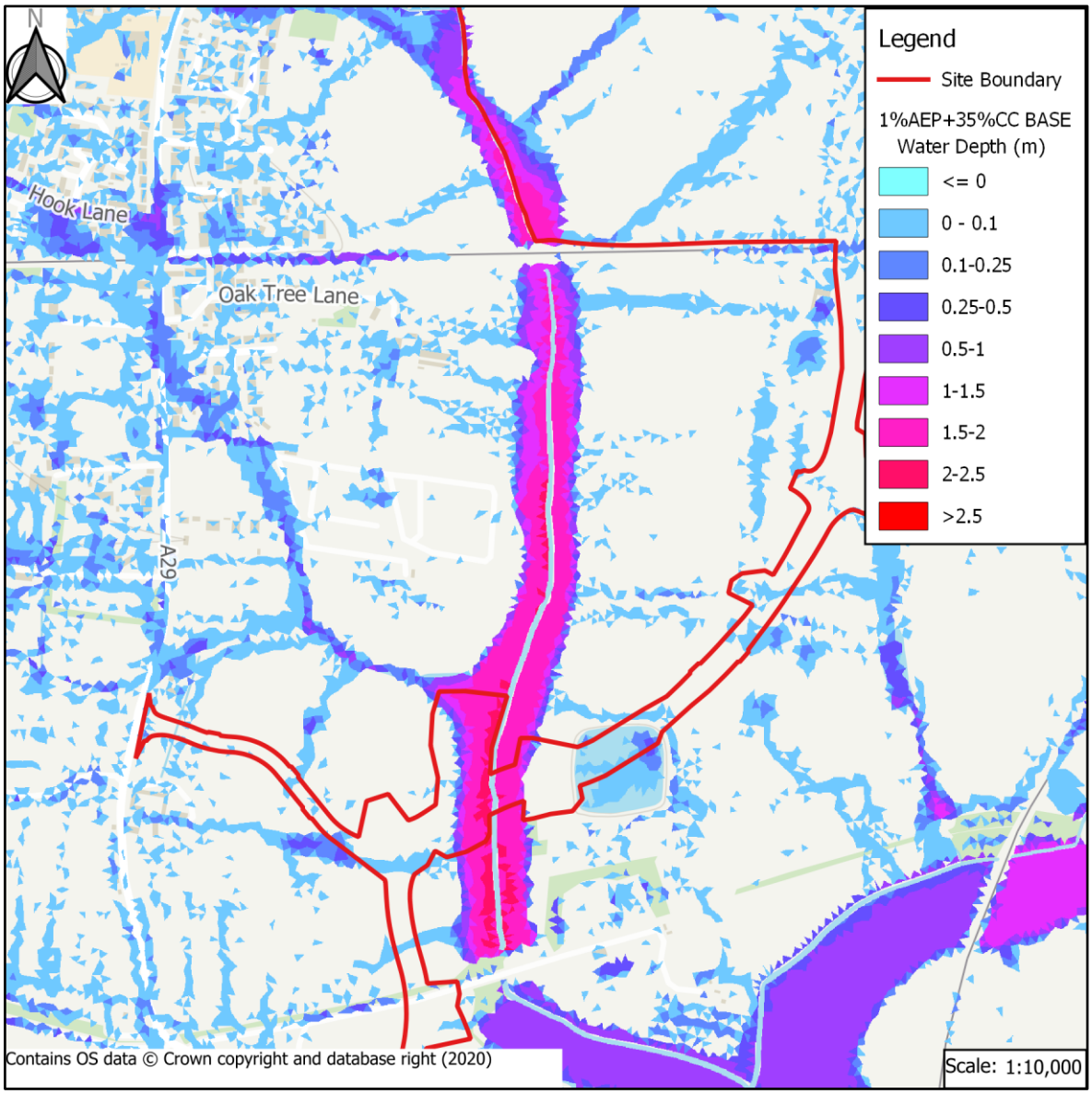


Figure 4.16 Modelled Baseline Water Depth

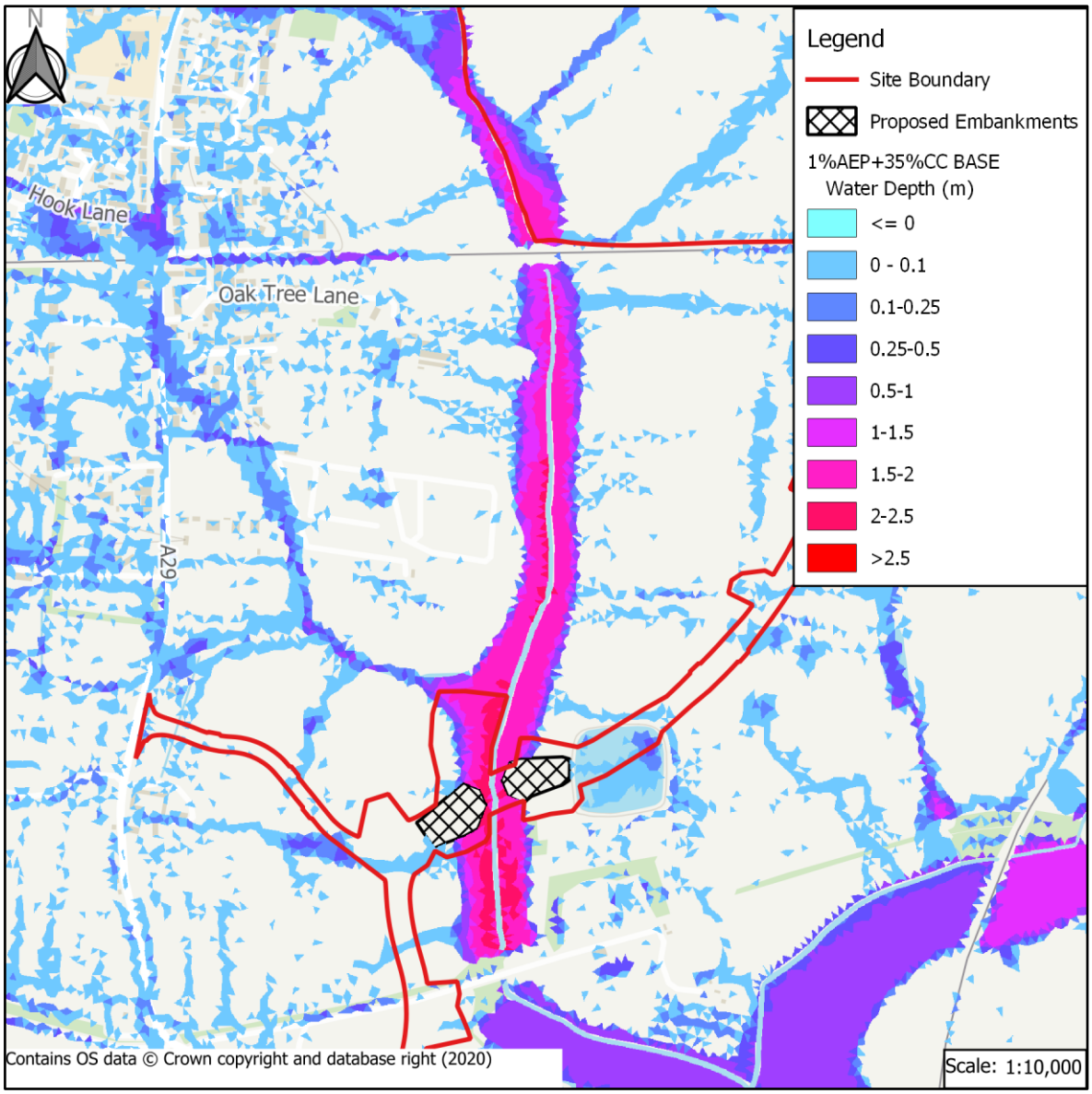


Figure 4.17 Modelled Embankment Water Depth

4.9.8 These figures show no detrimental increase in floodplain extents with the proposed A29 crossing embankments in place, when compared to the existing baseline extents.

4.9.9 Furthermore, the net difference in floodplain volume between the baseline and the proposed A29 crossing falls within the 1-2% region, within the tolerance of the model. As such, there is a negligible impact on the net volume of the floodplain as a result of the proposed A29 crossing.

4.9.10 The full modelling report and log is included for reference as **Appendix 3.2**.

4.9.11 Therefore, it can be concluded from the prepared model that the proposed A29 crossing is unlikely to cause any detrimental increase in flood risk on and off site or cause fundamental changes to the functional floodplain.

4.10 Impact of the Proposed Development

4.10.1 There are defined floodplain extents within the site boundary attributed to the Lidsey Rife, however within the main site application area there is a substantial linear park provided along the Lidsey Rife valley that means no construction will take place within the floodplain. As such, there will be no detrimental impact on floodplain storage volumes or conveyance routes.

ARUN DISTRICT COUNCIL BN/11/22/OUT

4.10.2 The proposed A29 realignment passes over the Lidsey Rife, with indicative proposals shown to include a 30m bridge span and crossing soffit level no lower than 2.8m AOD which is 600mm above the modelled design flood level, including an allowance for climate change.

4.10.3 The Technical Note (**Appendix 2**) has identified a negligible impact on flooding as a result of this crossing, and so the impact of the proposed development is considered negligible. Further detailed designs may refine this crossing, and as such, mitigation measures are recommended to ensure the impact of the crossing remains beneficial.

4.10.4 An increased impermeable footprint on site would give rise to an increase in the rate and volume of water discharged if not managed appropriately. This could result in increases in flood risk downstream and would require suitable mitigation.

ARUN DISTRICT COUNCIL BN/11/22/OUT

5 Flood Risk Mitigation

5.1 Sequential Arrangement

5.1.1 The site is considered sequentially preferable due to its location predominantly within Flood Zone 1. Furthermore, the allocation of the Site within the Arun Local Plan 2011-2031 confirms the suitability of the site for development.

5.1.2 Within the site boundary, a sequential approach to the layout has been considered by applying a substantial linear park along the Lidsey Rife valley, setting the built development far back from the watercourse and its associated floodplain. All development proposed is located within areas defined as Flood Zone 1 and considered at low risk of flooding from other sources as per the findings of this FRA.

5.2 Development Levels

5.2.1 Typically, minimum finished floor levels are proposed to mitigate the risk of flooding from fluvial and tidal sources. However, as development is proposed away from the floodplain extents there are no minimum requirements in this regard.

5.2.2 To manage the potential residual risk of groundwater flooding, it is recommended that due consideration is given to building thresholds and their relationship to surrounding external levels. Wherever possible, finished floor levels of dwellings should be nominally raised above immediately surrounding ground levels (maintaining compliance with relevant building regulations), with external levels falling away from buildings and towards positively drained areas.

5.2.3 In the event of groundwater emerging at the surface, such an arrangement would encourage water onto the surface into external areas and minimise ingress into buildings. Basement construction is unlikely given the nature of the development proposals, but nevertheless should be discouraged wherever possible to reduce longer term flood risk implications. Where any sub-ground level construction is proposed then suitable tanking should be specified to limit intrusion of groundwater into these levels.

5.3 Watercourse Standoff

5.3.1 Due to the Lidsey Rife being classified as a Main River by the Environment Agency, a minimum watercourse standoff of 8m from the top of the bank must be adhered to in which no development should take place. Any works within 8m of the Main River would require a suitable flood risk activity permit to be obtained from the Environment Agency. This includes the works associated with the A29 crossing.

5.3.2 The ordinary watercourses identified across the site, including the ditch along the northern boundary, parallel ditches in the west and the School Stream fall under the jurisdiction of West Sussex County Council as Lead Local Flood Authority and Arun District Council (through appropriate devolved powers) and therefore would be subject to their byelaws[13]. As a minimum, a 3m standoff from the top of bank of these watercourses should be applied for access and maintenance purposes.

5.3.3 This has been considered a part of the indicative layout proposals and parameters plans, and therefore should be included at detailed design as the scheme progresses.

5.4 School Stream Diversion

5.4.1 To provide significant environmental, ecological and amenity improvements it is proposed to implement a diversion of the School Stream, removing its current culverted section in favour of an open channel. An indicative route has been identified to re-route the watercourse along the northern boundary and then

[13] Arun District Council (2004); *Land Drainage Byelaws*; accessible via https://www.arun.gov.uk/watercourses-riparian-responsibilities/ and available at https://www.arun.gov.uk/download.cfm?doc=docm93jijm4n8475.pdf&ver=8245

south to re-join its current culvert under the railway. An indicative route has been shown for reference in **Figure 5.1**, that considers the current watercourse arrangements and the proposed development constraints including location of SuDS features, play areas and routes through the site.

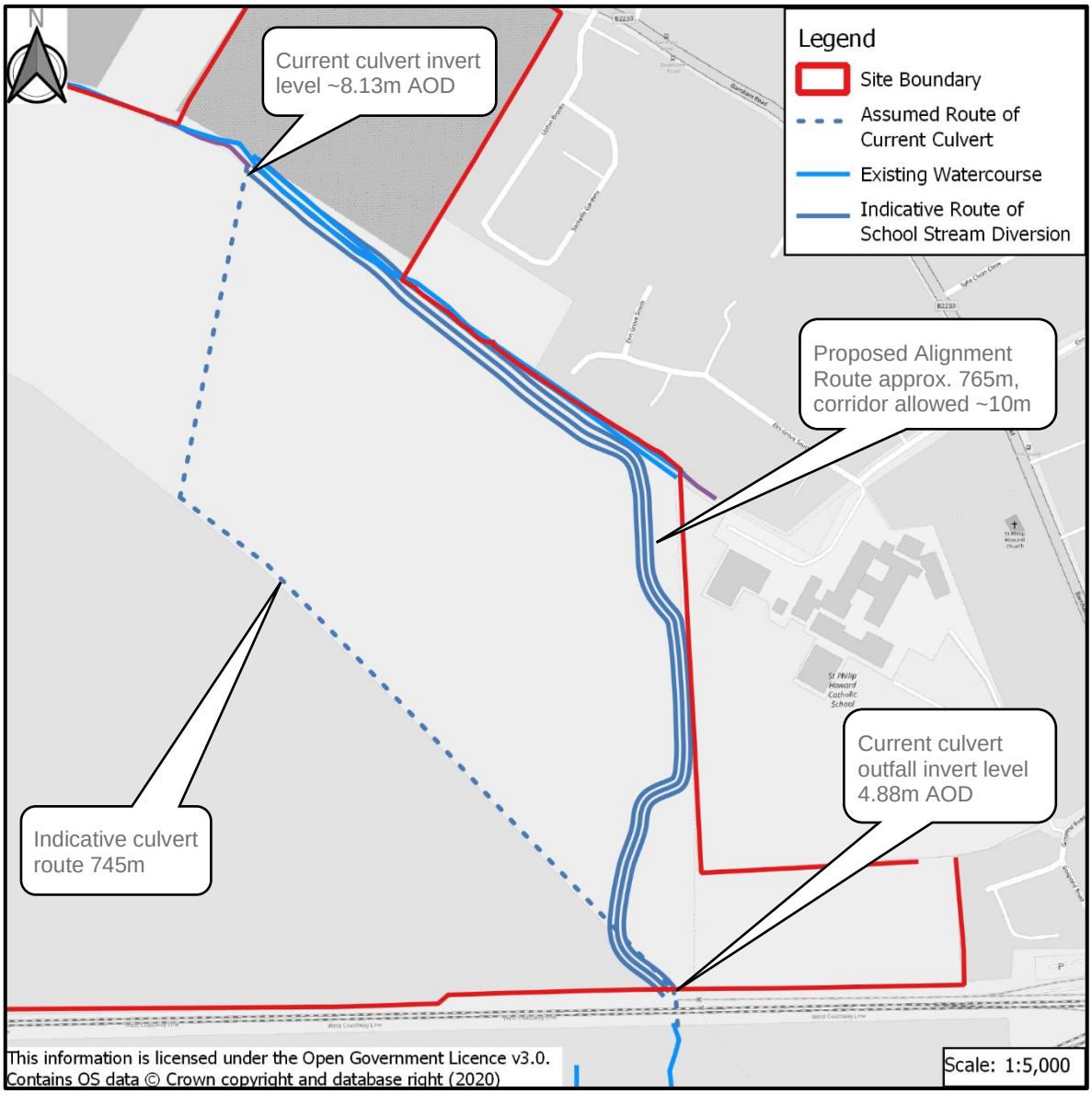


Figure 5.1 Indicative Route of School Stream Diversion

5.4.2 The proposed length of the School Stream diversion is largely similar to the current assumed route length of the culvert. Retaining similar invert levels at the upstream and downstream end of the diversion would allow an average gradient along the watercourse of 1:235 ([8.13-4.88]/765). This would encourage positive flow along the watercourse and ensure suitable conveyance so as not to impact functioning of current outfalls.

5.4.3 The current parameters plans allow for a ~10m wide corridor in which to design the School Stream diversion, which will allow for a suitable cross section to be developed, ensuring features maximise the biodiversity potential, provide a sufficient conveyance capacity for the anticipated flow and ensure no increase in flood risk to surrounding areas as a result of the new open section.

5.4.4 Further detailed designs of the School Stream diversion should be prepared as the scheme progresses, in consultation with Arun District and West Sussex County Councils.

5.5 A29 Crossing Design Principles

5.5.1 The potential flood risk implications of the proposed A29 crossing over the Lidsey Rife have been assessed as part of this FRA. Indicative designs put forward have been based on the appropriate fluvial design flood levels including a suitable allowance for climate change.

5.5.2 As designs for the A29 development, it is recommended that suitable design parameters are set in relation to the crossing over the Lidsey Rife to ensure flood risk is not exacerbated as a result.

5.5.3 This includes a minimum 30m clear bridge span over the Lidsey Rife channel and its immediate floodplain as per the modelled design parameters. This will ensure suitable conveyance beneath the structure to ensure no surcharging occurs when the Lidsey Rife is in spate. Furthermore, the soffit level of the crossing should be set no lower than 2.8m AOD, which is 600mm above the modelled design fluvial flood level, and where appropriate may be set higher to further reduce the impact of more extreme flood events.

5.5.4 Detailed highway design proposals should be re-assessed at the appropriate juncture to ensure no detrimental flood risk impacts. Subject to relevant planning approvals, the crossing will also require a flood risk activity permit to be obtained from the Environment Agency for works in or near a Main River, which will ensure a suitable design is put forward.

5.6 Surface Water Management Strategy

5.6.1 To manage the developments potential impact on flood risk elsewhere, a surface water drainage strategy based on sustainable drainage principles has been put forward as part of this application. The strategy builds on the framework identified as part of the Framework Masterplan process, utilising a series of attenuation basins to manage surface water on a strategic scale.

5.6.2 The strategy is based on a restricted outfall rate to the equivalent greenfield QBAR rate, and provision of above-ground attenuation features to manage and store the additional runoff. Recommendations are made for other SuDS features that could be incorporated throughout the development, utilising infiltration potential wherever appropriate to provide improvements to water quality and meet with local requirements laid out within the Arun Local Plan 2011-2031.

5.6.3 Appropriate foul drainage arrangements would also be put in place in consultation with Southern Water to ensure the proposed development does not adversely affect flood risk downstream as a result of the increase in foul drainage flows.

5.7 Monitoring

5.7.1 As the site has a potential for high groundwater level as identified by groundwater monitoring. It is suggested that groundwater monitoring continues during construction and post-development to identify and advise of periods of potentially elevated groundwater.

5.7.2 A suitable dewatering strategy will be required as part of the construction activity on site, managing groundwater levels in excavations, foundations etc. to ensure risks to construction activity are minimised. This may also require necessary abstraction and discharge permits to dispose of the arising groundwater in a manageable way.

5.7.3 It is recommended an agreement is reached between the developer and Arun District Council and/or WSCC to add the boreholes to their strategic scale monitoring network, taking responsibility for the monitoring and maintenance. Several boreholes are currently within areas designated for public open spaces which should be chosen over those within allocated for development.

ARUN DISTRICT COUNCIL BN/11/22/OUT

5.7.4 Long-term monitoring can be used to identify trigger points, or thresholds where elevated groundwater can be predicted, and information disseminated to local residents to prepare for a potential flood event. Whilst groundwater flooding cannot be prevented, raising awareness locally can improve the resilience of the local communities to the impacts of flooding.

5.8 A29 Crossing Floodplain Compensation

5.8.1 As a result of an ongoing objection made in December 2022 by the EA, floodplain compensation, based on a level-for-level analysis, has been demonstrated to be feasible within the bounds of the proposed A29 crossing. This is based on providing areas of compensation where floodplain is impacted as a result of the crossing.

5.8.2 **Appendix 6** provides an approximation of the scale and volume of compensation that would be required to compensate for the entire area covered by the A29 crossing.

5.8.3 It is estimated that 2,643m^3 of compensation would be displaced as a result of the bridge approach embankments being partially located within the floodplain. The compensation feasibility drawing (**Appendix 6**) shows that 2,768m^3 of compensation could be provided on the western banks of the Lidsey Rife. A breakdown of the level-for-level compensation is provided within **Table 5.1**.

Table 5.1 Floodplain Compensation Provision

Elevation Slice (mAOD)	Volume of Displaced Floodplain (m^3)	Volume of Floodplain Compensation (m^3)	Difference in Volume (m^3)
1.00-1.25	85	103	+18
1.25-1.50	506	520	+14
1.50-1.75	649	670	+21
1.75-2.00	731	790	+59
2.00-2.21	672	685	+13
Total	**2,643**	**2,768**	**+125**

5.8.4 The floodplain compensation exercise confirms that a suitable level-for-level compensation exercise can be provided for the displaced floodplain from the bridge embankments. A net increase in floodplain volume is provided at each elevation slice as a product of the design, providing a betterment to the existing situation. The works are in close proximity to the floodplain that will be displaced and so will provide an effective means of mitigating any potential impact resulting from the proposed bridge crossing.

5.8.5 Furthermore, it has previously been identified through modelling that the proposed A29 crossing will not cause detrimental increases in flood risk both on and off site, with changes limited to approximately 2-4cm of water levels rise, with no increase in flood extents and negligible changes to floodplain volume within the tolerance of the model.

5.8.6 As part of an outline planning permission, the proposed floodplain will offset any potential impacts as a result of increases to flood risk, which as part of modelling carried out by Pell Frischmann, has been identified to be very low to negligible. This is based on level-for-level compensation and meets the requirements outlined by the EA.

6 Conclusions & Recommendations

6.1.1 This FRA has been written in support of an outline planning permission application for a proposed mixed-use development on a portion of the allocated site, being referred to as BEW SC1 in the Arun District of West Sussex. The site is allocated within the adopted Arun Local Plan 2011-2031 and has passed the Sequential Test of the Arun Local Plan 2011-2031 and therefore considered a suitable development in flood risk terms for the proposed use.

6.1.2 To summarise the findings of the FRA:

- The site is shown to be mostly in Flood Zone 1, but areas of Flood Zone 2 and 3 are attributed to the Lidsey Rife on the western boundary. Floodplain extents are well contained to a defined valley line, when including latest allowances for climate change on peak river flows.
- Other ordinary watercourses and land drains on site are considered to pose a limited risk, to be managed because of redevelopment of the site.
- Tidal influences on the site are limited, although some extents are identified when considering extreme (undefended) scenarios so tidal flooding has been considered a 'residual' risk.
- Groundwater monitoring has identified generally elevated groundwater levels beneath the site, although this should be managed through appropriate dewatering strategies during construction, suitable design and construction techniques being employed, long term strategic monitoring and awareness of the risks raised to future residents.
- A currently culverted watercourse is proposed to be daylighted and diverted within the site, to improve water quality, local amenity, and biodiversity of the watercourse as a whole. This may also contribute to management of surface and groundwater in the locality.
- The proposed A29 crossing of the Lidsey Rife has been assessed using the Environment Agency's hydraulic model. Indicative bridge designs have confirmed a suitable design can be delivered in a cost-effective way, whilst still ensuring the road remains at very low risk of flooding without causing detriment to the wider area.
- Additional modelling completed by Pell Frischmann shows the propose A29 crossing is unlikely to cause detrimental changes to flood risk both on and off-site, along with negligible changes to floodplain extents within model tolerance levels and on average a 2-4cm increase in water levels of the Lidsey Rife, which is contained within the Rife's banks and does not impact the extent of the functional floodplain.
- Furthermore, Pell Frischmann has provided a feasibility assessment of floodplain compensation within the catchment and have deemed that subject to review at detailed design stage, floodplain compensation is a feasible mitigation option.

6.1.3 Recommendations are made in respect of appropriate consideration of finished floor levels and external levels designed above flood levels to manage the significant risk of any surface water and fluvial flooding. The current layout also provides 8m of standoff between the top of the bank of the Lidsey Rife and the development in accordance with guidance on Main River Standoff from the EA and 3m standoff from ordinary watercourses in line with Arun District Council Land Drainage Byelaws.

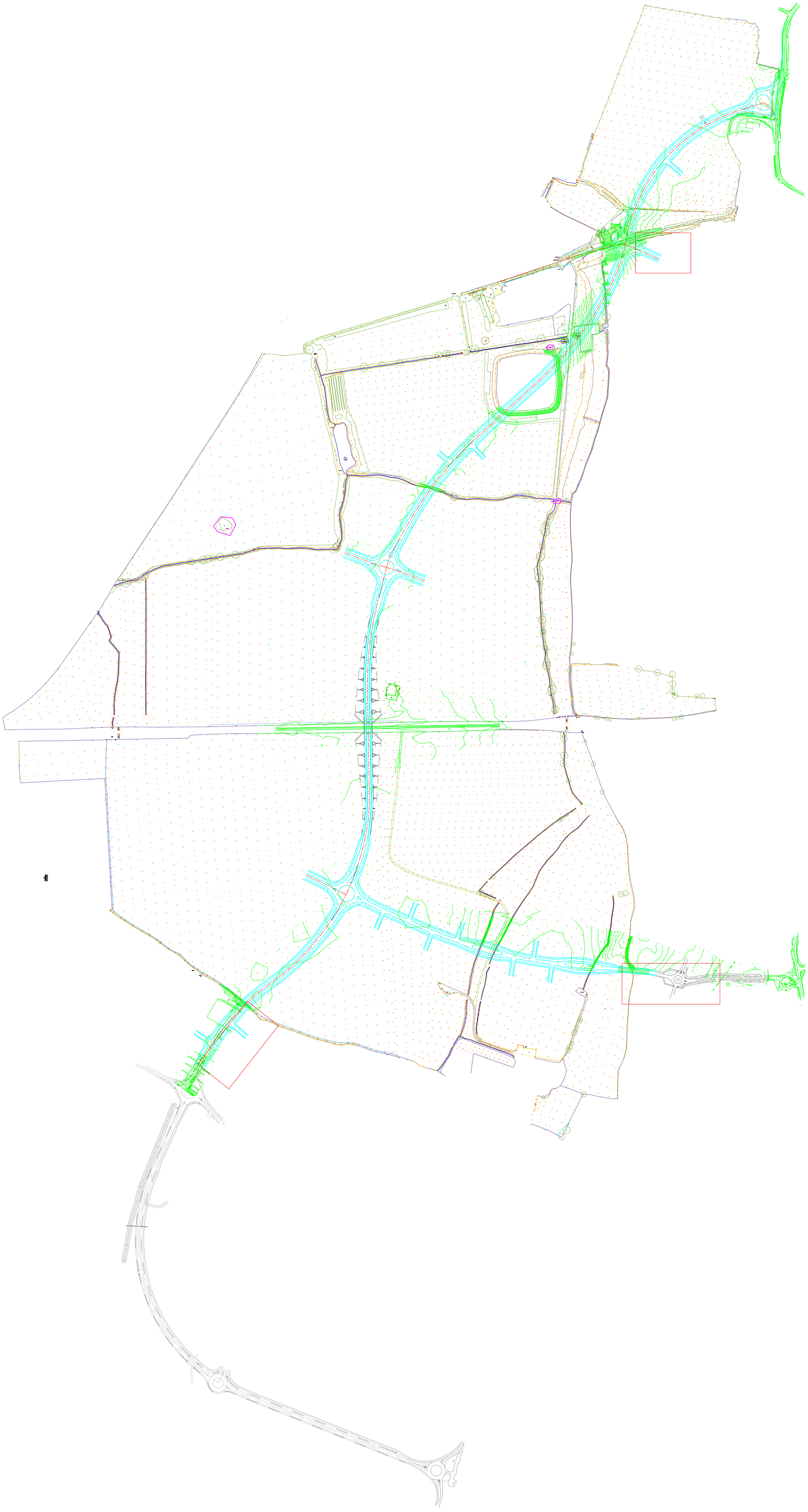
6.1.4 In accordance with the requirements of the NPPF, this FRA has demonstrated the development could proceed without being subject to significant flood risk and complies within relevant Local Plan policies.

6.1.5 Furthermore, the development will not result in increased flood risk to third parties because of suitable management of surface water runoff.

Appendix 1 Topographical Survey

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ABUNDISTRICT COUNCIL BN11 02/OUT



Appendix 2 Environment Agency Response to FoI Request

ARUN DISTRICT COUNCIL BN/11/22/OUT

Daniel Allum-Rooney
Pell Frischmann
Block B
Blenheim Court
86-88 Mansfield Road
Nottingham
NG1 3HD

Our ref: SSD154550
Date: 09/01/2020

Dear Daniel Allum-rooney,

Enquiry Regarding Product 4 for Flood Risk Assessment for Barnham, West Sussex, PO20 3XD.

Thank you for your enquiry which was received on 12 December 2019.

We respond to requests under the Freedom of Information Act 2000 and Environmental Information Regulations 2004. The information is attached.

The information on Flood Zones in the area relating to this address is as follows:

The site is in an area located within Flood Zone 1,2 & 3 as shown on our Flood Map for Planning (Rivers and Sea).

Note - This information relates to the area that the above named property is in and is not specific to the property itself as it is influenced by factors such as the height of door steps, air bricks or the height of surrounding walls. We do not have access to this information and is not currently used in our flood modelling.

Flood Zone definitions can be found at www.gov.uk/guidance/flood-risk-and-coastal-change#Table-1-Flood-Zones

Flood Defences
There are no formal raised flood defences in the vicinity of the site.

Model Information
The Fluvial model used was the Aldingbourne Flood Risk Mapping Study, completed in 2015 by JBA Consulting, plus updated climate change allowances completed in 2016. The tidal modal used was the River Arun to East Head Coastal Modelling, completed in 2016 by JBA Consulting.

Flood History
We hold no record of previous flooding events affecting this site.

Please note our records are not comprehensive and may not include all events. I recommend contacting the Lead Local Flood Authority, **West Sussex County**

ARUN DISTRICT COUNCIL BN/11/22/OUT

Council or the Local Authority, **Chichester District Council** for a more comprehensive flood history check.

FRA advisory text

Name	Product 4
Description	Detailed Flood Risk Assessment Map for **Barnham, West Sussex, PO20 3XD.**
Licence	Open Government Licence
Information Warning - OS background mapping	*The mapping of features provided as a background in this product is © Ordnance Survey. It is provided to give context to this product. The Open Government Licence does not apply to this background mapping. You are granted a non-exclusive, royalty free, revocable licence solely to view the Licensed Data for non-commercial purposes for the period during which the Environment Agency makes it available. You are not permitted to copy, sub-license, distribute, sell or otherwise make available the Licensed Data to third parties in any form. Third party rights to enforce the terms of this licence shall be reserved to OS.*
Attribution	Contains Environment Agency information © Environment Agency and/or database rights. Contains Ordnance Survey data © Crown copyright 2019 Ordnance Survey 100024198.

Data Available Online

Many of our flood datasets are available online:

- Flood Map For Planning (Flood Zone 2, Flood Zone 3 ,Flood Storage Areas, Flood Defences, Areas Benefiting from Defences)
- Risk of Flooding from Rivers and Sea
- Historic Flood Map
- Current Flood Warnings

Please get in touch if you have any further queries or contact us within two months if you'd like us to review the information we have sent.

Yours sincerely,

Tom Lamboo
FCRM Officer, Partnership & Strategic Overview, West Sussex | Solent and South Downs
Environment Agency | Guildbourne House, Chatsworth Road, Worthing, West Sussex, BN11 1LD

Use of Environment Agency Information for Flood Risk Assessments

Important

The Environment Agency are keen to work with partners to enable development which is resilient to flooding for its lifetime and provides wider benefits to communities. If you have requested this information to help inform a development proposal, then we recommend engaging with us as early as possible by using the pre-application form available from our website:

https://www.gov.uk/government/publications/pre-planning-application-enquiry-form-preliminary-opinion

We recognise the value of early engagement in development planning decisions. This allows complex issues to be discussed, innovative solutions to be developed that both enables new development and protects existing communities. Such engagement can often avoid delays in the planning process following planning application submission, by reaching agreements up-front. We offer a charged pre-application advice service for applicants who wish to discuss a development proposal.

We can also provide a preliminary opinion for free which will identify environmental constraints related to our responsibilities including flooding, waste, land contamination, water quality, biodiversity, navigation, pollution, water resources, foul drainage or Environmental Impact Assessment.

In preparing your planning application submission, you should refer to the Environment Agency's Flood Risk Standing Advice and the Planning Practice Guidance for information about what flood risk assessment is needed for new development in the different Flood Zones. This information can be accessed via:

https://www.gov.uk/flood-risk-assessment-standing-advice
http://planningguidance.planningportal.gov.uk/

You should also consult the Strategic Flood Risk Assessment or other relevant materials produced by your local planning authority.

You should note that:

1. Information supplied by the Environment Agency may be used to assist in producing a Flood Risk Assessment (FRA) where one is required, but does not constitute such an assessment on its own.

2. This information covers flood risk from main rivers and the sea, and you will need to consider other potential sources of flooding, such as groundwater or surface water runoff. Information produced by the local planning authority referred to above may assist here.

3. Where a planning application requires an FRA and this is not submitted or is deficient, the Environment Agency may raise an objection.

Solent & South Downs Area

Pre-application Advice Note

September 2019

This document sets out the environmental issues we will consider when providing our planning application consultation advice to Local Councils. It can be used by applicants, developers and consultants at the pre-planning stage.

Fluvial Flood Risk

Development must be safe and should not increase the risk of flooding.

You can view a site's flood zone on the Flood Map for Planning on our website: https://flood-map-for-planning.service.gov.uk

If your proposed development is located within flood zone 2 or 3 you should consult the Flood Risk and Coastal Change pages of the National Planning Policy Guidance (NPPG) http://planningguidance.communities.gov.uk/blog/guidance/flood-risk-and-coastal-change/

Here you can determine whether the flood risk vulnerability of your proposed development and the flood zone are compatible. You can also establish if there are flood risk sequential test and exception test requirements for your proposed development. In the first instance we recommend the developer/applicant liaises with the Local Planning Authority (LPA) to undertake the Sequential Test in accordance with the National Planning Policy Framework (NPPF).

If your proposed development is located within flood zone 2 orf 3 and its vulnerability and flood zone are considered acceptable under the NPPG then a site specific Flood Risk Assessment (FRA) is required to support any subsequent planning application. This is required by paragraph 163 of the NPPF: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/6077/2116950.pdf

Guidance on the content of a site specific FRA can be found in the NPPG and online: https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications

More detailed flood risk modelling data is available to help you produce a FRA please contact our Customers and Engagement team at SSDenquiries@environment-agency.gov.uk.

Climate Change Allowances

On 19 February 2016, we published new guidance for planners and developers on how to use climate change allowances in a site-specific FRA: https://www.gov.uk/guidance/flood-risk-assessments-climatechange-allowances

Groundwater Quality

Development must not cause pollution to the water environment.

Source Protection Zones

We have defined Source Protection Zones (SPZs) for 2000 groundwater sources such as wells, boreholes and springs used across the country for public drinking water supply. These zones are more sensitive to contamination from activities that might cause pollution in the area. The closer the activity, the greater the risk.

SPZ1s are the areas designated as most at risk from contamination and development activities and in these areas we may consider it inappropriate for development to discharge foul or surface water into the ground.

To see if your proposed development is located within a Source Protection Zone, please use our online map: https://magic.defra.gov.uk/

Contaminated Land

The NPPF takes a precautionary approach to land contamination. Before the principle of development can be determined, land contamination should be investigated to see whether it could preclude certain development due to environmental risk or cost of remediation. Where contamination is known or suspected, a desk study, site investigation, remediation and other works may be required to enable safe development.

Pollution

If the proposed development use has the potential to pollute ground or surface water receptors then an assessment to establish whether the risk of pollution is acceptable or can be mitigated will be required within any planning application.

Foul Drainage

When drawing up wastewater treatment proposals for any development, the first presumption is to provide a system of foul drainage discharging into a public sewer to be treated at a public sewage treatment works (those provided and operated by the water and sewerage companies). This should be done in consultation with the sewerage company of the area prior to the submission of a formal planning application.

If connection to a public sewage treatment plant is not feasible, a package sewage treatment plant may be considered. If you would like further advice please call 03708 506 506.

Cemeteries

The development of new cemeteries in areas where groundwater vulnerability is high should be avoided, except where the thickness and nature of the unsaturated zone, or the impermeable formations beneath the site, protect groundwater; or where the long-term risk is mitigated by appropriate engineering methods.

Main Rivers

Ecology

In accordance with the National Planning Policy Framework (NPPF), any development proposal should avoid significant harm to biodiversity and seek to protect and enhance it. Opportunities to incorporate biodiversity in and around the development will be encouraged.

Your scheme should be designed with a naturalised buffer zone of at least 8 metres from the main river to protect and enhance the conservation value of the watercourse and ensure access for flood defence maintenance.

This buffer zone should be managed for the benefit of biodiversity for example by the planting of locally appropriate, UK native species. The buffer zone should be undisturbed by development with no fencing, footpaths or other structures. This buffer zone will help provide more space for flood waters, provide improved habitat for local biodiversity and allows access for any maintenance requirements.

To identify any Main Rivers in proximity to your proposed development please see our Main Rivers Consultation Map: http://apps.environment-agency.gov.uk/wiyby/151293.aspx

Culverting

The Environment Agency is likely to oppose culverting as it is damaging to the ecological integrity of the river channel and its corridor and acts as a barrier to the movement of wildlife, including fish and may also increase flood risk. If the proposal will impact an existing culvert the Environment Agency may oppose planning consent for development either over, or within 8 metres of an existing culvert. Wherever possible, existing culverts should be removed and the river channel and bankside habitat reinstated to restore the ecological continuity of the river channel and its corridor.

Water Framework Directive (WFD)

Any marine works below MHWS require an assessment of possible impacts on Water Framework Directive (WFD) . The assessment should include all elements of the works that fall within, or have the potential to affect, a WFD water body and any of the protected areas therein (including Bathing Waters and Shellfish Waters).

The WFD assessment should follow the 'Clearing the Waters for All' guidance available at https://www.gov.uk/guidance/water-framework-directive-assessment-estuarine-and-coastal-waters

Where appropriate, a WFD Assessment should assess any potential impacts and demonstrate that the required enhancements will be delivered. In some cases the requirements of a WFD assessment can be incorporated into an Environmental Impact Assessment (EIA). Any development that has the potential to cause deterioration in classification under WFD or that precludes the recommended actions from being delivered in the future is likely to be considered unacceptable to us.

Permits & Consents

Environmental Permitting Regulations

To see if your proposed development requires an Environmental Permit under the Environment Permitting Regulations please refer to our website: https://www.gov.uk/guidance/check-if-you-need-an-environmental-permit

From 6 April 2016 an Environmental Permit is required for any proposed works or structures, in, under, over or within 8 metres of the top of the bank of designated Main River, and within 16 metres of a tidal defence.

Ordinary Watercourse Consent

The prior written consent of the relevant Lead Local Flood Authority is required for the erection of any flow control structures, culverting or diversion of ordinary watercourses, including streams, land drains and ditches.

Marine Licence

A marine licence may be required for any activities at the mean high water spring tide up to the territorial limit.This also includes the waters of every estuary, river or channel where the tide flows at mean high water spring tide.

Any development must demonstrate how adverse impacts on migratory fish, bathing waters, shellfish waters, designated sites, protected and priority species and habitats will be avoided, minimised, mitigated and if necessary compensated for. Works within or affecting a Water Framework Directive (WFD) waterbody will need to demonstrate that compliance with WFD objectives will be achieved. 'Clearing the Waters for All' provides guidance on how the impacts on WFD should be addressed, and should be used when preparing an assessment, including the screening and scoping of activities. https://www.gov.uk/guidance/water-framework-directive-assessment-estuarine-and-coastal-waters

Further pre-application options

The information provided above details generic information which may or may not be applicable to your development. We are able to provide more detailed and bespoke advice and answer technical questions for a charged fee of £100 per person per hour +VAT.

If you are interested in finding out more about this service, please email:

planningssd@environment-agency.gov.uk

We can explain this service and provide you with a bespoke quote for further pre-application advice that you may require please see .gov - https://www.gov.uk/government/publications/pre- planning-application-enquiry-form-preliminary-opinion

Please note

Please note that the view expressed in this letter by the Environment Agency is in response to the enquiry only and does not represent our final view in relation to any future planning application made in relation to this site.

We reserve the right to change our position in relation to any such application.

As part of this preliminary response we have not technically reviewed any documents. This opinion is based on the information submitted and current planning policy and guidance.

If you have any questions please contact the Solent & South Downs Sustainable Places team:

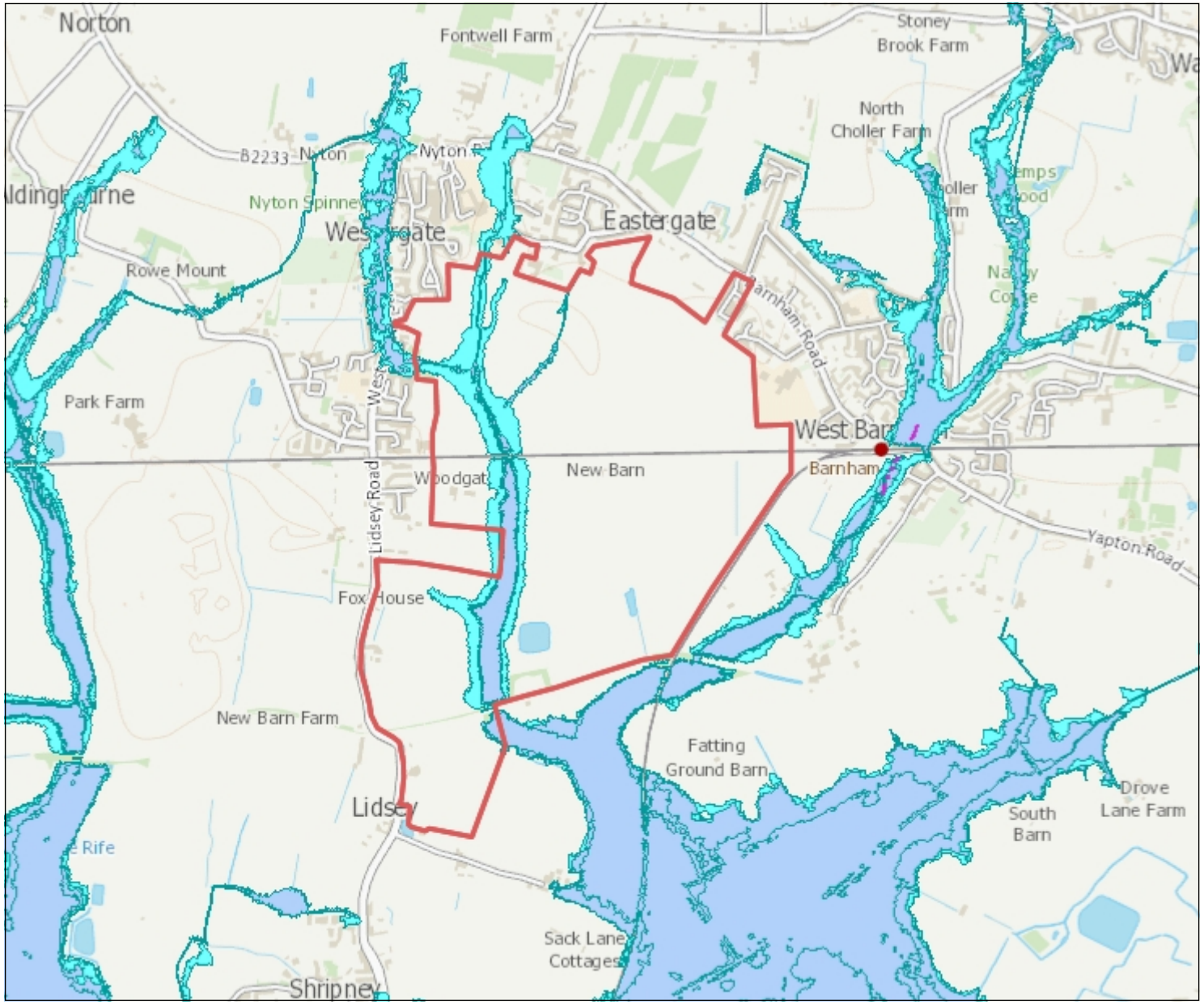
planningssd@environment-agency.gov.uk

To make a request for data

Please submit your request for data to ssdenquiries@environment-agency.gov.uk. You should get the information within 20 working days. We will tell you when to expect the information if we need more time.

There are many datasets available online at www.data.gov.uk including flood maps, historic landfill, waste exemptions, consented discharges to controlled waters, and much more.

Flood Map for Planning (Rivers and Sea). Centred PO20 3XD. Created 08/01/2020.



Environment Agency

1: 25,000

0 Metres 625

N W E S

Flood Map for Planning (Rivers & Sea)

- Defences
- Flood Storage Areas
- Areas benefiting from flood defences
- Flood Zone 3
- Flood Zone 2

Flood Map Areas (assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:

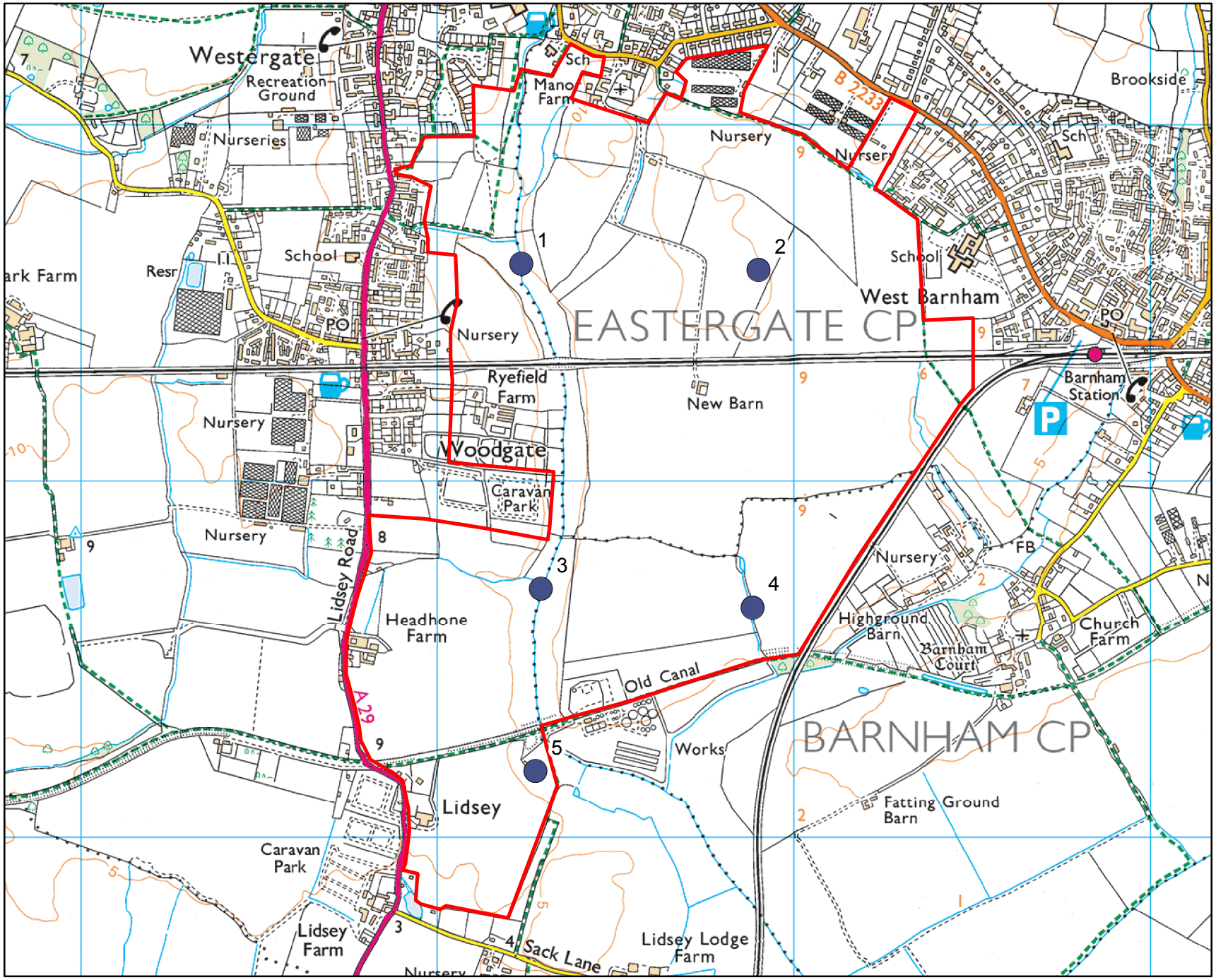
- from the sea with a 1 in 200 or greater chance of happening each year
- or from a river with a 1 in 100 or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 1 in 1000 chance of occuring each year.

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Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

FRA Site Boundary & Node Points. Centred PO20 3XD. Created 08/01/2020.



Environment Agency

N

Legend

- Site_Nodes
- Site_Boundary

Annual Exceedance Probability (AEP) The probability of a flood of a particular magnitude, or greater occurring in any given year.

Scale: 1:15,000

0 0.35 0.7
Kilometers

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Contact us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506. Email:enquiries@environment-agency.gov.uk

Product 4 Flood Risk Data Requested by: Pell Frischmann

Site: Barnham, West Sussex, PO20 3XD

Table 1: Water Levels: Fluvial Undefended

	NGR		Modelled Flood Levels in Metres AOD					
			Undefended Annual Exceedance Probability					
Node Ref	Eastings	Northings	5%	1%	1% +CC (35%)	1% +CC (45%)	1% +CC (105%)	0.1%
1	494238	104609	-	-	3.75	4.46	6.35	-
2	494904	104593	-	-	-	-	-	-
3	494293	103698	-	-	3.01	3.57	5.75	-
4	494887	103646	-	-	-	-	5.48	-
5	494277	103186	-	-	1.95	1.99	2.22	-

Table 2: Water Levels: Fluvial Defended

	NGR		Modelled Flood Levels in Metres AOD					
			Defended Annual Exceedance Probability					
Node Ref	Eastings	Northings	5%	1%	1% +CC (35%)	1% +CC (45%)	1% +CC (105%)	0.1%
1	494238	104609	-	-	3.13	3.13	6.29	5.77
2	494904	104593	-	-	-	-	-	-
3	494293	103698	1.45	1.84	2.19	2.19	5.58	4.96
4	494887	103646	-	-	-	-	5.48	-
5	494277	103186	-	-	-	1.80	2.22	2.05

Table 3: Water Levels: Tidal Undefended

	NGR		Modelled Flood Levels in Metres AOD			
			Undefended Annual Exceedance Probability			
Node Ref	Eastings	Northings	0.5%	0.5% (2070)	0.5% (2115)	0.1%
1	494238	104609	-	-	3.45	-
2	494904	104593	-	-	-	-
3	494293	103698	1.95	2.60	3.45	2.11
4	494887	103646	-	-	-	-
5	494277	103186	1.97	2.66	3.60	2.14

Office Address: Guildbourne House, Chatsworth Road, Worthing BN11 1LD.
Customer services line: 03708 506 506. Email: enquiries@environment-agency.gov.uk
www.gov.uk/government/organisations/environment-agency

Table 4: Water Levels: Tidal Defended

	NGR		Modelled Flood Levels in Metres AOD Defended Annual Exceedance Probability			
Node Ref	Eastings	Northings	0.5%	0.5% (2070)	0.5% (2115)	0.1%
1	494238	104609	-	-	-	-
2	494904	104593	-	-	-	-
3	494293	103698	-	-	0.56	-
4	494887	103646	-	-	-	-
5	494277	103186	-	-	-	-

Table 5: Water Depths: Fluvial Undefended

	NGR		Modelled Flood Depths in Metres Undefended Annual Exceedance Probability					
Node Ref	Eastings	Northings	5%	1%	1% +CC (35%)	1% +CC (45%)	1% +CC (105%)	0.1%
1	494238	104609	-	-	0.99	1.69	3.59	-
2	494904	104593	-	-	-	-	-	-
3	494293	103698	-	-	1.93	2.45	4.50	-
4	494887	103646	-	-	-	-	0.77	-
5	494277	103186	-	-	0.33	0.38	0.61	-

Table 6: Water Depths: Fluvial Defended

	NGR		Modelled Flood Depths in Metres Defended Annual Exceedance Probability					
Node Ref	Eastings	Northings	5%	1%	1% +CC (35%)	1% +CC (45%)	1% +CC (105%)	0.1%
1	494238	104609	-	-	0.11	0.11	3.27	1.82
2	494904	104593	-	-	-	-	-	-
3	494293	103698	0.34	0.74	1.02	1.02	4.50	3.75
4	494887	103646	-	-	-	-	0.37	-
5	494277	103186	-	-	-	0.18	0.61	0.41

Table 7: Water Depths: Tidal Undefended

	NGR		Modelled Flood Depths in Metres Undefended Annual Exceedance Probability			
Node Ref	Eastings	Northings	0.5%	0.5% (2070)	0.5% (2115)	0.1%
1	494238	104609	-	-	0.28	-
2	494904	104593	-	-	-	-
3	494293	103698	0.88	1.53	2.38	1.04
4	494887	103646	-	-	-	-
5	494277	103186	0.46	1.09	2.03	0.60

Table 8: Water Depths: Tidal Defended

	NGR		Modelled Flood Depths in Metres Defended Annual Exceedance Probability			
Node Ref	**Eastings**	**Northings**	**0.5%**	**0.5% (2070)**	**0.5% (2115)**	**0.1%**
1	494238	104609	-	-	-	-
2	494904	104593	-	-	-	-
3	494293	103698	-	-	0.01	-
4	494887	103646	-	-	-	-
5	494277	103186	-	-	-	-

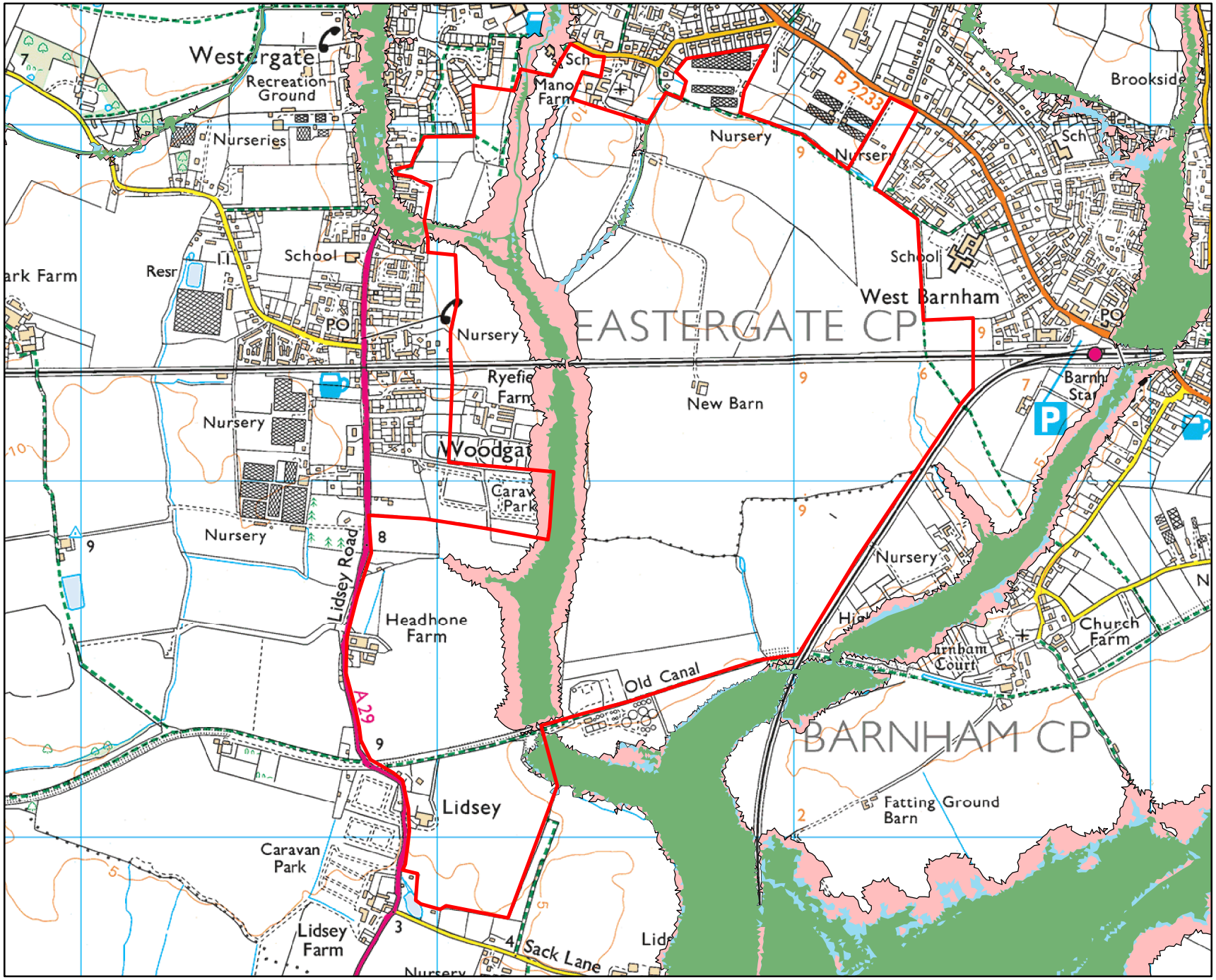
All levels taken from:

Fluvial: Aldingbourne Flood Risk Mapping Study, completed in 2015 by JBA Consulting, plus climate change allowances (2016). Tidal: River Arun to East Head, completed in 2016 by JBA Consulting.

Produced on: 09/01/2020

There is no additional information or health warnings for these levels/depths or the model from which they have been produced.

Modelled Flood Outlines- Climate Change Allowances (Defended Fluvial). Centred PO20 3XD. Created 08/01/2020.



Environment Agency

N

Legend

- Site_Boundary
- 1% AEP Plus Climate Change (35%) (Defended Fluvial)
- 1% AEP Plus Climate Change (45%) (Defended Fluvial)
- 1% AEP Plus Climate Change (105%) (Defended Fluvial)

Annual Exceedance Probability (AEP) The probability of a flood of a particular magnitude, or greater occurring in any given year.

Scale: 1:15,000

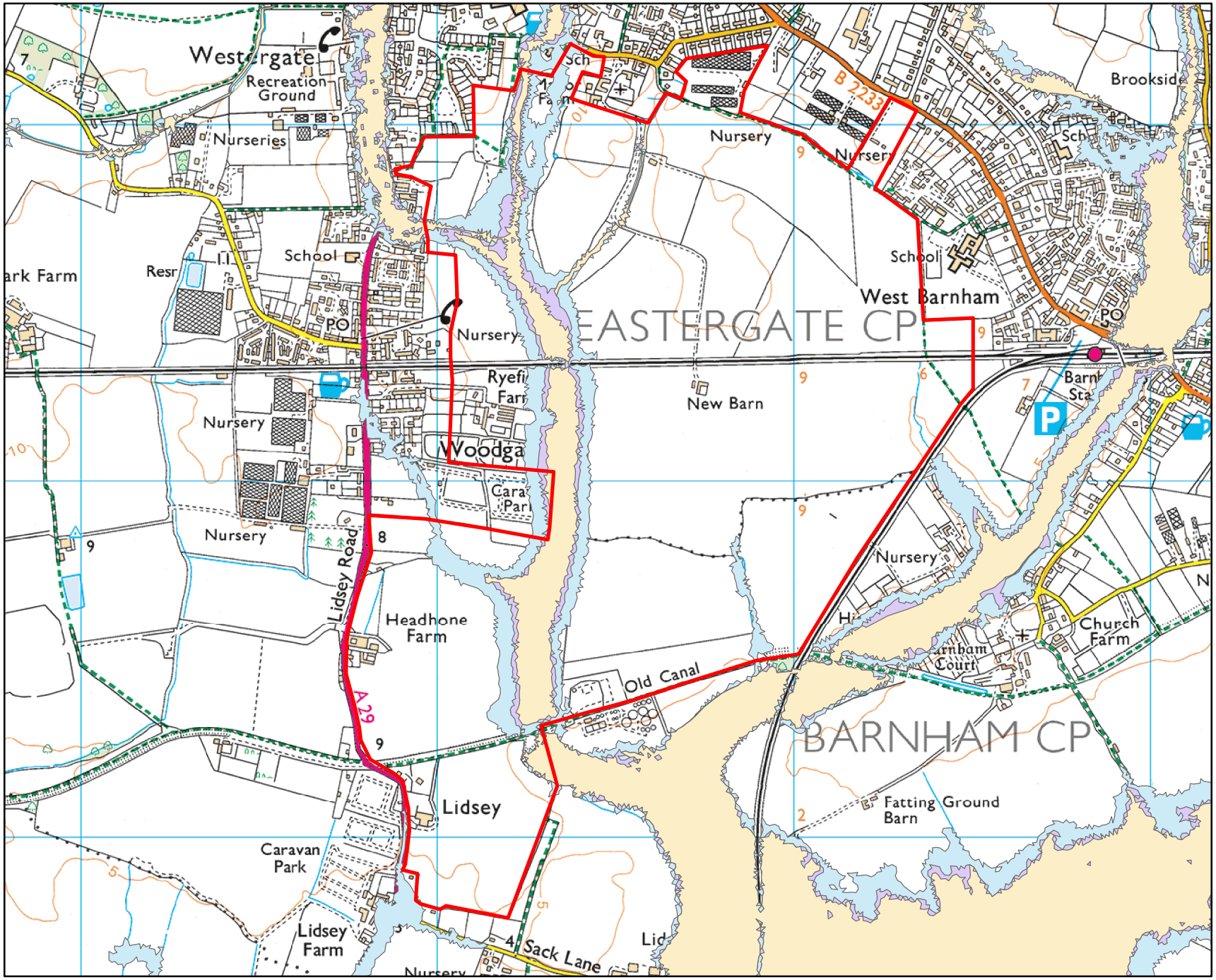
0 0.35 0.7

Kilometers

ARUN DISTRICT COUNCIL BN/11/22/OUT

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Modelled Flood Outlines- Climate Change Allowances (Undefended Fluvial).
Centred PO20 3XD. Created 08/01/2020.



Environment Agency

N

Legend

- Site_Boundary
- 1% AEP Plus Climate Change (35%) (Undefended Fluvial)
- 1% AEP Plus Climate Change (45%) (Undefended Fluvial)
- 1% AEP Plus Climate Change (105%) (Undefended Fluvial)

Annual Exceedance Probability (AEP) The probability of a flood of a particular magnitude, or greater occurring in any given year.

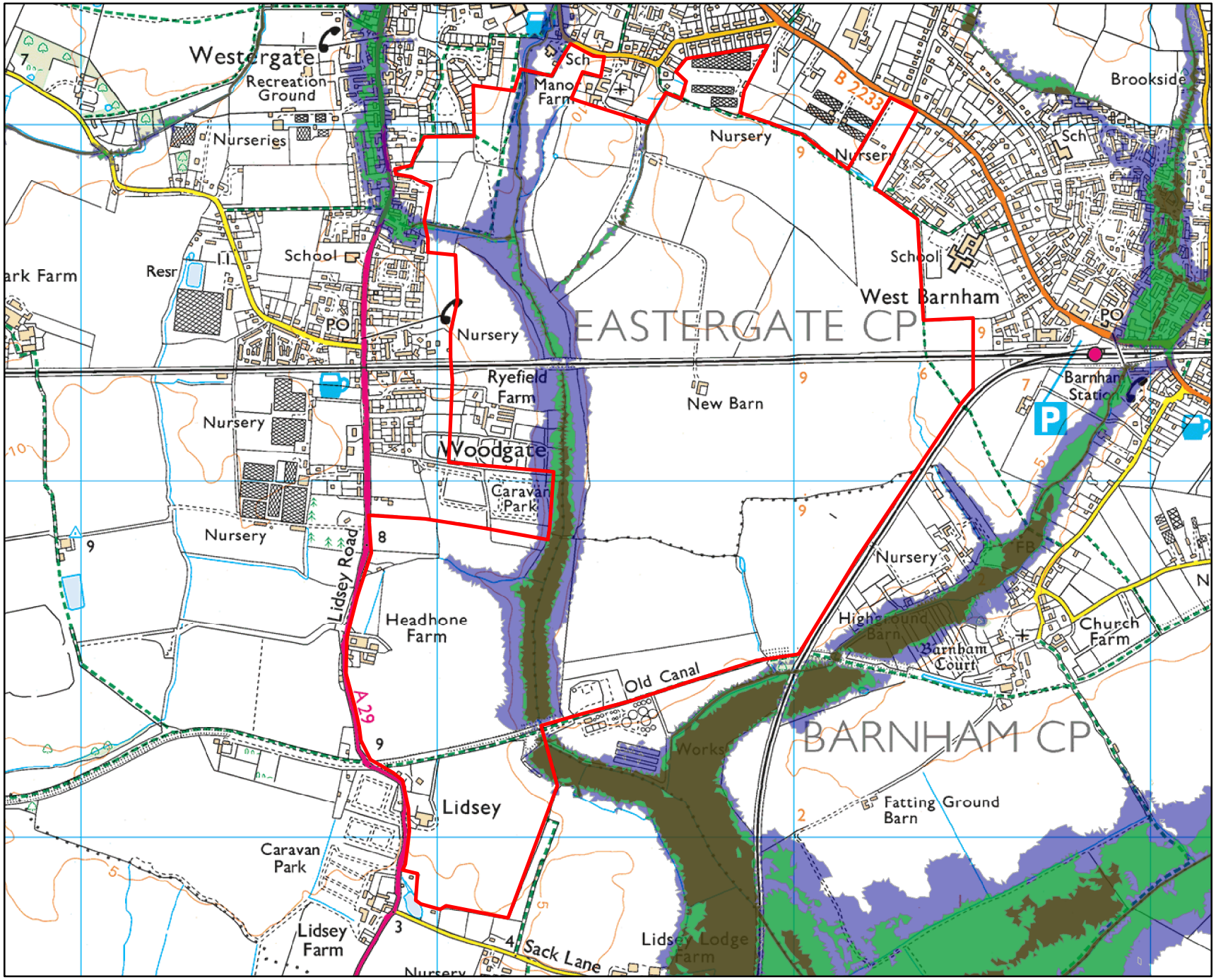
Scale: 1:15,000

0 0.35 0.7
Kilometers

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Modelled Flood Outlines (Defended Fluvial). Centred PO20 3XD. Created 08/01/2020.



Environment Agency

N

Legend

- Site_Boundary
- 5% AEP (Defended Fluvial)
- 1% AEP (Defended Fluvial)
- 0.1% AEP (Defended Fluvial)

Annual Exceedance Probability (AEP) The probability of a flood of a particular magnitude, or greater occurring in any given year.

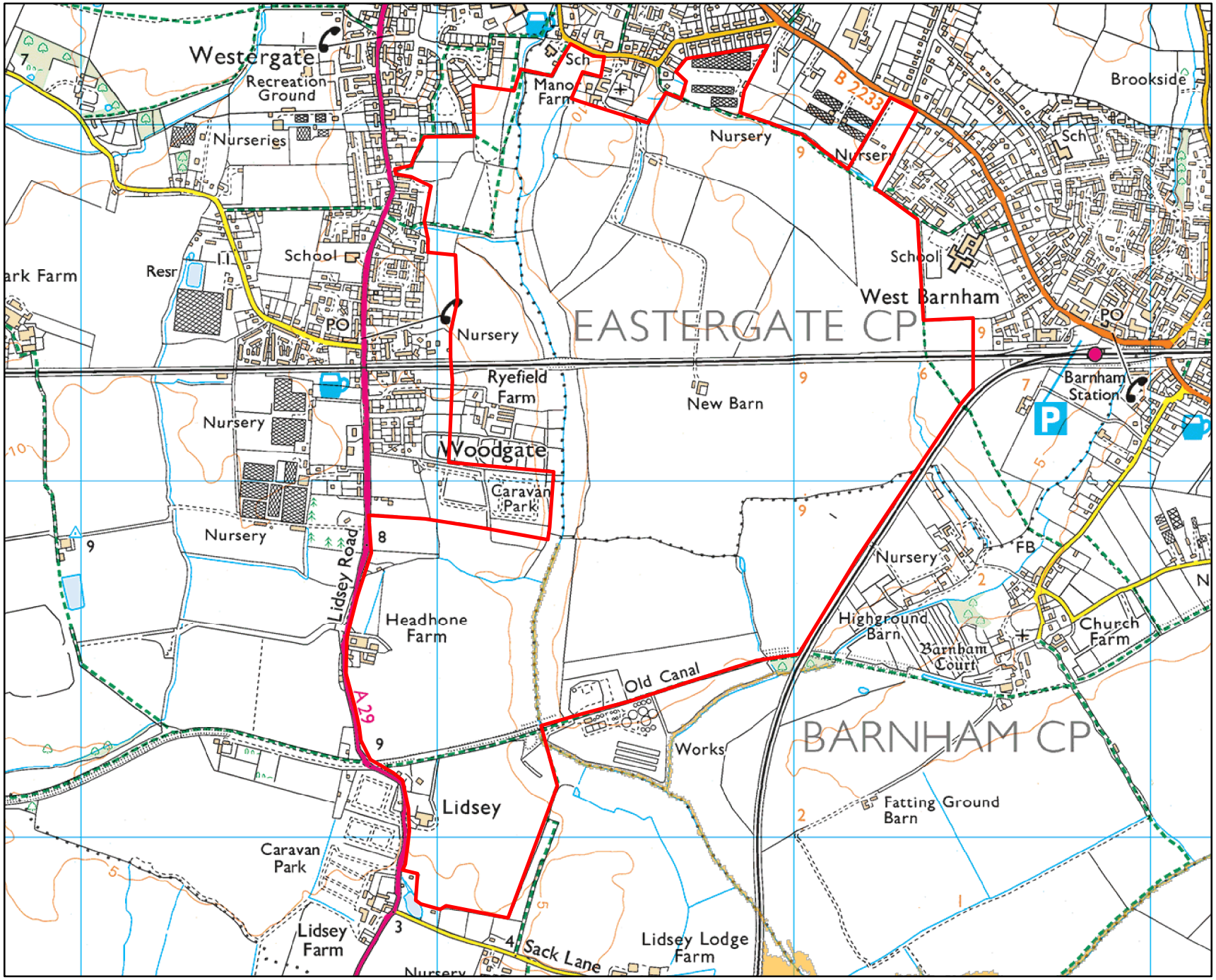
Scale: 1:15,000

0 0.35 0.7
Kilometers

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Modelled Flood Outlines (Defended Tidal). Centred PO20 3XD. Created 08/01/2020.



Environment Agency

N

Legend

- Site_Boundary
- 0.5% AEP (Defended Tidal)
- 0.5% AEP (2070) NPPF (Defended Tidal)
- 0.5% AEP (2115) NPPF (Defended Tidal)
- 0.1% AEP (Defended Tidal)

Annual Exceedance Probability (AEP) The probability of a flood of a particular magnitude, or greater occurring in any given year.

Scale: 1:15,000

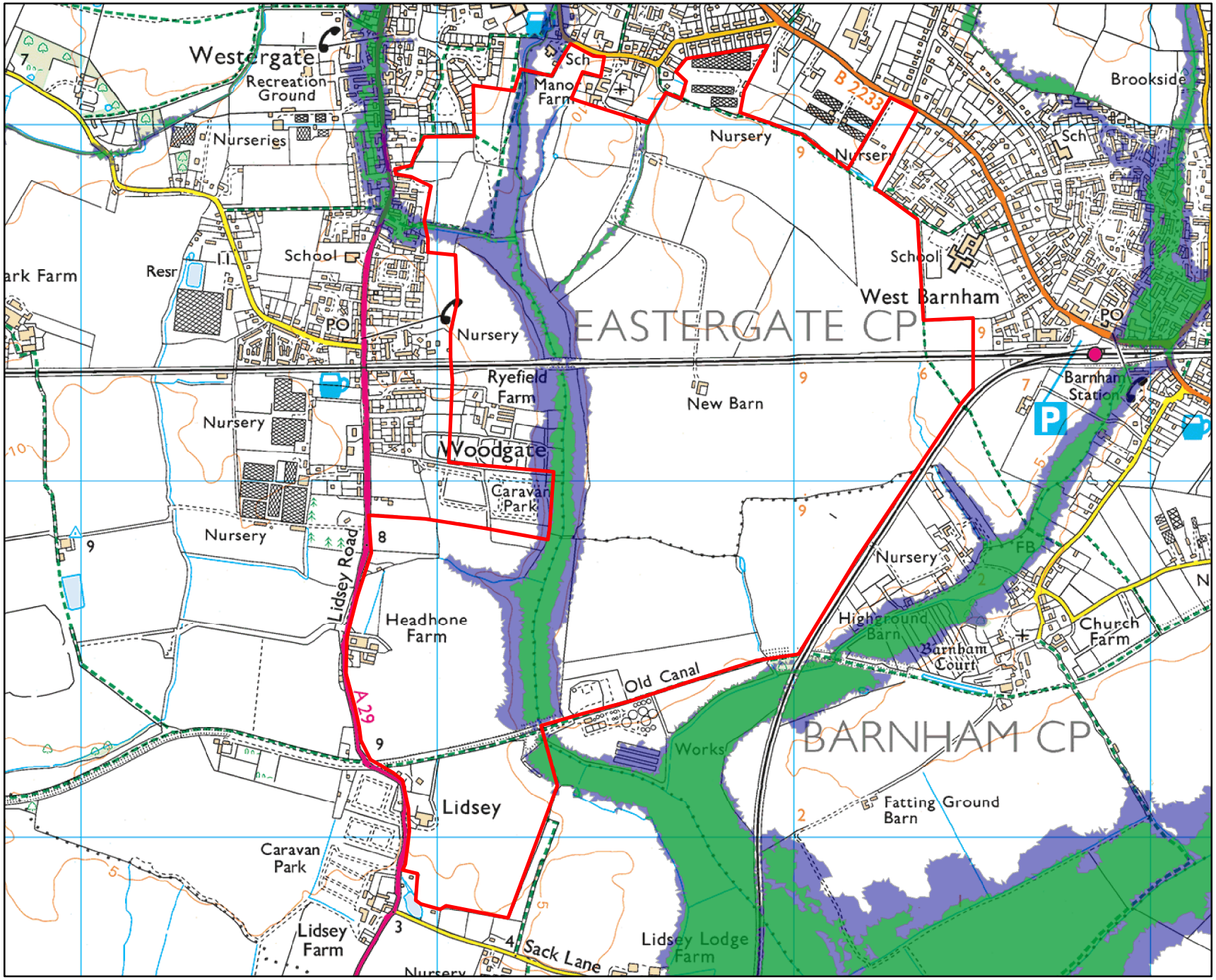
0 0.35 0.7

Kilometers

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Modelled Flood Outlines (Undefended Fluvial). Centred PO20 3XD. Created 08/01/2020.



Environment Agency

N

Legend

- Site_Boundary
- 1% AEP (Undefended Fluvial)
- 0.1% AEP (Undefended Fluvial)

Annual Exceedance Probability (AEP) The probability of a flood of a particular magnitude, or greater occurring in any given year.

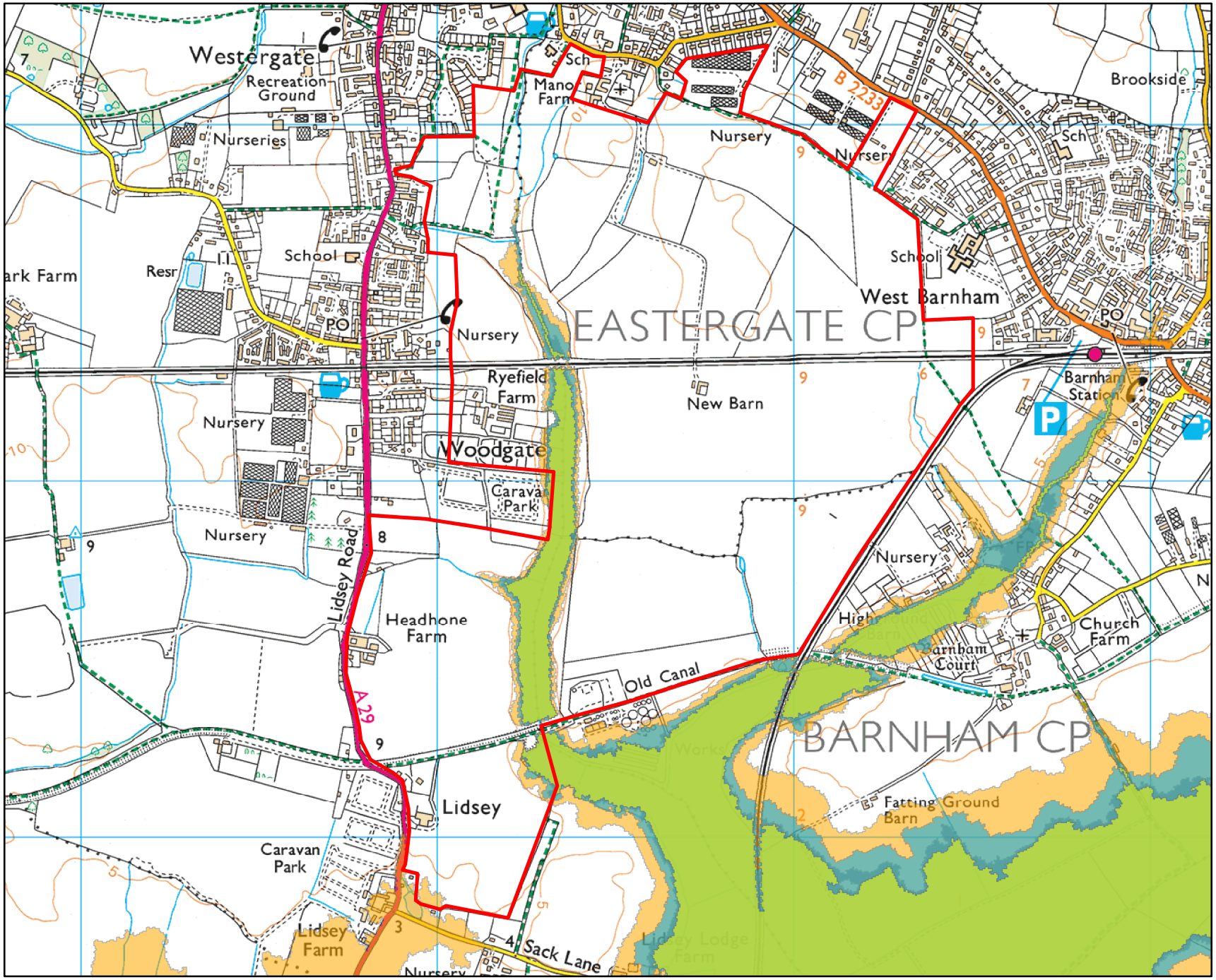
Scale: 1:15,000

0 0.35 0.7
Kilometers

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Modelled Flood Outlines (Undefended Tidal). Centred PO20 3XD. Created 08/01/2020.



Environment Agency

N

Legend

- Site_Boundary
- 0.5% AEP (Undefended Tidal)
- 0.5% AEP (2070) NPPF (Undefended Tidal)
- 0.5% AEP (2115) NPPF (Undefended Tidal)
- 0.1% AEP (Undefended Tidal)

Annual Exceedance Probability (AEP) The probability of a flood of a particular magnitude, or greater occurring in any given year.

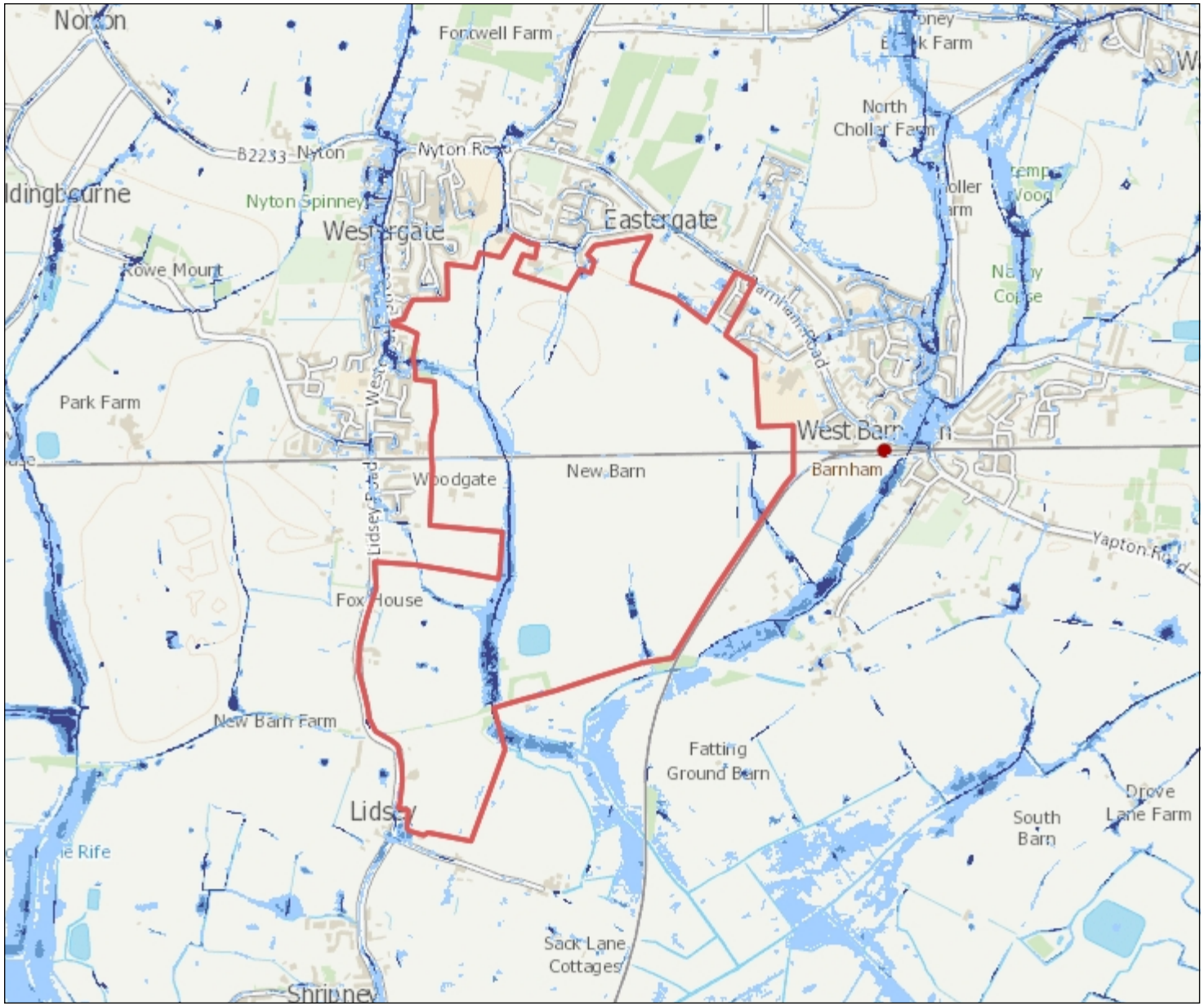
Scale: 1:15,000

0 0.35 0.7
Kilometers

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Risk of flooding from Surface Water. Centred PO20 3XD. Created 08/01/2020.



Environment Agency

1: 25,000

0 Metres 625

N W E S

Likelihood of flooding from Surface Water

- High (>=3.3%)
- Medium (3.3% - 1%)
- Low (1% - 01%)
- Very Low

Likelihood of flooding from Surface Water

High:	Greater than or equal to 3.3% (1 in 30) chance in any given year
Medium:	Less than 3.3% (1 in 30) but greater than or equal to 1% (1 in 100) chance in any given year
Low:	Less than 1% (1 in 100) but greater than or equal to 0.1% (1 in 1,000) chance in any given year
Very Low:	Less than 0.1% (1 in 1,000) chance in any given year

This information is shown on the Risk of Flooding from Surface Water map on GOV.UK.

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Appendix 3.1 A29 Crossing of Lidsey Rife: Flood Risk Technical Note

ARUN DISTRICT COUNCIL BN/11/22/OUT

Pell Frischmann

Barnham Eastergate Westergate

A29 Crossing of Lidsey Rife

Flood Risk Technical Note

ARUN DISTRICT COUNCIL BN/11/22/OUT

Pell Frischmann

Project	A13394 – Barnham Eastergate Westergate
Document Title or Subject	A29 Crossing of Lidsey Rife: Flood Risk Technical Note
Document Reference	100148-PEF-ZZ-XX-RP-YE-000030
Revision Reference	S2-P01
Date	14/09/2021

1 Introduction

1.1 Scope of Report

1.1.1 This report is intended to provide a technical review of potential bridge crossings over the Lidsey Rife, which would be required as part of the proposed A29 diversion works. The A29 realignment works are included in a planning application for a large proportion of the Barnham Eastergate Westergate (BEW) Strategic Allocation site, part of the Arun District Council Local Plan.

1.1.2 This Technical Note will cover the potential flood risk implications of crossing the Lidsey Rife and its associated floodplain, considering the potential implications of crossing options. It will identify potential opportunities and constraints, recommend suitable design parameters for the crossing and quantify the impact on flooding both locally and within the wider environs.

1.1.3 The scope of this report is limited to assessing the impact of high-level options commensurate with submission of an outline planning application. Further detailed design and analysis may be required at the appropriate juncture as designs for the A29 realignment scheme progress.

1.1.4 This Note should be read in conjunction with the 'A29 Realignment – Lidsey Rife Bridge Options' Technical Note (document ref: 13394-PEF-XX-BR-RP-S-000002) prepared by Pell Frischmann that provides detailed information on the feasibility of various crossing options from a structural perspective.

1.2 Context

1.2.1 The proposed development site, and A29 realignment route are shown on a location plan in **Figure 1.1**. In short, the A29 realignment phase extends to Barnham Road in the north (tying into the first phase of realignment works being designed by West Sussex County Council) and Lidsey Road (the current A29) in the south.

1.2.2 Towards the southern extent of the proposed realignment, the highway intersects with the Lidsey Rife watercourse and its associated floodplain and so will require a formalised crossing.

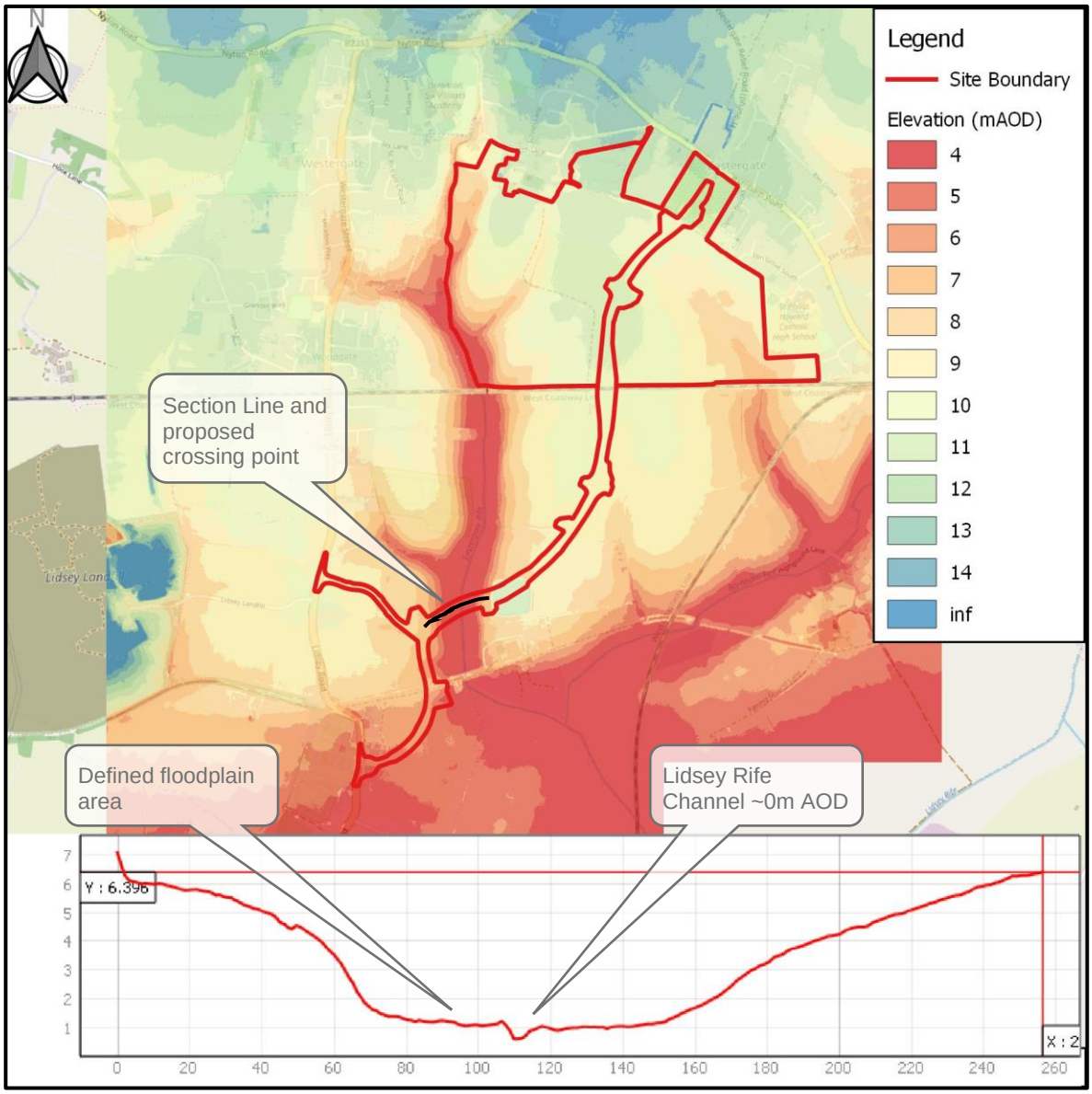
1.2.3 The Lidsey Rife floodplain in this location comprises a well-defined extent constrained by existing topography (see **Figure 1.2**). Flood extents have been derived through a combination of hydraulic modelling carried out by the Environment Agency and information from historic flood events.

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Figure 1.1 Site Location Plan



Figure 1.2 Local Topography from LiDAR

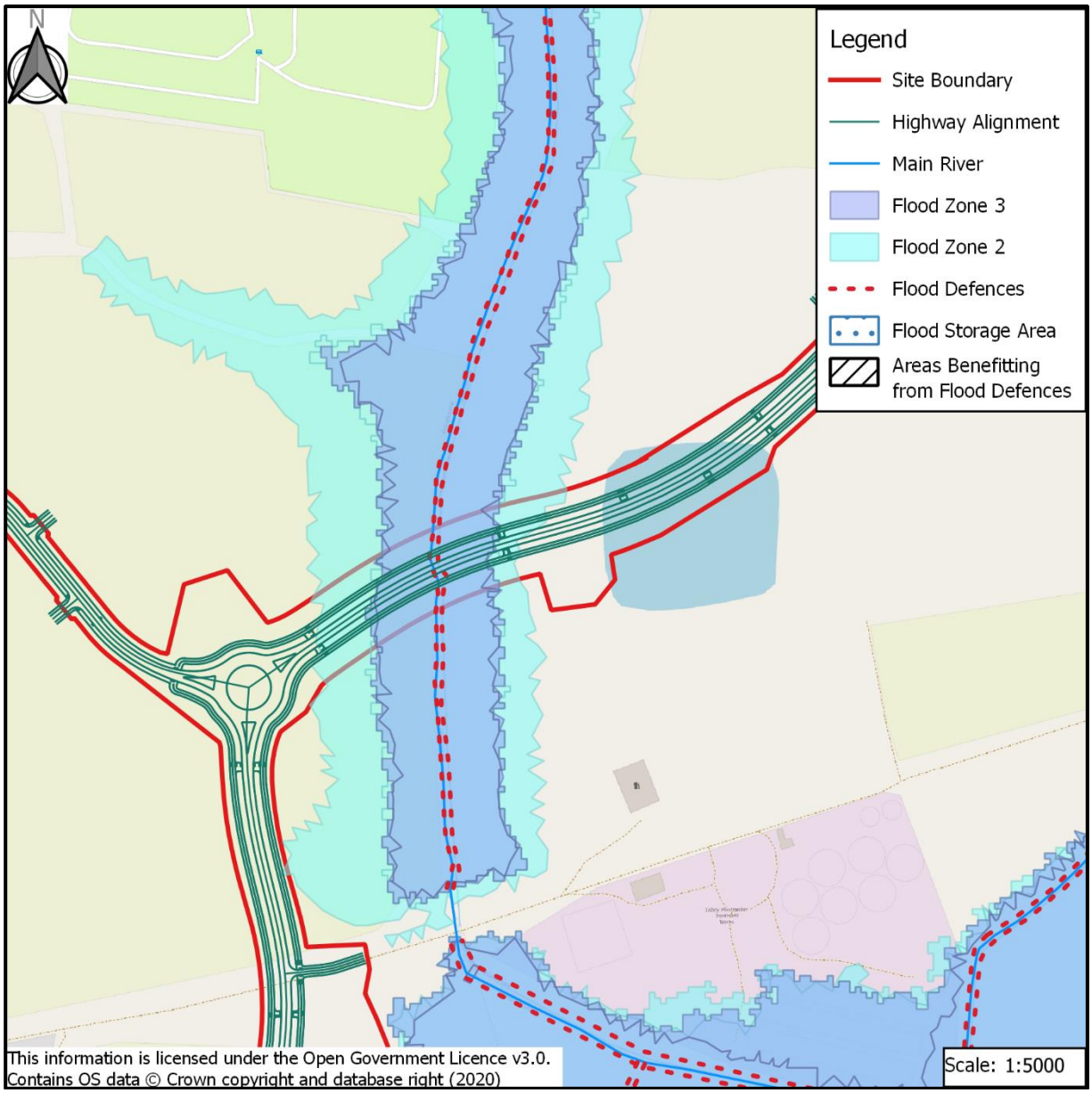


2 Flood Risk Context

2.1 Flood Map for Planning

2.1.1 The Flood Map for Planning prepared by the Environment Agency shows the extents of Flood Zone 2 and 3, which has been reproduced below as **Figure 2.1**, including the latest highway alignment proposals.

Figure 2.1 Flood Map for Planning



2.1.2 At the point of intersection, the width of Flood Zone 3 affected by the highway alignment is approximately 100m, extending to 175m when considering Flood Zone 2.

2.1.3 Further to this, a request was submitted to the Environment Agency to obtain any site-specific data they may hold. The Environment Agency shared various results from the Aldingbourne Flood Risk Mapping Study, completed by JBA Consulting in 2015. A further update to this study was prepared in 2016 to account for new climate change allowances published by the EA at that time.

2.1.4 Data relating to tidal flood risk has been provided from the Arun to East Head tidal flood risk mapping study completed in 2016. However, a review of the submitted information confirms flood risk at the study location to be fluvially dominated, so for the purposes of this technical note tidal flood risk is not considered further.

2.2 Hydraulic Modelling Data

2.2.1 Site-specific hydraulic modelling data has been supplied by the Environment Agency both in terms of data outputs and hydraulic modelling files for use as part of this study. To inform this report, inspection of the provided digital outputs has been used and presented here to ensure the results are appropriate at the location of the proposed crossing.

2.2.2 It should be noted that the information supplied by the Environment Agency in respect of climate change used climate change allowances based on guidance at the time split into River Basin Management areas. However, the Environment Agency has recently updated its approach to climate change allowances[1], refining the increases that should be considered based on operational catchments.

2.2.3 The Lidsey Rife and surrounding areas fall within the 'Arun and Western Streams' management catchment, and so the updated climate change allowances for peak river flows are presented in **Table 2.1**.

Table 2.1 Peak River Flow Climate Change Allowances

Epoch	Climate Change Allowance Band		
	Central	Higher	Upper
2020s	11%	16%	27%
2050s	13%	19%	36%
2080s	25%	36%	64%

2.2.4 For context, the previous allowances used by the Environment Agency as part of the Aldingbourne modelling study were 35%, 45% and 105% for the 2080s epoch central, higher and upper allowances respectively.

2.2.5 Given the site's strategic allocation status and proposals comprising 'essential infrastructure' under the definitions included in the NPPF, the EA's guidance suggests use of the higher allowance, which will be assessed against the 2080s epoch.

2.2.6 Therefore, the appropriate climate change allowance to be considered is a 36% increase in peak river flows.

2.2.7 Based on the information supplied by the Environment Agency, the flood extents for the 1% annual probability event including a 35% increase in river flow (used as an appropriate proxy result for a 36% increase in line with latest guidance) is shown for reference as **Figure 2.2**.

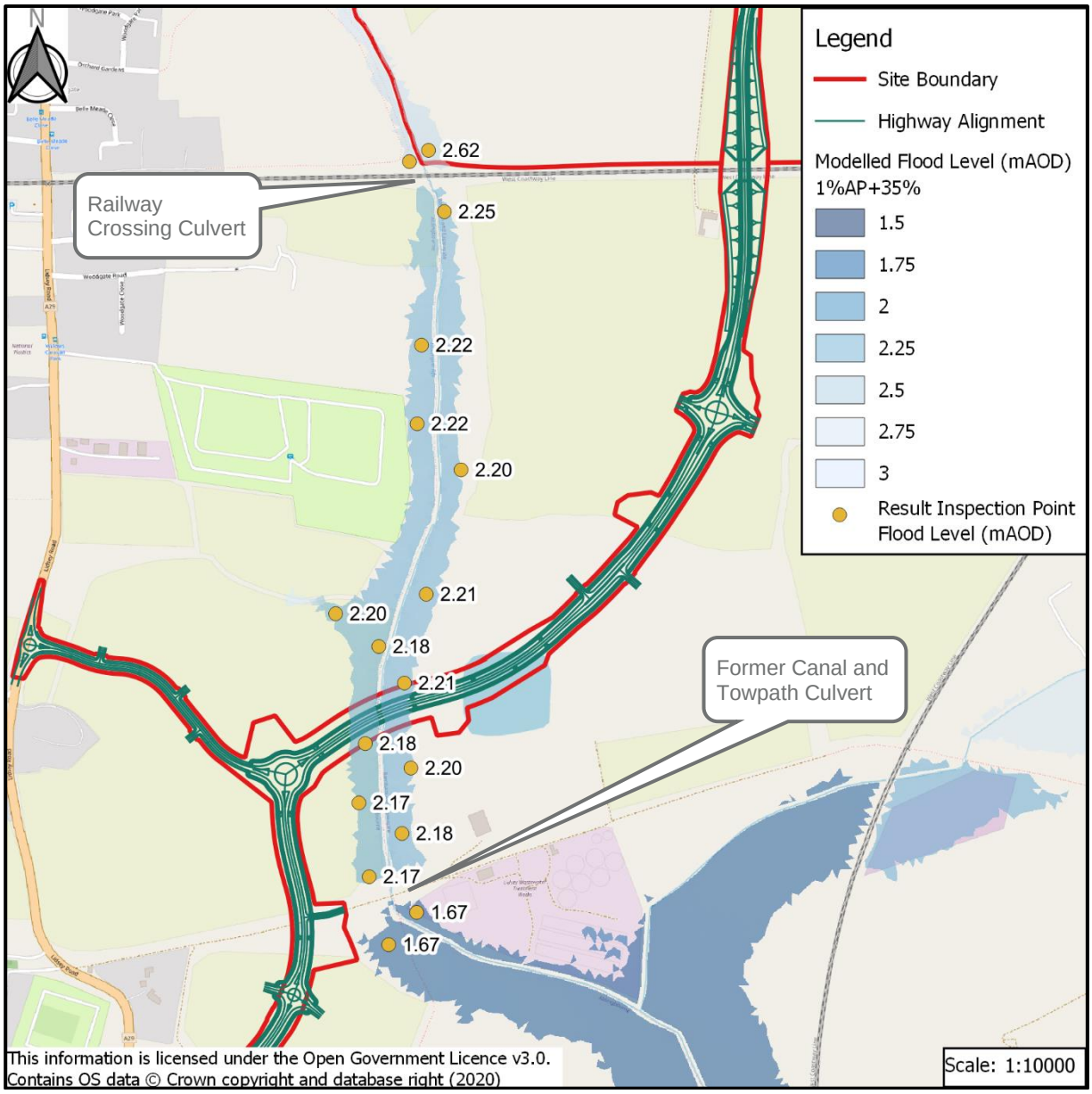
2.2.8 The model outputs indicate a peak flood level at the upstream (northern) side of the proposed crossing of 2.2m AOD, reducing slightly to 2.18m AOD at the downstream (southern) side.

2.2.9 The flood levels appear to be relatively consistent throughout the entire reach of the Lidsey Rife between the culvert under the railway to the north and the culverted section under the raised embankment (former canal and towpath) to the south. The noticeable difference in level upstream and downstream both structures indicate their significant influence on flooding along this stretch of the Lidsey Rife.

2.2.10 The culverted section of the Lidsey Rife under the former canal and towpath in particular appears to be the main control on flood levels in the vicinity of the proposed crossing. For context, the 1% annual probability event +45% increase for climate change results in very similar flood levels in the area.

[1] Environment Agency (2021); *Flood risk assessments: climate change allowances;* updated on 27 July 2021, available at https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Figure 2.2 Baseline Modelling Results – 1% Annual Probability +35% Increase



3 Design Parameters

3.1 Soffit Level

3.1.1 Based on the information presented within the above discussion, an appropriate flood level of 2.2mAOD has been determined at the point of the proposed A29 realignment crossing of the Lidsey Rife.

3.1.2 In line with prevailing best practice, it is recommended that any crossing over the watercourse has at least 600mm clearance above the modelled flood level to allow for potential uncertainties and to reduce the risk of blockage that could result in localised increases in flood risk.

3.1.3 Therefore, any structure over the Lidsey Rife should have a soffit level no lower than 2.8mAOD.

3.2 Bridge Span

3.2.1 As a minimum, the crossing of the Lidsey Rife should comprise a clear spanning structure over the watercourse channel itself. Based on the site topographical survey, the watercourse is between 8 and 10m wide at this location and so it is likely a bridge structure is the most suitable option for crossing.

3.2.2 To bridge the entire floodplain would require a structure greater than 100m in length. The Lidsey Rife Bridge Options Technical Note by Pell Frischmann considered a clear spanning structure but determined such a crossing would be prohibitively expensive to construct and maintain.

3.2.3 The Bridge Options Technical Note proposed an Option 2 comprising a 30m span structure over the watercourse with footings situated within the floodplain.

3.2.4 Initial designs, carried out prior to the release of the most recent climate change allowances, have been based on previous climate change allowances and assume a flood level of 5.8m AOD when allowing a 105% increase in flows, this is now considered well beyond even the requirements for a credible maximum scenario. Based on the new allowances presented in **Table 2.1**, a credible maximum scenario would require only a 64% increase in peak river flows.

3.2.5 These previous design parameters resulted in a soffit level was set to 6.4m AOD, which is a significant height above current ground levels and meant embankments on either side of the bridge span were required to accommodate this. Those embankments would be located in the floodplain and so sensitivity testing has been carried out using the Environment Agency's flood model to determine the impact such a structure may have on flood risk locally.

3.3 Flood Relief Culverts

3.3.1 The design for Option 2 (the 30m span bridge with approach embankments) also indicates flood relief culverts are incorporated into the embankments to manage the conveyance of water across the floodplain where the embankments may impact this.

3.3.2 With a positive flow across the floodplain, water may surcharge on the upstream face of the embankments, locally increasing the flood level and applying hydrostatic pressure to the embankment. However, as previously discussed, the water level in the floodplain along the stretch of the Lidsey Rife between the railway and former canal and towpath is consistent, brought about by surcharging of the existing culvert.

3.3.3 As such, it is unlikely that flood relief culverts in the embankment would provide any discernible benefit in terms of flood risk and therefore are unlikely to be required at detailed design.

4 Model Testing

4.1 Modelling Approach

4.1.1 An existing InfoWorks ICM 1D River / 2D Overland Flow model has been provided by the Environment Agency and has been used as a basis for this study.

4.1.2 As a conservative analysis, the model was run for baseline and proposed scenarios using the 1% annual probability event, including a 105% increase in peak river flows to account for climate change. This hydrological estimation is as per the parameters provided by the Environment Agency.

4.1.3 For both scenarios, the model was run at a duration of 1 day.

4.2 Changes to Baseline Model

4.2.1 Initial calibration simulations determined some run errors within the model related to the underlying data to create the baseline ground surface. Therefore, the 2D ground model was recreated using elevations from local LiDAR data.

4.2.2 No other changes were made to the simulation parameters or the 1D river network to re-run the simulation and provide updated baseline results.

4.3 Changes to Represent Proposals

4.3.1 Mesh Level Zones were added to raise the elevation of the ground surface to represent the proposed embankments for the bridge crossing (as per **Figure 4.1**). As the structure represents a clear span over the channel, with a soffit level above the anticipated flood level, no changes were applied to the 1D channel sections, nor a vertical constraint applied to represent the proposed bridge crossing.

4.3.2 This approach is considered reasonable given the parameters of the proposed structure. The changes adequately represent the impact on the floodplain brought about by the approach embankments displacing a potential storage volume and constriction of the floodplain flows parallel to the watercourse.

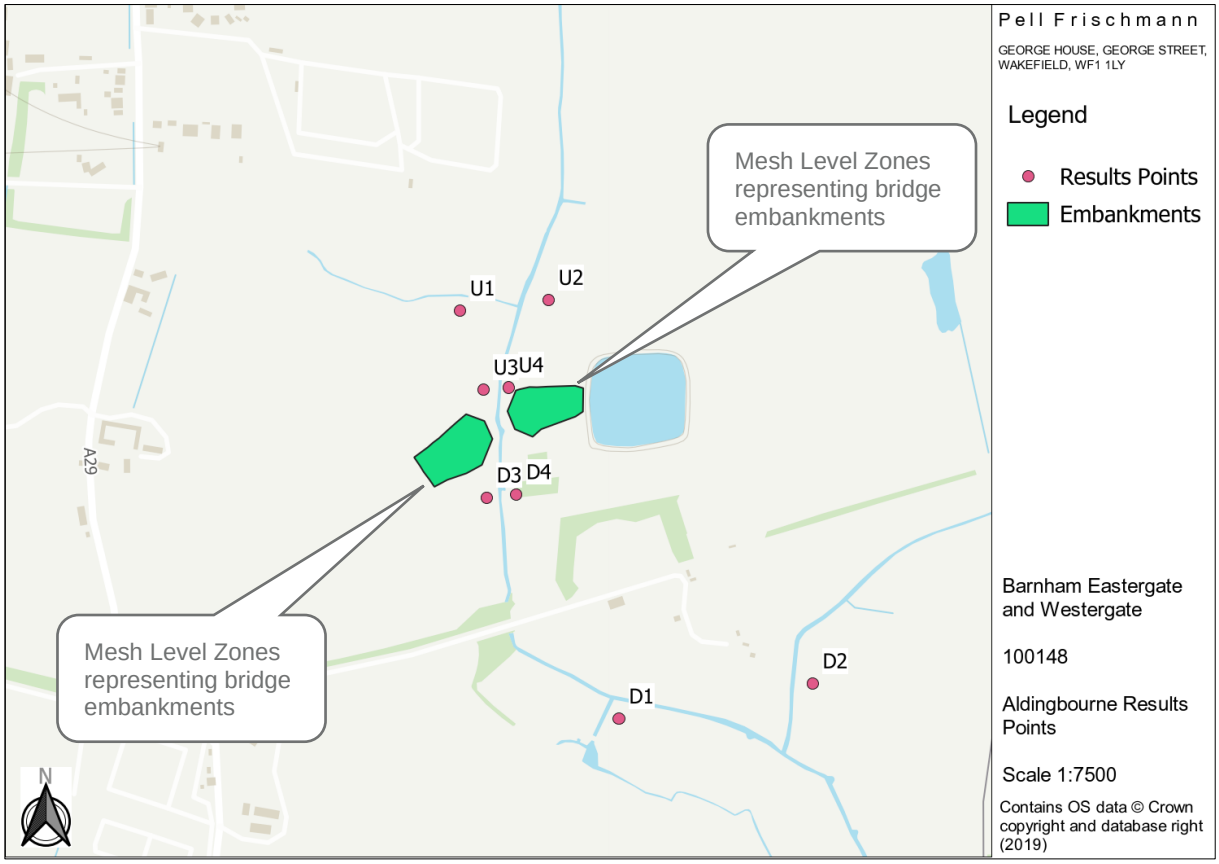
4.4 Results

4.4.1 Output grids were inspected to provide peak flood depths for several points set upstream and downstream of the embankment to quantify the impact of the structure on the surrounding floodplain. Inspection points are shown for reference on **Figure 4.1**, with results summarised in **Table 4.1**.

Table 4.1 Modelling Results Comparison

	U1	U2	U3	U4	D1	D2	D3	D4
Baseline Scenario Depth (m)	1.155	1.571	1.643	1.632	0.997	0.871	1.758	1.656
Embankment Scenario Depth (m)	1.251	1.512	1.629	1.671	0.990	0.864	1.827	1.684
Change in Depth (m)	+0.096	-0.059	-0.014	+0.039	-0.007	-0.007	+0.069	+0.028

Figure 4.1 Results Inspection Points



4.4.2 Review of the results confirms that the changes brought about by the impact of the embankments is limited, with many areas suggesting a nominal decrease in flood depth.

4.4.3 Importantly, points D1 and D2 are located downstream of the application site beyond the applicant's control. Both these points show a negligible change in flood level from the encroachment of the embankments into the floodplain. This is likely due to the restriction on pass forward flows imposed by the culvert under the former canal and towpath.

4.4.4 As such, any potential changes in flood risk are contained to areas immediately adjacent to the proposed crossing, and within land under the control of the applicant.

4.5 Assumptions and Limitations

4.5.1 Being a broad-scale model of the Aldingbourne Rife system means the overall model size is large in comparison to the area of interest. This means the ground model resolution has to be relatively coarse to avoid issues over file size and run time.

4.5.2 Even with this coarse resolution, the model is computationally intensive, and requires significant run times. Both issues combined limited the optioneering and testing available to assess the impact of the bridge crossing.

4.5.3 Nevertheless, the information provided represents an effective comparative tool to assess the impacts of the proposed bridge embankments.

4.5.4 In all likelihood, given the change in design parameters from the 105% climate change allowance tested to a 36% increase, the road deck level will be lowered, reducing the scale and extent of the proposed approach embankments. Coupled with a less extreme flood scenario the impacts generated by the crossing would be reduced further.

5 Summary & Conclusions

5.1.1 Proposals have been developed for a realignment of the A29, which requires a crossing over the Lidsey Rife (EA Main River) along its alignment.

5.1.2 Hydraulic modelling information provided by the Environment Agency has been reviewed to identify flood risk constraints and outline key design principles that should be adopted as part of detailed design of the highway.

5.1.3 Based on the latest climate change allowances provided by the Environment Agency, it is considered that the higher climate change allowance for the 2080s epoch is appropriate to consider when designing the A29 alignment over the Lidsey Rife. This equates to a 36% increase in peak river flows.

5.1.4 The Environment Agency supplied information for the 1% annual probability scenario including a 35% increase in flows in line with the prevailing guidance at the time of production, and these results have been used to inform this study.

5.1.5 At the point where the proposed A29 crosses the Lidsey Rife, an appropriate flood level of 2.2m AOD was identified from the results. Allowing a +600mm freeboard above this level has determined a minimum soffit level for the crossing that should be no lower than 2.8m AOD.

5.1.6 Options for bridge crossings were considered as part of a structural review of Bridge Options in a report by Pell Frischmann. The report recommends a single 30m clear span bridge crossing the main Lidsey Rife channel and a portion of floodplain either side of the channel, with approach embankments either side of the crossing as the road will be elevated above current ground levels.

5.1.7 The Environment Agency's model was used to assess the impacts of such a configuration on flood risk in the locality. It should be noted that previous climate change allowances were used for this analysis, so the impacts were quantified based on a 105% increase in flow, which is beyond even the credible maximum scenario required for this management catchment under the latest guidance.

5.1.8 This analysis confirmed a minor impact on flood levels locally, in areas within the control of the applicant. For areas downstream beyond the site boundary, negligible impacts on flood levels were reported. It is concluded that this is due to the control on flood levels within this discrete reach of the Lidsey Rife imposed by the restrictive culvert under the former canal and towpath.

5.1.9 Therefore, the proposed crossing is not considered to have a significant impact on flood risk, and any impact would likely be reduced when considering the design event with appropriate climate change allowances applied. It is recommended that further testing is carried out at the appropriate juncture as detailed designs of the A29 alignment progress.

A29 Crossing of Lidsey Rife
Flood Risk Technical Note

Report

This report is to be regarded as confidential to our Client and is intended for their use only and may not be assigned except in accordance with the contract. Consequently, and in accordance with current practice, any liability to any third party in respect of the whole or any part of its contents is hereby expressly excluded, except to the extent that the report has been assigned in accordance with the contract. Before the report or any part of it is reproduced or referred to in any document, circular or statement and before its contents or the contents of any part of it are disclosed orally to any third party, our written approval as to the form and context of such a publication or disclosure must be obtained.

Report Ref.	**100148-PEF-ZZ-XX-RP-YE-000030-S2-P01_Bridge TN.Docx**
File Path	I:\133--\A13394-VAA Barnham Eastergate Westergate\40 Reports\Flood Risk\Bridge TN\100148-PEF-ZZ-XX-RP-YE-000030-S2-P01_Bridge TN.docx

Suit	Rev	Description	Date	Originator	Checker	Approver
S2	P01	Preliminary Issue	17/09/2021	D. Allum-Rooney	Y. Lawson	D. Allum-Rooney

Ref. reference. Suit suitability. Rev revision.

ARUN DISTRICT COUNCIL BN/11/22/OUT

Appendix 3.2 EA Review and Modelling Log

Barnham Eastergate Westergate
Model Summary

Title	*Details*
Project	**A13394-VAA Barnham Eastergate Westergate**
Report Title	**ICM Model Summary**
Revision	**P02**
Date	**23/06/23**
Prepared By	Kristiyan Ivanov

Barnham Eastergate Westergate 1D-2D ICM Model	
BEW Model	***Details***
Model Build	The model is based on the existing Aldingbourne Rifes and SWS Innovyze ICM model, provided by the Environment Agency (EA) to Pell Frischmann. The purpose of the modelling exercise is to assess the impact of a proposed development of the A29 road, namely the introduction of a new bridge crossing over Lidsey Fife and the impact of its embankments on the existing floodplain. It has been assumed that the existing Aldingbourne model has been quality checked by EA and is used as a baseline scenario when undertaking comparative analysis between the proposed and existing scenarios. The model database was upgraded to ICM v. 2023.0.1 and the simulations were run in that version of the software. The incoming hydraulic model was assessed for suitability to the projects. The main purposes of the study are to determine the impact of the proposed infrastructure to the wider catchment, hence it was determined that the scale of the model is appropriate. Additional interpolated cross-sections were added to the model to aid stability, specifically around the area of interest. Bank lines were compared against most recent LiDAR information and updated where required. Some existing cross-sections based on older LiDAR information were updated to aid the model's accuracy. The floodplain extents within the area of interest were found to compare well with existing flood mapping.
Scenarios	The model has three modelled scenarios – baseline, proposed and multi-span: **Baseline scenario** The baseline scenario is developed from the existing model provided by the EA (version 104 of the network, dated 23/10/2017). The attempted rerun of the existing failed, which required alterations to the model as it was failing to converge in certain sections with some instabilities caused by negative river reach slopes and mismatched culvert inverts. The failure of the existing model to run may be due to upgrading the database to the most recent version of ICM, whereby the existing network and runs provided by the EA could have run in previous versions of the software.

ARUN DISTRICT COUNCIL BN/11/22/OUT

Barnham Eastergate Westergate
Model Summary

Barnham Eastergate Westergate 1D-2D ICM Model	
BEW Model	***Details***
	The alterations to the model in order to remove instabilities and aid convergence are detailed in the attached modelling log in Appendix A. **Proposed scenario** The proposed scenario consists of two bridge embankments located within the floodplain at Lidsey Fife. The embankments are represented as porous polygons with infinite crest levels. Their location and shape is based on drawing 13394-PEF-ZZ-XX-M2-S-000003 and Technical Note 3394-PEF-XX-BR-RP-S-000002. **Multi-span scenario** A multi-span option has been developed for the bridge crossing. Each individual pillar has been modelled as a porous polygon with infinite crest level as shown on drawing 13394-PEF-ZZ-XX-M2-S-000002. The drawings are shown in Appendix B
Data Sources	LiDAR: 1m resolution obtained through Defra's website, dated 2022 Proposed Bridge Abutments and Pillar Location: Pell Frischmann Design Drawings No other survey was made available for the purposes of this study.
2D Domain	Maximum element area: 100m^2 (from incoming model) Ground model grid: Latest 1m resolution LiDAR Minimum element area: 25m^2 (from incoming model) Mesh generation: Classic (from incoming model) Boundary: Normal condition (from incoming model) Terrain-sensitive meshing: enabled Max height variation: 1.5 (from incoming model) Minimum angle: 15 (from incoming model) Manning's n for mesh: 0.06 (from incoming model) Rainfall: applied outside subcatchments Mesh Zones: These have remained unaltered from the incoming mode. Minor vertex adjustment has been undertaken for some elements to decrease number of small triangles within the mesh. Roughness Zones: These have remained unaltered from the incoming model. General lines: These have remained unaltered from the incoming model.

ARUN DISTRICT COUNCIL BN/11/22/OUT

Barnham Eastergate Westergate 1D-2D ICM Model	
BEW Model	***Details***
	Structures: No additional structures were added to the 2D domain. The only structures within the floodplain are the abutments and piers of the proposed bridge across Lydsey Rife. Flexible meshing has been enabled in the model
1D Domain	Cross-sections: • Manning's roughness remained unaltered from incoming model 35 cross-sections were identified as having Manning's n values of "0" upon the first review of the model by the EA. These values have been altered in accordance with existing Manning's n roughness values within the sections and upstream and downstream values within the reach. A summary of the identified cross-sections has been provided Appendix C • Panel markers have been added on certain sections to help with model stability • Based on SurveyHub survey, previous ISIS model supplied by EA and inferred from LiDAR or interpolated Conduits and Structures: • No additional conduits or manholes were added to the model • Some conduits were altered/removed as they were causing the model runs to crash due to negative slope or inappropriate placement. The changes to the structures is recorded within the modelling log Appendix A. • No additional structures were added to the model. Bank lines: • Default discharge coefficient assumed for bank lines: 0.9 • Default modular ratio assumed for bank lines: 0.6
Hydrology/US Boundary	The hydrological inputs to the model remain unaltered. Climate change allowances were used in line with existing guidance. Actual values were modified in the guidance during the preparation of the work, and so the values presented are slightly conservative (higher) than current values but would represent negligible change to flows. A baseflow of 0.02m^3/s has been added to two river reaches to aid model stability by preventing the channels from running dry within the simulation. The magnitude of the baseflow will not present a material difference to the results. The 2D initial conditions have not been altered from the incoming model. The peak river flow allowance used in the assessment is 35% climate change uplift. The higher allowance for the 1% AEP for the 2050s epoch is 19% and for the 2070s epoch is 36%. Based on the lifespan and type of infrastructure, we deemed 35% as appropriate uplift.
Downstream Boundary	The downstream model boundaries have remained unaltered from the incoming Aldingbourne model.

Barnham Eastergate Westergate
Model Summary

Barnham Eastergate Westergate 1D-2D ICM Model	
BEW Model	***Details***
Simulation Run Parameters	The simulation run parameters have not been altered from the incoming model, apart from the addition of the baseflow to the watercourses to aid model stability.

Modelled Sensitivity Scenarios	
Title	***Details***
Manning's n	+/- 20% Manning's n variation within the channel The sensitivity scenarios show <10% change in flow within the channel when the Manning's n is adjusted. The depth and volume within the floodplain does not show material change.
Flow	+/- 20% Flow variation Upon analysis of the rainfall variation within the model, it was determined that the flood depths increase or decrease by approximately 10-15%, therefore the model is sensitive to flow alterations.

Model summary	
Title	***Details***
Validation errors and warnings	**Invert above ground level**: Warning for four conduits within the model. These have not been altered as no information is available and the conduits' invert levels may in reality be above existing ground level. **Manning's values differ by more than 20 percent within a panel:** Warning for four cross-sections within the model. The Manning's values of these cross-sections have not been altered by Pell Frischmann, hence it was assumed that the values are correct and no changes were made. **Bank connection for 2D zone overlaps 2D mesh in void region:** Warning for three bank connections and the associated storage areas at the start and ending of the river reaches. These have not been altered and kept as is from the incoming model.
Model convergence and stability	The model shows good convergence around the area of interest. The mass balance error is 9.7142m^3 considering a final volume of 3574208m^3 which is acceptable for the model.
Calibration	No calibration has been undertaken for the model as no data is available.
Model overview	The incoming model from the EA was unstable and was not converging at several locations. It is possible that the issues were related to upgrading the model database to the most recent ICM version.

Model summary	
Title	***Details***
	Given the size of the proposed scheme and the requirement to estimate changes within the large floodplain, it is considered that the existing model has sufficient resolution, and the obtained results give a good representation of the impact from the embankments and the proposed pillars.
Model Uncertainty	Due to the size of the hydraulic model, estimation of risk of flooding from rivers is considered robust for the level of assessment required in the SFRA. The greatest uncertainties in the hydraulic modelling occur as a result of: ➢ Models not having been fully calibrated or verified (they were only sensibility checked the EA). ➢ Hydrological estimates not having been generated through a detailed study. However due to the methods employed, hydrological estimates are considered conservative. ➢ Joint probability of storm surges with high river flows has not been assessed. ➢ The models assume that flood defences do not fail and the conditions of the defences do not change (i.e. the crest levels remain constant). The discrepancies of the modelled results and the existing Food Zone mapping are due to the difference in return period and the inherent uncertainty within the GIS interpolation points. The current hydraulic model utilises latest available LiDAR information while the flood zone Mapping within the wider area has been developed in 2010-2011.
Overview of Results	A network results polygon is created within the area of interest. Upon comparison of the enclosed flood water volume, it is found that the single-span proposed scenario and the multi-span option do not increase the flood volume within the network results polygon. The volumes are as follows: Baseline: 143264 m^3 Proposed single span: 139516 m^3 Proposed multi span: 139784 m^3 Further higher-resolution analysis will be undertaken to develop an impact mitigation option Upon further inspection Flood mapping of the generally conform the Risk of Flooding from Rivers and Sea (RoFRS) mapping. The main floodplains are well defined. Discrepancies between the RoFRS mapping and the modelled results are due to the differences in the return periods. It is therefore difficult to compare like-for-like of the outputs. The modelling, undertaken by Pell Frischmann also captures the smaller drainage routes which are not shown in RoFRS mapping, as the results have not been filtered for lower depths. Furthermore, water depths within the channel were compared between the existing and proposed scenarios, and it was found that the proposed bridge infrastructure does not have a tangible impact on the existing floodplain. The hydraulic modelling results mapping and cross-section comparison are shown in Appendix D.

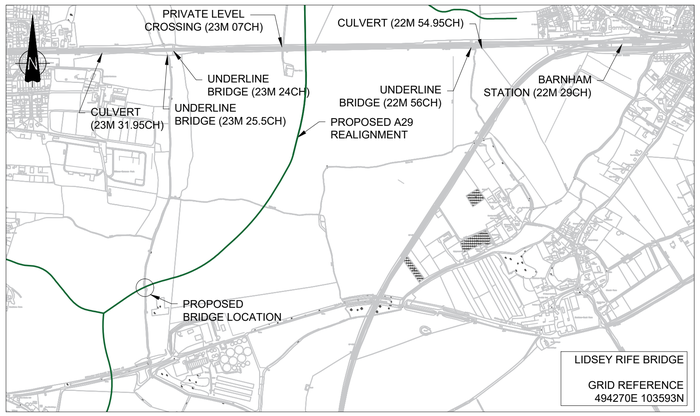
Appendix A Modelling Log

Version Number	Date	User	Changes Made	Comments
188	21/06/2022 16:32	TSharples	16	Added inflows at head of rivers
187	21/06/2022 15:20	TSharples	7	
186	21/06/2022 14:46	TSharples	3	Added inflow at 2.011 river reach of 50l/s
185	20/06/2022 20:26	TSharples	14	remeshed
184	20/06/2022 16:12	TSharples	3	
183	20/06/2022 14:56	TSharples	7	Ticked Terrain-Sensitive Meshing. Replaced flap with culvert outlet at 1.016!!!!
182	20/06/2022 07:36	TSharples	274	set discharge coefficient and discharge ration where this was missing
181	17/06/2022 15:34	TSharples	9	added bank connections and remeshed
180	17/06/2022 14:05	TSharples	12	remeshed
179	17/06/2022 10:19	TSharples	12	re-meshed, unticked lower mesh element to banks. Set min element back to 20m2. filled gap in cross sections at 1.006.
178	17/06/2022 08:24	TSharples	134	reduced 2d zone min grid size from 20 to 10
177	16/06/2022 14:50	TSharples	17	removed culvert at 1.009, re-meshed
176	16/06/2022 12:34	TSharples	14	removed bridge 1.006 and re-meshed
175	16/06/2022 08:25	TSharples	14	remeshed
174	15/06/2022 14:38	TSharples	5	removed irregular weir at 1.016!!!! due to model instability.
173	15/06/2022 11:18	TSharples	5	no changes
172	15/06/2022 08:03	TSharples	16	Convergence error at 1.016!!!!. Adjusted invert level of flap and ground level
171	14/06/2022 15:54	TSharples	129	Added embankments scenario. Modelled Embankments as mesh level zones
170	14/06/2022 14:50	TSharples	17	Added results polygons
169	14/06/2022 11:55	TSharples	39	Resolved some of the invert above ground level issues. Some still remain but these are at outfalls so shouldnt cause errors. Remeshed following rebuilding of river reach 1.006.
168	14/06/2022 10:01	TSharples	3	Commited with no changes
167	08/10/2021 10:39	TSharples	323	Deleted scenario s1 embankment, will re-add when baseline is running
166	08/10/2021 08:52	TSharples	14800	remeshed
165	07/10/2021 11:22	TSharples	57	moved break nodes into storage area to prevent convergence issues
164	07/10/2021 10:57	TSharples	303	
163	06/10/2021 15:59	TSharples	302	Edited storage areas and invert levels above ground, remeshed
162	06/10/2021 12:27	TSharples	266	remeshed model
161	06/10/2021 10:29	TSharples	17	remeshed and removed storage area at 14.002_DS
160	06/10/2021 09:03	TSharples	299	changed headloss to FIXED at 14.002
159	05/10/2021 17:33	TSharples	20	adjusted weir at 7.013
158	05/10/2021 16:57	TSharples	302	Adjusted 14.002_DS.1
157	05/10/2021 09:19	TSharples	8	updated culvert diameter
156	05/10/2021 09:16	TSharples	287	Remeshed and adjusted cross section around 7.013_U
155	04/10/2021 15:59	TSharples	14	Adjusted invert levels of culvert
154	04/10/2021 15:16	TSharples	291	removed watercourse around 7.013 as this was causing errors in simulations. Replaced with culvert.
153	04/10/2021 08:42	TSharples	21	
152	01/10/2021 15:12	TSharples	22	
151	01/10/2021 14:16	TSharples	16	
150	01/10/2021 12:59	TSharples	409	remeshed
149	30/09/2021 15:28	TSharples	129	created new scenario for embankments
148	30/09/2021 14:01	TSharples	141	remeshed embankment scenario
147	29/09/2021 08:56	TSharples	10	re-meshed removed overlaps
146	28/09/2021 16:40	TSharples	9	
145	23/09/2021 12:27	TSharples	1728	Removed bank and channel roughness zones
144	23/09/2021 11:13	TSharples	15445	created 1d version of model scenario
143	23/09/2021 09:02	TSharples	143	Culvert inlet and outlet at 1.003!!! model run failuress. Set reverse flow conditions to set inlet as outlet and outlet as inlet.
142	09/09/2021 13:09	TSharples	1	added 2d result points
141	15/06/2021 15:04	TSharples	135	added weir at 1.005 as pipes under capacity
140	15/06/2021 14:25	TSharples	5	adjusted weir at 1.016!!!!.1
139	15/06/2021 13:43	TSharples	148	adjusted 1.016!!!!.1 as it was causing convergence errors
138	15/06/2021 10:57	TSharples	158	updated mesh zones and re-meshed
137	15/06/2021 09:19	TSharples	9	adjusted mesh zones and re-meshed
136	14/06/2021 14:12	TSharples	435	Added scenario for embankments
135	14/06/2021 08:27	TSharples	1236	Removed scenarios not needed
134	14/06/2021 08:24	TSharples	15	Re-applied inflows and pipe size returned to original, revert back to v131 as version 131 ran successfully.
133	11/06/2021 19:30	TSharples	9	
132	11/06/2021 19:09	TSharples	14	

131	11/06/2021 18:46	TSharples	425	Incrased size of culvert 1.005_ub.1 as this was causing significant backing up of flows upstream
130	11/06/2021 18:29	TSharples	141	
129	11/06/2021 13:57	TSharples	300	
128	11/06/2021 11:53	TSharples	301	updated invert level of outfall orifices
127	11/06/2021 09:20	TSharples	343	replaced flap valves with orifices on river reach outfalls.
126	10/06/2021 13:05	TSharples	10	Added culvert inlet to 1.016!!!!
125	10/06/2021 10:41	TSharples	301	Added sections of culvert between river reaches where there was only an irregular weir. Hope that this improves model stability.
124	10/06/2021 09:32	TSharples	11	Flattened steep negative gradient from 19.024.1
123	10/06/2021 08:10	TSharples	14	updated infiltration zone boundaries as it was crossing a watercourse.
122	09/06/2021 15:53	TSharples	323	Remvoed river reach 5.014DS as it was causing fails during simulations
121	09/06/2021 09:03	TSharples	7	Culvert inlet 1.004!! values for K and M look to have been swapped. These have been corrected.
120	08/06/2021 18:15	TSharples	142	created new scenario for embankment
119	08/06/2021 16:52	TSharples	157	
118	08/06/2021 16:41	TSharples	63	updated outfalls to 2D maholes where they lie in the 2D zone
117	08/06/2021 15:23	TSharples	23	
116	08/06/2021 14:13	TSharples	23	Adjusted 2D zone to prevent small elements.
115	08/06/2021 11:26	TSharples	6	adjusted roughness values 19.016_ds
114	08/06/2021 10:52	TSharples	1251	rebuilt river sections where adjustments had been made and re-meshed to remove yellow validation errors
113	07/06/2021 12:54	TSharples	4	Re-meshed s01 with mesh lowering unticked.
112	07/06/2021 10:55	TSharples	11	Adjusted culvert invert levels at 19.018 as this was much higher than the river bed and causing instabilities.
111	07/06/2021 10:06	TSharples	6	unticked lower banks to mesh elements during meshing
110	07/06/2021 08:50	TSharples	159	terrain sensistive meshing applied, re-meshed
109	04/06/2021 15:03	TSharples	282	re-built 7.050 river reach and re-meshed
108	04/06/2021 10:41	TSharples	176	adjustments to 7.050 river roughness zones and re-meshed
107	03/06/2021 16:27	TSharples	271	
106	03/06/2021 13:56	TSharples	140	added scenario for embankments and remeshed.
105	03/06/2021 12:27	TSharples	23	added embankments using mesh level zones. re-meshed. corrected errors on RB177 where roughness zones werent lined up

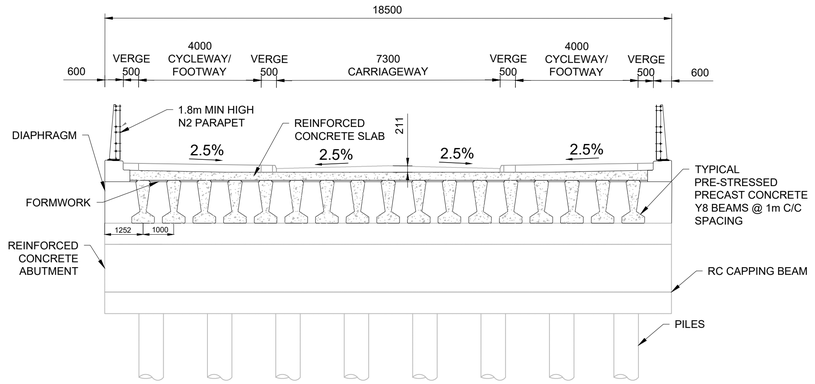
Version Number	Date	User	Changes Made	Comments
12	17/04/2022 17:57	KIvanov	1143	Amendments as per EA's review
11	27/09/2022 13:29	KIvanov	449	validates
10	22/09/2022 22:10	KIvanov	160	Multi-pier changed to mesh zones
9	17/09/2022 17:14	KIvanov	7	two new scnarios added
8	17/09/2022 16:51	KIvanov	309	added 2 scenarios
7	18/08/2022 09:08	KIvanov	139	Adjusted levels in 1.020!!!.1 river reach.
6	05/08/2022 13:59	KIvanov	164	Added floodplain results polygon and remeshed
5	19/07/2022 23:03	KIvanov	155	Remeshed again
4	14/07/2022 22:50	KIvanov	161	
3	14/07/2022 15:44	KIvanov	141	
2	14/07/2022 14:34	KIvanov	127	
1	14/07/2022 11:40	KIvanov	0	Created from copy

Appendix B Bridge Design Drawings



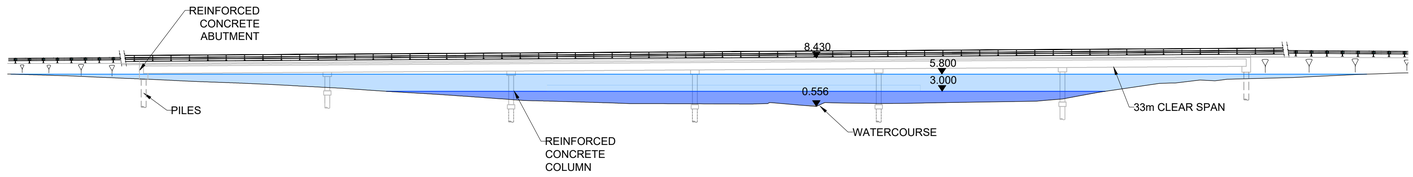
LOCATION PLAN

SCALE 1:10000



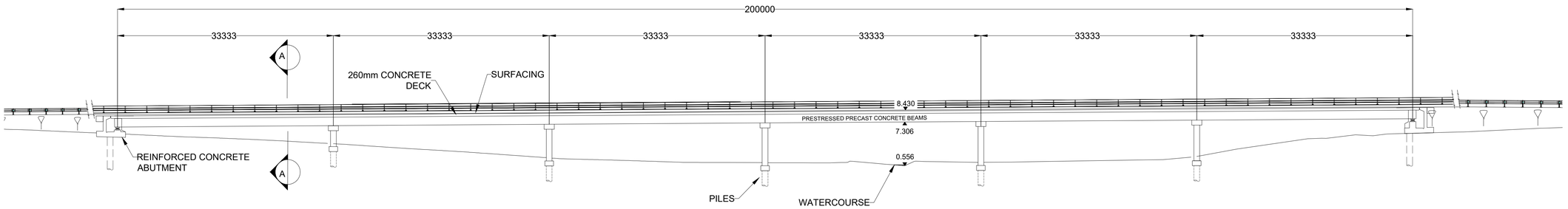
SECTION A-A

SCALE 1:100



WEST ELEVATION

SCALE 1:500



WEST ELEVATION

SCALE 1:350



PLAN

SCALE 1:350

GENERAL NOTES

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2. ANY DIMENSIONAL DISCREPANCIES SHOULD BE NOTIFIED TO THE DESIGNER IMMEDIATELY.
3. ALL DIMENSIONS ARE IN MILLIMETRES - (mm) AND ALL LEVELS ARE IN METRES - (m) UNLESS NOTED OTHERWISE.
4. NORTH SHOWN INDICATIVE ONLY
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6. ALL DRAWINGS AND WRITTEN MATERIAL CONTAINED WITHIN, CONSTITUTE ORIGINAL AND UNPUBLISHED WORK OF THE DESIGNER AND MAY NOT BE DUPLICATED, USED, REPRODUCED OR DISCLOSED WITHOUT WRITTEN CONSENT OR EXPRESS PERMISSION FROM THE DESIGNER.
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9. PROPOSED DESIGN SHALL BE IN ACCORDANCE WITH THE DEPARTMENT FOR TRANSPORT'S MANUAL OF CONTRACT DOCUMENTS FOR HIGHWAY WORKS (MCHW) SPECIFICATION.
10. PROPOSED DESIGN SHALL BE IN ACCORDANCE WITH THE DEPARTMENT FOR TRANSPORT'S DESIGN MANUAL FOR ROADS AND BRIDGES (DMRB) AND EUROCODES.

S1. ALL WORKS TO BE UNDERTAKEN IN ACCORDANCE WITH THE DEPARTMENT FOR TRANSPORT'S MANUAL OF CONTRACT DOCUMENTS FOR HIGHWAY WORKS (MCHW) SPECIFICATION.
S2. BACKFILL MATERIAL TO THE STRUCTURE SHALL BE OF CLASS 6I OR 6J IN ACCORDANCE WITH SPECIFICATION FOR HIGHWAY WORKS..
S3. PROPOSED WATERPROOFING SYSTEM SHALL BE IN ACCORDANCE WITH APP 20/01 OF THE SPECIFICATION.
S4. AN ADDITIONAL PROTECTIVE LAYER (APL) SHOULD ONLY BE USED WHEN REQUIRED BY INDIVIDUAL WATERPROOFING SYSTEM. WHERE APL IS USED IT SHOULD BE APPLIED IMMEDIATELY ABOVE THE PROPRIETARY WATERPROOFING SYSTEM. IN SUCH CASES A SEPARATE BBA ASSESSMENT OF THE SYSTEMS RESISTANCE TO AGGREGATE INDENTATION IS REQUIRED IN ACCORDANCE WITH IAN 96/07.
S5. THE LAND LOCATED NORTH AND SOUTH OF THE NETWORK RAIL BOUNDARY FENCE IS OWNED BY THE CHURCH COMMISSIONERS FOR ENGLAND AND IT IS REGISTERED UNDER THE FOLLOWING TITLE NUMBERS:
NORTHERN AREA: WSX309559 (74.60HA)
SOUTHERN AREA: WSX309592 (49.13HA)

KEY

1:100YR+ 105% CLIMATE CHANGE FLOOD LEVEL = 5.8 AOD

1:100YR FLOOD LEVEL = 3.0M AOD

REV	DESCRIPTION	DRN	CHK	APP	DATE
P02	ISSUE FOR INFORMATION	AG	AK	AK	05/05/2021
P01	DRAFT	KK	AK	AK	16/10/2020

Pell Frischmann
MILLARS THREE SOUTHMILL ROAD BISHOPS STORTFORD CM23 3DH
Telephone +44 (0)1279 507 346 Fax +44 (0)1279 758 219
Email: pfbstortford@pellfrischmann.com

Client

BEW CONSORTIUM

Project

A29 REALIGNMENT
LIDSEY RIFE

Drawing Title

INITIAL BRIDGE OPTIONS
MULTI SPAN

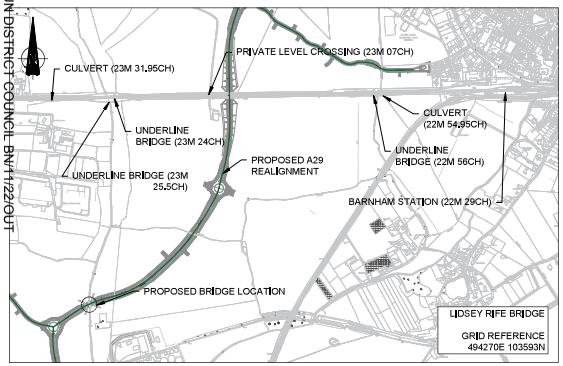
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Drawn	KK	16/10/2020		
Designed	AK	16/10/2020	Suitability	S2
Checked	AK	16/10/2020	Drawing Status	FOR INFORMATION
Approved	AK	16/10/2020		

Drawing No.
13394-PEF-ZZ-XX-M2-S-000002

Revision
P02

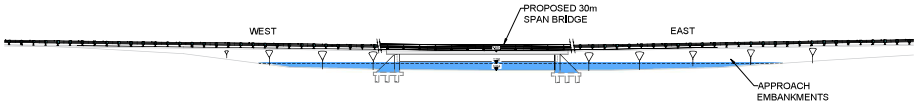
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ARUN DISTRICT COUNCIL
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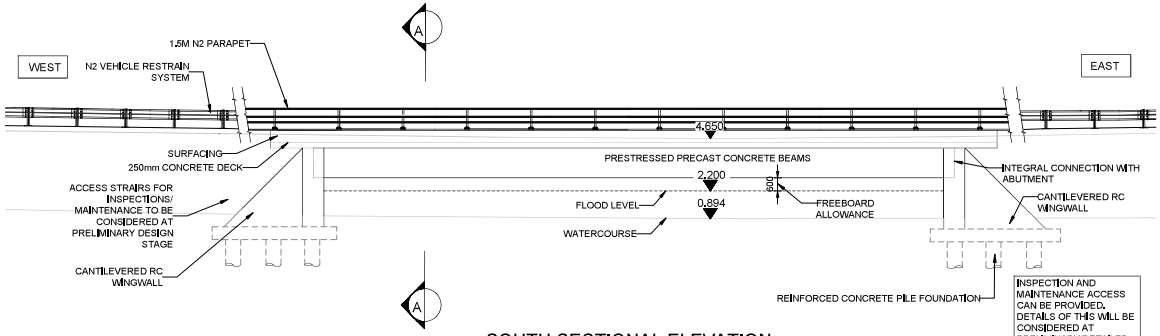
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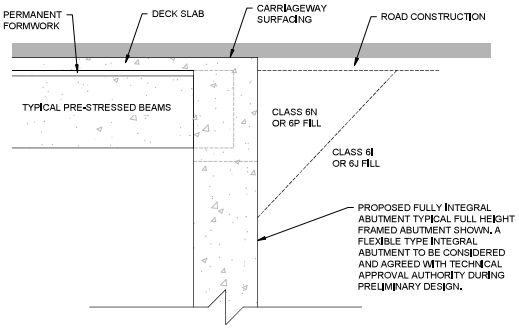
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SCALE 1:500



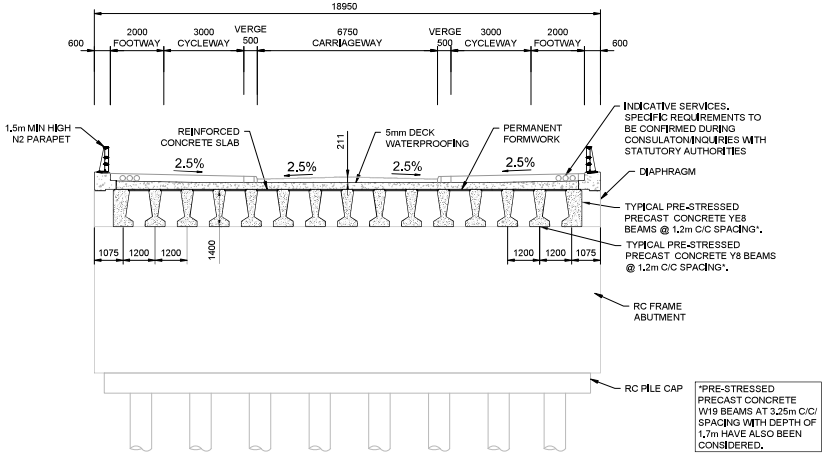
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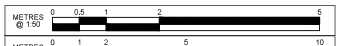
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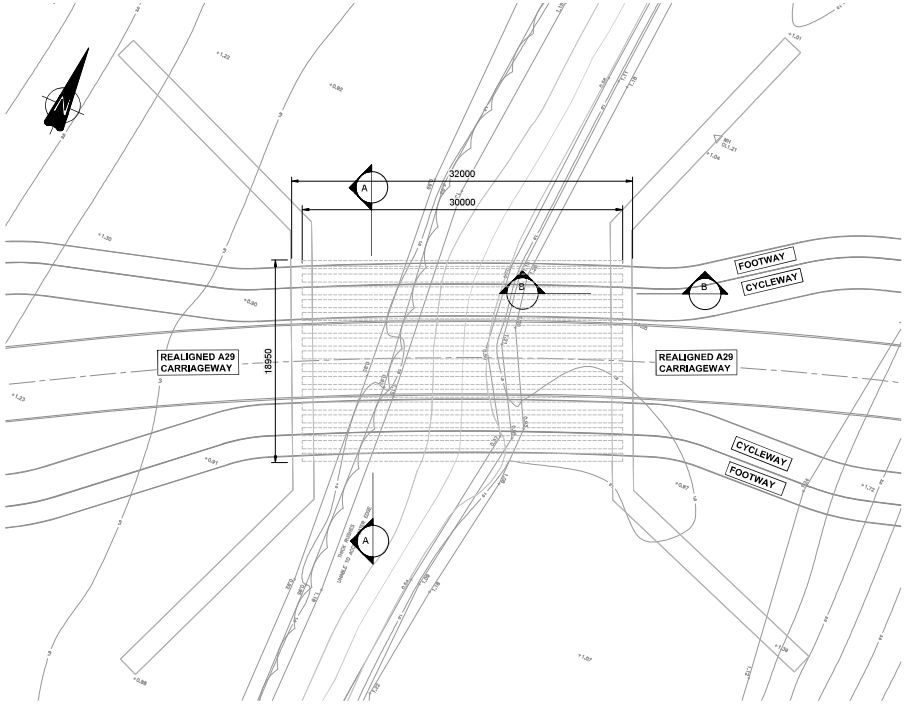
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SECTION A-A

SCALE 1:100





PLAN

SCALE 1:250

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S1. ALL WORKS TO BE UNDERTAKEN IN ACCORDANCE WITH THE DEPARTMENT FOR TRANSPORT'S MANUAL OF CONTRACT DOCUMENTS FOR HIGHWAY WORKS (MCHW) SPECIFICATION.
S2. BACKFILL MATERIAL TO THE STRUCTURE SHALL BE OF CLASS 6I OR 6J IN ACCORDANCE WITH SPECIFICATION FOR HIGHWAY WORKS..
S3. PROPOSED WATERPROOFING SYSTEM SHALL BE IN ACCORDANCE WITH APP 20/01 OF THE SPECIFICATION.
S4. AN ADDITIONAL PROTECTIVE LAYER (APL) SHOULD ONLY BE USED WHEN REQUIRED BY INDIVIDUAL WATERPROOFING SYSTEM. WHERE APL IS USED IT SHOULD BE APPLIED IMMEDIATELY ABOVE THE PROPRIETARY WATERPROOFING SYSTEM. IN SUCH CASES A SEPARATE BBA ASSESSMENT OF THE SYSTEMS RESISTANCE TO AGGREGATE INDENTATION IS REQUIRED IN ACCORDANCE WITH IAN 96/07.
S5. THE LAND LOCATED NORTH AND SOUTH OF THE NETWORK RAIL BOUNDARY FENCE IS OWNED BY THE CHURCH COMMISSIONERS FOR ENGLAND AND IT IS REGISTERED UNDER THE FOLLOWING TITLE NUMBERS:
NORTHERN AREA: WSX309559 (74,60HA)
SOUTHERN AREA: WSX309592 (49,13HA)

KEY

1:100YR+ 35% CLIMATE CHANGE FLOOD LEVEL = 2,2m AOD

REV	DESCRIPTION	DRN	CHK	APP	DATE
P06	CARRIAGEWAY WIDTH CHANGE	KK	AK	AK	03.03.2023
P05	PRESTRESSED BEAM CHANGES	AL	JH	AK	28/04/22
P04	CHANGE TO CLIENT NAME (CC PROJECTS)	KK	IR	AK	14/01/2022
P04	CHANGE TO CLIENT NAME (CC PROJECTS)	KK	IR	AK	14/01/2022
P03	SCALE BAR ADDED AND CHANGE TO CLIENT NAME	KK	IR	AK	15/11/2021
P02	ISSUE FOR INFORMATION	AG	AK	AK	05/05/2021
P01	DRAFT	KK	AK	AK	16/10/2020

Pell Frischmann
MILLARS THREE SOUTHWELL ROAD BISHOPS STORTFORD CM23 3DH
Telephone +44 (0)1279 507 346 Fax +44 (0)1279 758 219
Email pfbishopsstortford@pfmchmm.com

Client

CC PROJECTS
ASHMARDEN Ltd
AND HANBURY (PM) Ltd

Project

BEW PARCEL SC1
WSCC STRUCTURE REF:1780

Drawing Title

INITIAL BRIDGE OPTIONS
30m SINGLE SPAN
FRAME ABUTMENT

OS Ref.		Structure Type: Over Flood plain		ELR/Mileage	
	Name	Date	Scale	NOT TO SCALE	
Drawn	KK	16/10/2020			
Designed	AK	16/10/2020	Suitability	S2	
Checked	AK	16/10/2020	Drawing Status	FOR INFORMATION	
Approved	AK	16/10/2020			

Drawing No. 13394-PEF-ZZ-XX-M2-S-000003

Revision P06

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\\Rsbgukfs01\lonengineering\133--\A13394-VMA Barnham Eastergate Westergate\40 Reports\Front End Pack\2. Engineering\2.3 Report\Lidsey Rife Technical Note\13394-PEF-ZZ-XX-M2-S-000003 KK v4.dwg

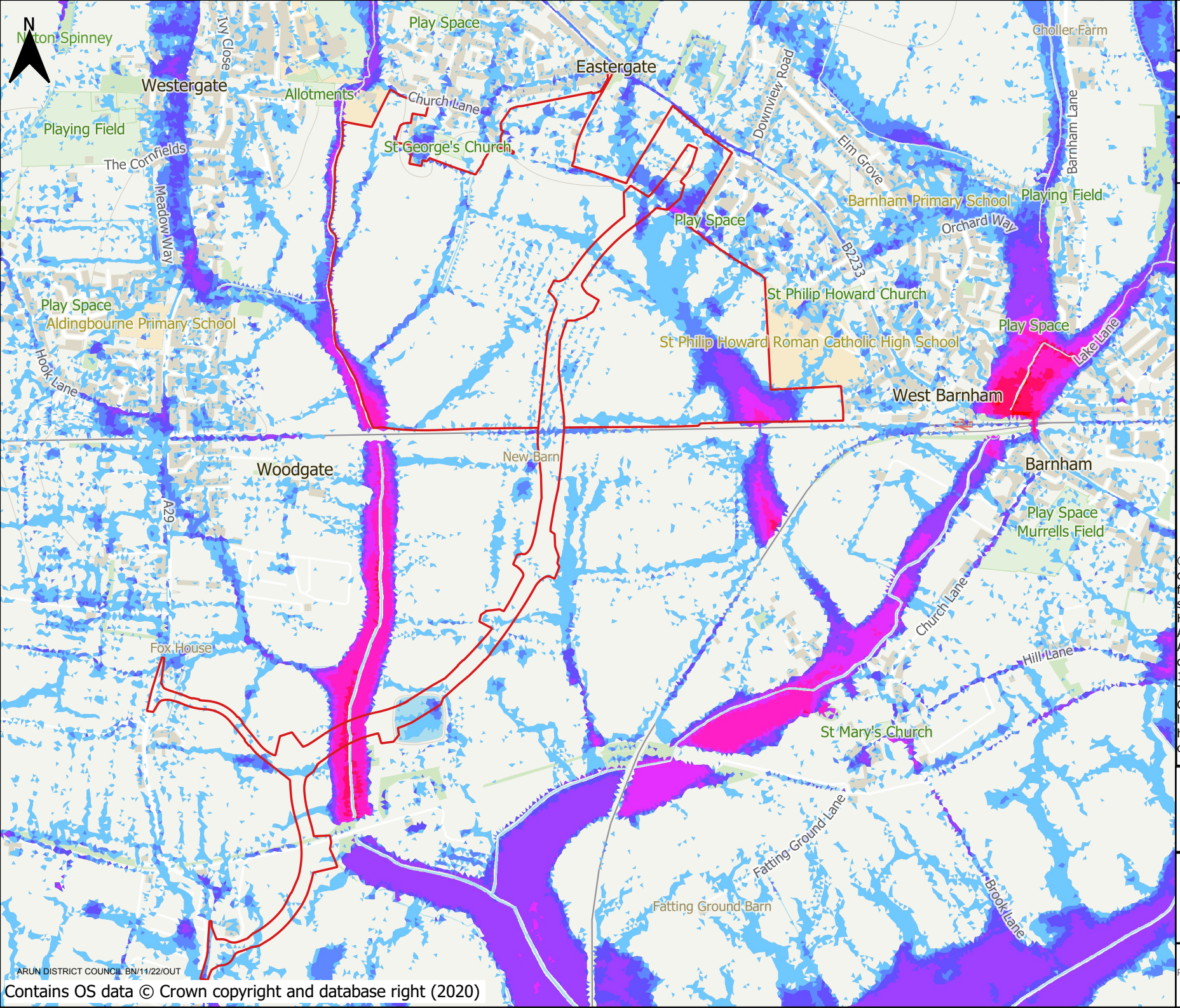
Appendix C Cross-sections with 'Zero' Manning's n

Manning's Roughness at Cross-Section Vertex	Cross-section name
0	1.002!!!
0	1.002!!!
0	1.002!!!
0	1.002!!!
0	1.002!!!
0	1.002!!!
0	1.002!!!
0	1.002!!!
0	1.001!!!
0	1.001!!!
0	2.001ds
0	2.003us
0	2.003us
0	2.003us
0	2.003us
0	2.003us
0	1.004!ds
0	1.004!ds
0	1.004!ds
0	1.004!ds
0	1.004!ds
0	1.004!ds
0	1.001!
0	1.001!
0	1.001!
0	1.001!
0	1.001!
0	1.001!
0	1.001!
0	1.001!
0	1.001!
0	1.001!
0	1.006!!_ds
0	1.006!!_ds
0	1.006!!_ds
0	1.006!!_ds
0	1.006!!_ds
0	1.006!!_ds
0	1.006!!_ds
0	1.006!!_ds
0	1.006!!_ds
0	1.006!!_ds
0	1.004!!
0	1.004!!
0	1.004!!
0	1.004!!
0	1.004!!
0	1.004!!
0	1.004!!

0	1.004!!
0	1.013!
0	1.013!
0	1.013!
0	1.013!
0	1.013!
0	1.013!
0	1.013!
0	1.009!_d
0	1.009!_d
0	1.014!us!
0	1.014!us!
0	1.014!us!
0	1.010!!
0	1.010!!
0	1.010!!
0	1.010!!
0	1.016!!!!
0	1.016!!!!
0	1.016!!!!
0	1.016!!!!
0	1.016!!!!
0	1.016!!!!
0	1.016!!!!
0	1.016!!!!
0	1.016!!!!
0	1.012!!!
0	1.012!!!
0	1.017_ds!
0	1.017_ds!
0	1.017_ds!
0	1.017_ds!
0	1.017_ds!
0	1.017_ds
0	1.017_ds
0	1.017_ds
0	1.017_ds
0	1.017_ds
0	1.025
0	1.025
0	1.025
0	1.023!
0	1.023!
0	1.023!
0	1.023!
0	1.027
0	1.027
0	1.027
0	1.027

0	1.026
0	1.026
0	1.031-1.031-1.030
0	1.031-1.031-1.030
0	1.031-1.031-1.030
0	1.031-1.031-1.030
0	1.031-1.031-1.030
0	1.031-1.031-1.030
0	1.031-1.031-1.030
0	1.031-1.031-1.030
0	1.025!
0	1.025!
0	1.025!
0	1.008!-1.009!_d
0	1.008!-1.009!_d
0	1.008!-1.009!_d
0	1.008!-1.009!_d
0	1.008!-1.009!_d
0	1.008!-1.009!_d
0	1.008!-1.009!_d
0	1.008!-1.009!_d
0	1.008!-1.009!_d
0	1.008!-1.009!_d
0	1.008!-1.009!_d
0	1.004!-1.005!
0	1.004!-1.005!
0	1.004!-1.005!
0	1.004!-1.005!
0	1.004!-1.005!
0	1.004!-1.005!
0	1.004!-1.005!
0	1.004!-1.005!
0	1.004!-1.005!
0	3.003!!!!!!
0	3.003!!!!!!
0	3.003!!!!!!
0	3.001!!!!!!
0	3.001!!!!!!
0	3.001!!!!!!
0	3.001!!!!!!
0	3.001!!!!!!
0	3.001!!!!!!
0	3.001!!!!!!
0	3.001!!!!!!
0	3.001!!!!!!
0	3.001!!!!!!
0	3.012ds
0	3.012ds
0	3.012ds-0-3.011

0	3.012ds-1-3.011
0	3.011
0	3.011-3.010
0	3.01
0	3.01
0	3.01
0	3.01
0	3.01
0	3.01
0	6.01
0	6.01
0	6.016
0	6.011!
0	6.011!
0	6.011!
0	6.011!
0	1.018!
0	1.018!



Pell Frischmann

BLOCK B, BLENHEIM COURT
86-88 MANSFIELD ROAD,
NOTTINGHAM, NG1 3HD

Legend

Site Boundary

Water Depth (m)

- <= 0
- 0 - 0.1
- 0.1-0.25
- 0.25-0.5
- 0.5-1
- 1-1.5
- 1.5-2
- 2-2.5
- >2.5

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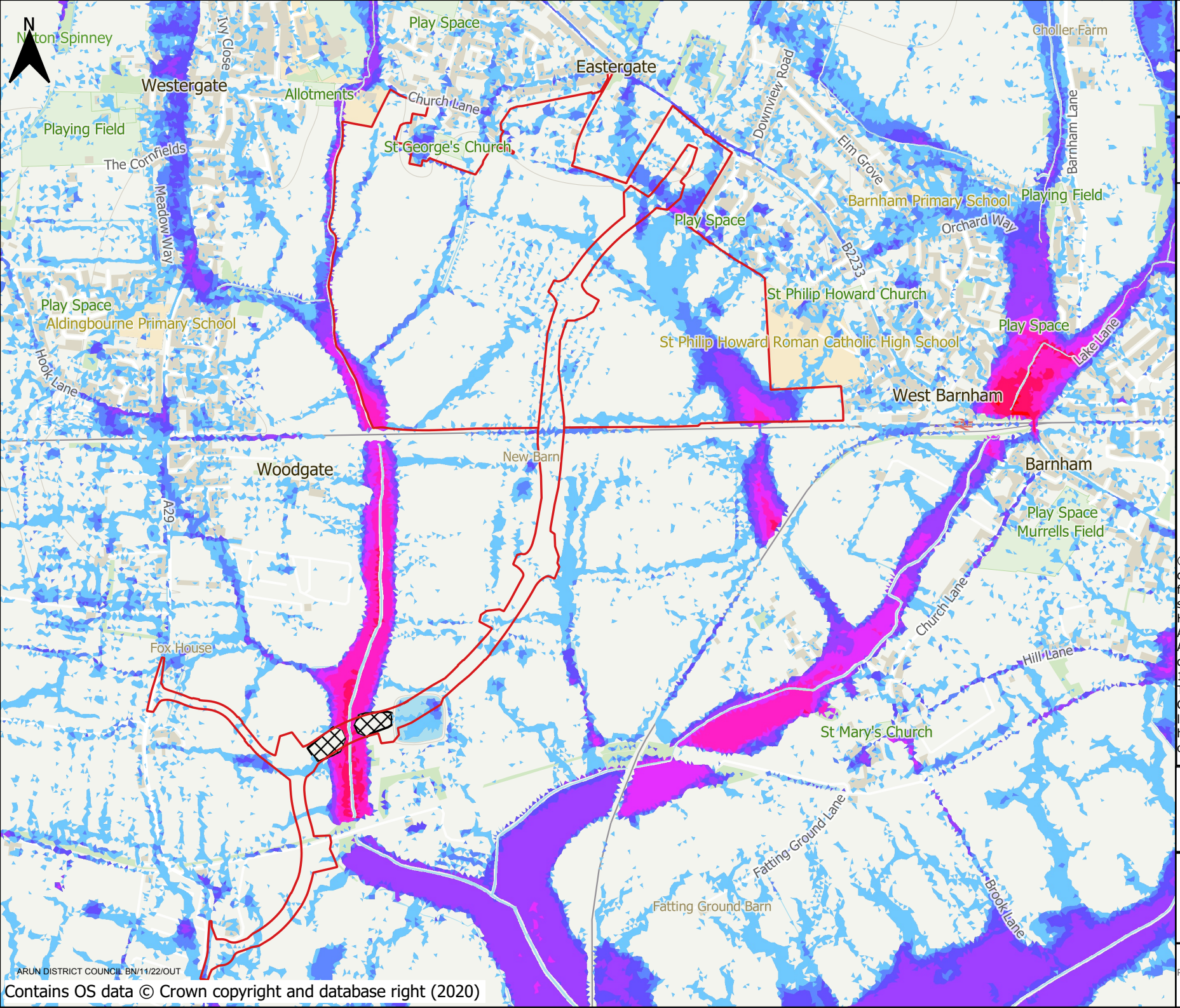
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Barnham Eastergate Westergate

SCALE 1:12500

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WATER DEPTH BASELINE
1%AEP + 35% CLIMATE
CHANGE

Drawing Reference:
PROJECT-ORIGINATOR-VOLUME-LEVEL-TYPE-ROLE-NUMBER

A13394-PEF-ZZ-XX-SK-YE-0801



Pell Frischmann

BLOCK B, BLENHEIM COURT
86-88 MANSFIELD ROAD,
NOTTINGHAM, NG1 3HD

Legend

- Site Boundary
- Proposed Bridge Embankments

Water Depth (m)

- <= 0
- 0 - 0.1
- 0.1-0.25
- 0.25-0.5
- 0.5-1
- 1-1.5
- 1.5-2
- 2-2.5
- >2.5

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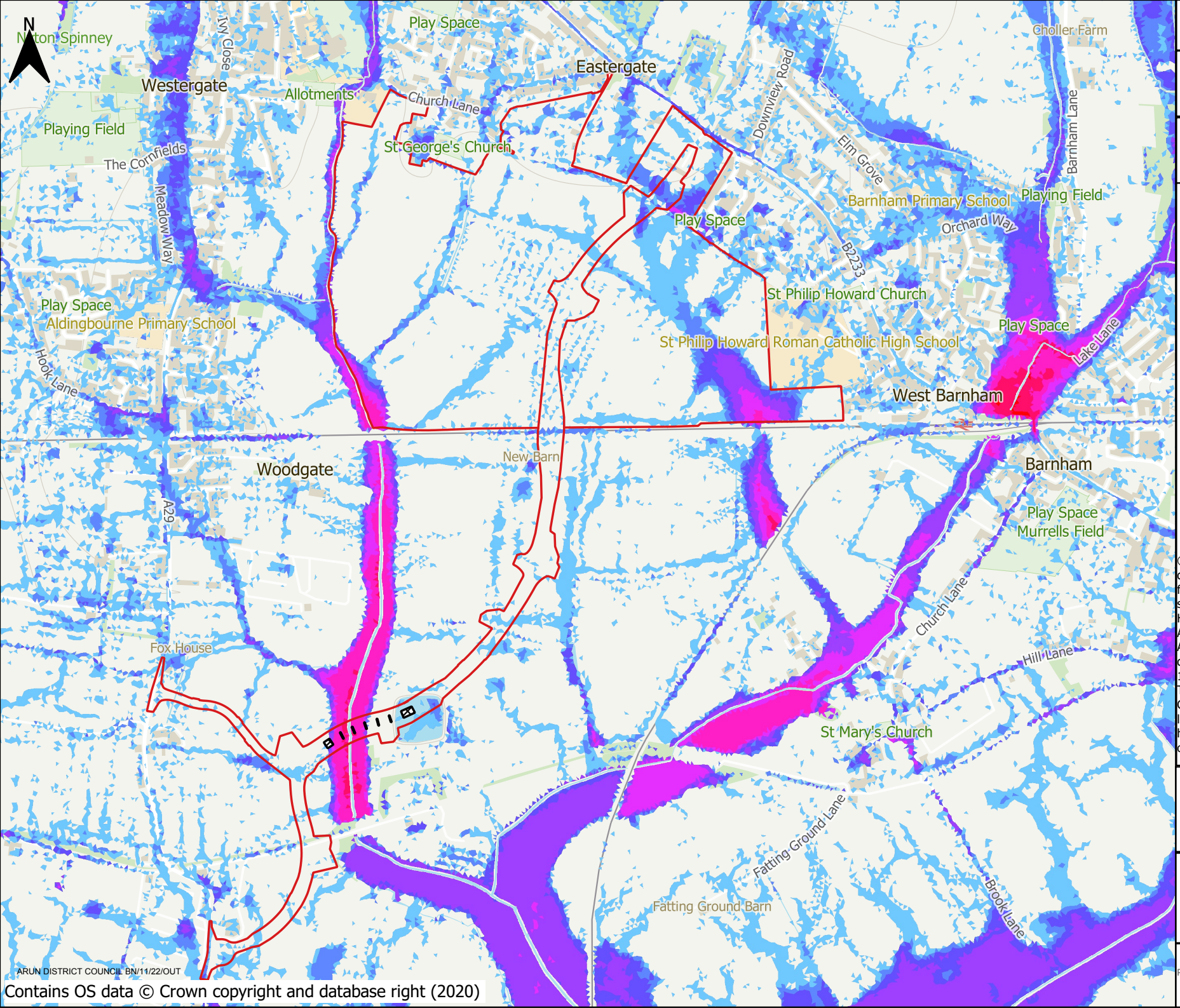
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1%AEP + 35% CLIMATE

Drawing Reference:
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A13394-PEF-ZZ-XX-SK-YE-0802



Pell Frischmann

BLOCK B, BLENHEIM COURT
86-88 MANSFIELD ROAD,
NOTTINGHAM, NG1 3HD

Legend

- Site Boundary
- Proposed Bridge Piers

Water Depth (m)

- <= 0
- 0 - 0.1
- 0.1-0.25
- 0.25-0.5
- 0.5-1
- 1-1.5
- 1.5-2
- 2-2.5
- >2.5

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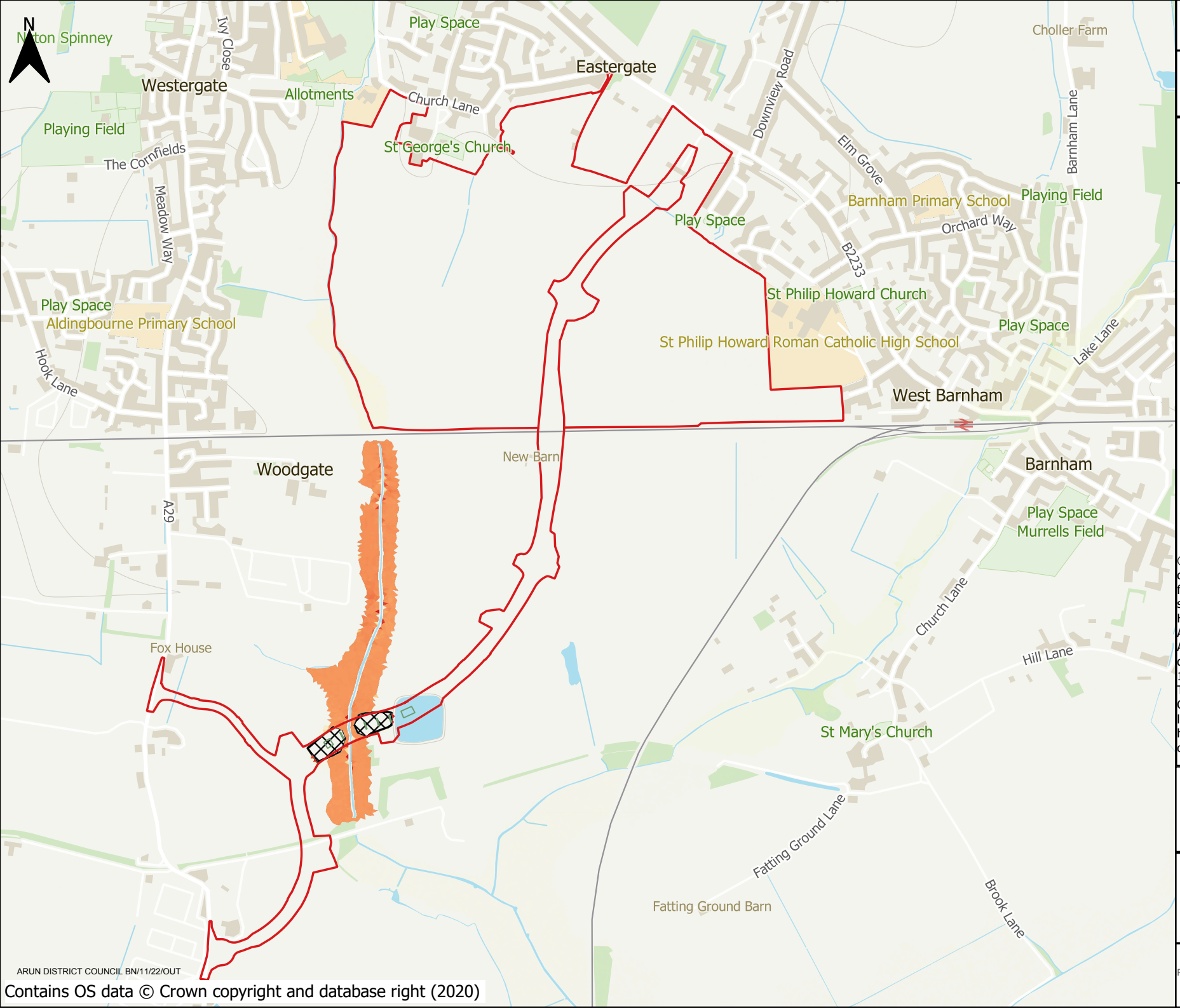
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1%AEP + 35% CLIMATE

Drawing Reference:
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A13394-PEF-ZZ-XX-SK-YE-0803



Pell Frischmann

BLOCK B, BLENHEIM COURT
86-88 MANSFIELD ROAD,
NOTTINGHAM, NG1 3HD

Legend

- Site Boundary
- Proposed Bridge Embankments

Water Depth Difference

- -0.0600
- -0.0400
- -0.0200
- 0.0000
- 0.0200
- 0.0400
- 0.0600

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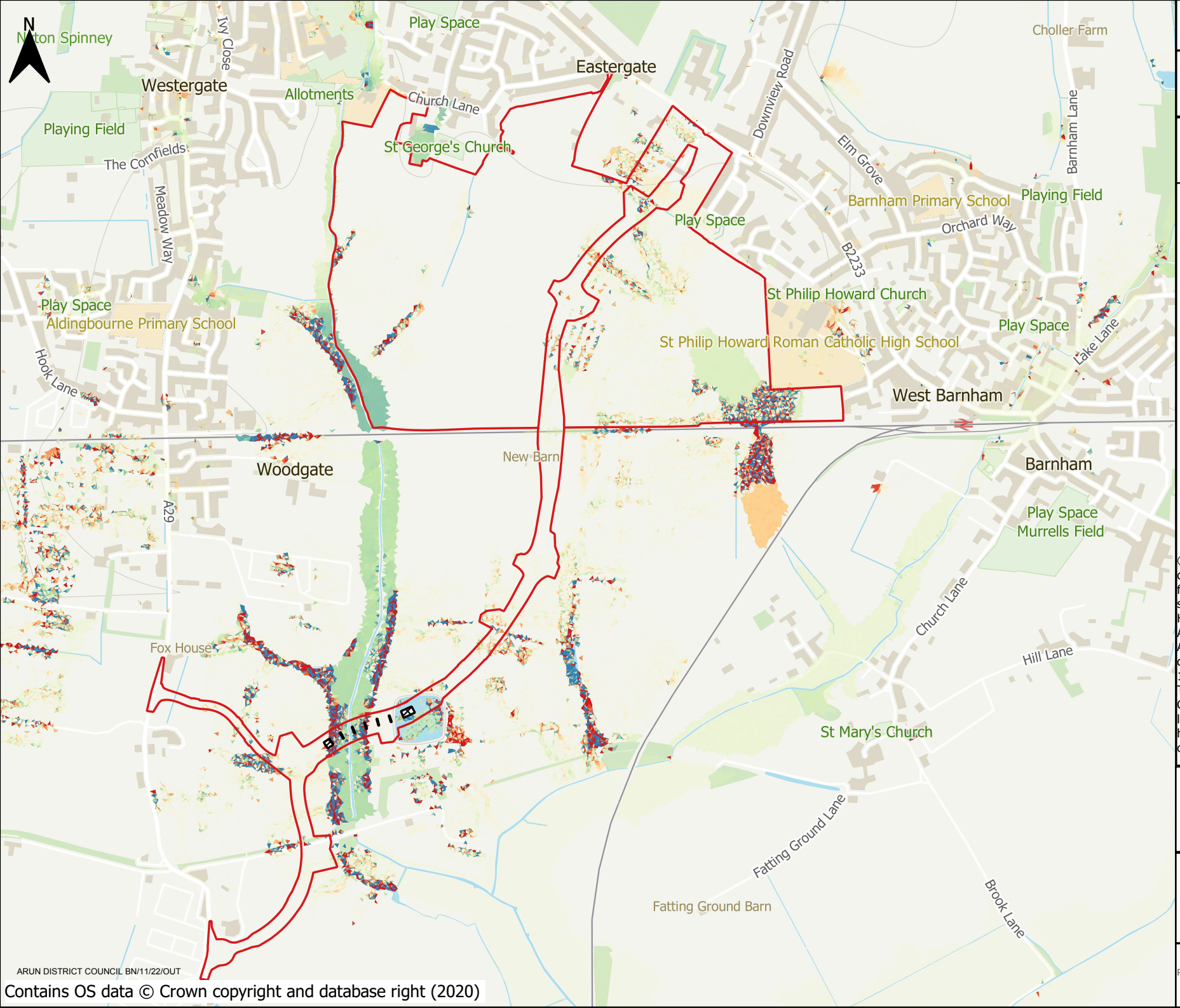
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Drawing Reference:
PROJECT-ORIGINATOR-VOLUME-LEVEL-TYPE-ROLE-NUMBER

A13394-PEF-ZZ-XX-SK-YE-0804



Pell Frischmann

BLOCK B, BLENHEIM COURT
86-88 MANSFIELD ROAD,
NOTTINGHAM, NG1 3HD

Legend

- Site Boundary
- Proposed Bridge Piers

Water Depth Difference

- -0.0600
- -0.0400
- -0.0200
- 0.0000
- 0.0200
- 0.0400
- 0.0600

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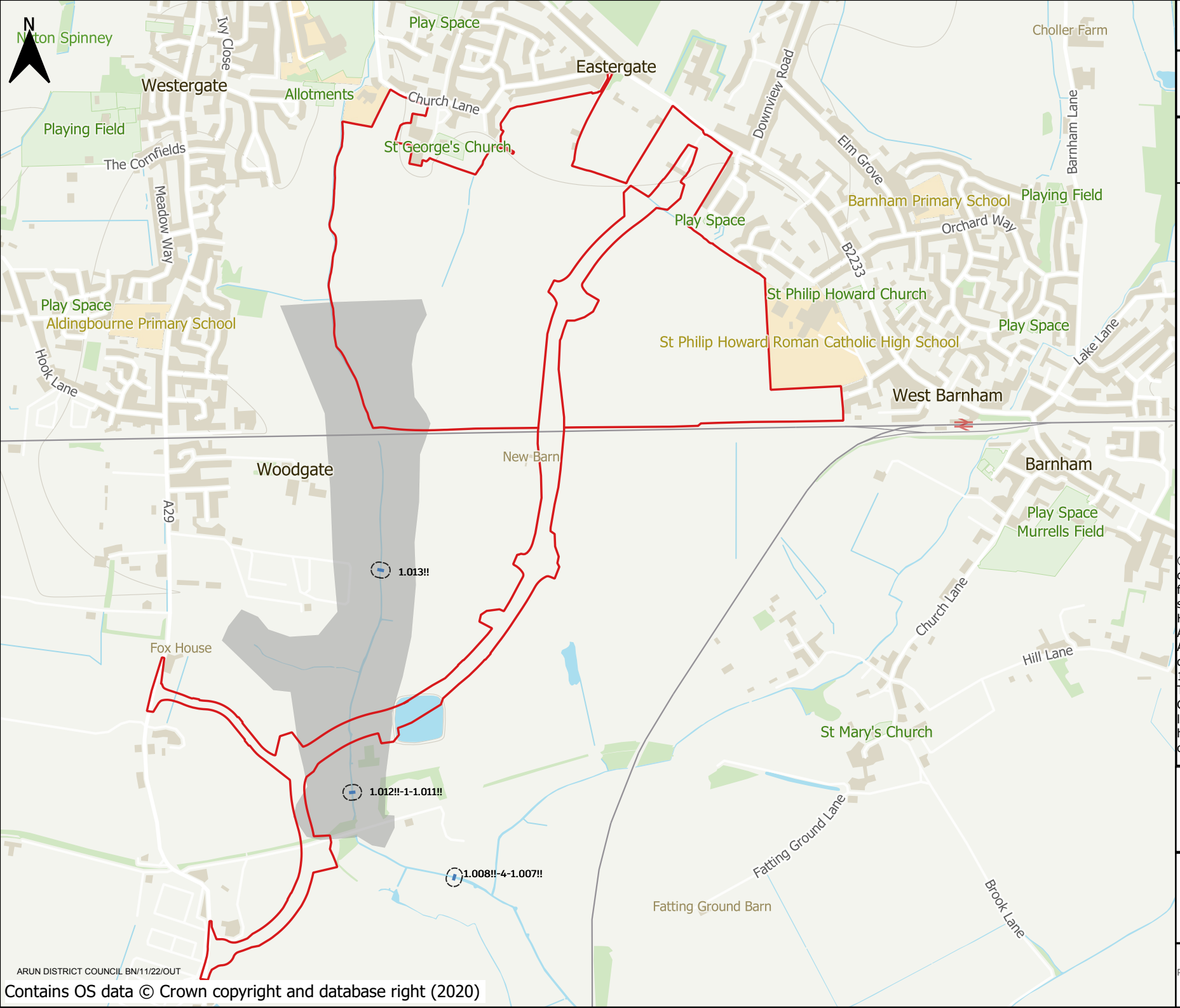
Project Name:
Barnham Eastergate Westergate

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Drawing Title:
WATER DEPTH DIFFERENCE
BRIDGE PIERS - BASELINE
1%AEP + 35% CLIMATE

Drawing Reference:
PROJECT-ORIGINATOR-VOLUME-LEVEL-TYPE-ROLE-NUMBER

A13394-PEF-ZZ-XX-SK-YE-0804



Pell Frischmann

BLOCK B, BLENHEIM COURT
86-88 MANSFIELD ROAD,
NOTTINGHAM, NG1 3HD

Legend

- Site Boundary
- Location of cross sections for water level comparison between scenarios
- Area of floodplain where impact is analised

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Barnham Eastergate Westergate

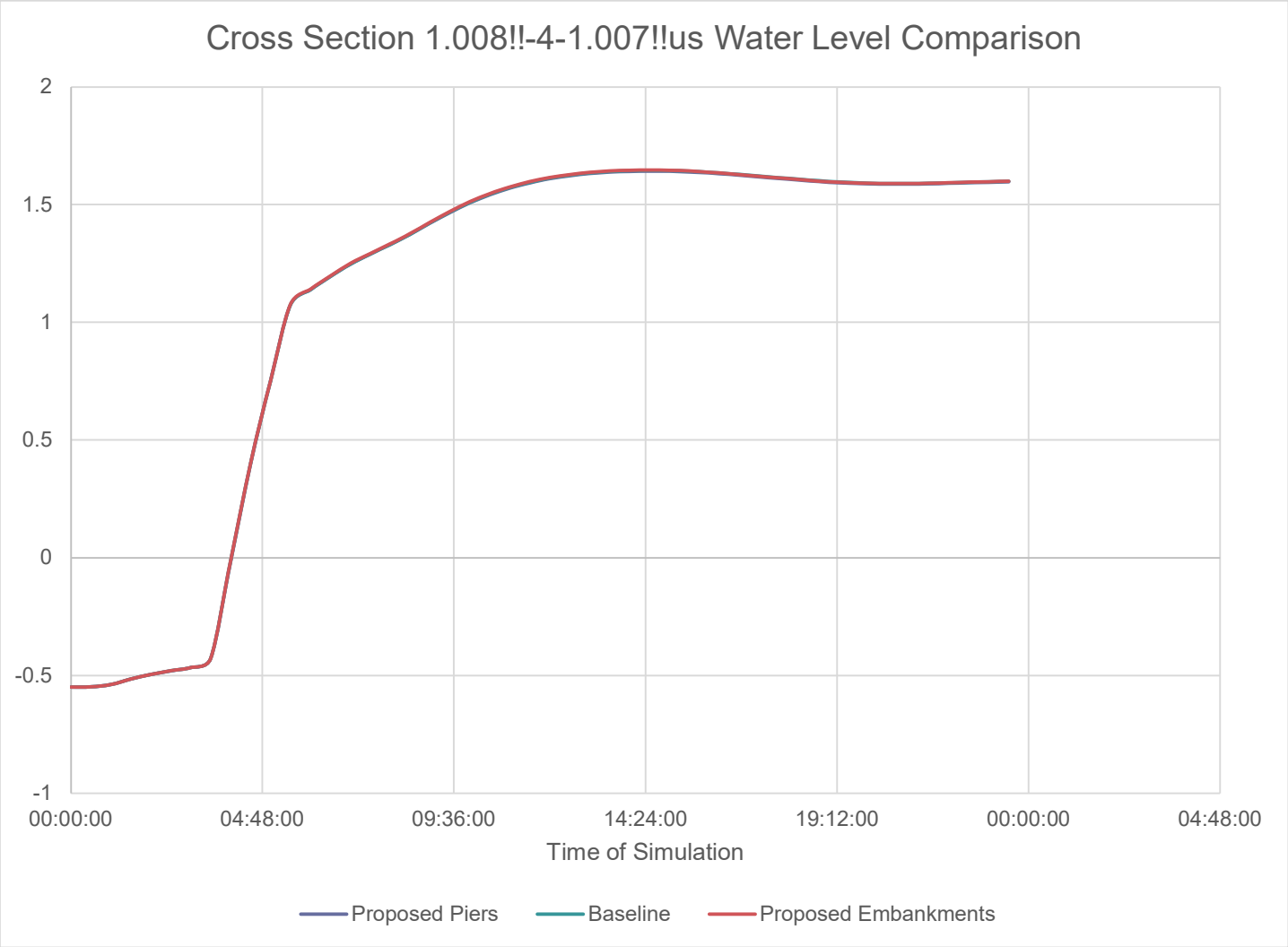
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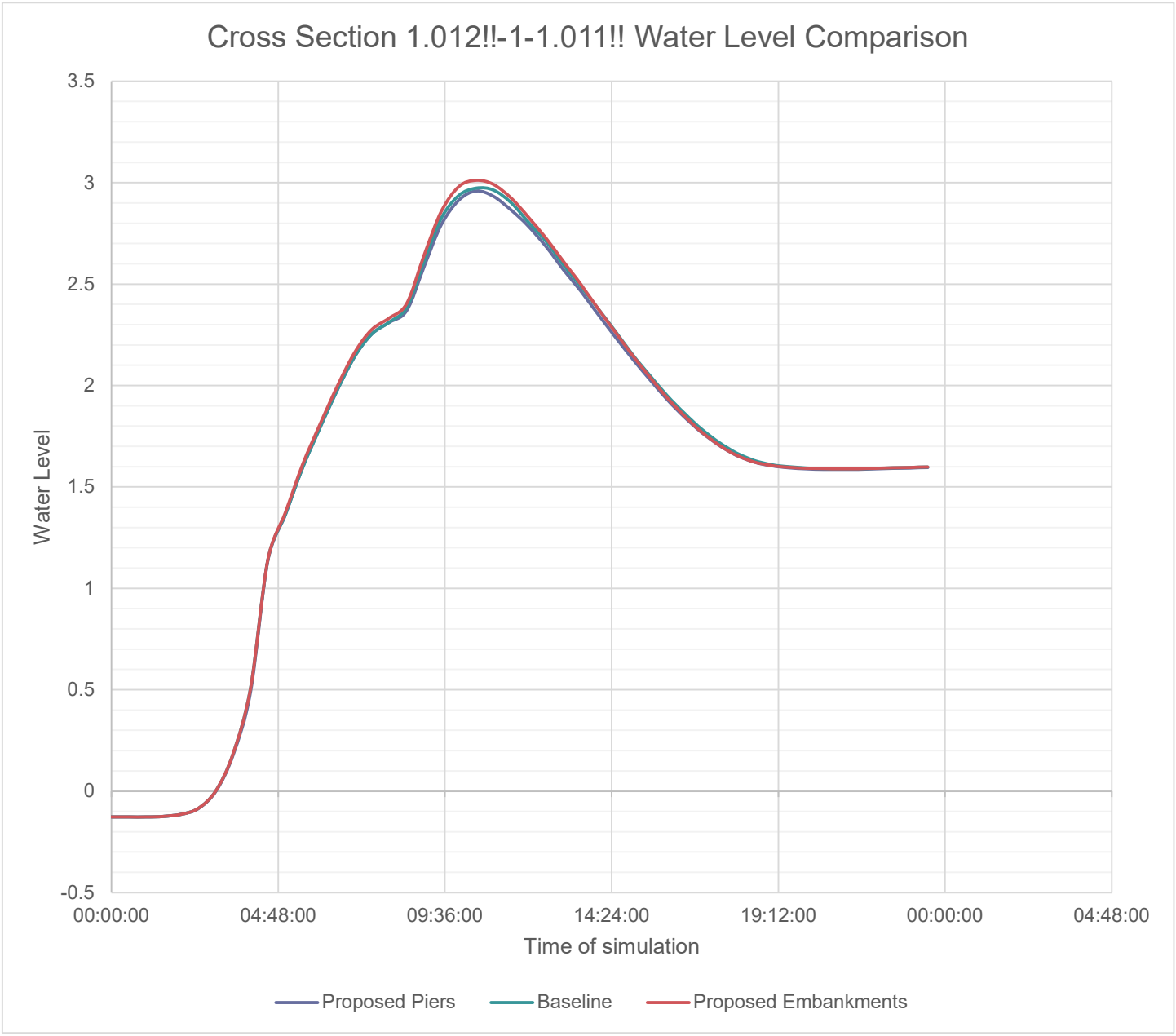
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1%AEP + 35% CLIMATE CHANGE

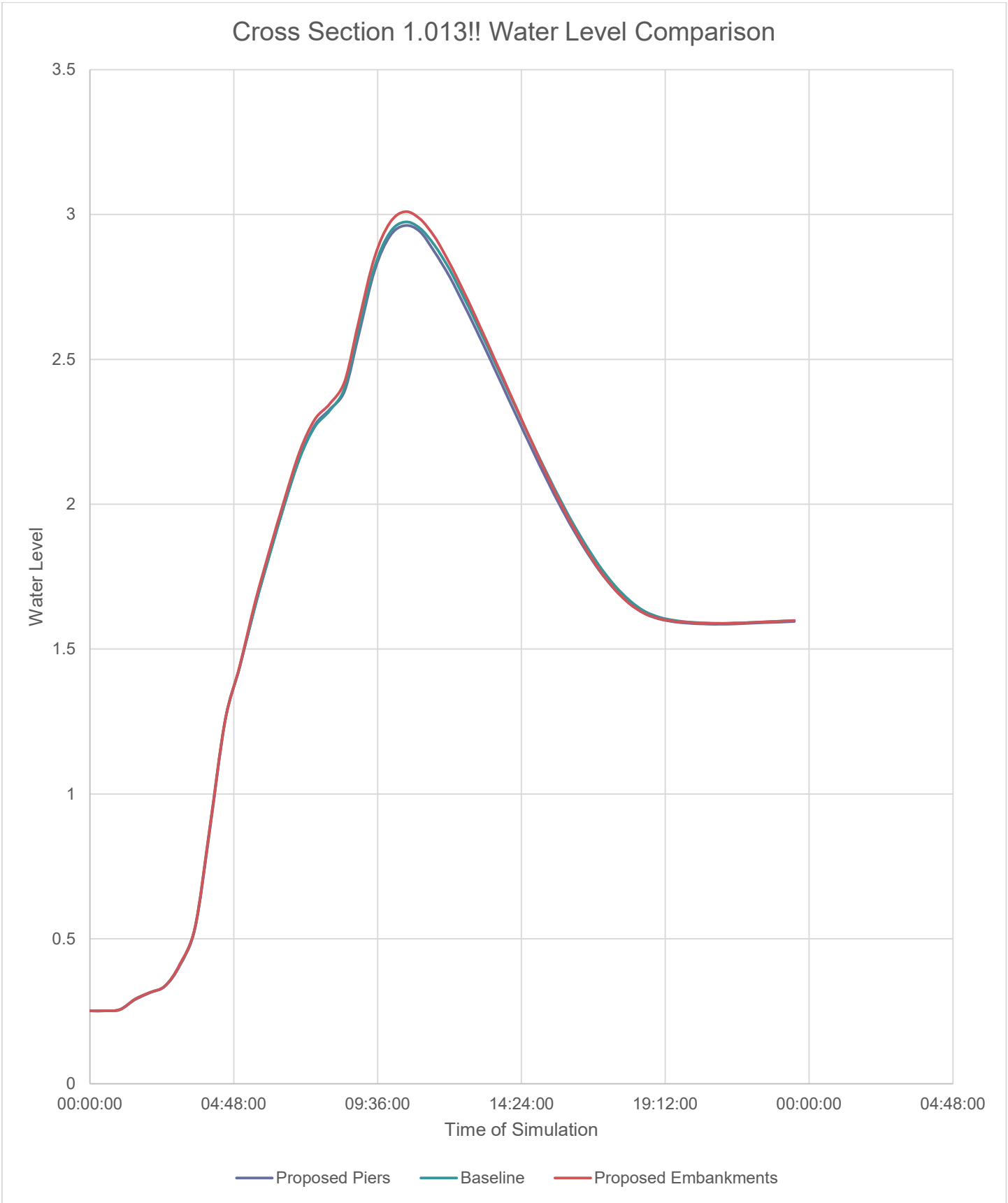
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PROJECT-ORIGINATOR-VOLUME-LEVEL-TYPE-ROLE-NUMBER

A13394-PEF-ZZ-XX-SK-YE-0806

Appendix D Flood Mapping and Water Depth Comparison




Cross Section 1.012!!-1-1.011!! Water Level Comparison
Water Level
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
00:00:00
04:48:00
09:36:00
14:24:00
19:12:00
00:00:00
04:48:00
Time of simulation
Proposed Piers
Baseline
Proposed Embankments


Cross Section 1.013!! Water Level Comparison
3.5
3
2.5
2
1.5
1
0.5
0
Water Level
00:00:00
04:48:00
09:36:00
14:24:00
19:12:00
00:00:00
04:48:00
Time of Simulation
Proposed Piers
Baseline
Proposed Embankments

Appendix 4 Groundwater Monitoring Factual Report

ARUN DISTRICT COUNCIL BN/11/22/OUT

BARNHAM, EASTERGATE, WESTERGATE (BEW) LONG TERM GROUND WATER MONITORING SOUTHERN CONSORTIUM 29TH JANUARY 2021

ARUN DISTRICT COUNCIL BN/11/22/OUT

Appendix 5 Southern Water Sewer Records

ARUN DISTRICT COUNCIL BN/11/22/OUT



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WARNING: BAC pipes are constructed of Bonded Asbestos Cement.

WARNING: Unknown (UNK) materials may include Bonded Asbestos Cement.

Foul Gravity Sewer | Combined Gravity Sewer | Culverted Water Course or Treated Effluent | Surface Water Gravity Sewer | Rising Main, Vacuum or Syphon

Combined Outfall | Foul Outfall | Surface Water Outfall | Surface Water Inlet

Combined Pumping Station | Surface Water Pumping Station | Foul Pumping Station | Water Treatment Works | Section 104 Area | Building Over Agreement Area

Foul Manhole | Combined Manhole | Surface Water Manhole | Side Entry Manhole, Decarcation Chamber, Dummy Manhole or Surface Water Soakaway

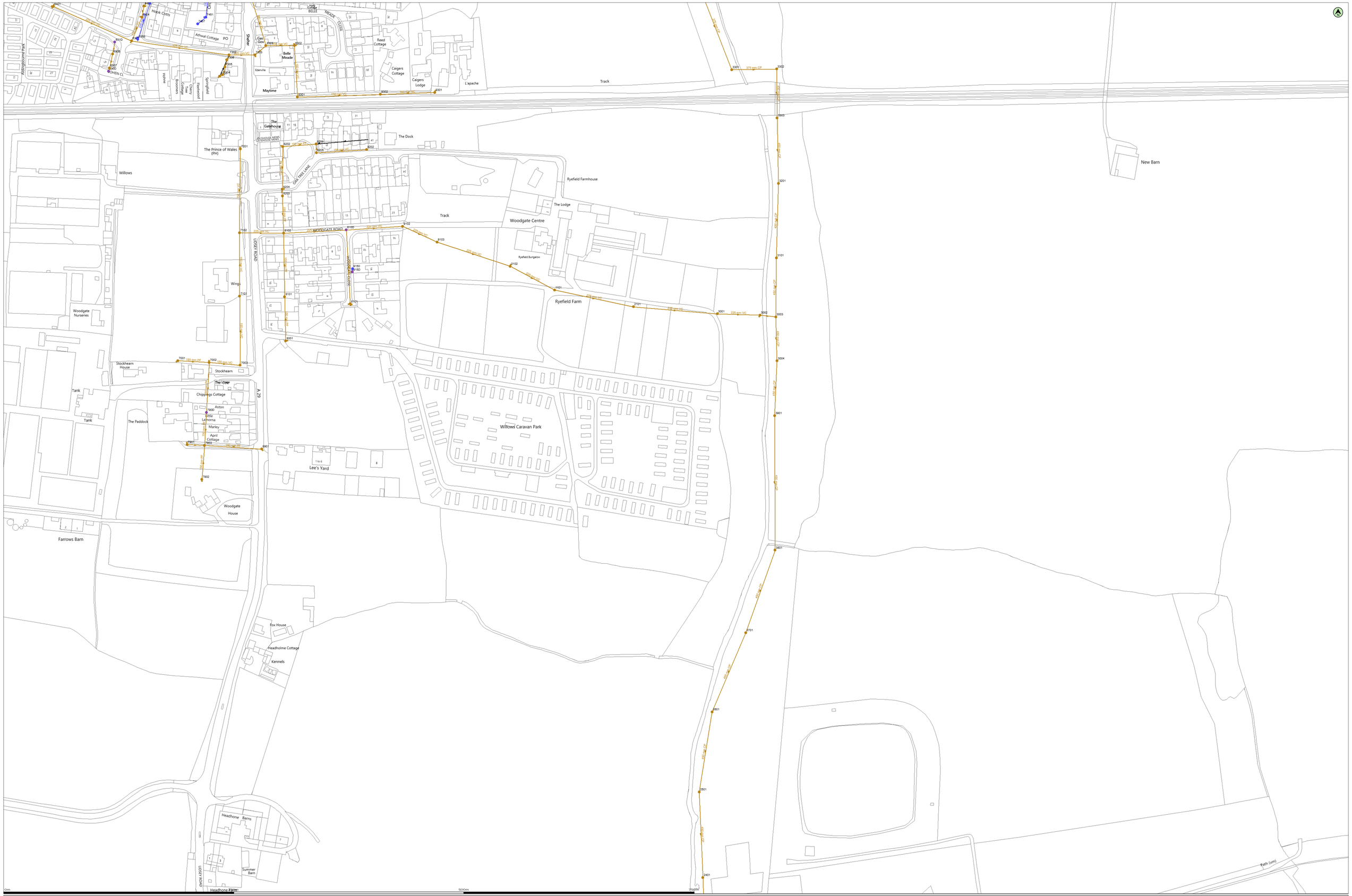
payments.utilitysolutions@atkinsglobal.com

83961_1

WATER for LIFE from Southern Water.

ARUN DISTRICT COUNCIL BN/11/22/OUT

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert
0201	F	10.71	9.07	
0203	F	10.69	8.93	
1101	F	10.71	8.77	
1102	F	10.69	8.59	
1302	F	10.83	8.42	
1303	F	11.11	8.76	
1601	F	4.88	2.93	
1801	F	6.65	4.87	
1901	F	7.40	6.85	
1902	F	7.06	5.51	
2001	F	6.04	4.64	
2001	F	10.57	8.28	
2002	F	10.54	8.10	
2101	F	10.65	8.45	
2101	F	6.81	4.84	
2201	F	7.27	5.83	
2202	F	8.33	0.00	
2301	F	10.55	8.12	
2401	F	2.36	0.66	
2501	F	2.54	1.20	
2601	F	3.51	2.21	
2602	F	3.04	1.66	
2701	F	4.63	3.56	
2801	F	5.39	4.04	
2901	F	5.71	4.30	
3001	F	11.17	9.65	
3002	F	10.58	7.98	
3003	F	10.62	7.79	
3101	F	11.53	9.37	
3201	F	8.96	7.34	
3201	F	11.45	8.97	
3202	F	7.97	7.07	
3202	F	11.11	8.23	
3303	F	8.06	6.54	
3304	F	8.20	6.43	
3701	F	9.51	7.96	
3703	F	9.82	7.99	
3704	F	9.66	7.76	
3705	F	9.52	7.96	
3802	F	9.77	8.37	
3804	F	9.92	8.46	
3805	F	9.79	0.00	
3806	F	9.52	0.00	
4101	F	9.77	7.76	
4101	F	10.61	7.83	
4201	F	9.20	7.54	
4202	F	11.20	8.03	
4203	F	10.86	7.97	
4301	F	11.69	0.00	
4302	F	11.37	0.00	
4701	F	9.67	7.59	
4702	F	9.84	6.76	
4703	F	9.81	6.57	
4901	F	10.42	7.53	
4902	F	10.08	7.41	
4903	F	9.61	7.24	
5101	F	10.23	7.44	
5101	F	9.75	8.15	
5102	F	9.78	7.99	
5102	F	0.00	0.00	
5100	F	0.00	0.00	
511D	F	0.00	0.00	
5201	F	11.73	10.18	
5204	F	11.59	9.83	
5208	F	0.00	0.00	
5209	F	0.00	0.00	
5308	F	0.00	0.00	
5309	F	0.00	0.00	
5310	F	0.00	0.00	
5401	F	8.93	7.96	
5403	F	9.05	8.00	
5701	F	8.73	5.91	
5702	F	9.40	6.11	
5802	F	8.99	6.97	
5803	F	0.00	0.00	
5804	F	0.00	0.00	
580D	F	0.00	0.00	
5901	F	9.54	7.12	
5902	F	0.00	0.00	
5903	F	0.00	0.00	
590D	F	0.00	0.00	
6101	F	9.60	9.13	
6102	F	9.82	8.42	
610D	F	9.82	8.39	
6202	F	11.50	9.64	
6203	F	11.41	9.34	
6204	F	11.49	9.13	
6205	F	11.03	8.99	
6206	F	10.63	8.88	
6207	F	10.24	8.73	
6208	F	10.00	8.64	
6302	F	11.80	10.07	
6303	F	11.58	9.65	
6403	F	9.15	7.41	
6407	F	9.13	7.56	
6701	F	8.89	5.66	
7201	F	11.25	10.07	
7202	F	10.97	9.43	
7303	F	12.21	10.50	
8201	F	11.74	9.86	
9201	F	10.88	9.34	
9202	F	10.73	9.19	
9203	F	11.68	9.64	
930D	F	11.52	9.60	
1250	S	0.00	0.00	
2250	S	9.36	5.90	
2251	S	7.12	5.82	
3750	S	0.00	0.00	
3851	S	0.00	0.00	
3852	S	0.00	0.00	
4851	S	0.00	0.00	



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Foul Gravity Sewer | Combined Gravity Sewer | Culverted Water Course or Inverted Syphon | Surface Water Gravity Sewer | Rising Main, Vacuum or Syphon | Combined Pumping Station | Surface Water Pumping Station | Foul Pumping Station | Water Treatment Works | Section 104 Area | Building Over Agreement Area | Foul Manhole | Combined Manhole | Surface Water Manhole | Dual Key Manhole, Combined Manhole or Surface Water Soakaway | Combined Outfall | Foul Outfall | Surface Water Outfall | Surface Water Main

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83961_2

from Southern Water.

ARUN DISTRICT COUNCIL WW1122OUT

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert
0102	F	8.99	5.36	
1101	F	8.71	5.22	
2101	F	7.00	4.95	
2401	F	0.95	-1.49	
2501	F	1.17	-1.37	
2601	F	1.09	-1.16	
3001	F	2.99	0.43	
3002	F	1.29	-0.17	
3003	F	1.44	-0.49	
3004	F	1.36	-0.50	
3101	F	1.46	-0.30	
3201	F	1.69	0.14	
3301	F	1.98	0.21	
3302	F	0.00	0.00	
3303	F	0.00	0.00	
3701	F	1.24	-1.08	
3801	F	1.22	-1.01	
3901	F	1.22	-0.68	
5401	F	9.30	7.27	
6306	F	8.87	7.01	
6307	F	0.00	0.00	
6308	F	0.00	0.00	
630D	F	0.00	0.00	
631D	F	0.00	0.00	
6403	F	9.83	8.05	
6404	F	9.57	7.95	
7001	F	9.33	8.08	
7002	F	8.98	6.83	
7003	F	8.90	6.75	
7101	F	8.90	6.48	
7102	F	8.23	6.30	
7201	F	8.46	6.85	
7301	F	9.14	7.99	
7302	F	8.77	6.86	
7303	F	8.84	6.66	
7304	F	9.14	7.93	
7305	F	9.14	7.81	
7306	F	9.00	7.72	
7901	F	9.41	8.33	
7902	F	9.02	7.97	
7903	F	9.32	7.32	
790D	F	0.00	0.00	
8001	F	8.24	6.39	
8101	F	8.05	6.18	
8102	F	8.31	5.99	
810D	F	8.75	5.83	
8202	F	8.85	7.47	
8203	F	8.53	7.20	
8204	F	9.14	7.25	
8205	F	9.42	7.88	
8206	F	9.48	7.81	
8301	F	9.61	8.05	
8302	F	9.60	7.60	
8303	F	9.48	6.59	
8901	F	8.95	8.21	
9101	F	7.89	6.48	
9102	F	8.98	5.72	
9103	F	9.16	5.52	
9202	F	9.48	8.35	
9301	F	9.97	8.76	
9302	F	10.01	8.45	
6358	S	8.89	8.21	
6453	S	10.00	0.00	
7451	S	9.83	9.20	
7457	S	0.00	0.00	
9150	S	0.00	0.00	
915D	S	0.00	0.00	



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Data updated: 18/12/19

Scale: 1:1250 | Date: 06/03/20 | Wastewater Plan A0

Map Centre: 495388,103827 | Our Ref: 374889 - 3 | Powered by digdat

Foul Gravity Sewer | Combined Gravity Sewer | Converted Water Course or Treated Effluent | Surface Water Gravity Sewer | Rising Main, Vacuum or Syphon

Combined Outfall | Foul Outfall | Surface Water Outfall | Surface Water Inlet

Combined Pumping Station | Surface Water Pumping Station | Foul Pumping Station | Water Treatment Works | Section 104 Area | Building Over Agreement Area

Foul Manhole | Combined Manhole | Surface Water Manhole | Side Entry Manhole, Combined Manhole, Gulley Manhole or Surface Water Soakaway

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83961_3

from Southern Water

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Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert
0401	F	1.22	-1.23	
0402	F	1.94	-0.31	
1401	F	1.34	-1.53	
1402	F	1.27	-0.31	
1501	F	2.09	-1.04	
1502	F	2.12	-0.31	
2501	F	1.48	-1.02	
2502	F	1.60	-0.30	
2601	F	1.64	-0.86	
3603	F	1.82	-0.70	
3604	F	1.69	-0.24	
4601	F	1.68	-0.36	
4602	F	1.76	-0.51	
4603	F	2.02	0.00	
4604	F	1.71	-0.72	
4701	F	2.38	0.00	
4702	F	0.00	0.00	
470D	F	0.00	0.00	
4801	F	0.00	0.00	
4802	F	0.00	0.00	
4803	F	0.00	0.00	
5401	F	8.93	7.96	
5403	F	9.05	8.00	
560D	F	0.00	0.00	
5701	F	1.78	-0.30	
5702	F	1.72	0.11	
630D	F	9.17	7.82	
6401	F	9.02	7.97	
6402	F	9.13	7.58	
6403	F	9.15	7.41	
6404	F	9.02	0.00	
6405	F	9.18	7.08	
6406	F	9.12	6.96	
6407	F	9.13	7.56	
6408	F	8.98	7.65	
6501	F	8.91	6.79	
6601	F	4.87	3.42	
6602	F	4.41	2.93	
6701	F	2.02	0.47	
6702	F	4.03	1.70	
6703	F	2.67	0.09	
6704	F	2.11	-0.09	
6801	F	2.82	0.17	
6802	F	2.05	0.47	
6803	F	1.75	0.03	
6901	F	3.91	0.68	
7001	F	2.48	0.96	
7002	F	2.45	0.96	
7003	F	2.07	0.50	
7402	F	8.43	4.66	
7403	F	7.50	4.53	
7405	F	0.00	0.00	
7406	F	0.00	0.00	
7407	F	0.00	0.00	
7408	F	0.00	0.00	
7409	F	0.00	0.00	
740D	F	0.00	0.00	
7410	F	0.00	0.00	
7411	F	0.00	0.00	
7412	F	0.00	0.00	
7413	F	0.00	0.00	
743D	F	0.00	0.00	
744D	F	0.00	0.00	
74AD	F	0.00	0.00	
74BD	F	0.00	0.00	
7501	F	8.84	4.88	
7508	F	0.00	0.00	
7701	F	4.60	3.33	
7801	F	4.98	3.50	
7802	F	5.34	3.75	
7901	F	2.97	0.36	
8001	F	2.14	0.64	
800D	F	2.07	0.57	
8101	F	3.07	1.23	
8102	F	2.50	0.84	
8201	F	2.80	0.96	
8401	F	1.37	-1.56	
8401	F	6.41	4.11	
8402	F	5.88	3.78	
8403	F	6.59	5.17	
8404	F	0.00	0.00	
8405	F	0.00	0.00	
840D	F	0.00	0.00	
841D	F	0.00	0.00	
8510	F	0.00	0.00	
8901	F	5.60	4.14	
9401	F	1.33	-1.26	
9402	F	1.52	-0.28	

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert
Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert
Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert
Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert



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Date: 06/03/20

Scale: 1:1250

Map Centre: 494260,103065

Data updated: 18/12/19

Our Ref: 374889 - 4

Wastewater Plan A0

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WATER for LIFE

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ARUN DISTRICT COUNCIL BN11 02OUT

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert
2301	F	0.98	-1.75	
2401	F	0.95	-1.49	
2402	F	0.94	-1.61	
3201	F	1.82	-1.95	
4201	F	3.39	-2.14	
4202	F	2.71	-2.49	
4203	F	3.05	-2.62	
4204	F	2.34	-2.20	
5201	F	2.36	-2.06	
5202	F	2.00	-1.33	
6201	F	1.53	-1.93	
6202	F	1.63	-1.27	
6203	F	1.22	0.00	
7301	F	1.11	-1.71	
7302	F	1.13	-0.48	
8301	F	1.52	-1.69	
8302	F	1.16	-0.32	
8401	F	1.37	-1.56	
9401	F	1.33	-1.26	
9402	F	1.52	-0.28	

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

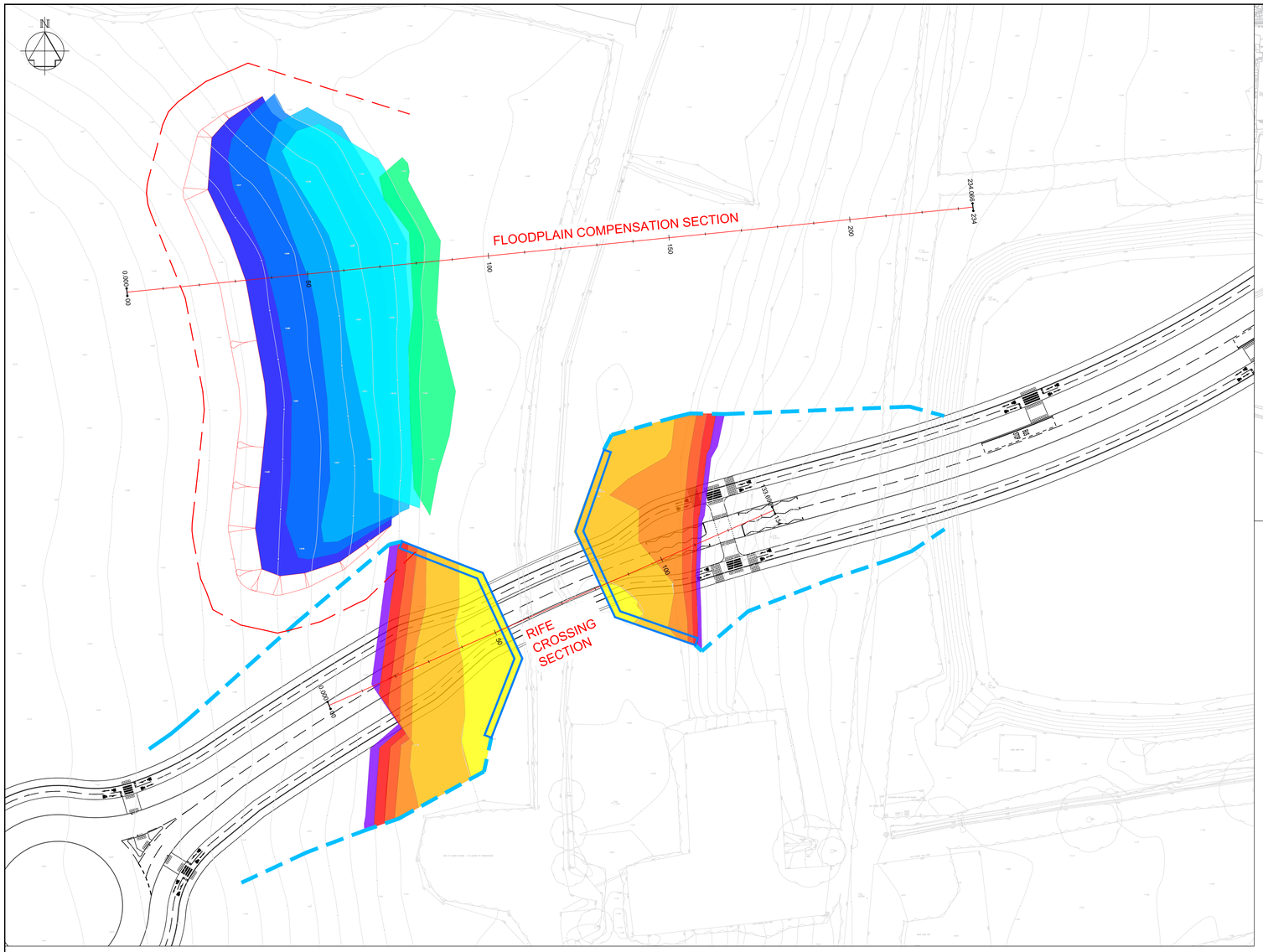
Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

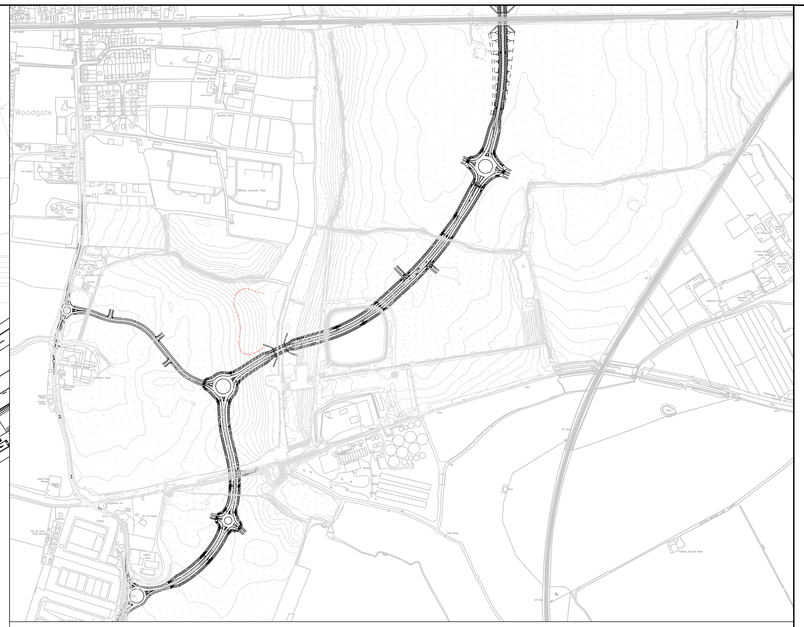
Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

Manhole Reference	Liquid Type	Cover Level	Invert Level	Depth to Invert

Appendix 6 Floodplain Compensation Feasibility

ARUN DISTRICT COUNCIL BN/11/22/OUT





GENERAL NOTES

G1. DO NOT SCALE THIS DRAWING.

G2. ANY DIMENSIONAL DISCREPANCIES SHOULD BE NOTIFIED TO THE ENGINEER IMMEDIATELY.

G3. ALL DIMENSIONS ARE IN MILLIMETRES - (mm) ALL LEVELS ARE IN METRES - (m) AND ARE ABOVE ORDNANCE DATUM AT NEWLYN, CORNWALL UNLESS NOTED OTHERWISE.

G4. NORTH SHOWN INDICATIVE ONLY

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EFFECTIVE FLOODPLAIN REMOVAL	
ELEVATION SLICE (mAOD)	VOLUME (m³)
1.0 - 1.25m	85
1.25 - 1.5m	506
1.5 - 1.75m	649
1.75 - 2.0m	731
2.0 - 2.21m	672

EFFECTIVE FLOODPLAIN REPLACEMENT	
ELEVATION SLICE (mAOD)	VOLUME (m³)
1.0 - 1.25m	103
1.25 - 1.5m	520
1.5 - 1.75m	670
1.75 - 2.0m	790
2.0 - 2.21m	685

FLOODPLAIN COMPENSATION NOTES

- THE FLOODING MECHANISM FOR THE WATERCOURSE IN THE STUDY AREA ORIGINATES IN THE SOUTH BEFORE SURCHARGING NORTHWARD ALONG THE CHANNEL
- THE REMOVAL OF FLOODPLAIN HAS BEEN CALCULATED IN PLAN AREA AND VOLUME WITHIN 0.25m SLICES
- THE PROVISION OF FLOODPLAIN REPLACEMENT HAS BEEN APPLIED IN SLICES AS ABOVE
- HYDROLOGY OF ANY CROSSING INTRODUCTION MUST BE APPLIED TO ENSURE ANY FLOOD COMPENSATION VOLUMES ARE ADEQUATE
- A DESIGN FLOOD LEVEL OF 2.21mAOD HAS BEEN USED AS THE 1% AEP + 30% CC EVENT.
- MAXIMUM EARTHWORK GRADIENT OF 1:4

DRAWING KEY

BRIDGE ABUTMENTS

EXTENT OF EARTHWORKS

10m BUFFER FROM WORKS

FLOODPLAIN REMOVAL KEY

BELOW 1.0m

1.0 - 1.25m

1.25 - 1.50m

1.50 - 1.75m

1.75 - 2.0m

2.0 - 2.21m

FLOODPLAIN REPLACEMENT KEY

1.0 - 1.25m

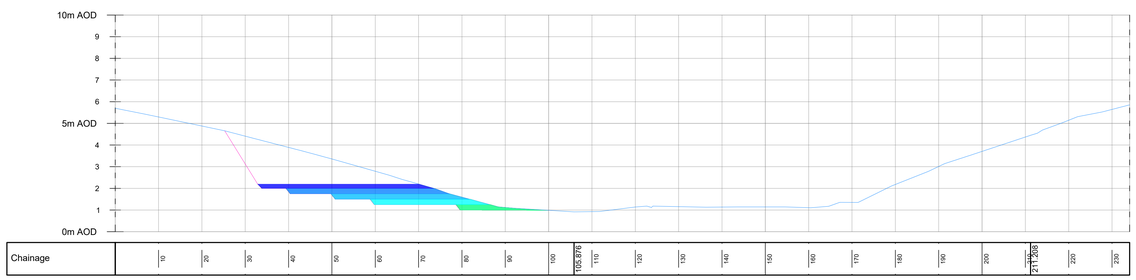
1.25 - 1.50m

1.50 - 1.75m

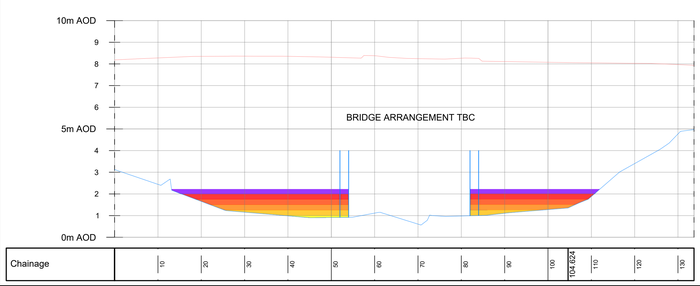
1.75 - 2.0m

2.0 - 2.21m

Flood Compensation Section
SCALE: H 1:500,V 1:100.



Rife Crossing Section
SCALE: H 1:500,V 1:100.



SECTIONS KEY

EXISTING GROUND

PROPOSED RIFE CROSSING

PROPOSED CHANNEL

REV	DESCRIPTION	DRN	CHK	APP	DATE
P02	10m BUFFER ADDED	HM	DAR	DAR	06.09.23
P01	INITIAL ISSUE	HM	DAR	DAR	21.08.23

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Architect/Client/Contractor
BEW SOUTHERN CONSORTIUM

Project
BARNHAM, EASTERGATE & WESTERGATE

Drawing Title
FLOODPLAIN COMPENSATION ARRANGEMENTS

Drawing Status
PRELIMINARY

	Name	Date	Status Code
Drawn	H. McCOLL	21.08.23	S2
Designed	H. McCOLL	21.08.23	Scale 1:500
Eng Chk	D. ALLUM-ROONEY	21.08.23	Revision P02
Approved	D. ALLUM-ROONEY	21.08.23	

Drawing No.
13394 - PEF - ZZ - XX - DR - CD - 0560

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