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NORTH HYKEHAM RELIEF ROAD
FLOOD RISK ASSESSMENT

TRANSPORT

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FLOOD RISK ASSESSMENT

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Ramboll
2nd Floor, The Exchange
St. John Street
Chester
CH1 1DA
Unite Kingdom

T +44 1244 311855
https://uk.ramboll.com

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Ramboll UK Limited
Registered in England & Wales
Company No: 03659970
Registered office:
240 Blackfriars Road
London
SE1 8NW

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1. INTRODUCTION

1.1. Appointment and Brief

1.1.1. Ramboll UK Limited (Ramboll) has been commissioned by Lincolnshire County Council to undertake a Flood Risk Assessment (FRA) to support the North Hykeham Relief Road scheme (the 'Proposed Scheme') in North Hykeham, Lincolnshire.

1.2. Proposed Scheme

1.2.1. The NHRR, comprises a Dual All-Purpose 2 lane Carriageway with a combined foot and cycleway running the length of the scheme from existing provision at the A46 to the A15 Sleaford Road roundabout. It links the A46 to the Lincoln Eastern Bypass (LEB).

1.3. Scope and Objectives

1.3.1. This report considers the risks of various sources of flooding to the site and the consequent risk of flooding to downstream receptors (such as people, property, habitats, infrastructure and statutory sites) from the Proposed Scheme as a result of surface water runoff. A comparison is made between the current situation and the Proposed Scheme.

1.3.2. This FRA has been carried out in accordance with the National Planning Policy Framework (NPPF)[1]. It is to be used to assist the Local Planning Authority (LPA) and relevant statutory consultees when considering the flooding issues of the Proposed Scheme, as part of a planning application.

1.3.3. This report provides the following information:

1. A review of the flood risk to the site based upon flood data and the flood maps provided by the Environment Agency (EA) and the relevant Strategic Flood Risk Assessment (SFRA);
2. An assessment of flood risk from all sources including tidal, fluvial, pluvial, groundwater and infrastructure failure to the Proposed Scheme;
3. An assessment of the compatibility of the Proposed Scheme for its location based on flood risk;
4. An assessment of the impact of the Proposed Scheme in terms of surface water runoff;
5. Proposals for measures to mitigate the generation of surface water runoff as a result of the Proposed Scheme; and,
6. Proposals to mitigate any residual flood risks to the development.

1.4. General Limitations and Reliance

1.4.1. In preparation of the report and performance of any other services, Ramboll has relied upon publicly-available information, information provided by the client and information provided by third parties. Accordingly, the conclusions reached in this report are valid only to the extent that the information provided to Ramboll was accurate, complete and available to Ramboll within the reporting schedule.

1.4.2. The key sources of information used to prepare this report are footnoted within the document. Whilst, in their professional capacity, Ramboll have validated and reviewed the supplied information, Ramboll cannot accept liability for the accuracy or otherwise of any information derived from third party sources.

1.4.3. Unless otherwise stated in this report, the scope of services, assessment and conclusions made assume that the site will continue to be used for its current purpose and end-use without significant changes either on-site or off-site. Unless stated otherwise, the geological information provided is for general environmental interpretation and should not be used for geotechnical and/or design purposes.

1.5. Consultation

1.5.1. Consultation was undertaken with the Environment Agency (EA) in respect of flood risk and mitigation plus the hydraulic modelling used to support this FRA. Minutes of meetings cited within this FRA are included in Appendix 1.

[1] Ministry of Housing, Communities & Local Government (2012) National Planning Policy Framework, updated July 2021, available at: https://www.gov.uk/government/publications/national-planning-policy-framework--2 (accessed 06/2023)

2. POLICY FRAMEWORK

2.1. National Planning Policy Framework, 2021

2.1.1. The NPPF was most recently updated in July 2021, with flood risk remaining primarily regulated through planning policy. The NPPF requires that an FRA should be submitted with planning applications for all development sites within Flood Zones 2 and 3; and all development sites over 1 ha in area to determine the risks of flooding from all sources including rivers, the sea, sewers, and groundwater. The NPPF sets out that flood risk should be defined according to Flood Zone 3 (High Probability), Flood Zone 2 (Medium Probability) and Flood Zone 1 (Low Probability).

2.1.2. In terms of flood risk, the NPPF classifies land uses according to vulnerability as follows:

- Essential infrastructure;
- Highly vulnerable;
- More vulnerable;
- Less vulnerable; and
- Water-compatible development.

2.2. The Town and Country Planning (Development Management Procedure) Order 2015

2.2.1. The Government has strengthened planning policy on the provision of sustainable drainage for 'major' planning applications as from 6 April 2015. Decisions about the suitability of sustainable drainage provision are made by the LPA. However, under The Town and Country Planning (Development Management Procedure) Order 2015[2], which came into force from 15 April 2015, Lead Local Flood Authorities (LLFA) are now statutory consultees for all major applications.

2.3. Climate Change Guidance

2.3.1. The government's current climate change guidance[3] for developers and their agents when they prepare flood risk assessments for planning applications, and development consent orders for nationally-significant infrastructure projects, is provided online and seeks to minimise vulnerability and provide resilience to flooding and coastal change. The key climate change factors which are covered with regard to flood risk include:

- Peak river flow allowances which show the anticipated changes to peak flow by river basin district;
- Increased rainfall depths which affect river levels and land and urban drainage systems; and
- A range of allowances for each river basin district and epoch for sea level rise.

2.3.2. This online guidance was originally published in February 2016 and has been updated periodically, most recently in May 2022, to reflect changes in climate science such as updated sea level rise allowance to reflect latest climate chance projections (UKCP18) which replaced previous projections (UKCP09).

2.4. Lincolnshire County Council Flood Risk and Water Management Strategy

2.4.1. Lincolnshire County Council (LCC) is the designated LLFA. The LCC Flood Risk and Water Management Strategy 2019-2050 aims to increase the safety of people across Lincolnshire by:

- reducing the number of people at risk of flooding;
- increasing the resilience of local communities; and
- reducing the impact of flooding.

[2] Statutory Instruments 2015, No. 596, Town and Country Planning, England, The Town, and Country Planning (General Permitted Development) (England) Order 2015.

[3] Environment Agency (2016) Flood risk assessments: climate change allowances, updated March 2022, available at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances (accessed 06/2023)

2.5. The Central Lincolnshire Local Plan (2023)

2.5.1. Policy S21: Flood Risk and Water Resources of the Central Lincolnshire Local Plan adopted in April 2023 sets out stipulations on flood risk and water quality, namely that all proposals be considered against the NPPF. It also stipulates that appropriate consultation and option appraisal for developments should take into account:

- all potential sources of flood risk;
- flood risk to existing properties;
- that the development is kept safe during its lifetime;
- that the development does not negatively affect the integrity of flood defences;
- that proposals consider adoption and management of mitigation measures;
- how proposals have taken a positive approach to decreasing flood risk; and
- that the proposals incorporate Sustainable Drainage Systems (SuDS) unless impractical.

2.5.2. The policy also sets out that development proposals which may impact on surface or groundwater should consider the requirements of the Water Framework Directive and necessitates that the development proposals demonstrate how adverse impacts on the water environment will be avoided.

3. SITE DESCRIPTION AND BASELINE

3.1. Location and Surrounds

3.1.1. The Proposed Scheme alignment and its associated planning boundary ('the site') is located between the Hykeham Roundabout on the A15 south-west of North Hykeham at National Gird Reference (NGR) SK 92057 65284 and the Sleaford Road-LEB roundabout south-east of Bracebridge Heath on the A46 at approximate NGR SK 98821 66504. The surrounds are predominately agricultural, with some suburban extents adjacent to the site boundary.

3.1.2. Lincoln City Centre is situated roughly 6 km to the north. The centre of the village of Waddington is less than 1 km south-east of the proposed alignment and the centre of North Hykeham is approximately 1.5 km north-west of the proposed alignment (which crosses both civil parishes). The proposed alignment also passes just south of the small village of South Hykeham, situated less than 300 m to the north.

3.1.3. The site location and surrounds are shown below in Figure 3-1.

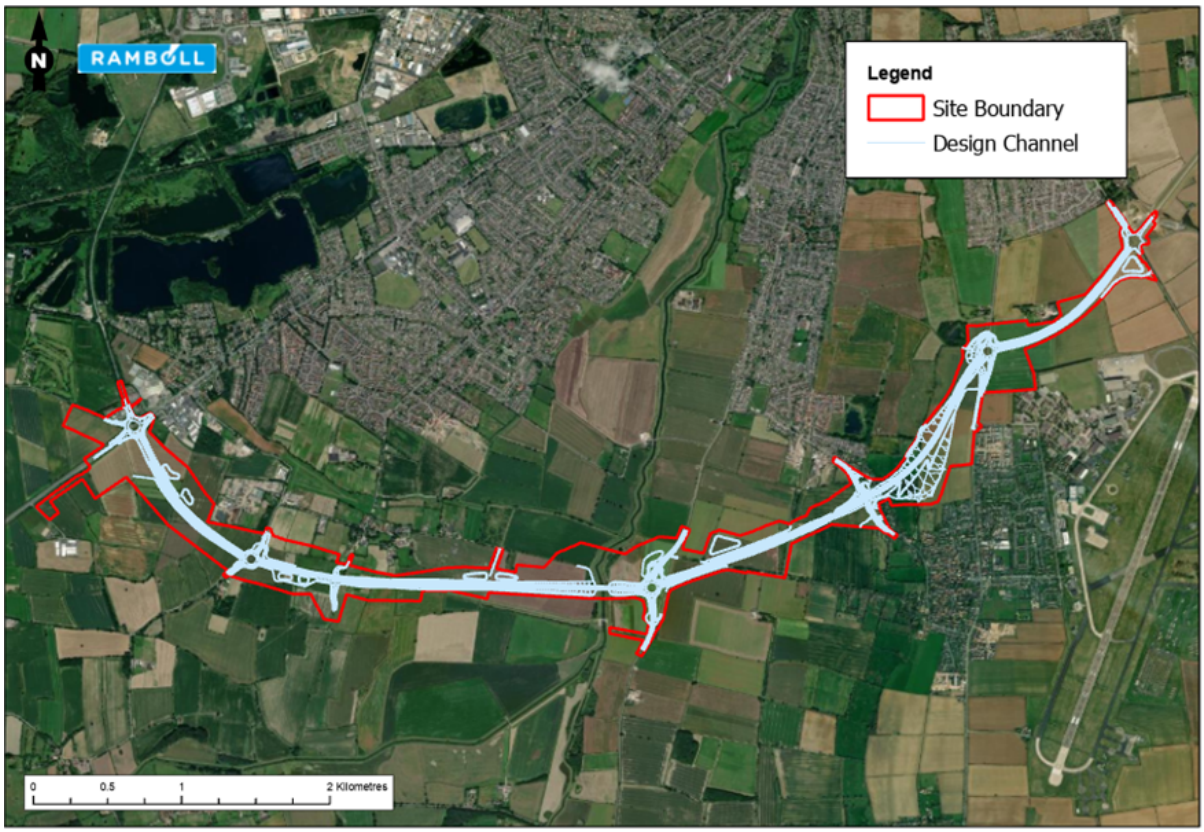


Figure 3-1 Site Location and Surrounds

3.2. Site Topography

3.2.1. The topography of the site and surrounding area has been analysed using the EA's 2 m Digital Terrain Model (DTM) LiDAR dataset (Figure 3-2). The lowest elevation is through the River Witham channel at approximately 2 m above ordnance datum (AOD), and the highest elevation along the Lincoln Cliff Escarpment through the east of the Proposed Scheme at approximately 75 m AOD. Elevations to the west of the Proposed Scheme are approximately 12 m AOD. There is no significant north-south gradient relative to the Proposed Scheme. The lowest elevation is where the Proposed Scheme crosses the River Witham.

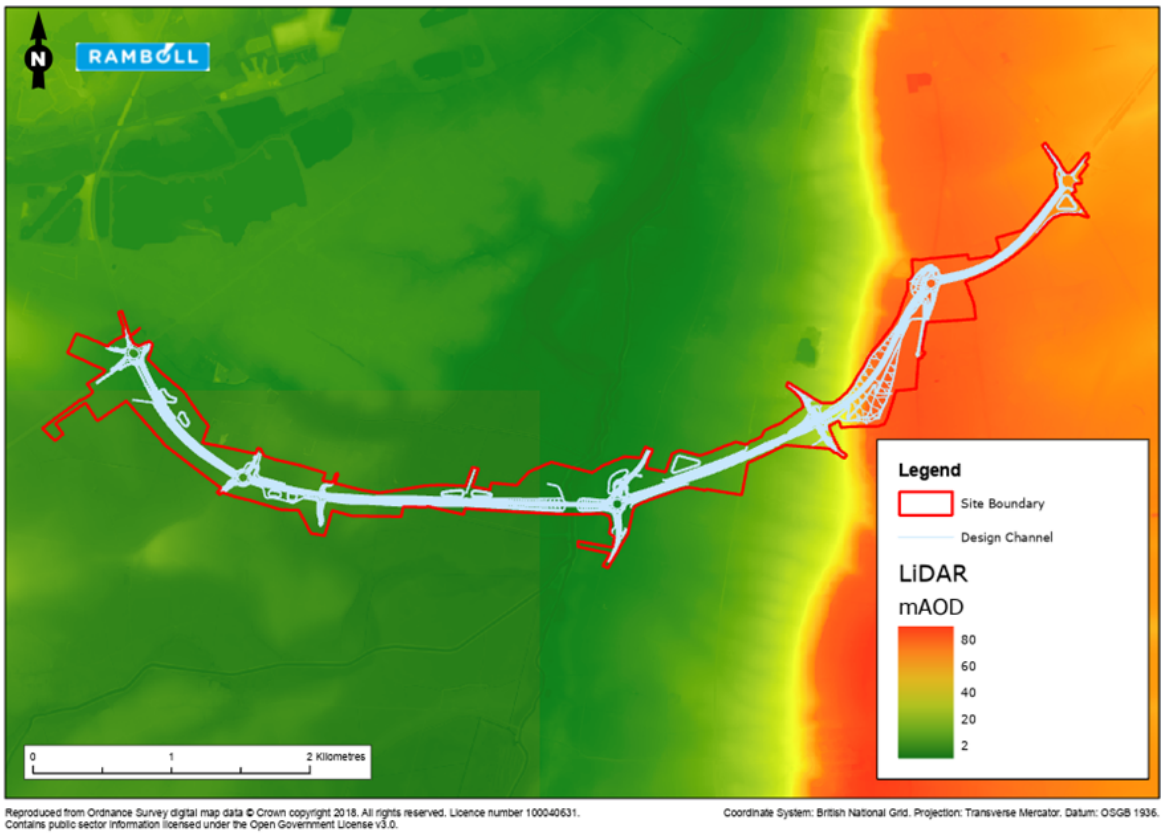


Figure 3-2 LIDAR Composite DTM 2022 - 2m

3.3. Geological Setting

3.3.1. British Geological Society (BGS) mapping of the area (1:50,000 scale map series) was accessed via the online BGS Onshore GeoIndex digital mapping database[4]. The map indicates that most of the site is not underlain by superficial deposits; however, some superficial deposits are present within localised areas. These consist of alluvium (silt, sand and gravel) adjacent to the River Witham perpendicular to the Proposed Scheme alignment, and a localised area of the Balderton Sand and Gravel Member (sand and gravel) in South Hykeham along the north of the site boundary.

3.3.2. Bedrock is broadly mudstone west of the Lincoln Cliff escarpment. These units are the Scunthorpe Mudstone Formation, Charmouth Mudstone Formation, and Whitby Mudstone Formation. The Grantham Formation and Northampton Sand Formation (Undifferentiated), which is a narrow band of sandstone and ironstone east of Waddington, is also present. East of Waddington and through the escarpment is primarily limestone, consisting of the Lower Lincolnshire Limestone Member and the Upper Lincolnshire Limestone member.

3.4. Hydrogeological Setting

3.4.1. The BGS 1:625,000 scale Hydrogeology Map (accessed via the online BGS Onshore GeoIndex) and the EA Catchment Data Explorer were used to identify underlying hydrogeology. The Scunthorpe Mudstone Formation, Whitby Mudstone Formation and Grantham Formation and Northampton Sand Formation in the Proposed Scheme's west are together described as the Witham Lias Water Body. The Lower and Upper Lincolnshire Limestone Members are together described as the Witham Limestone Unit A Water Body. The groundwater bodies are designated Secondary B and Principal aquifers within the BGS Aquifer Designation Map respectively. Limited areas of superficial deposits categorised as Secondary A aquifers by the EA are also present.

3.4.2. A 2022/2023 Ground Investigation by Coffey Geotechnics Ltd[5] recorded groundwater levels at variable depths along the Proposed Scheme.

[4] The British Geological Survey (BGS) Onshore GeoIndex, available at: http://mapapps2.bgs.ac.uk/geoindex/home.html (accessed 06/2023)
[5] Coffey Geotechnics Ltd (2023), North Hykeham Relief Road Ground Investigation Report, Document no. NHRR-COF-HGT-HYKE-RP-GI-06101

3.4.3. The monitored groundwater resting levels recorded along the central and western parts of the site ranged between 0.55 m below ground level (bgl) (at BH107 on 15/02/2023) and 8.00 m bgl (at BH109 on 24/01/2023), both of which are located in close proximity to each other and adjacent to the north of the Proposed Scheme, west of South Hykeham Road. It is observed that most of the wells within the western part of the proposed route recorded shallow groundwater at less than 1.0 m bgl. On top of the escarpment the levels were recorded between 1.60 m bgl (within Made Ground, at RC306) and 6.12 m bgl (within the Lincolnshire Limestone Member, at RC120).

3.4.4. The Defra MAGIC Map[6] indicates the Proposed Scheme is situated within a groundwater Source Protection Zone (SPZ) II (Outer Protection Zone) and SPZ 3 (Total Catchment) in the east.

3.5. Hydrological Setting

3.5.1. The Proposed Scheme crosses the River Witham, a main river located approximately at the mid-point of the Proposed Scheme, which flows in a south to north direction. No other main rivers are crossed by the scheme. The River Brant, also a main river, joins the River Witham approximately 300 m south (upstream) of the Proposed Scheme.

3.5.2. A main river known as 'The Beck' in Ordnance Survey (OS) mapping is situated approximately 100 m north (downstream) of the Proposed Scheme and flows in a west to east direction to also join with the River Witham. The Beck receives drainage from several IDB drains in the area. The Beck is only classified as a main river by the EA mapping in its final 900 m reach before entering the River Witham. A sluice gate on the River Witham for flood control is situated approximately 100 m south (upstream) of the Proposed Scheme alignment. Branston Beck is situated in Branston, more than 1 km east of the scheme.

3.5.3. Several drainage watercourses are present throughout the agricultural landscape and are also crossed by the Proposed Scheme. These flow to the River Witham. These drains are part of the Upper Witham Internal Drainage Board (IDB) network. The Upper Witham IDB manages the drainage network within this floodplain, which is largely flat. Part of the IDB network around the scheme flows to an IDB pumping station, which lifts water from the network and into the River Witham.

3.6. Fluvial and Tidal Flood Risk

3.6.1. The EA floodplain maps identify areas in England and Wales at risk of flooding by allocating them into Flood Zones. The Flood Zones shown on the flood maps are defined in Table 1 (Flood Zones) of Guidance to the NPPF[7] (the 'NPPG') as follows:

- **Flood Zone 1:** Low Probability. According to the NPPG, land in this zone is considered to have less than a 1-in-1,000 annual exceedance probability (AEP) (<0.1%) of river or sea flooding.
- **Flood Zone 2:** Medium Probability. According to the NPPG, land in this zone is considered to have between a 1-in-100 and 1-in-1,000 AEP of river flooding (between 1% and 0.1%) or between a 1-in-200 and 1-in-1,000 AEP of sea flooding (0.5% to 0.1%).
- **Flood Zone 3a:** High Probability. According to the NPPG, land in this zone is considered to have a 1-in-100 or greater AEP of river flooding (>1%) or a 1-in-200 or greater AEP of flooding from the sea (>0.5%).
- **Flood Zone 3b:** The Functional Floodplain. According to the NPPG, land in this zone is used for water flow or storage in times of flood. This Flood Zone should be identified by a Strategic Flood Risk Assessment (SFRA). It is typically defined as a flood with a 1-in-20 or greater AEP of river flooding (>5%). Another probability, however, can also be agreed between the LPA and the EA.

[6] Defra MAGIC Map, available at: https://magic.defra.gov.uk/MagicMap.aspx (accessed 06/2023)

[7] Department for Levelling Up, Housing and Communities, Flood risk and coastal change guidance, available at: https://www.gov.uk/guidance/flood-risk-and-coastal-change (accessed 06/2023)

3.6.2. According to the Flood Map for Planning[8], the Proposed Scheme is situated mostly within Flood Zone 1, which is land defined by the EA as having a low probability of flooding from rivers or the sea. The Proposed Scheme also crosses Flood Zones 2 and 3, both of which are associated with the River Witham. Areas of Flood Zone 2 associated with the Beck watercourse (<200 m from the scheme footprint) and with the River Brant (<1 km from the scheme footprint) are also present locally.

3.6.3. The Flood Zones in the EA's Flood Map for Planning only show flood risk from rivers and the sea. They are based on present day flood risk and do not show how this risk may change in the future due to climate change. The mapping also ignores the effect of any flood defences.

3.6.4. A large Flood Storage Area (FSA) is situated south of the sluice gate adjacent the west bank of the River Witham. This has been designed to retain flood water by means of a purpose-built embankment. The Proposed Scheme's southern red line boundary is near the retaining embankment.

3.6.5. The Flood Map for Planning is presented below in Figure 3.3 and the location of the FSA is presented in Figure 3-3.

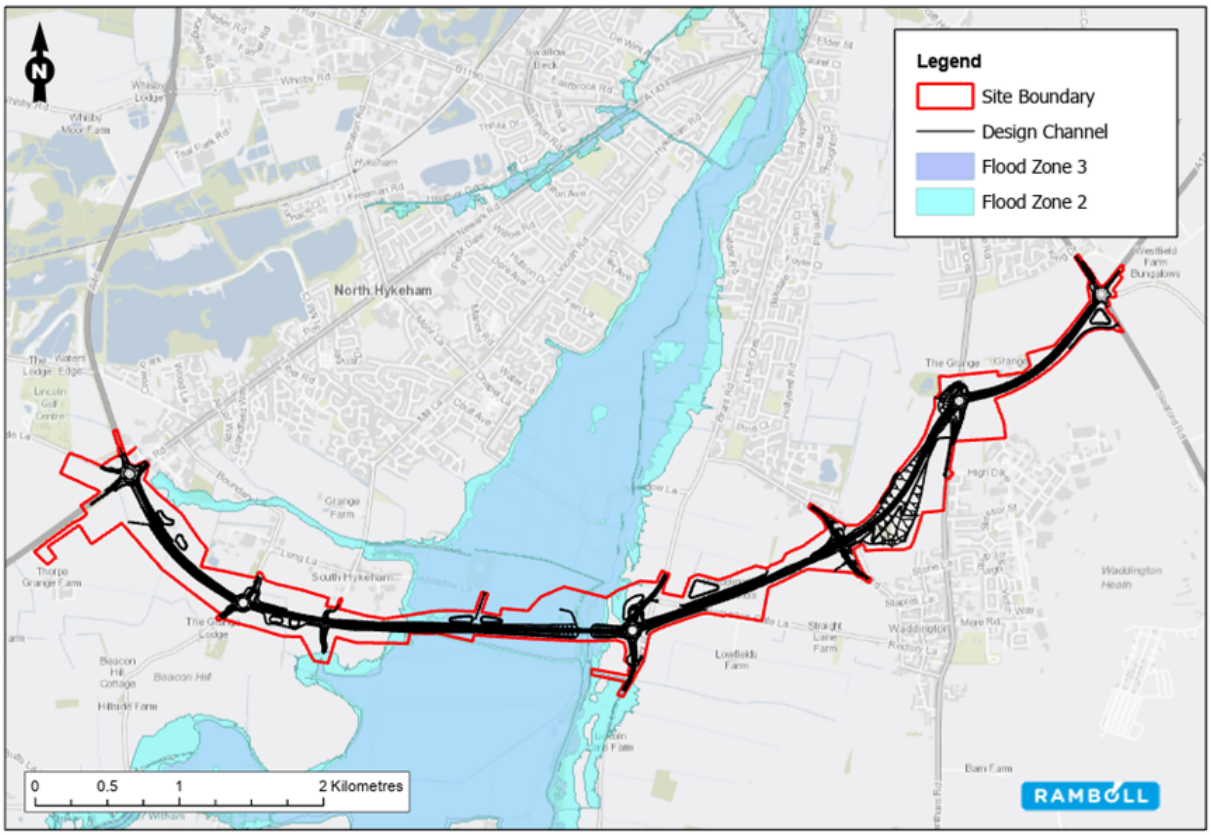


Figure 3-3 Flood Map for Planning

[8]Environment Agency, Flood Map for Planning ,available at: https://flood-map-for-planning.service.gov.uk/ (accessed 06/2023)

3.7. Flood Defences

3.7.1. Flood defences are present adjacent to the EA main rivers described above. The River Witham is flanked by raised embankments that extend along the riverbanks several kilometres north and south of the site. According to the EA's AIMS Spatial Flood Defences data[9] the effective crest level of these defences downstream of the sluice gate, and up to 500 m downstream of the proposed alignment, ranges between approximately 6.5 – 7.0 m AOD, and have a design standard of protection of 75 years. The condition of the embankments was rated '3' (Fair – *"Defects that could reduce performance of the asset"*) as of the most recent EA inspection in March 2021. Tributary main rivers in the River Witham floodplain, close to the proposed NHRR crossing, including The Beck and the River Brant, are also flanked by raised embankments.

3.7.2. A raised defence (River Witham Washland Defence) running perpendicular to the River Witham is present on the western floodplain. This creates the FSA to the south which is designed to mitigate flooding within the catchment during events up to and including the 1% AEP fluvial flood. The embankment is designed to withstand overtopping and also features a concrete capping beam. The FSA has sufficient volume for it to be classified under the Reservoirs Act. It has a maximum water depth (when full) of approximately 1.5 m. The condition of the embankment was rated '3' (Fair) as of the most recent EA inspection in March 2021.

3.7.3. There is a control structure on the River Witham adjacent to the perpendicular defence. If Lincoln is expected to flood and the sluice gate is raised, the side gates are opened to allow water to flood into the FSA.

3.7.4. Elsewhere, the river embankments were raised in the early 1990s. They are subject to vegetation growth and burrowing animals which may have reduced their ability to withstand a breach and/or erosion.

3.7.5. The EA's flood defence assets and the FSA are presented in Figure 3-4.

[9] Defra Data Services Platform, AIMS Spatial Flood Defences (inc. standardised attributes), available at: https://environment.data.gov.uk/dataset/8e5be50f-d465-11e4-ba9a-f0def148f590 (accessed 06/2023)

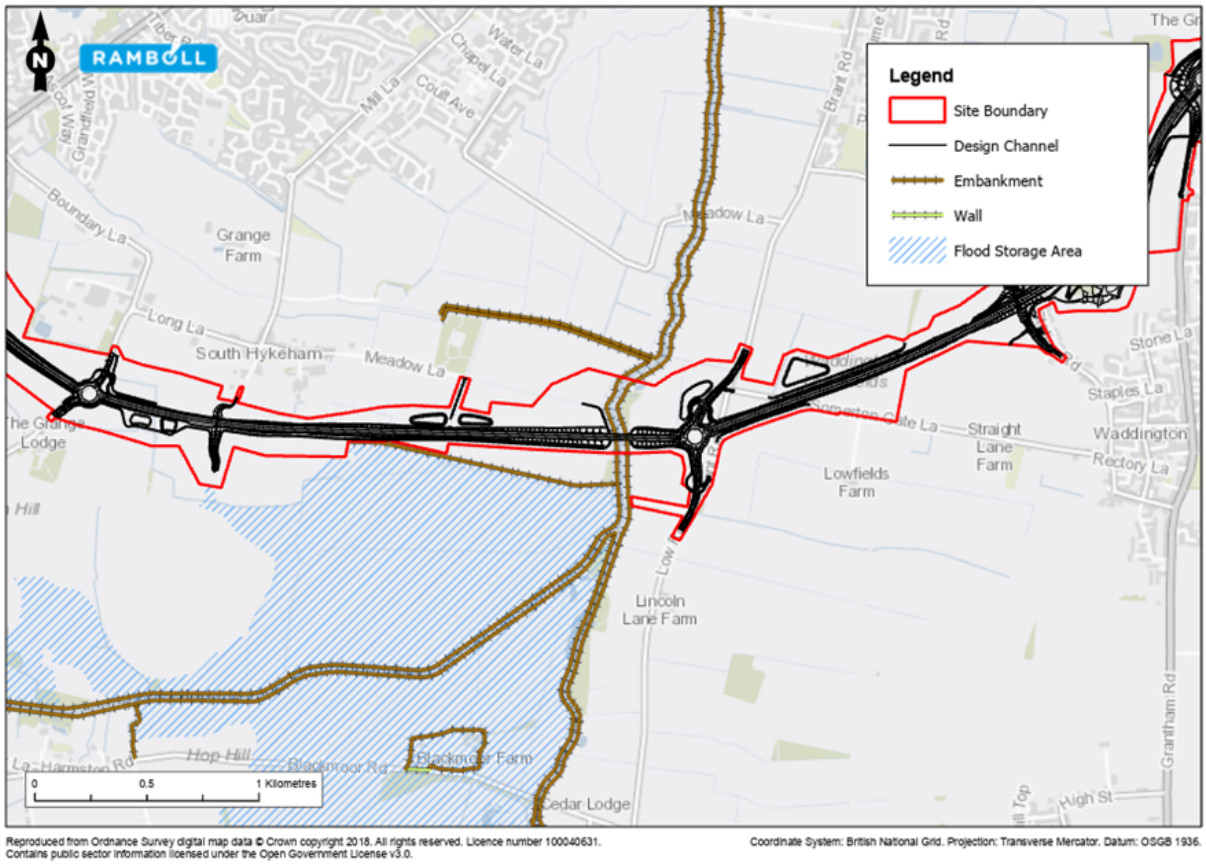


Figure 3-4 Flood Defences and Flood Storage Areas

3.8. Surface Water and Sewer Flood Risk

3.8.1. The Flood and Water Management Act 2010 defines surface water flooding as flooding that takes place when surface runoff, generated by rainwater, falls on to the surface of the ground and has not yet entered a watercourse, drainage system or public sewer.

3.8.2. The EA's Long-Term Flood Risk Map[10] identifies areas in England and Wales at potential risk of surface water (pluvial) flooding. The surface water flood maps define flood risk as follows:

- **High Risk.** Considered to have a greater than 1-in-30 AEP of surface water flooding (>3.3%).
- **Medium Risk.** Considered to have between a 1-in-30 and 1-in-100 AEP of surface water flooding (between 3.3% and 1%).
- **Low Risk.** Considered to have between a 1-in-100 and 1-in-1,000 AEP of surface water flooding (between 1% and 0.1%).
- **Very Low Risk.** Considered to have a less than 1-in-1,000 AEP surface water flooding (<0.1%). The EA surface water flood mapping is presented in Figure 3.5.

3.8.3. EA mapping indicates variable surface water flood risk within the study area and red line boundary. Areas of 'low', 'medium' and 'high' surface water flood risk are present, concentrated primarily around drains and low-lying areas. Areas of surface water flood risk above 1-in-1,000 AEP are generally more frequent to the west of the escarpment.

3.8.4. Linear features at risk of surface water flooding can indicate the presence of overland flow pathways. In this case these pathways are primarily associated with the Internal Drainage Board drains. Additionally, several overland flow pathways occur on the escarpment, flowing west, with surface water draining towards the River Witham.

[10] Environment Agency Long-Term Flood Risk Map, available at: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map (accessed 06/2023)

3.8.5. The EA's guidance on the Flood Map for Surface Water, published in 2013[11], has confirmed that there are many assumptions in the modelling which will affect its accuracy:

1. The main assumption related to urban drainage capacity and a national average 'drainage removal rate' of 12 mm/hr is assumed unless otherwise specified by an LLFA.
2. The underlying Digital Terrain Model was derived from LiDAR data which varies in horizontal resolution from 0.25 to 5.0 m. However, the DTM for the modelling was re-sampled to 2 m so local variation in topography is lost in the modelling.
3. Road surfaces within OS mapping data were lowered by 0.125 m in order to delineate flow paths along road surfaces.

3.8.6. The EA conclude that, because of the assumptions in the modelling, the resulting mapping should not be used to definitively show that an area of land or property is, or is not, at risk of flooding and the maps are not suitable for use at an individual property level. However, the maps are appropriate for the broader assessment of larger sites.

3.8.7. The EA's surface water flood mapping is presented in Figure 3-5 and Figure 3-6.

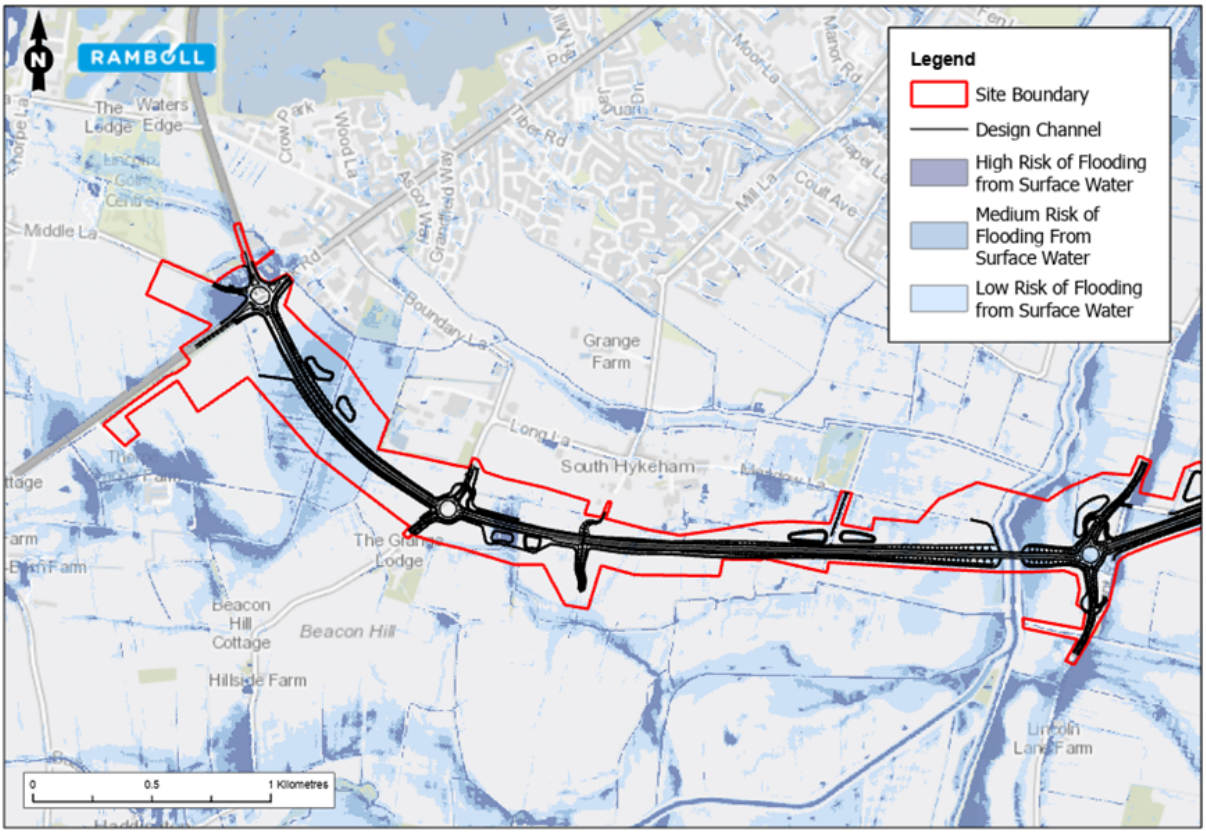


Figure 3-5 Risk of Surface Water Flooding (West)

[11] Gov.uk (2013) Flood risk maps for surface water: how to use the map, available at: https://www.gov.uk/government/publications/flood-risk-maps-for-surface-water-how-to-use-the-map (accessed 06/2023)

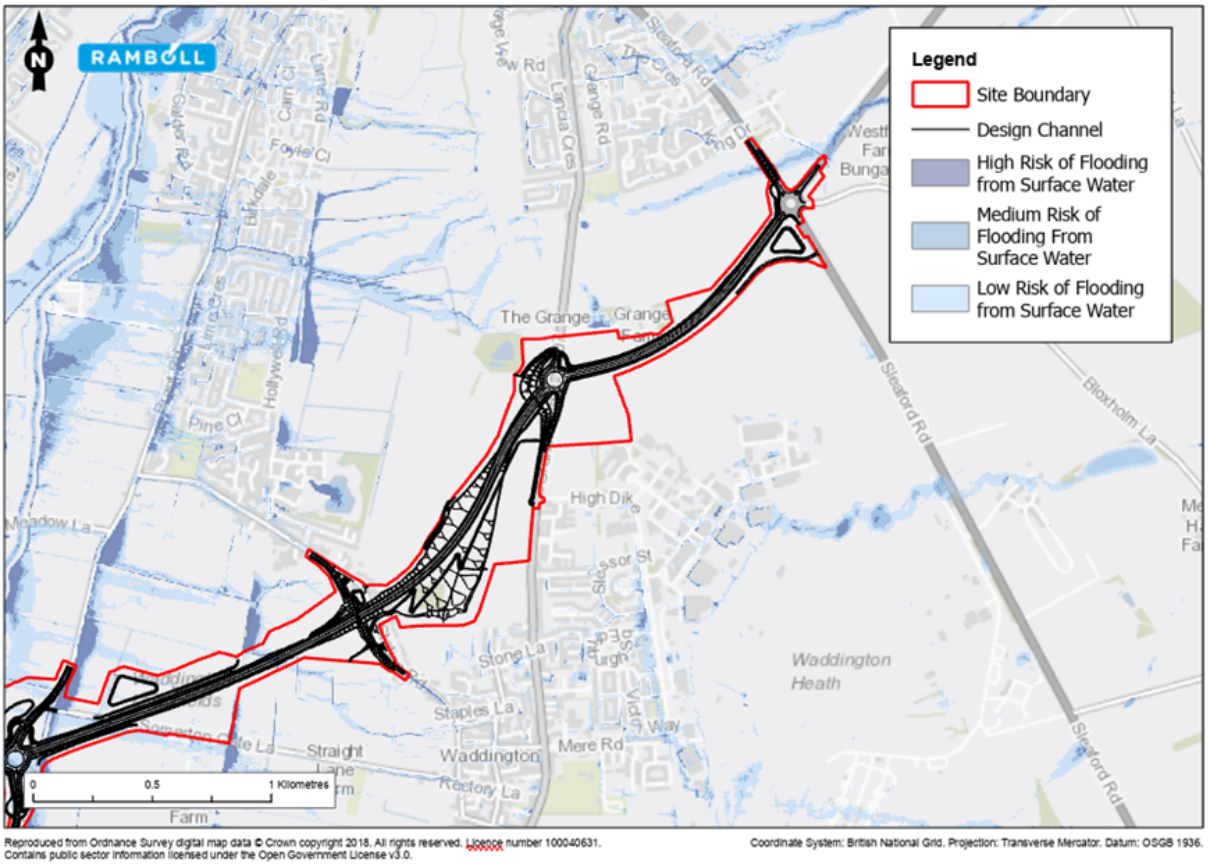


Figure 3-6 Risk of Surface Water Flooding (East)

3.9. Groundwater Flood Risk

3.9.1. Groundwater flooding is caused by the emergence of water originating from sub-surface permeable strata. A groundwater flood event results from a rise in groundwater level sufficient enough for the water table to intersect the ground surface and inundate low lying land and/or infrastructure below ground. Groundwater floods may emerge from either point or diffuse locations. They tend to be long in duration developing over weeks or months and prevailing for days or weeks.

3.9.2. The North Kesteven Strategic Flood Risk Assessment (2009) states that groundwater flooding has not been a historically common occurrence in the District and the flooding archive only contains one groundwater flooding incident. Additionally, the LCC Preliminary Flood Risk Assessment indicates that the Proposed Scheme is situated in an area where less than 25% of the land is susceptible to groundwater flooding. This information is described by LCC as being based on EA 'Areas susceptible to groundwater flooding' data. It is noted however that the dataset is low resolution and not necessarily an accurate representation of flood risk on a smaller (i.e. property-level) scale.

3.9.3. The Coffey groundwater monitoring data suggest the presence of shallow groundwater in the west of the Proposed Scheme, where recorded levels were less than 1 m bgl (though no groundwater at the surface was recorded). Groundwater in the limestone to the east was at least 3 m bgl. Therefore, groundwater flooding risk is assumed to be greater west of the River Witham. However, it should be cautioned that spatial and temporal data are too limited for a detailed baseline assessment.

3.10. Risk from Reservoirs, Canals and Other Artificial Sources

3.10.1. The EA's reservoir flood risk dataset[12] indicates flood extents for all large, raised reservoirs in the event that they were to fail. According to the EA's mapping, the site is within the potential extent of reservoir flooding including extents on wet days (when local rivers have already overflowed their banks) and dry days (when local rivers are at normal levels). The source reservoir is the River Witham Flood Washlands, immediately downstream of the sluice gate and River Witham Washland Defence embankment.

3.10.2. It should be noted that reservoir failures resulting in flooding are infrequent occurrences, and the integrity of reservoirs are regularly inspected by the EA. There has not been a loss of life due to reservoir failure for nearly 100 years indicating the relatively low risk such flooding poses.

3.10.3. The reservoir flood risk extents are presented in Figure 3-7.

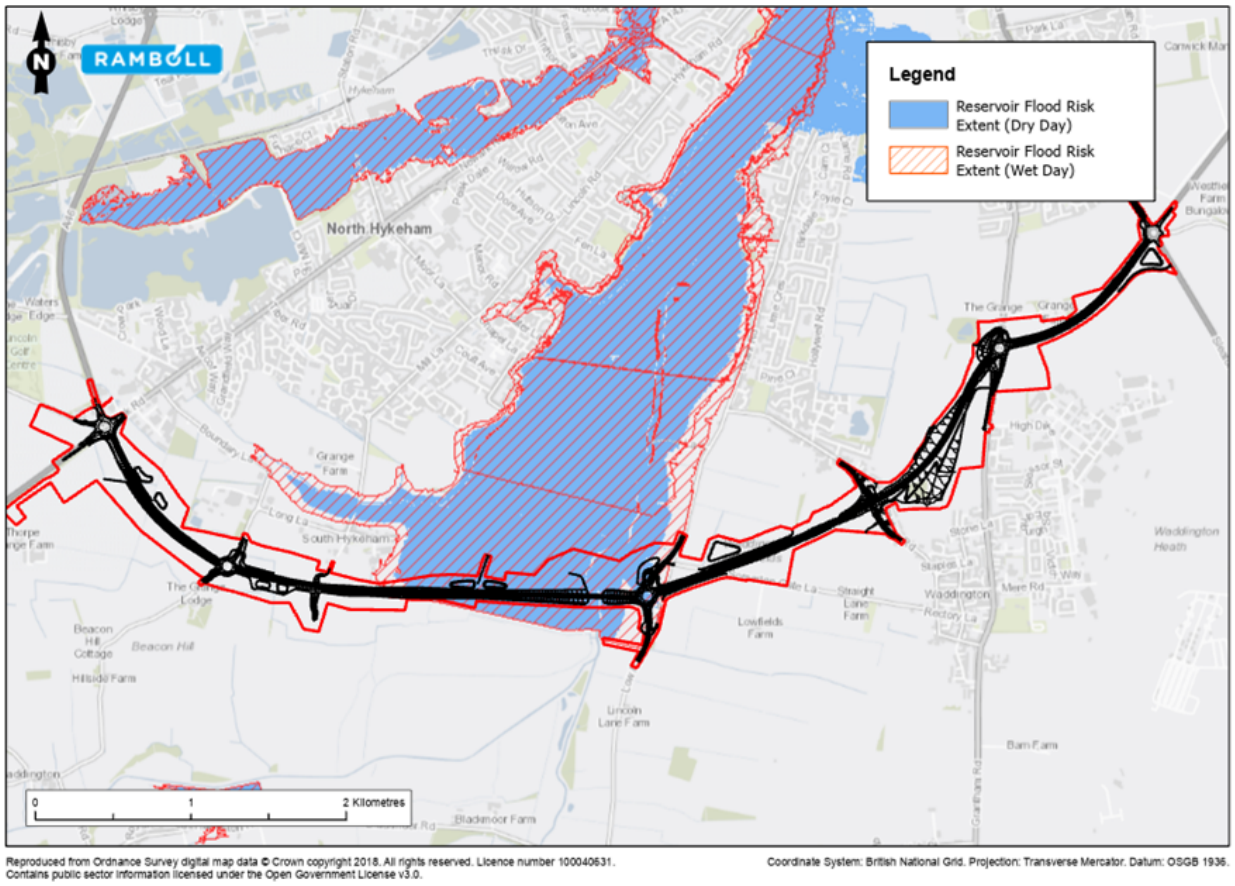


Figure 3-7 Reservoir Flooding Extents

3.11. Historical Flooding

3.11.1. According to Defra spatial data[13], the site has not experienced flooding historically. Fluvial flooding caused by the River Witham occurred upstream of the sluice gate and FSA embankment in November 2000. This covered a large area of 8.2 km^2 extending over 6 km south. Fluvial flooding caused by the River Witham, downstream of the site, occurred in March 1947 and covered 9.85 km^2, affecting much of central Lincoln. The latter was caused by an exceedance of channel capacity. At the time the current defences were not in place.

3.11.2. The historical flood outlines recorded by the EA are presented in Figure 3-8.

[12] UK Government (2022). Check the long term flood risk for an area in England, available at: https://www.gov.uk/check-long-term-flood-risk (accessed 06/2023)

[13] Defra Spatial Data Services Platform, Historic Flood Map, available at: https://environment.data.gov.uk/DefraDataDownload/?mapService=EA/HistoricFloodMap&Mode=spatial (accessed 06/2023)

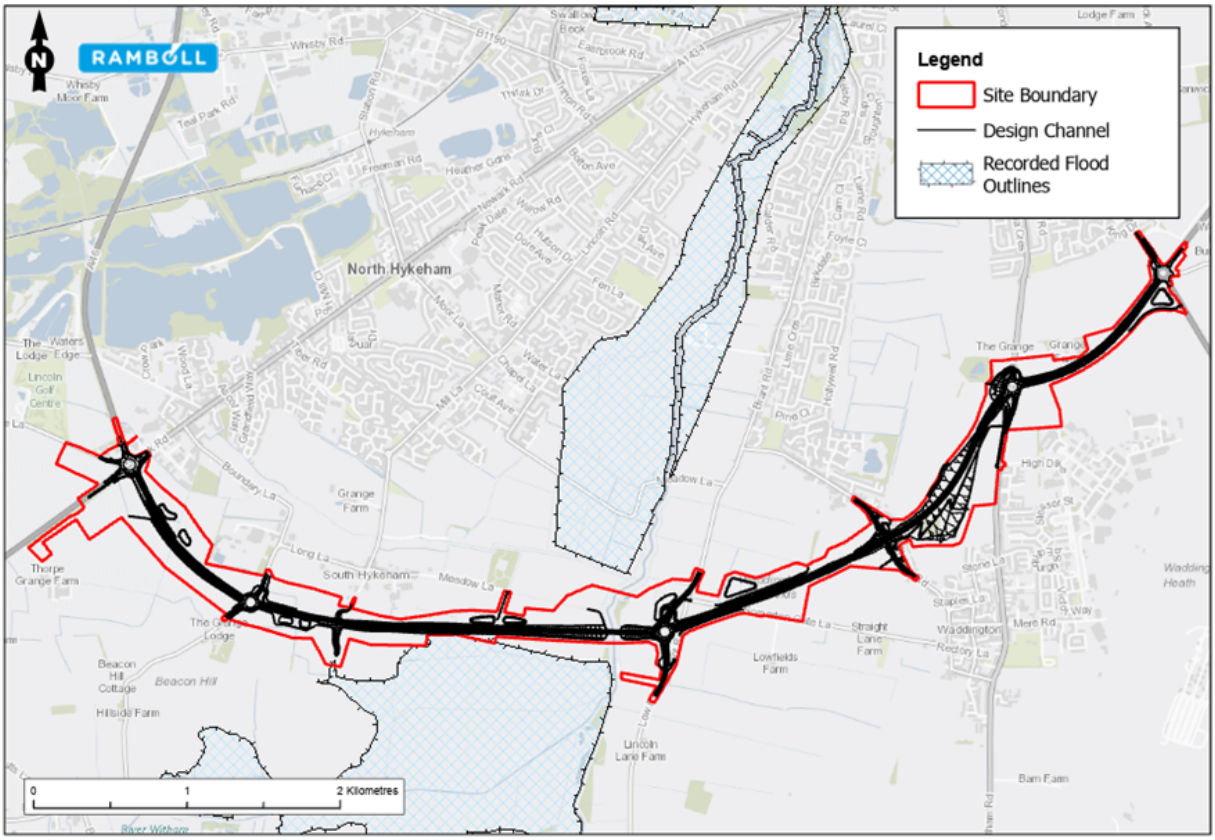


Figure 3-8 Historical Flooding Outlines

4. HYDRAULIC MODELLING

4.1. Background

4.1.1. To support this FRA, hydraulic modelling of the River Witham has been completed to determine potential risks from and to the Proposed Scheme. Full details of this model, including the methodology, are available in the NHRR Hydraulic Modelling report[14] prepared by Ramboll.

4.1.2. Following consultancy with the EA (Appendix 1), it was identified that the key concern relating to flood risk is how the Proposed Scheme could impact upon existing flood risk management arrangements, particularly the potential impact to/from the proposed NHRR structure should existing flood defences fail or be overtopped.

4.1.3. The modelling utilises 1D-2D ESTRY-TUFLOW software and simulated 1 in 100 year (1% AEP) and 1 in 1,000 year (0.1% AEP) events both with and without an appropriate allowance for climate change, following the latest Government Guidance[15]. The model also simulates breaches of the River Witham and FSA embankments.

4.2. Results

4.2.1. The following sections present modelling results for baseline and post-scheme (NHRR) 1 in 100 year + CC scenario model runs, with and without defence breaches. The results of all the simulated scenarios are included in Appendix 2. For reference, the minimum elevation for the road is 7.93 m AOD.

4.3. Without Breach

4.3.1. The baseline flood level reached 6.21 m AOD. When incorporated in the modelling, the Proposed Scheme is not predicted to flood under any of the scenarios modelled (including the 0.1% AEP event with an allowance for climate change). All flows were simulated to be conveyed under the proposed crossing or through an adjacent culvert supporting an IDB drain. In the 1 in 100 year with an allowance for climate change scenario, the Proposed Scheme maintains a freeboard of 1.57 m above the peak flood level of 6.36 m AOD.

4.3.2. The modelled depths are presented in Figure 4-1 and Figure 4-2.

[14] Ramboll (2023) North Hykeham Relief Road Hydraulic Modelling Report, report no. NHRR-RAM-EWE-HYKE-RP-LE-22003

[15] Gov.uk (2022) Flood risk assessments: climate change allowances, Peak river flow allowances, available at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#peak-river-flow-allowances (accessed 06/2023)

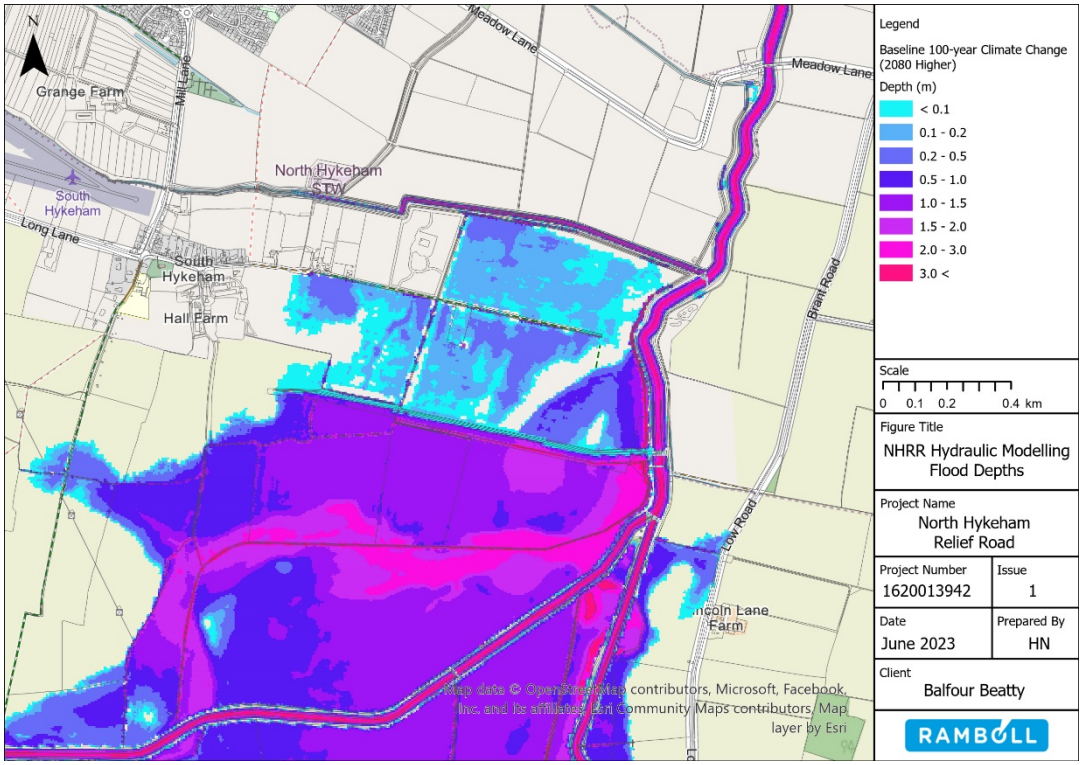


Figure 4-1 Baseline 1 in 100 year + CC flood depths

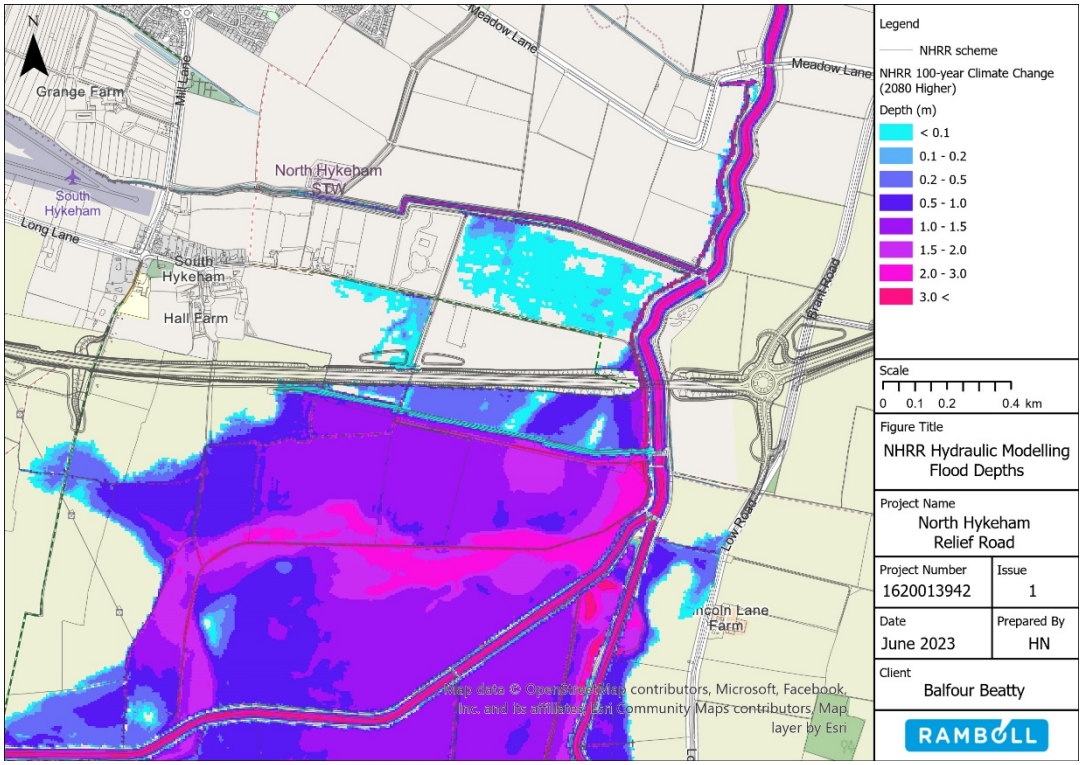


Figure 4-2 NHRR 1 in 100 year + CC flood depths

4.3.3. During the 100-year with an allowance for climate change event, the differences in flood extents as a result of the Proposed Scheme are marginal. The impact of the Proposed Scheme on flood depths is limited to the area upstream and downstream of the proposed crossing. The Proposed Scheme acts to prevent the northward spread of flood water overtopping the Witham Washland Defence, resulting in a reduction to the flood extents north of the proposed crossing and an increase to the flood extent to the south in the area between the NHRR crossing and the Witham Washland defence.

4.3.4. The difference in extents is illustrated below in Figure 4-3.

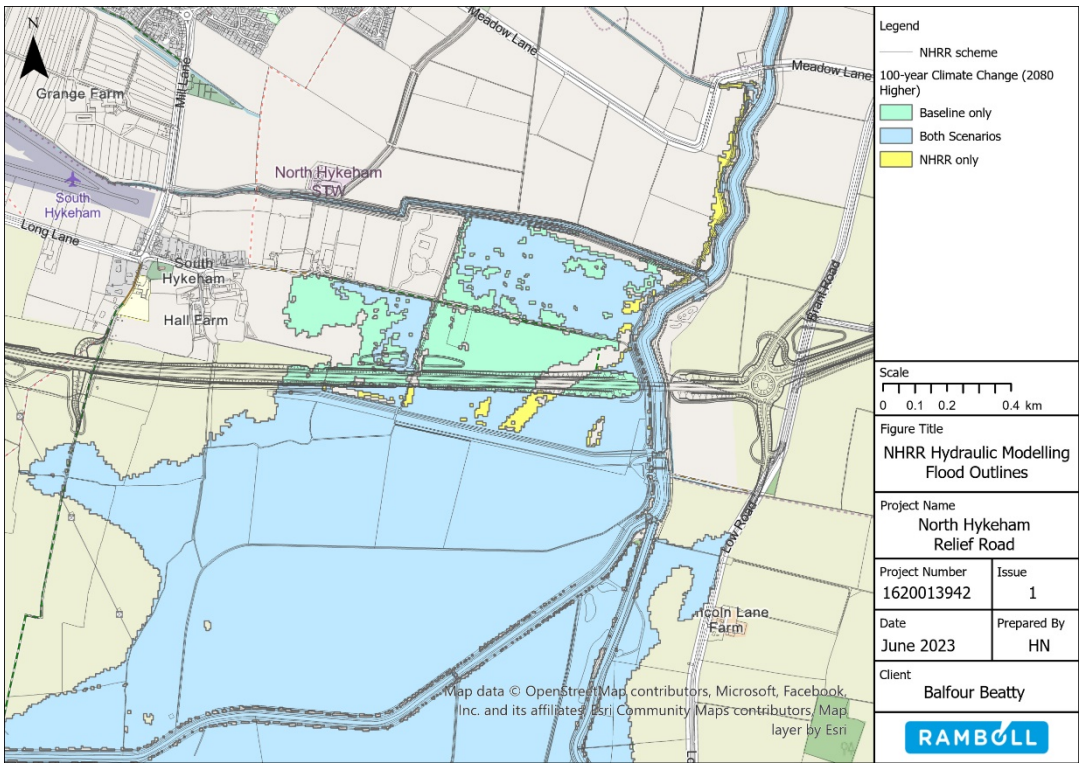


Figure 4-3 1 in 100 year + CC baseline and NHRR extent difference

4.3.5. The prevention of the spread of water overtopping the Witham Washland Defence also results in a lowering of te flood depths north of the proposed crossing between 20 mm to 100 mm and an increase to the flood depths to the south in the area between the proposed crossing and the Witham Washland defence by between 10 mm to 200 mm.

4.3.6. The water accumulating between the NHRR crossing and the Witham Washland defence during the 100-year plus climate change (Higher 2080) event passes north between the NHRR embankment and the existing river Witham defence under the proposed wide-span bridge. The water then spreads to the floodplain north of the NHRR crossing and into the IDB drain Hykeham Pump Drain South running parallel to the river Witham. This has been illustrated in Figure 4-4Figure 3-1. The additional water filling Hykeham Pump Drain South during the NHRR scenario compared to the baseline scenario causes an increase in flood depths of approximately 700 mm to the floodplain adjacent to Hykeham Pump Drain South north of the Beck.

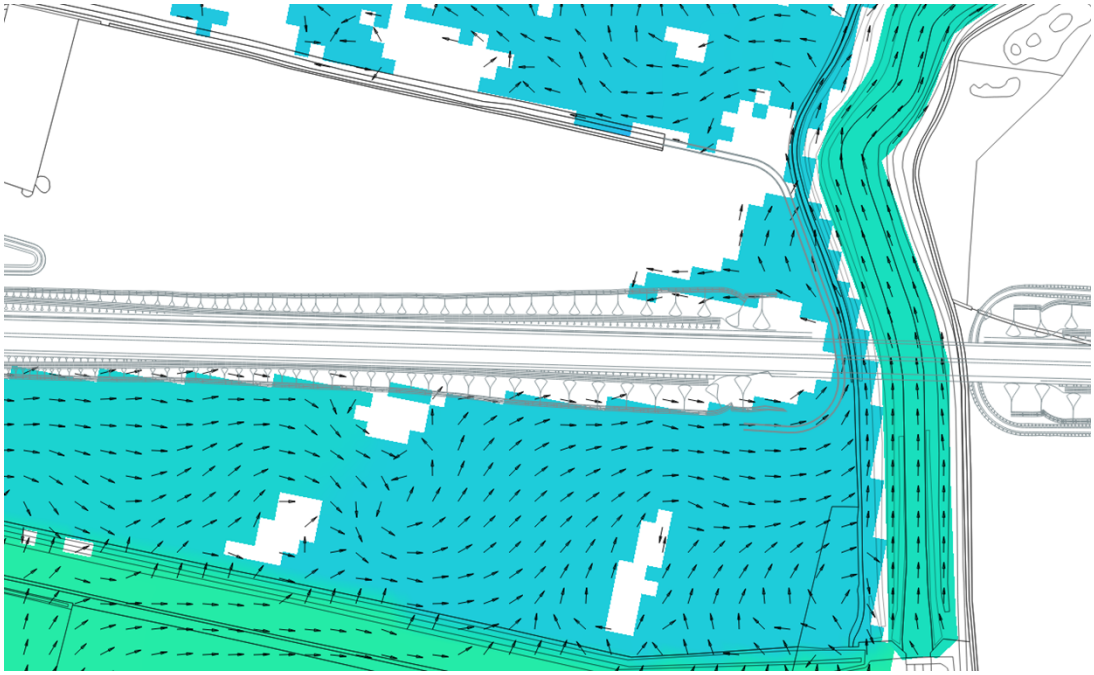


Figure 4-4: 1 in 100 year + CC flow direction

4.3.7. It should be noted that, despite the increase in depths and extents modelled, the changes in flood level/depth are considered acceptable on the basis of discussions held with the EA on 20/05/2022 (Appendix 1). It is the EA's opinion that the floodplain is passive by nature and that developments make no material difference to flood storage in the area for this reason.

4.3.8. The difference in depths is illustrated below in Figure 4-5.

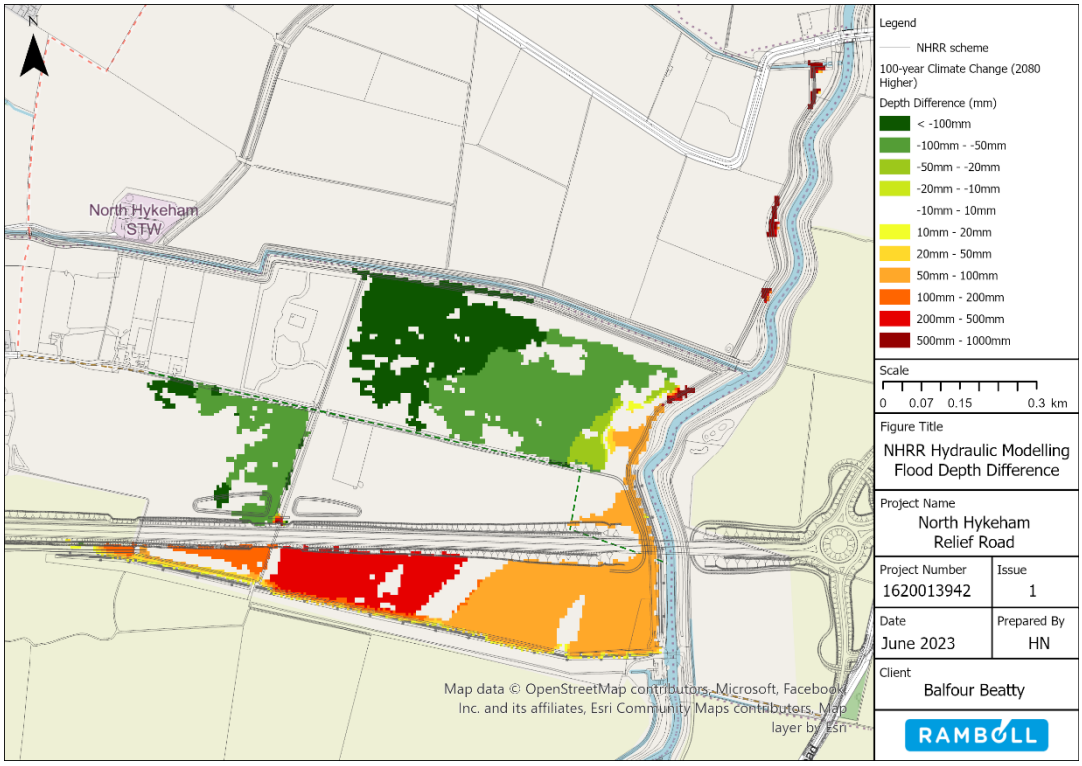


Figure 4-5 1 in 100 year + CC baseline and NHRR depth difference

4.4. River Witham Defence Breach (NHRR BREACH RWUS)

4.4.1. In the event of a breach of the River Witham's defences, flood waters pass from the River Witham into the floodplain and fill the area between the Witham Washland Defence and the embankment of the Proposed Scheme. The main pathway of flood flows in this area passes north-west towards the proposed crossing, opening to fill the floodplain to the north of the Proposed Scheme.

4.4.2. The Proposed scheme was not flooded in any of the simulated scenarios. In the 1 in 100 year with an allowance for climate change event including a breach in the River Witham's defences, the Proposed Scheme maintains a freeboard of 1.07 m above a flood level of 6.86 m AOD.

4.4.3. The 1 in 100 year with an allowance for climate change **River Witham defence breach scenario** is presented in Figure 4-6.

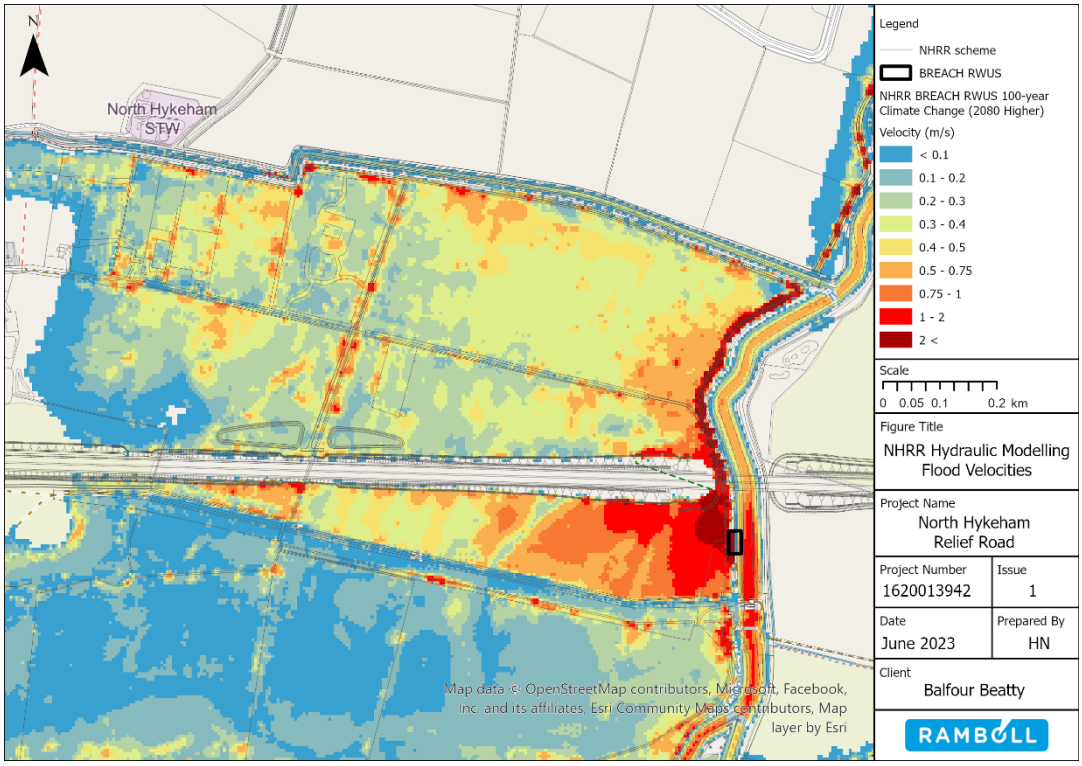


Figure 4-6 100-year plus climate change (Higher 2080) flood velocities for the NHRR BREACH RWUS scenario

4.5. Witham Washland Defence Breach (NHRR BREACH FSA)

4.5.1. In the event of a breach in the FSA embankment, all flows are conveyed under the Proposed Scheme during all events simulated. Additionally, the Proposed Scheme was not flooded in any of the simulated event scenarios. In the 1 in 100 year with an allowance for climate change event with a breach in the FSA embankment, the Proposed Scheme maintains a freeboard of 0.73 m above a flood level of 7.19 m AOD.

4.5.2. The 1 in 100 year with an allowance for climate change **Witham Washland Defence breach scenario** is presented in Figure 4-7

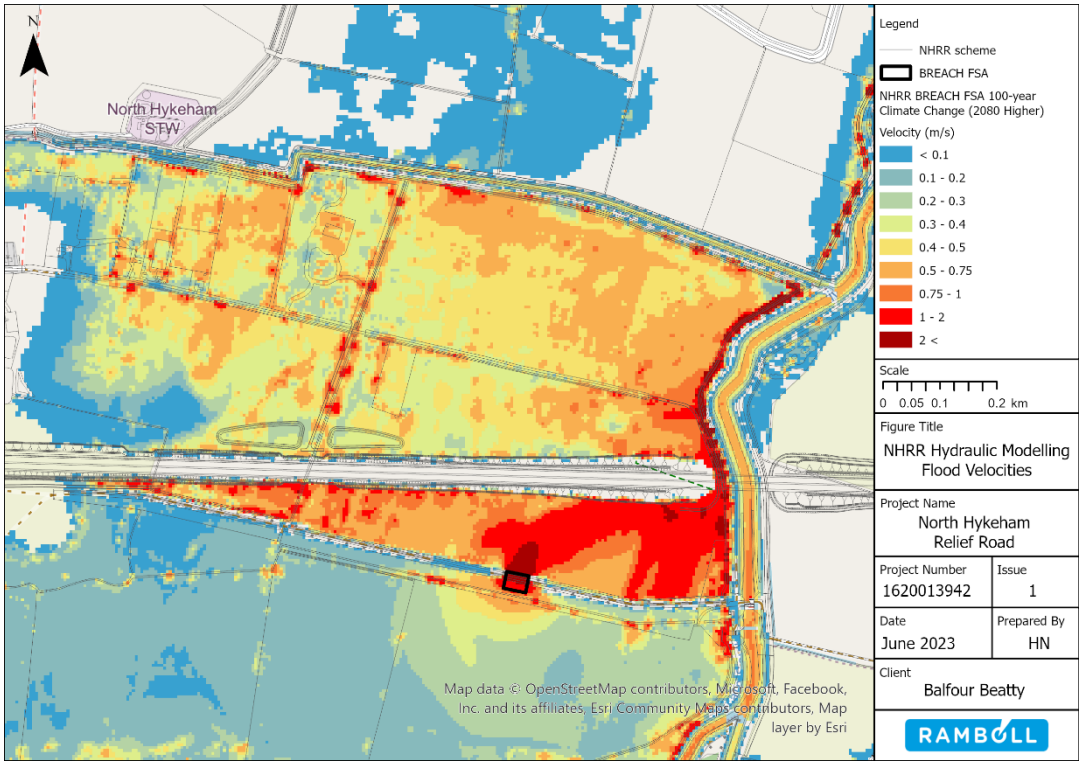


Figure 4-7 100-year plus climate change (Higher 2080) flood velocities for the NHRR BREACH FSA scenario

5. ASSESSMENT OF FLOOD RISK

5.1. Flood Risk Vulnerability

5.1.1. The Proposed Scheme is considered 'Essential infrastructure' under Annex 3 of the NPPF[16].

5.2. Sequential Test

5.2.1. Due to the nature of the Proposed Scheme it has to cross Flood Zones 2 and 3 and there are no reasonably-available routes within Flood Zone 1. According to Table 2 (Flood risk vulnerability and flood zone 'incompatibility') in the Planning Practice Guidance to NPPF[17] the Exception Test must therefore be applied to the Proposed Scheme.

5.3. Exception Test

5.3.1. For the Exception Test to be passed, it must be demonstrated that:

- the development would provide wider sustainability benefits to the community that outweigh the flood risk; and
- the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall

5.3.2. The Proposed Scheme was identified as being a top priority Lincoln Transport Strategy [18]. According to the strategy:

"The dual carriageway will link the A46 Pennell's Roundabout to the A15 at the new Lincoln Eastern Bypass roundabout, providing an east-west route for local and strategic traffic. It will help to reduce rat-running, improve resilience and route choice, reduce traffic and congestion on the existing network and unlock land allocated for the South."

5.3.3. The Proposed Scheme will therefore provide sustainability benefits to the wider community and, in line with the findings of this FRA discussed in the sections below, the Proposed Scheme will be safe without increasing flooding elsewhere. The Exception Test is therefore considered passed.

5.4. Mitigation Measures

Fluvial Flooding

5.4.1. The EA's Flood Map for Planning shows the Proposed Scheme crosses Flood Zones 2 and 3, the latter indicating a high risk of fluvial flooding. However, flood defences are not taken into account when determining the extent of risk. Flood defences are present in the vicinity and are designed to defend against a 1% AEP event. Additionally, the site-specific fluvial flood modelling undertaken by Ramboll has established the Proposed Scheme road level will have at least 1.57 m freeboard above the 1 in 100 with an allowance for climate change event without a defence breach and 0.73 m freeboard in the event of a breach of the FSA embankment. Risks to the Proposed Scheme are therefore acceptable under the design flood scenarios and a suitable minimum freeboard of at least 600 mm is maintained.

[16] Gov.uk (2012) National Planning Policy Framework, Annex 3: Flood Risk Vulnerability Classification, available at: https://www.gov.uk/guidance/national-planning-policy-framework/annex-3-flood-risk-vulnerability-classification (Accessed 06/2023)

[17] Gov.uk (2014) Planning Practice guidance: Flood Risk and Coastal Change https://www.gov.uk/guidance/flood-risk-and-coastal-change (accessed 06/2023)

[18] Lincolnshire County Council, Lincoln Transport Strategy 2020-2036, available at: https://www.lincolnshire.gov.uk/directory-record/64728/lincoln-transport-strategy (accessed 06/2023)

5.4.2. Ordinarily, flood compensatory storage would be a requirement per EA guidelines. However, the River Witham floodplain is passive by nature of the topography. Additionally, it was noted by the EA in a meeting held with Ramboll on 20/05/2022 (meeting minutes attached in Appendix 1) that developments make no material difference to flood storage in the area for this reason. The areas where flood depths are predicted to increase are agricultural land and therefore low vulnerability. These areas are already predicted to flood to a significant depth during a range of return period events so the increase would not materially change the hazard, and the frequency of flooding would also not change. There is no requirement to provide compensatory storage for the Proposed Scheme and fluvial flooding mitigation has therefore not been deemed necessary.

Surface Water Flooding

5.4.3. The increase in impermeable surface area resulting from the construction of the road will lead to a corresponding increase in surface water discharge, potentially increasing surface water flooding risk at the site and to downstream receptors. To collect and mitigate surface water discharges, a drainage strategy has been developed for the Proposed Scheme, detailed in the Drainage Strategy Report prepared by Ramboll (document ref. NHRR-RAM-HFG-HYKE-RP-CD-05003). The following paragraphs provide a summary though the full strategy report should be read in conjunction with this FRA.

5.4.4. The drainage strategy divides the Proposed Scheme into multiple drainage catchments. Surface water runoff from the road is to enter swales at the verge or concrete surface water channels (CSWCs) within the central reservation. Surface water is then conveyed to proposed attenuation basins before discharge at an agreed discharge rate to the Beck and River Witham. In the easternmost drainage catchment, adjacent to the proposed roundabout connection with the A15, the runoff enters a grassed surface water channel (GSWC) for pollution mitigation, and a proposed infiltration basin for discharge to ground as the underlying geology was considered suitable.

5.4.5. The drainage is designed based on guidance set out by the Design Manual for Roads and Bridges (DMRB). This guidance stipulates no surcharge for a 1 in 1-year AEP rainfall event for the drainage system, no flooding for a 1 in 5-year AEP rainfall event and no flooding beyond the highway boundary up to the 1 in 100-year AEP rainfall event including an allowance for climate change. The proposed attenuation basins have been sized to accommodate the 1 in 100 years plus climate change (40%) event. Discharge is to be controlled at a 1.4 L/s/ha rate when over-pumped to the River Witham, or at greenfield rate when discharging to a watercourse which runs directly to the Witham, and subject to agreement with the IDB.

5.4.6. With the drainage strategy implemented, it is expected that additional surface water flood risk arising from the Proposed Scheme is effectively mitigated. Additionally, existing surface water flood risk shown in the EA mapping, which does not take into account the presence of drainage infrastructure, is also expected to be mitigated as a result.

Groundwater Flooding

5.4.7. The risk of groundwater flooding to the Proposed Scheme, in the absence of more detailed groundwater monitoring, is considered low based on currently-available information. The nature of the local topography and hydrology is such that groundwater emerging at the surface is likely to ether enter an IDB drain (and eventually the River Witham) or accumulate in surface depressions. The design of roads surfaces is such that water is not permitted to accumulate without entering surface water drainage. Groundwater flooding mitigation has therefore not been deemed necessary.

Reservoir Flooding (Breach Analysis)

5.4.8. Reservoir failures resulting in flooding are infrequent occurrences, and the integrity of reservoirs are regularly inspected by the EA. Nevertheless, a potential breach of the FSA/reservoir embankment has been modelled. The results of the modelling determined the Proposed Development would not flood in the event of a breach in the FSA embankment. Flooding mitigation relating to reservoir flooding has therefore not been deemed necessary.

5.5. Summary

5.5.1. The assessment of flood risk to the Proposed Scheme and resulting from the Proposed Scheme is deemed acceptably low, with no mitigation beyond implementation of the surface water drainage strategy deemed necessary.

6. CONCLUSIONS

6.1.1. Based on the findings of this Flood Risk Assessment and in consideration of the recommendations made, it is concluded that any flood risk is appropriately managed over the lifetime of the Proposed Scheme, taking climate change into account and fittingly for the vulnerability of proposed users.

6.1.2. The Proposed Scheme is therefore considered suitable under the requirements of the NPPF and no further flood risk assessment is deemed necessary.

APPENDIX 1
MEETING MINUTES

MINUTES OF MEETING

Project name	**North Hykeham Relief Road**
Project no.	**1620013942**
Subject	**Water Environment**
Meeting date	**20/05/2022**
Location	**Online**
Meeting no.	**1**
Taken by	**Steve Cox**
Participants	Adam Lakin (AL) – Bentley Project Management on behalf of Lincolnshire County Council Andy Marginson (AM) – Ramboll, Structures Lead Gareth Dickinson (GD) – Balfour Beatty, Design Manager John Ray (JR) – Environment Agency, Flood Risk Senior Advisor Steve Cox (SC) – Ramboll, Water Environment Lead
Absent	-
Copy to	All above

Minutes of Meeting

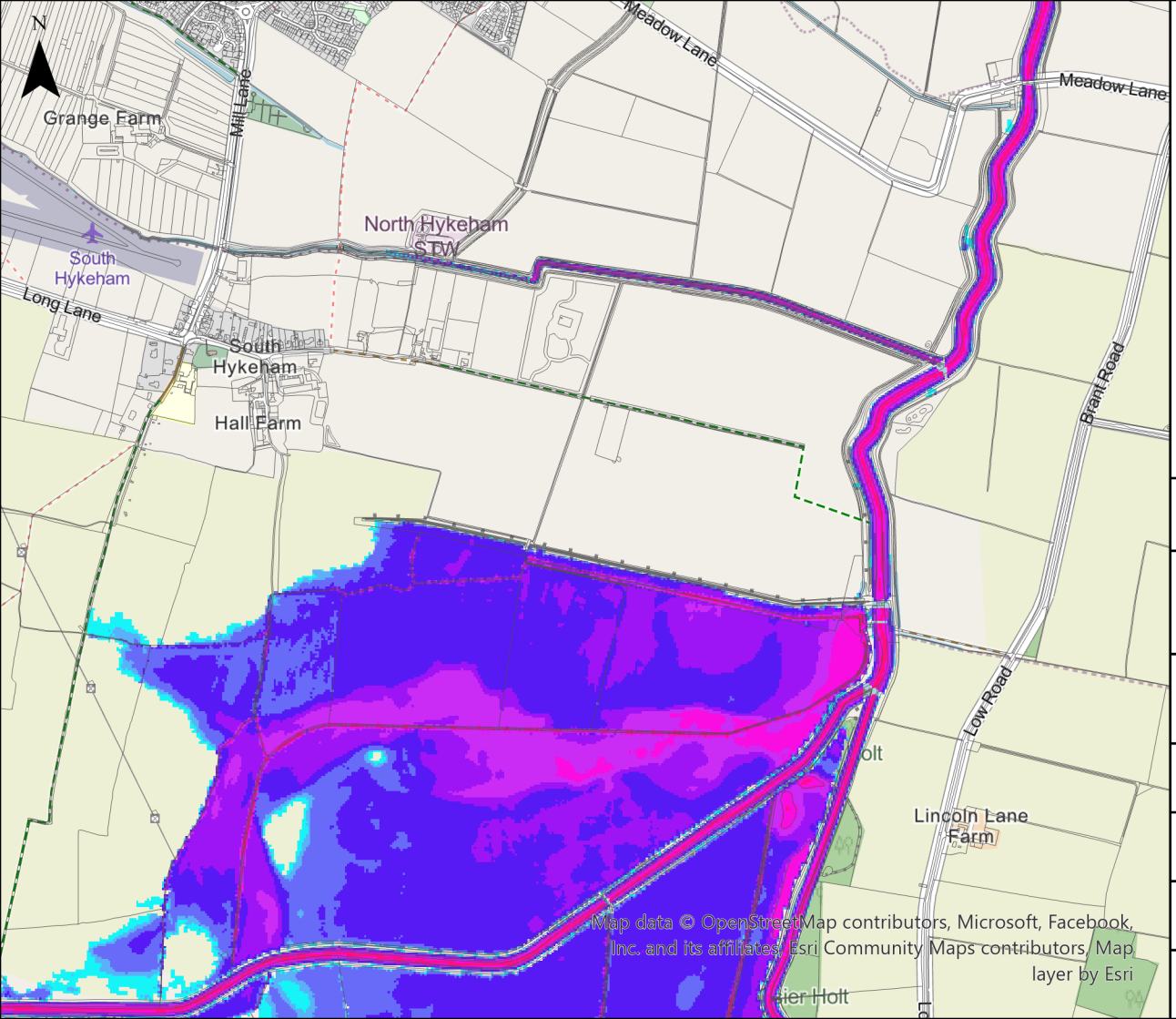
No.	Item	Action by
1	Meeting was called to ensure engagement with the EA at an early stage in order to understand the EA's main concerns and requirements with regard to the water environment, particularly flood risk.	
2	JR's team will do the permitting with regard to the NHRR bridges and structures around the washlands.	
3	JR will be key EA contact for flood risk. The EA Sustainable Places team will be involved with respect to water quality and groundwater.	
4	All parties keen for regular liaison as the design progresses. GD to suggest a schedule for meetings with JR and his team. JR suggested a small technical group could be put together.	GD
5	JR noted that the impacts of the scheme may be greater for the Internal Drainage Board (IDB). Key contact for the IDB is Guy Hird. AL noted that the IDB have provided specific information on their requirements. IDB ditches will need to be continued under/through the new NHRR embankment. There are IDB channels on either side of the River Witham embankment paralleling the river.	
6	JR described the current flood storage arrangement just south (upstream) of the scheme. There are raised defences along the banks of the River Witham and a raised defence perpendicular to the Witham on the west side. This latter defence creates a flood storage area. There is a control structure on the Witham adjacent to the perpendicular defence. If Lincoln is expected to flood the side gates are opened to allow water to flood into the storage area. If the river keeps rising then the control structure can be raised to further reduce flood risk.	

	The storage area has sufficient volume for it to be classified under the Reservoirs Act. The embankment retaining the storage area is designed for a 1% AEP flood. This embankment is designed to withstand overtopping and includes a concrete capping beam. The river embankments were raised in the early 1990s. They are subject to vegetation growth and burrowing animals which may have reduced their ability to withstand a breach/erosion. During a flood in November 2019 the storage area reached ~80% full. The max water depth in the storage area is only around 1.5 m. There is a further embankment running east-west along a ditch further downstream (and north of the proposed NHRR). This may retain some additional floodwater.	
7	Key considerations which will need to be demonstrated to the EA concern what happens when the flood storage embankment fails or, more likely, overtops in an exceedance event. • Does the water get trapped behind the proposed NHRR? • Might the embankment be eroded and/or the river embankments affecting their integrity? • Can the exceedance and breach flow be conveyed under the NHRR without risk to road users and exacerbating erosion of the flood retaining embankments? • How many / what size of flood conveyance culverts will be required through the NHRR embankment? JR noted that constructing a complex hydraulic model of the NHRR may not be necessary to answer the above questions. It may be sufficient to do empirical calculations demonstrating sufficient conveyance of flow through the NHRR. The recently completed Lincoln Eastern Bypass (LEB) included a bridge over the River Witham further downstream. JR envisaged a similar design for the proposed NHRR bridge. While the impacts of the NHRR bridge do of course need to be considered, they are not likely to be the main focus with regard to flood risk impacts. Residential estates in North Hykeham are slightly raised and the EA are confident that these are not currently at risk of fluvial flooding. There is only one property in the 0.1% AEP flood zone downstream of the storage area (the IDB depot). The reservoir embankment is inspected (as required by the Reservoirs Act). The inspector is David Rebollo from Mott MacDonald.	
8	AL noted that farmland severed by the NHRR may need to be reconnected and underpasses may be an option. The underpasses could also have a dual purpose of conveying flood flows.	

	JR noted that the road would not need to be too high above existing ground level for flood resilience but could of course be higher if required for other reasons.	
9	Compensatory storage. JR stated that because of the topography, the floodplains are passive (only in play if major incident) such that developments make no material difference to flood storage. There would therefore be no requirement to provide compensatory storage. Similarly, compensatory storage was not required for the LEB. JR considered that one design option could be for the road embankment to deliberately retain floodwater and create additional storage.	
10	The current hydraulic model for the area is the Upper Witham Infoworks model (2015). It is a 1D/2D model. Infoworks was chosen in 2006 as the favoured software but it is recognised that this is now not the case. The d/s boundary is in the centre of Lincoln at the confluence with the River Till. The current model contains a notable 0.5 m error at the downstream boundary. An update of the Upper Witham model is to be commissioned but there have been some delays appointing one of the three framework consultants so the update has not yet commenced. JR is still hopeful that the update can be completed in the autumn of 2022. If necessary, JR can point out the main errors in the existing model. The model (current and to be updated) covers a very large area – most of the Upper Witham to near Grantham. JR noted that this would be a much larger area/model than would be needed for assessing the impacts of the NHRR. The downstream flow restriction is primarily where the A1434 crosses the Witham in the Bracebridge area of Lincoln. The EA model update will: • Convert the model to Flood Modeller Pro (FMP) • Automate the control structures • Incorporate some survey that has already been undertaken from the storage area to the downstream boundary. The EA will ask the framework consultant undertaking the update to revisit the flows in the model but not necessarily update them. JR noted that if the reservoir engineer requires that the 1-in-10,000 year event or the Probable Maximum Flood (PMF) (i.e. the limit of the credible worst case) dictates the design, then changes to flow during more frequent events will be relatively small and immaterial in comparison.	
11	Tidal influence. JR noted this was at most a few millimetres and was built into the downstream boundary of the model where there is a sluice to retain water	

	to enable navigation. Tidal influence would not need to be considered in any modelling for the NHRR.	
12	NHRR Programme. BB/Ramboll surveys are due to commence in the next two to three months, with the hydraulic modelling programmed to start around September 2022. The modelling for the NHRR, and the EIA which relies on it, will need to be complete by ~April 2023 in order to meet the autumn 2023 target date for planning submission.	
13	GD said that BB/Ramboll would produce a Design Input Plan. Workshop perhaps. Set out the parameters at the beginning of the project so all parties know what is required, thereby reducing the likelihood of late requests which are difficult to accommodate.	GD
14	Groundwater. A brief discussion was held around groundwater and the presence of the Source Protection Zone (SPZ) to the east on the limestone geology. The LEB also crosses the SPZ and includes a large basin adjacent to the roundabout between Branston and Canwick. It is not known whether this is a soakaway or whether it discharges to a small surface water stream. GD noted that he has the detailed drainage drawings for the LEB and would provide these to SC. The water utility provider in the area is Anglian Water.	GD

APPENDIX 2
FLOOD MODEL OUTPUTS



Legend

Baseline 100-year

Depth (m)

- < 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 <

Scale

0 0.1 0.2 0.4 km

Figure Title

NHRR Hydraulic Modelling Flood Depths

Project Name

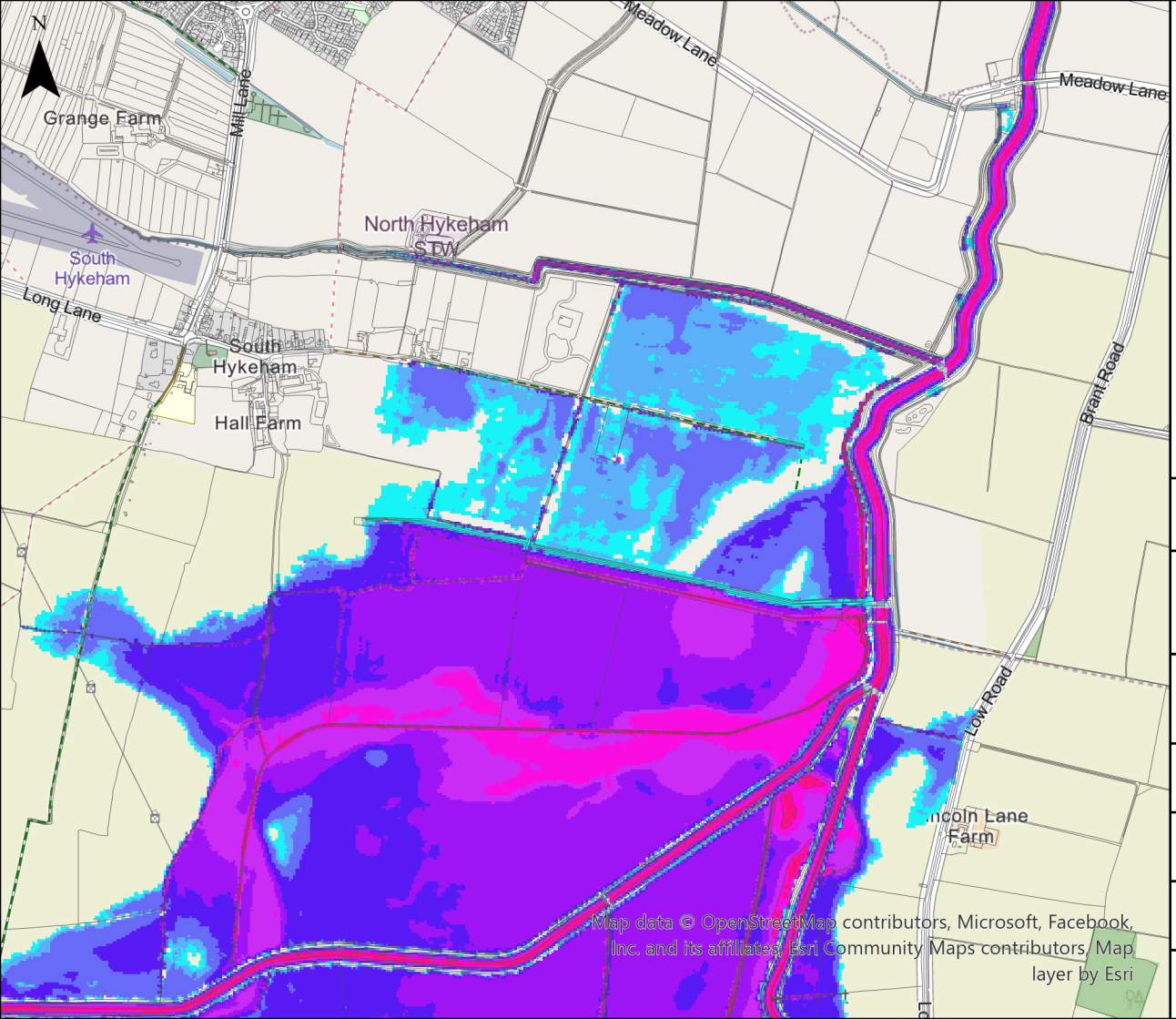
North Hykeham Relief Road

Project Number	Issue
1620013942	1
Date	Prepared By
June 2023	HN

Client

Balfour Beatty

RAMBOLL



Legend

Baseline 100-year Climate Change (2080 Higher)

Depth (m)

- < 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 <

Scale

0 0.1 0.2 0.4 km

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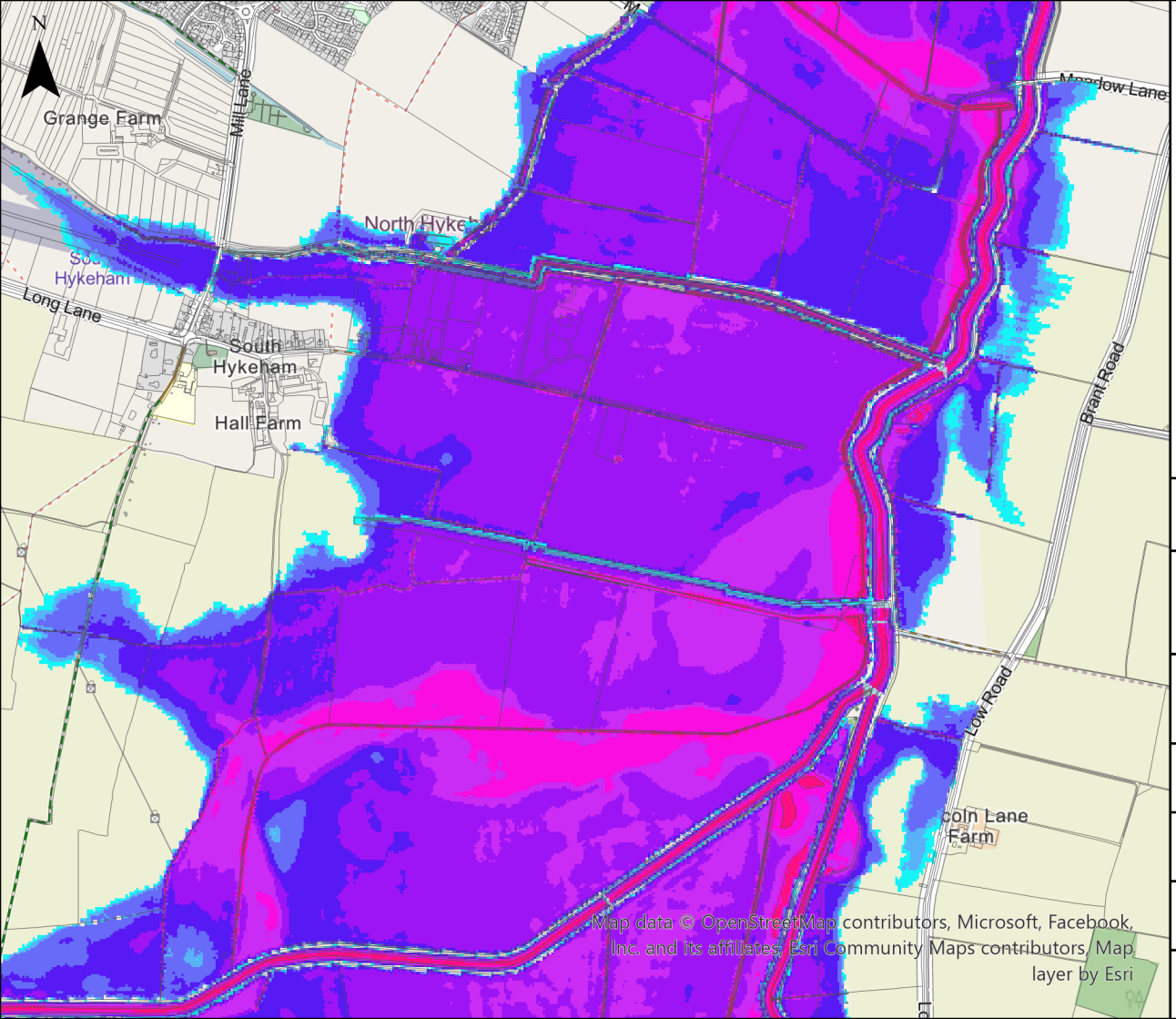

Legend

Baseline 1000-year

Depth (m)

- < 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 <

Scale

0 0.1 0.2 0.4 km

Figure Title

NHRR Hydraulic Modelling Flood Depths

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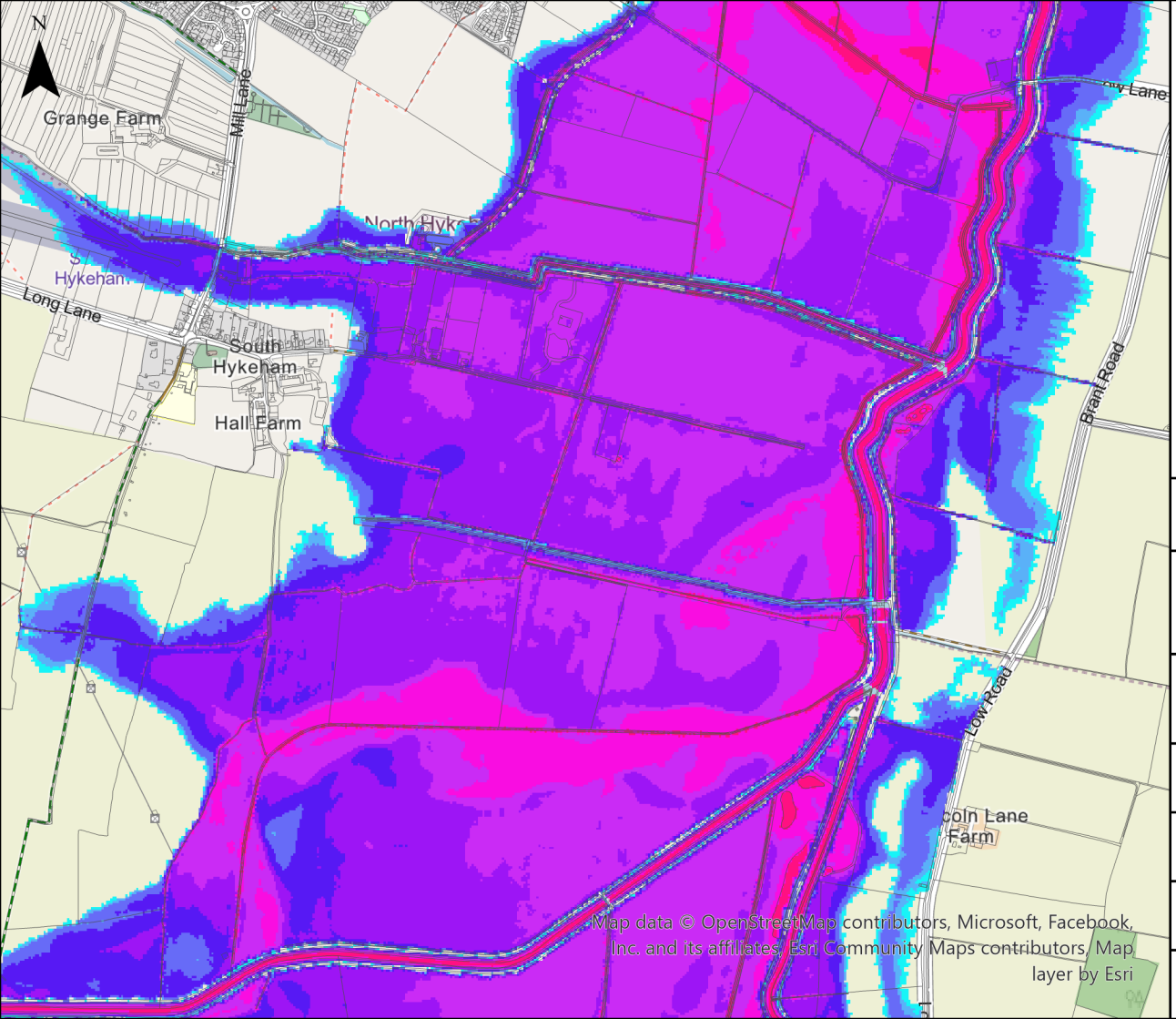

Legend

Baseline 1000-year Climate Change (2080 Higher)

Depth (m)

- < 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 <

Scale

0 0.1 0.2 0.4 km

Figure Title

NHRR Hydraulic Modelling Flood Depths

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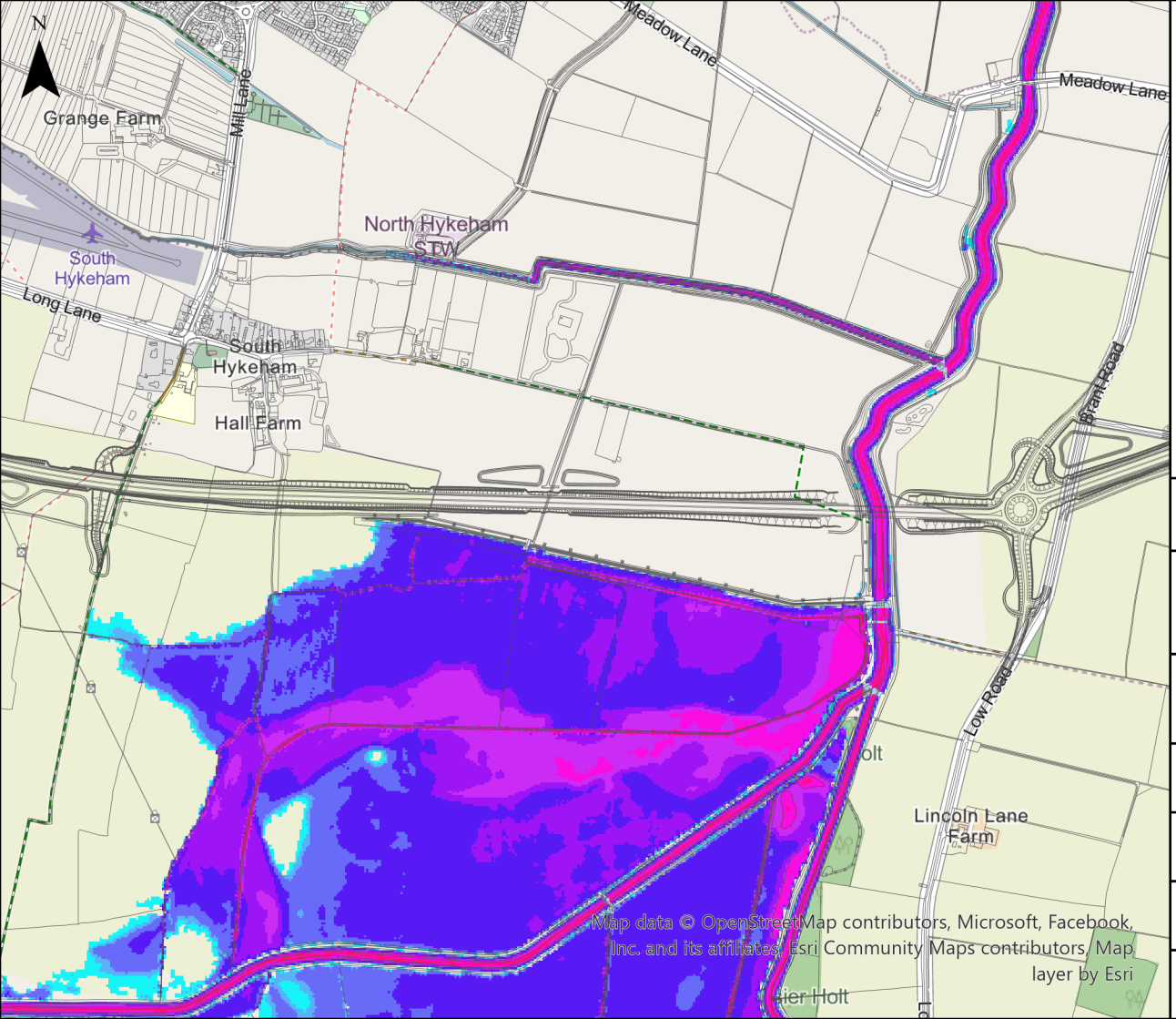

Legend

NHRR scheme

NHRR 100-year

Depth (m)

- < 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 <

Scale

0 0.1 0.2 0.4 km

Figure Title

NHRR Hydraulic Modelling Flood Depths

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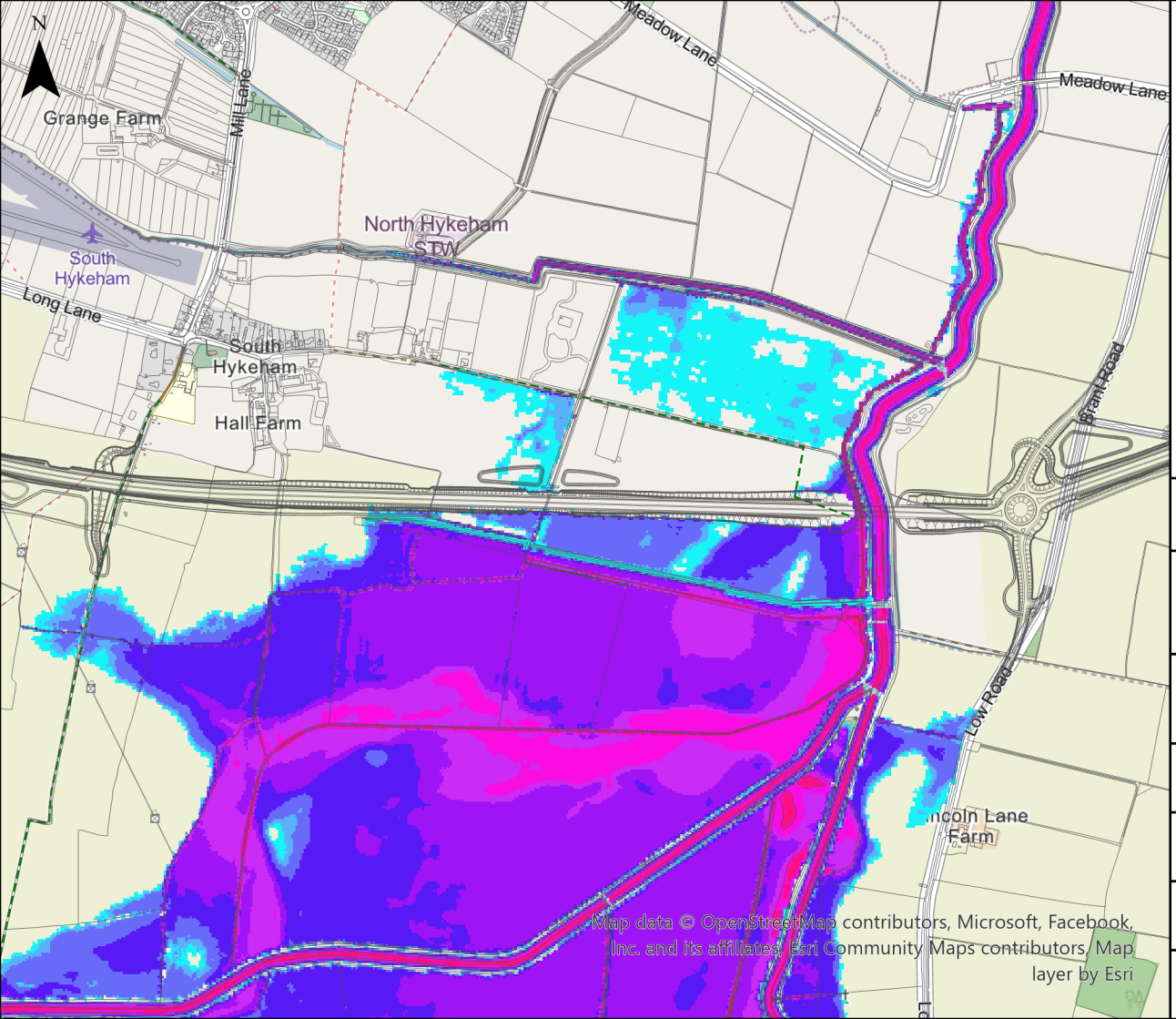
RAMBOLL



Legend

NHRR scheme

NHRR 100-year Climate Change (2080 Higher)

Depth (m)

- < 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 <

Scale

0 0.1 0.2 0.4 km

Figure Title

NHRR Hydraulic Modelling Flood Depths

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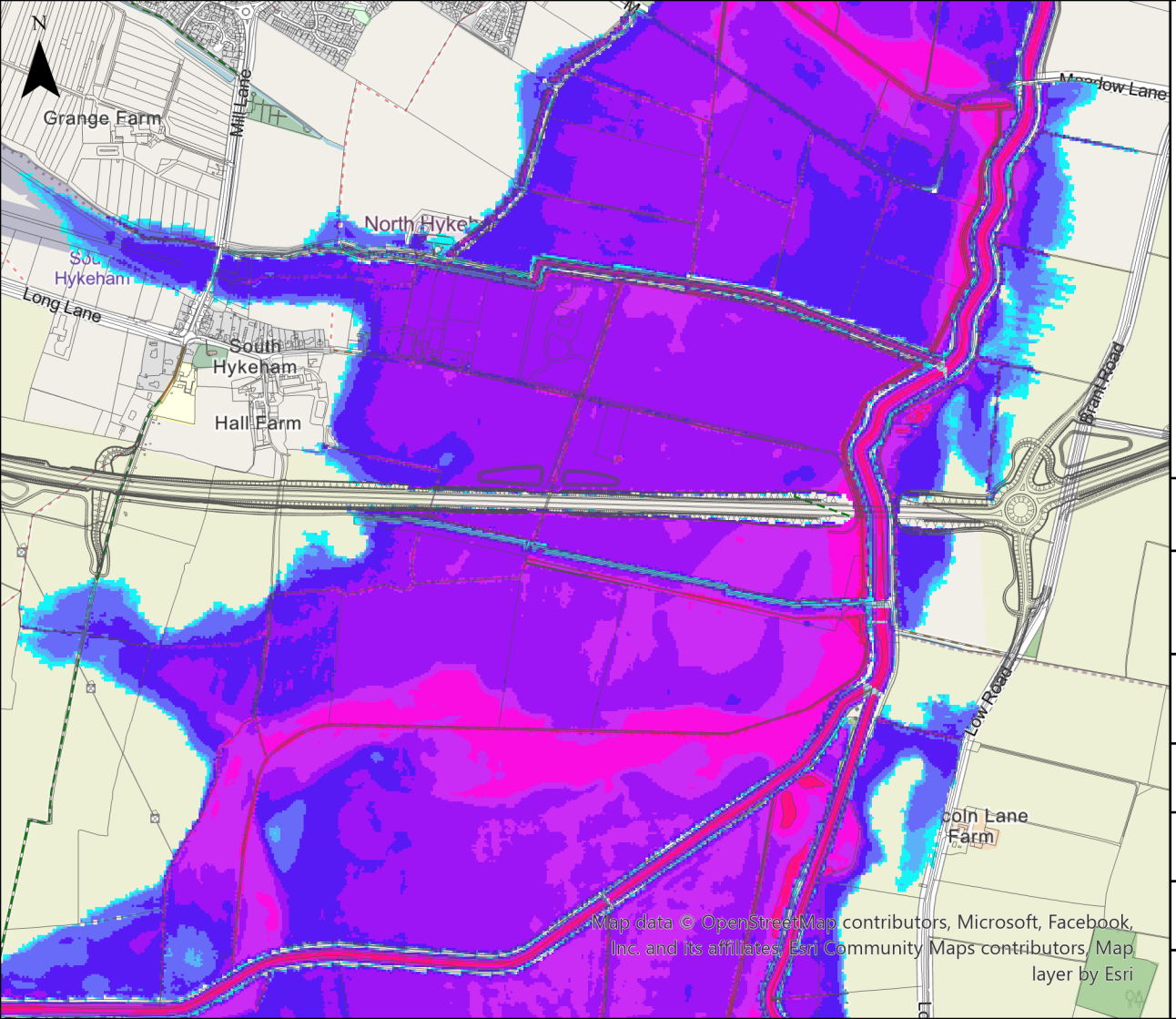
Balfour Beatty

RAMBOLL



Legend

NHRR scheme

NHRR 1000-year

Depth (m)

- < 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 <

Scale

0 0.1 0.2 0.4 km

Figure Title

NHRR Hydraulic Modelling Flood Depths

Project Name

North Hykeham Relief Road

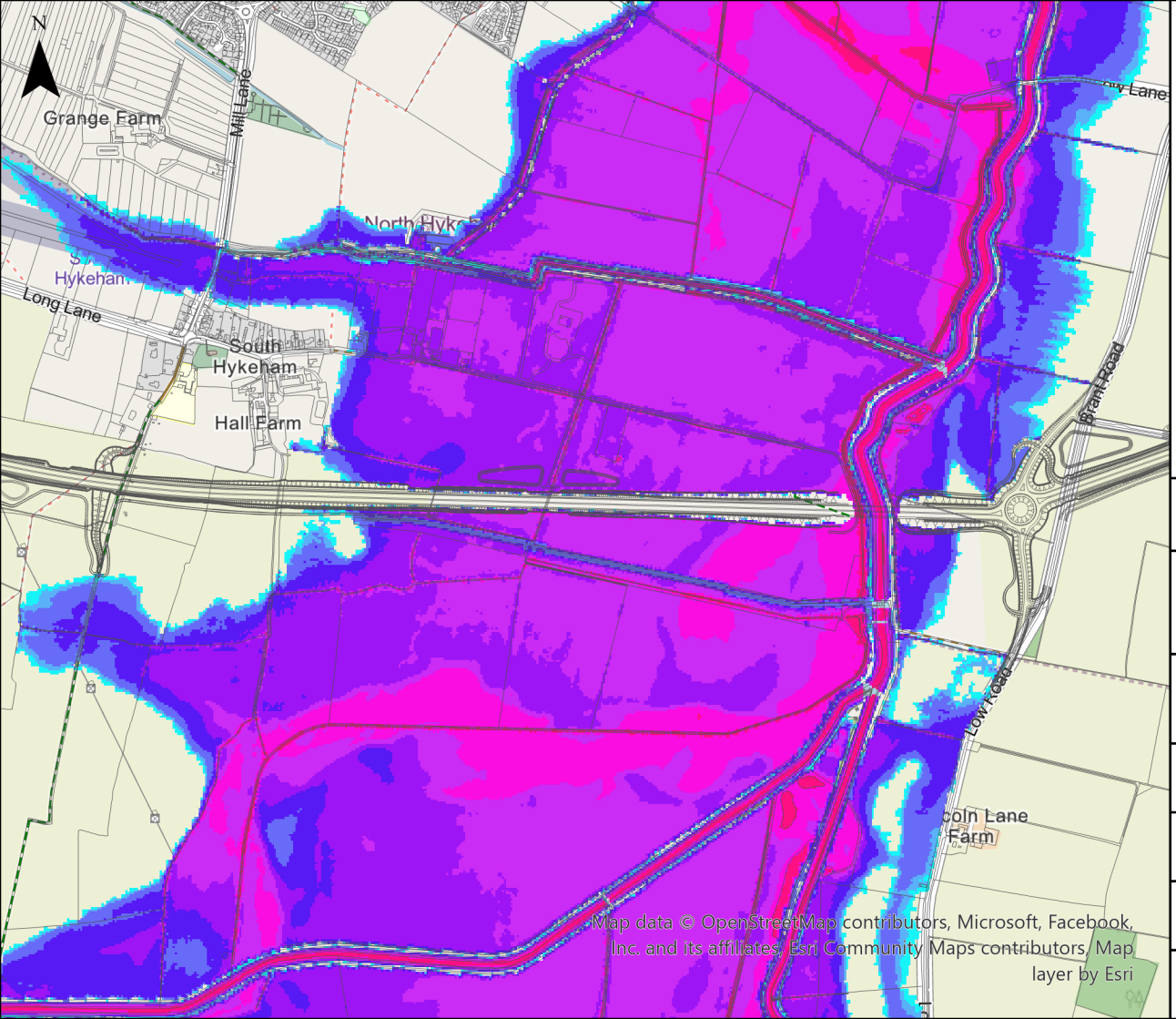
Project Number	Issue
1620013942	1

Date	Prepared By
June 2023	HN

Client

Balfour Beatty

RAMBOLL



Legend

NHRR scheme

NHRR 1000-year Climate Change (2080 Higher)

Depth (m)

- < 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
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0 0.1 0.2 0.4 km

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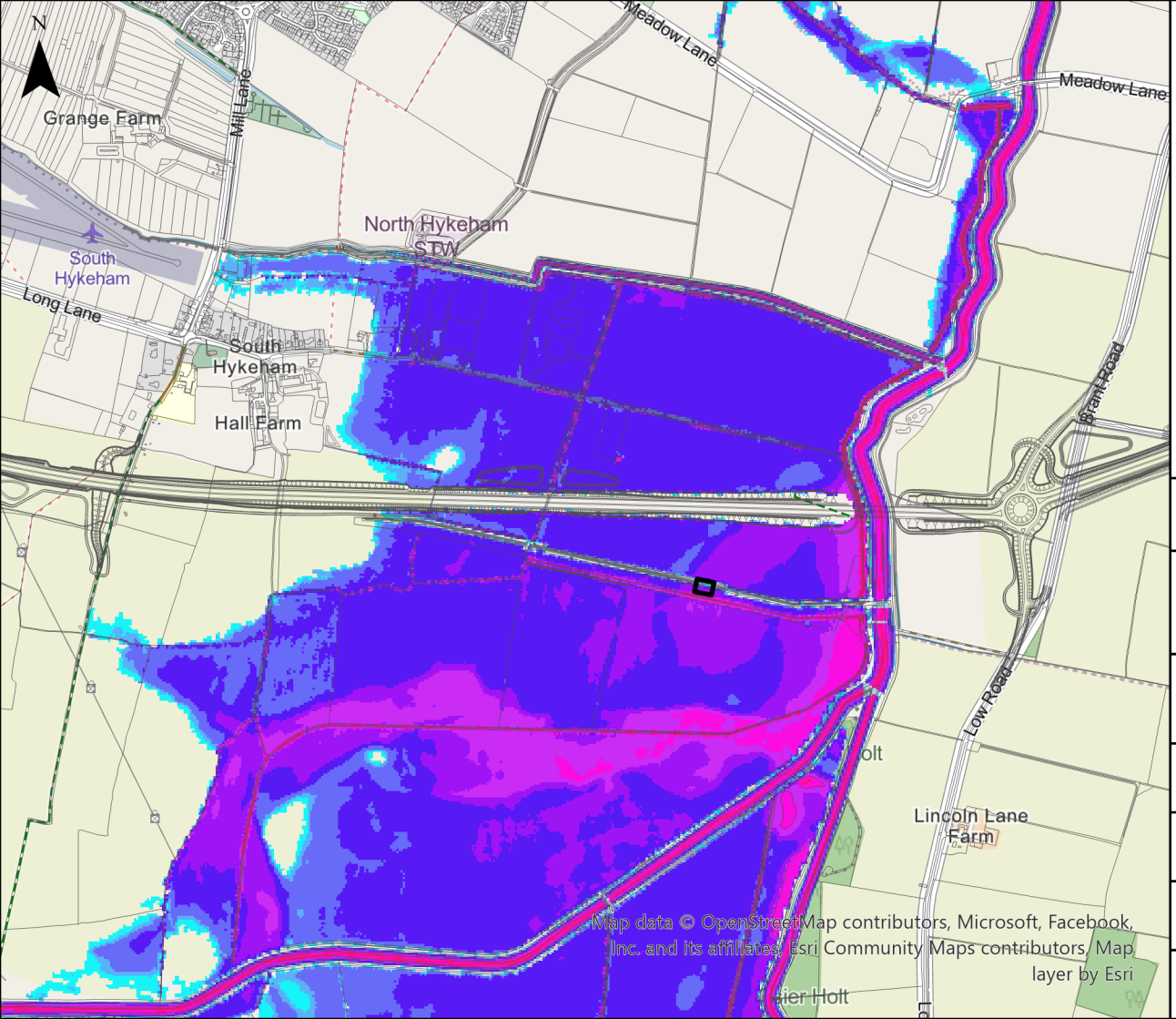

Legend

NHRR scheme

BREACH FSA

NHRR BREACH FSA 100-year Depth (m)

- < 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 <

Scale

0 0.1 0.2 0.4 km

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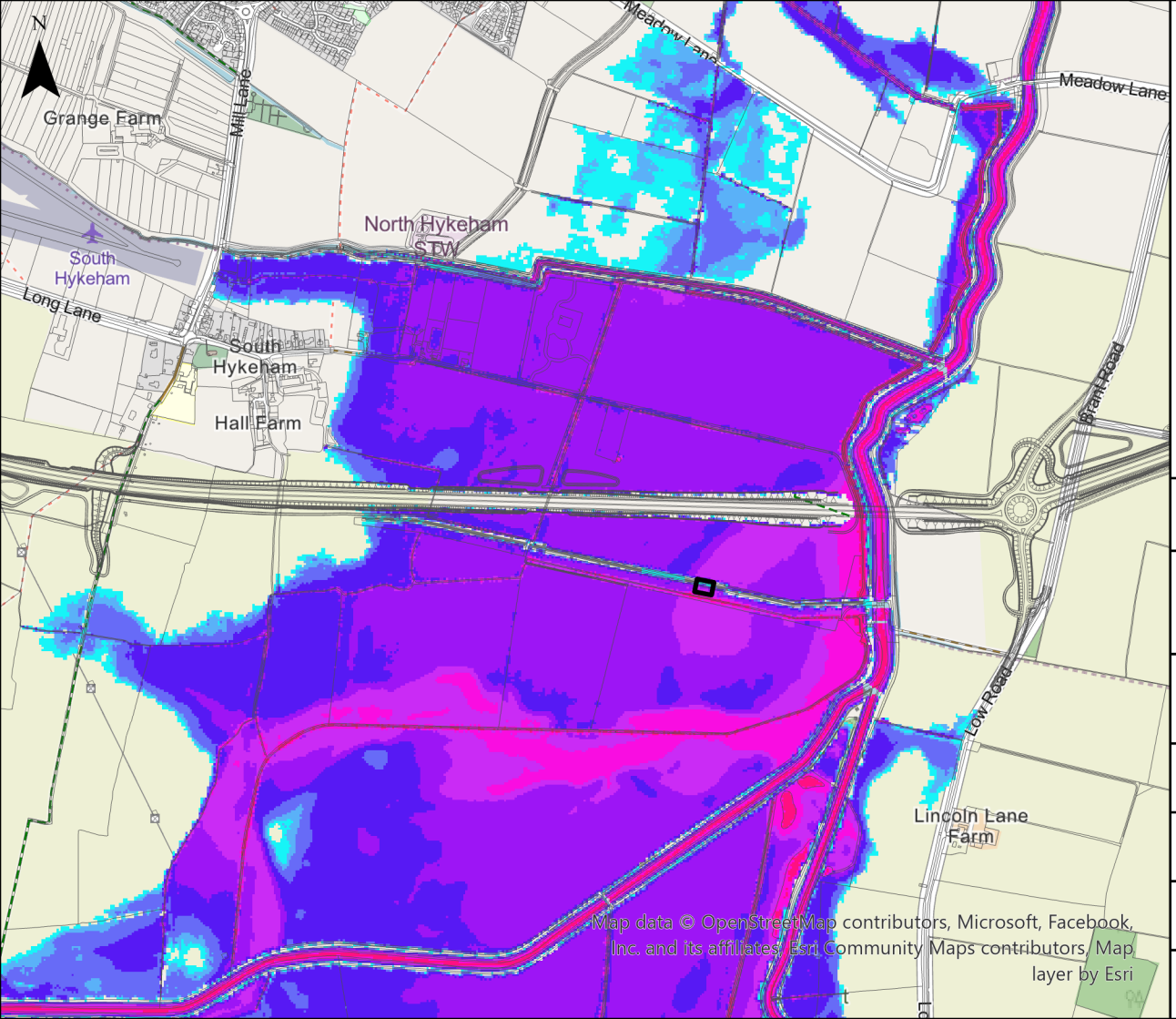

Legend

NHRR scheme

BREACH FSA

NHRR BREACH FSA 100-year Climate Change (2080 Higher)

Depth (m)

- < 0.1
- 0.1 - 0.2
- 0.2 - 0.5
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Scale

0 0.1 0.2 0.4 km

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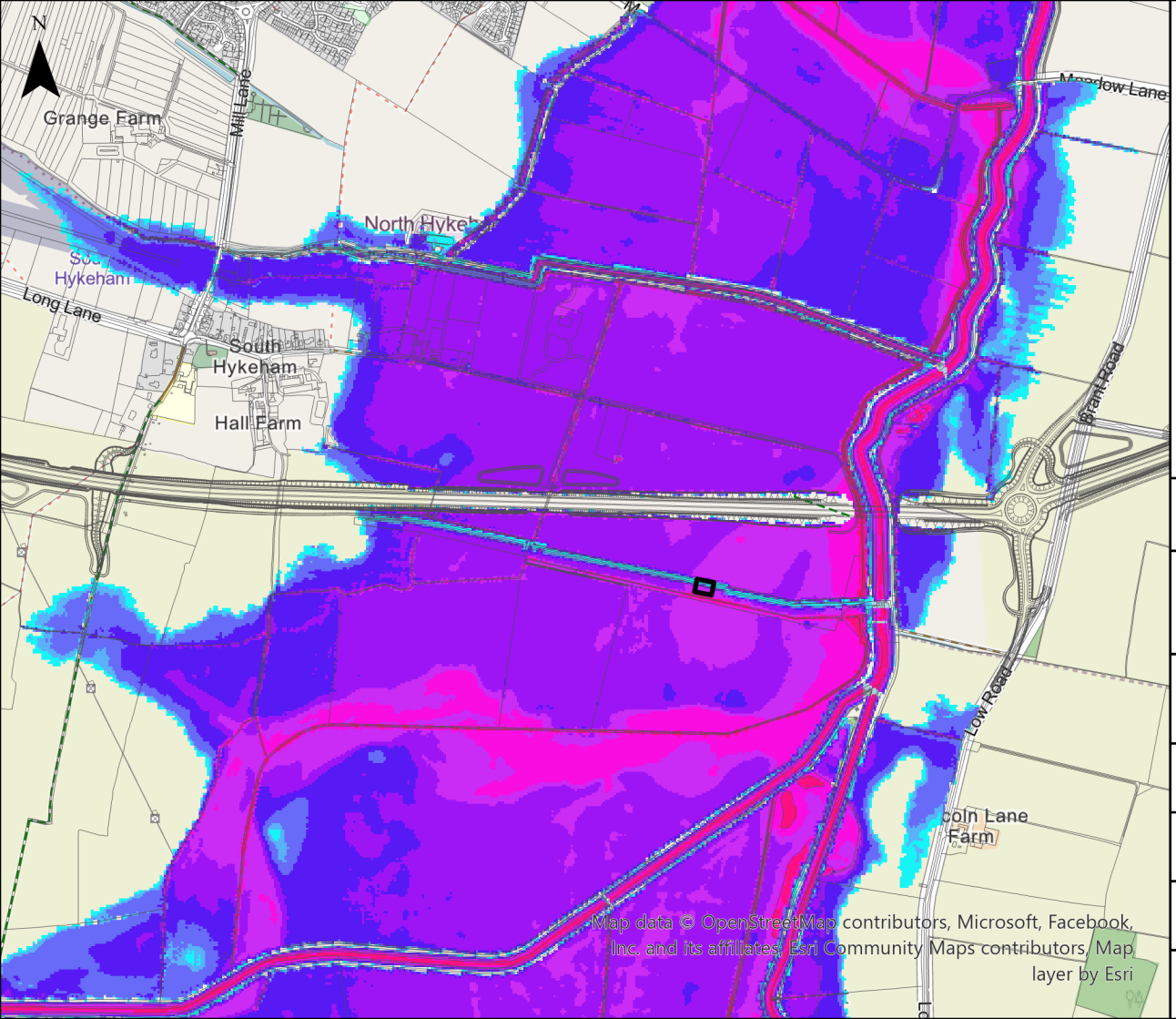

Legend

NHRR scheme

BREACH FSA

NHRR BREACH FSA 1000-year

Depth (m)

- < 0.1
- 0.1 - 0.2
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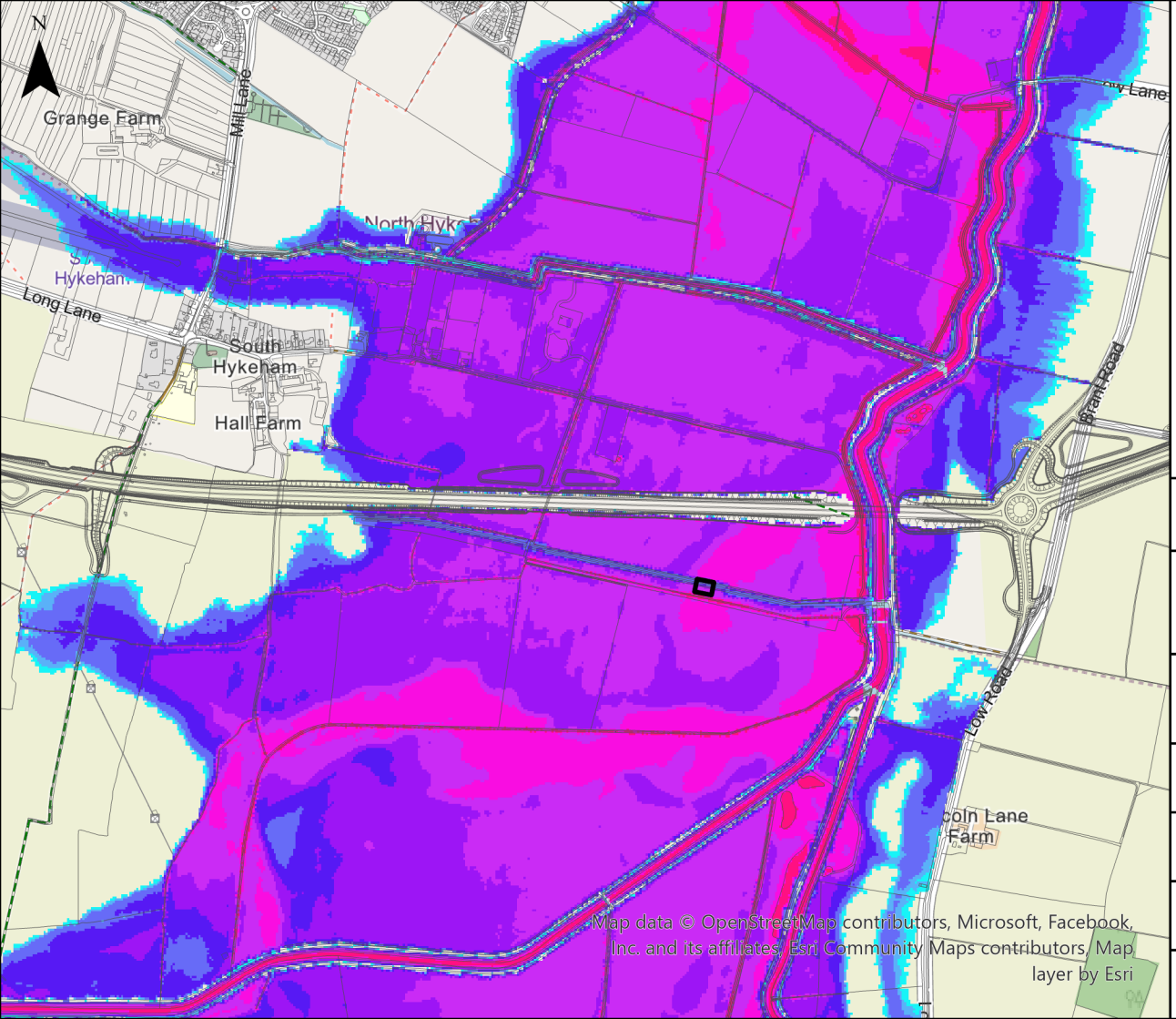

Legend

NHRR scheme

BREACH FSA

NHRR BREACH FSA 1000-year Climate Change (2080 Higher)

Depth (m)

- < 0.1
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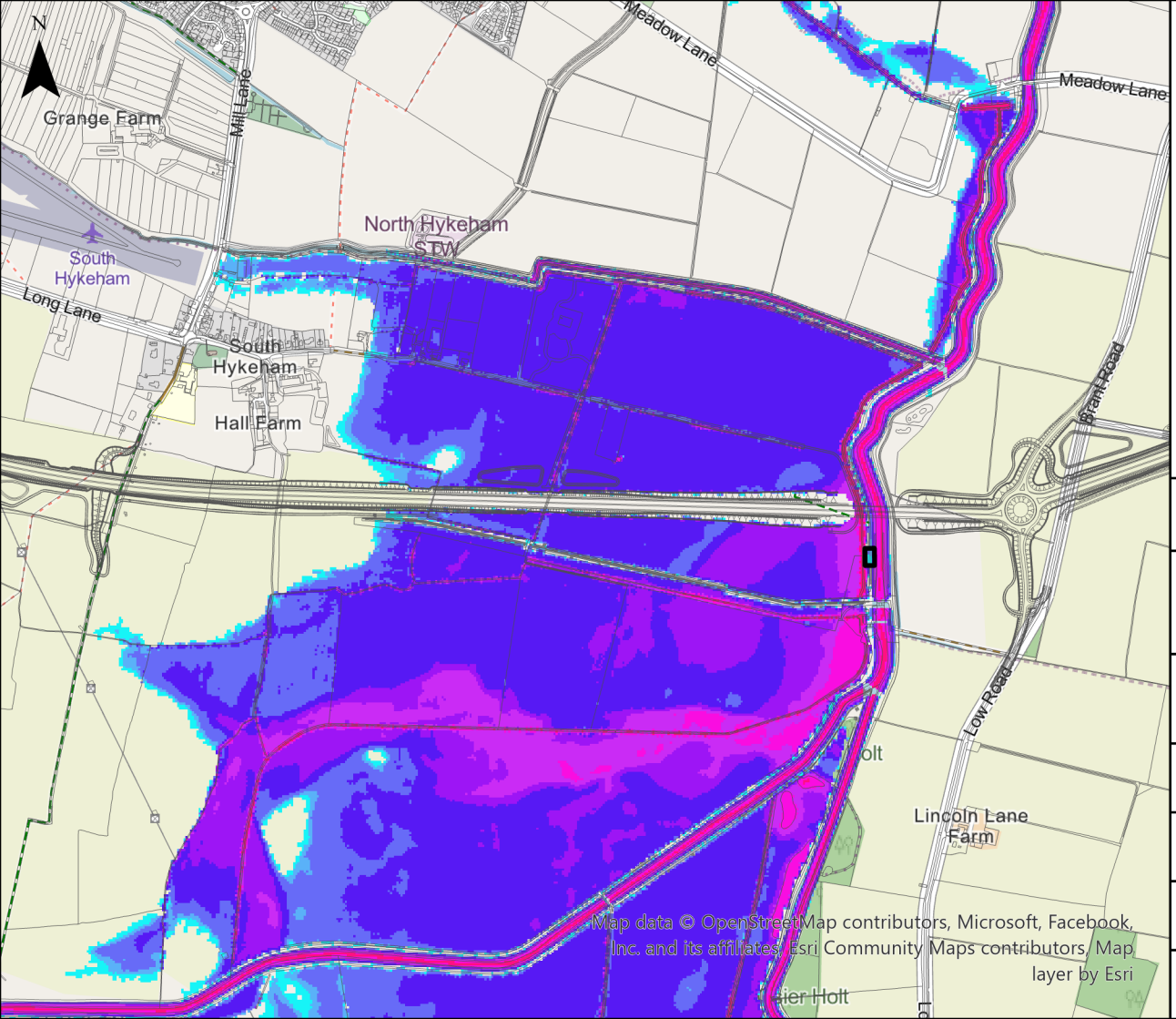

Legend

NHRR scheme

BREACH RWUS

NHRR BREACH RWUS 100-year Depth (m)

- < 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
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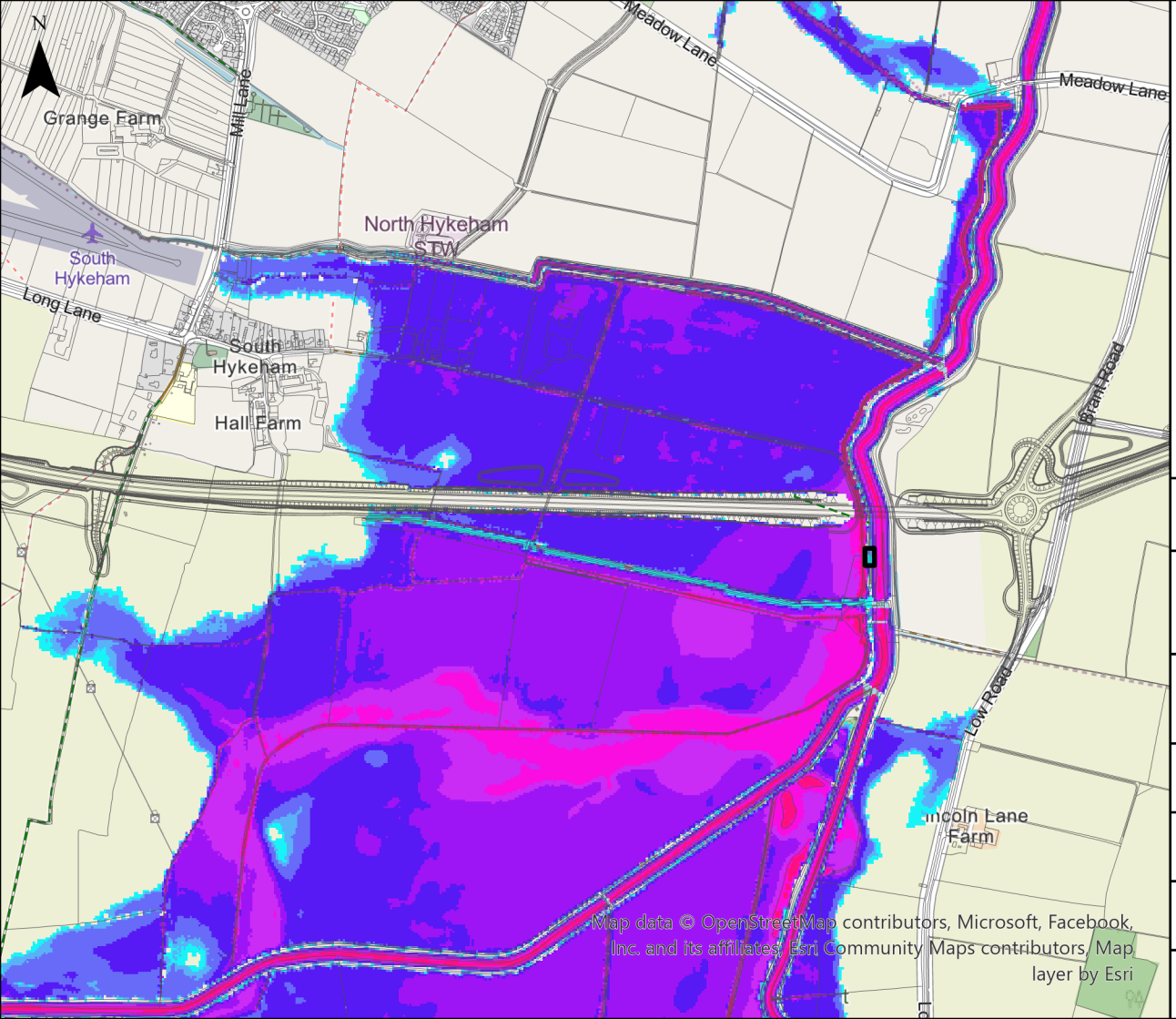

Legend

NHRR scheme

BREACH RWUS

NHRR BREACH RWUS 100-year Climate Change (2080 Higher)

Depth (m)

- < 0.1
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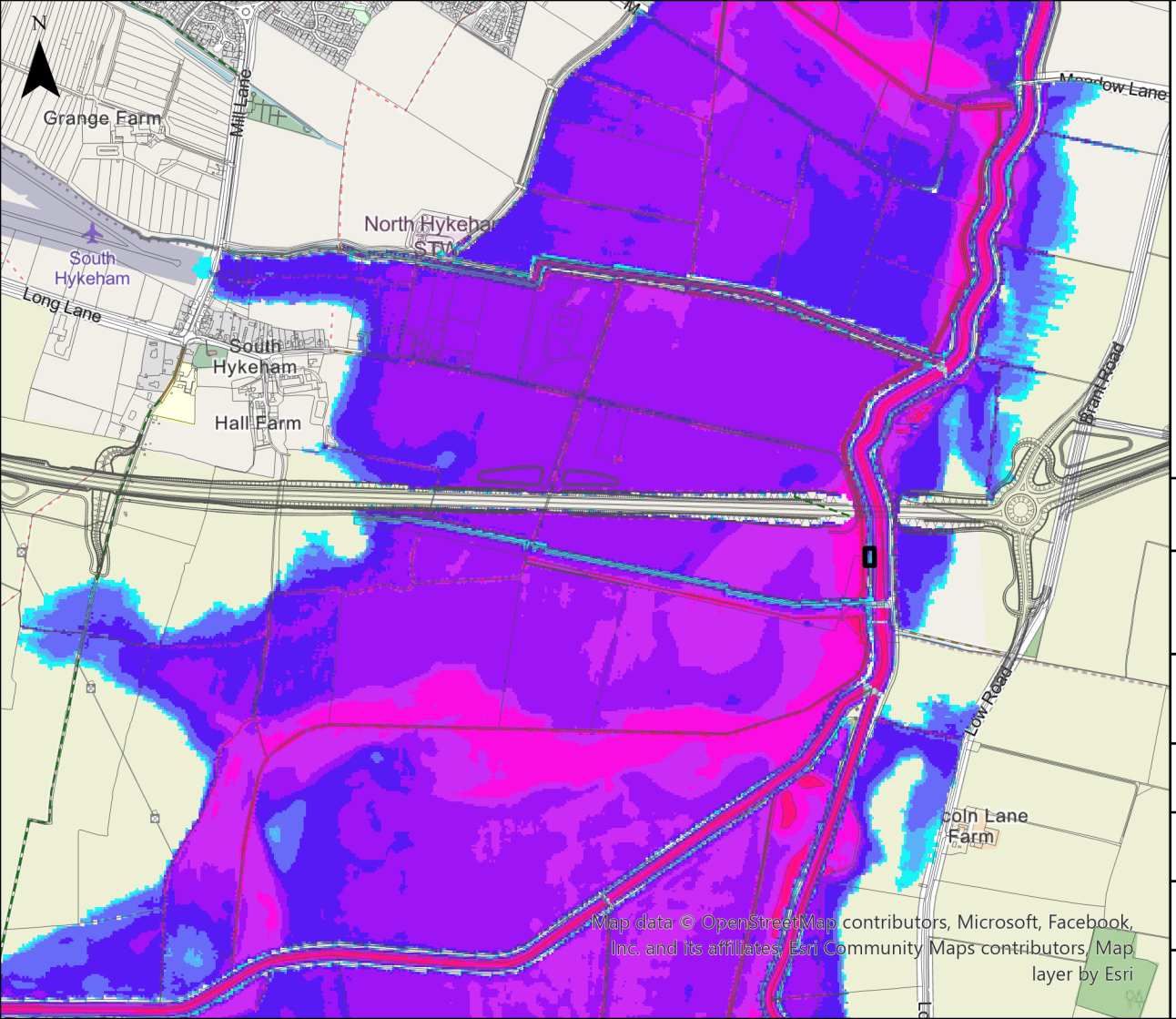

Legend

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BREACH RWUS

NHRR BREACH RWUS 1000-year

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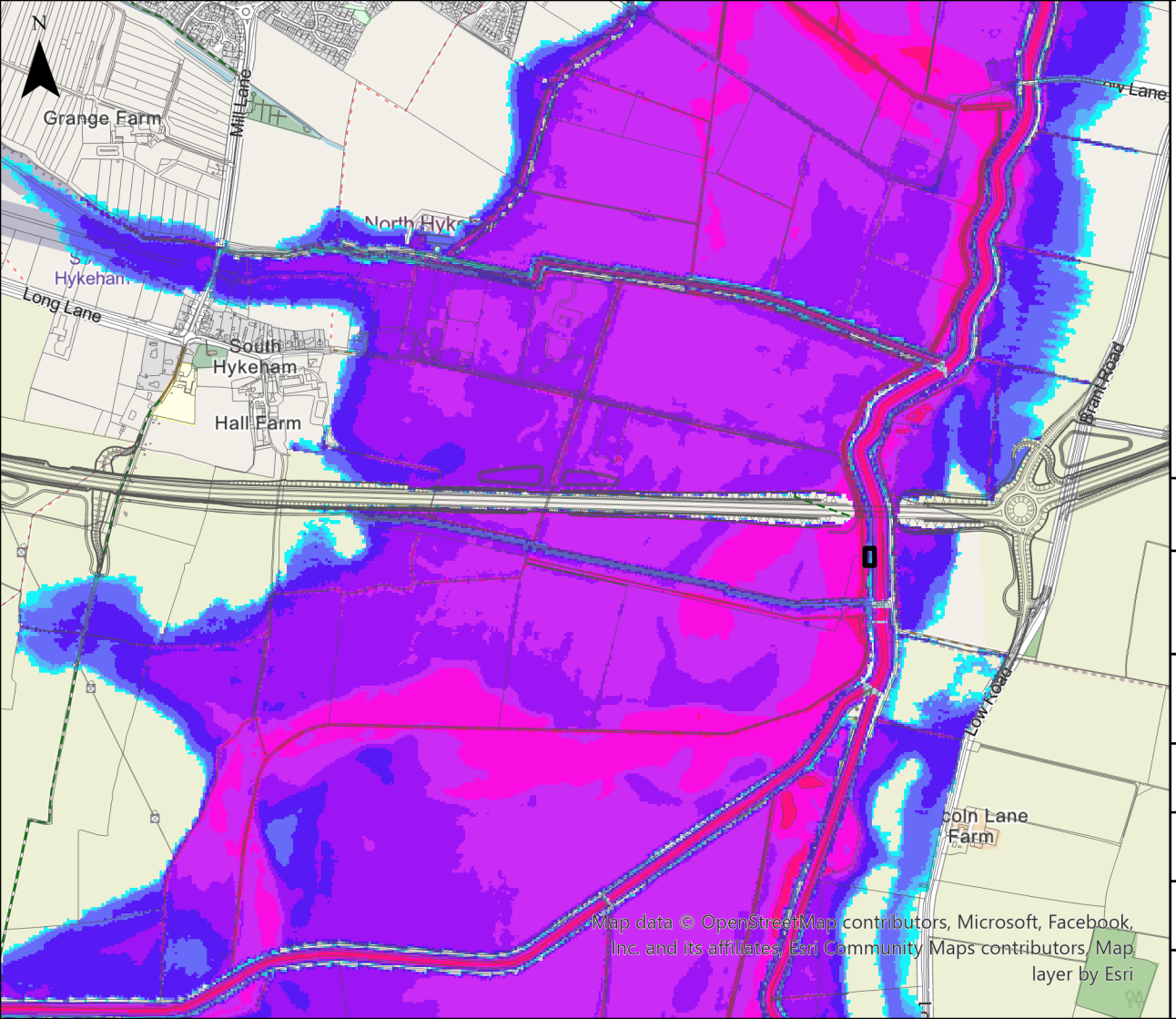

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