Cambridge South East Transport Phase 2

Environmental Statement

Appendix 8.1 Flood Risk Assessment

31st July 2023

Appendix 8.1 Flood Risk Assessment

Background and purpose of this report

8.1.1 This Flood Risk Assessment (FRA) has been prepared on behalf of the Greater Cambridge Partnership (GCP) in accordance with the National Planning Policy Framework (NPPF, revised July 2021). The NPPF is the overarching document in relation to development and flood risk and sets out the Government's policy on development relating to flood risk. The aim of the NPPF is to ensure that development is not at an unacceptable risk of flooding. Where development is unavoidable in areas at risk from flooding, the NPPF ensures that the development is safe without increasing flood risk elsewhere and where possible reducing flood risk overall. This is in line with the Cambridgeshire Flood and Water Supplementary Planning Document (2016)[1] and the Strategic Flood Risk Assessment for Cambridge City Council and South Cambridgeshire District Council (Cambridge Level 1 Strategic Flood Risk Assessment, September 2021)[2].

8.1.2 This FRA is submitted in support of an application for a Transport Works Act Order (TWAO) and deemed planning permissions for the Cambridge South East Transport (CSET) Phase 2 project (the Proposed Development). The location of the Proposed Development is shown in **Error! Reference source not found.**.1.

8.1.3 As outlined within the NPPF, flood risk from all sources must be addressed within the FRA to ensure that potential flood risk has been considered during the development design and proposed works. Therefore, this FRA outlines all the potential sources of flood risk, a quantification of the risk and the implications these risks have on the development. It is also necessary to outline any records of previous flooding events as these may identify areas vulnerable to flooding. This FRA outlines the consequences of flooding to the Proposed Development, and the consequences of flooding from the Proposed Development to third-party land, including any mitigation to be carried out prior to, during and post-construction. Atkins Ltd has followed standard procedure in the preparation of this FRA however, given the residual risk associated with any prediction and the variability which can be experienced in flood conditions, we take no liability for and give no warranty against actual flooding of any property or land (applicant's or third party's) or the consequences of flooding in relation to the performance of the service.

8.1.4 This report has been prepared for the purposes of TWAO approval only and is to assist the Secretary of State to make an informed decision on the flood risks associated with the site development.

8.1.5 It is anticipated that the FRA will have to be revisited at the detailed design stage to assess the effects of any changes to the design. The updated FRA will then have to be approved by the Environment Agency and Cambridgeshire County Council (CCC) as the Lead Local Flood Authority (LLFA).

Existing site description

8.1.6 The Proposed Development is located to the south-east of Cambridge from Francis Crick Avenue to the A1307 / A11 / A505 junction as shown on Figure A8.1.1. The route of the Proposed Development crosses one Ordinary Watercourse and one Main River. The Ordinary Watercourse, the Hobson's Brook[3], is crossed once whilst the Main River, the River Granta, is crossed twice.

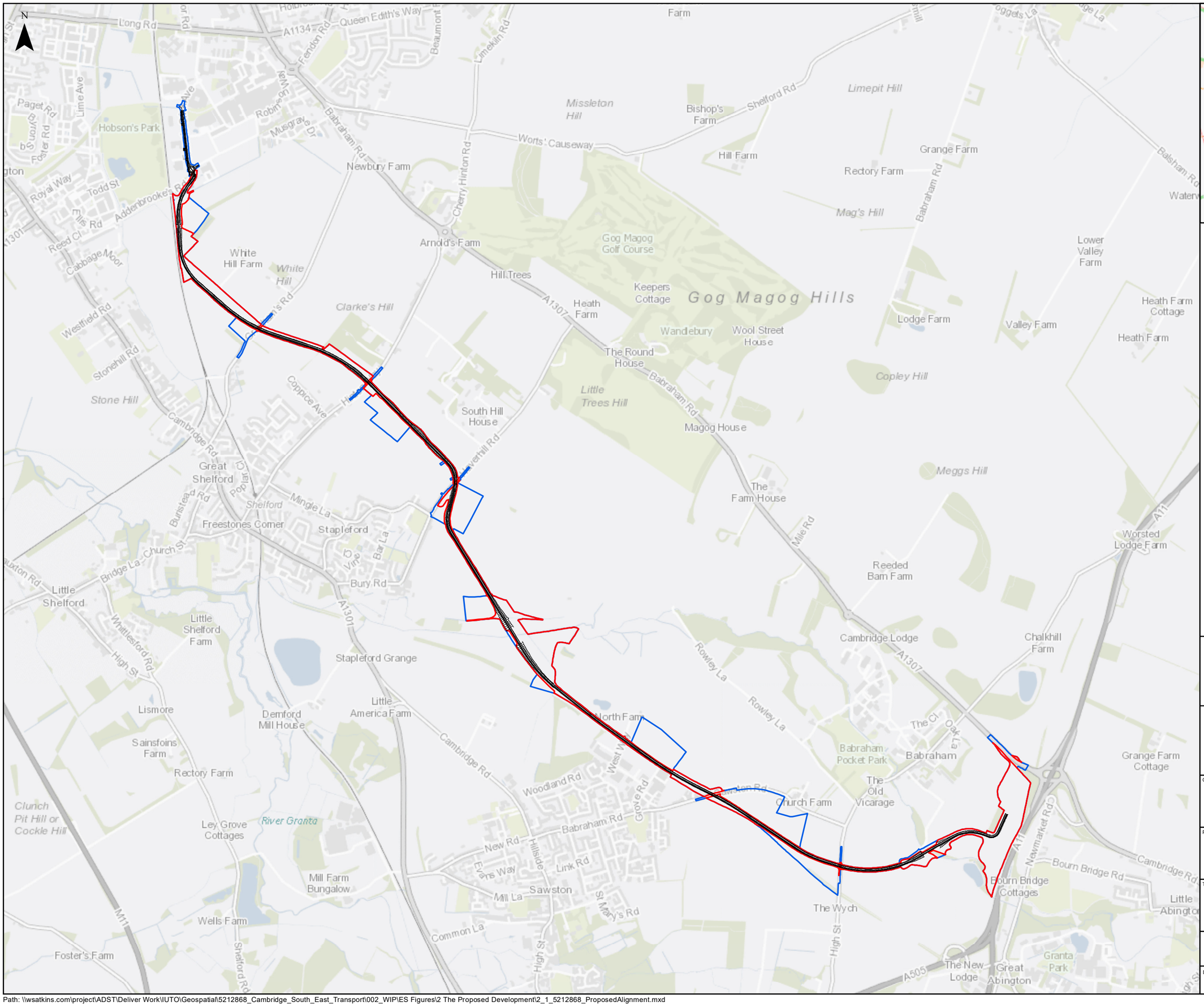
8.1.7 Much of the study area is currently agricultural land with only the developed area being in proximity to Francis Crick Avenue which forms part of the Cambridge Biomedical Campus (CBC).

8.1.8 The study area is comprised of low-lying land, Most of the land drains towards the River Granta, with only the last 1 km draining in to the Hobson's Brook through an existing highways drainage system to the north-west of the study area.

8.1.9 The River Granta and Hobson's Brook catchments are underlain by chalk bedrock, with superficial deposits of alluvium along the River Granta including in the vicinity of the crossings which form part of the Proposed Development. Therefore, the rainfall response of the watercourses will be influenced by the permeable chalk bedrock and in general these are slow response catchments. However, after periods of intense rainfall, when the volume of precipitation exceeds the infiltration capacity and runs off overland there will likely be a much faster response.

[1] https://www.cambridge.gov.uk/media/7107/cambridgeshire-flood-and-water-spd.pdf
[2] https://greatercambridgeplanning.org/media/2552/strategicfloodriskassessment_gclp_210831_accessible.pdf

[3] Hobson's Conduit is a local name for the Hobson Brook, and these two names can be found in use interchangeably but reference the same feature in relation to this FRA.



Permanent Site Boundary
Temporary Site Boundary
Route Alignment

Metres
0 250 500

Atkins, Member of the SNC-Lavalin Group
Nova North
11 Bressenden Place
London
SW1E 5BY

ATKINS
Member of the SNC-Lavalin Group

Client
GREATER CAMBRIDGE PARTNERSHIP

Project
CAMBRIDGE SOUTH EAST TRANSPORT
PHASE 2

Title
PROPOSED DEVELOPMENT
ROUTE ALIGNMENT

Sheet Size	Original Scale	Designed / Drawn	Checked	Authorised
A3	1:25,000	JM	WR	LM
		Date 22/01/23	Date 22/01/23	Date 22/01/23

Drawing Number: FIGURE A8.1.1
Rev: 00

Path: \\wsatkins.com\project\ADST\Deliver Work\IUTO\Geospatial\5212868_Cambridge_South_East_Transport\002_WIP\ES Figures\2 The Proposed Development\2_1_5212868_ProposedAlignment.mxd

Proposed Development description

8.1.10 The Proposed Development comprises approximately 8.5 km of new busway and Emergency Access and Maintenance Track (EMAT) from the A1307 / A11 / A505 junction to Francis Crick Avenue, along with a new Travel Hub by the A1307 / A11 / A505 junction.

8.1.11 The Proposed Development comprises the following elements that are relevant to flood risk:

- Hobson's Brook crossing (Figure A8.1.2) comprising:
  - A 15 m wide[4] single-span bridge across Hobson's Brook itself with at least 2.4 m clearance above river bank elevations.
  - Busway and EMAT rising up to 2.5 m above ground level on an earthen embankment at its highest point approaching the bridge.
  - Filter drains and conveyance swales either side of the carriageway draining into an attenuation pond to the north which discharges at a controlled rate into the unnamed ditch running east to west across the Proposed Development alignment (in culvert).
  - Three pre-cast box culverts to permit the un-named ditch to continue to flow under the Proposed Development and access road. Size will be sufficient to pass the 1% Annual Exceedance Probability (AEP) flood with climate change , without increasing afflux upstream. The precise dimensions of these culverts will be determined at detailed design, however, no significant changes are expected.
- River Granta (Stapleford) crossing (Figure A8.1.3) comprising:
  - A 118 m wide five-span bridge over the River Granta with a minimum of 3.5m clearance above river bank elevations for vehicles to pass under the bridge for maintenance
  - Four 1.5m wide piers with rounded ends supporting the bridge
  - A busway and EMAT on an earthen embankment rising up to at least 3 m above ground level
  - Up to 410 m^2 floodplain compensation area located to the north-east of the crossing on the right side of the floodplain.
  - Filter drains draining into an attenuation pond to the north-east of the crossing which will in turn discharge at a controlled rate into an existing local field / surface water ditch.
  - A 4.5 x 3.0m precast concrete box culvert with mammal shelf to permit discharge of the existing ditch to the north-east of the crossing.
  - A 4.0 x 1.5m precast concrete box culvert with mammal shelf to permit discharge of the existing ditch to the south-east of the crossing at the location of the old railway line. This is a replacement of an existing structure designed to be able to take the Proposed Development traffic and improve ecological connections over the existing structure.
- River Granta (Babraham) crossing (Figure A8.1.4) comprising:
  - A 130 m wide four-span bridge over the River Granta with a minimum of 2.5 m clearance above river bank elevations for vehicles to pass under the bridge for maintenance
  - Three 1.5m wide piers with rounded ends supporting the bridge.
  - A busway and EMAT on an earthen embankment rising up to at least 3 m above ground level
  - Up to 1,300 m^2 floodplain compensation area located to the north-east of the crossing on the right side of the floodplain.
  - Filter drains draining into an attenuation pond to the south of the crossing on the upstream side which will in turn discharge at a controlled rate into the River Granta.
- A11 Travel Hub by A1307 / A11 / A505 junction comprising:
  - 1250 car parking spaces and up to 10 visiting coach spaces
  - Solar photovoltaic (PV) panels on roofs over some of the car parking spaces
  - A facilities building with rainwater harvesting system and foul water drainage
  - The Drainage Strategy (Volume 3, Appendix 2.1) currently assumes the use of permeable paving into either a conveyance swale or a piped network, which would discharge via two detention basins containing up to 1,830 m^3 between them
  - These detention basins then discharge via another piped network into a 1,282m^3 attenuation pond to the south of the Travel Hub.
  - The last attenuation pond discharges at a controlled rate into a water meadow comprising terraced swales that eventually drain into the River Granta whilst providing opportunity for additional attenuation and / or infiltration.

[4] Width referred to here is in reference to hydraulic width across the channel or floodplain, measured perpendicular to flow.

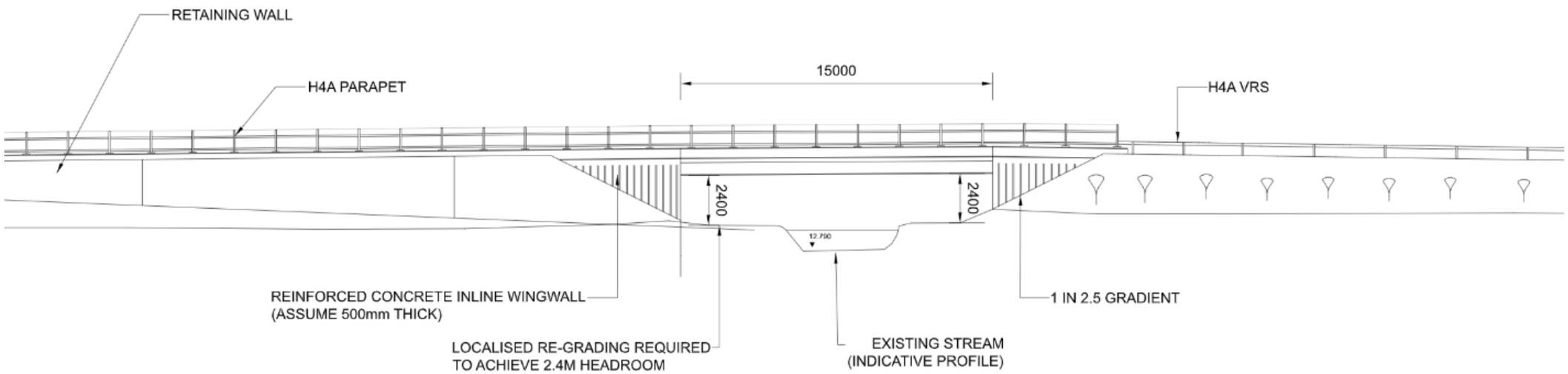


Figure A8.1.2 Elevation of the proposed Hobson's Conduit Bridge

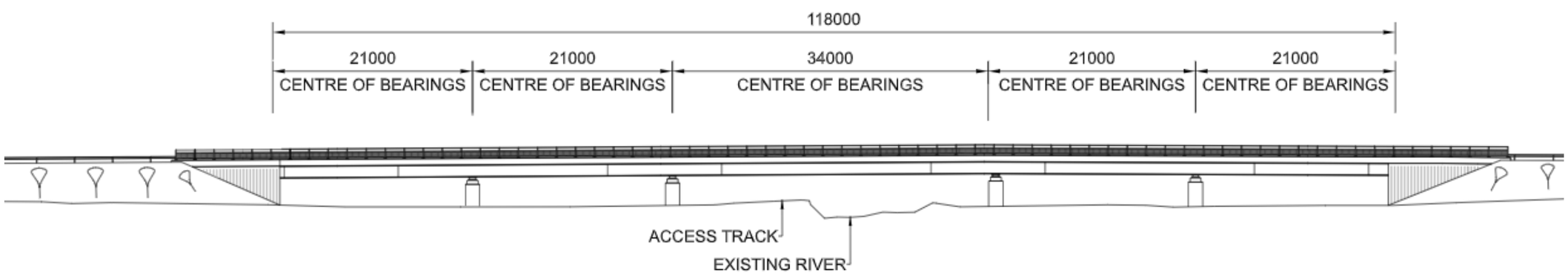


Figure A8.1.3 Elevation of the proposed River Granta (Stapleford) crossing viaduct. Numbers are in mm.

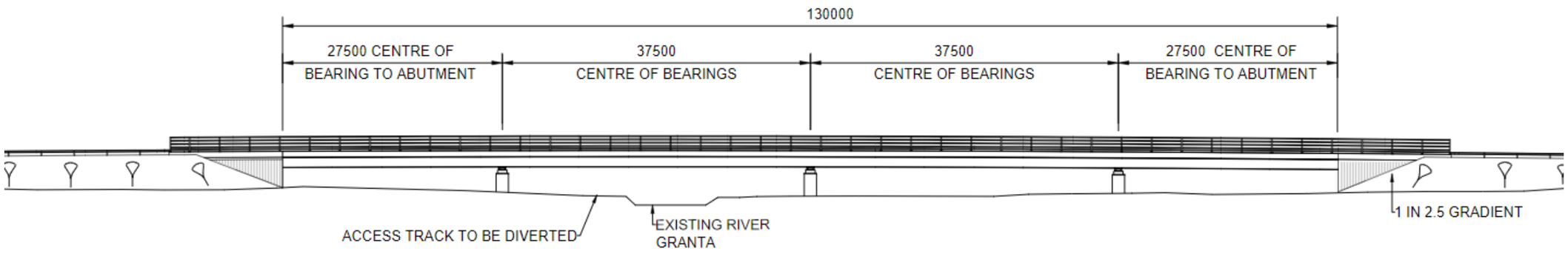


Figure A8.1.4 Elevation of the proposed River Granta (Babraham) crossing Viaduct. Numbers are in mm.

Programme

8.1.12 Subject to consent, it is currently anticipated that the construction of the Proposed Development will be over two years, starting in 2025 and being completed by 2027. The construction phase of the Proposed Development will occur over at least one winter when the ground is more likely to be saturated and river levels would be higher. The expected duration of the construction has been considered in the specification for temporary works in the Construction Environmental Management Plan (CEMP) (Volume 3, Appendix 2.4).

Approach

Flood risk assessment

8.1.13 The Proposed Development is predominately located in Flood Zone 1 (less than 0.1% Annual exceedance probability (AEP) of flooding from rivers and sea), except for the river crossings near Stapleford and Babraham, and a landscaped area of the Travel Hub which intersect Flood Zone 3 (more than 1% AEP of flooding from rivers and sea).

8.1.14 In accordance with the NPPF[5], schemes classified as "Essential Infrastructure" which cross Flood Zones 3a and 3b are subject to an Exception Test and required to carry out an FRA for all sources of flooding to assess the potential risk to the development and any increase in flood risk elsewhere.

8.1.15 A detailed fluvial assessment was carried out, as agreed with the Environment Agency and Cambridgeshire County Council (CCC) (at the pre-application meetings in July 2019, November 2020 and May 2022), to fully consider the impact of the Proposed Development on flood risk.

8.1.16 Hydraulic modelling was undertaken for the River Granta. There was an existing model of the Granta which was developed by JBA in 2013 and subsequently updated by Mott MacDonald in 2021, which has been used to assess the impact of the Proposed Development and any changes to flood risk. See the Modelling Report (Volume 3, Appendix 8.2) for details of the hydraulic modelling.

8.1.17 A comprehensive Drainage Strategy (Volume 3, Appendix 2.1) has also been prepared to assess and manage the flood risk arising from surface water along the entire carriageway and Travel Hub.

8.1.18 This FRA considers all sources of potential flood risk to the Proposed Development , the impact of the Proposed Development on changing flood risk elsewhere, and how any residual flood risk can be managed.

Flood vulnerability classification

8.1.19 The Proposed Development is classed as "Essential Infrastructure" under the NPPF. This is in accordance with Table 4.2 of the Cambridgeshire Flood and Water Supplementary Planning Document (2016) and Table 2 of the UK Government's Flood Risk and Coastal Change Guidance Scheme[6].

Sequential test

8.1.20 The purpose of the Sequential Test is to promote development within areas at lowest flood risk. Therefore, areas for development in Flood Zone 1 should be sought in the first instance. If there are no practicable areas for the development in Flood Zone 1, then areas in Flood Zone 2 should be sought, and so on.

8.1.21 The Proposed Development is predominately within Flood Zone 1 and outside the influence of any other local flood risk elements. The areas within Flood Zone 2 and Flood Zone 3 are limited to where the route must cross the River Granta to achieve its function as transport infrastructure.

Exception test

8.1.22 A passed Exception Test is required when there is a need to demonstrate wider benefits that outweigh flood risk and that the development will be safe from flooding without increasing risk elsewhere for its lifetime.

8.1.23 The Proposed Development will require a passed Exception Test since the development is classed as "Essential Infrastructure" and crosses Flood Zone 3a and 3b in accordance with paragraph 160 of the NPPF. The Proposed Development has been designed to meet the requirements of the exception test as follows:

- Sustainability benefits to the community outweigh the flood risk
  - The Outline Business Case found a strategic case for the Proposed Development to enable Cambridge to grow in a more sustainable manner and reduce the risk of increasing congestion and associated impacts on air quality, journey time and the environment for many of the areas experiencing growth which are currently poorly connected by public transport.
  - During operation, the intention to use extended range hybrid electric vehicles or fully electric vehicles on the route will reduce greenhouse gas (GHG) emissions throughout the operating lifetime of the Proposed Development .
  - All routes and Travel Hub sites assessed were found to have very similar environmental impacts, with water impacts assessed as net neutral providing the design criteria were met.
  - Therefore, the benefits of a more sustainable transport link outweighed the potential flood risk, which can be effectively managed through bridge and drainage design.
- Safe for its lifetime
  - The lifetime of the Proposed Development is assumed to be 100 years for the purpose of the FRA.
  - For the critical 3.3% AEP flood event, the Drainage Strategy (Volume 3, Appendix 2.1) ensures that there is no above-ground flooding from surface water along the route or in the Travel Hub.
  - For the 1% AEP flood event with a 45% allowance for climate change over the lifetime of the Proposed Development, the design ensures that there is minimal flood risk to the Proposed Development because:
    - The soffit level on the Babraham crossing is approximately 2.6 m above the in-channel maximum flood level.

[5] National Planning Policy Framework, 2012 Ref: ISBN 978-1-5286-1033-9, CP 48

[6] https://www.gov.uk/guidance/flood-risk-and-coastal-change#flood-zone-and-flood-risk-tables Paragraph: 066 Reference ID: 7-066-20140306 Revision date: 06 03 2014

- The soffit level on the Stapleford bridge crossing is approximately 3.2 m above the in-channel maximum flood level.
- The supporting embankments are kept outside Flood Zones 2 and 3 as far as possible.
- The supporting piers within Flood Zones 2 and 3 avoid obstruction of the river channel.
- Although some short-term surface water flooding is permitted, the drainage features and surface gradients have been designed such that any excess flow does not enter buildings or disrupts emergency routes for the public transport route or the Travel Hub.

Climate change allowance

8.1.24 Allowances for the effects of climate change have been made in accordance with government recommendations in place and statistical data available at the time of assessment in February 2023[7].

8.1.25 Surface water runoff and fluvial flows can change due to changes in rainfall intensity associated with climate change as well as changes in land use. The UK Government's guidance on climate change shows anticipated changes in extreme rainfall intensity (Table A8.1.1) and river (or fluvial) flows (Table A8.1.2). These climate change allowances have been considered in the fluvial assessment and the hydraulic modelling assessment (Volume 3, Appendix 8.2) in accordance with the Environment Agency Guidance[8]. The higher central allowance for the '2080s' epoch has been selected for both rainfall and river flow in order to test the sensitivity of the Proposed Development to climate change.

Table A8.1.1Peak rainfall intensity allowance in small and urban catchments (use 1961 to 1990 baseline)

Catchment Management Area	Allowance Category	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Cam and Ely Ouse	Upper	35%	35%
	Central	20%	20%

Table A8.1.2 Peak river flow allowances by river basin district (use 1961 to 1990 baseline)

Catchment Management Area	Allowance Category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Cam and Ely Ouse	Upper	21%	22%	45%
	Higher	7%	5%	19%
	Central	2%	-2%	9%

8.1.26 The impacts of any updates to rainfall and river flow in subsequent climate change allowance guidance should be assessed at detailed design stage.

Baseline flood risk

Fluvial flood risk

8.1.27 There are two Ordinary Watercourses and one Main River within the study area. The Main River is the River Granta which is the greatest source of fluvial flood risk within the study area. The Hobson's Brook is the largest of the Ordinary Watercourses and the only one crossed by the Proposed Development. The Hobson's Brook is sourced from chalk springs within the Nine Wells Local Nature Reserve (LNR), located approximately 500 m south of Francis Crick Avenue. The other ordinary watercourses is a tributary of the River Granta located just south of Stapleford.

8.1.28 The River Granta at Stapleford[9] has a catchment area of 114 km^2 and is groundwater-dominated with chalk bedrock. The superficial geology is comprised of river terrace deposits – sand and gravel, or alluvium[10].

8.1.29 The Environment Agency's Flood Map for Planning (Figure A8.1.5) shows that Flood Zones 2 and 3 follow the course of the River Granta and span approximately 200-500 m either side of the river. There is also a small area of Flood Zone 3 which covers the south of the Dame Mary Archer Way roundabout.

8.1.30 There is a small area (~0.001 km^2) on the right bank of the River Granta, to the south of Stapleford, where there is a Reduction in the Risk of Flooding from Rivers and Seas due to Defences which is associated with an embankment along the right bank in this location.

8.1.31 Although there are no Flood Zones shown near the Hobson's Brook, it is important to note that the Environment Agency only holds data on designated Main Rivers and Critical Ordinary Watercourses (COWs), therefore the Flood Zones are focused on the floodplains of these rivers only and the actual extent of the Hobson's Brook floodplain may vary.

[7] UK Government, Defra (2023) Flood risk assessments: climate change allowances. Last updated 27 May 2022. Online https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances
[8] Flood and coastal risk projects, schemes and strategies: climate change allowances - GOV.UK (www.gov.uk)
[9] National River Flow Archive Gauge Data – 33053 – Granta at Stapleford https://nrfa.ceh.ac.uk/data/station/info/33053
[10] British Geology Survey Geology Viewer https://geologyviewer.bgs.ac.uk/

Figure A8.1.5 Flood map for planning[11]

[11] Source: Environment Agency (2020) Flood Map for Planning – https://flood-map-for-planning.service.gov.uk/

Tidal flood risk

8.1.32 The River Granta is part of the Cam and Ely Ouse catchment and is a tributary of the River Great Ouse. The River Granta itself is not tidally influenced, as the tidal extent of the River Great Ouse ends at Brownshill Lock southwest of Earith, approximately 25 km north of Cambridge. Therefore, tidal flood risk is considered negligible.

Surface water (pluvial) flood risk

8.1.33 The Risk of Flooding from Surface Water (RoFSW) mapping[12] for the study area, shown in Figure A8.1.6, reveals minimal risk from this source, with surface water confined either to existing drainage channels or dispersed within the surrounding arable land.

8.1.34 At the Hobson's Brook, pluvial flood risk is low (between 0.1% and 1% AEP) between Nine Wells LNR springs, the railway line, and the roundabout to the south of Francis Crick Avenue. However, it is important to note that RoFSW maps do not fully consider the development of the Addenbrooke's (link) Road and significant SuDs installed as part of the Francis Crick Avenue and wider CBC development. However, the majority of surface water runoff arriving at the Proposed Development comes overland from the agricultural fields to the south of the CBC rather than from the CBC development itself.

8.1.35 The Addenbrooke's Surface Water Management Plan Report (2018) provided by Cambridge City Council considers the impacts of the CBC drainage. This found similar flood extents for the 1% AEP, if typical catchment wetness was considered, and greatly increased flooding for the 1% AEP if the ground was already saturated before a storm event (shown in Figure A8.1.6). Having no infiltration within the model provides an overly conservative assessment based on the typical ground conditions, as discussed in the Drainage Strategy (Volume 3, Appendix 2.1). Therefore, the flood extents mapping with typical ground condition was deemed appropriate for use for the TWAO stage as it was provided by the Lead Local Flood Authority (LLFA).

8.1.36 Detailed design may require a more detailed review of the surface water flood risk once more data on surface water levels and flows becomes available.

[12] Environment Agency (2023) Risk of Flooding from Surface Water (RoFSW) https://flood-warning-information.service.gov.uk/long-term-flood-risk/map

Figure A8.1.6 Risk of flooding from surface water mapping

Figure 64) Model Results Dry Catchment with Infiltration –1 in 100 years (1% AEP)

Figure 65) Model Results Saturated Catchment, no Infiltration –1 in 100 years (1% AEP)

Figure A8.1.7 Sensitivity of the 1% AEP Surface Water Flooding to ground saturation[13]

Groundwater flood risk

8.1.37 The Proposed Development route is underlain by chalk (see Figure A8.13), except where it crosses the River Granta where there are river terrace and gravel deposits (Volume 2, Chapter 9 provides further details of the groundwater environment).

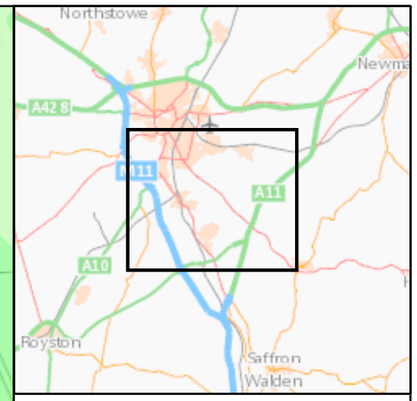
8.1.38 There are springs emerging from the Totternhoe Stone at the base of the Zig Zag Formation in the Nine Wells LNR. The chalk formation is associated with a Principal Aquifer which provides a high level of groundwater storage and supports conveyance of good quality groundwater in the area. Groundwater in the chalk flows broadly from the high topographic areas in the northwest towards the River Granta and River Cam valleys.

8.1.39 The superficial geology is shown in Figure A8.1.9. Any shallow groundwater in the superficial deposits is likely to be flowing under topographic control towards and along the River Granta valley. There are historical reports of groundwater flooding affecting basement levels in the CBC / Addenbrooke's Hospital area (Addenbrooke's SWMP, 2018) however, these are located north of the study area.

[13] Reproduced from Figures 64 and 65 of the Addenbrooke's Surface Water Management Plan (SWMP), 2018.

N

Nine Wells
Geological Site



Permanent Site Boundary
Temporary Site Boundary
Study Area - 1km Buffer
Nine Wells Geological Site

Bedrock Geology

New Pit Chalk Formation - Chalk
Holywell Nodular Chalk Formation - Chalk
Melbourn Rock Member – Chalk
Totternhoe Stone Member - Chalk
West Melbury Marly Chalk Formation - Chalk
Zig Zag Chalk Formation - Chalk
Gault Formation - Mudstone

Metres
0 500 1,000

Atkins, Member of the SNC-Lavalin Group
Nova North
11 Bressenden Place
London
SW1E 5BY

ATKINS
Member of the SNC-Lavalin Group

Client
GREATER CAMBRIDGE PARTNERSHIP

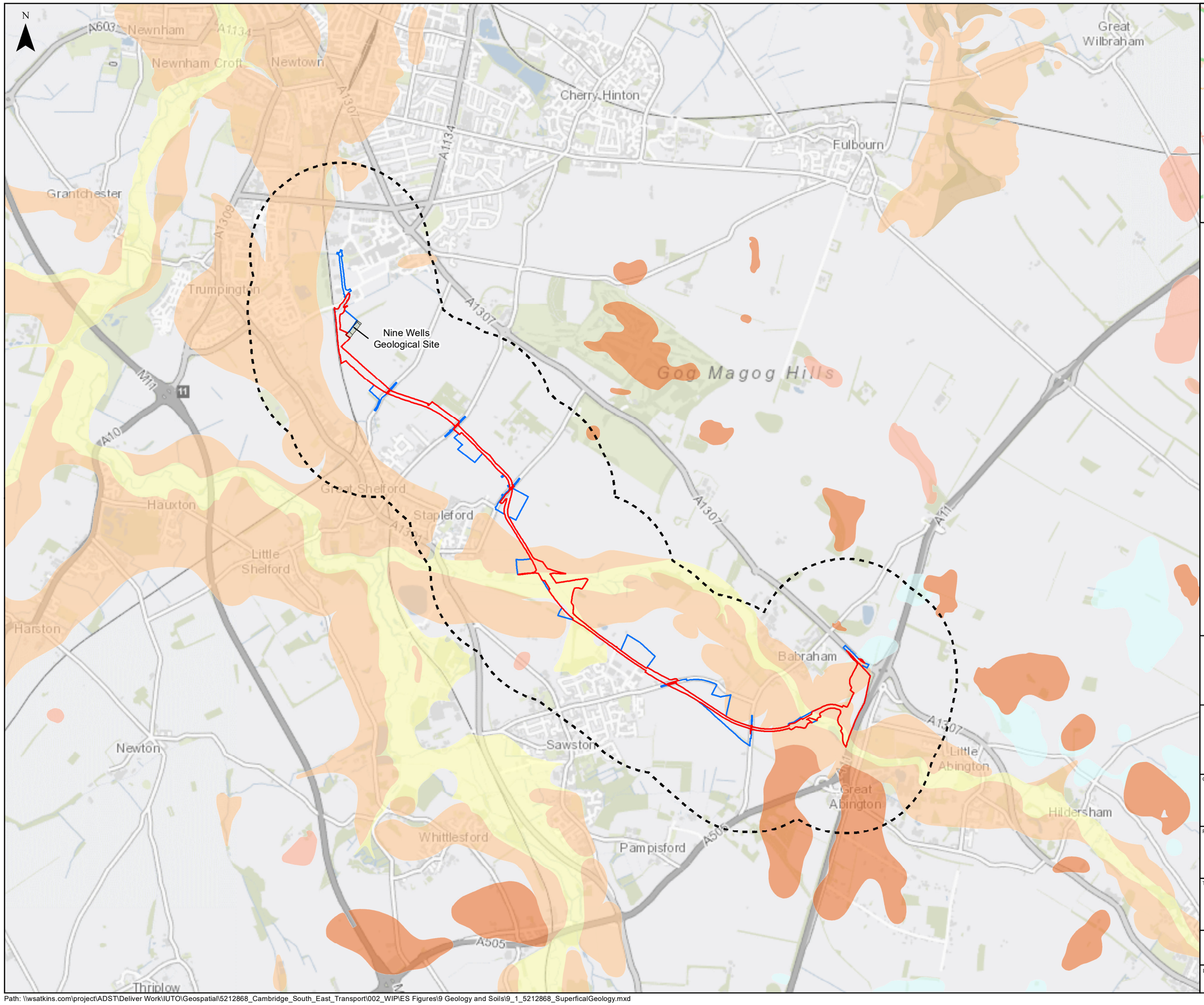
Project
CAMBRIDGE SOUTH EAST TRANSPORT
PHASE 2

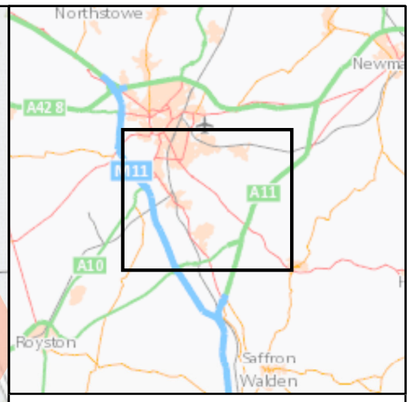
Title
BEDROCK GEOLOGY
MAP

Sheet Size	Original Scale	Designed / Drawn	Checked	Authorised
A3	1:40,000	JM Date 16/03/23	WR Date 16/03/23	LM Date 16/03/23

Drawing Number: FIGURE A8.1.8
Rev: 00

Path: \\wsatkins.com\project\ADST\Deliver Work\IUTO\Geospatial\5212868_Cambridge_South_East_Transport\002_WIP\ES Figures\9 Geology and Soils\9_2_5212868_BedrockGeology.mxd





Permanent Site Boundary
Temporary Site Boundary
Study Area - 1km Buffer
Nine Wells Geological Site

Superficial Geology

- Alluvial Fan Deposits – Clay, Silt, Sand and Gravel
- River Terrace Deposits, 1 to 2 Sand and Gravel
- Lowestoft Formation – Diamicton
- Lowestoft Formation – Sand and Gravel
- Alluvium – Clay, Silt, Sand and Gravel
- Peat – Peat
- River Terrace Deposits, 2 – Sand and Gravel
- River Terrance Deposits, 3 – Sand and Gravel
- River Terrace Deposits (Undifferentiated) – Sand and Gravel

Metres
0 500 1,000

Atkins, Member of the SNC-Lavalin Group
Nova North
11 Bressenden Place
London
SW1E 5BY
ATKINS
Member of the SNC-Lavalin Group

Client
GREATER CAMBRIDGE PARTNERSHIP

Project
CAMBRIDGE SOUTH EAST TRANSPORT
PHASE 2

Title
SUPERFICIAL GEOLOGY
MAP

Sheet Size	Original Scale	Designed / Drawn	Checked	Authorised
A3	1:40,000	JM Date 16/03/23	WR Date 16/03/23	LM Date 16/03/23

Drawing Number: FIGURE A8.1.9
Rev: 00

Path: \\wsatkins.com\project\ADST\Deliver Work\IUTO\Geospatial\5212868_Cambridge_South_East_Transport\002_WIP\ES Figures\9 Geology and Soils\9_1_5212868_SuperficalGeology.mxd

Artificial sources

8.1.40 Other sources of flood risk from artificial / man-made features such as drainage, reservoirs and canals have also been considered as part of this FRA.

Drainage and sewers

8.1.41 There are no existing drainage networks and sewers along this rural route other than existing highway drainage along Francis Crick Avenue. The Francis Crick Avenue drainage is formed by a series of swales on either side of the carriageway, with three attenuation ponds with controlled discharges into the unnamed ditch which leads to Hobson's Brook. It is understood that the original design was likely limited to 2 l/s/ha runoff. There were reported surface water flooding issues in July 2015, which affected Francis Crick Avenue and the wider CBC / Addenbrooke's Hospital site.

8.1.42 The integration of the Proposed Development with existing drainage requirements and management of surface water is addressed in the Drainage Strategy (Volume 3, Appendix 2.1).

Reservoirs

8.1.43 The River Granta does have a risk of flooding from reservoir breach. The worst-case scenario, maximum flood extent likely to be caused by a reservoir breach is shown in Figure A8.1.10.

8.1.44 The reservoir flood risk extent mostly follows the existing Flood Zones 2 and 3, with slightly wider areas at risk near Stapleford and Babraham. However, the stringent design, inspection, and maintenance requirements of the Reservoirs Act (1975) means that the risk of overtopping and / or breach (and thus flooding) is very low.

Canals

8.1.45 There are no other artificial sources of flooding affecting the study area, such as a canals.

Figure A8.1.10 Flood risk from reservoirs – River Granta[14]

[14] Source: Environment Agency Flood Risk from Reservoirs (2020) – https://flood-warning-information.service.gov.uk/long-term-flood-risk/map

Post-development flood risk

Fluvial flood risk

8.1.46 The River Granta hydraulic model has been simulated with the addition of the Proposed Development embankment footprint at both crossings (Stapleford and Babraham) for the standard range of events, including the 3.3% AEP, 1% AEP, 0.1% AEP events and '2080s' epoch climate change scenarios (central, higher, and upper end). Details on the updates made to the hydraulic model are presented in Volume 3, Appendix 8.2.

8.1.47 The River Granta peak water levels from the baseline model and the post-development model are also presented in the Hydraulic Modelling Report (Volume 3, Appendix 8.2).

8.1.48 At the Babraham viaduct the results show that there is a negligible change (<10 mm) in the peak water levels in the channel for all events simulated. Similarly, there is a minor adverse impact on the floodplain as a result of the Proposed Development, where some floodplain storage capacity is lost due to the east embankment and the piers associated with the crossing.

8.1.49 The floodplain volume lost is calculated as approximately 50 m^3 with losses at elevations between 25.41 mAOD and 25.70 mAOD.

8.1.50 The losses due to the piers were calculated as <5 m^3 therefore, it is not proposed that these losses will be compensated for directly, but rather incorporated into the overall volume of the floodplain compensation area.

8.1.51 At the Stapleford viaduct the results show that there is a negligible change (<10 mm) in the peak water levels in the channel for all events simulated up to and including the 1% AEP, as well as the upper end climate change allowance. There is a 14 mm increase in the 0.1% AEP event, however this is only at the viaduct location, upstream of this the impact reduces to negligible.

8.1.52 The impacts on the floodplain levels are seen in the 3.3% AEP event and for the more extreme events. The impacts are only on the right bank floodplain for all events, except the most extreme 0.1% AEP event.

8.1.53 In the 3.3% event, there is a very small area affected by the Proposed Development, and the increases in flood levels are very localised to within the footprint of the Stapleford viaduct.

8.1.54 During the design event the 1% AEP with the higher central climate change allowance the impact on the right bank is minor adverse, with an increase in flood depth between 10 mm and 50 mm. Outside the corridor width of the Stapleford viaduct embankment the increase in flood level is less than 20 mm, and this reduces to 0 mm approximately 60 m upstream of the viaduct.

8.1.55 Again, there was a minor adverse effect on the floodplain with storage capacity losses due to both embankments. The floodplain volume lost is calculated as approximately 85 m^3 between elevations of 17.15 mAOD and 17.44 mAOD.

8.1.56 Again, the volume of loss due to the piers were calculated as <5 m^3 therefore, it is not proposed that these losses will be compensated for directly, but rather incorporated into the overall volume of the floodplain compensation area.

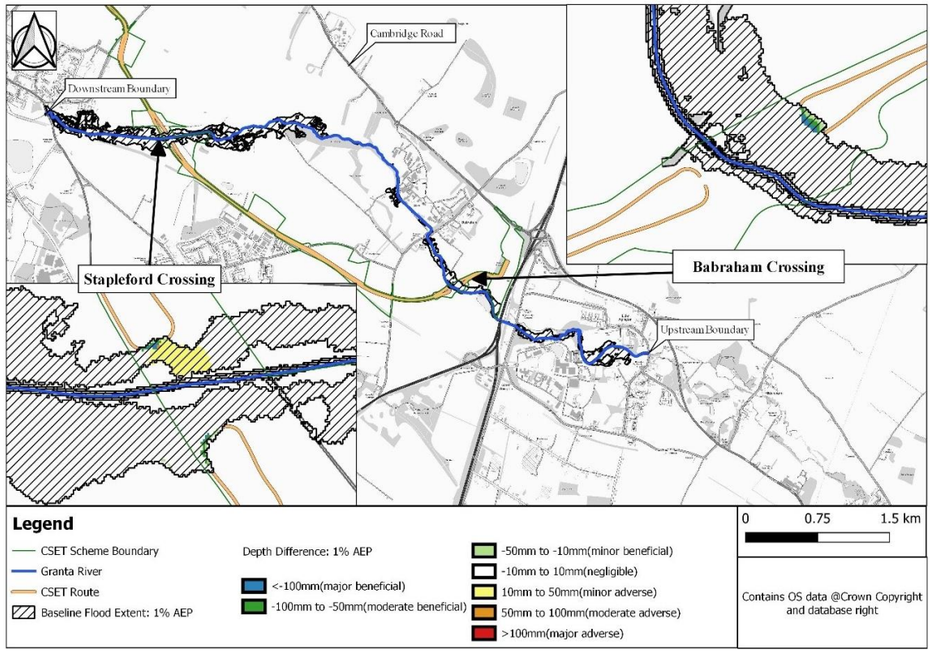


Figure A 8.1.11 Depth difference map between baseline and post Proposed Development model for the 1-in-100-year event

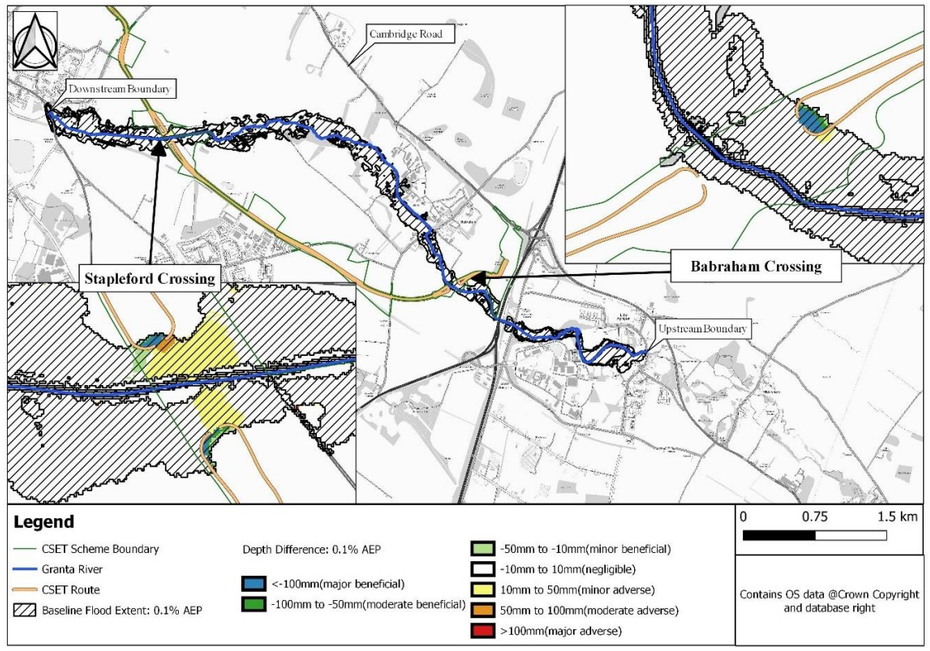


Figure A8.1.12 Depth difference map between baseline and post Proposed Development model for the 1-in-1000-year event

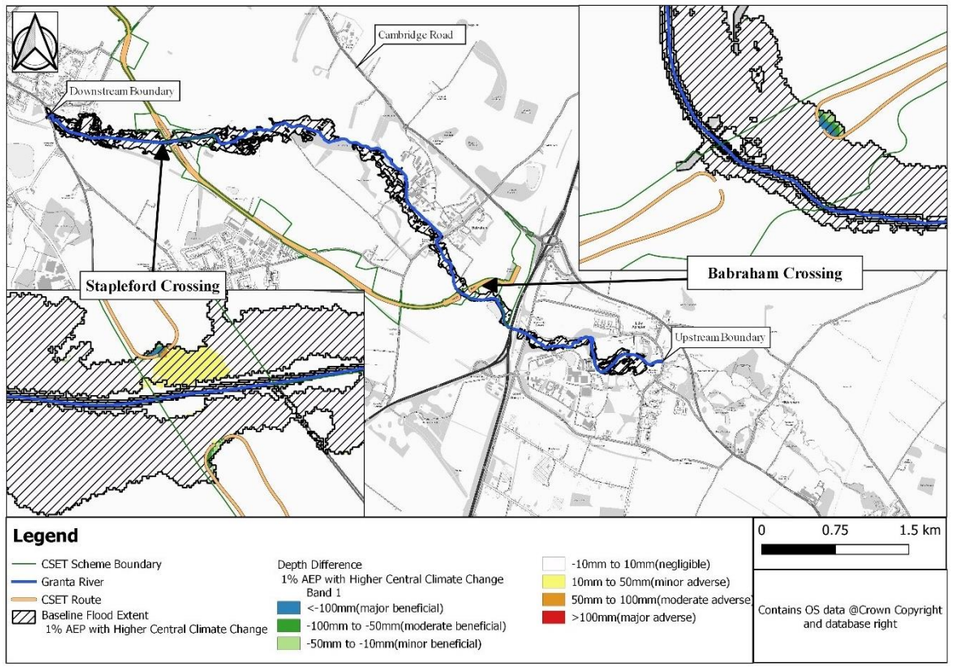


Figure A8.1.13 Depth difference map between baseline and post Proposed Development model for the Climate Change scenario

8.1.57 The change in flood extent between the baseline and the Proposed Development is negligible. As shown in Figure A8.1.11, Figure A8.1.12, and Figure A8.1.13.

8.1.58 Flooding mostly affects agricultural fields and does not affect the Proposed Development at any location. There is some displacement of floodplain volume expected at both crossings from the embankments and piers, and appropriate mitigation in the form of level-for-level and volume-for-volume floodplain compensation, will be required.

8.1.59 The A11 Travel Hub area is designed to be outside of the Flood Zone 3 and Flood Zone 2 extents (except for a small area used for landscaping), and this does not change in any scenario modelled.

8.1.60 Fluvial flood risk from Hobsons's Brook is likely to be minimal given the small size of the channel and small volume of flow it is likely to carry. Further investigation of flood risk from the Hobson's Brook will need to be undertaken at the detailed design phase.

8.1.61 Overall, fluvial flood risk remains localised to the same area as the baseline, with no increase in hazard to the community at risk. Differences in extent are local and mostly impact the fields near to the crossing.

Surface water (pluvial) flood risk

8.1.62 There is minimal pluvial flood risk along the Proposed Development route which is predominantly rural. Surface water is likely to be confined either to existing drainage channels or dispersed within the surrounding arable land.

8.1.63 Based on the Environment Agency's RoFSW mapping (Figure A8.1.6), where the proposed route joins Francis Crick Avenue at the Dame Mary Archer Way Roundabout, surface water flooding is likely to affect the route.

8.1.64 There is also an area at low surface water flood risk in the field on the approach to Francis Crick Avenue, with most of this flood risk contained to the north-west corner and the northern edge of the field.

8.1.65 The Proposed Development will increase the impermeable surface area as it is being built along predominantly rural land, therefore it is likely to increase surface water flood risk. Appropriate mitigation through the drainage design will be required.

8.1.66 In particular, the A11 Travel Hub will create a large impermeable surface area and therefore, as detailed in the Drainage Strategy (Volume 3, Appendix 2.1), the Proposed Development will incorporate SuDS as part of the design to reduce surface water flood risk. There are also three attenuation ponds proposed as part of the A11 Travel Hub's design.

Artificial sources

8.1.67 There is a risk of flooding from reservoirs to the Stapleford crossing, however it is unlikely to be at depths or extents great enough to impinge on design, as the route will be raised in this location.

8.1.68 The remainder of the route is not deemed to be at risk of flooding from a reservoir breach. Moreover, the stringent design, inspection, and maintenance requirements of the Reservoirs Act (1975) means that the risk of overtopping and / or breach (and thus flooding) is very low.

8.1.69 There are no other artificial sources of flooding which may impact the Proposed Development.

Mitigation measures

River Granta

8.1.70 Based on the model results and piers design, the volume loss on the floodplain has been calculated at both crossings.

8.1.71 The floodplain compensation calculations for both viaduct crossings are discussed within the Hydraulic Modelling Report (Volume 3, Appendix 8.2).

8.1.72 The volume loss on the floodplain, even though small, needs to be compensated for at level-for-level and volume-for-volume. To that aim, flood compensation areas will be designed at both crossings based on the full range of return periods assessed and the floodplain storage will be replaced. The compensation areas will need to have a slight overlap with the Flood Zones to ensure compensation for the more frequent events whilst still providing the additional storage in the most rare / extreme events. The details of the floodplain storage compensation areas and reprofiling to provide level-level compensation are subject to detailed design assessment and will require a ground investigation.

Hobson's Brook

8.1.73 Surface water flood risk is likely to be the main concern in the vicinity of Hobson's Brook. However, as discussed in Section 8.1.35, the risk only presents itself under the most extreme conditions and with the existing ground condition being saturated.

8.1.74 The details of any mitigation solutions and any residual risk from the Hobson's Brook are subject to detailed design assessment.

Temporary works

8.1.75 The management of surface water and fluvial flood risk during the construction phase has been incorporated into the CEMP to ensure there is no increase in flood risk (ES Volume 3, Appendix 2.4).

8.1.76 The design of the temporary structures, access roads and compounds will be the responsibility of the contractor appointed by the Applicant to deliver the Proposed Development. It is expected that temporary works will include access roads and crossing structures over the River Granta and Hobson's Brook at or close to the final river crossings assessed above.

8.1.77 The CEMP will set out the requirements for the temporary works to avoid increasing flood risk to third parties during construction. The structures over the channel should be clear span so as not to restrict flows up to the top of the river banks. The access or haul roads should be at grade so as not to obstruct any floodplain flows. Flood risk to the access roads will be managed by avoiding operation outside of flood conditions. Measures to control such risks will be incorporated into the final Code of Construction Practice (CoCP) (ES Volume 3, Appendix 2.4) and CEMP.

Drainage and management of surface water

8.1.78 A separate site-specific Drainage Strategy (Volume 3, Appendix 2.1) has been prepared to address the management of surface water quantity and quality as shown on the drainage drawings.

8.1.79 The relevant drainage criteria and resulting drainage design have been summarised here based on the updated drainage strategy including:

- Design of drainage measures to meet the Proposed Development performance standards as follows:
  - For the critical 3.3% AEP rainfall event, there should be no above-ground flooding.
  - For the 1% AEP rainfall event plus climate change allowance, some short-term flooding is permitted, however, it should be managed such that it does not enter buildings or disrupt emergency routes.
  - Allowable discharge rates set to 2 l/s/ha for events up to and including 1% AEP rainfall event plus 40% in accordance with CCC guidance.
- Drainage to control surface water runoff from the carriageway and Travel Hub, likely to be a capture conveyance type strategy involving the following features:
  - Permeable paving, swales and geocellular attenuation units underneath the pedestrian paths and cycleways
  - Flowing into attenuation ponds at strategic locations along the route and within the Travel Hub, limiting the outfall to the allowable discharge rate
  - Attenuation ponds positioned outside Flood Zone 2 and 3 to allow capacity to store extreme rainfall and to treat water quality
  - Infiltration is not considered due to ground conditions anticipated to have low permeability.

8.1.80 The Drainage Strategy (Volume 3, Appendix 2.1) includes a provision for the safe failure of the drainage systems during extreme events rarer than the 3.3% AEP storm. Operation of the Proposed Development can be judged as safe, if flood depths are less than 100 mm on the road and transport route element or less than 300 mm in car park areas, when a parked car could otherwise begin to float (Flood Hazard FD2320/21).

8.1.81 Cambridgeshire County Council will adopt and maintain the Proposed Development including all the drainage assets and bridges.

Summary of flood risk

8.1.82 Overall, the Proposed Development does not have a significant impact on flood risk, as it is predominantly located outside of Flood Zone 2 and Flood Zone 3, and other high risk areas, and will provide appropriate mitigation where this is not possible.

8.1.83 Table A8.7 summarises how the Proposed Development will manage flood risk from all flood risk sources up to the 0.1%AEP, ranked in order of highest to lowest risk.

8.1.84 Table A8.7 also summarises the flood risks to the Proposed Development and from the Proposed Development to third parties. The flood risk has been classified considering the main receptors of agricultural land and buildings as Less Vulnerable under Table 2: Flood risk vulnerability classification within Flood Risk Assessment guidance[15]. The classification for change in flood risk is as follows:

- High: >200mm change in water level or a change in flood hazard category
- Moderate: 100-200mm change in flood depth
- Minor: 50-100mm change in flood depth
- Very low or negligible: < 50mm change in flood depth.

8.1.85 Overall, the Proposed Development is not predicted to change fluvial flood risk as it remains in the very low or negligible category for the majority of its length. Only the two bridge crossings obstruct fluvial flow and cause minor change in flood risk. New level-for-level floodplain compensation areas are possible within the existing red line boundary and will be integrated into the design to offset any floodplain volume lost.

8.1.86 Surface water flooding has been managed through the drainage design to prevent flooding to the Proposed Development in the 3.3% AEP event and safely managed flows in the 1% AEP with climate change event.

8.1.87 The details of any mitigation and any residual risk on the Hobson's Brook is subject to a detailed design assessment.

8.1.88 The impacts of any updates to rainfall and river flow in subsequent climate change allowance guidance should be assessed at detailed design stage.

[15] Flood risk and coastal change - GOV.UK (www.gov.uk)).

Table A8.1.3: Flood risk management of the Proposed Development

Source of Flood Risk	Flood Risk to the Proposed Development without mitigation	Action required	Change in flood risk to the Proposed Development with mitigation	Change in flood risk to third parties with mitigation
Drainage and surface water	High Risk to the Proposed Development itself. Potentially moderate risk to third parties where surface water could be diverted by the Proposed Development without mitigation.	Design of drainage strategy with permeable paving, swales, attenuation units and attenuation ponds along the route and Travel Hub to ensure no flooding in the 3.3% AEP event. Design of drainage strategy that allows some short-term flooding along the route or in the Travel Hub during the 1% AEP + climate change storm but allows for safe egress of flows, avoiding buildings or disruption of emergency routes. Design of attenuation ponds to store up to the 1% AEP plus climate change flows safely and release at greenfield runoff rate into the River Granta. The attenuation pond to the north of Hobson's Brook / Conduit would be maximised alongside a swale solution running south to offset any flood storage volume displaced by the Proposed Development in the 0.1% AEP event. The details of this solution and any residual risk to the field drains are subject to a detailed design assessment.	<3.3% AEP	Very low subject to a detailed design assessment which will include the Hobson's Brook and which will have to be approved by the County Council as the Lead Local Flood Authority prior to construction.
Fluvial	Very low to the Proposed Development itself. Negligible change to communities or buildings. Minor change to agricultural fields immediately adjacent to the crossings.	Floodplain storage volume lost within the footprint of the bridge crossing at Babraham and Stapleford, creating minor changes in flood depth. Approximately 50 m^3 and 85 m^3 respectively. Mitigation in the form of volume-for-volume, level-for-level compensation will be provided, the exact location and design of the compensation area is subject to the detailed design	<0.1% AEP with climate change	Very low subject to the detailed design of the floodplain compensation areas.
Groundwater	%AEP not assessed. Risk assessed to be Very Low as the track is raised and not intersecting the aquifer.	None required. Groundwater flood risk is already negligible or managed by the drainage strategy at Francis Crick Avenue. Note that drainage via infiltration is not considered due to the relatively high groundwater level at this location.	No change	No change
Coastal	Not applicable	Not at risk from coastal flooding.	Not applicable	Not applicable
Reservoirs and canals	Reservoir breach risk present but less than fluvial flood flows- see fluvial assessment.	Extent and velocities at Stapleford and Babraham Crossings are predicted to be less than the fluvial flooding conditions. Therefore, the risk is managed as part of the fluvial flooding assessment.	See fluvial assessment	See fluvial assessment