M27 Southampton Junctions

FLOOD RISK ASSESSMENT

HE551514-JAC-EWE-PCF3_SS1-RP-LE-0002 | P01

16/01/20

HE551514

M27 Southampton Junctions

Project No: B229H190
Document Title: FLOOD RISK ASSESSMENT
Document No.: HE551514-JAC-EWE-PCF3_SS1-RP-LE-0002
Revision: P01
Date: 16/01/20
Client Name: HIGHWAYS ENGLAND
Client No: HE551514
Project Manager: Paul McKay
Author: A. HOSSAIN
File Name: HE551514-JAC-EWE-PCF3_SS1-RP-LE-0002.docx

Jacobs U.K. Limited

1180 Eskdale Road
Winnersh, Wokingham
Reading RG41 5TU
United Kingdom
T +44 (0)118 946 7000
F +44 (0)118 946 7001
www.jacobs.com

Document history and status

Revision	Date	Description	By	Checked	Reviewed	Approved
P01	16/01/20	FINAL	AH	DS	DS	PM
P00	11/11/19	FIRST ISSUE	AH	CD	DS	PM

Contents

JACOBS

Executive summary

Jacobs UK Ltd. (Jacobs) was commissioned by Highways England to undertake a site-specific Flood Risk Assessment (FRA) as part of the M27 Southampton Junctions scheme (hereafter referred to as the proposed 'Scheme'). The aim of the proposed Scheme is to reduce congestion and improve safety around the M27 junction 8 and A27 Windhover Roundabout. The site is situated north of the village of Bursledon, Hampshire, within the Eastleigh Borough Council area.

The purpose of this report is to provide a summary of the existing flood risk to the proposed Scheme and demonstrate that the proposed Scheme complies with the flood risk requirements of the National Planning Policy Framework (NPPF), the Design Manual for Roads and Bridges (DMRB), and the Lead Local Flood Authority (LLFA). The assessment of flood risk from all sources is largely based on the results of a desk-based study undertaken between August and October 2019. However, hydraulic modelling of an ordinary watercourse located at junction 8 has also been undertaken to assess the flood risk it poses to the scheme and the effect of the proposed Scheme on flood risk elsewhere.

All the proposed improvement works are to be undertaken within the existing highway boundary. Due to the spatial constraints of the scheme, the proposed drainage strategy will re-use as much of the existing drainage system as possible. The proposed Scheme has been designed to ensure the Scheme is safe for its lifetime as well as ensuring that the Scheme does not negatively impact flood risk elsewhere. As per DMRB guidelines, drainage has been designed to ensure that the following design standards are met: no surcharging in the 100% (1 in 1) Annual Exceedance Probability (AEP) event; no flooding in the 20% (1 in 5) AEP event; and no surface water flooding extending beyond the highway boundary in the 1% (1 in 100) AEP event. The proposed drainage strategy has also been designed to provide a potential reduction to existing peak discharge rates for all events up to the 1% (1 in 100) AEP event including an increase in rainfall intensity of 20% due to climate change of 20%.

The impacts of all sources of flood risk to the development have been assessed. The published Environment Agency (EA) flood mapping indicates that the entirety of the proposed Scheme lies within Flood Zone 1 and is remote from flood risk associated with main rivers and the sea. However, two tributaries of an ordinary watercourse (Bursledon Brook) are culverted beneath junction 8. The risk of flooding from these minor watercourses is not accounted for on the Flood Map for Planning. Therefore, hydraulic modelling of this watercourse was undertaken as part of this assessment. The results of this modelling indicate that flooding currently onsets during events greater than the 50% (1 in 2) AEP event when a culvert upstream of junction 8 surcharges, resulting in flow passing overland to the south before ponding on the roundabout of the A3024.

The design flood event for this this scheme is the 1% AEP flood event including a 35% increase in flows to account for climate change during the 100 year life of the development. During this design event flood depths greater than 850mm are predicted on the existing carriageway and roundabout. Based on this, the existing fluvial flood risk to the scheme is considered high.

To manage the risk of fluvial flooding from the two tributaries of Bursledon Brook, the design of the proposed Scheme includes several mitigation measures. To manage flows from the eastern tributary, a series of flood storage measures comprising a basin, an underground tank and a pond are proposed. Risk from the western tributary would be managed by a flood wall along the north-west corner of the roundabout to prevent water from flowing onto the carriageway, another storage area adjacent to this wall would then partially mitigate for the loss of floodplain storage on the carriageway.

With these mitigation measures in place, hydraulic modelling demonstrates that the proposed Scheme would remain safe from flooding during the 1% AEP flood event including an allowance for climate change. Therefore, the risk of fluvial flooding to the proposed Scheme is considered to remain low throughout its 100 year design life. However, the reduction in floodplain volume as a result of the proposed wall will displace flood water upstream of this point increasing flood extents and depths on land to the land north-west of junction 8. It is proposed that this localised increase in risk will be resolved through landowner compensation or by increasing the size of the north-western flood storage area.

The Environment Agency's surface water flood risk map identifies existing areas of high surface water flood risk (greater than 3.3% (1 in 30) AEP) at the site. At junction 8 the flooding shown on this map is attributed to both surface water runoff and flooding from the ordinary watercourse. These risks will be mitigated by proposed drainage and fluvial mitigation. At Windhover Roundabout the EA surface water flood risk map shows two small areas at high risk of flooding on the existing road. However, the EA's surface water flood maps do not include any representation of road drainage and any surface water risk in these areas will be effectively mitigated by the proposed drainage.

The risk of groundwater flooding, sewer flooding and flooding from other sources to the site and arising from the proposed Scheme has been assessed and is considered to be low.

To manage flood risk and meet the NPPF requirements it is recommended that:

- Further liaison should be undertaken with landowners to enable the expansion of flood storage areas to the north west of the scheme or to agree the increased level of flood risk to their land at the north-east corner of junction 8
- Any changes to the proposed Scheme that impact on flood risk are re-assessed to ensure compliance with this FRA. These will be agreed with the LLFA at detailed design stage or as part of the ordinary watercourse consenting process
- A detailed maintenance and management plan should be produced at the detailed design stage to detail requirements for the on-going management of the proposed surface water drainage network, including the sustainable drainage (SuDS) features, for the lifetime of the development
- Information and data from the relevant council bodies and the Environment Agency is regularly reviewed throughout the planning process, as new information might be made available
- The contractor should obtain all required permits prior to construction phase works

It should also be noted that there may be an opportunity to rationalise the mitigation and drainage proposed if more detailed assessment were undertaken using an integrated hydraulic model incorporating both drainage and fluvial elements.

Subject to the recommendations being met, it is considered that the development would meet the requirements of the NPPF and would:

- Remain operational and safe for users in times of flood
- Would not result in an increase in flood risk elsewhere

1. Introduction

1.1 Purpose

Jacobs UK Ltd. were commissioned by Highways England to prepare a site-specific Flood Risk Assessment (FRA) for the M27 Southampton Junctions Scheme (herein referred to as the proposed 'Scheme').

The purpose of this report is to demonstrate that the proposed Scheme complies with the flood risk requirements of the National Planning Policy Framework (NPPF), the Design Manual for Roads and Bridges (DMRB), and other relevant standards (*see Section 2*). It includes:

- An assessment of the flood risk to the proposed development, demonstrating that the intended use is appropriate in terms of flood risk
- An assessment of the predicted impact of the development upon flood risk
- Demonstration that the development will not have a negative impact upon flood risk to other parties
- A summary of any mitigation measures required to achieve this outcome

1.2 Context

The proposed Scheme concerns two junctions, namely M27 junction 8 and A27 Windhover Roundabout, and the road that links them, namely Bert Betts Way (A3024). The site is situated in the county of Hampshire, within the local planning authority area of Eastleigh Borough. The Lead Local Flood Authority (LLFA) for this area is Hampshire County Council (HCC). The site is located south-east of the city of Southampton in the parish of Bursledon.

The aim of the proposed Scheme is to reduce congestion and improve safety around M27 junction 8 and Windhover Roundabout. It seeks to do this by local widening and signalisation of all approach arms to both junctions. By improving M27 junction 8 and Windhover Roundabout, the proposed Scheme aims to encourage city centre bound traffic from the east of Southampton to use the shorter sign-posted routes via M27 junction 8 / A3024. This in turn will improve traffic flow and reliability on the M27 between junctions 8 and 5.

1.3 Approach

A desk-based study has been undertaken to inform the impact of the development site on flood risk and the wider water environment. In accordance with the national planning policy guidance (PPG) the assessment of the flood risk to the development site has been completed based on the following sources of information:

- Flood risk information, LiDAR, main river map and national policy information available from the Gov.uk website
- Geological information available from the British Geological Society (BGS)
- Eastleigh Borough Local Plan (Eastleigh Borough Council, 2014)
- Hampshire County Council (HCC) Preliminary Flood Risk Assessment (HCC, 2011)
- Partnership for Urban South Hampshire (PUSH) Strategic Flood Risk Assessment (PUSH, 2016)
- Eastleigh Surface Water Management Plan (HCC, 2012)
- Hampshire Local Flood Risk Management Strategy (HCC, 2013)
- South East Hampshire Catchment Flood Management Plan (Environment Agency, 2009)

Additional data sources used include:

- Environment Agency (EA) Catchment Explorer (Environment Agency, 2018)
- Contemporary OS maps
- Current aerial photography
- Designated areas (Natural England, 2019)

The assessment of flood risk from all sources undertaken within this report is based largely on information available from these online sources. The assessment of surface water and reservoir flood risk impacts is based on information on flood extents readily available from the Environment Agency (EA) at the time of this assessment. The EA undertakes a continual programme of model updates; consequently, flood extents are subject to change.

In addition to a review of published information, hydraulic modelling has also been carried out as part of this assessment. Following an initial assessment, a more detailed assessment of the flood risk from an ordinary watercourse identified at junction 8 was deemed necessary as the initial assessment identified areas at high risk of flooding that would be impacted by the Proposed Scheme. Hydraulic modelling was therefore undertaken to assess this risk to the scheme, identify if the scheme would impact on existing risk elsewhere and to enable the development of mitigation options where required.

Throughout this report flood events are represented by annual exceedance probability (AEP) events such as 1% and 0.1%, which are equivalent to the 100 and 1000-year return period respectively.

The assessment of potential impacts and mitigation are based on the results of the hydraulic modelling along with professional judgement and available design drawings; these may change during later phases when additional or updated information and data is available.

1.4 Sources of flooding

Consideration has been given to the following sources of flooding within the proposed Scheme area:

- **Fluvial** – Flooding originating from either a natural or man-made watercourse
- **Tidal** – Flooding of low-lying areas resulting from exceptionally high tides
- **Surface Water (pluvial)** – Flooding resulting from high intensity rainfall saturating the drainage system (either natural or man-made) with excess water travelling overland and ponding in local topographic depressions. This also includes consideration of the impact of the new road drainage on flood risk elsewhere
- **Sewer** – Flooding due to surcharging of man-made drainage systems. This can be as a result of extreme weather or blockages in the system
- **Water (potable) Supply** – Flooding due to a burst water main
- **Groundwater** – Flooding due to elevated ground water levels
- **Reservoirs** – Flooding due to the collapse/failure of water retaining feature
- **Canals** – Flooding originating from a canal, often as a result of heavy rainfall

2. Flood risk policy

2.1 European and national policy

2.1.1 National Planning Policy Framework

The NPPF (Ref 18) published in March 2012, updated in July 2018 and revised in June 2019, sets out the Government's planning policies for England.

The NPPF sets strict tests to protect people and property from flooding which all local planning authorities are expected to follow. Where these tests are not met, national policy is clear that new development should not be allowed. The main steps are designed to ensure that if there are better sites in terms of flood risk, or a proposed development cannot be made safe, it should not be permitted. The update in July 2018 added the requirement for major developments to incorporate sustainable drainage systems (SuDS) unless there is clear evidence that this would be inappropriate.

In March 2014 the Technical Guidance of the NPPF was replaced with the National Planning Practice Guidance (NPPG) (Ref 17). This provides further guidance to local planning authorities to ensure the effective implementation of planning policy set out in the NPPF on development in areas at risk of flooding.

2.1.2 Site-specific Flood Risk Assessment

Footnote 20 in the NPPF states that a site-specific FRA is required for proposals of 1 hectare or greater in Flood Zone 1; all proposals for new development (including minor development and change of use) in Flood Zones 2 and 3, or in an area within Flood Zone 1 which has critical drainage problems (as notified to the local planning authority by the Environment Agency); and where proposed development or a change of use to a more vulnerable class may be subject to other sources of flooding. Although the proposed Scheme is located within Flood Zone 1, it is greater than 1ha in area and therefore a site-specific flood risk assessment has been prepared.

Additionally, the FRA should demonstrate to the decision-maker how flood risk will be managed now and over the development's lifetime, taking climate change into account, and with regard to the vulnerability of its users. The FRA should establish:

- Whether a proposed development is likely to be affected by current or future flooding from any source
- Whether it will increase flood risk elsewhere
- Whether the measures proposed to deal with these effects and risks are appropriate
- The evidence for the local planning authority to apply (if necessary) the Sequential Test
- Whether the development will be safe and pass the Exception Test, if applicable

2.1.3 Design Manual for Roads and Bridges

The Design Manual for Roads and Bridges (DMRB) is a suite of documents containing requirements and advice for works on highways. It is required that the site drainage be designed in compliance with HD33/16 Design of Highway Drainage Systems (Ref 4).

The proposed design strategy must comply with the following design principals:

- Removal of surface water from the carriageway as quickly as possible to provide safety and minimum nuisance to the travelling public
- Provision of effective sub-surface drainage to maximise longevity of the pavement and its associated earthworks
- Minimisation of the impact of the runoff on the receiving environment in terms of flood risk and water quality

The following discharge destinations are the order of preference for highway runoff options:

1) Ground
2) Surface watercourse
3) Surface water sewer

2.2 Local flood risk policy

2.2.1 Eastleigh Borough Local Plan

The Eastleigh Borough Local Plan 2011-2029 (Ref 5) is the key strategic planning document for Eastleigh and will guide and support the delivery of new infrastructure (along with other items) until 2029. The report is currently a revised pre-submission draft produced in 2014 that is now up for public consultation, before it will be submitted for examination by the Secretary of State for Communities and Local Government. The Local Plan acknowledges the proposed Scheme in 'Strategic policy S7', however, it does not discuss site specific details with regards to flood risk.

The Local Plan states that development within areas at risk from fluvial or coastal flooding will only be supported if:

- A sequential test is carried out in line with NPPF guidance to demonstrate that this is the only site where the development can be located.
- Where necessary, an exception test is carried out in line with NPPF guidance to demonstrate that:
  - The proposed Scheme will provide wider sustainability benefits to the community that outweigh the flood risk
  - There is a site-specific FRA to show that the development will be safe for its lifetime taking into account the vulnerability of its users, without increasing flood risk elsewhere
  - That the development will not adversely affect existing flood defence or flood risk management structures or measures

The Local Plan also states that there must be no increase in surface water run-off as a result of the proposed Scheme, and sets out the following requirements:

- Surface water run-off should be managed as near to its source as possible through the use of SuDS, unless it is justified why these are not appropriate.
- Where a watercourse is present it should be retained or restored into a natural state and enhanced where possible. Culverting is not permitted.

The Local Plan advises that the following documents are consulted by developers:

- Most recent Environment Agency published flood maps
- Most recent contingency allowances as set out in the NPPF
- The Surface Water Management Plan (SWMP) for the borough prepared in 2013
- The Local Flood Risk Management Strategy prepared by Hampshire City Council

2.2.2 Strategic Flood Risk Assessment

The NPPF requires that local planning authorities prepare a Strategic Flood Risk Assessment (SFRA) in consultation with the EA and others. The primary purpose of a Level 1 SFRA is to determine the variation in flood risk across the District, based upon data from a variety of sources in order to apply the Sequential Test.

A SFRA for Hampshire as a whole has been prepared by the Partnership for Urban South Hampshire (PUSH), a voluntary working group consisting of ten Hampshire local authorities and the County Council. The original SFRA was produced in 2007 (Ref 1), however a revision was published in 2016 (Ref 6) to replace this with current information. The Appendices to the SFRA include individual Guidance Documents specific to each local authority – the Eastleigh Borough Council Guidance Document is also referred to for the purposes of this FRA. It recommends the following key guidance be applied in the preparation of an FRA:

- The NPPF
- Planning Practice Guidance: Flood Risk and Coastal Change
- Flood risk assessment for planning applications, Environment Agency
- Flood risk assessment: standing advice, Environment Agency

Further to this the Eastleigh Borough Council Guidance Document gives additional guidance including:

- It is recommended that FRAs for sites located within the fluvial flood hazard zones undertake a more detailed quantitative assessment of flood hazard based on an improved understanding of defences and flow routes
- The impact of climate change on sea levels and flood extents should be considered to inform the assessment of the long-term sustainability of developments currently within Flood Zone 1 and the likely increases in flood risk in Flood Zones 2 and 3
- Site specific FRAs should consider the impact of development on the local surface water runoff regime and should investigate SuDS options to manage surface water where achievable

2.2.3 Local Flood Risk Management Strategy

The Hampshire Local Flood Risk Management Strategy (LFRMS) (Ref 15) provides a general overview of flood risk throughout the county of Hampshire, with the exception of Southampton, Portsmouth and the Isle of Wight. The strategy focusses on local flooding caused by surface water, groundwater and flooding from ordinary watercourses but recognises that all sources of flooding are inter-related. As such, it identifies the areas within the county at highest risk of each type of flooding and associates the level of risk with a monetary value. Eastleigh is not mentioned as one of these priority areas, but it is stated that flooding from the sea is the predominant source of flood risk here – although not at the site of the proposed Scheme. The proposed actions for developers outlined in the LFRMS are summarised below:

- Consider flooding in its wider context, particularly in terms of the downstream effects of decisions made in specific locations and wider catchment effects.
- Aim to secure ‘multiple benefits’ (especially environmental and ecological) and deliver sustainability and Water Framework Directive benefits wherever possible in the decision-making process for delivering flood risk management infrastructure. This is likely to involve developing increased understanding of environmental impacts and mitigation measures at a project level.
- Ensure adequate maintenance is undertaken of flood risk management assets and infrastructure for which individual authorities, bodies and organisations are responsible.
- Take this Strategy into account when making decisions over land acquisitions.
- Design and layout sites to make the best use of natural drainage and topography.
- Ensure SuDS are used, wherever possible, to provide multiple benefits.

2.3 The Sequential Test

The PUSH SFRA, in accordance with NPPF, sets out the requirements for applying the Sequential Test when locating the development. The Sequential Test aims to steer new development to areas with the lowest probability of flooding. The flood zones as refined in the Local Planning Authorities SFRA for the area provide the basis for applying the Test. The aim is to steer new development to Flood Zone 1 (areas with a low probability of river or sea flooding). Where there are no reasonably available sites in Flood Zone 1, local planning authorities in their decision-making should take into account the flood risk vulnerability of land uses and consider reasonably available sites in Flood Zone 2 (areas with a medium probability of river or sea flooding), applying the Exception Test if required. Only where there are no reasonably available sites in Flood Zones 1 or 2 should the suitability of sites in Flood Zone 3 (areas with a high probability of river or sea flooding) be considered, taking into account the flood risk vulnerability of land uses and applying the Exception Test if required.

The NPPG (Ref 17) also adds that surface water and other sources of flooding should be considered consistently with river flooding in the assessment of vulnerability and application of the sequential test where information is available.

The Sequential Test is applied to the proposed Scheme in Section 4.3.1.

2.4 The Exception Test

If a development is proposed that is not ‘appropriate’, as defined in Table 3 of the NPPG, then the Exception Test is a method to demonstrate and ensure that flood risk to people and property will be managed satisfactorily, while allowing necessary development to go ahead in situations where suitable sites at lower risk of flooding are not available.

The two parts to the Test require the proposed development to show that it will provide wider sustainability benefits to the community that outweigh flood risk, and that it will be safe for its lifetime, without increasing flood risk elsewhere and where possible reduce flood risk overall.

The Exception Test in relation to the proposed Scheme is discussed in Section 4.3.2.

3. Site characteristics

3.1 Location

The site is situated north of the village of Bursledon, Hampshire, under the authority of Eastleigh Borough Council. Junction 8 is located where the M27 meets Dodwell Lane, and links via Bert Betts Way (A3024) to Windhover Roundabout approximately 400m to the west. This link provides the main means of access to the parish of Bursledon. The A27 West End Road, the A3024 Bursledon Road and Hamble Lane also converge at this roundabout. The National Grid Reference for junction 8 is SU 48463 11219 and for Windhover Roundabout is SU 47975 10985. The Scheme location is shown on figure 3.1.

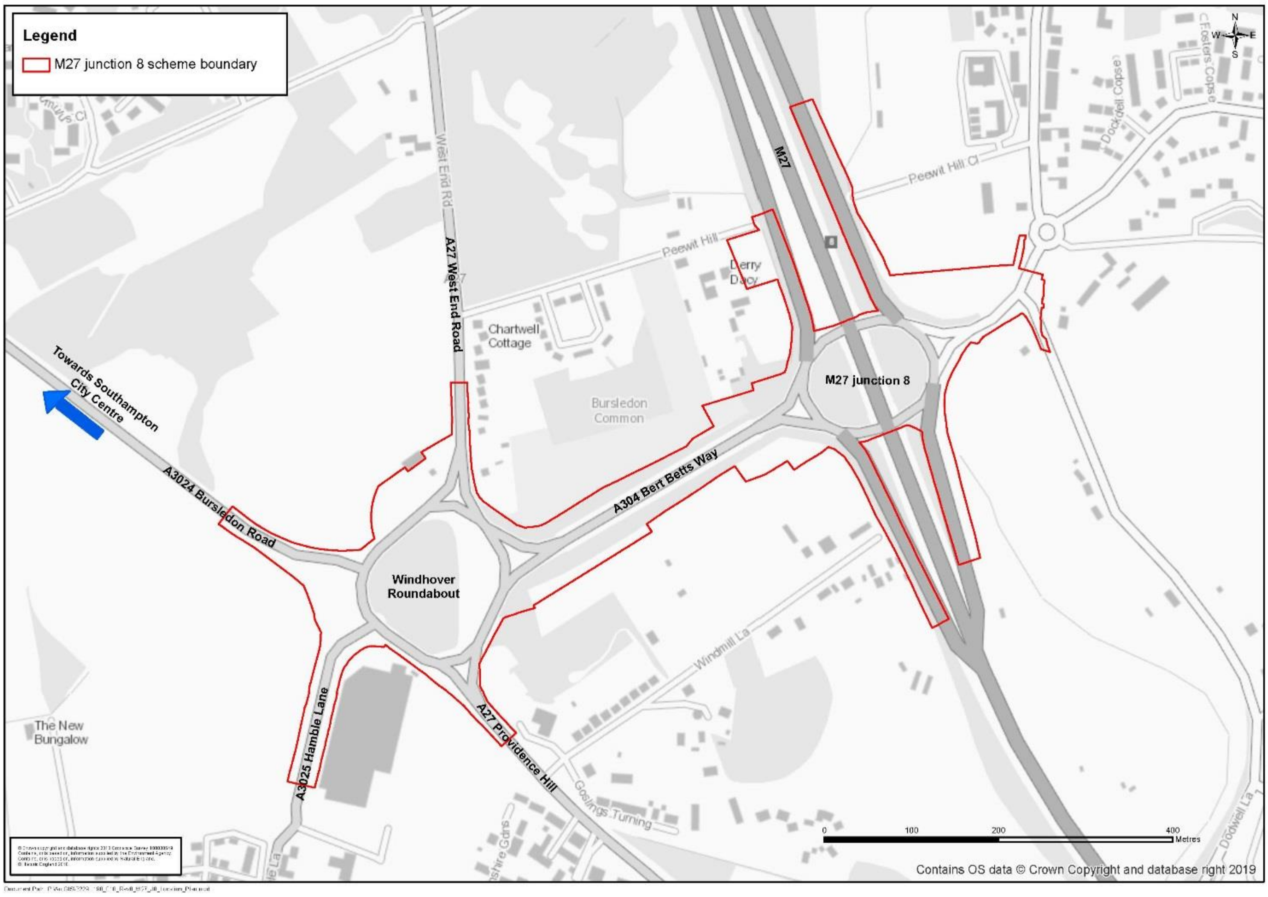


Figure 3.1: Scheme location

3.2 Existing site characteristics

3.2.1 Land use

Land use outside of the existing highways boundary in the immediate area of the proposed Scheme predominantly comprises arable land (generally located to the north and east of Windhover Roundabout). Various light industrial and commercial uses lie within 500m of the Scheme boundary to the south and south-east. There are residential areas located to the south of the proposed Scheme in Bursledon and to the north in Hightown.

3.2.2 Topography

The ground level surrounding both junction 8 and Windhover Roundabout generally increases from south to north. At junction 8 the M27 passes over the top of the roundabout. The level of the M27 at this point is approximately 49 m above Ordnance Datum (AOD) while the level of the A3024 below is approximately 42m AOD. Windhover Roundabout is uphill of junction 8, where the road level is approximately 60m AOD.

3.2.3 Geology

A review of the published British Geological Survey (BGS) map (Ref 2) indicates that the underlying bedrock at junction 8 is of the London Clay Formation, and at Windhover Roundabout it is Wittering Formation, which comprises laminated clay interbedded with some sandy layers. The Wittering Formation is classified as a Secondary A aquifer. The London Clay Formation is classified as unproductive and is generally considered to act as an aquitard.

There are no overlying superficial deposits recorded across the majority of the site, apart from River Terrace Deposits along the western edge of Windhover Roundabout.

For further information regarding the geology of the site please refer to the Ground Investigation Report (GIR) produced by Jacobs, 2019. The results of this investigation confirmed that the ground material agrees with the information from BGS. The historic boreholes reviewed within this report encountered groundwater levels at differing depths. This is assumed to be due to the interbedded granular layers of the Wittering Formation and London Clay Formation.

3.2.4 Watercourses

According to the EA Flood Map for Planning (Ref 8), the nearest main river to the proposed Scheme is a tributary associated with the River Hamble, approximately 600m north-east of junction 8.

There is an ordinary watercourse, Bursledon Brook, crossing the M27 junction 8 that is not recorded on the Flood Map for Planning but has been identified from the EA surface water flood risk map (Ref 9). It rises in the vicinity of the M27 / St. John’s Road (B3033) crossroad and consists of two unnamed minor tributaries, defined in this document as the eastern tributary and the western tributary. The two minor tributaries are culverted separately before reaching the M27 junction 8. The culverts pass under the M27 junction 8 roundabout and discharge to an open channel to the south east of the roundabout. The open channel reach of the Bursledon Brook flows approximately 600m due south east, before crossing the M27 once again.

3.2.5 Existing site drainage

Surface water drainage runs of traditional kerb and gully and/or kerb inlet gully drainage appear to be the most commonly used edge collection drainage for the arms and central islands of the existing junctions at Windhover Roundabout and M27 junction 8, including the link road (Bert Betts Way) connecting the two junctions. Collected surface water runoff is conveyed using either filter drains (i.e. perforated carrier drains within granular filter media), standard carrier drains and/or road side drainage ditches.

The existing drainage system at and around M27 junction 8 (includes the drainage from Bert Betts Way) discharges to an existing ordinary watercourse south east of M27 junction 8. The existing drainage systems at and around Windhover Roundabout (including three different drainage catchments) discharge to existing drainage systems along Bursledon Road, Providence Hill and Hamble Lane. Existing surface water attenuation features such as attenuation storage ponds, underground attenuation storage tanks or pollution control measures are not present for the above-mentioned existing outfalls.

MicroDrainage modelling has been undertaken for the existing drainage system to establish existing peak discharge rates and existing flooded volumes for the 100% (1 in 1), 20% (1 in 5), 3.33% (1 in 30) and 1% (1 in 100) AEP events. The results of this analysis are presented in appendix A. The modelling results suggest that the existing system has capacity to accommodate the 100% (1 in 1) AEP event with some catchments having capacity to accommodate up to the 20% (1 in 5) AEP event.

3.3 Proposed works

Works to the M27 junction 8 and Windhover Roundabout include junction widening and traffic signal improvements, including improved facilities for pedestrians and cyclists. Further details are provided in the sections below. The proposed Scheme design is shown in Appendix B of the Environmental Assessment Report.

3.3.1 M27 junction 8

Proposed works at junction 8 will include:

- Localised junction widening around the circulatory carriageway and on the on-slip and off-slip roads:
  - a third lane around the circulatory carriageway
  - an additional lane on the approaches to the roundabout entry
- The introduction of traffic signals, including provisions for walkers, cyclists and horse riders (WCH). It is proposed that the give way method of control is removed, and traffic signals are introduced on all arms of the roundabout
- A new WCH path linking M27 junction 8 with Windhover Roundabout and onwards to A3024 Bursledon Road

3.3.2 A27 Windhover Roundabout

Proposed works at Windhover Roundabout, similarly to those at junction 8, will include:

- Localised junction widening around the circulatory carriageway and the entry / exit lanes:
  - the circulatory carriageway will be widened to have three lanes
  - an extra entry lane will be added at the A3024 Bert Betts Way, A27 Providence Hill, and A27 West End Road
- Signal improvements, including provisions for WCH:
  - new crossing facilities will be included to accommodate pedestrian and cycle movements around the junction. These WCH crossings will connect to existing pedestrian and cycle paths as well as the new WCH link from M27 junction 8
- A new 3m wide shared WCH route to the south of A3024 Bert Betts Way (connecting to M27 junction 8) and across the centre of the roundabout from A27 West End Road to A27 Providence Hill

3.3.3 Proposed site drainage

The proposed highway improvement works include the widening of the existing road in certain areas and improvement works at roundabouts, which results in a total increase in impermeable area (see Table 3.1). This increase in impermeable area will require adequate drainage to manage the increased surface water runoff.

Table 3.1: Area summary for existing vs proposed site conditions

	Total Catchment Area (ha)	Impermeable/Paved Area (ha)	Permeable/ Grass/Verge Area (ha)	Natural Catchment Area (ha)
Windhover Roundabout: Network 1 (Outfall to existing drainage system at Bursledon Road)				
Existing Site Condition	4.808	0.839	1.425	2.544
Proposed Site Condition	5.459	1.191	1.724	2.544
Windhover Roundabout: Network 2 (Outfall to existing drainage system at Providence Hill Road)				
Existing Site Condition	0.843	0.535	0.308	-
Proposed Site Condition	0.843	0.581	0.262	-
Windhover Roundabout: Network 3 (Outfall to existing drainage system at Hamble Lane)				
Existing Site Condition	0.852	0.331	0.521	-
Proposed Site Condition	0.852	0.464	0.388	-
M27 junction 8 - Outfall to an existing watercourse				
Existing Site Condition	58.091	6.161	5.93	46
Proposed Site Condition	58.091	6.841	5.25	46

The proposed highway improvement works at Windhover Roundabout and M27 junction 8 include kerbed sections, therefore the new surface water collection system will use either trapped gullies or combined kerb drains. Collected surface water runoff will be conveyed using filter drains (i.e. perforated carrier drains within granular filter media) or swale/road side drainage ditches in most locations. Standard carrier drains will be used at other locations. Attenuation storage is to be provided by an underground geocellular storage systems and attenuation basins to restrict increased surface water runoff rates and volumes from the proposed Scheme prior to discharge to existing watercourses/existing drainage systems. As all the proposed improvement works are to be undertaken within the existing highway boundary, it is proposed that any additional attenuation storage will be provided by means of oversized combined kerb drains, oversized pipes and maximising the capacity of roadside drainage ditches via provision of check dams.

Due to the spatial constraints of the highway boundary, it is also proposed that the existing drainage system be re-used as much as possible. The proposed drainage system will include SuDS measures in the form of existing filter drains in certain locations where these are being retained and new filter drains where the existing drainage is affected by the scheme, swales, roadside drainage ditches and attenuation storage provided by means of attenuation basins and underground geocellular storage systems.

Details of the proposed scheme drainage design can be found in Appendix A. Assessment of the impact of the proposed drainage system on surface water flood risk is discussed in Section 5.2.

4. Existing flood risk

4.1 Assessment of flood risk

4.1.1 Fluvial flood risk

The EA Flood Map for Planning (FMfP, Ref 8) indicates that the footprint of the proposed Scheme lies entirely within Flood Zone 1 which is defined as areas where the risk of flooding from major fluvial sources is less than 0.1% (1 in 1000) AEP. The closest mapped floodplain is approximately 600m to the north and is associated with tributaries of the River Hamble. The flood risk from main rivers is therefore considered to be very low, however the Flood Map for Planning generally does not map floodplains from smaller watercourses. An extract from the EA Flood Map for Planning at the location of the existing site is shown in Figure 4.1 below.

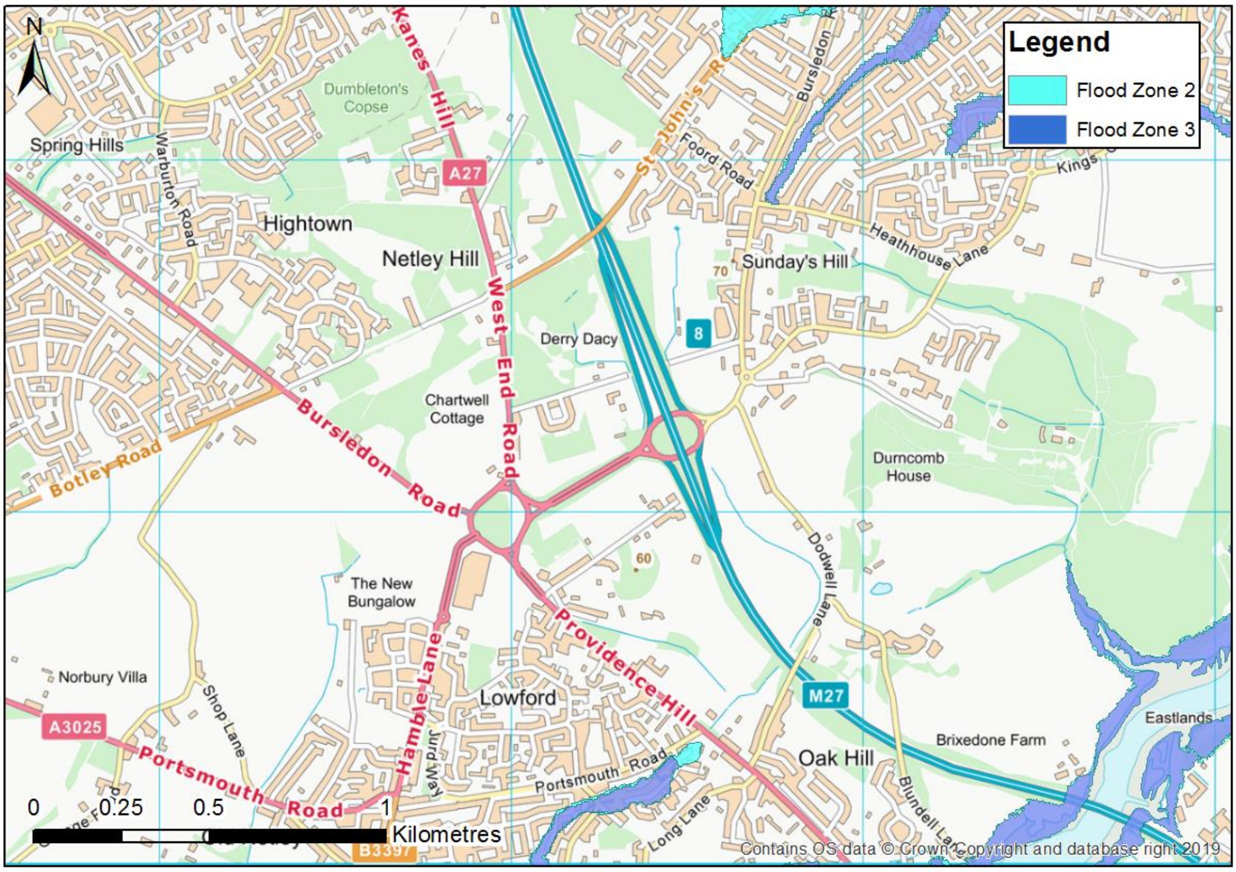


Figure 4.1: EA Flood Map for Planning

Two ordinary watercourses which are tributaries of Bursledon Brook flow from north to south and are culverted beneath junction 8. The western tributary flows through a network of culverts ranging in size from 600mm diameter under Peewit Hill to a 525mm diameter culvert beneath junction 8. The eastern tributary enters a 450mm diameter culvert at Peewit Hill which extends under Dodwell Lane. At the confluence of the two tributaries the watercourse enters another 675mm culvert before discharging to an open channel to the east of the M27.

The risk of flooding from these minor watercourses is not accounted for on the FMfP but the EA surface water flood risk map indicates that these are potential sources of local flood risk with flooding to the roundabout predicted during the 3.33% AEP flood event. These culverts also pose a risk of flooding due to blockages and collapse.

To further understand the risk associated with these watercourses, hydraulic modelling has been undertaken. This considered a range of flood events and included representations of the culverted sections of watercourse. The details of the hydraulic modelling undertaken can be found in the modelling report in Appendix C.

Analysis of the results of this modelling indicates that localised flooding occurs on the western tributary during events greater than the 50% (1 in 2) AEP event. The culvert which conveys the western tributary under Peewit Hill surcharges during the 3.33% AEP flood event resulting in out of bank flow which passes towards junction 8. The culvert that conveys the western tributary beneath junction 8 is even smaller and also surcharges during this flood event with water ponding at the north-west corner of the roundabout.

The eastern tributary also floods in events greater than 50% (1 in 2) AEP where the tributary is culverted at Peewit Hill Close. The excess floodwater flows onto the adjacent slip road north of the junction and continues down onto the roundabout. There is some pooling at the north-east corner of the roundabout at the mouth of the culvert that crosses Dodwell Lane. Flood extents on the eastern side of the roundabout are considerably less than to the west, however flooding on both sides contributes to flooding on the roundabout itself. In the 3.3% (1 in 30) AEP flood depths on the carriageway are predicted to reach a maximum of 620mm.

During the 1% AEP flood event, flood depths observed in the north-east and north-west corners of the junction are predicted to reach a maximum of 1.1m with shallower flooding up to 750mm deep extending onto the carriageway of the A3024.

During the 100 year design life of the proposed Scheme, fluvial flows are predicted to increase. Climate change is discussed in detail in section 4.2 but based on EA guidance, an uplift of fluvial flows of 35% has been modelled. During the 1% AEP event with 35% climate change allowance flood depths up to 1.5m are observed in the north-east and north-west corners of the junction and flooding up to 850mm deep is observed on the carriageway. A map showing the predicted flood depths during this flood event is presented in Figure 4.2.

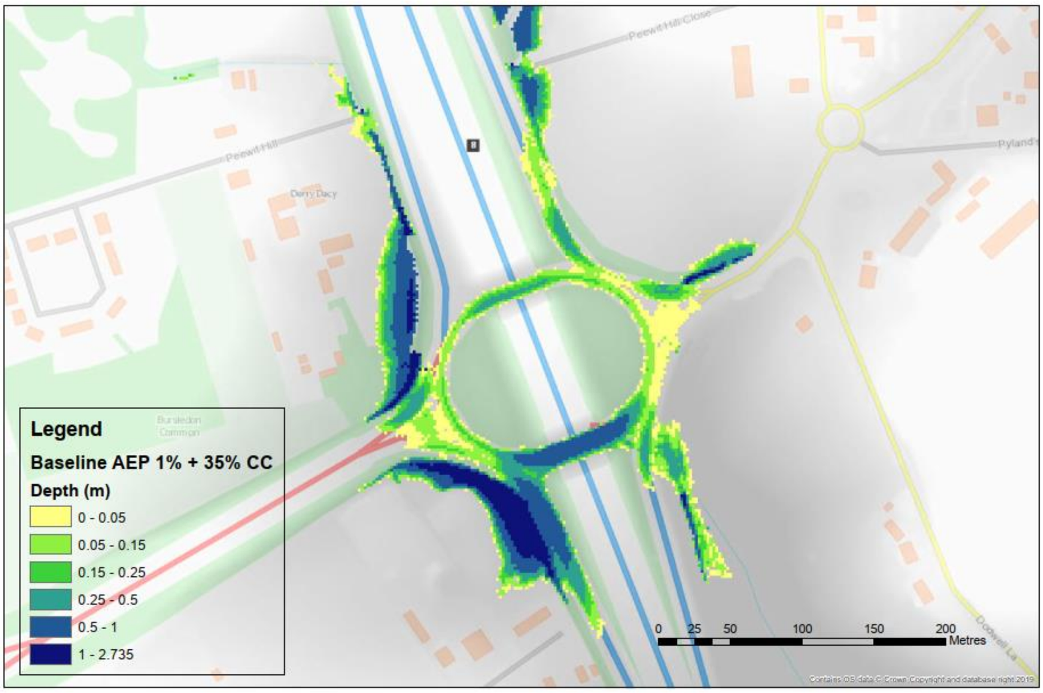


Figure 4.2: Baseline hydraulic model of ordinary watercourse - 1% AEP + 35% Climate Change

The results of the modelling are confirmed by historical flood events with two flood events recorded on the Highways Agency Drainage Data Management System (HADDMS) (Ref 16) at the location where the open channel becomes culverted at Peewit Hill, which have both been attributed to issues with the culvert.

With flooding of the junction 8 roundabout predicted during the 1% AEP flood event, the baseline fluvial flood risk from ordinary watercourses in this location is considered to be high.

No watercourses are recorded in the vicinity of Windhover Roundabout. Based on the information available, it is considered that there is low risk of fluvial flooding at the Windhover Roundabout end of the proposed Scheme.

4.1.2 Tidal flood risk

As confirmed in the Eastleigh Local Plan and PUSH SFRA, the river Hamble is tidal up to Botley Mill. The highest tide level recorded on the river Hamble is 2.80m AOD (Ref 11) while the lowest point of the site of the proposed Scheme is 42m AOD. Based on this information it is considered that there is no risk of tidal flooding to the existing site and it will not be considered further within this report.

4.1.3 Surface water flood risk

The Environment Agency's surface water flood risk map (see Figure 4.3) identifies existing surface water flood risk at junction 8 in the form of two flow paths travelling south towards the junction and converging into one flow path south east of the junction. This map shows the existing site to be at a high risk of flooding (greater than 3.3% (1 in 30) AEP) in areas along the roundabout and in surrounding land. In the low risk event, there are areas of flooding on the roundabout where flood depths over 900mm are shown.

As discussed in Section 4.1.1 it is considered that a proportion of the flooding on the roundabout shown on this map is associated with the ordinary watercourse crossing junction 8, and thus is being treated as fluvial flood risk. Surface water runoff as a result of rainfall events will also contribute to the extent of flood risk at the roundabout.

At Windhover Roundabout the EA surface water flood risk map shows two small areas at risk of surface water flooding during the 3.33% AEP event on the existing road. However, it is noted that the EA's surface water flood maps do not include any representation of road drainage and that any surface water risk in these areas may be effectively mitigated by the existing drainage system.

The HCC Eastleigh SWMP (Ref 14) does not include any accounts of surface water flooding issues within proximity of either junction. Highways England's Drainage Data Management System (HADDMS) (Ref 16) was consulted and records of seven historic flood events were identified within proximity to junction 8, occurring in the years between 2005 and 2015. These are all ranked as low to medium severity events, and several are attributed to drainage inefficiencies.

Based on available information from the EA's surface water flood risk map it is considered that the existing surface water flood risk at the site of the proposed Scheme is high. This may be a conservative assessment however as fluvial flood risk from the ordinary watercourse is assumed to contribute.

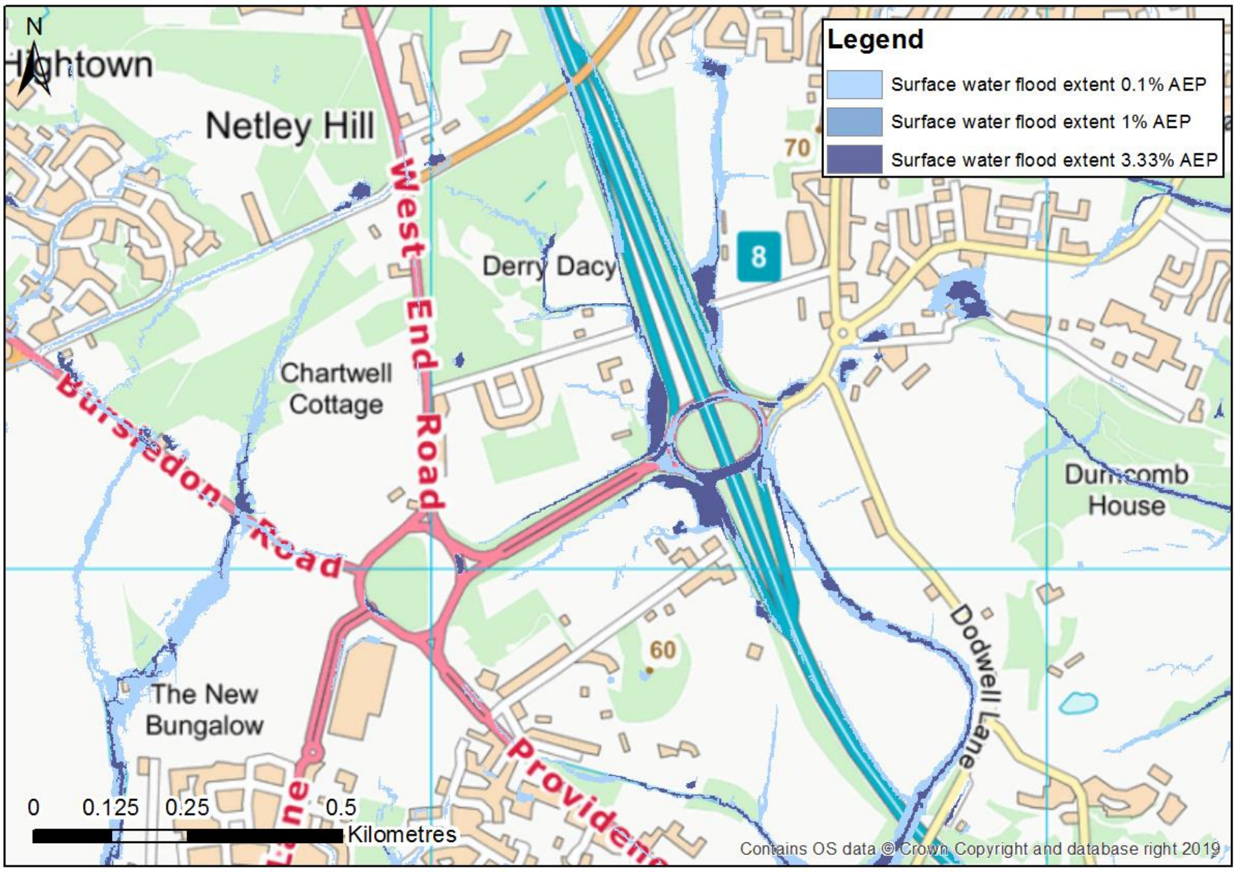


Figure 4.3: EA Surface Water Flood Risk Map

4.1.4 Flood risk from sewers

Flooding from surface water sewers and combined sewers primarily occurs when flow entering the system exceeds its available capacity. As a result, the collected water can begin to surcharge the sewer system emerging at ground level through chambers and gullies giving rise to flooding. As stated in the HCC LFRMS, sewer flooding is very much inter-related with the other sources of flooding. When surface water and groundwater flooding occurs, this can inundate sewer systems. Sewer flooding can also be a result of blockages within the network, and so proper maintenance is key to minimise sewer flooding risk.

The borough of Eastleigh is served by Southern Water, who are responsible for the supply and maintenance of foul and surface water sewerage systems. On review of the sewer records obtained from Southern Water it was observed that there is significant sewer infrastructure around the junctions. This map is included in Appendix B. The HCC Eastleigh SWMP highlights two known locations with sewer flooding issues within the parish of Bursledon. These occur at Church Lane and Long Lane, which are both more than 900m south of the proposed Scheme. The flooding at Church Lane is attributed to its proximity to the River Hamble, as the high tides block the drainage outfall, and the flooding at Long Lane is attributed an under-capacity drainage system. Both issues are managed with regular maintenance. The 'Eastleigh Historic Flooding' map in Appendix B of the SWMP does not identify any other flooding incidents within proximity of the site. A request was sent to Southern Water for information regarding historic flooding in this area, however it was found that Southern Water does not hold any flood risk data for this area.

Based on the information provided in the HCC Eastleigh SWMP as described above, the risk of sewer flooding to the existing site is considered to be low.

4.1.5 Flood risk from water (potable) supply infrastructure

According to data published by the Environment Agency (Ref 12) there are no groundwater Source Protection Zones (SPZ) or groundwater abstraction points within the study area.

Southern Water is the regional water authority for this location. Based on the existing services drawing and C2 replies received, Southern Water have several existing potable water mains buried under the existing carriageway on both Windhover Roundabout and M27 junction 8.

One of the seven flood events identified on HADDMS within proximity to the proposed Scheme has been attributed to a burst water main. This event occurred in 2015 on the westbound on-slip road to M27 junction 8 and was the first known instance of flooding here from this source.

Whilst there is a potential risk of flooding from this source, it is considered to be a residual risk associated with failures of the supply network. The resulting flooding is likely to be shallow with flows managed by the surface water drainage network. Therefore, it is assumed that the risk of flooding from this source is low.

4.1.6 Groundwater flood risk

According to the PUSH SFRA for Eastleigh (2016), there have been several incidences of groundwater flooding in northern parts of the borough within the River Itchen catchment. This region is far from the site of the proposed Scheme, and no other accounts of groundwater flood risk elsewhere in the borough are mentioned. Further to this the ‘Eastleigh Historic Flooding’ map in Appendix B of the HCC Eastleigh SWMP does not show any incidents of groundwater flooding south of the town of Eastleigh, approximately 8.2km from the proposed Scheme.

As discussed in Section 3.2.3, the eastern part of the existing site, including M27 junction 8, lies above the London Clay Formation which is generally considered to act as an aquiclude i.e. it provides an impermeable layer which acts as a barrier to the flow of groundwater. The western part of the site, including Windhover Roundabout, is located above the Wittering Formation, which is a secondary A bedrock aquifer. Superficial deposits are absent except for pockets of high permeability River Terrace Deposits to the west of Windhover Roundabout and the A27. These superficial deposits are also classed as secondary A aquifer.

Historical borehole logs available have been reviewed in the GIR prepared by Jacobs in 2019. Amongst these, groundwater has been found at differing depths across the site, the shallowest groundwater strike being 1.1 metres below ground level. Where groundwater is shallow it is considered that there are perched aquifers on top of the London Clay Formation that are in continuity with local watercourses. While there is the possibility that these perched water bodies and the secondary A aquifers identified may contribute to flood flows, it is considered that this will be insignificant compared to surface water contributions.

Based on the review of information as described above, the risk of groundwater flooding to the existing site is considered to be low.

4.1.7 Flood risk from reservoirs

Reservoir failure can be a particularly dangerous form of flooding as it results in the sudden release of large volumes of water which can travel down a river valley at high velocity. This can result in deep and widespread flooding, potentially resulting in significant damage, although it should be noted that flooding from reservoirs is extremely unlikely.

The EA flood risk from reservoirs mapping (Ref 9) illustrates the maximum extent of flooding that could potentially occur in the event of a reservoir failure. There are no potential reservoir flooding flow paths shown within proximity of the existing site. Based on this evidence there is not considered to be any potential flood risk from reservoirs at the existing site.

4.1.8 Flood risk from canals

The nearest canal is the Titchfield Canal, located approximately 8km south west of the proposed Scheme and outside of the catchment of the River Hamble. Therefore, no potential flood risk from canals to the proposed Scheme is identified.

4.1.9 Historical flooding

The HCC PFRA (Ref 13) includes reports on the historic flooding incidents within Hampshire between 2000 and 2001 when there was exceptional rainfall flooding. On the map showing the location of known flooding incidents, the distribution of events in the vicinity of the proposed Scheme appears extremely sparse. The document does indicate that events within the Hamble catchment were mainly attributed to rainfall runoff from saturated ground, and a few attributed to spring flows from local minor aquifers.

The 'Eastleigh Historic Flooding' map in Appendix B of the HCC Eastleigh SWMP does not show any flooding incidents within the existing site. The closest events to the site are attributed to foul water and surface water flooding, which occurred approximately 900m south of the scheme and 850m north of the scheme respectively.

4.2 Climate change

It is important to understand the impacts of climate change on all sources of flooding in order for the development to be suitably resilient to changes throughout its design life. The assumed design life of this development is 100 years; the climate change assessment has therefore been based on this time period.

In February 2016 the Environment Agency (EA) published updated climate change allowance guidance (Ref 10) to support the NPPF which has been considered for this assessment. The EA's guidance details the level of technical assessment required to assess the impacts of climate change on flooding for new developments, this is dependent on the location (flood zones), design life and vulnerability classification (detailed in Table 2 of the PPG) of the development.

4.2.1 Peak river flow

In accordance with the EA's guidance, the allowance to be made for the predicted impact of climate change on peak river flows is subject to the river basin district. The proposed Scheme is located within the South East river basin district. The sensitivity ranges recommended by the EA to assess peak river flow in the South East region are detailed in Table 4.1.

Table 4.1: Climate change allowances for peak river flow in the South East river basin (using 1961 to 1990 baseline)

Allowance Category	Total Anticipated Change for the '2020's' (2015 to 2039)	Total Anticipated Change for the '2050's' (2040 to 2069)	Total Anticipated Change for the '2080's' (2070 to 2115)
Upper end	25%	50%	105%
Higher Central	15%	30%	45%
Central	10%	20%	35%

The Allowance Category used is dependent on the vulnerability classification of the development and the Flood Zone it is located in. As explained in Section 4.3, the development is Essential Infrastructure located in fluvial Flood Zone 1.

Assuming a 100-year design life, a climate change uplift of 35% should be used.

4.2.2 Peak rainfall intensity

The sensitivity ranges in Table 4.2 provide the EA's appropriate precautionary response to the uncertainty about climate change impacts on peak rainfall intensity. The uplift factors detailed should be used for design purposes to assess the impacts on the surface water drainage networks.

Table 4.2: Peak rainfall intensity allowance in small and urban catchments

Allowance Category	Total Anticipated Change for the '2020's' (2015 to 2039)	Total Anticipated Change for the '2050's' (2040 to 2069)	Total Anticipated Change for the '2080's' (2070 to 2115)
Upper end	10%	20%	40%
Central	5%	10%	20%

Assuming a 100-year design life, a climate change uplift of 20% should be used with a check of the consequences of 40% uplift.

4.3 Vulnerability classification

Table 2 of the Flood Zone and Flood Risk Tables section of the NPPG classifies the flood risk vulnerability of all land uses. The proposed Scheme has been classified as 'Essential Infrastructure' in accordance with this Table, as the road should remain operational during times of flood.

4.3.1 The Sequential Test

The aim of the sequential test is to steer new development to areas with the lowest probability of flooding. As the works are an expansion of two existing roundabouts, relocating the Scheme is considered impractical. Road improvements at this junction are also identified as being required within the Eastleigh Borough Council's Local Plan. Therefore, the sequential test is assumed to be passed.

4.3.2 The Exception Test

Table 3 of the NPPF (substantially reproduced here as Table 4.3) defines appropriate land uses for each flood zone and helps guide development to areas of lower flood risk. The proposed Scheme, being classified as 'Essential Infrastructure' would be considered appropriate within Flood Zones 1 and 2 but would have to pass the Exception Test if they were located within Flood Zone 3 or are at risk of flooding from other sources. In this case the site is located within Flood Zone 1 according to the Environment Agency's '*Flood map for planning*' but a high risk has been identified from ordinary watercourses.

Due to the magnitude of flood risk associated with the ordinary watercourse at junction 8, the Exception Test is assumed to be required. As such the proposed Scheme will need to be safe throughout its lifetime and not adversely impact the environment whilst also providing wider benefits to the community that outweigh the flood risk issues.

Table 4.3: Flood risk vulnerability and flood zone 'compatibility' (NPPG Table 3)

Flood risk vulnerability classification (see table 2)		Essential infrastructure	Water compatible	Highly vulnerable	More vulnerable	Less vulnerable
Flood zone (see table 1)	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	✓	Exception Test required	✓	✓
	Zone 3a	Exception Test required	✓	×	Exception Test required	✓
	Zone 3b functional floodplain	Exception Test required	✓	×	×	×

Key: ✓ Development is appropriate.
× Development should not be permitted.

The wider sustainability benefits of the proposed Scheme include improved road safety and the improved traffic flow. The need for these improvements is detailed in the Environmental Assessment Report for the proposed Scheme. Therefore, it is assumed that the wider benefits of the scheme have been established and that the exception test can be passed subject to the Scheme being shown to be safe. Safe access and operation of the proposed Scheme is discussed in Section 6.1.

5. Flood risk to the proposed Scheme

5.1 Fluvial

As discussed in Section 4.1.1, hydraulic modelling undertaken as part of this assessment has identified that the proposed Scheme is at risk of flooding from ordinary watercourses at M27 junction 8 during the 1% (1 in 100) AEP event.

To manage the risk of fluvial flooding from the two tributaries of Bursledon Brook, the design of the proposed Scheme includes several mitigation measures. To manage flows from the eastern tributary, a series of flood storage measures comprising a basin, an underground tank and a pond are proposed which would provide a total of 5,866 m^3 of storage.

Risk from the western tributary would be managed by a flood wall along the north-west corner of the roundabout to prevent water from flowing onto the carriageway. Another storage area adjacent to this wall with a capacity of 2,917 m^3 would then partially mitigate for the loss of floodplain storage on the carriageway. A plan of the proposed mitigation can be seen in Appendix F.

With the proposed mitigation measures in place, the hydraulic modelling demonstrates that there would be no flooding on the carriageway during the 1% AEP fluvial flood event with 35% climate change allowance.

Whilst the mitigation has a beneficial effect on flood risk to the proposed Scheme, land ownership constraints have restricted the size of the storage areas and the volume available is not sufficient to fully mitigate the displacement of flows from the carriageway. Therefore, the modelling predicts that there would be an increase in flood extents and depths at the north-west corner of the junction 8 roundabout as a result of the proposed Scheme outside of the proposed storage area.

In the 1% AEP event with 35% climate change allowance the proposed Scheme would result in flood extents increasing by approximately 880 m^2 across the adjacent land with flood depths in this area increasing by up to approximately 300 mm. The area of this adverse impact comprises fields for horse grazing with no buildings or access routes impacted. At the time of writing, landowner agreement around these impacts has not been finalised. It is anticipated however, that this will be managed during the detailed design phase through landowner compensation or by increasing the size of the flood storage area to 2,617 m^2 to enable the impacts of the scheme to be fully mitigated during detailed design.

5.2 Surface water

As the proposed Scheme will result an increase in impermeable surface area, the proposed Scheme design incorporates additional surface water management measures to manage the increase in surface water runoff. A description of the proposed drainage infrastructure is provided in Section 3.3.3.

In accordance with DMRB guidelines, the proposed drainage strategy adheres to the following design standards:

- 100% (1 in 1) – No surcharge of the drainage system
- 20% (1 in 5) + 20% climate change allowance – No flooding from the drainage system
- 1% (1 in 100) + 20% climate change allowance – Not exceed allowable discharge rates

MicroDrainage modelling has been undertaken for the proposed Scheme. The modelling results suggest that the proposed drainage measures outlined in Section 3.3.3 would maintain and/or provide a reduction to existing peak discharge rates for the 100% (1 in 1), 20% (1 in 5) , 3.33% (1 in 30) and 1% (1 in 100) AEP events allowing for a climate change uplift of 20% across all events. The modelling results also confirmed that there is no increase to existing flooded volumes from the drainage network and/or flood risk over the existing site conditions as a result of the mitigation storage for all events up to and including the 1% (1 in 100) AEP event allowing for a climate change uplift of 20%. Details of the attenuated volumes and discharge rates of the proposed drainage strategy can be found in Appendix A.

The surface water flooding shown on the EA surface water flood risk maps at junction 8 is being treated as fluvial flooding resulting from the ordinary watercourse that passes through the site and will be dealt with through separate mitigation measures as discussed in Section 5.1. It should be noted that the fluvial model has made conservative assumptions based on storage usage in the with-scheme drainage model regarding the likely capacity available within the drainage network at the time of any fluvial flooding. It is likely therefore that integrated modelling of the surface water and fluvial flood risk would reduce the volume of flooding in the with-scheme scenario.

5.3 Groundwater

The proposed Scheme comprises new areas of road carriageway at or above existing ground level. No deep excavations or deep buried structures are proposed. Therefore, no mechanism by which the proposed development could impact groundwater flooding has been identified. It is therefore considered that groundwater flood risk will not be affected as a result of the scheme.

5.4 Other sources

There is a predominately low flood risk from other sources as detailed in Section 4, and it is considered that this will not be affected as a result of the proposed Scheme.

5.5 Construction phase

Detailed construction plans and method statements are not available at the time of writing this FRA. However, this section provides an overview of potential flood risks for the Contractor to consider during the construction phase. It is the Contractor's responsibility to assess the flood risk to work areas, to assess the flood risk resulting both to and from temporary works, and to provide appropriate mitigation measures where necessary.

Temporary works can be at risk of flooding and have the potential to impact flood risks both to work areas and to receptors beyond the work site. Table 5.1 below outlines some typical construction activities and the potential impacts of these with respect to flooding.

Table 5.1: Typical construction elements

Temporary Works	Description	Potential Short-Term Impacts
Temporary earthworks	Including excavation for access road cuttings, pre-earthworks drainage, trenches; and filling for access roads, site compound areas and temporary spoil storage	Excavation works could result in the pooling of pluvial runoff, the emergence of groundwater, the creation of an impounded body of water or a water mains strike. Works associated with filling could result in the diversion of overland flow routes, a reduction in floodplain storage, impacts on floodplain conveyance, and increased volumes of surface water runoff.
Temporary drainage	Including site compound drainage, temporary road drainage, pre-earthworks drainage	Temporary drainage could increase both the rate and volume of pluvial runoff to a receiving watercourse or sewer and has the potential to transfer sediment to the receiving watercourse or sewer (potentially affecting the flooding mechanisms of the watercourse).
Works within or adjacent to watercourses	Including temporary river works, such as over-pumping, diversions, damming; and temporary access crossings, requiring culverting or bridging of watercourses	Temporary work located within or adjacent to watercourses could affect the frequency, depth, extent and duration of fluvial flooding.

Temporary Works	Description	Potential Short-Term Impacts
General site activities	Including site compounds and the storage of construction materials and equipment; and works traffic	The location of site compounds and the storage of construction materials and equipment on site could potentially reduce floodplain storage and divert flood flow routes. Placing working sites within the floodplain could also place human life at risk. Works traffic could also damage existing sewers or land drains, and could also compact ground, which could increase pluvial runoff.

During the construction phase there are several sources of flood risk that the Contractor should be aware of when planning the works. It is considered that there is the potential for an increase in surface water runoff as a result of soil compaction due to works traffic and increases in impermeable area from temporary hard standings. Any increase in surface water runoff should be mitigated through provision of temporary site drainage. It may be necessary to provide standby pumping equipment to remove any surface water runoff that enters the working area. It should be ensured that site drainage is not discharged to a local sewer. Drainage receiving runoff which is expected to contain sediment should be directed towards a suitable sized temporary settlement pond that provides sufficient treatment before being discharged to a watercourse. These measures will prevent an increase in surface water flood risk to the site or to surrounding areas during the construction phase.

During construction, encroachment into the fluvial and surface water flood extents should be minimised. The location of site compounds and storage areas should be located outside of the ordinary watercourse flow paths which traverse junction 8 in culverted sections. The hydraulic modelling carried out indicates that there is risk of flooding in the land adjacent to M27 junction 8 for events greater than the 50% (1 in 2) AEP event. Where there are areas of pooled floodwater in the 1% (1 in 100) AEP event with climate change allowance, flood depths of up to 1.5 metres are observed. Where it is not practical to avoid temporary works in areas at risk of flooding, the Contractor should take into account the depth of flooding, potential floodplain flows and local site conditions to place more vulnerable works in lower risk areas. It is recommended that the Contractor prepare a flood response plan and, if necessary, monitor water levels or design temporary works to divert the watercourse.

Although groundwater flood risk at the site is considered to be low, the Contractor may deem it necessary that groundwater control be provided in any proposed excavations in the Withering and London Clay Formations.

There is also a risk posed by the existing potable water mains that are located under the existing carriageway, discussed in Section 4.1.5. The water supply needs to stay connected, so the mains may need to be diverted prior to work commencing. The proposed works on these water mains has not been dealt with as part of this application. It is considered that the flood risk associated with burst main pipes will be mitigated as part of the construction works to be agreed with the water company.

6. Development considerations

In accordance with NPPF guidance, the development should:

- Remain operational and safe for users in times of flood
- Result in no net loss of floodplain storage
- Not impede water flows and not increase flood risk elsewhere

The following sections discuss these development considerations.

6.1 Safe access and operation

The NPPF states that development should not increase flood risk elsewhere and that development should only be considered appropriate in areas at risk of flooding where it can be demonstrated that the most vulnerable development is located in areas of lowest flood risk. The development must also make provision for safe access and escape during times of flood.

As discussed in Section 5.1, hydraulic modelling undertaken has identified that the design of the scheme will enable it to remain operational during a 1% AEP flood event with safe access provided during this event. The design has included consideration of the predicted impacts of climate change to ensure that this design requirement will be met throughout the proposed Scheme's 100 year life.

6.2 Loss of floodplain storage

As the site is located within Flood Zone 1, no loss of active floodplain associated with main rivers will occur as a result of the proposed Scheme.

With regards to the ordinary watercourse that intersects the scheme at junction 8, the existing areas of flooding that occur at the north-east, north-west and south-west corners of the junction would be displaced by the proposed works. Mitigation has been incorporated into the design to minimise this loss of floodplain as discussed in Section 5.1.

Despite this mitigation, there is still predicted to be an increase in flood extents as a result of the proposed Scheme. However, it is proposed that this will be addressed by landowner compensation or by increasing the size of the north-east storage area to 2,617 m^2 enabling the impacts of the scheme to be fully mitigated during detailed design.

6.3 Interaction of flood flow paths and development and flood risk elsewhere

As discussed in Section 6.3, the flood wall that is proposed to protect the carriageway from flooding from the western tributary of Bursledon Brook will block off flood flows and is predicted to result in increased flooding to land adjacent to the scheme.

With the proposed drainage strategy and flood mitigation in place it is considered that flow paths crossing the site will be managed by the proposed drainage and peak flows downstream will remain as existing or be reduced. Attenuation features are incorporated within the design to prevent an increase in runoff rates, as discussed in Section 3.3.3.

In the case of the ordinary watercourse at junction 8, it is expected that the proposed mitigation will prevent an increase in flood extents in surrounding land. Hydraulic modelling demonstrates no increase in peak flows downstream of the proposed Scheme and therefore there will be no increase in flood risk downstream as a result of the Scheme.

6.4 Groundwater

It is not expected that the proposed storage areas will act as an artificial recharge to the groundwater system. As the bedrock below the scheme at junction 8 is described as impermeable, there is potential for perched water to result at this location. Given that the existing groundwater flood risk is considered to be low and the storage areas will only be active for short periods of time during a flood event it is considered that the proposed storage areas will not affect groundwater flood risk elsewhere.

Towards the eastern end of the scheme at Windhover Roundabout the geology identified is classified as a secondary aquifer. However, as the majority of the proposed Scheme is at or above existing ground level with only some minor shallow depth excavation required, it is considered that the scheme will not impact groundwater flood risk within the site or elsewhere.

7. Conclusion and recommendations

7.1 Development suitability

The proposed Scheme is located within Flood Zone 1 and is classified as 'Essential Infrastructure' in accordance with the NPPG. As such, the development is considered appropriate. Due to the level of flood risk associated with an ordinary watercourse identified at junction 8, it has been demonstrated through the undertaking of the Exception Test that there is no other appropriate site available with lower flood risk, and that the proposed Scheme will remain safe throughout its lifetime and provide wider sustainability benefits to the community.

7.2 Summary of flood risk

The flood risk assessment has found that the main sources of risk to the proposed Scheme are fluvial flood risk from ordinary watercourses and surface water.

The site of the proposed Scheme is located in Flood Zone 1 but has a high risk of flooding from Ordinary Watercourses. Mitigation measures have been incorporated into the scheme design to ensure that the proposed Scheme would remain safe from flooding during the 1% AEP fluvial flood event including an allowance for climate change.

Whilst the mitigation measures would result in an increased level of flood risk to land adjacent to the scheme, this would be further mitigated through landowner agreements to expand the volume of the proposed flood storage areas or to compensate for the increase level of flood risk.

The proposed Scheme has been designed to include surface water drainage infrastructure that will manage surface water runoff from the site through use of SuDS measures. An assessment of the proposed system has demonstrated that it will meet the requirements of the DMRB and that risks from surface water to the scheme will be effectively managed. Attenuation storage will be sufficient to ensure that discharges from the proposed Scheme do not increase.

7.3 Flood risk impact of the development

Whilst most of the potential impacts of the proposed development on flood risk elsewhere have been effectively mitigated, it is predicted that there would be some adverse impacts to fluvial flood risk.

At the time of writing landowner agreement around these impacts has not been finalised. It is anticipated that this will be resolved with landowner compensation or increasing the size of the north-western storage area.

7.4 Recommendations

To ensure that the proposed Scheme meets the requirements of the NPPF the following actions are recommended:

- Further liaison should be undertaken with landowners to enable the expansion of flood storage areas to the north west of the scheme or to agree the increased level of flood risk to their land at the north-east corner of junction 8
- Any changes to the proposed Scheme that impact on flood risk are re-assessed to ensure compliance with this FRA. These will be agreed with the LLFA at detailed design stage or as part of the ordinary watercourse consenting process
- A detailed maintenance and management plan should be produced at the detailed design stage to detail requirements for the on-going management of the proposed surface water drainage network, including the SuDS features, for the lifetime of the development
- Information and data from the relevant council bodies and the Environment Agency is regularly reviewed throughout the planning process, as new information might be made available

- The contractor should obtain all required permits prior to construction phase works

It should also be noted that there may be an opportunity to rationalise the mitigation and drainage proposed if more detailed assessment were undertaken using an integrated hydraulic model incorporating both drainage and fluvial elements.

8. References

1 Atkins. (2007). Partnership for Urban South Hampshire Strategic Flood Risk Assessment

2 British Geological Survey. (2019). Geology of Britain online map viewer. Available at: http://mapapps.bgs.ac.uk/geologyofbritain/home.html [Accessed: September 2019]

3 CIRIA. (2007). SuDs Manual (C753)

4 Design Manual for Roads and Bridges (2016) Design of Highway Drainage Systems HD 33/16. Vol.4 Section 2 Part 3. Available at: http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol4/section2.htm [Accessed September 2019]

5 Eastleigh Borough Council. (2014). Eastleigh Borough Local Plan 2011-2029 Revised Pre-Submission

6 Eastern Solent Coastal Partnership. (2016). PUSH Strategic Flood Risk Assessment – 2016 Update

7 Environment Agency. (2009). South East Hampshire Catchment Flood Management Plan

8 Environment Agency. (2019). Flood Map for Planning. Available at: https://flood-map-for-planning.service.gov.uk/. [Accessed: August 2019]

9 Environment Agency. (2019). Long term flood risk information. Available at: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map [Accessed: August 2019]

10 Environment Agency. (2019). Flood Risk Assessments: Climate Change Allowances. Available at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances [Accessed: August 2019]

11 Environment Agency. (2019). Flood information service: Tidal level Tide at Hamble. Available at: https://flood-warning-information.service.gov.uk/station/9200?direction=u [Accessed: August 2019]

12 Environment Agency. (2019). Source Protection Zones [Merged]. Available at: https://data.gov.uk/dataset/09889a48-0439-4bbe-8f2a-87bba26fbbf5/source-protection-zones-merged [Accessed: October 2019]

13 Hampshire City Council. (2011). Preliminary Flood Risk Assessment

14 Hampshire City Council. (2012). Eastleigh Surface Water Management Plan

15 Hampshire City Council. (2013). Hampshire Local Flood Risk Management Strategy

16 Highways Agency Drainage Data Management System Drainage Data Management System, v5.12.0 (HADDMS). (2018). Available at: http://haddms.com/ [Accessed: September 2019]

17 Ministry of Housing, Communities and Local Government. (2014). National Planning Practice Guidance. Available at: https://www.gov.uk/guidance/flood-risk-and-coastal-change [Accessed: August 2019]

18 Ministry of Housing, Communities and Local Government. (2019). National Planning Policy Framework

Appendix A. Site drainage design and details

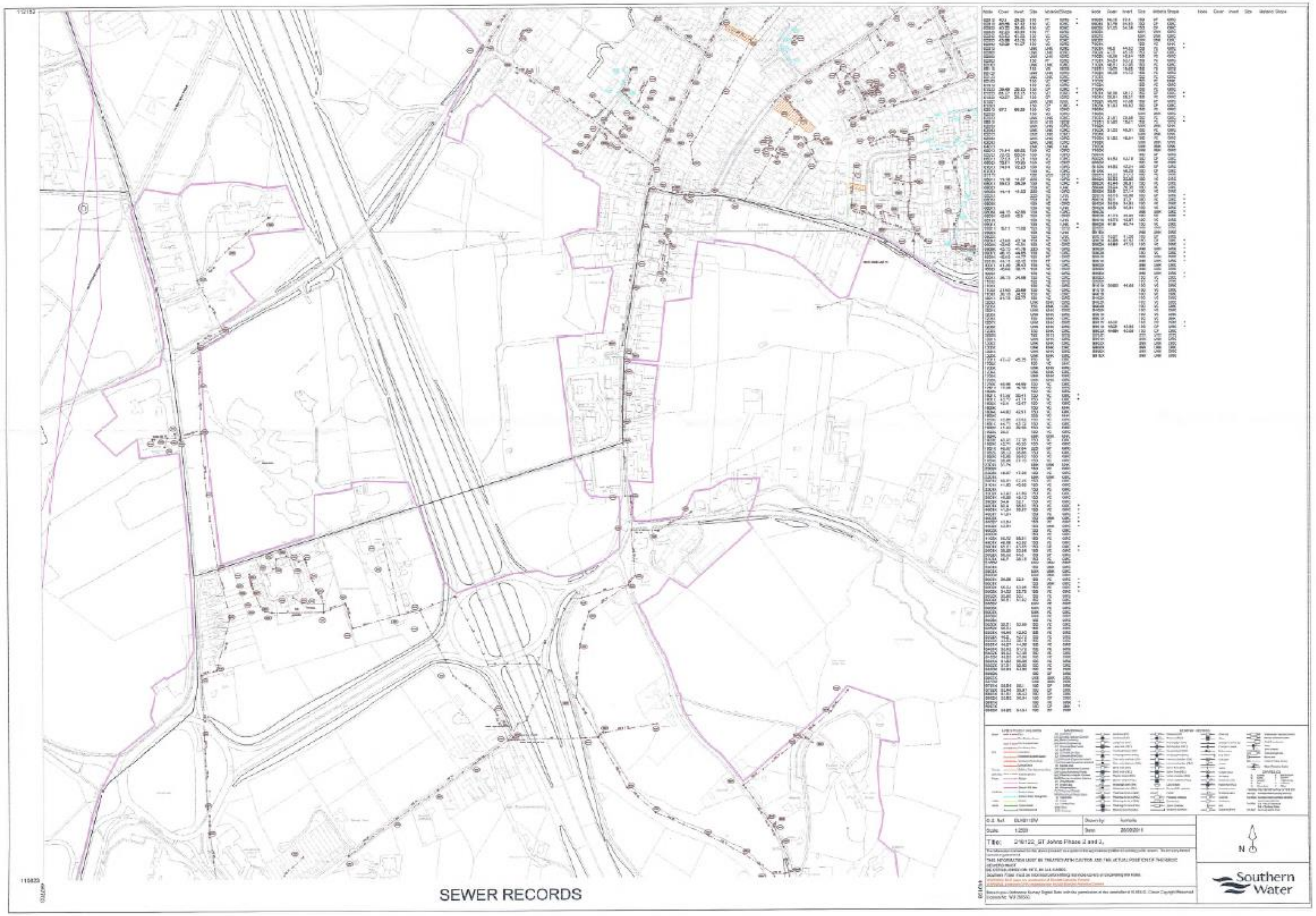
Table A-1: Existing and Proposed Discharge Rates

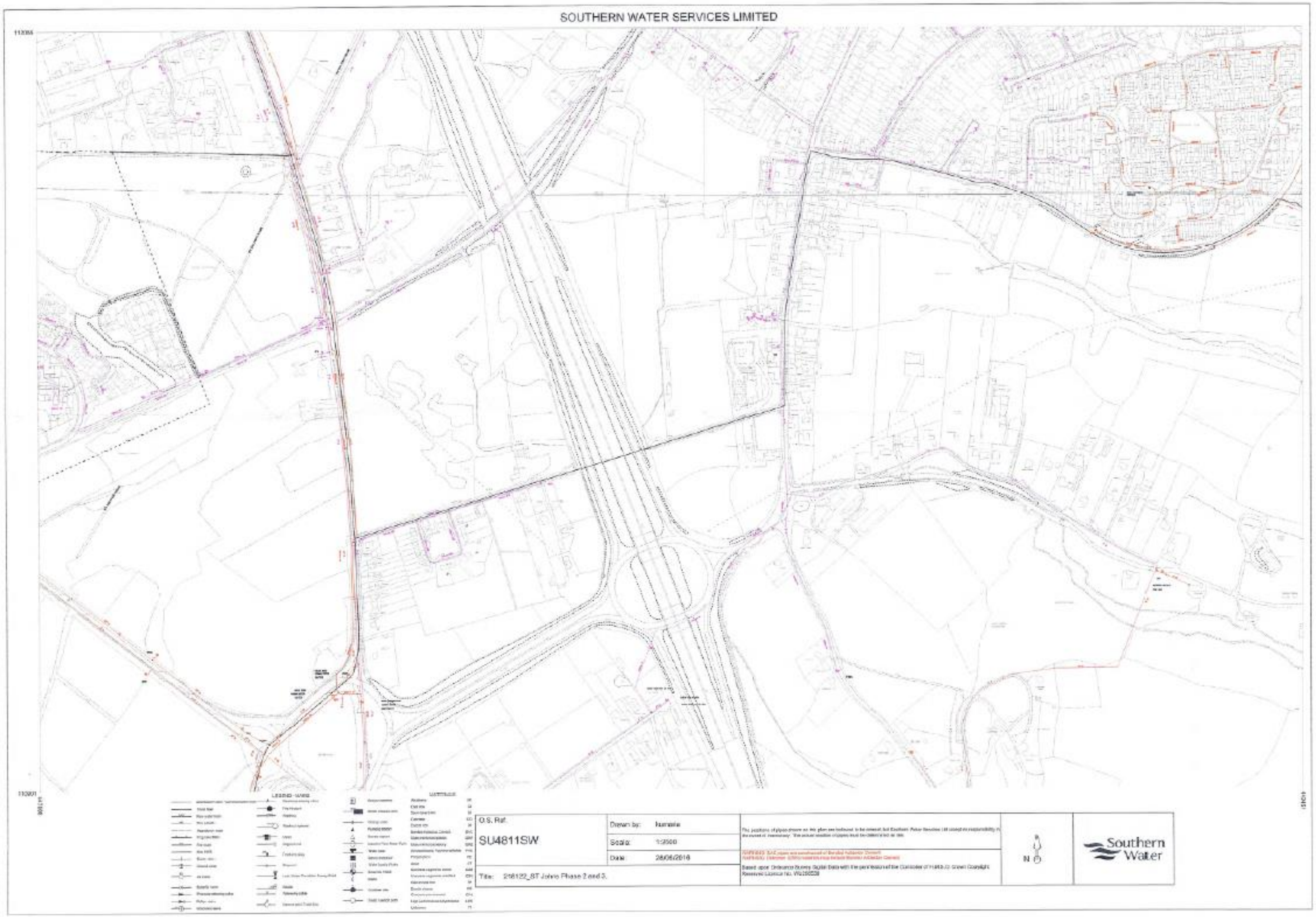
Storm Return Period	Allowable Discharge Rate (l/s)							
	Windhover Roundabout						M27 Junction 8 Roundabout	
	Network 1 (Outfall to existing drainage system at Bursledon Road)		Network 2 (outfall to existing drainage system at Providence Hill Road)		Network 3 (Outfall to existing drainage system at Hamble Lane)		(Outfall to an existing watercourse)	
	Existing Case	Proposed Case	Existing Case	Proposed Case	Existing Case	Proposed Case	Existing Case	Proposed Case
1yr	79.9	48.7	41.7	31	46.3	26.3	536.1	473.8
5yr	112.4	77.2	59.5	45.8	69.4	58	794.1	590.5
30yr	155	144	64.3	63.3	104.1	69.9	1137	1086.1
100yr	178.9	178.9	64.6	63.7	107	91.6	1212.8	1190.7

Table A-2: Attenuation Volumes in Proposed Drainage Strategy

Windhover Roundabout: Network 1 (Outfall to existing drainage system at Bursledon Road)		
Attenuation Basin (WN1-New-Atten1)	125	m3
Attenuation Basin (WN1-New-Atten2)	270	m3
Windhover Roundabout: Network 2 (outfall to existing drainage system at Providence Hill Road)		
Attenuation Basin (WN2-New-Atten1)	140	m3
Attenuation Basin (WN2-New-Atten2)	162	m3
Windhover Roundabout: Network 3 (Outfall to existing drainage system at Hamble Lane)		
Underground Geocellular Storage System (WN3-New-Atten1)	112	m3
M27 Junction 8 Roundabout - Outfall to existing watercourse		
Attenuation Basin (J8-New-Atten4)	390	m3
Underground Geocellular Storage System (J8-New-Atten1)	160	m3
Underground Geocellular Storage System (J8-New-Atten2)	160	m3
Underground Geocellular Storage System (J8-New-Atten3)	50	m3
Underground Geocellular Storage System (J8-New-Atten4)	198	m3

Appendix B. Southern Water sewer maps


SEWER RECORDS
Scale: 1:2500
N
Southern Water


SOUTHERN WATER SERVICES LIMITED
LEGEND
O.S. Ref.
SU4811SW
Drawn by:
Scale:
1:2500
Date:
28/06/2016
Title:
Southern Water
N

Appendix C. M27 junction 8 hydraulic modelling technical note

C.1 Introduction

C.1.1 Background

Jacobs were commissioned by Highways England to prepare a site-specific Flood Risk Assessment (FRA) for the M27 Southampton Junction 8 Scheme.

Bursledon Brook is an ordinary watercourse that crosses the M27 Junction 8. It rises in the vicinity of the M27 / St. John's Road (B3033) cross road and consists of two unnamed minor tributaries, namely, the eastern tributary and the western tributary. The two minor tributaries are culverted separately before reaching the M27 Junction 8, and the culverts pass under the M27 Junction 8 roundabout and discharge to an open channel as a single culvert just to the southeast of the roundabout. The open channel reach of the Bursledon Brook flows approximately 600m due southeast, before crossing the M27 once again. Approximately 300m further downstream of the M27 crossing, the Bursledon Brook crosses the Providence Hill Road (A27).

This Technical Note provides detailed information on the hydraulic model build process undertaken to assess the risk of fluvial flooding from the Bursledon Brook to the proposed scheme at Junction 8 of the M27.

This report supports the hydraulic modelling results presented separately in the FRA report[1].

C.1.2 Modelling objectives

The hydraulic modelling aimed to predict the peak water levels within the modelled river reach and the floodplain for the 50% Annual Exceedance Probability (AEP), 3.33% AEP (1 in 30 years), 1% AEP (1 in 100 years), 0.1% AEP (1 in 1000 years) and 1% AEP (1 in 100 years) plus an allowance for Climate Change[2] (plus CC) flood events for both the baseline (existing situation) and proposed scheme scenarios. These were then used to understand the existing fluvial flood risk and assess the potential impacts of the proposed scheme on flooding. Subsequently, the hydraulic model was used to test options to mitigate these impacts.

C.1.3 Study area and modelling approach

The modelled area is approximately 0.82 km^2. The topography for the Bursledon Brook catchment is generally steep ranging from approximately 74 m AOD in the north west to approximately 17.5 m AOD in the south east of the catchment. Figure C.1 shows the modelled area and some of its key features.

The hydraulic model has been built using a linked one-dimensional/two-dimensional (1D/2D) technique, where the river channel is represented as a 1D component using Flood Modeller Pro (FMP) version 4.4.1 software and the floodplain is represented as a 2D component using TUFLOW 2018-03-AD-iDP-w64 software. The linked 1D/2D modelling approach means that the model dynamically transfers water between the watercourses and the floodplain.

[1] Jacobs, M27 Southampton Junction Flood Risk Assessment, 2019

[2] A 35% uplift has been applied to all hydrological inflows for the climate change allowance. See Section C.3 for further details

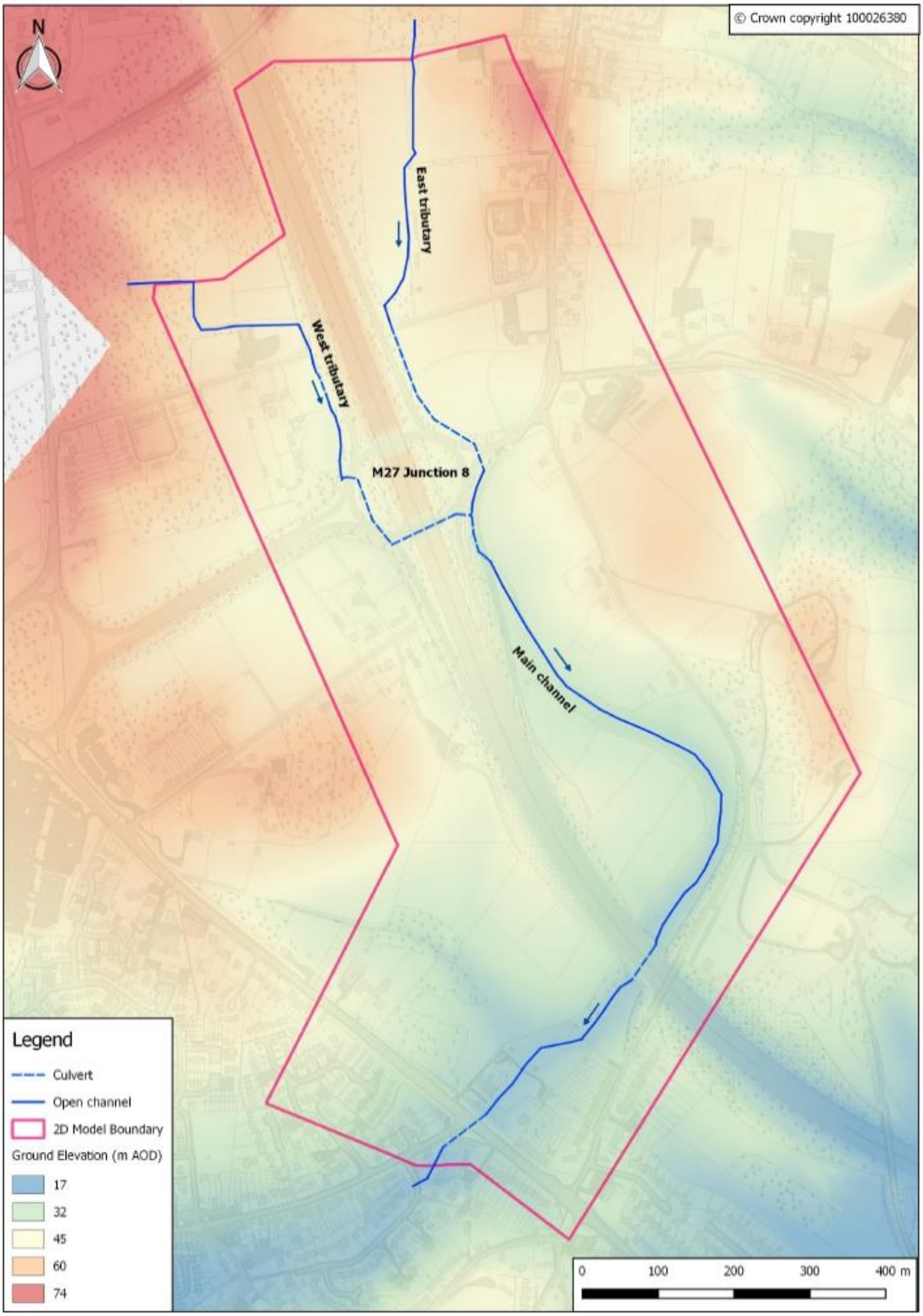


Figure C.1: Study area

C.2 Data collection

The datasets used to build the Bursledon Brook hydraulic model are summarised in Table C.1.

Table C.1: Datasets used to build the Bursledon Brook Hydraulic Model

Data	Description	Source
Survey data	River Survey data of Burleson Brook for the full extent indicated in Figure C.1. The survey includes: • 32 cross-sections with XYZ coordinates and photos • Invert levels and dimensions of structures crossing the watercourse • The survey was undertaken in August 2017.	Jacobs
Digital Terrain Model (DTM)	DTM derived from filtered 0.5m resolution LiDAR (Light Detection And Ranging) data used to inform the hydraulic model with ground elevation information downloaded from https://environment.data.gov.uk/DefraDataDownload. The LiDAR was flown in 2016.	DEFRA
Inflows hydrographs	Model inflow hydrographs produced from the hydrological analysis of the Bursledon Brook catchment.	Jacobs
Ordnance Survey (OS) maps	Mastermap data 1:10,000 raster map	Ordnance Survey
Scheme information	3D model and CAD drawings of current state surface and proposed design scheme	Jacobs
Highways drainage information	Table with dimensions of the existing and design drainage system, CAD drawings with proposed mitigation measures	Jacobs

C.3 Hydrology

The details of the hydrological analysis carried out to produce design inflows for the hydraulic model are provided in Appendix D of this report. A summary of this analysis is presented below

Design peak flows were estimated using the FEH (Flood Estimation Handbook) Statistical method and ReFH2.2 method. The latter, resulting in the larger flood peaks, was adopted. ReFH2.2 method-based hydrograph shapes were used to derive the model inflows required for the numerical hydraulic modelling of the watercourse to be assessed for the potential flood risk.

The FEH catchment descriptors of the Bursledon Brook have been purchased from FEH Web Service at two locations, namely, one at the M27 Junction 8 (termed hereafter as FEP1; easting:448450, northing: 111200) and the other at the downstream modelling extent (termed hereafter as FEP2; easting:448500, northing: 110300).

Two hydrographs (Res12 and FEP1) have been produced for the following Annual Exceedance Probabilities (AEP) events (see Figure C.2):

- 50% AEP event (1 in 2 years);
- 3.33% AEP event (1 in 30 years);
- 1% AEP event (1 in 100 years); and
- 0.1% AEP event (1 in 1000 years).

Additionally, flow hydrographs were also produced for the 1% AEP plus Climate Change assuming a 35% uplift of the flow in accordance with the EA’s projection for South East England, central allowance category.

Table C.2 below present the estimated peak flows for FEP1, Res 12 and FEP2 for a 3.5hr summer storm duration.

Table C.2: Design peak inflows (m^3/s)

AEP event	50% (2yr)	3.3% (30yr)	1% (100yr)	1% (100yr+35%CC)	0.1% (1000yr)
Target peak flow at the downstream modelling extent (FEP2) – ReFH2.2					
FEP2 (Storm Duration = 3.5hrs, Summer)	1.42	2.92	3.69	4.98	6.19
Model inflows (FEP1 and Res12) – ReFH2.2					
FEP1 (Storm Duration = 3.5hrs, Summer)	0.69	1.43	1.81	2.44	3.04
Res12 (Storm Duration = 3.5hrs, Summer)	1.07	2.21	2.78	3.76	4.66

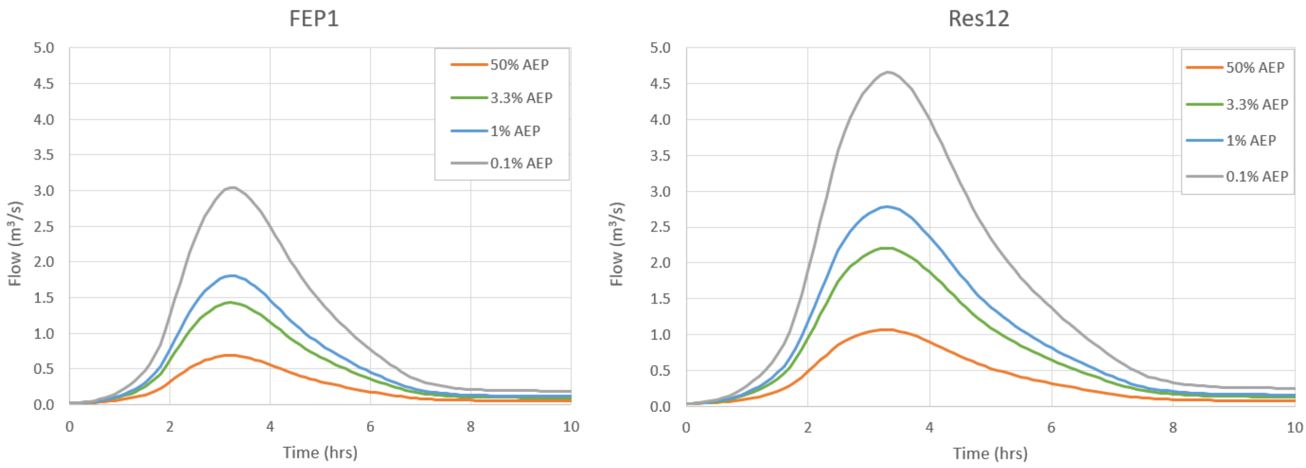


Figure C.2: Inflow hydrographs (unscaled)

Hydrograph FEP1 was divided in to two inflows which were applied in the hydraulic model at the head of the western tributary (Model node: BURL_IN1 - 53.1% of the total flow) and eastern tributary (BURL_IN2 - 46.9% of the total). The lateral inflow (Res12; node name BURL_Lat) was laterally distributed between Junction 8 and the downstream modelling extent.

Following review of preliminary model results it was found more appropriate to split lateral inflow (RES12) into two inflows. One was applied to the model as a point inflow (Model node BURL_CatC) located at the southwest corner of Junction 8 roundabout and accounting for 18.5% of Res12 catchment area. The remaining 81.5 % of the Res12 sub-catchment was laterally distributed as originally applied. Figure C.3 provides a description of the hydrological inflow schematisation.

A flow reconciliation exercise at FEP2 was carried out with the hydraulic model. Due to the high retention in the northern part of the modelled catchment associated with flow restrictions caused by the culverts and road embankments the reconciliation process was done by applying the upstream flows unrestricted. All inflows were scaled by 0.87 to achieve flow reconciliation at the downstream modelling extent (FEP2).

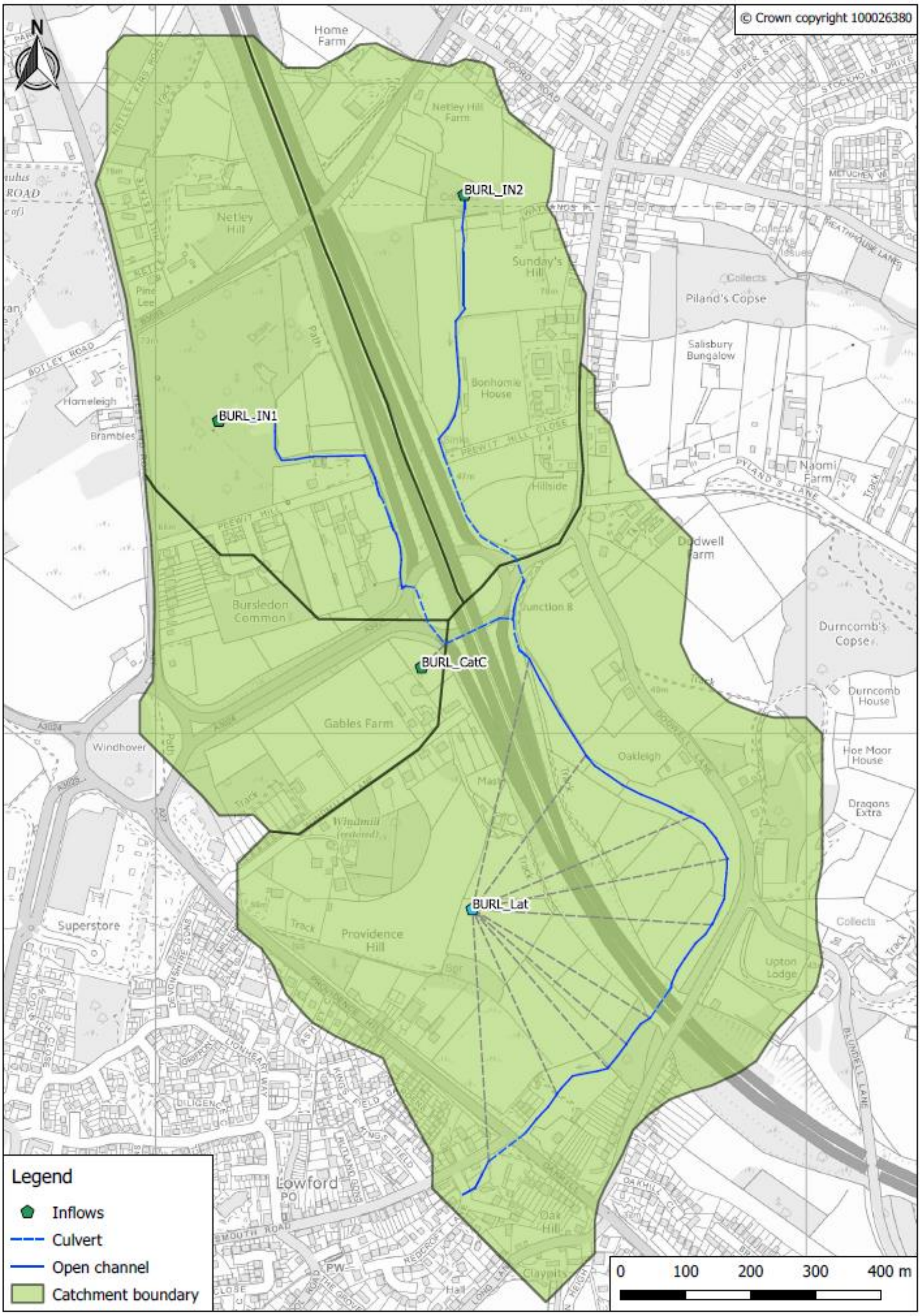


Figure C.3: Catchment inflow schematisation

C.4 Baseline modelling

The following sections provide information relating to the model schematisation for the baseline (existing) scenario.

C.4.1 Watercourse schematisation (1D FM Model)

Surveyed cross-section data of the Bursledon Brook was used to represent the in-channel geometry of the watercourse in Flood Modeller Pro. A 1D/2D link has been enabled along the bank tops of the watercourse as shown in Figure C.4. The model includes the reaches listed in Table C.3 and their associated structures listed in Table C.4.

Table C.3: Watercourse reaches included in the model

Reach	Start (FM Node)	End (FM Node)	Total Length (m)	Number of Structures Included
West Branch "BURL"	On the west side of the M27 near St. John's Road (B3033) cross road - BURL_1728	The two minor tributaries are culverted separately before reaching the M27 Junction 8, and the culverts pass under the M27 Junction 8 roundabout and discharge to an open channel as a single culvert - BURL_1323C2c.	600m	5
East Branch "BUTR"	On the east side of the M27 near St. John's Road (B3033) cross road - BUTR_0373		660m	1
Main Reach	Culvert on the south east of the roundabout - BURL_1323C2c	Ends downstream of the A27 culvert - BURL_0000	1130m	11

Table C.4: Structures included in the model

Structure Description	Location	Representation
Rectangular concrete culvert with a $1.74m^2$ bore area	West Branch- BURL_1622 - Access road– 130m upstream of Peewit Hill	Rectangular orifice with spill representing deck to allow overflow
Circular concrete culvert with a diameter of 600mm	West Branch- BURL_1539 - Footbridge– 45m upstream of Peewit Hill	Circular orifice with spill representing deck to allow overflow
Circular concrete culvert with a diameter of 600mm	West Branch- BURL_1498 – Peewit Hill	Circular conduit
Circular concrete culvert with a diameter of 525mm	West Branch- BURL_1323 – culvert under the roundabout (M27 junction 8)	Circular conduit
Circular concrete culvert with a diameter of 600mm	West Branch- BURL_1323C1 – culvert under the roundabout (M27 junction 8)	Circular conduit
Circular concrete culvert with a diameter of 450mm	East Branch – BUTR_0000 – culvert along M27 and under Dodwell Lane	Circular conduit
Circular concrete culvert with a diameter of 675mm	Main Reach - BURL_1323C2c - culvert under the roundabout (M27 junction 8) after confluence with west and east branches.	Circular conduit
Circular concrete culvert with a diameter of 850mm	Main Reach - BURL_1113Cu – Footbridge -90m south east from the roundabout	Circular conduit

Structure Description	Location	Representation
Rectangular concrete culvert with a 0.89m^2 bore area	Main Branch- BURL_0916- Access road– 260m south east from the roundabout	Rectangular orifice with spill representing deck to allow overflow
Circular concrete culvert with a diameter of 1000mm	Main Branch- BURL_0748- Access road– 400m south east from the roundabout	Circular orifice with spill representing deck to allow overflow
Rectangular concrete culvert with a 0.61m^2 bore area	Main Branch- BURL_0642- Small footbridge – 500m south east from the roundabout and 30m from Dodwell Lane	Rectangular orifice with spill representing deck to allow overflow
Rectangular concrete culvert with a 0.83m^2 bore area	Main Branch- BURL_0537- Access road – 135m upstream of M27 Highway and 30m from Dodwell Lane	Rectangular orifice with spill representing deck to allow overflow
Circular concrete culvert with a diameter of 1000mm	Main Branch- BURL_0425 – culvert under M27 Highway	Circular conduit
Circular concrete culvert with a diameter of 1000mm	Main Branch- BURL_0309- Access road– 80m downstream from the M27 Highway	Circular orifice with spill representing deck to allow overflow
Rectangular concrete culvert with a 0.27m^2 bore area	Main Branch- BURL_0264- Small footbridge – 120m downstream from the M27 Highway	Rectangular orifice with spill representing deck to allow overflow
Rectangular concrete culvert with a 0.96m^2 bore area	Main Branch- BURL_0169 - Access road – 100m upstream from the A27 road	Rectangular orifice with spill representing deck to allow overflow
Circular concrete culvert with a diameter of 1000mm	Main Branch- BURL_0091 – culvert under the A27 road	Circular conduit

Hydraulic roughness values (Manning's "n") for Bursledon Brook were determined using site visit and survey photographs and established reference literatures such as Chow[3]. For western and eastern branches, a Manning's n value of 0.05 has been used for the river bed and 0.06 for the banks. For the main branch a single roughness value of 0.045 was adopted for both river bed and banks.

Hydrological inflows to the model were applied as discussed in Section C.3. These are shown in Figure C.3.

A normal depth condition (i.e. free flow) was used as downstream boundary with a bed slope of 0.013 which was calculated based on the average slope of the river bed at this location.

C.4.2 Floodplain schematisation (2D Tuflow Model)

The 2D domain covers an area of 0.82 km^2, as shown in Figure C.4. The topography is represented using a 2 m resolution grid. The levels for the grid cells are based on a 0.5 m horizontal resolution Digital Terrain Model (DTM) derived from LiDAR.

Appropriate use has been made of 2D breaklines and elevation polygons (z-shapes) to accurately represent roads and ditches where they have a significant impact on flow across the floodplain.

Hydraulic roughness coefficients were applied across each cell of the 2D domain depending on land use taken from OS Mastermap data, as shown in Table C.5. Roughness values adopted in the model were taken from standard guidance (Chow, 1959).

[3] Chow, Manning's n for Channels, 1959

The link between the 1D and the 2D domains was defined along the banks of the river reaches represented in Flood Modeller Pro using HX and SX connections as appropriate (see Figure C.4 and Figure C.5).

Table C.5: Manning's 'n' coefficients - 2D domain

Land Use	Manning’s ‘n’
Water bodies	0.03
Roads, tracks and paths	0.025 - 0.03
Manmade embankment around ponds	0.03
Rough Grassland	0.08
Woodland	0.10
Buildings and glasshouses	0.50
Rural Land	0.04 - 0.05

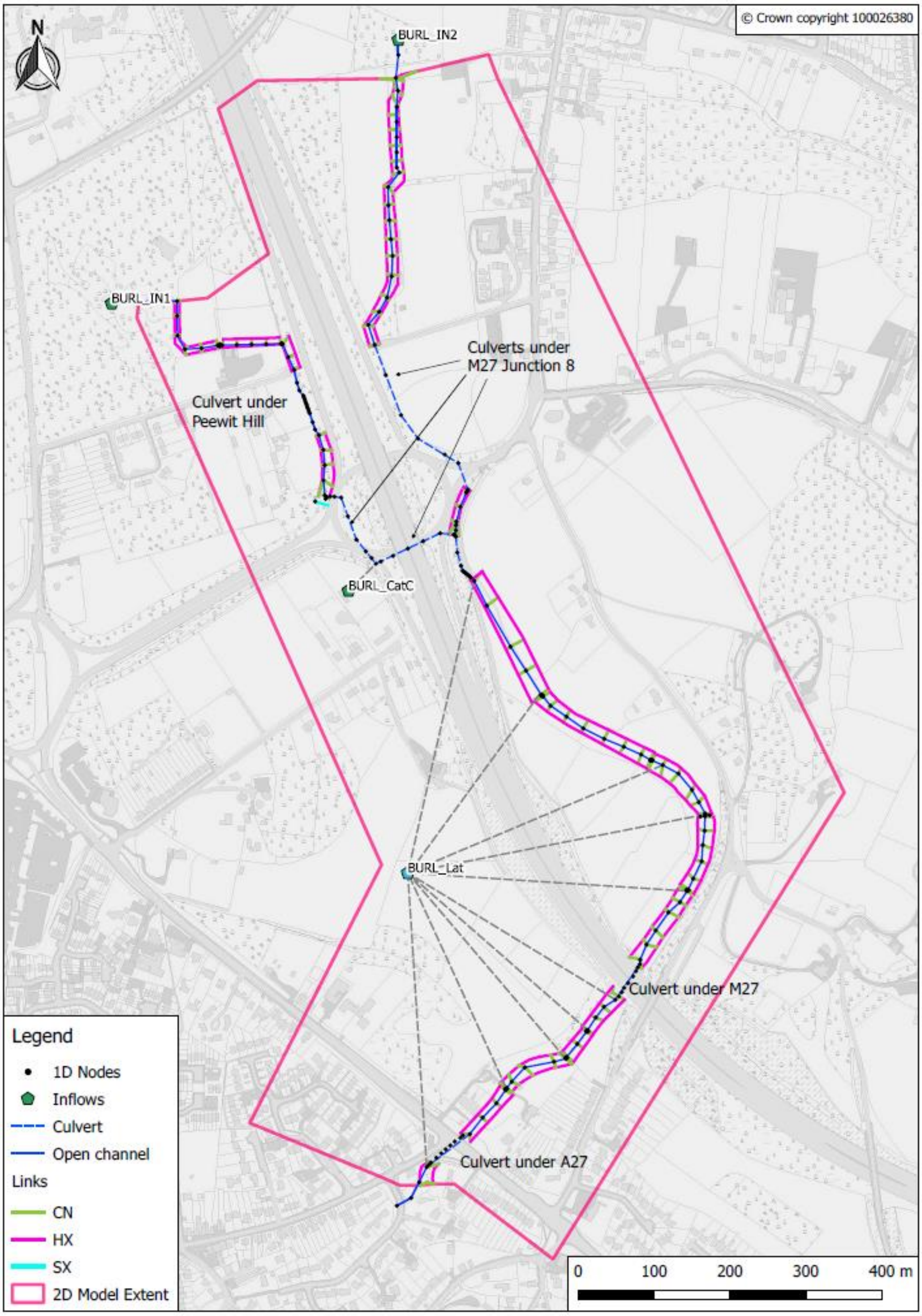


Figure C.4: Baseline model schematisation

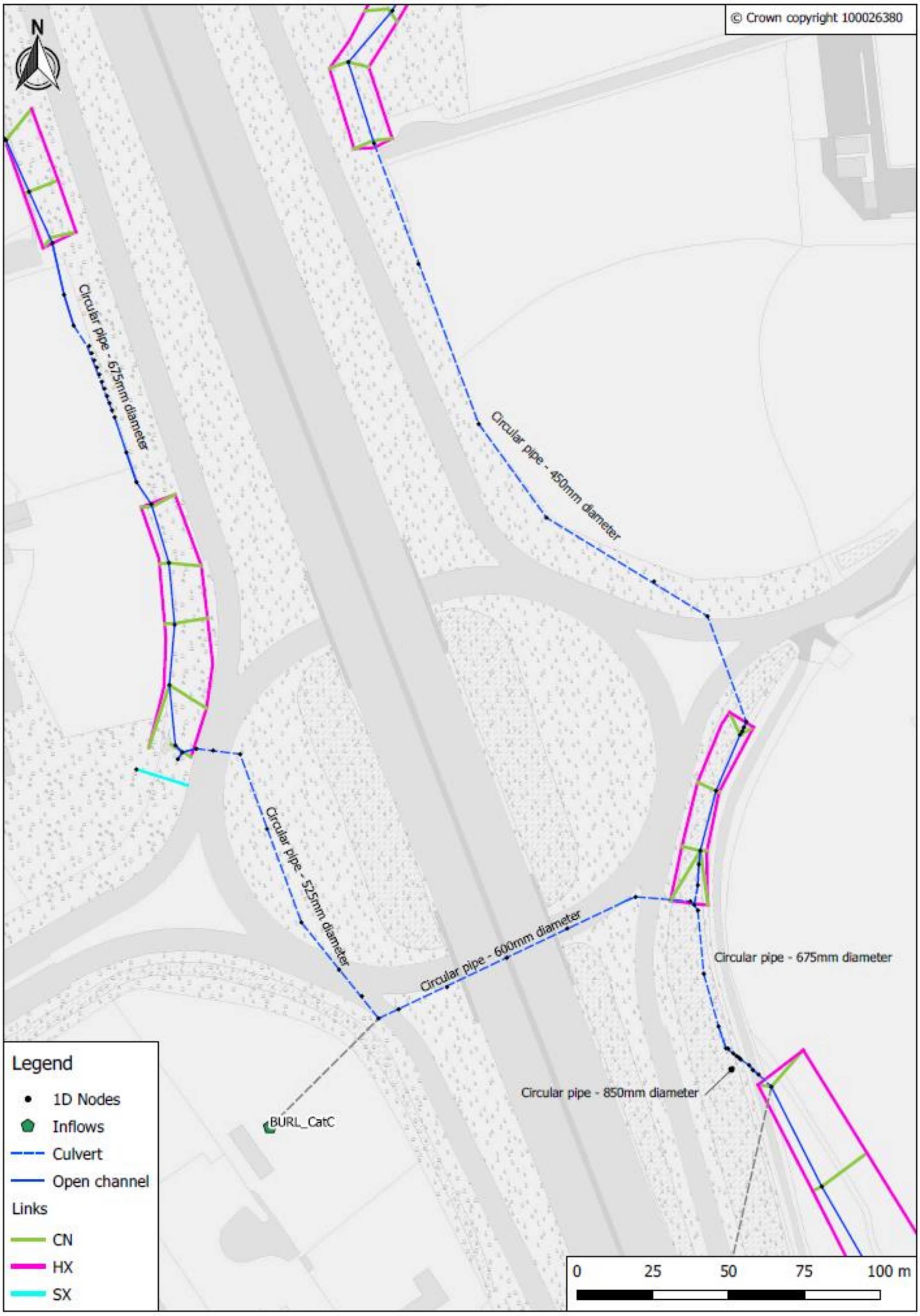


Figure C.5: Baseline model schematisation – Junction 8 roundabout

C.5 Proposed Scheme modelling

C.5.1 Proposed Scheme arrangement

Figure C.6 shows the layout of the proposed scheme at the M27 Junction 8. The modifications to the baseline model for the inclusion of the proposed scheme include the updates to the road elevations and roughness values along the scheme footprint, updates to the dimensions, lengths and invert levels for the existing culverts under the Junction 8 roundabout within Flood Modeller Pro.

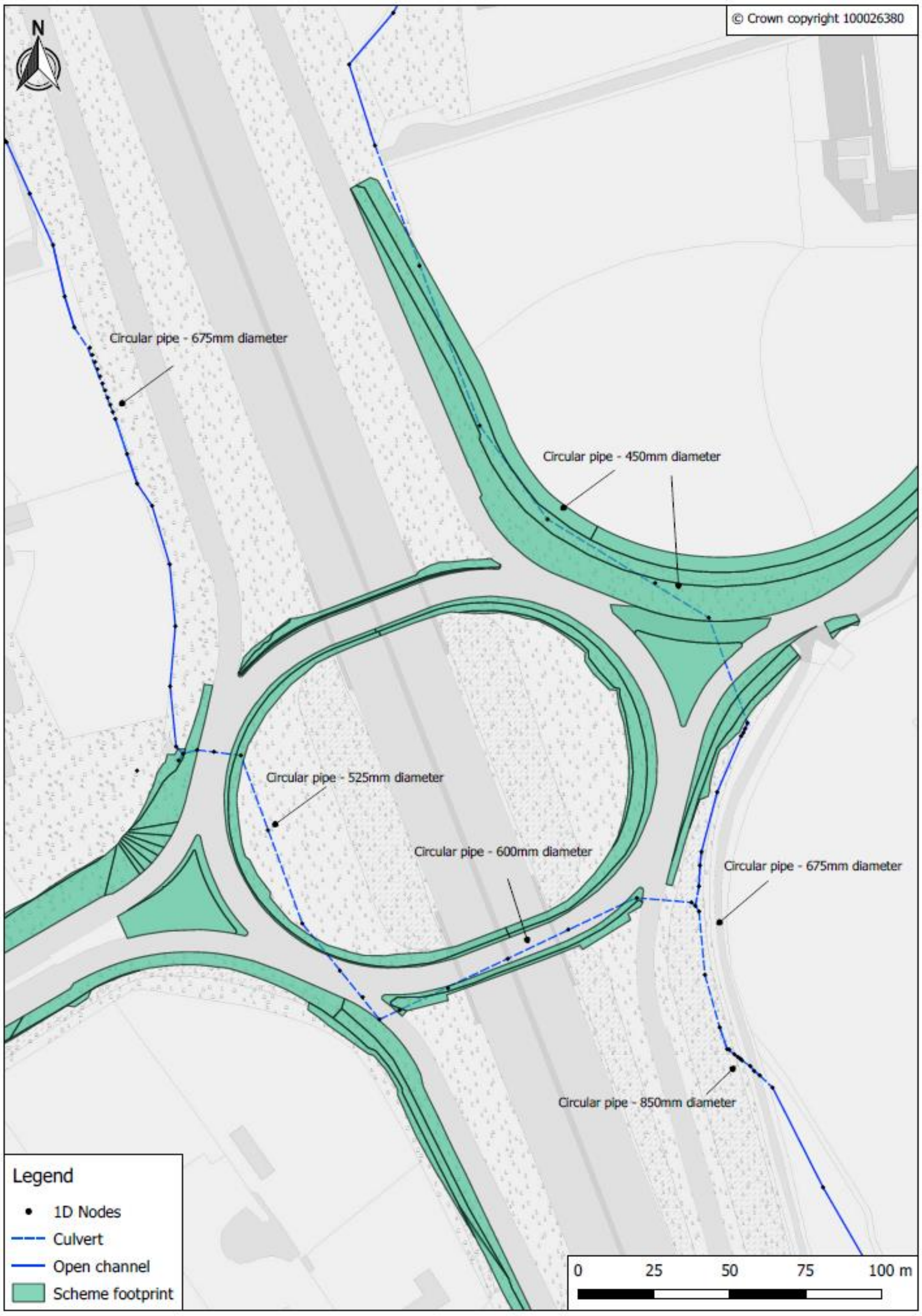


Figure C.6: With Scheme model schematisation

C.5.2 Mitigation measures

The proposed scheme was found to increase flood risk to the Junction 8 roundabout, as shown in Appendix E and further discussed in the Flood Risk Assessment Report. Several mitigation options have been tested to try and reduce flood risk associated with the 1% AEP + 35%CC event in this area. The following section discusses the final options which have been incorporated into the proposed scheme.

Mitigation measures consist of four storage areas which retain water during the peak of the flood. These storage areas are associated with Sustainable Drainage System (SuDS) features to allow flood waters to drain back to the system. Size and capacity of these areas are indicated in Table C.6.

To connect the Pond and Tank with the drainage and river system, new culverts have been incorporated to the hydraulic model. These are indicated in Figure C.7.

As part of the mitigation measures, a flood wall has been set along the north west edge of the M27 Junction 8 roundabout (see Figure C.7). Length and height of the wall are indicated in Table C.6.

Two final mitigation options are currently considered to mitigate flood risk associated with the 1% AEP + 35%CC event. The second mitigation option only differs from the first one as it involves an extended version of the NW Storage area to further reduce flood extent so that it exactly matches with the flood extent in the baseline situation.

Table C.6: Mitigation measures implemented in the mitigation model

Mitigation measure	Model representation	First mitigation option	Second mitigation option
NW Storage area	2D polygon	area: 1535m^2 bed level: 40.67m AOD excavation depth: 1.9 to 4m storage capacity: 2917m^3	area: 2617m^2 bed level: 40.67m AOD excavation depth: 1.9 to 4m storage capacity: 4972m^3
NE Storage area	2D polygon	area: 1972m^2 bed level: 41.00m AOD excavation depth: 2.5 to 4.4m storage capacity: 4930 m^3	area: 1972m^2 bed level: 41.00m AOD excavation depth: 2.5 to 4.4m storage capacity: 4930 m^3
Pond	1D reservoir unit	area: 585m^2 bed level: 41.00m AOD excavation depth: 2 to 3.5m storage capacity: 895 m^3	area: 585m^2 bed level: 41.00m AOD excavation depth: 2 to 3.5m storage capacity: 895 m^3
Tank – underground storm tank	1D reservoir unit	available capacity: 80m^3 bed level: 41.00m AOD	available capacity: 80m^3 bed level: 41.00m AOD
Wall	2D polyline	length: 160 m height: 0.5m elevation: 43.8m AO	length: 160 m height: 0.5m elevation: 43.8m AOD

The with scheme model schematisation including the mitigation measures is shown in Figure C.7.

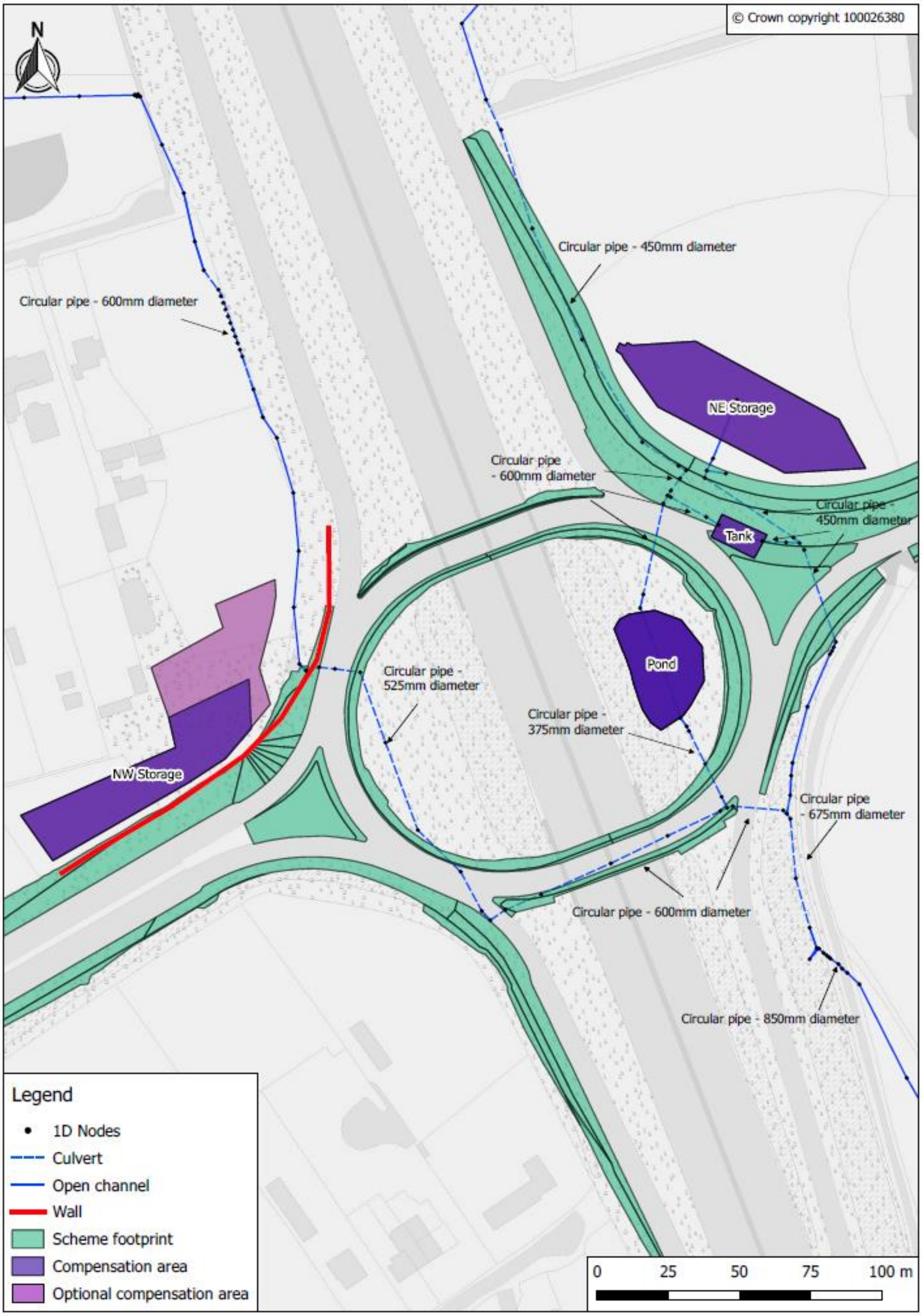


Figure C.7: With Scheme model schematisation including flood compensation areas

C.6 Modelled events

The modelled events and scenarios simulated are shown in Table C.7.

As already mentioned, hydraulic model results have been used to inform the flood risk assessment and are fully discussed in the Flood Risk Assessment Report.

Table C.7: Modelled events and scenarios simulated

Scenario	50% AEP	3.3% AEP	1% AEP	1% AEP +35% CC	0.1% AEP
Baseline scenario	✓	✓	✓	✓	✓
Proposed scheme scenario (no mitigation)				✓	
Proposed scheme scenario (with mitigation) first option				✓	
Proposed scheme scenario (with Mitigation) second option				✓	
Flow sensitivity test (±20% flow)			✓		
Roughness sensitivity test (±20% roughness)			✓		
Downstream boundary sensitivity test (±20% downstream boundary slope)			✓		

Maximum flood depth maps have been produced for all simulated scenarios for the 1% AEP + 35%CC event. These are provided in Appendix E of this document.

C.7 Model Proving

C.7.1 Model Performance

Run performance has been monitored throughout the model build process and then during each simulation carried out, to ensure a suitable model convergence was achieved. Convergence refers to the ability of the modelling software to arrive at a solution for which the variation of the found solution between successive iterations is either zero or negligibly small and lies within a pre-specified tolerance limit.

As shown in Figure C.8, 1D Flood Modeller Pro convergence for the 1% AEP + 35%CC flood event is good throughout the run duration, except for some spikes of non-convergence occurring for a short time and associated with switching mode in the orifice units. This convergence plot is generally typical for all the modelled events.

After the peak of the flood, there is a slight instability on the flow that occurs towards the downstream end of the model (A27 crossing) when the water flows back to the open channel from the 2D domain. This has no impact on the maximum flood peaks/levels predicted by the model in the area of interest (i.e. near Junction 8).

The cumulative mass error reports output from the TUFLOW 2D model have been checked for all simulated events. The accepted tolerance range recommended by the software manual is +/- 1% mass balance error. Figure C.9 shows that for the 1% AEP + 35%CC flood event the cumulative mass error is well within this tolerance range for most of the duration of the run. The spike of the mass error at the beginning of the simulation is expected and relate to when the water flows from 1D to 2D. Mass Error rapidly decreases to negligible values around -0.03%.

Smooth variation of the change in volume through the model simulation is another indicator of good convergence of the 2D model (Figure C.9).

These 2D mass error and dV diagnostics are typical for all events simulated.

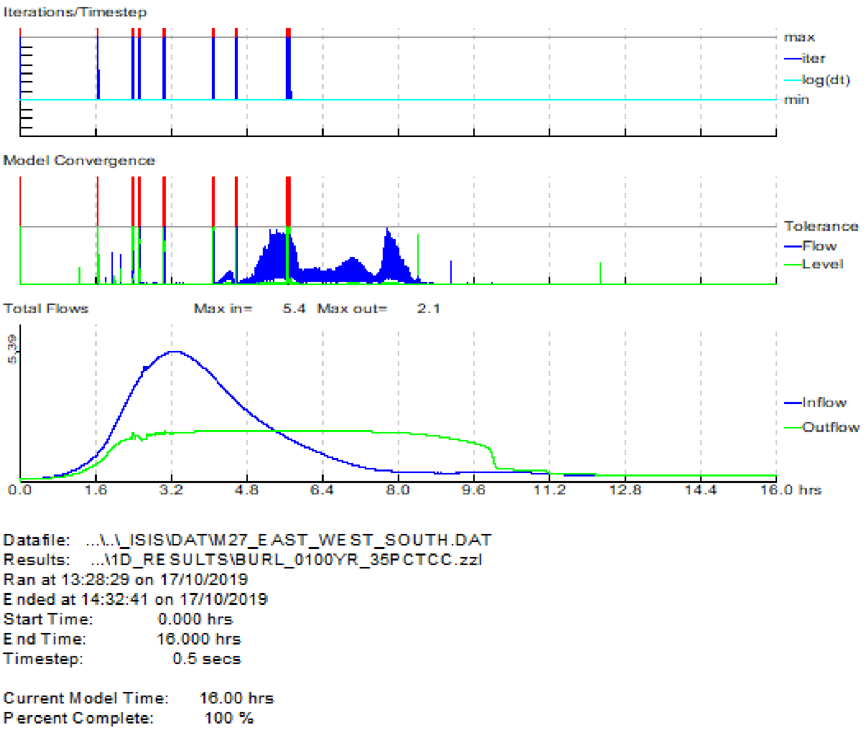


Figure C.8: Flood Modeller Pro 1D Model convergence plot – Baseline Run - 1% AEP plus 35%CC

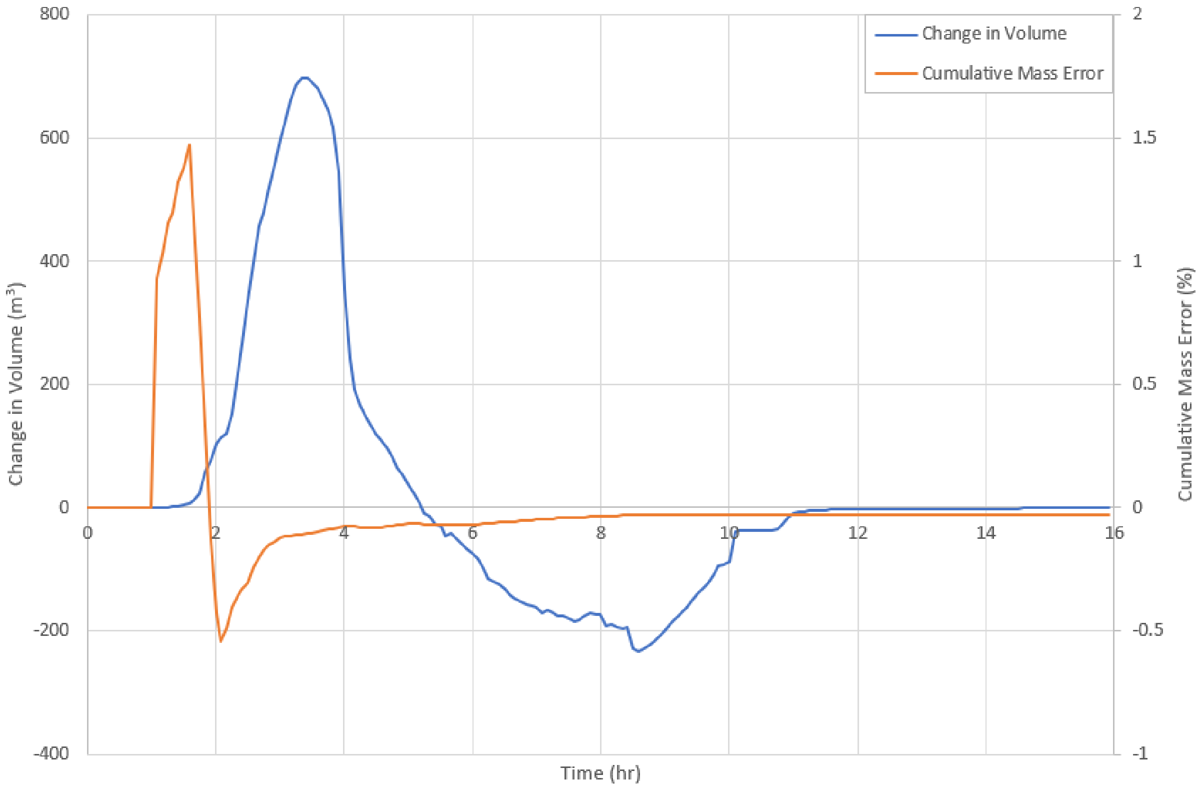


Figure C.9: **Cumulative mass error and change in volume – Baseline Run - 1% AEP + 35%CC**

C.7.2 Model calibration

The Bursledon Brook catchment being ungauged there is a lack of suitable information available to calibrate the hydraulic model.

A high level verification of the model results was made by ground truthing the flood mechanisms predicted by the model using observations made through Google Earth Street View. The model verification was also made by comparing the model results against flood risk maps from surface water[4] available on the Environment Agency web page (https://flood-warning-information.service.gov.uk), this showed a good correlation in terms of the areas predicted to flood by the model.

C.7.3 Sensitivity analysis

In order to test the model sensitivity to key hydraulic parameters a series of simulations were undertaken for the 1% AEP event under the baseline scenario. The assessed hydraulic parameters were: Manning's 'n' roughness coefficients, hydrological inflows and downstream boundary slope.

The results show that the Bursledon Brook model is most sensitive to flow change. Increasing and decreasing inflows, resulted in a -21.8% and +11.9% change in the flood extent respectively. Increased flow results in more extensive flooding across the whole modelled reach. A reduction in flow resulted in smaller flood extent in the same areas affected by increased flows. The biggest difference is located on the south part of the roundabout.

Model results are not sensitive to roughness changes and downstream boundary condition changes. The flooded area change compared to the baseline flood extents is below 0.4% for the roughness sensitivity test. Downstream boundary sensitivity shows no difference in flood extent when compared to baseline simulation. The outcome of the sensitivity tests indicates that greatest benefit in improving model confidence would be achieved through improved flow estimates.

[4] There is no fluvial flood map available on the EA website, this is why a high level comparison was made against surface water flood map.

C.8 Model assumptions and limitations

The accuracy and validity of the hydraulic model results is strongly dependent on the accuracy of the hydrological and topographic data included in the model. While the most appropriate available information has been used to construct the model to represent fluvial flooding mechanisms, there are uncertainties and limitations associated with the model. These include assumptions made as part of the model build process.

Efforts have been made to assess and reduce levels of uncertainty in each aspect of the modelling process. The assumptions made are considered to be generally conservative for modelled water levels at the proposed scheme location and are therefore appropriate for the flood risk assessment. Additionally, the sensitivity analysis has quantified the magnitude of potential uncertainty, and the verification process indicates that the modelling outputs are sensible.

The key assumptions and limitations are the following:

- The hydraulic model has been designed to simulate fluvial flood risk. As such it does not cater for surface water flood risk and therefore does not include a representation of the highway drainage system in both existing and proposed scheme situation. Separate analysis would be required to estimate the capacity needed for the highway draining system to deal with surface water. This is particularly true for the proposed mitigation measures put in place across the roundabout (new culverts, storage tanks).
- Due the lack of gauging information the hydraulic model could not be calibrated. It also worth noting the uncertainty associated with the hydrological inflows used in the model. The Bursledon Brook has small catchment area, e.g. approximately 0.5km^2 at FEP1 and 1.3km^2 at FEP2. Although the catchment is impermeable in nature, has no attenuation and is moderately urbanised, the derivation of flow in such a small catchment is always associated with some degree of uncertainty. Therefore, two independent methods, namely, the FEH Statistical method and ReFH2.2 methods have been applied for the estimation of peak flows, and the conservative value has been adopted.
- All design event simulated assumes a 3.5 hour summer storm. No critical storm duration analysis has been carried out in this study.
- All culverts incorporated to the model have been assumed free from blockages.
- Representation of the SuDS feature to drain the storage areas as part of the mitigation measures have not been modelled in a great level of details.

C.9 Conclusions and recommendations

In order to support the development of a Flood Risk Assessment for the M27 Southampton Junction 8 Scheme, a hydraulic model was constructed to establish a baseline scenario for the flood risk along the Bursledon Brook that crosses the M27 Junction 8. A 2km long reach of the Bursledon Brook was represented along with the key structures.

A range of flood events from 50% to 0.1% AEP and climate change events were simulated using the model.

The baseline model was then adapted to represent the proposed scheme scenario in order to assess the impact of the proposed scheme on the flood risk. Where increases to flood risk were identified, mitigation measures were developed and incorporated into the proposed scheme and tested with hydraulic model simulations.

The assumptions and limitations associated with the hydraulic modelling are discussed in Section C.8 of this technical note, which should be considered for any future use of the hydraulic model.

Model results have been used to inform the Flood Risk Assessment and are presented in detail in the Flood Risk Assessment report.

The following is recommended if any of the flood mitigation options discussed in this report are progressed to detail design:

- Finer representation of the storage areas and associated drainage features would be required in the model.
- A critical storm duration analysis would be required to estimate accurately the required capacity of the storage areas.

Roughness sensitivity tests for all conduits in the model and blockage scenario for culverts inlets for both branches will provide better understanding of the robustness of the proposed mitigation measures under different maintenance conditions.

JACOBS

Appendix D. Flood estimation calculation record

Flood estimation calculation record for single sites – Bursledon Brook at M27 Junction 8

Introduction

This document is to provide a record of the calculations and decisions made during flood estimation. It will often be complemented by more general hydrological information given in a project report. The information given here should enable the work to be reproduced in the future. This record sheet is to be used where flood estimates are needed at a single location.

Approval

	Signature	Name	Competence level (see below)
Calculations prepared by:	Maryann McDonald	Maryann McDonald	1
Calculations checked by:	K.P. Bhattarai	Keshav Bhattarai	3
Calculations reviewed by:	K.P. Bhattarai	Keshav Bhattarai	3
Calculations approved by:			

- Level 1 – Hydrologist with minimum approved experience in flood estimation
- Level 2 – Senior Hydrologist
- Level 3 – Senior Hydrologist with extensive experience of flood estimation

Abbreviations

AM	Annual Maximum
AREA	Catchment area (km^2)
BFI	Base Flow Index
BFIHOST	Base Flow Index derived using the HOST soil classification
CFMP	Catchment Flood Management Plan
CPRE	Council for the Protection of Rural England
DT	Data Transfer
FARL	FEH index of flood attenuation due to reservoirs and lakes
FEH	Flood Estimation Handbook
FSR	Flood Studies Report
HOST	Hydrology of Soil Types
NRFA	National River Flow Archive
POT	Peaks Over a Threshold
QMED	Median Annual Flood (with return period 2 years)
ReFH	Revitalised Flood Hydrograph method
SAAR	Standard Average Annual Rainfall (mm)
SPR	Standard percentage runoff
SPRHOST	Standard percentage runoff derived using the HOST soil classification
Tp (0)	Time to peak of the instantaneous unit hydrograph
URBAN	Flood Studies Report index of fractional urban extent
URBEXT1990	FEH index of fractional urban extent
URBEXT2000	Revised index of urban extent, measured differently from URBEXT1990
WINFAP-FEH	Windows Frequency Analysis Package – used for FEH statistical method

JACOBS

D.1 Method statement

Overview of requirements for flood estimate

Item	Comments
Give an overview which includes: • Purpose of study • Peak flow or hydrograph? • Range of return periods • Approx. time available	This FEH calculation record reports on the hydrological analysis of a minor watercourse for the flood risk assessment as part of extension of Junction 8 on the M7 Motorway near Southampton (SU 48500 10300). For the estimation of design peak flow, the FEH Statistical method and ReFH2.2 methods were applied and the method resulting in the larger flood peaks was adopted. The ReFH2.2 method-based hydrograph shapes were used to derive the model inflows required for the numerical hydraulic modelling of the watercourse to be assessed for the potential flood risk. Design peak flows were required for a range of AEPs, including the 50% AEP (2-year), 3.3% AEP (30-year), 1% AEP (100-year), 0.1% AEP (1000-year) events, with the 1% AEP (100-year) event flow including an allowance of 35% to cater for the future climate change (CC).

Overview of catchment

Item	Comments
Brief description of catchment, or reference to section in accompanying report	The Bursledon Brook that crosses the M27 Junction 8 rises in the vicinity of the M27 / St. John's Road (B3033) cross road and consists of two unnamed minor tributaries, namely, the eastern tributary and the western tributary. The two minor tributaries are culverted separately before reaching the M27 Junction 8, and the culvert(s) pass under the M27 Junction 8 roundabout and discharge to an open channel as a single culvert just to the southeast of the roundabout. The catchment area of the Bursledon Brook up to the M27 Junction 8 is approximately 0.54km^2; with the eastern tributary draining approximately 53% and the western tributary draining the remaining approximately 47% of the above catchment area. The open channel reach of the Bursledon Brook flows approximately 600m due southeast, before crossing the M27 once again. Approximately 300m further downstream of the M27 crossing, the Bursledon Brook crosses the Providence Hill Road (A27). The numerical hydraulic modelling extent of the Bursledon Brook spans between upstream of the M27 Junction 8 and downstream of the A27 culvert. The total catchment area of the Bursledon Brook up to the downstream modelling extent is approximately 1.3km^2. The FEH catchment descriptors of the Bursledon Brook have been purchased from FEH Web Service at two locations, namely, one at the M27 Junction 8 (termed hereafter as FEP1) and the other at the downstream modelling extent (termed hereafter as FEP2). The FEH catchment boundary of the Bursledon Brook was plotted on the QGIS map and revised using the 2m contour LiDAR data freely available from the Environment Agency website. Figure D.3a shows the FEH catchment boundary together with the revised catchment boundary of the minor watercourse. The catchment is classed as *moderately urbanised* by the FEH definition (the FEH CDs $URBEXT_{2000}$=0.078 for the upper catchment and 0.112 for the overall catchment) and has no attenuation from reservoirs and lakes (FARL=1.0).

	According to the Geology of Britain Viewer Online1 (British Geological Survey, 2019), the majority of the site comprises of the London Clay Formation of Clay, Silt and Sand Sedimentary Bedrock. No superficial deposits have been recorded for the area. According to Cranfield Soil and AgriFood Institute (CSAI) Soilscapes Viewer2, the catchment soil composition consists of slowly permeable, seasonally wet, slightly acid but base-rich loamy and clayey soils. The drainage is classed as impeded (BFIHOST = 0.321 for the upper catchment and 0.298 for the overall catchment; SPRHOST = 43.11% for the upper catchment and 44.02% for the overall catchment). [1]Accessed at: http://mapapps.bgs.ac.uk/geologyofbritain/home.html [2]Accessed at: http://www.landis.org.uk/soilscapes/

Source of flood peak data

Was the HiFlows UK dataset used? If so, which version? Record any changes made.	HiFlows UK v7 was used.

Initial choice of approach

Is FEH appropriate? (it may not be for very small, heavily urbanised or complex catchments). If not, describe other methods to be used.	Yes, moderately urbanised catchment, no impact from reservoirs.
Outline the conceptual model, addressing questions such as: • What is likely to cause flooding at the site (peak flows, flood volumes, combinations of peaks, groundwater, snowmelt, tides…) • Might the site flood from runoff generated on part of the catchment only, e.g. downstream of a reservoir? • Is there a need to consider temporary debris dams that could collapse?	Peak flow dominant; no reservoirs, FARL = 1, negligible floodplain extent. FEH statistical and ReFH2.2 methods are applicable to estimate peak flow.
Any unusual catchment features to take into account? e.g. • highly permeable – avoid ReFH if BFIHOST>0.65, use permeable catchment adjustment for statistical method if SPRHOST<20% • highly urbanised – avoid ReFH if URBEXT1990>0.125; consider FEH Statistical or other alternatives • pumped watercourse – consider lowland catchment version of rainfall-runoff method • major reservoir influence (FARL<0.90) – consider flood routing • extensive floodplain storage – consider choice of method carefully	- Impermeable soil, BFIHOST= 0.321 (upper catchment) / 0.298 (overall modelled catchment) - Moderately urbanised catchment URBEXT2000 = 0.078 (upper catchment) & 0.112 (overall modelled catchment) - not affected by reservoirs (FARL= 1.0) - negligible floodplain extent for the upper catchment (FPEXT = 0.0049) and minor floodplain extent (FEP = 0.0209) for the overall modelled catchment.
Initial choice of method(s) and reasons	Full hydrograph is required for model inflow. So, the peak flows are based on the conservative value from two method (FEH Statistical and ReFH2.2) whereas the hydrograph shape is adopted from ReFH2.2 method.

Software to be used (with version numbers) e.g. FEH CD-ROM v3.0[5] WINFAP-FEH v3[6] / ReFH spreadsheet HiFlows v3.0.2	FEH web service WinFAP-FEH 4 ReFH2 (v2.2) with FEH13 rainfall Peak flows data (NRFA) (WinFAP-FEH database) v7

Site details

Watercourse	Site	Easting	Northing	AREA on FEH WEB Service (km^2)	Revised AREA if altered
Unnamed (u/s)	Near M27 – Junction 8 (FEP1)	448450	111200	0.513	0.545
Unnamed (d/s)	Near M27 culvert (FEP2)	448500	110300	1.315	1.317

Catchment descriptors (incorporating any changes made) for the catchment of the Bursledon Brook at up to the M27 J8

	FARL	PROPWET	BFIHOST	DPLBAR (km)	DPSBAR (m/km)	SAAR (mm)	SPRHOST (%)	URBEXT 2000 (present)	FPEXT
Full catchment									
FEP1*	1	0.33	0.321	0.58	52.0	806	43.11	~~0.078~~ 0.111	0.0049
FEP2	1	0.33	0.298	1.28	67.6	799	44.02	~~0.112~~ 0.136	0.0209
Residual catchment area between FEP1 and FEP2 (for model inflow purpose)									
Res12*	1	0.33	0.282	0.88	78.6	794	44.66	0.153	0.0322

**For model inflow purpose, the inflows were derived at FEP1 and at the residual catchment Res12 (AREA = 1.317- 0.545 = 0.772km^2). The CDs for Res12 were derived using the procedure suggested in FEH Volume 5.*

The strikethrough values are from FEH Web Service.

Checking catchment descriptors

Record how catchment boundary was checked and describe any changes (refer to maps if needed)	The FEH derived catchment boundary was visually checked against the 2m contour generated from LiDAR data, freely available from the Environment Agency[1]. From a comparison, some minor adjustment was undertaken at both FEP1 and FEP2 boundary. However, these changes have resulted in only marginal increase in the overall catchment area and hence all other CDs except URBEXT were kept unchanged. See Figure D.3a for the FEH and revised catchment boundaries. [1]Accessed at: https://environment.data.gov.uk/DefraDataDownload/?Mode=survey

[5] FEH CD-ROM v3.0 © NERC (CEH). © Crown copyright. © AA. 2009. All rights reserved.
[6] WINFAP-FEH v3.0.003 © Wallingford HydroSolutions Limited and NERC (CEH) 2009.

Record how other catchment descriptors (especially soils) were checked and describe any changes. Include before/after table if necessary.	Geology mapping on the BGS online viewer at 1:50,000 scale and the Cranfield Soilscape web viewer were used to get an appreciation of the catchment permeability.
Source of URBEXT	FEH Web Service
Method for updating of URBEXT	URBEXT was revised by comparing the FEH Web Service URBEXT2000 extent and that appearing on the latest topography map. From the comparison, it is observed that a part of the M27 road in the vicinity of the Junction 8 was not included in the calculation of URBEXT2000, which is now included in the revised URBEXT2000.

D.2 Statistical method

Overview of estimation of QMED

Used	Condition	Approach followed
	N >=30	Estimate QMED using annual maxima
	14=< N =<29	Estimate QMED from annual maxima & optionally adjust for climatic variation
	2=< N= <13	Estimate QMED from POT data & adjust for climatic variation
	N <2 & suitable donor site with 20 years or more of record	Ignore record at subject site; transfer QMED from donor site
	N <2 & suitable donor with 10 to 19 years of record & 12 month overlap between records	Estimate QMED using procedure based on flood peak regression
	N <2 & suitable donor with 10 to 19 years of record but no 12 month overlap	Ignore record at subject site; transfer QMED from donor site
	N <2 & no long-record site nearby	Estimate QMED from very short POT record
	N <2 & no long-record site nearby	Treat site as ungauged catchment
	N <2 & no long-record site nearby	Defer analysis until longer flow record available
	N <2 & no long-record site nearby	(Abstract flood event information and apply the UH rainfall-runoff model as an alternative, to the pooling group procedure. Particularly recommended when site is urbanised)
✓	Ungauged catchment	Estimate QMED from catchment descriptors
✓	Ungauged catchment	Estimate QMED by data transfer from donor catchment
	Ungauged catchment	Estimate QMED by data transfer from analogue catchment
	Ungauged catchment	Estimate QMED from channel dimensions
	Ungauged catchment	Compare to regional pattern of mapped QMED adjustment factors

JACOBS

Search for donor sites for QMED

Comment on potential donor sites	
Comment on potential donor sites Mention: • Number of potential donor sites available • Distances from subject site • Similarity in terms of AREA, URBEXT, FARL and other catchment descriptors • Quality of flood peak data Include a map if necessary. Note that donor catchments should usually be rural.	The following six potential local donor stations were considered, as suggested by the WinFAP4 software package: 42011 (Hamble @ Frogmill) 42006 (Neon @ Mislingford) 42008 (Cheriton Stream @ Sewards Bridge) 42003 (Lymington @ Brockenhurst) 42010 (Itchen @ Highbridge & Allbrook Total) 42014 (Blackwater @ Ower)

Donor sites chosen and QMED adjustment factors

	Reasons for choosing or rejecting	Method (AM or POT)	Adjust-ment for climatic variation?	QMED from flow data (A)	QMED from catchment descriptors (B)	Adjust-ment ratio (A/B)
42011 (Hamble @ Frogmill)	Large AREA (55km^2), BFIHOST>0.65	AM	No	7.687	4.694	1.64
42006 (Neon @ Mislingford)	Large AREA (79km^2), BFIHOST>0.65	AM	No	2.789	2.331	1.20
42008 (Cheriton Stream @ Sewards Bridge)	Large AREA (74km^2), BFIHOST>0.65	AM	No	1.286	2.517	0.51
42003 (Lymington @ Brockenhurst)	Large AREA (100km^2)	AM	No	27.207	29.070	0.94
42010 (Itchen @ Highbridge & Allbrook Total)	Large AREA (340km^2), BFIHOST>0.65	AM	No	7.765	6.537	1.19
42014 (Blackwater @ Ower)	Large AREA (102km^2)	AM	No	14.506	20.867	0.70

Figure D.4 shows the possible donor station locations and Figure D.5 shows the details of these six donor catchments suggested by WinFAP4.

QMED estimation from catchment descriptors (FEP2 – Target location)

$$\mathbf{QMED}_{cds} = \mathbf{8.3062AREA^{0.8510}0.1536^{\left(\frac{1000}{SAAR}\right)}FARL^{3.4451}0.0460^{BFIHOST^2}}$$

$QMED_{\text{catchment descriptors, rural}} =$ 0.766m^3/s

68% confidence interval = (0.54, 1.1)

95% confidence interval = (0.37, 1.6)

$QMED_{\text{catchment descriptors, urban}} =$ 0.854m^3/s

Method	Initial estimate of $QMED_{urban}$ (m^3/s)	Data transfer				Final estimate of QMED (m^3/s)
		NRFA numbers for donor sites used (see 3.3)	Distance between centroids d_{ij} (km)	Power term, a	Moderated QMED adjustment factor, $(A/B)^a$	
CDs	0.854	NA	NA	NA	NA	**0.854**

Notes

Methods: AM – Annual maxima; POT – Peaks over threshold; DT – Data transfer; CD – Catchment descriptors alone.

When QMED is estimated from POT data, it should also be adjusted for climatic variation. Details should be added below.

When QMED is estimated from catchment descriptors, the revised 2008 equation from Science Report SC050050 should be used. If the original FEH equation has been used, say so and give the reason why.

The data transfer procedure is the revised one from Science Report SC050050. The QMED adjustment factor A/B for each donor site is given in the previous table. This is moderated using the power term, a, which is a function of the distance between the centroids of the subject catchment and the donor catchment. The final estimate of QMED is $(A/B)^a$ times the initial estimate from catchment descriptors.

If more than one donor has been used, give the weights used in the averaging.

The six potential donor sites suggested by WinFAP4, namely Stations 42003, 42006, 42008, 42010, 42011 and 42014, all have catchment areas much larger than that of the subject site. In addition, four of the WinFAP4 suggested donor catchments are permeable, with BFIHOST >0.9. Station 42003 has a more similar permeability, with a BFIHOST value of 0.387, however it has an area of approximately 100km^2, significantly larger than the subject site. The ratio of QMEDobs to QMEDcds for station 42003 is 0.947, which is just below unity.

Therefore, no QMED adjustment factor was applied, i.e., QMED adjustment factor of 1.0 has been chosen since no suitable donor catchment has been found as mentioned above.

D.3 Pooling Group Analysis

Pooling group construction

Site of interest

(a) Station Number	Ungauged	(b) Name	

Name of saved **.feh4** group file	M27Junction8_FullCatchment
Target return period (years) for 5T rule	500

Initial Pooling group details

Total number of sites	18	Total number of years	527

Total number of initial high discordancy sites	0

List them: -

Total number of short records (< 7 years) removed	1

List them: GS Number 49005

Number of pooled years after sites removed	520

Is subject site included as Rank 1 in pooled group: ~~yes~~ no

If no state reason why: Site is ungauged

Test statistics on validity of pooling group for flood frequency analysis

Heterogeneity test H2 value = 2.16

Status			
	Review not necessary		H2 < 1
	Review optional		1 < H2 < 2
	Review desirable	✓	2 < H2 < 4
	Review essential		H2 > 4

					Value
Goodness-of-fit test	Z values	GL	acceptable	/ ~~not acceptable~~	-0.36
		GEV	acceptable	/ ~~not acceptable~~	-1.73
		PT3	acceptable	/ ~~not acceptable~~	-3.25
	other				

(Note: in the FEH the GL is the generally favoured distribution for use)

ACTION is construction of flood frequency curve valid?

No ~~Yes~~ Check suitability of sites in the pooling group

Revision of Pooling Group

Revision No. 1

Station Number	Reason for changes in pooling group
26802, 27073	Removed, permeable, BFIHOST>0.65
47022	Removed, FARL < 0.95
206006, 49005	Added to increase total station years

Number of sites: 15 | Years: 518

Heterogeneity test | H2 value = 1.42

Status			
	Review not necessary		H2 < 1
	Review optional	✓	1 < H2 < 2
	Review desirable		2 < H2 < 4
	Review essential		H2 > 4

Note: FEH Vol.3, chapter 16.3.2: "The ideal pooling-group is homogeneous. However, a representative but heterogeneous pooling-group gives better flood frequency estimates than either single-site data or a pooling-group that has been made homogeneous by inappropriately removing sites. In general, it is anticipated that a significant proportion of pooling-groups will remain heterogeneous, even after review."

Goodness-of-fit test	Z values			Value
		GL	acceptable / ~~not acceptable~~	-1.32
		GEV	acceptable / ~~not acceptable~~	-2.55
		PT3	acceptable / ~~not acceptable~~	-4.20
	other			

ACTION is construction of flood frequency curve valid?

~~No~~ Yes

Comment? Gooodness-of-fit acceptable, heterogeneity (H2) reduced. No further revision, as the group found to be appropriate

Flood frequency analysis of pooling group

Distributions selected	GL	✓	PT3	
	GEV		other	

Standardisation method selected Median (this acts as a check as median is the only method allowed within ~~Mean~~ the pooling group method)

Construct flood frequency curve

			If yes			
URBEXT updated	yes	~~no~~	from	0.112	to	0.136
Urban adjustment*	yes	~~no~~				

Value of QMED = 0.85 m^3/s

Flood Frequency Curve		
Return period (yrs)	**GL - Growth factors**	**GEF – Growth factors**
2	1.00	1.00
5	1.30	1.33
10	1.54	1.58
20	1.81	1.85
25	1.91	1.94
30	1.99	2.02
50	2.24	2.24
75	2.46	2.43
100	2.64	2.58
200	3.12	2.94
1000	4.64	3.97

The GL distribution was selected as it passes the goodness-of-fit test and is described in FEH as the preferred distribution in the UK. See Table D.1 for Final pooling group details. See Figure D.6 for Pooling group diagnostic plots.

Derivation of flood growth curves

Method: SS – Single site P – Pooled J – Joint analysis	**If SS, distribution used and reason for choice** **If J, details of averaging**	**If SS, parameters of distribution** (location, scale and shape)	**Growth factor for 100-year return period**
P	N/A	N/A	2.69
Note: Growth curves were derived using the revised procedures from Science Report SC050050 (2008).			

Flood estimates from the statistical method

FEH Statistical Peak Flow Estimates (m^3/s)											
Return Period (Years)	**2**	**5**	**10**	**20**	**25**	**30**	**50**	**75**	**100**	**200**	**1000**
Growth Factor	1.00	1.30	1.54	1.81	1.91	1.99	2.24	2.46	2.64	3.12	4.64
FEP2	0.85	1.11	1.31	1.54	1.63	1.70	1.91	2.10	2.25	2.66	3.96

D.4 Revitalised flood hydrograph (ReFH2) method

Parameters for ReFH2 model

Method: OPT: Optimisation BR: Baseflow recession fitting CD: Catchment descriptors DT: Data transfer (give details)	**Tp (hours)** Time to peak	**C_{max} (mm)** Maximum storage capacity	**BL (hours)** Baseflow lag	**BR** Baseflow recharge
CD (with FEH13 rainfall model) for full catchment (FEP2)	2.05	243.23	26.07	0.67
Brief description of any flood event analysis carried out (further details should be given below or in a project report)	N/A			

Design events for ReFH2 method

Urban or rural	**Season of design event (summer or winter)**	**Storm duration (hours)**	**Storm area for ARF** (if not catchment area)
Urban	Summer	3.5	Catchment Area used

Flood estimates from the ReFH2 method

ReFH2 Peak Flow Estimates (m^3/s)				
Return Period (Years)	**2**	**30**	**100**	**1000**
FEP2 (Target site)	1.42	2.92	3.69	6.19

Comparison of results from different methods

This table compares peak flows from the ReFH2.2 methods with those from the FEH Statistical method for two key return periods. Blank cells indicate that results were not calculated using that method.

Ratio of ReFH2.2 Summer peak flow to FEH Statistical peak at FEP2.2					
Return period 2 years			**Return period 100 years**		
FEH pooling	**ReFH2.2**	**Ratio**	**FEH pooling**	**ReFH2.2**	**Ratio**
0.85	1.42	1.67	2.25	3.69	1.64

Final choice of method

Assumptions, limitations and uncertainty

List the main assumptions made (specific to this study)	As the two minor tributaries (eastern and western) of the Bursledon Brook has catchment areas less than 0.5km^2 no catchment descriptors are available for them at the FEH Web Service. Therefore, the model inflows are calculated at FEP1 (at the confluence of these two minor tributaries) and the derived inflow at FEP1 is allocated to the two minor tributaries based on the proportion of their catchment areas. The flow from the Motorway surface water drainage network is assumed to be discharged to this the un-named watercourse. The revisions of URBEXT2000 in the catchment is based on the Motorway area in the vicinity of M27 Junction 8 which does not seem to be incorporated in the URBEXT FEH CDs URBEXT calculation, as observed from the urban extent suggested by FEH Web Service mapping.
Discuss any particular limitations, e.g. applying methods outside the range of catchment types or return periods for which they were developed	The Bursledon Brook has small catchment area, e.g. approximately 0.5km^2 at FEP1 and 1.3km^2 at FEP2. Although the catchment is impermeable in nature, has no attenuation and is moderately urbanised, the derivation of flow in such a small catchment is always associated with some degree of uncertainty. Therefore, two independent methods, namely, the FEH Statistical method and ReFH2.2 methods have been applied for the estimation of peak flows, and the conservative value has been adopted.
Give what information you can on uncertainty in the results – e.g. confidence limits for the QMED estimates using FEH 3 12.5 or the factorial standard error from Science Report SC050050 (2008).	QMED catchment descriptors (FEP2) rural = 0.77m^3/s 68% confidence interval = (0.54, 1.10) 95% confidence interval = (0.37, 1.57)
Comment on the suitability of the results for future studies, e.g. at nearby locations or for different purposes.	Results are suitable for the purposes of the current study.
Give any other comments on the study, for example suggestions for additional work.	N/A
What do the results imply regarding the return periods of floods during the period of record?	N/A – the study site is ungauged.
What is the 100-year growth factor? Is this realistic? (The guidance suggests a typical range of 2.1 to 4.0)	2.64 – the 100-year growth factor using FEH Statistical and is within the typical range.
If 1000-year flows have been derived, what is the ratio for 1000-year flow over 100-year flow?	1.76 using FEH Statistical method; 1.68 using ReFH2.2 method.

What specific runoff (l/s/ha) does the design flow equate to?	A 2-year flow equates to 6.5l/s/ha using FEH Statistical method (and 10.8 l/s/ha using ReFH2.2 method). This is generally within the typical range (0.5-10 l/s/ha).
How do the results compare with those of other studies? Explain any differences and conclude which results should be preferred.	None have been made available.
Are the results compatible with the longer-term flood history?	N/A
Describe any other checks on the results	N/A

Final results

	50% (2yr)	3.3% (30yr)	1% (100yr)	1% (100yr) +CC	0.1% (1000yr)
Target peak flow at the downstream modelling extent (FEP2) – ReFH2.2					
FEP2 (Storm Duration = 3.5hrs, Summer)	1.42	2.92	3.69	4.98	6.19
Model inflows (FEP1 and Res12) – ReFH2.2					
*FEP1 (Storm Duration = 3.5hrs, Summer)	0.69	1.43	1.81	2.44	3.04
**Res12 (Storm Duration = 3.5hrs, Summer)	1.07	2.21	2.78	3.76	4.66

**Of the total FEP1 inflow, 47% to be applied in the eastern tributary and 53% in the western tributary;*

***Res12 inflow to be applied as lateral flow in the open channel reach from Junction 8 to the downstream modelling extent)*

If flood hydrographs are needed for the next stage of the study, where are they provided? (e.g. give filename of spreadsheet, name of ISIS model, or reference to table below)	The inflow hydrographs are needed, which are saved as P:\Data3\Water_Environment_Glasgow\05 Projects\B229H190 M27 Junction 8\Technical\M27_Junction8_Model_Inflows.xlsx in the Jacobs Glasgow server. Model inflow hydrographs to be applied at the eastern and western tributaries (the total inflow is shown as FEP1) and the model inflows from the residual catchment to be applied as a lateral flow (Res12) are shown in Figures D.1 and D.2 overleaf.

Figure D.1: FEP1 Inflow Hydrograph (m^3/s) for 3.5hr CSD for 2yr,30yr,100yr and 1000yr design storm events

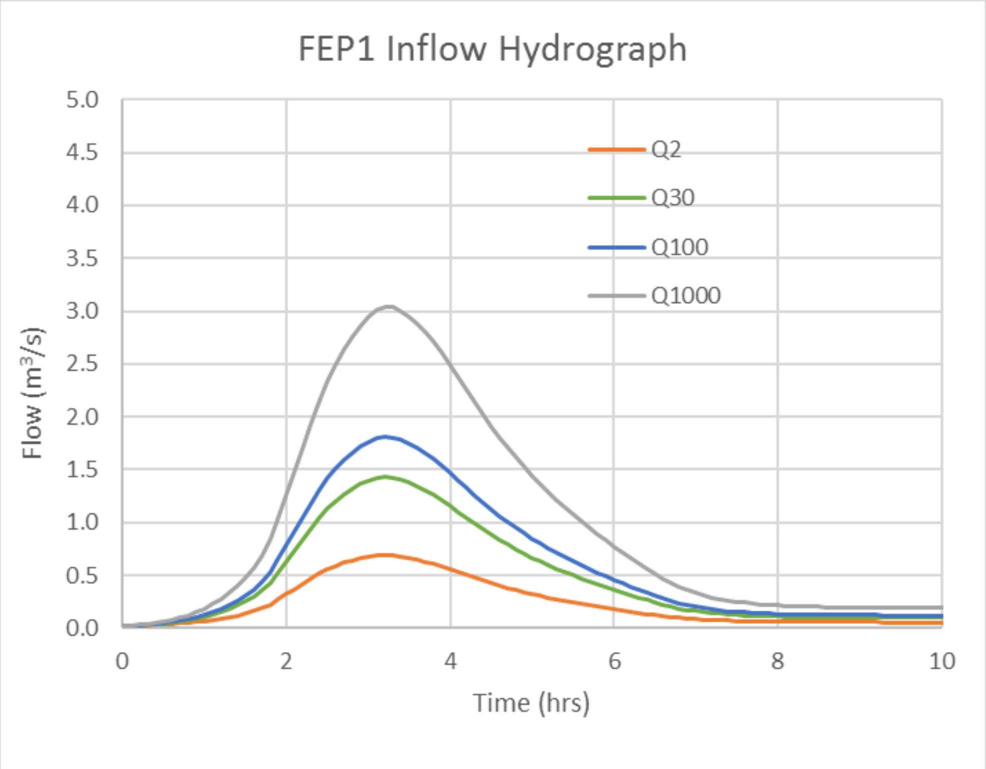


Figure D.2: Res12 Inflow Hydrograph (m^3/s) for 3.5hr CSD for 2yr,30yr,100yr and 1000yr design storm events

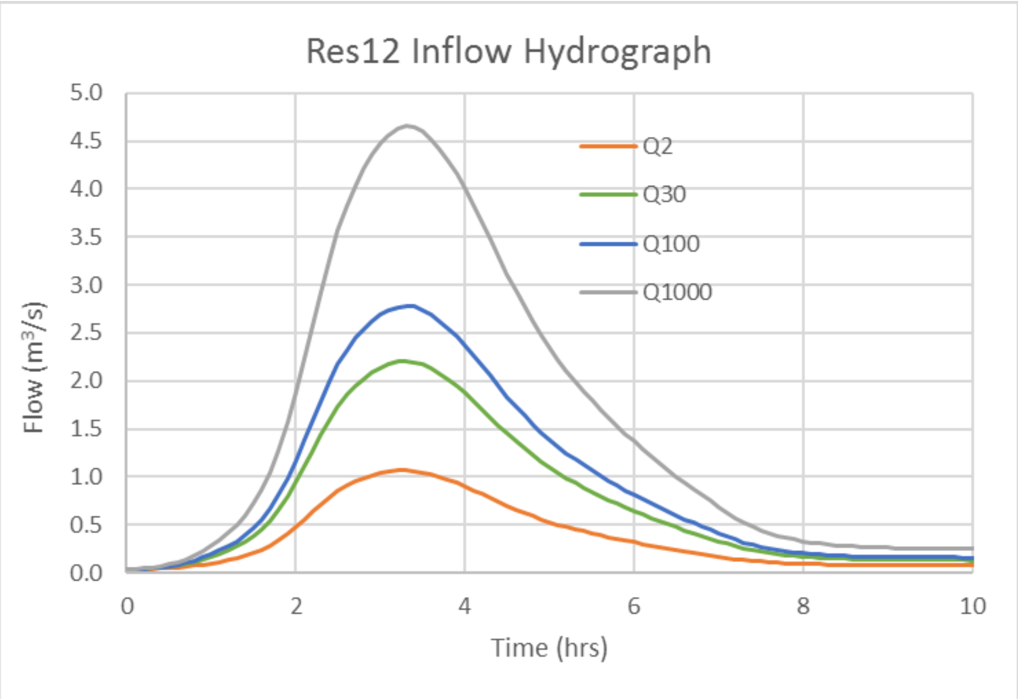


Figure D.3a: The FEH catchment boundary of the Bursledon Brook (revised boundary in blue)

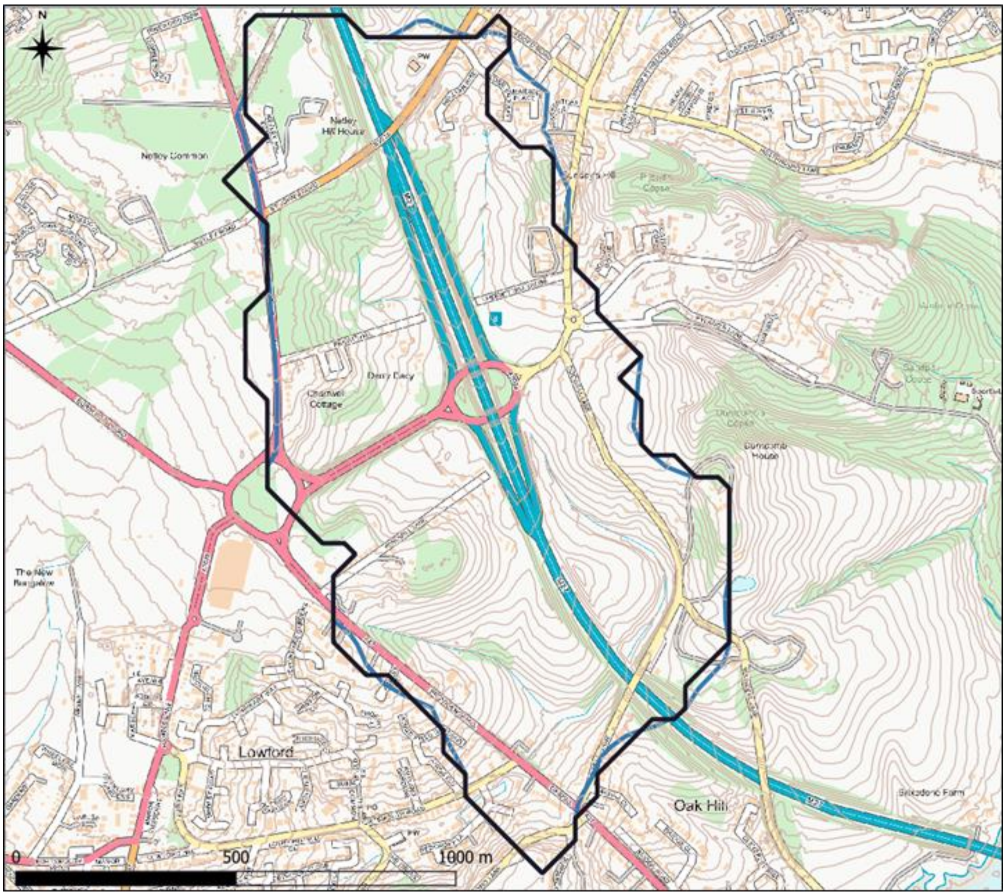
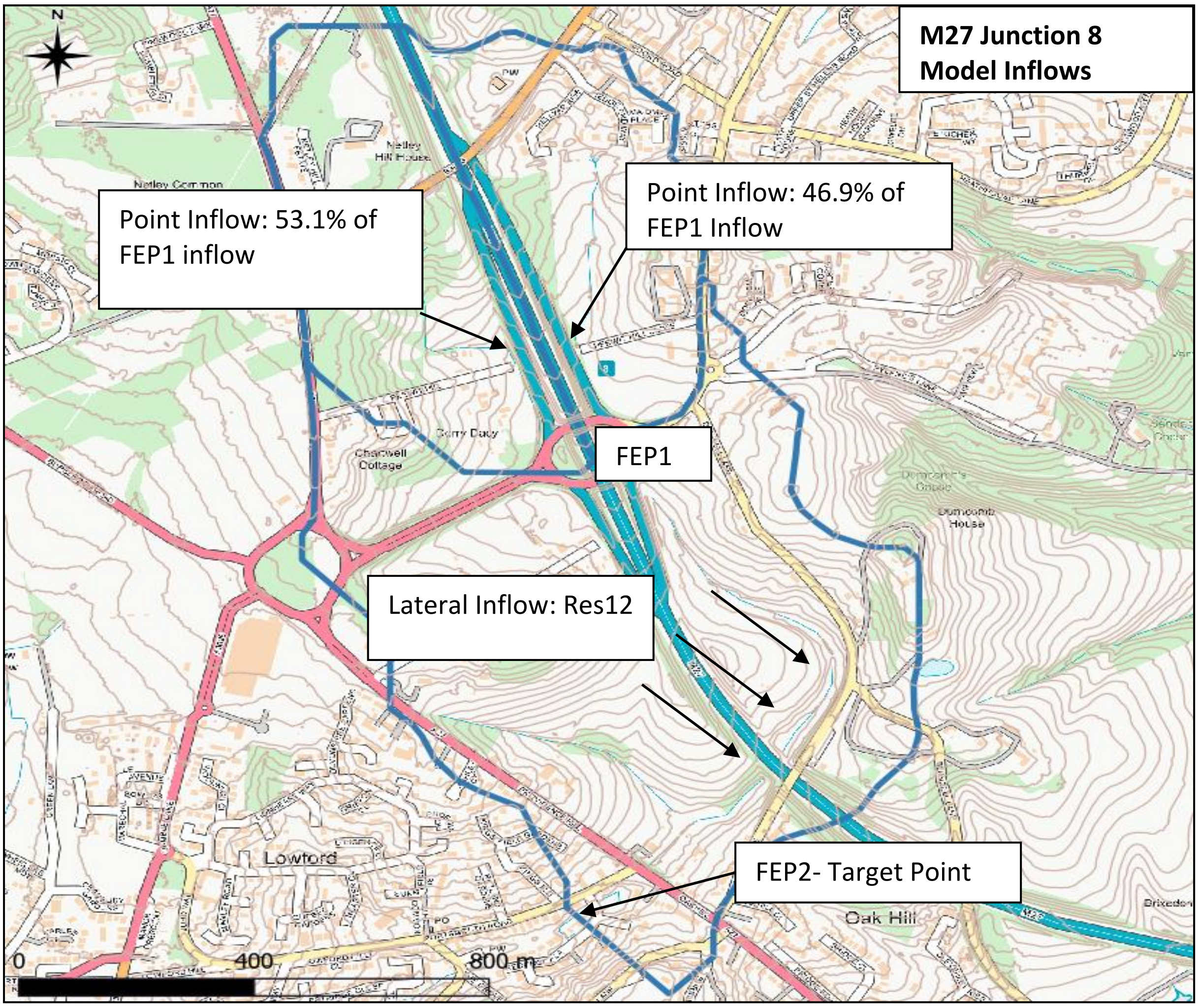


Figure D.3b: Flow estimation point and Model Inflow location



Contains OS data © Crown Copyright and database right (2019)

Figure D.4: Location of the six donor gauges suggested by WinFAP4

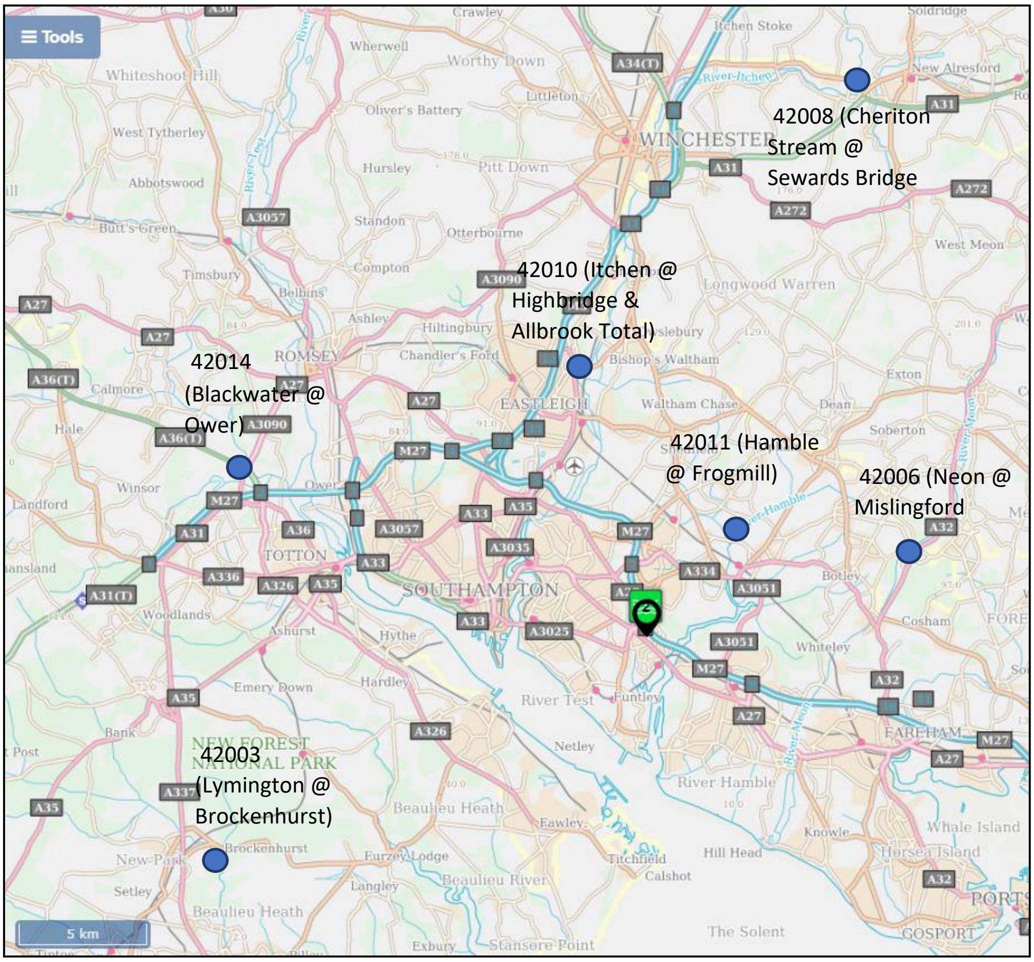
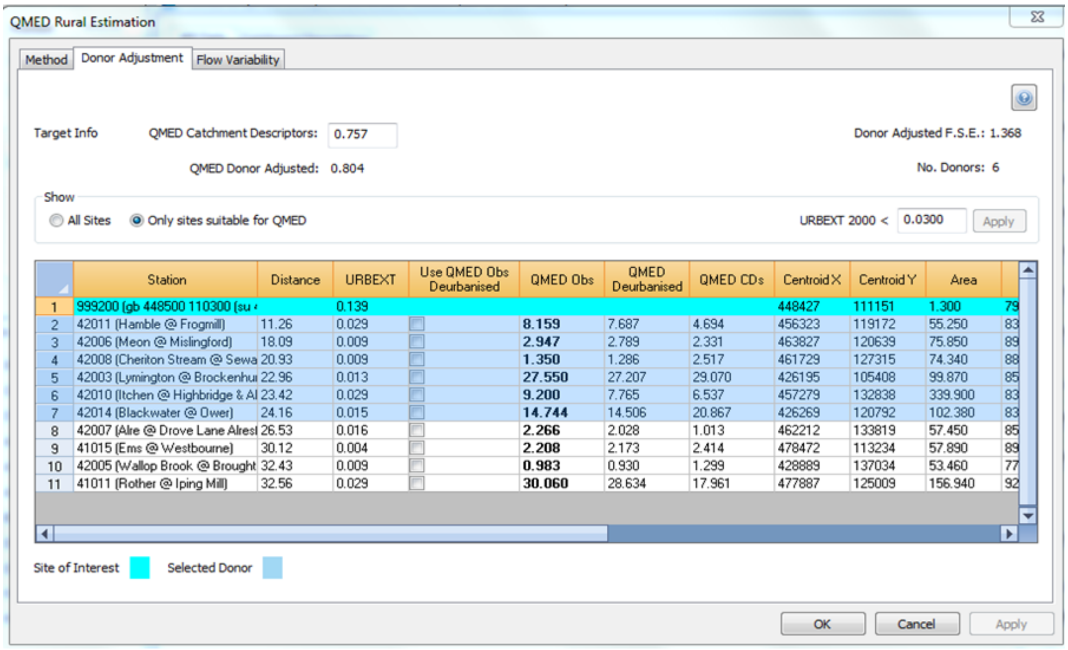
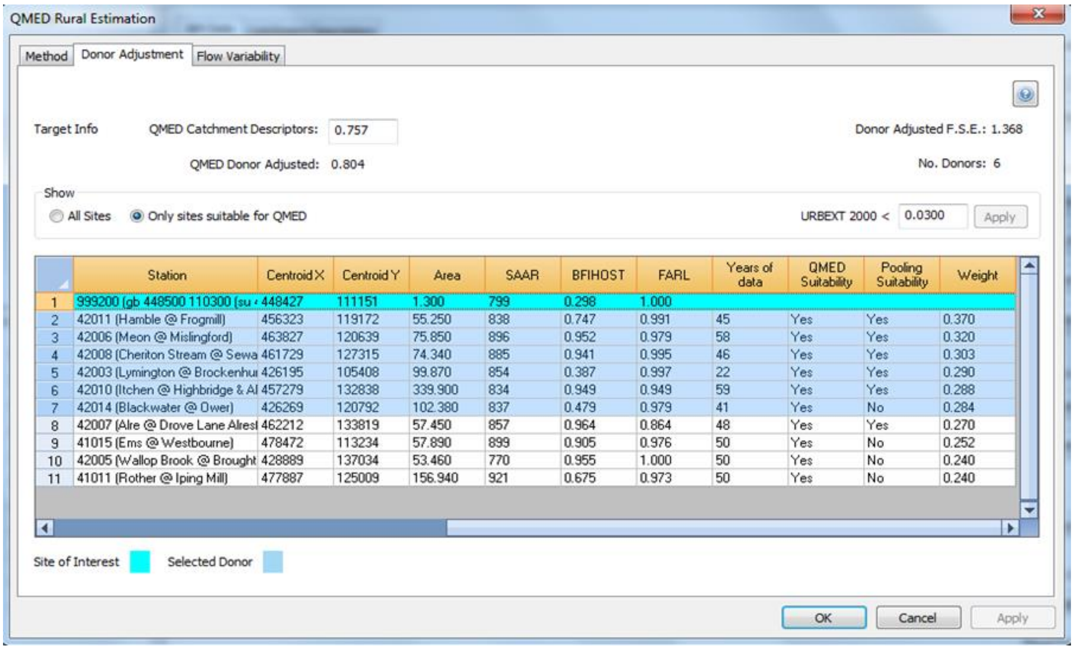


Figure D.5: Donor site details for QMED estimation by data transfer (WINFAP4 suggested 6 donors)



	Station	Distance	URBEXT	Use QMED Obs Deurbanised	QMED Obs	QMED Deurbanised	QMED CDs	Centroid X	Centroid Y	Area	
1	999200 (gb 448500 110300 (su ·		0.139					448427	111151	1.300	79
2	42011 (Hamble @ Frogmill)	11.26	0.029		8.159	7.687	4.694	456323	119172	55.250	83
3	42006 (Meon @ Mislingford)	18.09	0.009		2.947	2.789	2.331	463827	120639	75.850	89
4	42008 (Cheriton Stream @ Sewa	20.93	0.009		1.350	1.286	2.517	461729	127315	74.340	88
5	42003 (Lymington @ Brockenhu	22.96	0.013		27.550	27.207	29.070	426195	105408	99.870	85
6	42010 (Itchen @ Highbridge & Al	23.42	0.029		9.200	7.765	6.537	457279	132838	339.900	83
7	42014 (Blackwater @ Ower)	24.16	0.015		14.744	14.506	20.867	426269	120792	102.380	83
8	42007 (Alre @ Drove Lane Alresf	26.53	0.016		2.266	2.028	1.013	462212	133819	57.450	85
9	41015 (Ems @ Westbourne)	30.12	0.004		2.208	2.173	2.414	478472	113234	57.890	89
10	42005 (Wallop Brook @ Brought	32.43	0.009		0.983	0.930	1.299	428889	137034	53.460	77
11	41011 (Rother @ Iping Mill)	32.56	0.029		30.060	28.634	17.961	477887	125009	156.940	92

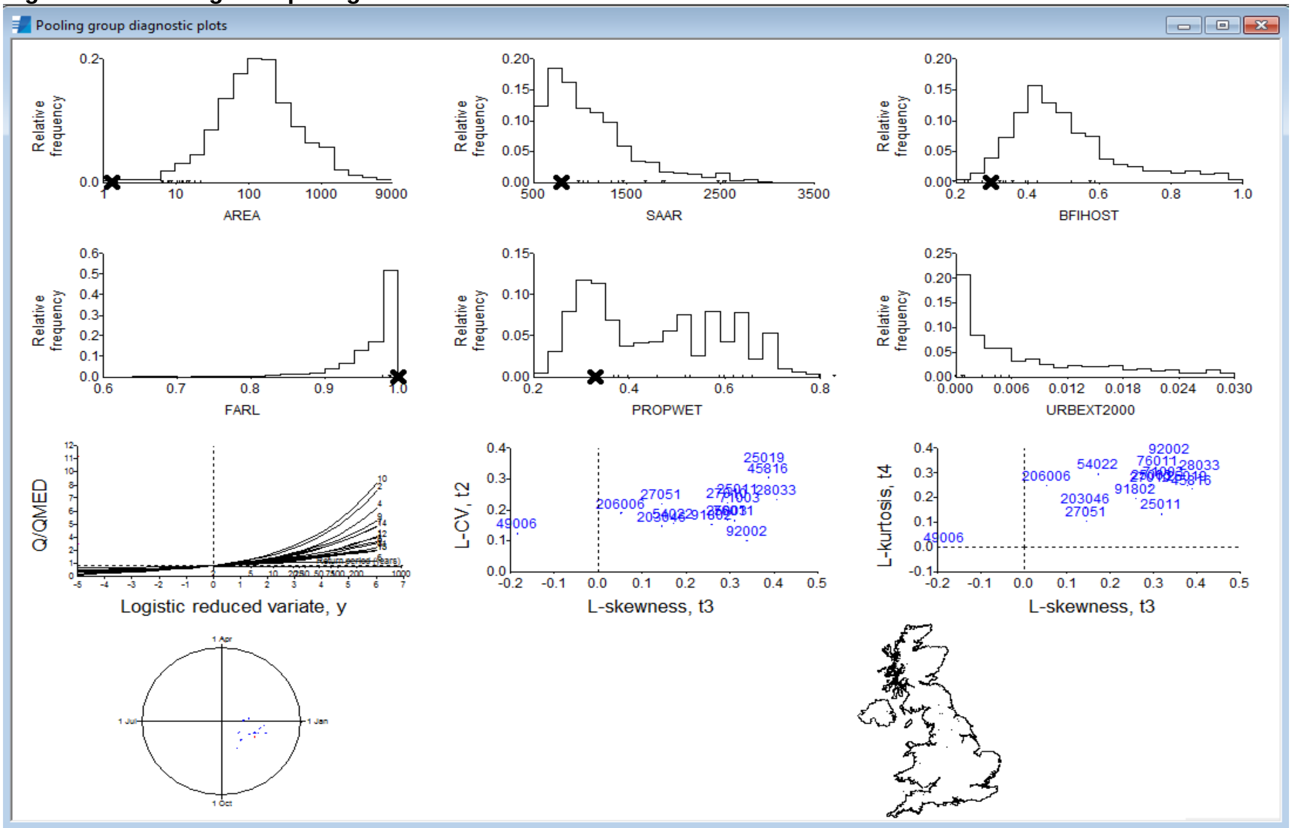


	Station	Centroid X	Centroid Y	Area	SAAR	BFIHOST	FARL	Years of data	QMED Suitability	Pooling Suitability	Weight
1	999200 (gb 448500 110300 (su ·	448427	111151	1.300	799	0.298	1.000				
2	42011 (Hamble @ Frogmill)	456323	119172	55.250	838	0.747	0.991	45	Yes	Yes	0.370
3	42006 (Meon @ Mislingford)	463827	120639	75.850	896	0.952	0.979	58	Yes	Yes	0.320
4	42008 (Cheriton Stream @ Sewa	461729	127315	74.340	885	0.941	0.995	46	Yes	Yes	0.303
5	42003 (Lymington @ Brockenhu	426195	105408	99.870	854	0.387	0.997	22	Yes	Yes	0.290
6	42010 (Itchen @ Highbridge & Al	457279	132838	339.900	834	0.949	0.949	59	Yes	Yes	0.288
7	42014 (Blackwater @ Ower)	426269	120792	102.380	837	0.479	0.979	41	Yes	No	0.284
8	42007 (Alre @ Drove Lane Alresf	462212	133819	57.450	857	0.964	0.864	48	Yes	Yes	0.270
9	41015 (Ems @ Westbourne)	478472	113234	57.890	899	0.905	0.976	50	Yes	No	0.252
10	42005 (Wallop Brook @ Brought	428889	137034	53.460	770	0.955	1.000	50	Yes	No	0.240
11	41011 (Rother @ Iping Mill)	477887	125009	156.940	921	0.675	0.973	50	Yes	No	0.240

Table D.1: Final pooling group details

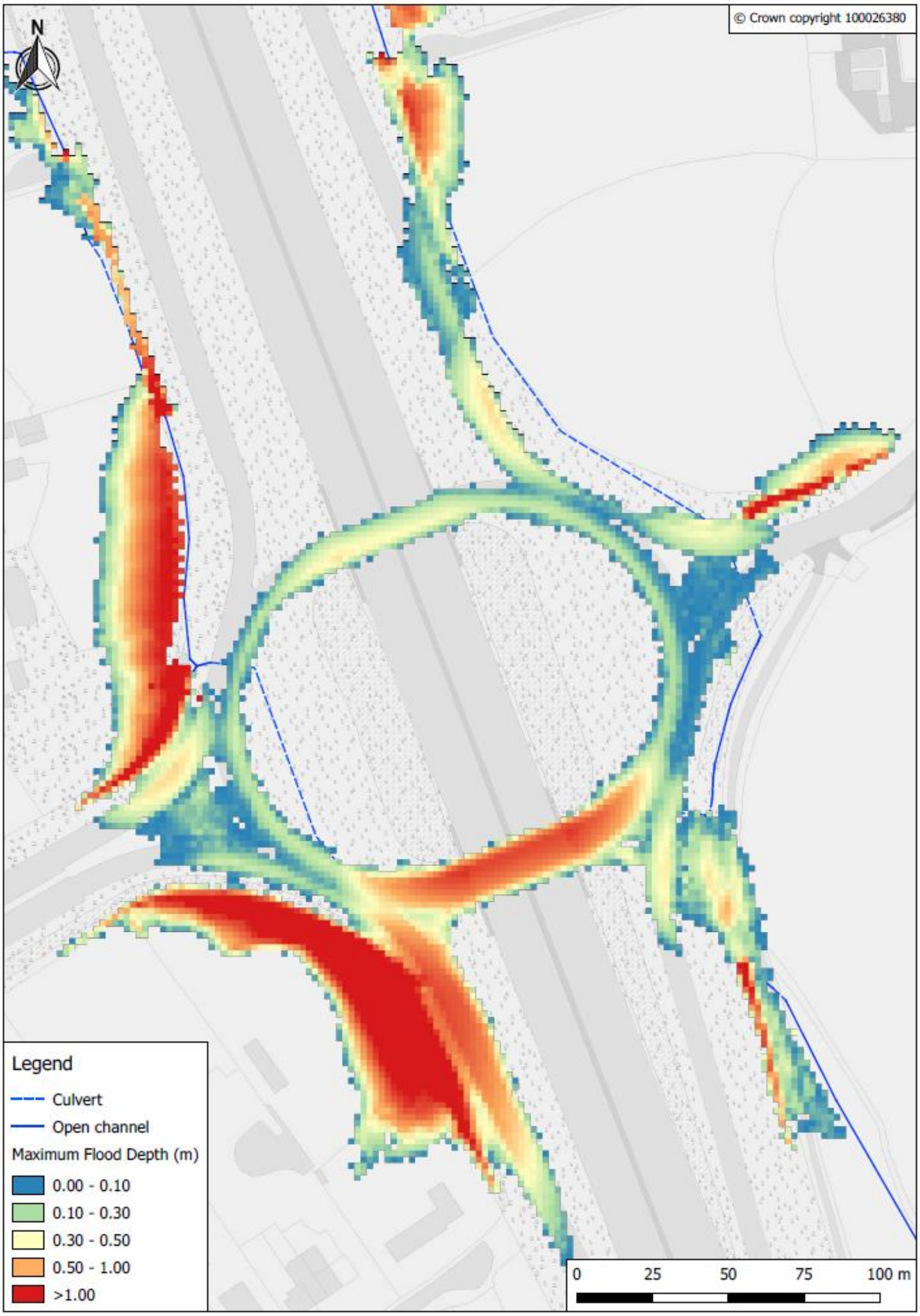
Station	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy	AREA	SAAR	FPEXT	FARL	URBEXT 2000
76011 (Coal Burn @ Coalburn)	0.896	40	1.84	0.166	0.31	0.418	1.63	1096	0.074	1	0
45816 (Haddeo @ Upton)	2.434	24	3.489	0.306	0.387	0.977	6.81	1210	0.011	1	0.005
27051 (Crimple @ Burn Bridge)	2.557	45	4.564	0.221	0.144	0.661	8.17	855	0.013	1	0.006
28033 (Dove @ Hollinsclough)	2.704	38	4.225	0.234	0.405	0.394	7.92	1346	0.007	1	0
91802 (Allt Leachdach @ Intake)	3.162	34	6.35	0.153	0.257	0.676	6.54	2554	0.003	0.99	0
49006 (Camel @ Camelford)	3.336	11	11.154	0.124	-0.185	2.887	12.52	1418	0.013	1	0.003
71003 (Croasdale Beck @ Croasdale Flume)	3.358	37	10.9	0.212	0.323	0.105	10.71	1882	0.016	1	0
92002 (Allt Coire Nan Con @ Polloch)	3.367	16	13.54	0.101	0.337	1.793	8.06	2541	0.007	0.99	0
25011 (Langdon Beck @ Langdon)	3.384	28	15.878	0.238	0.318	1.356	12.79	1463	0.012	1	0.001
25019 (Leven @ Easby)	3.411	39	5.677	0.34	0.377	1.858	15.09	830	0.019	1	0.004
54022 (Severn @ Plynlimon Flume)	3.423	38	14.988	0.156	0.171	0.921	8.75	2481	0.01	1	0
25003 (Trout Beck @ Moor House)	3.452	44	15.142	0.168	0.294	0.266	11.4	1905	0.041	1	0
206006 (Annalong @ Recorder)	3.65	48	15.33	0.189	0.052	2.173	14.44	1704	0.023	0.98	0
27010 (Hodge Beck @ Bransdale Weir)	3.743	41	9.42	0.224	0.293	0.074	18.82	987	0.009	1	0.001
203046 (Rathmore Burn @ Rathmore Bridge)	4.042	35	10.72	0.147	0.144	0.44	22.5	1043	0.072	1	0
Total		518									
Weighted means				0.2	0.251						

Figure D.6: Pooling Group Diagnostic Plots

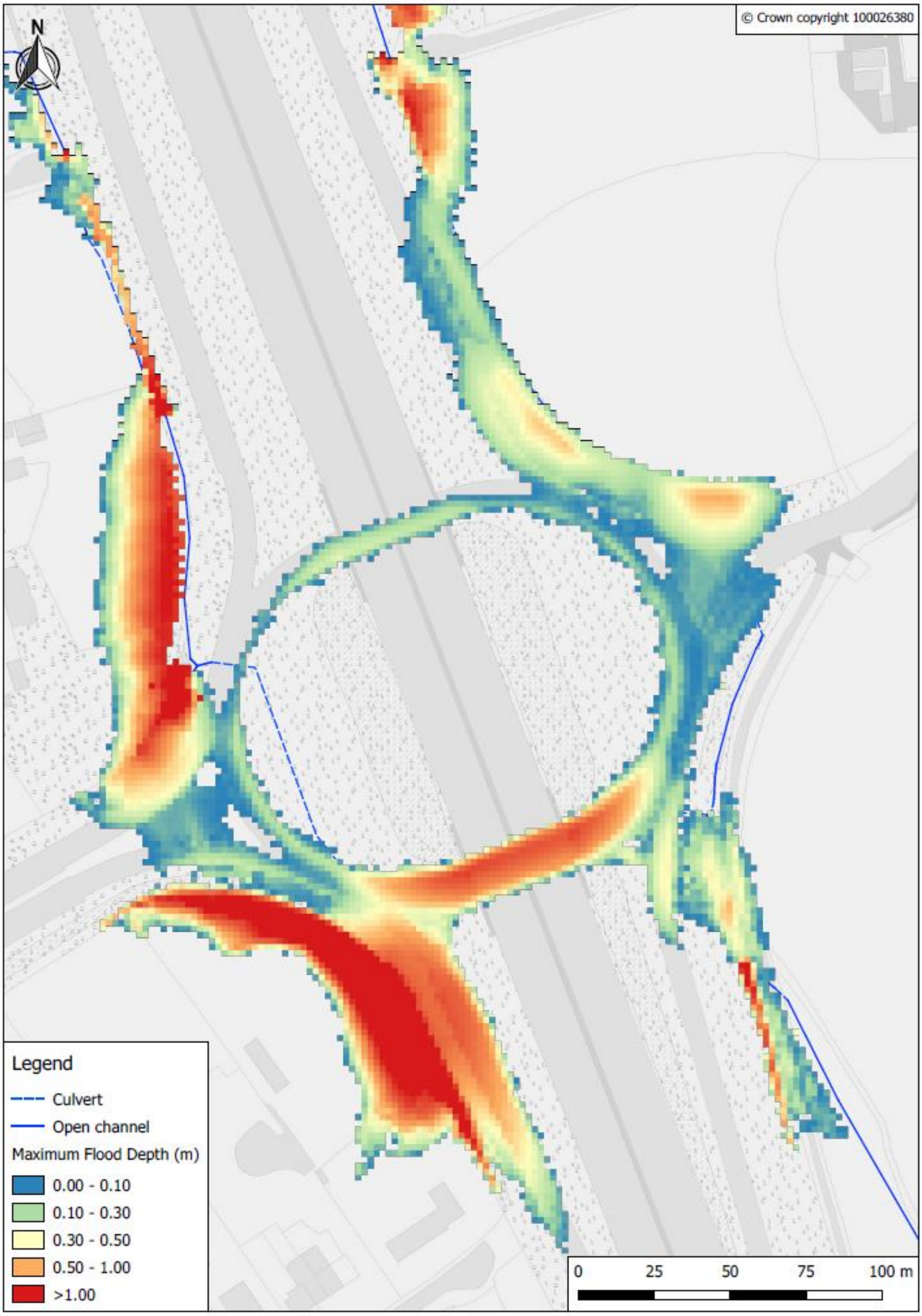


Appendix E. Flood maps

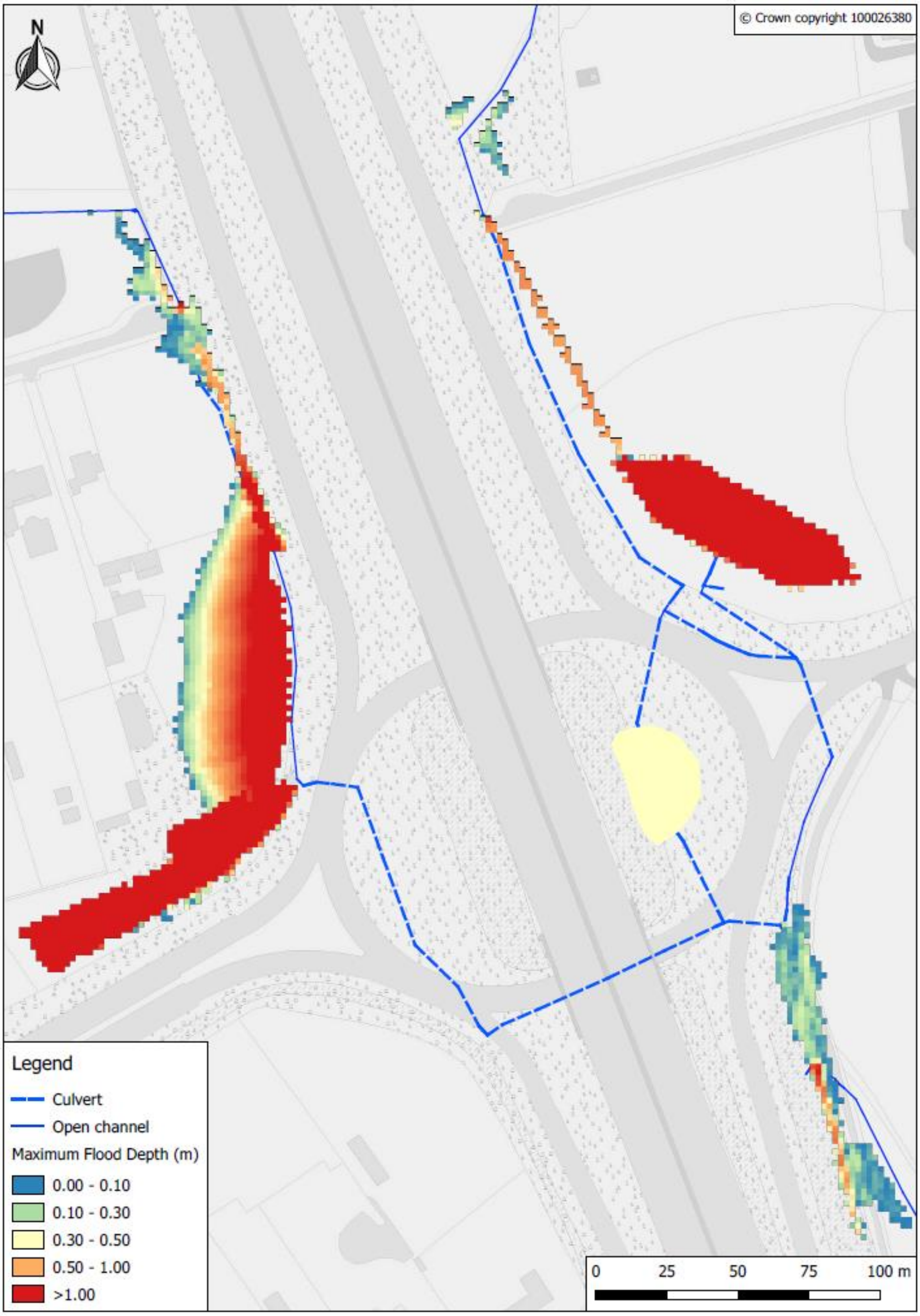
E.1 Baseline scenario – maximum flood depth map – 1% AEP + 35%CC event



E.2 Proposed scheme scenario (No Mitigation) – maximum flood depth map – 1% AEP + 35%CC event

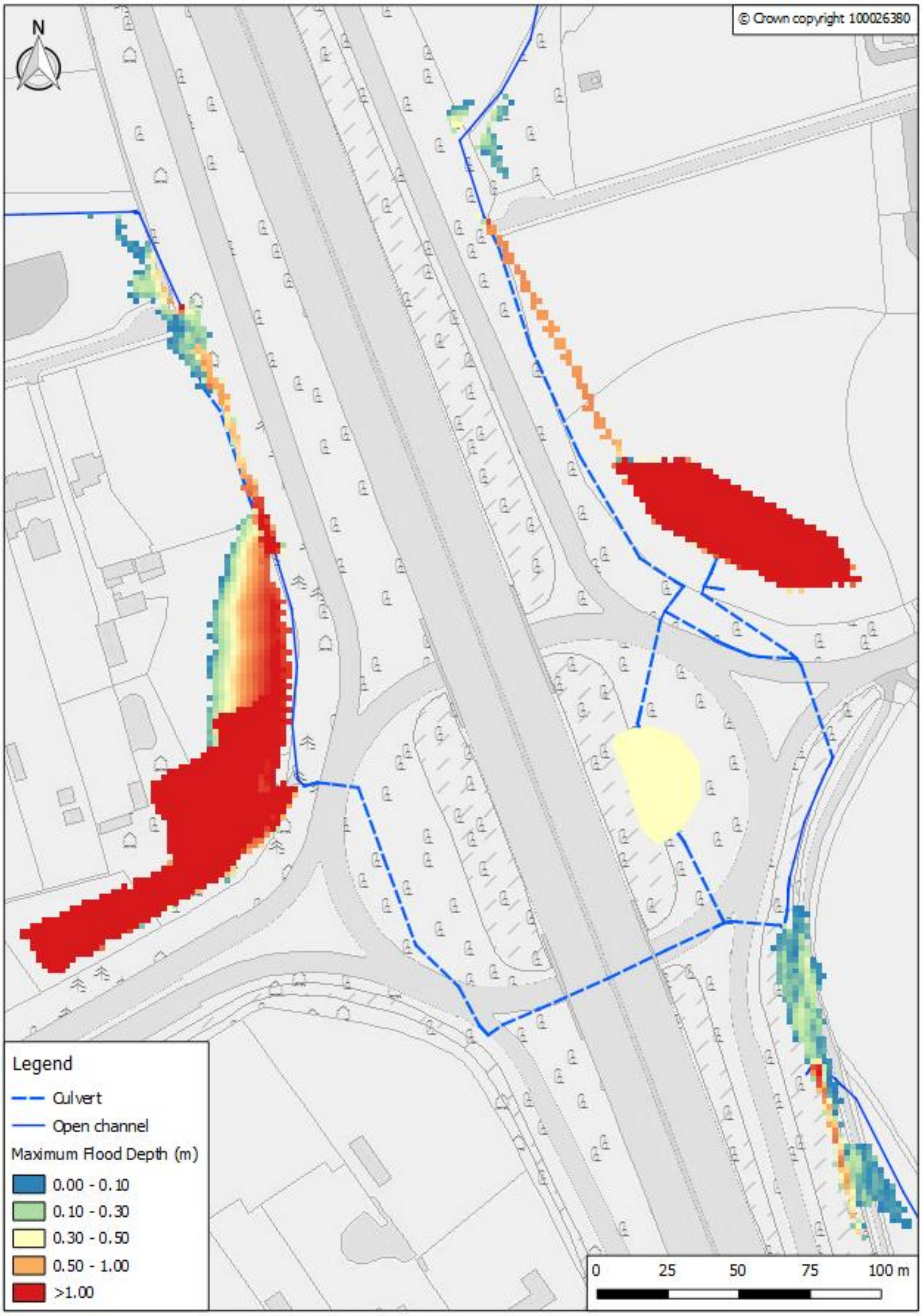


E.3 Proposed scheme scenario (With Mitigation) First option – maximum flood depth map – 1% AEP + 35%CC event



JACOBS

E.4 Proposed scheme scenario (With Mitigation) second option – maximum flood depth map – 1% AEP + 35%CC event



JACOBS

Appendix F. Proposed mitigation plan