Halebank Flood Risk and Development Feasibility Study

Golden Triangle Industrial Estate, Halebank

Draft Report

April 2019

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Revision History

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April 2019	Draft Report	Sally McDonald

Contract

This report describes work commissioned by Sally McDonald on behalf of Halton Borough Council, by a letter dated 22nd November 2018. Halton Borough Council's representatives for the contract were Jonathan Farmer and Sally McDonald. Josh Rutherford, Rachel Bryan and Jack Pordham of JBA Consulting carried out this work.

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Purpose

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Abbreviations

AEP	Annual Exceedance Probability
AOD	Above Ordnance Datum
CC	Climate Change
DTM	Digital Terrain Model
EA	Environment Agency
FEH	Flood Estimation Handbook
FFL	Finished Floor Level
FRA	Flood Risk Assessment
GTIE	Golden Triangle Industrial Estate
HRAA	Halebank Regeneration Action Area
HBC	Halton Borough Council
LA	Local Authority
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
LPA	Local Planning Authority
NPPF	National Planning Policy Framework (2018)
SFRA	Strategic Flood Risk Assessment
SHLAA	Strategic Land Housing Availability Assessment
SuDS	Sustainable Drainage Systems
uFMfSW	Updated Flood Map for Surface Water

Definitions

Flood Frequencies

Return Period	Annual Exceedance Probability
1 in 1000 year	0.1%
1 in 500 year	0.5%
1 in 100 year	1%
1 in 30 year	3.33%

Flood Zones

Flood Zone	Flood Risk
Flood Zone 1	land assessed as having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1%)
Flood Zone 2	land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% – 0.1%), or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% – 0.1%) in any year
Flood Zone 3	land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year

1 Introduction

1.1 Overview

The following report has been prepared on instruction of Jonathan Farmer and Sally McDonald of Halton Borough Council (HBC), following an initial email request of 22 November 2018.

HBC are currently reviewing potential redevelopment opportunities for the Golden Triangle Industrial Estate. Current aspirations for the Industrial Estate is for future redevelopment. However, owing to the extent of existing flood risk, various mitigation options will need to be considered and subsequently implemented to ensure that redevelopment can be undertaken safely, without increasing flood risk elsewhere. This report summarises the various potential options for redevelopment including appraisal of technical constraints to development.

In accordance with the Environment Agency's Flood Map for Planning, the site is located in both Flood Zones 2 & 3. The area is protected by flood defences along both banks of Ditton Brook. However, these defences are considered to be in poor condition.

Whilst the flood map for planning indicates the anticipated level of risk, more up-to-date modelling works on the Environment Agency's Mersey Estuary model has been undertaken (updated in December 2018). These new extents are not currently represented in the EA's published mapping, but indicate that the potential redevelopment area is now at a reduced level of tidal flood risk.

For the purposes of this review, we have assumed that the new modelled extents will be incorporated into EA updates of the Flood Map for Planning.

At this stage there are numerous stakeholders and businesses on the site. No future redevelopment plan has been drawn up for the site and it is intended that this appraisal will be used to develop potential options for redevelopment.

Depending on development aspirations, the site may be used for continued industrial purposes or employment uses. Development would, therefore, be defined as being 'less vulnerable', in accordance with the NPPF. Alternatively, the development could be defined as 'more vulnerable' if areas of the site are proposed for residential or mixed-use development.

No specific development proposals are being considered at this stage. This report will outline the various constraints associated with safe development in areas of flood risk. For example, residential development will be subject to a more stringent level of assessment in accordance with Sequential and Exception Testing.

2 Development Description and Location

2.1 Overview

The development area is the Golden Triangle Industrial Estate (GTIE), located in Halebank, Widnes. There are two nearby watercourses which influence flood risk to the site. These are Ditton Brook, an EA defined Main River, and the tidally influenced Mersey Estuary. Ditton Brook outfalls into the tidal Mersey.

Figure 2-1 identifies current site uses, with shapefiles provided by Halton Borough Council. This defines the extent of the sites under consideration for redevelopment.

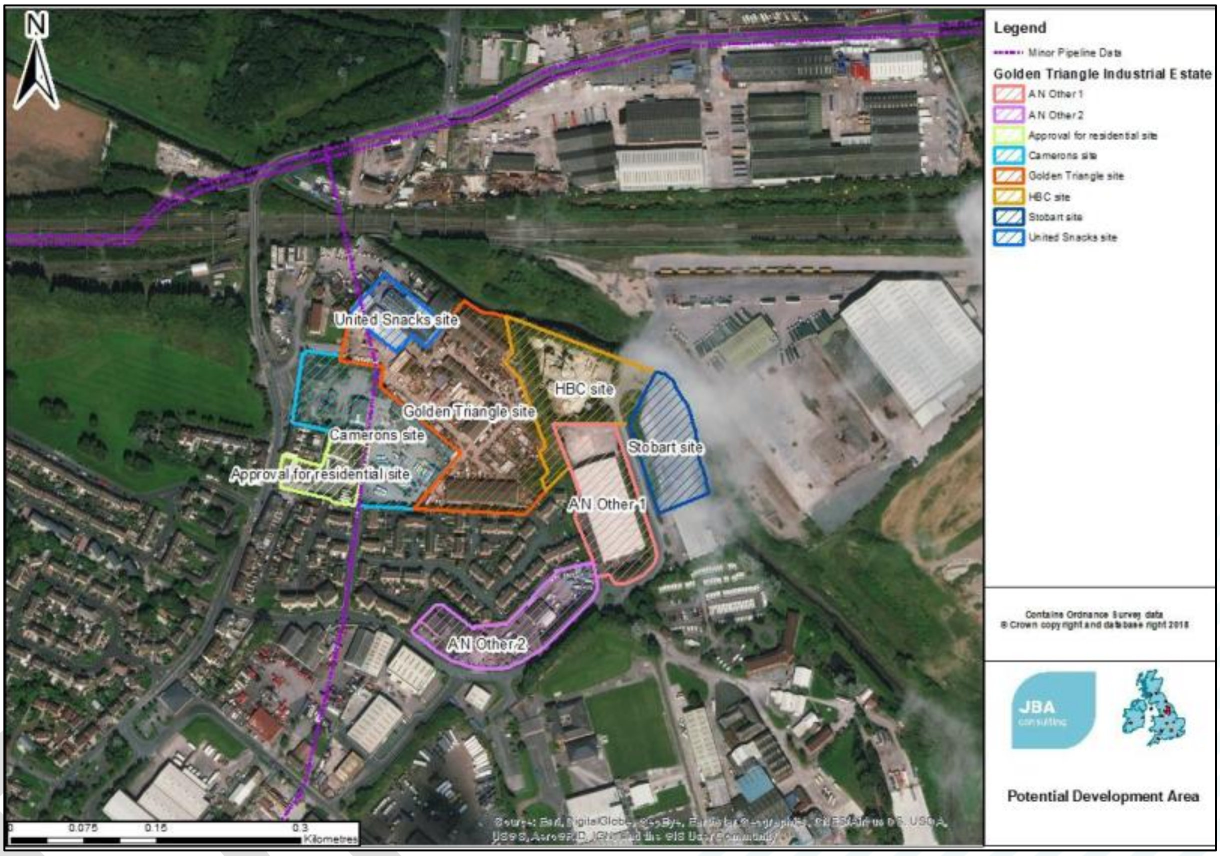

Figure 2-1 Potential development area

2.2 Description

The site is bounded by a new residential development at the south, to the east by Foundry Lane, Hale Road to the west and Ditton Brook to the north. The site of interest is further separated into proposed development areas and eight existing sites.

There is an existing United Utilities pipeline which passes underneath the western half of the site, continuing under Ditton Brook, before connecting with additional services on Hale Road to the north. (The presence of other services has not been confirmed or identified on Figure 2-1).

Potential areas for redevelopment have been based on flood risk including depths and extents of flooding. Existing landownership and redevelopment priority has not been taken into consideration at this stage.

2.3 Location

Golden Triangle Industrial Estate is located just off Hale Road in Widnes.

Its nearest watercourse is Ditton Brook, which flows in a south-easterly direction before discharging into the River Mersey. The Lead Local Flood Authority (LLFA) is Halton Borough Council.

The Industrial Estate is bounded to the west by Hale Road and to the north by the railway.

2.4 Site History

Due to a history of industrial uses the site is assumed to be contaminated. Managing contamination falls outside of this assessment but may present further constraints to development when outlining potential mitigation options.

The 2005 Draft Supplementary Planning Document[1] (SPD) indicates that the land located north of Lovell Terrace (a potential area for compensatory storage) used to be owned by British Rail. Historically this land was used for slurry beds. The land has since been remediated and subsequently designated as a Village Green by Halton Borough Council (Figure 2-2).

The Industrial Estate itself is presumed contaminated. It is anticipated that contamination testing and remediation will be required at a later stage as this will be required to inform detailed design works and the viability of any mitigation measures.

The land identified as "Housing Development" has already been re-developed as a residential estate. This land has been raised to elevate the buildings above a previously defined design flood level.

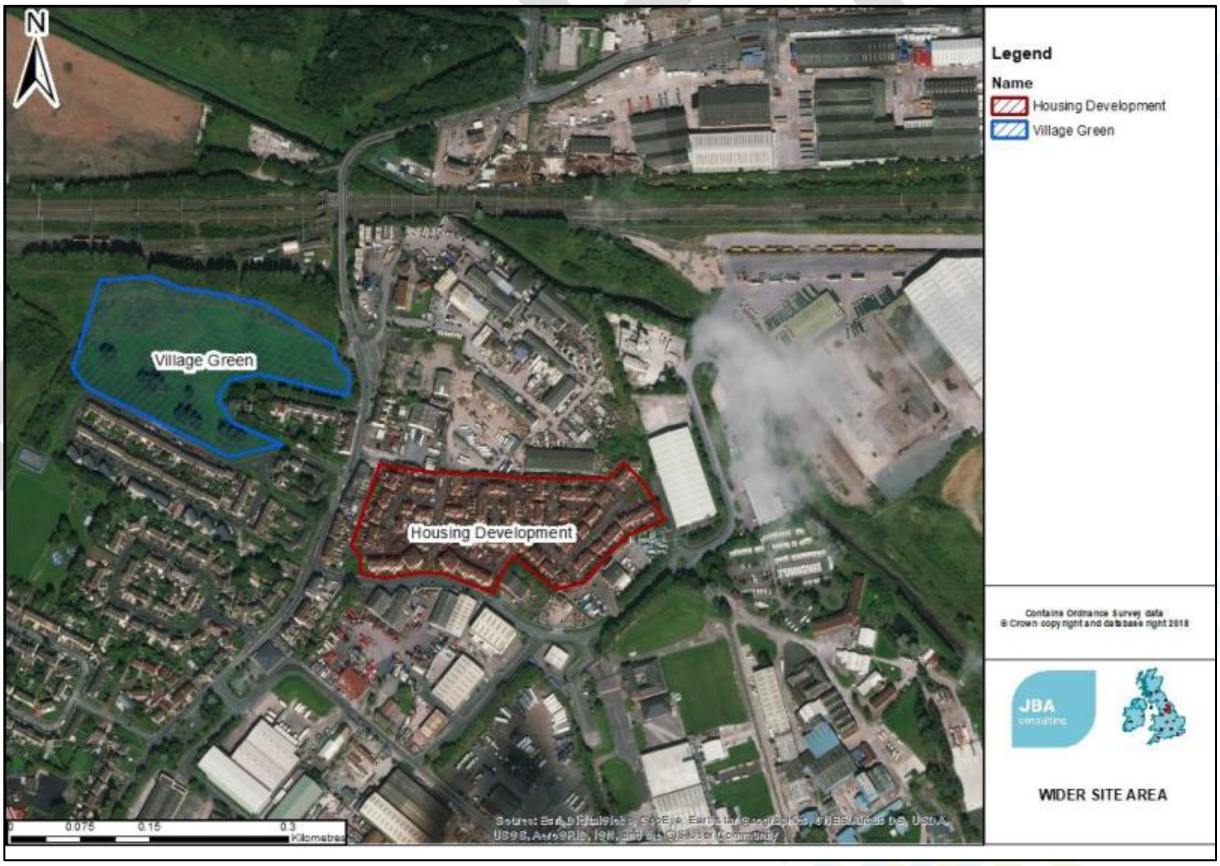

Figure 2-2 Existing uses and wider site areas

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1 https://www3.halton.gov.uk/Pages/planning/policyguidance/pdf/Supplementary%20Planning%20Documents/Draft/Draft_Halebank_Regeneration_Area_SPD.pdf

2.5 Village Green Contamination Issues

A contamination assessment was previously undertaken by AMEC Earth & Environmental UK on behalf of Halton Borough Council in 2006 with the purpose of determining levels of contaminants and to provide of summary of potential pollution issues in the Village Green area. The Halebank Village Green, located to the immediate east of the sites was summarised as having *"concentrations (of pollutants) that may pose an unacceptable risk to human health depending upon the final land use configuration to be adopted within this area"*.[2]

The cost and associated practicalities of providing additional flood attenuation within the Village Green are likely to limit the viability of using the Village Green to provide additional flood storage.

2.6 Local Topography

Figure 2-3, indicates the general topography of the area. Ditton Brook is lower than the surrounding areas and there is a general fall towards the brook. The Industrial Estate is located within a depression of low-lying land that is surrounded by higher ground levels.

The current level of fluvial flood risk will need to include consideration of mitigation measures required to offset any loss of floodplain storage volume or conveyance capacity. Development must not result in increased flood risk elsewhere.

Requirements for land raising alone may prove particularly difficult as effective compensatory storage will be required for any areas of fluvial inundation. A suite of potential mitigation options will need to be considered.

2 Section 14.4, pg. 48 http://3-mg.co.uk/wp-content/uploads/2014/03/Contamination-Assessment-Ditton-Rail-Freight.pdf

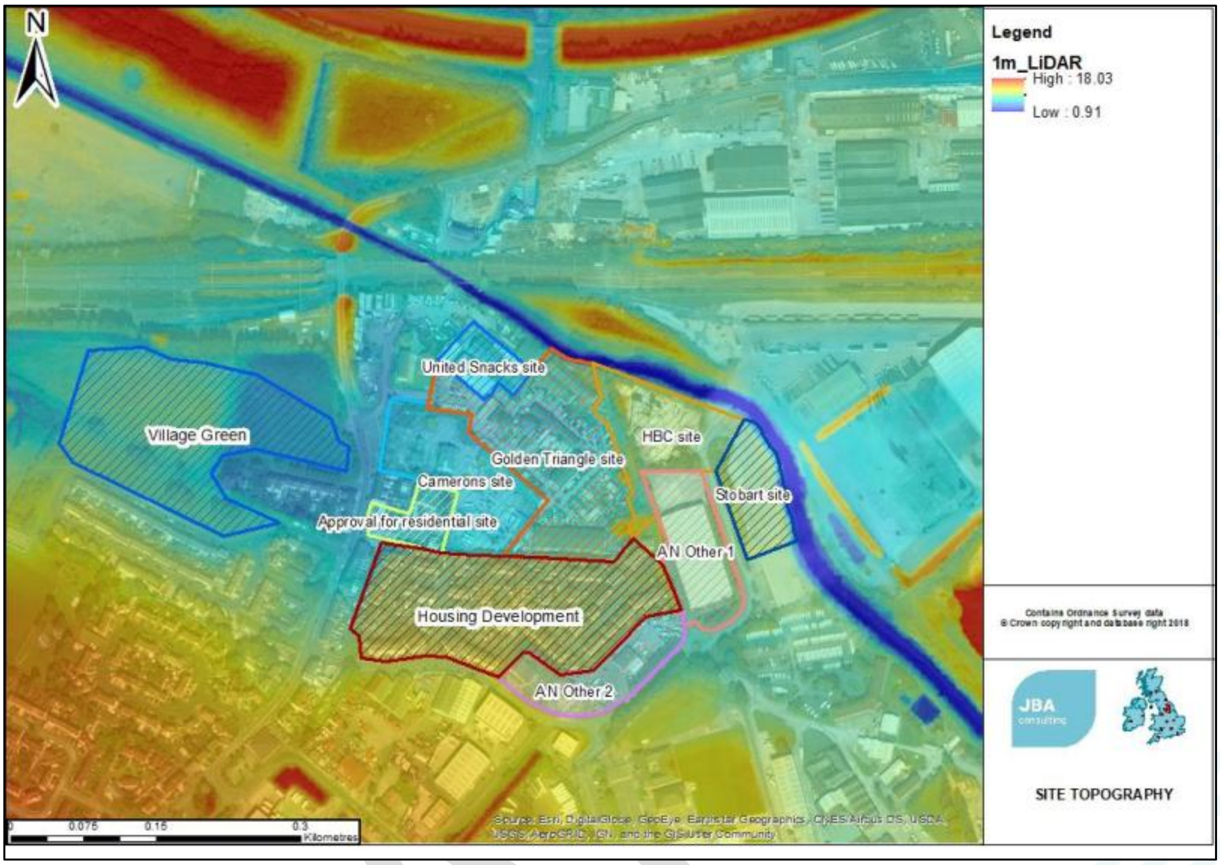

Figure 2-3 Site topography (LiDAR)

Figure 2-3 indicates a raised section of land associated with recent housing development to the south of the site. These areas have been raised approximately by 1.5m.

Land within the "Cameron's" site boundary is approximately set at 6.5m AOD, with the Housing Development set at approximately 8m AOD. The Ditton Brook watercourse is at an elevation between 4m AOD and 2m AOD, so there is a fall from the Industrial Estate towards the brook.

3 Potential Flood Risks

3.1 EA Flood Map for Planning

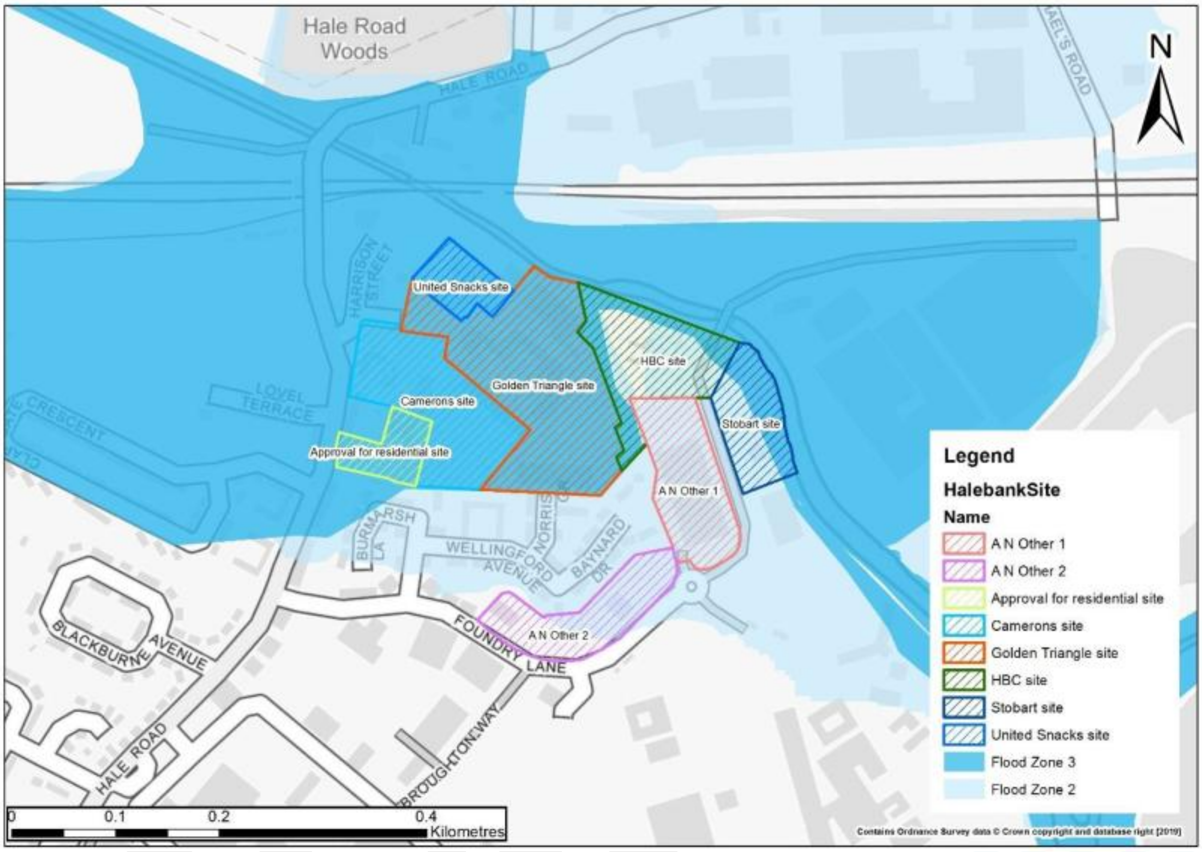

Figure 3-1 EA Flood Map for Planning

The EA's Flood Map for Planning, Figure 3-1, indicates that the potential redevelopment site is located within Flood Zones 2 and 3, with the northern parts of the site being at the highest risk.

According to mapping, the site is at medium to high risk from fluvial/tidal events due the tidal influence the Mersey has upon Ditton Brook. Further mapping indicates the extent of flood embankments along the brook. These defences mainly comprise earth bunds which are located 4m to 5m from the banks of the watercourse. These defences have been assigned poor condition grades of 4 or 5 in the EA Spatial Flood Defences database.

The current EA Flood Map for Planning forms the basis for assessment of development suitability in terms of flood risk and planning. Areas of land at lowest risk of flooding should be considered for development in preference to high risk areas. In accordance with the National Planning Policy Framework the suitability of proposed development is also dependent on the proposed land use and development vulnerability.

The flooding extents are derived from EA model outlines. These outlines define the extents of the 1% and 0.1% Annual Exceedance Probability (AEP) events, as Flood Zone 3 and 2, respectively.

However, the tidal modelling for the area has recently been updated (Mersey Estuary Model 2018) and the flood outlines are not yet reflected in the most current EA Flood Maps. The EA have confirmed that the tidal outlines can be used as the basis for this appraisal and reporting. It is assumed that the EA Flood Maps will be updated in line with the most recent modelling updates and that the corresponding flood outlines will form the new Flood Zone maps.

3.2 Fluvial Flood Risk (1% AEP Fluvial with 1% AEP Tidal boundary condition)

Fluvial risk to the site area is defined by conveyance restrictions that cause elevated flood levels on Ditton Brook. The Brook flows into the Mersey at its downstream extent. A tidally influenced boundary is used at the end of the reach as the basis for the modelling.

To define the standard 1% AEP risk outline, a 1% AEP tidal event, taken from the Mersey Estuary model, has been applied at the downstream boundary of Ditton Brook to simulate tidal interactions. Combined probability analysis has not been undertaken and the combination of a 1% AEP fluvial event, combined with a 1% AEP tidal event, significantly exceeds typical design flood standards for planning. These outlines are therefore considered conservative. The resulting flood extent is shown as Figure 3-2. The defended scenario results in floodwater remaining largely in channel. The exception is at the bridge on Foundry Lane where water surcharges and flows into the 'HBC Site'. The resultant extent of flooding is considered to be highly localised.

As the condition rating of the Environment Agency's flood defences is classified as 'Poor', the undefended flood extent for the 1% AEP fluvial event (combined with a 1% AEP tidal boundary) are also included (Figure 3-2). Under failure conditions the extent of flooding is significantly increased. Fluvial flood water is predicted to exceed both left and right bank levels at the northern extent of the site.

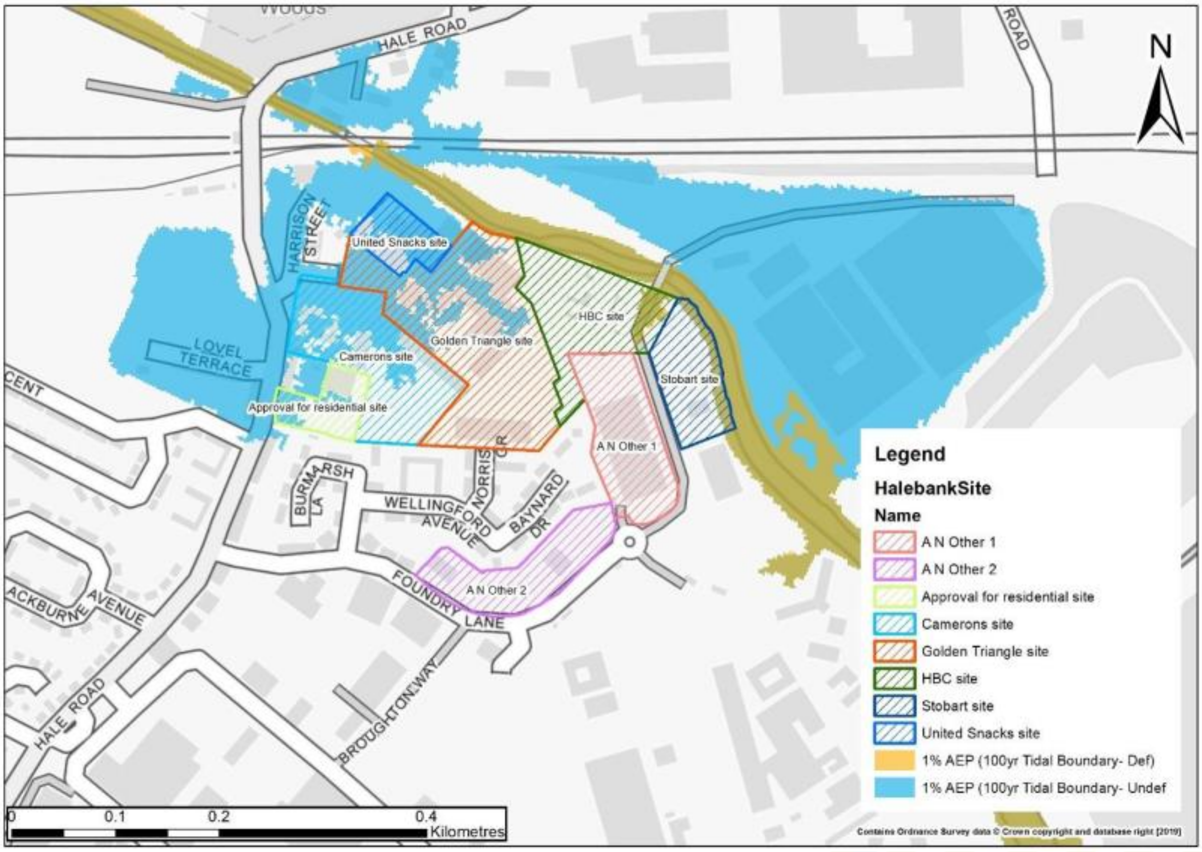

Figure 3-2 Ditton Brook defended and undefended fluvial model (with 1% AEP tidal boundary)

3.3 Fluvial Flood Risk (1% AEP +Climate Change Fluvial with 1% AEP Tidal boundary condition)

Similar flood mapping has been completed for climate change scenarios. Flood extents corresponding to climate change impacts of +30% are included as Figure 3-3. When compared to Figure 3-2, flooding extents remain closely comparable for both fluvial defended and undefended scenarios. Flood depths do increase as a result with the most western sites seeing flooding of between 0.2m and 0.5m.

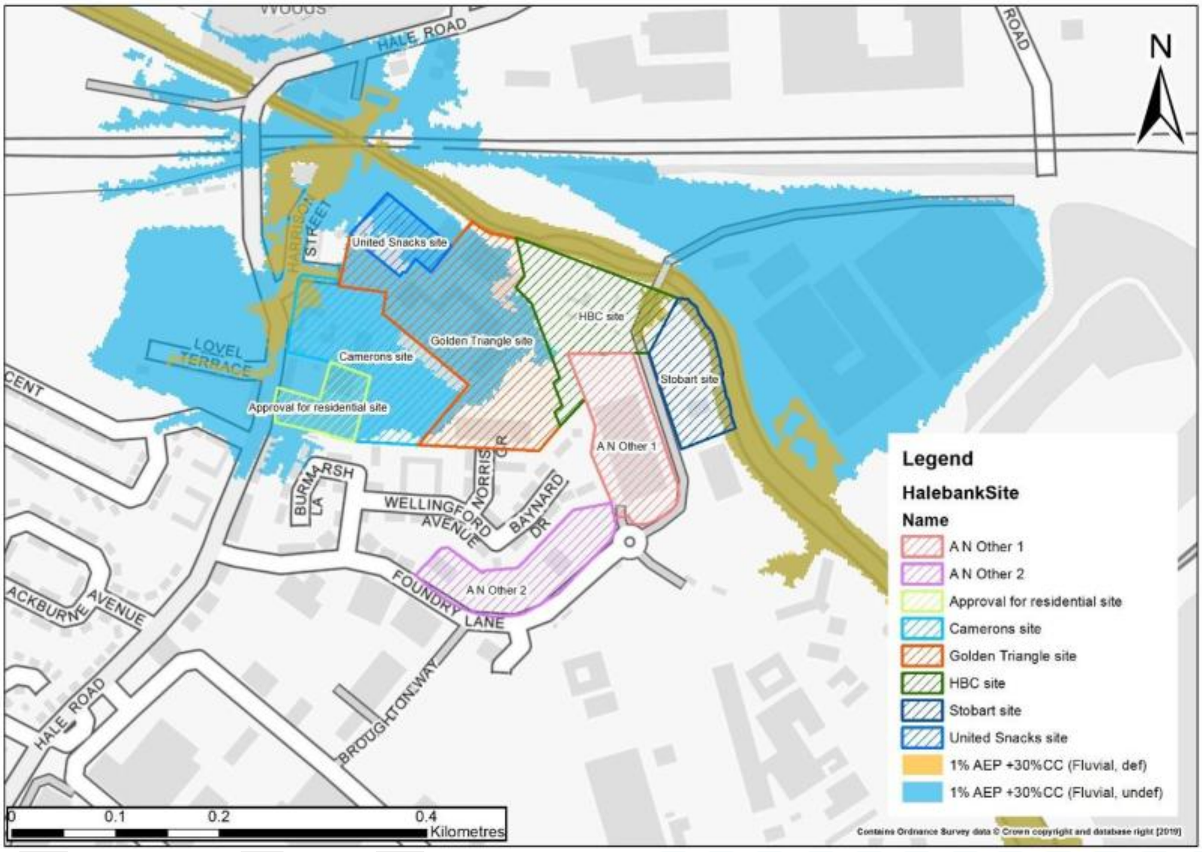

Figure 3-3 Ditton Brook fluvial model with Climate Change (1% AEP tidal boundary)

The associated depths of flooding for the undefended scenario are included as Figure 3-4. Flooding during the undefended scenario results in depths of between 0.13m and 0.33m within the industrial estate. The main access/egress route off Hale Road is predicted to flood to depths of between 0.4m and 0.6m. Flood water is also predicted to flow off the road into the Village Green, flooding residences on Lovel Terrace.

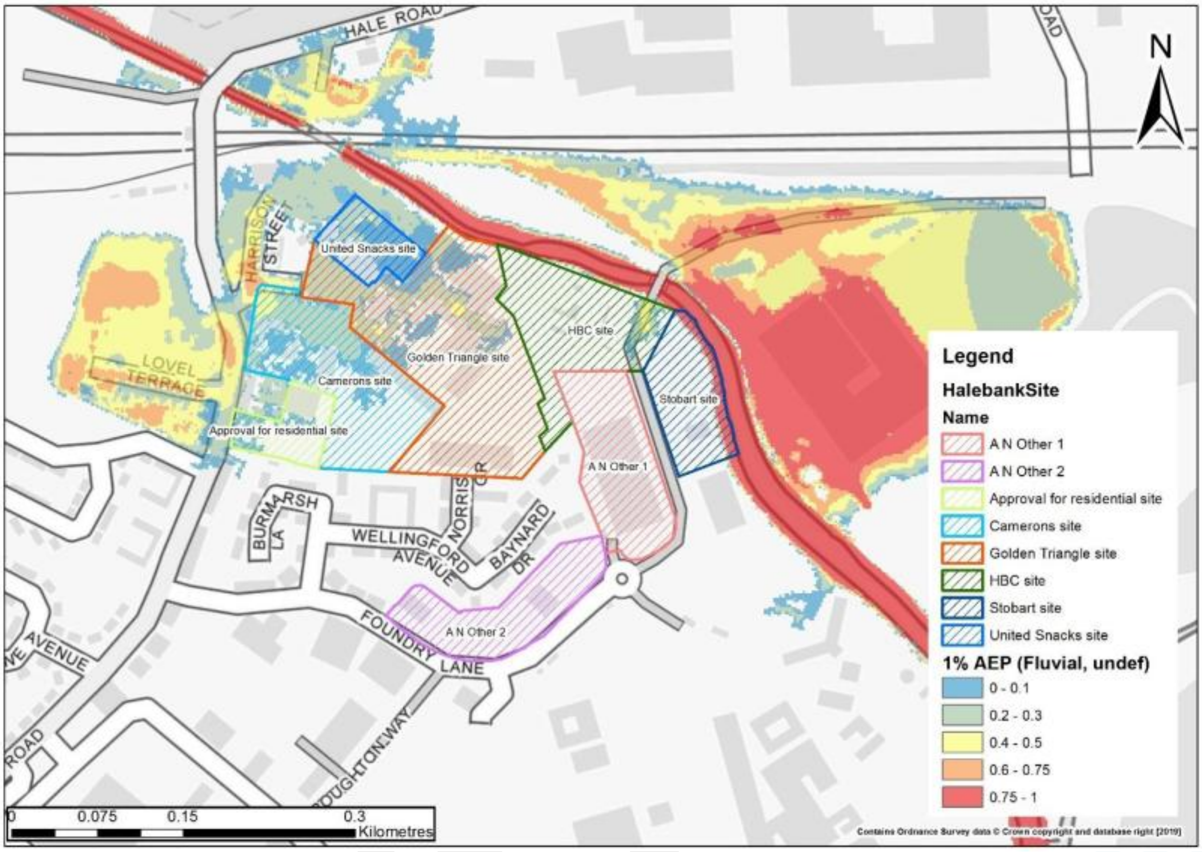

Figure 3-4 Ditton Brook fluvial Depth of flooding (1% AEP tidal boundary, undefended)

3.4 Sensitivity Testing Fluvial Flood Risk (1% AEP Fluvial with 50% AEP tidal boundary condition)

In order to confirm the likely impacts of a reduced tidal boundary conditions on fluvial risk, a 50% AEP tidal event, taken from the Mersey Estuary model, has also been applied at the downstream boundary of Ditton Brook. Again, combined probability analysis has not been undertaken but the combination of a 1% AEP fluvial event, combined with a 50% AEP tidal event, still exceeds typical design flood standards for flood risk and planning.

The resulting flood extent is shown as Figure 3-5. Under these conditions the site is does not flood from a fluvial dominant scenario.

Outside of the Industrial Estate fluvial flooding is predicted to still occur on the left bank alongside Hale Road and to the warehouse facility located beyond the left bank of the brook to the east of the Stobart site. With this lower tidal boundary being applied, flooding is mainly contained to depths of 0.1 - 0.3m within these offsite areas.

Modelling indicates that fluvial risk does not result in inundation of the Industrial Estate during the 1% AEP event. Whilst the estate will remain at risk of tidal inundation, **the absence of fluvial flooding potentially negates the need for any compensatory storage required to offset land raising.**

However, based on published mapping (Figure 3-9) the site remains at risk of fluvial inundation during a 0.1% AEP event and land raising under this event would reduce available floodplain storage.

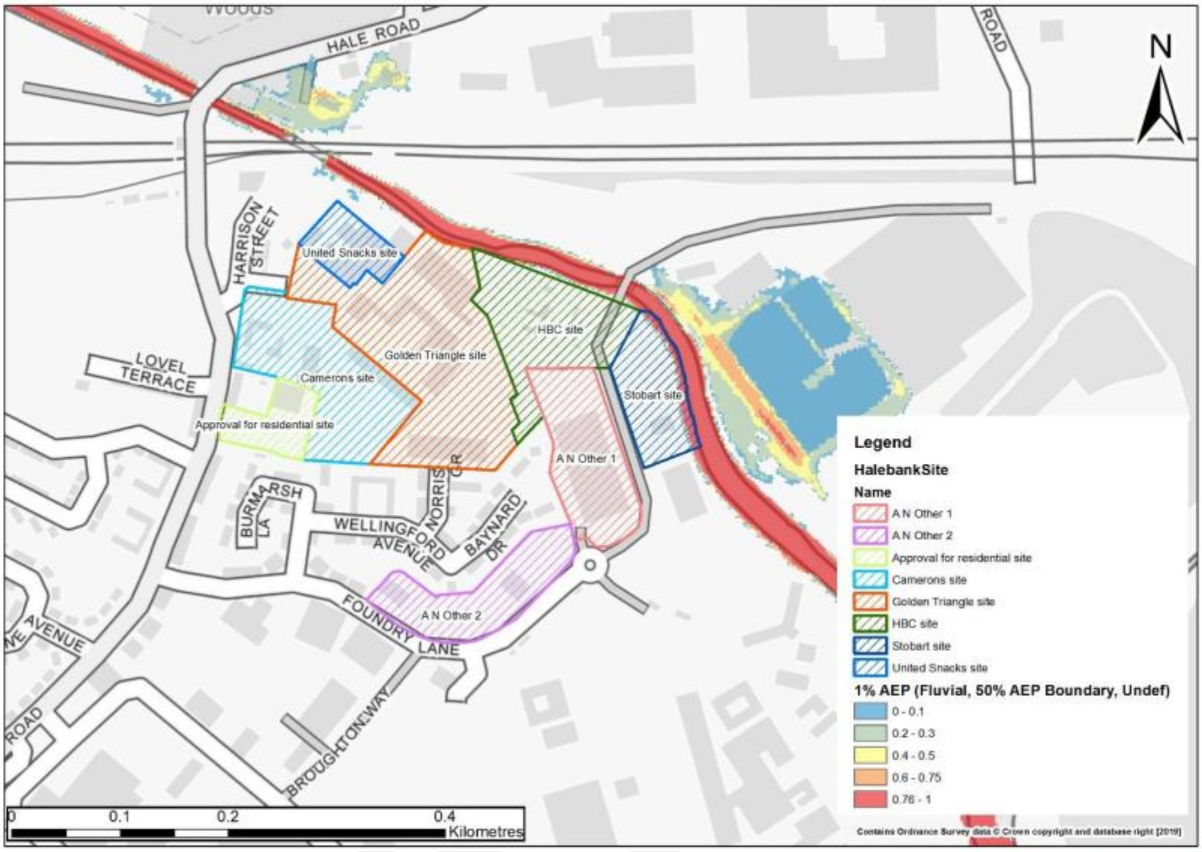

Figure 3-5 Ditton Brook fluvial model (50%AEP tidal boundary, undefended)

3.5 Tidal Flood Risk (defended scenario)

Figure 3-6 indicates the modelled tidal risk outlines to the site for both the 0.5% AEP and 0.1% AEP design events. In this instance flood outlines are based on defended scenarios.

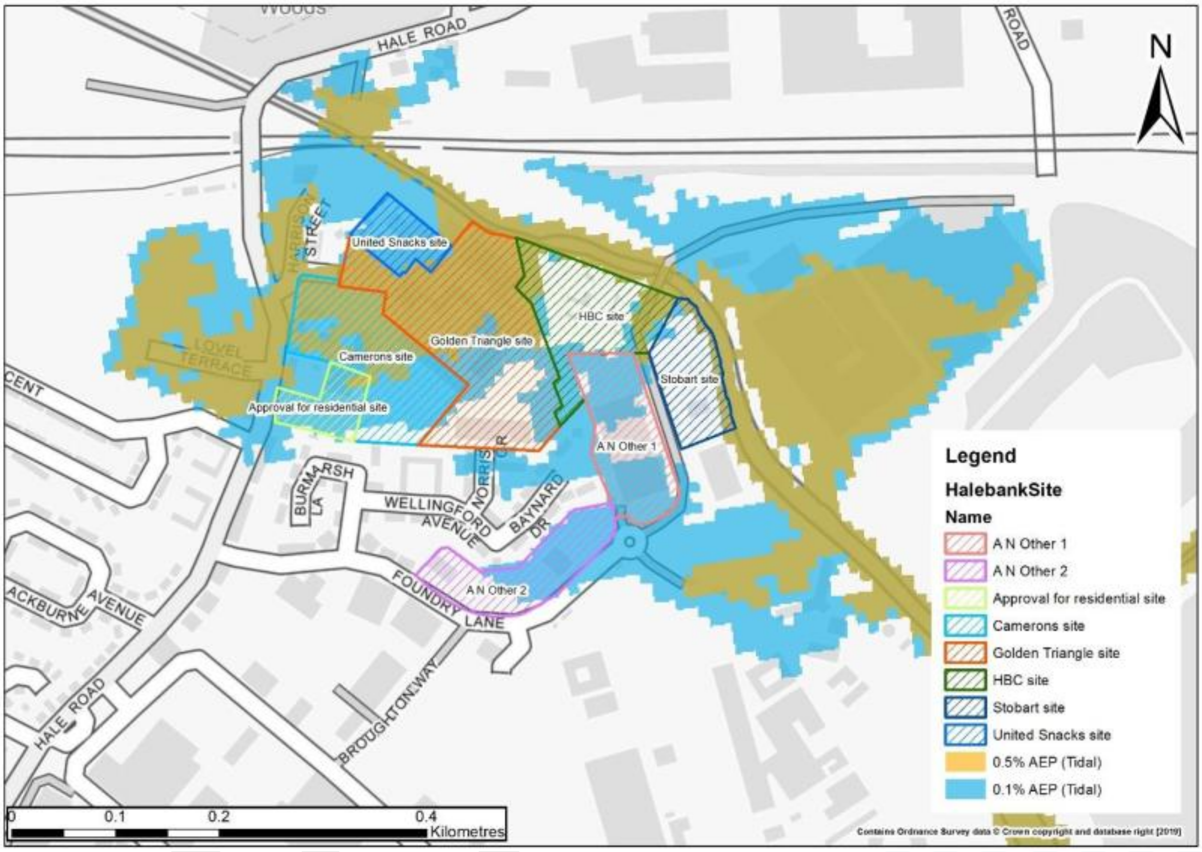

Figure 3-6 Mersey Estuary Tidal Model (defended)

In both scenarios, the area is at risk of tidal inundation with flooding focused on three main areas:

- Overtopping on the right bank close to the railway culvert at the northern edge of the United Snacks Site, this flow path extends into the site causing flooding during the 0.5% AEP event. Flooding extends midway through the 'Golden Triangle' and 'Camerons' sites. In the extreme 0.1% AEP event, this outline increases to encompass the remainder of the western half of the site.
- A second flow path is focused around the bridge at Foundry Lane where flood water is predicted to extend along the eastern boundary of the 'HBC site'. This mechanism of flooding follows the fluvial flow route. This flood extent becomes significant during the 0.1% AEP event.
- The third area of significant flooding is found further downstream on Ditton Brook, south of the Stobart site. Water overtops the left and right banks with floodwater being modelled to extend into the eastern 'AN Other 2' site.

Depths of water within the potential redevelopment site during the 0.5% AEP event are between 0.1m and 0.25m, with these depths increasing to 0.16m and 0.46m during a 0.1% AEP event. The worst areas of flooding are seen in the eastern sites, following a flow path down from the bridge along Hale Road.

As inundation is based on tidal levels, land raising may be considered as a potential means of mitigating flood risk outside of fluvial flood extents. Raising ground levels will not increase tidal flood levels.

3.6 Tidal Flood Risk (undefended scenario)

The extent of tidal inundation, for the undefended scenario, has also been mapped. In the undefended scenario (Figure 3-7) the 0.5% and 0.1% AEP extents remain closely comparable.

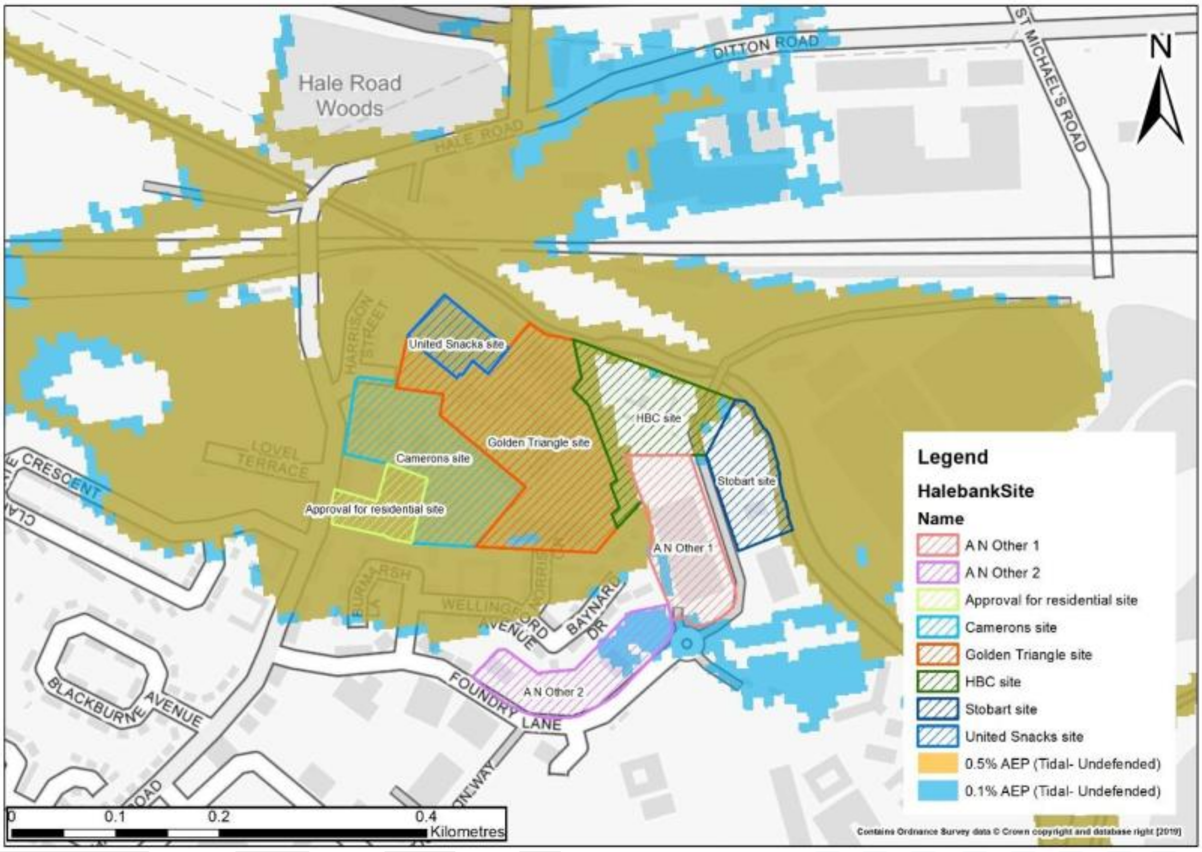

Figure 3-7 Mersey Estuary Tidal Model (undefended scenario)

Owing to the assigned condition of the flood defences the undefended outlines may be considered more representative of flood extents.

In summary, during the defended scenario, 5 sites remain free from tidal inundation during an 0.5% AEP event. This reduces to 3 sites in the same event for the undefended scenario.

Figure 3-8 indicates the predicted depths of flood water to the site during a 0.5% AEP undefended modelled scenario. As with the defended scenario, the areas of greatest flooding are seen to the west. Depths of tidal flooding in the area are between 1.26m and 1.5m with flood water inundating the Camerons site and beyond. The remainder of the more central sites are likely to flood to depths of between 1.11m and 1.25m.

As a result, the main access to the site from the west, via Harrison Street is predicted to be inundated. This will no longer be a viable access route based on current ground levels. The eastern sites that border Ditton Brook remains relatively free from flooding as does Foundry Lane. This route remains accessible by vehicles and pedestrians.

Again, as inundation is based on tidal levels, land raising may be considered as a potential means of mitigating flood risk outside of fluvial flood extents.

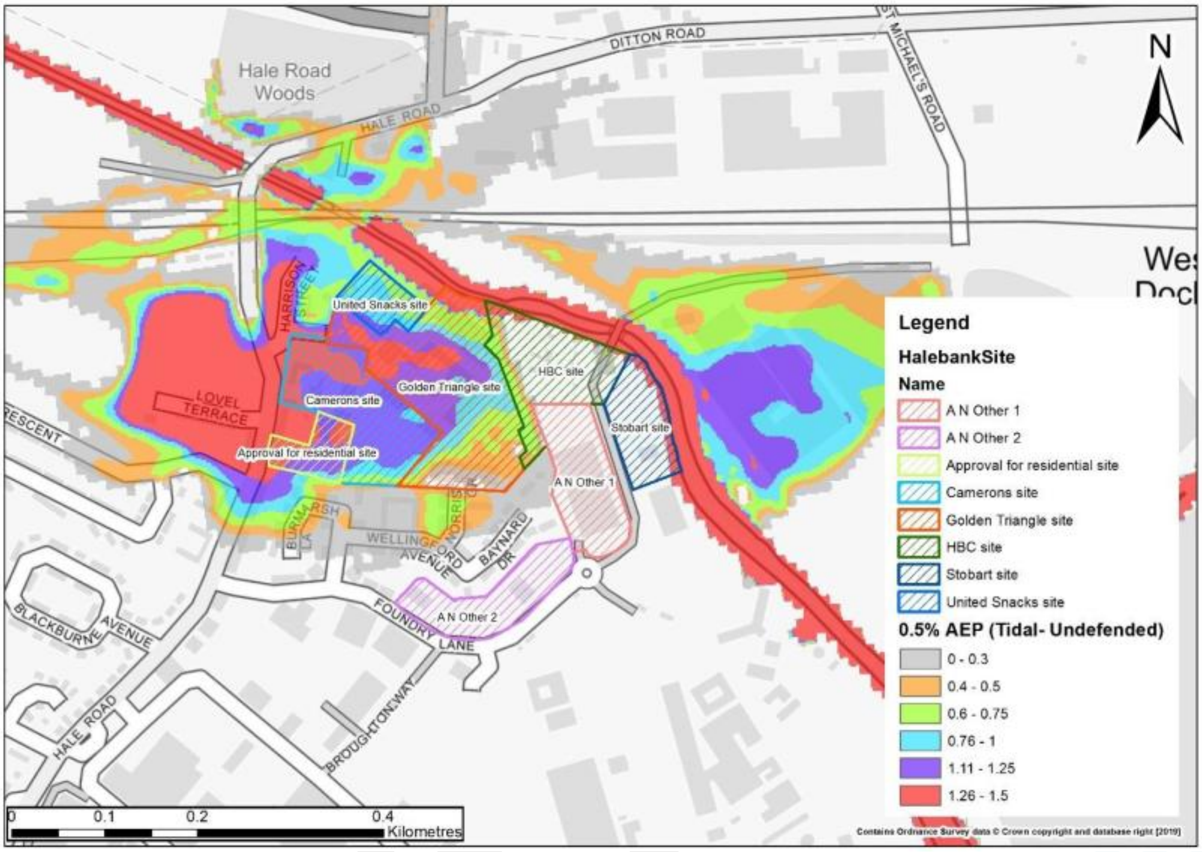

Figure 3-8 Mersey Estuary Tidal Model 0.5% AEP (undefended)

Figure 3-8 represents flood depths for the undefended scenario. Tidal inundation primarily occurs from one area of the bank.

3.7 Comparison of tidal outlines with current published flood mapping

The EA Flood Map for Planning is updated quarterly, and the current EA published outlines do not include the latest Tidal inundation modelling. There is, therefore, a discrepancy in flood outlines. This explains some of the differences that are observed between the newly modelled outlines from both Ditton Brook and the Mersey Estuary models.

One of the largest differences between the published flood outline and the newer Tidal Mersey modelling is in the extent of tidal risk. The current published mapping indicates that the Industrial Estate is not at risk from tidal inundation. However, when compared to the updated Tidal Mersey modelling the site is inside both the 0.5% AEP and 0.1% AEP extents. For comparison, the largest differences are indicated to be within Flood Zone 2 (Figure 3-9).

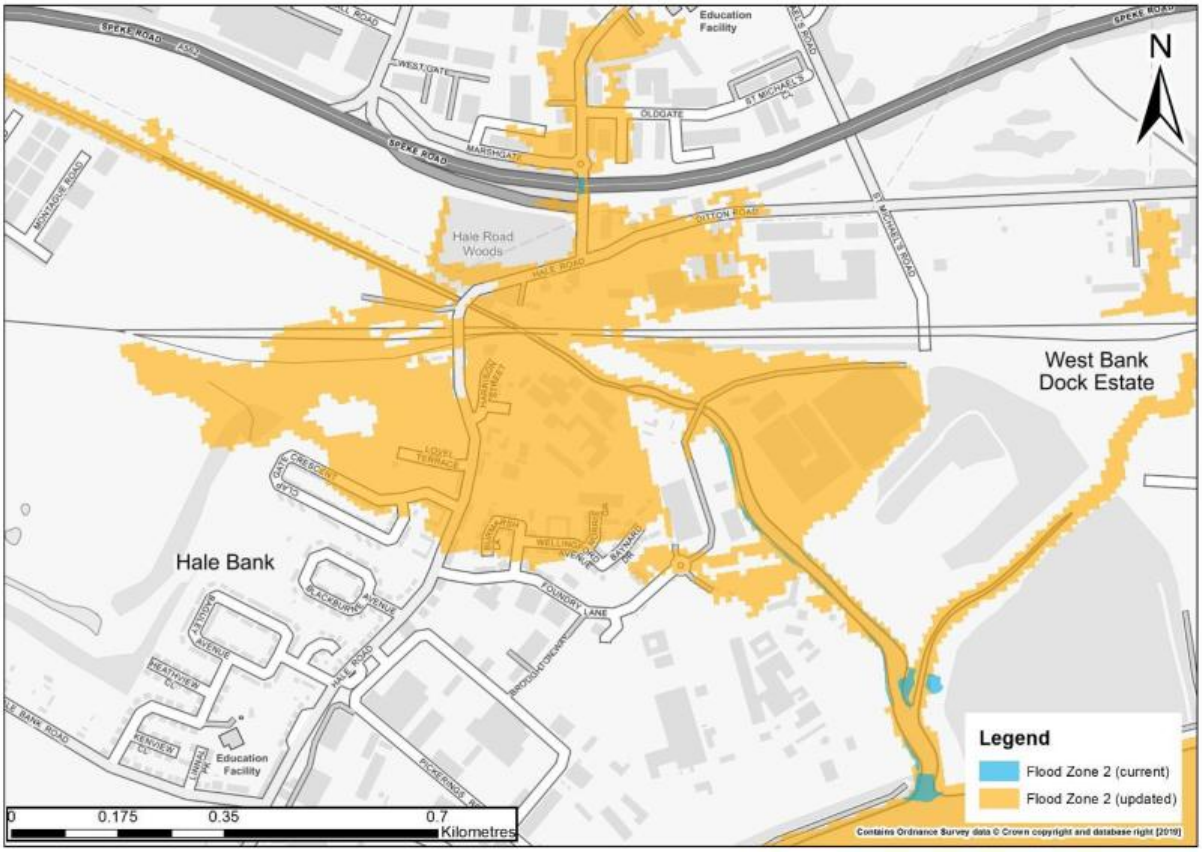

Figure 3-9 Comparison of modelled tidal risk with current risk mapping (FZ2)

3.8 Comparison of fluvial outlines with current published flood mapping (0.1% AEP event)

There are additional changes in the fluvial risk. From Figure 3-10 comparison of modelled fluvial risk to current risk mapping (FZ2) indicates that the actual risk to the site is significantly reduced based on current flood modelling. Possible explanations for this would be:

- Inclusion of historical flooded outlines in the current mapping
- Differences in downstream tidal boundary used on fluvial watercourse
- Updates to modelling methods used

The exact reason for this variation is unclear. However, as the site remains at risk during the 0.1% AEP fluvial event, land raising may impact on flood storage even if the 1% AEP event does not result in fluvial inundation. Further consultation with the EA will be required as land raising (to reduce the risk of flooding during the 0.1% AEP event) will result in excessive requirements for compensatory storage. Requirements for Sequential and Exceptions Testing would also need to be considered.

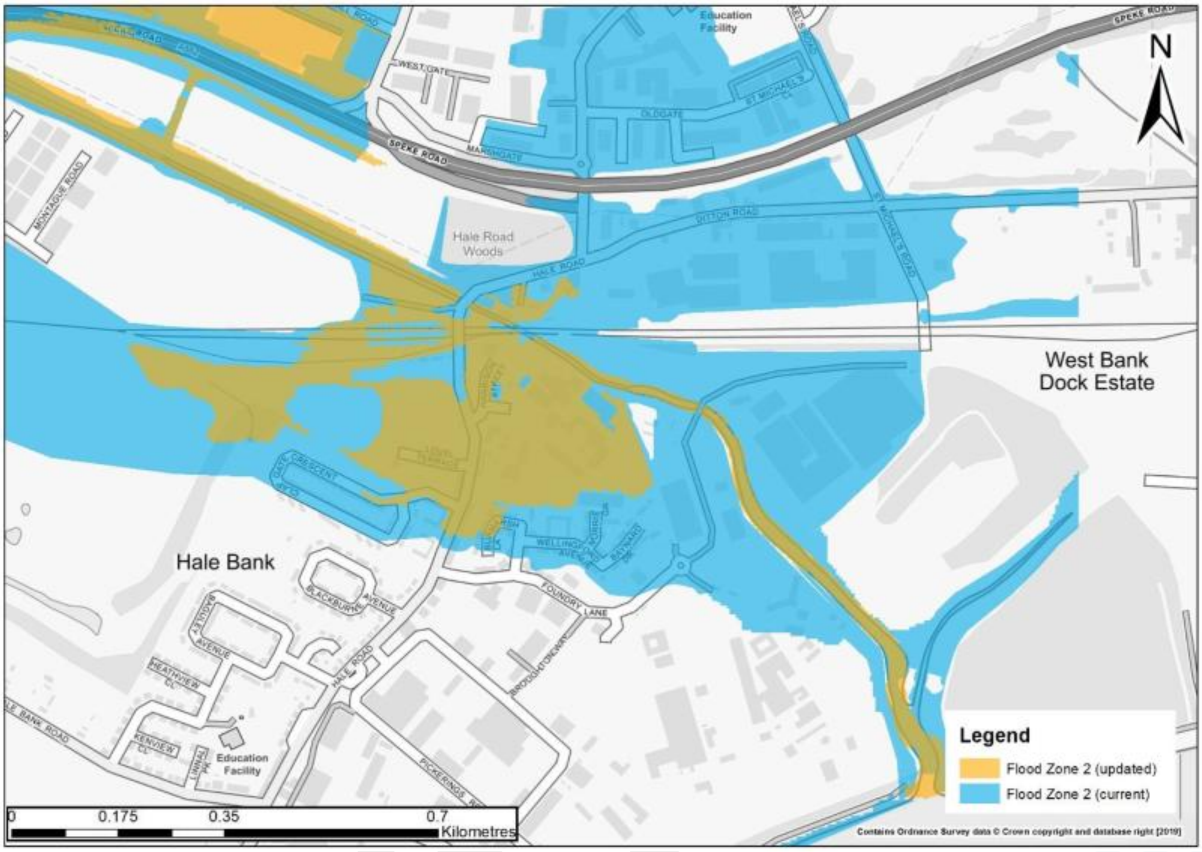

Figure 3-10 Comparison of modelled fluvial risk to current risk mapping (FZ2)

Whilst redevelopment within Flood Zone 2 may be considered, development within this area will need to take any residual risk into account.

In this instance the extent of fluvial flooding is based on an assumed 1% AEP Tidal boundary.

3.9 Surface Water Flood Risk

Using the available mapping from the EA, we have examined the surface water flood extents to the potential development to understand the risk from surface water inundation.

Overall risk to the site from surface water is considered to be limited and localised either to small areas of ponding or flow paths during the low risk (1 in 1000) event.

The 'A N Other 2' site does result in some inundation during both a 1 in 30 and 1 in 100 events. This appears to be a localised issue with surface water from outside the site flowing into the development area. By looking at aerial imagery (Figure 2-1) this would seem to agree with localised land conditions with this location being surrounded by site roads.

The surface water mapping available from the Environment Agency indicates that the 'A N Other 2' site is at risk from surface water inundation. However, it is situated directly east and is lower in elevation than the adjacent raised housing development. It is noted that there are a series of kerb drains located along Foundry Lane that appear to be relatively new and it is assumed that these were installed to reduce the impact of surface water flood risk to the site.

The methodology for the broad-scale mapping approach indicates that a value of 12mm/hr should be used as a blanket value for a drainage rate. The extents of the drainage along Foundry Lane would suggest that a higher value for urban drainage may be considered in the model parameters which may effectively reduce the flood risk observed within the EA Surface Water Flood Maps. At this stage however, without any further clarification related to road drainage, it is assumed that the surface water flood maps remain representative of the surface water flood risk.

3.10 Groundwater Flood Risk

It was identified in the 2011 Level 2 Strategic Flood Risk Assessment that the Ditton Brook catchment 'has mainly heavy clay soils', precluding its suitability for SuDS features. However, this also indicates that the site could be at risk from groundwater flooding due to expected low infiltration rates. The area is already heavily developed for industrial uses and no sub-surface structures are envisaged i.e. basements. So, the risk would lie with the effectiveness of the urban drainage to ensure that the area is drained to a location where runoff can be managed effectively.

3.11 Reservoir Flood Risk

There is no risk posed by reservoir flooding, according to available flood mapping from the EA[3].

3.12 Sewer Flood Risk

The current condition of the gullies along Harrison Street indicate that an intense rainfall event would result in localised flooding along this street, due to a reduced ability to effectively drain the area. Jetting may be required to restore the capacity of the drainage network to an acceptable level.

3.13 Planning Policy

3.13.1 National Planning Policy Framework

The National Planning Policy Framework (NPPF), published in March 2012, was updated July 2018 and February 2019 and is based on core principles of sustainability. It forms the national policy framework in England and is accompanied by a number of Planning Practice Guidance notes. It must be taken in to account in the preparation of Local Plans and is a material consideration in planning decisions.

The Flood Risk and Coastal Change Planning Practice Guidance (FRCC-PPG) sits alongside the revised NPPF and sets out detailed guidance on how this policy should be implemented.

Section 14 Paragraph 156 and 157 of the NPPF states that Local Plans…

"...should be supported by a Strategic Flood Risk Assessment and develop policies to manage flood risk from all sources, taking account of advice from the Environment Agency and other relevant flood risk management bodies, such as Lead Local Flood Authorities and Internal Drainage Boards. Local Plans should apply a sequential, risk-based approach to the location of development to avoid, where possible, flood risk to people and property and manage any residual risk, taking account of the impacts of climate change, by applying the Sequential Test, if necessary applying the Exception Test, safeguarding land from development that is required for current and future flood management, using opportunities offered by new development to reduce the causes and impacts of flooding and where climate change is expected to increase flood risk so that some existing development may not be sustainable in the long term, seeking opportunities to facilitate the relocation of development including housing to more sustainable locations".

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3 Mapping available from- https://flood-warning-information.service.gov.uk/long-term-flood-risk/map (date accessed 12 February 2019)

3.13.2 Key elements of the updated February 2019 NPPF include:

Planning and flood risk para. 155 to 165:

155. Inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk (whether existing or future). Where development is necessary in such areas, the development should be made safe for its lifetime without increasing flood risk elsewhere.

156. Strategic policies should be informed by a strategic flood risk assessment, and should manage flood risk from all sources. They should consider cumulative impacts in, or affecting, local areas susceptible to flooding, and take account of advice from the Environment Agency and other relevant flood risk management authorities, such as lead local flood authorities and internal drainage boards.

157. All plans should apply a sequential, risk-based approach to the location of development – taking into account the current and future impacts of climate change – so as to avoid, where possible, flood risk to people and property. They should do this, and manage any residual risk, by:

a) applying the sequential test and then, if necessary, the exception test as set out below;

b) safeguarding land from development that is required, or likely to be required, for current or future flood management;

c) using opportunities provided by new development to reduce the causes and impacts of flooding (where appropriate through the use of natural flood management techniques); and

d) where climate change is expected to increase flood risk so that some existing development may not be sustainable in the long-term, seeking opportunities to relocate development, including housing, to more sustainable locations.

158. The aim of the sequential test is to steer new development to areas with the lowest risk of flooding. Development should not be allocated or permitted if there are reasonably available sites appropriate for the proposed development in areas with a lower risk of flooding. The strategic flood risk assessment will provide the basis for applying this test. The sequential approach should be used in areas known to be at risk now or in the future from any form of flooding.

159. If it is not possible for development to be located in zones with a lower risk of flooding (taking into account wider sustainable development objectives), the exception test may have to be applied. The need for the exception test will depend on the potential vulnerability of the site and of the development proposed, in line with the Flood Risk Vulnerability Classification set out in national planning guidance.

160. The application of the exception test should be informed by a strategic or site-specific flood risk assessment, depending on whether it is being applied during plan production or at the application stage. For the exception test to be passed it should be demonstrated that:

a) the development would provide wider sustainability benefits to the community that outweigh the flood risk; and

b) the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

161. Both elements of the exception test should be satisfied for development to be allocated or permitted.

162. Where planning applications come forward on sites allocated in the development plan through the sequential test, applicants need not apply the sequential test again. However, the exception test may need to be reapplied if relevant aspects of the proposal had not been considered when the test was applied at the plan-making stage,

or if more recent information about existing or potential flood risk should be taken into account.

163. When determining any planning applications, local planning authorities should ensure that flood risk is not increased elsewhere. Where appropriate, applications should be supported by a site-specific flood-risk assessment. Development should only be allowed in areas at risk of flooding where, in the light of this assessment (and the sequential and exception tests, as applicable) it can be demonstrated that:

a) within the site, the most vulnerable development is located in areas of lowest flood risk, unless there are overriding reasons to prefer a different location;

b) the development is appropriately flood resistant and resilient;

c) it incorporates sustainable drainage systems, unless there is clear evidence that this would be inappropriate;

d) any residual risk can be safely managed; and

e) safe access and escape routes are included where appropriate, as part of an agreed emergency plan.

164. Applications for some minor development and changes of use should not be subject to the sequential or exception tests but should still meet the requirements for site-specific flood risk assessments set out in footnote 50.

165. Major developments should incorporate sustainable drainage systems unless there is clear evidence that this would be inappropriate. The systems used should:

a) take account of advice from the lead local flood authority;

b) have appropriate proposed minimum operational standards;

c) have maintenance arrangements in place to ensure an acceptable standard of operation for the lifetime of the development; and

d) where possible, provide multifunctional benefits.

3.13.3 Sites passing the Sequential and Exception Tests

Development sites can be allocated or granted planning permission where the Sequential Test and the Exception Test (if required) are passed. In addition, a site is likely to be allocated without the need to assess flood risk where the proposed use is for open space. Assuming the site is not to include any development and is to be left open then the allocations is likely to be acceptable from a flood risk point of view. For such sites, opportunities for flood storage should be explored however as part of an FRA.

All development proposals within Flood Zones 2 or 3 must be accompanied by a Flood Risk Assessment. Any sites 100% within Flood Zone 1 that are 1 hectare or more in area must be accompanied by a Flood Risk Assessment to determine vulnerability to flooding from other sources as well as fluvial. The FRA should determine the potential of increased flood risk elsewhere as a result of the addition of hard surfaces on-site and the effect of new development on surface water runoff.

The Flood Risk and Coastal Change PPG states:

"…*carried out by (or on behalf of) a developer to assess the flood risk to and from a development site. Where necessary (see footnote 20 in the National Planning Policy Framework), the assessment should accompany a planning application submitted to the local planning authority. The assessment 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 (see Table 2 – Flood Risk Vulnerability of PPG)." (Paragraph 30)*

and

"Local authorities and developers should seek opportunities to reduce the overall level of flood risk in the area and beyond. This can be achieved, for instance, through the

layout and form of development, including green infrastructure and the appropriate application of sustainable drainage systems, through safeguarding land for flood risk management, or where appropriate, through designing off-site works required to protect and support development in ways that benefit the area more generally." (Paragraph 50).

4 Development Options

4.1 Land Raising

One way to reduce flood risk to a particular site is to elevate ground levels above known flood extents. Modelled outputs are used to identify safe levels of development which should be set above a specific water level.

In this instance:

- 0.5% AEP and 0.1% AEP - tidal flood risk when considered in isolation, can be mitigated by land raising.
- 1% AEP – fluvial risk (assuming a 50% AEP tidal boundary) does not inundate the site.
- 0.1% AEP – fluvial risk based on published mapping does represent a residual risk and land raising is likely to reduce available flood storage.

However, in accordance with the NPPF, development cannot be allowed to increase flood risk elsewhere. Therefore, any land raising in this area would remove a proportion of land from the available floodplain. To avoid this issue, compensatory storage can be provided to store the volume of flood water which has been displaced through land raising. This will need to be verified through modelling to ensure that the compensatory storage is defined within areas which are affected by the land raising issue.

For tidally influenced events however, land raising can be achieved without the need to mitigate through compensatory storage. This is due to the fact that the 'tidal' floodplain covers such a vast area that localised pockets of land raising cannot be determined to increase tidal flood levels elsewhere.

The extent of flooding is also dependent on the combination of tidal boundary and design fluvial events assessed. If a conservative approach is used (ie a 1% AEP tidal boundary) then fluvial inundation is predicted to occur during both the 1% and 0.1% AEP fluvial events. However, if a lower value is used (ie a 50% AEP tidal boundary) then fluvial flooding is not predicted to occur during the 1% AEP event. A combined event, based on using either of these boundary conditions, will still exceed the design fluvial standard for development. Further consultation with the Environment Agency will be required in order to review the outcomes of this feasibility report and to confirm the suitability of basing development on the lower tidal boundary condition.

- Residential development will typically be set above the 1% fluvial level (with allowance for climate change).
- Less vulnerable development including industrial and commercial may be considered at lower development thresholds, depending on flood risk and resilient design. First floor accommodation may be acceptable subject to emergency planning and access arrangements.
- Raising on stilts would not impact on 0.1% AEP flood extents

If tidal flooding is considered to represent the primary cause of flood risk, and in the absence of fluvial risk, then land raising may be considered without compensatory flood storage to offset the risk of tidal inundation.

If fluvial risk remains then as well being able to provide suitable compensatory storage for development purposes, the placement and location of flood storage areas has critical impacts on flood risk mitigation as a whole. Simply compensating by lowering land anywhere will not provide adequate compensation in regards to flood storage. Available space, ground conditions, flow paths, localised elevation changes and defence locations are aspects which need to be considered and can have critical effects upon overall water storage.

For the purpose of this feasibility assessment, several options, based on raising land within the industrial estate, have been considered. Opportunities for flood storage either within the site or on nearby land such as the Halebank Village Green have been considered.

In total, 7 modelled options were considered for both the 1% AEP and 1% +30% CC events, Figure 4-1 shows the outlines of the raised/lowered areas.

Two scenarios relating to the flood defences have also been explored, see Section 4.2. The reasoning behind this approach was to enhance the current standard of flood defence locally by improving the current defence condition grades and by eliminating any potential low spots. Potential difficulties associated with defence enhancement relate to subsequent increased offsite flood risk, constructability and any associated costs involved in enhancing the defences.

Finally two options regarding land raising were tested at the north-west corner of the development site, focusing on attenuating water from the overtopping culvert, see sections 4.3 and 4.4 for further detail.

It should be noted that this feasibility modelling is considered high level screening and further sensitivity testing would be required to understand Flood Zone 2 interactions with specific design layouts. This would also form the basis for any subsequent site-specific FRAs. Key scenarios considered comprise:

Scenario 1 – Raised land on western side of site, lowered land on eastern side of site (to provide fill)

Scenario 2 – Raised land on western side of site, lowered land on Halebank Village Green (to provide compensatory flood storage)

Scenario 3 – Raised (less) land on western side of site, lowered land on eastern side of site (to provide fill)

- Note: For scenarios 1,2 and 3 The extent of land raising or lowering is in accordance with Figure 4-1.

Scenario 4 – Placement of 'theoretical' high flood wall along top of Harrison Street

Scenario 5 – Raised Ditton Brook defences by 2m

- Note: Scenarios 4 and 5 are covered in more detail in Section 4.2.

Scenario 6 – Raised 1/3 of area within defined fluvial extent (and lowering the remaining 2/3 of this area to provide additional compensatory storage).

Scenario 7 – Raised 1/2 of area within defined fluvial extent (and lowering the remaining 1/2 of this area to provide additional compensatory storage).

- Note: Scenario 6 and 7 land extents are shown in maps in in Sections 4.3 and 4.4.

It should be made clear that any land raising can only be freely carried out in respect to mitigating tidal only risk. Anywhere there is a defined fluvial risk, land raising must be matched with compensatory flood storage.

For these scenarios, a 1% AEP fluvial event with a 1% AEP tidal event placed at the downstream boundary of Ditton Brook to represent any tidal impacts that would have an effect upon the watercourse was modelled. A 1% AEP tidal boundary represents a more extreme scenario that might potentially be expected as occurring.

For instance, a 50% AEP tidal boundary used during a 1% AEP fluvial run saw flooding contained mainly to the channel. In this instance a 1% boundary was chosen to represent a more conservative flood outline on potential development at the site.

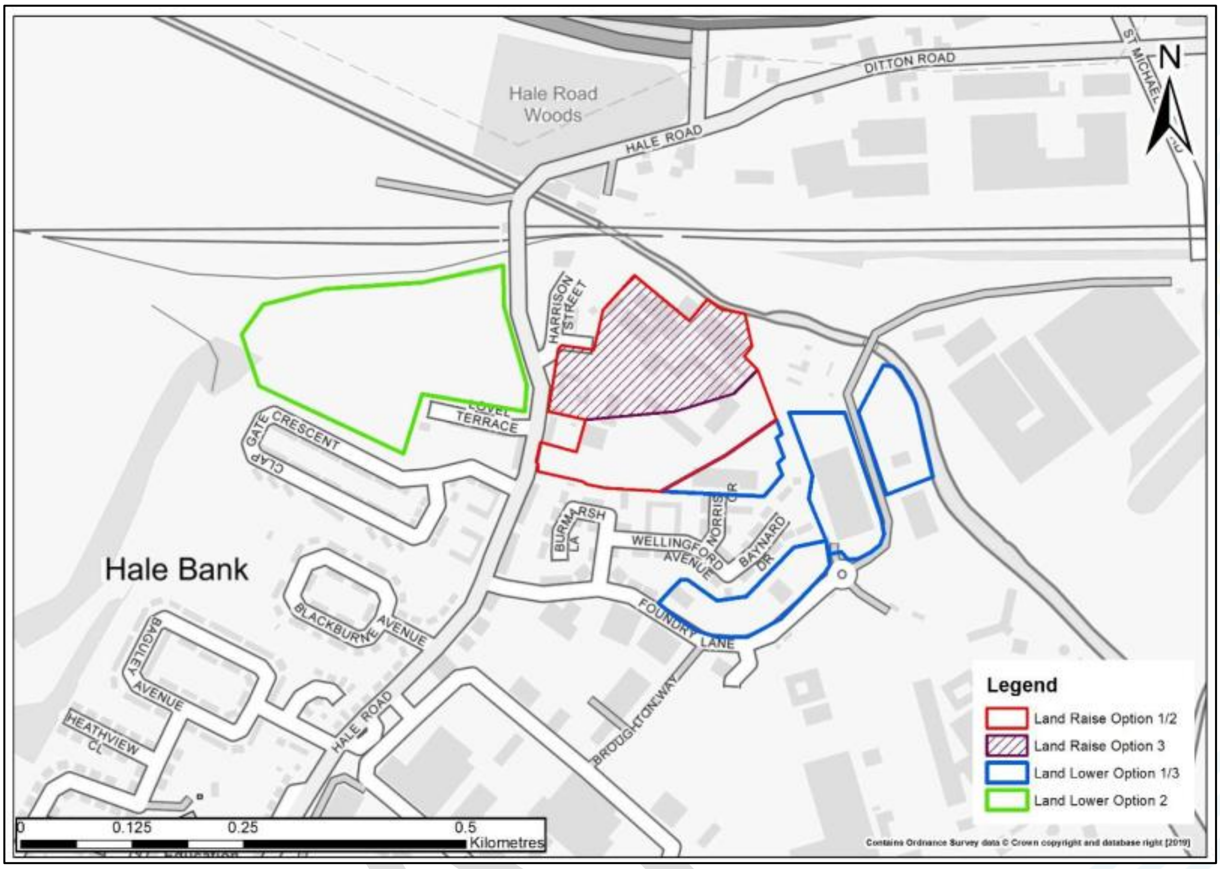

Figure 4-1 Extent of land raising and lowering for Scenarios 1, 2 and 3

Table 4-1 Outlined Modelled Scenarios (land raising/lowering)

Scenario	Description	Estimated Volume (m^3)
Land Raise Scenarios 1 and 2	Raised land focused on western border of site to halfway through total site	+54,000
Land Raise Scenario 3	Raised land focused on same area as previous though stopping midway through Golden Triangle site	+31,000
Land Lower Scenarios 1 and 3	Lowered land focusing on the eastern sites	-42,000
Land Lower Scenario 2	Lowered land in Halebank Village Green	-55,000
Land Lower Scenario 6	66% of land in north west corner lowered	-27,300
Land Lower Scenario 7	50% of land in north west corner lowered	-21,600

4.1.1 Scenario 1 – Raised land on western side of site, lowered land on eastern side of site (to provide fill)

This scenario modelled land raising and lowering to the eastern sites in order to provide fill material (but not compensatory flood storage) (Figure 4-2).

As a result, raised sites are prevented from flooding during a 1% AEP event. This is outcome is also seen in a future risk scenario where flows are increased by +30% to represent climate change.

However, land raising on its own results in an increased risk of flooding elsewhere. This option is not, therefore, considered acceptable in terms of flood risk management.

- Tidal flooding is prevented to almost all of the site with the exception being 'Stobart' site on the far east of the boundary. Lowering the land here caused the entire site to be flooded from the brook to depths of 1.5m. (In reality ground level would be maintained at a higher level to prevent flooding).
- Flooding along Hale Road results in depths of flooding between 0.6m and 1.2m. This is an increase of approximately 0.4m as modelled during an undefended 1% AEP event (with 1% tidal boundary).
- Scenario 1 also sees flood outlines increase in two key areas, west along the Village Green and north along Hale Road, past Speke Road.

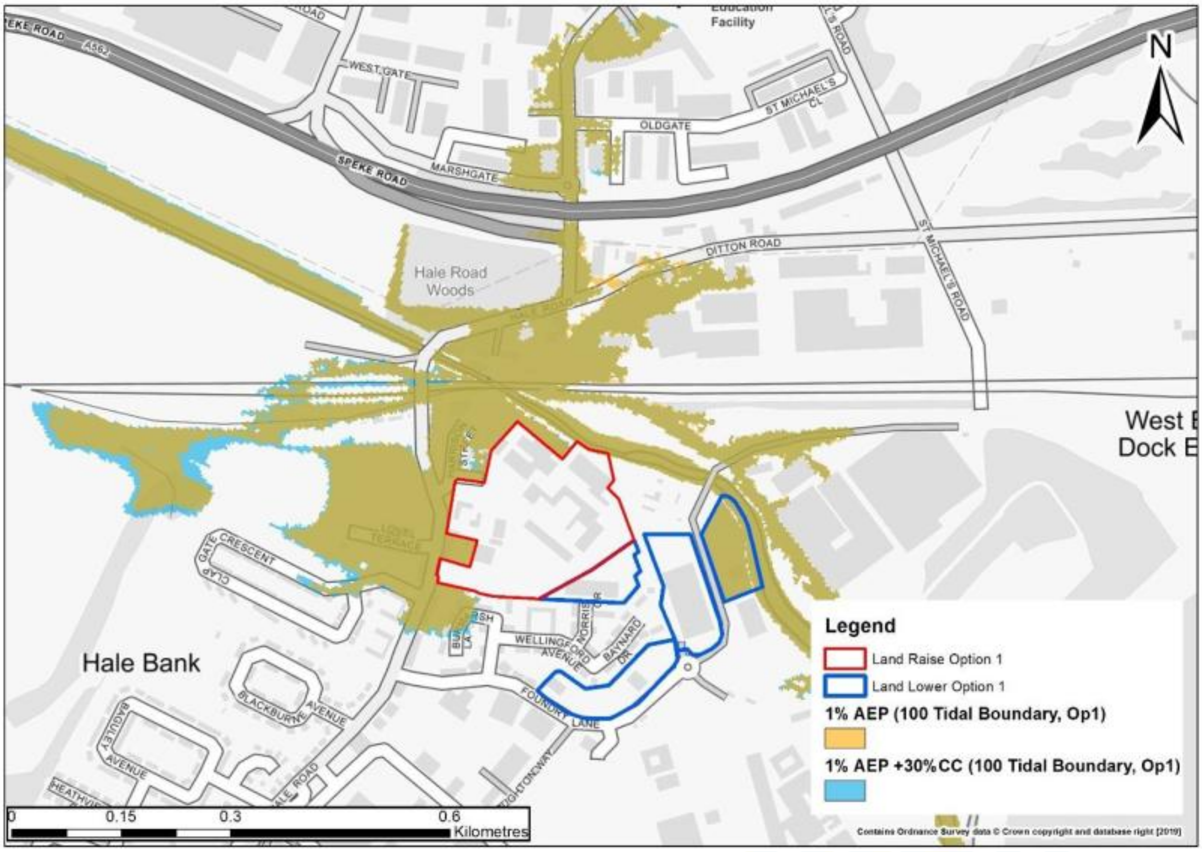

Figure 4-2 Modelled outlines from 1% AEP and 1% AEP +30%CC event, Scenario 1

4.1.2 Scenario 2 – Raised land on western side of site, lowered land on Halebank Village Green (to provide compensatory flood storage)

Scenario 2 focused on providing compensatory flood storage within the Village Green to the immediate west of the site. Despite potential contamination issues, this area is suitably located in terms of providing the wider scale flood alleviation required to offset land raising within the Industrial Estate. Figure 4-3 indicates the modelled depths for this scenario during a 1% AEP event.

Scenario 2 results in the greatest extent of fluvial flooding to the Village Green due to this land being lowered to form compensatory flood storage.

To test this scenario land has been lowered by 1.3m. Modelling indicates that the basin will completely fill. Lowering the Village Green may also provide local benefit by reducing the average flood depth on Hale Road to 0.3m during design events. This depth of flooding is still likely to affect safe pedestrian and vehicular access.

Compared to the baseline maximum extents, this scenario prevents flooding to the site during the fluvial 1% and 1% + 30% climate change event.

However, as with Scenarios 1 and 3, there are increased fluvial flooding outlines north of the site along Ditton Brook with water also flowing down Hale Road and affecting buildings on Marshgate and Oldgate. The addition of climate change sees an expansion of flood extents, i.e. outlines from scenario 2 increase to the approximately the same extent as scenario 1.

Whilst this scenario succeeded in removing the site from flood risk, there are additional areas of flooding off-site. Further detailed modelling and adaptation would be required as part of any development plan for the area. However, the approach to flood mitigation, assuming cost and technical challenges associated with any contamination can be managed means that a scheme here may be achievable.

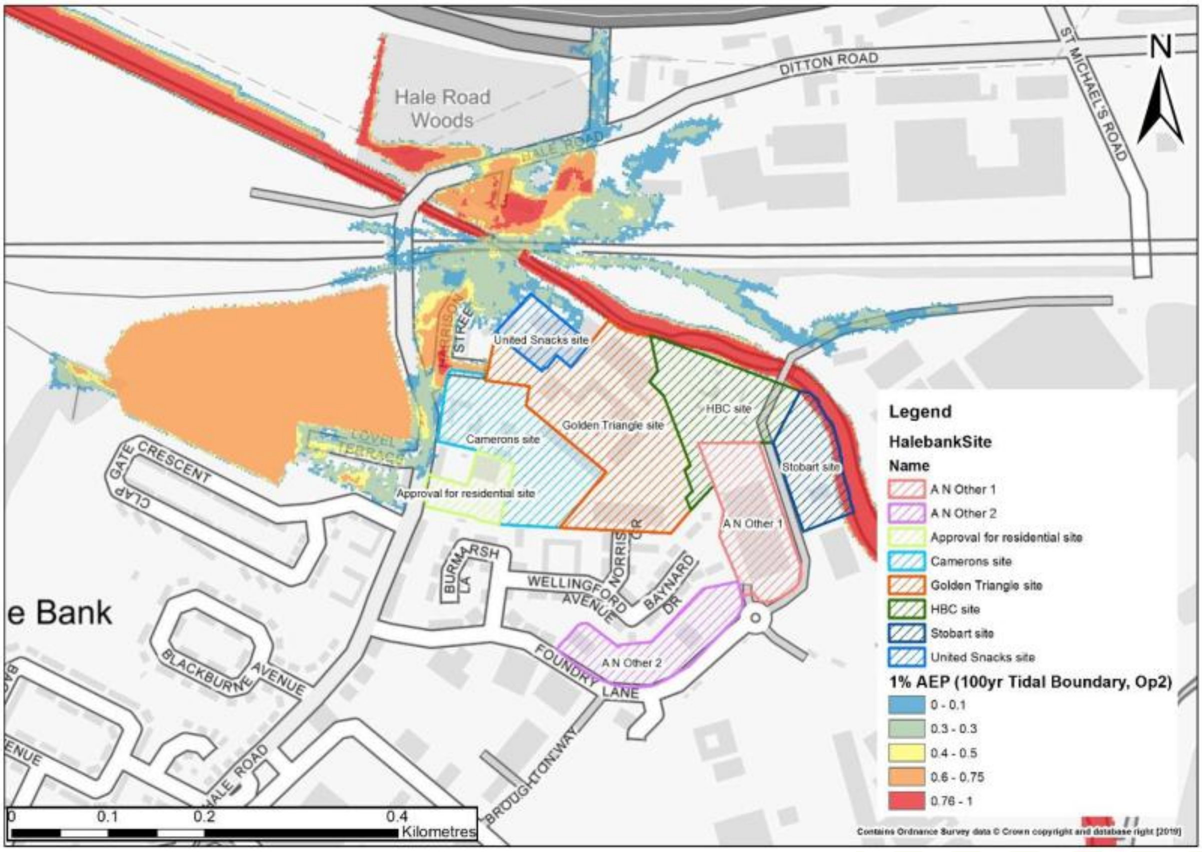

Figure 4-3 Modelled depths to the site during a 1% AEP, Scenario 2

4.1.3 Scenario 3 – Raised (reduced) land on western side of site with lowered land on eastern side of site (to provide fill)

When compared to scenarios 1 and 2, scenario 3 represents a reduction in the total area of land raising from 4.16ha to 2.4ha.

Overall outlines from modelling scenario 3 remain similar to the flood extents defined by scenario 2. In this scenario, the raised areas remain free from flooding including during a future risk climate change event (Figure 4-4).

- A new flow path is created as a result of the brook surcharging near the railway culvert at the top end of Harrison Street with flood water being predicted to flow down Hale Road and into the site.
- These outlines are produced using a conservative 1% AEP tidal boundary.
- Flood depths in the site range between 0.1m and 0.3m (1% AEP event) and between 0.25m and 0.58m in the 1% AEP event +30% climate change event. These are largely comparable with depths seen in a 1% AEP undefended existing risk scenario.

Water is predicted to be deepest on the road with general depths decreasing the further flood water extents into the site.

In all of the modelled scenarios, water fails to propagate further south along Hale Road than is seen in the baseline outlines.

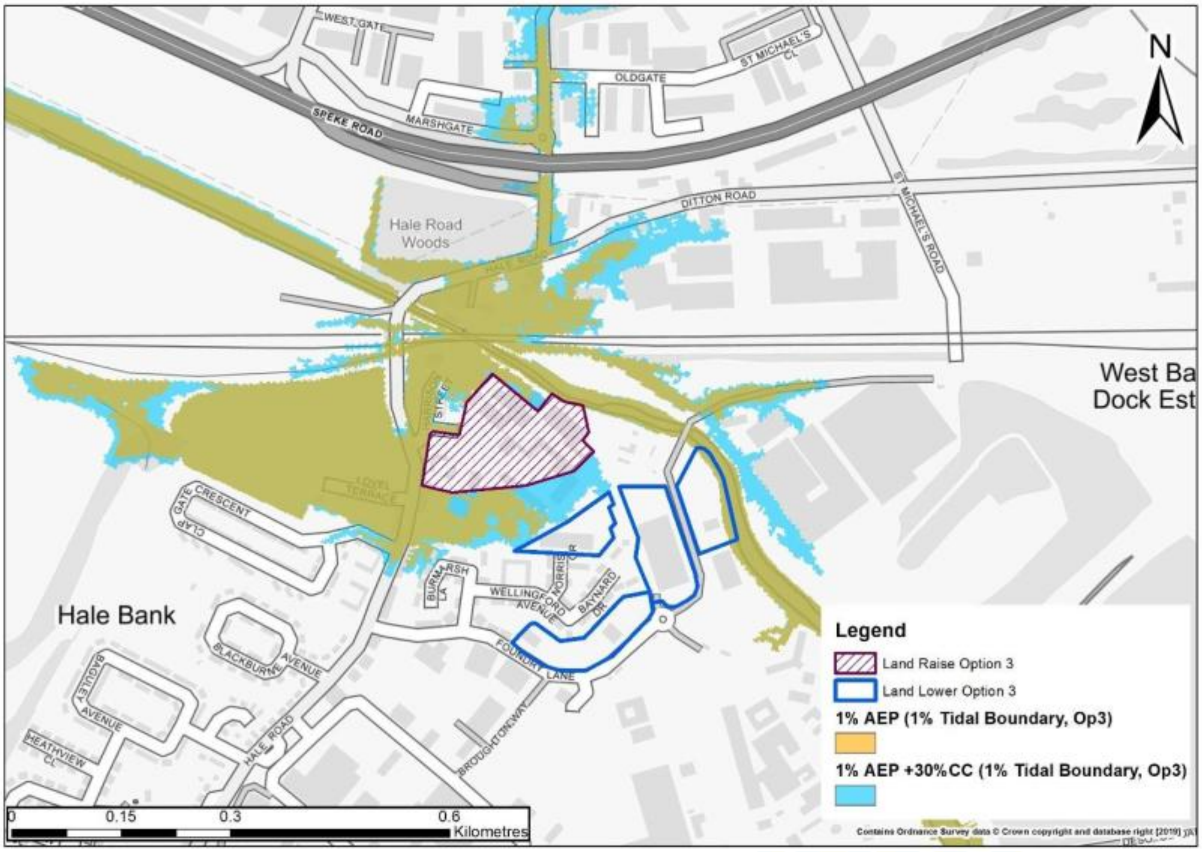

Figure 4-4 Modelled outlines from 1% AEP and 1% AEP +30%CC event, Scenario 3

4.2 Scenario 4 – Placement of high flood wall along top of Harrison Street

The existing defences along the banks of Ditton Brook comprise earth embankments with some areas topped with flood walls. These defences run parallel to Ditton Brook on both river banks.

The design standard of this section of flood defence provides a nominal standard of protection up to the 1% AEP event. However, owing to their poor condition rating, these defences a cannot be relied on to mitigate or prevent flood risk as intended for the lifetime of the development.

The first defence scenario, Scenario 4, incorporated a high flood defence from the north-western edge of the site across Harrison Street, tying into the high ground on the left of Hale Road and to the right bank of Ditton Brook. This was effectively a model sensitivity test to understand the likely impact of forming a raised flood wall at this location.

- Whilst flooding to the site was prevented, flood outlines were modelled moving north along Hale Road at depths of up to 0.3m. Additional new areas of flooding were seen west of the site along the railway tracks and the Village Green (Figure 4-5).
- Whilst raised walling prevented flooding to the site, flood risk elsewhere is exacerbated. This option is not therefore acceptable on its own without wider flood risk management strategy on Ditton Brook.

4.2.1 Scenario 5

Scenario 5 represented the height of flood defence walls on Ditton Brook, between Hale Road Bridge and the entrance to the culvert, being increased by 2m.

Unlike Scenario 4, the raised defences appeared to have no impact on reducing flood risk to the site. Instead, flood water overtopped the newly raised defences and flowed into the Industrial Estate (Figure 4-5). The resultant flood outlines are largely the same as the undefended baseline current and future risk events, Figure 3-2 and Figure 3-3.

This suggests that the raising of defences has little to no effect upon overall outlines as flood water from the brook either surcharges or bypasses them.

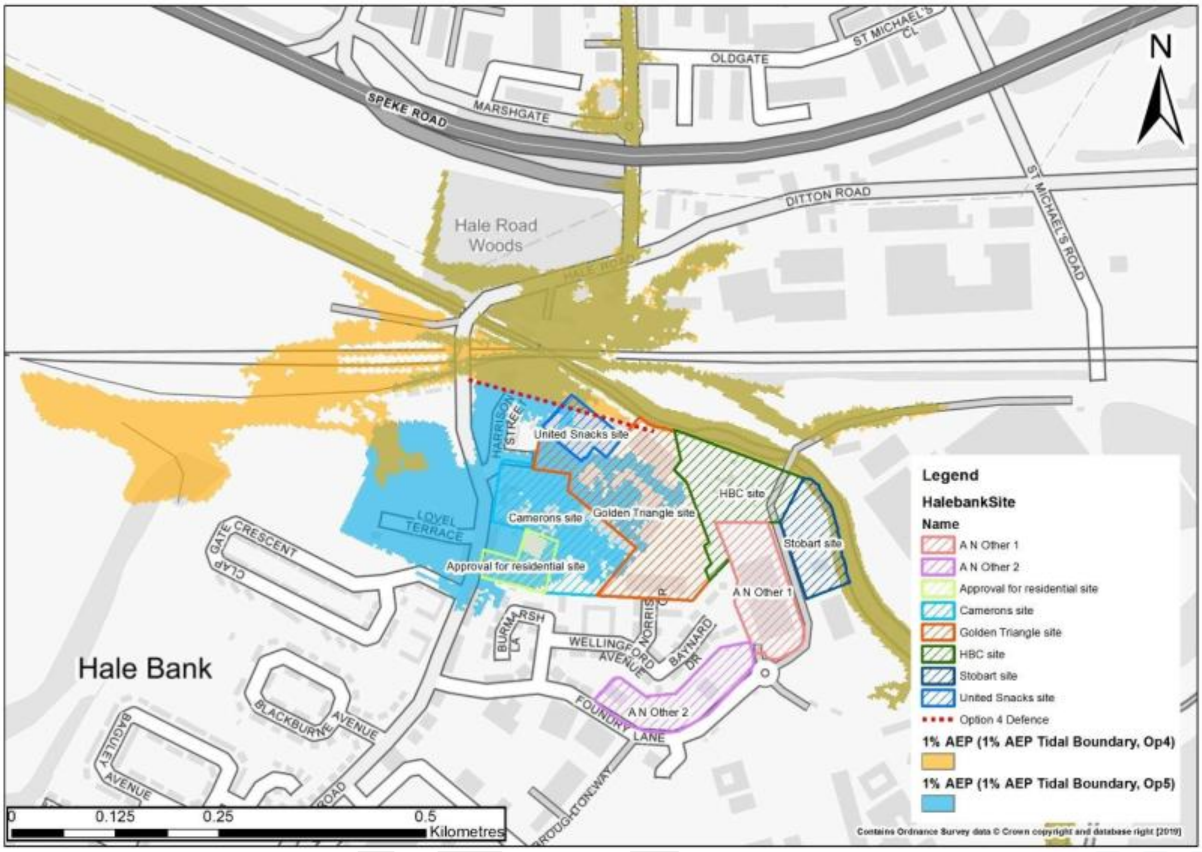

Figure 4-5 Modelled outlines from 1% AEP and 1% AEP +30%CC event, Scenario 4 & 5

4.3 Scenario 6

Two further scenarios have been tested to confirm the effects of raising ground levels within the western and northern areas of the industrial development. These additional scenarios sought to investigate how to potentially mitigate flood water flowing through the site.

Land raising and lowering has been restricted to areas of the industrial estate where fluvial flooding is predicted. Land raising within these areas is combined with associated compensatory storage within the estate (Figure 4-6).

Scenario 6 focused on an area in the north-west corner where approximately two thirds of the site were lowered by 1m (arbitrary areas located closest to the brook consisting of United Snacks Site and parts of Cameron's and Golden Triangle). The remaining third of the flood prone area was raised above flood levels, representing the effects of land raising.

Land ownership has not been taken into consideration at this stage.

This scenario was assessed against a 1% AEP fluvial event with a 1% AEP tidal boundary to ensure comparable results with the previous scenarios.

- Flooding within the site is localised to the lowered areas with flooding outside the site see outlines including the village green, Lovel Terrace and land located east of Stobart Site.

Depths within the flooded areas of the development site are on average >1m as would be expected from creating a basin to capture overtopping water from the railway culvert on Ditton Brook. In this sense, Scenario 6 is similar to Scenario 1 in that a site has to be considered sacrificial, in this case the upper north-west corner instead of Stobart site.

- A key difference here is the lack of additional flood risk generated in additional areas as a result of land raising, i.e. no additional flooding generated on Hale Road and other land to the north of the site. A flood outline that is currently shown as occurring in Scenarios 1-5.

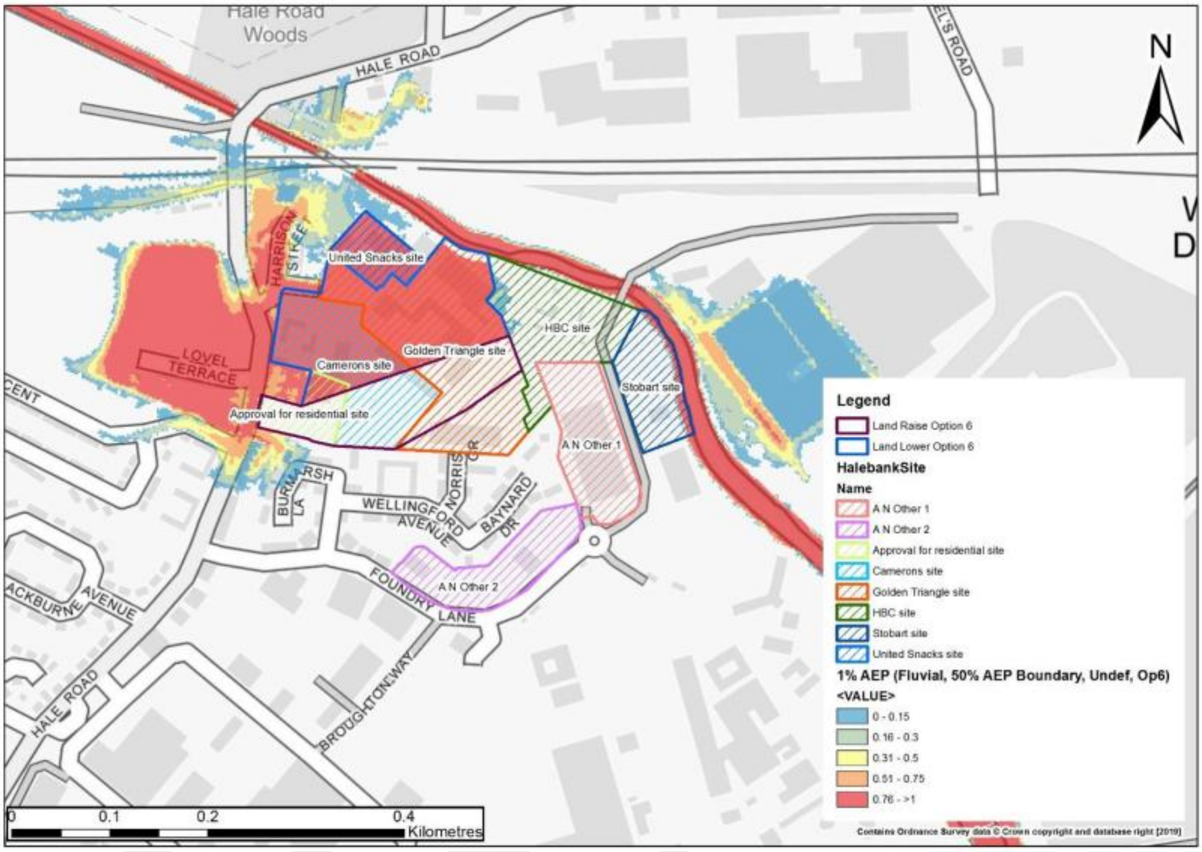

Figure 4-6 Modelled flood depths for Scenario 6 (1% AEP with 50% AEP tidal boundary) with site development layout

Additional areas of flooding that have been mentioned, the village green and land east of Stobart site are pre-existing flood risk areas shown in current flood zone mapping and modelled Scenario runs.

4.4 Scenario 7

This Scenario acted as a further extension to the test carried out in the Scenario 6, namely if the same land raising outline was used, could less land be raised to achieve the same attenuation impacts. For this Scenario, 1/2 of the land was lowered compared to 1/3 in the previous run, see Figure 4-7.

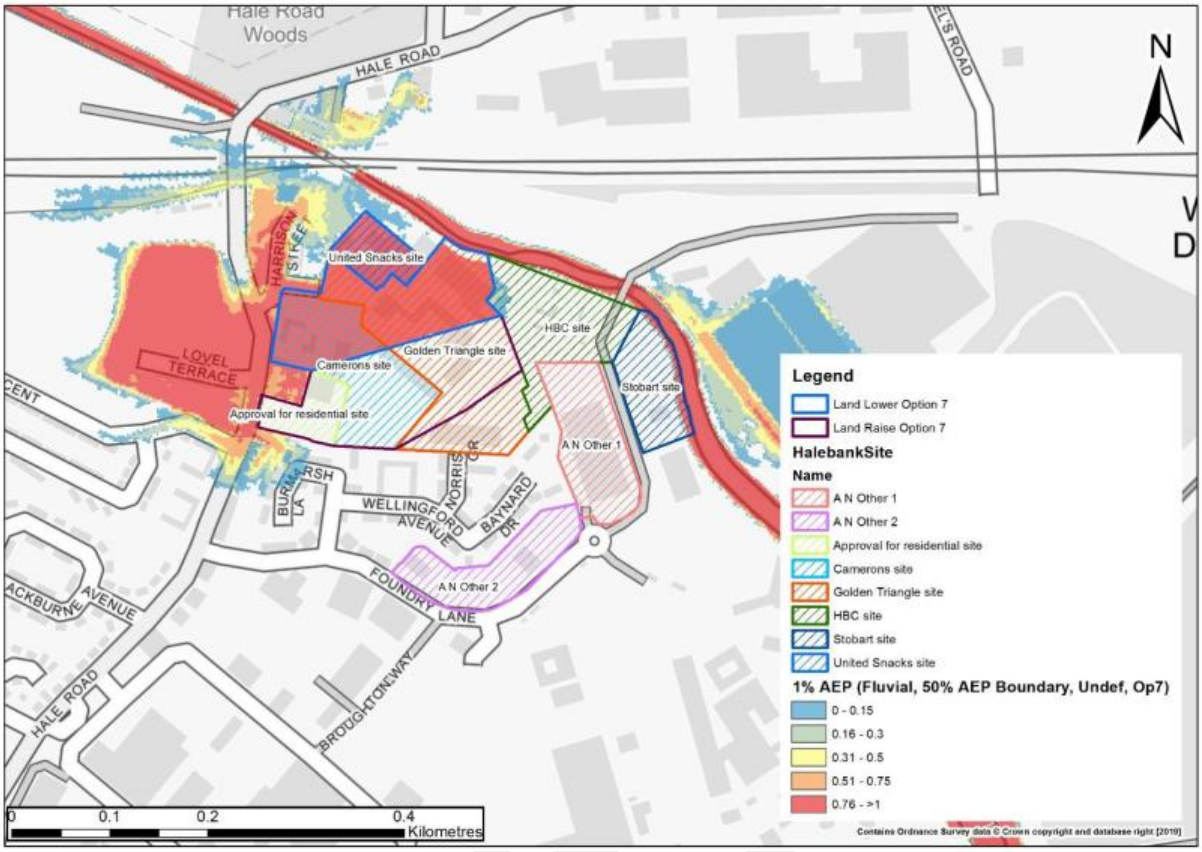

Figure 4-7 Modelled flood depths for Scenario 7 (1% AEP with 1% AEP tidal boundary) with site development layout

Depths in this run are approximately 1.5m which is comparably the same as seen in Scenario 6 meaning that flood depth is not increased anymore within the site when the total land lowered is reduced.

- In general, both modelled flood depths and outlines remain comparatively similar to the outputs from Scenario 6 meaning there is a potential for more developable land in the north-west corner with no adverse impact on flood risk.
- Both Scenarios 6 and 7 have shown that lowering land in the site closest to overtopping water is shown to capture much of the water that has been modelled as flooding the site during the existing scenario and other Scenario runs.
- Since the land raised in Scenarios 6 and 7 were raised above flood levels, further modelling would be required to accurately determine the ground level that would be needed to effectively allow water to attenuate in northern sites whilst not increasing flood risk elsewhere.
- Of the Scenarios modelled thus far, Scenarios 6 and 7 remain free from increasing flood risk elsewhere as a result of land raising.

4.5 Additional Storage Upstream

Adding flood storage basins or attenuation ponds around Ditton Brook, further upstream of the development sites may prove to have positive impacts and help mitigate the overall risk of flooding to the site. Figure 4-8 details some potential areas where this storage could be provided based upon LIDAR and general proximity to Ditton Brook. These are mainly focused on the left bank of the Brook due to previously mentioned contamination issues to land on the right bank of Ditton Brook. Additionally, the land between Speke Road and Ditton Brook is higher ground meaning there is greater capacity and flood storage volume to be gained from excavating here.

- A test model scenario, which lowered land at Hale Road Woods, saw no change to flood outlines to the development in a 1% AEP defended run.
- Options are considered preliminary at this stage.

As already discussed, the importance of locating these storage basins is critical however and as a result further detailed modelling would be required to accurately define the key locations and whether they have any effect upon flood risk mitigation.

- Further considerations of land ownership, services, defined excavation volumes and access for offsite disposal of materials has also not been made at this stage.

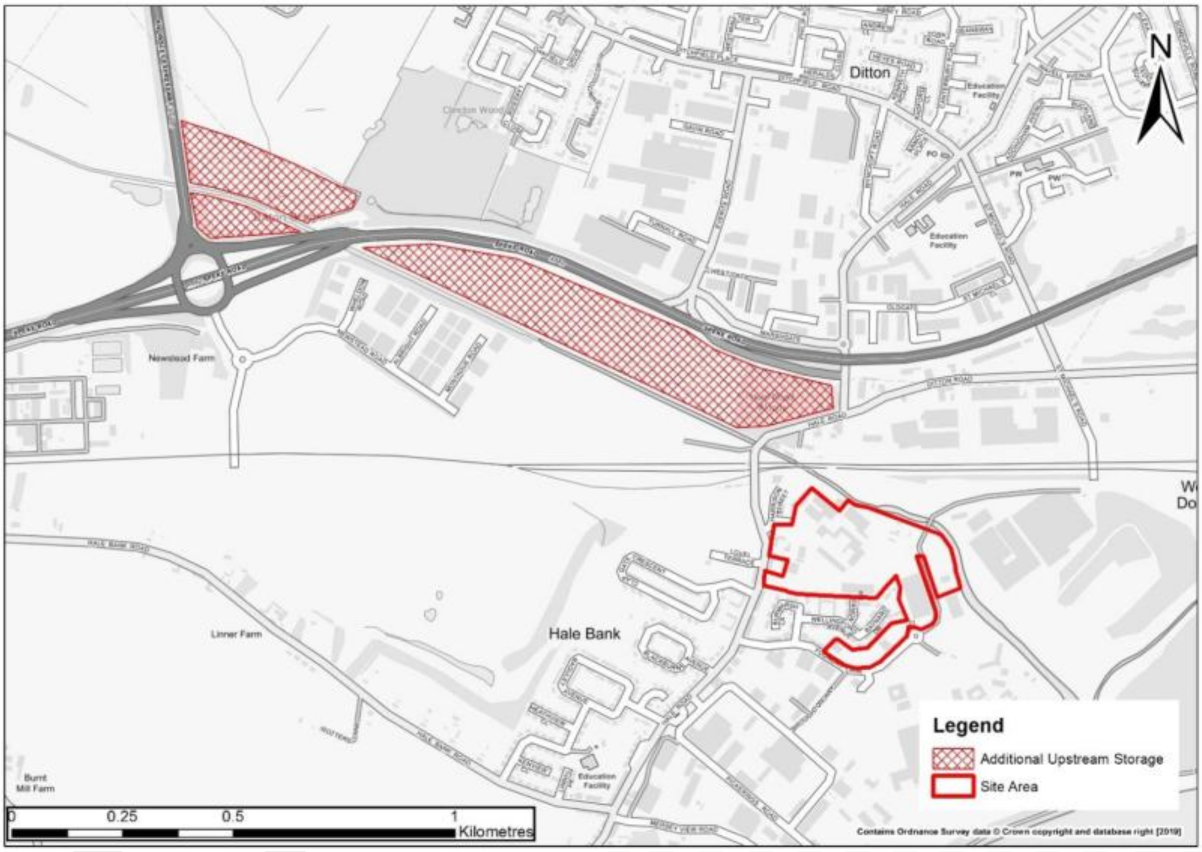

Figure 4-8 Potential areas for upstream storage

4.6 Stilted Development

Aside from land raising to remove buildings and development sites from flood risk, an alternative Scenario is the construction of stilted development. This allows for the developments to be removed from flood risk, without additional work in providing compensatory storage or increasing flood risk elsewhere. This method would require buildings to be raised above the modelled flooding depth, in the worst cases this would be approximately 1.3m.

- In addition, this Scenario would likely not be suitable for any residential dwellings due to the high vulnerability of the buildings and overall depth of flooding within the site.

Furthermore, stilted development does not aid the issues related to access/egress and safe evacuation during times of a flood. It is noted that 95% of the site is within a

Flood Warning Area, displayed in Figure 4-9, and regardless of the end result in terms of development, the potential users of the site should sign up to the Environment Agency early notification system to try and limit the potential impact of an impending flood event.

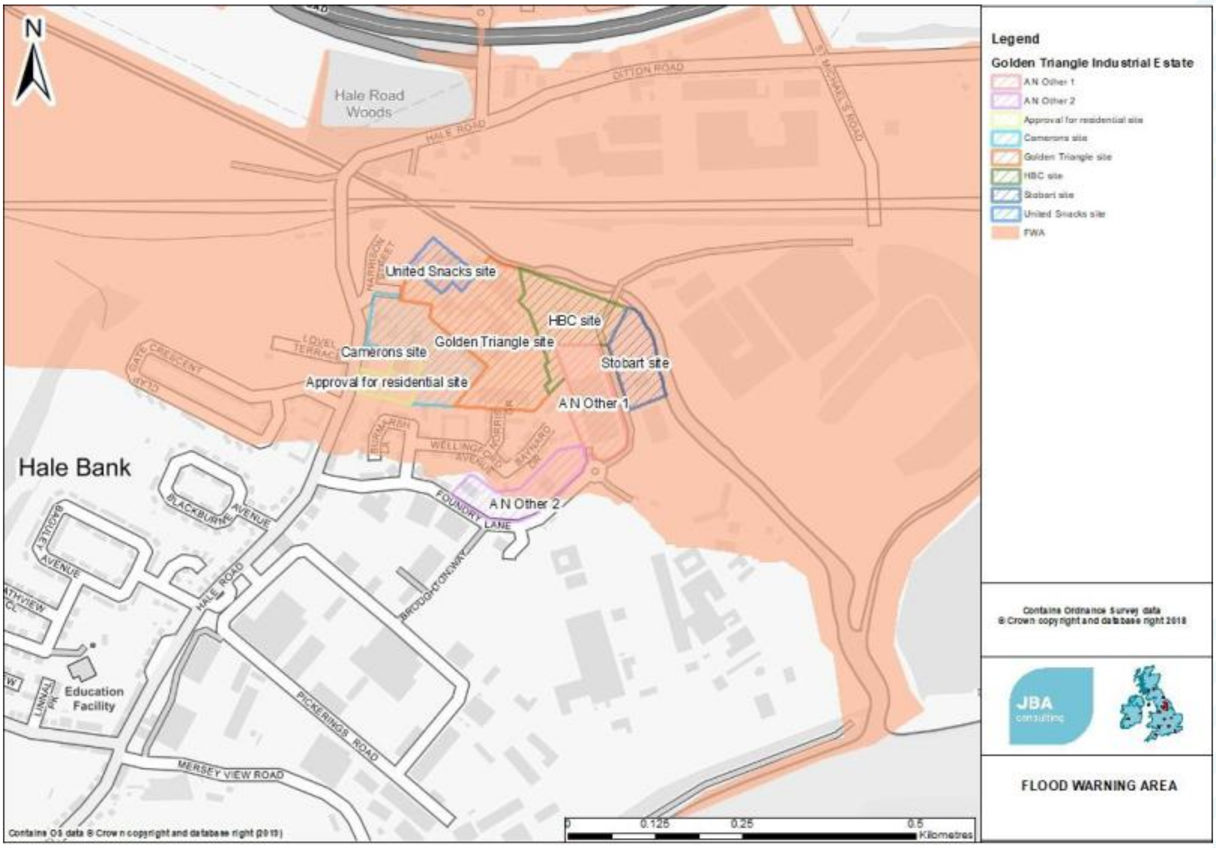

Figure 4-9 Flood Warning Area

4.7 Key modelling outcomes

It should be noted that:

- This is considered to be feasibility modelling
- Consideration of Flood Zone 2 has not been made and further consultation with the Environment Agency is required to confirm acceptability of modelling assumptions and downstream tidal boundary in particular.
- Land ownership has not been considered in-terms of land raising or lowering.
- Compensatory storage is only required to offset fluvial risk.
- Fluvial risk is not apparent based on a 50% tidal flood boundary for both the 1% and 0.1% events.

Key conclusions to be drawn from the Scenarios modelling:

- Despite Scenarios 1-5 providing localised reductions in flooding to certain site areas or in fact a prevention of flooding to the site as a whole by land raising/lowering or defence improvement. None of these manage to achieve this without exacerbating flood risk elsewhere and cannot be considered feasible for allowing development on the site without more detailed feasibility modelling and/or site specific FRA's.
- Further testing with Scenarios 6 and 7 managed to prevent flood risk increasing as a result of land raising suggesting further modelling scenarios should be based around these scenarios.

- Further modelling would be required to calculate more accurate ground levels to which any land lowering or raising would be required.

Possible alternatives to Scenarios include the use of stilled development (see 4.6) or a change in land use, i.e. more employment and mixed use rather than residential as this would be considered less vulnerable in regard to planning policy for flood risk and development.

5 Surface Water Management

5.1 Overview

Surface water management will form a key part of discussions when moving this scheme through the planning stages. There is a key flow route that currently exists through the Golden Triangle Industrial Estate, according to the EA Surface Water Flood Map. For the purposes of this assessment, the key flow routes have been quantified and will inform the next stage of development proposals in conjunction with the other findings within this report. Furthermore, likely attenuation volumes have been generated for this report as it is a requirement within the NPPF to ensure that flood risk is not increased elsewhere following development.

The Industrial Estate is predominantly a brownfield and urbanised development site. There are some smaller areas of open space, which have had limited development. Building and redeveloping the area, with sustainable surface water management in mind, can help:

- Facilitate new development removing reliance on upgrading public sewerage system at a local and regional level by remove surface water from the combined sewers by separating sewer or restoring existing land drainage networks (natural drainage)
- Reduce the volume of surface water by managing surface water runoff and reducing areas of impermeable surfaces
- Manage or reduce surface water flooding by maximising the potential for flood storage through ponds, swales and reopening ('day lighting') sections of the existing drainage network including surface water sewers and culverted watercourses
- Manage water on the surface during exceedance events by re-establishing overland flow paths and designing multi-functional open spaces to safely route and manage temporary surface water
- Enhance local biodiversity and water quality by protecting, enhancing and providing high quality blue and green infrastructure
- Improve local access to natural, shady outdoor spaces
- Provide an attractive setting for development, with better public access, particularly around the riverside

Without a high-level strategy, there is a possibility that development will occur in isolation, adopting inconsistent SuDS or more traditional systems that reduce the likelihood of achieving many of the benefits identified above. Managing surface water on a site by site basis can also be less cost effective especially if each site has to implement all three stages of treatment and sites have to sacrifice larger areas to store flood water.

In order to avoid this and ensure HBC achieve their development objectives for the industrial estate, a single and co-ordinated surface water management approach across the whole development area is required. By doing so, constraints can be overcome, opportunities realised and sites can be brought forward through a coordinated and logical approach.

5.2 JFlow

The nationally produced EA surface water flood maps indicate the presence of a key flow route throughout the industrial estate. For this assessment, a JFlow model has been generated to abstract more detailed information relating to the surface water management for the site. This model will enable the quantification of flow routes so they can be attenuated within the site's boundary, ensuring that flood risk is not increased elsewhere following development.

It has been assumed that a 12mm/hr drainage rate will be required in the JFlow setup to account for urban drainage within the area. However, it is noted from the site visit undertake by JBA on 15 January 2019; that the current drainage network appear to be heavily silted.

5.2.1 Model Setup

The JFlow model was set up in line with the updated Flood Map for Surface Water (uFMfSW) methodology which was completed in 2013. This involved the delineation of surfaces based on OS MasterMap fields which define areas based on their use, e.g. buildings, paths, gardens. From this, spatially varying roughness values were incorporated into the model based on the corresponding land-use.

Roads were represented within the model by lowering the road polygons by 0.125m (height of a British standard kerb) as they provide a volume of storage which is not accounted for within the LiDAR.

The three-hour storm events were considered to be the most reflective of surface water flood risk to the site and as such, these events were chosen for analysis in Section 5.3.

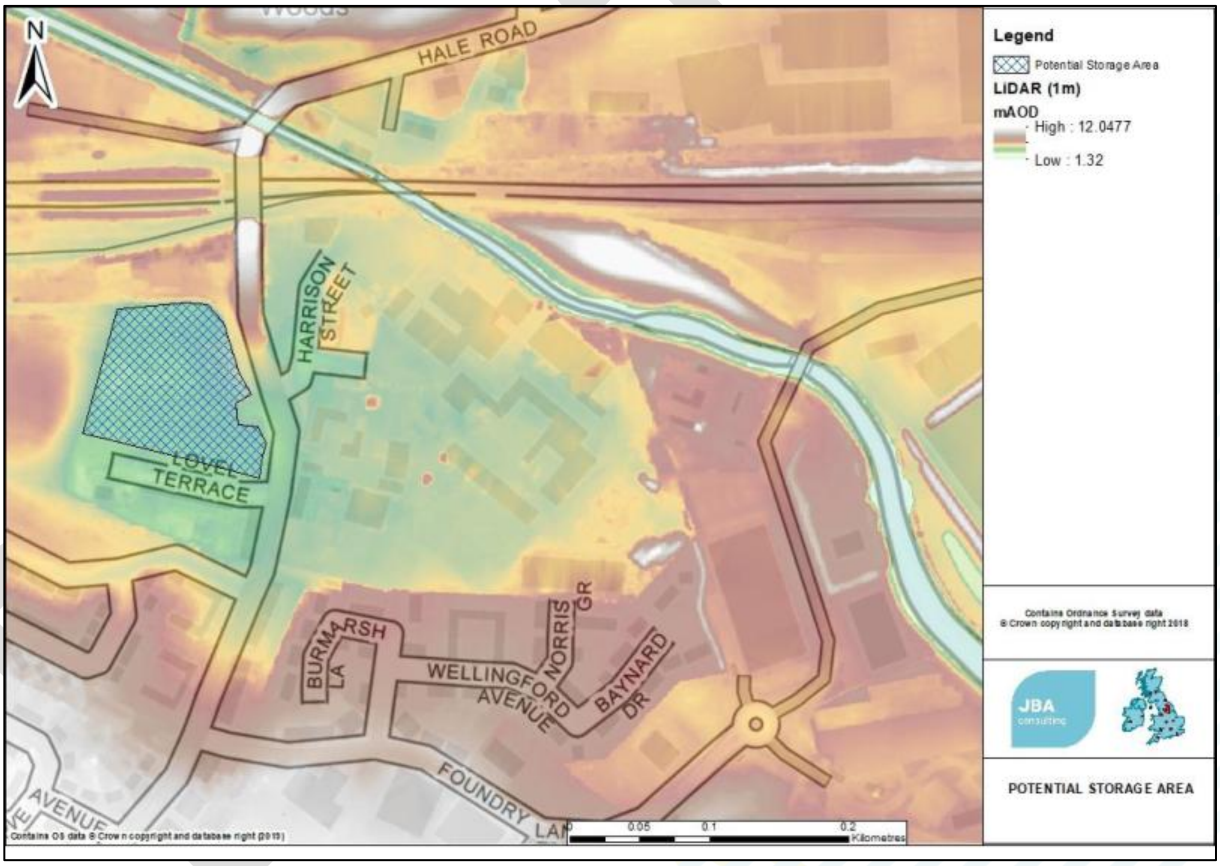

Figure 5-1 Potential storage area north of Lovell Terrace

Two models were developed:

- Model-001 – Baseline Scenario
- Model-002 – Potential Storage Area with land lowered by 0.75m (as shown in Figure 5-1)

Model-002 includes the creation of extra surface water storage within the area of land identified in Figure 5-1. Figure 5-1 displays one of the key surface water constraints to flood risk in this area as topography is noticeably lower within the industrial estate.

5.3 Surface water model outlines (0.33% AEP event)

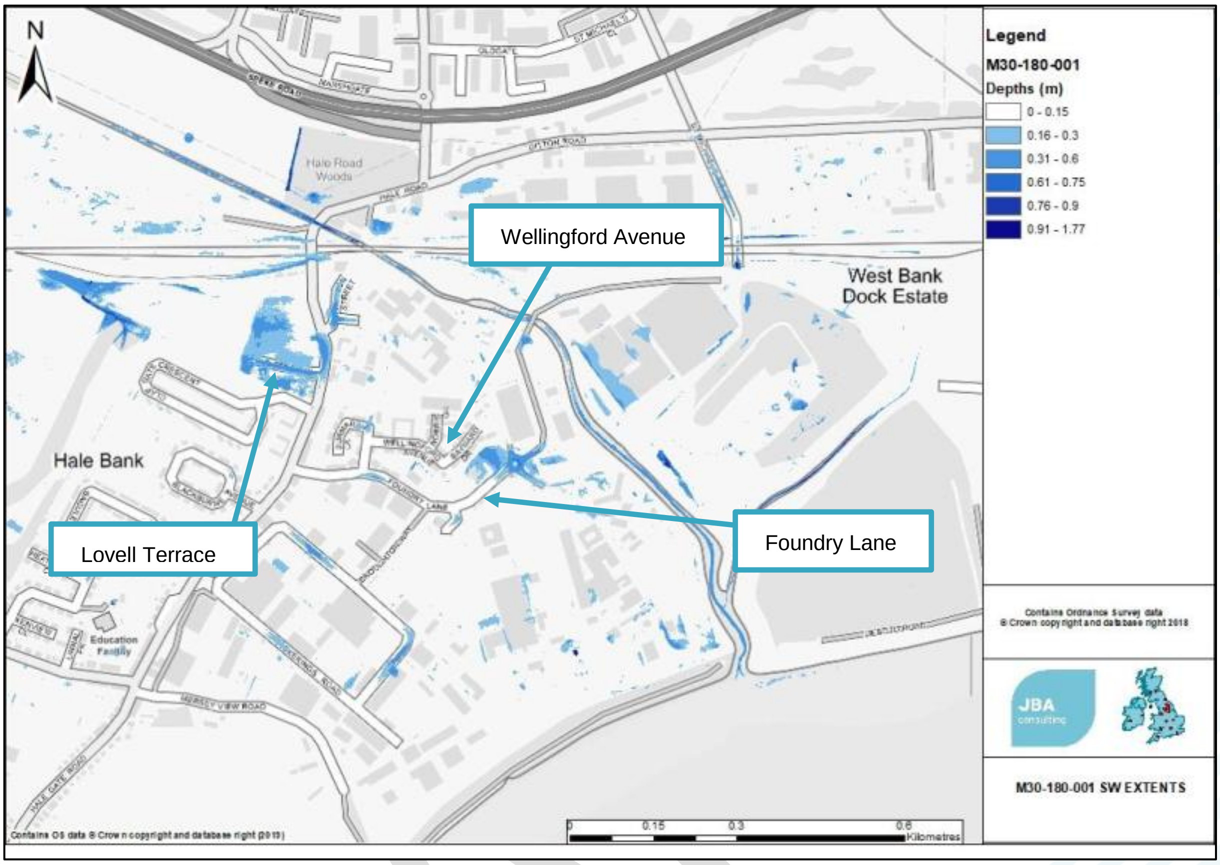

Figure 5-2 3.3% AEP, 3hr storm, Model-001

For the 3.3% AEP event, there are some small localised areas of ponding within the mapped extents. These coincide with areas north of Lovell Terrace and between the new housing estate located on Foundry Lane and Wellingford Avenue. These areas will flood to greater depths of flooding during larger, more intense surface water flood events.

As the housing estate on Foundry Lane is raised compared to surrounding ground levels this results in some ponding along this road.

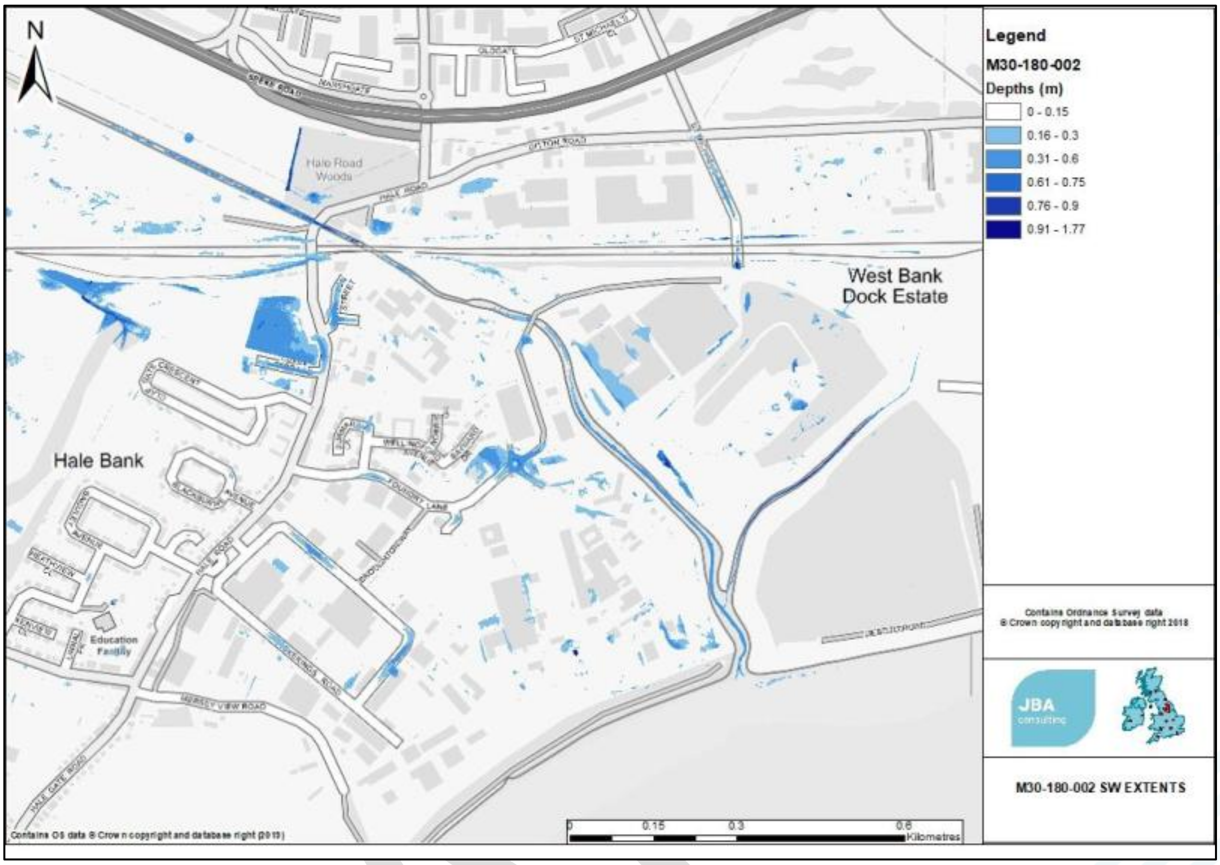

Figure 5-3 3.3% AEP, 3hr storm, Model-002

In this scenario the land north of Lovell Terrace was lowered by 0.75m to model how flood risk could be mitigated through the use of a detention basin in this land (alternatives including tank sewers may also be considered). The area is a designated Village Green. Detention basins are only operational during times of an extreme flood. The practicalities surrounding altering the status of village green into a detention basin, including consideration of historic land uses and contamination issues have not been investigated further at this stage.

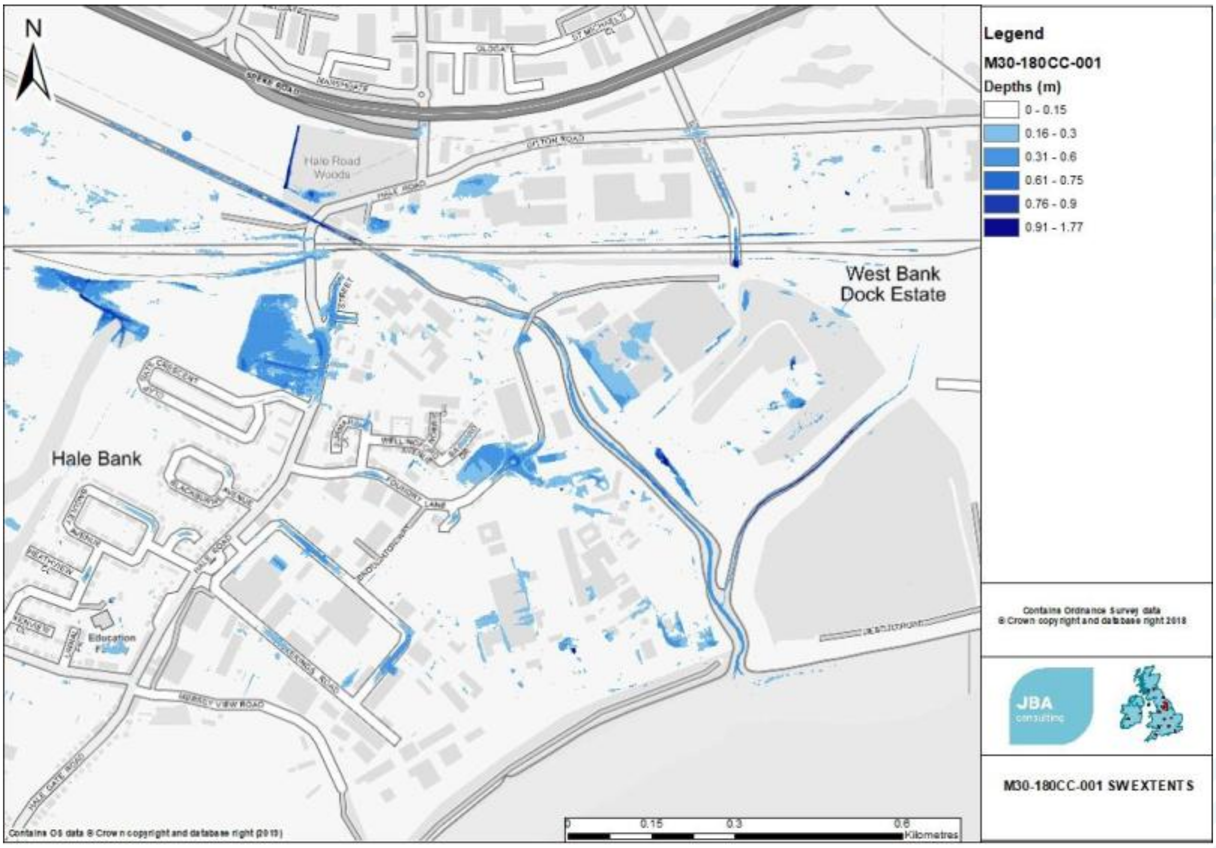

Figure 5-4 3.3% AEP + CC, 3hr storm, Model-001

Climate change uplifts have been applied (10%) for the 3.3% AEP event to simulate the anticipated increase in rainfall due to climate change. This results in a larger volume of water emerging from the Village Green and across the land towards the industrial estate.

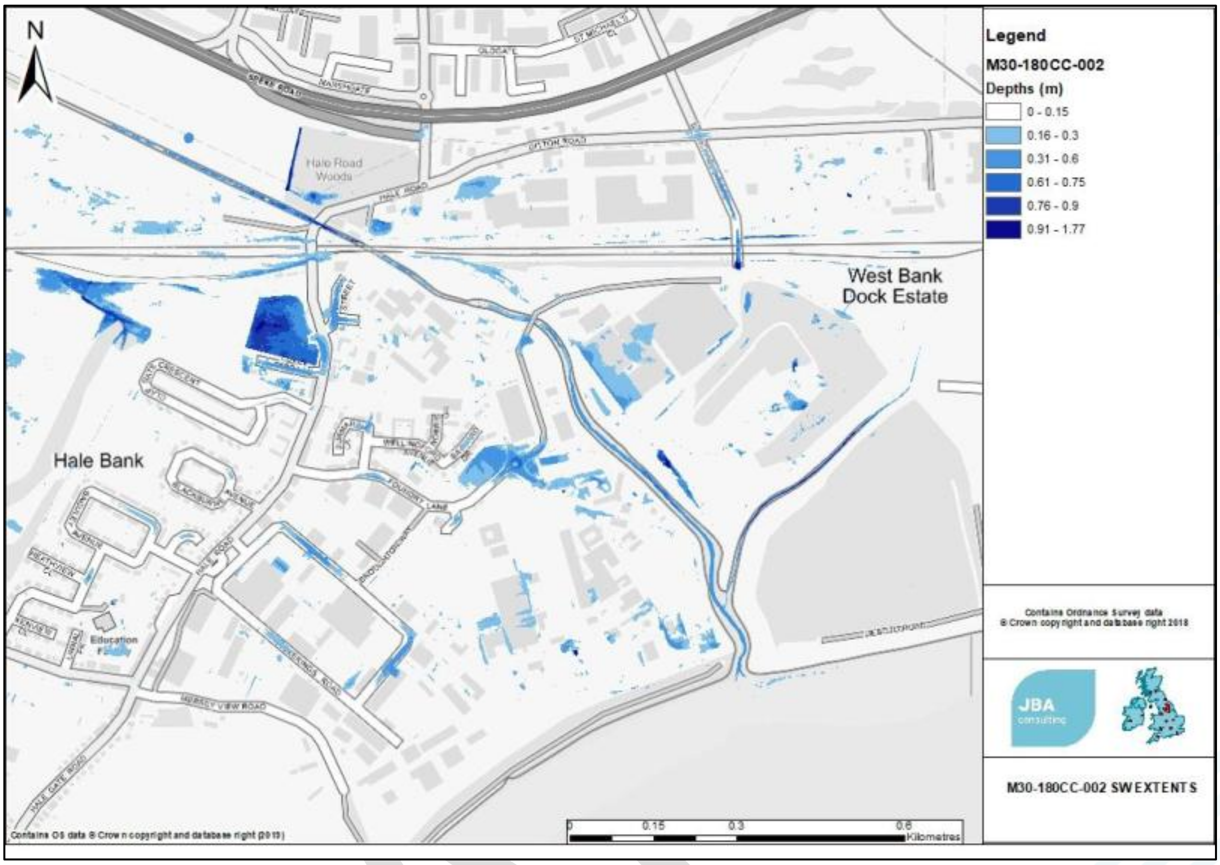

Figure 5-5 3.3% AEP + CC, 3hr storm, Model-002

Runoff is more successfully confined to the land north of Lovell Terrace due to the creation of a detention basin in this area. Whilst ponding still occurs around the roundabout on Foundry Lane, as discussed, this may be an overestimation of the total volume of runoff in this area due to the extra drainage along this road.

5.4 Surface water model outlines (1% AEP event)

Similar flood outlines for the 1% AEP event have also been mapped.

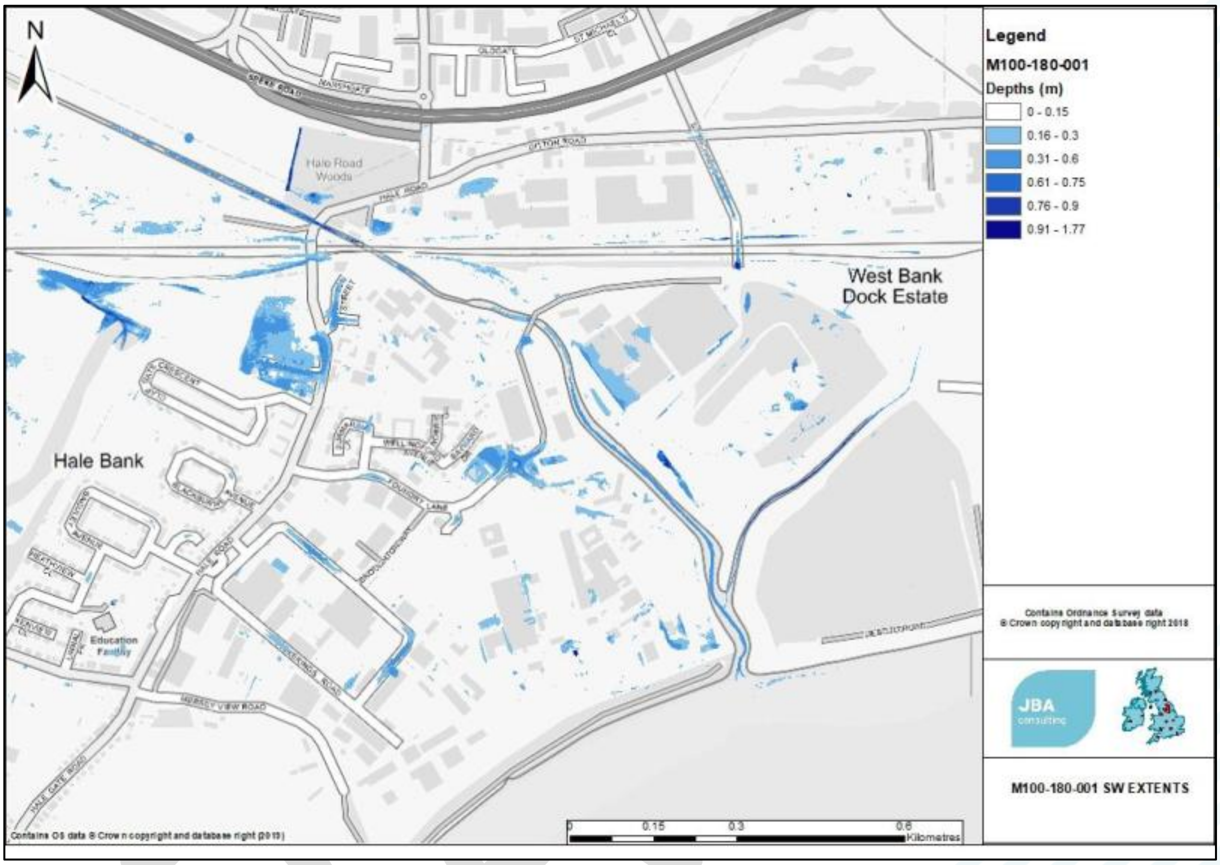

Figure 5-6 1% AEP, 3hr storm, Model-001

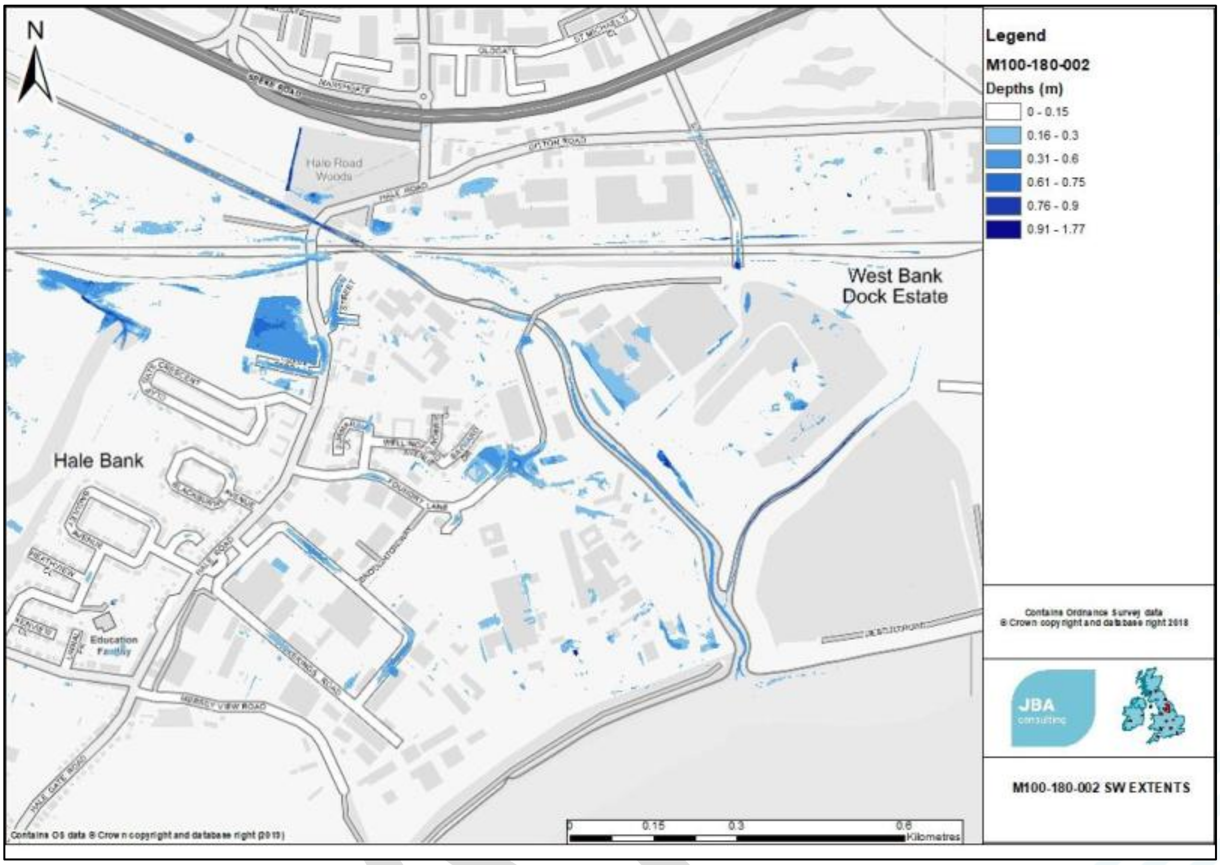

Figure 5-7 1% AEP, 3hr storm, Model-002

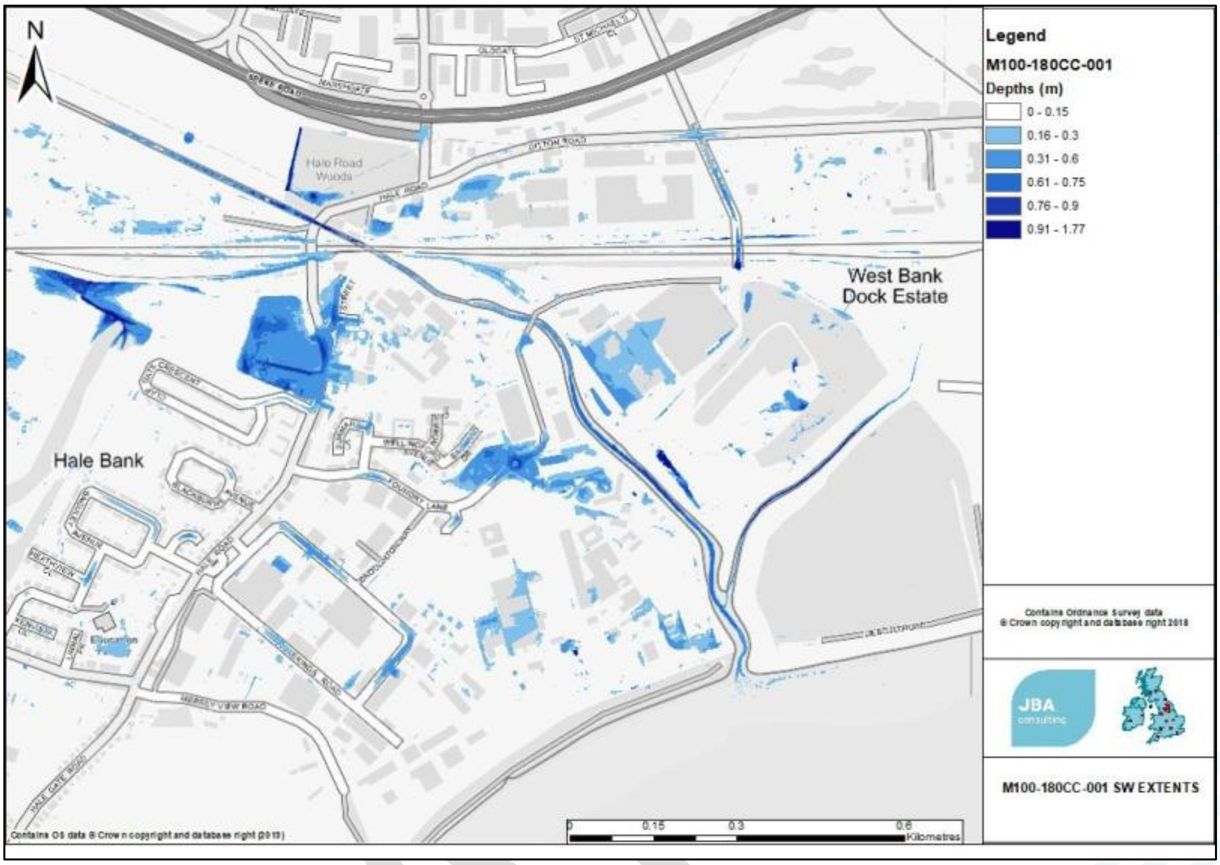

Figure 5-8 1% AEP + CC, 3hr storm, Model-001

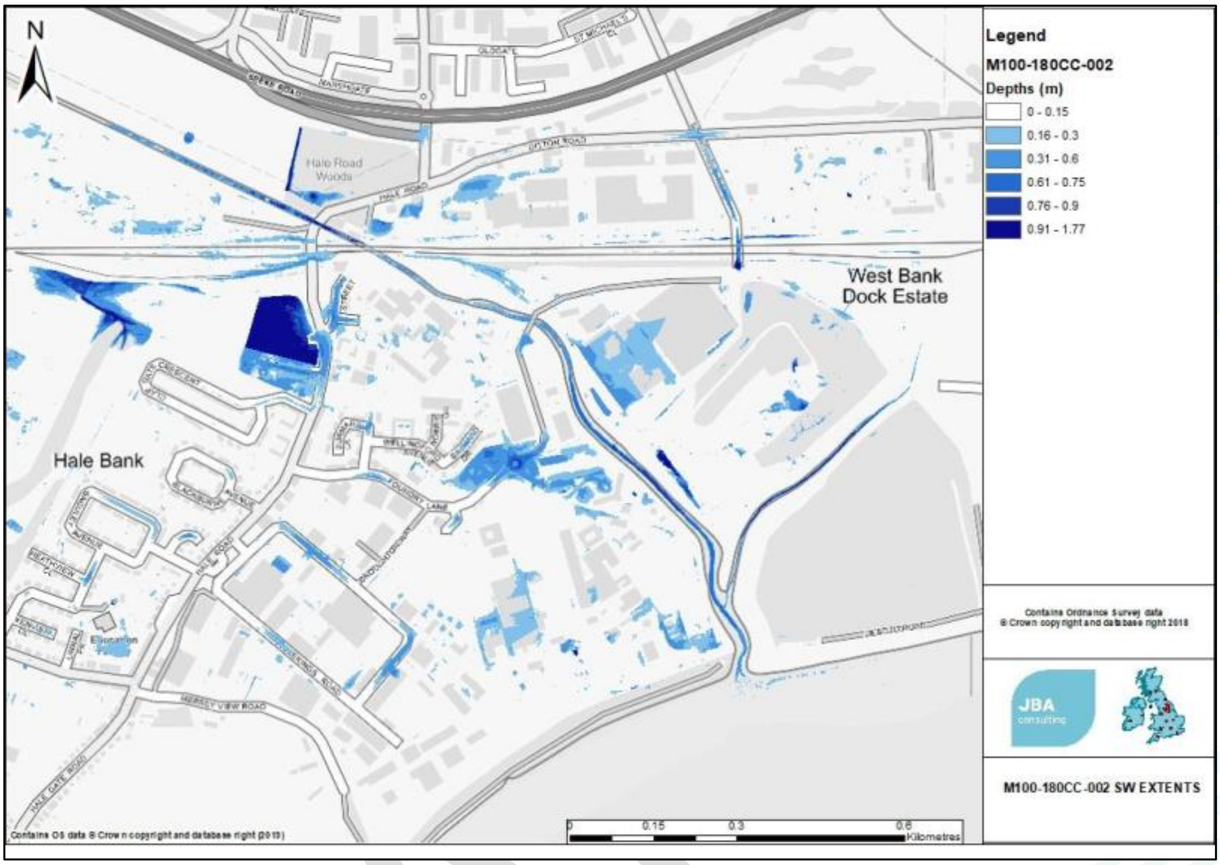

Figure 5-9 1% AEP + CC, 3hr storm, Model-002

5.5 Surface Water Analysis

There is a significant surface water flood risk issue related to the ponding of runoff on the site identified as 'A N OTHER 2'. This is driven by the fact the housing estate on Wellingford Avenue is higher in elevation than the 'A N OTHER 2' site. There are kerb drains installed along Foundry Lane which may be helping to mitigate this surface water flood risk at a more detailed level than the current model accounts for. No further drainage information is available regarding the drainage along Foundry Lane.

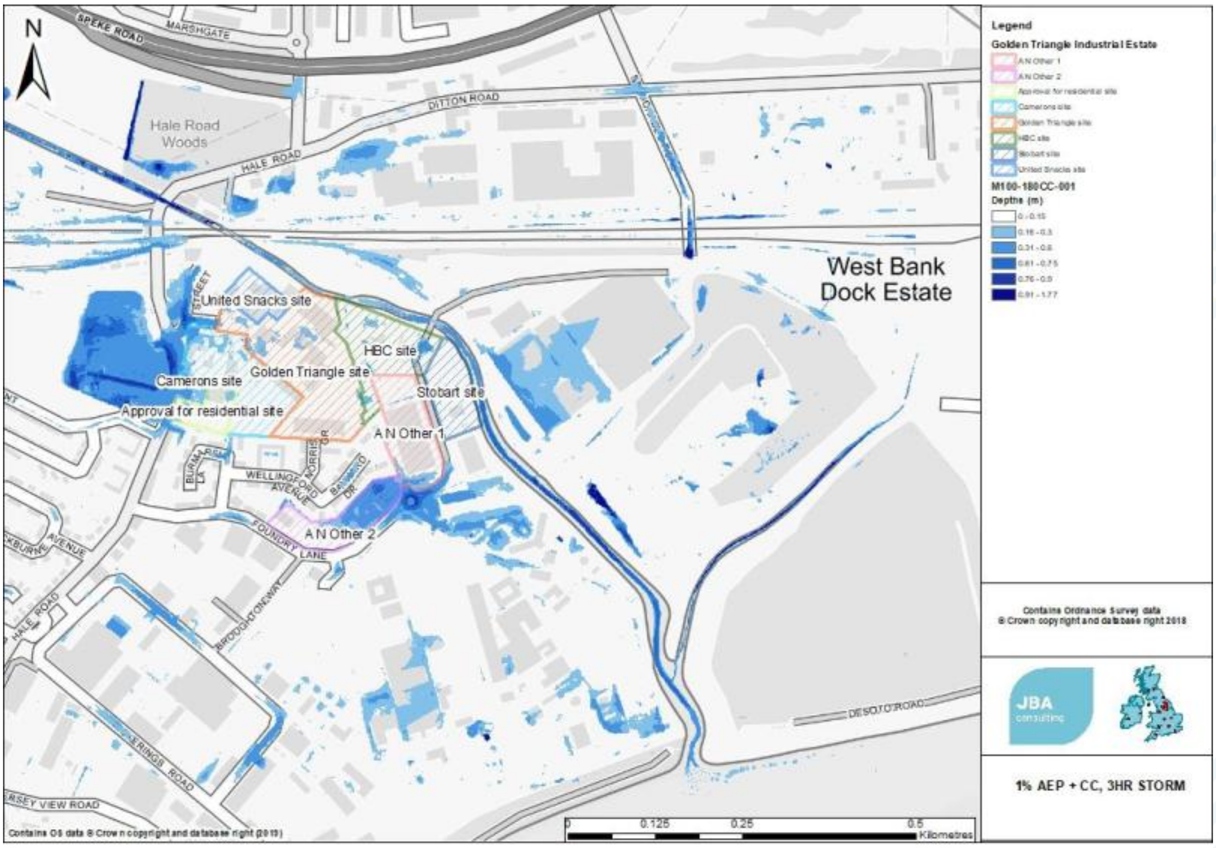

Figure 5-10 1% AEP, 3hr, development layout risk (Model-001)

Figure 5-10 displays the surface water flood risk to the site for the 1% AEP + CC, 3hr storm duration. Overlain onto the extents is the potential development layout plan provided by HBC. It indicates that across the site, there are a few localised sections of surface water ponding that may be accumulating against buildings. The key surface water flood risk issue to the site is within the 'A N OTHER 2' boundary where approximately 50% of the site is within flood extents to a depth greater than 150mm. Model outlines indicate flooding in this area and if the site were to be developed, it would require appropriate mitigation to reduce the level of flood risk to the site.

Either, 'A N OTHER 2' will require effective containment of the potential runoff observed in Figure 5-10, or, this site could be highlighted as a sacrificial area where runoff could be stored before out falling into Ditton Brook. Ground levels within 'A N OTHER 2' are at an average of approximately 7.0m AOD, with levels in the brook on average about 2.0m AOD. Therefore, a reasonable fall will still be achievable from the site to the watercourse, which should allow for gravity-fed free discharge.

'Cameron's Site', the site closest to Hale Road, is within an area at risk from surface water runoff in this area for the baseline model scenario (Model-001). The flood risk is improved by the lowering of the land north of Lovell Terrace as the runoff is better confined within this area, as shown in Figure 5-11.

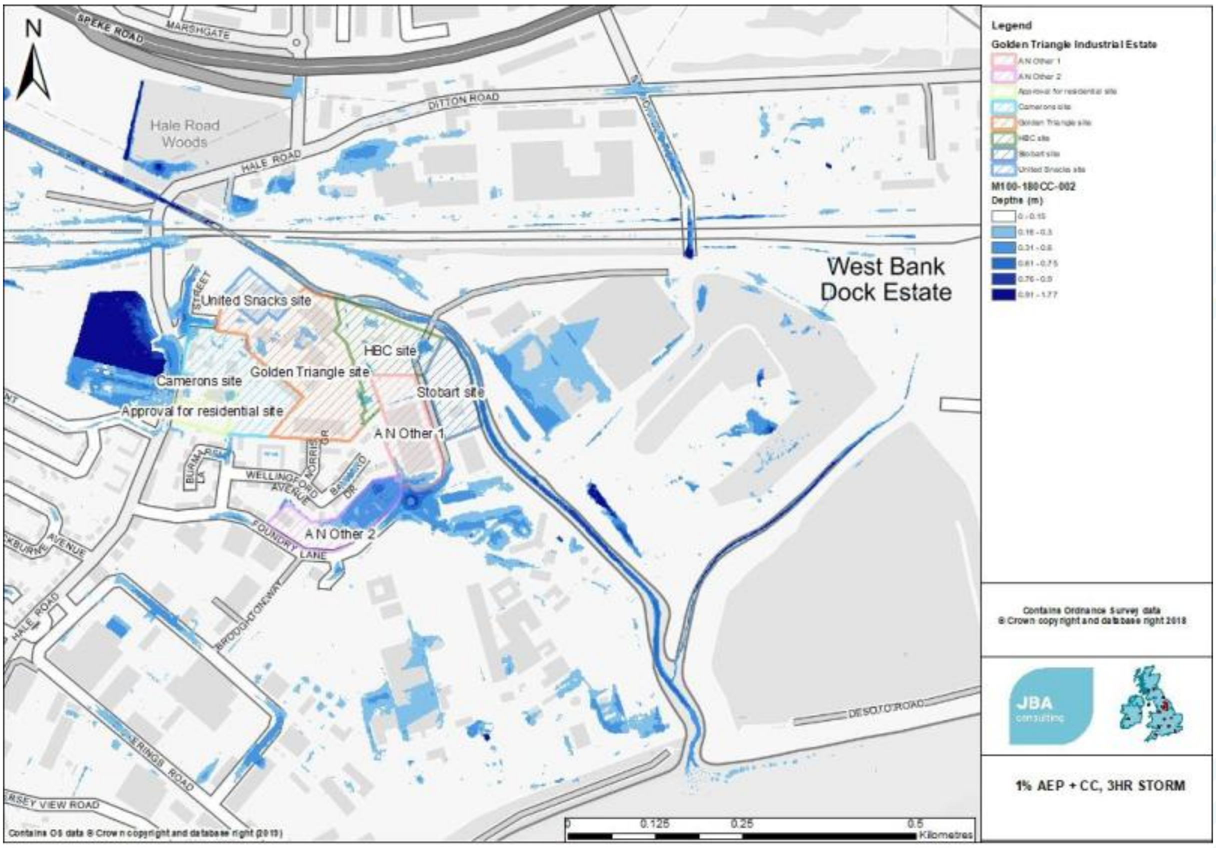

Figure 5-11 1% AEP, 3hr, development layout risk (Model-002)

The modelled scenario of lowering the land north of Lovell Terrace results in an improvement to the local vicinity in terms of surface water flood risk and can be seen by the increase in depths of flooding across the field. This also reduces the volume of runoff available to cause flood risk issues in the area. The existing houses along Lovell Terrace are at risk from surface water runoff in both modelled scenarios, however, the depths of flooding are noticeably shallower, ranging from approximately 0.5m of flooding to approximately 0.3m of flooding, for scenario Model-002.

6 Surface Water Management Options

Having developed the understanding of the existing levels of risk associated with surface water flooding and the potential flooding mechanisms, this section will assess the feasibility of employing Sustainable Drainage Systems (SuDS) within the Industrial Estate.

The aim of SuDS is to mimic the natural processes surface water flows would undertake within the undeveloped catchment area. The intention is to reduce overall flood risk away from properties and develop a drainage system that can manage the exceedance of the existing traditional drainage during extreme rainfall events.

This section will identify the SuDS approaches which may be feasible to adopt across the Industrial Estate by utilising existing modelling output to undertake a simplified assessment within drainage sub catchments to quantify the flood risk benefits that an area wide SuDS approach can provide.

There are a number of challenges associated with retrofitting SuDS within an existing area of intensive development. Taking these constraints into account, this preliminary review has considered a spatial approach to the application of SuDS based on the likely ease of implementation.

The assessment has considered the following in order of priority in order to assess the level of flood risk benefit that can be provided:

1 Utilisation of existing undeveloped green open areas **(Key constraint - third party land ownership issues)**.

2 Incorporation of attenuation and other SuDS approaches in identified new development sites. A Key consideration for these sites (and all other development areas) includes the need to include for the provision of site specific attenuation including climate change impacts AND consideration of offsite flow routes and wider attenuation requirements.

3 Retrofitting of SuDS to existing development **(Key constraint - third party land ownership issues and potential cost)**.

The assessment has then been used to identify the potential benefits that could be provided and sets out the overriding case for a strategic approach to surface water flooding.

Surface water from each area may be managed through the use of SuDS provided that identified areas of land are considered suitable and can be made available for temporary flood storage. HBC will need to consult further with land owners to determine the suitability of measures proposed and areas identified.

No specific ground investigation information is available for these areas and confirmation of services will be required. On the basis that basins and swales will provide attenuation, rather than act as soakaways, positive connections to existing or new surface water system may be required to ensure. It is noted that the majority of the area is likely to require the use of the existing drainage system based on the distance away from the section of available watercourse to which discharge may be acceptable. There may also be opportunities to direct flows to limit flooding to areas of highway. These approaches will require further engagement with the Highways Authority and United Utilities and the Environment Agency.

Surface water modelling does not include threshold surveys to individual business units. A threshold survey is recommended to screen and confirm actual development that is at risk of surface water inundation. Specific property at risk would then be identified.

It is recognised that sites may be prone to ongoing flood risk, due to the likely timescales involved in implementing a site wide SuDS Strategy. It may not be possible to reduce the flood risk to all property and therefore both new and existing development should consider flood resilience and resistance measures to both construction and operation. Flood resilience helps reduce the damage once floodwater enters the property. This includes measures such as installing high level storage racking and raising electrical and IT networks and machinery above the maximum expected flood level. Flood resistance is used to limit water entry into the property. This may include door and flood barriers, dewatering pumps and ensuring walls are appropriately watertight up to the maximum anticipated flood level.

Further work will need to include more detailed modelling of attenuation features. This will require further adaptation of the integrated modelling to more fully represent attenuation features and requirements for connectivity and discharge.

It is envisaged that standard SuDS details will be used for all redevelopment areas. This will help to ensure effective standardised construction details and delivery of longer-term maintenance planning. Whilst these details are likely to be developed as part of further refinement of this Surface Water Management Plan, they will be based on meeting the requirements of the current HBC SuDS Guidance and the CIRIA SuDS Manual.

Typical attenuation requirements have been estimated for identified development sites. This assumes green field runoff rates for all new development. New development may also help alleviate existing flood risk especially where addition attenuation is incorporated into the design. This should include detailed review of options for community scale flood storage within obsolete development plots (possibly including the village green) where premises are coming up for renewal.

This preliminary review is based on an assumption that surface water runoff will tend to flow along highways to the river. However, surface water does appear to follow highway topography (as defined by LiDAR) and reliance on areas of third-party land ownership will be required to mitigate flood risk.

Attenuation requirements are based on achieving brownfield runoff rates. Measures to limit surface water risk to individual development sites and adjacent areas in general will need to be based on a more stringent approach to risk management.

Numerous approaches to SuDS are available and in this instance, we have assumed these will predominantly be based on a combination of basins, swales or tanks. However, other options should not be discounted as they may have less impact on development proposals and land take. For example, through design, new and existing development could be encouraged to accommodate green roofs where practicable and all new carparking must accommodate SuDS. The multifunctional benefits to the Industrial Estate (above flood risk management) of integrating SuDS should be a key driver for their incorporation.

The following key principals should be applied:

- New development should include consideration of onsite surface water management to offset runoff from development. Surface water runoff is to be managed at source (avoiding disposal to public sewer systems wherever possible). In addition, development will need to consider the impact and interactions with offsite flows. Offsite flow routes will need to be managed to ensure that flood risk to adjacent property is not increased following construction of any new building. New development will need to consider flow routes and consider the integration into the wider flow route management of the estate.
- Developers should be required to set part of their site aside for surface water management, to contribute to flood risk management across the wider area and supplement green infrastructure networks.
- New development must strive to achieve greenfield runoff rates.
- Developers should also be required to maximise permeable surfaces and encourage innovation in managing surface water (e.g. green roofs and permeable paving to be retrofitted wherever possible, with sites using

surface water as a resource rather than disposing of it). All new carparking areas must accommodate SuDS.

- Landscape management practices will need to be modified to contribute to the effective management of surface water.
- Surface water management when undertaking public highways schemes in the industrial estate. All new schemes should include appropriate SuDS to manage flood risk. Potential opportunities for retrofitting and integrating SuDS within adjacent green verges and HBC owned open space. Private highways, carparking and accesses should also include SuDS.

As well as ensuring all schemes comply with the national standards and local policies on flood mitigation, the HBC may seek to secure SuDS schemes which demonstrate best practice and maximize amenity, biodiversity and other benefits to the local area in response to non-drainage related policies. Fundamental to this approach are the four components of SuDS design as set out in the CIRIA SuDS Manual (C753):

- water quality
- water quantity
- amenity
- biodiversity

The above components shall all be considered with equal weight and should be considered in a holistic way to achieve 'best value' from the design.

6.1 Runoff Mitigation Measures

The modelled surface water extents indicate flooding to the site named 'A N Other 2'

Whilst it is noted that we assume the additional kerb drains along Foundry Lane are aiding to mitigate the modelled surface water flooding extents, further mitigatory measures could be integrated to ensure that as much runoff as possible is contained within storage areas rather than encroaching on development.

6.2 Outline Drainage Strategy

The purposes of the outline drainage strategy is to ensure that enough attenuation is provided to allow flows to be restricted from the site at an agreed rate. At this stage, specific discharge rates have not been agreed, therefore, a rate has been assumed. The site has been previously developed which indicates that the discharge from the site is currently unrestricted. From the 2011 Level 2 Strategic Flood Risk Assessment (SFRA), previously developed sites should seek to achieve a 50% betterment on the existing brownfield runoff rate.

The total site area of the provided shapefiles for the Golden Triangle Industrial Estate totals 8.58 ha. For the purposes of this calculation, 95% of the total site area has been assumed to be impermeable and this area will result in runoff that will need to be attenuated.

The Modified Rational Method can be used to estimate the unrestricted peak runoff rate from the site.

Modified Rational Method

$$Q = 2.78CiA$$

Where:

Q = Peak flow rate (l/s)

C = Runoff coefficient (Dimensionless)

i = Rainfall intensity (mm/hr)

A = Area (ha)

Q = 1636.7 l/s (30 year return period).

This gives a peak unrestricted runoff rate of approximately 1640 l/s for the site. A 50% betterment would result in a target discharge rate of 820 l/s for the 8.15 ha site area.

Table 6-1 Preliminary Attenuation Requirements

Design event (including climate change)	Critical storm duration (Hours)	Inflow volume (m^3)	Outflow volume (m^3)	Attenuation required (m^3)	Time to empty (assuming no infiltration) (Hours)
1:30 rainfall plus 30%	0.5	2493	1033	1460	0.7
1:100 rainfall plus 30%	0.5	3335	1033	2302	1.1

Table 6-1 is based upon the calculated brownfield runoff rate, with a 50% betterment applied, in line with the 2011 SFRA.

Table 6-2 Greenfield Runoff Rates

Method	IH124	FEH
QBAR*	46.66	30.86
1 in 1 year	40.60	26.85
1 in 30 years	79.32	52.46
1 in 100 years	97.06	64.19
*QBAR - Mean Annual Flood flow rate.		

Confirmation of a specific agreed discharge rate will be required at a more appropriate stage of planning. For reference; Table 6-2 indicates the greenfield runoff rates for the site, dependent upon the method for estimating the greenfield runoff rate, the estimated brownfield runoff rate is between 10 and 16 times greater than the greenfield runoff rate (30 year return period). Longer term critical storm duration should also be considered.

It is now recognised that surface water flooding at the Industrial Estate is a result of extensive historical development that included overreliance on conventional drainage systems to convey surface water to the river.

Surface water flood risk will now only be reduced through positive interventions including enhanced dependence on surface water flood attenuation measures, to be implemented through the planning system. Key measures required to help manage surface water flooding comprise:

- For new development, the introduction of SuDS to manage surface water runoff by attenuation of surface water for design flood events including climate change. This may need to include provision of additional storage capacity to help offset wider flood risks in the area;
- Retention of available green space areas for wider community scale flood alleviation; and,
- Retrofitting of SuDS within areas of private land ownership and highways.

7 Conclusion and Recommendations

This report is to assess the development feasibility and suitability of the GTIE, located in Halebank, Halton. From the latest EA flood zone mapping the site was deemed to be at risk from both fluvial and tidal sources, these being from Ditton Brook and the Mersey Estuary respectively. This risk has been further interrogated through recent and approved EA modelling on both of these watercourses.

Approximately ≥50% of the site is located within Flood Zone 3.

There are flood defences in place along Ditton Brook although these are graded at a poor or very poor condition and as such cannot be effectively relied upon to protect the development site from flooding.

Fluvial risk to the site is primarily focused upon the western sites in a 1% AEP undefended event, water depths here are approximately 0.13-0.33m. This worsens in the future risk scenario with added climate change values whereby depths increase to 0.2-0.5m.

Tidal risk (modelled using a 1% AEP boundary placed upon the Ditton Brook) is also primarily focused upon the western-most sites though there is an additional flow path from further downstream on Ditton Brook that sees inundation to the 'A N Other' sites though this is during a 0.1% AEP event. The undefended tidal risk sees the western half of the site being flooded whilst the remainder remains largely free from risk. Depths of water within the site during a 0.5% tidal undefended scenario are between 1.11-1.5m.

Flood risk, both fluvial and tidal, appears to stem from the bank and/or defences failing around a culvert that passes underneath the railway; north of the site at the top of Harrison Street. Flooding begins here with flow paths moving down Hale Road and through the site.

In order to confirm the likely impacts of a reduced tidal boundary conditions on fluvial risk a 50% AEP tidal event, taken from the Mersey Estuary model, has also been applied at the downstream boundary of Ditton Brook. Again, combined probability analysis has not been undertaken but the combination of a 1% AEP fluvial event, combined with a 50% AEP tidal event, still exceeds typical design flood standards for flood risk and planning.

Under these conditions the site is does not flood from a fluvial dominant scenario.

Outside of the Industrial Estate fluvial flooding is predicted to still occur on the left bank alongside Hale Road and to the warehouse facility located beyond the left bank of the brook to the east of the Stobart site. With this lower tidal boundary being applied, flooding is mainly contained to depths of 0.1 - 0.3m within these offsite areas.

Modelling indicates that fluvial risk does not result in inundation of the Industrial Estate during the 1% AEP event. Whilst the estate will remain at risk of tidal inundation, the absence of fluvial flooding potentially negates the need for any compensatory storage required to offset land raising.

However, based on published mapping the site remains at risk of fluvial inundation during a 0.1% AEP event and land raising under this event would reduce available floodplain storage.

Hale Road to the immediate west of the site cannot be relied upon as an emergency access/egress route due to the roadway seeing flooding during both fluvial and tidal events. Foundry Lane to the east and south remains largely free with this being the preferred access route.

Land raising options focusing upon raising these western sites out of flood risk whilst lowering areas both internally as a sensitivity test and outside the site so as to provide compensatory storage due to the fluvial risk that has been modelled. In the first 3 land raising options, flood risk to the development sites can be prevented though this is alongside additional flood risk being created elsewhere. This on its own would be deemed unacceptable as a future development option.

Lowering land internally in the west sees the 'Stobart' site being inundated with flood water to depths of 1.25m, essentially making this site an artificial flood basin. External land lowering focused on the Halebank Village Green to the west of Hale Road sees the green space work effectively to attenuate water. Land raising/lowering levels were based upon modelled levels with no additional consideration given to the issue of contaminated land at this site which could likely have constrictions upon development options.

The outline drainage strategy in Section 6.2 provides an indicative estimation of the likely required volume of attenuation to ensure that flows can be restricted to a pre-agreed rate. Whilst rates have not been agreed at this stage, it is assumed that a 50% betterment will be sought on the existing brownfield rate, in line with the recommendations made within the 2011 SFRA.

Future recommendations of this feasibility study would suggest:

- Consultation with EA on acceptable tidal boundary influences upon flood risk, i.e. a 1% AEP or 50% AEP boundary.
- Consultation regarding land ownership at the development.
- Consideration of changing land use, i.e. a focus on mixed use or industrial.
- Consideration of combined land raising and stilled development where appropriate to be supported by further modelling.
- Accurate potential of developable ground levels as a result of contaminated land issues in the site location.

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