

River Avon Tidal Flood Risk Management Strategy

**Activity 9B: Options
Identification and Environmental
Appraisal Addendum**

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Quality information

Prepared by

N. Titley

Checked by

J. Drummond

Approved by

N. Smith

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Prepared for: Bristol City Council (BCC)

Prepared by: AECOM

AECOM Infrastructure & Environment UK Limited
3rd Floor
Portwall Place
Portwall Lane
Bristol
BS1 6NA
UK

T: +44 117 901 7000
aecom.com

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1. Purpose of this Report

The purpose of this Addendum is to present the changes to the River Avon Tidal Flood Risk Management Strategy since the 9B Option's Identification and Environmental Appraisal Report (the 9B Report), which was submitted to Bristol City Council in October 2016.

This Addendum should be read in conjunction with the 9B Report and therefore does not repeat information such as the approach to the assessment and methodology, which has not changed since the original report.

The 9B Report was a high-level environmental appraisal of 39 strategic options as part of the long list options phase. Since then the 39 options were reduced to seven options during shortlisting, before a preferred option was selected (Option D). The options considered a range of flood risk intervention measures including: a Do Minimum approach, property level protection / temporary defences, low defences, high defences, and a tidal barrier. The preferred strategic option that was selected encompasses the construction of low defences during Epochs 1 and 2, and then raising these defences in Epoch 3.

In this latest phase of work the preferred strategic option, Option D, has been refined to create Option D1, with further consideration of defence alignments, design, cost estimates, and phasing. It is the purpose of this report to present an updated environmental appraisal of the preferred option and report the relative merits and disadvantages against the 9B Report.

An overview of the River Avon Tidal Flood Risk Management Strategy is presented in the 9B Report.

2. Methodology

The methodology described in the 9B Report remains valid and is therefore not repeated here.

3. The Preferred Option

The option which has been selected as the 'Preferred Option' from the shortlisting contains the following measures:

- Epoch 1 (2015-2030) – Low Defences;
- Epoch 2 (2030-2065) – Low Defences; and
- Epoch 3 (2065-2115) – High Defences.

To deliver the preferred option (Option D1), approximately 5 km of new raised defences will be required across the study area. Within central Bristol, new raised defences will be required in core areas, comprising: Cumberland Road, Commercial Road, Clarence Road, Cattle Market Road, Totterdown, and St. Phillips. Defences in these locations should prevent local flooding to the properties and assets situated behind. In addition, new defences at additional core areas including Entrance Lock, Netham, Bathurst Dam, and Cumberland Road underpass will also be required. These defences will prevent water from flowing into the floating harbour and flooding properties in central Bristol once the harbour capacity is exceeded. Part of the new defences at Entrance Lock and Netham will be the installation of new tidal stop gates and operating infrastructure. A description of the defences is provided in Section 4.1 and 4.2. The proposed defence alignment is shown in **Figure 3-2**. For further information on how the preferred option has been refined see the Outline Design Phase Report. The detailed plans of the proposed defences at each location are contained with Appendix A.

For the preferred strategic option new raised defences across the city are required from Epoch 1 onwards. The defences will be constructed in two separate waves; low defences during Epochs 1 & 2 and then high defences during Epoch 3. The exact time within Epoch 3 when the defences are upgraded is flexible and the upgrade will involve crest raising of the low defences rather than starting the construction of high defences from scratch.

The low defences will be constructed to a 1:200 year standard of protection for 2030. The upgraded high defences will provide a 1:200 year standard of protection for 2115.

In addition to the construction of Low and High Defences in the core areas considered as part of the preferred option, the refined option also includes the provision of 'Detriment Mitigation Measures' (i.e. property protection). These measures were not considered in the 9B Report and are discussed in this Addendum.

Freeboard Allowance

The maximum height of the defences includes a 'freeboard allowance'. This is the height of the defence above the design water level, which can be seen as a safety margin that makes allowance for uncertainties in modelling.

Defence Finish

In some, isolated, locations the new defences will be up to 3.9 m in height relative to existing ground levels (high defences)¹. This has the potential to negatively impact the landscape and visual character of the area. To limit this impact, new defences up to 1.2 m in height (relative to existing ground levels) will be finished with masonry cladding or an alternative finish that is suitable for the local landscape. For defences greater than 1.2 m in height (relative to existing ground levels) several approaches will be developed, and specific locations will be identified for each treatment. One of the options is to install reinforced glass on top of the masonry clad defences instead of a solid structure. A photograph example showing installed glass walls is shown in **Figure 3-1** below.

Figure 3-1 Example of a High Wall



3.1 Low Defences

Low Defences are proposed to be constructed in Epochs 1 and 2. Whether the defence is proposed to be constructed in Epoch 1 or Epoch 2 depends on its priority in terms of flood risk based on flood modelling predictions.

3.1.1 Epoch 1

In Epoch 1 Low Defences are proposed at Entrance Lock, Netham, Bathurst Dam; and Totterdown. A summary of the design details for these measures is provided in **Table 3.1** below which includes information of the alignment length area, average defence height above ground level, maximum defence height and structure type(s).

¹ There is some uncertainty in the LiDAR data.

Table 3-1 Summary of Low Defence alignments in Epoch 1

Defence Section	Structure type(s)	Defence length for low defences (m)	Average height for low defences (m)	Max height for low defences (m)
Entrance Lock	Floodwalls, flood/lock gate replacement, highway/bridge abutments, ramps, road raising	904	1.1	1.9
Netham	Floodwalls, flood/lock gate replacement, road raising	738	1.6	3.9 ¹
Bathurst Dam	Raising of existing structure, floodwall tie-ins	39	1.1	1.4
Totterdown	Floodwalls, ramps, resilience structures to existing buildings, bridge abutment	1498	0.9	2.1

3.1.2 Epoch 2

In Epoch 2 Low Defences are proposed at Cumberland Road, Cumberland Road East, Commercial Road, Clarence Road and Cattle Market Road. A summary is provided in **Table 3.2** below which includes information of the alignment length area, average defence height above ground level, maximum defence height and structure type(s).

Table 3-2 Summary of Low Defence alignments in Epoch 2

Defence Section	Structure type(s)	Defence length for low defences (m)	Average height for low defences (m)	Max height for low defences (m)
Cumberland Road	Floodwalls	635	0.8	1.2
Cumberland Road East	Floodgate, ramp and flood wall tie ins	16	1.1	1.3
Commercial Road	Floodwalls, retaining structure, ramp	193	0.7	1.2
Clarence Road	Floodwalls, retaining structure, bridge abutment	622	1.0	2.0
Cattle Market Road	Floodwalls, retaining structure	181	0.8	2.1

3.2 High Defences

In Epoch 3 all of the Low Defences constructed in Epoch 1 and 2 will be raised to High Defences. A summary is provided in **Table 3.3** below which includes information of the alignment length area, average defence height above ground level, maximum defence height and structure type(s).

Table 3-3 Summary of High Defence alignments in Epoch 3

Defence Section	Structure type(s)	Defence length for high defences (m)	Average height for high defences (m)	Max height for high defences (m)
Entrance Lock	Floodwalls, flood/lock gate replacement, highway / bridge abutments, ramps, road raising	912	1.8	2.6
Cumberland Road	Floodwalls	635	1.5	1.8
Cumberland Road underpass	Floodgate, ramp and floodwall tie-ins	16	1.7	2.0
Bathurst Dam	Raising of existing structure, floodwall tie-ins	39	1.7	2.0
Commercial Road	Floodwalls, retaining structure, ramp	244	1.4	1.8
Clarence Road	Floodwalls, retaining structure, bridge abutment	622	1.6	2.7
Cattle Market Road	Floodwalls, retaining structure	192	1.4	2.7
Totterdown / St. Phillips	Floodwalls, ramps, resilience structures to existing buildings, bridge abutment	1,498	1.4	2.7
Netham	Floodwalls, flood/lock gate replacement, road raising	742	1.6	3.9 ²

² There is some uncertainty in the LiDAR data at this location



LEGEND

- Alignment Name**
- BATHURST DAM
 - CATTLE MARKET ROAD
 - CLARENCE ROAD
 - COMMERCIAL ROAD
 - CUMBERLAND ROAD
 - CUMBERLAND ROAD EAST
 - ENTRANCE LOCK
 - NETHAM
 - TOTTERDOWN



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AECOM Internal Project No:
 60478613

Drawing Title:
 Preferred Option Alignment

Scale at A3: 1:15,000

Drawing No: **Rev:**
 FIGURE 3.2 V2

Drawn: Chk'd: App'd: Date:
 GM SM NT 24/01/17



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



3.3 Detriment Mitigation

Detriment Mitigation is proposed in four locations: Bower Ashton, Totterdown, Netham and Bedminster. It is important to note that at this stage the design proposals are still being considered and will be determined at outline design stage.

Bower Ashton

At Bower Ashton it is proposed that the existing bank will be raised to a height of 10.3 m, as shown in **Figure 3-3**. This bank will be approximately 480 m long, with an average height increase of 1.4 m (from 8.9 m to 10.3 m), and a maximum height increase of 2.4 m (from 7.9 m above ground level to 10.3 m above ground level). This is an average 16% increase to the existing bank, and maximum 30% increase to achieve a consistent 10.3 m height above ground level. The difference in height between high tide level and the height of the proposed embankment is circa 5 m.

Totterdown

An estimated 200 m of existing private flood defence will be raised by up to 1.3 m in Totterdown.

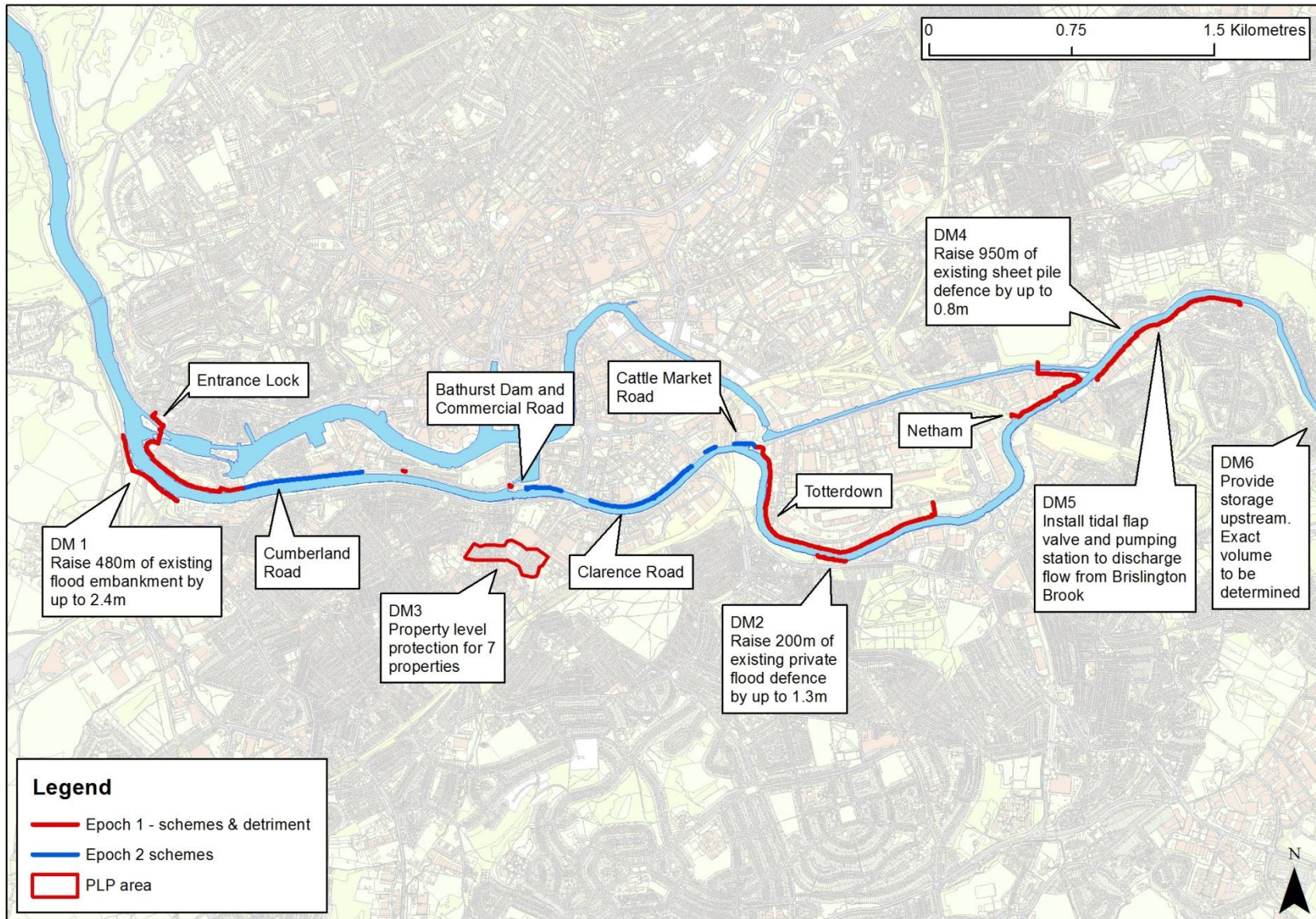
Netham

At Netham several measures are proposed:

- Raise the existing sheet piled defence to a height of 10.40m AOD to match the design levels downstream to prevent overflowing / overtopping. The maximum length of defence required is approximately 950m with an average raising of approximately 0.80m.
- Install at tidal flap valve at the Brislington Brook outfall
- Culvert the open section of Brislington Brook or raise the defences around it
- Provide overpumping when Brislington Brook cannot discharge under gravity

Bedminster

Detriment Mitigation in the form of Property Level Protection is proposed to be installed into seven properties. The specific properties where this measure is are currently being considered.



4. Findings

This section provides a summary of the scores given for Option D1. Only the scores which deviate from the 9B Report are presented here. Where a social-environmental aspect is not discussed, the score presented for Option D is considered still valid. A comparative assessment is presented in **Tables 5-1 to 5-5** in Section 5 of this Addendum to summarise the scores and any changes since the 9B report.

It is important to note the difference in the way the options were scored in the 9B Report compared to how they are scored in this Addendum. In the 9B Report the Low Defences and High Defences were an amalgamation of all reaches, i.e. a single score applied to all locations within the study area, and therefore the score represented the worst-case impact along all reaches. However, in this Addendum the locations of the proposed defences are considered in more detail geographically, and therefore multiple locations are assessed for Option D1. An overview of the proposed locations of the Defences is presented in Figure 3. The detailed plans of each defence alignment are presented in Appendix A.

4.1 Option D1

4.1.1 Epoch 1 (Low Defences)

4.1.1.1 Entrance Lock

This section of the defence alignment involves a number of measures including the construction of a masonry clad floodwall, installation of a flood gate, and the replacement of the upper lock gate. The foundations of the flood wall will be constructed to support the additional height of defences required in Epoch 3.

The Option D scores presented in the 9B Report remain valid for this measure.

4.1.1.2 Netham

This section of the defence alignment involves constructing a frontline retaining structure and floodwall. Road raising and a new lock gate will also be required at this location.

The Option D scores presented in the 9B Report remain valid for this measure.

4.1.1.3 Bathurst Dam

At this location the crest level of Bathurst Dam will be raised to 1.4 m for Low Defences.

The Option D scores presented in the 9B Report remain valid for this measure.

4.1.1.4 Totterdown

This section of the defence alignment includes a flood wall which is set back behind an existing footpath as well as flood gates across roadways and footpaths which tie-in to sections of floodwall on either side. The Option D scores in the 9B Report remain valid for Totterdam, with the exception of Estuarine Ecology.

Aspect	Description	Score
Estuarine Ecology	This alignment is likely to have a negligible impact on Estuarine/Riverine Ecology as the alignment is set back from the River Avon.	0

4.1.2 Epoch 2 (Low Defences)

4.1.2.1 Cumberland Road

This section of the alignment involves a floodwall which follows the existing MetroBus flood defence. At the eastern extent of the MetroBus flood defence the flood wall will tie-in to the railings on the edge

of the highway. Where there is a change to the scores given in the 9B Report these are presented in the table below.

Aspect	Description	Score
Landscape and Visual	This alignment is likely to have a negligible impact on Landscape and Visual. The majority of the defences will be 0.3-0.7 m above existing ground levels. A large section of defence will follow the alignment of the MetroBus flood defence and appropriately clad, and therefore will not have a detrimental impact on the character of the area.	0
Estuarine Ecology	This alignment is likely to have a negligible impact on Estuarine/Riverine Ecology as the alignment is set back from the River Avon.	0

4.1.2.2 Cumberland Road East

A flood gate will be installed at this location across the railway. Where there is a change to the scores given in the 9B Report these are presented in the table below.

Aspect	Description	Score
Landscape and Visual	This alignment is likely to have a negligible impact on Landscape and Visual. Within this section of the alignment a floodgate is proposed to be installed across the railway and therefore will not affect the landscape character of the area. The defence height relative to existing ground levels is 1.2 m for Low Defences and will be temporarily installed during periods of flood risk, and therefore will not affect key views to or from the River.	0
Estuarine Ecology	This alignment is likely to have a negligible impact on Estuarine/Riverine Ecology as the alignment is set back from the River Avon.	0
Archaeology and Heritage	This alignment is likely to have a negligible impact on Archaeology and Heritage as there are no statutory or non-statutory designated assets that will be impacted in the vicinity of the proposed flood gate.	0

4.1.2.3 Commercial Road

This section of the alignment involves a flood wall along the edge of the roadway, following the alignment of an existing railway. In addition a ramp or flood gate will be installed across roads to complete the defence. Where there is a change to the scores given in the 9B Report these are presented in the table below.

Aspect	Description	Score
Archaeology and Heritage	This alignment is likely to have a negligible impact on Archaeology and Heritage as there are no statutory or non-statutory designated assets that will be impacted in the vicinity of the proposed alignment.	0

4.1.2.4 Clarence Road

A frontline flood wall will be constructed at this location, as well as a footbridge abutment across Langton Street Bridge.

The Option D scores in the 9B report remain valid.

4.1.2.5 Cattle Market Road

It is proposed that a frontline flood wall will be constructed at this location. Where there is a change to the scores given in the 9B Report these are presented in the table below.

Aspect	Description	Score
Landscape and Visual	This alignment is likely to have a negligible impact on Landscape and Visual as the defence will be approximately 0.1-0.8 m high above ground level, and would tie into the existing rail bridge abutment and therefore is unlikely to affect the landscape character of the area, or key views to and from the river.	0
Archaeology and Heritage	This alignment is likely to have a negligible impact on Archaeology and Heritage as there are no statutory or non-statutory designated assets that will be impacted in the vicinity of the proposed alignment.	0
Traffic and Transport	The defence would need to tie into the abutments of a Network Rail Bridge, which would likely have to be closed during these works. The length of time the bridge would need to be closed for is currently unknown, and therefore a worst case scenario has been assumed.	-2

4.1.3 Epoch 3 (High Defences)

4.1.3.1 Entrance Lock

This section of the defence alignment involves raising the height of the Low Defences which were constructed in Epoch 1 including the masonry clad floodwall, flood gate and lock gate. Where there is a change to the scores given in the 9B Report these are presented in the table below.

Aspect	Description	Score
Estuarine Ecology	There is likely to be a negligible impact on Estuarine Ecology in this Epoch. The foundations for the High Defences will be constructed in Epoch 1 and therefore there will be no need for extensive construction activity such as piling in this Epoch. The defence alignment are also mainly set back (except for the area around Entrance Lock) and therefore there will be little disturbance to estuarine ecology.	0

4.1.3.2 Netham

This section of the defence alignment involves raising the frontline floodwall constructed in Epoch 1 and the construction of a set-back floodwall along the alignment of the existing boundary wall between Feeder Road and commercial properties. Road raising and a new lock gate will also be required at this location. Where there is a change to the scores given in the 9B Report these are presented in the table below.

Aspect	Description	Score
Estuarine Ecology	There is likely to be a negligible impact on Estuarine Ecology as the alignment is mainly set back from the River Avon and therefore is unlikely to have a noticeable impact on Estuarine/Riverine Ecology.	0

4.1.3.3 Bathurst Basin

At this location the Low Defences will be raised to a crest level of approximately 2 m above ground level. Where there is a change to the scores given in the 9B Report these are presented in the table below.

Aspect	Description	Score
Estuarine Ecology	This alignment is likely to have a negligible impact on Estuarine/Riverine Ecology as any extensive construction activity required such as piling to establish foundations will be carried out in Epoch 1.	0

4.1.3.4 Totterdown

In this section the setback flood wall constructed in Epoch 1 will be raised. Flood gates will be used across footpaths to tie in to sections of flood wall on either side. Where there is a change to the scores given in the 9B Report these are presented in the table below.

Aspect	Description	Score
Estuarine Ecology	This alignment is likely to have a negligible impact on Estuarine/Riverine Ecology as any extensive construction activity required such as piling to establish foundations will be carried out in Epoch 1.	0
Archaeology and Heritage	There are no Listed Buildings in close proximity to the alignment. However there may be an indirect minor impact on the setting of the following non-statutory designated assets: <ul style="list-style-type: none"> • Railway Bridge on Cattle Market Road AMIE; • Office on Cattle Market Road AMIE; • Cattle Market Tavern AMIE; • Corporation Yard AMIE; • Road Bridge on Bath Road AMIE; • Foot Bridge at Amos Vale AMIE; • Avon Works, Albert Road, St Phillips HER; • Totterdown Bridge HER; • Gallows HER; • Railway Bridge across the River Avon; and • Totterdown Lock and Bridge. 	-1

4.1.3.5 Cumberland Road

The floodwall constructed in Epoch 2 will be raised to between 1.4 and 1.9 m in height above existing ground levels. Where there is a change to the scores given in the 9B Report these are presented in the table below.

Aspect	Description	Score
Landscape and Visual	This alignment is likely to have a minor negative impact on Landscape and Visual. A large section of defence will follow the alignment of the MetroBus flood defence and appropriately clad. However the height of the defences will be 1.4-1.9 m above existing ground levels, and therefore may affect key views to and from the River.	-1
Estuarine Ecology	This alignment is likely to have a negligible impact on Estuarine/Riverine Ecology as any extensive construction activity required such as piling to establish foundations will be carried out in Epoch 1.	0
Archaeology and Heritage	This alignment may have a minor indirect impact on the setting of the Grade II Vauxhall Bridge which is located in close proximity to the defence alignment. There may also be an indirect minor negative impact on the setting of the following non-statutory designated assets:	-1

	<ul style="list-style-type: none"> • Overfall Dam Bridge HER; • Cumberland Road Gate HER; and Engine House associated with excavation of New Cut HER. 	
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4.1.3.6 Cumberland Road East

The flood gate installed in Epoch 2 will be raised from 1.2 m to 2 m above existing ground levels. Where there is a change to the scores given in the 9B Report these are presented in the table below.

Aspect	Description	Score
Landscape and Visual	This alignment is likely to have a negligible impact on Landscape and Visual. Within this section of the alignment a floodgate is proposed to be installed across the railway. The defence height relative to existing ground levels is approximately 2.0 m above ground level. As the flood gate is set back it is unlikely to have a negative impact on key views to or from the River.	0
Estuarine Ecology	This option is likely to have a negligible impact on Estuarine/Riverine Ecology as this alignment is set back from the River Avon, and any extensive construction activity required such as piling in order to establish the Defence foundations will be carried out in Epoch 1.	0
Archaeology and Heritage	This option is likely to have a negligible impact on the Archaeology & Heritage as there are no statutory or non-statutory designated assets that will be impacted in the vicinity of the proposed flood gate.	0

4.1.3.7 Commercial Road

The flood wall along the edge of the roadway constructed in Epoch 2 will be raised to between 1-1.8 m above existing ground levels. Where there is a change to the scores given in the 9B Report these are presented in the table below.

Aspect	Description	Score
Estuarine Ecology	This alignment is likely to have a negligible impact on Estuarine/Riverine Ecology as any extensive construction activity required such as piling to establish foundations will be carried out in Epoch 1.	0
Archaeology and Heritage	This alignment is unlikely to have a noticeable impact on Archaeology & Heritage as there are no statutory or non-statutory designated assets that will be impacted in the vicinity of the defence.	0

4.1.3.8 Clarence Road

The frontline flood wall constructed in Epoch 2 will be raised to between 0.9-2.7 m above existing ground levels. Where there is a change to the scores given in the 9B Report these are presented in the table below.

Aspect	Description	Score
Estuarine Ecology	This alignment is likely to have a negligible impact on Estuarine/Riverine Ecology as any extensive construction activity required such as piling to establish foundations will be carried out in Epoch 1.	0

4.1.3.9 Cattle Market Road

It is proposed that the frontline flood wall constructed in Epoch 2 will be raised to a maximum of 2.5 m in height. Where there is a change to the scores given in the 9B Report these are presented in the table below.

Aspect	Description	Score
Landscape and Visual	This alignment is likely to have a negligible impact on Landscape and Visual as the defence will be approximately 0.1-2.5 m high relative to existing ground levels, and would be set back and therefore would not have a noticeable impact on key views to or from the river.	0
Estuarine Ecology	This alignment is likely to have a negligible impact on Estuarine/Riverine Ecology as any extensive construction activity required such as piling to establish foundations will be carried out in Epoch 1.	0
Archaeology and Heritage	This alignment is likely to have a negligible impact on the Archaeology & Heritage as there are no statutory or non-statutory designated assets that will be impacted in the vicinity of the proposed flood gate.	0

4.2 Detriment Mitigation

It is proposed that PLP will be installed into a small number of properties (an expected ten properties), in Bedminster and Netham. The environmental impacts associated with this measure remain the same as presented in the 9B report, and therefore are not repeated here.

The potential location, nature, and scale of the flood storage area measure is yet to be decided, and therefore it is not possible to score this option, however this will be considered at the EIA stage when more design information is available.

The scores for the additional detriment mitigation measures are presented in the table below.

Environmental Aspect	Bower Ashton – Embankment	Netham - Defence Raising	Brislington Brook Outfall Flap	Brislington Brook - Culvert	Totterdown – Wall Raising	Brislington Brook - Overpumping
Landscape	-1	-1	0	0	0	0
Terrestrial Ecology	-1	-1	0	-1	-1	0
Estuarine Ecology	-1	-1	-1	-2	0	-1
Archaeology and Heritage	0	0	0	0	0	0
Air Quality and Noise	0	0	0	0	0	0
Geomorphology and Water Quality	-1	0	0	-2	0	0
Traffic and Transport	0	0	0	0	0	0

Soil and Groundwater	0	0	0	0	0	0
Socio-economics	0	0	0	0	0	0
Total	-4	-3	-1	-5	-1	-1

Bower Ashton - Embankment

The main negative impact associated with the construction of the Bower Ashton Embankment is expected to be concerned with landscape and visual as the presence of the embankment may affect the landscape character of the area and also key views to and from the river. However as the defence will be an earth embankment, when vegetated, this is expected to be less visually intrusive compared to masonry defences.

Designated sites within the vicinity of the proposed embankment include:

- Ashton Court SSSI (approximately 100 m from the proposed embankment)
- Bower Ashton Site of Nature Conservation Interest (SNCI) (approximately 250 m from the proposed embankment)
- Avon Gorge and Woodlands SSSI (approximately 300 m from the proposed embankment)
- River Avon (part of) SNCI

It is not thought that the presence of the embankment would have any impact on these locally designated sites, except for the River Avon (part of) SNCI which has the potential to be impacted directly or indirectly.

At Bower Ashton there is the potential for a negative impact on estuarine geomorphology as a result of the Strategy constructing a new flood defence and causing coastal squeeze. At this location there is an undeveloped area of grassland behind the proposed embankment; although this is not an entirely naturalised area due to the presence of the channelised River Avon and water infrastructure (e.g. culverted watercourses), theoretically, without the embankment the river banks could erode over time, allowing the intertidal mudflat in this location to retreat inland and thus be preserved in extent notwithstanding sea level rise.

The Severn Estuary Shoreline Management Plan (SMP) Review (2010) provides an assessment of the risks associated with coastal processes and presents a policy framework to reduce these risks to people and the developed, historic and natural environment in a sustainable manner. The SMP policy for the area (policy unit BRIS5) is Hold the Line (HTL) which is “to provide some level of coastal defence, keeping the position of the defence approximately where it is at the moment”. In terms of coastal squeeze, it is considered the Strategy is in conformity with the Severn Estuary SMP, despite the construction of the earth embankment at Bower Ashton. The adopted SMP and its policies have been accepted by key consultees (Bristol City Council, Environment Agency and Natural England). Despite the SMP stating that HTL for this policy unit is the best environmental option, it is acknowledged that this does not mean that there are no environmental effects at all and therefore any habitat loss as a result of coastal squeeze will be mitigated/compensated before this embankment is constructed.

The Bower Ashton embankment’s alignment would also be setback at a level above high tide. This means it would not directly encroach into the intertidal zone at the time of construction in the first epoch, and the landward transgression of intertidal habitats, assuming the gradient of the river bank permits transgression, would not be impeded until sometime later on in the Strategy. It is anticipated that the intertidal habitats would be monitored at regular intervals following the implementation of the scheme to verify the conclusions of the Environmental Statement (or identify the need for additional mitigation). The method and frequency of this monitoring will be determined at EIA stage.

In total, the direct footprint loss for estuarine habitats associated with the Strategy is estimated to be 2218 m². This is based on 2218 m length of defences and a maximum 1 m encroachment out from current defences. This estimate includes the Netham detriment works and at this stage there is uncertainty as to whether these works will lead to encroachment in order to raise defence heights; should the footprint not be increased at Netham the maximum estuarine land take will reduce to an estimated 1268 m² (0.127 ha). Such losses would require compensation in order to maintain habitat balances. It would be the responsibility of BCC to ensure compensatory habitat has been provided, and agreed with the Environment Agency and Natural England, prior to any losses occurring. Whilst recognising the need to potentially compensate as a result of the Strategy, suitable sites for habitat creation should be identified at a later stage of scheme development once the total area of habitat loss, both direct loss via encroachment and indirect losses by altering tidal water levels and impedance of habitat “rollback” has been predicted using hydraulic modelling, habitat characterisation and geomorphological appraisal.

The further work for scheme implementation should include identifying the type of habitat that could be lost as a result of coastal squeeze. At this early stage of design we have assumed a worst case scenario that encroachment will be in the intertidal zone. A targeted, Phase 1 Habitat Survey should be completed at EIA stage to characterise habitats and confirm the type and quality of habitat which has the potential to be impacted directly and indirectly. Alongside ecological work, a geomorphological appraisal would be necessary to confirm whether the estuary’s form and adjacent hinterland would permit the rollback of intertidal habitats under rising sea levels i.e. steep river bank gradients may limit the likelihood of rollback.

It would be prudent to ascertain when the habitat losses are likely to occur. A separate modelling exercise is recommended for scheme implementation during the EIA phase in order to estimate the projected coastal squeeze under the future baseline and with development scenarios. It is not considered possible or appropriate to estimate the potential habitat losses at this stage of the project because more detailed baseline information and design is required than is currently available at the time of writing.

It is acknowledged that the River Avon intertidal mud in the Strategy area is outside any European site, but could be used by larval lamprey (ammocoetes) associated with the Severn Estuary SAC, or by non-breeding birds associated with the Severn Estuary SPA (at least occasionally in small numbers). However, given the small amount of intertidal mudflat in this area, it is unlikely that creating the embankment at Bower Ashton will radically affect the ability of the Bristol Avon to support ammocoetes. The Preliminary HRA Report provides further information on this issue.

Netham – Defence Raising

In terms of raising the defences at Netham the negative impacts associated with this measure are likely to be concerned with landscape and visual amenity, as well as estuarine ecology should the alignment be frontline. Considering the existing sheet piled wall is only proposed to be raised 1 m the impact on landscape and estuarine ecology is expected to be minor.

Brislington Brook – Outfall Flap

The measure involving installing a flap onto the Brislington Brook outfall is likely to have a negligible impact for most environmental aspects, with the exception of estuarine ecology. The flap would need to maintain eel passage in order to comply with the Eel Regulations 2009; therefore mitigation such as a smaller ‘cat-flap’ or spring retarder would need to be fitted.

Brislington Brook - Culverting

Culverting the Brislington Brook, if required, is likely to involve negligible impacts for most environmental aspects with the exception of estuarine ecology and geomorphology/water quality where more substantial impacts are expected for these aspects. Adequate mitigation should be installed to maintain eel passage.

The need for culverting is currently considered to be unlikely, if raising of the defences around the open channel is not viable, and it is to be determined during further design work after this phase of the Strategy is complete.

Totterdown – Wall Raising

The raising of the wall at Totterdown is expected to have limited environmental impacts as the wall is an existing masonry wall and would be set back from the River.

Brislington Outfall - Overpumping

In terms of the overpumping at Brislington the potential environmental impacts are largely concerned with estuarine ecology. Mitigation is required to ensure pumps are adequately screened to prevent the ingress of fish, in particular eels to comply with the Eel Regulations 2009.

These measures will be considered further in a WFD Assessment and HRA which will be produced to support a planning application when more design information becomes available.

5. Summary and Conclusions

This Section provides a summary of the scores for each environmental aspect at each location compared to the scores given for Option D to show the relative merits and disadvantages of the refined option.

5.1 Epoch 1 - Low Defences

A summary of the scores for Low Defences in Epoch 1 is presented below along with the scores of 'Low Defences' from the 9B Report for comparison. Where an environmental aspect has scored more favourably it is highlighted in green. Where an aspect has scored less favourably (i.e. worse), it is highlighted red.

Table 5-5-1: Epoch 1 Score of Environmental Aspects for each location compared to Option D score

Environmental Aspect	Option D (9B Report)	Entrance Lock	Netham	Bathurst Basin	Totterdown
Landscape	-1	-1	-1	-1	-1
Terrestrial Ecology	-1	-1	-1	-1	-1
Estuarine Ecology	-1	-1	-1	-1	0
Archaeology and Heritage	-1	-1	-1	-1	-1
Air Quality and Noise	0	0	0	0	0
Geomorphology and Water Quality	0	0	0	0	0
Traffic and Transport	-1	-1	-1	-1	-1
Soil and Groundwater	0	0	0	0	0
Socio-economics	1	1	1	1	1
Total	-4	-4	-4	-4	-3

* **Green** = Scored more positively than Option D

* **Red** = Scored less favourably than Option D

Generally, the scores remain unchanged from those presented in the original 9B Report, with the exception of Totterdown which scored slightly more positively for Estuarine Ecology (0) negligible compared to the original score given for Estuarine Ecology in the 9B Report (-1). The reason for this is the alignment is due to be set back on an existing footpath and therefore having no interaction with the River (resulting in a negligible impact on Estuarine Ecology).

5.2 Epoch 2 Low Defences

A summary of the scores for Low Defences in Epoch 2 is presented below along with the scores of 'Low Defences' from the original 9B report for comparison. Where an environmental aspect has scored more favourably it is highlighted in green. Less favourable scores are highlighted red.

Table 5-2 Epoch 2 Environmental Aspects Scores for each location compared with Option D

Environmental Aspect	Option D (9B report)	Cumberland Road	Cumberland Road East	Commercial Road	Clarence Road	Cattle Market Road
Landscape	-1	0	0	-1	-1	0
Terrestrial Ecology	-1	-1	-1	-1	-1	-1
Estuarine Ecology	-1	0	0	-1	-1	-1
Archaeology and Heritage	-1	-1	0	0	-1	0
Air Quality and Noise	0	0	0	0	0	0
Geomorphology and Water Quality	0	0	0	0	0	0
Traffic and Transport	-1	-1	-1	-1	-1	-2
Soil and Groundwater	0	0	0	0	0	0
Socio-economics	1	1	1	1	1	1
Total	-4	-2	-1	-3	-4	-3

* Green = Scored more positively than Option D

* Red = Scored less favourably than Option D

Landscape aspects have been downgraded from minor impact (-1) to a negligible impact (0) for the alignments at Cumberland Road, Cumberland Road East and Cattle Market Road. The reason for this is that the alignments are mainly set-back at these locations and therefore are not expected to have a noticeable impact on the landscape character of the area or key views to and from the River. In addition, a large portion of the Cumberland Road alignment follows the existing MetroBus flood defence and therefore will be in keeping with existing baseline conditions.

Estuarine ecology has scored more positively for Cumberland Road and Cumberland Road East compared to the score presented in the 9B Report. This is because the alignment at these locations is set back, and therefore it is expected that there will be no interaction with the River at these locations. The alignments at Commercial Road, Clarence Road and Cattle Market Road have been scored as having a minor impact (-1) as per the original score in the 9B Report, due to the alignment being front line at these locations which may result in a minor impact on estuarine ecology particularly during the construction phase. Furthermore, as the alignment is frontline at these locations there is likely to be a negative impact associated with a loss of intertidal habitat which might require compensation, and this could be potentially addressed through the Environment Agency's Regional Habitat Creation Programme.

The score given in the 9B Report for archaeology and heritage has been downgraded to negligible (0) at Cumberland Road East, Commercial Road and Cattle Market Road as there are no high value receptors in close proximity to the Low Defence alignment. A minor impact is predicted for Clarence Road and Cumberland Road as there is one or more high value receptor in close proximity to the Low Defence alignment at these locations, although it is recognised that the defences may actually have a beneficial impact on these assets in some cases, as the defences should protect the setting and the fabric of the asset from future flooding.

The score for traffic and transport has been downgraded at Cattle Market Road to -2 (major impact) as the defence would need to tie into the abutments of a Network Rail Bridge. There is a risk that Network Rail may insist on a track closure while the tie-in works are completed. However, it is currently considered to be a very small risk and can almost certainly be avoided by appropriate early discussion, provision of design details and construction methodology. In the unlikely event a track possession would be required it could be undertaken on either overnight or on weekends to minimise disruption. At this preliminary stage of the project, and given the level of liaison with Network Rail expected and additional design work that needs to be undertaken, it is considered prudent to allocate a -2 score for this aspect.

5.3 Epoch 3 High Defences

A summary of the scores for High Defences in Epoch 3 is presented in **Table 5-3** along with the scores of 'High Defences' from the original 9B Report for comparison. Where an environmental aspect has scored more favourably it is highlighted in green.

Table 5-3 Epoch 3 Environmental Aspect Scores for each location compared to Option D

Environmental Aspect	Option D (9B report)	Entrance Lock	Netham	Bathurst Dam	Totterdown	Cumberland Road	Cumberland Road East	Commercial Road	Clarence Road	Cattle Market Road
Landscape	-2	-2	-2	-2	-2	-1	0	-2	-2	0
Terrestrial Ecology	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
Estuarine Ecology	-1	0	0	0	0	0	0	0	0	0
Archaeology and Heritage	-2	-2	-2	-2	-1	-1	0	0	-2	0
Air Quality & Noise	0	0	0	0	0	0	0	0	0	0
Geomorphology and Water Quality	0	0	0	0	0	0	0	0	0	0
Traffic and Transport	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
Soil / Groundwater	0	0	0	0	0	0	0	0	0	0
Socio-economics	2	2	2	2	2	2	2	2	2	2
Total	-5	-4	-4	-4	-3	-2	0	-2	-4	0

* Green = Scored more positively than Option D * Red = Scored less favourably than Option D

The impact on landscape and visual amenity has been downgraded from a major impact (-2) to a minor impact (-1) at Cumberland Road as the high defences are expected to be lower (less than 2 m high) in height at this location, and will largely follow the alignment of the existing MetroBus flood wall. To maintain key views to and from the River it is possible to construct the high defence at this location with a masonry clad brick wall topped with glass as per Figure 3-1, this would not reduce inter-visibility with the river and could even increase it compared with the existing railings, (and especially with oblique views), and as such the glass panels could even be classed as an improvement to the public realm. The landscape and visual score for high defences has also been downgraded at Cumberland Road East and Cattle Market Road. The impact here is now expected to be negligible (0) as the alignments at these locations are mainly set back from the River, and therefore are not expected to have an impact on the landscape character of the area or key views to or from the River.

The refined 'Option D1' scored more positively at all locations for estuarine ecology. This is because foundations used to construct the low defences in epoch 1 and 2 will be 'future proofed' to support the height of the high defences in epoch 3 and therefore no intensive construction activity such as piling will be required in this epoch.

The impact on archaeology and heritage has been downgraded from a major impact (-2) to a minor impact (-1) at Totterdown and Cumberland Road as there are fewer statutory designated heritage assets in close proximity to the defence alignment (particularly at Totterdown) than assumed in the 9B report. A negligible (0) impact is now predicted at Cattle Market Road, Commercial Road and Cumberland Road East as there are no heritage assets in close proximity to the proposed defence alignment at these locations. It is also recognised that in some cases the defences may actually have a beneficial impact on some assets as the defences would protect the setting and the fabric of the asset from future flooding.

5.4 Detriment Mitigation

In terms of PLP, due to the absence of detailed design information for this measure the scores remain the same as was reported in the 9B Report.

As the additional detriment mitigation measures were not assessed or scored in the 9B report, the scores presented in section 4.2 represent new information, but cannot be compared with any previous assessment. A summary of the average score for the detriment mitigation measures for all topics is presented in section 5.5.

5.5 Summary

This section provides a summary of the scores across the whole lifetime of the Strategy (2015-2115).

Table 5-4 Score of Environmental Aspects for each location compared to Option D score

Location	Low Defences in Epoch 1 or 2	High Defences Epoch 3	Detriment Mitigation	Total Score
Option D (9B Report)	-4	-5	-	-9
Option D1/ Average of 9 sub options:	-3	-4	-	-7
• Entrance Lock	-4	-4	-	-8
• Netham	-4	-4	-	-8
• Bathurst Dam	-4	-4	-	-8
• Totterdown	-3	-3	-	-6
• Cumberland	-2	-2	-	-4

Road					
•	Cumberland Road East	-1	0	-	-1
•	Commercial Road	-3	-2	-	-5
•	Clarence Road	-4	-4	-	-8
•	Cattle Market Road	-3	0	-	-3
Netham/Bower Ashton		-	-	-	-3
(Average of all options)					

Table 5-4 shows that Option D1 scores more positively than the score presented for Option D in the 9B Report. When comparing the proposed alignment locations it is clear that the key environmental impacts associated with the defence alignments will occur at Entrance Lock, Netham, Bathurst Dam, and Clarence Road. This is mainly attributed to these locations involving a front line alignment/ partial frontline alignment and therefore all of these locations scored negatively for Landscape and Visual and Estuarine Ecology compared with those alignments which are set back. Furthermore, there are also one or more high value heritage receptors that are in close proximity to the defence alignment which meant that at these locations the defence alignment scored less favourably for Archaeology and Heritage.

The locations which are expected to have the least environmental impacts are at Cumberland Road East and Cattle Market Road. This is attributed to the alignment at these locations being set back from the River which means that these alignments scored more favourably for environmental aspects such as Landscape and Visual and Estuarine Ecology. There are also no high value heritage receptors in close proximity to the alignment at these locations and therefore these options scored more positively for Archaeology and Heritage compared to other locations. Although it is acknowledged that there is always the potential for archaeological remains, it is considered that this can be adequately mitigated in measures contained within a CEMP.

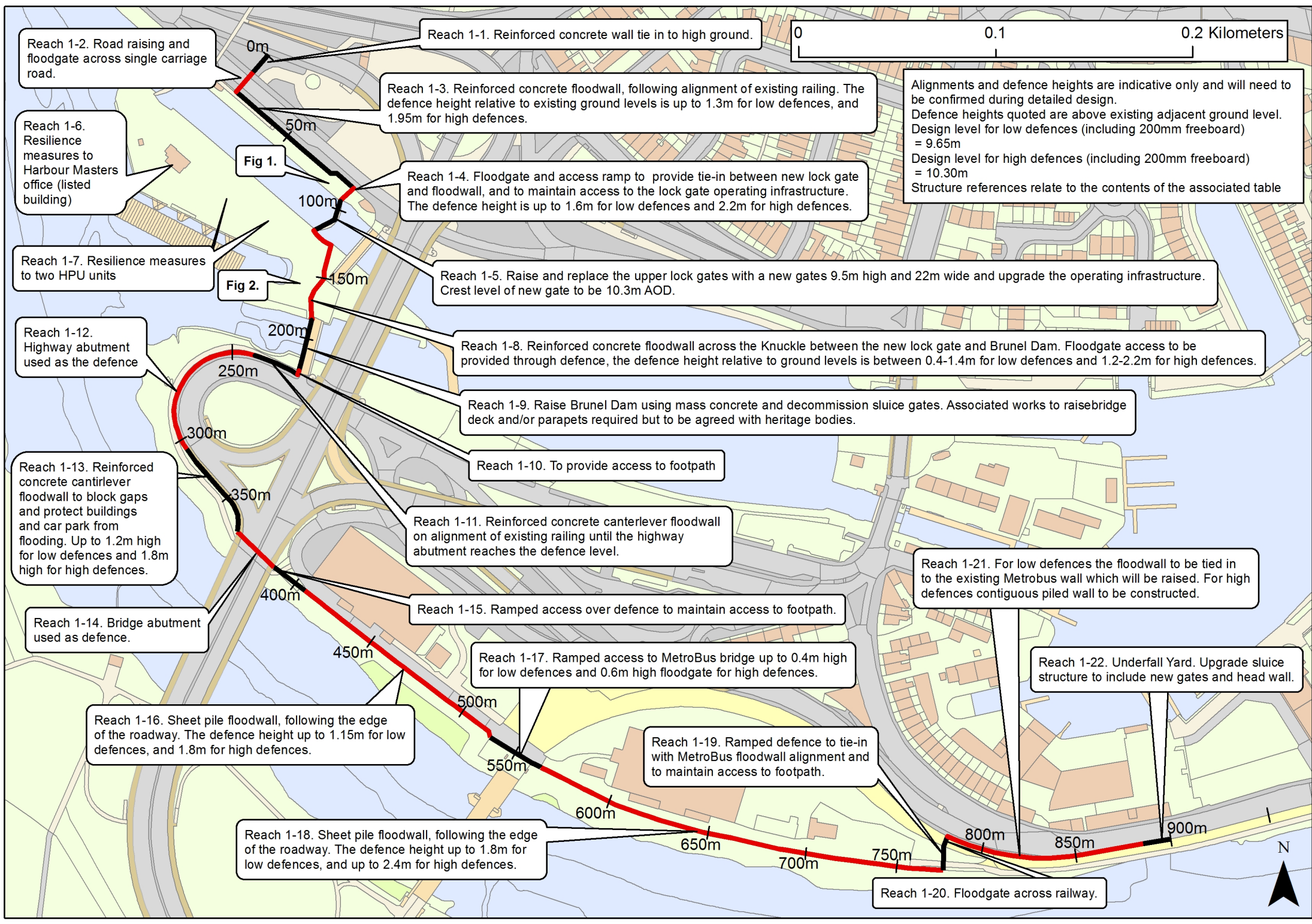
The only aspect which was scored as having a major impact was traffic and transport at Cattle Market Road during the construction of the low defence at this location. This is due to the potential for a Network Rail bridge being closed during the construction of the defence; it is not currently known how long the bridge would have to be closed for, and therefore a worst case scenario has been assumed, although it is expected that this may be an overestimation and the impact in reality is likely to be less substantial.

In terms of detriment mitigation, there is likely to be a minimal environmental impact as a result of these measures. Any negative impacts are expected to be limited to estuarine ecology and landscape, both of which should be adequately mitigated through sensitive design and by using appropriate construction techniques to avoid any significant likely effects. At Bower Ashton there is the potential for a negative impact on estuarine ecology and geomorphology as the proposed embankment may result in possible habitat loss at this location. The extent of loss is expected to be small and considerably less for the preferred option compared to alternatives, such as a no barrier or defences at Pill and Shirehampton. Due to a lack of design information at this stage the significance of this impact is currently unknown however, this will be considered in a future HRA and WFD Assessment when more design information becomes available.

A number of potential enhancement opportunities have been identified for the Strategy; these should be further explored as the design evolves with a requirement for schemes to deliver appropriate additional benefits (in addition to required mitigation and compensation). Key areas of opportunity lie within public realm and landscape enhancement, where potential measures such as green infrastructure resilience corridor initiatives should be further assessed during scheme development to

provide betterment. In addition biodiversity enhancement through removal of invasive species (e.g. Japanese Knotweed), re-planting of native species, regrading and riverbank restoration should be sought. Where hard defences are required in the watercourse, measures such as vertipools could be considered to improve the biodiversity potential of otherwise largely sterile sheet piling / walls.

Appendix A - Detailed Alignment Plans



Reach 1-2. Road raising and floodgate across single carriage road.

Reach 1-6. Resilience measures to Harbour Masters office (listed building)

Reach 1-7. Resilience measures to two HPU units

Reach 1-12. Highway abutment used as the defence

Reach 1-13. Reinforced concrete cantilever floodwall to block gaps and protect buildings and car park from flooding. Up to 1.2m high for low defences and 1.8m high for high defences.

Reach 1-14. Bridge abutment used as defence.

Reach 1-16. Sheet pile floodwall, following the edge of the roadway. The defence height up to 1.15m for low defences, and 1.8m for high defences.

Reach 1-18. Sheet pile floodwall, following the edge of the roadway. The defence height up to 1.8m for low defences, and up to 2.4m for high defences.

Reach 1-1. Reinforced concrete wall tie in to high ground.

Reach 1-3. Reinforced concrete floodwall, following alignment of existing railing. The defence height relative to existing ground levels is up to 1.3m for low defences, and 1.95m for high defences.

Reach 1-4. Floodgate and access ramp to provide tie-in between new lock gate and floodwall, and to maintain access to the lock gate operating infrastructure. The defence height is up to 1.6m for low defences and 2.2m for high defences.

Reach 1-5. Raise and replace the upper lock gates with a new gates 9.5m high and 22m wide and upgrade the operating infrastructure. Crest level of new gate to be 10.3m AOD.

Reach 1-8. Reinforced concrete floodwall across the Knuckle between the new lock gate and Brunel Dam. Floodgate access to be provided through defence, the defence height relative to ground levels is between 0.4-1.4m for low defences and 1.2-2.2m for high defences.

Reach 1-9. Raise Brunel Dam using mass concrete and decommission sluice gates. Associated works to raise bridge deck and/or parapets required but to be agreed with heritage bodies.

Reach 1-10. To provide access to footpath

Reach 1-11. Reinforced concrete cantilever floodwall on alignment of existing railing until the highway abutment reaches the defence level.

Reach 1-15. Ramped access over defence to maintain access to footpath.

Reach 1-17. Ramped access to MetroBus bridge up to 0.4m high for low defences and 0.6m high floodgate for high defences.

Reach 1-19. Ramped defence to tie-in with MetroBus floodwall alignment and to maintain access to footpath.

Reach 1-21. For low defences the floodwall to be tied in to the existing Metrobus wall which will be raised. For high defences contiguous piled wall to be constructed.

Reach 1-22. Underfall Yard. Upgrade sluice structure to include new gates and head wall.

Reach 1-20. Floodgate across railway.

Alignments and defence heights are indicative only and will need to be confirmed during detailed design.
 Defence heights quoted are above existing adjacent ground level.
 Design level for low defences (including 200mm freeboard) = 9.65m
 Design level for high defences (including 200mm freeboard) = 10.30m
 Structure references relate to the contents of the associated table



Fig 1.

Fig 2.

200m

300m

350m

400m

450m

500m

550m

600m

650m

700m

750m

800m

850m

900m

0m

50m

100m

150m

250m

Alignments and defence heights are indicative only and will need to be confirmed during detailed design.
Defence heights quoted are above existing adjacent ground level.
Design level for low defences (including 200mm freeboard) = 9.65m
Design level for high defences (including 200mm freeboard) = 10.30m
Structure references relate to the contents of the associated table



Reach 2-2. Floodwall, following the alignment of railings on the edge of the highway raising or extending the Metrobus wall. For high defences a new contiguous piled wall with a inforced concrete wall on the same metrobus alignment will be constructed. The new defence height is up to 0.9m for low defences and 1.5m for high defences.

Reach 2-4. Floodwall defence tied in to high ground

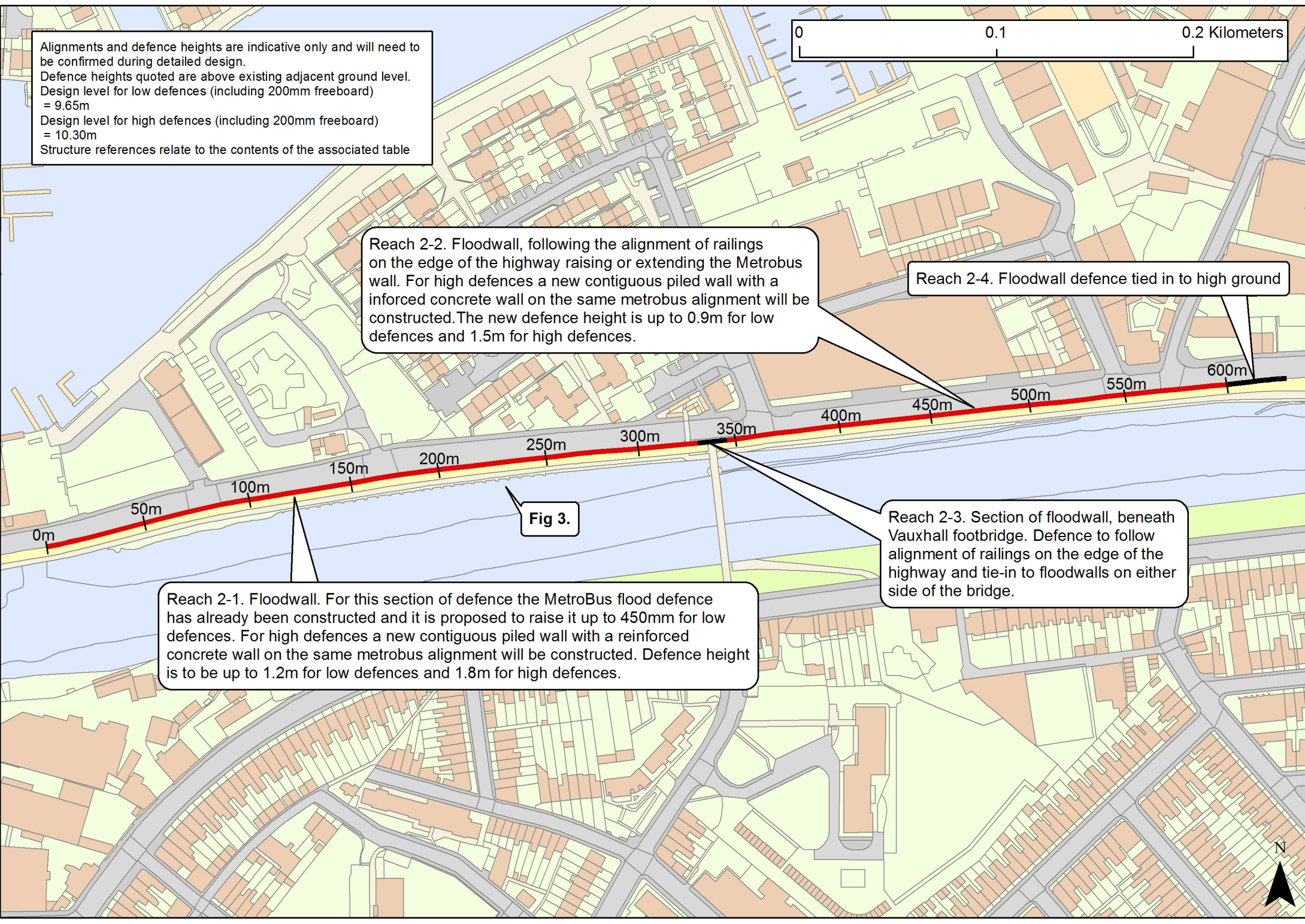


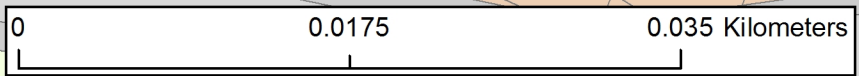
Fig 3.

Reach 2-3. Section of floodwall, beneath Vauxhall footbridge. Defence to follow alignment of railings on the edge of the highway and tie-in to floodwalls on either side of the bridge.

Reach 2-1. Floodwall. For this section of defence the MetroBus flood defence has already been constructed and it is proposed to raise it up to 450mm for low defences. For high defences a new contiguous piled wall with a reinforced concrete wall on the same metrobus alignment will be constructed. Defence height is to be up to 1.2m for low defences and 1.8m for high defences.



Alignments and defence heights are indicative only and will need to be confirmed during detailed design.
Defence heights quoted are above existing adjacent ground level.
Design level for low defences (including 200mm freeboard)
= 9.65m
Design level for high defences (including 200mm freeboard)
= 10.30m from
Structure references relate to the contents of the associated table



Heritage Railway

Highway bridge over railway and footpath



Reach 3-1. Floodgate across railway (beneath the road bridge). 6m wide and 2m high with floodwalls to tie in to tunnel sides and ramp.

Reach 3-2. Ramped footpath up to 2m high if tunnel clearances allow.





Reach 4-1. Raise Bathurst Dam using mass concrete raising to be 1.35m for low defences and 2m for high defences above existing crest level (8.3m).

Reach 4-3. Reinforced concrete cantirlever floodwall along the edge of the roadway, following the alignment of the railing. The defence height is up to 0.85m for low defences and 1.5m for high defences.

Reach 4-5. Contiguous piled floodwall set 1-2m into river chanel. Height is 1.2m for low defences, and 1.8m for high defences.

Reach 4-2. Floodwall tie-in to higher ground.

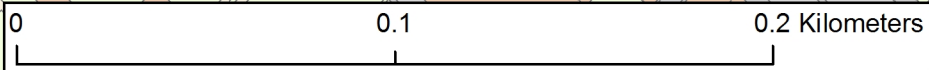
Reach 4-4. Ramp across access road. To tie-in to floodwall either side.

Reach 4-6. Defence tie-in to high ground. Contiguous piled floodwall set 1.2m into river chanel. Height is up to 0.7m for low defences and 1.3m for high defences.

Alignments and defence heights are indicative only and will need to be confirmed during detailed design.
 Defence heights quoted are above existing adjacent ground level.
 Design level for low defences (including 200mm freeboard)
 = 9.65m
 Design level for high defences (including 200mm freeboard)
 = 10.30m
 Structure references relate to the contents of the associated table

N





Alignments and defence heights are indicative only and will need to be confirmed during detailed design.
Defence heights quoted are above existing adjacent ground level.
Design level for low defences (including 200mm freeboard) = 9.65m
Design level for high defences (including 200mm freeboard) = 10.30m
Structure references relate to the contents of the associated table

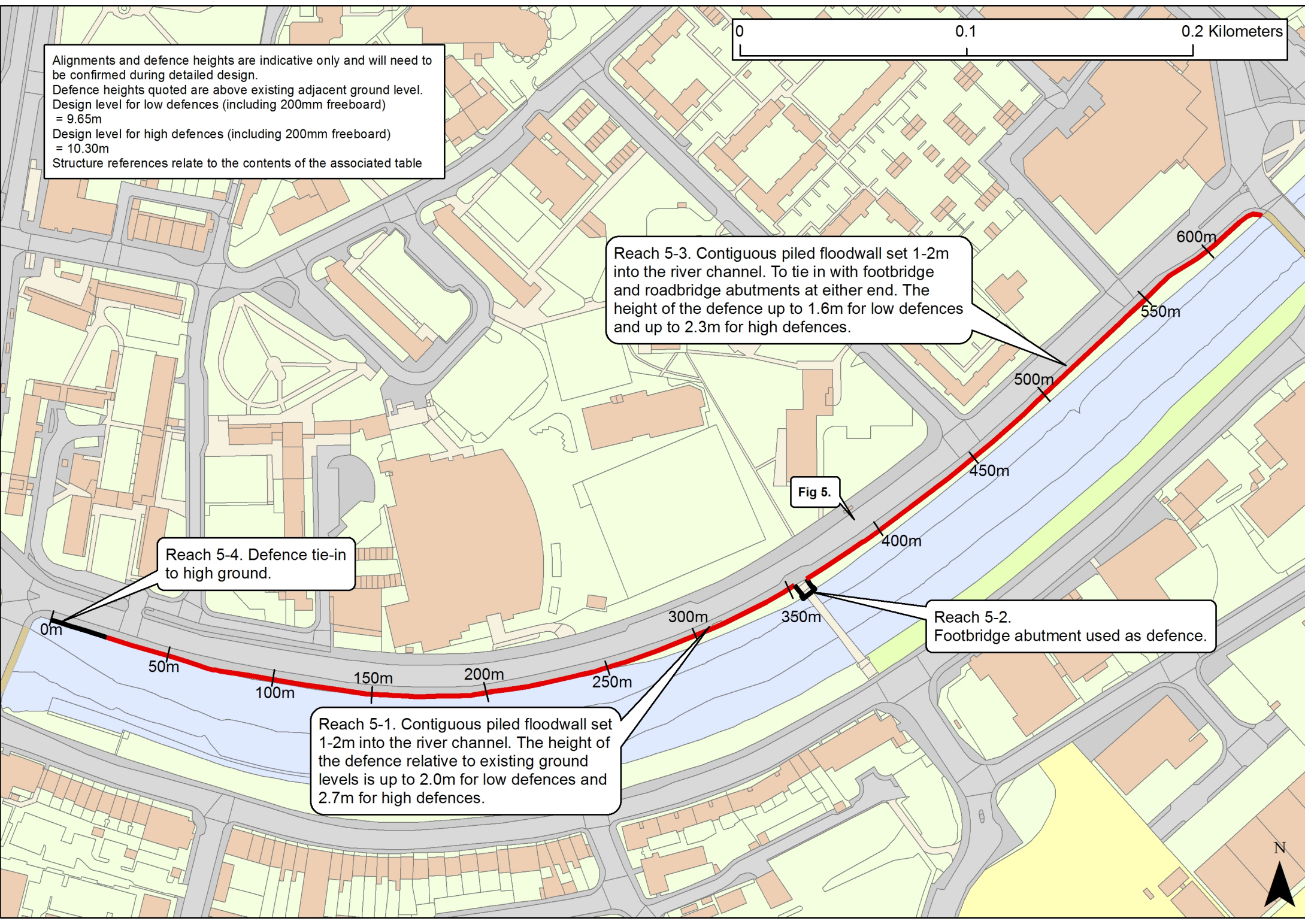
Reach 5-3. Contiguous piled floodwall set 1-2m into the river channel. To tie in with footbridge and roadbridge abutments at either end. The height of the defence up to 1.6m for low defences and up to 2.3m for high defences.

Reach 5-4. Defence tie-in to high ground.

Reach 5-2. Footbridge abutment used as defence.

Reach 5-1. Contiguous piled floodwall set 1-2m into the river channel. The height of the defence relative to existing ground levels is up to 2.0m for low defences and 2.7m for high defences.

Fig 5.

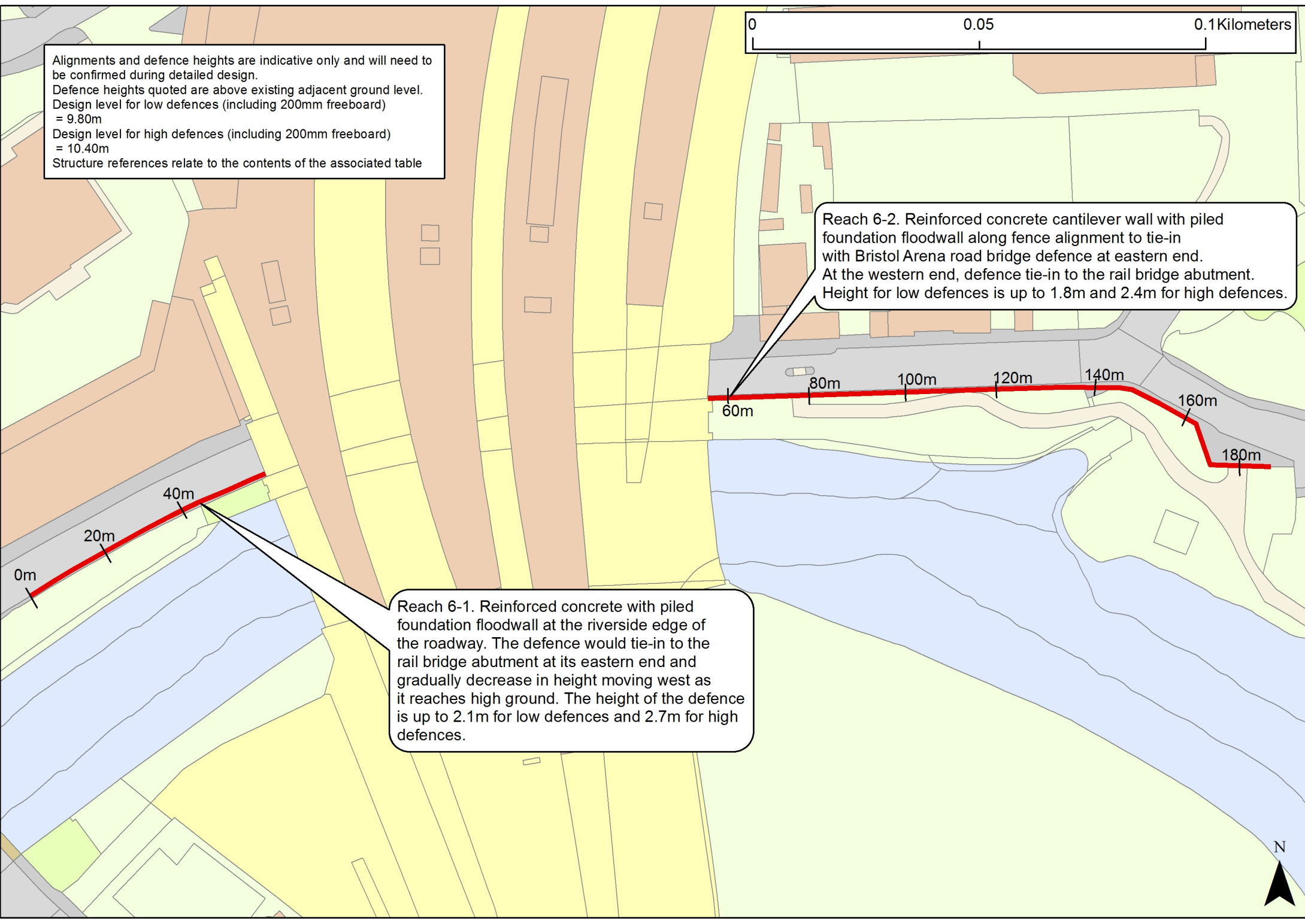




Alignments and defence heights are indicative only and will need to be confirmed during detailed design.
Defence heights quoted are above existing adjacent ground level.
Design level for low defences (including 200mm freeboard)
= 9.80m
Design level for high defences (including 200mm freeboard)
= 10.40m
Structure references relate to the contents of the associated table

Reach 6-2. Reinforced concrete cantilever wall with piled foundation floodwall along fence alignment to tie-in with Bristol Arena road bridge defence at eastern end. At the western end, defence tie-in to the rail bridge abutment. Height for low defences is up to 1.8m and 2.4m for high defences.

Reach 6-1. Reinforced concrete with piled foundation floodwall at the riverside edge of the roadway. The defence would tie-in to the rail bridge abutment at its eastern end and gradually decrease in height moving west as it reaches high ground. The height of the defence is up to 2.1m for low defences and 2.7m for high defences.



Alignments and defence heights are indicative only and will need to be confirmed during detailed design.
Defence heights quoted are above existing adjacent ground level.
Design level for low defences (including 200mm freeboard) = 9.80m
Design level for high defences (including 200mm freeboard) = 10.40m
Structure references relate to the contents of the associated table



Reach 7-36. embankment tie-in to boundary wall

Reach 7-28. For low defences reinforced concrete cantilever walls constructed to infill between buildings. For high defences it is assumed a new sheet piled defence will be installed during any future redevelopment on the site.

Reach 7-29, 31, 33 & 35. Ramps to maintain footpath access.

Reach 7-27. For low defences buildings to be flood proofed including installation of flood doors, air brick covers and, where appropriate, tanking and structural support. For high defences it is assumed a new sheet piled defence will be installed during any future redevelopment of the site.

Reach 7-25. For low defences buildings to be flood proofed including installation of flood doors, air brick covers and, where appropriate, tanking and structural support. For high defences it is assumed a new sheet piled defence will be installed during any future redevelopment of the site.

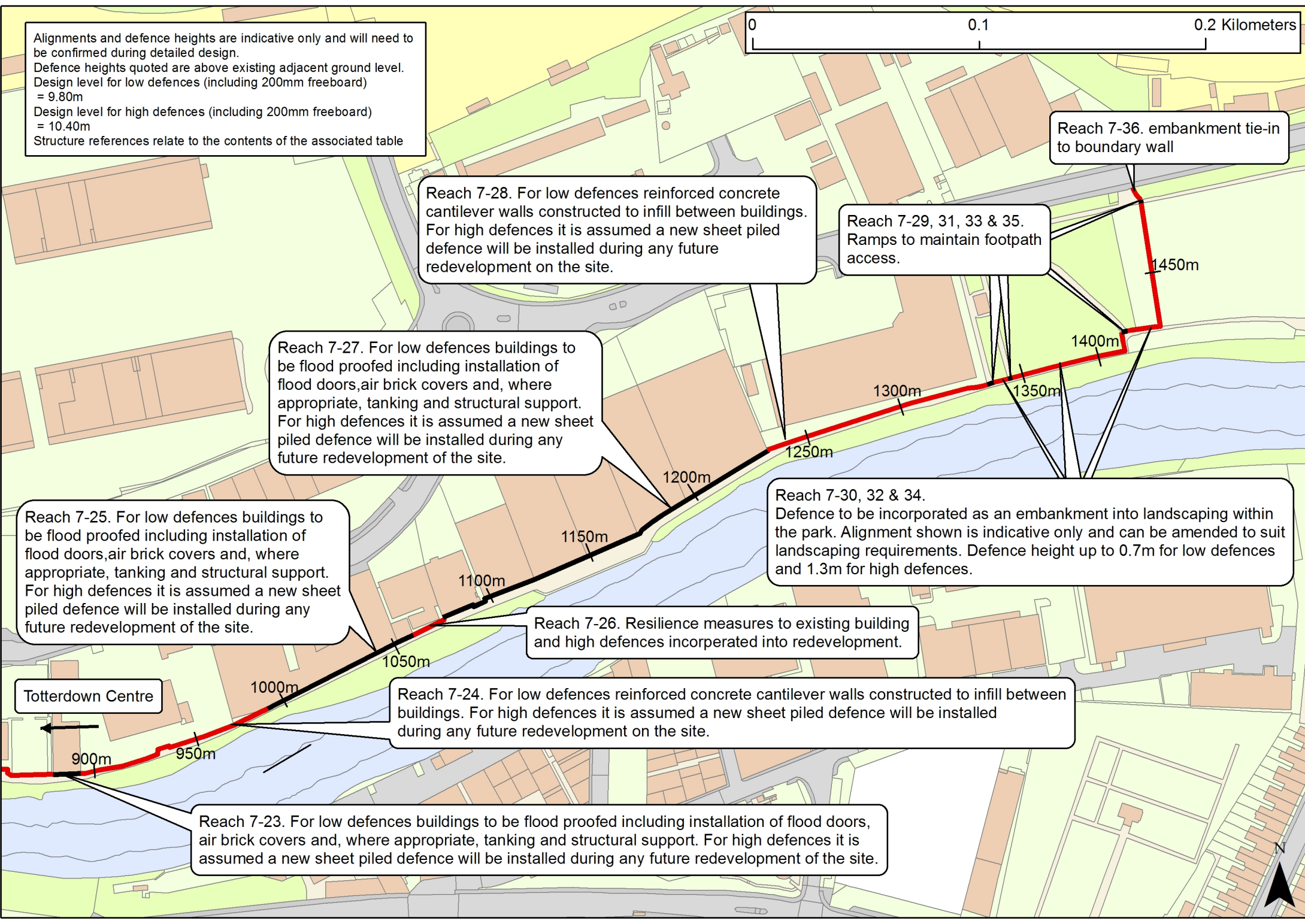
Reach 7-30, 32 & 34. Defence to be incorporated as an embankment into landscaping within the park. Alignment shown is indicative only and can be amended to suit landscaping requirements. Defence height up to 0.7m for low defences and 1.3m for high defences.

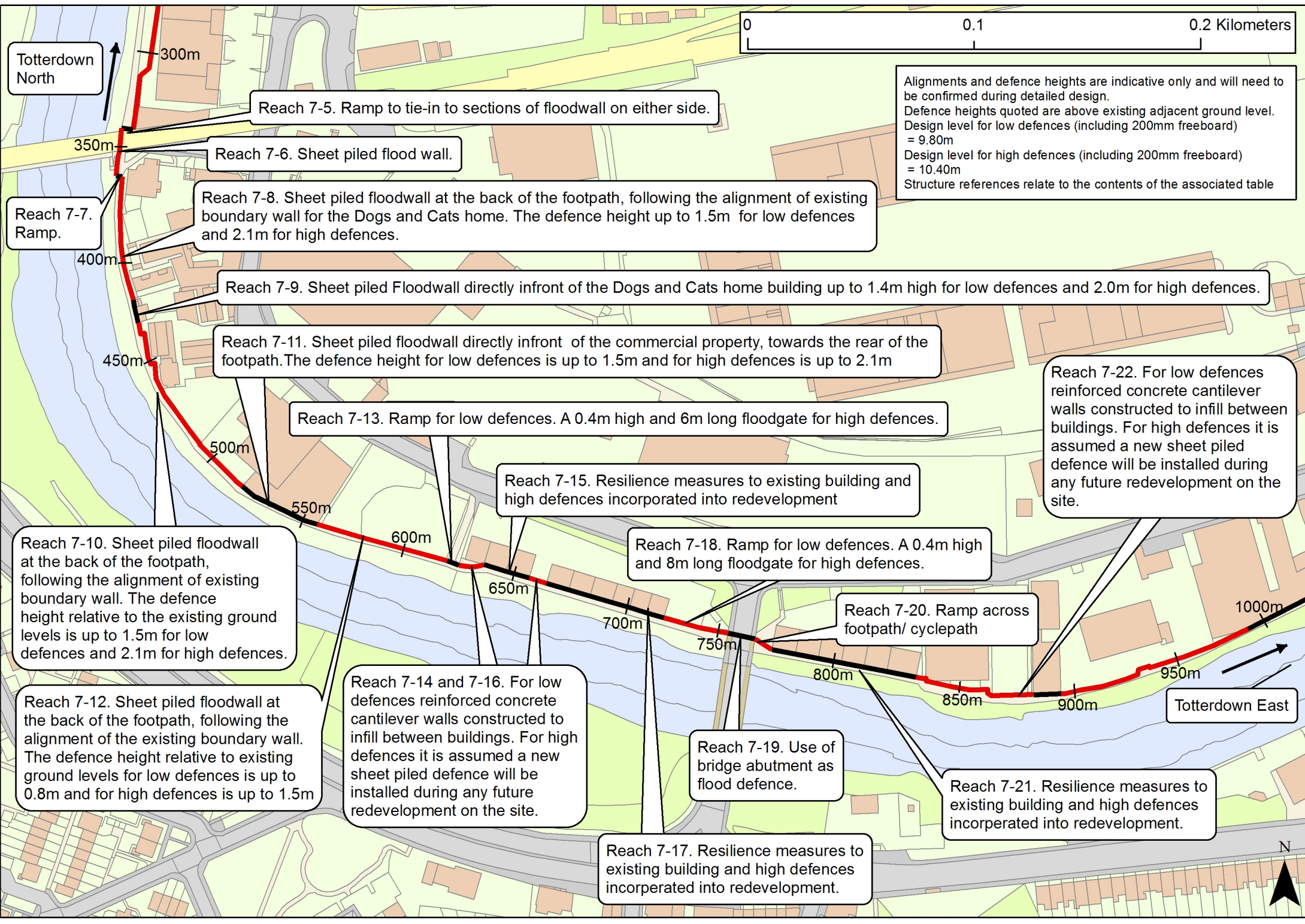
Reach 7-26. Resilience measures to existing building and high defences incorporated into redevelopment.

Totterdown Centre

Reach 7-24. For low defences reinforced concrete cantilever walls constructed to infill between buildings. For high defences it is assumed a new sheet piled defence will be installed during any future redevelopment on the site.

Reach 7-23. For low defences buildings to be flood proofed including installation of flood doors, air brick covers and, where appropriate, tanking and structural support. For high defences it is assumed a new sheet piled defence will be installed during any future redevelopment of the site.





Alignments and defence heights are indicative only and will need to be confirmed during detailed design.
 Defence heights quoted are above existing adjacent ground level.
 Design level for low defences (including 200mm freeboard) = 9.80m
 Design level for high defences (including 200mm freeboard) = 10.40m
 Structure references relate to the contents of the associated table

Totterdown North

300m

Reach 7-5. Ramp to tie-in to sections of floodwall on either side.

350m

Reach 7-6. Sheet piled flood wall.

Reach 7-7. Ramp.

400m

Reach 7-8. Sheet piled floodwall at the back of the footpath, following the alignment of existing boundary wall for the Dogs and Cats home. The defence height up to 1.5m for low defences and 2.1m for high defences.

Reach 7-9. Sheet piled Floodwall directly in front of the Dogs and Cats home building up to 1.4m high for low defences and 2.0m for high defences.

450m

Reach 7-11. Sheet piled floodwall directly in front of the commercial property, towards the rear of the footpath. The defence height for low defences is up to 1.5m and for high defences is up to 2.1m

500m

Reach 7-13. Ramp for low defences. A 0.4m high and 6m long floodgate for high defences.

550m

Reach 7-15. Resilience measures to existing building and high defences incorporated into redevelopment

Reach 7-10. Sheet piled floodwall at the back of the footpath, following the alignment of existing boundary wall. The defence height relative to the existing ground levels is up to 1.5m for low defences and 2.1m for high defences.

600m

Reach 7-18. Ramp for low defences. A 0.4m high and 8m long floodgate for high defences.

650m

Reach 7-20. Ramp across footpath/ cyclepath

700m

Reach 7-12. Sheet piled floodwall at the back of the footpath, following the alignment of the existing boundary wall. The defence height relative to existing ground levels for low defences is up to 0.8m and for high defences is up to 1.5m

Reach 7-14 and 7-16. For low defences reinforced concrete cantilever walls constructed to infill between buildings. For high defences it is assumed a new sheet piled defence will be installed during any future redevelopment on the site.

750m

Reach 7-19. Use of bridge abutment as flood defence.

800m

Reach 7-21. Resilience measures to existing building and high defences incorporated into redevelopment.

850m

Reach 7-17. Resilience measures to existing building and high defences incorporated into redevelopment.

900m

Totterdown East

1000m





Alignments and defence heights are indicative only and will need to be confirmed during detailed design.
Defence heights quoted are above existing adjacent ground level.
Design level for low defences (including 200mm freeboard) = 9.80m
Design level for high defences (including 200mm freeboard) = 10.40m
Structure references relate to the contents of the associated table

Cattle Market Road

Reach 7-1. Ramped access to the new bridge crossing to the arena.

0m

50m

100m

Reach 7-2. Sheet piled floodwall at the back of the access path which leads to the St. Phillips footpath. The defence to follow alignment of existing masonry wall at the back of the path.

Reach 7-3. Sheet piled floodwall at the back of the footpath. The defence height up to 2.1m for low defences and 2.7m for high defences

150m

200m

Reach 7-4. Redevelopment associated with the Arena includes footpath raising and a new frontline wall which will provide the low defence level. High defences assumed to be incorporated into redevelopment of Enterprise zone. Assumed to be a sheet piled wall for costing purposes.

250m

300m

350m

Totterdown Centre



