



Radcliffe & Redvales FRMS

Flood Risk Assessment – Phase 2

12 May 2023

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P05	12/05/23	B Brown	T Atkinson	L Edmonds	Update for Planning Submission

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1 Introduction

BMM JV has been commissioned under Lot 4 of the Water and Environment Management (WEM) framework to deliver a package of flood risk management scheme appraisals and other studies for the Environment Agency. The Radcliffe and Redvales Flood Risk Management Scheme (FRMS) appraisal forms part of this package of work.

1.1 Background

The Radcliffe and Redvales area of Bury in Greater Manchester is subject to significant flood risk. The primary source of this flood risk is fluvial flooding from the River Irwell. On Boxing Day in 2015 the area suffered significant flooding following a period of heavy rainfall in the upper River Irwell catchment. Over 700 properties were flooded, and this has provided the momentum and justification to reassess the viability of delivering a Flood Risk Management Scheme (FRMS) for the area.

The Full Business Case (FBC) for the scheme was approved by the Large Project Review Group (LPRG) in May 2019. A Flood Risk Assessment (FRA) is required to support the planning application. This needs to demonstrate that the scheme can be successfully and safely delivered in accordance with the National Planning Policy Framework (NPPF).

1.2 Purpose of this Document

As the flood scheme will be constructed within Flood Zone 3, a Flood Risk Assessment (FRA) is required as part of the planning application, in accordance with NPPF.

The scheme is being delivered in two phases and supported by separate planning submissions. This FRA, whilst relevant to both phases, is focussed on the impacts of Phase 2 which are being submitted for planning approval. A separate document (ENV0000389C-MMD-DZ-00-RP-Z-0215010 Flood Risk Assessment - Phase 1) was prepared and submitted for planning approval in December 2018 for the Phase 1 works and have since been approved.

This FRA will look at:

- An overview of the proposed development;
- Current flood risk;
- Future flood risk, and
- Residual flood risk following the delivery of the scheme;

This document covers Phase 2 of the scheme only to demonstrate the suitability of Phase 2, assuming Phase 1 is completed as planned and that the two phases are completed as one combined scheme.

Some updated comments and text changes have been added to this report as part of Rev P05 to explain the final measures being applied at Bury Grammar School and Hardy's Gate Bridge.

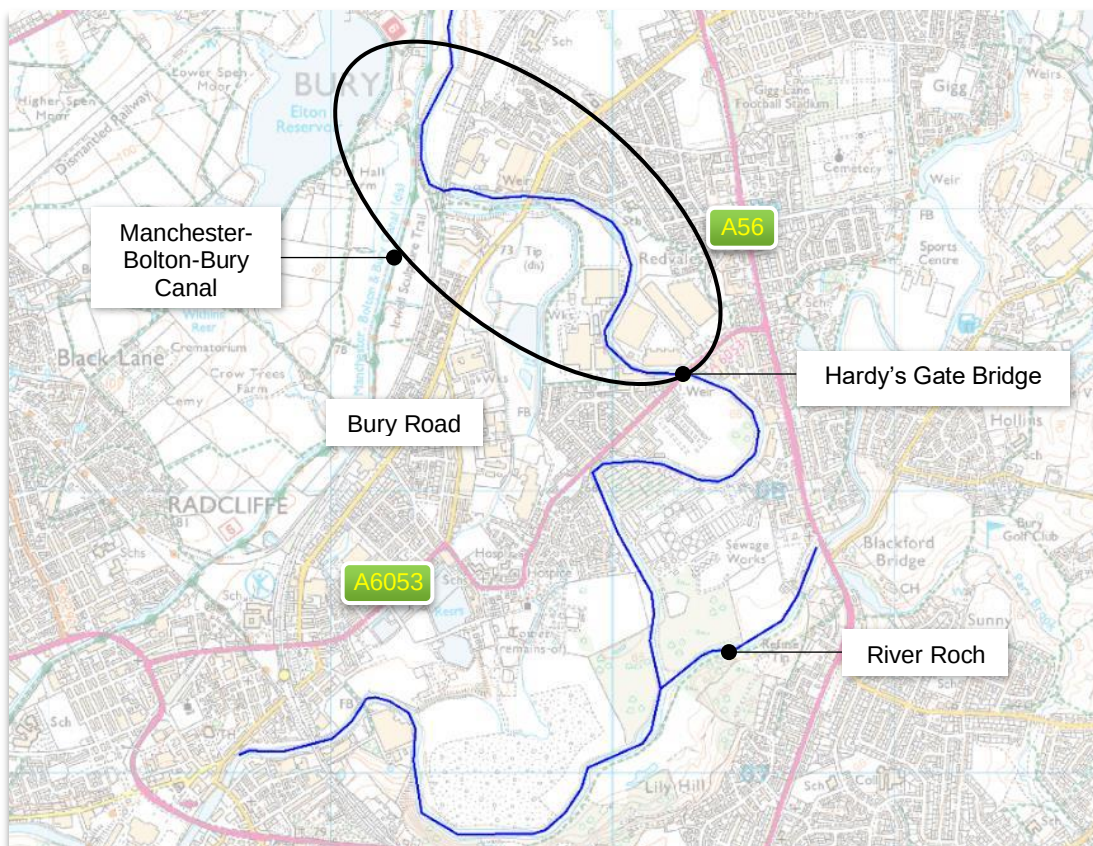
2 Site Description

2.1 Current Development and Site Layout

The study reach extends from upstream of the Metrolink crossing of the River Irwell at Lower Hinds through Redvales to Radcliffe Town Centre. Within this reach, flows are dominated by the runoff generated in the catchment upstream and incoming flows from the neighbouring River Roch catchment that joins the Irwell within the study area. The approximate study area, defined as the collective extent of the FRMS is shown in Figure 1.

For the purposes of the FBC, the flood scheme has been split into two delivery phases, referred to as Phase 1 and Phase 2 throughout this document. Phase 1 consists of works downstream of Hardy's Gate Bridge with Phase 2 including all work upstream.

Figure 1: Study Area (Approx extent of Phase 2 FRMS Circled)



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2.2 Proposed Development

The key components of the scheme are listed below.

Phase 1:

- Component 19A, 19B– raised defences at Dumers Lane & Morris Street

- Component 21A, 21B – raised defences at Close Park
- Outfall protection at various locations

Phase 2:

- Component 6 – raised defences to west of Metrolink line and to the south of Bury Grammar School sport pitches
- Component 10 – raised defences at Warth Industrial Park
- Component 45 – raised defences at Keswick Drive
- Component 38 – raised defences at Redvales Business Park
- Component 37 – raised defences at York Street
- Component BP – raised defences at Bury Point (NOT to 1% AEP Standard of Protection)
- Hardy's Gate Bridge – flood gate defences at each end of the bridge deck
- Hutchinson's Goit Culvert – culvert entrance flow control structure and localised raised defences
- Outfall protection at various locations

Phase 2 defences are shown in the *Site Location Plan* located in Appendix A.

The scheme has been designed to provide a 1% AEP Standard of Protection (with the exception of the Bury Point defences which are provided as lower level, supplementary defences to a private business) including an allowance for future climate change based on the 2016 Environment Agency Guidance¹, central estimate projections and the long term 2080s epoch (2070 to 2115).

Note that new raised defences around United Utilities owned Bury Wastewater Treatment Works (WwTW) are not part of this scheme. However, it is recognised that United Utilities may upgrade this component in due course. The defence levels for this scheme have therefore been designed to accommodate potential level increases that in the channel that future defences at Bury WwTW are predicted to cause. However, for the purposes of this FRA report, the results are based on Bury WwTW remaining unchanged to illustrate the potential effects on the site should these defences not go ahead.

2.3 Flood Zone Definition

The proposed development covers a wide area but predominantly falls within Flood Zone 3a. As the scheme functions as flood control infrastructure it is classed as 'Water Compatible' by the NPPF Technical Guidance² and thus is appropriate for construction in Flood Zone 3. For further information see Table 1.

Based on Table 1, the exception test is not required.

¹ 2016 Environment Agency Adapting to Climate Change Guidance.

² <https://www.gov.uk/guidance/flood-risk-and-coastal-change>

Table 1: Flood Risk Vulnerability and Flood Zone ‘Compatibility’

Flood Zone	Flood Risk Vulnerability Classification				
	Essential Infrastructure	Water Compatible	Highly Vulnerable	More Less Vulnerable	Vulnerable
Zone 1	Y	Y	Y	Y	Y
Zone 2	Y	Y	Exception test required	Y	Y
Zone 3a	Exception test required	Y (Proposed site)	X	Exception test required	Y
Zone 3b	Exception test required	Y	X	X	X
Y Development is appropriate					
X Development should not be permitted					

Source: Flood Risk and Coastal Change Technical Guidance, NPPF, March 2014.

3 Current Flood Risk – Phase 2 Area

This section summarises the current (pre-scheme) flood risk to the Phase 2 area and in the local vicinity to the site.

3.1 Fluvial Flooding from Main Rivers

3.1.1 River Irwell

The River Irwell is the principal source of flood risk across the study area and reducing this is the primary focus of the FRMS.

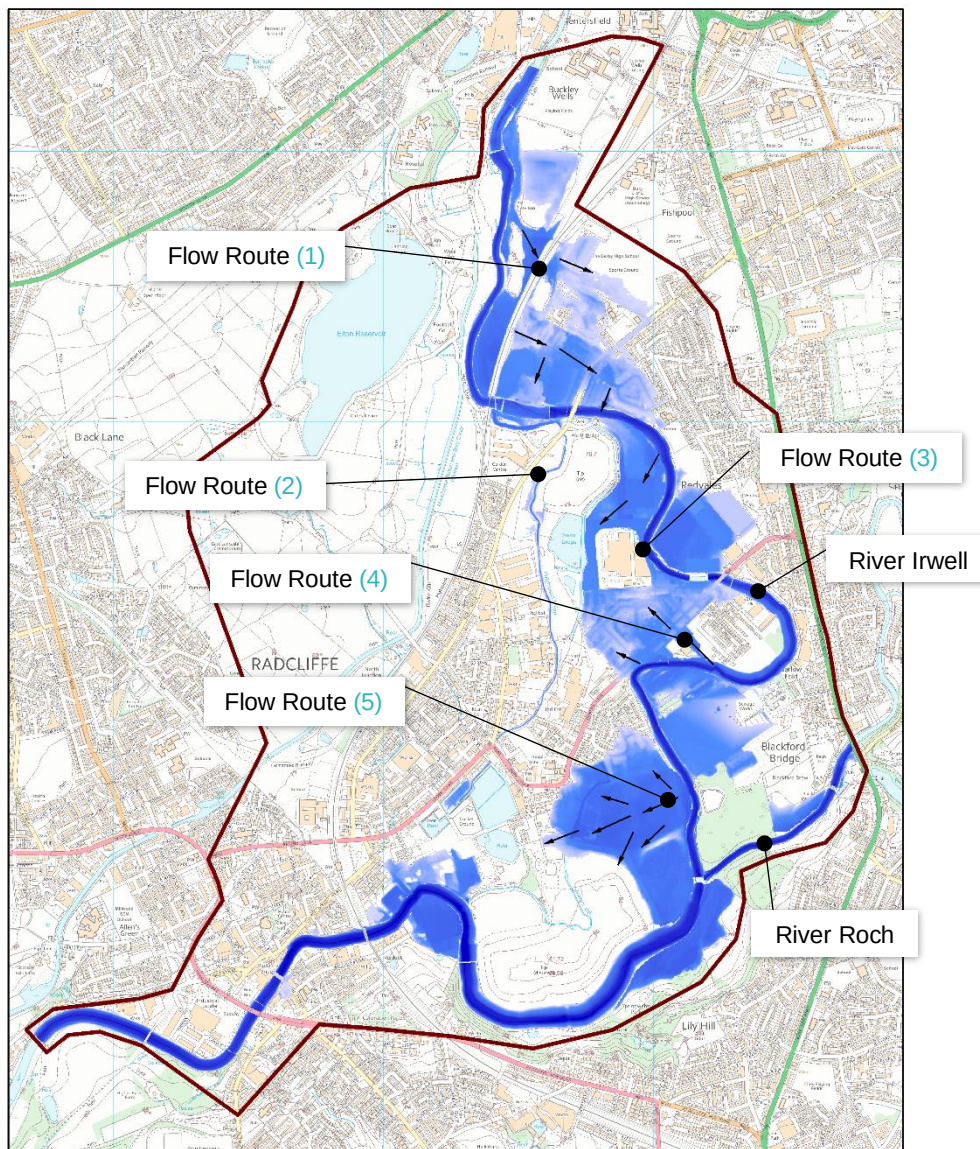
The Environment Agency's Flood Map for Planning indicates that there is significant flood risk on the reaches of the River Irwell within the study area, affecting a large number of properties. To inform the FRA, fluvial flooding has been quantified using the Bury South 2016 1D-2D hydraulic model produced by JBA Consulting. The defended model outputs indicate that the onset of flooding to properties within the study area is as low as the 10% AEP event. Undefended flood depth outputs for the 2080 climate change enhanced 1% AEP event are shown in Figure 2, with key overland flow routes identified. Flooding through the study area is caused by the limited capacity of the channel and structures that cross it.

3.1.2 River Roch

The River Roch joins the Irwell downstream of the study area and provides a significant contribution to flow that is roughly equivalent to the flow from the River Irwell catchment upstream. There is no flood risk originating from the River Roch within the study area. However, further upstream, there are extensive areas of flood risk within the River Roch catchment in Rochdale and Littleborough. A separate FRMS is being progressed to manage the flood risk within these areas. The planned scheme, currently at FBC stage, will include a significant flood storage element and due to the linked hydrology, if delivered, will result in a reduction in downstream flows in the River Roch and subsequently the River Irwell.

The impact of the FRMS on fluvial flood risk is assessed in Section 4.

Figure 2: Flow Routes and Flood Extents on River Irwell within the Study Area



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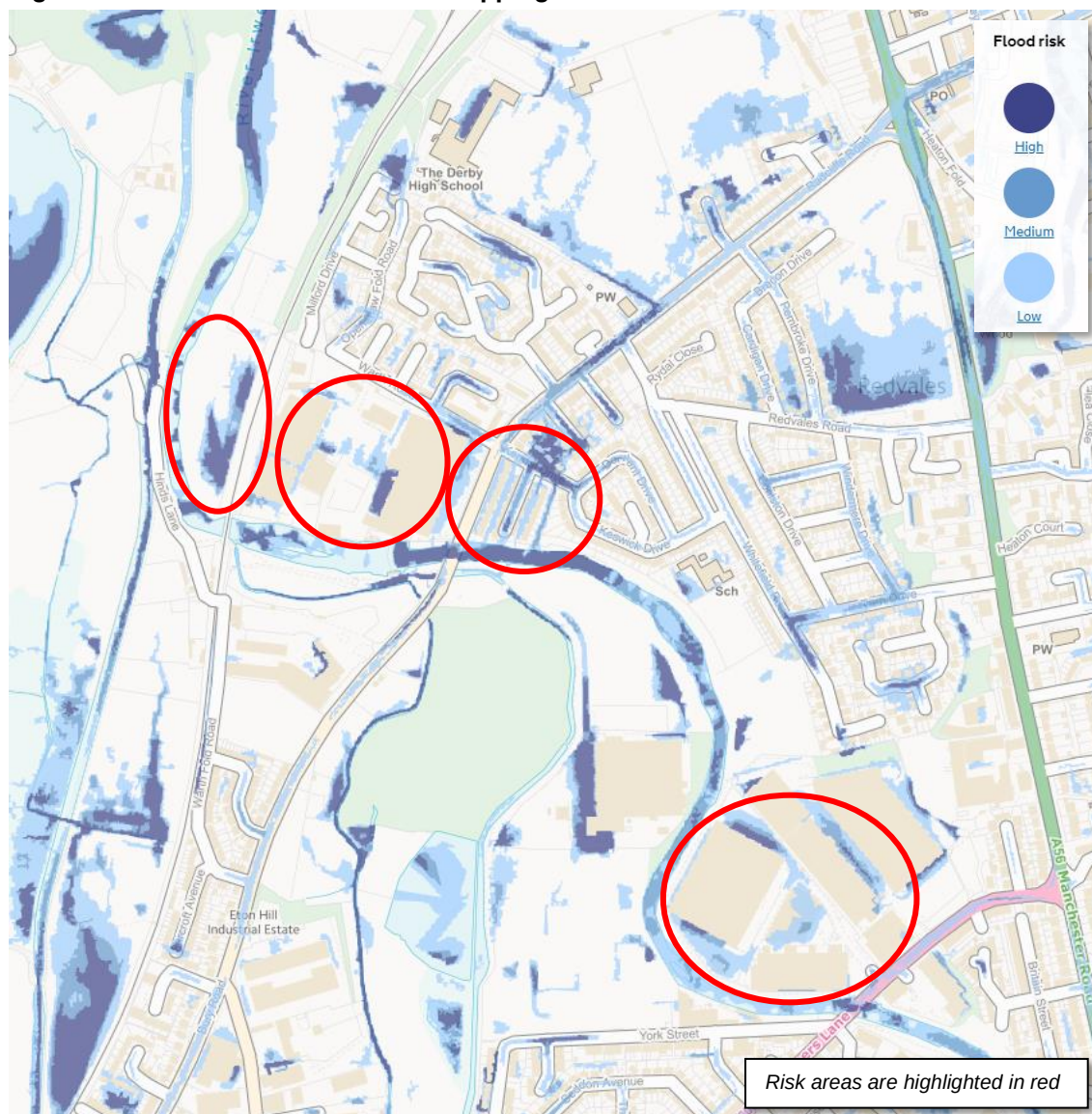
3.2 Flooding from Surface Water

The Environment Agency's Risk of Flooding from Surface Water shows that surface water flood risk is significant across the wider study area, however the risk in the immediate vicinity of the Phase 2 area is generally fairly low. The exception to this is the Kendal Drive/Keswick Drive residential area in Component 45 where surface water drains towards the river in several locations and there is potential for significant entrapment of surface water drainage by the defences. This is backed up by the outputs of the 2012 Greater Manchester Surface Water Management Plan (prepared by JBA Consulting).

Figure 3 shows the predicted flood risk areas for surface water events in Phase 2. This shows that there are localised areas of high (> 3.3% AEP) and medium (1% AEP – 3.3% AEP) surface water flood risk across the site.

The majority of these areas are not adjacent to proposed defences and do not drain back into the River Irwell via overland flow routes. However, the mapping does indicate several flow routes for surface water back into the River Irwell across the proposed defence alignments, most notably across Component 10 at Warth Business Park (adjacent to Radcliffe Road) and Component 45 at Keswick Drive. The interruption of these return routes necessitates suitable drainage and outfall provision along the defence. The provision of additional drainage and outfalls in these locations to mitigate the possible impacts of the raised defences will be reviewed and included as part of the proposed works.

Figure 3: Surface Water Flood Risk Mapping for the Phase 2 Area



Source: Contains OS data © Crown copyright and database right (2019). Contains outputs from the Greater Manchester Surface Water Management Plan, JBA Consulting, 2012.

3.3 Flooding from Reservoirs, Canals and Ordinary Watercourses

3.3.1 Elton Reservoir/Elton Brook

Elton Reservoir is a Reservoir under the Reservoirs Act 1975 with a plan area of 226,000 m² and a capacity of 1 million cubic metres, built to supply water to the Manchester Bolton Bury Canal. As a reservoir under the Reservoirs Act 1975, with an appointed Inspecting Engineer and Supervising Engineer, Elton Reservoir is considered to be at low risk of failure because regular inspection should ensure a standard of protection of at least a 1 in 150-year design flood and a 1 in 1,000-year safety check flood.

The reservoir outfalls via an unnamed channel that splits the flow in two; into the Manchester-Bolton-Bury Canal, and via Warth Fold Road culvert to Hutchinson's Goit. This culvert introduces a potential flood risk given its low diameter (300mm) and visible sedimentation identified in recent site visits. However, the flood risk associated with this watercourse is isolated from the main flood mechanism on the River Irwell and will remain unaffected by this FRMS scheme.

3.3.2 Hutchinson's Goit and Bealey's Goit

Hutchinson's Goit is an artificial channel which formerly served the reservoirs of Withins Mill and then the East Lancashire Paper Company. It is intermittently culverted along its length and includes several control structures, most of which are in poor condition. The channel is heavily overgrown for much of its length with little to no flow during dry weather.

Bealey's Goit is a disused industrial goit originally constructed to provide water and power to Bealey's Bleach Works in Radcliffe. The goit has since been partially infilled and has fallen into disrepair. Flow paths into the goit are largely isolated or heavily constrained and it is generally unaffected by river flow.

Hutchinson's Goit is isolated from the main channel by a closed off penstock at the inlet structure. It has no river flow entering it during normal conditions. However, flows still enter the goit from via connecting surface water drainage and via out of bank flows upstream of Bealey's Weir. At its origin, just downstream of the Metrolink bridge, the goit comprises a short section of open channel before passing through an arched culvert below Warth Road Bridge which acts as a flow constraint. Due to its elevated position above the main River Irwell watercourse section below Bealey's Weir, flows in the goit tend to quickly back up and spill back into the main watercourse downstream of the weir, limiting the overall flow down the goit. The open channel section of Hutchinson's Goit between Bury Road and Cross Lane has a low capacity (~3m³/s) and is at a higher elevation than Bealey's Goit and the Ripon Close development, so out of bank flows will flow overland into Bealey's Goit and ultimately overflow onto Ripon Close – evidenced by an EA Operations Team in the aftermath of the 2015 Boxing Day floods³.

Though each has its own small direct catchment, the flood risk from both goits is linked to fluvial flood risk on the Irwell. Specifically, it is considered that Hutchinson's Goit has the potential to create a pathway for fluvial flows from the main river into the centre of Radcliffe. Video evidence⁴ shows that floodwater from the River Irwell did enter Hutchinson's Goit in the December 2015 event. Modelling has shown that uncontrolled flow into Hutchinson's Goit can lead to overtopping of the goit and short-circuiting of the flood defences.

³ Site Visit Report, Environment Agency, 11th Jan 2016.

⁴ Mick Butterworth, Radcliffe floods River Irwell Monkey Bridge Boxing Day 2015, <https://youtu.be/eeQevXhx70M> [accessed 27/02/2017]

3.3.3 Manchester-Bolton-Bury Canal

The canal is managed by the Canal and River Trust who have responsibility for its maintenance, and it is considered that this maintenance will include maintenance of the embankment to avoid breach failure. The flood risk from the canal is therefore considered to be negligible in the context of this study and will remain unaffected by Phase 2 of the FRMS.

3.3.4 Withins Reservoir and Goit

Withins Reservoir is privately-owned and categorised as a reservoir under the Reservoirs Act 1975, with an appointed Inspecting Engineer and Supervising Engineer. As such, Withins Reservoir is considered to be at low risk of failure because regular inspection should ensure a standard of protection of at least a 1 in 150-year design flood and a 1 in 1,000-year safety check flood.

The reservoir outfalls via Crow Trees Farm Brook. Withins Goit bifurcates from Crow Trees Farm Brook and is intermittently culverted under Radcliffe before flowing into the infilled reservoirs of the East Lancashire Paper Mill. Sections have been infilled as part of development proposals with only a residual drain included. Flooding from Withins Reservoir and goit will remain unaffected by Phase 2 of the FRMS.

3.4 Flooding from Groundwater

Groundwater flood risk is low across the study area. This will remain unaffected by Phase 2 of the FRMS.

3.5 Flooding from Sewers and Artificial Drainage

Site surveys carried out in the aftermath of the Boxing Day 2015 flood event noted that flooding in Redvales Business Park was associated with the below ground drainage systems in that area, rather than with the overtopping of the banks of the River Irwell. However, it is unclear whether this flooding originates from backflow from the Irwell or hydraulic locking of non-return valves coupled with surface water ponding.

Table 2 lists the recorded flood events originating from surface water flooding in Radcliffe & Redvales.

Table 2: Breakdown of United Utilities surface water flooding events in Radcliffe and Redvales

United Utilities Record	Number of Entries in Radcliffe & Redvales
DG5 Register (Internal and External)	0
W.I.R.S.	3
S.I.R.S.	11

These events are distributed across the area. The impact of the FRMS on flooding from sewers and artificial drainage is assessed in Section 4.

3.6 Flood Risk Due to Climate Change

In the future, flood risk within the study area is expected to increase as a result of future climate change. Climate change has been reflected in the assessment of flood risk drawing on the 2016 Environment Agency Adapting to Climate Change Guidance. Given the vulnerability of the flood scheme (that is classed as water compatible development) and the longevity of the

scheme, it is appropriate to assess the flood risk associated with Central climate change projections, for the long term 2080s epoch that covers the period from 2070 to 2115.

Based on this guidance, a 30% uplift has been applied to design flows to represent the future impact of climate change. The event used to inform the FRA is the climate change enhanced 1% AEP (2080s) event.

4 Post-development Flood Risk - Phase 2

The flood scheme has been designed to reduce flood risk to residential and commercial properties within the study area and provide protection up to the climate change enhanced 1% AEP (2080s) event. As described in Section 2.1, the construction and delivery of the scheme has been split into two phases. The technical detail presented in this section of the FRA covers the impact produced by the combined delivery of both Phases 1 and 2 as well as the potential risk and impact of individual components of Phase 2.

4.1 Flooding from Rivers

4.1.1 Impact on the Flood Extent and Floodplain within the Study Area

Delivery of the full scheme (Phase 1 and Phase 2) produces a clear flood risk management benefit to 873 properties of which Phase 2 is the largest contributor. The scheme wide benefit of the full scheme being delivered considering the climate change enhanced 1% AEP (2080s) event is shown in Figure 4.

The defences have been designed to tie into existing high ground and structures where appropriate including existing parapets on Warth Road Bridge, Hardy's Gate Bridge and the raised PIN development platform, to ensure a continuous defence.

The potential increased risk of short-circuiting of the defences via Hutchinson's Goit is fully mitigated by the scheme proposal to constrain flows at the entrance to the Bury Road (Warth Bridge) culvert entrance.

The modelling indicates no detriment to existing flood extents in the floodplain within the study area resulting from delivery of scheme. The predicted change in water levels and flood depths resulting from the scheme is shown in Figure 5.

Figure 4: Predicted Flood Extents Through the Study Area

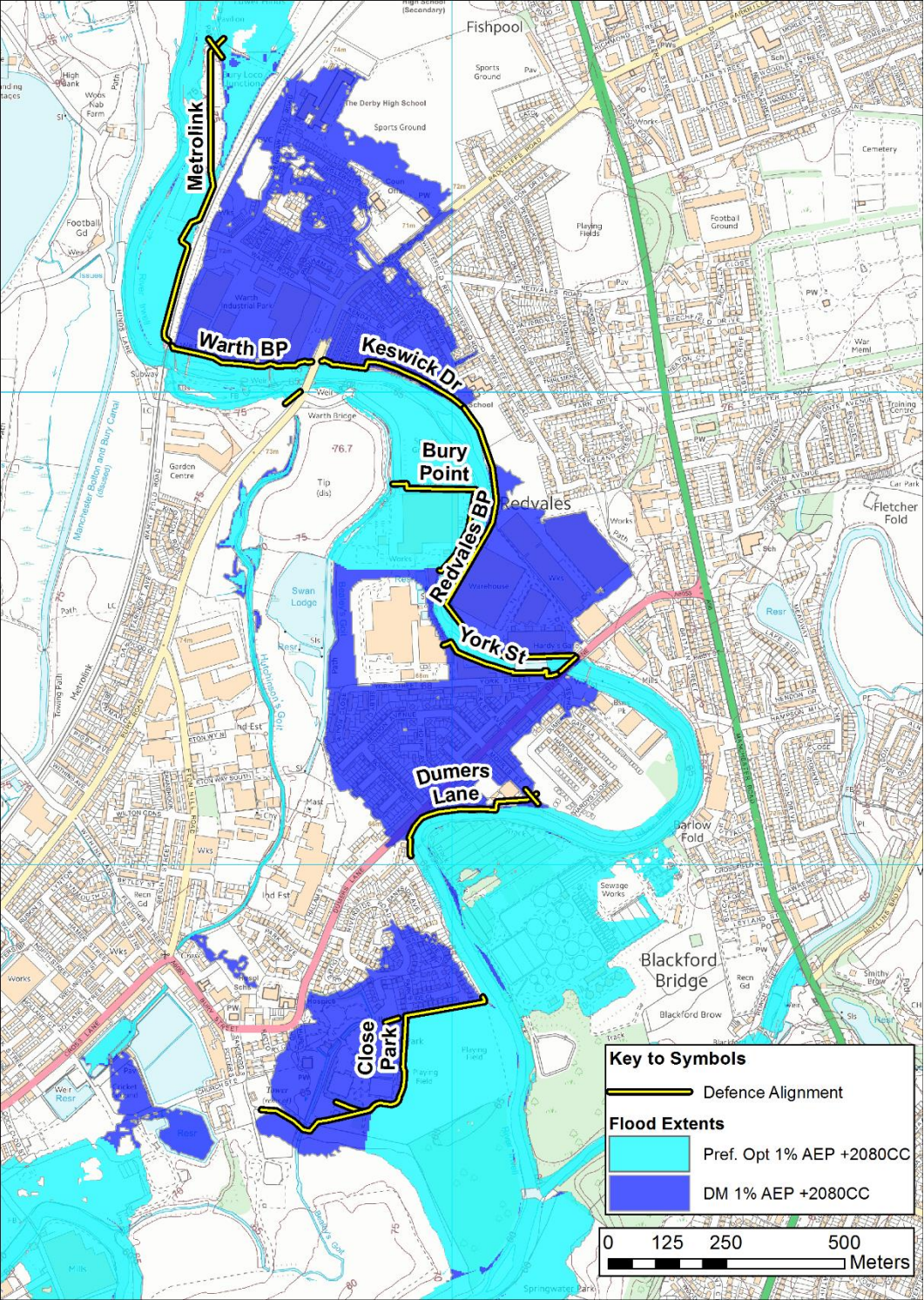
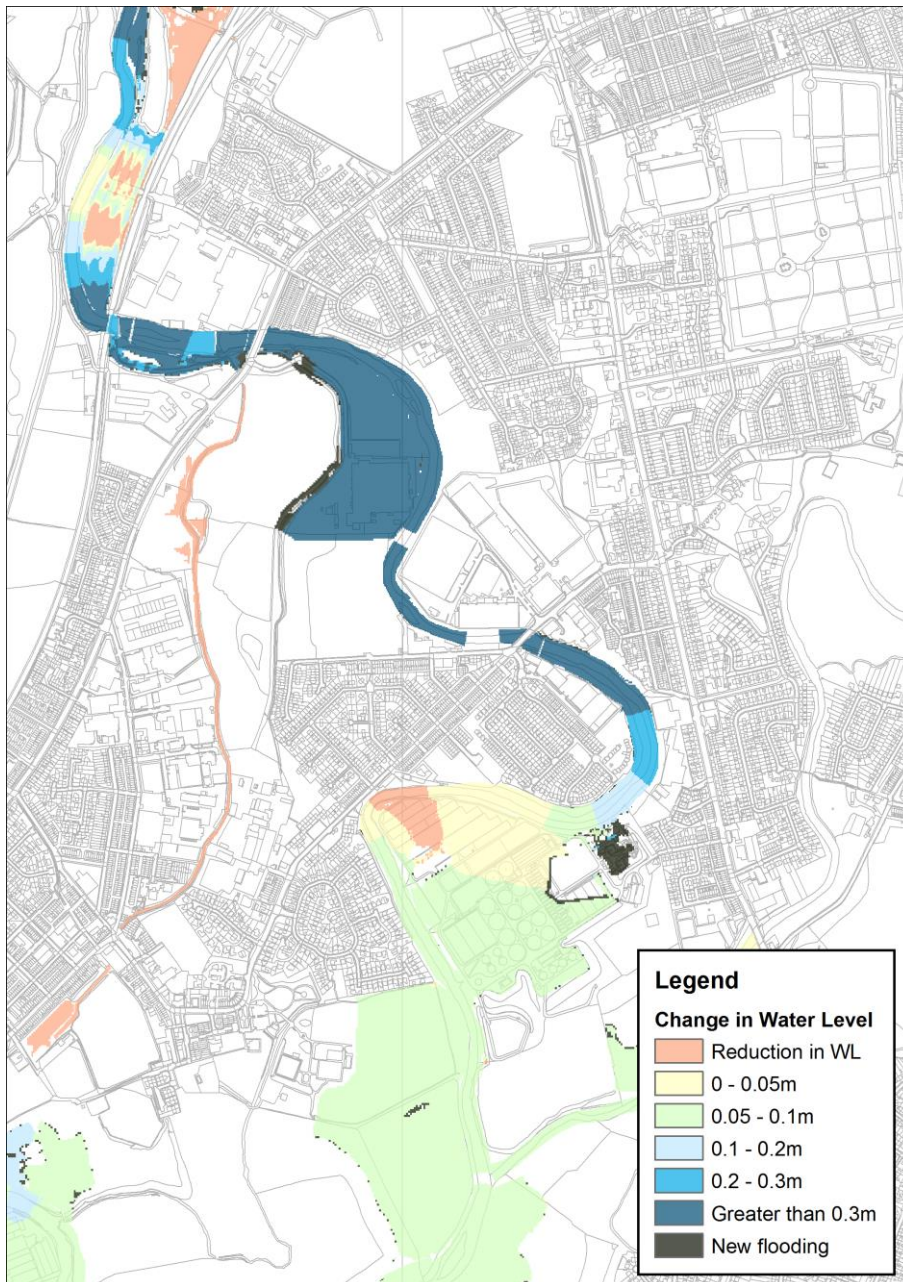


Figure 5: Predicted Change in Peak Water Levels Throughout the Study Area



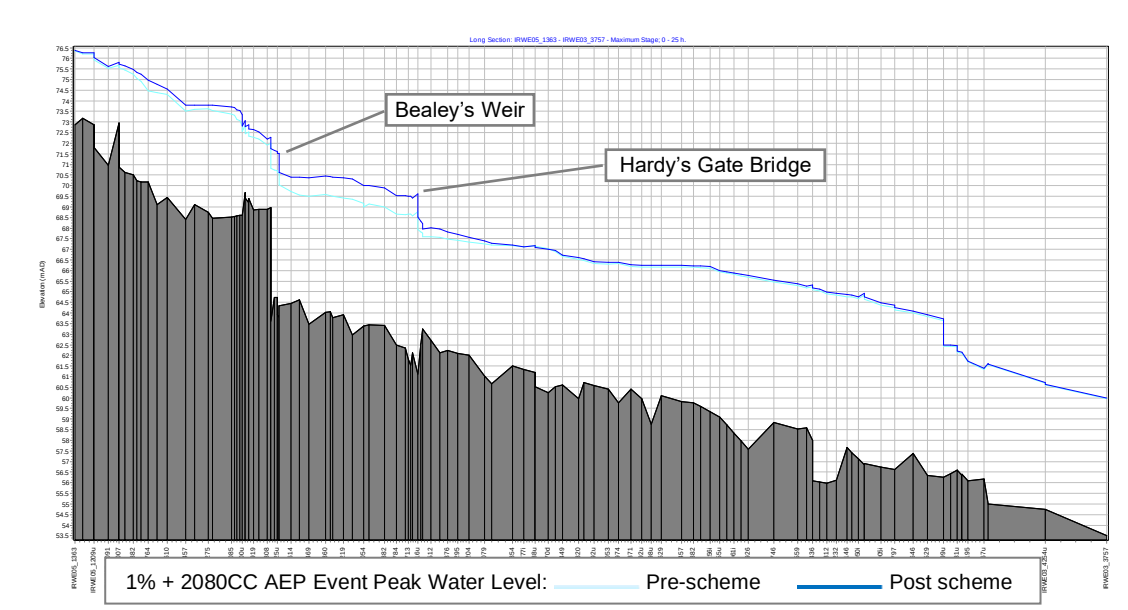
4.1.2 Impact on Peak Water Levels in the Channel

Due to the much greater containment of flow within the channel, water depths within the channel logically increase. The impact of the full scheme of the FRMS on predicted peak water levels upstream and downstream of the site area are shown in Figure 6. This shows that;

- There is considerable variation in changes in flood levels across the study area with the most significant change in peak water levels occurring where flows are most contained between the Metrolink Bridge and Hardy's Gate Bridge as expected.

- Flows are generally constrained by existing bridge structures, with the most significant increases occurring at the upstream faces of Metrolink Bridge (+550mm), Bury Road (Warth) Bridge (+940mm) and Hardy's Gate Bridge (+830mm).
- Changes in peak water levels across Durers Lane, Close Park and Bury WwTW are shown to be marginal (<0.1m) based on Bury WwTW remaining unchanged. It is noted that the flood defences have been designed to accommodate the predicted increase in flood levels should Bury WwTW be defended to the 1% AEP level in the future.
- There is a reduction in peak water levels on Hutchinson's Goit.

Figure 6: Predicted Peak Flood Levels Through the Study Area



4.1.3 Downstream Impacts Beyond the Study Area

The increased flood conveyance caused by greater containment of flows within the channel and the relative reduced floodplain storage volumes resulting from the completion of Phase 1 and Phase 2 result in a net increase in the pass forward flow downstream, as shown in Figure 7. This highlights a $10\text{m}^3/\text{s}^*$ (<2%) increase from $570\text{m}^3/\text{s}$ to $580\text{m}^3/\text{s}$ in the peak flow downstream in the climate change enhanced 1% AEP event. *see update below.

However, almost immediately downstream of Close Park, the River Irwell combines with the River Roch and downstream flows are impacted almost equally by both flow sources. At the time of writing, a separate FRMS project is ongoing on the River Roch catchment at Rochdale and Littleborough, which will include a significant flood storage element. It is currently estimated that this will result in a net decrease in peak flow from the River Roch that will be of sufficient magnitude to offset the predicted increase in peak flows in the River Irwell above, resulting in no net increase in flood risk downstream.

In the event that the River Roch scheme were not to progress or fail to provide sufficient offsetting of the respective flow increase, Phase 3 of this FRMS would be implemented to provide additional flood attenuation storage via the enlargement of the Swan Lodge area supplied by Hutchinson's Goit which would mitigate the downstream impacts.

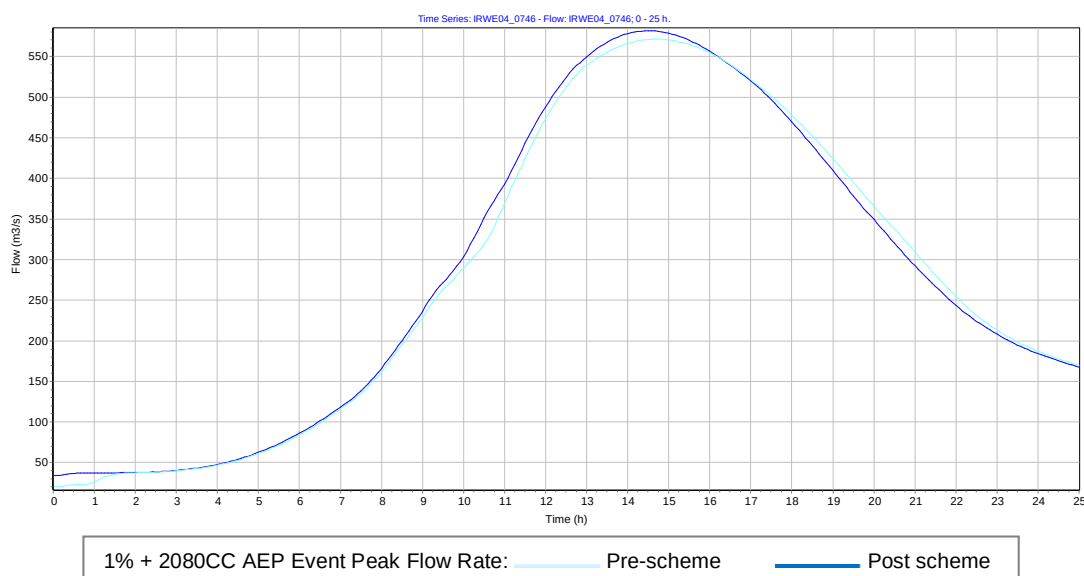
Update 24/01/22 Rev P04: The overall change in peak flow as a result of the scheme has been reduced to c.6m³/s through various improvements to the model and scheme. It is accepted that mitigation is still required to offset this impact.

The benefits of the River Roch Scheme remain unconfirmed at the time of writing. Hence, pending any confirmation of this scheme, it is currently intended to progress with the creation of an offline storage reservoir on the site of the Swan Lodge Lake. This will be designed to fill and flood the existing lake and surrounding via a high-level inlet weir and set to overflow during extreme events only. The inlet is now proposed to spill directly from the floodplain to the east of the site (not via Hutchinson's Goit as initially planned above). Enlargement and containment of the storage area by low embankment is proposed. It is noted that upstream NFM measures are also being considered as an alternative/supplementary measure which may remove or reduce the scale or need for the reservoir in due course.

The effect of the proposed offline storage reservoir at Swan Lodge will only occur at very extreme events (typ. >1:75yr event). The application of the reservoir will clearly result in flooding of the planned storage area during these extreme events, but it will only have a beneficial effect on the overall peak flow and water depths within the main river channel.

Update 12/05/23 Rev P05: Swan Lodge is currently no longer being considered as part of this scheme.

Figure 7: Predicted Pre and Post Scheme Hydrographs in Radcliffe for the 1% AEP +2080CC Event



4.2 Flooding from Surface Water

Surface water in the residential areas at Components 45 and the commercial business parks at Components 10, 37 and 38 is currently managed by the system of private and public highway drains that cover the local area. Generally, these are limited by their ability to drain to the river.

The project has consulted and worked directly with United Utilities to identify risk areas where localised increased water levels in the river may have a detrimental impact on the performance of their network and lead to increased flood risk. This assessment has concluded that there are no areas within the FRMS study area where there is sufficient increase in surface water flooding risk to cause concern. This analysis has been based on a conservative scenario of outfalls being 'tide locked' by a 1-in-100-year flood event whilst a 1 in 30 rainfall event also occurs. The combined probability of this is closer to 1 in 3,000 and hence considered conservative.

Full details of the assessment are available in United Utilities "Radcliffe and Redvales Flood Risk Management Scheme Modelling Report (MP 569 Radcliffe and Redvales)"

Surface water flood risk is therefore expected to remain largely unchanged from the pre-scheme case.

4.3 Flooding from Artificial Drainage

Throughout the study area there are numerous highway and surface water drainage outfalls that discharge into the River Irwell.

The function of these outfalls will be constrained by water levels in the River Irwell, however, during flood conditions they are expected to be locked due to the relatively low invert level of the outfalls. Section 4.1 has highlighted that peak water levels will generally increase, particularly within the Phase 2 area upstream of Hardy's Gate Bridge.

To manage any risk of backflow, key outfalls identified as being at significant risk of backflow will be protected with flap valves or similar non-return fittings as part of the scheme.

4.4 Residual Risk from Partial Delivery of Phase 2 Elements

Phase 2 has been designed and will be delivered as a single scheme to complete and complement the proposed system of defences initiated by Phase 1 (due for completion in Mar 2020). Whilst a number of separate planning applications are being submitted for Phase 2, there is no planned scenario where only part of the Phase 2 elements would be constructed. For completeness, the following sections of this FRA consider the residual risks of individual components being constructed in isolation. However, it should be noted that in reality, individual components of the scheme would not be constructed if it became clear that any component would not be approved (the exception to this is Bury Point which is a localised defence only and not critical to the standard of protection provided by the overall flood defence scheme).

As Phase 1 will already have been delivered, there are no temporary impacts of delivering Phase 2 in isolation from Phase 1.

Breakdown of Phase 2 Application

The Phase 2 proposal is expected to be submitted as 4 separate planning applications, all within 2 months of each other and to be constructed under one contract as a continuous construction activity. The elements within each planning submission are as follows:

- Component 10 (Warth Business Park) only
- Component 45 (Keswick Drive) only
- Component 6, Component 37, Component 38 and Bury Point combined
- Work elements to Hardy's Gate and Warth Road Bridges, Hutchinson's Goit culvert and possible additional re-profiling to north of Component 6 (need to be confirmed by final modelling – refer to specific entry in 4.6 below).

Whilst the construction programme shows work occurring simultaneously at these locations and being complete by March 2021, it is recognised that as such there exists a short-term risk of a flood occurring while the scheme is only part complete, or part delivered. The following sections consider the potential impacts of completion of individual components.

Construction of Component 10 only

The defences at Component 10 would act to contain flood waters within the business park that may have previously escaped back into the river via the banks. Without completion of Component 6, flooding to the area could continue via the Metrolink underpass, leading to detrimental entrapment of flood water (See Figure 8). Without this return path, floodwater does three things:

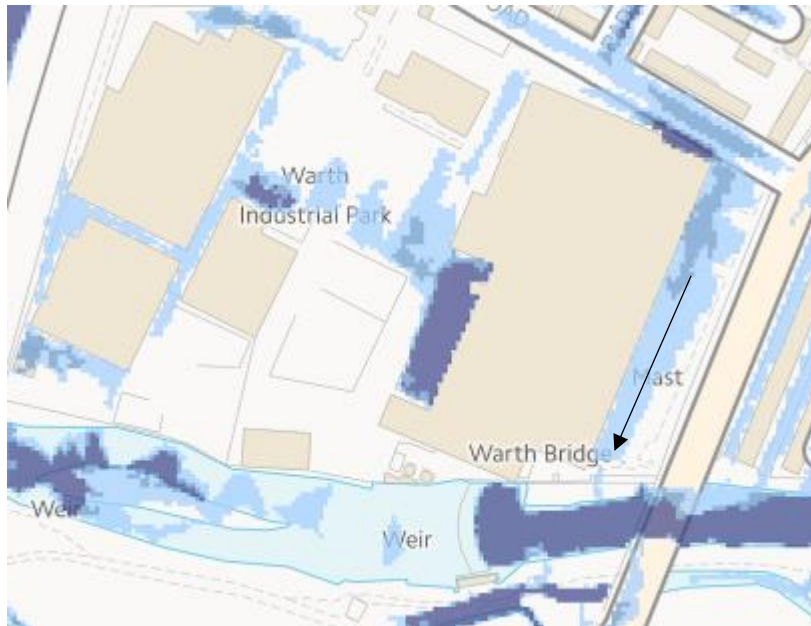
- builds up against the business park building and ponds inside Warth Business Park,
- floods Warth Road and the row of houses opposite, and
- flows onto Warth Bridge, flooding the bridge and returning to the river on the south bank. This may also act to mobilise Hutchinson's Goit and/or Bealey's Goit, which could channel floodwaters to other parts of the study area.

This can be substantially mitigated by two measures which would be applied should completion of this component only be achieved:

- The flow path to the area from Component 6 is limited to two 4m wide underpasses below the Metrolink line. If necessary, a system of temporary defences across the underpass openings could be installed to prevent floodwaters entering the area.
- Provision of rear wall drainage and improvements to outfalls as part of the defence design.
- Strategic gaps could be left in the defence to leave at 'near completion', with full enclosure only being complete once other components are in place.

Based on this, it is expected that any negative impacts of construction of component 10 only can be mitigated to avoid significant increase in flood risk to properties in the study area.

Figure 8: Component 10 Return Flow Paths



Source: © Crown copyright and database rights 2019. OS 100024198.

Construction of Component 45 only

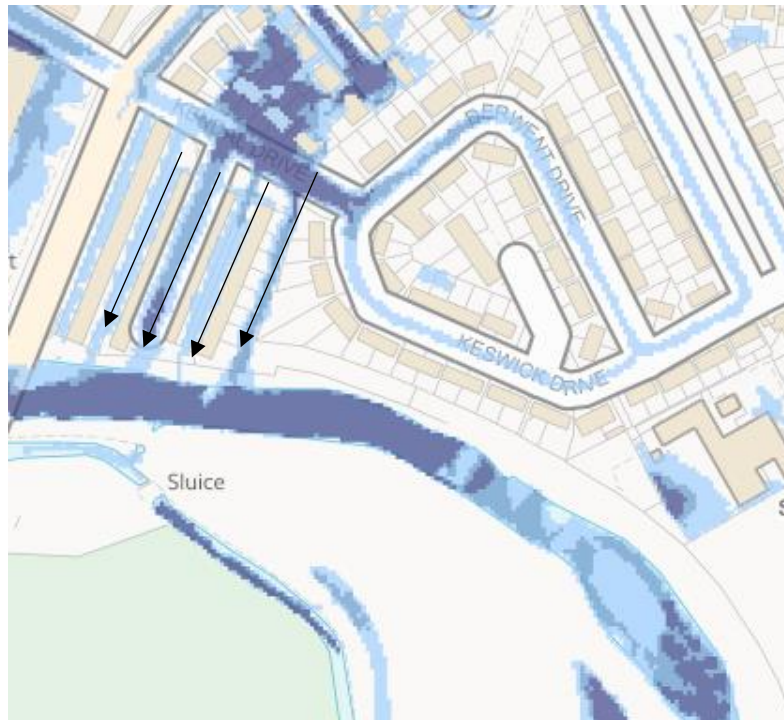
There are a number of return flow paths which would be interrupted by the construction of the proposed Component 45 (see Figure 9). These paths are activated by surface water and fluvial flood events.

Similar to Component 10, the primary route for flood water is from the underpasses from Component 6. Due to the number and importance of these flow routes in the prevention of flooding to a large number of residential properties, the drainage in this area will be increased to ensure sufficient capacity is available to drain floodwater. As such, mitigation would be made by two measures which would be applied should partial approval only be achieved:

- The flow path to the area from Component 6 is limited to two 4m wide underpasses below the Metrolink line. If necessary, a system of temporary defences across the underpass openings could be installed to prevent floodwaters entering the area.
- Provision of additional surface water drainage and improvements to outfalls as part of the defence design.
- Provision of a relief valve at the low point to enable release of significant build-up of contained surface water
- Strategic gaps could be left in the defence to leave at 'near completion', with full enclosure only being complete once other components are in place.

Based on this, it is expected that any negative impacts of construction of component 45 only can be mitigated to avoid significant increase in flood risk to properties in the study area

Figure 9: Component 45 Return Flow Paths



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Construction of Component 6, 37, 38 and Bury Point only

There would be no significant change to current flood depths or extents due to the completion of these components, because;

- The Metrolink underpass is an inflow route for floodwater. Blocking this floodwater route (Component 6) would not adversely affect flooding in other areas, including Warth Road (Component 10) or Keswick Drive (Component 45) areas.
- York Street/Dumers Lane is an isolated flood cell 'bowl' which is defended by Component 37. Due to the topography of the region, in isolation this component would only protect these properties and no other areas would be negatively affected. In a surface water event, where floodwater would pool inside the defended line, the defence could act to block the natural flow path of these waters back into the River Irwell. Drainage outfalls in the defence itself would be sufficient to mitigate this risk.
- Redvales Business Park, another 'bowl' of flood risk, is protected by Component 38. If constructed in isolation, this component would increase flood risk only to the business park itself – by cutting off the return route of floodwater to the Irwell. Again, provision of drainage outfalls in the defence itself would be sufficient to mitigate any detrimental surface water flood impacts created by the defence.
- The defences at Bury Point only provide localised protection, at a lower return period, to a specific business premises. There is no significant impact or detriment to other areas if this component is not delivered.

Amendment works to Hardy's Gate and Warth Road Bridges and Hutchinson's Goit only

There would be no significant change to current flood depths or extents due to the completion of these minor works as the floodplain is not being significantly altered.

Other combinations

The installation of Components 10 and 45 in combination would create a barrier to returning floodwater which effectively removes all natural flow routes back to the River Irwell – see Figure 8 and Figure 9 for these flow routes. However, the drainage provisions and mitigations measures for each component remain applicable and should be sufficient to mitigate the combined risk.

Other combinations of defences have been considered and none have been identified as having any significantly greater residual flood risk.

4.5 Reliance on Third Parties

Phase 2 has been designed to accommodate and incorporate proposed plans by third parties as far as reasonably practicable. For Phase 2 components, the following specific proposals by third parties are included and noted:

- PIN Development /York Street – the area of land to the north of Component 37 and south of Bury Point is planned for housing. The plans are conditioned by the Environment Agency and are required to raise the land to at least the 1:100year flood level. As such, the flood defences in this location will be effectively delivered by the third-party PIN development and the Phase 2 scheme defences have been designed to tie into this area of elevated land to create a continuous scheme defence. Should the PIN development fail to be delivered or substantially delayed, the defences at Component 37 would be compromised. Were this to occur, the scheme would propose to construct a temporary flood defence bund across the area to provide a similar Standard of Protection. Hence the risks to the overall scheme are considered low.

4.6 Other Residual Risks and Impacts

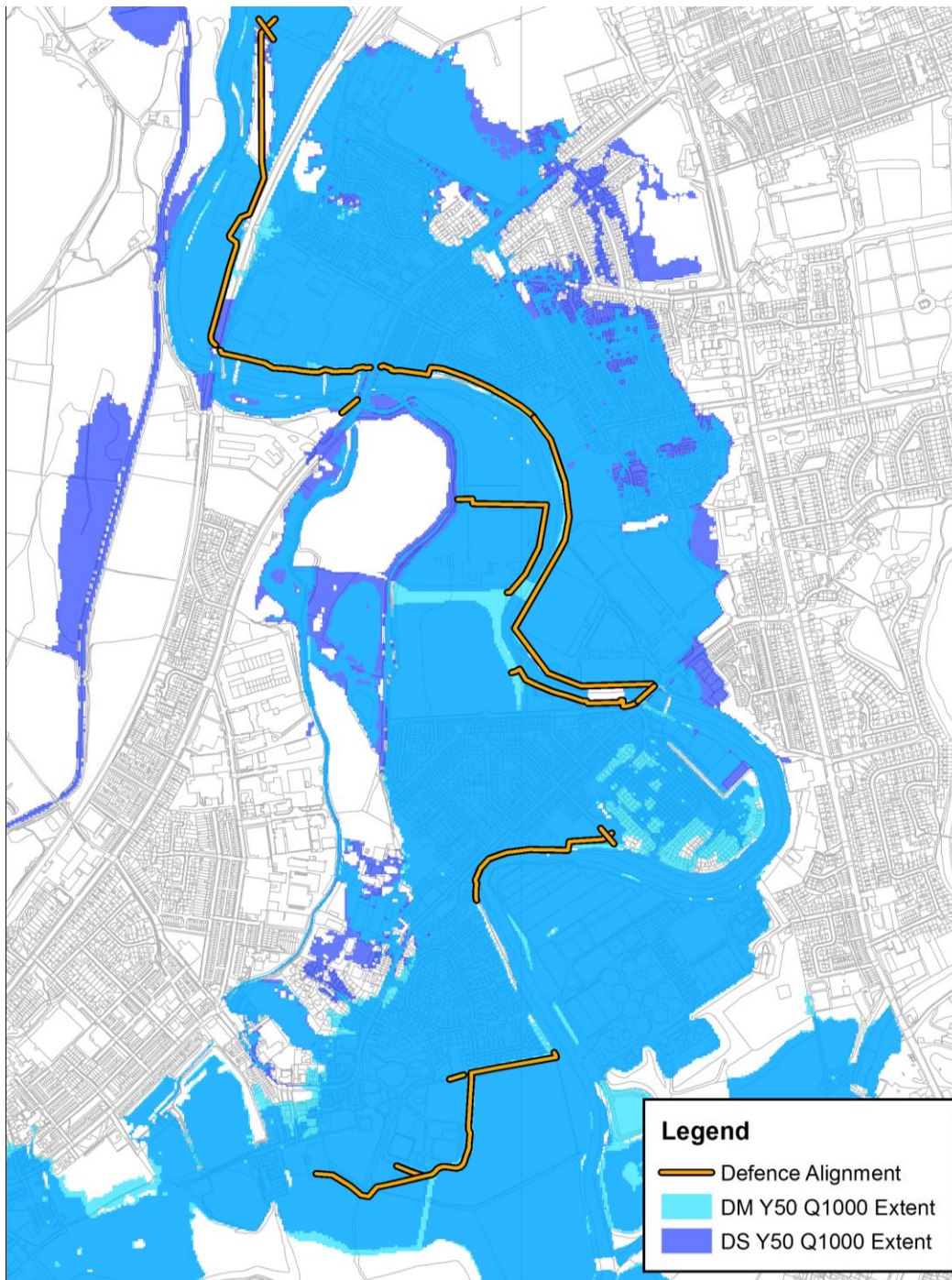
Other residual risks associated with the delivery of the FRMS are discussed below;

Exceedance events

The impact of the FRMS during the 0.1% AEP Year 0 event, which exceeds the design standard of the FRMS has been tested using the hydraulic model. The outputs from this model run have been compared to the pre-scheme case and are shown in Figure 10 below. This demonstrates:

- The scheme reduces the 0.1% AEP flood extents and depths in many areas, although there are small increases in others due to the varying impact of the walls in containing flood waters. A particular area of improvement is around Dumers Lane, with pre-scheme flood depths in this area in excess of 500mm lowered in the post-scheme by an average of 360mm (an average of 140mm depth in the post-scheme). In addition, 95 fewer properties flood in the Q1000 event around this area.
- The post-scheme causes some new areas of flooding to occur. However, the majority of this flooding occurs in unpopulated areas – fields, farmland, wetland etc - around the outskirts of the scheme flooding. The exception to this is an area to the North East of Keswick Drive, where, whilst it may impact properties, the flooding only has an average depth of 180mm which is within a typical property threshold (<200mm). Hence, it is feasible that no actual new property flooding would occur in these areas post-scheme.

Figure 10: Predicted Pre and Post Scheme Flood Extents for the 0.1% AEP Event



Breach

The risk of a breach in the new sections of flood defence are considered negligible given that the new sections of flood defence are not predicted to overtop in the climate change enhanced 1% AEP event. They have been designed to withstand any overtopping that might occur during an exceedance event.

Blockage

The risk of major blockage (i.e. >15% loss of area) at the Hardy's Gate Bridge, Warth Road Bridge and Metrolink Bridge is considered low given the significantly reduced risk of large debris (i.e. from industrial parks) entering the watercourse between the Metrolink bridge and Hardy's Gate Bridge.

Bridge surcharging and debris strikes

There is some increase in frequency of surcharging of Hardy's Gate Bridge, Warth Road Bridge and Metrolink Bridge due to the increase in elevated water levels caused by containment of the flood waters. However, the periods of surcharge remain of short duration during only extreme events such that the overall risk of excess surcharging or debris strikes to parapets etc remains low.

Update 24/01/22 Rev P04: A review of the increased risk on bridge stability was carried out and confirmed acceptable with Metrolink and Bury Council respectively.

It was originally envisaged that the upstream bridge parapet at Hardy's Gate Bridge would be raised slightly and reinforced to withstand the elevated water levels. However, analysis of the bridge structure indicated a significant risk to the overall bridge stability in attempting containment to full parapet height coupled with the potential catastrophic impact of a sudden parapet failure. It is therefore now planned to include a number of 750mm deep 'cut outs' in both the upstream and downstream parapets to allow floodwater to flow onto and over the bridge deck during extreme events (typically >1:50yr event). Spilling flows would be contained from flooding top the wider area by 1m high demountable flood defences which can be rapidly deployed on the existing road surface to either side of the bridge deck. This provides the 100yr defence standard to the wider area. It is noted that the application of the cut outs helps to relieve the forces on the bridge and may also provide some emergency relief for flow build up should severe bridge blockage occur (including better containment of parapet failure if that were to occur).

Update 12/05/2023 Rev P05: Proposed demountable defences along Hardy's Gate Bridge to contain spilling flows not considered suitable by the Environment Agency, Spilling flows will now be contained along the bridge by flood gates at both the northern and southern end of the bridge deck This will provide the 100yr defence standard to the wider area.

The defences are predicted to overtop elsewhere before any flooding of the Metrolink line occurs.

Existing structures

A number of existing structures exist within or near the watercourse. A number are specifically referenced:

- Existing riverside buildings – a number of existing commercial buildings and structures, most notably at Components 10 and 37, are built to the edge of the watercourse and are currently at risk from damage or collapse from loading by extreme flood waters. The scheme will reduce this risk by providing protection from the river to the 100year standard of protection.
- Bealey's Weir – the operation and structure of the weir structure will remain unaffected by the proposals
- Hydropower plant (adjacent to Bealey's Weir) - whilst the depth of flooding is predicted to increase, the onset of flooding of the hydropower plant is not significantly changed by the proposals. Protection of the plant within the defence is not viable. Methods to reduce the impact of flooding on the hydropower plant are to be considered.

Channel Cross Section

The scheme proposes some construction of new walls within the existing riparian channel. This is necessary due to significant constraints relating to access, the proximity of existing buildings, condition of existing river walls and sensitivity of the potential impact of river working on silt release, fish spawning and fish migration. Where applied, walls within the channel are in areas of existing walled bank and will be installed as close as practical to the existing face. The overall loss of channel area as a result is not expected to have a significant impact on the capacity of the river channel.

5 Conclusions

This Flood Risk Assessment has been completed in accordance with the NPPF and the 2016 Environment Agency Adapting to Climate Change guidance to support Phase 2 of the Radcliffe and Redvales FRMS. The nature of the development (FRMS) and the staged delivery of the scheme requires the adoption of a pragmatic approach to the assessment of impacts of the scheme on wider flood risk. Specifically, it is important to note that the scheme has been developed as one scheme and will be funded as one project, with the two phases introduced for planning and construction purposes only. Therefore, the longer-term view is important.

The report has evaluated the impact of Phase 2 of the FRMS on a range of flood risk sources. There is the greatest potential for fluvial, surface water and artificial drainage to be affected by the scheme. The assessment has demonstrated that delivering the full scheme provides significant flood benefits to 873 properties within the Radcliffe area. The raised defences to both sides, particularly alongside existing waterside business parks, will significantly reduce the risk of debris entering the watercourse during flood events and hence substantially reduce the risk of blockage at bridge structures. The risk and scale of any short-term adverse impacts during the delivery of Phase 2 are relatively low and methods for mitigation have been identified. These risks are considered acceptable given that Phase 2 will be delivered under one contract as a continuous construction activity and will result in completion of the scheme. In addition, a Phase 3 of the scheme has already been identified which could provide additional attenuation storage volume if required to provide additional mitigation.

Update 24/01/22 Rev P04: It is now expected that the Swan Lodge reservoir will proceed, although it remains subject to confirmation of possible alternative mitigation via the River Roch scheme and upstream NFM measures which are both still being explored. As the scheme has developed, some modifications to the design have been necessary to ensure suitable containment of flood waters during design events, most notably an additional low embankment and low wall to the south of Bury Grammar school. The approach to Hardy's Gate Bridge has also been adapted to reduce the risks to the existing bridge structure and parapet. These have had no significant impact on the predicted impacts or overall scheme benefits which remain valid.

Update 12/05/22 Rev P05: Swan Lodge no longer considered part of this scheme due to topographic and hydraulic limitations within the design.

Appendices

A. Site Location Plan

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