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Jacobs

Preston and South Ribble FRMS

Flood Risk Assessment

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Environment Agency

In partnership with:

Lancashire County Council

North West Regional Flood & Coastal Committee

Environment Agency

Preston and South Ribble FRMS

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Contents

1. Introduction

1.1 Purpose

This Flood Risk Assessment (FRA) forms part of the Planning Applications to be submitted by the Environment Agency (EA) for the construction of the Preston & South Ribble Flood Risk Management Scheme (FRMS). The FRA has been prepared by Jacobs on behalf of the EA who have commissioned this assessment in accordance with the Communities and Local Government's 'National Planning Policy Framework, 2012' (NPPF), which lays out the principles for flood risk assessment in England.

The EA have developed a single business case supporting the technical, economic and financial case, and to obtain stakeholder approvals for the whole scheme. However, the FRMS has been split into three separate planning applications to facilitate the planning process and construction programme. This FRA focuses on the first planning application submission of the FRMS encompassing Area 1 (Riversway and Broadgate) and Area 2 (Lower Penwortham), which are referred to within this report as the proposed Scheme, but reference will also be made to the full FRMS where appropriate.

1.2 Site Location

Areas 1 and 2 of the Preston & South Ribble FRMS are located adjacent to the River Ribble, south of Preston city centre, and extend along the right (north) bank and the left (south) bank. Figure 1.1 illustrates the general location of the proposed scheme (national grid reference (NGR) SD 53174 28203) in the context of the other areas that form part of the full FRMS.

1.3 Current Situation

The River Ribble has a long history of flooding. To manage the risk of tidal and fluvial flooding, an extensive network of linear defences throughout the Preston area have been constructed. The standard of protection that these defences provide, varies along the course of the River Ribble. A summary of the present-day level of flood risk from tidal and fluvial sources is outlined in the sections below.

1.3.1 Current tidal flood risk

Modelling undertaken for this FRA identifies that in Areas 1 and 2, the existing defences provide protection against the 0.5% Annual Exceedance Probability (AEP) tidal flood event. In the Lower Penwortham area, the main area at risk from tidal flooding is known as the Holme, which is largely undeveloped land comprising recreation grounds, allotment gardens and small numbers of non-residential property. Agricultural land and playing fields upstream of the West Coast Mainline Railway are also at risk from tidal flooding. No tidal flood risk is identified to the Frenchwood area of Preston, or any areas further upstream.

1.3.2 Current fluvial flood risk

In the Riversway and Broadgate area, the existing defences provide protection against the 1% AEP fluvial flood event although, modelling shows that water spilling from Avenham Park during this flood event would bypass the defences along the Ribble and would flood playing fields. Lower Penwortham also currently benefits from protection against the 1% AEP fluvial flood event. However, both areas would be at risk of flooding during the 0.5% AEP flood event with the defences along the Ribble overtopping and water from the floodplain upstream of the West Coast Mainline Railway able to enter Lower Penwortham via an underpass beneath the railway.

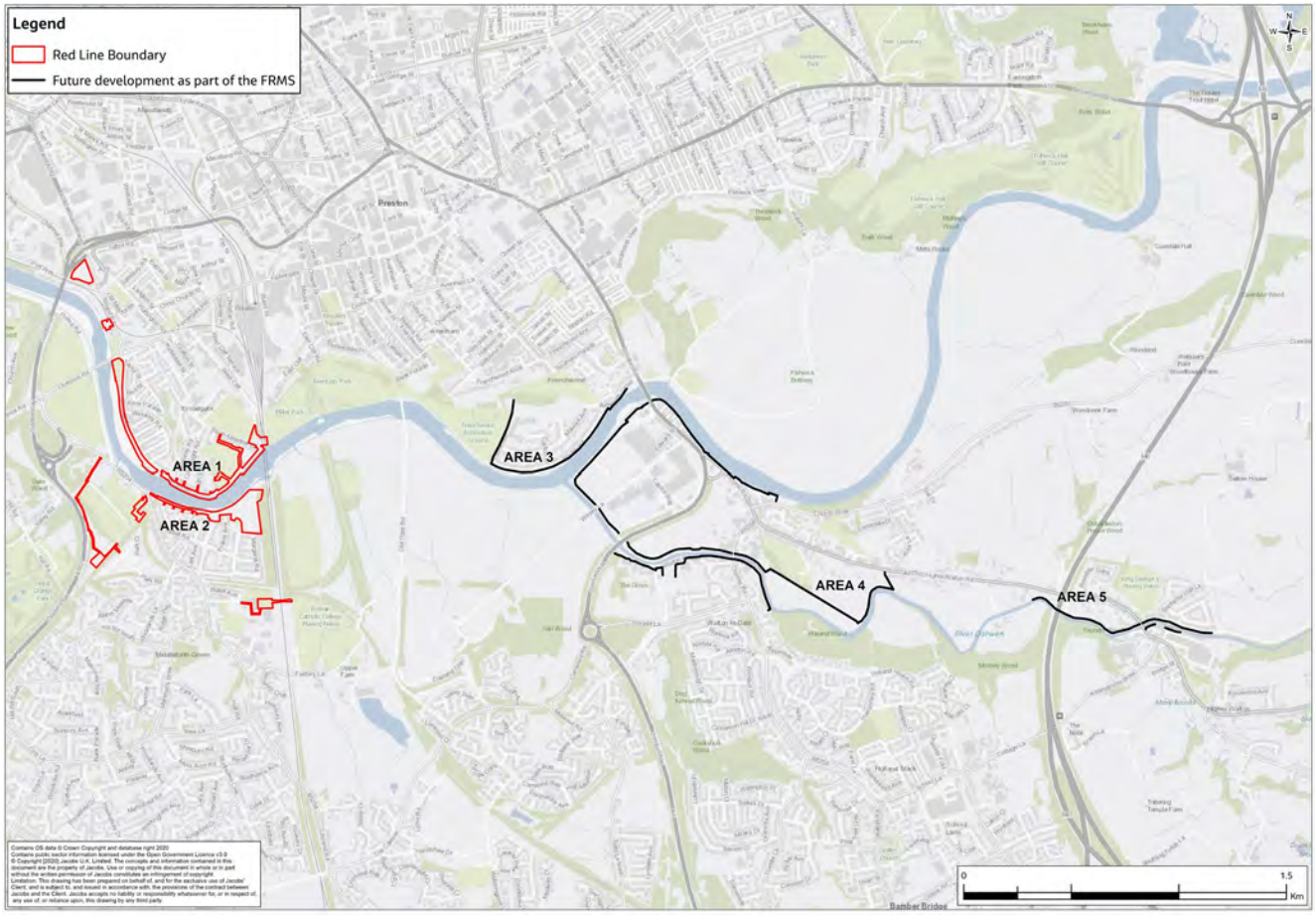
Further upstream, locations within Walton-le-Dale are at risk during a 2% AEP fluvial flood event whilst flooding onsets at in Higher Walton during the 5% AEP flood event.

1.3.3 Strategies and previous studies

A key part of the EA corporate strategy is to better protect 300,000 homes by 2021. Even though existing flood defences are in place, the Ribble Catchment Flood Management Plan (2009)[1] and the North West River Basin Management Plan 2015- 2021[2] identified a significant number of properties at risk of flooding within this area. The EA therefore commissioned a series of studies to develop a business case for a new FRMS. The Outline Business Case (OBC) identified approximately 4,778 properties (including 517 businesses) within Preston to be at a "high level of flood risk"[3] with 1,709 considered to be at Significant Flood Risk as defined in the Environment Agency Appraisal Guidance[4].

Due to the predicted increase in peak river flow rates as a result of climate change, further analysis undertaken as part of the OBC confirms that the standard of protection of the existing defences will decrease over time. This, coupled with further deterioration in condition, would increase the probability of overtopping and potential failure, increasing the overall risk of flooding to the properties currently benefiting from these defences.

Figure 1.1: Preston & South Ribble FRMS site location



[1] Environment Agency (2009) *Ribble Catchment Flood Management Plan.* [Online] Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/293727/Ribble_Catchment_Flood_Management_Plan.pdf [Accessed September 2020]

[2] Environment Agency (2016) *North West River Basin Flood Management Plan.* [Online] Available from: https://www.gov.uk/government/publications/north-west-river-basin-district-flood-risk-management-plan [Accessed September 2020]

[3] ENV0000009C Preston and South Ribble Flood Risk Management Scheme, Outline Business Case Revision 1.1

[4] Environment Agency (2010) Flood and Coastal Erosion Risk Management appraisal guidance. [Online] Available from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/481768/LIT_4909.pdf [Accessed September 2020]

1.4 Aims and Objectives

The proposed Scheme for Areas 1 and 2 is designed to increase the present-day Standard of Protection (SoP) from fluvial and tidal flooding from 1% AEP to 0.5% AEP.

This SoP is however predicted to reduce over time due to the impact of climate change to a 1.33% AEP SoP by the end of the 2080's climate change epoch as defined within the EA's guidance for considering climate change (2070 to 2115)[5].

The SoP was determined in accordance with FCERM (Flood and Coastal Erosion Risk Management) appraisal guidance[4], with defence raising beyond that proposed not possible on engineering or affordability grounds.

Unlike other forms of development, the proposed development must be located in an area of high flood risk, and by its very nature, is designed to reduce the overall level of flood risk.

The overall aim of this FRA is therefore to demonstrate that the proposed Scheme complies with national and local development and flood risk policies. Specifically, that once constructed the scheme:

- Would be safe for its lifetime taking account of the vulnerability of its users;
- Would not increase flood risk elsewhere; and where possible,
- Would reduce flood risk overall.

[5] EA (2020) *Flood and coastal risk projects, schemes and strategies: climate change allowances* [Available online] https://www.gov.uk/guidance/flood-and-coastal-risk-projects-schemes-and-strategies-climate-change-allowances [Accessed November 2020]

2. Scope and Methodology

This section describes the scope of this FRA and outlines the methodology of the assessment along with key datasets, assumptions and limitations.

2.1 Assessment of Flood Risk

2.1.1 Source-pathway-receptor

Flood risk is conceptualised using the source-pathway-receptor model. For a flood risk to be present each of the three elements is required:

- A **source** of flood water such as a river or groundwater body;
- A **pathway** that enables the flow of floodwater from a 'source' to a 'receptor'. This could include low lying land within a floodplain or permeable strata that enables groundwater to seep to the surface, or construction activities such a tunnelling; and
- A **receptor** such as a person, property or habitat that may be impacted by a flood event.

Flood risk is therefore dependent on all elements being present and is assessed in terms of the **probability** (likelihood) of an event occurring and the **consequence** of the flood.

2.1.2 Probability

The probability of flooding in this report is defined using Annual Exceedance Probability (AEP). This is the preferred approach in comparison to the annual maximum return period (e.g. 1 in 100-year event). This is due to the potential misconception that return periods are associated with a regular occurrence rather than an average recurrence interval. For example, it is sometimes assumed that the 1 in 100-year event flood will occur once every 100-years. However, events with a magnitude of the 1 in 100-year event have a 1% chance of being exceeded in any one year. Table 2-1 provides a comparison of AEP to return periods to aid the understanding of flood frequency.

Table 2-1: Equivalent annual exceedance probabilities and return periods

AEP	10%	5%	2%	1.33%	1%	0.5%
Return Period	1 in 10-year	1 in 20-year	1 in 50-year	1 in 75-year	1 in 100-year	1 in 200-year

2.1.3 Consequence

The consequence of flooding is dependent on two factors:

- Exposure – For example, the number of people or properties potentially affected.
- Vulnerability – The potential for people or property to be harmed or damaged.

Floods impact both individuals and communities, and have social, economic, and environmental consequences. These can be both negative and positive and can include direct and indirect loss.

With regards to development and flood risk, vulnerability is largely driven by the type of development proposed or affected. Different classes of vulnerability are defined in Table 2 of PPG Flood Risk and Coastal Change[6].

[6] Department for Communities and Local Governments (2019) Planning Practice Guidance. [Online] Available from: https://www.gov.uk/guidance/flood-risk-and-coastal-change#Table-2-Flood-Risk-Vulnerability-Classification. [Accessed: 22/05/20].

2.1.4 Impacts

The assessment of the flood risk impacts as a result of the proposed Scheme and the magnitude of the change in flood risk, considers the potential effects on all elements of flood risk including frequency, extent, depth, velocity and combinations of these components.

The duration of changes to flooding is also considered when assessing flood risk impacts, where a distinction is made between **permanent** changes and **temporary** changes where the effect would cease to be felt after a period. Temporary changes can be long-term or short term in nature.

Embedded mitigation measures are also considered when determining potential impacts on flood risk. These measures form part of an optimised design used to reduce the significance of flood risk effects, for example:

- Following the sequential approach to avoid placing assets, features and activities within areas at high flood risk where possible;
- Designing the scheme, including construction phase, in accordance with established good practice; and
- Discharge surface water run-off as high up the drainage hierarchy and implementing Sustainable Drainage Systems (SuDS) where possible, to minimise the impact on the receiving watercourse.

2.2 Scope

This FRA has been carried out in accordance with the National Planning Policy Framework (NPPF)[7] and the Planning Practice Guidance (PPG)[8].

2.2.1 Sources of information and data

This FRA has been informed by the following sources of information:

- The Outline Business Case for the proposed Scheme
- Designs of the proposed Scheme (Key drawings are included in Appendix A)
- Detailed hydraulic modelling undertaken to support the scheme design and the Full Business Case (A summary is provided in Appendix B)
- Environment Agency Flood Map for Planning[9]
- Environment Agency Risk of Flooding from Surface Water Mapping[10]
- Environment Agency Reservoir Flood Mapping[11]
- British Geological Survey (BGS) mapping[12]
- Ordnance Survey Datasets including 1:25,000 scale mapping
- United Utilities asset data
- A web search of historical flood incidents

[7] Department for Communities and Local Government (2018) National Planning Policy Framework. [Online] Available from: https://www.gov.uk/government/publications/national-planning-policy-framework--2. [Accessed: 22/05/20].
[8] Department for Communities and Local Governments (2019) Planning Practice Guidance. [Online] Available from: https://www.gov.uk/government/collections/planning-practice-guidance. [Accessed: 22/05/20].
[9] Environment Agency (2020) Flood Map for Planning. [Online] Available from: https://flood-map-for-planning.service.gov.uk/. [Accessed: June 2020].
[10] Environment Agency (2020) Risk of Flooding from Surface Water Mapping. [Online] Available from: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map. [Accessed: June 2020].
[11] Environment Agency (2020) Risk of Flooding from Reservoirs. [Online] Available from: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map. [Accessed: June 2020].
[12] British Geological Survey (2020) Geology of Britain viewer (classic). [Online] Available from: https://mapapps.bgs.ac.uk/geologyofbritain/home.html. [Accessed: June 2020].

- Central Lancashire Strategic Flood Risk Assessment[13].

2.2.2 Sources of flooding considered

Using the datasets listed above, an initial scoping exercise was carried out to identify those sources of flooding present and worth considering as part of this FRA. Table 2.2 provides a summary.

Table 2.2: Summary of flood sources

Flood Source	Description	Consider Further
Fluvial	The proposed Scheme would be located within Flood Zone 3 adjacent to the River Ribble and would therefore have a high probability flooding from fluvial sources.	Yes
Tidal	The proposed Scheme would be located within the zone of tidal influence along the Ribble Estuary. Therefore, there is a potential risk of tidal flooding.	Yes
Surface water	The proposed Scheme would be located in areas at risk of surface water ponding or along key surface water flow paths.	Yes
Groundwater	The proposed Scheme would be located along a watercourse and therefore below ground elements such as foundations would have potential to intersect groundwater flow paths and areas of high groundwater levels.	Yes
Reservoirs	Several large reservoirs are located upstream of the proposed Scheme and EA reservoir flood risk map indicates that the proposed Scheme would be within an area that would be at risk in the event of a reservoir failure.	Yes
Canals	The Lancaster Canal is located approximately 2 km north of the site of the proposed Scheme. The Central Lancashire SFRA does not identify this canal as a potential source of flooding or any historical flood incidents associated with it. Due to this, this source of flooding has not been considered further.	No
Sewers and water mains	The proposed scheme would be located within an urban area. There is therefore potential for interaction with sewers and potable water mains	Yes

2.2.3 Interim impacts on flood risk

The FRMS will form three separate planning applications with construction starting on upstream sections after construction of Areas 1 and 2 has commenced. This means that there is a potential for interim beneficial or adverse impacts following the construction of the proposed Scheme (Areas 1 and 2) and before completion of Areas 3, 4 and 5. Since this FRA is focussed on Areas 1 and 2, these interim impacts would need to be considered, with any adverse impacts identified and mitigated.

- As designed, the construction of Areas 1 and 2 would reduce fluvial flood risk by protecting existing floodplain and forming barriers to floodplain flow. Before Areas 3, 4 and 5 are constructed, the proposed Scheme could adversely impact on areas of existing fluvial flood risk upstream. Therefore, an analysis of these interim impacts is presented.
- Tidal flood risk along the Ribble Estuary is limited to Areas 1 and 2 of the FRMS. Therefore, any impacts on tidal risk identified would be limited to these areas and therefore would be present through the lifetime of the proposed Scheme and therefore no analysis of interim impacts outside of Areas 1 and 2 has been undertaken for this flood source.

[13] Scott Wilson (2007) Central Lancashire Strategic Flood Risk Assessment- Prepared for Preston City Council, South Ribble Borough Council and Chorley Borough Council. [Online] Available from https://www.preston.gov.uk/media/1693/CL-Flood-risk-assessment/pdf/EVL-08-Central-Lancs-Strategic-Flood-Risk-Assessment-Level-1-Final-Report-Dec-2007_1.pdf?m=636977626435930000 [Accessed September 2020]

- Any impacts on surface water, groundwater and sewer flooding are likely to be localised and would not interfere with Areas 3, 4 and 5.

In addition, as the proposed Scheme would involve replacing existing defences, there is potential for short term increases in flood risk due to the construction work. The removal of existing defences to enable the construction of the proposed structures, could leave properties vulnerable to flooding. These potential impacts would be assessed by the contractor as part of their Environmental Permit application. This is discussed in Section 7.3.

2.2.4 Impacts of climate change on flood risk

The current EA guidance "Flood Risk Assessments: climate change allowances[14]" sets out how likely climate change impacts on river flows, sea levels and rainfall intensity should be considered within FRAs. However, as a Flood Risk Management Scheme, specific guidance regarding the impact of climate change on these type of schemes has been used[5]. It is noted that these two guidance documents have the same recommendations regarding the percentage increases that should be applied to account for the impacts of climate change on fluvial flows and rainfall intensity.

The anticipated percentage increase in peak river flows for the 2020s, 2050s and 2080s climate change epochs is associated with the River Basin District in which the site lies. A range of possible increases are given for each epoch based on the following percentiles:

- Central allowance is based on the 50th percentile
- Higher central is based on the 70th percentile
- Upper end is based on the 90th percentile.

Preston lies in the North West River Basin District for which allowances are presented in Table 2.3. For context, changes in flows along the River Ribble at Samlesbury due to climate change are illustrated in Table 2.4.

Table 2.3: Climate change precautionary sensitivity for peak river flow and rainfall intensity

Parameter	Allowance Category	Total potential change anticipated for the "2020s" (2015-2039)	Total potential change anticipated for the "2050s" (2040-2069)	Total potential change anticipated for the "2080s" (2070-2115)
Peak river flow (North West River Basin District)	Upper end	20%	35%	70%
	Higher Central	20%	30%	35%
	Central	15%	25%	30%
Peak rainfall intensity	Upper end	10%	20%	40%
	Central	5%	10%	20%

Table 2.4: Peak flows for the 1% AEP Flood event on the River Ribble

Location	"Present-day" Peak	"2020s" Peak Flow	"2050s" Peak Flow	"2080s" Peak Flow
Samlesbury	1,372 m^3/s	1,425 m^3/s	1,562 m^3/s	1,631 m^3/s

The Ribble Estuary adjacent to the proposed Scheme is tidally influenced. Recommended climate change allowances for the North West coast are set out in Table 2.5.

[14] Environment Agency (2020) Guidance - Flood risk assessments: climate change allowances. [Online] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances [Accessed September 2020]

Table 2.5: Climate change allowanced for sea level rise

Allowance	Sea level rise (mm) per epoch for North West England				
	2000 - 2035	2036 - 2065	2066 - 2095	2096 - 2125	Cumulative rise to 2125
Higher Central	158 mm	219 mm	300 mm	336 mm	1001 mm
Upper	200 mm	297 mm	426 mm	489 mm	1410 mm

In line with EA guidance, **the central allowance for both peak river flow and sea level rise have been adopted for the design of the proposed Scheme.** This FRA has also considered the upper end allowances to understand the sensitivity of the design to a range of climate change impacts.

2.2.5 Assessment approach

The approach to the flood risk assessment is mirrored within the structure of this report, as outlined below:

- The assessment of flood risk has been used to:
  - Define the level of flood risk to the proposed Scheme;
  - Determine the potential impacts of the proposed Scheme and the wider FRMS;
  - Outline any proposed measures required to mitigate the risk and impacts identified.
- The assessment is reported across three sections, linked to key phases of the design life of the proposed Scheme including:
  - Flood risk to the proposed Scheme during operation (Section 5);
  - Flood risk impacts of the proposed Scheme during operation (Section 6);
  - Construction phase risks and impacts (Section 7);
- Section 8 summarises the key flood risk issues and any additional mitigation measures identified.

2.2.6 Limitations and assumptions

A detailed 1D-2D Flood Modeller-TUFLOW hydraulic model of the River Ribble has been used to develop the design of the proposed Scheme. By its very nature, the hydraulic model is a simplified representation of the river system and its interaction with the urban environment during flood events. Whilst it contains several assumptions, it has been constructed in accordance with EA guidance and accepted good practice and has been subject to third party reviews by the Environment Agency. It is therefore considered fit for purpose for this FRA. Further details of the hydraulic model are presented in Appendix B.

Other sources of flooding have been assessed based on a conceptual understanding of flood mechanisms and impacts using a range of data sources rather than detailed hydraulic modelling.

The assessment is based on the design of the proposed Scheme at the time of writing. Any future design changes would require this assessment to be re-visited.

3. Proposed Scheme

3.1 Overview

The OBC for the full Preston & South Ribble FRMS found that it would offer protection to approximately 4,778 properties along the Rivers Ribble and Darwen, to the south of Preston. The FRMS is mainly a combination of replacing or raising existing flood walls and embankments, and is split into five areas:

- Area 1: Riversway and Broadgate;
- Area 2: Lower Penwortham;
- Area 3: Frenchwood and Walton-le-Dale along the River Ribble;
- Area 4: Walton-le-Dale along the River Darwen;
- Area 5: Higher Walton and Samlesbury.

This FRA is linked to the planning application for Area 1 (Riversway and Broadgate) and Area 2 (Lower Penwortham).

3.1.1 Design process

In accordance with the requirements of the FCERM appraisal guidance and of the national planning policy, the EA has developed the scheme over several stages in order to identify the most technically, economically and environmentally preferable solution.

Nine long list options were initially taken forward from the Strategic Outline Case (SOC) for consideration in support of the OBC, including:

- Option 1 – Do Nothing: Includes blockages at key structures and failure of defences;
- Option 2 – Do Minimum: Includes some blockages at key structures and breaches of defences further into the appraisal period;
- Option 3 – Linear Defences: Solid permanent defences along the channel banks;
- Option 4 – Linear Defences: Active management/transparent defences in targeted areas;
- Option 5 – Flood Storage;
- Option 6 –River Conveyance Improvements;
- Option 7 – Natural Flood Management (NFM);
- Option 8 – Urban Re-development/Re-naturalisation of the River;
- Option 9 – Property Level Protection/Property Flood Resilience (e.g. air brick covers, flood doors etc.).

Options 1, 2, 3, 4 and 9 were shortlisted for more detailed consideration during the OBC, with the remaining four options rejected on various grounds. Having appraised the shortlisted options, an enhanced version of Option 4 that also included Option 9 (Property Level Protection/Property Flood Resilience measures) was selected as the preferred option.

Detailed descriptions of the preferred option in each area are provided in Section 3.2. Design drawings detailing the general arrangement, and elevations of the proposed Scheme (Areas 1 and 2 only) are presented in Appendix A.

3.2 Scheme Areas

3.2.1 Area 1: Riversway and Broadgate

Area 1 is Located on the right (north) bank of the River Ribble, to the south of the city centre. This area is approximately 1.2 km long, extending from the West Coast Main Line (WCML), downstream to Liverpool Road Bridge (B5254) and is split into four reaches. General arrangement drawings for Area 1 are presented in Appendix A. Proposed defences comprise:

Reach A

- Replacement of the existing concrete wall (0.75 m to 1.23 m high), with a new concrete wall (1.19 m to 1.34 m high), between Liverpool Road Bridge and Penwortham Old Bridge.

Reach B

- Replacement of the existing concrete flood wall (0.78 m to 1.08 m high), with a new pre-cast concrete flood wall (0.77 m to 1.4 m high) with glass panels on top (0.8 m high), along Riverside between Penwortham Old Bridge and Miller Gardens Apartments;
- A new flood gate (1.35 m high) located in front of Miller Gardens Apartments;
- A new concrete wall (1.14 m to 1.26 m high) along the boundary of the BAC/EE Preston Social and Sports Association cricket pitch between Miller Gardens Apartments and Ribble Cottage.
- A new flood gate (1.45 m high) located close to Ribble Cottage;
- Replacement of the existing concrete wall (1.09 m high), with a new concrete wall (1.34 m to 1.4 m high) with glass panels (0.8 m high) on top, running on the river side of the road between Ribble Cottage and the railway viaduct;
- Three lengths of the existing riverbank from just downstream of Old Penwortham Bridge to the WCML will be stabilised with a blockwork revetment. These lengths are estimated as 82 m, 247 m, and 151 m respectively.

Reach C

- A concrete wall (1.3 m to 2.6 m high in relation to existing ground levels) will be constructed along the boundary of the existing Preston City Council compound, with two flood gates tying into the abutments of the WCML viaduct. The northern most flood gate will be 1.4 m in height, and the southernmost flood gate will be 1.8 m high.

Reach D

- In addition, to the works detailed above, some works to improve emergency access to the river via an existing slipway at the Sea Cadets just downstream of Liverpool Road Bridge are also proposed.

3.2.2 Area 2: Lower Penwortham

Area 2 is located on the left (south) bank of the River Ribble, to the south of the city centre. This area is approximately 0.8 km long, extending from the WCML, downstream to Penwortham Old Bridge, and turning inland to tie into the abandoned railway embankment. General arrangement drawings for Area 1 are presented in Appendix A. Proposed defences comprise:

Reach A

- A new concrete wall (1.0 m to 2.2 m high) along the boundary of the Penwortham Methodist Church between the church and the allotments. In order to maintain security of the allotments, fencing will be installed along the top of the new wall to ensure that a minimum height of 1.8 m is provided;
- A new ramp to raise existing road levels by approximately 1.0 m at the entrance to Penwortham Methodist Church and a up and over ramp along the Golden Way Footpath between the Penwortham Methodist Church and the disused railway embankment.

- A new ramp over a low embankment adjacent to the Golden Way Footpath where a path cuts through the disused railway embankment into the Penwortham Residential Park.

Reach B

- A new concrete wall (1.4 m high) with glass panels (0.8 m high) on top, along Riverside Road extending upstream from the Cadent Gas pipe bridge to Stanley Avenue.
- A new concrete wall (1.5 m high) along the river front linking Riverside Road to Ribble Sidings. A blockwork retaining wall (70 m long) will be constructed to stabilise the existing riverbank;
- Removal of the existing flood defence embankment (1.7 m high) at Ribble Sidings and construction of a new 3.5 m high flood defence embankment with a 3 m crest width and 1 in 3 side slopes. The existing riverside footpath (NCR 55 and PRoW 7-9-BW34) route will be maintained with an access ramp over the proposed flood defence embankment.

Reach C

- Filling in of a culvert under the WCML, approximately 500 m inland from the Ribble Viaduct.

3.2.3 Area 3: Frenchwood and Walton-le-Dale along the River Ribble

Area 3 is located on the left (south) and right (north) banks of the River Ribble, to the east of the city, upstream of the confluence with the River Darwen. The proposed work comprises:

- 1.1 km of earth embankment and concrete wall running along the Esplanade, and replacing or raising existing wall and embankment along the Boulevard in Frenchwood, on the north bank;
- Raising 0.5 km of existing earth embankment and concrete wall between the confluence of the Ribble and Darwen and London Road Bridge on the south bank; and
- Replacement of the existing concrete wall (0.8 km), with some sections of glass panels on top, between London Road Bridge and Kings Croft.

3.2.4 Area 4: Walton-le-Dale along the River Darwen

Area 4 is located on the right (east) and left (west) banks of the River Darwen, in Walton-le-Dale to the south of the city centre. The proposed work comprises

- Predominantly raising the existing earth embankments on the right bank, extending some 1.9 km upstream from the confluence with the Ribble. The short sections of existing flood walls, only in close proximity of buildings, will be raised or replaced; and
- A combination of raising or replacing the existing concrete walls, earth embankments and road ramps on the left bank extending approximately 0.8 km upstream of the confluence.

3.2.5 Area 5: Higher Walton and Samlesbury

Area 5 is located on the right (east) and left (west) banks of the River Darwen, at Higher Walton, extending upstream from the M6 motorway. The proposed work here comprises

- construction of a combination of new concrete walls and earth embankments on the right bank, extending some 1.0 km upstream from the M6 motorway; and
- construction of new concrete or sheet pile walls on the left bank, extending approximately 0.5 km upstream of Cann Bridge.

3.2.6 Construction programme

Table 3.1 provides an overview of the delivery programme. Based on these dates, the proposed Scheme (Areas 1 and 2) would be complete approximately 19 months before the full FRMS is completed.

Table 3.1: Construction programme

Project Millstone	Start Date	End Date
Approval of the full Business Case for the full FRMS	N/A	July 2021
Construction on Areas 1 and 2	September 2021	March 2023
Construction on Areas 3, 4 and 5	March 2022	October 2024

4. Planning Policy

4.1 Introduction

The proposed Scheme is well aligned with national and local development and flood risk planning policy and would enable sustainable economic growth within the Preston and South Ribble area. This section of the FRA provides a high-level overview of relevant plans, policies and strategies relevant to the proposed Scheme.

4.2 National Planning Policy

4.2.1 National Planning Policy Framework

In England, the National Planning Policy Framework (NPPF) and its practice guides recommend the sequential, risk-based approach to the location of development. This framework is designed to ensure that areas at little or no risk of flooding from any source are developed in preference to areas at higher risk, but where development is necessary, making it safe without increasing flood risk elsewhere.

This is achieved through the identification and assessment of flood risk through the preparation of Strategic Flood Risk Assessments (SFRAs) and site-specific FRAs, and the successful application of the Sequential and Exception Tests at all stages of the planning process, which considers flood probability, land use, development vulnerability, and long-term sustainability.

The NPPF recommends the use of the Environment Agency's national Flood Map, also called the Flood Map for Planning (FMfP), as a primary dataset to help steer development to areas at lowest risk of flooding. These maps only consider flooding from Main Rivers (fluvial) and the Sea (coastal). This map has three main zones of risk, the third of which is subdivided into two categories:

- **Zone 1 "Low probability of flooding"** - This zone comprises land assessed as having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1%).
- **Zone 2 "Medium probability of flooding"** - This zone comprises land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% – 0.1%), or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% – 0.1%) in any year.
- **Zone 3a "High probability of flooding"** - This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.
- **Zone 3b "Functional Floodplain"** – A sub-part of Zone 3, this zone comprises land where water has to flow or be stored in times of flood.

As well as fluvial and coastal flooding, it is also necessary to consider flood risk from all other sources, including surface water, groundwater, Ordinary Watercourses, and artificial drainage systems and infrastructure failure. Once appropriate information has been used to identify areas at risk of flooding, the NPPF recommends the application of the Sequential Test, and where applicable, the Exception Test.

As set out in the NPPF, the aim of the **Sequential Test** is steering new development to areas with the lowest probability of flooding, with the Flood Zones listed above as a starting point. The Local Planning Authority (LPA) should not permit development if there are reasonably available sites appropriate for that development in areas of lower probability of flood risk.

If following the application of the Sequential Test, it is not possible to locate the proposed Scheme in areas at low risk of flooding (Flood Zone 1) , the NPPF states that the vulnerability of the development to flooding should be considered in relation to the Flood Zone it lies within. Table 4.1 provides a matrix illustrating the different development vulnerability classifications and their respective Flood Zone compatibility. The matrix also illustrates were the application of the Exception Test is required. Where relevant, in order to pass the Exception Test:

- *"It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a Strategic Flood Risk Assessment (SFRA) where one has been prepared; and*
- *A site-specific flood risk assessment must demonstrate that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall."*

Table 4.1: Flood risk vulnerability and flood zone 'compatibility'

Flood risk vulnerability classification	Essential infrastructure	Water compatible	Highly vulnerable	More vulnerable	Less vulnerable
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	✓	Exception Test required	✓	✓
Zone 3a	Exception Test required	✓	×	Exception Test required	✓
Zone 3b	Exception Test required	✓	×	×	×

The proposed Scheme is a FRMS, which includes individual measures located within two specific areas of Preston. Whilst the proposed Scheme lies within Flood Zone 3 and areas at risk of other sources of flooding (as discussed later in this FRA), the EA have concluded that the proposed measures are the most effective and economical solution to protect properties in Preston and South Ribble. By their very nature, the proposed measures have to be located along the riverbank and critical flood flow pathways to be technically effective. The appraisal process confirmed that there are no other locations or group of measures that are more cost effective. **The Sequential Test is therefore passed**.

In addition, the NPPF classifies the proposed Scheme **Flood Control Infrastructure** which are considered to be as **Water-Compatible** development. The NPPF permits this type of development in all Flood Zones and Exception Test is also not applicable (Table 4.1).

Although the Exception Test is not applicable for this development, this FRA has still been undertaken to support the Planning Application and provide a comprehensive assessment of existing and residual flood risks using the principles set out within the exception test. This will help ensure that the development has been designed and will be constructed in a safe and sustainable manner.

4.2.2 National FCERM strategy

The National FCERM Strategy was updated in July 2020. This updated strategy has 3 long-term ambitions, underpinned by evidence about future risk and investment needs. They are:

- Climate resilient places: working with partners to bolster resilience to flooding and coastal change across the nation, both now and in the face of climate change;
- Today's growth and infrastructure resilient in tomorrow's climate: making the right investment and planning decisions to secure sustainable growth and environmental improvements, as well as infrastructure resilient to flooding and coastal change; and
- A nation ready to respond and adapt to flooding and coastal change: ensuring local people understand their risk to flooding and coastal change and know their responsibilities and how to take action.

The proposed scheme aligns with the aims of the national strategy through improvements to the standard of protection to the local communities, investigating options which provide climate change resilience and identification of opportunities to work with partners.

4.3 Local Planning Policy

4.3.1 Local economic strategy

Lancashire Economic Partnership (LEP) Strategic Economic Plan aims to direct resources from the European Structural and Investment Fund (ESIF) to realise this ambition. One of the aims is to maximise the benefit from high value business clusters and linking key economic assets. Improved FRM to Preston delivers for this ambition in the benefits provided to a key economic area in Lancashire.

The draft EU Structural and Investment Fund Strategy for Lancashire 2014-20 (September 2015) prioritises the potential for funding to create up to 50,000 new jobs and generate additional economic activity worth over £3bn to Lancashire's economy. Coastal and inland flood risk is listed as a threat that will impede economic growth. It states that protection of key economic sites through flood mitigation and coastal resilience measures are expected to be resourced by ERDF PA5 funding.

4.3.2 Local planning policy

The Central Lancashire Core Strategy[15] strategic objective SO 23 seeks to manage flood risk and the impacts of flooding. This aligns with the proposed scheme, as captured in the EA national 6-year capital programme, as well as within the 2015-2021 North West Flood Risk Management Plan.

Climate change resilience and wider social and environmental benefits are recognised as important themes for local socio-economic development, aligning with Environment Agency objectives. This includes improved provision for walking and cycle paths, riverbanks planted and managed to encourage greater habitat and biodiversity, increasing its amenity value for locals and visitors.

4.3.3 Other plans, policies and strategies

The proposed scheme has been developed to meet the objectives of the following strategies and plans:

- Lancashire and Blackpool Local Flood Risk Management Strategy[16]
- Ribble Catchment Flood Management Plan (2009)[17]
- North West river basin district Flood Risk Management Plan 2015- 2021[18]
- North West District River Basin Management Plan 2015-2021[19]
- Preston Surface Water Management Plan (SWMP)

[15] Central Lancashire (2012) *Central Lancashire Adopted Core Strategy Local Development Framework.* [Online] Available from; https://www.preston.gov.uk/media/974/Adopted-Core-Strategy-Part-1/pdf/Adopted-Core-Strategy-July-2012-Part-1_1.pdf?m=636941232688970000 [Accessed September 2020]

[16] Lancashire County Council and Blackpool Borough Council (2013) *Lancashire and Blackpool Local Flood Risk Management Strategy.* [Online] Available from https://www.lancashire.gov.uk/media/900474/lancashire-and-blackpool-local-flood-risk-management-strategy-consultation-draft.pdf [Accessed September 2020]

[17] Environment Agency (2009) *Ribble Catchment Flood Management Plan.* [Online] Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/293727/Ribble_Catchment_Flood_Management_Plan.pdf [Accessed September 2020]

[18] Environment Agency (2016) *North West River Basin Flood Management Plan*. [Online] Available from: https://www.gov.uk/government/publications/north-west-river-basin-district-flood-risk-management-plan [Accessed September 2020]

[19] Environment Agency (2018) *North West River Basin Management Plan*.

5. Operational Phase - Flood Risk to the Scheme

5.1 Introduction

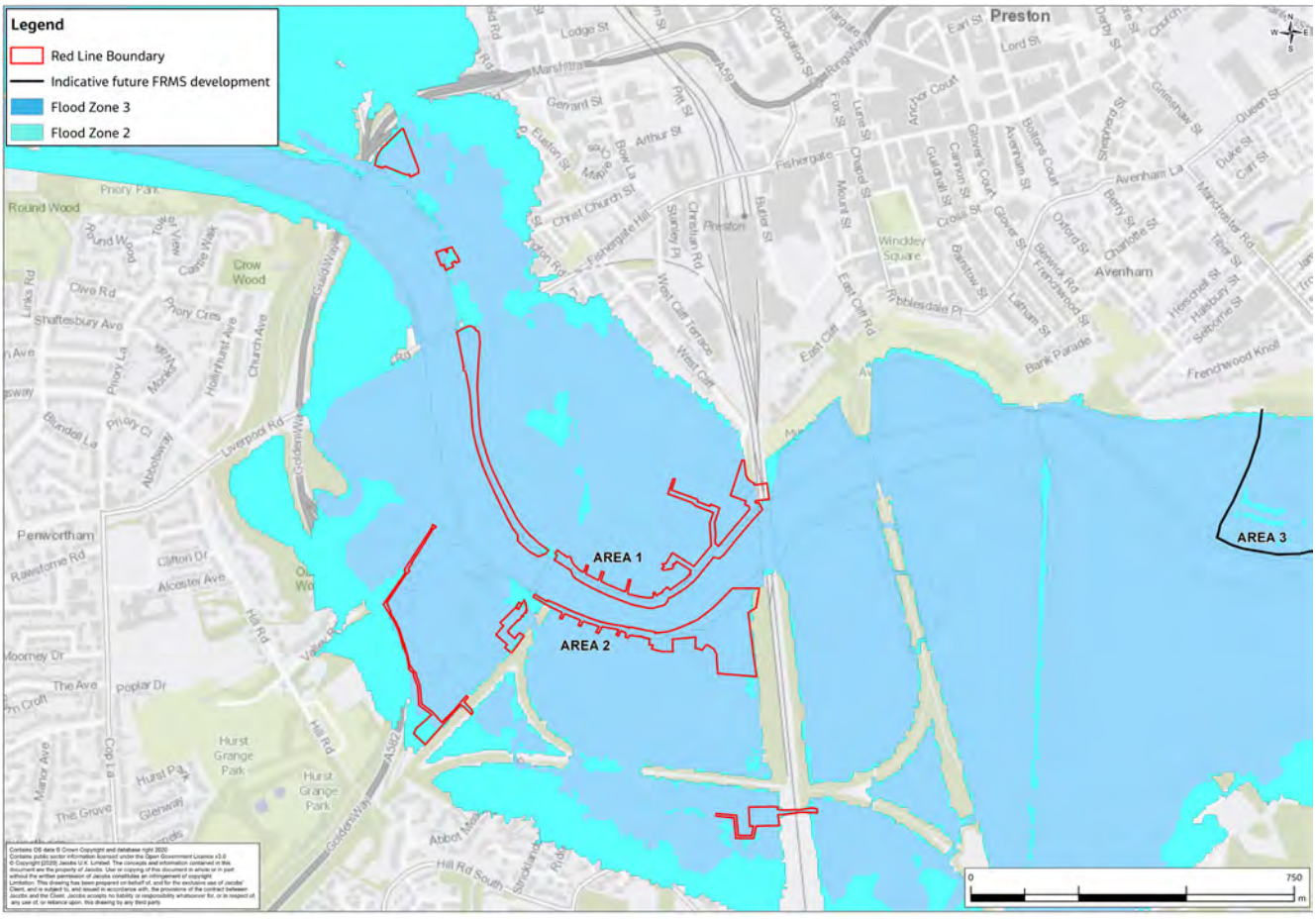
This Section of the FRA documents the assessment of flood risk to the Scheme. The outcomes of the assessment are discussed in detail in Sections 5.2 - 5.7.

5.2 Tidal Flood Risk

Tidal flooding is caused by high tides, often coinciding with a low-pressure storm system, which raises sea and tidal water levels overwhelming coastal and river defences. This may be made worse by strong winds blowing the raised body of water up tidal river basins some distance from the coast. Such flooding may become more frequent in future years due to rising sea levels as detailed in Section 2.2.4.

The Ribble Estuary is subject to tidal influence as far upstream as the Frenchwood area of Preston and therefore Areas 1 and 2 of the FRMS would be at risk from tidal flood events. The EA's Flood Map for Planning, as presented in Figure 5.1, indicates that the proposed Scheme would be located within Flood Zone 3. The Flood Map for Planning does not differentiate between tidal and fluvial sources of risk, but Flood Zone 3 represents areas where the risk from tidal flooding would be equal to or greater than 0.5% AEP.

Figure 5.1: Flood Map for Planning



A detailed 1D-2D Flood Modeller-TUFLOW hydraulic model has been developed for the River Ribble to support the development of the business case and design of the proposed Scheme and has been used to inform this FRA. Details of this modelling are provided in Appendix B.

The results of hydraulic modelling indicate that the main area at risk from tidal flooding is an area of floodplain on the left (south) bank known as the Holme which is largely undeveloped comprising recreation grounds, allotment gardens and small numbers of non-residential property.

As shown in Table 5.1, the existing defences would not be overtopped during the present-day 0.1% AEP tidal flood event, with average crest levels of the existing defences approximately 7.7 m AOD.

Under the central climate change scenario, by the 2080s (2070 – 2115) tidal flood levels are predicted to increase but the existing defences would not be overtopped up to and including the 0.5% AEP tidal flood event. However, during the 1% AEP flood event, water from the Holme area would bypass the defences and result in flooding to Penwortham Methodist Church during the 10% AEP flood event with water spilling onto Leyland Road (B5254).

In comparison, under the upper end climate change scenario, in the 2080s (2070 – 2115) the Penwortham Methodist Church and Leyland Road would be at risk of flooding in the 20% AEP tidal flood event.

Table 5.1: Predicted maximum water levels during tidal flood events combined with 10% AEP fluvial event

Model node (Location)		**Tidal Event / Peak Water Level (m AOD)**					
	10% AEP	**5% AEP**	**2% AEP**	**1.3% AEP**	**1% AEP**	**1% AEP +CC***	**0.5% AEP**
RIBB_13278u (upstream of Penwortham Old Bridge	6.5	6.6	6.73	6.78	6.82	7.27	6.87
RIBB_13873 (downstream of the West Coast Mainline Crossing	6.73	6.81	6.92	6.96	6.99	7.43	7.05

*Climate change uplift based on the central allowance for the 2080's climate change scenario

Whilst the probability of flooding across all elements of the development is high and will increase as a result of climate change, all elements of the Scheme have been designed in accordance with Eurocode 7 to withstand the anticipated loading from the 0.5% AEP present-day flood event. Therefore, the flood risk to the development from tidal flooding is considered to be low.

During the operational phase of the proposed Scheme, the EA would undertake regular inspection and maintenance activities that would, out of necessity, occur in Flood Zone 3. Due to the high level of risk to staff and contractors, mitigation would be required. This is detailed in Section 5.7.

5.3 Fluvial Flood Risk

Fluvial flooding typically occurs when a river's capacity is exceeded, and the excess water overtops the riverbanks. It can also occur when the watercourse has a high level downstream, perhaps due to structures or blockage, thus limiting conveyance. This creates a back-up of water and again water can overtop the banks.

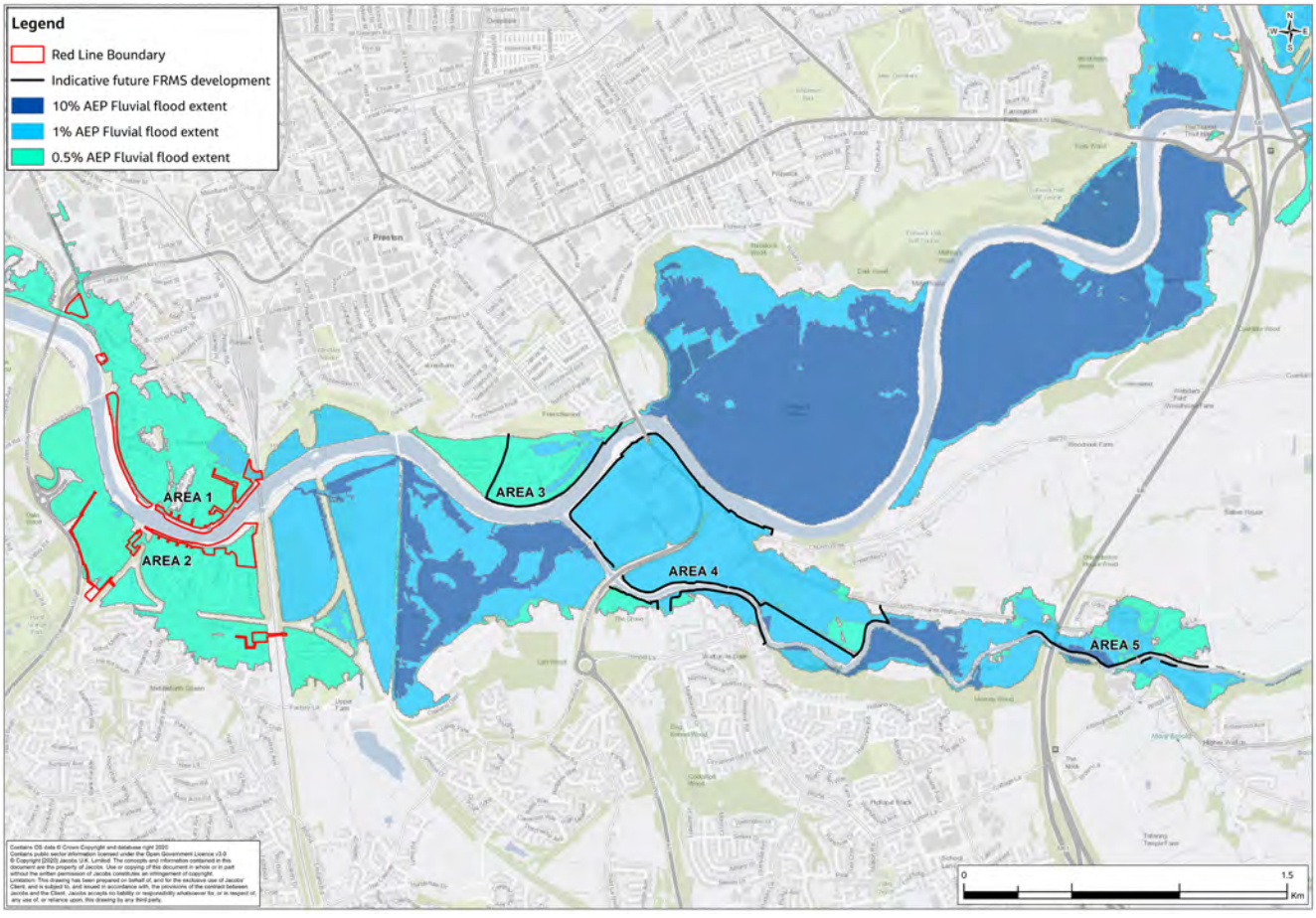
5.3.1 Fluvial flood risk from the River Ribble

The EA's Flood Map for Planning, as presented in Figure 5.1, indicates that the proposed Scheme would be located within Flood Zone 3, indicating that the risk of fluvial flooding would be equal to or greater than 1% AEP. The Central Lancashire SFRA[13] also identifies that the proposed Scheme to be located within Flood Zone 3b, which comprises land where water has to flow or be stored in times of flood. This generally corresponds to the

5% AEP flood extent, although where this is not known, the 4% AEP flood extent is used. The main source of risk of fluvial flooding to the site is the River Ribble which is classified as a Main River. The detailed 1D-2D Flood Modeller-TUFLOW hydraulic model of the River Ribble has been used to test a range of flood scenarios including the deterioration of existing flood defence assets and the impacts of climate change. Appendix B contains further detail on the modelling approach.

Figure 5.2 illustrates the extent of fluvial flooding during three key fluvial events during the present-day baseline scenario, with the existing defences in place. This is in contrast to the EA's Flood Map for Planning shown in Figure 5.1, which does not consider the presence of existing defences.

Figure 5.2: Baseline scenario present-day flood extents



Analysis of the hydraulic modelling results indicate that the existing level of flood risk is due to exceedance of the channel capacity and out of bank flows.

In the present-day scenario, flood events with a magnitude greater than 1.33% AEP flow would spill from Avenham Park beneath the WCML and into Area 1. During the larger 0.5% AEP fluvial flood event, the existing defences at Areas 1 and 2 would be overtopped as well as flood water passing through a culvert beneath the WCML from the playing fields to the east of the railway, resulting in extensive flooding within Area 2.

Under the central climate change scenario, by the 2080s (2070 – 2115), the existing defences would be overtopped during events greater than the 5% AEP flood event.

In comparison, under the upper end climate change scenario, by the 2080s (2070 – 2115) significant flooding would be predicted within Areas 1 and 2 during the 10% AEP flood event.

A summary of modelled fluvial flood levels is presented in Table 5.2. the crest level of the existing defences is approximately 7.7 m AOD.

Table 5.2: Predicted maximum water levels during fluvial flood events

Model node (Location)		Fluvial event peak water level (m AOD)					
	10% AEP	5% AEP	2% AEP	1.33% AEP	1% AEP	1% AEP +CC*	0.5% AEP
RIBB_13278u (upstream of Penwortham Old Bridge	5.77	6.05	6.48	6.68	6.85	7.84	7.33
RIBB_13873 (downstream of the West Coast Mainline Crossing	6.35	6.7	7.24	7.51	7.7	8.67	8.26

* Climate change uplift based on central allowance for the 2080's climate change scenario (25%)

Whilst the data shows that there is an existing risk of flooding, all elements of the Scheme are designed in accordance with Eurocode 7 to withstand the anticipated loading from the 0.5% AEP present-day flood event from the River Ribble. Therefore, the flood risk to the proposed Scheme is considered to be low.

During the operational phase of the proposed Scheme, the EA will undertake regular inspection and maintenance activities that would, out of necessity, occur in Flood Zone 3. Due to the high level of risk to staff and contractors, mitigation would be required. This is detailed in Section 5.7.

5.3.2 Impact of combined tidal of fluvial flood risk

Due to the location of the proposed Scheme within the tidal zone of the Ribble Estuary, there is potential for interaction between fluvial flows and high tides. A joint probability analysis has been undertaken, which is summarised in Section 4.3 of Appendix B.

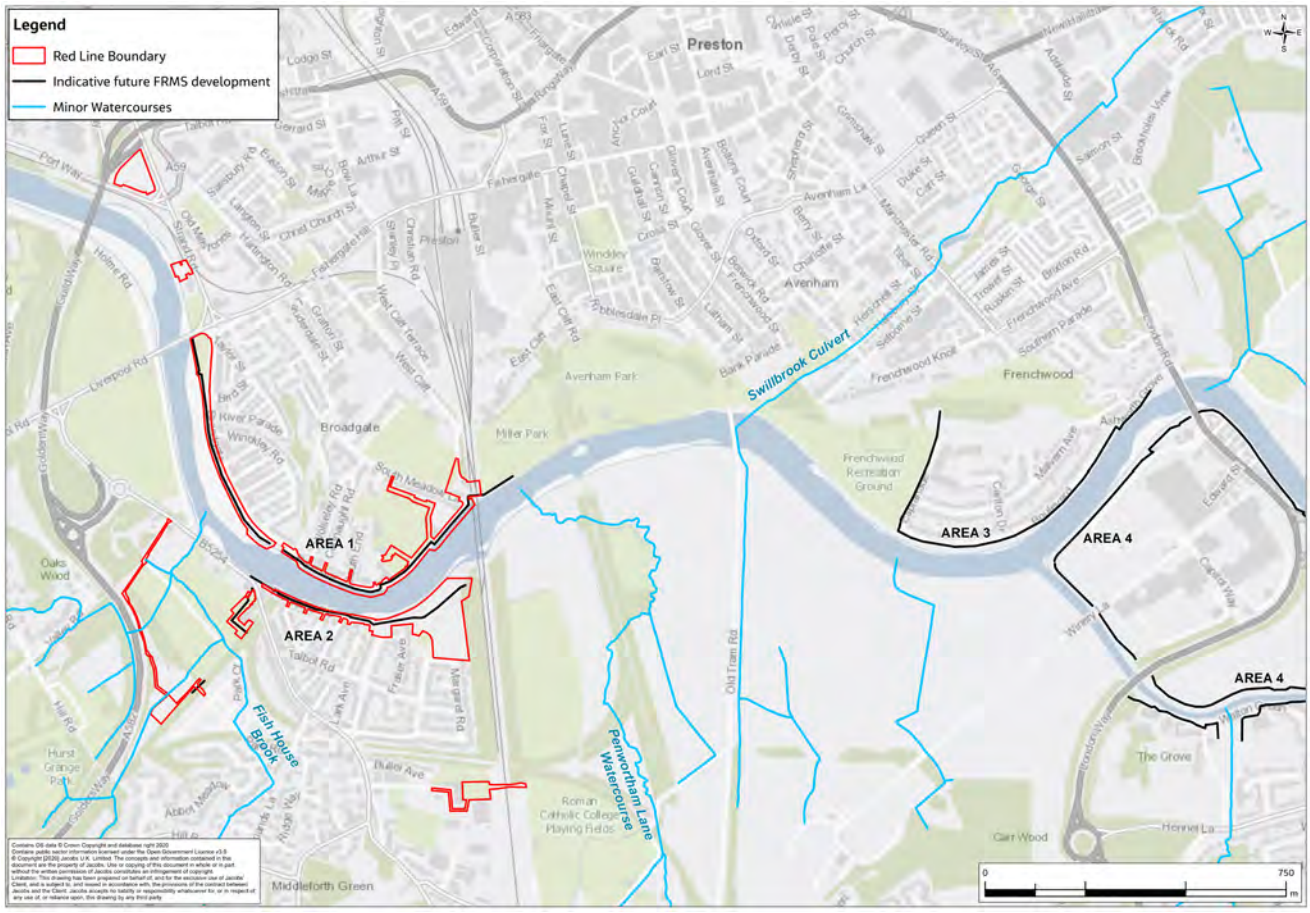
The results show that for extreme events, the fluvial and tidal variables are independent. For example, a 1% AEP event could comprise:

- A fluvial dominant event with a fluvial 1% AEP flow (1371.9 m^3/s) is estimated to be coincident with a tidal peak of no greater than 4.43 m AOD (MHWS); or
- A tidal dominant event with a tidal peak level of 6.08 m AOD (1% AEP) is estimated to be coincident with a fluvial peak of no greater than 623.3 m^3/s (50% AEP fluvial event).

5.3.3 Fluvial flood risk from tributaries of the River Ribble

Tributaries of the River Ribble within the vicinity of the proposed Scheme include Fish House Brook (Main River) which flows from south to North through Lower Penwortham, Penwortham Lane Watercourse (Ordinary Watercourse) which flows from south to north through the area of open space on the east side of the WCML. Swillbrook is a culverted Main River which flows from north to south through Preston.

Figure 5.3: Tributary locations



Fish House Brook is a Main River that flows as an open channel through Middleforth Green before entering a culvert beneath Hill Road South. Shorter sections of open channel lead into other culverts beneath roads and disused railway tracks before it becomes an open channel again and discharges into the Ribble Estuary via a flapped outfall approximately 175 m downstream of Penwortham Old Bridge.

Fish House Brook was modelled as part of the Strategic Outline Business Case (SOC) for the FRMS using a1D-2D Flood Modeller-TUFLOW hydraulic model of the River Ribble. This modelling indicates that the capacity of the culverts beneath Hill Road South and the disused railway would be exceeded during the 1.33% AEP fluvial flood event with flood flows passing onto and long Penwortham Road towards Area 2 of the proposed Scheme. Whilst the proposed Scheme itself is not predicted to flood from this source during the 1.33% AEP flood event, the area behind the defences including access routes to it would be at risk. Flood extents during events of greater magnitude could intersect with the proposed Scheme.

However, as discussed in Section 5.3.1, the proposed Scheme has been designed in accordance with Eurocode 7 to withstand the anticipated loading from the 0.5% AEP present-day flood event from the River Ribble and no additional risks would occur from shallow flooding of the landward face of the proposed Scheme. Therefore, the risk to the proposed Scheme from this source is low. Mitigation to ensure the safety of staff during operational activities is detailed in Section 5.7.

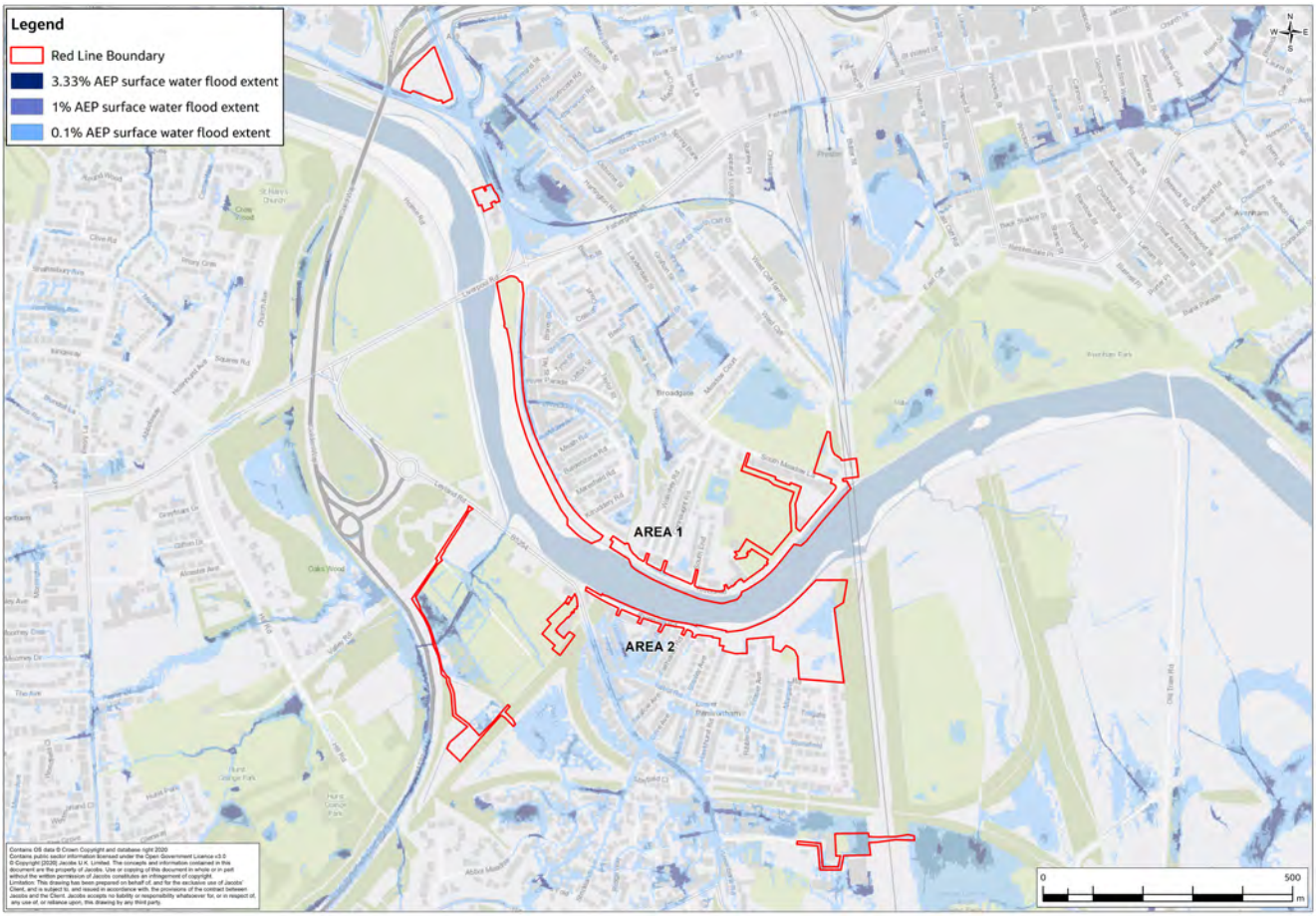
Penwortham Lane and Swillbrook Culvert are remote of the proposed Scheme and would not pose a direct risk to the proposed Scheme.

5.4 Surface Water Flood Risk

Surface water runoff is defined as water flowing over the ground that has not yet entered a drainage channel or similar. It usually occurs as a result of an intense period of rainfall which exceeds the infiltration capacity of the ground. Typically, runoff occurs on sloping land or where the ground surface is relatively impermeable. The ground can be impermeable either naturally due to the soil type or geology, or due to development which places impervious material over the ground surface (e.g. paving and roads).

The EA Flood Map for Surface Water (Figure 5.4) indicates that existing surface water flood risk in the vicinity of the proposed Scheme is generally low, although areas of moderate flood risk (1% AEP) are present between Liverpool Road and Penwortham Old Bridge.

Figure 5.4: Risk of Flooding from Surface Water Mapping



During flood events with a magnitude greater than 1% AEP, surface water flooding less than 300 mm deep would occur in two locations along Riverside Road in Lower Penwortham (Area 2). Surface water would flow southwards, away from the river and form an area of deep ponding around Gaskell Street. Another area of low (less than 1% AEP) surface water flood risk is located within Lower Penwortham behind the existing embankment, in the park to the west of the West Coast Mainline Railway. During the 0.1% AEP flood event flooding within the park would be up to 900 mm deep.

In Broadgate (Area 1) located on the right (north) bank of the Ribble, EA surface water flood mapping indicates that downstream of Penwortham Old Bridge, there is a long section of Broadgate that would be at risk of flooding to a depth of less than 300 mm during the 1% AEP surface water flood event. On the upstream side of Penwortham Old Bridge, a very small stretch (less than 50 m long) of Riverside would be at risk of flooding during the 1% AEP flood event, whilst a slightly larger area would be at risk of flooding to a depth of 300 mm during the 0.1% AEP flood event.

In summary, the probability of surface water flooding in the vicinity of the proposed Scheme is generally low with localised areas of moderate risk. However, as all elements of the proposed Scheme are designed in accordance with Eurocode 7 to withstand the anticipated loading from the 0.5% AEP present-day flood event from the River Ribble, the flood risk to the proposed Scheme is considered to be low.

5.5 Groundwater Flood Risk

Groundwater flooding is defined as the emergence of groundwater at the ground surface away from perennial river channels or the rising of groundwater into man-made ground, under conditions where the 'normal' ranges of groundwater level and groundwater flow are exceeded. Groundwater flooding can cause significant damage to property, especially in urban areas, and can pose further risks to the environment and ground stability.

A detailed ground investigation (GI) was completed to in 2019 in addition to the exploratory site investigation completed in June 2012. The 2019 investigation included a programme of continuous groundwater monitoring between September 2019 and January 2020. Full details of the ground investigation and its results are presented within the *Ground Investigation Report Areas 1 and 2* (ENV0000009C-JAC-DW-00-RP-GT-0001) and are summarised below.

The monitoring results show that groundwater levels in the area around the proposed Scheme generally vary between 1.9 and 6.2 m AOD although lower levels were observed in one of the boreholes monitored. The results of this groundwater monitoring also show what appears to be a daily pattern of the groundwater levels rising and falling once a day by approximately 1.6m at most. The groundwater response has been compared to changing river levels at Walton-Le-Dale monitoring station and it is concluded that the groundwater level across the study area is in hydraulic continuity with the River Ribble. Therefore, whilst the proposed Scheme may be subject to high groundwater levels, fluvial or tidal flooding would occur prior to the emergence of any groundwater and the risk of direct groundwater flooding as defined above is considered to be low.

Groundwater conditions have been factored into the design of the proposed Scheme, which include foundations designed in accordance with Eurocode 7 to withstand the hydrostatic pressures from groundwater and a cut-off below the line of the defences to prevent ingress beneath them. The proposed Scheme is therefore considered to be resilient to groundwater flooding. As such, the risk of groundwater flooding to the Scheme is considered low.

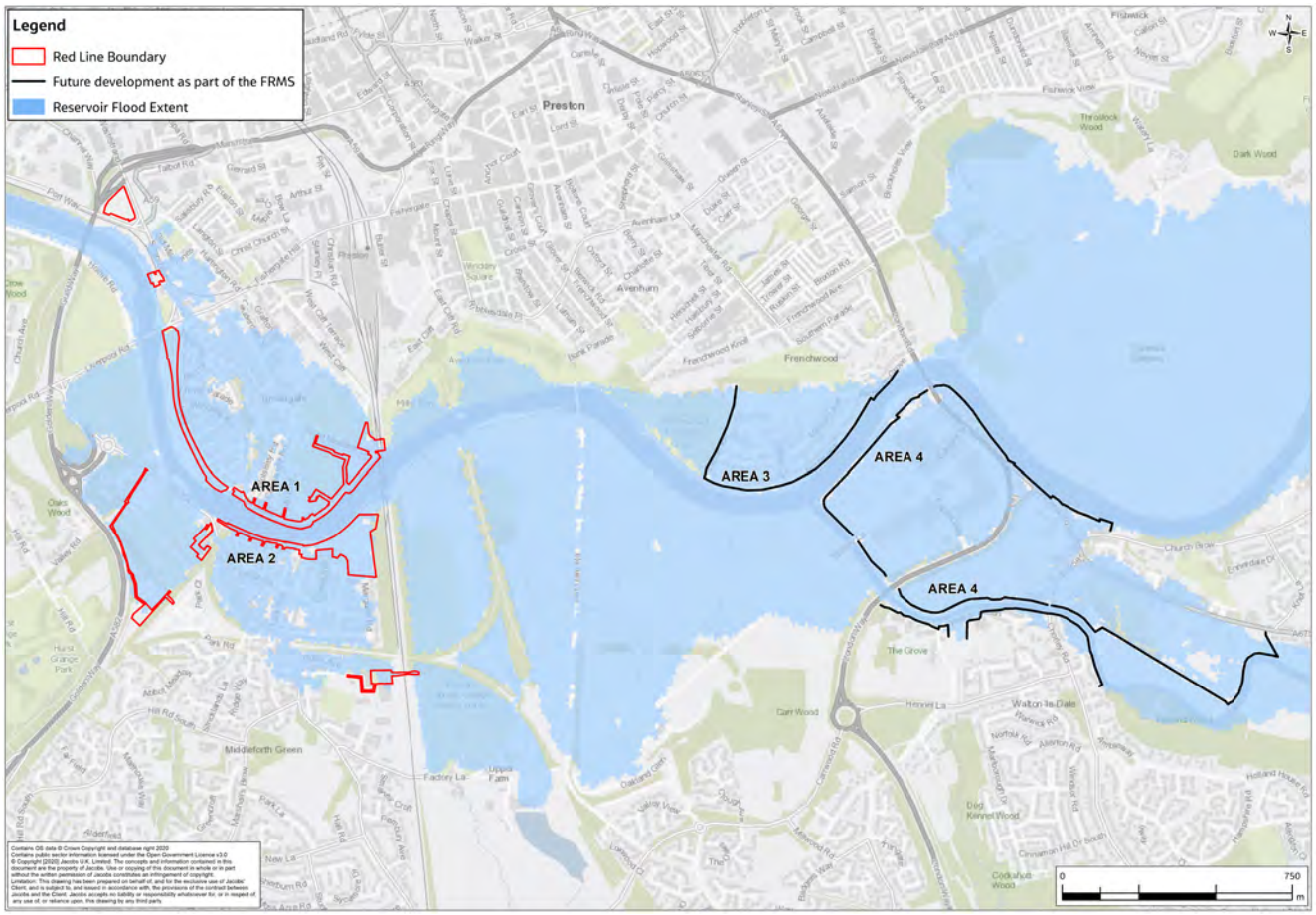
5.6 Flood Risk from Artificial Infrastructure

5.6.1 Reservoir flooding

Reservoir failure can be a particularly dangerous form of flooding as it results in the sudden release of large volumes of water that can travel at high velocity. This can result in deep and widespread flooding, potentially resulting in significant damage. The likelihood of reservoir flooding occurring is generally extremely low given that all large reservoirs are managed in accordance with the Reservoirs Act 1975. Under the Reservoirs Act 1975, a large raised reservoir is defined as one that holds over 25,000 cubic metres of water above the level of the surrounding land. The EA's reservoir inundation map illustrates the maximum flood extents that could potentially occur in the event of a reservoir failure.

As is shown on Figure 5.5, all elements of the proposed Scheme intersect with the maximum extent of flooding as indicated by the EA's Reservoir Failure Flood Mapping. Flood depths are predicted to be between 0.3 and 2 m. The nearest reservoirs to the proposed Scheme are located more than 10 km upstream. However, all elements of the Scheme are designed in accordance with Eurocode 7 to withstand the anticipated loading from the 0.5% AEP present-day flood event from the River Ribble. As the nearest reservoirs are more than 5 km upstream of the proposed Scheme, the loading from a reservoir flood is not considered likely to be significantly greater than the design flood event. Based on the low likelihood of flooding from this source and the low vulnerability of the proposed Scheme, the risk from reservoirs is considered to be low.

Figure 5.5: Reservoir Flood Map



5.6.2 Sewers and water mains

Sewer flooding is when sewage or foul water leaks from the sewerage system (through pipes, drains or manholes) or floods up through toilets, sinks or showers inside a building. It can be caused by capacity of the sewer system being exceeded or due to blockages or collapses. The failure of water mains can also result in localised flooding.

The Central Lancashire SFRA[13] identifies that there are records of sewer flood events within the Preston and South Ribble area including in the vicinity of the proposed Scheme. No further information is provided on the cause of this flooding. However, as all elements of the Scheme are designed in accordance with Eurocode 7 to withstand the anticipated loading from the 0.5% AEP present-day flood event from the River Ribble they are not considered to be at risk from sewer flooding, therefore the flood risk to the development is considered to be low.

5.7 Flood Risk Mitigation

The proposed Scheme has been designed to manage and interact with flood flows. Therefore, it is generally at low risk from all sources of flooding.

However, operational activities would require that workers access the area of high flood risk from fluvial and tidal sources in which the proposed Scheme is located. In addition to planned access by EA staff and contractors, the proposed scheme would be located in an area with public access. Operational activities include:

- Closure of the flood gates within area 1 prior to the flood event;
- Routine inspection and maintenance; and
- Post flood inspections.

Mitigation for the operational works would be provided in the form of detailed risk assessments and working procedures which would be documented within the Health and Safety File for the proposed Scheme and the Maintenance Management Plan. Both of these documents would be developed following a successful planning application. These documents would draw on information within this FRA, and would include requirements for a review of flood warnings for the following areas prior to any works:

- Ribble estuary at Broadgate, between Connaught Rd and Fishergate Hill;
- Ribble estuary at Broadgate, around Riverside, The Continental pub and Preston Sports Club;
- Ribble estuary at Lower Penwortham, between A582 and the railway line; and
- Ribble estuary at Lower Penwortham, around Leyland Road close to the River Ribble.

Method statements and risk assessments would also need to identify safe access and egress routes. The information within this report should be used as a basis for identifying these routes. However, the precise routes would be determined by the location of works and any access considerations of relevance at the time of the works.

The proposed Scheme would also be accessible by the public and existing signage would continue to be displayed providing a warning of the risk of flooding and other health and safety considerations.

With this mitigation in the form of effective management plans and strategies in place, the residual risk to the operational activities associated with the proposed Scheme would be low.

6. Operational Phase - Flood Risk Impacts from the Scheme

6.1 Introduction

Flood risk management schemes are designed to reduce the risk of flooding in specific areas. However, by changing the way that flood water flows through a catchment, they can also have a range of beneficial and adverse impacts on flood risk away from the areas they are designed to protect. This Section of the FRA documents the assessment of the benefits of the proposed Scheme and provides details of any adverse impact of the proposed Scheme on flood risk elsewhere.

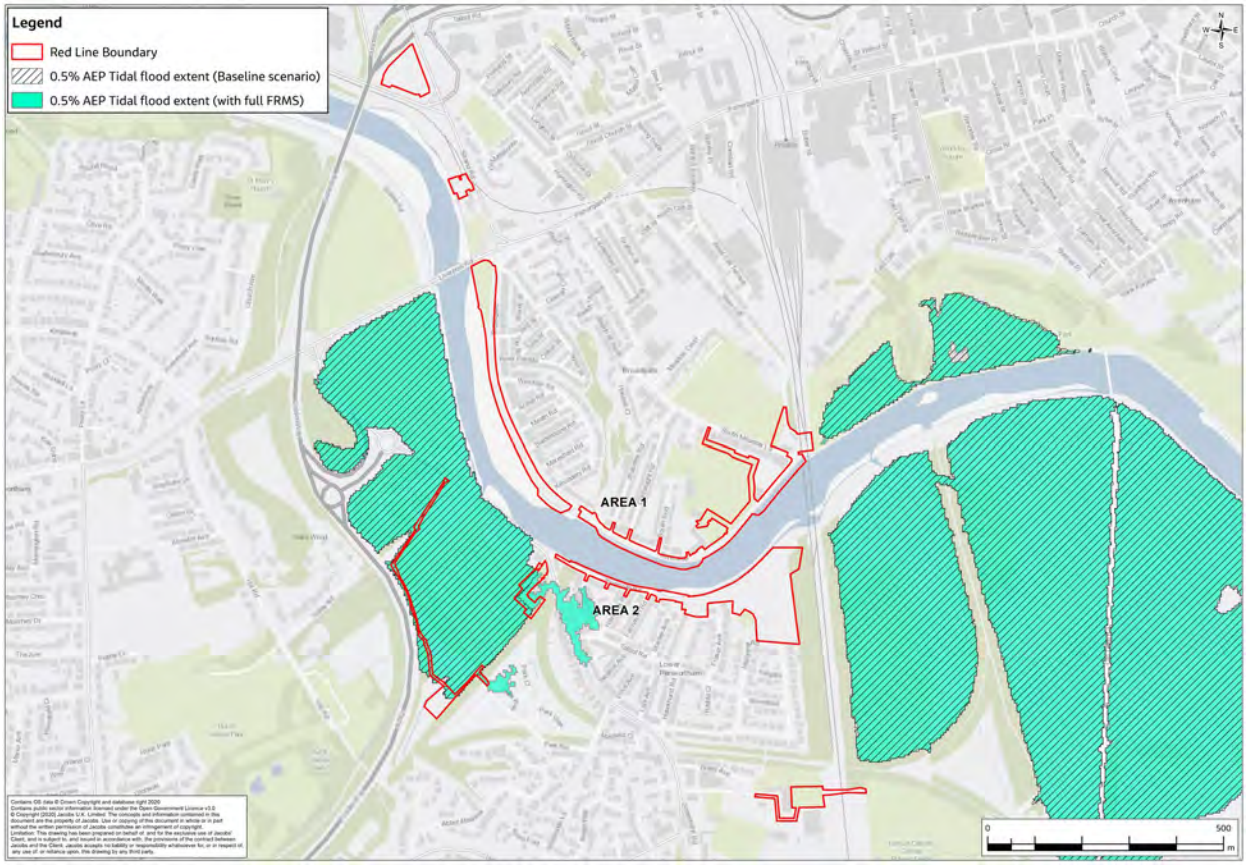
As discussed in Section 2.1.4, it has been identified that there is potential for interim impacts to fluvial flood risk following the completion of Areas 1 and 2; and prior to the completion of the full FRMS. These interim impacts are detailed in Section 6.3.1 whilst the impacts of the full FRMS are detailed in Section 6.3.2.

Tidal flood risk along the Ribble Estuary is limited to Areas 1 and 2 of the FRMS. Therefore, any impacts on tidal risk identified would be limited to these areas and therefore would be present through the lifetime of the proposed Scheme and therefore no analysis of interim impacts outside of Areas 1 and 2 has been undertaken for this flood source. Any impacts on surface water, groundwater and sewer flooding are likely to be localised and would not interfere with Areas 3, 4 and 5.

6.2 Impacts on Tidal Flood Risk

The impact of the proposed Scheme on tidal flooding has been assessed through a1D-2D Flood Modeller-TUFLOW hydraulic model of the River Ribble with the baseline model updated to include a representation of the proposed Scheme. Further details of the modelling are presented in Appendix B. A comparison of the baseline and with scheme flood extents is presented in Figure 6.1.

Figure 6.1: Impacts on tidal flood extents



The proposed Scheme has been designed so that Penwortham Methodist Church and Penwortham Residential Park would benefit from a 0.5% AEP SoP. The reduction in flood extents can be seen on Figure 6.1. Analysis of the climate change impacts on peak tidal levels have confirmed that this standard of protection would remain up to and including the 2080s (2070 – 2115) during both the central and upper end climate change scenarios.

The results of the hydraulic modelling indicate that there would be very minor adverse impacts on peak tidal flood levels within the channel and limited areas of floodplain that would be at risk during the 0.5% AEP tidal flood event as a result of the development of the proposed Scheme. This would remain following completion of the full FRMS. However, this predicted impact is considered likely to be result of model tolerances as no mechanism has been identified which would result in this increase. Also, the receptors of this predicted increase would be limited to areas of undeveloped open space with no planned development. Therefore, impact is considered to be negligible and mitigation is not required.

6.3 Impact on Fluvial Flood Risk

The impacts of the fully completed Preston & South Ribble FRMS are presented in Section 6.3.1, whilst the interim impacts of Areas 1 and 2 prior to the completion of the full FRMS are discussed in Section 6.3.2 Impact on fluvial flood risk (Area 1 and 2 only)

As previously discussed, the proposed Scheme (Areas 1 and 2) would be in place for approximately 19-months prior to the completion of Areas 3, 4 and 5 based on the construction programme detailed in Section 3.2.6. Therefore, the benefits of Areas 1 and 2 to the locations they are designed to protect has been assessed along with the interim impact of the proposed Scheme on fluvial flooding elsewhere prior to the completion of the full FRMS.

6.3.1 Impact of the proposed Scheme on fluvial flood risk

Analysis of the hydraulic model results confirm that the proposed Scheme would result in a benefit to several hundred properties in the areas it is designed to protect with an improved SoP for Areas 1 and 2 to the present-day 0.5% AEP fluvial event.

By the 2080s (2070 – 2115), this SoP is however predicted to reduce to the 1.33% AEP event or the 5% AEP when considering both the central and upper end climate change scenarios respectively.

Once constructed, Areas 1 and 2 would result in a loss of floodplain storage and floodplain flow routes during flood events greater than 1% AEP. This would result in short-term adverse impacts to locations upstream before Areas 3, 4 and 5 of the FRMS are constructed. A comparison of predicted flood extents and depths during the 0.5% AEP fluvial flood event is presented in Figure 6.2.

Whilst the adverse impacts of the proposed Scheme are largely limited to undeveloped areas, adverse impacts are predicted to affect Areas 3, and 4 in addition to several isolated properties which are collectively known as Area 6. Area 6 properties are spread across four locations as shown on Figure 6.3.

Details of the adverse impacts are described in the following sections. As the predicted impacts would be limited to a 19-month period, only the present-day flood events have been assessed with regard to the interim impacts.

Figure 6.2: Impacts on fluvial flood extents from the proposed Scheme during the present-day 0.5% AEP event

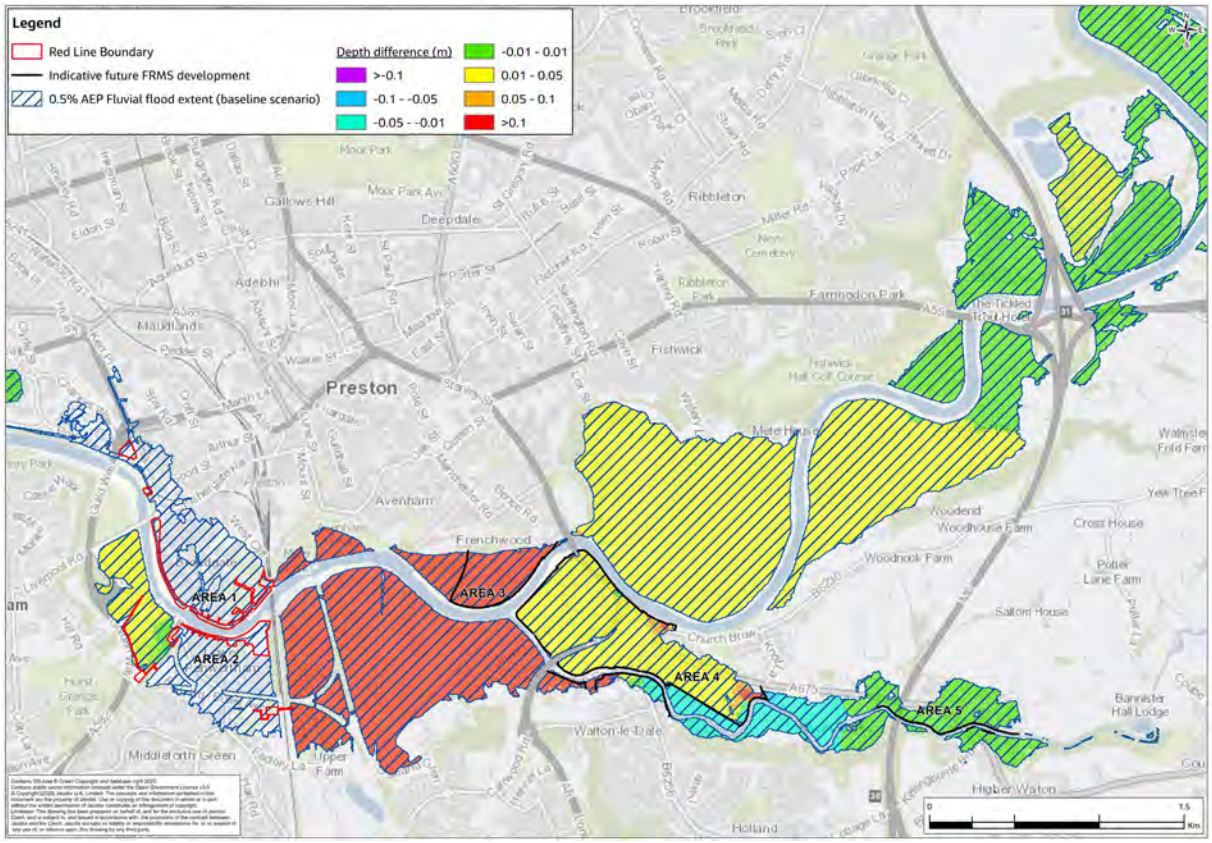
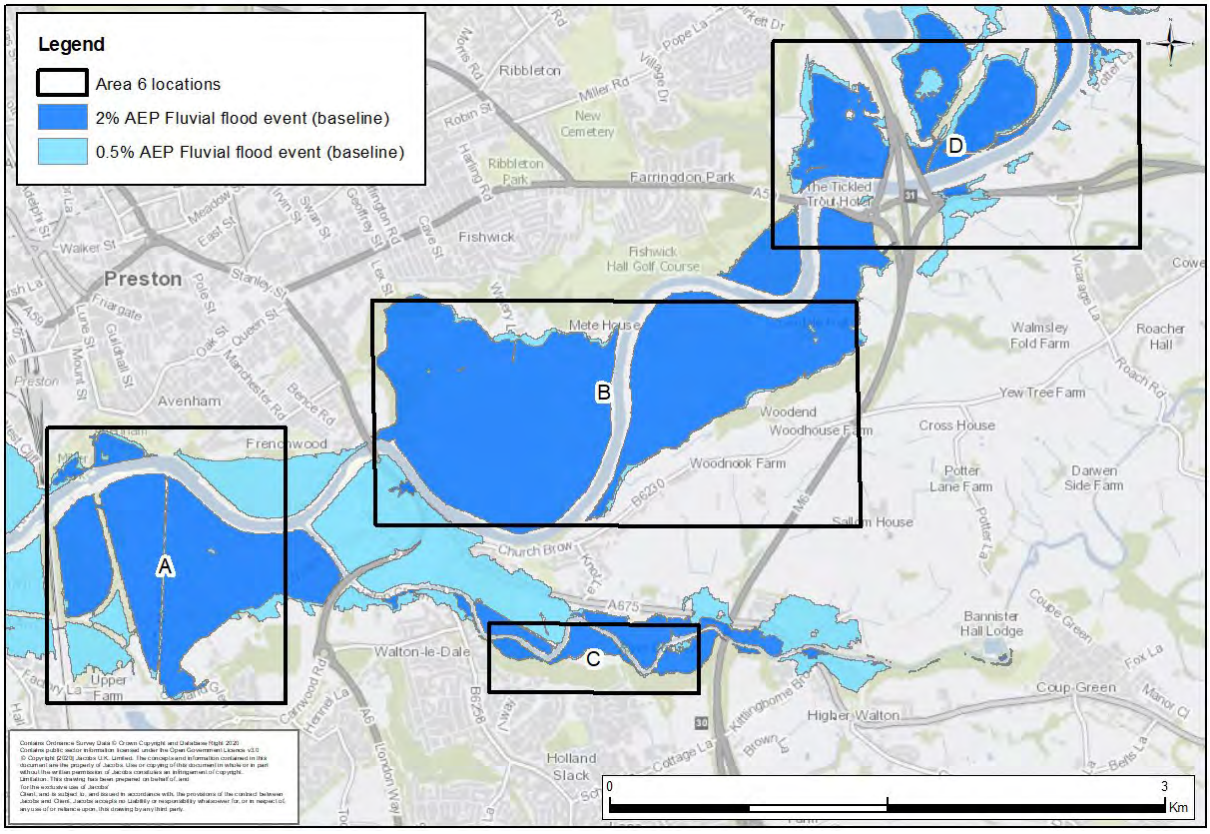


Figure 6.3: Location of Area 6 properties



6.3.1.1 Adverse impacts to Area 3: Frenchwood and Walton-le-Dale along the River Ribble

With the proposed Scheme in place, this location would remain safe from flooding during the 1.33% AEP fluvial event. However, during the 1% AEP event, the extent and depth would increase. Additional properties would be at risk of flooding and those already at risk would experience flood depths approximately 0.5 m deeper during the 1% AEP event. This change in flood extent is shown in Figure 6.4.

6.3.1.2 Adverse impacts to Area 4: Walton-le-Dale along the River Darwen

The development of Areas 1 and 2 would result in increases in flood depth and flood extent with impacts first noted during the 2% AEP event. The increases in flood extent are shown on Figure 6.5 and Figure 6.6. Whilst short term impacts during the 2% AEP event would be limited to non-residential property, the impact during the 1.33% AEP event would potentially impact residential property.

6.3.1.3 Adverse impacts to Area 5: Higher Walton and Samlesbury.

Whilst some negative impacts on flood risk are predicted in this area as a result of the development of the proposed Scheme in Areas 1 and 2, these are limited to increases in flood depths in the order of millimetres during the 0.5% AEP flood event. With this area being approximately 4 km upstream of Areas 1 and 2 these limited impacts are considered to be within model tolerances and the overall the impact is considered to be negligible.

6.3.1.4 Adverse impacts to Area 6 location A

On the northern bank of the River Ribble, the Avenham Park Pavilion is currently at risk of flooding during the 2% AEP present-day flood event. Peak flood depths during this event would increase by approximately 0.2 m with Areas 1 and 2 in place with further increases of approximately 0.4 m predicted during the 0.5% AEP event.

A single non-residential property is located just outside of the maximum extent of the 0.5% AEP present-day fluvial flood event on the south side of the River Ribble. With Areas 1 and 2 in place, flood extents would increase, and the property would be flooded to a depth of approximately 0.5 m during an event of this magnitude.

Properties within a caravan park would be at risk from the 1.33% AEP present-day fluvial flood event with flood depths of approximately 0.1 m affecting approximately two properties. With the proposed Scheme in place, the depth would increase to approximately 0.2 m during the 1.33% AEP flood event although flood extents would remain largely unchanged. During higher magnitude events, additional properties would be impacted by the increase in peak flood depths.

6.3.1.5 Adverse impacts to Area 6 location B

Flooding within this area onsets during relatively low magnitude events with two non-residential properties flooding during the 10% AEP flood event. These properties would be at risk from very deep (>2 m) flooding during the 0.5% AEP flood event. A residential property at the edge of the floodplain in this area would not flood in the baseline scenario until the 0.5% AEP flood event.

With the full FRMS in place, flood depths during the 0.5% AEP flood event would increase by approximately 0.03 m. Due to the relatively flat topography in this area changes in flood extent are also predicted with the FRMS in place and approximately five residential properties that are currently outside of the maximum flood extent for the 0.5% AEP flood are predicted to flood during the 1.33% AEP flood event.

6.3.1.6 Adverse impacts to Area 6 location C

Two residential properties are currently at risk from flooding along the River Darwen. One is currently at risk of flooding during the 2% AEP flood event to a maximum depth of approximately 0.8 m. The other property is

located at the upstream end of location C. Due to its location on the edge of the floodplain, this property is only currently at risk of internal flooding during the 0.5% AEP flood event.

Flood depths are predicted to reduce in this area during the 0.5% AEP event with the proposed Scheme in place by a maximum of 0.03 m. As this location is approximately 3 km upstream of the proposed Scheme it is likely that these minor reductions are a product of model tolerances and that the overall impact on flood risk in this area is considered to be negligible.

6.3.1.7 Adverse impacts to Area 6 location D

Flooding onsets in this area during the 5% AEP flood event. However, with the location of this area being over 4 km upstream of the proposed Scheme, the impacts in this location are currently predicted to be negligible with peak flood depth increases of less than 0.01 m during the 0.5% AEP flood present-day event.

Figure 6.4: 1% AEP flood extents in Area 3 during baseline scenario and with Areas 1 and 2 only

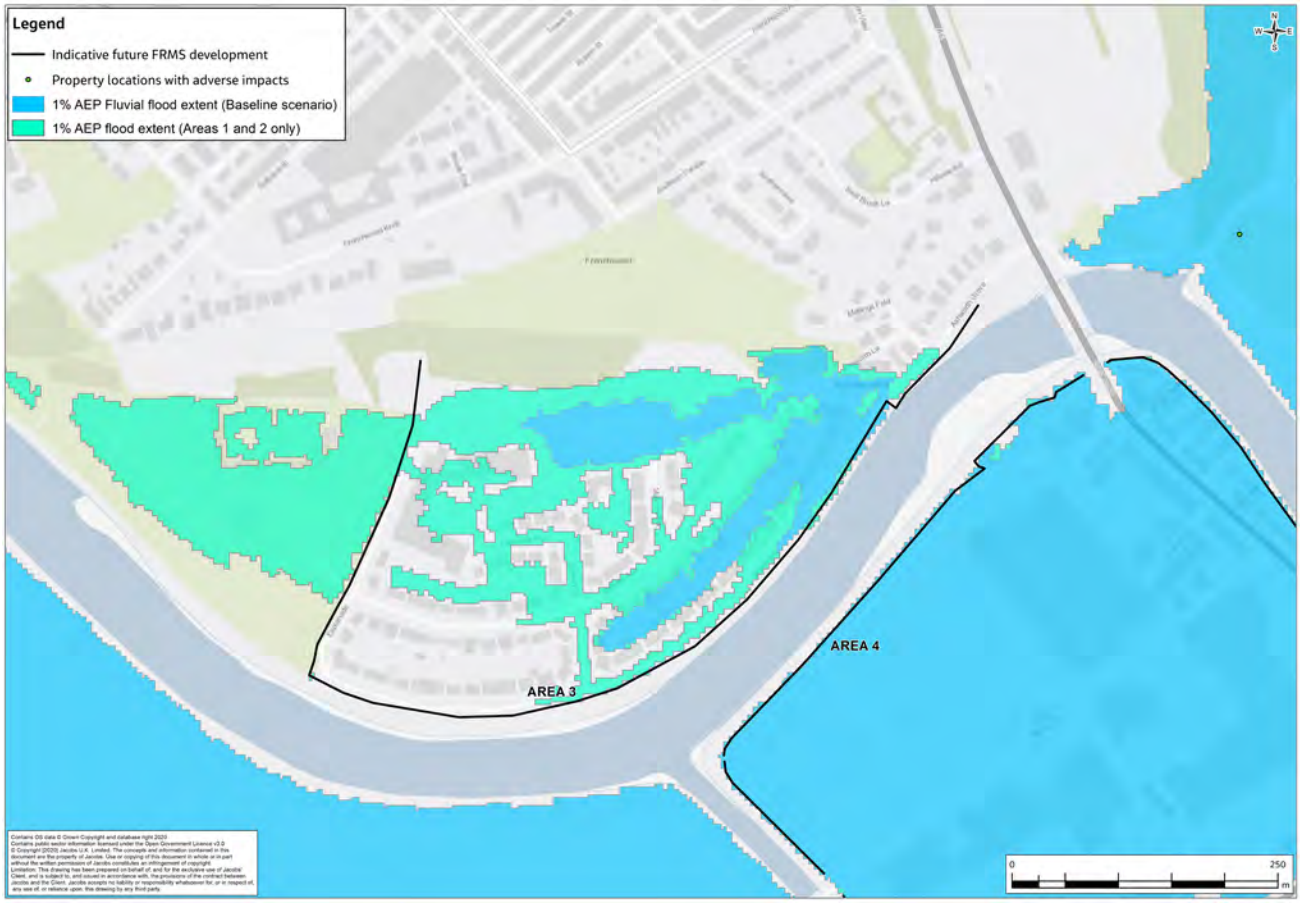


Figure 6.5: 2% AEP flood extents in Area 4 during baseline scenario and with Areas 1 and 2 only

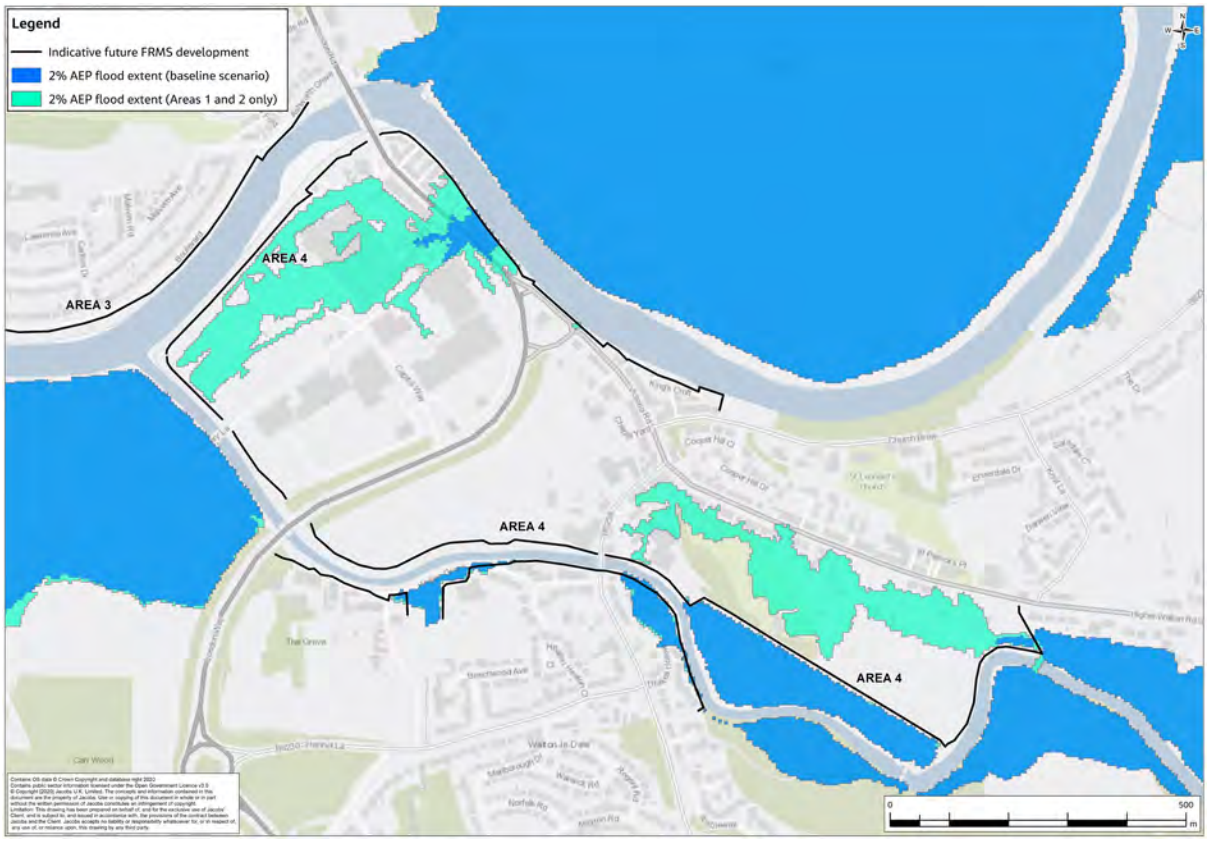
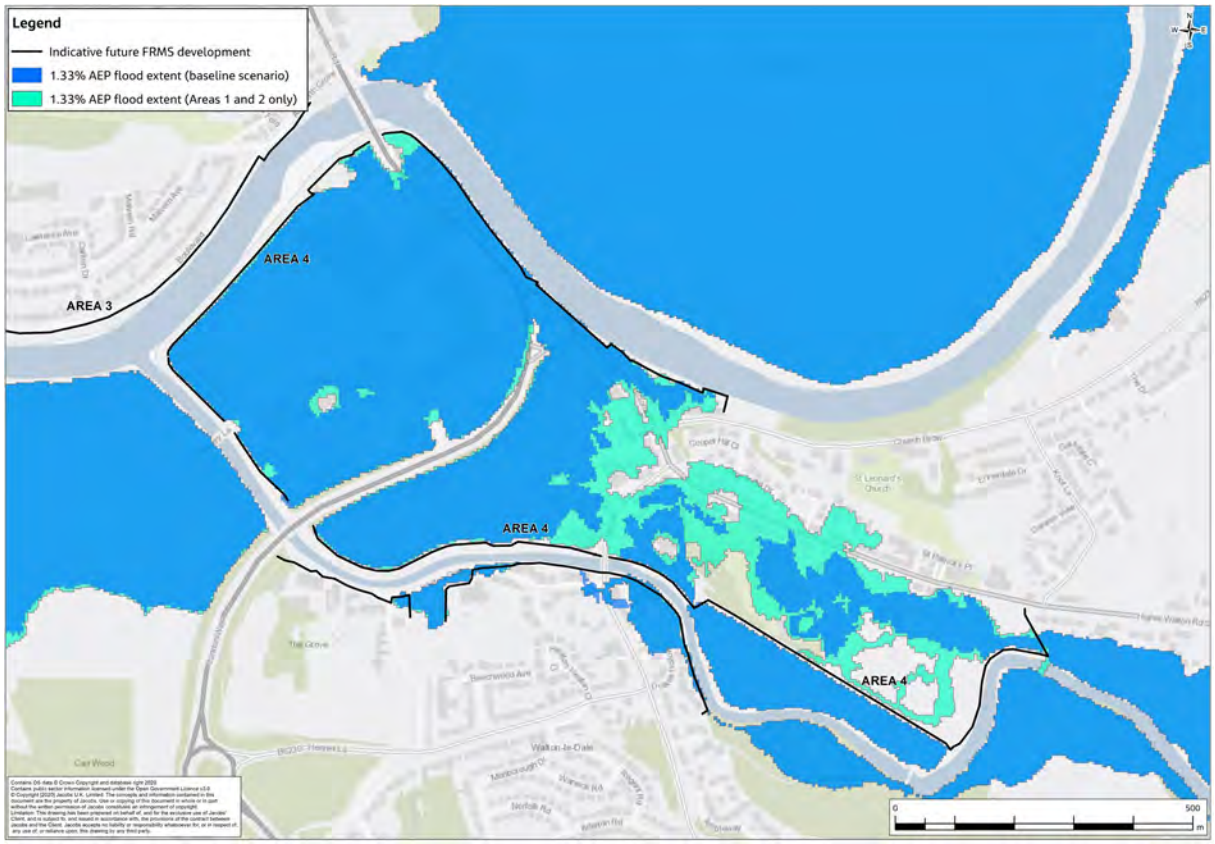


Figure 6.6: 1.33% AEP flood extents in Area 4 during baseline scenario and with Areas 1 and 2 only



6.3.1.8 Summary of adverse impacts from the proposed Scheme

With the potential adverse impacts to Areas 3 and 4 limited to a 19-month period and during events greater than or equal to the 2% AEP, the likelihood of adverse impacts occurring is considered to be low. Existing measures in place to manage the risk of fluvial flooding would also continue, helping to provide community flood resilience. These include:

- Operation of the existing defences;
- Continued community engagement by the EA with at-risk-properties encouraged to sign up to the flood warning service;
- Continued timely flood warning issued across the flood warning areas affected; and
- Planned responses from EA and other Risk Management Authorities teams in advance of a forecast storm event would be undertaken.

The impacts to the Area 6 properties in locations A and B would be long-term and would continue to be experienced throughout the life of the FRMS. The impacts of climate change would further exacerbate the impact over time.

The long-term increase in flood risk to these vulnerable receptors is not consistent with the requirement of NPPF in that new development should not increase flood risk elsewhere. Therefore, additional mitigation is required. This is detailed in Section 6.7.

6.3.2 Impact of the complete FRMS

The impact of the full Preston & South Ribble FRMS on fluvial flooding has been investigated through a1D-2D Flood Modeller-TUFLOW hydraulic model of the River Ribble and Darwen. Analysis of the modelling results confirms that the full FRMS would provide a 0.5% AEP SoP to fluvial flooding within Areas 1 and 2 during the present-day scenario as designed. Under the central climate change scenario, this would however reduce in time to a 1.33% AEP SoP by the 2080s (2070 – 2115). Under the upper end climate change scenario, the SoP would be reduced to 5% AEP.

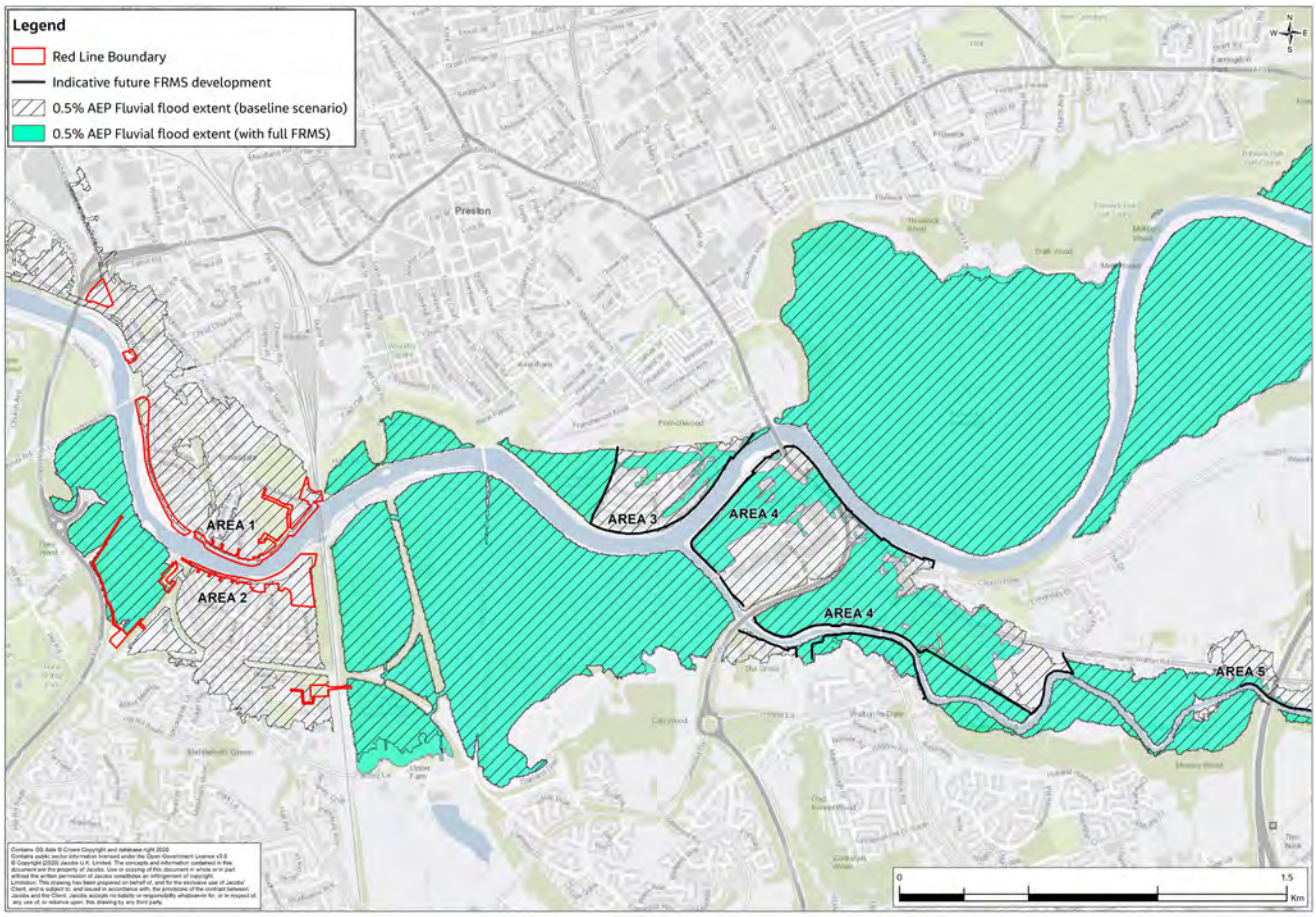
Hydraulic modelling has been based on the outline design for Areas 3, 4 and 5. As such, the results show that the SoP in these areas would be lower (1.33% AEP SoP) than Areas 1 and 2 (0.5% AEP SoP). However, the intention is to develop the design of the defences in these areas to enable them to offer the same SoP as Areas 1 and 2.

A comparison of predicted flood extents during the 0.5% AEP fluvial flood event is presented in Figure 6.7. As can be seen from this figure, urban areas which are currently at risk during the 0.5% AEP flood event (hatched areas with no fill) would benefit from the FRMS with flooding restricted to the areas shown in green.

The construction of the full FRMS would also have the benefit of reducing the residual impact of failure compared to the existing aging flood defences. However, whilst significantly reduced, this residual risk would remain following completion of the Scheme although a programme of inspection and maintenance would ensure that the risk would be low.

Due to a reduction in floodplain storage and the cutting off of floodplain flow routes as a result of the full FRMS, some adverse impacts of the full FRMS would remain. As with the areas of adverse impact associated with Areas 1 and 2, the majority of these adverse impacts would be limited to undeveloped areas comprising agricultural land or playing fields. However, adverse impacts are also predicted to the Area 6 locations identified in Section 6.3. These adverse impacts would be investigated further during the detailed design of the defences in Areas 3, 4 and 5 and additional mitigation would be recommended if appropriate. It is considered likely that this mitigation would be similar to that detailed in Section 6.7.

Figure 6.7: Impacts on fluvial flood extents from the full FRMS



6.3.3 Impacts on tributaries of the River Ribble

6.3.3.1 Fish House Brook (Main River)

Hydraulic modelling indicates that the FRMS would result in an increase in water levels within the River Ribble by 21 mm (6.593 to 6.614 m AOD) during the fluvial1.33% AEP present-day flood event. However, the impact of this increase on the flapped outfall from Fish House Brook is considered to be negligible. With an outfall invert of 3.56 m AOD, the flap valve would already be tide locked during normal high tides so high-water levels within the Ribble Estuary would be prevented from flowing upstream along this watercourse. Flood risk impacts along this watercourse would therefore be negligible.

6.3.3.2 Penwortham Lane (Ordinary Watercourse):

Hydraulic modelling indicates that the FRMS would result in an increase in water levels within the River Ribble at its confluence of Penwortham Lane. As with other locations with negative impacts, the adverse effects of the FRMS would onset during the 2% AEP event. Increases in peak flood depth of 310 mm (from 7.481 to 7.793 m AOD) are predicted during the 1.33% AEP present-day fluvial flood event and by approximately 400 mm during the 1.33% AEP flood event in the 2080s (2070 – 2115) climate scenario.

A previous study (JBA SFRM Ribble tributaries, 2006) reviewed flood risk and sensitivity to downstream boundary conditions for 1% AEP event. This found that a 0.5 m increase in levels at the downstream boundary (the River Ribble) would result in an upstream increase in maximum water levels for 1.1 km. The location of this 1.1 km limit of influence is a track culvert downstream of Vernon Carus Sports and Social Club (Model node

reference: RN0601_1156). Upstream of this location, flood risk is shown to be independent of downstream boundary conditions. The floodplain downstream of the Sports and Social club is already active floodplain with no sensitive receptors and therefore, the change in flood risk to the surrounding area as a result of impacts to this watercourse is considered to be negligible.

6.3.3.3 Swillbrook culvert (Main River)

This culverted watercourse has not been modelled to date and no detailed survey of the culvert has been identified. Whilst the depth and gradient of the culvert is not known, it does flow through an area with a relatively steep gradient with ground levels falling from approximately 40 m AOD down to its outfall into the River Ribble over a distance of approximately 1 km.

The closest properties to the River Ribble located along the course of Swillbrook Culvert are at a level of approximately 20 m AOD and 130 m from the banks of the Ribble. Based on this information, two scenarios are likely. Either the culvert would be set at a shallow depth below ground level and therefore, the pressurised flow along a steep gradient would have a low sensitivity to changes in tailwater depth. Or, if the culvert is very deep, with a shallow gradient, manholes leading to the surface would also be very deep and the likelihood of fluvial flow backing up to ground level would be low. Therefore, the impact of the FRMS on flood risk associated with Swillbrook Culvert is considered to be negligible.

6.3.4 Residual flood risks

Whilst all flood defences have the potential to fail and overtop, the full FRMS would replace an aging system of existing defences. Therefore, the likelihood of failure would reduce as a result of the construction of the FRMS. The raising of the defences would also reduce the likelihood of overtopping.

As detailed earlier in this section, the risk of overtopping would increase due to the effects of climate change and under the upper end climate change scenario this would result in the SoP reducing to 5% AEP by the 2080s (2070 to 2115). However, whilst there would be a reduction in the standard of protection that the proposed Scheme would provide towards the end of its design life, even in the worst case climate change scenario, the standard of protection would be significantly greater than that of the existing defences.

6.4 Impact on Surface Water Flood Risk

The Environment Agency Flood Map for Surface Water (presented on Figure 5.4) indicates that existing surface water flood risk in the vicinity of the proposed Scheme is low.

As the proposed Scheme would replace existing defences, there would be no impact to surface water flow routes. Flow towards the River Ribble would already be impeded by the existing defences and routed into drainage, which leads into the combined sewer network or into the River Ribble via flapped outfalls. The proposed increase in the level of the defences would not change this arrangement.

Whilst the proposed Scheme in Area 2 would involve the improvement of defences along their existing alignment, in Area 1, approximately half of the defence line would extend out towards the River Ribble by approximately 5 m. This would create a new area of impermeable surface behind the defence that would have the potential to generate additional surface water flows. A variety of constraints exist including limited physical space, and buried services which would make the attenuation of runoff extremely challenging. Therefore, this runoff would be managed by the installation of additional drainage gullies that would discharge into the River Ribble via new flapped outfalls. This would also divert areas that currently discharge into the combined sewer network into the watercourse which would represent an improvement over the existing situation. The proposed drainage design is shown on the general arrangement drawings in Appendix A.

6.5 Impact on Groundwater Flood Risk

The proposed Scheme is designed to mitigate flooding from the River Ribble through the use of linear defences (flood walls and embankments) to increase flow capacity within the river channel. This would increase peak water levels within the river channel by confining flows behind flood walls and create a hydraulic gradient between the exposed face and the landward face of the proposed defences.

Quantitative seepage assessments (ENV000009C-JAC-ZZ-41A-CA-GT-0001) have been undertaken which have established that there is potential for groundwater to be forced under the flood defences which would emerge on the landward side, creating an additional flood risk.

The results of this seepage assessment have been used to inform the design of the defences which would include a cut-off extending 2.5 m below the base of the proposed defences across the whole reach. This cut-off design is detailed on the section and detail drawings for each area. This has been assessed to reduce seepage volumes to acceptable levels and satisfy the Eurocode 7 design checks of hydraulic failure.

The cut-off could however, form a barrier to groundwater flow into the River Ribble increasing groundwater levels on the landward side of the defences. However, groundwater levels have been found to be in continuity with the River Ribble in the vicinity of the proposed Scheme. Therefore, significant groundwater flows towards the river would only occur during periods of low water levels within the Ribble and these would be able to pass beneath the cut-off. There is potential for minor increases in groundwater level in some areas. However, these are not expected to be sufficient to result in flooding at ground level and as no properties with basements that might be vulnerable to sub-surface flooding have been identified in close proximity to the proposed Scheme the overall impact is considered to be negligible.

6.6 Impact on Artificial Infrastructure Flood Risk

6.6.1 Sewers

The proposed Scheme would require the following new works to the sewer network as outlined below. Details of these works can be found on Drawings ENV0000009C-JAC-ZZ-42B-DR-C-0013, ENV0000009C-JAC-ZZ-42B-DR-C-0014 and ENV0000009C-JAC-ZZ-42A-DR-C-0011.

- Area 1: Riversway and Broadgate:
  - A diversion of foul water sewer down Broadgate and Riverside including installing two new manholes;
  - Surface water gullies would be removed and replaced along the working area. The discharge location would change with the gullies discharging into the River Ribble rather than the combined sewer network as they currently do.
- Area 2: Penwortham:
  - The raising of ground levels near to the entrance of Penwortham Methodist Church would require the raising of a United Utilities Combined Sewer manhole by approximately 300 mm;
  - A localised diversion of the 225 mm diameter sewer at Riverside Road is also required to avoid conflict with construction works.

The proposed diversion works would be designed like for like to ensure that there would be no adverse impacts on sewer performance. Since the sewer network does not discharge into the River Ribble, no impacts have been identified as a result of the predicted small increases in peak water levels within the channel. Therefore, the impacts on flood risk from sewers is considered to be negligible.

It is noted that no potable water mains would need to be diverted and no impact from flooding associated with failed water mains is predicted.

6.6.2 Reservoirs

The proposed Scheme is remote from any reservoirs and would not increase the probability of failure of any reservoir structures upstream of the proposed Scheme.

In the event of reservoir flooding occurring, the proposed Scheme would offer an increased standard of protection to properties. The increased channel capacity created by the proposed Scheme would have the potential to change flood extents which may have adverse impacts in some areas. These would be similar to the fluvial flood risk impacts discussed in Section 6.3. However, based on the low probability of reservoir flooding occurring, the impact on reservoir flood risk is considered to be negligible.

6.7 Flood Risk Impact Mitigation

As discussed in Section6.3.1, several properties would experience long term adverse impacts to flood risk as a result of the full FRMS. Mitigation would take the form of property level protection and resilience measures. The precise nature of these measures is currently subject to a consultation process with the property owners and tenants. However, it is assumed that a satisfactory range of measures would be agreed at each location and that the residual impact following the implementation of this mitigation would be negligible if not beneficial.

7. Construction Phase

7.1 Introduction

Whilst the design of the proposed Scheme is well progressed enabling a detailed assessment of the completed FRMS, detailed construction plans and method statements are still to be prepared. The assessment of construction phase flood risk is therefore not site specific. It would be the Contractor's responsibility to assess the flood risk to work areas, to assess the flood risk resulting both to and from temporary works, and to provide appropriate mitigation measures where necessary in accordance with the requirements of the Environmental Permits for the works.

This section of the FRA therefore, provides an overview of potential flood risks for the Contractor to consider during the construction phase, to set out high-level requirements with respect to managing flood risk, and to provide general guidance to assist the Contractor.

7.2 Flood Risk to Temporary Works

The temporary works associated with the construction of the proposed Scheme would be located within areas with a high probability of fluvial and tidal flooding. Details of predicted flood depths are presented in Section 5. The contractor should also be aware that it is possible for multiple significant flood events to occur during a single year. Due to the significant risk of flooding, mitigation would be required to minimise the risks to workers and to the construction programme. This should be detailed within the Environmental Permit application.

7.3 Temporary Flood Risk Impacts

As well as temporary construction works being a potential receptor of flood risk. The works themselves could have wider impacts on flood risk albeit temporary and limited to the duration of the works. The impacts would include works to existing defences which would reduce their effectiveness. This would include the dismantling of existing defences to enable the construction of the proposed structures.

Any works that would reduce the effectiveness of the existing defences would require the installation of temporary defences. This would ensure that the standard of protection to properties that benefit from the existing defences would not reduce as a result of the construction works themselves. Full details of the temporary works would be provided within the Environmental Permit Application.

The type and location of such temporary defences would be confirmed through the Flood Risk Activities Environmental Permitting (FRAP) process and would be appropriate to the nature and scale of flooding. Temporary defences could include, but would not be limited to the following:

- Tubes (air-filled or water-filled)
- Filled containers
- Free-standing barriers (flexible or rigid)

Temporary defences would be designed in accordance with the EA's Temporary and Demountable Flood Protection Guide[20]. The crest level of any temporary defences would be at least as high as the existing defences they would temporarily replace.

Finally, a quality assurance system would be in place to ensure that the temporary defences are deployed effectively, and ongoing monitoring and maintenance will be undertaken to ensure they remain effective and provide the standard of protection required. This is likely to include a programme of inspections at specified intervals and following Flood Alerts. Security and monitoring procedures would also be put in place to reduce

[20] EA (2002) *Temporary and Demountable Flood Protection Guide.* Flood and Coastal Erosion Risk Management Research and Development Programme Project: SC080019

the likelihood of accidental damage and vandalism; and to enable any damage sustained to be identified and repaired.

Other potential impacts would be associated with the storage of materials within the floodplain, changes to surface water runoff rates and patterns due to earthworks and the potential for damage to buried services. Standard good site management practices would be outlined within the Environmental Permit application to mitigate any adverse impacts from the construction works.

In summary, the impact of the construction works themselves on flood risk would be negligible.

7.3.1 Flood response plans

A flood response plan should be incorporated into the wider Construction Code of Practice. This should include:

- Signing up to the relevant EA flood warning areas. The areas understood to be relevant are:
  - Ribble estuary at Broadgate, between Connaught Rd and Fishergate Hill
  - Ribble estuary at Broadgate, around Riverside, The Continental pub and Preston Sports Club
  - Ribble estuary at Lower Penwortham, between A582 and the railway line; and
  - Ribble estuary at Lower Penwortham, around Leyland Road close to the River Ribble.
- Ensuring all activities that require environmental permits are permitted appropriately;
- Water levels within the Ribble Estuary and any excavations should be monitored to enable appropriate actions to be taken if sudden rises in levels are noted;
- Prepare emergency evacuation plans for each construction area given issue of a Flood Warning or following rapid rises in river level or continuous heavy rainfall, identifying safe access and egress routes and refuge points;
- Provide standby pumping equipment to remove any surface water runoff that enters the working area;
- Ensure site drainage is not discharged to a local sewer; and
- Contact the EA during a flooding event greater in magnitude than the temporary works are designed to, particularly where receptors could be at increased risk of flooding.

7.3.2 Residual risks

Given that the Contractor follows and correctly implements the principles outline in this section of the report, the main residual flood risks during the construction phase of the proposed scheme are considered to be:

- Fluvial or surface water events, which exceed the design standard of the temporary works or general site work;
- Groundwater emergence within the culvert construction area due to shallow water levels and/or associated with fluvial or pluvial flooding;
- Blockages within temporary surface water drainage; and
- Failure (including blockage) of temporary works within watercourses.

In the event of flood events of greater magnitude than the design standard, or blockages causing temporary drainage systems to surcharge, flooding within construction areas could occur. The main risk is likely to be to the site operatives in this event. However, assuming that conditions on site, weather forecasts, flood warnings and river levels are monitored appropriately, and site evacuation plans are in place, the residual risk is considered low.

In the majority of cases, failure of temporary works within or adjacent to watercourses is unlikely to result in a significant detrimental impact to the flood risk on the watercourse affected, as flows are unlikely to be impacted.

Again, the main risk is likely to be to site operatives in this event. However, assuming that the Contractor has emergency plans in place for how to deal with failure of works where operatives are at significant risk, then the residual risk is considered low.

8. Summary and Conclusion

8.1 Summary

The proposed Preston & South Ribble FRMS has been designed to provide a present-day 0.5% AEP SoP to approximately 4,778 properties along the Rivers Ribble and Darwen, to the south of Preston. The FRMS is mainly a combination of improvements to existing concrete walls and earth embankments with some new defence elements added. This FRA focuses on phase one of FRMS encompassing Area 1 (Riversway and Broadgate) and Area 2 (Lower Penwortham), but reference has been made to the full FRMS where appropriate.

Unlike other forms of development, it must be located in an area of high flood risk, and by its very nature, is designed to reduce the overall level of flood risk. The proposed Scheme is classified as "water-compatible" and therefore, is considered appropriate development within Flood Zone 3 and 3b in accordance with the NPPF. Although the proposed Scheme is within predicted flood extents for fluvial, surface water and reservoir flooding, the Scheme is designed to withstand floodwater and be safe during times of flood. Therefore, the flood risk to the Scheme is considered to be low.

Operational and maintenance works would however be required within an area of high risk and Maintenance Management Plans and Health and Safety files will need to be developed along with method statements for specific tasks. Management of these activities would ensure that the risk to staff and members of the public would be low.

Whilst the hydraulic modelling confirms the SoP provided as designed, the results do show that the proposed Scheme does have an adverse impact on a number of locations. Most of these impacts are short-term in duration, limited the 19-month period before Areas 3, 4 and 5 are complete, and only realised during high magnitude fluvial events. Following the completion of the full FRMS, adverse impacts would remain to a small number of properties. These would be long-term in nature for the full design life of the scheme. The impacts to these properties would be mitigated through property level protection and resilience measures.

The impacts to different sources of flooding across the different areas of risk are summarised in Table 8.1.

Table 8.1: Summary of flood risk impacts

Area	Tidal	Fluvial	Surface Water	Groundwater	Artificial Flood Sources
Area 1: Broadgate	No Change	Betterment	No Change	No Change	No Change
Area 2: Lower Penwortham	Betterment	Betterment	No Change	No Change	No Change
Area 3: Frenchwood	No Change	Short-term increased risk	No Change	No Change	No Change
Area 4: Walton- le-dale	No Change	Short-term increased risk	No Change	No Change	No Change
Area 5: Higher Walton	No Change	No Change	No Change	No Change	No Change
Area 6: Other areas	No Change	Increased risk would require mitigation	No Change	No Change	No Change

8.2 Conclusion

In conclusion, although the scheme would have some long-term adverse impacts, it is assumed that these would be mitigated effectively through the use of property level protection and resilience measures. The adverse impacts would be significantly outweighed by the benefits the proposed Scheme would bring to large areas of Preston and South Ribble. Therefore, the proposed Scheme is considered to be in accordance with local and national planning policy.

Appendix A. Figures

Drawing ENV0000009C-JAC-ZZ-41A-DR-C-0001 - Area 1A General Arrangement Plan 1 of 3

Drawing ENV0000009C-JAC-ZZ-41A-DR-C-0002 - Area 1A General Arrangement Plan 2 of 3

Drawing ENV0000009C-JAC-ZZ-41A-DR-C-0003 - Area 1A General Arrangement Plan 3 of 3

Drawing ENV0000009C-JAC-ZZ-41B-DR-C-0001 - Area 1B General Arrangement Plan 1 of 3

Drawing ENV0000009C-JAC-ZZ-41B-DR-C-0002 - Area 1B General Arrangement Plan 2 of 3

Drawing ENV0000009C-JAC-ZZ-41B-DR-C-0003 - Area 1B General Arrangement Plan 3 of 3

Drawing ENV0000009C-JAC-ZZ-41C-DR-C-0001 - Area 1C General Arrangement Plan 1 of 1

Drawing ENV0000009C-JAC-ZZ-41D-DR-C-0001 - Area 1D General Arrangement Plan 1 of 1

Drawing ENV0000009C-JAC-ZZ-42A-DR-C-0001 - Area 2A General Arrangement Plan 1 of 2

Drawing ENV0000009C-JAC-ZZ-42A-DR-C-0002 - Area 2A General Arrangement Plan 2 of 2

Drawing ENV0000009C-JAC-ZZ-42B -DR-C-0001 - Area 2B General Arrangement Plan 1 of 3

Drawing ENV0000009C-JAC-ZZ-42B -DR-C-0002 - Area 2B General Arrangement Plan 2 of 3

Drawing ENV0000009C-JAC-ZZ-42B -DR-C-0003 - Area 2B General Arrangement Plan 3 of 3

Drawing ENV0000009C-JAC-ZZ-42C-DR-C-0001 - Area 2C General Arrangement Plan 1 of 1

Drawing ENV0000009C-JAC-ZZ-42A-DR-C-0011 – Service Diversions

Drawing ENV0000009C-JAC-ZZ-42B-DR-C-0013 – Service Diversions

Drawing ENV0000009C-JAC-ZZ-42B-DR-C-0014 – Service Diversions

Appendix B. Hydraulic Modelling Report