In Parliament – Session 2021 - 2022

HS2

High Speed Rail (Crewe – Manchester) Environmental Statement

Volume 5: Appendix WR-005-0MA04

Water resources and flood risk

MA04: Broomedge to Glazebrook

Flood risk assessment

M327

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Department for Transport

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1 Introduction

1.1.1 This report is an appendix to the water resources and flood risk assessment. It presents the flood risk assessment for the Proposed Scheme in relation to the Broomedge to Glazebrook area (MA04).

1.1.2 This appendix should be read in conjunction with:

- Volume 2, Community Area reports;
- Volume 3, Route-wide effects;
- Volume 4, Off-route effects; and
- Volume 5, Appendices.

1.1.3 The water resources and flood risk assessments include both route-wide and community area specific appendices. The route-wide appendices comprise:

- a Water Framework Directive (WFD) compliance assessment (Volume 5: Appendix WR-001-00000); and
- a Draft water resources operation and maintenance plan (Volume 5: Appendix WR-007-00000).

1.1.4 For the Broomedge to Glazebrook area, the relevant Hydraulic modelling report (Volume 5: Appendix WR-006-00002) and the Water resources assessment (Volume 5: Appendix WR-003-0MA04) should also be referred to.

1.1.5 Additional information relevant to this assessment is set out in Background Information and Data (BID):

- Water resources assessment baseline data (BID WR-004-0MA04)[1]; and
- Water Framework Directive compliance assessment baseline data which are reported for the Proposed Scheme (BID WR-002-00001)[2].

1.1.6 Maps referred to throughout this assessment are contained in the Volume 2, MA04 Map Book: Map Series CT-05 and CT-06.

1.1.7 Issues associated with the Sequential Test and Exception Test in the National Planning Policy Framework (NPPF) are discussed on a route-wide basis in Volume 3.

[1] High Speed Two Ltd (2022), High Speed Rail (Crewe – Manchester), *Background Information and Data, Water resources assessment baseline data,* BID WR-004-0MA04. Available online at: http://www.gov.uk/government/collections/hs2–phase–2b–crewe–manchester–environmental–statement.

[2] High Speed Two Ltd (2022), High Speed Rail (Crewe – Manchester), *Background Information and Data, Water Framework Directive compliance assessment baseline data,* BID WR-002-00001. Available online at: http://www.gov.uk/government/collections/hs2–phase–2b–crewe–manchester–environmental–statement.

1.2 Scope, assumptions and limitations

1.2.1 The purpose of this flood risk assessment is to consider the flood risk implications of the permanent works associated with the Proposed Scheme within the Broomedge to Glazebrook area.

1.2.2 Temporary works have not been assessed unless they are of a significant scale compared to the permanent works proposed and have the potential to adversely affect flood risk.

1.2.3 The risk of flooding to site compounds will be managed through the draft Code of Construction Practice (CoCP) (see Volume 5: Appendix CT-002-00000). A sequential approach will be applied to the allocation of use within the compounds, seeking primarily to avoid using areas at flood risk wherever practical, but where this is unavoidable using areas at risk of flooding for the least vulnerable components and those that will avoid/limit the potential for off-site impacts.

1.2.4 All sources of flood risk are considered, other than tidal flooding.

1.2.5 The flood risk assessment considers the impact of the Proposed Scheme during the 1 in 100 year event plus an allowance for climate change as set out in the Environmental Impact Assessment Scope and Methodology Report (SMR) (see Volume 5: Appendix CT-001-00001).

1.2.6 Receptors considered in this assessment include the Proposed Scheme itself, other existing infrastructure assets, residential, commercial and agricultural buildings and property potentially affected by the Proposed Scheme.

1.2.7 The assessment has involved an initial scoping study using existing available information, including data provided by statutory consultees and stakeholders. Visual surveys have been undertaken of accessible water features to verify the dimensions of key hydraulic structures. Not all structures have been visually surveyed due to access constraints. Hydraulic modelling techniques, or other suitable quantitative methods, have been adopted in locations where the potential for adverse impacts on flood risk were identified in the scoping study. Details of the modelling decision tree process are provided in the SMR Technical Note: Flood risk. Hydraulic modelling has made best use of existing models provided by the Environment Agency. No new channel or floodplain survey data has been obtained.

1.2.8 The hydraulic analysis work is based on conservative assumptions about the potential hydraulic impacts of the structures proposed. All hydraulic calculations will require refinement during design development using additional topographical survey data. The models will then require further development to reflect the design development of hydraulic structures and flood risk mitigation measures.

1.2.9 The Volume 2, Community Area report for the Broomedge to Glazebrook area describes the avoidance strategy and mitigation measures included in the design to limit the temporary and permanent effects of the Proposed Scheme as far as is reasonably practicable. This flood risk assessment therefore assesses the impacts and effects arising following the

implementation of the avoidance and mitigation measures, and reports on whether any additional mitigation may be needed where the Proposed Scheme may result in significant effects.

1.3 Location and extent

1.3.1 The location and extent of the MA04 study area is shown in Figure 1.

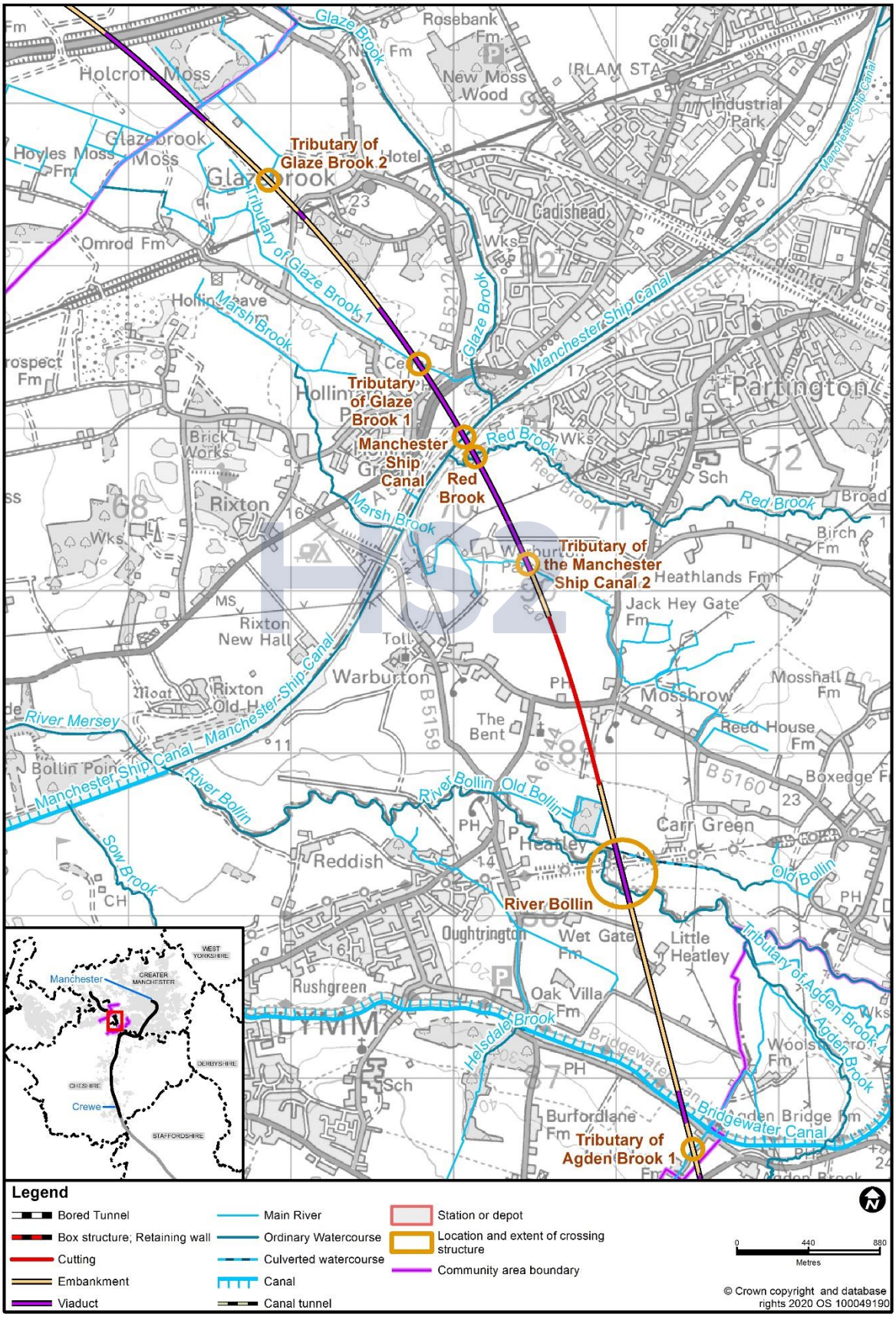
1.3.2 The study area extends 1km from the Proposed Scheme. All flood risk receptors have been identified within these limits. If modelling assessments identified potential impacts beyond these limits, the study area has been extended accordingly.

1.3.3 The extent of the land required during construction of the Proposed Scheme, Environment Agency Flood Zones 2 and 3[3], as well as the areas at risk from surface water flooding are shown on Volume 5, Water resources and flood risk Map Book, Map Series WR-01. The flood zone information is based on the Environment Agency's Flood map for planning (rivers and sea) and the risk of flooding from surface water maps (RoFSW)[4].

[3] Flood Zone 2 comprises land assessed as having between a 1 in 100 (1.0%) and 1 in 1,000 (0.1%) annual probability of river flooding; Flood Zone 3 comprises land assessed as having a 1 in 100 (1.0%) or greater annual probability of river flooding.

[4] Environment Agency (2021), *Long term flood risk information.* Available online at: https://flood-warning-information.service.gov.uk/long-term-flood-risk/.

Figure 1: Location and extent of the study area



2 Policy context and consultation

2.1 National

2.1.1 The Proposed Scheme design has been developed in general accordance with the requirements of the NPPF[5]. This aims to prevent inappropriate development in areas at risk of flooding and to ensure that, where development is necessary in areas at risk of flooding, it is safe, will not increase flood risk elsewhere and, where possible, reduces flood risk overall. The Sequential Test and Exception Test in the NPPF aim to achieve these policy objectives.

2.1.2 The Flood and Water Management Act 2010[6] requires the Environment Agency to 'develop, maintain, apply and monitor a strategy for flood and coastal erosion risk management in England'. The Environment Agency therefore has oversight of all matters related to flood risk and is a statutory consultee for flood risks associated with main rivers and reservoirs. The Environment Agency has been consulted throughout the process of undertaking this assessment and has provided extensive data and guidance on the interpretation of policy.

2.2 Regional and local

2.2.1 Under the Flood and Water Management Act 2010, the statutory consultee for all matters related to local flood risk, including works affecting ordinary watercourses, is the Lead Local Flood Authority (LLFA). Warrington Borough Council (WBC) and Trafford Metropolitan Borough Council (TMBC) are the LLFA in the Broomedge to Glazebrook area. Discussions have been held with WBC, TMBC and the Environment Agency technical specialists to agree the principles related to the hydraulic design of the Proposed Scheme and the approach adopted for the assessment of flood risk on main rivers and ordinary watercourses. The modelling is presented in the Hydraulic modelling report – Manchester Ship Canal (see Volume 5: Appendix WR-006-00002).

[5] Department for Communities and Local Government (2019), *National Planning Policy Framework.* Available online at: https://www.gov.uk/government/publications/national-planning-policy-framework--2.

[6] Environment Agency (2010), *Flood and Water Management Act 2010, Section 19*. London. Her Majesty's Stationary Office. Available online at: http://www.legislation.gov.uk/ukpga/2010/29/contents.

2.2.2 The WBC Preliminary Flood Risk Assessment (PFRA)[7] was published in 2017, the WBC Local Flood Risk Management Strategy (LFRMS)[8] was published in 2017, and the Trafford LFRMS[9] was published in 2014. The LFRMS contain a number of policies related to sustainable development, access to, and maintenance of, ordinary watercourses and the need to consider environmental opportunities that reinforce the objectives of the River Basin Management Plan (RBMP)[10]. The Proposed Scheme design has sought to align with these objectives where reasonably practicable.

2.2.3 The Local Planning Authorities (LPA) WBC[11], Manchester City, Salford City and TMBC[12] have produced a Strategic Flood Risk Assessment (SFRA) that covers the Broomedge to Glazebrook area. The key flood risk objectives outlined in the SFRA are to reduce surface water runoff, support Water Framework Directive delivery and prevent new development within sensitive development locations. The Proposed Scheme design has sought to align with these objectives, where reasonably practicable.

2.2.4 The Canal & River Trust (CRT) has been consulted to provide input on the design of the crossing of the Bridgewater Canal. The CRT has also provided information on dimensions for existing culverts.

[7] Warrington Borough Council (2017), *Warrington Preliminary Flood Risk Assessment.* Available online at: https://www.warrington.gov.uk/sites/default/files/2019-10/preliminary_flood_risk_assessment_pfra_2017_-_2023.pdf.

[8] Warrington Borough Council (2017), *Warrington Local Flood Risk Management Strategy*. Available online at: https://www.warrington.gov.uk/sites/default/files/2019-10/local_flood_risk_management_strategy_2017_v7_af_approved.pdf.

[9] Trafford Council (2014), *Trafford Local Flood Risk Management Strategy.* Available online at: https://www.trafford.gov.uk/planning/strategic-planning/docs/lfrms-trafford-final-2014.pdf.

[10] Environment Agency (2015), *North West River Basin Management Plan.* Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/718335/North_West_RBD_Part_1_river_basin_management_plan.pdf.

[11] JBA Consulting (2011), *Warrington Strategic Flood Risk Assessment.* Available online at: https://www.warrington.gov.uk/sites/default/files/2019-08/warrington_strategic_flood_risk_assessment_ii_vol_1_2011.pdf.

[12] JBA Consulting (2011), *Manchester City, Salford City and Trafford Council Hybrid Strategic Flood Risk Assessment.* Available online at: https://secure.manchester.gov.uk/downloads/download/3871/strategic_flood_risk_assessment-manchester_salford_trafford.

3 Flood risk baseline

3.1 Historical flooding incidents

3.1.1 The PFRA and SFRA published by WBC and TMBC report incidents of historical flooding, but no incidents of flooding from watercourses or surface water sources are reported within 1km of the Proposed Scheme.

3.1.2 A review of the Section 19[13] historical flood reports in the Broomedge and Glazebrook area showed no recorded historical flooding within 1km of the Proposed Scheme. However, Section 19 reports have been produced for flood events within 10km of the Proposed Scheme. These reports have been reviewed but have not been included in detail due to the distance from the Proposed Scheme. These are:

- Thelwall and Lymm (December 2015)[14];
- Massey Brook Lane, Lymm (December 2015)[15]; and
- borough wide rainfall event, Oughtrington Lane, Lymm (September 2018)[16].

3.2 Risks associated with main rivers

3.2.1 The key flood risk is that associated with the following main rivers:

- River Bollin, east of Oughtrington;
- Manchester Ship Canal[17] between Hollinfare and Partington;
- Glaze Brook, at Cadishead;
- Tributary of the Manchester Ship Canal 2 (also known as Warburton Park Brook) at Warburton Park; and
- Red Brook (also known as Sinderland Brook), south of Partington.

[13] Section 19 of the Flood and Water Management Act 2010 sets out the requirement for that on becoming aware of a flood in its area, a LLFA must investigate and report on which risk management authorities have relevant flood risk management functions and whether each authority has exercised those functions in response to the flood.

[14] Warrington Borough Council (2016), *S19 flood investigation report – Thelwall/Lymm.* Available online at: https://www.warrington.gov.uk/sites/default/files/2019-10/thelwall_and_lymm_flood_final_01_v6_1.pdf.

[15] Warrington Borough Council (2016), *S19 flood investigation report – Massey Brook Lane, Lymm.* Available online at: https://www.warrington.gov.uk/sites/default/files/2019-10/s19_report_-_massey_brook_lane.pdf.

[16] Warrington Borough Council (2018), *S19 flood investigation report –Borough wide rainfall event.* Available online at: https://www.warrington.gov.uk/sites/default/files/2019-10/s19_report_-_borough_wide_sep_18.pdf.

[17] The Manchester Ship Canal is a canalised section of the River Mersey in the study area. It is referred to as the Manchester Ship Canal throughout this report. This watercourse is not officially designated as a main river due to the canalised nature of the watercourse but is a significant watercourse and will be considered as a main river in this assessment.

3.2.2 The areas at risk of flooding from these watercourses, the receptors potentially affected, and the climate change allowances used in the design and assessment of impacts and effects are considered below. Receptors have been identified based on OS mapping and committed development information[18].

River Bollin, Tributary of the Manchester Ship Canal 2, and Red Brook

3.2.3 These main watercourses have mapped flood zones indicated by the Environment Agency Flood map for planning (rivers and sea)[4] dataset. This dataset was used to assess the receptors at potential risk from flooding. As these watercourses have viaduct crossings that do not affect the floodplains other than at the viaduct piers, it was determined through the decision tree process that modelling was not required at these locations at this stage. Details of the modelling decision tree process are provided in the SMR: Technical Note: Flood risk.

3.2.4 The receptors upstream and downstream of the Proposed Scheme that are at potential risk from these watercourses are listed below. The relative vulnerability to flooding of each receptor (as defined in NPPF and Table 55 of the SMR) is also indicated. Undeveloped agricultural land (less vulnerable[19]) is the most common receptor for these watercourses:

- River Bollin (Figure 2):
  - footpaths: including Bollin Valley Way and footpath Lymm 37 (less vulnerable);
  - agricultural land (less vulnerable[19]); and
  - cycle track: Trans Pennine Trail - National Cycle Route 62 (less vulnerable).
- Tributary of Manchester Ship Canal 2:
  - residential properties on Park Road (more vulnerable); and
  - agricultural land (less vulnerable) (Figure 3);
- Red Brook:
  - footpath: Bollin Valley Way (less vulnerable) (Figure 3).

3.2.5 In line with the SMR, a climate change allowance has been adopted to assess the future flood risk to receptors associated with each watercourse crossing using the Environment Agency guidelines. The guidance recommends that a peak river flow allowance is used. The percentage uplift in peak river flow, used to assess flood risk to receptors, reflects the location of the receptor in the floodplain (flood zone) and its flood risk vulnerability

[18] Further details of these planning applications and allocations can be found in Planning data, Volume 5: Appendix CT-004-00000.

[19] Agricultural land is assessed to be a less vulnerable receptor irrespective of the agricultural land quality classification. The assessment of agriculture land quality is set out in the Volume 2, Community Area report: Broomedge to Glazebrook (MA04), Section 4: Agriculture, forestry and soils.

classification. The upper end allowance of 70% increase in peak river flow has been adopted on a precautionary basis for this assessment.

Manchester Ship Canal

3.2.6 A 2D Infoworks ICM hydraulic model of the Manchester Ship Canal has been developed to define the peak flood levels and extents associated with a range of annual probabilities. Further detail is provided in the Hydraulic modelling report – Manchester Ship Canal. The inundation extents for the 1 in 100 (1.0%) annual exceedance probability (AEP) plus 70% climate change (CC) allowance flood are shown in Figure 4. The 2D hydraulic model upstream boundary is located at Irlam, approximately 3.8km upstream from the Proposed Scheme crossing and extends downstream to Biffa Rixton before the confluence with the River Bollin.

3.2.7 The receptors that are at potential risk from this watercourse are listed below. The relative vulnerability to flooding of each receptor (as defined in NPPF and Table 55 of the SMR) is also indicated:

- telecommunications mast (essential infrastructure);
- wastewater treatment works (less vulnerable);
- water works pumping station (water compatible);
- towpath (less vulnerable);
- A57 (essential infrastructure);
- Mytholme Avenue (less vulnerable);
- residential properties along Mytholme Avenue (more vulnerable);
- Liverpool Road (less vulnerable);
- Rosebank Road (less vulnerable);
- residential properties along Rosebank Road (more vulnerable);
- residential properties along Haig Avenue (more vulnerable);
- residential properties along Victory Road (more vulnerable);
- residential properties along Essex Gardens (more vulnerable);
- industrial property on Cadishead Way, Irlam (more vulnerable);
- potential future residential developments (planning applications MA04/126 and MA04/105[18]) (more vulnerable); and
- potential future allocation for recreational land and facilities (planning allocation MA04\026[18]) (water compatible).

3.2.8 In line with the SMR, a climate change allowance has been adopted to assess the future flood risk to receptors associated with each watercourse crossing using the Environment Agency guidelines. The guidance recommends that a peak river flow allowance is used. The percentage uplift in peak river flow used to assess flood risk to receptors reflects the

location of the receptor in the floodplain (flood zone) and its flood risk vulnerability classification. The upper end allowance of 70% increase in peak river flow has been adopted on a precautionary basis for this assessment.

Figure 2: Extent of the Environment Agency's Flood Zones 2 and 3, River Bollin

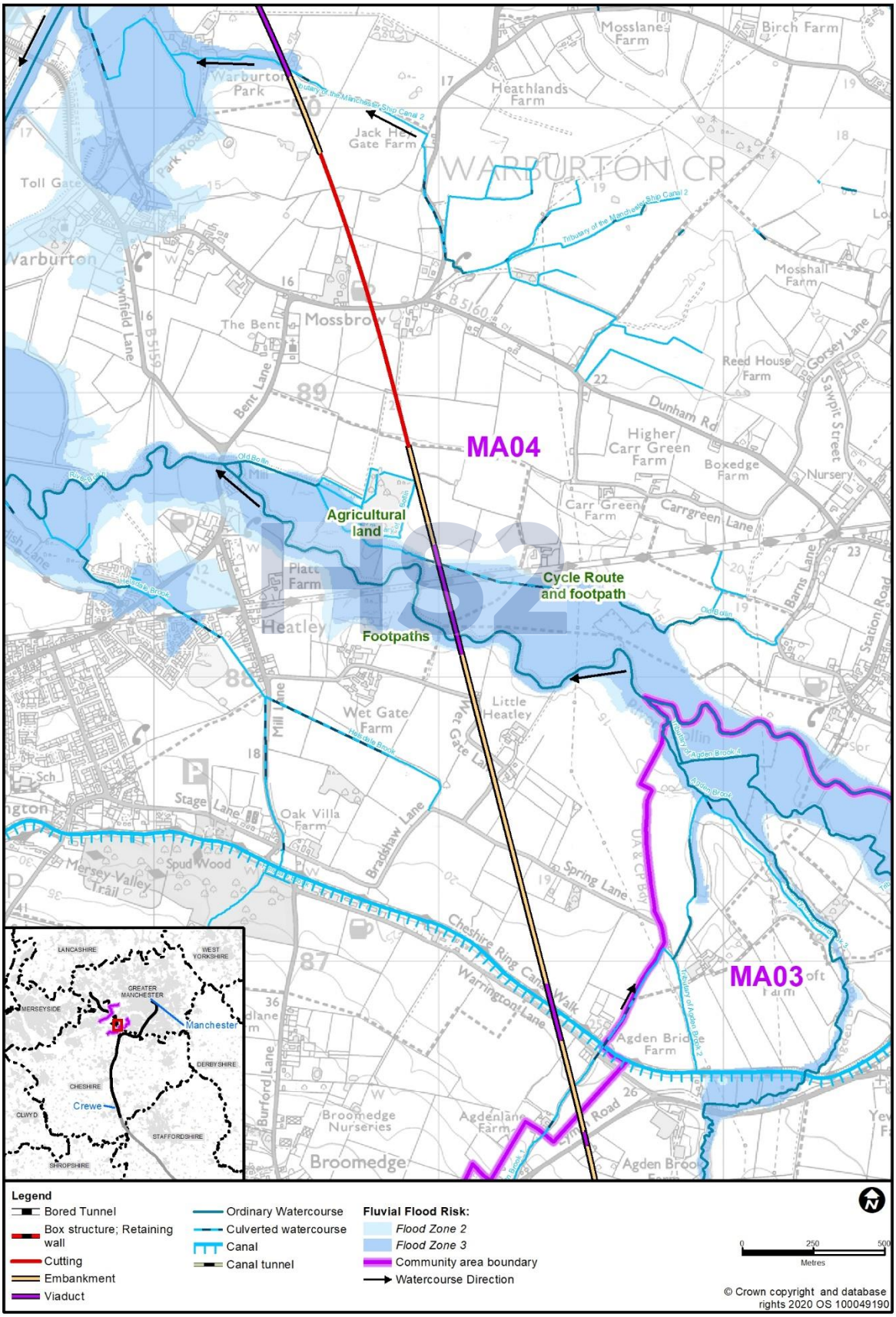


Figure 3: Extent of the Environment Agency's Flood Zones 2 and 3, Tributary of the Manchester Ship Canal 2 and Red Brook

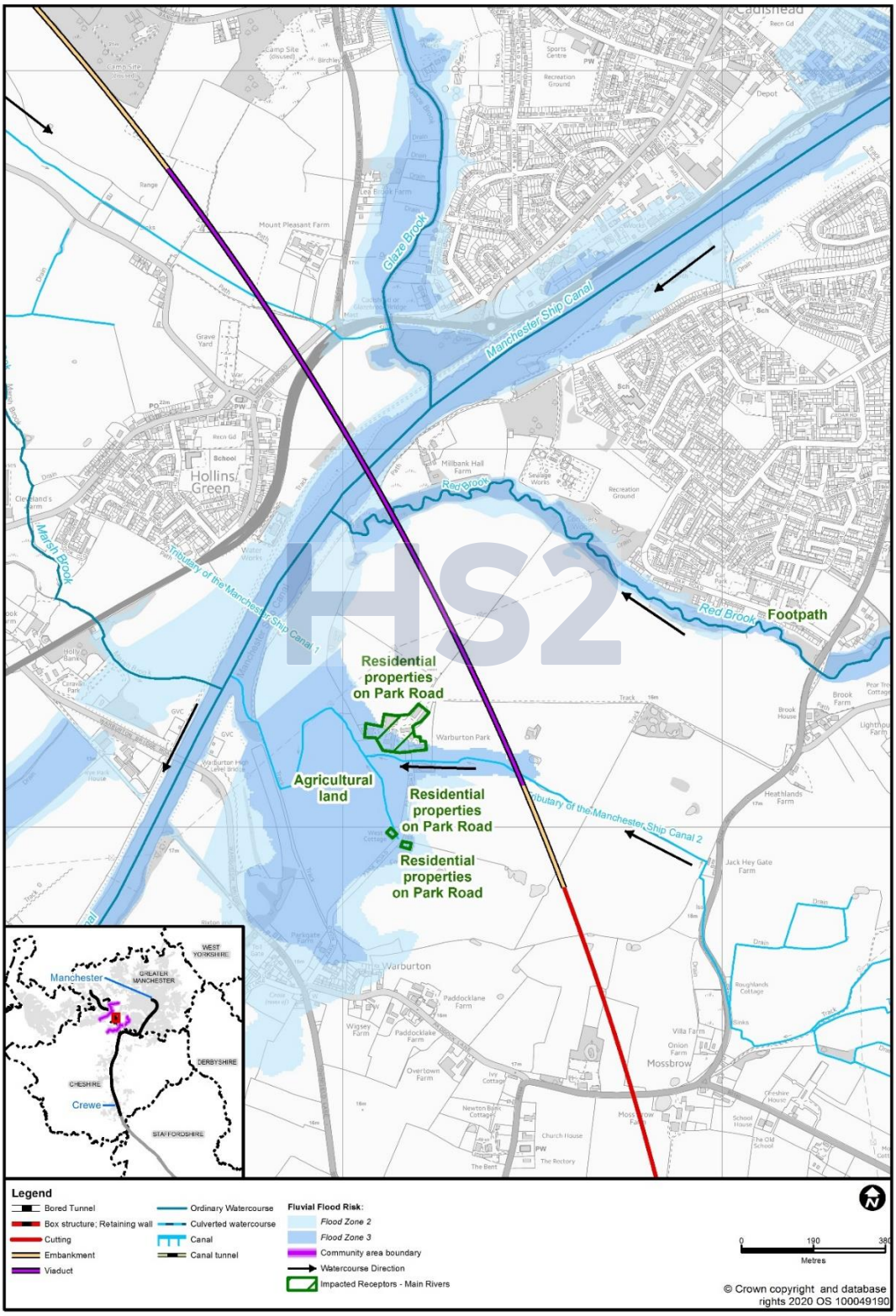
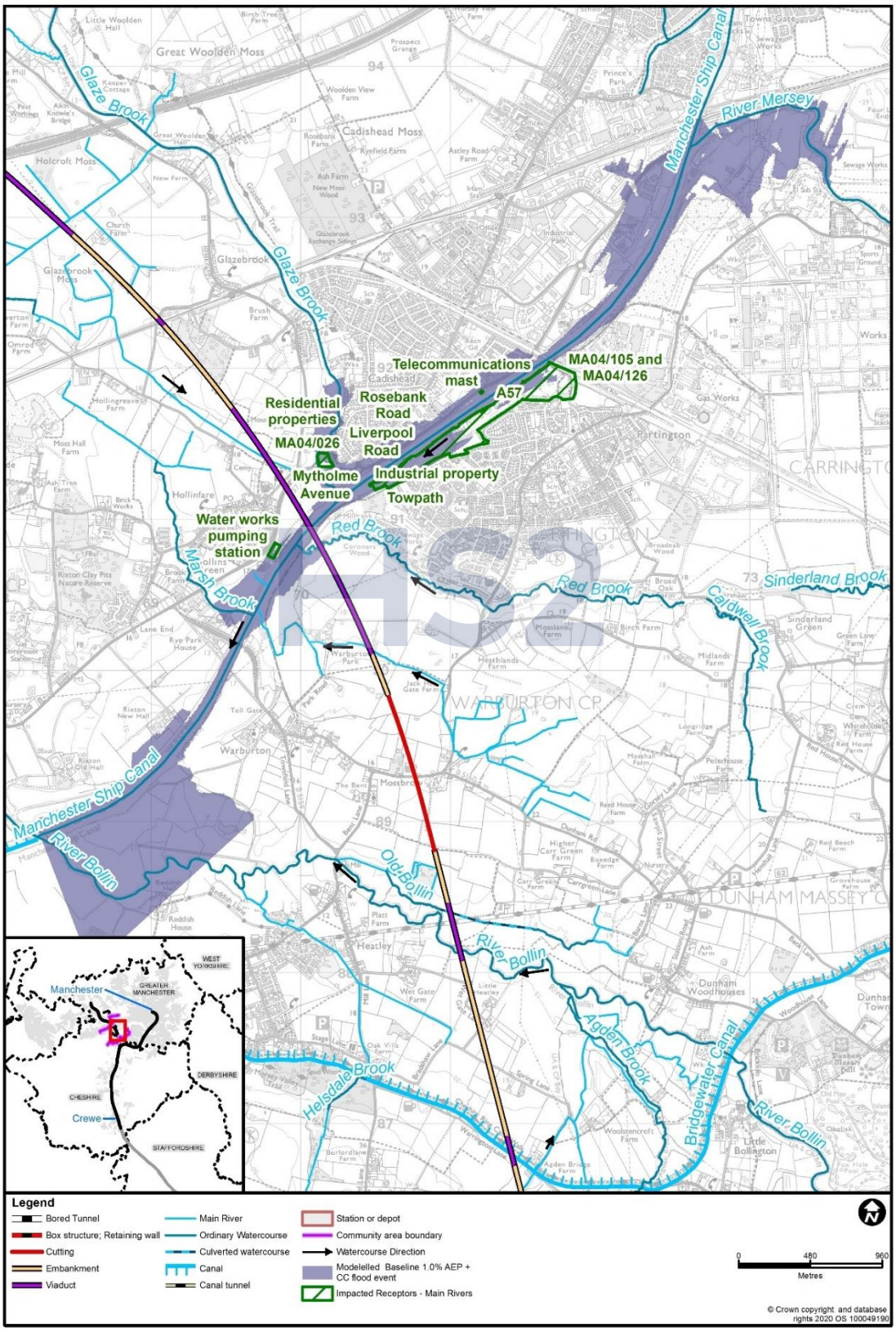


Figure 4: Baseline extent of the modelled 1% AEP + CC flood extent, Manchester Ship Canal



Other watercourses

3.2.9 Other watercourses located within the Broomedge to Glazebrook area include:

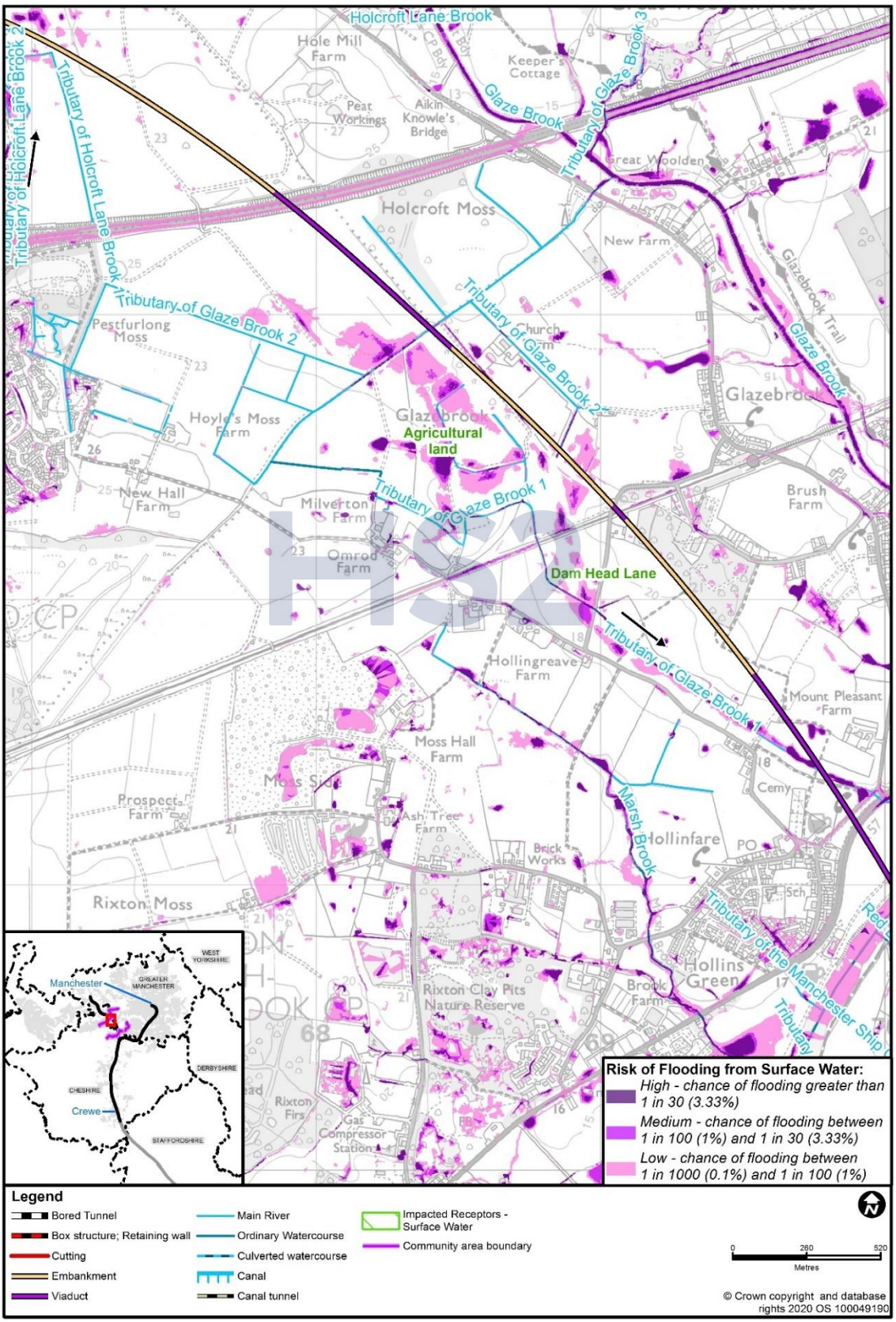
- Tributary of Glaze Brook 1 (also known as Hollins Green Brook) (main river), north of Hollinfare;
- Tributary of Glaze Brook 2, (ordinary watercourse), east of Gorse Covert; and
- Tributary of Agden Brook 1 (ordinary watercourse), east of Broomedge.

3.2.10 These main rivers and ordinary watercourses do not have mapped flood zones indicated by the Environment Agency's Flood map for planning (rivers and sea) dataset, and so the RoFSW outputs were used to determine possible flood extents generated by these watercourses.

3.2.11 Figure 5 indicates the receptors at risk for the surface water flow paths associated with Tributary of Glaze Brook 1 and Tributary of Glaze Brook 2. Undeveloped agricultural land is the most common receptor from Tributary of Glaze Brook 1 and Tributary of Glaze Brook 2. Dam Head Lane (less vulnerable) is at risk from Tributary of Glaze Brook 1. The decision tree process, described in the SMR: Technical Note: Flood risk, determined that modelling of Tributary of Agden Brook 1 was not required. However, due to the potential risk to a more vulnerable residential property and the lack of flood zone information hydraulic modelling has been undertaken.

3.2.12 In line with the SMR a climate change allowance has been adopted to assess the future flood risk to receptors associated with each watercourse crossing using the Environment Agency guidelines. For catchment areas less than 5km^2 in size the guidance recommends that a peak rainfall intensity allowance is used. The percentage uplift in peak rainfall intensity used to assess flood risk to receptors reflects the location of the receptor in the floodplain (flood zone) and its flood risk vulnerability classification. The upper end allowance of 40% increase has been adopted on a precautionary basis for this assessment.

Figure 5: Extent of the Environment Agency's RoFSW dataset, Tributaries of Glaze Brook 1 and Tributary of Glaze Brook 2



Tributary of Agden Brook 1

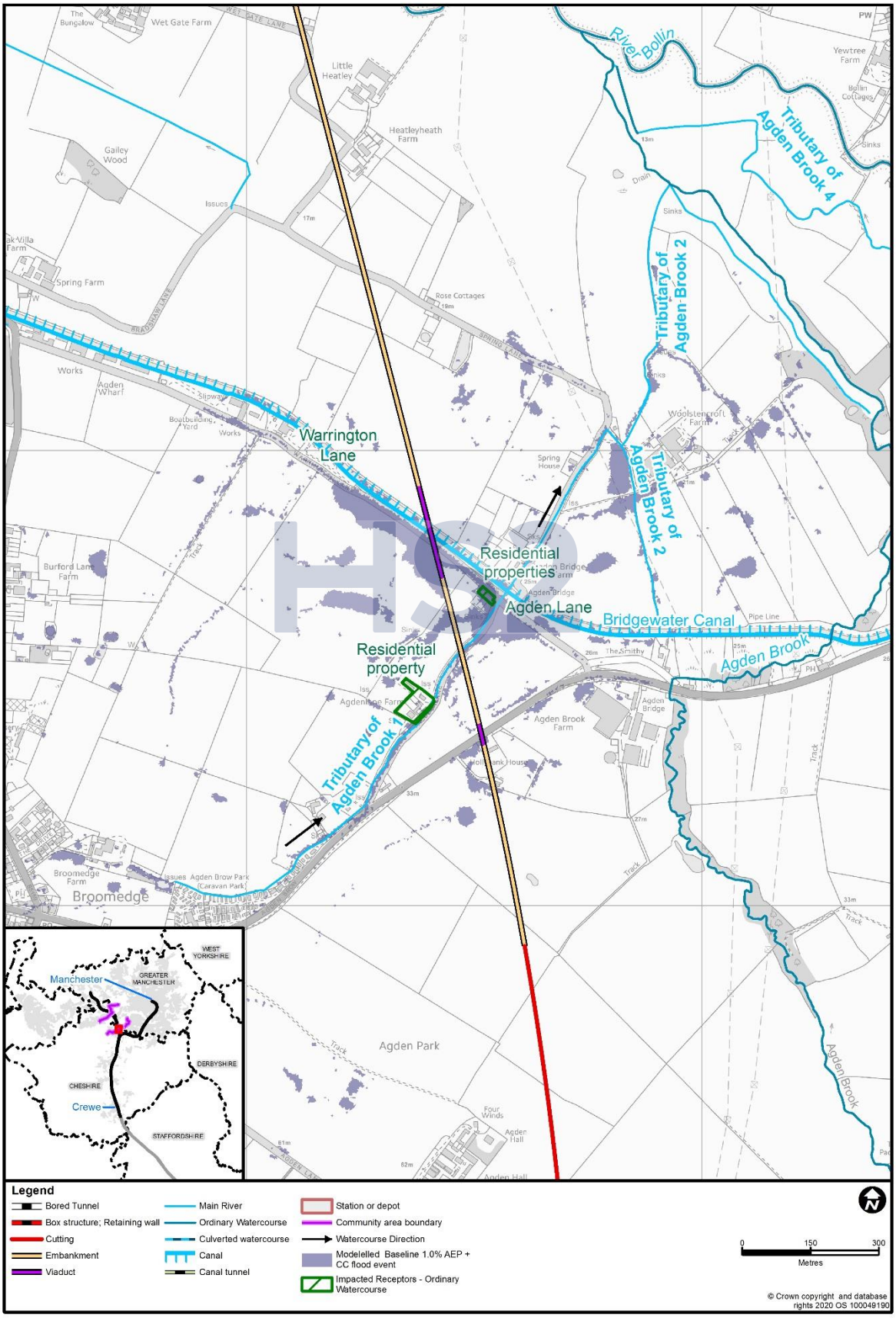
3.2.13 A 2D hydraulic model of Tributary of Agden Brook 1 has been developed to define the peak flood levels and extents associated with a range of annual probabilities. The inundation extent for the 1.0% AEP + climate change (CC) event is shown in Figure 6.

3.2.14 The receptors upstream and downstream of the Proposed Scheme that are potentially at risk of flooding from this watercourse are listed below. The relative vulnerability to flooding of each receptor (as defined in NPPF and Table 55 of the SMR) is also indicated:

- Agden Lane (less vulnerable);
- residential property along Agden Lane (more vulnerable);
- residential properties along Warrington Lane (more vulnerable); and
- Warrington Lane (less vulnerable).

3.2.15 In line with the SMR, a climate change allowance has been adopted to assess the future flood risk to receptors associated with each watercourse crossing using the Environment Agency guidelines. For catchment areas less than 5km^2 in size the guidance recommends that a peak rainfall intensity allowance is used. The percentage uplift in peak rainfall intensity used to assess flood risk to receptors reflects the location of the receptor in the floodplain (flood zone) and its flood risk vulnerability classification. The upper end allowance of 40% increase has been adopted on a precautionary basis for this assessment.

Figure 6: Extent of the modelled 1.0% AEP + CC flood event, Tributary of Agden Brook 1



3.3 Risks associated with surface water

3.3.1 This section describes the risk associated with surface water as shown by the Environment Agency's RoFSW dataset for the 1 in 1000 (0.1%) AEP flood event. No further surface water flow paths, other than those addressed using the RoFSW dataset in Section 3.2, have been identified in the Broomedge to Glazebrook area.

3.3.2 A summary of the baseline flood risk from surface water is provided in Table 1.

3.4 Risks associated with groundwater

3.4.1 The British Geology Society (BGS) susceptibility to groundwater flooding dataset[20] provides the main dataset used to scope the future risk of groundwater flooding. The assessment of susceptibility is based on rock type and estimated groundwater levels during periods of extended intense rainfall. The dataset shows groundwater flooding susceptibility, on a 50m grid, using the following three classes:

- A – limited potential for groundwater flooding to occur;
- B – potential for groundwater flooding of property situated below ground level; and
- C – potential for groundwater flooding to occur at the surface.

3.4.2 The BGS susceptibility to groundwater flooding dataset is a hazard dataset based on favourable geological conditions for groundwater flooding. The dataset is not based on risk and as such does not show the likelihood of a groundwater flooding event actually occurring.

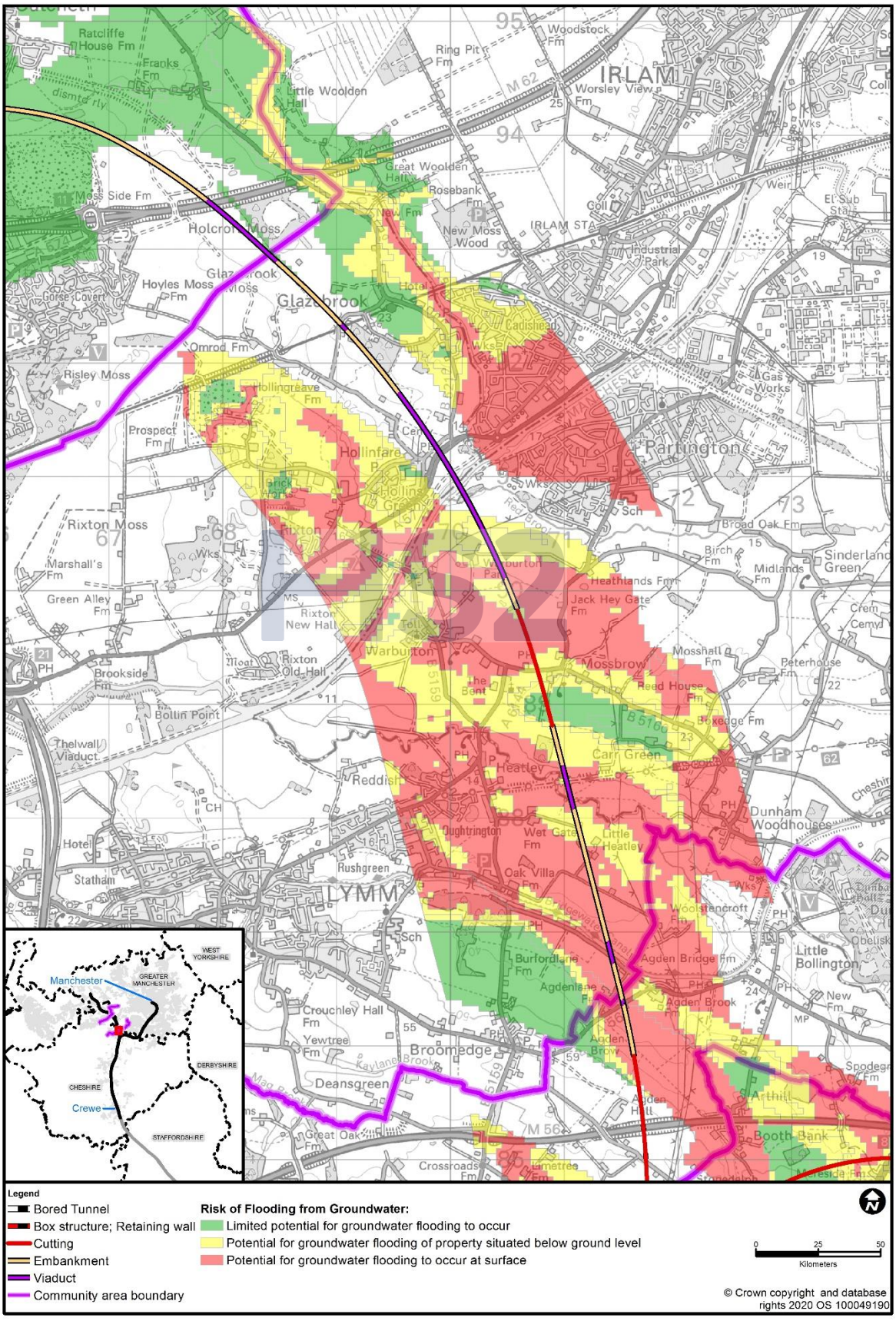
3.4.3 The BGS susceptibility to groundwater flooding dataset (presented in Figure 7) indicates that there is potential for groundwater flooding to occur at surface across much of the study area, including:

- River Bollin floodplain;
- Manchester Ship Canal floodplain;
- Little Heatley; and
- Warburton.

3.4.4 This is due to the nature of the superficial deposits (glacial till). The SFRA[11,12] does not report any historic groundwater flooding incidents within the study area.

[20] British Geological Survey (2018), *BGS susceptibility to groundwater flooding dataset*. Available online at: http://www.bgs.ac.uk/products/hydrogeology/groundwaterFlooding.html.

Figure 7: Susceptibility to groundwater flooding throughout the study area



3.5 Risks associated with artificial sources

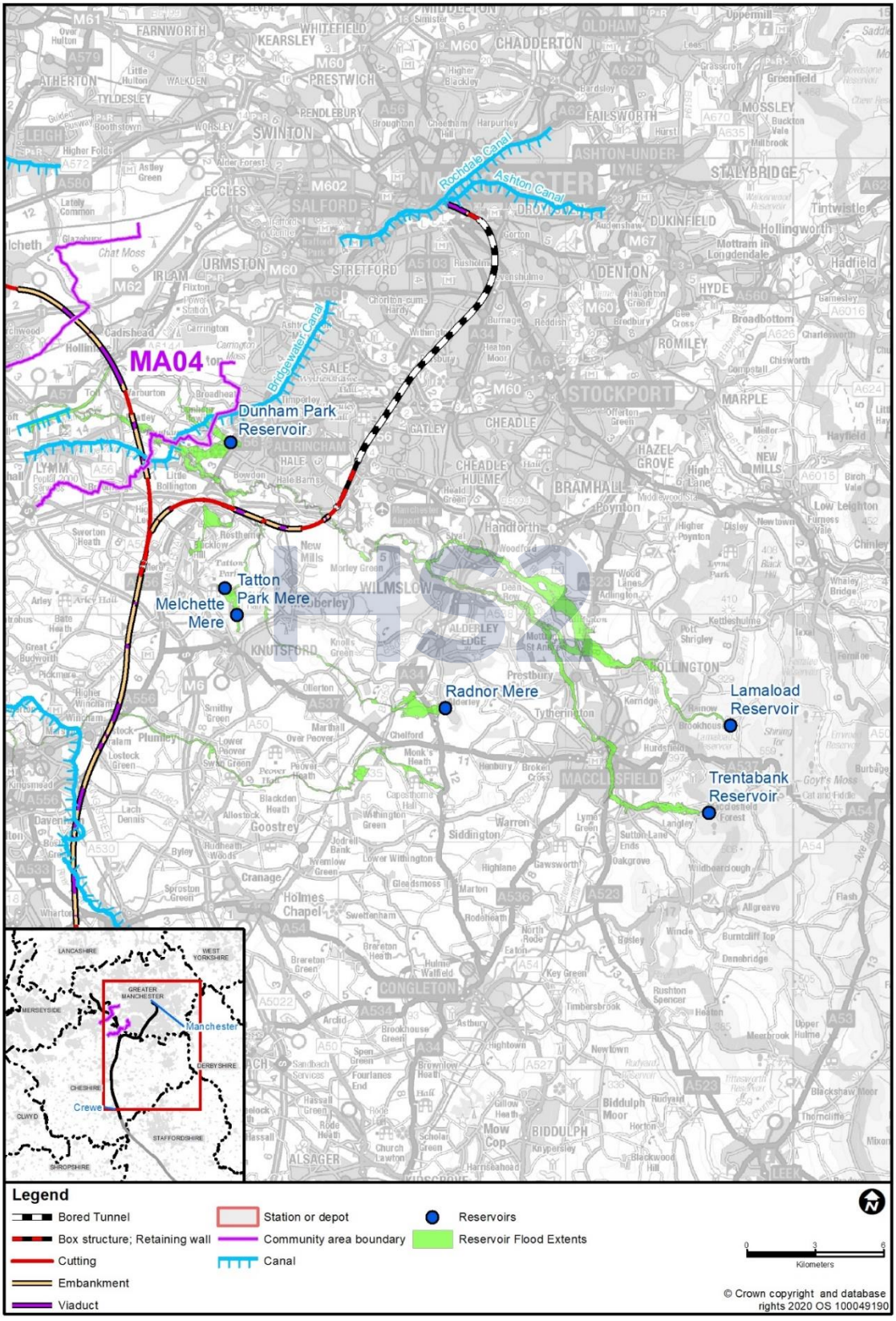
3.5.1 Flooding from artificial water bodies may occur due to failure of an impounding structure, such as a dam or canal embankment. The following features have been identified within the study area that are a potential source of flood risk:

- Tatton Park Mere, Lamaload Reservoir, Dunham Park Reservoir, Melchett Mere, Radnor Mere, and Trentabank Reservoir. These are large, raised reservoirs or impounded water bodies[21] and are shown on the Environment Agency's Flood risk from reservoirs mapping[3];
- Bridgewater Canal and Manchester Ship Canal which pass through the Broomedge to Glazebrook area; and
- major water supply pipelines and sewerage (foul and surface water) infrastructure have potential to cause flooding should it fail. However, this infrastructure, and its potential failure, is accounted for in the assessment of surface water flooding and in the design of the Proposed Scheme, as shown in Volume 2, MA04 Map Book: Map Series CT-05 and CT-06.

3.5.2 Figure 8 shows the location of artificial sources within the Broomedge to Glazebrook area and a summary of the baseline flood risk from artificial sources is provided in Table 1.

[21] Meres listed have been analysed for dam breach by the Environment Agency and are included in the Reservoir Flood Maps dataset.

Figure 8: Artificial flood sources in the vicinity of the study area



3.6 Summary of baseline flood risk

3.6.1 Table 1 provides a summary of all the relevant sources of flood risk identified, the receptors potentially affected, their relative vulnerability and the climate change allowances used in the modelling assessments and calculations.

Table 1: Summary of baseline flood risk

Source / pathway	Receptors	Data source	Highest receptor vulnerability level	Climate change allowance used for assessment
River Bollin	Footpaths: Bollin Valley Way and Lymm 37 (less vulnerable)	Environment Agency Flood Zones 2 and 3	Less vulnerable	70% (increase to peak river flow)
	Trans Pennine Trail (National Cycle Route 62) (less vulnerable)			
	Agricultural land[19] (less vulnerable)			
Tributary of the Manchester Ship Canal 2 (also known as Warburton Park Brook)	Residential properties on Park Road (more vulnerable)	Environment Agency Flood Zones 2 and 3	More vulnerable	70% (increase to peak river flow)
	Agricultural land[19] (less vulnerable)			
Red Brook (also known as Sinderland Brook)	Footpath - Bollin Valley Way (less vulnerable)	Environment Agency Flood Zones 2 and 3	Less vulnerable	70% (increase to peak river flow)
Manchester Ship Canal	Telecommunications mast (essential infrastructure)	Environment Agency Flood Zones 2 and 3	Essential infrastructure	70% (increase to peak river flow)
	Water works pumping station (water compatible)			
	Towpath (less vulnerable)			
	A57 (essential infrastructure)			
	Mytholme Avenue (less vulnerable)			
	Residential properties along Mytholme Avenue (more vulnerable)			
	Liverpool Road (less vulnerable)			
	Rosebank Road (less vulnerable)			
	Residential properties along Rosebank Road (more vulnerable)			

Source / pathway	Receptors	Data source	Highest receptor vulnerability level	Climate change allowance used for assessment
	Industrial property on Cadishead Way (less vulnerable)			
	Planning applications for residential developments (MA04/126, MA04/105) (more vulnerable)			
	Potential future allocation for recreational land and facilities (MA04\026) (water compatible)			
Tributary of Glaze Brook 1 (also known as Hollins Green Brook)	Dam Head Lane (less vulnerable)	RoFSW 0.1% AEP flood extent	Less Vulnerable	40% (increase in peak rainfall intensity)
	Agricultural land (less vulnerable)			
Tributary of Glaze Brook 2	Agricultural land (less vulnerable)	RoFSW 0.1% AEP flood extent	Less Vulnerable	40% (increase in peak rainfall intensity)
Tributary of Agden Brook 1	Residential properties along Warrington Lane (more vulnerable)	1.0% AEP + CC flood extent	More vulnerable	40% (increase in peak rainfall intensity)
	Warrington Lane (less vulnerable)			
	Residential property along Agden Lane (more vulnerable)			
	Agden Lane (less vulnerable)			
Groundwater	Agricultural land[19] (less vulnerable)	BGS Susceptibility to groundwater flooding dataset	Essential Infrastructure	Not defined
	Footpaths (less vulnerable)			
	Cycle track (less vulnerable)			
	Telecommunications mast (essential infrastructure)			
	Water works pumping station (water compatible)			
	Towpath (less vulnerable)			
	A57 (essential infrastructure)			
	Mytholme Avenue (less vulnerable)			
	Residential properties along Mytholme Avenue (more vulnerable)			
	Liverpool Road (less vulnerable)			

Source / pathway	Receptors	Data source	Highest receptor vulnerability level	Climate change allowance used for assessment
	Rosebank Road (less vulnerable)			
	Residential properties along Rosebank Road (more vulnerable)			
	Industrial property on Cadishead Way (less vulnerable)			
	Mill lane (less vulnerable)			
	Residential properties in Heatley (more vulnerable)			
	Park Road, Paddock Lane, Warburton Lane (less vulnerable)			
	Residential properties along Paddock Lane (more vulnerable)			
Tatton Park Mere, Lamaload Reservoir, Dunham Park Reservoir, Melchett Mere, Radnor Mere, and Trentabank Reservoir	Footpaths (less vulnerable)	Environment Agency long-term flood risk information	Less vulnerable	Not defined
	Cycle track (less vulnerable)			
	Agricultural land[19] (less vulnerable)			

4 Flood risk impacts and effects

4.1 Rivers and ordinary watercourses

Viaducts

4.1.1 The Proposed Scheme within the Broomedge to Glazebrook area includes viaduct crossings of the River Bollin West and the Manchester Ship Canal. Hydraulic analysis of these watercourses has been used in the design and assessment of the Proposed Scheme to determine the likely impact on flood levels from intermediate piers, or any other permanent features associated with the Proposed Scheme that are within the flood zones or predicted flood extents.

River Bollin West viaduct

4.1.2 The River Bollin West viaduct is approximately 430m in length. The hydraulic analysis for this viaduct was undertaken using simplified 2D modelling with Light Detection and Ranging (LiDAR) data defining the 2D surface and refinements made to represent the watercourse and piers. This analysis has been used to provide greater certainty over the level of impacts the Proposed Scheme is likely to have on peak flood levels. The hydraulic analysis was used to define the impact on the 1.0% AEP plus an allowance for the CC flood level.

4.1.3 Hydraulic analysis of head loss associated with the piers indicates that without any mitigation the viaduct piers have the potential to cause localised (generally within 10m) changes in peak flood levels of less than 30mm. The increase in peak water level is classified as a minor impact as it is a highly localised impact constrained to the immediate vicinity of the piers and will affect agricultural land (a moderate value receptor). This results in a minor adverse effect which is not significant.

4.1.4 Replacement floodplain storage (RFS) has been identified on a level for level basis as a precautionary measure to address the loss of floodplain storage at this crossing (Figure 10). The RFS will be refined during design development to ensure that there is no net loss of floodplain storage. The volume required was estimated using the Flood Zone 2 (1 in 1000 year) extent which is considered to be similar to the 1 in 100 year flood extent including climate change.

4.1.5 Further topographical survey, other surveys as required, hydraulic modelling, including incorporation of the proposed RFS, design development, and refinement of the mitigation measures will be undertaken during design development and will, as far as reasonably practical, ensure that flood risk is not increased.

Manchester Ship Canal viaduct

4.1.6 The Manchester Ship Canal viaduct is approximately 1.9km in length and spans Manchester Ship Canal, Red Brook, Tributary of Manchester Ship Canal 2 and Tributary of Glaze Brook 1. Two piers and their foundations encroach into the canal itself and are located in the vicinity of the canal edge. To protect the viaduct piers from the risk of collision from ships, the piers and their foundations will be constructed behind retaining walls on both sides of the canal banks. These walls result in a narrowing of the canal at the Proposed Scheme crossing.

4.1.7 Hydraulic modelling of the Manchester Ship Canal has been used in the design and assessment of the Proposed Scheme. The modelling was used to determine the likely impact on flood levels and flow velocities. Details of the Hydraulic modelling are reported in Volume 5: Appendix WR-006-00002.

4.1.8 Hydraulic modelling indicates the potential for major adverse impacts on peak flood levels in Glaze Brook, upstream of the confluence with the Manchester Ship Canal, affecting high value residential receptors along Glazebrook Lane and Rosebank Lane in Cadishead. RFS has been identified on a level for level basis as a precautionary measure to address the loss of floodplain storage associated with the viaduct piers at this crossing (Figure 10). The RFS has not been included in the hydraulic modelling at this stage. The volume required was estimated using the Flood Zone 2 (1 in 1000 year) extent which is considered to be similar to the 1 in 100 year flood extent including climate change.

4.1.9 The modelled impact of the Proposed Scheme shows increases in peak water level for the 1.0% AEP plus climate change event of greater than 100mm, a major adverse impact, affecting up to 32 high value residential receptors along Glazebrook Lane, Mythholme Avenue, Rosebank Road, Haig Avenue, Victory Road and Essex Gardens and part of a wastewater treatment works (moderate value receptor) as shown in Figure 9, resulting in significant effects. This is due to the new retaining walls associated with the Proposed Scheme which will be constructed on the north and south bank of the Manchester Ship Canal to protect Manchester Ship Canal viaduct piers against ship impact. These retaining walls will constrict the flow in the canal in this area, causing the backing-up of flow in Glaze Brook. Flow velocities are increased as a result of narrowing the canal and therefore localised scour protection of the bed and the banks will be required and in particular at the edge of the retaining walls and the soft banks.

4.1.10 To mitigate the increase in upstream flood risk additional mitigation measures will be required. These measures may include provision of additional floodplain storage (particularly around Glazebrook) or consideration of measures to increase the conveyance through the Manchester Ship Canal channel (such as increasing the spans between the piers to avoid the requirement for retaining walls or consideration of a bypass channel) in order to reduce the impacts.

4.1.11 The potential mitigation has not been included in the design at this stage. A review of the most appropriate mitigation is currently underway and will be considered further during the

passage of the hybrid Bill. This mitigation will be further refined during design development to ensure that there is no adverse impact on flood risk elsewhere due to the proposed crossing.

4.1.12 Further topographical survey, other surveys as required, hydraulic modelling, including incorporation of the proposed RFS, design development, and refinement of appropriate other mitigation measures will be undertaken during design development and will, as far as reasonably practicable, ensure that flood risk is not increased.

Figure 9: Manchester Ship Canal impact map for the 1.0% AEP + CC flood event

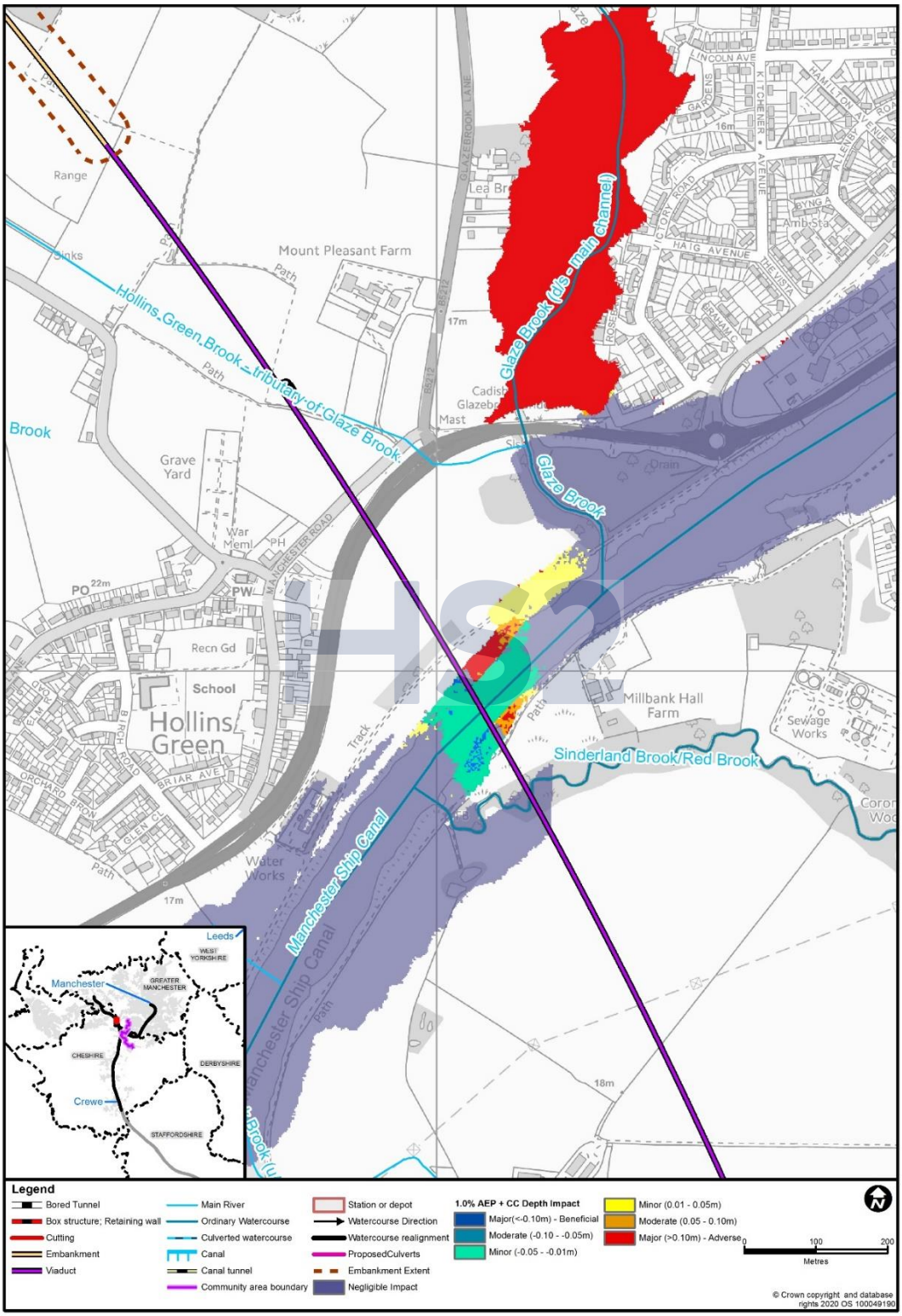
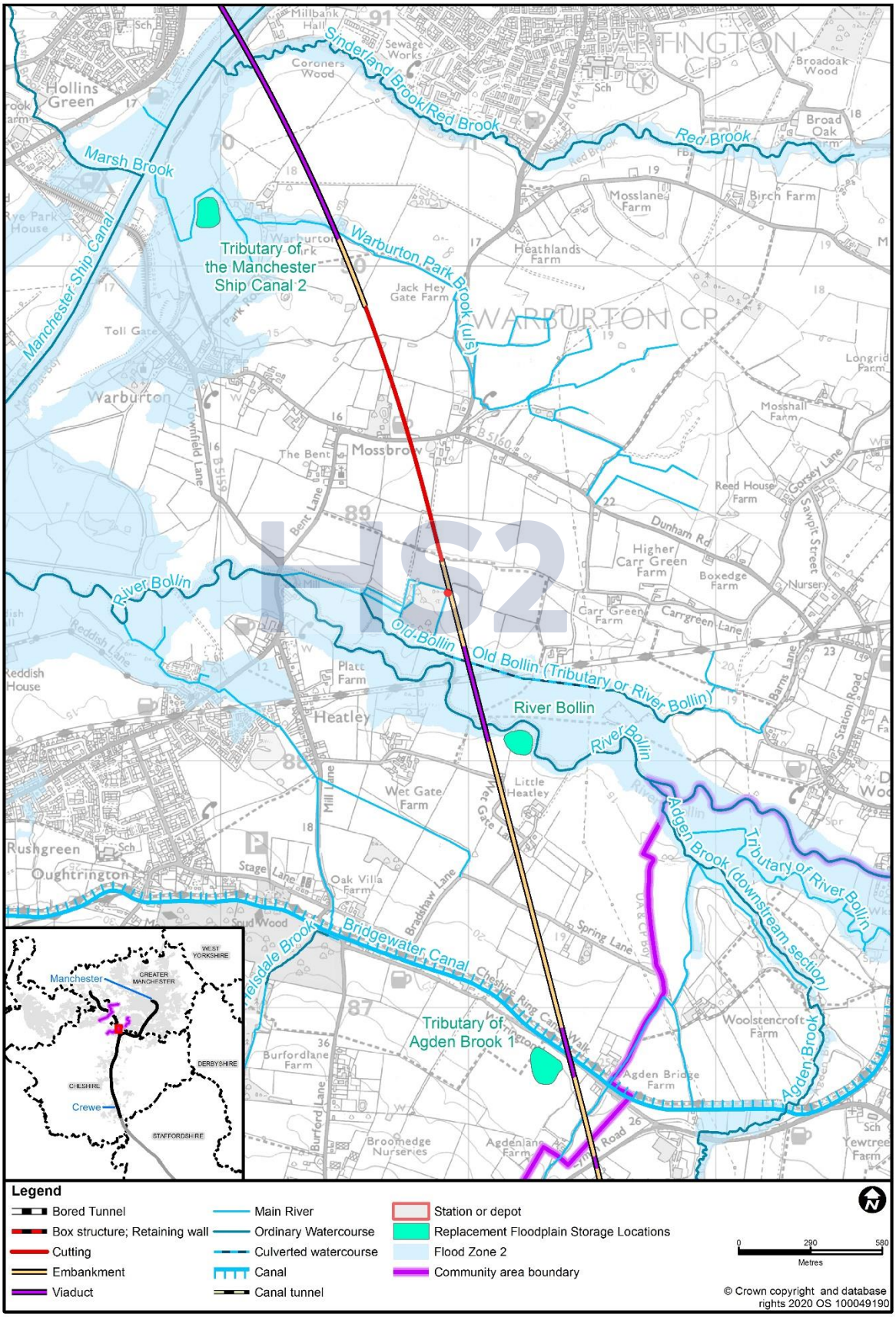


Figure 10: Replacement floodplain storage areas



Culverts and channel realignments

4.1.13 The Proposed Scheme crosses a number of ordinary watercourses that have not been hydraulically modelled or mapped as part of the Environment Agency Flood map for planning (rivers and sea) dataset[4]. The RoFSW[4] dataset has therefore been used to indicate the potential flood extent generated and the receptors affected along these ordinary watercourses.

4.1.14 At the locations where these ordinary watercourses cross the Proposed Scheme, or offline features, culverts are required to convey the water under the route. Figure 11 shows the location of proposed culverts. The following calculation procedure has been undertaken to size the culverts:

- use of the Revitalised Rainfall-Runoff Model version 2.2 (ReFH2)[22] to determine the peak flow generated during the 1.0% AEP storm event;
- determination of the appropriate climate change allowance to be applied following the procedure outlined in the SMR;
- determination of the existing gradient of the watercourse using Ordnance Survey Mapping and LiDAR data;
- determination of the roughness characteristics of the culvert; and
- selection of a structure with the capacity to convey the 1.0% AEP peak flow, incorporating the appropriate allowance for climate change, whilst ensuring a 300mm freeboard to the culvert soffit above this design flood level and allowing for 300mm substrate at the culvert invert.

4.1.15 The details of the culvert design applied to the ordinary water courses are provided in Table 2.

Table 2: Details of culvert design at ordinary watercourse crossings

Watercourse / location	Structure name	Estimated 1.0% AEP peak flow (m^3/s)	Climate change allowance	Estimated 1.0% AEP + CC peak flow (m^3/s)	Culvert dimensions of opening (m)	Culvert capacity (m^3/s)[23]
Tributary of Glaze Brook 1	This tributary passes under the Manchester Ship Canal viaduct, therefore no culvert is required.					
Tributary of Glaze Brook 2	This tributary passes under the M62 West viaduct, therefore no culvert is required.					
Tributary of Agden Brook 1	Agden Lane Culvert	0.11	40%	0.15	2.1 x 1.35	5.10

[22] Wallingford HydroSolutions (2016), *Revitalised Flood Hydrograph Model ReFH2: Technical Guidance*.

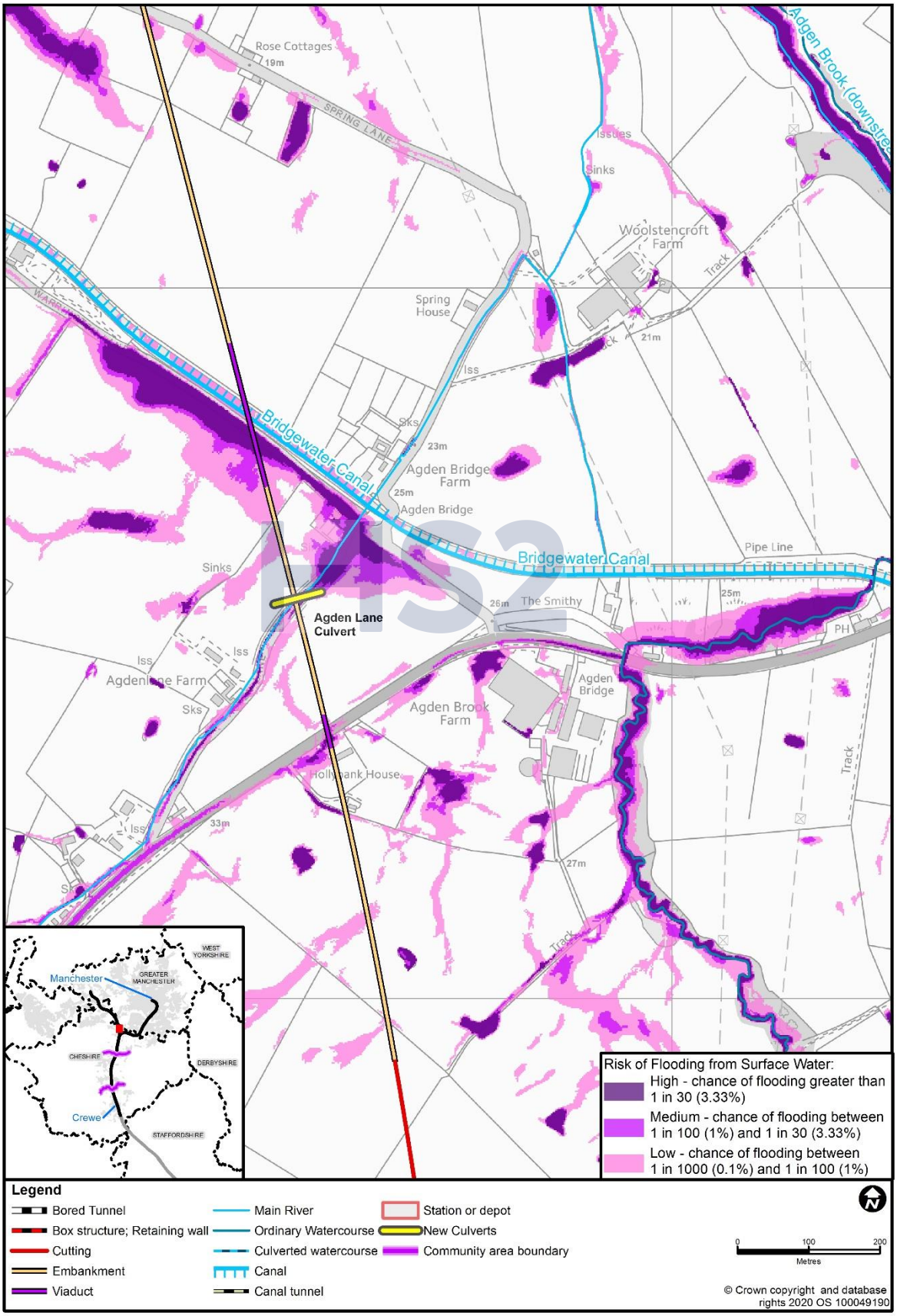
[23] Culvert may be designed to contain not only flow for the watercourse but for provision of other services, such as footpath or ecological reasons. This results in a culvert size larger than that required to convey just the flow from the watercourse.

4.1.16 By following this design approach, the flood risk to the receptors identified is unlikely to be changed.

4.1.17 Each of the ordinary watercourse crossings in Table 2 is associated with a channel realignment to reduce the length of culvert required as far as is reasonably practicable. The realigned channels will have the same hydraulic capacity as the existing channel unless it is identified during design development that a change in size is required to ensure no adverse impacts on flood risk.

4.1.18 Due to the risk to more vulnerable residential property, Tributary of Agden Brook 1 surface water flow path has undergone hydraulic modelling and is discussed below.

Figure 11: Proposed culverts



Tributary of Agden Brook 1

4.1.19 Hydraulic modelling of this watercourse has been used in the design and assessment of the Proposed Scheme to determine the likely impact on local peak flood levels.

4.1.20 The model has been used to:

- define the 1.0% AEP flood extent including an allowance for climate change for the baseline and post-development scenarios; and
- confirm that the culverts are sufficient in size to convey the 1.0% AEP + CC peak river flow with a 300mm freeboard.

4.1.21 The baseline model was amended to represent the Proposed Scheme by including the embankment as a raised impermeable wall and the proposed Agden Lane culvert. Provision for replacement floodplain storage mitigation embedded in the design upstream of the Proposed Scheme embankment was made by lowering the ground level by an average of 1m.

4.1.22 The existing Tributary of Agden Brook 1 culvert (in the baseline and Proposed Scheme scenarios) under Warrington Lane and Bridgewater Canal has been assumed to be 0.8m in diameter. This assumption is based on aerial imagery and is considered reasonable when compared to the size of the channel cross sections (assumed from LiDAR and aerial imagery).

4.1.23 A short, localised realignment is proposed by the outlet of the Proposed Scheme culvert crossing. Associated re-grading of the channel bed will ensure the channel crosses at a ninety-degree angle to the Proposed Scheme alignment.

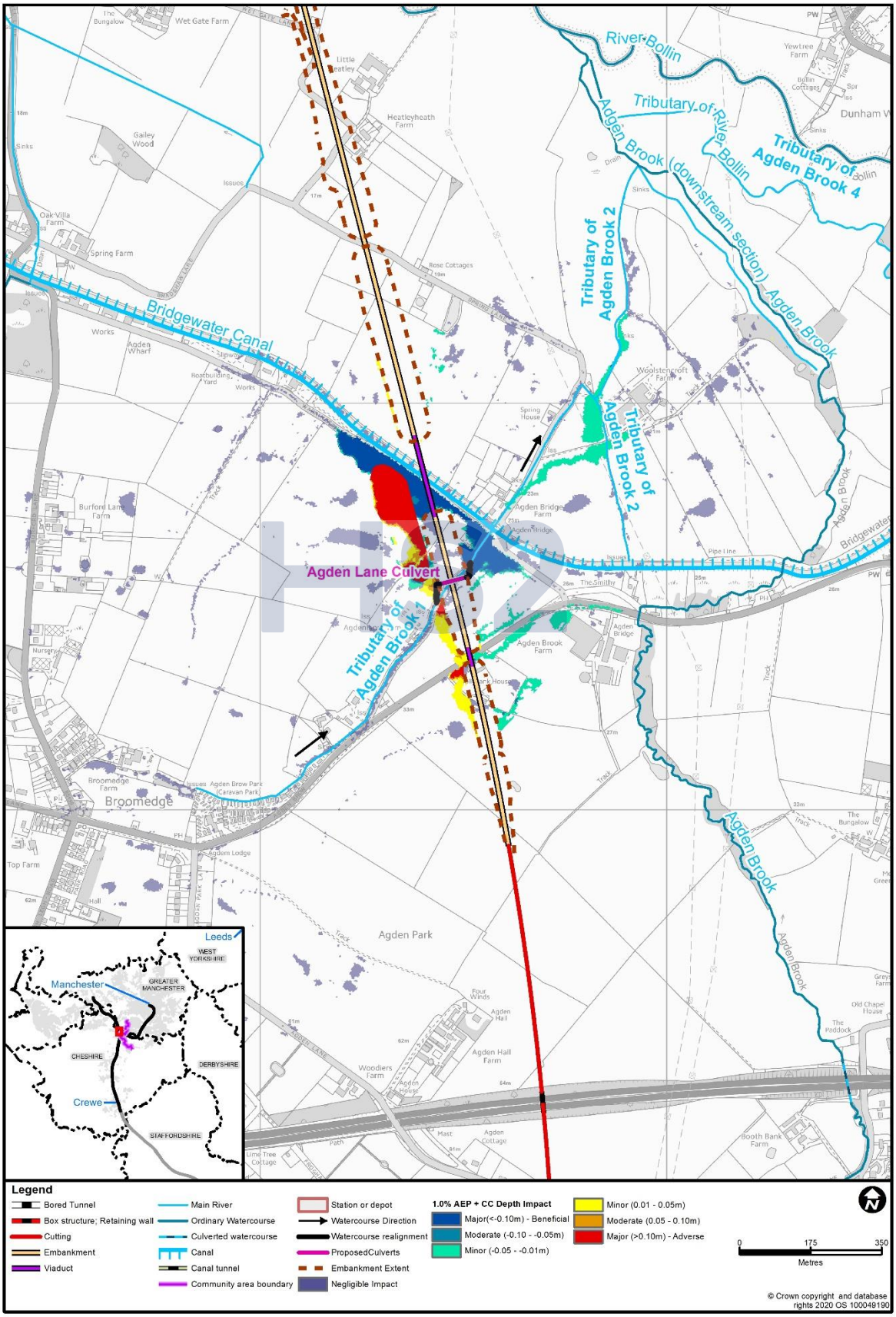
4.1.24 The modelled impact of the Proposed Scheme on peak flood level is shown in Figure 12. This indicates the potential for:

- an increase in flood depth of 260mm within the proposed replacement flood storage area upstream of the Proposed Scheme culvert; and
- a decrease in flood depth of approximately 140mm downstream of the Proposed Scheme culvert.

4.1.25 The upstream increase in flood depth is contained within the modelled replacement flood storage area as this has been sized on a precautionary basis and is 1m deep. The modelling shows that the indicative replacement floodplain storage area provided at this stage is effective at mitigating the flood risk posed by the Proposed Scheme. The modelled replacement floodplain storage area is indicative at this stage and will be refined during design development. Peak flood levels downstream of the culvert are reduced and therefore the Proposed Scheme positively affects the flood risk to receptors downstream.

4.1.26 Model results indicate that the current proposed design achieves the freeboard requirements for the Proposed Scheme watercourse crossing soffit.

Figure 12: Tributary of Agden Brook 1 impact map for the 1.0% AEP + CC flood event



Construction compounds

4.1.27 Table 3 highlights the temporary site compounds and stockpiles located in areas at risk of flooding. A number of the proposed stockpiles are located within or across existing surface water flow paths.

4.1.28 The risk of flooding to these compounds and stockpiles will be managed through the draft CoCP. A sequential approach will be applied to the allocation of use within the compounds, seeking primarily to avoid using areas at flood risk wherever practical, but where this is unavoidable using areas at risk of flooding for the least vulnerable components and those that will avoid/limit the potential for off-site impacts. The sites will be registered with the Environment Agency Flood Warning and Flood Alert service, if applicable.

Table 3: Details of temporary site compounds and stockpiles at risk of flooding

Watercourse/location	Construction compound	Risk of flooding from surface water	Location constraints	Potential mitigation
Tributary of Agden Brook 1	Stockpile	Stockpile crosses a surface water flow path	Satellite compound constraint in the west, scheme alignment to the east and watercourse to the north	Stockpile can be stopped either side of flow path
Tributary of Agden Brook 1	Stockpile	Southern end of stockpile covers a surface water flow path	Canal constraint to the north, scheme alignment to the east	Stockpile can be stopped either side of flow path
Tributary of Glaze Brook 1	Stockpile	Stockpile crosses a surface water flow path	Scheme alignment constraint to the east	Stockpile can be stopped either side of flow path

4.2 Surface water

4.2.1 As outlined previously the RoFSW[4] dataset and inspection of topographical survey information has identified surface water flow paths that are not represented by any formal channel feature and so are not watercourses. No surface water flow paths have been identified in this area, therefore no further assessment is required.

4.3 Groundwater

4.3.1 The principal mechanism by which the Proposed Scheme could increase groundwater flood risk is where sub surface structures of lower permeability than the existing geology, such as lined tunnels or pile walls, may act as a barrier to groundwater flow. These barriers have the potential to cause a rise in groundwater level in the vicinity of the structures.

4.3.2 To assess the possible changes to groundwater levels and flow, and the associated change in groundwater flood risk, a high-level assessment of the groundwater conditions along the route has been undertaken to understand where the Proposed Scheme is likely to interact with groundwater. The high-level assessment identified where elements of the scheme design such as cuttings, retaining walls, viaduct and bridge foundations, basements, excavations and temporary works intercept aquifers which pose a groundwater flood risk. An assessment has been made of the degree to which the design features encroach on the aquifer and the potential changes in groundwater level and restrictions on groundwater flow. Receptors within the area at risk of potential changes in groundwater level or flow were then identified. The likely maximum zone of influence from any dewatering taking place has also been assessed.

4.3.3 The assessment has shown that there are no features of the Proposed Scheme in the Broomedge to Glazebrook area that will act as a significant barrier to groundwater flow. Therefore, there are unlikely to be any significant increases in groundwater levels across the aquifers which could lead to increased risks of groundwater flooding as a result of the Proposed Scheme. Further details of groundwater level changes are set out in the Water resources assessment Volume 5: Appendix WR-003-0MA04.

4.4 Artificial sources

4.4.1 Tatton Park Mere, Dunham Park Reservoir, Lamaload Reservoir, Melcheet Mere, Radnor Mere and Trentabank Reservoirs are shown on the Environment Agency's flood risk from reservoirs mapping[4] dataset. This dataset indicates that, in the event of a failure of these artificial reservoirs, the River Bollin and Manchester Ship Canal floodplain areas will be affected by the resulting flood. The extent of flooding from reservoirs is less than the fluvial flood zones in the vicinity of the Proposed Scheme, therefore the effects can be considered to be mitigated. These large reservoirs are subject to the requirements of the Reservoirs Act 1975[24], and as such are inspected annually. This increases the likelihood that any degradation in the operational performance of a reservoir will be identified and addressed before there is an increased risk of failure. Whilst the consequences of failure are potentially very high, this inspection and maintenance regime means that the overall risk of flooding from this source is considered low and very unlikely to change as a result of the Proposed Scheme.

4.4.2 Major water supply pipelines and sewerage (foul and surface water) infrastructure have been identified and are accounted for on the Volume 2, MA04 Map Book: Map Series CT-05 and CT-06. This infrastructure has been identified and diverted where appropriate. Measures will be taken to safeguard the local receptors during this diversion process.

[24] Department for Communities and Local Government (2014), *Reservoirs: owner and operator requirements*. Available online at: https://www.gov.uk/guidance/reservoirs-owner-and-operator-requirements.

4.4.3 Bridgewater Canal is located in the Broomedge to Glazebrook study area. The Proposed Scheme will not encroach into the canal channels or embankments and will therefore not change the canal flood risk. In the event of embankment failure, flood risk posed to the Proposed Scheme will be unchanged as the Proposed Scheme is elevated on an overbridge over Bridgewater Canal (Proposed Scheme track elevations defined following HS2 Ltd technical standards).

4.4.4 The Proposed Scheme does not change the flood risk posed by failure of artificial water sources.

4.5 Off-site impacts and effects (surface water management)

4.5.1 Runoff from the footprint of the Proposed Scheme could occur more rapidly post-construction due to steeper slope angles and the permeability of the newly created surfaces.

4.5.2 The design of drainage systems will, as far as reasonably practical, ensure that there will be no significant increases in flood risk, during storms up to and including the 1.0% AEP + CC event, as set out in the SMR.

4.5.3 Balancing ponds for new sections of highway and railway drainage have been sized on a precautionary basis, pending more detailed information about the permeability and runoff characteristics of existing and proposed ground surfaces[25].

[25] High Speed Two Ltd (2022), *Phase 2b Western Leg Information Paper E21: Balancing ponds and replacement flood storage areas.*

5 Additional flood risk management measures

5.1.1 The next stage of the design process will involve incorporation of topographical survey information into the existing hydraulic models to improve the representation of existing watercourses and floodplain. Designs for the viaducts, bridges and culverts will be incorporated into the hydraulic models along with the identified areas of RFS, the mitigation measures will be refined during design development to remove potential effects on flood risk as far as is reasonably practicable. The effect of RFS areas on the agricultural land quality classification is assessed in Volume 2, Community Area report: Broomedge to Glazebrook (MA04), Section 4: Agriculture, forestry and soils.

5.1.2 RFS has been proposed on a precautionary basis to address the loss of floodplain storage caused by the intermediate piers at the viaduct crossings and the embankment at the Tributary of Agden Brook 1 crossing and compensate for any wider cumulative impacts. The provision for RFS has been made on a level for level basis and, together with other design measures, will mitigate the loss of floodplain storage, resulting in negligible impacts and negligible effects, which are not significant.

5.1.3 Additional mitigation is required at Manchester Ship Canal to reduce the significant effects at Cadishead. Potential mitigation may include provision of additional floodplain storage or consideration of measures to increase the conveyance through the channel in order to minimise the impacts. No mitigation is currently included in the design. Further investigation is underway to refine the proposed mitigation during the passage of the hybrid Bill, to ensure that there is no significant increase in flood risk from the Proposed Scheme.

5.1.4 Further topographical survey, other surveys as required, hydraulic modelling, including incorporation of the RFS, design development, and refinement of the mitigation measures will be undertaken during design development.

5.1.5 The above activities will be undertaken in close consultation with the Environment Agency and the LLFA. If any residual effects are identified, the affected landowners will also be consulted. As far as reasonably practical no parties will be affected by unacceptable increases in flood risk.

6 Summary of significant flood risk effects

6.1.1 On a precautionary basis, subject to confirmation during design development, it is anticipated that significant residual effects will remain on flood risk at Manchester Ship Canal (permanent major adverse effect) due to the construction of Manchester Ship Canal retaining walls which will locally narrow the canal. Additional mitigation will be required to ensure no increase in flood risk in this area.

6.2 Conclusions

6.2.1 This flood risk assessment presents the impacts and effects of the Proposed Scheme, taking into account avoidance and mitigation measures described in Volume 2, Community Area report: Broomedge to Glazebrook. Additional mitigation measures have been developed to further reduce the temporary and permanent impacts of construction stage activities, where there is potential for the Proposed Scheme to result in significant effects.

6.2.2 RFS mitigation has been identified to address the loss of floodplain storage caused by the intermediate piers at the viaduct crossings and by the embankment at the Tributary of Agden Brook 1 crossing. Further assessment and refinement of the models and mitigation measures during design development will ensure any localised impacts on peak flood levels are mitigated and flood risk is unchanged as a result of the Proposed Scheme.

6.2.3 The hydraulic modelling undertaken at Tributary of Agden Brook 1 has shown that the embedded RFS provided is effective at mitigating flood risk posed by the Proposed Scheme. Peak flood levels downstream of the Tributary of Agden Brook 1 crossing are reduced, showing a betterment to flood risk due to the Proposed Scheme. The modelling has shown that it should be possible to develop a design for the Proposed Scheme that does not increase flood risk. Further modelling and refinement of the RFS mitigation measure will be undertaken during design development.

6.2.4 The hydraulic modelling undertaken for the Manchester Ship Canal has shown that there is an impact from the localised narrowing of the Manchester Ship Canal by the Proposed Scheme. Further modelling and refinement of the mitigation measures will be undertaken, and appropriate mitigation measures will be considered during the passage of the hybrid Bill.

6.2.5 The assessment indicates that subject to the implementation of the avoidance and mitigation measures identified, and the measures included in the Draft water resources operation and maintenance plan, the Proposed Scheme will not result in any significant adverse effects on flood risk in MA04.

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